RIVERTON CITY
STORM DRAINAGE
MASTER PLAN

AMENDMENT

(WEST OF BANGERTER HIGHWAY)

FINAL REPORT

June, 2004

RIVERTON CITY

STORM DRAINAGE MASTER PLAN

WEST OF BANGERTER HIGHWAY

Project Engineer

Prepared by:

HANSEN, ALLEN & LUCE, INC.
Consulting Engineers
6771 South 900 East
Midvale, Utah 84047
(801)566-5599

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ACKNOWLEDGMENTS

Successful completion of this study was made possible by the cooperation and assistance of many individuals including: the Mayor of Riverton City, City Council Members, and City Staff as shown below. We sincerely appreciate the cooperation and assistance provided by these individuals.

<u>Riverton City</u>

Mayor

Mont Evans

City Council

Bill Applegarth
Gayla Brinkerhoff
Al Leavitt
Lisa Leonard
Roy Tingey

City Staff

Frederick Lutze - City Engineer
Thomas Beesley - Staff Engineer

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EXECUTIVE SUMMARY

INTRODUCTION

This amendment to the storm drainage master plan is primarily for the portion of Riverton City west of Bangerter Highway. It also presents activities and public policies to effectively manage and regulate storm water runoff caused by development to mitigate flooding and environmental impacts throughout the City. The document will be a means for educating developers, private property owners, City staff and elected officials regarding the capability and needs of Riverton City's storm drainage system. The storm drainage study includes an examination of the existing storm drainage system and future development impact on the system. Storm Drainage deficiencies are identified and the preferred solution alternatives to the deficiencies are presented with cost estimates.

A computer model was developed as part of the storm drainage master plan that simulates water runoff during a storm event in Riverton City. The storm drainage model operates within ArcView GIS and uses the HEC-1 Army Corps of Engineers Flood Hydrograph Package for computing the storm runoff hydrographs. Not only was the model a vital tool in analyzing the existing and future storm drainage situation for the master plan, but will allow Riverton City to continue to update and analyze for potential drainage deficiencies. This includes facilitating the analysis of conceptual design of alternative mitigation measures due to the impacts of new development.

EXISTING STORM DRAINAGE SYSTEM EVALUATION

The area of Riverton City west of Bangerter Highway is new to development. Ten years ago development was essentially nonexistent and the land was used primarily for agricultural purposes. The only storm drainage features were open ditches along the roads, irrigation ditches and canals, and the natural washes and creeks flowing to the Jordan River. Major topographic relief for Riverton City is from the mountains on the west and south toward the Jordan River in the east. The storm drainage runoff in the study area eventually flows into Midas Creek to the North, Rose Creek to the south, the Provo Reservoir Canal that flows north through the middle of the study area, or past Bangerter Highway to the east through culverts.

Recent residential developments in the study area have been constructed with storm drainage pipes and retention/detention ponds to control storm runoff within the individual developments. The newer storm drainage facilities consist of properly graded lots to drain runoff away from homes and other buildings, streets and gutters to collect runoff, and storm drainage piping to convey the runoff to retention/detention basins.

Riverton City is fortunate to have Midas Creek and Rose Creek which flow through the City providing a convenient discharge location for the City's storm drainage facilities. Existing storm drainage facilities in Riverton City rely on these two creeks for the conveyance of storm water runoff to the Jordan River reducing the need for large main storm drain lines. Each creek system is under the jurisdiction of Salt Lake County Department of Public Works. The 2002 Salt Lake County Southwest Creek and Canal Study provides guidance for creek channel improvements that correct years of disruptions by irrigation and farming activities. The general plan is for the Midas Creek and Rose Creek to be able to convey the historical or pre-development 100-year storm event (which produces about a 0.2 cfs per acre runoff rate) under future development conditions.

Butterfield Creek is a third natural creek located between Rose Creek and Midas Creek. Unfortunately, Butterfield Creek has become a problem the City of Riverton has had to address rather than a solution. Over 100 years ago, canals were constructed to flow from the south to the north perpendicular to the natural creeks. Flow from Butterfield Creek was intercepted by these canals and no longer reaches the lower portions of the valley. In addition, earlier development in Riverton City built in the path of Butterfield Creek because the channel was no longer contiguous. As new development has replaced farmland in the west portion of Riverton, runoff during storm events has increased beyond the capacity of the canals causing flooding. Restoring the natural channel for Butterfield Creek would be extremely costly and disruptive to existing development. Salt Lake County and Riverton City has decided not to restore or maintain Butterfield Creek. A major part of this study was to develop an alternative storm drainage route for areas tributary to Butterfield Creek in Riverton City.

The Provo Reservoir Canal, otherwise known as the Welby-Jacobs Canal, flows through the study area perpendicular to Rose Creek and Midas Creek. The canal is still used to deliver irrigation water, but also receives storm drainage. Canals are usually not the best conveyances for storm water because they are designed to distribute water rather than collect it. Canal capacities decrease from upstream to downstream, while runoff flowrates increase from upstream to downstream. Water quality, debris and sediment, liability issues, and canal maintenance are problems associated with use of the canals to convey storm drainage. Capacity and water quality issues have made the Welby-Jacobs Canal an unacceptable system to convey storm water.

Prior to this study, the only storm drain master plan for this area was a county-wide storm drain system. Riverton City has not previously included this area into the City storm drain master plan since it was annexed into the City in 1996. It became obvious that a comprehensive master plan was needed on August 21, 2001 when a storm produced a total of 1.49 inches of rain. With 1.1 inches of rain falling in 30 minutes, the rainfall event was classified as an 80-90 year storm by Salt Lake County. Prior to any development, a storm of this magnitude produced less runoff and mainly affected farmland. Even though the storm drainage systems within the new developments in the study area appear to be adequate, an outlet system or storm drainage system downstream of these developments does not exist.

Residential developments are being built in the City of Herriman just to the west of Riverton. The increased impervious area created by the new development is creating greater runoff tributary to Riverton City. During the August 21, 2001 storm, runoff from Herriman flooded homes and developments in Riverton City. Runoff then entered the Provo Reservoir Canal causing the canal to overtop the banks and flood homes on the eastside of the canal. This study will address these issues and others in providing solutions within the context of the master plan to minimize flooding.

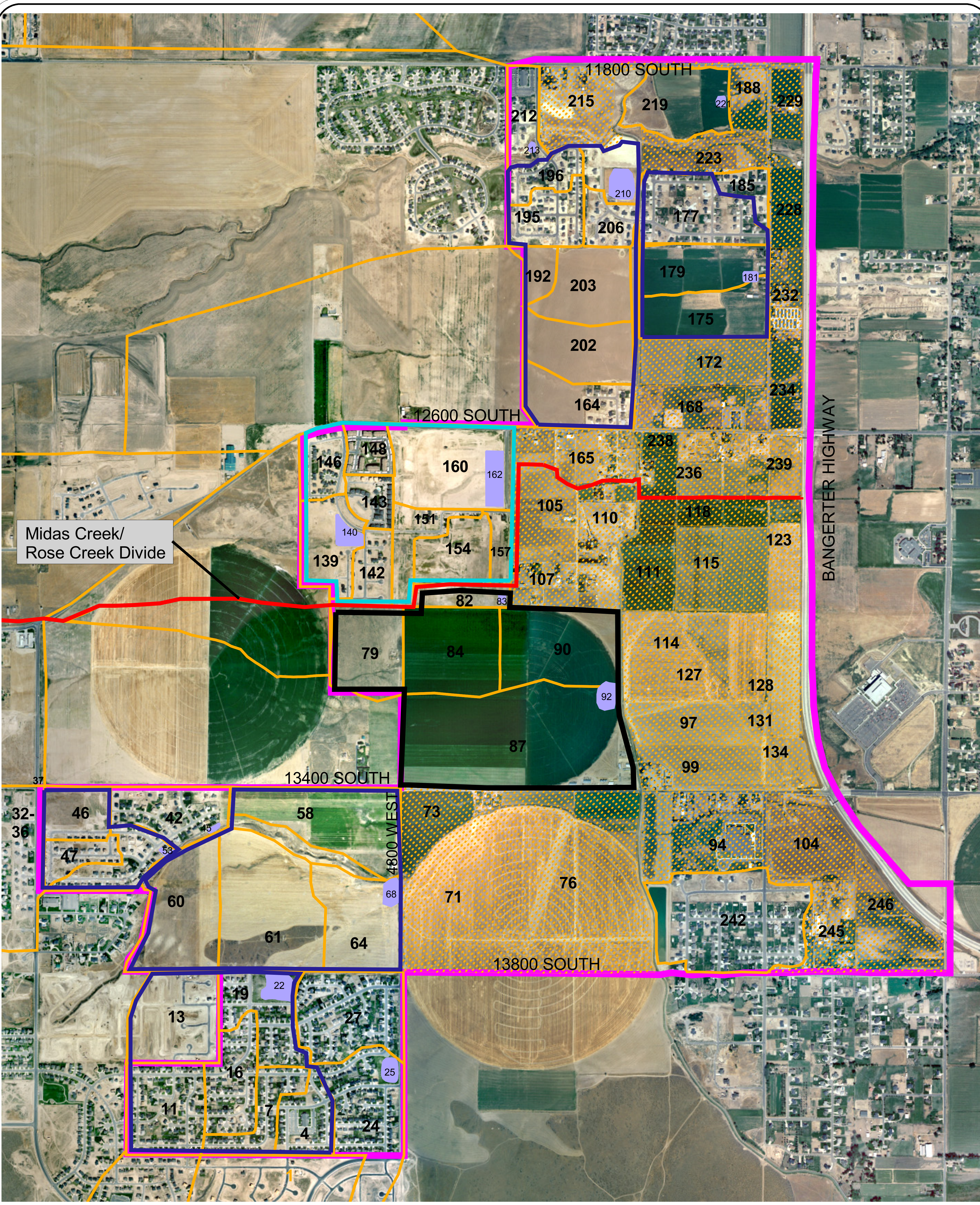
MASTER PLAN PROJECTS

The overall goal of the master plan projects is to convey storm runoff to Midas Creek or Rose Creek away from Butterfield Creek and the Provo Reservoir Canal. Flow historically tributary to Butterfield Creek will need to be conveyed to Midas Creek and Rose Creek. Commercial developments are required to have an on-site detention facility to detain runoff from a 100-year storm event and release at a rate of 0.2 cfs per acre. Storm runoff from residential developments is required to be detained in regional or local detention facilities (see Figure I). Residential developments not located within an area of a regional detention facility are required to have an on-site detention facility to detain runoff from a 100-year storm event and release at a rate of 0.2 cfs per acre. The duration of the 100-year storm event used to size a detention facility should be the duration that produces the largest volume of runoff in the detention facility given the allowable release rate. In addition, both commercial and residential development are to accommodate or identify a safe route for a storm event larger than a 100-year storm event.

Regional detention facilities are required to detain runoff from a 100-year storm event and release at a rate of 0.2 cfs per acre – with the exception of two areas. The first exception area is roughly between 13000 South and 13400 South and between 4300 West and 5000 West (see Figure I). This area is required to detain runoff from a 100-year storm event and release at a rate of 0.1 cfs per acre. Western Springs is the second exception area. It is located between 12600 South and 13000 South and 4570 West and 5000 West (see Figure I). This area is required to detain runoff from a 100-year storm event and release at a maximum flow rate of 5 cfs. These two exception areas require larger detention facilities and smaller release rates to compensate for conveying historical storm runoff from Butterfield Creek to Midas Creek and Rose Creek. Flow rates from any storm up to a 100-year event cannot be higher than the historical peak flow rates reported in the 2002 Salt Lake County Southwest Creek and Canal Study. The duration of the 100-year storm event used to size the detention facility should be the duration that produces the largest volume of runoff in the detention facility given the required release rate. In addition to accommodate or identify a safe route for a storm event larger than a 100-year storm event.

A master plan computer model was completed to help develop and analyze master plan projects (see Figure II). The master plan model analyzed the performance of the projects in future build-out conditions.

The master plan projects are listed in Table ES-1. The location of each project is shown on Figure III by project ”ID Number”. The flows and pipe diameters given in Table ES-1 are approximate and are for planning purposes only. A detailed hydraulic analysis should be performed during the design process for the master plan improvement projects to identify final design pipe sizes.



KEY

- 24 Detention
- 23 Subbasin
- 22 Subbasin Restricted to 0.2 cfs per acre in the model
- 5 cfs Flow Restriction
- 0.1 cfs per acre Flow Restriction
- Regional Detention Areas
- Study Boundary

N
W E
S

0 700 1400 Feet

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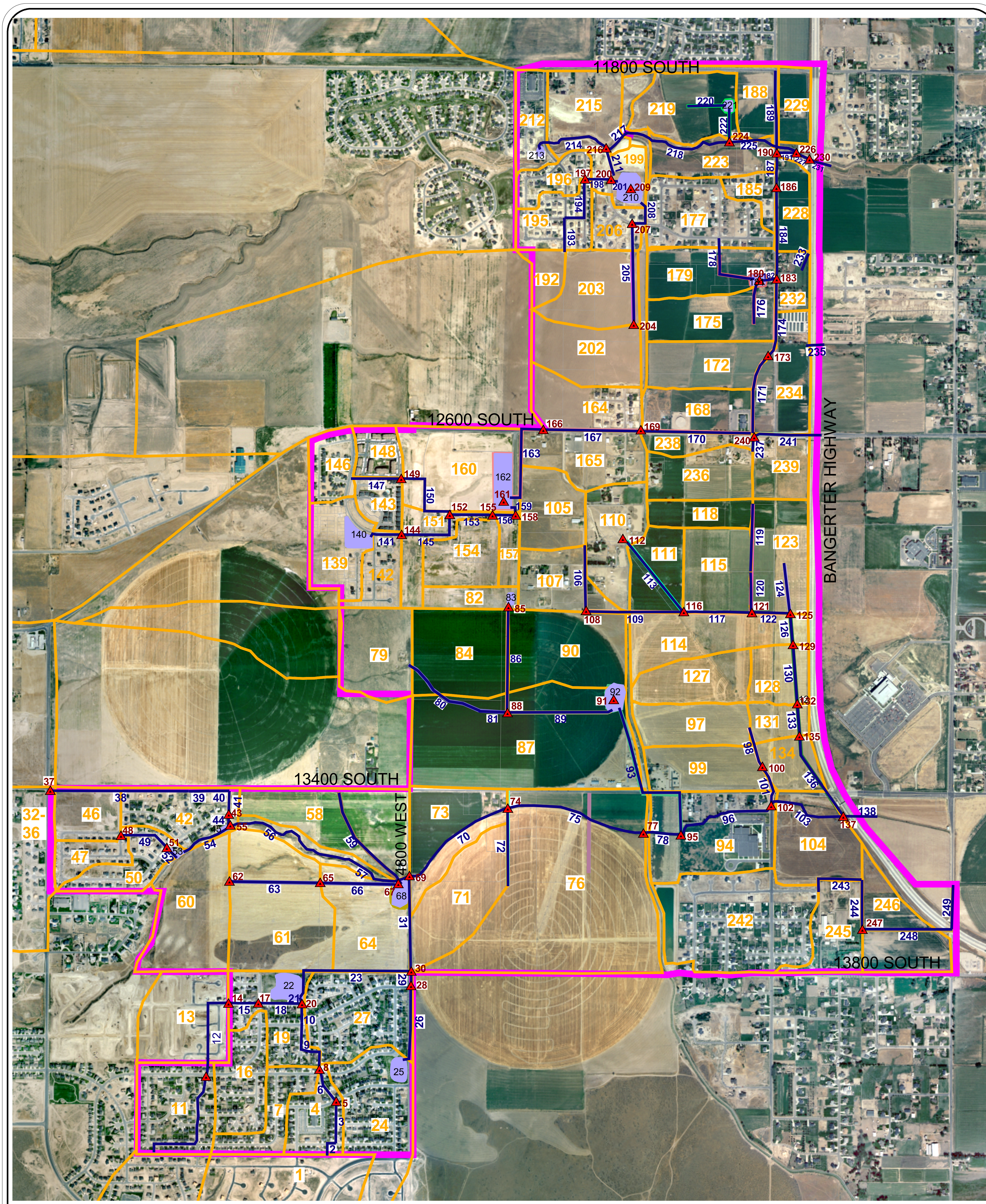
WEST OF BANGERTER HIGHWAY

REGIONAL DETENTION AREAS
AND DISCHARGE RESTRICTIONS

FIGURE I



KEY

26 Confluence

25 Conveyance

24 Detention

23 Subbasin

Study Boundary

N
W
E
S

0 700 1400 Feet

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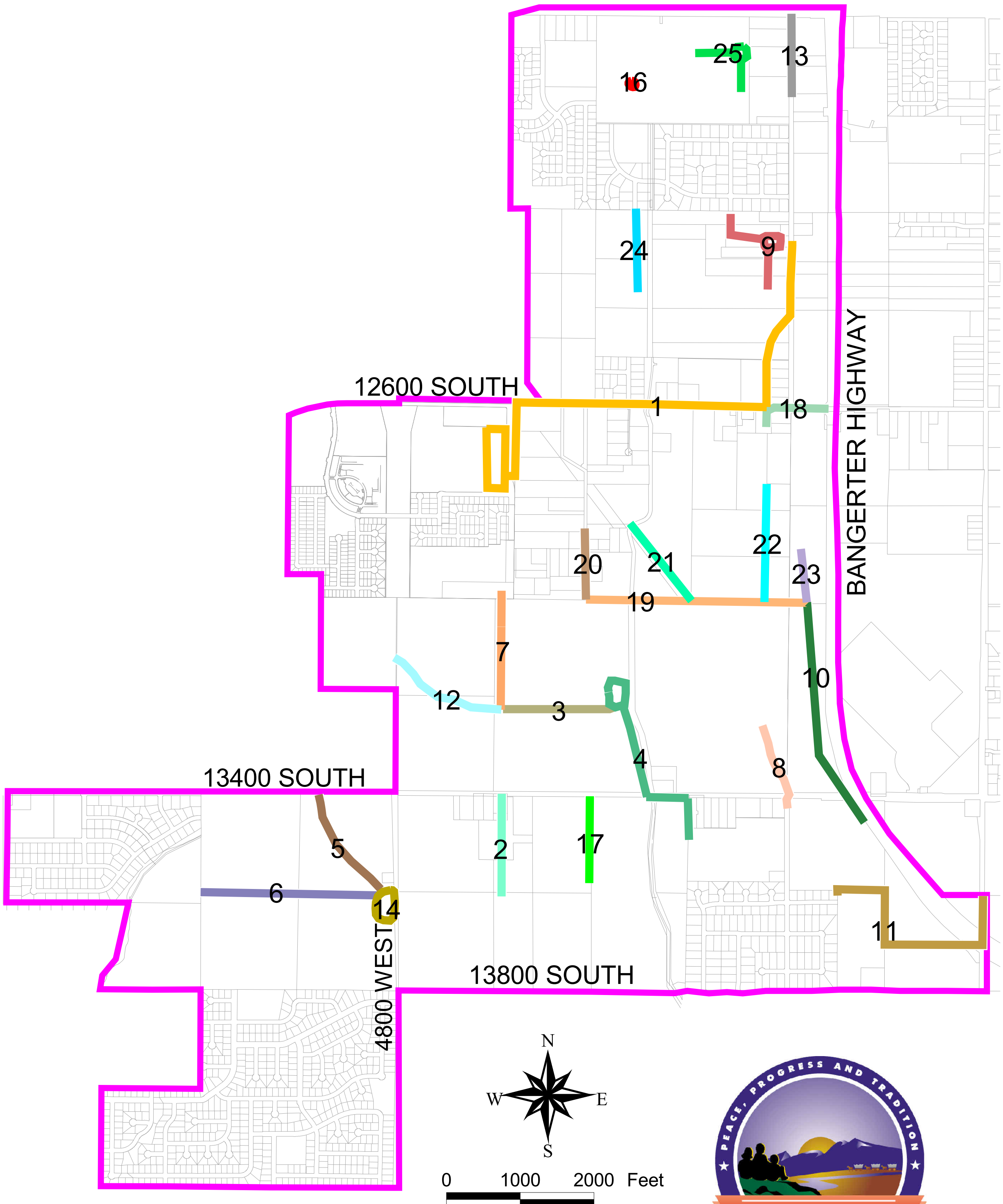
STORM DRAINAGE MASTER PLAN
WEST OF BANGERTER HIGHWAY

STORM DRAINAGE MODEL CONNECTIVITY

FIGURE II



KEY

Identification Number

25 Project Location

Study Boundary

RIVERTON CITY
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PROPOSED STORM
DRAINAGE PROJECTS

FIGURE III

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TABLE ES-1
STORM DRAINAGE MASTER PLAN PROJECTS

ID	DESCRIPTION [1]	ESTIMATED COST [2]
1	Modify the retention pond at about 4570 W and Goshute with an outlet structure. Also, install 4500 feet of 24 inch diameter pipe to convey 22 cfs from the retention pond north in 4570 W to 12600 S and east in 12600 S to 4000 W. Install 2350 feet of 30 inch diameter pipe to convey 27 cfs from 12600 S and 4000 W north in 4000 W to about Swensen Farms Dr.	$937,000
2	Install 1,400 feet of 21 inch diameter pipe to convey 7 cfs from about 13600 S to Rose Creek and 13400 S to Rose Creek in 4600 S.	$126,000
3	Install 1,550 feet of 42 inch diameter pipe to convey 135 cfs from about 4600 W to Master Plan Project ID 4 detention basin in about 13200 S.	$286,000
4	Construct an 8 acre-ft detention basin at about 4400 W and 13200 S and install 2,500 feet of 30 inch diameter pipe to convey 20 cfs from the detention basin to Rose Creek.	$734,000
5	Install 1,600 feet of 30 inch diameter pipe to convey 29 cfs from about 5100 W in 13400 S to Master Plan Project ID 14 detention basin.	$202,000
6	Install 2,500 feet of 30 and 36 inch diameter pipe to convey 50-70 cfs from about 4800 W to 5200 W in about 13600 S.	$359,000
7	Install 1,600 feet of 30 inch diameter pipe to convey 23 cfs in 4600 W from about 13000 S to 13200 S.	$207,000
8	Install 2,000 feet of 18 and 24 inch diameter to convey 7-15 cfs from about 4000 W and 13200 S to Rose Creek.	$110,000
9	Install 1400 feet of 27 and 30 inch diameter pipe and a 1.5 acre-ft detention basin at about 4000 W and 12300 S.	$309,000
10	Install 3,150 feet of 42 and 48 inch diameter pipe from about 4000 W and 13000 S to Rose Creek at about 13500 S and 3900 W.	$623,000
11	Install 3,500 feet of 30 and 36 inch diameter pipe to convey 42-50 cfs from 3900 W and 13650 S to 3600 W and Rose Creek.	$531,000
12	Install 1,800 feet of 36 inch diameter pipe to convey 75 cfs from 4600 W to 4800 W at about 13200 S.	$285,000

TABLE ES-1
STORM DRAINAGE MASTER PLAN PROJECTS
(Continued)

ID	DESCRIPTION [1]	ESTIMATED COST [2]
13	Install 1,150 feet of 21inch diameter pipe to convey 4-7 cfs from about 11800 S South to Midas Creek in 4000 W.	$104,000
14	Construct a 5 acre-ft detention basin at about 4800 W and 13600 S.	$410,000
15	Install 1,000 feet of 18 and 24 inch diameter pipe and a 1 acre-ft detention basin at about 4130 W and 11900 S to Midas Creek.	$160,000
16	Construct a waste way at Midas Creek and the Provo Reservoir Canal.	$14,000
17	Install 1,200 feet of 21 inch diameter to convey 10 cfs from 13400 S and 4500 W to Rose Creek	$108,000
18	Install 1,000 feet of 18 inch diameter pipe to convey 10 cfs from 4000 W and 12700 S to 12600 S and Bangerter Highway	$83,000
19	Install 3,000 feet of 18 and 30 inch diameter pipe to convey 7-34 cfs from 4400 W to 3950 W at about 13000 S.	$322,000
20	Install 1,000 feet of 18 inch diameter pipe to convey 4 cfs from 12800 S to 13000 S in 4400 W.	$83,000
21	Install 1,300 feet of 18 inch diameter pipe to convey 9 cfs from about 4300 W and 12800 S to 4200 W and 13000 S.	$108,000
22	Install 1,600 feet of 18 inch diameter pipe to convey 5 cfs in 4100 W from 12700 S to 13000 S.	$133,000
23	Install 700 feet of 21 inch diameter pipe to convey 9 cfs at about 3950 W from 12800 S to 13000 S.	$63,000
24	Install 1,000 feet of 36 inch diameter pipe in 4300 W from 12350 S to 12200 S.	$158,000
25	Construct a waste way at Rose Creek and the Provo Reservoir Canal.	$14,000
	TOTAL	$6,474,000

1) The flows and pipe diameters given are approximate and are for planning purposes only. A detailed hydraulic analysis should be performed during the design process for the master plan improvement projects to identify final design pipe sizes.
2) Estimated construction costs include manholes, inlets, contingency, and engineering. Costs are in 2004 dollars.

FUNDING SOURCE OPTIONS

Riverton City has the option to expand its authority as a Utah Municipal Corporation to establish a Storm Water Utility. Under this authority, the City can establish funding mechanisms necessary to support planned storm water system improvements as well as the day to day operations and maintenance of the existing system. The funding options available are similar to those established for other municipal utility functions. The flexibility established in Utah Code for sanitary sewers (and therefore for storm sewers) allows the City access to most generally accepted methods of public infrastructure financing. These funding options could include general obligation bonds, revenue bonds, State/Federal grants and loans, impact fees, and storm water management service charges (a Storm Water Utility). In reality, the City may need to consider a combination of these funding options.

STORM DRAINAGE ORDINANCE AND DESIGN STANDARDS

Responsibilities regarding the Storm Drainage Plan should be incorporated into City design standards and/or ordinances. The City has the responsibility of implementing the Storm Drainage Master Plan. However, developers must also assume responsibility for conforming to the requirements of the Storm Water Master Plan. It is the developer's responsibility to comply with runoff restrictions, to show that the storm runoff which is generated upstream from the development can be conveyed through the development, and to demonstrate that runoff generated by the proposed development will not increase the impact of drainage waters on downstream property owners.

It is important that existing and future developments comply with runoff restrictions. Existing and future storm drain facilities were evaluated in the storm drain model assuming the allowable runoff restrictions will be achieved with detention facilities. If detention facilities are not constructed or properly maintained, runoff flowrates will exceed the capacity of the existing or future facilities. It is recommended that the City continue the design review and inspection practices that will ensure that runoff restrictions are met.

RECOMMENDATIONS

1. The City should proceed with following the recommendations made in this report and construct the storm drainage master plan projects as the area of Riverton City west of Bangerter Highway develops. The City should also follow the recommendations made in the 2002 Salt Lake County Southwest Creek and Canal Study.

2. Model data should be updated as land use, conveyance, capacity, and detention are modified or constructed.

3. Commercial developments shall be required to detain their own runoff. Residential developments shall be required to detain their own runoff or be required to detain the runoff in a regional detention facility as appropriate for the location (see Figure I).

4. Regional and local detention facilities shall be designed to detain storm runoff from a 100-year event and released at 0.1 cfs per acre, 0.2 cfs per acre, or 5 cfs as appropriate for the location (see Figure I). The duration of the 100-year storm event used to size the detention facility shall be the duration that produces the largest volume of runoff in the detention facility given the required release rate. All storm drain outfalls to Midas Creek or Rose Creek shall be approved by Salt Lake County Flood Control.

5. The City should consider adopting the site development storm drainage and erosion control plan submittal requirements included in Appendix D.

CHAPTER I

INTRODUCTION

This chapter provides an overview of the Riverton City Storm Drainage Master Plan project for west of Bangerter Highway. The following topics are presented in this section:

- Background
- Authority
- Study Activities
- Study Area
- Definitions

BACKGROUND

Riverton City is located in the southwest portion of the Salt Lake Valley. Developers have discovered Riverton City's large amount of undeveloped property in an attractive location. Riverton offers the feel of living in the country yet is located conveniently to an abundance of employment available in both Salt Lake County and Utah County. Riverton City is seeing a large increase in population. The area of the City experiencing a rapid rate of development is the portion of Riverton City west of Bangerter Highway.

Riverton City has decided to complete a storm drainage master plan in phases to be able to focus on key issues related to the rapid growth in the west portion of the City. This is allowing the City to spend their storm drain master plan budget more conservatively by addressing the pressing storm drainage issues first instead of completing a comprehensive master plan for the entire city. This report includes a study of the area in Riverton City west of Bangerter Highway.

Storm water runoff is a difficult resource to manage. In a dry climate such as Utah's, existing drainage ways are often dry and to the inexperienced citizen may appear to be prime places to construct buildings. Unlike sanitary sewers and culinary water systems, there are no clearly defined minimum service requirements for storm water systems. Storm water flows are dependent on many complex time and spatially varied factors. Even a natural undeveloped drainage system is not static: streams can erode in one section while depositing in another; stream courses can also change alignment and cross section dramatically with just one storm runoff event. Urbanization compounds the problem and creates a need for a drainage system with the basic goals of managing nuisance water, protecting development from damage, and protecting downstream waters from adverse quality and quantity impacts.

This storm drainage master plan for the portion of Riverton City west of Bangerter Highway presents activities and public policies to effectively manage and regulate storm water runoff caused by development to mitigate flooding and environmental impacts. The document will be a means for educating developers, private property owners, City staff and elected officials regarding the capability and needs of Riverton City's storm drainage system. The storm drainage study includes an examination of the existing storm drainage system and future development impact on the system. Existing and future deficiencies are identified and the preferred solution alternatives to the deficiencies are presented with cost estimates. An implementation plan is developed with master plan projects.

A computer model was developed as part of the storm drainage master plan that simulates water runoff during a storm event in Riverton City. The storm drainage model operates within ArcView GIS and uses the HEC-1 Army Corps of Engineers Flood Hydrograph Package for computing the storm runoff hydrographs. Not only was the model a vital tool in analyzing the existing and future storm drainage situation for the master plan, but will allow Riverton City to continue to update and analyze for potential drainage deficiencies and facilitate the analysis of conceptual design of alternative mitigation measures.

AUTHORITY

Riverton City selected Hansen, Allen & Luce, Inc. (HAL) to assist them in preparation of a Storm Drainage Master Plan for the area west of Bangerter Highway. This study has been completed in accordance with an agreement between the Riverton City and HAL dated April 2001.

STUDY ACTIVITIES

Specific tasks performed for this storm drainage study included:

Task 1 - Review of Existing Master Plans and Facilities Inventory

Information contained in available reports and standards was reviewed and summarized to make use of these prior studies in this master planning process. Study activities for this task included the following:

1. Met with City Staff to review project objectives and obtain available drainage studies and standards.
2. Used available storm drainage facilities mapping, available "as builts", contour mapping and other additional information to prepare the existing facilities mapping in ArcView GIS.

Task 2 - Computer Model Development

A storm drainage computer model for the storm drainage and flood control system was prepared to evaluate the performance of the existing facilities and to confirm the effect of recommended improvements. The City was provided an in house computer model which can be used by City staff on a day to day basis to meet City needs. The model works directly with the City's Geographical Information System. Study activities for this task included the following:

1. Assisted the City in selection of the storm drainage model. Reviewed the advantages and disadvantages of available storm drainage models.
2. Drainage basin, subbasin boundaries, and flow paths were delineated using aerial photography mapping, contour data, and drainage basin maps from previous studies.
3. Met with City staff to review drainage basin boundaries and existing hydrologic characteristics. Subbasin boundaries were modified based on input from the City.
4. Using the facilities inventory coverage (Task 2 above), a model of the storm drainage conveyance system was prepared and the existing capacity of the conveyance system facilities were assessed.
5. Using available mapping, field reconnaissance, and land use planning, hydrologic characteristics for each subbasin were developed for existing conditions.
6. Using land use planning, subbasin hydrologic characteristics for the future planning period were predicted.
7. Input data files were prepared to run the storm drainage model.
8. Runoff hydrographs at key locations for the existing storm drainage facilities were computed. Critical storm durations were found by performing a duration sensitivity analysis using the 1, 3, and 6-hour storm durations. The storm drainage model was calibrated qualitatively through evaluation with City personnel.
9. Runoff outflow hydrographs for each subbasin under future conditions were computed.
10. A manual of the GIS computer model was prepared.

Task 3 - Existing System Evaluation

The existing storm drainage facilities were evaluated and deficiencies were identified in regards to the storm drain network, detention basin storage, and other difficulties encountered during the investigation. Study activities for this task included the following:

1. Evaluated adequacy of existing facilities to meet existing and future needs. Defined areas of deficiency such as lack of storm drain capacity, inadequate detention volume, inadequate natural channel capacity, and erosion and maintenance problems.
2. Located existing and future problem areas on GIS coverage.

Task 4 - Recommendations

A master storm drainage plan was prepared, including recommendations for immediate and future improvements. Study activities for this task included the following:

1. Evaluated, with City staff, potential locations for storm water detention facilities.
2. Met with City personnel to develop and screen conceptual level drainage plans with alternatives that included detention, flood channels, storm drains, etc.
3. Compared the alternative plans on the basis of conceptual level construction costs, maintenance requirements, public acceptability, and ability to accommodate changes in the City's land use plan.

4. Met with City personnel to evaluate the drainage plan alternatives to help the City select the preferred alternative.
5. Refined the preferred drainage plan and prioritized recommendations into immediate and future improvement recommendations. (Future was defined as build-out development).
6. Developed a draft of the Capital Improvement Plan for the portion of the City west of Bangerter Highway, including estimated construction costs for the improvements.

Task 5 - Master Plan Document Preparation

A report was prepared, documenting the capability and needs of the Riverton City storm drainage system west of Bangerter Highway. The document will be a means for educating developers, private property owners, City staff and elected officials regarding the capability and needs of Riverton City's storm drainage system. Study activities for this task included the following:

1. Prepared a draft table of contents and outline. Met with City staff to review the draft outline, receive suggestions, and revise the outline as needed to meet City needs.
2. Prepared Draft Master Plan Document.
3. Presented the draft document to City staff for review.
4. Received comments and prepared the Final Master Plan Document.

STUDY AREA

The study area included all of the area within Riverton City boundaries west of the Bangerter Highway (See Figure I).

DEFINITIONS

Initial storm drainage system:	The drainage system which provides for conveyance of the storm runoff from minor storm events. The initial drainage system usually consists of curb and gutter, storm drains, and local detention facilities. The initial drainage system should be designed to reduce street maintenance, control nuisance flooding, help create an orderly urban system, and provide convenience to urban residents.
Major storm drainage system:	The drainage system that provides protection from flooding of homes during a major storm event. The major storm drainage system may include streets (including overtopping the curb onto the lawn area), large conduits, open channels, and regional detention facilities
Minor storm event:	Storm event which is less than or equal to a 10-year storm.

Major storm event:	Generally accepted as the 100-year storm.
10-year storm:	The storm event that has a 10-percent (1 in 10) chance of being equaled or exceeded in any given year.
100-year storm:	The storm event that has a 1-percent (1 in 100) chance of being equaled or exceeded in any given year.
500-year storm:	The storm event that has a 0.2-percent (1 in 500) chance of being equaled or exceeded in any given year.
Cross drainage structures:	Structures that convey storm drainage flows from one side of the street to the other and normally consist of storm drains or culverts.
Retention basin:	An impoundment structure designed to contain all of the runoff from a design storm event. Retention basins usually contain the runoff until it evaporates or infiltrates into the ground.
Detention basin:	An impoundment structure designed to reduce peak runoff flowrates by detaining a portion of the runoff during periods of peak flow and then releasing the runoff at lower flowrates.
Storm frequency:	A measure of the relative risk that the precipitation depth for a particular design storm will be equaled or exceeded in any given year. This risk is usually expressed in years. For example, a storm with a 100-year frequency will have a 1-percent chance of being equaled or exceeded in a given year.
Storm duration:	The length of time of a storm event, from the beginning of rainfall to the point where no further accumulation of precipitation is occurring.
Storm intensity:	The rate at which precipitation accumulates during a storm event.
Storm depth:	The total depth of precipitation produced by a storm event.
Design rainstorm:	A rainfall event, defined by storm frequency, storm duration, and rainfall distribution, that is used to design drainage structures or conveyance systems.
HEC-1:	The Flood Hydrograph Package developed by the U.S. Army Corps of Engineers used to model storm runoff.

CHAPTER II

EXISTING STORM DRAINAGE SYSTEM EVALUATION

This chapter includes an overview of the Riverton City storm drainage system west of Bangerter Highway followed by an assessment of the adequacy of the system.

OVERVIEW OF EXISTING SYSTEM

The area of Riverton City west of Bangerter Highway is new to development. Ten years ago development was essentially nonexistent and the land was used primarily for agricultural purposes. The only storm drainage features were open ditches along the roads, irrigation ditches and canals, and the natural washes and creeks flowing to the Jordan River. Major topographic relief for Riverton City is from the mountains on the west and south toward the Jordan River in the east. The storm drainage runoff in the study area eventually flows into Midas Creek to the North, Rose Creek to the south, the Provo Reservoir Canal that flows north through the middle of the study area, or past Bangerter Highway to the east through culverts.

Recent residential developments in the study area have been constructed with storm drainage pipes and retention/detention ponds to control storm runoff from the individual developments. The newer storm drainage facilities consist of properly graded lots to drain runoff away from homes and other buildings, streets and gutters to collect runoff, and storm drainage piping to convey the runoff to detention basins.

Each aspect of the existing storm drainage system for the study area will be discussed in greater detail in the following paragraphs.

Creeks and Canals

Riverton City is fortunate to have Midas Creek and Rose Creek which flow through the City providing a convenient discharge location for the City's storm drainage facilities. Existing storm drainage facilities in Riverton City rely on these two creeks for the conveyance of storm water runoff from the City to the Jordan River reducing the need for large main storm drain lines. Each stream system is under the responsibility of Salt Lake County Department of Public Works. The 2002 Salt Lake County Southwest Creek and Canal Study Midas Creek provides guidance for Midas Creek and Rose Creek channel improvements and future watershed developments. The general plan is for the creeks to be able to convey the pre-development 100-year storm event under future development conditions.

Butterfield Creek, on the other hand, was abandoned as a county maintained drainage facility and is no longer under the responsibility of Salt Lake County Department of Public Works. In addition, Butterfield Creek is unable to convey runoff to the Jordan River because of modifications to the natural creek channel from over 100 years of farming, canal construction and development. Lastly, the Provo Reservoir Canal cannot effectively convey storm runoff. Each of the creeks and the canal in the study area are described individually in the following paragraphs.

Midas Creek

Midas Creek generally drains the northern portion of the City. It flows east, from the mountains on the west side of Riverton City, to the Jordan River. The 2002 Salt Lake County Southwest Creek and Canal Study outlines projects for Midas Creek that would provide capacity in the Creek to convey a 100-year storm event with historical runoff flow rates of 0.2 cfs per acre. The projects also provide capacity in Midas Creek for runoff historically tributary to Butterfield Creek west of 6000 West. Salt Lake County's goal is to provide capacity for the historical or pre-development 100-year storm event.

Rose Creek

Rose Creek drains the southern portion of the City. It flows from the mountains southwest of Riverton City west to the Jordan River. Similar to Midas Creek, the Rose Creek channel has been disrupted by irrigation and farming activities. Rose Creek drainage area has also had a history of large amounts of sediment deposition. The 2002 Salt Lake County Southwest Creek and Canal Study outlines projects to allow Rose Creek to convey the pre-development 100-year storm event. A number of improvements have been completed. Salt Lake County's goal is to provide capacity for the pre-development 100-year storm event defined in the study.

Butterfield Creek

Butterfield Creek is a third natural creek located between Rose Creek and Midas Creek. Much of Butterfield Creek has unfortunately is no longer continuous. Over 100 years ago canals were constructed to flow from the south to the north perpendicular to the natural creeks. Flow from Butterfield Creek was intercepted by these canals and no longer reached the lower portions of the valley. Also, farming activities disrupted portions of the historical channel. Earlier development in Riverton City built in the path of Butterfield Creek because of an absence of the threat of flooding. As new development has replaced farmland in the west portion of Riverton, runoff during storm events has increased beyond the capacity of the canals which has caused flooding.

Restoring the natural channel for Butterfield Creek would be extremely costly and disruptive to existing development. Salt Lake County and Riverton City has decided not to restore or maintain Butterfield Creek. The 2002 Salt Lake County Southwest Creek and Canal Study indicates that the Butterfield Creek channel disappears at 6000 West. The study recommends that a new conduit be installed in 6000 West to convey all runoff from the end of Butterfield Creek at 6000 West to Midas Creek (page 7-7). A major part of this study was to develop a solution for Butterfield Creek drainage east of 6000 West in Riverton City.

Provo Reservoir Canal

The Provo Reservoir Canal, otherwise known as the Welby-Jacobs Canal, flows through the study area perpendicular to Rose Creek and Midas Creek. The canal is still used to deliver irrigation water and receives storm drainage. Canals are usually not the best conveyances for storm water because they are designed to distribute water rather than collect it. Canal capacities decrease from upstream to downstream, while runoff flowrates increase from upstream to downstream. Water quality, debris and sediment, liability issues, and canal maintenance are problems associated with use of the canals to convey storm drainage. The City and the canal owners would rather not have canals as the primary point of discharge. The city may need some metered releases into canals to address some storm water issues.

Detention

Detention basins have been built for new residential developments to minimize the impact of the development on storm drainage runoff. Also, various temporary detention/retention ponds have been necessary due to incomplete conveyance systems down stream. The County has required all runoff from development to be detained before entering Rose Creek or Midas Creek. As part of this study, the existing detention basins in the study area were analyzed.

Storm Drains And Ditches

Capacities of storm drainage pipes were estimated based upon the pipe slope, pipe material type, and Manning's equation. Where pipe slope was not provided in the City facilities inventory, slope was assumed based on ground surface contours using 2-foot contour mapping. Estimated pipe capacities are based upon conceptual level engineering and do not consider limitations due to inlet capacities or downstream restrictions. Estimated capacities also do not consider allowable surcharging that might provide additional capacity. While the estimated capacities may not be precise, they are consistent with the precision of the runoff estimates and are sufficient for drainage planning efforts.

The capacity of the curb and gutter was estimated for a standard residential street with the water surface level with the top of the curb. Maximum flow capacities were calculated with Manning's equation for gutter slopes from 0.3 to 10 percent. Because gutters are usually obstructed by parked cars or other obstacles, the maximum flow capacity was reduced to an allowable capacity according to a methodology outlined in the *Urban Storm Drainage Criteria Manual* (Denver Regional Council of Governments, 1990). This methodology applies a reduction factor to the maximum capacity to estimate the allowable capacity of the gutter. The reduction factor is a function of the gutter slope. Curb and gutter capacity varies from 4 to 8 cfs for the typical range of slopes allowed on residential streets. Gutter capacity was not considered unless the model indicated peak runoff was exceeding the capacity of a pipe and the pipe was installed in a street with gutters.

Most of the ditches in the study area are roadside ditches along older roads. Based on discussions with City staff, roadside ditches are planned to be replaced with storm drain pipe when the older roads are improved. It was assumed in this study that all of these ditches will be replaced with piped storm drain systems for the future.

ADEQUACY OF EXISTING STORM DRAINAGE FACILITIES

Prior to this study, the only storm drain master plan for this area was a county-wide storm drain system. Riverton City has not previously included this area into the City storm drain master plan since it was annexed into the City in 1996. It became obvious that a comprehensive master plan was needed on August 21, 2001 when a storm produced a total of 1.49 inches of rain over a duration of 60 minutes. With an intensity of 1.1 inches of rain falling in 30 minutes, the rainfall event was classified as an 80-90 year storm by Salt Lake County. Prior to any development, a storm of this magnitude produced less runoff and mainly affected farmland. Even though the storm drainage systems within the new developments in the study area appear to be adequate, an outlet system or storm drainage system downstream of these developments does not exist.

Residential developments are being built in the City of Herriman just to the west of Riverton. The increased impervious area created by the new development is creating greater runoff tributary to Riverton City. During the August 21, 2001 storm, runoff flooded homes and uncompleted developments in Riverton City. Runoff then entered the Provo Reservoir Canal until the canal overtopped the banks and flooded homes on the eastside of the canal.

Both the models of existing and future conditions were used to evaluate the existing storm drainage system. Existing storm drainage deficiencies for the study area were identified using the storm drainage system models, as well as by Riverton City staff based upon field experience.

CHAPTER III

STORM DRAINAGE COMPUTER MODEL DEVELOPMENT

This chapter describes the methodology and process behind the storm drainage model for Riverton City. First, the hydrology and basin characteristics will be discussed followed by a model description.

HYDROLOGY AND BASIN CHARACTERISTICS

Drainage Design Frequency

The approach selected by Riverton City for determining the drainage design frequency is based upon methodology given in the *Urban Storm Drainage Criteria Manual* (Denver Regional Council of Governments, 1990). The *Urban Storm Drainage Criteria Manual* defines the urban drainage system as follows:

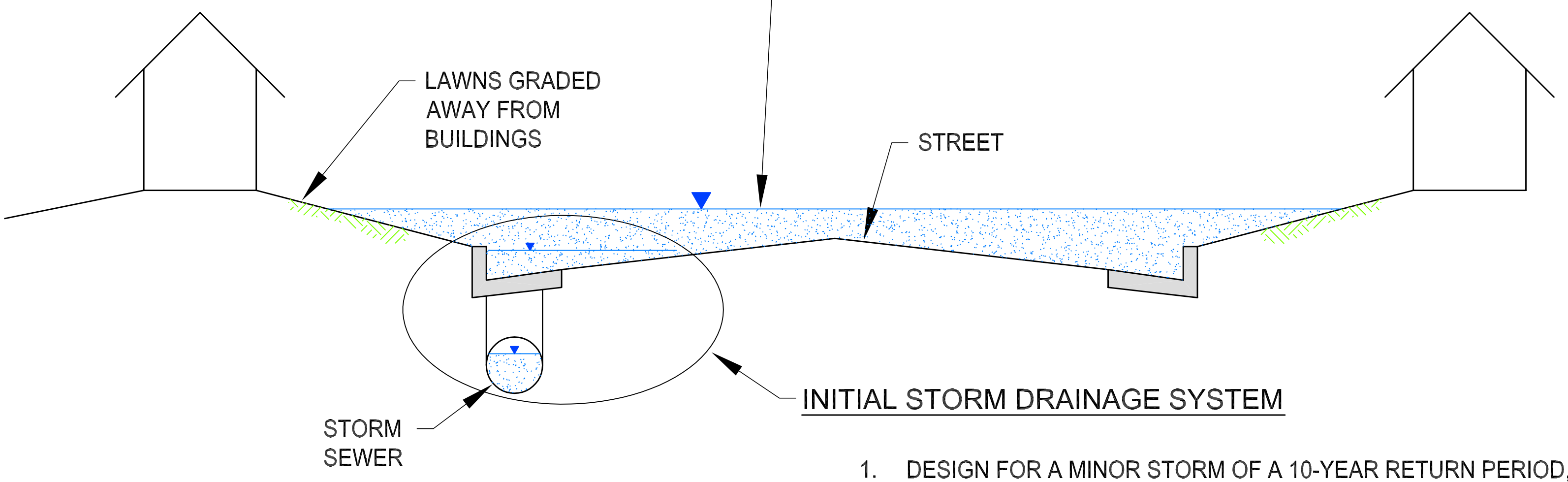
> "Every urban area has two separate and distinct drainage systems, whether or not they are actually planned for and designed. One is the initial system, and the other is the major system. To provide for an orderly urban growth, reduce costs to future generations, and obviate loss of life and major property damage, both systems must be planned and properly engineered."

The initial storm drainage system is sometimes referred to as the convenience system in that the initial system is designed to "reduce street maintenance costs, to provide protection against regularly recurring damage from storm runoff (of a 10-year recurrence interval or less), to help create an orderly urban system, and to provide convenience to the urban residents" (Denver Regional Council of Governments, 1990). Storm sewer systems are generally considered part of the initial storm drainage system. In conjunction with the initial storm drainage system, provisions should be made to avoid major property damage or loss of life from a major storm event. Such provisions are considered to comprise the major storm drainage system.

The major storm drainage system in newly developing urban areas or business districts should generally be designed for the 100-year event with the objective to eliminate major damage to edifices (homes, buildings, etc.) and to prevent loss of life. This does not mean that storm sewers (which are considered part of the initial storm drainage system) should be designed for the 100-year event. It means that the combination of storm sewers and channelized surface flow, which may include using part of the grassed frontage area of a home as part of a 100-year channel (see Figure IV), should be designed to accommodate the 100-year event thereby preventing damage to the edifice. There appears to be general agreement among most major flood control agencies that in the design of the major storm drainage system for urban areas the 1-percent storm (100-year return period) should be used, except in the design of water impoundment structures that exceed a specified capacity.

MAJOR STORM DRAINAGE SYSTEM

1. DESIGN FOR A MAJOR STORM OF A 100-YEAR RETURN PERIOD.
2. THE MAJOR DRAINAGE SYSTEM MAY INCLUDE STREETS (INCLUDING OVERTOPPING OF CURB ON TO LAWN AREA), LARGE CONDUITS, OPEN CHANNELS, AND REGIONAL DETENTION BASINS.
3. DESIGN CRITERIA IS TO ELIMINATE FLOOD DAMAGE TO BUILDINGS AND TO PREVENT LOSS OF LIFE DURING A MAJOR STORM.



INITIAL STORM DRAINAGE SYSTEM

1. DESIGN FOR A MINOR STORM OF A 10-YEAR RETURN PERIOD, OR LESS.
2. THE INITIAL OR MINOR DRAINAGE SYSTEM MAY INCLUDE CURB AND GUTTER, STREETS, STORM SEWERS, AND DETENTION BASINS.
3. DESIGN CRITERIA FOR FLOW IN THE STREET IS THAT THE CURB MAY NOT BE OVERTOPPED, OTHERWISE FLOW MUST BE CARRIED IN THE STORM SEWER OR IN A CONVEYANCE CHANNEL WHICH MAY BE PART OF THE MAJOR STORM DRAINAGE SYSTEM.

HANSEN ALLEN & LUCE INC
ENGINEERS

URBAN STORM
DRAINAGE CRITERIA

FIGURE
IV

Riverton City has selected the 10-year storm event for the design of the initial storm drainage system and the 100-year storm event for design of the major storm drainage system. The 10-year storm event was selected by Riverton City for the design of the initial storm drainage system because:

1. The 10-year storm event is the design frequency selected by most large municipalities along the Wasatch Front, and
2. The 10-year storm event provides a level of protection most likely experienced historically throughout much of Riverton City.

Applying the storm drainage criteria (100-year storm event) to the major storm drainage system in Riverton City is a more complex issue, because the major storm drainage system in Riverton City is very difficult to define and analyze. In most of the newer developments, roadways are lower in elevation than adjacent lots which allow the roadways to carry the runoff that exceeds the capacity of the initial storm drainage system. However, the older sections of Riverton City were developed around an existing open channel irrigation system where ditches along roadways deliver irrigation water to adjacent lots and agricultural land. The ditches along the roadways must be higher than the lots, so the roadways are higher in elevation than adjacent properties. Runoff that exceeds the capacity of the initial storm drainage system will collect in low areas between the homes and the roadways, and in some cases may flow through lots between homes. Determining the local storage in existing lots and identifying flow patterns for the 100-year storm event, is not feasible with the topography information that is currently available. Although the 100-year storm event was not analyzed as part of this study, it is recommended that Riverton City apply the major drainage system design criteria (100-year storm event) to new development whenever it is appropriate.

Design Rainstorm

The Rainfall Intensity Duration Analysis, Salt Lake County, Utah, (TRC North American Weather Consultants and Meteorological Solutions Incorporated, 1999), was used to develop design rainstorm depths for the study area. The TRC report gives design rainfall depths for storms with durations of 1- hour and 6-hours. Rainfall depth for the 3-hour design storm was determined using a linear regression equation.

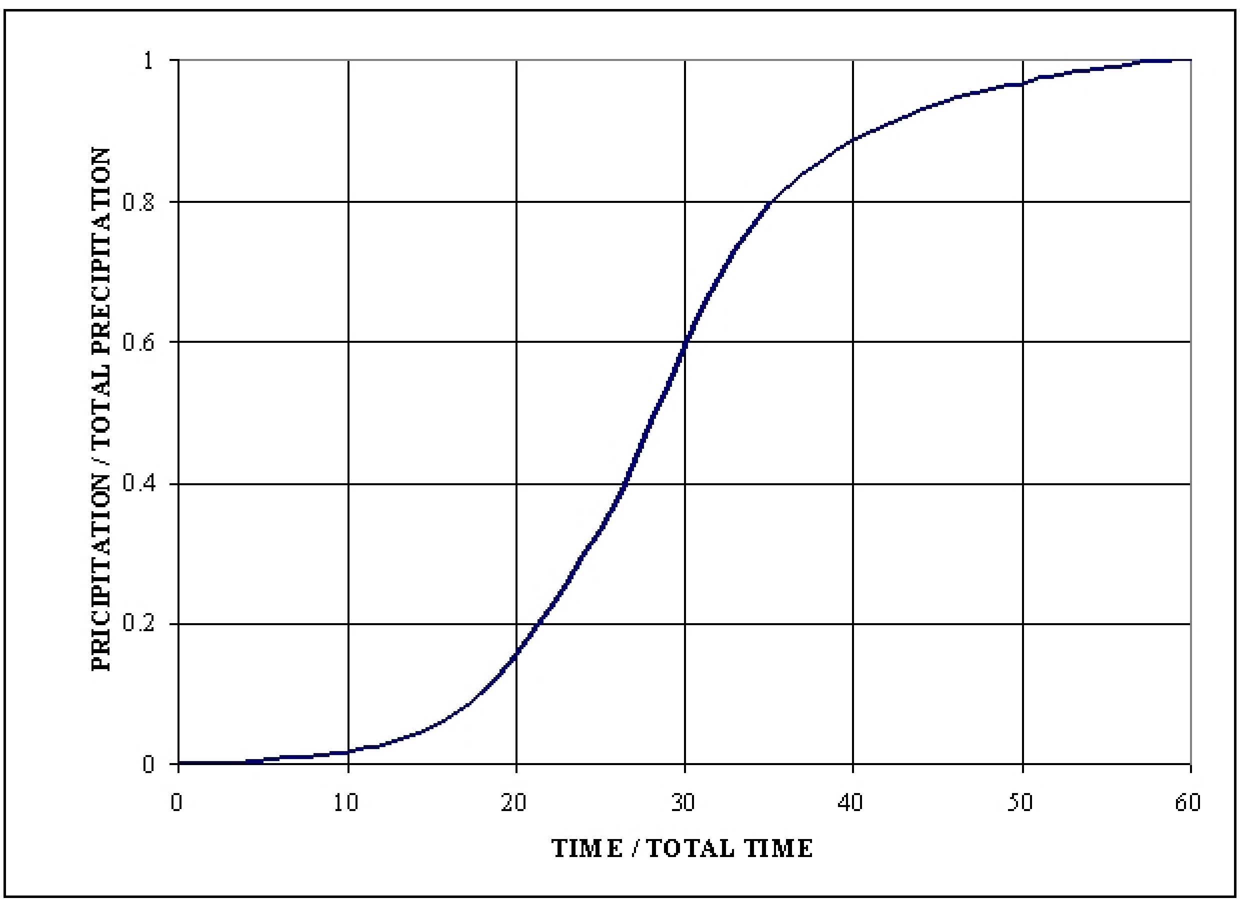
The rainfall depths during a 10-year storm for the study area are: 0.88 inches for a 1-hour duration, 1.13 inches for a 3-hour duration, and 1.38 inches for a 6-hour duration. The rainfall depths during a 100-year storm for the study area are: 1.44 inches for a 1-hour duration, 1.65 inches for a 3-hour duration, and 1.85 inches for a 6-hour duration.

The storm duration that will produce the highest peak runoff flow rate is dependent on rainfall-duration relationships, the characteristics of the basin, and upon the level of detention storage. Generally speaking, the longer runoff takes to flow through a drainage basin or detention basin, the longer the critical storm duration. A duration sensitivity analysis of the hydrologic study area was performed by successive model runs using 1-hour, 3-hour, and 6-hour storm durations. The

6-hour storm duration was found to govern peak runoff flowrates downstream from detention basins. The 1-hour storm duration was usually found to produce the largest peak runoff flowrates for local areas upstream from detention basins.

To compute runoff from a given storm, the distribution of the rainfall through time must be known. Critical runoff events from urban areas along the Wasatch Front are caused by cloudburst type storms, characterized by short periods of high intensity rainfall. During the 1960's and early 1970's, Dr. Eugene E. Farmer and Dr. Joel E. Fletcher completed a major study of the precipitation characteristics for storms in northern Utah. This effort has become the definitive source for rainfall distributions appropriate for the Wasatch Front area. In Davis County, Farmer and Fletcher (1971) examined rainfall gage records and classified storms based on whether the heaviest rainfall of the storm fell in the first, second, third, or fourth quarter of the storm period. Farmer and Fletcher found that "first and second quartile storms together comprise 76 percent of those storms containing a burst of 5-minute duration, with a 2-year recurrence interval and 92 percent of storms containing a burst of 10-minute duration, with a 10-year recurrence interval." Farmer and Fletcher developed model storms for first and second quartile storms. The second quartile storm distribution produces the higher runoff peaks and is the rainfall distribution used in this study for runoff hydrograph calculations (see Figure V).

FIGURE V
FARMER AND FLETCHER 2ND QUARTILE STORM DISTRIBUTION



Drainage Basin Characteristics

A drainage basin is an area where all storm runoff within the area will collect to a common point. Another name for a drainage basin is watershed or catchment. Subbasins are smaller drainage basins located within a larger drainage basin. Drainage subbasin boundaries depend upon both the topography and the location of storm drainage facilities. The drainage subbasin boundaries delineated for the master plan model are shown on Figure II.

Subbasins characteristics were developed based on field observations and the GIS mapping supplied by Riverton City. Important subbasin characteristics included:

- Subbasin area / Topography
- Hydrologic soil type
- Percentage of impervious area
- SCS curve number
- Conveyance characteristics

Hydrologic characteristics of each subbasin are given in the model output provided in Appendix A. Subbasins with connectivity numbers are on Figure II.

Subbasin Area

Subbasins were delineated within the GIS database using topographic mapping and the locations of storm drainage facilities. Digital base mapping of Riverton City consisted of 2-foot contours with physical features such as property lines, canals, and streets. Subbasins varied in size depending upon the level of development within the subbasin and the locations for which hydrographs were needed. Average subbasin size in developed areas was approximately 30-acres. Each mountain watershed, directly tributary to Riverton City, was delineated as a single subbasin.

Hydrologic Soil Type

Hydrologic soil type is a general indication of the soil's infiltration capacity. Soils are assigned a hydrologic type of A, B, C, or D by the Natural Resource Conservation Service (NRCS). Soils of hydrologic soil type A have the highest infiltration rate, and therefore produce the least amount of runoff. Soils of hydrologic soil type D have the lowest infiltration rate, and therefore produce the highest amount of runoff. Most of soils within study area are hydrologic soil type C. Each subbasin was assigned a hydrologic soil type based upon the NRCS mapping.

Impervious Area

Impervious areas within each subbasins were estimated using the GIS model. The impervious area was divided into two components, directly connected impervious areas and unconnected impervious areas. Directly connected impervious areas provide a direct path for runoff from the impervious area to a conveyance such as a pipe, gutter, or channel. Directly connected impervious areas include roadways, parking lots, driveways, and sometimes the roofs of buildings. Runoff from unconnected impervious areas must cross a pervious area before reaching a conveyance. Examples of unconnected impervious areas include sidewalks that are not adjacent to the curb, patios, sheds, and usually some portion of the roof of a house.

It is important to distinguish between directly connected and unconnected impervious areas because runoff from the directly connected impervious areas reaches the drainage conveyance system quickly and usually determines the magnitude of the peak flow rate upstream from detention. Because of the permeable soils in the study area, unconnected impervious areas such as back yard patios which drain to grassed or landscaped areas have much less impact on storm runoff peak flows. Based upon field observations, the directly contributing impervious area for a typical residential lot in Riverton City is assumed to include the driveway, and 50 percent of the home and garage area. It is assumed that runoff from the remaining 50 percent of the home and garage area flows over grassed areas before reaching the street. For large commercial structures, it was assumed that 100 percent of the roof area is directly connected impervious area.

SCS Curve Number

Each basin was assigned an SCS curve number. The curve number describes the relationship between precipitation and runoff for the pervious and unconnected impervious portions of the subbasin. Curve numbers for each subbasin were estimated using a methodology presented by the Soil Conservation Service (SCS, 1972).

Future Land Use and Hydrologic Characteristics

Many large portions of Riverton City west of Bangerter Highway have not been fully developed. Current zoning and land use maps were used to determine the future land use for full buildout. Future hydrologic characteristics for the existing undeveloped subbasins were changed to reflect anticipated conditions when developed. Future percentage of impervious area for currently undeveloped subbasins was estimated based upon current zoning and land use in similar adjoining property that has already been developed.

MODEL DESCRIPTION

The Riverton City Storm Drainage Model is a combination of an ArcView GIS model and the Army Corps of Engineers (COE) "Flood Hydrograph Package (HEC-1)" linked by the Hydrologic Model Interface (HMI). HMI is a custom user interface developed by HAL to operate within the ArcView GIS environment. HMI provides an interactive link between the user, the GIS database, and HEC-1. A description of the model is contained in Appendix B.

The Riverton City Storm Drainage Model incorporates the Army Corps of Engineer's "Flood Hydrograph Package (HEC-1)" for calculation of runoff hydrographs. HEC-1 can be used for both urban and rural watershed models. HEC-1 allows use of both the Soil Conservation Service (SCS) curve number and unit hydrograph method for modeling undeveloped watersheds, and the kinematic wave modeling method for urban areas. The HEC-1 input file is written by HMI from the information within the GIS database. Sources used to create the GIS database and calculate hydrological characteristics for the Riverton City Storm Drainage Model include:

- "Soil Survey, Utah County, Utah" (SCS, 1968).
- Aerial photo mapping and contour data from Salt Lake County.
- Digital mapping from Riverton City
- 7-½ Minute U.S. Geological Survey topographical maps.
- Curve number selection procedures provided by the Soils Conservation Service (SCS, 1972).
- Field reconnaissance.

Model Components

The Storm Drainage Model is comprised of five major components. Each of these model components is described below.

- **Subbasin Elements** - Subbasins are the basic elements for which runoff hydrographs are calculated. Subbasin elements represent a geographic area, and they are described by all of the hydrologic characteristics required by HEC-1 for calculation of a runoff hydrograph. Subbasins are identified on Figure II. Hydrologic characteristics of the subbasin elements are discussed in previous sections.

- **Conveyance Elements** - Conveyance elements are used to represent routing of runoff through pipes, gutters, and channels. Conveyance elements are described by slope, length, hydraulic roughness, and cross section dimensions.

- **Confluence Elements** - Confluence elements are used to combine runoff hydrographs. Confluences are described by a single value which defines the number of hydrographs to be combined.

- **Detention Basin Elements** - Detention basin elements route runoff through a detention basin. Detention basin elements are described numerically by a stage-volume relationship, a stage discharge relationship, and an initial water level.

  The model also includes unit detention basins which modify the runoff hydrographs from subbasins where runoff is restricted to a peak discharge (see Figure I). The basic stage-volume and stage-discharge relationships for the unit detention basin were calculated to limit the peak runoff flow rate to 0.2 cfs per acre. Unit detention basins produce a runoff hydrograph with a peak flow rate that is approximately equal to the area of the upstream subbasin multiplied by 0.2 cfs. Unit detention basins do not represent an actual facility, but rather the approximate performance of local detention facilities located at individual developments within the subbasin.

- **Connectivity Data** - Connectivity data defines the order in which the model elements are processed by HEC-1. Each model element is assigned a rank and the HEC-1 input file is written according to that rank. The order in which model elements are processed by HEC-1 establishes hydrograph routing and when hydrographs are combined.

Model Tools

All of the data associated with the model elements are contained within the GIS database. HMI accesses the GIS database, calculates hydrologic characteristics of the subbasins, and assembles the data to create input files for HEC-1. Input files are processed by HEC-1 to calculate the runoff hydrographs. Runoff hydrographs are calculated for subbasins, conveyances, confluences, and detention basins. HMI can then read the HEC-1 hydrograph files, identify peak flowrates, and write the hydrograph data to the GIS database. Some of the tools used to accomplish these tasks are as follows:

- **Connectivity Editor** - This tool allows the user to define hydrograph routing by assigning a rank to each of the model elements. The rank establishes the order that the element is written to the HEC-1 file. When a new element is inserted into the model, this tool automatically adjusts the rank of the subsequent elements.

- **Subbasin Analysis -** This tool uses information from the GIS database to calculate subbasin area, the percentages of connected and unconnected impervious area, and the representative SCS curve number for each subbasin.

- **HEC-1 Input File Writer** - The HEC-1 input file writer gathers the model data from the GIS database and writes the input file that is used by HEC-1 to calculate the runoff hydrographs.

Modeling Existing Conditions

The existing storm drain system was modeled as accurately as possible given the available information and resources. Not all existing pipes, ditches, and gutters are included in the model, but major storm drainage facilities and features are represented in the model. Many of the smaller facilities are represented in the characteristics of the subbasins. The model was used to identify existing inadequacies in the storm drain system and to serve as a base to develop the future model.

Modeling Future Conditions

A model of the future storm drainage system was prepared to assist with development of a preferred drainage plan for the area of Riverton City west of Bangerter Highway. Drainage plan alternatives were modeled and then refined until a preferred drainage plan was developed. The development of the preferred drainage plan is described in the following section. The future system was modeled with anticipated land use at buildout conditions. Land use and hydrologic characteristics in existing developed areas were assumed to remain the same. Future land use and hydrologic characteristics in currently undeveloped areas were estimated for a buildout condition based upon current zoning and land use provided by Riverton City.

Regional detention facilities are required to detain runoff from a 100-year storm event and release at a rate of 0.2 cfs per acre –. The first exception area is roughly between 13000 South and 13400 South and between 4300 West and 5000 West (see Figure I). This area is required to detain runoff from a 100-year storm event and release at a rate of 0.1 cfs per acre. Western Springs is the second exception area. It is located between 12600 South and 13000 South and 4570 West and 5000 West (see Figure I). This area is required to detain runoff from a 100-year storm event and release at a maximum flow rate of 5 cfs. These two exception areas require larger detention facilities and smaller release rates to compensate for conveying historical storm runoff from Butterfield Creek to Midas Creek and Rose Creek. Flow rates from any storm up to a 100-year event cannot be higher than the historical peak flow rates reported in the 2002 Salt Lake County Southwest Creek and Canal Study. The duration of the 100-year storm event used to size the detention facility should be the duration that produces the largest volume of runoff in the detention facility given the required release rate.

It is assumed in the future conditions model that runoff is detained to 0.2 cfs per acre – with the exception of two areas. The first exception area is roughly between 13000 South and 13400 South and between 4300 West and 5000 West (see Figure I). Runoff in this area was detained to a rate of 0.1 cfs per acre. Western Springs is the second exception area. It is located between 12600 South and 13000 South and 4570 West and 5000 West (see Figure I). Runoff in this area was detained to a flow of 5 cfs.

Computation of Runoff Hydrographs

Hydrographs were computed for each subbasin, conveyance, confluence, detention basin inlet, and detention basin outlet. The maximum value from each hydrograph is the peak runoff flow rate. HMI determines the peak runoff flow rate for each hydrograph and adds the hydrographs to the GIS database. Hydrographs were calculated for the 1-hour, 3-hour, and 6-hour storm duration. The highest peak flow rate identifies the critical storm duration and is the flow rate used for design or evaluation of that element of the model. Elements in the future drainage system were designed for the 10-year storm event and the critical storm duration.

As the drainage plan for the future system was developed, runoff hydrographs were calculated for various alternatives. The peak flowrates were then compared to the capacities of the model elements to determine where additional refinements were needed. Peak runoff flowrates for each conveyance and other model elements are provided in Appendix A. The location of each conveyance by element connectivity number is illustrated on Figure II.

CHAPTER IV

IMPLEMENTATION PLAN

This Chapter contains a discussion of the actions Riverton City staff and HAL recommends be implemented to improve the storm drainage system in the study area. The following topics are included in this section:

- Master Plan Projects
- Estimated Construction Costs of Master Plan Projects
- Funding Sources
- Maintenance
- Storm Drainage Policies
- Summary of Recommendations

MASTER PLAN PROJECTS

Meetings were held with Riverton City personnel to evaluate alternatives for the storm drainage plan west of Bangerter Highway. Selection of the preferred alternative was a process of evaluation and refinement, rather than a simple choice between alternatives. Riverton City personnel efficiently eliminated impractical solutions and formulated practical solutions. The process of selecting a preferred alternative by City staff included: reviewing the recent flooding problems and storm drainage inadequacies, brainstorming possible solutions to the problems, screening alternatives based on feasibility and public acceptance, development of alternatives, comparison based on cost and function, and selection of the preferred alternative. The preferred alternatives are the master plan improvement projects.

Master Plan Projects Description

The overall goal of the master plan projects is to convey storm runoff to Midas Creek or Rose Creek away from Butterfield Creek and the Provo Reservoir Canal. Flow historically tributary to Butterfield Creek will need to be conveyed to Midas Creek and Rose Creek. Commercial developments are required to have an on-site detention facility to detain runoff from a 100-year storm event and release at a rate of 0.2 cfs per acre. Storm runoff from residential developments is required to be detained in regional or local detention facilities (see Figure I). Residential developments not located within an area of a regional detention facility are required to have an on-site detention facility to detain runoff from a 100-year storm event and release at a rate of 0.2 cfs per acre. The duration of the 100-year storm event used to size a detention facility should be the duration that produces the largest volume of runoff in the detention facility given the allowable release rate. In addition, both commercial and residential development are to accommodate or identify a safe route for a storm event larger than a 100-year storm event.

Regional detention facilities are required to detain runoff from a 100-year storm event and release at a rate of 0.2 cfs per acre – with the exception of two areas. The first exception area is roughly between 13000 South and 13400 South and between 4300 West and 5000 West (see Figure I). This area is required to detain runoff from a 100-year storm event and release at a rate of 0.1 cfs per acre. Western Springs is the second exception area. It is located between 12600 South and 13000 South and 4570 West and 5000 West (see Figure I). This area is required to detain runoff from a 100-year storm event and release at a maximum flow rate of 5 cfs. These two exception areas require larger detention facilities and smaller release rates to compensate for conveying historical storm runoff from Butterfield Creek to Midas Creek and Rose Creek. Flow rates from any storm up to a 100-year event cannot be higher than the historical peak flow rates reported in the 2002 Salt Lake County Southwest Creek and Canal Study. The duration of the 100-year storm event used to size the detention facility should be the duration that produces the largest volume of runoff in the detention facility given the required release rate. In addition to accommodate or identify a safe route for a storm event larger than a 100-year storm event.

Estimated Construction Costs for Master Plan Projects

Estimated construction costs for the storm drainage pipe lines include manholes and inlets. It was assumed most of these projects are not located in roads or in new development and do not include costs for repairs, replacing, or relocating existing road features. Estimated construction costs for detention facilities include excavation, grading, low flow pipes, inlet and outlet structures, irrigation systems, general landscaping, and land cost.

Unit costs for the construction cost estimates are based on conceptual level engineering. Sources used to estimate construction costs include:

1. "Means Heavy Construction Cost Data, 2004"
2. Price quotes from equipment suppliers
3. Recent construction bids for similar work

All costs are presented in 2004 dollars. Recent price and economic trends indicate that future costs are difficult to predict with certainty. Engineering cost estimates given in this study should be regarded as conceptual level as appropriate for use as a planning guide. Only during final design can a definitive and more accurate estimate be provided. Table IV-1 is a unit pipe cost table with assumptions used in calculating an estimated cost for each project. A detailed cost estimate of each project is provided in Appendix C.

TABLE IV-1
PIPE COST ASSUMPTIONS FOR STORM DRAIN MASTER PLAN PROJECTS

DIAMETER (IN)	COST PER FOOT
15	$50
18	$61
21	$66
24	$73
27	$84
30	$95
36	$116
42	$135
48	$158
54	$186

The projects are listed in Table IV-2. The location of each project is shown on Figure III by project "ID" number. The flows and pipe diameters given in Table IV-2 are approximate and are for planning purposes only. A detailed hydraulic analysis should be performed during the design process for the master plan improvement projects to identify final design pipe sizes.

TABLE IV-2
STORM DRAINAGE MASTER PLAN PROJECTS

ID	DESCRIPTION [1]	ESTIMATED COST [2]
1	Modify the retention pond at about 4570 W and Goshute with an outlet structure. Also, install 4500 feet of 24 inch diameter pipe to convey 22 cfs from the retention pond north in 4570 W to 12600 S and east in 12600 S to 4000 W. Install 2350 feet of 30 inch diameter pipe to convey 27 cfs from 12600 S and 4000 W north in 4000 W to about Swensen Farms Dr.	$937,000
2	Install 1,400 feet of 21 inch diameter pipe to convey 7 cfs from about 13600 S to Rose Creek and 13400 S to Rose Creek in 4600 S.	$126,000
3	Install 1,550 feet of 42 inch diameter pipe to convey 135 cfs from about 4600 W to Master Plan Project ID 4 detention basin in about 13200 S.	$286,000

TABLE IV-2
STORM DRAINAGE MASTER PLAN PROJECTS
(Continued)

ID	DESCRIPTION [1]	ESTIMATED COST [2]
4	Construct an 8 acre-ft detention basin at about 4400 W and 13200 S and install 2,500 feet of 30 inch diameter pipe to convey 20 cfs from the detention basin to Rose Creek.	$734,000
5	Install 1,600 feet of 30 inch diameter pipe to convey 29 cfs from about 5100 W in 13400 S to Master Plan Project ID 14 detention basin.	$202,000
6	Install 2,500 feet of 30 and 36 inch diameter pipe to convey 50-70 cfs from about 4800 W to 5200 W in about 13600 S.	$359,000
7	Install 1,600 feet of 30 inch diameter pipe to convey 23 cfs in 4600 W from about 13000 S to 13200 S.	$207,000
8	Install 2,000 feet of 18 and 24 inch diameter to convey 7-15 cfs from about 4000 W and 13200 S to Rose Creek.	$110,000
9	Install 1400 feet of 27 and 30 inch diameter pipe and a 1.5 acre-ft detention basin at about 4000 W and 12300 S.	$309,000
10	Install 3,150 feet of 42 and 48 inch diameter pipe from about 4000 W and 13000 S to Rose Creek at about 13500 S and 3900 W.	$623,000
11	Install 3,500 feet of 30 and 36 inch diameter pipe to convey 42-50 cfs from 3900 W and 13650 S to 3600 W and Rose Creek.	$531,000
12	Install 1,800 feet of 36 inch diameter pipe to convey 75 cfs from 4600 W to 4800 W at about 13200 S.	$285,000
13	Install 1,150 feet of 21inch diameter pipe to convey 4-7 cfs from about 11800 S to Midas Creek in 4000 W.	$104,000
14	Construct a 5 acre-ft detention basin at about 4800 W and 13600 S.	$410,000
15	Install 1,000 feet of 18 and 24 inch diameter pipe and a 1 acre-ft detention basin at about 4130 W and 11900 S to Midas Creek.	$160,000
16	Construct a waste way at Midas Creek and the Provo Reservoir Canal.	$14,000
17	Install 1,200 feet of 21 inch diameter to convey 10 cfs from 13400 S and 4500 W to Rose Creek	$108,000
18	Install 1,000 feet of 18 inch diameter pipe to convey 10 cfs from 4000 W and 12700 S to 12600 S and Bangerter Highway	$83,000

TABLE IV-2
STORM DRAINAGE MASTER PLAN PROJECTS
(Continued)

ID	DESCRIPTION [1]	ESTIMATED COST [2]
19	Install 3,000 feet of 18 and 30 inch diameter pipe to convey 7-34 cfs from 4400 W to 3950 W at about 13000 S.	$322,000
20	Install 1,000 feet of 18 inch diameter pipe to convey 4 cfs from 12800 S to 13000 S in 4400 W.	$83,000
21	Install 1,300 feet of 18 inch diameter pipe to convey 9 cfs from about 4300 W and 12800 S to 4200 W and 13000 S.	$108,000
22	Install 1,600 feet of 18 inch diameter pipe to convey 5 cfs in 4100 W from 12700 S to 13000 S.	$133,000
23	Install 700 feet of 21 inch diameter pipe to convey 9 cfs at about 3950 W from 12800 S to 13000 S.	$63,000
24	Install 1,000 feet of 36 inch diameter pipe in 4300 W from 12350 S to 12200 S.	$158,000
25	Construct a waste way at Rose Creek and the Provo Reservoir Canal.	$14,000
	TOTAL	$6,474,000

1) The flows and pipe diameters given are approximate and are for planning purposes only. A detailed hydraulic analysis should be performed during the design process for the master plan improvement projects to identify final design pipe sizes.
2) Estimated construction costs include manholes, inlets, contingency, and engineering. Costs are in 2004 dollars.

FUNDING SOURCE OPTIONS

Riverton City has the option to expand its authority as a Utah Municipal Corporation to establish a Storm Water Utility. Under this authority, the City can establish funding mechanisms necessary to support planned storm water system improvements as well as the day to day operations and maintenance of the existing system. The funding options available are similar to those established for other municipal utility functions. The flexibility established in Utah Code for sanitary sewers (and therefore for storm sewers) allows the City access to most generally accepted methods of public infrastructure financing. These funding options could include general obligation bonds, revenue bonds, State/Federal grants and loans, impact fees, and storm water management service charges (a Storm Water Utility). In reality, the City may need to consider a combination of these funding options. The following discussion describes each of these options.

General Obligation Bonds

This form of debt enables the City to issue general obligation bonds for capital improvements and replacement. General Obligation (G.O.) Bonds are debt instruments backed by the full faith and credit of the City which would be secured by an unconditional pledge of the City to levy assessments, charges or ad valorem taxes necessary to retire the bonds. G.O. bonds are the lowest-cost form of debt financing available to local governments and can be combined with other revenue sources such as specific fees, or special assessment charges to form a dual security through the City's revenue generating authority. These bonds are supported by the City as a whole, so the amount of debt issued for storm water is limited to a fixed percentage of the real market value for taxable property within the City.

Revenue Bonds

This form of debt financing is also available to the City for utility related capital improvements. Unlike G.O. bonds, revenue bonds are not backed by the City as a whole, but constitute a lien against the storm water service charge revenues of a Storm Water Utility. Revenue bonds present a greater risk to the investor than do G.O. bonds, since repayment of debt depends on an adequate revenue stream, legally defensible rate structure /and sound fiscal management by the issuing jurisdiction. Due to this increased risk, revenue bonds generally require a higher interest rate than G.O. bonds. This type of debt also has very specific coverage requirements in the form of a reserve fund specifying an amount, usually expressed in terms of average or maximum debt service due in any future year. This debt service is required to be held as a cash reserve for annual debt service payment to the benefit of bondholders. Typically, voter approval is not required when issuing revenue bonds. In addition, revenue bonding for a storm water program that has a limited track record may be problematic. The bond underwriters may have some concerns regarding the viability of a relatively new program and its legal defensibility. Therefore, a city that is just starting out may need to use G.O. bonds at first, until a track record is established.

State/Federal Grants and Loans

Historically, both local and county governments have experienced significant infrastructure funding support from state and federal government agencies in the form of block grants, direct grants in aid, interagency loans, and general revenue sharing. Federal expenditure pressures and virtual elimination of federal revenue sharing dollars are clear indicators that local government may be left to its own devices regarding infrastructure finance in general and storm water funding in particular. However, state/federal grants and loans should be further investigated as a possible funding source for needed storm water improvements.

It is also important to assess likely trends regarding federal / state assistance in infrastructure financing. Where federal mandate for sanitary sewer improvements in the 1960's was accompanied by a very generous and available grant program, future trends indicate that grants will be replaced by loans through a public works revolving fund. Local governments can expect to access these revolving funds or public works trust funds by demonstrating both the need for and the ability to repay the borrowed monies, with interest. As with the revenue bonds discussed earlier, the ability of infrastructure programs to wisely manage their own finances will be a key element in evaluating whether many secondary funding sources, such as federal/state loans, will be available to the City's storm water management program.

Impact Fees

Impact fees can be applied to drainage related facilities under the Utah Impact Fees Act. The Utah Impacts Fees Act is designed to provide a logical and clear framework for establishing new development assessments. It is also designed to establish the basis for the fee calculation which the City must follow in order to comply with the statute. However, the fundamental objective for the fee structure is the imposition on new development of only those costs associated with providing or expanding storm water infrastructure to meet the capacity needs created by that specific new development. Also, impact fees cannot be applied retroactively.

There are significant areas of potential development within the Riverton City study area. Development of these areas could represent a significant source of revenue through the assessment of a storm water impact fee. The impact fee must be calculated such that it will represent a fair and equitable allocation of cost to proposed storm drainage facilities based on impacts to those facilities from the new development areas. Impact fees generated from new development will not pay for all of the costs of the needed drainage facilities. Existing development within the City is also contributing to the required sizing of these facilities. Therefore, the impact fees must be determined by taking into consideration what portion of the proposed facilities is required due to new development versus what portion is required due to existing development.

Storm Water Management Service Charges (Storm Water Utility)

As conventional funding sources for storm water management become more difficult to access and as federal (Environmental Protection Agency - National Pollutant Discharge Elimination System) and state storm water quality requirements become mandatory, the utility approach toward funding is becoming generally accepted. There are numerous combinations and variations for storm water service charges. The City could employ an equivalent service unit (ESU) approach which is based on measured impervious surface. Because most single family residents have very similar impervious surface footprints, all single family homes are considered to be one ESU. All other properties are charged based on their measured impervious surface area divided by the base ESU square footage to determine the number of ESU's applied to that property.

MAINTENANCE

It is impossible to overstate the importance of effective maintenance in the overall storm water management effort. Without maintenance, drainage facilities will deteriorate, and their design capacities will be reduced by accumulations of sediments, weeds and debris. Not only will they fail to function as intended, but they will become hazards and a blight on the City's landscape. Inadequate maintenance, as with any facility, transforms a productive resource into a multi-faceted liability. Storm drainage facilities within the city have historically been well maintained. The City's public works staff has done an excellent job of prioritizing and implementing maintenance activities.

The construction of additional facilities in the future increases the maintenance burden. Existing and future operating costs need to be addressed as part of an overall financial analysis of the storm drain system. It is imperative that sufficient maintenance manpower and equipment are made available to ensure proper function and community acceptance.

STORM DRAINAGE ORDINANCE AND DESIGN STANDARDS

Responsibilities regarding the Storm Drainage Plan should be incorporated into City design standards and/or ordinances. The City has the responsibility of implementing the Storm Drainage Master Plan. However, developers must also assume responsibility for conforming to the requirements of the Storm Water Master Plan. It is the developer's responsibility to comply with runoff restrictions, to show that the storm runoff which is generated upstream from the development can be conveyed through the development, and to demonstrate that runoff generated by the proposed development will not increase the impact of drainage waters on downstream property owners.

It is important that existing and future developments comply with runoff restrictions. Existing and future storm drain facilities were evaluated in the storm drain model assuming the allowable runoff restrictions will be achieved with detention facilities. If detention facilities are not constructed or properly maintained, runoff flowrates will exceed the capacity of the existing or future facilities. It is recommended that the City continue the design review and inspection practices that will ensure that runoff restrictions are met. The City should consider adopting the recommended site development storm drainage and erosion control plan submittal requirements included in Appendix D.

RECOMMENDATIONS

1. The City should proceed with following the recommendations made in this report and construct the storm drainage master plan projects as the area of Riverton City west of Bangerter Highway develops. The City should also follow the recommendations made in the 2002 Salt Lake County Southwest Creek and Canal Study.

2. Model data should be updated as land use, conveyance, capacity, and detention are modified or constructed.

3. Commercial developments shall be required to detain their own runoff. Residential developments shall be required to detain their own runoff or be required to detain the runoff in a regional detention facility as appropriate for the location (see Figure I).

4. Regional and local detention facilities shall be designed to detain storm runoff from a 100-year event and released at 0.1 cfs per acre, 0.2 cfs per acre, or 5 cfs as appropriate for the location (see Figure I). The duration of the 100-year storm event used to size the detention facility shall be the duration that produces the largest volume of runoff in the detention facility given the required release rate. All storm drain outfalls to Midas Creek or Rose Creek shall be approved by Salt Lake County Flood Control.

5. The City should consider adopting the site development storm drainage and erosion control plan submittal requirements included in Appendix D.

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APPENDIX A

STORM DRAINAGE
MODEL OUTPUT

STORM DRAINAGE MODEL CONNECTIVITY AND PEAK FLOW

ORDER	HMI ID	TYPE	PEAK (CFS)
1	SB69	Subbasin	5.7
2	CV34	Conveyance	5.7
3	CV35	Conveyance	5.6
4	SB59	Subbasin	12.5
5	HC24	Confluence	12.5
6	CV36	Conveyance	12.5
7	SB56	Subbasin	10.8
8	HC25	Confluence	22.9
9	CV10	Conveyance	22.9
10	CV11	Conveyance	22.8
11	SB66	Subbasin	20.6
12	CV37	Conveyance	20.5
13	SB77	Subbasin	22.6
14	HC26	Confluence	41.5
15	CV9	Conveyance	41.1
16	SB55	Subbasin	14.3
17	HC7	Confluence	55.5
18	CV12	Conveyance	55.2
19	SB57	Subbasin	13.6
20	HC8	Confluence	88.8
21	CV13	Conveyance	88.7
22	DB2	Detention	9.8
23	CV16	Conveyance	9.7
24	SB60	Subbasin	21.7
25	DB3	Detention	0.5
26	CV14	Conveyance	0.5
27	SB58	Subbasin	22.5
28	HC10	Confluence	22.5
29	CV15	Conveyance	22.3
30	HC9	Confluence	22.4
31	CV19	Conveyance	22.4
32	SB63	Subbasin	9.1
33	SB28	Subbasin	5.5
34	SB27	Subbasin	8.8
35	SB26	Subbasin	21.7
36	SB25	Subbasin	23.6
37	HC38	Confluence	54.5
38	CV42	Conveyance	54.5
39	CV41	Conveyance	54.5
40	CV38	Conveyance	54.5
41	CV39	Conveyance	54.5
42	SB36	Subbasin	13.5
43	HC18	Confluence	55.8
44	CV40	Conveyance	55.8
45	DB5	Detention	33.5
46	SB34	Subbasin	2.0
47	SB33	Subbasin	11.1
48	HC13	Confluence	13.1
49	CV21	Conveyance	13.1

ORDER	HMI ID	TYPE	PEAK (CFS)
50	SB35	Subbasin	9.5
51	HC14	Confluence	22.5
52	CV22	Conveyance	22.2
53	DB4	Detention	0.5
54	CV23	Conveyance	0.5
55	HC27	Confluence	34.0
56	CV18	Conveyance	32.2
57	CV100	Conveyance	30.3
58	SB113	Subbasin	29.4
59	CV104	Conveyance	28.9
60	SB30	Subbasin	21.3
61	SB111	Subbasin	36.3
62	HC80	Confluence	50.0
63	CV102	Conveyance	50.0
64	SB112	Subbasin	22.5
65	HC73	Confluence	68.4
66	CV103	Conveyance	68.5
67	HC79	Confluence	94.1
68	DB16	Detention	18.2
69	HC12	Confluence	58.7
70	CV101	Conveyance	56.9
71	SB110	Subbasin	23.7
72	CV105	Conveyance	6.6
73	SB118	Subbasin	10.1
74	HC71	Confluence	61.6
75	CV20	Conveyance	59.6
76	SB72	Subbasin	62.4
77	HC28	Confluence	71.0
78	CV95	Conveyance	70.5
79	SB75	Subbasin	56.3
80	CV88	Conveyance	56.4
81	CV89	Conveyance	56.1
82	SB45	Subbasin	6.8
83	DB6	Detention	1.0
84	SB29	Subbasin	24.0
85	HC78	Confluence	24.0
86	CV91	Conveyance	23.1
87	SB73	Subbasin	63.1
88	HC63	Confluence	135.6
89	CV90	Conveyance	135.3
90	SB103	Subbasin	26.8
91	HC64	Confluence	155.4
92	DB13	Detention	19.3
93	CV50	Conveyance	19.3
94	SB99	Subbasin	31.5
95	HC67	Confluence	95.0
96	CV52	Conveyance	93.9
97	SB93	Subbasin	33.9
98	CV93	Conveyance	6.9
99	SB94	Subbasin	37.2
100	HC65	Confluence	14.3
101	CV94	Conveyance	14.3
102	HC51	Confluence	104.2

ORDER	HMI ID	TYPE	PEAK (CFS)
103	CV71	Conveyance	103.2
104	SB98	Subbasin	33.9
105	SB49	Subbasin	8.8
106	CV24	Conveyance	3.7
107	SB48	Subbasin	8.3
108	HC55	Confluence	7.3
109	CV64	Conveyance	7.4
110	SB117	Subbasin	17.4
111	SB88	Subbasin	13.2
112	HC23	Confluence	8.7
113	CV114	Conveyance	8.7
114	SB91	Subbasin	53.6
115	SB89	Subbasin	39.3
116	HC45	Confluence	31.1
117	CV65	Conveyance	31.1
118	SB107	Subbasin	8.8
119	CV97	Conveyance	2.5
120	CV98	Conveyance	2.5
121	HC68	Confluence	33.4
122	CV99	Conveyance	33.4
123	SB90	Subbasin	45.4
124	CV66	Conveyance	9.2
125	HC46	Confluence	42.5
126	CV67	Conveyance	42.4
127	SB92	Subbasin	36.7
128	SB104	Subbasin	24.5
129	HC47	Confluence	54.3
130	CV68	Conveyance	54.3
131	SB105	Subbasin	15.5
132	HC48	Confluence	57.2
133	CV69	Conveyance	57.1
134	SB106	Subbasin	14.3
135	HC49	Confluence	60.8
136	CV70	Conveyance	60.7
137	HC50	Confluence	69.3
138	CV78	Conveyance	69.3
139	SB40	Subbasin	13.3
140	DB7	Detention	1.2
141	CV25	Conveyance	1.2
142	SB39	Subbasin	12.1
143	SB41	Subbasin	10.9
144	HC31	Confluence	23.1
145	CV26	Conveyance	22.8
146	SB37	Subbasin	9.1
147	CV53	Conveyance	9.1
148	SB38	Subbasin	10.2
149	HC35	Confluence	18.8
150	CV27	Conveyance	18.4
151	SB43	Subbasin	5.9
152	HC32	Confluence	45.7
153	CV28	Conveyance	45.3
154	SB44	Subbasin	12.0
155	HC36	Confluence	55.7

ORDER	HMI ID	TYPE	PEAK (CFS)
156	CV29	Conveyance	55.3
157	SB46	Subbasin	3.9
158	HC33	Confluence	59.2
159	CV30	Conveyance	58.7
160	SB42	Subbasin	1.2
161	HC34	Confluence	58.9
162	DB8	Detention	3.5
163	CV119	Conveyance	3.4
164	SB76	Subbasin	13.2
165	SB47	Subbasin	10.8
166	HC37	Confluence	17.6
167	CV55	Conveyance	17.6
168	SB84	Subbasin	14.7
169	HC20	Confluence	21.6
170	CV79	Conveyance	21.6
171	CV61	Conveyance	21.5
172	SB82	Subbasin	38.9
173	HC82	Confluence	26.6
174	CV84	Conveyance	26.5
175	SB81	Subbasin	18.8
176	CV59	Conveyance	18.4
177	SB78	Subbasin	23.0
178	CV86	Conveyance	22.3
179	SB80	Subbasin	17.8
180	HC60	Confluence	57.5
181	DB15	Detention	13.7
182	CV85	Conveyance	13.7
183	HC43	Confluence	35.8
184	CV58	Conveyance	34.8
185	SB116	Subbasin	5.2
186	HC41	Confluence	35.8
187	CV57	Conveyance	35.4
188	SB115	Subbasin	19.0
189	CV109	Conveyance	3.6
190	HC81	Confluence	39.0
191	CV117	Conveyance	39.0
192	SB6	Subbasin	4.9
193	CV5	Conveyance	4.8
194	CV6	Conveyance	4.6
195	SB2	Subbasin	11.6
196	SB1	Subbasin	7.3
197	HC1	Confluence	21.6
198	CV1	Conveyance	21.2
199	SB3	Subbasin	1.8
200	HC4	Confluence	22.4
201	CV2	Conveyance	22.3
202	SB7	Subbasin	16.0
203	SB5	Subbasin	16.0
204	HC5	Confluence	32.0
205	CV4	Conveyance	31.0
206	SB4	Subbasin	3.8
207	HC2	Confluence	34.4
208	CV3	Conveyance	34.1

ORDER	HMI ID	TYPE	PEAK (CFS)
209	HC3	Confluence	54.4
210	DB1	Detention	9.2
211	CV7	Conveyance	9.2
212	SB50	Subbasin	6.5
213	DB9	Detention	0.2
214	CV31	Conveyance	0.2
215	SB51	Subbasin	7.4
216	HC16	Confluence	15.3
217	CV33	Conveyance	15.3
218	CV110	Conveyance	15.3
219	SB114	Subbasin	19.4
220	CV115	Conveyance	19.3
221	DB14	Detention	4.6
222	CV116	Conveyance	4.6
223	SB100	Subbasin	13.5
224	HC83	Confluence	23.6
225	CV118	Conveyance	23.6
226	HC61	Confluence	62.3
227	CV111	Conveyance	62.3
228	SB101	Subbasin	20.5
229	SB86	Subbasin	7.3
230	HC59	Confluence	68.1
231	CV112	Conveyance	68.1
232	SB79	Subbasin	6.1
233	CV82	Conveyance	1.7
234	SB83	Subbasin	17.8
235	CV83	Conveyance	5.0
236	SB108	Subbasin	15.6
237	CV62	Conveyance	4.4
238	SB85	Subbasin	6.2
239	SB87	Subbasin	11.1
240	HC44	Confluence	9.3
241	CV60	Conveyance	9.3
242	SB96	Subbasin	42.4
243	CV72	Conveyance	42.3
244	CV76	Conveyance	41.7
245	SB97	Subbasin	14.4
246	SB95	Subbasin	44.1
247	HC54	Confluence	49.4
248	CV73	Conveyance	49.6
249	CV75	Conveyance	49.3

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THIS PROGRAM REPLACES ALL PREVIOUS VERSIONS OF HEC-1 KNOWN AS HEC1 (JAN 73), HEC1GS, HEC1DB, AND HEC1KW.

THE DEFINITIONS OF VARIABLES -RTIMP- AND -RTIOR- HAVE CHANGED FROM THOSE USED WITH THE 1973-STYLE INPUT STRUCTURE.
THE DEFINITION OF -AMSKK- ON RM-CARD WAS CHANGED WITH REVISIONS DATED 28 SEP 81. THIS IS THE FORTRAN77 VERSION
NEW OPTIONS: DAMBREAK OUTFLOW SUBMERGENCE , SINGLE EVENT DAMAGE CALCULATION, DSS:WRITE STAGE FREQUENCY,
DSS:READ TIME SERIES AT DESIRED CALCULATION INTERVAL   LOSS RATE:GREEN AND AMPT INFILTRATION
KINEMATIC WAVE: NEW FINITE DIFFERENCE ALGORITHM

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 LINE           ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

                *DIAGRAM

*** FREE ***
    1           ID    SD Master Plan West of Bangerter E:\gisfiles\065\05.100\MODEL\Phase2-future\
    2           ID
    3           ID
    4           IT       1                     288
    5           IO       1

    6           KK    SB69
    7           BA    1.09
    8           PB   0.875
    9           IN       1
   10           PI   0.000   0.000   0.002   0.002   0.002   0.002   0.002   0.002   0.003   0.003
   11           PI   0.004   0.005   0.008   0.009   0.009   0.013   0.017    0.02   0.024   0.029
   12           PI   0.033   0.034   0.035   0.038   0.039   0.045   0.052   0.054   0.054   0.054
   13           PI   0.052   0.045    0.04   0.035    0.03   0.022    0.02   0.018   0.016   0.014
   14           PI   0.012   0.011    0.01   0.009   0.009   0.008   0.006   0.006   0.005   0.005
   15           PI   0.005   0.005   0.004   0.004   0.004   0.003   0.003   0.002   0.002   0.001
   16           LS       0      65     0.1
   17           UD    1.00
   18           KO                                      22

   19           KK    CV34
   20           RD 306.052 0.02000   0.015            CIRC    3.50    0.00
   21           KO                                      22

   22           KK    CV35
   23           RD 605.262 0.04800   0.015            CIRC    3.00    0.00
   24           KO                                      22

   25           KK    SB59
   26           BA  0.0297
   27           LS     0.1  98.000                  76.756     0.1
   28           UK      25     .02      .1   27.24
   29           UK      60     .02      .4   72.76
   30           RD     600     .01     .02            TRAP       2      25
   31           KO                                      22

   32           KK    HC24
   33           HC       2
   34           KO                                      22

   35           KK    CV36
   36           RD 558.153 0.01000   0.015            CIRC    4.00    0.00
   37           KO                                      22

   38           KK    SB56
   39           BA  0.0290
   40           LS     0.1  98.000                  77.049     0.1
   41           UK      25     .02     0.1   25.69
   42           UK      60     .02     .04   74.31
   43           RD     400     .01     .02    .005    TRAP       2      25
   44           RD    2300     .01    .015            CIRC    1.25
   45           KO                                      22
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LINE      ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

  46      KK    HC25
  47      HC       2
  48      KO                                      22

  49      KK    CV10
  50      RD 922.974 0.01000   0.015            CIRC    4.00    0.00
  51      KO                                      22

  52      KK    CV11
  53      RD 275.246 0.01000   0.015            CIRC    4.50    0.00
  54      KO                                      22

  55      KK    SB66
  56      BA  0.0550
  57      LS     0.1  98.000                  78.152     0.1
  58      UK      25    0.02     0.1   24.84
  59      UK      60    0.02     0.4   75.16
  60      RD     400     .01     .02   0.005    TRAP       2      25
  61      RD    1500     .01    .015            CIRC    1.25
  62      KO                                      22

  63      KK    CV37
  64      RD 1375.48 0.01000   0.015            CIRC    3.00    0.00
  65      KO                                      22

  66      KK    SB77
  67      BA  0.0604
  68      LS     0.1  98.000                  75.000     0.1
  69      UK      25     .02      .1   25.00
  70      UK      60     .02      .4   75.00
  71      RD    1000     .01     .02            TRAP       2      25
  72      KO                                      22

  73      KK    HC26
  74      HC       2
  75      KO                                      22

  76      KK     CV9
  77      RD 433.758 0.04200   0.015            CIRC    2.50    0.00
  78      KO                                      22

  79      KK    SB55
  80      BA  0.0400
  81      LS     0.1  98.000                  77.272     0.1
  82      UK      25     .02      .1   24.31
  83      UK      60     .02      .4   75.69
  84      RD     500     .01     .02    .005    TRAP       2      25
  85      RD    1800     .01    .015            CIRC     1.5
  86      KO                                      22
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 LINE           ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10


  87            KK     HC7
  88            HC       2
  89            KO                                      22

  90            KK    CV12
  91            RD 640.004 0.04000   0.015            CIRC    3.00    0.00
  92            KO                                      22

  93            KK    SB57
  94            BA  0.0465
  95            LS     0.1  98.000                  70.952     0.1
  96            UK      25     .02      .1   18.88
  97            UK      60     .02      .4   81.12
  98            RD     500     .01     .02            TRAP       2      25
  99            KO                                      22

 100            KK     HC8
 101            HC       3
 102            KO                                      22

 103            KK    CV13
 104            RD  96.377 0.01000   0.015            CIRC    4.50    0.00
 105            KO                                      22

 106            KK     DB2
 107            RS            FLOW
 108            SV       0       1       2       3       4       5       6       7       8       9
 109            SE       0     0.5       1     1.5       2     2.5       3     3.5       4     4.5
 110            SQ       0       1       2       8      10      20      23      27      30      60
 111            KO                                      22

 112            KK    CV16
 113            RD 1979.21 0.03000   0.015            CIRC    2.50    0.00
 114            KO                                      22

 115            KK    SB60
 116            BA  0.0797
 117            LS     0.1  98.000                  72.246     0.1
 118            UK      25     .02      .1   18.43
 119            UK      60     .02      .4   81.57
 120            RD     800     .01     .02     .05    TRAP       2      25
 121            RD    1500     .01    .015            CIRC    1.25
 122            KO                                      22

 123            KK     DB3
 124            RS            FLOW
 125            SV       0     0.5       1     1.5       2     2.5       3       4
 126            SE       0     0.5       1     1.5       2     2.5       3       4
 127            SQ       0    0.25     0.5       1       2       4       5      25
 128            KO                                      22
```

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 LINE          ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10


  129          KK    CV14
  130          RD 1167.79 0.01000   0.015            CIRC    2.25    0.00
  131          KO                                      22

  132          KK    SB58
  133          BA  0.0678
  134          LS     0.1  98.000                  78.003     0.1
  135          UK      25     .02      .1   22.61
  136          UK      60     .02      .4   77.39
  137          RD     900     .02     .02    .005    TRAP       2      25
  138          RD     825    .025    .015            CIRC       2
  139          KO                                      22

  140          KK    HC10
  141          HC       2
  142          KO                                      22

  143          KK    CV15
  144          RD 212.594 0.01000   0.015            CIRC    3.00    0.00
  145          KO                                      22

  146          KK     HC9
  147          HC       2
  148          KO                                      22

  149          KK    CV19
  150          RD 1390.35 0.02240   0.015            CIRC    3.00    0.00
  151          KO                                      22

  152          KK    SB63
  153          BA    1.19
  154          LS       0      65     0.1
  155          UD    0.55
  156          KO                                      22

  157          KK    SB28
  158          BA    0.72
  159          LS       0      65     0.1
  160          UD    0.55
  161          KO                                      22

  162          KK    SB27
  163          BA    1.30
  164          LS       0      67     0.1
  165          UD    1.36
  166          KO                                      22

  167          KK    SB26
  168          BA    0.43
  169          LS       0      74     0.1
  170          UD    0.37
  171          KO                                      22
```

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LINE           ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

 172           KK    SB25
 173           BA    0.53
 174           LS       0      74     0.1
 175           UD    0.56
 176           KO                                      22

 177           KK    HC38
 178           HC       5
 179           KO                                      22

 180           KK    CV42
 181           RD 2017.17 0.02000   0.015            CIRC    3.00    0.00
 182           KO                                      22

 183           KK    CV41
 184           RD 266.177 0.01280   0.015            CIRC    3.00    0.00
 185           KO                                      22

 186           KK    CV38
 187           RD 329.565 0.00750   0.015            CIRC    3.00    0.00
 188           KO                                      22

 189           KK    CV39
 190           RD 335.146 0.00460   0.015            CIRC    3.00    0.00
 191           KO                                      22

 192           KK    SB36
 193           BA  0.0435
 194           LS     0.1  98.000                  68.287     0.1
 195           UK      25     .02      .1   20.24
 196           UK      60     .02      .4   79.76
 197           RD     400     .01     .02    .005    TRAP       2      25
 198           RD     800    .015    .015            CIRC     1.5
 199           KO                                      22

 200           KK    HC18
 201           HC       2
 202           KO                                      22

 203           KK    CV40
 204           RD 183.028 0.00460   0.015            CIRC    3.00    0.00
 205           KO                                      22

 206           KK     DB5
 207           RS            FLOW
 208           SV       0     0.5       1     1.5       2     2.5       3
 209           SE       0     0.5       1     1.5       2     2.5       3
 210           SQ       0    0.25     0.5       1       2       3      10
 211           KO                                      22
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 LINE           ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10


  212           KK    SB34
  213           BA  0.0271
  214           LS     0.1  98.000                  69.482     0.1
  215           UK      20     .02      .1    4.63
  216           UK     100     .02      .4   95.37
  217           RD     100    .025    .015            CIRC    1.25
  218           KO                                      22

  219           KK    SB33
  220           BA  0.0181
  221           LS     0.1  98.000                  64.990     0.1
  222           UK      25     .02      .1   39.72
  223           UK      60     .02      .4   60.28
  224           RD     300     .02     .02    .004    TRAP       2      25
  225           RD    1300     .02    .015            CIRC    1.25
  226           KO                                      22

  227           KK    HC13
  228           HC       2
  229           KO                                      22

  230           KK    CV21
  231           RD 764.982 0.02080   0.015            CIRC    2.00    0.00
  232           KO                                      22

  233           KK    SB35
  234           BA  0.0295
  235           LS     0.1  98.000                  74.938     0.1
  236           UK      25     .02      .1   20.58
  237           UK      60     .02      .4   79.42
  238           RD     400     .02     .02    .004    TRAP       2      25
  239           RD     760     .02    .015            CIRC    1.25
  240           KO                                      22

  241           KK    HC14
  242           HC       2
  243           KO                                      22

  244           KK    CV22
  245           RD 202.938 0.00500   0.015            CIRC    2.00    0.00
  246           KO                                      22

  247           KK     DB4
  248           RS            FLOW
  249           SV       0     0.5       1     1.5       2     2.5       3     3.5
  250           SE       0      .5       1     1.5       2     2.5       3     3.5
  251           SQ       0    0.25     0.5       1       2       4       5      15
  252           KO                                      22
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 LINE          ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10


  253          KK    CV23
  254          RD 807.569 0.02000   0.040            TRAP    4.00    2.00
  255          KO                                      22

  256          KK    HC27
  257          HC       2
  258          KO                                      22

  259          KK    CV18
  260          RD 1608.00 0.02000   0.040            TRAP    4.00    2.00
  261          KO                                      22

  262          KK   CV100
  263          RD 1460.09 0.02000   0.040            TRAP    4.00    2.00
  264          KO                                      22

  265          KK   SB113
  266          BA  0.0748
  267          LS     0.1  98.000                  70.000     0.1
  268          UK      25     .02      .1   25.00
  269          UK      60     .02      .4   75.00
  270          RD     400     .01     .02            TRAP       2      25
  271          KO                                      22

  272          KK   CV104
  273          RD 1671.68 0.01000   0.014            CIRC    2.00    0.00
  274          KO                                      22

  275          KK    SB30
  276          BA  0.0725
  277          LS     0.1  98.000                  70.580     0.1
  278          UK      25     .02      .1   25.00
  279          UK      60     .02      .4   75.00
  280          RD    1300     .01     .02     .06    TRAP       2      25
  281          RD    2700     .02     .04            TRAP       5       2
  282          KO                                      22

  283          KK   SB111
  284          BA  0.0990
  285          LS     0.1  98.000                  70.000     0.1
  286          UK      25     .02      .1   25.00
  287          UK      60     .02      .4   75.00
  288          RD    1000     .01     .02     .05    TRAP       2      25
  289          RD    2000     .02    .015            CIRC     1.5
  290          KO                                      22

  291          KK    HC80
  292          HC       2
  293          KO                                      22
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LINE          ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

 294          KK   CV102
 295          RD 1300.49 0.02000   0.015            CIRC    2.50    0.00
 296          KO                                      22

 297          KK   SB112
 298          BA  0.0603
 299          LS     0.1  98.000                  70.000     0.1
 300          UK      25     .02      .1   25.00
 301          UK      60     .02      .4   75.00
 302          RD    1000     .01     .02     .05    TRAP       2      25
 303          RD    1000     .02    .015            CIRC     1.5
 304          KO                                      22

 305          KK    HC73
 306          HC       2
 307          KO                                      22

 308          KK   CV103
 309          RD 1133.61 0.02000   0.015            CIRC    3.00    0.00
 310          KO                                      22

 311          KK    HC79
 312          HC       2
 313          KO                                      22

 314          KK    DB16
 315          RS            FLOW
 316          SV       0      .5       1     1.5       2     2.5       3       4       5     5.1
 317          SE       0      .5       1     1.5       2     2.5       3     3.5       4     4.1
 318          SQ       0       3       6      10      15      20      20      20      20      80
 319          KO                                      22

 320          KK    HC12
 321          HC       3
 322          KO                                      22

 323          KK   CV101
 324          RD 1812.85 0.02000   0.040            TRAP    4.00    2.00
 325          KO                                      22

 326          KK   SB110
 327          BA  0.0602
 328          LS     0.1  98.000                  72.000     0.1
 329          UK      25     .02      .1   25.00
 330          UK      60     .02      .4   75.00
 331          RD    1000     .02    .015            CIRC     1.5
 332          KO                                      22

 333          KK  USB110DETENTION BASIN FROM REGULATED AREAS
 334          KM   ELEVATION CURVE IS VOLUME IN AC-FT OF THEORETICAL DETENTION BASIN
 335          RS            FLOW       0
 336          SV  0.0000  0.0542  0.1096  0.1639  0.2349  0.3072  0.3783  0.4385  0.4928   0.548
 337          SE  0.0000  0.0542  0.1096  0.1639  0.2349  0.3072  0.3783  0.4385  0.4928   0.548
 338          SQ  0.0000  3.1613  4.4335  5.4359  6.2841  7.0552  7.7106  8.0961  8.4816   23.13
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 LINE          ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

  339          KO                                      22

  340          KK   CV105
  341          RD 1143.83 0.00500   0.015            CIRC    1.75    0.00
  342          KO                                      22

  343          KK   SB118
  344          BA  0.0544
  345          LS     0.1  89.000                  72.000     0.1
  346          UK      25     .02      .1   25.00
  347          UK      60     .02      .4   75.00
  348          RD     500     .01    .015            CIRC     1.5
  349          KO                                      22

  350          KK  USB118DETENTION BASIN FROM REGULATED AREAS
  351          KM   ELEVATION CURVE IS VOLUME IN AC-FT OF THEORETICAL DETENTION BASIN
  352          RS            FLOW       0
  353          SV  0.0000  0.0490  0.0991  0.1481  0.2123  0.2776  0.3419  0.3963  0.4453   0.495
  354          SE  0.0000  0.0490  0.0991  0.1481  0.2123  0.2776  0.3419  0.3963  0.4453   0.495
  355          SQ  0.0000  2.8570  4.0068  4.9127  5.6792  6.3760  6.9684  7.3168  7.6652   20.90
  356          KO                                      22

  357          KK    HC71
  358          HC       3
  359          KO                                      22

  360          KK    CV20
  361          RD 2094.31 0.02000   0.040            TRAP    4.00    2.00
  362          KO                                      22

  363          KK    SB72
  364          BA  0.2119
  365          LS     0.1  98.000                  71.870     0.1
  366          UK      25     .02      .1   25.00
  367          UK      60     .02      .4   75.00
  368          RD    1000     .01     .02     .05    TRAP       2      25
  369          RD    3800     .02     .04            TRAP       5       2
  370          KO                                      22

  371          KK   USB72DETENTION BASIN FROM REGULATED AREAS
  372          KM   ELEVATION CURVE IS VOLUME IN AC-FT OF THEORETICAL DETENTION BASIN
  373          RS            FLOW       0
  374          SV  0.0000  0.1907  0.3856  0.5764  0.8264  1.0806  1.3306  1.5425  1.7332   1.928
  375          SE  0.0000  0.1907  0.3856  0.5764  0.8264  1.0806  1.3306  1.5425  1.7332   1.928
  376          SQ  0.0000  11.120  15.595  19.121  22.104  24.817  27.122  28.478  29.834   81.36
  377          KO                                      22

  378          KK    HC28
  379          HC       2
  380          KO                                      22
```

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LINE          ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

 381          KK    CV95
 382          RD 523.591 0.02000   0.040            TRAP    4.00    2.00
 383          KO                                      22

 384          KK    SB75
 385          BA  0.0498
 386          LS     0.1  98.000                  75.410     0.1
 387          UK      25     .02      .1   75.00
 388          UK      60     .02      .4   25.00
 389          RD     500     .02     .04    .005    TRAP       2      25
 390          RD     500     .02     .04            TRAP       2       2
 391          KO                                      22

 392          KK    CV88
 393          RD 1281.56 0.02000   0.015            CIRC    3.00    0.00
 394          KO                                      22

 395          KK    CV89
 396          RD 418.210 0.02000   0.015            CIRC    3.00    0.00
 397          KO                                      22

 398          KK    SB45
 399          BA  0.0163
 400          LS     0.1  98.000                  73.593     0.1
 401          UK      25     .02      .1   27.65
 402          UK      60     .02      .4   72.35
 403          RD     900     .02     .02            TRAP       2      25
 404          KO                                      22

 405          KK     DB6
 406          RS            FLOW
 407          SV       0   0.025    0.05   0.075     0.1   0.125    0.15     0.2   0.225    0.25
 408          SE       0    0.17    0.33    0.50    0.67    0.83    1.00    1.17    1.33    1.50
 409          SQ       0       0       0       0       0       0       0    0.25     0.5       1
 410          KO                                      22

 411          KK    SB29
 412          BA  0.0646
 413          LS     0.1  98.000                  74.820     0.1
 414          UK      25     .02      .1   25.00
 415          UK      60     .02      .4   75.00
 416          RD     400     .02     .02     .01    TRAP       2      25
 417          RD    1000     .01     .04            TRAP       2       2
 418          KO                                      22

 419          KK    HC78
 420          HC       2
 421          KO                                      22
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 LINE          ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

  422          KK    CV91
  423          RD 1587.23 0.00500   0.015            CIRC    2.50    0.00
  424          KO                                      22

  425          KK    SB73
  426          BA  0.1674
  427          LS     0.1  98.000                  73.350     0.1
  428          UK      25     .02      .1   25.00
  429          UK      60     .02      .4   75.00
  430          RD     400     .02     .02     .01    TRAP       2      25
  431          RD    1000     .01     .04            TRAP       2       2
  432          KO                                      22

  433          KK    HC63
  434          HC       3
  435          KO                                      22

  436          KK    CV90
  437          RD 1552.93 0.02000   0.014            CIRC    3.50    0.00
  438          KO                                      22

  439          KK   SB103
  440          BA  0.0685
  441          LS     0.1  98.000                  75.000     0.1
  442          UK      25     .02      .1   25.00
  443          UK      60     .02      .4   75.00
  444          RD     250     .01     .02     .01    TRAP       2      25
  445          RD     500     .01    .015            CIRC       2
  446          KO                                      22

  447          KK    HC64
  448          HC       2
  449          KO                                      22

  450          KK    DB13
  451          RS            FLOW
  452          SV       0       1       2       3       5       6       7       8       9     9.1
  453          SE       0       1     1.5       2     2.5       3     3.5       4    4.25     4.5
  454          SQ       0       3       6      12      20      25      26      27    27.5      50
  455          KO                                      22

  456          KK    CV50
  457          RD 2456.98 0.00600   0.015            CIRC    2.50    0.00
  458          KO                                      22

  459          KK    SB99
  460          BA  0.0809
  461          LS     0.1  98.000                  77.000     0.1
  462          UK      25     .02      .1   25.00
  463          UK      60     .02      .4   75.00
  464          RD     400    .005    .015            CIRC     1.5
  465          KO                                      22
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LINE      ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

 466      KK   USB99DETENTION BASIN FROM REGULATED AREAS
 467      KM   ELEVATION CURVE IS VOLUME IN AC-FT OF THEORETICAL DETENTION BASIN
 468      RS            FLOW       0
 469      SV  0.0000  0.0728  0.1473  0.2201  0.3156  0.4127  0.5082  0.5891  0.6619   0.736
 470      SE  0.0000  0.0728  0.1473  0.2201  0.3156  0.4127  0.5082  0.5891  0.6619   0.736
 471      SQ  0.0000  4.2467  5.9557  7.3022  8.4416  9.4773  10.357  10.875  11.393   31.07
 472      KO                                      22

 473      KK    HC67
 474      HC       3
 475      KO                                      22

 476      KK    CV52
 477      RD 1503.11 0.02000   0.040            TRAP    4.00    2.00
 478      KO                                      22

 479      KK    SB93
 480      BA  0.0373
 481      LS     0.1  98.000                  86.000     0.1
 482      UK      50     .02     .14   60.00
 483      UK      30     .02      .4   40.00
 484      RD    1300     .02    .015            CIRC       2
 485      KO                                      22

 486      KK   USB93DETENTION BASIN FROM REGULATED AREAS
 487      KM   ELEVATION CURVE IS VOLUME IN AC-FT OF THEORETICAL DETENTION BASIN
 488      RS            FLOW       0
 489      SV  0.0000  0.0806  0.1629  0.2435  0.3491  0.4565  0.5622  0.6517  0.7322   0.814
 490      SE  0.0000  0.0806  0.1629  0.2435  0.3491  0.4565  0.5622  0.6517  0.7322   0.814
 491      SQ  0.0000  1.9574  2.7451  3.3658  3.8909  4.3683  4.7742  5.0129  5.2516   14.32
 492      KO                                      22

 493      KK    CV93
 494      RD 600.955 0.01000   0.015            CIRC    1.50    0.00
 495      KO                                      22

 496      KK    SB94
 497      BA  0.0409
 498      LS     0.1  98.000                  86.000     0.1
 499      UK      50     .02     .14   60.00
 500      UK      30     .02      .4   40.00
 501      RD    1300     .02    .015            CIRC       2
 502      KO                                      22

 503      KK   USB94DETENTION BASIN FROM REGULATED AREAS
 504      KM   ELEVATION CURVE IS VOLUME IN AC-FT OF THEORETICAL DETENTION BASIN
 505      RS            FLOW       0
 506      SV  0.0000  0.0884  0.1788  0.2673  0.3832  0.5011  0.6170  0.7153  0.8037   0.894
 507      SE  0.0000  0.0884  0.1788  0.2673  0.3832  0.5011  0.6170  0.7153  0.8037   0.894
 508      SQ  0.0000  2.1484  3.0131  3.6943  4.2707  4.7947  5.2402  5.5022  5.7642   15.72
 509      KO                                      22
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LINE          ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

 510          KK    HC65
 511          HC       2
 512          KO                                       22

 513          KK    CV94
 514          RD 623.598 0.01000   0.015            CIRC    2.00    0.00
 515          KO                                       22

 516          KK    HC51
 517          HC       2
 518          KO                                       22

 519          KK    CV71
 520          RD 1198.25 0.02000   0.040            TRAP    4.00    2.00
 521          KO                                       22

 522          KK    SB98
 523          BA  0.0538
 524          LS     0.1  98.000                  86.000     0.1
 525          UK      50     .02      .1   40.00
 526          UK      30     .02      .4   60.00
 527          RD    1000     .02    .015            CIRC     1.5
 528          KO                                       22

 529          KK   USB98DETENTION BASIN FROM REGULATED AREAS
 530          KM   ELEVATION CURVE IS VOLUME IN AC-FT OF THEORETICAL DETENTION BASIN
 531          RS            FLOW       0
 532          SV  0.0000  0.0774  0.1565  0.2339  0.3354  0.4386  0.5401  0.6261  0.7035   0.782
 533          SE  0.0000  0.0774  0.1565  0.2339  0.3354  0.4386  0.5401  0.6261  0.7035   0.782
 534          SQ  0.0000  2.8209  3.9562  4.8506  5.6075  6.2955  6.8804  7.2244  7.5684   20.64
 535          KO                                       22

 536          KK    SB49
 537          BA  0.0380
 538          LS     0.1  98.000                  75.038     0.1
 539          UK      25     .02      .1   15.00
 540          UK      90     .02      .4   85.00
 541          RD     500     .02     .02     .01    TRAP       2      25
 542          RD     500     .02     .04            TRAP       1       2
 543          KO                                       22

 544          KK   USB49DETENTION BASIN FROM REGULATED AREAS
 545          KM   ELEVATION CURVE IS VOLUME IN AC-FT OF THEORETICAL DETENTION BASIN
 546          RS            FLOW       0
 547          SV  0.0000  0.0205  0.0415  0.0620  0.0889  0.1162  0.1431  0.1659  0.1864   0.207
 548          SE  0.0000  0.0205  0.0415  0.0620  0.0889  0.1162  0.1431  0.1659  0.1864   0.207
 549          SQ  0.0000  1.9931  2.7953  3.4272  3.9620  4.4481  4.8614  5.1044  5.3475   14.58
 550          KO                                       22
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LINE      ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

          KK    CV24
          RD 962.679 0.00500   0.015            CIRC    1.50    0.00
          KO                                      22

          KK    SB48
          BA  0.0374
          LS     0.1  98.000                  73.160     0.1
          UK      25     .02      .1   15.00
          UK      90     .02      .4   85.00
          RD     600     .02     .02    .005    TRAP       2      25
          RD     800     .02     .04            TRAP       2       2
          KO                                      22

          KK   USB48DETENTION BASIN FROM REGULATED AREAS
          KM   ELEVATION CURVE IS VOLUME IN AC-FT OF THEORETICAL DETENTION BASIN
          RS            FLOW       0
          SV  0.0000  0.0202  0.0408  0.0610  0.0874  0.1143  0.1408  0.1632  0.1834   0.204
          SE  0.0000  0.0202  0.0408  0.0610  0.0874  0.1143  0.1408  0.1632  0.1834   0.204
          SQ  0.0000  1.9606  2.7496  3.3713  3.8973  4.3755   4.782  5.0211  5.2602  14.346
          KO                                      22

          KK    HC55
          HC       2
          KO                                      22

          KK    CV64
          RD 1426.23 0.01800   0.015            CIRC    1.50    2.00
          KO                                      22

          KK   SB117
          BA  0.0456
          LS     0.1  98.000                  72.000     0.1
          UK      25     .02      .1   25.00
          UK      60     .02      .4   75.00
          RD     800    .005    .015    .023    CIRC     1.5
          RD     300     .01     .02            CIRC     1.5
          KO                                      22

          KK  USB117DETENTION BASIN FROM REGULATED AREAS
          KM   ELEVATION CURVE IS VOLUME IN AC-FT OF THEORETICAL DETENTION BASIN
          RS            FLOW       0
          SV  0.0000  0.0411  0.0831  0.1241  0.1780  0.2327  0.2866  0.3322  0.3733   0.415
          SE  0.0000  0.0411  0.0831  0.1241  0.1780  0.2327  0.2866  0.3322  0.3733   0.415
          SQ  0.0000  2.3948  3.3585  4.1179  4.7604  5.3445   5.841  6.1330  6.4251  17.523
          KO                                      22

          KK    SB88
          BA  0.0337
          LS     0.1  98.000                  77.000     0.1
          UK      25     .02      .1   25.00
          UK      60     .02      .4   75.00
          RD     400    .005    .015            CIRC     1.5
          KO                                      22
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LINE          ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10


 597          KK   USB88DETENTION BASIN FROM REGULATED AREAS
 598          KM   ELEVATION CURVE IS VOLUME IN AC-FT OF THEORETICAL DETENTION BASIN
 599          RS            FLOW       0
 600          SV  0.0000  0.0303  0.0614  0.0917  0.1315  0.1720  0.2118  0.2455  0.2758   0.306
 601          SE  0.0000  0.0303  0.0614  0.0917  0.1315  0.1720  0.2118  0.2455  0.2758   0.306
 602          SQ  0.0000  1.7696  2.4818  3.0429  3.5177  3.9493  4.3162  4.5320  4.7478   12.94
 603          KO                                       22

 604          KK    HC23
 605          HC       2
 606          KO                                       22

 607          KK   CV114
 608          RD 1318.87 0.01000   0.014            CIRC    1.50    0.00
 609          KO                                       22

 610          KK    SB91
 611          BA  0.0589
 612          LS     0.1  98.000                  86.000     0.1
 613          UK      50     .02     .14   60.00
 614          UK      30     .02      .4   40.00
 615          RD    1300     .02    .015            CIRC       2
 616          KO                                       22

 617          KK   USB91DETENTION BASIN FROM REGULATED AREAS
 618          KM   ELEVATION CURVE IS VOLUME IN AC-FT OF THEORETICAL DETENTION BASIN
 619          RS            FLOW       0
 620          SV  0.0000  0.1272  0.2572  0.3845  0.5512  0.7209  0.8876  1.0289  1.1562   1.286
 621          SE  0.0000  0.1272  0.2572  0.3845  0.5512  0.7209  0.8876  1.0289  1.1562   1.286
 622          SQ  0.0000  3.0907  4.3345  5.3145  6.1438  6.8976  7.5384  7.9153  8.2922   22.61
 623          KO                                       22

 624          KK    SB89
 625          BA  0.0438
 626          LS     0.1  98.000                  86.000     0.1
 627          UK      50     .02     .14   60.00
 628          UK      30     .02      .4   40.00
 629          RD     500    .005    .015            CIRC       2
 630          KO                                       22

 631          KK   USB89DETENTION BASIN FROM REGULATED AREAS
 632          KM   ELEVATION CURVE IS VOLUME IN AC-FT OF THEORETICAL DETENTION BASIN
 633          RS            FLOW       0
 634          SV  0.0000  0.0947  0.1915  0.2862  0.4103  0.5365  0.6607  0.7659  0.8606   0.957
 635          SE  0.0000  0.0947  0.1915  0.2862  0.4103  0.5365  0.6607  0.7659  0.8606   0.957
 636          SQ  0.0000  2.3004  3.2262  3.9556  4.5728  5.1338  5.6108  5.8913  6.1718   16.83
 637          KO                                       22

 638          KK    HC45
 639          HC       4
 640          KO                                       22
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 LINE          ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10


  641          KK    CV65
  642          RD 977.717 0.01800   0.015            CIRC    2.50    2.00
  643          KO                                      22

  644          KK   SB107
  645          BA  0.0224
  646          LS     0.1  98.000                  77.000     0.1
  647          UK      25     .02      .1   25.00
  648          UK      60     .02      .4   75.00
  649          RD     500     .02    .015            CIRC     1.5
  650          KO                                      22

  651          KK  USB107DETENTION BASIN FROM REGULATED AREAS
  652          KM   ELEVATION CURVE IS VOLUME IN AC-FT OF THEORETICAL DETENTION BASIN
  653          RS            FLOW       0
  654          SV  0.0000  0.0202  0.0408  0.0609  0.0874  0.1143  0.1407  0.1631  0.1833   0.203
  655          SE  0.0000  0.0202  0.0408  0.0609  0.0874  0.1143  0.1407  0.1631  0.1833   0.203
  656          SQ  0.0000  1.1757  1.6488  2.0216  2.3370  2.6238  2.8676  3.0109  3.1543   8.602
  657          KO                                      22

  658          KK    CV97
  659          RD 996.647 0.00500   0.015            CIRC    2.00    0.00
  660          KO                                      22

  661          KK    CV98
  662          RD 563.543 0.00500   0.015            CIRC    1.50    0.00
  663          KO                                      22

  664          KK    HC68
  665          HC       2
  666          KO                                      22

  667          KK    CV99
  668          RD 566.379 0.02000   0.015            CIRC    2.50    0.00
  669          KO                                      22

  670          KK    SB90
  671          BA  0.0501
  672          LS     0.1  98.000                  86.000     0.1
  673          UK      50     .02     .14   60.00
  674          UK      30     .02      .4   40.00
  675          RD    1000     .01    .015            CIRC       2
  676          KO                                      22

  677          KK   USB90DETENTION BASIN FROM REGULATED AREAS
  678          KM   ELEVATION CURVE IS VOLUME IN AC-FT OF THEORETICAL DETENTION BASIN
  679          RS            FLOW       0
  680          SV  0.0000  0.1083  0.2190  0.3273  0.4694  0.6138  0.7558  0.8761  0.9845   1.095
  681          SE  0.0000  0.1083  0.2190  0.3273  0.4694  0.6138  0.7558  0.8761  0.9845   1.095
  682          SQ  0.0000  2.6316  3.6907  4.5251  5.2311  5.8730  6.4186  6.7395  7.0604   19.25
  683          KO                                      22
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LINE          ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

 684          KK    CV66
 685          RD 740.469 0.00500   0.015            CIRC    2.50    0.00
 686          KO                                      22

 687          KK    HC46
 688          HC       2
 689          KO                                      22

 690          KK    CV67
 691          RD 457.366 0.00400   0.014            CIRC    3.50    0.00
 692          KO                                      22

 693          KK    SB92
 694          BA  0.0396
 695          LS     0.1  98.000                  86.000     0.1
 696          UK      50     .02      .1   60.00
 697          UK      30     .02      .4   40.00
 698          RD    1000     .02    .015            CIRC       2
 699          KO                                      22

 700          KK   USB92DETENTION BASIN FROM REGULATED AREAS
 701          KM   ELEVATION CURVE IS VOLUME IN AC-FT OF THEORETICAL DETENTION BASIN
 702          RS            FLOW       0
 703          SV  0.0000  0.0855  0.1729  0.2584  0.3705  0.4845  0.5966  0.6916  0.7771   0.864
 704          SE  0.0000  0.0855  0.1729  0.2584  0.3705  0.4845  0.5966  0.6916  0.7771   0.864
 705          SQ  0.0000  2.0773  2.9133  3.5719  4.1292  4.6359  5.0666  5.3199  5.5732   15.19
 706          KO                                      22

 707          KK   SB104
 708          BA  0.0264
 709          LS     0.1  98.000                  86.000     0.1
 710          UK      50     .02      .1   60.00
 711          UK      30     .02      .4   40.00
 712          RD     500     .02    .015            CIRC     1.5
 713          KO                                      22

 714          KK  USB104DETENTION BASIN FROM REGULATED AREAS
 715          KM   ELEVATION CURVE IS VOLUME IN AC-FT OF THEORETICAL DETENTION BASIN
 716          RS            FLOW       0
 717          SV  0.0000  0.0570  0.1153  0.1723  0.2470  0.3230  0.3977  0.4611  0.5181   0.576
 718          SE  0.0000  0.0570  0.1153  0.1723  0.2470  0.3230  0.3977  0.4611  0.5181   0.576
 719          SQ  0.0000  1.3849  1.9422  2.3813  2.7529  3.0906  3.3778  3.5466  3.7155   10.13
 720          KO                                      22

 721          KK    HC47
 722          HC       3
 723          KO                                      22

 724          KK    CV68
 725          RD 887.251 0.00500   0.014            CIRC    3.50    0.00
 726          KO                                      22
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 LINE          ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10


  727          KK   SB105
  728          BA  0.0163
  729          LS     0.1  98.000                  86.000     0.1
  730          UK      25     .02      .1   60.00
  731          UK      30     .02      .4   40.00
  732          RD     500     .02    .015            CIRC     1.5
  733          KO                                      22

  734          KK  USB105DETENTION BASIN FROM REGULATED AREAS
  735          KM   ELEVATION CURVE IS VOLUME IN AC-FT OF THEORETICAL DETENTION BASIN
  736          RS            FLOW       0
  737          SV  0.0000  0.0352  0.0712  0.1063  0.1525  0.1994  0.2455  0.2846  0.3198   0.355
  738          SE  0.0000  0.0352  0.0712  0.1063  0.1525  0.1994  0.2455  0.2846  0.3198   0.355
  739          SQ  0.0000  0.8549  1.1989  1.4700  1.6994  1.9079  2.0852  2.1894  2.2937   6.255
  740          KO                                      22

  741          KK    HC48
  742          HC       2
  743          KO                                      22

  744          KK    CV69
  745          RD 469.429 0.00500   0.014            CIRC    3.50    0.00
  746          KO                                      22

  747          KK   SB106
  748          BA  0.0228
  749          LS     0.1  98.000                  86.000     0.1
  750          UK      50     .02      .1   40.00
  751          UK      30     .02      .4   60.00
  752          RD     300     .02    .015            CIRC     1.5
  753          KO                                      22

  754          KK  USB106DETENTION BASIN FROM REGULATED AREAS
  755          KM   ELEVATION CURVE IS VOLUME IN AC-FT OF THEORETICAL DETENTION BASIN
  756          RS            FLOW       0
  757          SV  0.0000  0.0328  0.0663  0.0991  0.1422  0.1859  0.2289  0.2654  0.2982   0.331
  758          SE  0.0000  0.0328  0.0663  0.0991  0.1422  0.1859  0.2289  0.2654  0.2982   0.331
  759          SQ  0.0000  1.1955  1.6767  2.0557  2.3765  2.6681   2.916  3.0618  3.2076   8.748
  760          KO                                      22

  761          KK    HC49
  762          HC       2
  763          KO                                      22

  764          KK    CV70
  765          RD 1368.21 0.00400   0.014            CIRC    4.00    0.00
  766          KO                                      22

  767          KK    HC50
  768          HC       2
  769          KO                                      22
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 LINE      ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

  770      KK    CV78
  771      RD 498.057 0.02000   0.040            TRAP    4.00    2.00
  772      KO                                      22

  773      KK    SB40
  774      BA  0.0401
  775      LS     0.1  98.000                73.232     0.1
  776      UK      25     .02      .1   28.00
  777      UK      60     .02      .4   72.00
  778      RD     900     .01     .04    .008    TRAP       2      25
  779      RD    1000     .02    .015            CIRC    1.25
  780      KO                                      22

  781      KK     DB7
  782      RS            FLOW
  783      SV       0       1       2       3
  784      SE       0      .5       1     1.5
  785      SQ       0       2       8      12
  786      KO                                      22

  787      KK    CV25
  788      RD 481.517 0.03830   0.015            CIRC    1.50    0.00
  789      KO                                      22

  790      KK    SB39
  791      BA  0.0230
  792      LS     0.1  98.000                75.333     0.1
  793      UK      25     .02      .1   34.79
  794      UK      60     .02      .4   65.21
  795      RD     400     .02     .04    .005    TRAP       2      25
  796      RD     975     .01    .015            CIRC    1.25       2
  797      KO                                      22

  798      KK    SB41
  799      BA  0.0172
  800      LS     0.1  98.000                75.456     0.1
  801      UK      30     .01      .1   42.90
  802      UK      50     .02      .4   57.10
  803      RD     500     .01     .04            TRAP       2      25
  804      KO                                      22

  805      KK    HC31
  806      HC       3
  807      KO                                      22

  808      KK    CV26
  809      RD 1005.34 0.00750   0.014            CIRC    2.00    0.00
  810      KO                                      22
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 LINE           ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10


  811           KK    SB37
  812           BA  0.0248
  813           LS     0.1  98.000                  76.000     0.1
  814           UK      25     .02      .1   25.00
  815           UK      60     .02      .4   75.00
  816           RD     400     .01     .04    .005    TRAP       2      25
  817           RD     500     .02    .015            CIRC    1.25
  818           KO                                      22

  819           KK    CV53
  820           RD 733.326 0.02760   0.015            CIRC    1.50    0.00
  821           KO                                      22

  822           KK    SB38
  823           BA  0.0182
  824           LS     0.1  98.000                  75.606     0.1
  825           UK      30     .01      .1   36.48
  826           UK      50     .02      .4   63.52
  827           RD     300     .01     .02    .005    TRAP       2      25
  828           RD     500     .01    .015            CIRC    1.25
  829           KO                                      22

  830           KK    HC35
  831           HC       2
  832           KO                                      22

  833           KK    CV27
  834           RD 1238.85 0.00660   0.014            CIRC    2.00    0.00
  835           KO                                      22

  836           KK    SB43
  837           BA  0.0262
  838           LS     0.1  98.000                  70.588     0.1
  839           UK      25     .02      .1   14.46
  840           UK      60     .02      .4   85.54
  841           RD     400     .01     .02            TRAP       2      25
  842           KO                                      22

  843           KK    HC32
  844           HC       3
  845           KO                                      22

  846           KK    CV28
  847           RD 630.174 0.02880   0.015            CIRC    2.50    0.00
  848           KO                                      22

  849           KK    SB44
  850           BA  0.0344
  851           LS     0.1  98.000                  70.014     0.1
  852           UK      25     .02      .1   22.83
  853           UK      60     .02      .4   77.17
  854           RD     400     .01     .02    .005    TRAP       2      25
  855           RD     830     .01    .015            CIRC    1.25
  856           KO                                      22
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LINE          ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

 857          KK    HC36
 858          HC       2
 859          KO                                       22

 860          KK    CV29
 861          RD 345.220 0.02880   0.015             CIRC    2.50    0.00
 862          KO                                       22

 863          KK    SB46
 864          BA  0.0120
 865          LS     0.1  98.000                   76.000     0.1
 866          UK      25     .02      .1   25.00
 867          UK      60     .02      .4   75.00
 868          RD     800     .01     .04             TRAP       2      25
 869          KO                                       22

 870          KK    HC33
 871          HC       2
 872          KO                                       22

 873          KK    CV30
 874          RD 185.232 0.00500   0.015             CIRC    2.50    0.00
 875          KO                                       22

 876          KK    SB42
 877          BA  0.0770
 878          LS     0.1  98.000                   71.325     0.1
 879          UK      50     .02      .1    0.10
 880          UK     200     .02      .4   99.90
 881          RD    1400     .02    .015             CIRC       2
 882          KO                                       22

 883          KK    HC34
 884          HC       2
 885          KO                                       22

 886          KK     DB8
 887          RS            FLOW
 888          SV       0       1       2       3       4       5       6       7       8       9
 889          SE       0    0.33    0.67       1    1.33    1.67       2    2.33    2.67       3
 890          SQ       0       0       1       2       4       8      16      25      25      33
 891          KO                                       22

 892          KK   CV119
 893          RD 1473.36 0.00500   0.015             CIRC    2.00    0.00
 894          KO                                       22

 895          KK    SB76
 896          BA  0.0412
 897          LS     0.1  98.000                   77.709     0.1
 898          UK      25     .02      .1   25.00
 899          UK      80     .02      .4   75.00
 900          RD    1500     .02     .02    .005     TRAP       2      25
 901          RD     200     .02    .015             CIRC     1.5       2
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LINE          ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

 902          KO                                        22

 903          KK    SB47
 904          BA  0.0469
 905          LS     0.1  98.000                    79.935     0.1
 906          UK      25     .02      .1   15.00
 907          UK      90     .02      .4   85.00
 908          RD     500     .02     .02     .01    TRAP       2      25
 909          RD     500     .02     .04            TRAP       2       2
 910          KO                                        22

 911          KK   USB47DETENTION BASIN FROM REGULATED AREAS
 912          KM   ELEVATION CURVE IS VOLUME IN AC-FT OF THEORETICAL DETENTION BASIN
 913          RS            FLOW       0
 914          SV  0.0000  0.0253  0.0512  0.0765  0.1097  0.1434  0.1766  0.2047  0.2300   0.255
 915          SE  0.0000  0.0253  0.0512  0.0765  0.1097  0.1434  0.1766  0.2047  0.2300   0.255
 916          SQ  0.0000  2.4598  3.4497  4.2297  4.8896  5.4896  5.9996  6.2995  6.5995   17.99
 917          KO                                        22

 918          KK    HC37
 919          HC       3
 920          KO                                        22

 921          KK    CV55Proposed pipe
 922          RD 1417.65 0.02000   0.015            CIRC    2.00    0.00
 923          KO                                        22

 924          KK    SB84
 925          BA  0.0375
 926          LS     0.1  98.000                    77.000     0.1
 927          UK      25     .02      .1   25.00
 928          UK      60     .02      .4   75.00
 929          RD    1300     .02    .015            CIRC       2
 930          KO                                        22

 931          KK   USB84DETENTION BASIN FROM REGULATED AREAS
 932          KM   ELEVATION CURVE IS VOLUME IN AC-FT OF THEORETICAL DETENTION BASIN
 933          RS            FLOW       0
 934          SV  0.0000  0.0337  0.0682  0.1019  0.1462  0.1911  0.2353  0.2728  0.3065   0.341
 935          SE  0.0000  0.0337  0.0682  0.1019  0.1462  0.1911  0.2353  0.2728  0.3065   0.341
 936          SQ  0.0000  1.9666  2.7581  3.3817  3.9093  4.3890  4.7968  5.0366  5.2764   14.39
 937          KO                                        22

 938          KK    HC20
 939          HC       2
 940          KO                                        22

 941          KK    CV79
 942          RD 1626.81 0.01940   0.014            CIRC    2.00    0.00
 943          KO                                        22
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 LINE          ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10


  944          KK    CV61
  945          RD 1181.90 0.00850   0.014            CIRC    2.50    0.00
  946          KO                                      22

  947          KK    SB82
  948          BA  0.0425
  949          LS     0.1  98.000                  82.000     0.1
  950          UK      50     .02      .1   60.00
  951          UK      40     .02      .4   40.00
  952          RD    1300     .02    .015            CIRC     1.5
  953          KO                                      22

  954          KK   USB82DETENTION BASIN FROM REGULATED AREAS
  955          KM   ELEVATION CURVE IS VOLUME IN AC-FT OF THEORETICAL DETENTION BASIN
  956          RS            FLOW       0
  957          SV  0.0000  0.0918  0.1855  0.2773  0.3976  0.5199  0.6402  0.7422  0.8339   0.927
  958          SE  0.0000  0.0918  0.1855  0.2773  0.3976  0.5199  0.6402  0.7422  0.8339   0.927
  959          SQ  0.0000  2.2292  3.1263  3.8332  4.4313  4.9750  5.4372  5.7090  5.9809   16.31
  960          KO                                      22

  961          KK    HC82
  962          HC       2
  963          KO                                      22

  964          KK    CV84
  965          RD 1169.01 0.00680   0.015            CIRC    2.50    0.00
  966          KO                                      22

  967          KK    SB81
  968          BA  0.0480
  969          LS     0.1  98.000                  77.000     0.1
  970          UK      25     .02      .1   25.00
  971          UK      60     .02      .4   75.00
  972          RD    1300     .02    .015            CIRC     1.5
  973          KO                                      22

  974          KK    CV59
  975          RD 590.170 0.00500   0.015            CIRC    2.25    0.00
  976          KO                                      22

  977          KK    SB78
  978          BA  0.0582
  979          LS     0.1  98.000                  77.000     0.1
  980          UK      25     .02      .1   25.00
  981          UK      60     .02      .4   75.00
  982          RD     800     .01    .015   0.018    TRAP     1.5
  983          RD     800     .02    .015            CIRC     1.5
  984          KO                                      22
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 LINE          ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10


  985          KK    CV86
  986          RD 1046.19 0.00500   0.015            CIRC    2.50    0.00
  987          KO                                      22

  988          KK    SB80
  989          BA  0.0454
  990          LS     0.1  98.000                77.000     0.1
  991          UK      25     .02      .1   25.00
  992          UK      60     .02      .4   75.00
  993          RD    1300     .02    .015            CIRC     1.5
  994          KO                                      22

  995          KK    HC60
  996          HC       3
  997          KO                                      22

  998          KK    DB15
  999          RS            FLOW
 1000          SV       0      .3      .6      .9     1.2     1.5     1.8       2     2.1     2.2
 1001          SE       0      .3      .6      .9     1.2     1.5     1.8       2     2.1     2.2
 1002          SQ       0       2       5      10      14      16      18      20      25      50
 1003          KO                                      22

 1004          KK    CV85
 1005          RD 196.193 0.00750   0.014            CIRC    2.00    0.00
 1006          KO                                      22

 1007          KK    HC43
 1008          HC       2
 1009          KO                                      22

 1010          KK    CV58
 1011          RD 1338.03 0.00250   0.014            CIRC    3.50    0.00
 1012          KO                                      22

 1013          KK   SB116
 1014          BA  0.0135
 1015          LS     0.1  98.000                77.000     0.1
 1016          UK      25     .02      .1   25.00
 1017          UK      60     .02      .4   75.00
 1018          RD     750     .02     .02            TRAP       2      25
 1019          KO                                      22

 1020          KK    HC41
 1021          HC       2
 1022          KO                                      22

 1023          KK    CV57
 1024          RD 507.761 0.00250   0.014            CIRC    3.50    0.00
 1025          KO                                      22
```

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LINE          ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10


1026          KK   SB115
1027          BA  0.0301
1028          LS     0.1  98.000                  77.000     0.1
1029          UK      25     .02      .1   40.00
1030          UK      60     .02      .4   60.00
1031          RD     400     .02     .02            TRAP       2      25
1032          KO                                      22

1033          KK  USB115DETENTION BASIN FROM REGULATED AREAS
1034          KM   ELEVATION CURVE IS VOLUME IN AC-FT OF THEORETICAL DETENTION BASIN
1035          RS            FLOW       0
1036          SV  0.0000  0.0433  0.0875  0.1308  0.1876  0.2453  0.3020  0.3501  0.3934   0.437
1037          SE  0.0000  0.0433  0.0875  0.1308  0.1876  0.2453  0.3020  0.3501  0.3934   0.437
1038          SQ  0.0000  1.5774  2.2122  2.7124  3.1356  3.5203  3.8474  4.0397  4.2321   11.54
1039          KO                                      22

1040          KK   CV109
1041          RD 1206.67 0.00300   0.015            CIRC    1.50    0.00
1042          KO                                      22

1043          KK    HC81
1044          HC       2
1045          KO                                      22

1046          KK   CV117
1047          RD 284.559 0.00230   0.014            CIRC    3.50    0.00
1048          KO                                      22

1049          KK     SB6
1050          BA  0.0139
1051          LS     0.1  98.000                  75.000     0.1
1052          UK      25     .02      .1   25.00
1053          UK      60     .02      .4   75.00
1054          RD     700    .004     .02            TRAP       2      25
1055          KO                                      22

1056          KK     CV5
1057          RD 504.839 0.00400   0.015            CIRC    1.25    0.00
1058          KO                                      22

1059          KK     CV6
1060          RD 850.434 0.00400   0.015            CIRC    1.50    0.00
1061          KO                                      22

1062          KK     SB2
1063          BA  0.0318
1064          LS     0.1  98.000                  79.826     0.1
1065          UK      25     .02      .1   25.94
1066          UK      60     .02      .4   74.06
1067          RD     350    .004     .02    .004    TRAP       2      25
1068          RD    1330    .004    .015            CIRC     1.5
1069          KO                                      22
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LINE          ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

1070          KK     SB1
1071          BA  0.0200
1072          LS     0.1  98.000                  79.698     0.1
1073          UK      20     .02      .1   24.42
1074          UK      60     .02      .4   75.58
1075          RD     850    .004    .015            CIRC     1.5
1076          RD     400    .004     .02    .007    TRAP       2      25
1077          KO                                      22

1078          KK     HC1
1079          HC       3
1080          KO                                      22

1081          KK     CV1
1082          RD 370.835 0.00500   0.015            CIRC    2.00    0.00
1083          KO                                      22

1084          KK     SB3
1085          BA  0.0222
1086          LS     0.1  98.000                  76.861     0.1
1087          UK      25     .02      .1    5.36
1088          UK      60     .02      .4   94.64
1089          RD     700    .004     .02   .0048    TRAP       2      25
1090          RD     400    .005    .015            CIRC       2
1091          KO                                      22

1092          KK     HC4
1093          HC       2
1094          KO                                      22

1095          KK     CV2
1096          RD 122.150 0.00500   0.015            CIRC    2.00    0.00
1097          KO                                      22

1098          KK     SB7
1099          BA  0.0481
1100          LS     0.1  98.000                  75.000     0.1
1101          UK      25     .02      .1   25.00
1102          UK      60     .02      .4   75.00
1103          RD     600    .004     .02    .005    TRAP       2      25
1104          RD    1000    .004    .015            CIRC     1.5
1105          KO                                      22

1106          KK     SB5
1107          BA  0.0480
1108          LS     0.1  98.000                  76.000     0.1
1109          UK      25     .02      .1   25.00
1110          UK      60     .02      .4   75.00
1111          RD     600    .004     .02    .005    TRAP       2      25
1112          RD    1300    .004    .015            CIRC       2
1113          KO                                      22
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 LINE           ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10


 1114           KK     HC5
 1115           HC       2
 1116           KO                                      22

 1117           KK     CV4
 1118           RD 1472.34 0.00500   0.015            CIRC    2.50    0.00
 1119           KO                                      22

 1120           KK     SB4
 1121           BA  0.0194
 1122           LS     0.1  98.000                  71.511     0.1
 1123           UK      25     .02      .1   15.03
 1124           UK      60     .02      .4   84.97
 1125           RD     650    .004     .02   .0054    TRAP       2      25
 1126           RD     820    .004    .015            CIRC       3
 1127           KO                                      22

 1128           KK     HC2
 1129           HC       2
 1130           KO                                      22

 1131           KK     CV3
 1132           RD 531.325 0.00500   0.015            CIRC    3.00    0.00
 1133           KO                                      22

 1134           KK     HC3
 1135           HC       2
 1136           KO                                      22

 1137           KK     DB1
 1138           RS            FLOW
 1139           SV       0     .25      .5       1     1.5       2     2.5       3     3.5       4
 1140           SE       0     .25      .5       1     1.5       2     2.5       3     3.5       4
 1141           SQ       0       2       4       6       8       9      10      11      12      12
 1142           KO                                      22

 1143           KK     CV7
 1144           RD 418.687 0.02000   0.015            CIRC    2.00    0.00
 1145           KO                                      22

 1146           KK    SB50
 1147           BA  0.0252
 1148           LS     0.1  98.000                  81.917     0.1
 1149           UK      25     .02      .1   16.54
 1150           UK      60     .02      .4   83.46
 1151           RD     400     .01     .02            TRAP       2      25
 1152           KO                                      22

 1153           KK     DB9
 1154           RS            FLOW
 1155           SV       0     0.5       1     1.5       2     2.5
 1156           SE       0     0.5       1     1.5       2     2.5
 1157           SQ       0    0.25     0.5       1       2      10
 1158           KO                                      22
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 LINE          ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10


 1159          KK    CV31
 1160          RD 1146.65 0.01000   0.040            TRAP    4.00    2.00
 1161          KO                                      22

 1162          KK    SB51
 1163          BA  0.0473
 1164          LS     0.1  98.000                83.844     0.1
 1165          UK      25     .02      .1    0.10
 1166          UK     100     .02      .4   99.90
 1167          RD    1000     .02     .04            TRAP       2       2
 1168          KO                                      22

 1169          KK    HC16
 1170          HC       3
 1171          KO                                      22

 1172          KK    CV33
 1173          RD 350.969 0.01000   0.040            TRAP    4.00    2.00
 1174          KO                                      22

 1175          KK   CV110
 1176          RD 1657.08 0.01000   0.040            TRAP    4.00    2.00
 1177          KO                                      22

 1178          KK   SB114
 1179          BA  0.0493
 1180          LS     0.1  98.000                77.000     0.1
 1181          UK      25     .02      .1   25.00
 1182          UK      60     .02      .4   75.00
 1183          RD    1000     .02    .015            CIRC      18
 1184          KO                                      22

 1185          KK   CV115
 1186          RD 567.047 0.01000   0.014            CIRC    2.00    0.00
 1187          KO                                      22

 1188          KK    DB14
 1189          RS            FLOW
 1190          SV       0     .17     .33      .5     .66     .83       1    1.17     1.5       2
 1191          SE       0     .33     .66       1    1.33    1.66       2    2.33    2.66       3
 1192          SQ       0     2.3     4.6     6.9     9.2    11.5      15      20      28      60
 1193          KO                                      22

 1194          KK   CV116
 1195          RD 485.929 0.00500   0.014            CIRC    1.50    0.00
 1196          KO                                      22

 1197          KK   SB100
 1198          BA  0.0360
 1199          LS     0.1  98.000                77.000     0.1
 1200          UK      25    0.02      .1   25.00
 1201          UK      60     .02      .4   75.00
 1202          RD    1100     .02     .02            TRAP       2      25
 1203          KO                                      22
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LINE         ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

1204         KK  USB100DETENTION BASIN FROM REGULATED AREAS
1205         KM   ELEVATION CURVE IS VOLUME IN AC-FT OF THEORETICAL DETENTION BASIN
1206         RS           FLOW       0
1207         SV  0.0000  0.0324  0.0655  0.0979  0.1404  0.1836  0.2261  0.2621  0.2945   0.327
1208         SE  0.0000  0.0324  0.0655  0.0979  0.1404  0.1836  0.2261  0.2621  0.2945   0.327
1209         SQ  0.0000  1.8896  2.6501  3.2493  3.7563  4.2172   4.609  4.8394  5.0699  13.827
1210         KO                                      22

1211         KK    HC83
1212         HC       3
1213         KO                                      22

1214         KK   CV118
1215         RD 1032.63 0.01000   0.040            TRAP    4.00    2.00
1216         KO                                      22

1217         KK    HC61
1218         HC       2
1219         KO                                      22

1220         KK   CV111
1221         RD 209.613 0.01000   0.040            TRAP    4.00    2.00
1222         KO                                      22

1223         KK   SB101
1224         BA  0.0234
1225         LS     0.1  98.000                  86.000     0.1
1226         UK      50     .02     .14   60.00
1227         UK      30     .02      .4   40.00
1228         RD    1100    .005    .015            CIRC     1.5
1229         KO                                      22

1230         KK  USB101DETENTION BASIN FROM REGULATED AREAS
1231         KM   ELEVATION CURVE IS VOLUME IN AC-FT OF THEORETICAL DETENTION BASIN
1232         RS           FLOW       0
1233         SV  0.0000  0.0506  0.1023  0.1529  0.2192  0.2867  0.3530  0.4092  0.4598   0.511
1234         SE  0.0000  0.0506  0.1023  0.1529  0.2192  0.2867  0.3530  0.4092  0.4598   0.511
1235         SQ  0.0000  1.2291  1.7238  2.1135  2.4433  2.7431   2.998  3.1479  3.2978   8.994
1236         KO                                      22

1237         KK    SB86
1238         BA  0.0186
1239         LS     0.1  98.000                  77.000     0.1
1240         UK      25     .02      .1   25.00
1241         UK      60     .02      .4   75.00
1242         RD    1300     .02    .015            CIRC       2
1243         KO                                      22

1244         KK   USB86DETENTION BASIN FROM REGULATED AREAS
1245         KM   ELEVATION CURVE IS VOLUME IN AC-FT OF THEORETICAL DETENTION BASIN
1246         RS           FLOW       0
1247         SV  0.0000  0.0168  0.0339  0.0507  0.0727  0.0951  0.1170  0.1357  0.1525   0.169
1248         SE  0.0000  0.0168  0.0339  0.0507  0.0727  0.0951  0.1170  0.1357  0.1525   0.169
1249         SQ  0.0000  0.9781  1.3717  1.6818  1.9442  2.1828  2.3856  2.5048  2.6241   7.156
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LINE          ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

1250          KO                                       22

1251          KK    HC59
1252          HC       3
1253          KO                                       22

1254          KK   CV112
1255          RD 337.416 0.01000   0.015            TRAP    4.00    2.00
1256          KO                                       22

1257          KK    SB79
1258          BA  0.0156
1259          LS     0.1  98.000                  77.000     0.1
1260          UK      25     .02      .1   25.00
1261          UK      60     .02      .4   75.00
1262          RD     800    .015    .015            CIRC     1.5
1263          KO                                       22

1264          KK   USB79DETENTION BASIN FROM REGULATED AREAS
1265          KM   ELEVATION CURVE IS VOLUME IN AC-FT OF THEORETICAL DETENTION BASIN
1266          RS            FLOW       0
1267          SV  0.0000  0.0140  0.0283  0.0423  0.0607  0.0793  0.0977  0.1132  0.1272   0.141
1268          SE  0.0000  0.0140  0.0283  0.0423  0.0607  0.0793  0.0977  0.1132  0.1272   0.141
1269          SQ  0.0000  0.8163  1.1448  1.4036  1.6226  1.8217   1.991  2.0905  2.1901   5.973
1270          KO                                       22

1271          KK    CV82
1272          RD 268.907 0.01000   0.015            CIRC    1.50    0.00
1273          KO                                       22

1274          KK    SB83
1275          BA  0.0453
1276          LS     0.1  98.000                  77.000     0.1
1277          UK      25     .02      .1   25.00
1278          UK      60     .02      .4   75.00
1279          RD     800    .015    .015            CIRC     1.5
1280          KO                                       22

1281          KK   USB83DETENTION BASIN FROM REGULATED AREAS
1282          KM   ELEVATION CURVE IS VOLUME IN AC-FT OF THEORETICAL DETENTION BASIN
1283          RS            FLOW       0
1284          SV  0.0000  0.0407  0.0824  0.1231  0.1765  0.2308  0.2842  0.3294  0.3702   0.411
1285          SE  0.0000  0.0407  0.0824  0.1231  0.1765  0.2308  0.2842  0.3294  0.3702   0.411
1286          SQ  0.0000  2.3748  3.3305  4.0835  4.7206  5.2998  5.7922  6.0818  6.3714   17.37
1287          KO                                       22

1288          KK    CV83
1289          RD 270.979 0.01000   0.015            CIRC    2.00    0.00
1290          KO                                       22
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 LINE          ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10


 1291          KK   SB108
 1292          BA  0.0397
 1293          LS     0.1  98.000                  77.000     0.1
 1294          UK      25     .02      .1   25.00
 1295          UK      60     .02      .4   75.00
 1296          RD     500     .02    .015            CIRC     1.5
 1297          KO                                    22

 1298          KK  USB108DETENTION BASIN FROM REGULATED AREAS
 1299          KM   ELEVATION CURVE IS VOLUME IN AC-FT OF THEORETICAL DETENTION BASIN
 1300          RS            FLOW       0
 1301          SV  0.0000  0.0357  0.0722  0.1079  0.1547  0.2023  0.2491  0.2888  0.3245   0.361
 1302          SE  0.0000  0.0357  0.0722  0.1079  0.1547  0.2023  0.2491  0.2888  0.3245   0.361
 1303          SQ  0.0000  2.0816  2.9193  3.5794  4.1379  4.6456  5.0772  5.3310  5.5849   15.23
 1304          KO                                    22

 1305          KK    CV62
 1306          RD 225.850 0.00500   0.015            CIRC    1.50    0.00
 1307          KO                                    22

 1308          KK    SB85
 1309          BA  0.0157
 1310          LS     0.1  98.000                  77.000     0.1
 1311          UK      25     .02      .1   25.00
 1312          UK      60     .02      .4   75.00
 1313          RD     100     .01    .015            CIRC       2
 1314          KO                                    22

 1315          KK   USB85DETENTION BASIN FROM REGULATED AREAS
 1316          KM   ELEVATION CURVE IS VOLUME IN AC-FT OF THEORETICAL DETENTION BASIN
 1317          RS            FLOW       0
 1318          SV  0.0000  0.0142  0.0287  0.0428  0.0614  0.0803  0.0989  0.1146  0.1288   0.143
 1319          SE  0.0000  0.0142  0.0287  0.0428  0.0614  0.0803  0.0989  0.1146  0.1288   0.143
 1320          SQ  0.0000  0.8261  1.1586  1.4205  1.6422  1.8437   2.015  2.1157  2.2165   6.045
 1321          KO                                    22

 1322          KK    SB87
 1323          BA  0.0283
 1324          LS     0.1  98.000                  77.000     0.1
 1325          UK      25     .02      .1   25.00
 1326          UK      60     .02      .4   75.00
 1327          RD     400     .02    .015            CIRC     1.5
 1328          KO                                    22

 1329          KK   USB87DETENTION BASIN FROM REGULATED AREAS
 1330          KM   ELEVATION CURVE IS VOLUME IN AC-FT OF THEORETICAL DETENTION BASIN
 1331          RS            FLOW       0
 1332          SV  0.0000  0.0254  0.0514  0.0769  0.1102  0.1441  0.1775  0.2057  0.2312   0.257
 1333          SE  0.0000  0.0254  0.0514  0.0769  0.1102  0.1441  0.1775  0.2057  0.2312   0.257
 1334          SQ  0.0000  1.4831    2.08  2.5502  2.9481  3.3099  3.6174  3.7982  3.9791  10.852
 1335          KO                                    22
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 LINE           ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10


 1336           KK    HC44
 1337           HC       3
 1338           KO                                        22

 1339           KK    CV60
 1340           RD 1005.68 0.01690   0.014            CIRC    1.50    0.00
 1341           KO                                        22

 1342           KK    SB96
 1343           BA  0.1079
 1344           LS     0.1  98.000                  77.000     0.1
 1345           UK      25     .02      .1   25.00
 1346           UK      60     .02      .4   75.00
 1347           RD    1100    .015    .015     .02    TRAP     1.5
 1348           RD     700     .02    .015            CIRC       2
 1349           KO                                        22

 1350           KK    CV72
 1351           RD 828.408 0.01500   0.015            CIRC    2.50    2.00
 1352           KO                                        22

 1353           KK    CV76
 1354           RD 729.378 0.00600   0.015            CIRC    3.00    0.00
 1355           KO                                        22

 1356           KK    SB97
 1357           BA  0.0365
 1358           LS     0.1  98.000                  77.000     0.1
 1359           UK      25     .02      .1   25.00
 1360           UK      60     .02      .4   75.00
 1361           RD     400     .01    .015            CIRC     1.5
 1362           KO                                        22

 1363           KK   USB97DETENTION BASIN FROM REGULATED AREAS
 1364           KM   ELEVATION CURVE IS VOLUME IN AC-FT OF THEORETICAL DETENTION BASIN
 1365           RS            FLOW       0
 1366           SV  0.0000  0.0329  0.0665  0.0994  0.1425  0.1863  0.2294  0.2659  0.2988   0.332
 1367           SE  0.0000  0.0329  0.0665  0.0994  0.1425  0.1863  0.2294  0.2659  0.2988   0.332
 1368           SQ  0.0000   1.917  2.6884  3.2963  3.8106  4.2781  4.6756  4.9093  5.1431  14.026
 1369           KO                                        22

 1370           KK    SB95
 1371           BA  0.0492
 1372           LS     0.1  98.000                  86.000     0.1
 1373           UK      50     .02     .14   60.00
 1374           UK      30     .02      .4   40.00
 1375           RD    1500     .01    .015            CIRC     1.5
 1376           KO                                        22
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LINE          ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10


1377          KK   USB95DETENTION BASIN FROM REGULATED AREAS
1378          KM   ELEVATION CURVE IS VOLUME IN AC-FT OF THEORETICAL DETENTION BASIN
1379          RS            FLOW       0
1380          SV  0.0000  0.1063  0.2149  0.3211  0.4604  0.6021  0.7414  0.8595  0.9657   1.074
1381          SE  0.0000  0.1063  0.2149  0.3211  0.4604  0.6021  0.7414  0.8595  0.9657   1.074
1382          SQ  0.0000  2.5815  3.6204  4.4389  5.1315  5.7612  6.2964  6.6112  6.9260   18.88
1383          KO                                      22

1384          KK    HC54
1385          HC       3
1386          KO                                      22

1387          KK    CV73
1388          RD 1308.82 0.02000   0.015            CIRC    2.50    0.00
1389          KO                                      22

1390          KK    CV75
1391          RD 648.054 0.00800   0.015            CIRC    3.00    0.00
1392          KO                                      22
1393          ZZ
```

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                    SCHEMATIC DIAGRAM OF STREAM NETWORK
INPUT
 LINE      (V) ROUTING          (--->) DIVERSION OR PUMP FLOW

  NO.      (.) CONNECTOR        (<---) RETURN OF DIVERTED OR PUMPED FLOW

    6        SB69
                V
                V
   19        CV34
                V
                V
   22        CV35
                .
                .
   25           .        SB59
                .            .
                .            .
   32        HC24............
                V
                V
   35        CV36
                .
                .
   38           .        SB56
                .            .
                .            .
   46        HC25............
                V
                V
   49        CV10
                V
                V
   52        CV11
                .
                .
   55           .        SB66
                .            V
                .            V
   63           .        CV37
                .            .
                .            .
   66           .            .        SB77
                .            .            .
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              .           .           .
 73           .        HC26............
              .           V
              .           V
 76           .         CV9
              .           .
              .           .
 79           .           .        SB55
              .           .           .
              .           .           .
 87           .         HC7............
              .           V
              .           V
 90           .        CV12
              .           .
              .           .
 93           .           .        SB57
              .           .           .
              .           .           .
100        HC8........................
              V
              V
103        CV13
              V
              V
106         DB2
              V
              V
112        CV16
              .
              .
115           .        SB60
              .           V
              .           V
123           .         DB3
              .           V
              .           V
129           .        CV14
              .           .
              .           .
132           .           .        SB58
              .           .           .
              .           .           .
140           .        HC10............
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            .         V
            .         V
143         .      CV15
            .         .
            .         .
146      HC9...........
            V
            V
149      CV19
            .
            .
152         .      SB63
            .         .
            .         .
157         .         .      SB28
            .         .         .
            .         .         .
162         .         .         .      SB27
            .         .         .         .
            .         .         .         .
167         .         .         .         .      SB26
            .         .         .         .         .
            .         .         .         .         .
172         .         .         .         .         .      SB25
            .         .         .         .         .         .
            .         .         .         .         .         .
177         .      HC38........................................
            .         V
            .         V
180         .      CV42
            .         V
            .         V
183         .      CV41
            .         V
            .         V
186         .      CV38
            .         V
            .         V
189         .      CV39
            .         .
            .         .
192         .         .      SB36
            .         .         .
            .         .         .
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200           .        HC18............
              .           V
              .           V
203           .        CV40
              .           V
              .           V
206           .         DB5
              .           .
              .           .
212           .           .        SB34
              .           .           .
              .           .           .
219           .           .           .        SB33
              .           .           .           .
              .           .           .           .
227           .           .        HC13............
              .           .           V
              .           .           V
230           .           .        CV21
              .           .           .
              .           .           .
233           .           .           .        SB35
              .           .           .           .
              .           .           .           .
241           .           .        HC14............
              .           .           V
              .           .           V
244           .           .        CV22
              .           .           V
              .           .           V
247           .           .         DB4
              .           .           V
              .           .           V
253           .           .        CV23
              .           .           .
              .           .           .
256           .        HC27............
              .           V
              .           V
259           .        CV18
              .           V
              .           V
262           .       CV100
              .           .
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              .           .
265           .           .       SB113
              .           .           V
              .           .           V
272           .           .       CV104
              .           .           .
              .           .           .
275           .           .           .        SB30
              .           .           .           .
              .           .           .           .
283           .           .           .           .       SB111
              .           .           .           .           .
              .           .           .           .           .
291           .           .           .        HC80............
              .           .           .           V
              .           .           .           V
294           .           .           .       CV102
              .           .           .           .
              .           .           .           .
297           .           .           .           .       SB112
              .           .           .           .           .
              .           .           .           .           .
305           .           .           .        HC73............
              .           .           .           V
              .           .           .           V
308           .           .           .       CV103
              .           .           .           .
              .           .           .           .
311           .           .        HC79............
              .           .           V
              .           .           V
314           .           .        DB16
              .           .           .
              .           .           .
320        HC12........................
              V
              V
323       CV101
              .
              .
326           .       SB110
              .           V
              .           V
333           .      USB110
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              .           V
              .           V
340           .       CV105
              .           .
              .           .
343           .           .       SB118
              .           .           V
              .           .           V
350           .           .      USB118
              .           .           .
              .           .           .
357        HC71........................
              V
              V
360        CV20
              .
              .
363           .        SB72
              .           V
              .           V
371           .       USB72
              .           .
              .           .
378        HC28............
              V
              V
381        CV95
              .
              .
384           .        SB75
              .           V
              .           V
392           .        CV88
              .           V
              .           V
395           .        CV89
              .           .
              .           .
398           .           .        SB45
              .           .           V
              .           .           V
405           .           .         DB6
              .           .           .
              .           .           .
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411           .           .           .        SB29
              .           .           .           .
              .           .           .           .
419           .           .        HC78............
              .           .           V
              .           .           V
422           .           .        CV91
              .           .           .
              .           .           .
425           .           .           .        SB73
              .           .           .           .
              .           .           .           .
433           .        HC63........................
              .           V
              .           V
436           .        CV90
              .           .
              .           .
439           .           .       SB103
              .           .           .
              .           .           .
447           .        HC64............
              .           V
              .           V
450           .        DB13
              .           V
              .           V
456           .        CV50
              .           .
              .           .
459           .           .        SB99
              .           .           V
              .           .           V
466           .           .       USB99
              .           .           .
              .           .           .
473        HC67........................
              V
              V
476        CV52
              .
              .
479           .        SB93
              .           V
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              .           V
486           .       USB93
              .           V
              .           V
493           .        CV93
              .           .
              .           .
496           .           .        SB94
              .           .           V
              .           .           V
503           .           .       USB94
              .           .           .
              .           .           .
510           .        HC65............
              .           V
              .           V
513           .        CV94
              .           .
              .           .
516        HC51............
              V
              V
519        CV71
              .
              .
522           .        SB98
              .           V
              .           V
529           .       USB98
              .           .
              .           .
536           .           .        SB49
              .           .           V
              .           .           V
544           .           .       USB49
              .           .           V
              .           .           V
551           .           .        CV24
              .           .           .
              .           .           .
554           .           .           .        SB48
              .           .           .           V
              .           .           .           V
562           .           .           .       USB48
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               .           .           .           .
               .           .           .           .
569            .           .        HC55............
               .           .           V
               .           .           V
572            .           .        CV64
               .           .           .
               .           .           .
575            .           .           .       SB117
               .           .           .           V
               .           .           .           V
583            .           .           .      USB117
               .           .           .           .
               .           .           .           .
590            .           .           .           .        SB88
               .           .           .           .           V
               .           .           .           .           V
597            .           .           .           .       USB88
               .           .           .           .           .
               .           .           .           .           .
604            .           .           .        HC23............
               .           .           .           V
               .           .           .           V
607            .           .           .       CV114
               .           .           .           .
               .           .           .           .
610            .           .           .           .        SB91
               .           .           .           .           V
               .           .           .           .           V
617            .           .           .           .       USB91
               .           .           .           .           .
               .           .           .           .           .
624            .           .           .           .           .        SB89
               .           .           .           .           .           V
               .           .           .           .           .           V
631            .           .           .           .           .       USB89
               .           .           .           .           .           .
               .           .           .           .           .           .
638            .           .        HC45....................................
               .           .           V
               .           .           V
641            .           .        CV65
               .           .           .
               .           .           .
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644           .           .           .       SB107
              .           .           .           V
              .           .           .           V
651           .           .           .      USB107
              .           .           .           V
              .           .           .           V
658           .           .           .        CV97
              .           .           .           V
              .           .           .           V
661           .           .           .        CV98
              .           .           .           .
              .           .           .           .
664           .           .        HC68............
              .           .           V
              .           .           V
667           .           .        CV99
              .           .           .
              .           .           .
670           .           .           .        SB90
              .           .           .           V
              .           .           .           V
677           .           .           .       USB90
              .           .           .           V
              .           .           .           V
684           .           .           .        CV66
              .           .           .           .
              .           .           .           .
687           .           .        HC46............
              .           .           V
              .           .           V
690           .           .        CV67
              .           .           .
              .           .           .
693           .           .           .        SB92
              .           .           .           V
              .           .           .           V
700           .           .           .       USB92
              .           .           .           .
              .           .           .           .
707           .           .           .           .       SB104
              .           .           .           .           V
              .           .           .           .           V
714           .           .           .           .      USB104
              .           .           .           .           .
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               .           .           .           .           .
721            .           .        HC47........................
               .           .           V
               .           .           V
724            .           .        CV68
               .           .           .
               .           .           .
727            .           .           .       SB105
               .           .           .           V
               .           .           .           V
734            .           .           .      USB105
               .           .           .           .
               .           .           .           .
741            .           .        HC48............
               .           .           V
               .           .           V
744            .           .        CV69
               .           .           .
               .           .           .
747            .           .           .       SB106
               .           .           .           V
               .           .           .           V
754            .           .           .      USB106
               .           .           .           .
               .           .           .           .
761            .           .        HC49............
               .           .           V
               .           .           V
764            .           .        CV70
               .           .           .
               .           .           .
767            .        HC50............
               .           V
               .           V
770            .        CV78
               .           .
               .           .
773            .           .        SB40
               .           .           V
               .           .           V
781            .           .         DB7
               .           .           V
               .           .           V
787            .           .        CV25
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              .           .           .
              .           .           .
790           .           .           .        SB39
              .           .           .           .
              .           .           .           .
798           .           .           .           .        SB41
              .           .           .           .           .
              .           .           .           .           .
805           .           .        HC31........................
              .           .           V
              .           .           V
808           .           .        CV26
              .           .           .
              .           .           .
811           .           .           .        SB37
              .           .           .           V
              .           .           .           V
819           .           .           .        CV53
              .           .           .           .
              .           .           .           .
822           .           .           .           .        SB38
              .           .           .           .           .
              .           .           .           .           .
830           .           .           .        HC35............
              .           .           .           V
              .           .           .           V
833           .           .           .        CV27
              .           .           .           .
              .           .           .           .
836           .           .           .           .        SB43
              .           .           .           .           .
              .           .           .           .           .
843           .           .        HC32........................
              .           .           V
              .           .           V
846           .           .        CV28
              .           .           .
              .           .           .
849           .           .           .        SB44
              .           .           .           .
              .           .           .           .
857           .           .        HC36............
              .           .           V
              .           .           V
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860         .           .        CV29
            .           .           .
            .           .           .
863         .           .           .        SB46
            .           .           .           .
            .           .           .           .
870         .           .        HC33............
            .           .           V
            .           .           V
873         .           .        CV30
            .           .           .
            .           .           .
876         .           .           .        SB42
            .           .           .           .
            .           .           .           .
883         .           .        HC34............
            .           .           V
            .           .           V
886         .           .         DB8
            .           .           V
            .           .           V
892         .           .       CV119
            .           .           .
            .           .           .
895         .           .           .        SB76
            .           .           .           .
            .           .           .           .
903         .           .           .           .        SB47
            .           .           .           .           V
            .           .           .           .           V
911         .           .           .           .       USB47
            .           .           .           .           .
            .           .           .           .           .
918         .           .        HC37.......................
            .           .           V
            .           .           V
921         .           .        CV55
            .           .           .
            .           .           .
924         .           .           .        SB84
            .           .           .           V
            .           .           .           V
931         .           .           .       USB84
            .           .           .           .
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               .           .           .           .
 938           .           .        HC20............
               .           .           V
               .           .           V
 941           .           .        CV79
               .           .           V
               .           .           V
 944           .           .        CV61
               .           .           .
               .           .           .
 947           .           .           .        SB82
               .           .           .           V
               .           .           .           V
 954           .           .           .       USB82
               .           .           .           .
               .           .           .           .
 961           .           .        HC82............
               .           .           V
               .           .           V
 964           .           .        CV84
               .           .           .
               .           .           .
 967           .           .           .        SB81
               .           .           .           V
               .           .           .           V
 974           .           .           .        CV59
               .           .           .           .
               .           .           .           .
 977           .           .           .           .        SB78
               .           .           .           .           V
               .           .           .           .           V
 985           .           .           .           .        CV86
               .           .           .           .           .
               .           .           .           .           .
 988           .           .           .           .           .        SB80
               .           .           .           .           .           .
               .           .           .           .           .           .
 995           .           .           .        HC60........................
               .           .           .           V
               .           .           .           V
 998           .           .           .        DB15
               .           .           .           V
               .           .           .           V
1004           .           .           .        CV85
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               .           .           .           .
               .           .           .           .
1007           .           .        HC43............
               .           .           V
               .           .           V
1010           .           .        CV58
               .           .           .
               .           .           .
1013           .           .           .       SB116
               .           .           .           .
               .           .           .           .
1020           .           .        HC41............
               .           .           V
               .           .           V
1023           .           .        CV57
               .           .           .
               .           .           .
1026           .           .           .       SB115
               .           .           .           V
               .           .           .           V
1033           .           .           .      USB115
               .           .           .           V
               .           .           .           V
1040           .           .           .       CV109
               .           .           .           .
               .           .           .           .
1043           .           .        HC81............
               .           .           V
               .           .           V
1046           .           .       CV117
               .           .           .
               .           .           .
1049           .           .           .         SB6
               .           .           .           V
               .           .           .           V
1056           .           .           .         CV5
               .           .           .           V
               .           .           .           V
1059           .           .           .         CV6
               .           .           .           .
               .           .           .           .
1062           .           .           .           .         SB2
               .           .           .           .           .
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1070           .           .           .           .           .         SB1
               .           .           .           .           .           .
               .           .           .           .           .           .
1078           .           .           .         HC1........................
               .           .           .           V
               .           .           .           V
1081           .           .           .         CV1
               .           .           .           .
               .           .           .           .
1084           .           .           .           .         SB3
               .           .           .           .           .
               .           .           .           .           .
1092           .           .           .         HC4............
               .           .           .           V
               .           .           .           V
1095           .           .           .         CV2
               .           .           .           .
               .           .           .           .
1098           .           .           .           .         SB7
               .           .           .           .           .
               .           .           .           .           .
1106           .           .           .           .           .         SB5
               .           .           .           .           .           .
               .           .           .           .           .           .
1114           .           .           .           .         HC5............
               .           .           .           .           V
               .           .           .           .           V
1117           .           .           .           .         CV4
               .           .           .           .           .
               .           .           .           .           .
1120           .           .           .           .           .         SB4
               .           .           .           .           .           .
               .           .           .           .           .           .
1128           .           .           .           .         HC2............
               .           .           .           .           V
               .           .           .           .           V
1131           .           .           .           .         CV3
               .           .           .           .           .
               .           .           .           .           .
1134           .           .           .         HC3............
               .           .           .           V
               .           .           .           V
1137           .           .           .         DB1
               .           .           .           V
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                .           .           .           V
1143            .           .           .         CV7
                .           .           .           .
                .           .           .           .
1146            .           .           .           .        SB50
                .           .           .           .           V
                .           .           .           .           V
1153            .           .           .           .         DB9
                .           .           .           .           V
                .           .           .           .           V
1159            .           .           .           .        CV31
                .           .           .           .           .
                .           .           .           .           .
1162            .           .           .           .           .        SB51
                .           .           .           .           .           .
                .           .           .           .           .           .
1169            .           .           .        HC16........................
                .           .           .           V
                .           .           .           V
1172            .           .           .        CV33
                .           .           .           V
                .           .           .           V
1175            .           .           .       CV110
                .           .           .           .
                .           .           .           .
1178            .           .           .           .       SB114
                .           .           .           .           V
                .           .           .           .           V
1185            .           .           .           .       CV115
                .           .           .           .           V
                .           .           .           .           V
1188            .           .           .           .        DB14
                .           .           .           .           V
                .           .           .           .           V
1194            .           .           .           .       CV116
                .           .           .           .           .
                .           .           .           .           .
1197            .           .           .           .           .       SB100
                .           .           .           .           .           V
                .           .           .           .           .           V
1204            .           .           .           .           .      USB100
                .           .           .           .           .           .
                .           .           .           .           .           .
1211            .           .           .        HC83........................
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               .           .           .           V
               .           .           .           V
1214           .           .           .       CV118
               .           .           .           .
               .           .           .           .
1217           .           .        HC61............
               .           .           V
               .           .           V
1220           .           .       CV111
               .           .           .
               .           .           .
1223           .           .           .       SB101
               .           .           .           V
               .           .           .           V
1230           .           .           .      USB101
               .           .           .           .
               .           .           .           .
1237           .           .           .           .        SB86
               .           .           .           .           V
               .           .           .           .           V
1244           .           .           .           .       USB86
               .           .           .           .           .
               .           .           .           .           .
1251           .           .        HC59........................
               .           .           V
               .           .           V
1254           .           .       CV112
               .           .           .
               .           .           .
1257           .           .           .        SB79
               .           .           .           V
               .           .           .           V
1264           .           .           .       USB79
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1271           .           .           .        CV82
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               .           .           .           .
1274           .           .           .           .        SB83
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               .           .           .           .           V
1281           .           .           .           .       USB83
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1288           .           .           .           .        CV83
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1291           .           .           .           .           .       SB108
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               .           .           .           .           .           V
1298           .           .           .           .           .      USB108
               .           .           .           .           .           V
               .           .           .           .           .           V
1305           .           .           .           .           .        CV62
               .           .           .           .           .           .
               .           .           .           .           .           .
1308           .           .           .           .           .           .        SB85
               .           .           .           .           .           .           V
               .           .           .           .           .           .           V
1315           .           .           .           .           .           .       USB85
               .           .           .           .           .           .           .
               .           .           .           .           .           .           .
1322           .           .           .           .           .           .           .        SB87
               .           .           .           .           .           .           .           V
               .           .           .           .           .           .           .           V
1329           .           .           .           .           .           .           .       USB87
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               .           .           .           .           .           .           .           .
1336           .           .           .           .           .        HC44........................
               .           .           .           .           .           V
               .           .           .           .           .           V
1339           .           .           .           .           .        CV60
               .           .           .           .           .           .
               .           .           .           .           .           .
1342           .           .           .           .           .           .        SB96
               .           .           .           .           .           .           V
               .           .           .           .           .           .           V
1350           .           .           .           .           .           .        CV72
               .           .           .           .           .           .           V
               .           .           .           .           .           .           V
1353           .           .           .           .           .           .        CV76
               .           .           .           .           .           .           .
               .           .           .           .           .           .           .
1356           .           .           .           .           .           .           .        SB97
               .           .           .           .           .           .           .           V
               .           .           .           .           .           .           .           V
1363           .           .           .           .           .           .           .       USB97
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                    .         .         .         .         .         .         .         .
1370                .         .         .         .         .         .         .         .       SB95
                    .         .         .         .         .         .         .         .          V
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1377                .         .         .         .         .         .         .         .      USB95
                    .         .         .         .         .         .         .         .          .
                    .         .         .         .         .         .         .         .          .
1384                .         .         .         .         .         .      HC54.......................
                    .         .         .         .         .         .         V
                    .         .         .         .         .         .         V
1387                .         .         .         .         .         .      CV73
                    .         .         .         .         .         .         V
                    .         .         .         .         .         .         V
1390                .         .         .         .         .         .      CV75
```

(***) RUNOFF ALSO COMPUTED AT THIS LOCATION

*** NORMAL END OF HEC-1 ***

APPENDIX B

MODEL DESCRIPTION

RIVERTON CITY

HAL HYDROLOGIC MODEL FOR ARCVIEW

USER'S MANUAL

Prepared by:

HANSEN, ALLEN & LUCE, INC.
Consulting Engineers
Salt Lake Area Office
6771 South 900 East
Midvale, Utah 84047
(801) 566-5599

December, 2001

TABLE OF CONTENTS

INTRODUCTION

This document serves as a how-to manual for the HAL Hydrologic Model interface with ArcView. The HAL Hydrologic Model Interface is a customization of the ArcView environment. All of the features of ArcView GIS are available when using the model because it runs inside of ArcView GIS. This manual only explains features that are unique to the HAL Hydrologic Model Interface. All other issues would be for standard features in the ArcView GIS environment. Help issues not related to the HAL Hydrologic Model Interface can be found in the ArcView GIS on-line help or user's manual.

This manual is organized as following manner.

The Table of Contents contains all of the help topics discussed in the manual. It is anticipated that the user will look in the table of contents to find the topic of interest.

Project Setup is discussed first, which covers the topic of how to setup and organize your project and scenarios contained within your project.

Overview of the Scenario View describes the environment where all of the features of the HAL Wastewater Collection Model customized ArcView extension are performed from except the project setup and organization features.

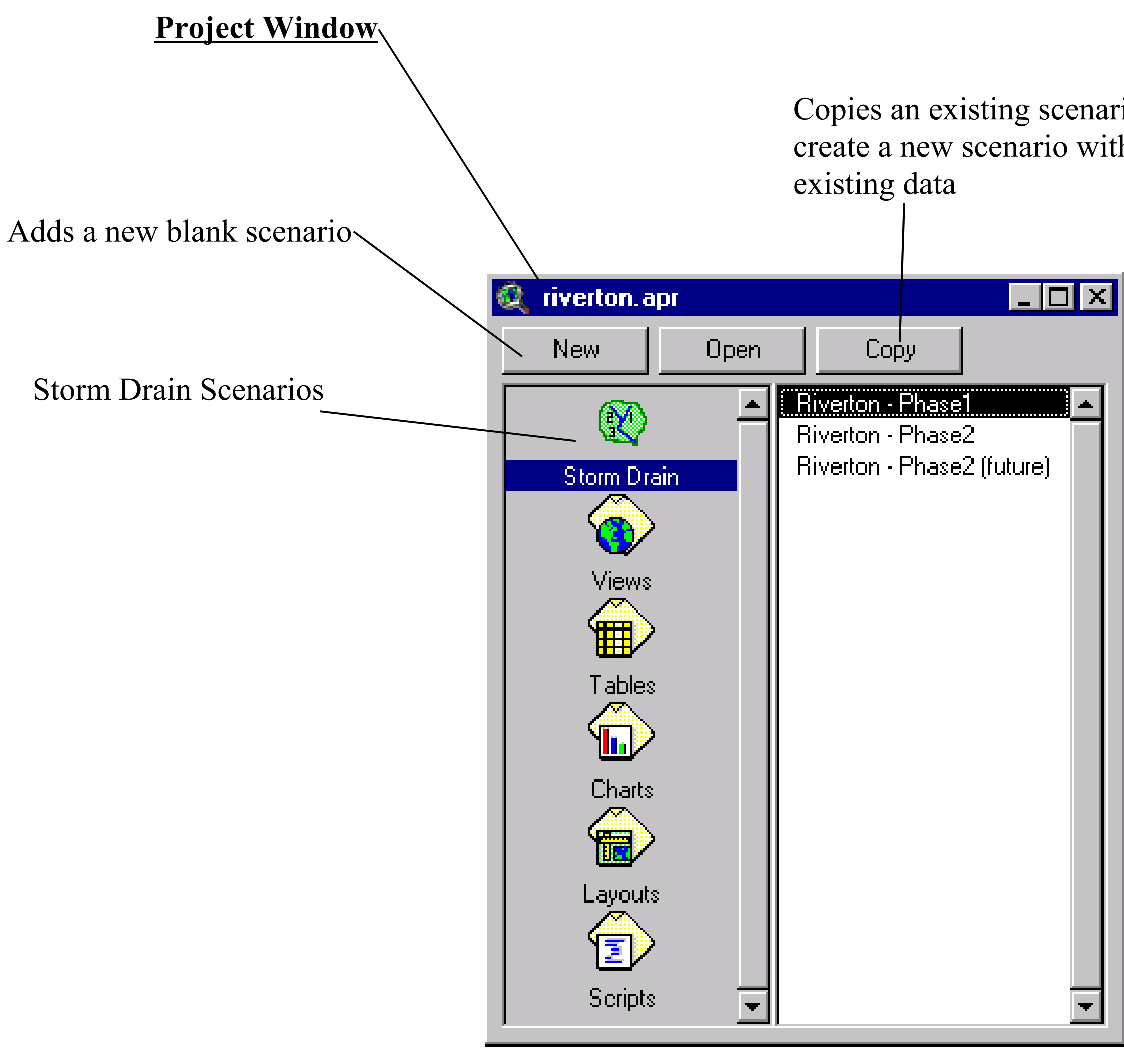
The Setup the Scenario section describes the features used to set up and define the scenario.

The function of each wastewater collection system feature is then described in the following order: Subbasins, Conveyances, Confluences, and Diversions.

The section, Layouts, describes how to print maps and data from the model using the Layout feature in ArcView. This section is quoted from the on-line user manual in ArcView because the Layout feature is part of ArcView and not the model.

PROJECT SETUP

In ArcView, you work within a project. A project is a collection of documents (tables, charts, layouts, etc), document user interfaces, and scripts. Only one project is open at a time. Every ArcView project has a Project Window that you use to manage the views, tables, charts, layouts, scripts, and other components in the project. The project window in ArcView is like the table of contents to your project. A project with the HAL Hydrologic Model Interface extension loaded has a Storm Drain Scenario document user interface icon added to the Project Window. When the Wastewater Collection Scenario icon is selected, the scenarios in the project are listed. The Project Window is where the scenarios are managed. The tasks in this section are performed from the Project Window.



How to create a new scenario:

1. In the Project Window, select the Wastewater Collection icon.

2. Select New

3. To change the name of the new scenario select Project – Rename from the Menu Bar or select the Control and R keys.

How to open a scenario:

1. In the Project Window, select the Wastewater Collection icon.

2. Select the scenario you want to open.

3. Select Open or double click on the scenario name you want to open.

How to create a new scenario from an existing scenario:

- In the Project Window, select the Wastewater Collection icon.

- Select the existing scenario that you want to create a new scenario from.

- Select Copy .

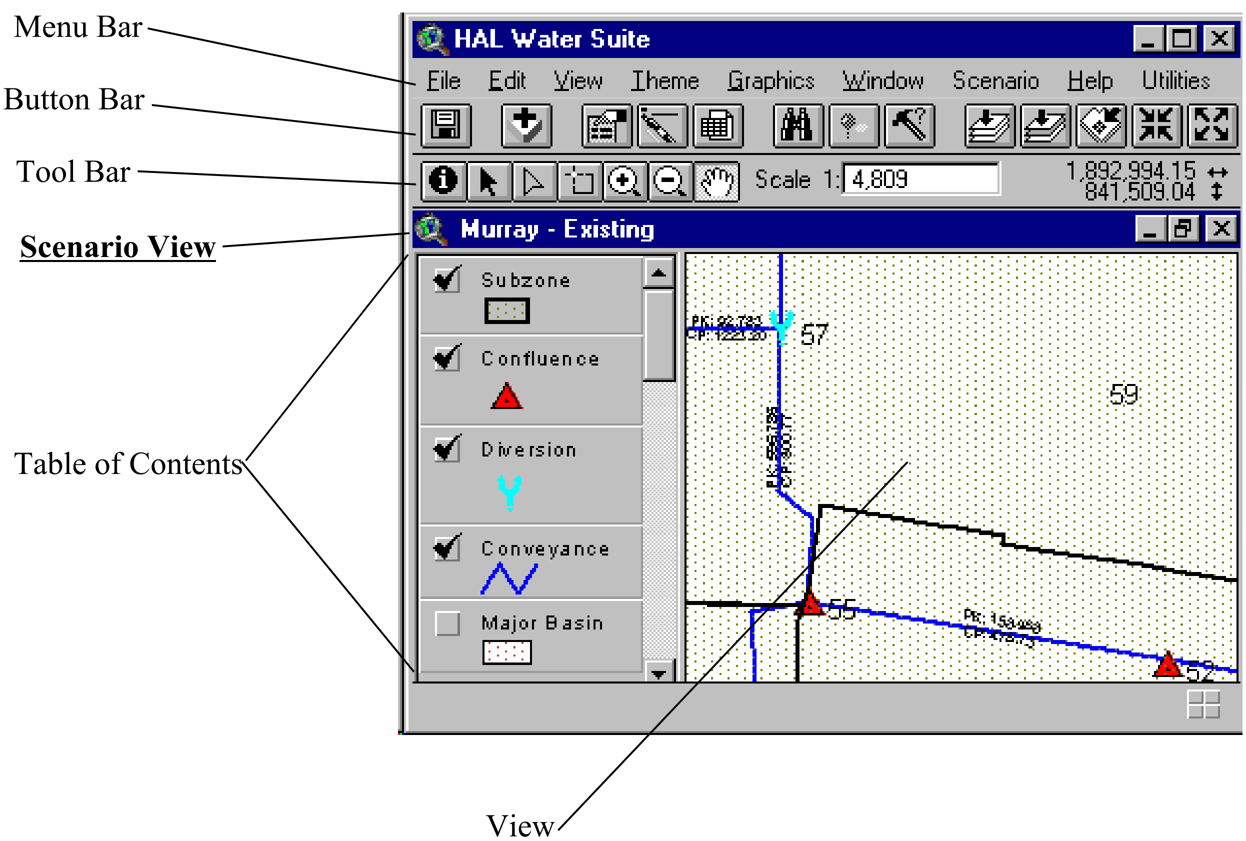
- To change the name of the new scenario select Project – Rename from the Menu Bar.

OVERVIEW OF THE SCENARIO VIEW

A view is an interactive map that lets you display, explore, query, and analyze geographic data in ArcView. The remaining tasks in the manual are performed from the Scenario View. The Scenario View contains the following features:

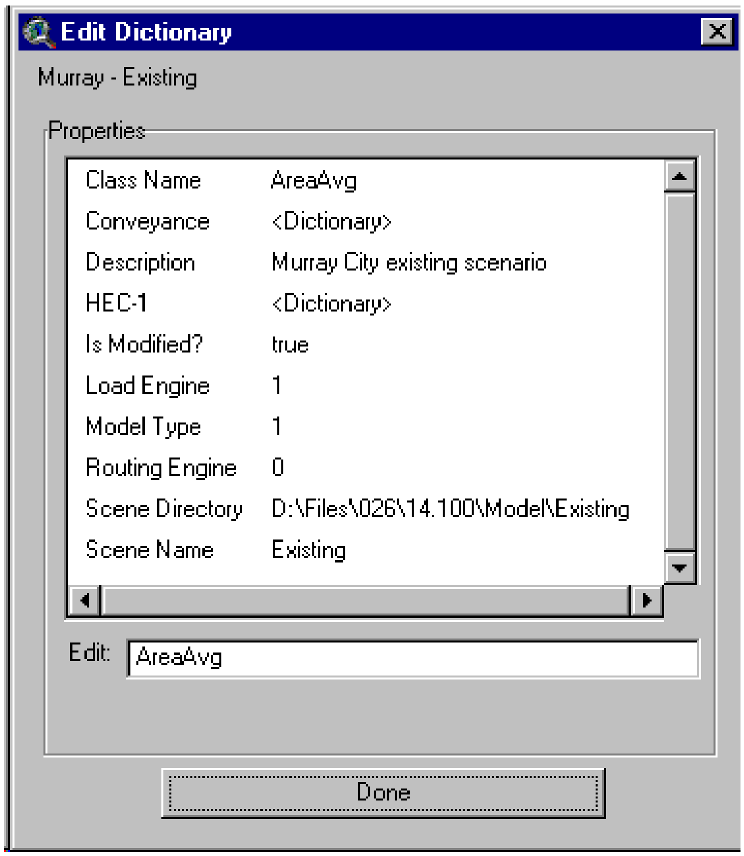
- The **Menu Bar** is a list of pull-down menus.
- The **Button Bar** is a list of button task controls.
- The **Tool Bar** is a list of tools that are used to interact with the View.
- The current **Scenario View** open is labeled at the top of the View window.
- The **Table of Contents** lists all of the geographical features in the View.
- The **View** is where the geographical features of the model scenario are viewed.

The following is a map of a Scenario View indicating these features.



SETUP THE SCENARIO

To setup the Scenario, select Scenario – Setup from the Menu Bar. The Edit Dictionary window will open. The edit dictionary contains the properties that define the current scenario. To edit a property, click on the property and edit the parameters of the property. When done editing, select the Done button.



SUBBASINS

A Subbasin is an area defining wastewater loading.   The attributes of a Subbasin are: Subbasin identification number, loading flow, and infiltration flow

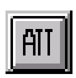
How to create a new Subbasin:

1. Select the Subbasin theme in the Table of Contents.
2. Start editing the Subbasin theme by selecting Theme - Start Editing from the Menu Bar.
3. Draw the new Subbasin using the Draw Line tool from the Tool Bar.
4. Select Theme - Stop Editing from the Menu Bar when done creating Subbasins. Save edits if desired.

How to modify the shape of an existing Subbasin:

1. Select the Subbasin theme in the Table of Contents.
2. Start editing the Subbasin theme by selecting Theme - Start Editing from the Menu Bar.
3. Select the Vertex Edit tool from the Tool Bar to edit the shape of the existing Subbasin.
4. Select Theme - Stop Editing from the Menu Bar when done modifying Subbasins. Save edits if desired.

How to modify the attributes of an existing Subbasin:

1. Select the Subbasin theme in the Table of Contents.
2. Select the Edit Attributes tool 

from the Tool Bar and select the Subbasin to be edited to open the Properties window.
3. Make edits to the Subbasin attributes in Properties window and select OK.

CONVEYANCES

A Conveyance is a pipe that conveys wastewater from one point to another. The attributes of a Conveyance are: Conveyance identification number, length, slope, roughness coefficient, depth to diameter ratio, shape, diameter, capacity.

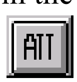
How to create a new Conveyance:

1. Select the Conveyance theme in the Table of Contents.
2. Start editing the Conveyance theme by selecting Theme - Start Editing from the Menu Bar.
3. Draw the new Conveyance with the Draw Line Tool from the Tool Bar.
4. Select Theme - Stop Editing when done creating Conveyances. Save edits if desired.

How to modify the shape of an existing Confluence:

1. Select the Confluence theme in the Table of Contents.
2. Start editing the Confluence theme by selecting Theme - Start Editing from the Menu Bar.
3. Select the Vertex Edit tool from the Tool Bar to select and edit the existing Conveyance.
4. Select Theme - Stop Editing from the Menu Bar when done modifying Conveyances . Save edits if desired.

How to modify the attributes of an existing Confluence:

1. Select the Conveyance theme in the Table of Contents.
2. Select the Edit Attributes tool 

from the Tool Bar from the Tool Bar and select the Conveyance to be edited to open the Properties window.
3. Make edits to the Conveyance attributes in the Properties window and select OK.

CONFLUENCES

A confluence is a point where the wastewater flow form more than one Subbasin or Conveyance combines into one Conveyance. The attributes of a Confluence are the Confluence identification number and the number of flows from Subbasins and Conveyances are combined.

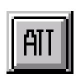
How to create a new Confluence:

1. Select the Confluence theme in the Table of Contents.
2. Start editing the Confluence theme by selecting Theme - Start Editing from the Menu Bar.
3. Create the new Confluence with the Draw Point tool in the Tool Bar.
4. Select Theme - Stop Editing from the Menu Bar when done creating Confluences. Save edits if desired.

How to modify the location of an existing Confluence:

1. Select the Confluence theme in the Table of Contents.
2. Start editing the Confluence theme by selecting Theme - Start Editing from the Menu Bar.
3. Select the Pointer tool from the Tool Bar to select and move the Confluence.
4. Select Theme - Stop Editing from the Menu Bar when done modifying Confluences. Save edits if desired.

How to modify the attributes of an existing Confluence:

1. Select the Subbasin theme in the Table of Contents.
2. Select the Edit Attributes tool  from the Tool Bar and select the Confluence to be edited to open the Properties window.
3. Make edits to the Confluence attributes in the Properties window and select OK.

DIVERSIONS

A Diversion is the splitting of wastewater flow from one Conveyance to more than one Conveyances or Confluences. Attributes of a Diversion are: Diversion identification number, the Conveyance or Confluence identification number of the Conveyance or Confluence the flow is being diverted to, and the percentage of wastewater flow being diverted to each Conveyance or Confluence.

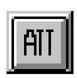
How to create a new Diversion:

1. Select the Diversion theme in the Table of Contents.
2. Start editing the Diversion theme by selecting Theme - Start Editing from the Menu Bar.
3. Create the new Diversion with the Draw Point tool in the Tool Bar.
4. Select Theme - Stop Editing from the Menu Bar when done creating Diversions. Save edits if desired.

How to modify the location of an existing Diversion:

1. Select the Diversion theme in the Table of Contents.
2. Start editing the Diversion theme by selecting Theme - Start Editing from the Menu Bar.
3. Select the Pointer tool from the Tool Bar to select and move the Diversion.
4. Select Theme - Stop Editing from the Menu Bar when done modifying Diversions. Save edits if desired.

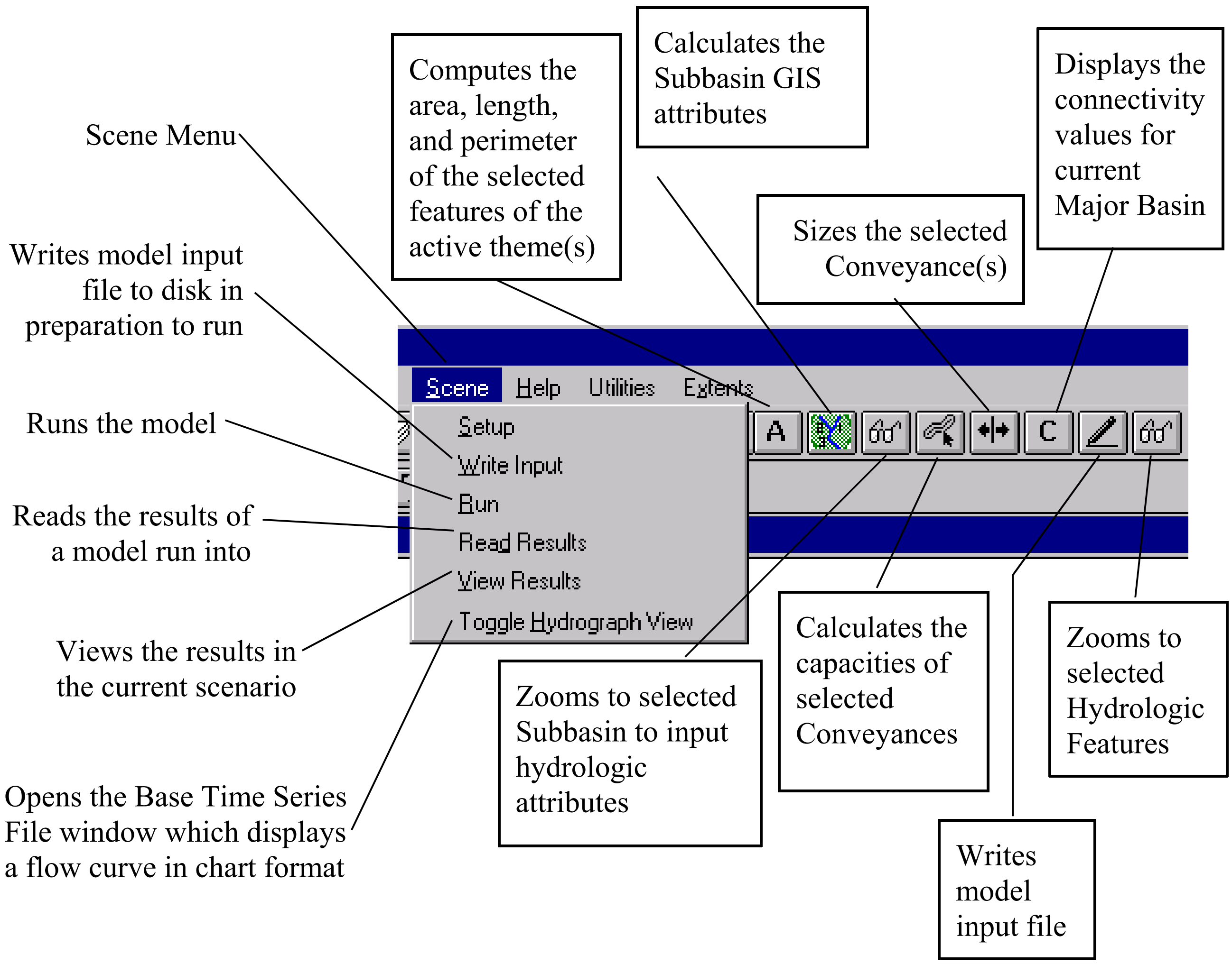
How to modify the attributes of an existing Diversion:

1. Select the Diversion theme in the Table of Contents.
2. Select the Edit Attributes tool 

from the Tool Bar and select the Diversion to be edited to open the Properties window.
3. Make edits to the Diversion attributes in the Properties window and select OK.

SCENE MENU AND BUTTON BAR

The Scene Menu and Button Bar provides easy access to the functions needed to use the model. The Scene Menu is located in the Menu Bar. The Scene Menu and Button Bar contains the following features:



How to run the model:

1. Open the Tool Box with the F2 key or by selecting Scenario - Show Tool Box.

2. Select Scene - Write Input from the Menu Bar or select  from the Button Bar to write an input file to disk in preparation to run the HEC-1 model.

3. Select Scene - Run from the Menu Bar to run the HEC-1 Model.

4. When the model has finished successfully, select Scene - Read Results from the Menu Bar to read the results of the model run into ArcView. The Select Hydrograph File(s) window will open.

5. In the Select Hydrograph File(s) window that has opened, select the hydrograph file (*.hyd) from the model run you wish to read into ArcView.

How to view the results of a model run:

1. Select Scene - View Results from the Menu Bar.

2. In the Select Summary File window, select the summary file (*.sum) from the model run you wish to view the results.

3. To change the size of the results text, zoom in or out, and repeat steps 1 and 2.

How to display flow curve in chart format:

1. Select Scene - Toggle Hydrograph View in the Menu Bar to open the Select Base Time Series File window.

2. Select the Time Series Data (*.hg) file in the Select Base Time Series File window that contains the data for the flow curve you wish to display.

3. Select YES and pick another Time Series Data file if you would like to display more than one flow curve in the same chart. Select NO when you are finished selecting the data files.

4. If the program cannot find the Link Field, it will ask you to pick the Field that will be the link.

5. If the program cannot find the Value field and Time field, you will be asked to identify them.

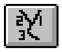
How to use the Edit Attribute tool to edit the attributes of a Hydrologic Feature:

1. Select the theme of the Hydrologic Feature (Subbasin, Confluence, Diversion, or Conveyance) in the Table of Contents.

2. Select  from the Tool Bar and select the Hydrologic feature to be edited to open the Properties window.

3. Make edits to the attributes of Hydrologic Feature in the Properties window and select OK.

How to use the Edit Connectivity tool to edit the connectivity of Hydrologic Features:

1. Select  from the Tool Bar.

2. Select the theme of the Hydrologic Feature (Subbasin, Confluence, Diversion, or Conveyance) in the Table of Contents.

3. Select the Hydrologic Feature to be edited to open the Input New Order window.

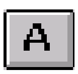
4. In the Input New Order window, input the new order number and select OK.

5. To edit the connectivity order of a different type of feature, select the theme of the Hydrologic Feature in the Table of Contents before selecting the feature with the Edit Connectivity tool.

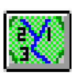
How to compute the area, length, and perimeter of selected features of the active theme(s):

1. Using the Select Feature tool from the Tool Bar, select the feature(s) for which you would like to compute the area, length, and/or perimeter.

2. Select the theme(s) of the features in the Table of Contents. Hold down the Shift key to select more than one.

3. Select  from the Button Bar.

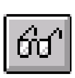
How to calculate Subbasin GIS attributes:

1. Select  from the Button Bar. Subbasin attributes will be automatically calculated for every Subbasin.

How to input or view Subbasin Hydrologic attributes:

1. Select the Subbasin theme in the Table of Contents.

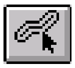
2. Select the Select Feature tool from the Tool Bar and click on the Subbasin of interest or skip this step to input hydrologic attributes of all the Subbasins.

3. Select  from the Button Bar. A series of windows will open to input or view Subbasin Hydraulic Attributes.

How to calculate capacities for Conveyances:

1. Select the Conveyance theme in the Table of Contents.

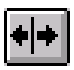
2. Select the Select Feature tool from the Tool Bar and click on the Conveyance of interest or select none to calculate capacities of all the Conveyances.

3. Select  from the Button Bar. The capacity of the Conveyance(s) will be computed.

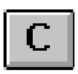
How to size a Conveyance based on peak flow:

1. Select the Conveyance theme in the Table of Contents.

2. Select the Select Feature tool from the Tool Bar and click on the Conveyance(s) in which you want the size of the pipe to be adjusted to accommodate the peak flow calculated by the model.

3. Select  from the Button Bar. The size of the pipe is adjusted to accommodate the peak flow calculated by the model.

How to label the connectivity of the Hydrologic Features:

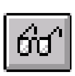
1. Select 

from the Button Bar.

How to zoom to selected features of the active theme:

1. Select the feature(s) you would like to inspect using the Select Feature tool from the Tool Bar.

2. Select the theme of the feature(s) in the Table of Contents.

3. Select  from the Button Bar.

LAYOUTS

This section describes how to print maps and data from the model using the Layout feature in ArcView. Because the Layout feature is part of ArcView this section is quoted from the on-line user manual in ArcView.

A layout is a map that lets you display views, charts, tables, imported graphics, and graphic primitives. The layout is used to prepare these graphics for output from ArcView.
A layout defines what data will be used for output and how they will be displayed. A layout can be dynamic because it allows you to make specific graphics live. When a graphic is live, it reflects the current status of the data. For example, if the data in a view changes, the layout automatically reflects the change.

The same data can be displayed on a number of different layouts. Think of each layout as being a different way of presenting the data. If you are doing a marketing presentation you will probably want to present data differently than if you are doing cartographic production. With ArcView, a different layout of the data can be created for each application. Using Avenue you can extend the power of ArcView by creating custom functions, user interfaces and cartographic templates that will assist you in creating output.

What a layout can contain

The Layout provides the standard graphics and operations one would expect in a typical 'drawing' package. These graphics are drawn using the Draw tools and include points, lines, polygons, rectangles, and circles. The Layout also contains objects specific to the ArcView environment, including frames containing ArcView views, charts, and tables, and ancillary objects such as legends and scale bars.

Printing layouts

You can print a layout or export a layout to a number of formats to use with other software packages.

WORKING WITH LAYOUTS IN THE MODEL

An ArcView project can contain any number of layouts.

How to see which layouts are in a project:

Click on the Layouts icon on the Project Window. The layouts in the current project are shown in the list.

How to create a new layout:

With the Layouts icon selected, click the New button at the top of the Project window. ArcView creates a new layout and its name will appear in the list of layouts in the project. ArcView names new layouts in numerical order: Layout1, Layout2, Layout3, etc. See Overview of creating a layout. You can also double-click the Layouts icon to create a new layout.

How to open a layout:

Double-click the layout's name in the list of layouts in the Project window, or select the layout's name and click the Open button.

How to close a layout:

From the File menu, choose Close, or click the close option on the layout's window (This option varies according to the GUI you are using).

How to rename a layout:

Click once on the layout in the list in the Project window and choose Rename from the Project menu. A layout's name is also a layout property you can edit.

How to save the work you do with a layout:

In ArcView, you save the work you do with any project component by saving the project. To save your project, choose Save Project from the File menu or click the Save Project button . See Saving your work.

How to copy a layout from one project to another:

If you want to copy a layout from another project into your current project, you should import the other project into your current one using Import on the Project menu. This will copy all the components of the other project into your current project. You can then delete the components that you don't require using Delete from the Project menu.

CREATING A LAYOUT

You create a layout from the components in your project such as views, charts, and tables. You can also draw various graphics on the layout too.

How to open or create a project:

If you have not yet opened a project, choose Open Project or New Project from the File menu to either open an existing project or create a new one.

How to create a new layout in your project:

On the Project window select the Layouts icon and then press the New button. A new layout will appear in your project.

How to define the layout page:

Before you begin adding things to the layout, you should define some of its characteristics like units, page size, orientation and margins.

How to add a view:

To create a map for output containing geographic data you must first add a view to your layout. When you add the view you can choose to make it live linked. This causes any changes in the view to be reflected in the layout. If you decide not to live link your view, it will not change in the layout even if you make changes to the view.

How to add a legend:

After adding a view you can add a legend to the layout. The legend will show the symbology for the themes that are displayed in the view.

How to add a scale bar:

There are a number of different styles of scale bars supported by ArcView. After you select a view to associate the scale bar to, you can select the type of units, interval values and number of intervals that the scale bar will have.

How to add a title:

When you are satisfied with the geographically based parts of your layout you can add a title to it.

How to create graphics:

If you need to add any graphic (points, lines, circles, etc.) you can do so.

How to add other graphics to the layout:

There are a number of additional "standard" graphics you can add to your layout. You can place both ArcView tables and charts on the layout if so desired in your output product. You can also choose from a provided list of north arrows, or import a file from a another graphics package into the layout.

How to arrange the layout graphics as needed:

When all of the graphics you want are present in the layout you can use a number of different tools to arrange them as needed. Among the actions you can perform on layout graphics are the following: align, bring to front, group, etc.

How to assign patterns, colors and fonts to the graphics:

By double-clicking any graphic in the layout you can change its properties. In the case of a view or legend, you will see a properties menu. For any graphic primitive you will see ArcView's Symbol Window.

How to Print the layout:

When you are finally satisfied with your layout you can send it to a printer.

APPENDIX C

ESTIMATED CONSTRUCTION COSTS

RIVERTON CITY STORM DRAINAGE MASTER PLAN
PROJECT COST ESTIMATES

West of Bangerter Highway

PROJECT NUMBER	DESCRIPTION	ROAD COSTS INCLUDED	DESIGN FLOW	MASTER PLAN SIZE	QUANTITY	UNITS	UNIT COST	TOTAL
1)	Western Springs to 4000 W							
	Land Scaping				3	acre	$15,000	$45,000
	SD Structures & Field Drains				3	acre	$20,000	$60,000
	Earth Work				3	acre	$20,000	$60,000
	Land				3	acre	$45,000	$135,000
	Install pipe - Retention Pond to 12600 S	NO	22cfs	24	4,500	ft	$73	$328,500
	Install pipe - 12600 S to Swensen Farms	NO	27cfs	30	2,350	ft	$95	$223,250
	Mobilization							$34,338
	SUB TOTAL							**$721,088**
	Contingency & Engineering (30%)							$216,326
	TOTAL (rounded to nearest 1,000)							**$937,000**
2)								
	Install pipe - 4600 S to Rose Creek	NO	7cfs	21	1400	ft	$66	$92,400
	Mobilization							$4,620
	SUB TOTAL							**$97,020**
	Contingency & Engineering (30%)							$29,106
	TOTAL (rounded to nearest 1,000)							**$126,000**
3)								
	Install pipe - 13200 S to Detention	NO	135cfs	42	1,550	ft	$135	$209,250
	Mobilization							$10,463
	SUB TOTAL							**$219,713**
	Contingency & Engineering (30%)							$65,914
	TOTAL (rounded to nearest 1,000)							**$286,000**
4)	8 ac-ft Detention Basin							
	4320W & 13160S							
	Land Scaping			8.5 ac-ft	3	acre	$15,000	$45,000
	SD Structures & Field Drains				3	acre	$20,000	$60,000
	Earth Work				3	acre	$20,000	$60,000
	Land				3	acre	$45,000	$135,000
	Install pipe - Detention to Rose Creek	NO	20cfs	30	2500	ft	$95	$237,500
	Mobilization							$26,875
	SUB TOTAL							**$564,375**
	Contingency & Engineering (30%)							$169,313
	TOTAL (rounded to nearest 1,000)							**$734,000**
5)								
	Install pipe - 5100 W east in 13400 S	NO		30	1600	ft	$95	$152,000
	Mobilization							$7,600
	SUB TOTAL							**$159,600**
	Contingency & Engineering (30%)							$47,880
	TOTAL (rounded to nearest 1,000)							**$207,000**
6)								
	Install Pipe - 4800 W in 13600 S	NO	50cfs	30	1,300	ft	$95	$123,500
	Install Pipe - 5200 W in 13600 S	NO	70cfs	36	1,200	ft	$116	$139,200
	Mobilization							$13,135
	SUB TOTAL							**$275,835**
	Contingency & Engineering (30%)							$82,751
	TOTAL (rounded to nearest 1,000)							**$359,000**
7)								
	Install Pipe - 13000 S in 4600 W	NO	23cfs	30	1,600	ft	$95	$152,000
	Mobilization							$7,600
	SUB TOTAL							**$159,600**
	Contingency & Engineering (30%)							$47,880
	TOTAL (rounded to nearest 1,000)							**$207,000**
8)								
	4000 W 13200 S	NO	7cfs	18	600	ft	$61	$36,600
	4600W 13200 S to Rose Creek	NO	15cfs	24	600	ft	$73	$43,800
	Mobilization							$4,020
	SUB TOTAL							**$84,420**
	Contingency & Engineering (30%)							$25,326
	TOTAL (rounded to nearest 1,000)							**$110,000**

PROJECT NUMBER	DESCRIPTION	ROAD COSTS INCLUDED	DESIGN FLOW	MASTER PLAN SIZE	QUANTITY	UNITS	UNIT COST	TOTAL
9)	1.5 ac-ft Detention Basin							
	4000W & 12300S							
	Land Scaping				1	acre	$15,000	$15,000
	SD Structures & Field Drains				1	acre	$20,000	$20,000
	Earth Work				1	acre	$20,000	$20,000
	Land				1	acre	$45,000	$45,000
	Install pipe	NO		27	600	ft	$84	$50,400
	Install pipe	NO		30	800	ft	$95	$76,000
	Mobilization							$11,320
	SUB TOTAL							**$237,720**
	Contingency & Engineering (30%)							$71,316
	TOTAL (rounded to nearest 1,000)							**$309,000**
10)	4000 W 13000 S							
	Install pipe - 13000S to 13300S in 3900 W	NO		42	1,800	ft	$135	$243,000
	Install pipe - 3300S to Rose Cr in 3900 W	NO		48	1,350	ft	$158	$213,300
	Mobilization							$22,815
	SUB TOTAL							**$479,115**
	Contingency & Engineering (30%)							$143,735
	TOTAL (rounded to nearest 1,000)							**$623,000**
11)	3900 W and 13650 S to 3600 W and Rose							
	Install pipe	NO		30	800	ft	$95	$76,000
	Install pipe	NO		36	2,700	ft	$116	$313,200
	Mobilization							$19,460
	SUB TOTAL							**$408,660**
	Contingency & Engineering (30%)							$122,598
	TOTAL (rounded to nearest 1,000)							**$531,000**
12)								
	Install pipe - 4600 W to 4800 W in 13200 S	NO	75cfs	36	1800	ft	$116	$208,800
	Mobilization							$10,440
	SUB TOTAL							**$219,240**
	Contingency & Engineering (30%)							$65,772
	TOTAL (rounded to nearest 1,000)							**$285,000**
13)								
	Install pipe - 11800 S to Midas Creek in 4000	NO	7cfs	21	1150	ft	$66	$75,900
	Mobilization							$3,795
	SUB TOTAL							**$79,695**
	Contingency & Engineering (30%)							$23,909
	TOTAL (rounded to nearest 1,000)							**$104,000**
14)	4800W&13500S 5 ac-ft Detention							
	Land Scaping				3	acre	$15,000	$45,000
	SD Structures & Field Drains				3	acre	$20,000	$60,000
	Earth Work				3	acre	$20,000	$60,000
	Land				3	acre	$45,000	$135,000
	Mobilization							$15,000
	SUB TOTAL							**$315,000**
	Contingency & Engineering (30%)							$94,500
	TOTAL (rounded to nearest 1,000)							**$410,000**
15)	1 ac-ft Detention Basin							
	4100S & 11990S							
	Land Scaping				0.5	acre	$15,000	$7,500
	SD Structures & Field Drains				0.5	acre	$20,000	$10,000
	Earth Work				0.5	acre	$20,000	$10,000
	Land				0.5	acre	$45,000	$22,500
	Install pipe	NO		18	500	ft	$61	$30,500
	Install pipe	NO		24	500	ft	$73	$36,500
	Mobilization							$5,850
	SUB TOTAL							**$122,850**
	Contingency & Engineering (30%)							$36,855
	TOTAL (rounded to nearest 1,000)							**$160,000**

PROJECT NUMBER	DESCRIPTION	ROAD COSTS INCLUDED	DESIGN FLOW	MASTER PLAN SIZE	QUANTITY	UNITS	UNIT COST	TOTAL
16)	Wasteway at Midas Creek and							
	Provo Resevoir Canal							
	Wasteway				1	acre	$10,000	$10,000
	Mobilization							$500
	SUB TOTAL							**$10,500**
	Contingency & Engineering (30%)							$3,150
	TOTAL (rounded to nearest 1,000)							**$14,000**
17)	134000 S and 4500 W to Rose Creek							
	Install pipe	NO	10cfs	21	1200	ft	$66	$79,200
	Mobilization							$3,960
	SUB TOTAL							**$83,160**
	Contingency & Engineering (30%)							$24,948
	TOTAL (rounded to nearest 1,000)							**$108,000**
18)	4000 W and 12700 S to Bangerter							
	Install pipe	NO	10cfs	18	1000	ft	$61	$61,000
	Mobilization							$3,050
	SUB TOTAL							**$64,050**
	Contingency & Engineering (30%)							$19,215
	TOTAL (rounded to nearest 1,000)							**$83,000**
19)	4400 W to 3950 W in 13000 S							
	Install pipe	NO	7cfs	18	1,450	ft	$61	$88,450
	Install pipe	NO	34cfs	30	1,550	ft	$95	$147,250
	Mobilization							$11,785
	SUB TOTAL							**$247,485**
	Contingency & Engineering (30%)							$74,246
	TOTAL (rounded to nearest 1,000)							**$322,000**
20)	12800 S to 13000 S in 4400 W							
	Install pipe	NO	4cfs	18	1,000	ft	$61	$61,000
	Mobilization							$3,050
	SUB TOTAL							**$64,050**
	Contingency & Engineering (30%)							$19,215
	TOTAL (rounded to nearest 1,000)							**$83,000**
21)	4300 W and 12800 S to 4200 W and 13000 S							
	Install pipe	NO	9cfs	18	1300	ft	$61	$79,300
	Mobilization							$3,965
	SUB TOTAL							**$83,265**
	Contingency & Engineering (30%)							$24,980
	TOTAL (rounded to nearest 1,000)							**$108,000**
22)	12700 S to 13000 S in 4100 W							
	Install pipe	NO	5cfs	18	1,600	ft	$61	$97,600
	Mobilization							$4,880.00
	SUB TOTAL							**$102,480**
	Contingency & Engineering (30%)							$30,744
	TOTAL (rounded to nearest 1,000)							**$133,000**
23)	12800 S to 13000 S in 3950 W							
	Install pipe	NO	9cfs	21	700	ft	$66	$46,200
	Mobilization							$2,310
	SUB TOTAL							**$48,510**
	Contingency & Engineering (30%)							$14,553
	TOTAL (rounded to nearest 1,000)							**$63,000**
24)	12350 S to 12200 S in 4300 W							
	Install pipe	NO		36	1,000	ft	$116	$116,000
	Mobilization							$5,800
	SUB TOTAL							**$121,800**
	Contingency & Engineering (30%)							$36,540
	TOTAL (rounded to nearest 1,000)							**$158,000**
25)	Wasteway at Rose Creek and							
	Provo Resevoir Canal							
	Wasteway				1		$10,000	$10,000
	Mobilization							$500
	SUB TOTAL							**$10,500**
	Contingency & Engineering (30%)							$3,150
	TOTAL (rounded to nearest 1,000)							**$14,000**

ACRE	**1836.5**
TOTAL	**$6,474,000**
TOTAL/ARCE	**$3,525**

AVERAGE STORM DRAIN PIPE INSTALLATION COST PER FOOT

Diameter (in)	Diameter (ft)	Adjusted Cost per foot	Outside Diameter (ft)	Pipe Material & Installation	Excavation	Bedding	Hauling	Backfill Material & Installation	Trench Box per Day	Average Daily Output	Trench Box Cost	Top Trench Width	Manhole Cost	Inlet Cost	Total Cost per Foot of Pipe	Adjusted Cost per foot
15	1.25	50.00	1.46	19.20	6.33	4.04	8.19	2.62	160.00	190.00	0.84	5.36	3.99	10.50	56	50
18	1.50	61.00	1.75	29.00	6.76	4.62	8.75	2.79	160.00	130.00	1.23	5.65	3.99	10.50	68	61
21	1.75	66.00	2.04	33.00	7.19	5.21	9.31	2.97	160.00	115.00	1.39	5.94	3.99	10.50	74	66
24	2.00	73.00	2.33	39.50	7.62	5.82	9.87	3.15	160.00	100.00	1.60	6.23	3.99	10.50	82	73
27	2.25	84.00	2.63	49.50	8.05	6.45	10.43	3.32	160.00	94.00	1.71	6.53	3.99	10.50	94	84
30	2.50	95.00	2.92	59.50	8.48	7.10	10.99	3.50	160.00	88.00	1.82	6.82	3.99	10.50	106	95
33	2.75	105.00	3.21	68.75	8.92	7.76	11.54	3.68	160.00	88.00	1.82	7.11	3.99	10.50	117	105
36	3.00	116.00	3.50	78.00	9.35	8.44	12.10	3.86	160.00	72.00	2.22	7.40	4.34	10.50	129	116
42	3.50	135.00	4.08	96.50	10.21	9.86	13.22	4.21	160.00	72.00	2.22	7.98	4.34	10.50	151	135
48	4.00	158.00	4.67	115.00	11.07	11.34	14.34	4.57	160.00	64.00	2.50	8.57	6.61	10.50	176	158
54	4.50	186.00	5.25	142.50	11.94	12.89	15.45	4.92	160.00	56.00	2.86	9.15	6.61	10.50	208	186
60	5.00	216.00	5.83	170.00	12.80	14.51	16.57	5.28	160.00	48.00	3.33	9.73	8.20	10.50	241	216
66	5.50	246.00	6.42	198.50	13.66	16.19	17.69	5.63	160.00	44.00	3.64	10.32	8.20	10.50	274	246
72	6.00	275.00	7.00	227.00	14.52	17.95	18.80	5.99	160.00	40.00	4.00	10.90	8.20	10.50	307	275
78	6.50	341.00	7.58	296.00	15.39	19.78	19.92	6.34	160.00	36.00	4.44	11.48	8.20	10.50	381	341
84	7.00	407.00	8.17	365.00	16.25	21.67	21.04	6.69	160.00	32.00	5.00	12.07	8.20	10.50	454	407

Reference: 2004 Means Guide

Assumptions:

PVC and Class III RCP Pipe
One side of street C&G is regraded.
10 v :1h trench side slope (use trench boxes)
10 ' average depth to top of pipe
0.33 ' thick asphalt road covering
0.75 ' thick untreated base course
0.896 Salt Lake City adjustment factor
500 ' Average distance between manholes
2 + Outside Diameter = Bottom trench width
0.5 ' bedding over pipe
1 ' bedding under pipe
1 Inlets per 100 ft of pipe
0.4 of curb & gutter is on radius
0.045 Inflation (used in updating Utility Relocation costs).

Costs:

1.95 /CY Imported granular backfill (p. 55, minimal haul)
12.75 /CY Pipe bedding (p. 56, Sand, dead or bank)
3.63 /CY Excavation (p. 54, 10-14 ft deep, 1 CY backhoe)
22.69 /SY 4" Asphalt Pavement (p. 72, 2" Binder, 2" Wear; p. 58, 9" Bank Run GravelBase Course; p. 56, Hauling)
1.24 /LF 3" Asphalt cutting (p. 38)
1993 /EA 4' Manhole (for pipes =< 2.5' diameter, p. 92; p. 92, 30" Ring & Cover)
2171 /EA 5' Manhole (for pipes > 2.5' and <= 3.5', p. 92; p. 92, 30" Ring & Cover)
3305 /EA 6' Manhole (for pipes > 3.5' and <= 4.5', p. 92; p. 92, 30" Ring & Cover)
4100 /EA Manholes (for pipes > 4.5')
1050 /EA Catch basins (p. 91)
9.55 /LF Curb & Gutter (Steel forms, 24" wide, p. 99)
4.7 /CY Hauling (p. 53, 2-mi round trip, 12 CY truck)
1 /LF Trench box

APPENDIX D

SITE DEVELOPMENT
STORM DRAINAGE AND
EROSION CONTROL PLAN
SUBMITTAL REQUIREMENTS

SITE DEVELOPMENT
STORM DRAINAGE AND EROSION CONTROL
PLAN SUBMITTAL REQUIREMENTS

REVIEW PROCESS

All subdivisions, resubdivisions, Planned Unit Development or any other development or redevelopment done within the jurisdiction of these CRITERIA shall be required to submit drainage reports, plans, construction drawings, specifications and as-constructed information in conformance to the requirements of these CRITERIA. Drainage aspects of these submittals are provided below. It is fully anticipated that the drainage components identified below will be included within the full submittal provided by the developer.

Subdivision Process The general requirements for the subdivision of land in Riverton City, and conditions requiring subdivision, are set forth in the Riverton City Development Code. Readers are referred to the development code for standards and procedures for the review and approval of subdivision plats.

Permit Process Any structure, or other development or redevelopment, which requires a building permit under the Riverton City code may also require a City Storm Drainage Permit to be issued by the Riverton City Engineering Department. These permits will only be issued upon conformance to requirements contained in these and other applicable CRITERIA as evidenced by approval of the Final Drainage Report.

A summary of submittals which are required of the developer to be submitted for Planning Commission review and approval include:

A. Conceptual Level Drainage Control Plan. This plan is to be submitted for review by the Riverton City Flood Control Director for conceptual level feasibility.

B. Preliminary Plan. This plan is to be submitted for review and preliminary approval by Riverton City Planning Commission and City Commission.

C. Final Drainage Plan. The final drainage plan will be submitted subsequent to preliminary approval and must receive approval from both the Planning Commission and City Council. It is requested that review meetings be held with the developer prior to the preparation of the final drainage plan, and again prior to the development of final construction details and documents to help avert potential problems with final design. These meetings would be held prior to formal submittal of the final plans to the City Planning Commission and City Council.

The requirements for each of these plans are found within the following sections:

6. Conceptual Level Drainage Control Plan
7. Preliminary Drainage Control Plans
8. Final Drainage Control Plans, Plat and Document
9. As-built Drawings and Certification

CONCEPTUAL LEVEL DRAINAGE CONTROL PLAN

At the conceptual level the following general project information shall be provided to Riverton City for review and approval prior to the development of a Preliminary Plan.

General Location and Description of Project

1. Township, range, section, 1/4 section, (subdivision, lot and block).
2. Major drainage ways and facilities.
3. Area in acres.
4. Proposed land use.

Drainage Basins and Sub-basins

1. References to major drainage way planning studies such as flood hazard delineation reports, major drainage way planning reports, and flood insurance rate maps.

Drainage Design Criteria

1. Proposed drainage concept and how it fits existing drainage patterns.
2. Discussions of drainage problems, including storm water quality, and potential solutions at specific design points.
3. Discussion of detention storage and outlet design.
4. Discussion of minor and major drainage system.

Identification of Potential Improvements to Public Drainage Systems

1. Identification of potential design concepts and impacts to local drainage systems.

PRELIMINARY DRAINAGE CONTROL PLANS

At the time of land zoning, rezoning, or proposal for development or redevelopment, a preliminary drainage report is required in advance of the final drainage report. Ten copies of the preliminary drainage report, prepared and signed by a Professional Engineer registered in the State of Utah, shall be submitted to the Planning Commission for review. Reports shall be cleanly and clearly reproduced and legible throughout. Blurred or unreadable portions of the report will be deemed unacceptable and will require resubmittal. Incomplete or absent information may require resubmittal of the report.

The purpose of a preliminary report is to define on a conceptual level the nature of the proposed development or project and to describe all existing conditions and propose facilities needed to conform to the requirements of these CRITERIA. Each preliminary drainage report shall provide the following report information and mapping. It is recommended that the Preliminary Plan prepared by the developer follow the general outline provided below to facilitate City review.

REPORT CONTENT

General Location and Description

A. Location
  1. City, County, State Highway and local streets within and adjacent to the site, or the area to be served by the drainage improvements.
  2. Township, range, section, 1/4 section, (subdivision, lot and block).
  3. Major drainage ways and facilities.
  4. Names of surrounding developments.
  5. Name of receiving water(s).

B. Description of Property
  1. Existing ground cover (type and vegetation).
  2. Area in acres.
  3. Existing major irrigation facilities such as ditches and canals.
  4. Proposed land use and ground cover.

Drainage Basins and Sub-basins

A. Major Basin Description
  1. References to major drainage way planning studies such as flood hazard delineation reports, major drainage way planning reports, and flood insurance rate maps.
  2. Major basin drainage characteristics, and existing and planned land uses within the basin, as defined by the planning commission.
  3. Identification of all nearby irrigation facilities that will influence or be influenced by the local drainage.

B. Sub-Basin Description

  1. Describe historic drainage patterns of the property.
  2. Describe offsite drainage flow patterns and impact on development under existing and fully developed basin conditions.

Drainage Facility Design Criteria

A. General Concept. Discuss the following:
  1. Proposed drainage concept and how it fits existing drainage patterns.
  2. How offsite runoff will be considered and how expected impacts will be addressed.
  3. Anticipated and proposed drainage patterns.
  4. Storm water quantity and quality management concept and how it will be employed. The use of computer-based models for the evaluation of storm water quality and quantity will not be universally required of new developments, although their use is recommended. Under site specific conditions where it is believed by the City that impacts from the development may unacceptably impact downstream water quality or quantity however, their use may be required. The recommendation to use computer modeling during the evaluation process is made since it is likely that the review process will check the validity of the developers conclusions utilizing SEDIMOT or other appropriate computer technology.

5. Maintenance and maintenance access.
6. Describe the content of tables, charts, figures, plates, drawings and design calculations presented in the report.

B. Specific Details (Optional Information)
1. Discussions of drainage problems, including storm water quality, and solutions at specific design points.
2. Discussion of detention storage and outlet design.
3. Discussion of impacts of concentrating flow on downstream properties.

Public Drainage Improvements

If the project requires that drainage improvements be constructed that will be turned over and owned and maintained by Riverton City, the following must also be provided, obtained, or completed:

A. A preliminary plan and/or design of the public improvement.

References

A. Reference all criteria, master plans, and technical information used in support of concept.

MAPPING

Preliminary Report Mapping

A. The General Location Map shall show the following information and conform to the following standards.
1) All drawings shall be 22" x 34" in size.
2) Map shall provide sufficient detail to identify drainage flows entering and leaving the development and general drainage patterns.
3) The general location map should be at a scale of 1" = 500' to 1" = 4000' and show the path of all Drainage from the upper end of any offsite basins to the defined major drainage ways.
4) Identify all major facilities (i.e., irrigation ditches, existing detention facilities, storm water quality facilities, culverts, storm sewers) downstream of the property along the flow path to the nearest major drainage way.
5) Basins, basin identification numbers, drainage divides, and topographic contours are to be included.

B. Flood plain Mapping:
1) A copy of any published flood plain maps (i.e., flood hazard area delineation, flood insurance rate maps)
2) All major drainage ways shall have the defined flood plain shown on the report drawings.
3) Flood hazards from either shallow overland flow, side channels, or concentrated flows.
4) The location of the property in relation to the flood plain(s) and/or flood hazards.

C. Drainage Plan Mapping:
1) Prepare at a scale of 1" = 20' to 1" = 200' on a 22" x 34" size drawing sheet.

2) Existing topographic contours at 2-feet (or less) intervals, In mountainous areas, the maximum interval may be extended to 5 feet. Final plan approval 1 foot contour intervals shall be shown for areas of little relief. The contours shall extend a minimum of 100-feet beyond the property lines.
3) All existing drainage facilities within map limits including basin boundaries and sub-boundaries.
4) Conceptual major drainage facilities including proposed storm water quality BMPs, detention basins, storm sewers, swales, riprap, and outlet structures in the detail consistent with the proposed development plan.
5) Any offsite feature including drainage that influences the development.
6) Proposed drainage patterns and, if available, proposed contours.
7) Legend to define map symbols.
8) Project name, address, engineering firm and seal, and date the Title block in lower right corner.
9) North arrow, scale and available bench mark information and location for each benchmark.

FINAL DRAINAGE CONTROL PLANS, PLAT, DOCUMENT & CONSTRUCTION SPECIFICATIONS

The final drainage report serves to define and expand the concepts shown in the preliminary report or is sufficient of itself to assure conformance to these CRITERIA. The final report may be submitted at any point during the permitting and platting process, but must be reviewed and approved prior to issuance of any permit.

Ten (10) copies of the report shall be submitted to the Planning Commission. Reports shall be typed and bound on 8-1/2" x 11" paper with pages numbered consecutively. Drawings, figures, tables, etc., shall be bound with the report or contained in an attached pocket. The report shall include a cover letter presenting the design for review prepared or supervised by a Professional Engineer licensed in the State of Utah. The report shall contain a certification that reads as follows:

> "This report for the drainage design of (name of development) was prepared by me (or under my direct supervision) in accordance with the provisions of the Riverton City storm drainage design and technical criteria, and was designed to comply with the provisions thereof. I understand that Riverton City does not and will not assume liability for drainage facilities design."

____
Registered Professional Engineer
State of Utah No. ____________
(Affix Seal)

REPORT CONTENT

The report shall be in accordance with the following outline and contains the following applicable information:

General Location and Description

A. Location
   1. Information as required for Preliminary Plans.
   2. Local streets within the adjacent to the subdivision.
   3. Easements within and adjacent to the site.

B. Description of Property
   1. Information as required for Preliminary Plans.
   2. General project description.
   3. Area in acres.
   4. General soil conditions, topography, and slope.
   5. Irrigation facilities.

Drainage Basins and Sub-basins

A. Major Basin Description
   1. Information as required for Preliminary Plans.
   2. Identification of all irrigation facilities within the basin that will influence or be influenced by proposed site drainage.

B. Sub-Basin Description
   1. Information as required for Preliminary Plans.

Drainage Facility Design Criteria

The design criteria used in the development of the drainage plan should be clearly identified including a discussion related to the use or implementation of any optional provisions intended by the developer or any deviation from the CRITERIA. Any deviation from the CRITERIA must be fully justified in the final design report. Development criteria should consider and discuss the following:

A. Previous Studies and Specific Site Constraints
   1. Previous drainage studies (i.e., project master plans) for the site that influence or are influenced by the drainage design and how implementation of the plan will affect drainage and storm water quality for the site.
   2. Potential impacts identified from adjacent drainage studies.
   3. Drainage impacts of site constraints such as streets, utilities, transit ways, existing structures, and development or site plans.

B. Hydrologic Criteria
   1. Design storm rainfall and its return period(s).
   2. Runoff calculation method(s).

3. Detention discharge and storage calculation method(s).
4. Discussion and justification of other criteria or calculation methods used that are not presented in or referenced by the CRITERIA.

C. Hydraulic Criteria
1. Identify various capacity references.
2. Discussion of other drainage facility design criteria used that are not presented in these CRITERIA.

D. Storm water Quality Criteria
1. BMPs to be used for storm water quality control.
2. Identify, as appropriate, water-quality capture volume and drain time for extended-detention basins, retention ponds and constructed wetland basins.
3. Identify, as appropriate, runoff volume and flow rates for design of water-quality swales, wetland channels, etc.
4. Discussion of other drainage facility design criteria used that are not presented in these CRITERIA or other manuals referenced by Riverton City.

E. Waivers from Criteria
1. Identify provisions by section number for which a waiver is requested.
2. Provide justification for each waiver requested.

Drainage Facility Design

Discuss the following:

A. Proposed concept and typical drainage patterns.
B. Compliance with offsite runoff considerations.
C. Anticipated and proposed drainage patterns.
D. Proposed storm water quality management strategy.
E. The content of tables, charts, figures, plates, or drawings presented in the report.
F. Drainage problems encountered and solutions at specific design points.
G. Detention storage and outlet design.
H. Storm water quality BMPs to be used.
I. Maintenance access and aspects of the design.
J. Easements and tracts for drainage purposes, including the conditions and limitations for use.

Public Drainage Improvements

If the project requires that drainage improvements be constructed that will be turned over and owned and maintained by Riverton City, the following must also be provided, obtained, or completed:

A. Two sets of plans (22" x 34") submitted for initial review.
B. An application to design, plan, construct, re-construct or remodel a public improvement must be filed with the Planning Commission.
C. A bond or letter of credit guaranteeing payment and performance must be executed prior to commencing with work on the project.

D. Upon completion of the project, a set of reproducible as-constructed plans, certified by a licensed engineer, must be submitted before the bond or other guarantee is released.

E. After approval of the initial review set, ten (10) sets of plans must be supplied which will be distributed by the City for review by all departments and utility companies. After comments are received and addressed four (4) final sets will be stamped as approved and returned to the design engineer for use by the contractor and owner.

The information required for the plans shall be in accordance with sound engineering principles, the technical provisions of any City manuals (where appropriate), these CRITERIA, and other applicable Riverton City ordinances, regulations, criteria or design guidelines. The plans may also be subject to review by outside agencies such as Salt Lake County, Federal Emergency Management Agency, U.S. Army Corps of Engineers, Environmental Protection Agency, Utah Water, or other agencies as required. The plans shall be signed and sealed by a Professional Engineer registered in the state of Utah.

Conclusions

The Proposed Drainage Facility Plan will be evaluated based upon the material and data submitted in accordance with these CRITERIA and other manuals referenced by Riverton City. The plan must evaluate the effectiveness of the drainage design in controlling damage from storm runoff, in removing pollutants from storm runoff, and its potential influence on downstream drainages.

References

Reference all criteria and technical information used.

Appendices

Appendices should include all backup and supporting materials including:

A. Hydrologic Computations (Including computer model input and output listings.)

1. Land use assumptions regarding adjacent properties.
2. Initial and major storm runoff at specific design points.
3. Historic and fully-developed runoff computations at specific design points.
4. Hydrographs at critical design points.
5. Time of concentration and runoff coefficients for each basin.
6. Storm water quality BMP sizing calculations including runoff adjustments for minimizing directly-connected impervious areas.

B. Hydraulic Computations(Including computer model input and output listings.)

1. Culvert capacities.
2. Storm sewer capacity, including energy grade line (EGL) and hydraulic grade line (HGL) elevations.
3. Gutter capacity as compared to allowable capacity.
4. Storm inlet capacity including inlet control rating at connection to storm sewer.

5. Open channel design.
6. Check and/or channel drop design.
7. Detention area/volume capacity and outlet capacity calculations for flood detention and water quality basins; depths of detention basins.
8. Wetland area and area/depth distribution for constructed wetland basins.
9. Infiltration rates and volumes for porous pavement or release rates where under drains or infiltration is not possible.
10. Flow rates, velocities, longitudinal slopes and cross-sections for wetland channels and water quality swales.
11. Downstream/outfall system capacity to the Major Drainage way System.

MAPPING

Final Report Mapping

A. General Location Map.

Shall include all items as identified for the Preliminary Plan.

B. Flood plain Mapping.

Shall include all items as identified for the Preliminary Plan.

C. Drainage Plan Mapping.

In addition to those items identified for the development of the Preliminary Plan, Drainage mapping shall include the following:

1. Property lines, existing easements, and easements proposed for dedication, with purposes noted.
2. Streets, indicating ROW width, flow line width, curb or roadside swale type, sidewalk, and approximate slopes.
3. Existing drainage facilities and structures, including irrigation ditches, roadside ditches, cross pans, drainage ways, gutter flow directions, and culverts. Also, show pertinent information such as material, size, shape, slope and locations.
4. Proposed type of street flow (i.e., vertical or combination curb and gutter), roadside ditch or swale, gutter, slope and flow directions, and cross pans.
5. Proposed storm sewers and open drainage ways, including inlets, manholes, culverts, and other appurtenances, including riprap or other erosion protection.
6. Proposed structural water-quality BMPs, their location, sizing, and design information.
7. Proposed outfall point for runoff from the developed area and, if required, facilities to convey flows to the final outfall point without damage to downstream properties.
8. Routing and accumulation of flows at various critical points for the initial and water-quality storm runoff events, and major storm runoff events.
9. Volumes and release rates for detention storage and water-quality capture volume for facilities and information on outlet works.

10. Location and water surface profiles or elevations of all previously defined flood plains affecting the property. If flood plains have not been previously published, they shall be defined and shown on the drainage plan.
11. Location, and measured or estimated elevations of all existing and proposed utilities affected by or affecting the drainage design.
12. Routing of upstream offsite drainage flow through or around the development.
13. Location of any improvements included in the appropriate or accepted outfall system plan, major drainage plan, and/or storm drainage plan.
14. Definition of flow path leaving the development through the downstream properties ending at a major drainage way or receiving water.

CONSTRUCTION PLANS

For on-site drainage improvements, the final construction plans (22" x 34") shall be submitted after approval of the Final Drainage Report. Ten (10) sets of plans shall be submitted for approval. Upon approval, four sets, stamped and signed, will be returned to the design engineer for use by the contractor, owner and design engineer. However, before any construction work begins, appropriate bonds, letters-of-credit, or other surety as required by these CRITERIA should be issued to Riverton City. The construction plans as a minimum and as appropriate will include:

A. Plan and profile of proposed pipe installations, inlets and manholes with pertinent elevations, dimensions, type and horizontal control shown.
B. Property and right-of-way lines, existing and proposed structures, fences and other land features.
C. Plan and profile of existing and proposed channels, ditches swales, and on-site water-quality BMPs with construction details, cross-sections and erosion controls.
D. Detention and water quality (if separate) facility grading, trickle channels (if any), outlet and inlet location, cross-sections or contours sufficient to verify volumes, etc.
E. Details of inlet and outlet control devices and of all structural components being constructed.
F. Maintenance access.
G. General over lot grading and the erosion and sediment control plan prepared in accordance with applicable provisions of these CRITERIA and the MANUAL.
H. Areas of modular block porous pavement, if any, and installation details.
I. Landscaping and revegetation plans and details.
J. Proposed finish floor elevations of structures.
K. Relation of site to current and, if appropriate, modified flood plain boundaries.
L. A statement agreeing to maintain and operate all privately-owned facilities (if any) in a working manner and/or in accordance with the requirements of the Utah Water Quality Control Division specified in the storm water discharge permit issued to Riverton City.
M. Signature and seal of a professional engineer preparing these plans.

Approval by Riverton City does not constitute an approval or the issuance of permits by the State of Utah, which approval and/or permits shall be obtained prior to initiating any construction activities on the site.

AS-BUILT DRAWINGS AND CERTIFICATION

Upon completion of construction, the professional engineer that prepared the design plans (or a professional engineer that assumes the responsibility for the inspection if the design engineer is no longer available) shall provide Riverton City with a signed and sealed Certification of Inspection verifying that all work was performed in accordance with the approved plans and in compliance with all applicable criteria of Riverton City and that any changes which occurred during construction are included in the as-built drawings. Special circumstances may require that as-built reproducible drawings of the drainage improvements also be provided. Certification of Inspection and as-built drawings (if required) will be required prior to the issuance of a final sewer connection permit or the issuance of a Certificate of Occupancy.