DRAINAGE BASIN DESIGN PLAN

FOR

SOUTH TRUCK ROUTE DRAINAGE BASIN

October 29, 2003

PREPARED FOR:

CITY OF RAPID CITY

RAPID CITY, SOUTH DAKOTA

October 29, 2003

Mr. Ted Vore P.E.
Public Works Director
City of Rapid City
300 Sixth Street
Rapid City, SD 57701

RE: Design Plan for South Truck Route Drainage Basin

Dear Mr. Vore:

Presented herewith is our DESIGN PLAN FOR SOUTH TRUCK ROUTE DRAINAGE BASIN. The plan is a comprehensive basinwide design plan for stormwater management in the South Truck Route Drainage Basin. The plan includes design guidelines and data necessary for stormwater improvements in the basin.

As directed, various alternates were reviewed during the preparation of the plan. This final report includes a Design Plan and a Design Plan With Optional Routing. The Design Plan generally follows historical flow routes. The Design Plan With Optional Routing has two modifications of the Design Plan. The Optional Routing modifications are (1) replacing one of the historical routes with a pipeline along a new route and (2) increasing the size of one of the Design Plan metering dams. The Optional Routing is described in Appendix F. **The City Council approved the Design Plan With Optional Routing on September 15, 2003.**

Please be assured of our readiness to meet with City Officials to discuss the contents of the report. We are available to answer any questions and are prepared to proceed with the design of the recommended improvements if desired.

Thank you for the opportunity to be of service.

Respectfully submitted,

FMG, Inc.

Jerry D. Foster P.E.

cc: File 8467

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INTRODUCTION

BACKGROUND

Proper management of urban drainage has historically been neglected as cities develop. Management has consisted of piecemeal planning, crisis control, expensive after the fact corrective solutions, and generally hoping the problem will go away or not happen again. Development has been allowed with little or no consideration given to basinwide impacts on flooding. Consequently severe and damaging flooding has occurred.

The City of Rapid City has recognized that this traditional method of urban drainage management is not appropriate. Rapid City views drainage control as a significant component of the urban infrastructure system rather than a problem that is simply tolerated. Consequently the City of Rapid City has implemented a program for comprehensive basinwide drainage design planning. This design plan was thus prepared by FMG, Inc., for the South Truck Route Drainage Basin. It is one of many design plans prepared for drainage basins in and around the City of Rapid City.

OBJECTIVE

The purpose of this design plan is to define existing and future stormwater related problems in the study area and to present a conceptual design plan for control of the problems. This conceptual design plan is intended to provide stormwater guidance to the City, County, SDDOT, developers, and others in the basin. It provides necessary information to allow the basin to be developed with proper stormwater controls.

DESIGN PLAN LIMITATIONS

It was beyond the scope of work to provide final engineering drawings suitable for construction. The Design Plan presented herein is conceptual and is intended to provide the general information necessary for the final working design of an efficient, planned system. The Design Plan is based on a practical hydraulic system which is suitable for further evaluation and implementation as the basin develops.

It is unlikely that the final design of any recommended improvement will exactly follow guidelines presented in this report; therefore, it will be necessary to make a final detailed technical analysis of the proposed improvements prior to their construction. Time lags play an important role in a planned basinwide system; thus, final project design must include a computer analysis of the entire system even if individual element design flows are smaller than those proposed in this report. The computer models used in the Design Plan allow for updating and/or modification of the design plan.

Since the plan lends itself to updating or revisions, users of the plan are advised to contact the City of Rapid City to determine if this original document has been modified.

This Design Plan provides for only major drainages. Unless specifically addressed in the report, localized or minor drainage was beyond the scope of the study.

The Design Plan runoff/routing analysis is considered an approximation since storms rarely follow ideal patterns, and other factors such as ground cover, infiltration, and channel conditions may vary with time or from assumed conditions. The intent of a hydrologic runoff/routing analysis is to provide a reasonably dependable and consistent approximation of rainfall-runoff characteristics.

The Design Plan is based on a 100 year storm event. It should be noted that larger storms can and will occur in the basin.

DESIGN PLAN WITH OPTIONAL ROUTING

As directed, various alternates were reviewed during the preparation of the plan. This final report includes a Design Plan and a Design Plan With Optional Routing. The Design Plan generally follows historical flow routes. The Design Plan With Optional Routing has two modifications of the Design Plan. The Optional Routing modifications are (1) replacing one of the historical routes with a pipeline along a new route and (2) increasing the size of one of the Design Plan metering dams. The Design Plan With Optional Routing is described in Appendix F. **The City Council approved the Design Plan With Optional Routing on September 15, 2003.**

The Design Plan With Optional Routing is included as Appendix F. This option has certain features that vary significantly from the Design Plan. These features are:

1. Element 13 will be a storm sewer that follows the route of proposed 5th Street. Element 13 will convey flow from Metering Dam 305 to the upstream end of the Element 9 channel.

2. Increase storage and decrease discharge at Metering Dam 305.

A more detailed description of the DESIGN PLAN WITH OPTIONAL ROUTING OPTION is included in Appendix F.

BASIN DESCRIPTION

GENERAL BASIN DESCRIPTION

The South Truck Route Drainage Basin is in the Rapid Creek drainage basin with portions of the basin being outside of the City limits. It is generally described as being in the southeast part of the Rapid City area. The basin is about 1,878 acres in size.

Figure 1 shows the boundary and sub-basins used for the analysis of the South Truck Route Drainage Basin.

Subdivision of a drainage basin allows flows to be calculated at various locations and then routed though a basin rather than simply assuming all runoff reaches the outlet simultaneously. There is no established rule for basin subdivision, and the sub-basins using in this study were based on specific project engineering needs and engineering judgment.

Sub-basin boundaries were established following major flow patterns and unaccounted for sub-basin transfer could occur. Unless otherwise specified it is intended that sub-basin transfer will be prevented upon plan implementation; however, owing to map scale limitations, difficulties in establishing exact flow patterns, etc., some unaccounted for sub-basin transfer may still occur.

Basin boundaries were determined from City provided aerial topography maps where possible. Digitized USGS contours were used in those areas where aerial topography was not available during the project. The maps used in the study may differ from recent City of Rapid City GIS maps.

LAND USE

In accordance with the City of Rapid City Drainage Criteria Manual this Design Plan is based on a fully developed drainage basin.

Portions of the South Truck Route Basin are currently developed. This existing development is mostly low density residential. Small areas of existing industrial, commercial, and governmental development also exist.

It is expected that future land use in the study area will be of various types. Future land use in the basin was taken from the South Robbinsdale Neighborhood Area Future Land Use Map. A copy of the future land use map is included as Figure 2.

The land use map does not include the extreme southern portion of the basin. It was assumed this area will have residential development with densities similar to the adjacent areas of like terrain on the map.

Engineering judgement was used to adjust impervious values in certain locations which were judged to be too steep to support the dense development indicated on the land use map. Overall sub-basin imperviousness will need to be verified when any significant development is proposed in the basin.

If land use or imperviousness changes from that assumed it will be necessary to remodel the basins involved to determine the effects of the changes. Increased imperviousness may require an increase in detention storage or other improvements such as larger channels or pipes. A significant decrease in imperviousness may allow for downsizing of improvements.

TOPOGRAPHY AND SPECIAL FEATURES

Basin topography is characteristic of the interface between foothills and plains. The lowest point in the basin is at about elevation 3200 feet. The maximum elevation is at about elevation 3840 feet.

Several major roadways exist or are planned in the study area. These include the South Truck Route, 5th Street, Elm Avenue, Parkview Drive, Highway 79, Highway 16, and Rearage Roads. These are shown on the Future Land Use map.

Significant highway improvements are planned by SDDOT as part of the Heartland Express project. These include a grade separated interchange at the Highway 79/Truck Route intersection and an extension of the Truck Route to the east.

A portion of the Rapid City Sanitary Landfill site is in the study area.

EXISTING PROBLEMS

There are few existing problems due to the small areas of existing development. A brief description of some of the existing or potential problems is given below.

The existing box culvert under Highway 79 is undersized and will cause significant ponding. Overtopping of Highway 79 with resultant flow splits out of the study area will also occur. This flow split would be directed north into the South Robbinsdale Basin.

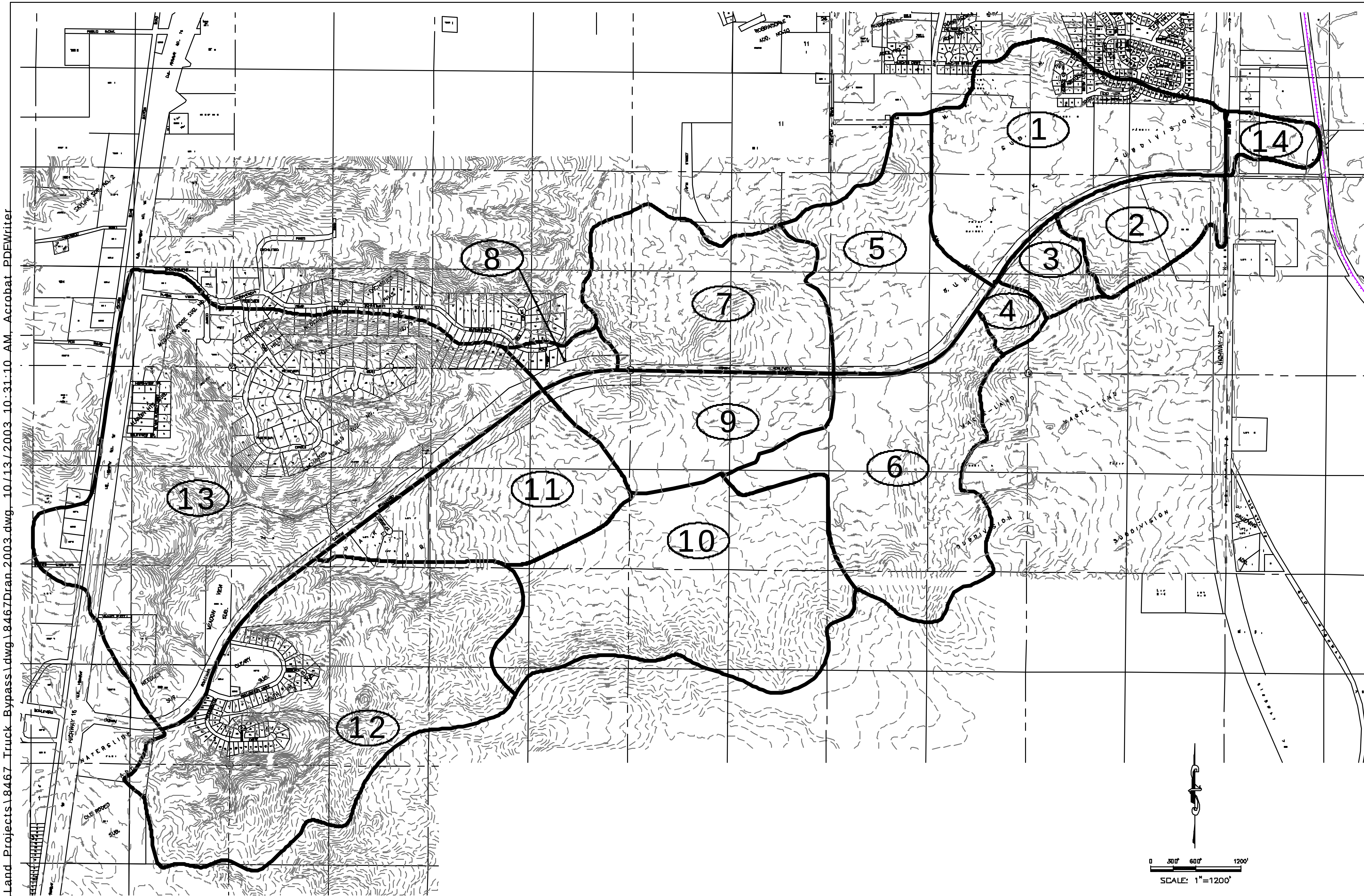
Defined channels in the lower reaches of the study area have capacity for only small flows. High flows will spread over large areas. The channel downstream of Highway 79 has only minor capacity due to fill and debris.

Several channels in the basin are "steep." These channels can be expected to experience severe degradation when the basin is developed and runoff occurs frequently.

FLOODPLAINS AND WETLANDS

There is a FEMA Zone A floodplain at the extreme downstream limit of the study area. This area is generally located between Highway 79 and the railroad tracks.

Several areas of wetlands exist in the basin. These include linear wetlands, stock ponds, swampy areas, and other general wetland areas. Wetland mitigation may be required as a result of hydraulic improvements recommended in this plan. It was beyond the scope of work to determine wetland areas or make mitigation recommendations.



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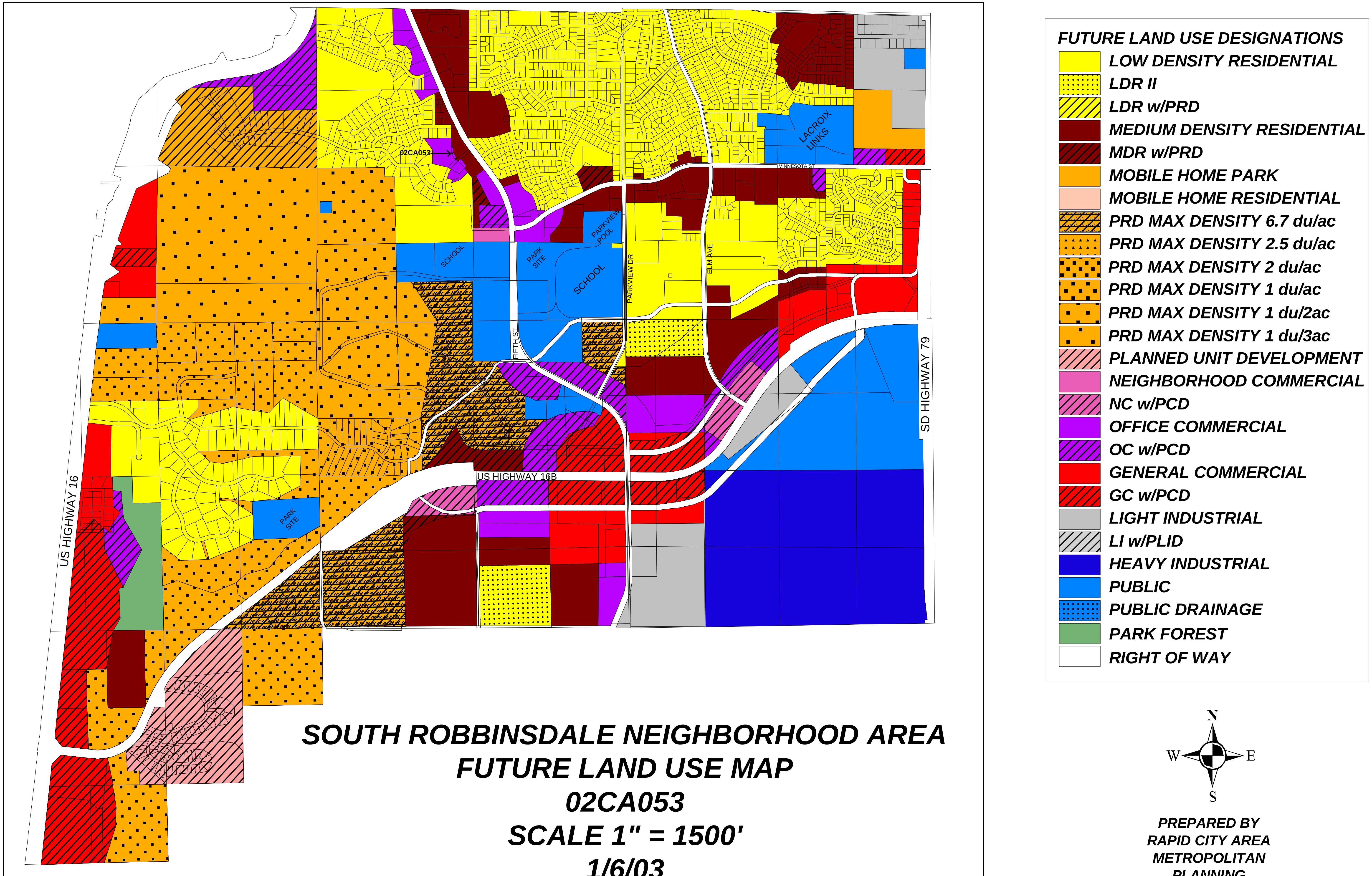
OCTOBER, 2003

SOUTH TRUCK ROUTE
DRAINAGE BASIN DESIGN PLAN
RAPID CITY, SOUTH DAKOTA

Revision / Date

Sheet Name:
SUB-BASINS

Figure Number:
1



SOUTH ROBBINSDALE NEIGHBORHOOD AREA
FUTURE LAND USE MAP
02CA053
SCALE 1" = 1500'
1/6/03

PREPARED BY
RAPID CITY AREA
METROPOLITAN
PLANNING
ORGANIZATION

D:/Landuse/SRob02CA053

DESIGN PLAN

GENERAL

Preparing the Design Plan involved completion of various tasks in an orderly process. The process involved sub-basin flow calculations, routing of the flows, problem identification, and evaluation of proposed solutions. A basinwide approach was used to determine effects of flows, problems, and improvements on the entire basin.

The entire basin was subdivided into numerous smaller basins with a network of hydraulic elements connecting the sub-basins. Flows were then calculated and routed using CUHPF95 and UDSWM95 computer models. After flows were calculated for various scenarios it was possible to identify problems and begin the design analysis.

After completion of the above steps, the analysis became a systematic evaluation of solutions. Economics, development needs, restrictions from existing infrastructure, and engineering judgment were included in the design plan evaluation and recommendation process.

The result of the above process is the SOUTH TRUCK ROUTE DRAINAGE BASIN DESIGN PLAN. This plan is not intended to be a final project design suitable for construction. Detailed survey, engineering analysis, and project design are necessary prior to implementation of any proposed improvement.

The Design Plan presented herein is conceptual and is intended to provide the general information necessary for the final design of a planned drainage system. It has been prepared within the limits of computer modeling to provide a functional drainage development guide. Rarely will a drainage basin respond and develop exactly as assumed; thus, this design is based on a practical hydraulic system that is suitable for further evaluation as the basin develops, improvements become necessary, or various changes are requested.

Since the plan lends itself to updating or revisions, users of the plan are advised to check with the City of Rapid City to determine if this original document has been modified.

DESIGN PLAN OVERVIEW

In accordance with the City of Rapid City Drainage Criteria Manual, the Design Plan presented herein is based on a 100 year storm occurring in a fully developed basin. Two-year and ten-year flows were also calculated to help in evaluation of problems and proposed improvements.

The Design Plan is generally described as a series of detention ponds interconnected with an open channel flow system. The Design Plan recommends channel improvements, new roadway crossings, new storm sewers, and metering ponds.

New metering dams are proposed in addition to improvements to existing metering ponds. Pond 205 is of sufficient size to be considered a Small Dam by State of South Dakota regulations.

Improvements to many existing channels are recommended even though the existing channel system generally has adequate capacity. Many of these channels would have a wide floodplain. It was assumed that developers would want to regrade channels to minimize the flooded area. Furthermore, most of the channels are steep or otherwise erosive. These steep channels would require significant erosion control devices, including check structures and bank protection, to prevent channel and bank degradation from frequent urbanized flows.

There are existing wetlands along various channels. The roughness value for most new channels was assumed as 0.045 to account for a certain amount of "wetland" channel bottoms that are assumed necessary for wetland mitigation or for expected future requirements for "water quality" type channels.

Recommendations are made for crossings of the various major streets shown on the City Major Street Plan. Other street crossings are likely when the basin develops; however, recommendations for those crossings are beyond the scope of the project. It will be necessary for others to evaluate future roadway crossings when they are proposed. These crossings will create a certain amount of unaccounted for detention storage thus providing a certain amount of additional safety factor for the design plan.

Several stock ponds are located in the study area. Unless otherwise noted these ponds are recommended for removal. Wetland mitigation may be necessary as part of the stock pond removal.

Numerous plan summaries are given in figures and tables at the back of this chapter; however, the user is cautioned to refer to the INDIVIDUAL ELEMENT DESIGN section for a complete understanding of the design plan. The user should also be familiar with the HYDROLOGY and HYDRAULICS chapters. A summary of design plan recommendations and estimated costs of each element is given as Table 1; a summary of peak flows for the sub-basins is given as Table 2; and a summary of individual element peak routed flows with various conditions is given as Table 3. A schematic of the design plan hydrologic routing network is shown on Figure 4. A schematic of the existing condition hydrologic routing network is shown on Figure 5.

Design plan hydrographs for direct flow elements and detention ponds are included as Appendix A. CUHPF95 and UDSWM95 computer printouts are included as Appendix B – D. Appendix E includes an HY8 printout for Element 2 improvements and normal depth printouts for various elements. Hydrologic Schematic drawings at 1” = 400’ are under separate cover.

COST ESTIMATE

Recommended Design Plan improvements are estimated to cost $3,915,000.00. The cost estimate is itemized by element on Table 1. A description of each recommended improvement is given in the INDIVIDUAL ELEMENT DESIGN section of this chapter.

The total cost estimate includes a 5% contingency and 25% engineering/administration costs. Cost estimates do not include costs of land or easement acquisition as it has been assumed that easements or right-of-way would be dedicated in accordance with city subdivision regulations. Cost estimates do not include any costs for utility adjustments or multiple purpose improvements. The estimate has been prepared without the benefit of design drawings and could vary significantly upon final project design.

Many of the proposed improvements will be constructed by developers as part of the land development projects. As directed by the City, the cost estimate includes the improvements that are anticipated to be constructed by developers. The cost estimate also includes projects by SDDOT as part of highway improvement projects.

INDIVIDUAL ELEMENT DESIGN

Following is a discussion of each element used in the Design Plan. This section expands on the summarized information presented in the Design Plan overview. Included is a description of each proposed design plan element, special problems encountered, design data, recommendations, and other appropriate information.

The user should also read the RECOMMENDATIONS section of this chapter for additional overall design requirements.

Unless otherwise noted the flow and storage data given in the following narrative refers to the 100 year storm. The reader can refer to the various tables and computer printouts for 2 year and 10 year flow information. Unless otherwise described, the following individual element discussion assumes full implementation of all Design Plan elements.

<u>ELEMENT 1</u>

Element 1 is an existing open channel beginning at Element 100 and ending at Element 2. The existing channel is undersized, has various areas of random filling, and has undersized culvert crossings. Improvements are recommended.

It is recommended that a new channel be graded throughout the entire length of element. The property owner in this area has proposed grading a new channel along the south side of their property. They have had preliminary discussions with SDDOT about this channel location as part of right of way negotiations for the proposed Southeast Connector Highway.

It is recommended the new channel be graded along the south side of the site as proposed by the property owner. The channel could remain in the existing location; however, grading will be very expensive due to extensive areas of rubble. Final design of the channel should be coordinated with SDDOT plans for the proposed Southeast Connector Highway.

Design discharge for the channel is 1,077 cfs as calculated at Element 100. The recommended channel has a 35' bottom, 4:1 side slopes, n value of 0.045, and an invert slope of 0.005 ft/ft. Normal depth for 1,077 cfs is about 4.2 feet and velocity is 5.0 fps. Based on a preliminary review of grades it is judged that drop structures will not be necessary.

Element 1 was UDSWM95 modeled with the above data. The n value was increased by 25% for modeling as suggested in the User manual.

ELEMENT 2

Element 2 represents the existing 10' x 8' concrete box culvert under Highway 79. Element 2 is the outlet structure for metering pond Element 200. SDDOT is proposing to extend both ends of the culvert as part of the Heartland Express project. Modifications to the SDDOT preliminary design are recommended.

The design flow approaching Element 2 is 1,118 cfs as calculated at Element 101. Final flow through the box culvert will be reduced slightly to 1,073 cfs as a result of metering pond Element 200.

Preliminary plans prepared by SDDOT indicate a skewed inlet extension as well as a flared wingwall inlet opening. It is recommended that a side tapered inlet be used in lieu of the flared wingwall opening. Grading improvements in the inlet area are recommended under Element 200.

A preliminary HY8 analysis, including assumptions, for a side tapered inlet is included in Appendix E. The box culvert is further discussed under Element 200.

Other alternates to a side tapered inlet could be investigated. These would include (1) a transition/acceleration chute such that the box acts as an "open channel" rather than a culvert or (2) install a parallel culvert system. If either of these options are selected it may be necessary to revise or eliminate metering pond Element 200.

It is recommended that the outlet extension be aligned with the new channel proposed under Element 1.

Overtopping of Highway 79 was not considered as an option because (1) the RCDCM does not allow overtopping of arterial roadway and (2) portions of the overtopping flows would divert to the South Robbinsdale Drainage Basin.

ELEMENT 3

Element 3 is an existing open channel beginning at Element 101 and ending at Element 304. The existing channel would be adequate; however, a new channel is recommended as a result of the Southeast Connector Project and proposed adjacent land development.

Design discharge for the channel is 43 cfs as calculated at Element 304. The recommended channel has a 5' bottom, 4:1 side slopes, n value of 0.035, and an invert slope of 0.012 ft/ft. Normal depth is about 1.2 feet and velocity is 3.9 fps.

Element 3 was UDSWM95 modeled with the above data. The n value was increased by 25% for modeling as suggested in the User manual.

ELEMENT 4

Element 4 is an existing open channel beginning at Element 101 and ending at Element 6. The existing channel is poorly defined for all but low flows. A new channel is recommended as a result of proposed development in the area.

A layout plats of the Element 4 area is on file at the City Planning Office. A new channel, including certain areas of relocation, is shown on that layout and discussed in an Interim Drainage Report that was submitted with that layout.

Design discharge for the channel is about 1,118 cfs as calculated at Element 101. The recommended channel has a 35' bottom, 4:1 side slopes, n value of 0.045, and an invert slope of 0.007 ft/ft. Normal depth is about 3.9 feet and velocity is 5.7 fps.

Drop structures will be required to flatten grade. Roadways are expected to cross Elements 4 and it may be possible to use those roadway crossings as drop structures.

Element 4 was UDSWM95 modeled with the above data. The n value was increased by 25% for modeling as suggested in the User manual.

In addition to channel improvements it is recommended that property upstream of Highway 79 adjacent to Element 4 be elevated above the Highway 79/Pond 200 overtopping elevations. This will provide freeboard as a safety factor against backwater from culvert plugging or larger than expected flows. Filling of this upstream land was not been included in the cost estimate.

The preliminary design of Elm Avenue shown in the 1994 South Robbinsdale Corridor Study indicates a significant roadway cut in the area of the Elm Street crossing. This cut requires lowering of the Element 7 channel which may also influence final design of Element 4.

It is recommended that the existing stock dam midway along Element 4 be removed.

ELEMENT 5

Element 5 is an existing open channel beginning at Element 4 and ending at metering pond Element 201. A new channel is recommended as a result of proposed development in the area.

Preliminary design discharge for the channel is 57 cfs as calculated at Element 201. Depending upon final development it is possible additional localized flows could be discharged to this channel. The final design discharge should be increased for these flows as required.

The recommended channel has a 5' bottom, 4:1 side slopes, and an n value of 0.035. Because of terrain it is likely that slopes will vary from about 1% to about 2.5%. At a slope of 1% the normal depth is about 1.4 feet and velocity is 4.0 fps. At a slope of 2.5% the normal depth is about 1.1 feet and velocity is 5.5 fps. The Froude Number with the 2.5% slope is 1.1 which exceeds the 0.8 value allowed by the RCDCM. Geotextile lining of the channel where the Froude Number exceeds 0.8 is recommended.

An option to an improved channel is a storm sewer with capacity for 57 cfs. The estimated pipe size is a 36" RCP.

Element 5 was UDSWM95 modeled with the above data. The n value was increased by 25% for modeling as suggested in the User manual. An averaged slope of 2% was used for modeling.

ELEMENT 6

Element 6 is an existing open channel beginning at the confluence of Elements 4 and 5 and ending at Element 7. The existing channel is poorly defined for all but low flows. A new channel is recommended as a result of proposed development in the area.

A layout plat of the Element 6 area is on file at the City Planning Office. A new channel location is shown on that layout plat.

Routed flow in Element 6 is 936 cfs. It is recommended the design discharge be increased to about 1,050 cfs to account for additional inflows from sub-basin 1. The recommended channel has a 30' bottom, 4:1 side slopes, n value of 0.045, and an invert slope of 0.007 ft/ft. Normal depth is about 4.0 feet and velocity is 5.7 fps. Drop structures will be required to flatten grade.

The preliminary design of Elm Avenue shown in the 1994 South Robbinsdale Corridor Study indicates a significant roadway cut in the area of the Elm Avenue crossing. This cut requires lowering of the Element 7 channel which may also influence final design of Elements 4 and 6.

Element 6 was UDSWM95 modeled with the above data. The n value was increased by 25% for modeling as suggested in the User manual.

<u>ELEMENT 7</u>

Element 7 is an existing open channel beginning at Element 6 and ending at Element 102. The existing channel is poorly defined for all but low flows. A new channel is recommended as a result of proposed development in the area.

A layout plat of the Element 7 area is on file at the City Planning Office. A new channel location is shown on that layout plat.

Routed flow in Element 7 is 564 cfs. It is recommended the design discharge be increased to about 800 cfs to account for additional inflows from sub-basin 1. The recommended channel has a 20' bottom, 4:1 side slopes, n value of 0.045, and an invert slope of 0.007 ft/ft. Normal depth is about 4.1 feet and velocity is 5.4 fps.

Element 7 was UDSWM95 modeled with the above data. The n value was increased by 25% for modeling as suggested in the User manual.

The preliminary design of Elm Avenue shown in the 1994 South Robbinsdale Corridor Study indicates a significant roadway cut in the area of the Elm Avenue crossing. The roadway low point is shown as being about 5’ lower than the existing channel bottom. This roadway cut results in the Element 7 channel being substantially lower than existing grade. This channel lowering will influence the channel design and drop structure requirements for significant distances upstream and downstream of the crossing. Final design of the roadway should include a review of the upstream and downstream channels. Consideration should be given to raising the proposed roadway grade to reduce the required channel cut.

A 14’ x 5’ RC Box Culvert is proposed for the Elm Avenue crossing. The 100 year design flow at this crossing is 629 cfs as determined by Element 102. Elm Avenue is currently defined as an Arterial Street; therefore, the crossing needs to pass the 100 year flow with no overtopping. Final design of the crossing will depend upon final road and channel grades.

ELEMENT 8

Element 8 is an existing open channel beginning at Element 102 and ending at the confluence of Elements 9 and 13. The existing channel is "steep" and poorly defined for all but low flows. A new channel is recommended in order to flatten grade and to better allow for development in the area.

Routed flow in the channel is 324 cfs. Since most of sub-basin 5 drains to Element 8 the recommended design discharge is 629 cfs as calculated at Element 102. The recommended channel has a 15' bottom, 4:1 side slopes, n value of 0.045, and an invert slope of 0.007 ft/ft. Normal depth is about 3.9 feet and velocity is 5.2 fps.

Drop structures will be required to flatten grade. The drop structures can be at various locations such as the inlet to the Elm Avenue crossing or along the channel as required.

Element 8 was UDSWM95 modeled with the above data. The n value was increased by 25% for modeling as suggested in the User manual.

ELEMENT 9

Element 9 is an existing open channel beginning at Element 8 and ending at metering pond Element 301. The existing channel is "steep" and poorly defined for all but low flows. A new channel is recommended in order to flatten grade and to better allow for development in the area.

Routed flow in the channel is 121 cfs. A certain amount of additional localized flow will also enter the channel from sub-basin 5. It will be necessary to determine the added flows when final development is proposed. A design discharge of 300 cfs was assumed for the purpose of preliminary channel size recommendations.

The recommended channel has an 8' bottom, 4:1 side slopes, n value of 0.045, and an invert slope of 0.008 ft/ft. Normal depth using 300 cfs is about 3.2 feet and velocity is 4.6 fps. Drop structures will be required to flatten grade. The drop structures can be at various locations such as the outlet from the Element 301 pipe, at local road crossings, or along the channel as required.

Element 9 was UDSWM95 modeled with the above data. The n value was increased by 25% for modeling as suggested in the User manual.

An alternate to drop structures may be to use a steeper channel grade with a geotextile liner.

ELEMENTS 10, 12, and 31

Elements 10, 12, and 31 are existing open channels beginning at Element 6 and ending at the Element 203. The existing channels are steep and poorly defined for all but low flows. Flows that would exceed the capacity of the defined channel will spill into a broad floodplain area.

Improved channels are recommended. The Design Plan route generally follows the route of the primary existing channels.

Routed flow in Element 10 is 677 cfs. It is recommended that the design discharge at the lower end of element 10 be increased to about 750 cfs to account for a certain amount of inflow from sub-basin 1. The recommended Element 10 channel has a 20' bottom, 4:1 side slopes, n value of 0.045, and an invert slope of 0.007 ft/ft. Normal depth is about 3.9 feet and velocity is 5.3 fps.

Routed flow in Element 12 is 672 cfs. This is the flow used for channel design since only insignificant flows from the adjacent sub-basins would enter the channel. The recommended Element 12 channel has a 20' bottom, 4:1 side slopes, n value of 0.045, and an invert slope of 0.007 ft/ft. Normal depth is about 3.7 feet and velocity is 5.2 fps.

Routed flow in Element 31 is 672 cfs. This is the flow used for channel design since only insignificant flows from the adjacent sub-basins would enter the channel. The recommended Element 31 channel has a 20' bottom, 4:1 side slopes, n value of 0.045, and an invert slope of 0.007 ft/ft. Normal depth is about 3.7 feet and velocity is 5.2 fps.

It is recommended that the existing stock dam at the upstream end of Element 31 be removed. Under existing conditions the stock dam will overflow to the west and east creating a split flow situation as shown on the Existing Routing Schematic. It was judged appropriate to eliminate this split flow as part of the overall improvement recommendations in the area. Portions of the split flow would spread over wide areas and would also split over a ridge and enter the Element 8 and 13 areas. Based on discussions with City staff it is recommended that the flow split be eliminated and all flows confined to a single defined channel system when the area is developed. Elimination of the flow split results in Elements 10 and 31, including the Elm Avenue crossing, being larger than would be required with the flow split.

Drop structures will be required to flatten the channel grades. The drop structures can be at various locations such as the inlet to the Elm Avenue crossing, at the outlet of the box culvert under South Truck Route, or along the channel as required.

Elements 10, 12, and 31 were UDSWM95 modeled with the above data. The n value was increased by 25% for modeling as suggested in the User manual.

The existing channel system crosses through the future intersection of Elm Avenue and the Rearage Road. Elm Avenue is currently defined as an Arterial Street; therefore, the crossing needs to pass the 100 year flow with no overtopping. The crossing is near the upstream end of Element 10 thus 677 cfs was used for the 100 year flow at the crossing. Twin 78” RCP culverts are proposed for this crossing. Final design of the crossing will depend upon final road and channel grades.

Other channel locations may be possible depending upon future development plans for the area. It was beyond the scope of this report to determine revised locations for the channel.

ELEMENT 11

Element 11 is an existing 24" RCP under the South Truck Bypass. No improvements are necessary except for entrance modifications discussed under Element 202.

Element 11 was UDSWM95 modeled as a 36" RCP because of the increased n value required for UDSWM95. Peak routed flow is 8 cfs.

ELEMENT 12

Element 12 is described under ELEMENTS 10, 12 AND 31.

ELEMENT 13

Element 13 is an existing open channel beginning at Element 8 and ending at Element 305. The existing channel is “steep” and will likely be subject to erosion. An improved channel is recommended to flatten grades and to better allow for development in the area. The Design Plan route generally follows the route of the existing channels.

Routed flow in the channel is 207 cfs. A certain amount of additional localized flow will also enter the channel from sub-basin 5. It will be necessary to determine the added flows when final development is proposed. A design discharge of 250 cfs was assumed for the purpose of preliminary channel size recommendations.

The recommended channel has an 8' bottom, 4:1 side slopes, n value of 0.045, and an invert slope of 0.0075 ft/ft. Normal depth using 250 cfs is about 3.0 feet and velocity is 4.2 fps.

Elements 13 was UDSWM95 modeled with the above data. The n value was increased by 25% for modeling as suggested in the User manual.

Drop structures will be required to flatten grade. The drop structures can be at various locations such as the outlet from the existing pipe system under South Truck Route, at the Rearage Road, or along the channel as required.

A crossing will be required at the proposed Rearage Road shown on the Major Street Plan. The Rearage Road is proposed as a Collector Street. The Rapid City Drainage Criteria Manual limits overtopping of a Collector Street to 12” at gutter flow line (6” above top of curb.) The crossing is near the upstream end of Element 13 thus 210 cfs is the design flow used for the crossing analysis. A 54” RCP is proposed for the crossing. Final design of the culvert crossing will depend upon final overtopping geometry, road grades, and channel grades.

An option for Element 13 was approved by the City Council on September 15, 2003. In general this option is for installation of a storm sewer to carry Element 13 flows from the South Truck route crossing to near the outlet of the Element 301 metering dam. The storm sewer would be installed along future 5th Street and be sized for a minimum of 216 cfs. This option is further discussed in Appendix F.

ELEMENT 14

Element 14 is an existing open channel beginning at Element 104 and ending at Element 15. The existing channel system is "steep" and generally follows the route of a future east-west Rearage Road shown on the South Robbinsdale Neighborhood Area Future Land Use Plan. The Rearage Road is shown as a Collector Street on the Major Street Plan. Because of the location and street classification it is recommended that the channel be replaced with a storm sewer.

The storm sewer will be installed as part of development and street construction in the area. A portion of sub-basin 9 will drain to the pipe system. The pipe has been initially sized for 200 cfs which is somewhat less than the 10 year flow of 274 cfs since all of the sub-basin does not drain to the pipe. A 48" RCP with an invert slope of 0.020 ft/ft is recommended.

Additional flows from the 100 year storm will be carried on the street system above the pipe. Final design pipe capacity will have to be checked against street capacity as allowed by the RCDCM. Final design discharge is also dependent on how much of sub-basin 9 is actually intercepted by the system.

The storm sewer is to discharge to the proposed metering dam at Element 305

An option to the storm sewer would be to construct a new channel with drop structures or lining. Alternately flows could be conveyed on “on site” parking lots, swales, etc. Final improvements will be dependent upon design of the futures developments including location of the Rearage Road.

Element 14 was UDSWM95 modeled as 48" RCP with street overflow. The overflow section was modeled using recommended characteristics in the UDSWM95 manual. An invert slope of 0.020 ft/ft was used for the pipe and street.

ELEMENT 15

Element 15 is an existing open channel beginning at Element 14 and ending at metering pond Element 204. Improvements to the existing channel are recommended.

Discharge to the channel from Element 204 is 13 cfs. Based on a review of existing topography it is assumed additional flows will enter the channel from the upper reaches of sub-basin 9. These flows are not expected to be significant in size and a design discharge of 75 cfs was assumed for the purpose of preliminary channel size recommendations. It will be necessary to determine final design flow when development is proposed.

The existing channel is "steep" and varies in cross section. It is recommended the channel be reshaped to a trapezoidal section and lined with a permanent geotextile. The recommended channel has an 8' bottom, 4:1 side slopes, n value of 0.035. The invert slope will vary and has been averaged at 0.044 ft/ft for modeling. Normal depth is about 0.9 feet and velocity is 7 fps. Velocity is within allowable parameters; however, lining is recommended because of the "steep" grade and Froude Number of 1.5.

Element 15 was UDSWM95 modeled with the above data. The n value was increased by 25% for modeling as suggested in the User manual.

ELEMENT 16

Element 16 is an existing open channel beginning at Element 103 and ending at Element 306. The existing defined channel system has capacity for low flows only and high flows will spread out over large areas. The channel is steep and will be subject to erosion. An improved channel is recommended to flatten grades and to better allow for development in the area.

Discharge into the channel from Element 306 is 635 cfs. The channel will also intercept a significant amount of flow from sub-basin 6. The preliminary design discharge for the channel is 882 cfs as determined at Element 103 under the assumption that all of sub-basin 6 is drained to the channel.

The recommended channel has a 25' bottom, 4:1 side slopes, n value of 0.045, and an invert slope of 0.008 ft/ft. Normal depth is about 3.8 feet and velocity is 5.8 fps.

Drop structures will be required to adjust grade. Potential locations for drop structures are at the outlet from the metering pond at Element 306, in the channel as required, or by using a rundown chute in the metering dam at Element 203.

Element 16 was UDSWM95 modeled with the above data. The n value was increased by 25% for modeling as suggested in the User manual.

ELEMENT 17

Element 17 is an existing open channel beginning at Element 306 and ending at the confluence of Elements 18 and 19. The existing channel is "steep" and an improved channel is recommended.

Design discharge for the channel is 833 cfs as calculated at Element 105. The recommended channel has a 20' bottom, 4:1 side slopes, n value of 0.045, and an invert slope of 0.0075 ft/ft. Drop structures will be required to flatten grade. Normal depth is about 4.1 feet and velocity is 5.6 fps.

Element 17 was UDSWM95 modeled with the above data. The n value was increased by 25% for modeling as suggested in the User manual.

It is recommended that the existing stock dam in Element 17 will be removed. If the dam is left in place a new spillway will be required.

Element 17 has a number of trees along certain reaches. An option to a graded channel may be to install stabilization structures thus preserving the natural channel and trees. Flow capacity of the natural channel would have to be verified.

ELEMENT 18

Element 18 is an existing open channel beginning at Element 17 and ending at metering pond Element 300. The existing channel is "steep" and follows the route of a proposed future road shown on the future land use plan for part of its route. An improved channel is recommended to parallel the future road.

Discharge into the channel is 252 cfs from metering pond Element 300. The channel will also receive flows from the upper reaches of sub-basin 10. The preliminary design discharge for the channel has thus been assumed as 400 cfs. It will be necessary to determine the final design flow when final development of adjacent areas is proposed.

The recommended channel has an 8' bottom, 4:1 side slopes, n value of 0.045, and an invert slope of 0.008 ft/ft. Drop structures will be required to flatten grade. Normal depth is about 3.6 feet and velocity is 4.9 fps.

Element 18 was UDSWM95 modeled with the above data. The n value was increased by 25% for modeling as suggested in the User manual.

Element 18 has a number of trees along certain reaches. An option to a graded channel may be to install channel stabilization structures thus preserving the natural channel and trees. Flow capacity of the natural channel would have to be verified.

The South Robbinsdale Future Land Use Plan shows an east-west road and north-south road in the Element 17 area. It may be possible to use these street crossings for drop structures or for additional metering.

ELEMENT 19

Element 19 is an existing open channel beginning at Element 17 and ending at metering pond Element 302. The existing channel is "steep" and an improved channel is recommended.

Design discharge for the channel is 229 cfs as calculated at Element 302. The recommended channel has an 8' bottom, 4:1 side slopes, n value of 0.045, and an invert slope of 0.0080 ft/ft. Drop structures will be required to flatten grade. Normal depth is about 2.8 feet and velocity is 4.3 fps.

Element 19 was UDSWM95 modeled with the above data. The n value was increased by 25% for modeling as suggested in the User manual.

Developers may wish to preserve the natural channel in the Element 19 area. An option to a graded channel may be to install channel check structures thus preserving the natural channel and trees. Flow capacity of the natural channel would have to be verified.

ELEMENT 20

Element 20 is an existing open channel beginning at Element 106 and ending at metering pond Element 205. Improvements are recommended.

Discharge to the channel from Pond 205 is 177 cfs. Based on a review of existing topography it is assumed additional flows will enter the channel from portions of sub-basin 11. Peak flow from Pond 205 will occur "late" due to staging and sub-basin 11 flows will have little effect on the peak discharge. A design discharge of 200 cfs was assumed for the purpose of preliminary channel size recommendations. It will be necessary to determine the final design flows when final development is proposed.

The upper portion of Element 20, between the Pond 205 discharge and the historic channel, is about 9% in grade and is adjacent to the Pond 205 fill slope. It is recommended this upper portion of the channel be reshaped to a trapezoidal section and armored. It is recommended this section of the channel be designed for about 615 cfs which is the maximum allowable emergency discharge capacity from the Pond 205 pipe. For the purposes of this report it is assumed that gabions will be used for the channel armor.

The recommended channel for the armored section has a 12' bottom and 4:1 side slopes. Depth for the 100 year flow of 177 cfs is about 1 foot and velocity is about 12 fps. Depth for 615 cfs is about 1.9 feet and velocity is about 16.5 fps. The 100 year velocity of 12 fps meets requirements of the RCDCM of 15 fps maximum for gabions. The emergency flow velocity of 16.5 fps exceeds RCDCM requirements but is less than the 19 fps critical velocity indicated in Gabion manufacturer manuals. Refer to ELEMENT 205 for additional discussion regarding this channel section.

The existing channel section between the gabion lining and Element 106 is adequate and only minor improvements are necessary. The channel is "bordering" on being "steep" and it is recommended that erosion control check structures be placed in the natural low flow channel.

It is recommended that the existing stock pond midway along Element 20 be removed or an adequate emergency spillway be graded.

Element 20 was UDSWM95 modeled with the averaged channel data. Modeling used a 10' bottom, 4:1 side slopes, invert slope of 0.029 ft/ft, and an n value of 0.056.

ELEMENT 30

Element 30 is not used in the Design Plan. It is used to carry split flow from Element 130 in the existing condition model.

ELEMENT 31

Element 31 is described under ELEMENTS 10, 12 AND 31.

ELEMENT 100

Element 100 is a direct flow element. It summarizes flow from sub-basin 14 and Element 1 to provide the final discharge hydrograph from the study area. Peak 100 year flow is 1,077 cfs.

ELEMENT 101

Element 101 is a direct flow element. It summarizes flow from sub-basin 1, Element 3 and Element 4 to provide an inflow hydrograph to metering pond Element 200. Peak 100 year flow is 1,118 cfs.

ELEMENT 102

Element 102 is a direct flow element. It summarizes flow from sub-basin 5 and Element 8 to provide a hydrograph at the Elm Avenue crossing. Peak 100 year flow is 629 cfs.

ELEMENT 103

Element 103 is a direct flow element. It summarizes flow from sub-basin 6 and Element 16 to provide an inflow hydrograph to metering pond Element 203. Peak 100 year flow is 882 cfs.

ELEMENT 104

Element 104 is a direct flow element. It summarizes flow from sub-basin 9 and Element 14 to provide an inflow hydrograph to metering pond Element 305. Peak 100 year flow is 500 cfs.

ELEMENT 105

Element 105 is a direct flow element. It summarizes flow from sub-basin 10 and Element 17 to provide an inflow hydrograph to metering pond Element 306. Peak 100 year flow is 833 cfs.

ELEMENT 106

Element 106 is a direct flow element. It summarizes flow from sub-basin 11 and Element 20 to provide an inflow hydrograph to metering pond Element 302. Peak 100 year flow is 545 cfs.

ELEMENT 130

Element 130 is a direct flow element. Element 130 is located at an existing stock dam that is recommended for removal. Under existing conditions Element 130 creates a flow split. The Design Plan recommends that the flow split be eliminated. This is discussed under ELEMENTS 10, 12, and 31. Peak flow at Element 130 is 672 cfs.

The flow split was modeled in the existing condition analysis. The existing flow split in the vicinity of Element 130 was approximated as:

INFLOW (CFS)	TO #30 (CFS)	TO #31 (CFS)
0	0	0
20	0	20
230	50	180
375	95	280
680	190	490
800	225	575

ELEMENT 200

Element 200 is an existing metering pond area created by Highway 79. Modifications to outlet system are necessary. The storage area will also be modified.

The existing outlet is the Element 2 box culvert. It is recommended that the outlet be modified to increase capacity as discussed under Element 2.

The existing Highway 79 crossing and existing upstream ground conditions create a significant backwater pool. This existing large storage pool will be slightly reduced by placement of roadway embankment for the proposed Southeast Connector/Highway 79 interchange. Filling for development in the upstream area will also reduce the storage pool. An existing layout plat and Interim Drainage Basin Design Plan on file at the City indicate no metering pond storage at this area. However, a certain amount of ponding area will remain between the proposed roadway embankments and development fill.

Element 200 is at the bottom of the study area and results in a slight reduction in flows. It has been modeled as a metering dam per the request of City staff.

Peak inflow is 1,118 cfs and peak outflow is 1,073 cfs. The 100 year water elevation is calculated at about elevation 3228.5 with storage of 7.3 acre foot. Preliminary SDDOT plans show the flow line of the proposed box culvert inlet at elevation 3217.01.

A ditch block north of the box culvert will be necessary to prevent flow splits into the Highway 79 ditch north of the box culvert. Any flow splits would enter the west ditch line which drains into the South Robbinsdale Drainage Basin.

Stage/storage/discharge data for Element 200 is given below. Data given below assumes top of ditch block at elevation 3229. The discharge data is based on an improved box culvert inlet as discussed under Element 2.

STAGE/STORAGE/DISCHARGE DATA – ELEMENT 200

ELEVATION	STORAGE (AC-FT)	DISCHARGE (CFS)
3217	0	0
3220	0.5	75
3225	4.0	650
3229	8.0	1,170

ELEMENT 201

Element 201 is an existing metering pond area created by the South Truck Route. The only recommended improvement is a ditch block to increase storage capacity.

The pond outlet is a 36" RCP at flow line elevation 3269.1. The existing overflow into the South Truck Route ditch is at about elevation 3271.2. It is recommended a ditch block be installed to increase storage to elevation 3274.
Peak inflow is 112 cfs and peak outflow is 57 cfs. The 100 year water elevation is calculated at about elevation 3274 with 1.7 acre feet of storage.

Stage/storage/discharge data for Element 201 is given below.

STAGE/STORAGE/DISCHARGE DATA – ELEMENT 201

ELEVATION	STORAGE (AC-FT)	DISCHARGE (CFS)
3269.1	0	0
3270	0.1	6
3271.2	0.3	20
3272	0.6	35
3274	1.8	60

ELEMENT 202

Element 202 is an existing metering pond area created by the South Truck Route. It is recommended that the existing 24" RCP outlet pipe be necked down to function as a 12" orifice.

Pond flow line is at elevation 3296.4. The existing overflow into the South Truck Route ditch is at about elevation 3303.5.

Peak inflow is 49 cfs and peak outflow is 8 cfs. The 100 year water elevation is calculated at about elevation 3301.5 with 1.9 acre feet of storage.

Stage/storage/discharge data for Element 202 is given below. The discharge curve assumes no overflow below elevation 3304.

STAGE/STORAGE/DISCHARGE DATA – ELEMENT 202

ELEVATION	STORAGE (AC-FT)	DISCHARGE (CFS)
3296.4	0	0
3298	0.2	4
3300	0.7	7
3302	2.7	9
3304	4.2	10

ELEMENT 203

Element 203 is an existing metering pond area created by the South Truck Route. Improvements are recommended.

The existing metering dam area is limited in capacity due to freeboard requirements at the existing roadway. Overtopping characteristics are poor and development is expected in areas where overflow would occur. Consequently it was judged reasonable to assume that a minimum of 2 to 3 feet of freeboard should be provided at the highway. Two feet of freeboard resulted in only about 24 acre-feet of storage being available. It was not possible to grade for measurable extra storage since existing storage at roadway overflow is about 45 acre-feet which approaches South Dakota limits for Small Dams.

Due to the above limitations it is recommended that a new embankment be constructed about 300 feet upstream of the existing roadway crossing. This will create a new metering dam with more volume. The dam embankment will be between the South Truck Route embankment and natural high ground to the south. A certain amount of pool excavation is also required.

Top of dam is proposed at elevation 3306.0, a splillway is proposed at elevation 3302.0, and pond flow line is at elevation 3294.0.

The outlet system is staged. The proposed outlet is a 78” RCP with riser box for low flow control. The riser will have a 48” diameter orifice for low flow control at flow line elevation 3294.0. Top of riser box is proposed at elevation 3330.0. The riser needs to be of adequate size such that the 78” RCP acts as control for higher flows rather than the riser overflow weir. A 20’ overflow spillway through the embankment is also required at elevation 3302.0 for control of 100 year flows.

Peak inflow is 882 cfs and peak outflow is 672 cfs. The 100 year water elevation is calculated at about elevation 3305.0 with 34.1 acre feet of storage. The South Truck Route is at about elevation 3308 at this location.

Approximately one foot of freeboard has been provided between the calculated highwater elevation and top of embankment. About 13 acre feet of additional storage is available in the freeboard area. The dam could be raised for additional freeboard but this would create a Small Dam as regulated by the State of South Dakota.

Stage/storage/discharge data for Element 203 is given below.

STAGE/STORAGE/DISCHARGE DATA – ELEMENT 203

ELEVATION	STORAGE (AC-FT)	DISCHARGE (CFS)
3294	0	0
3296	1.0	18
3298	4.0	65
3299	7.0	92
3300	10.0	115
3302	18.0	305
3303	23.0	420
3304	30.0	570
3305	37.0	745
3306	47.0	950

It is necessary to improve the existing 8' x 8' box culvert under the South Truck Route in order to provide freeboard against roadway overtopping and so backwater from the box culvert does not influence discharge from new Pond 203. The box culvert should be improved by constructing a side tapered entrance. Preliminary calculations indicate a water elevation of about 3301.0 for 672 cfs with an improved side tapered box culvert inlet. This is about 3 feet below top of roadway, about 2 foot below the roadway ditch overflow elevation, and is below the Pond 203 overflow weir elevation. A minor amount of unaccounted for detention storage will be created by the area between the South Truck Route box culvert and the Element 203 embankment.

Another alternate to using an improved inlet at the existing box culvert would be to construct an acceleration chute so the box acts as an open channel rather as a culvert.

ELEMENT 204

Element 204 is an existing metering pond area created by the South Truck Route. Modifications to the outlet pipe are recommended.

It is recommended the existing 30" RCP outlet pipe be necked down to function as a 12" orifice between elevations 3414.8 and 3428. A riser system/overflow is recommended above elevation 3428 to allow extra inflow such that the 30" RCP controls flow.

Pond flow line is at elevation 3414.8. The existing overflow into the South Truck Route ditch is at about elevation 3431. Peak inflow is 33 cfs and peak outflow is 13 cfs. The 100 year water elevation is calculated at about elevation 3327 with 1.4 acre feet of storage.

Stage/storage/discharge data for Element 204 is given below.

STAGE/STORAGE/DISCHARGE DATA – ELEMENT 204

ELEVATION	STORAGE (AC-FT)	DISCHARGE (CFS)
3414.8	0	0
3416	0	4
3418	0	6
3420	0.1	9
3422	0.3	10
3424	0.6	11
3426	1.1	13
3428	1.8	14
3430	2.8	86
3431	3.4	90

ELEMENT 205

Element 205 is an existing metering pond created by the South Truck Route. This pond has significant storage capacity and meets the definitions of a South Dakota "Small Dam." Modifications to the outlet pipe are recommended.

The existing outlet is a 5' x 7' RC underpass. It is recommended that a riser system with low flow orifice be constructed at the underpass entrance to reduce pond discharge. Flow line of the outlet is at elevation 3459.8 and top of the proposed riser is at elevation 3468. A 24" orifice in the riser is proposed for low flow control. Orifice flow line will match outlet flow line of 3459.8. The riser is proposed as a 6' x 6' concrete box.

Peak inflow is 755 cfs and peak outflow is 177 cfs. The 100 year water elevation is calculated at about elevation 3469.5 with 61.1 acre feet of storage. Significant freeboard is available as the overflow elevation into the South Truck Route north ditch is at 3478.

Stage/storage/discharge data for Element 205 is given below.

STAGE/STORAGE/DISCHARGE DATA – ELEMENT 205

ELEVATION	STORAGE (AC-FT)	DISCHARGE (CFS)
3459.8	0	0
3465	30	31
3468	50	40
3469	57	115
3470	66	250
3475	114	515
3478	150	615

About 60 hours are required to drain the 61.1 acre-feet of storage compared to the RCDCM requirement of 72 hours maximum.

A conservation pool, estimated to be about 20 feet deep, exists below elevation 3459.8. As a safety factor the conservation pool was assumed as being full prior to any storm runoff event.

It was beyond the scope of the project to analyze the dam for "Small Dam" requirements. A lined channel is proposed along the downstream embankment for emergency flows. This is discussed under Element 20.

ELEMENT 300

Element 300 is a proposed metering dam located at the mouth of sub-basin 12.

Pond flow line is proposed at elevation 3420 and top of dam is at elevation 3440 assuming one foot of freeboard. The proposed outlet is a 48" RCP with riser for low flow control. The riser will have two 12" orifices at elevation 3420, one 12" orifice at elevation 3425, and two 12" orifices at elevation 3430. Top of riser is proposed at elevation 3435.

Peak inflow is 548 cfs and peak outflow is 252 cfs. The 100 year water elevation is calculated at about elevation 3439 with 26.0 acre feet of storage.

Stage/storage/discharge data for Element 300 is given below.

STAGE/STORAGE/DISCHARGE DATA – ELEMENT 300

ELEVATION	STORAGE (AC-FT)	DISCHARGE (CFS)
3420	0	0
3425	3	16
3430	7	32
3435	17	58
3436	18.5	132
3437	21	235
3440	30	265

The storage curve assumes a certain amount of excavation in the pool area. Storage areas were determined from USGS contours.

An option to the 15' high free standing riser would be a standpipe in the embankment with staged pipes of equivalent capacity to the recommended orifices.

ELEMENT 301

Element 301 is a proposed metering dam located at the mouth of sub-basin 7. It will be constructed as part of the extension of 5th Street. Storage and elevation data discussed below is from a report and preliminary plans prepared by Ferber Engineering Company as part of the design of the 5th Street extension.

It is recommended that the discharge system be modified from that proposed by Ferber Engineering. This is a result of the basin size in this DBDP being larger than the basin size used by Ferber Engineering. The basin size is larger because the north ditch along the South Truck Route is proposed to be drained to Pond 301.

Pond bottom is proposed at elevation 3296. The roadway low point is at about elevation 3312.5. This elevation is along the west curb line. The roadway is super elevated and top of curb on the east side is at about elevation 3314.5. Curb elevations were scaled from the preliminary engineering drawings for the street improvement project.

The proposed outlet is a 36" RCP with riser for low flow control. Flow line of the 36" RCP is 3295.0 and the pipe is assumed at 1% slope. The riser will have two 12" orifices at elevation 3296, two 12" orifices at elevation 3300, four 12" orifices at elevation 3302, and four 12" orifices at elevation 3304. Top of riser is proposed at 3306. The riser diameter will be as required for the 36" RCP. The 36" RCP, rather than the riser weir, will control flows.

Peak inflow is 700 cfs and peak outflow is 121 cfs. The 100 year water elevation is calculated at about elevation 3311.5 with 18.8 acre feet of storage.

Stage/storage/discharge data for Element 301 is given below.

STAGE/STORAGE/DISCHARGE DATA – ELEMENT 301

ELEVATION	STORAGE (AC-FT)	DISCHARGE (CFS)
3296	0.0	0
3298	0.8	9
3300	2.2	14
3302	4.0	27
3304	6.2	53
3306	8.8	87
3307	10.3	104
3308	12.0	108
3309	13.9	113
3311	18.1	120
3312	20.5	123
3314	25.8	130

It is recommended that all structures west of 5th Street be above the high side of the superelevated roadway.

ELEMENT 302

Element 302 is a proposed metering dam located at the mouth of sub-basin 11. It is assumed the embankment will be constructed as part of the local road network shown on the South Robbinsdale Neighborhood Area Future Land Use Map.

Pond flow line is proposed at elevation 3378. Top of pond is proposed at elevation 3392 which provides about 2 feet of freeboard.

The proposed outlet is a 54" RCP with riser for low flow control. The riser will have three 12" orifices at elevation 3378, three 12" orifices at elevation 3382, and three 12" orifices at elevation 3385. Top of riser is proposed at elevation 3387. The riser needs to be sized such that the 54" RCP, rather than the riser weir, controls high flows.

Peak inflow is 545 cfs and peak outflow is 229 cfs. The 100 year water elevation is calculated at about elevation 3390 with 11.7 acre feet of storage.

Stage/storage/discharge data for Element 302 is given below.

STAGE/STORAGE/DISCHARGE DATA – ELEMENT 302

ELEVATION	STORAGE (AC-FT)	DISCHARGE (CFS)
3378	0	0
3380	0.1	15
3382	2	21
3385	5	48
3387	7	72
3390	12	240
3392	17	265

ELEMENT 304

Element 304 is a proposed metering dam that will be created by the embankments for the proposed interchange at the Highway 79/South Truck Route intersection. Modifications to the drainage system shown on the SDDOT preliminary plans for a diamond interchange are recommended at this location to create the metering dam.

Pond storage volume was determined using the preliminary cross sections for the SDDOT project. Volume would have to be verified against the final design plans. It is anticipated that little or no excavation would be required. Storage is created by the proposed roadway embankments.

The preliminary roadway plans show a proposed 36" RCP at this location. It is recommended that a 24" RCP be used in lieu of the 36" RCP. A riser should be constructed on the 24" RCP for low flow control.

Flow line of the 24" RCP is proposed at elevation 3234. The riser will have one 12" orifice at elevation 3234 and top of riser is proposed at elevation 3240. Peak inflow is 227 cfs and peak outflow is 43 cfs. The 100 year water elevation is calculated at about elevation 3244.5 with 7.3 acre feet of storage.

Stage/storage/discharge data for Element 304 is given below.

STAGE/STORAGE/DISCHARGE DATA – ELEMENT 304

ELEVATION	STORAGE (AC-FT)	DISCHARGE (CFS)
3234	0	0
3238	0.5	7
3240	1.5	9
3242	3.5	37
3244	6.5	42
3246	10.0	46

ELEMENT 305

Element 305 is a proposed metering dam located at the mouth of sub-basin 9. It is assumed the embankment will be created by the extension of 5th Street south of the South Truck Route.

Pond flow line is proposed at elevation 3314. Top of pond is proposed at elevation 3324 which provides about 1.5 feet of freeboard.

The proposed outlet is a 60" RCP with riser for low flow control. The riser will have one 18" round orifice at elevation 3314. Top of riser is proposed at elevation 3320. The riser needs to be sized such that the 60" RCP, rather than the riser overflow weir, controls high flows.

Peak inflow is 500 cfs and peak outflow is 216 cfs. The 100 year water elevation is calculated at about elevation 3322.5 with 11.0 acre feet of storage.

Stage/storage/discharge data for Element 305 is given below.

STAGE/STORAGE/DISCHARGE DATA – ELEMENT 305

ELEVATION	STORAGE (AC-FT)	DISCHARGE (CFS)
3314	0	0
3316	0.7	9
3318	2.8	15
3320	6.2	18
3322	10.5	212
3324	15.3	250

The storage pool curve assumes the existing lake is drained. Pool area excavation is also required to create the proposed storage.

ELEMENT 306

Element 306 is a proposed metering dam located at the mouth of sub-basin 10. It is assumed the embankment will be created by the extension of 5th Street south of the South Truck Route.

Pond flow line is proposed at elevation 3324. Top of pond is proposed at elevation 3334 which provides about 1.0 foot of freeboard.

The proposed outlet consists of twin 72" RCP culverts with a riser box for low flow control. The riser will have one 36" round orifice at elevation 3324. Top of riser is proposed at elevation 3330. The riser needs to be sized such that the 78" culverts, rather than the riser weir, control high flows. Pool area excavation is required to create the proposed storage.

Peak inflow is 833 cfs and peak outflow is 635 cfs. The 100 year water elevation is calculated at about elevation 3333 with 16.4 acre feet of storage.

Stage/storage/discharge data for Element 306 is given below.

STAGE/STORAGE/DISCHARGE DATA – ELEMENT 306

ELEVATION	STORAGE (AC-FT)	DISCHARGE (CFS)
3324	0	0
3326	0.8	16
3328	3.5	50
3330	7.8	70
3332	13.0	560
3334	19.3	700

ADDITIONAL DESIGN RECOMMENDATIONS

As mentioned earlier it was beyond the scope of the project to provide final construction design plans and the recommendations given in the plan are conceptual in nature. It will be necessary to prepare final engineering plans for the improvements and the following recommendations are made for use during the final project design phase.

1. All improvements should be designed in accordance with proper engineering standards and in accordance with the Rapid City Drainage Criteria Manual.

2. If final detention pond curves are not practically identical to the plan recommended curves, a new computer analysis of the actual design should be performed to review basinwide impacts.

3. Future roadway crossings should be evaluated during development design to determine if they can be used for metering. These crossings will create a certain amount of unaccounted for detention storage thus providing a certain amount of additional safety factor for the design plan.

4. During final design, the conceptual sections, sizes, grades, etc., recommended in the design plan shall be checked for applicability to actual project requirements. Final design should include flow carrying characteristics, freeboard, constructability, economics, etc,. A new computer analysis using final design should be performed to review any basinwide impacts.

5. Detention pond freeboard and spillway requirements shall be determined at final design.

6. Geotechnical review and analysis was beyond the scope of the project. Geotechnical review and analysis should be completed for all metering dams. Geotechnical analysis should also be completed for other improvements as determined necessary.

7. Low flow subchannels should be considered for channels. "Wetland" or "water quality" type low flow channels should be given consideration.

8. Channel roughness and geometry should be checked against that assumed in design. Values that are different than assumed could result in either an increase or decrease in design plan flows. Modifications to the design plan may be warranted if changes are significant.

9. HEC-2 or HEC-RAS should be used to calculate water surface profiles as determined necessary for major open channels.

10. All topography and elevation data should be confirmed with field surveys prior to plan implementation or final design of recommended improvements.

11. Multiple use of channels and detention ponds for recreation purposes is recommended.

12. Water quality enhancement/protection should be considered during design of all improvements.

13. Wetland mitigation may be required as a result of hydraulic improvements recommended in this plan. It was beyond the scope of work to determine wetland areas or make mitigation recommendations. Design of channels and ponds should be done with wetland mitigation possibilities in mind.

14. The plan should be reviewed and updated on a regular basis as the basin develops.

TABLE 1 - SUMMARY OF DESIGN PLAN
RECOMMENDED IMPROVEMENTS AND ESTIMATED COSTS

NUMBER	RECOMMENDED IMPROVEMENT	ESTIMATED COST
1	Construct new channel.	$50,000.00
2	Extend both ends of box culvert, side taper inlet.	$160,000.00
3	Construct new channel.	$10,000.00
4	Construct new channel with drop structures	$225,000.00
5	Construct new channel with partial geotextile lining.	$15,000.00
6	Construct new channel with drop structures	$75,000.00
7	Construct new channel with drop structures & construct box culvert at Elm Avenue crossing.	$155,000.00
8	Construct new channel with drop structures.	$140,000.00
9	Construct new channel with drop structures.	$75,000.00
10	Construct new channel with drop structures &. construct Elm Avenue/Rearage Road crossing	$265,000.00
11	No improvements	NA
12	Construct new channel with drop structures.	$60,000.00
13	Construct new channel with drop structures & construct Rearage Road Crossing	$150,000.00
14	Replace channel with storm sewer.	$220,000.00
15	Regrade channel and line with geotextile..	$40,000.00
16	Construct new channel with drop structures.	$110,000.00
17	Construct new channel with drop structures.	$175,000.00
18	Construct new channel with drop structures.	$225,000.00
19	Construct new channel.	$15,000.00
20	Line upper segment of channel with gabions.	$160,000.00
31	Construct new channel with drop structures	$45,000.00
200	Modify existing metering pond. (Costs Under Element 2)	NA
201	Modify existing metering pond.	$2,000.00
202	Modify existing metering pond.	$3,000.00
203	Modify existing metering pond.	$140,000.00
204	Modify existing metering pond.	$5,000.00
205	Modify existing metering pond..	$15,000.00
300	New metering pond.	$65,000.00
301	New metering pond.	$110,000.00
302	New metering pond.	$75,000.00
304	Install riser to create new metering pond.	$5,000.00
305	New metering pond	$75,000.00
306	New metering pond	$150,000.00
	IMPROVEMENTS SUBTOTAL TOTAL	$3,015,000.00
	5% CONTINGENCY	$150,000.00
	25% ENGINEERING/ADMINISTRATION	$750,000.00
	TOTAL COST OF DESIGN PLAN IMPROVEMENTS	$3,915,000.00

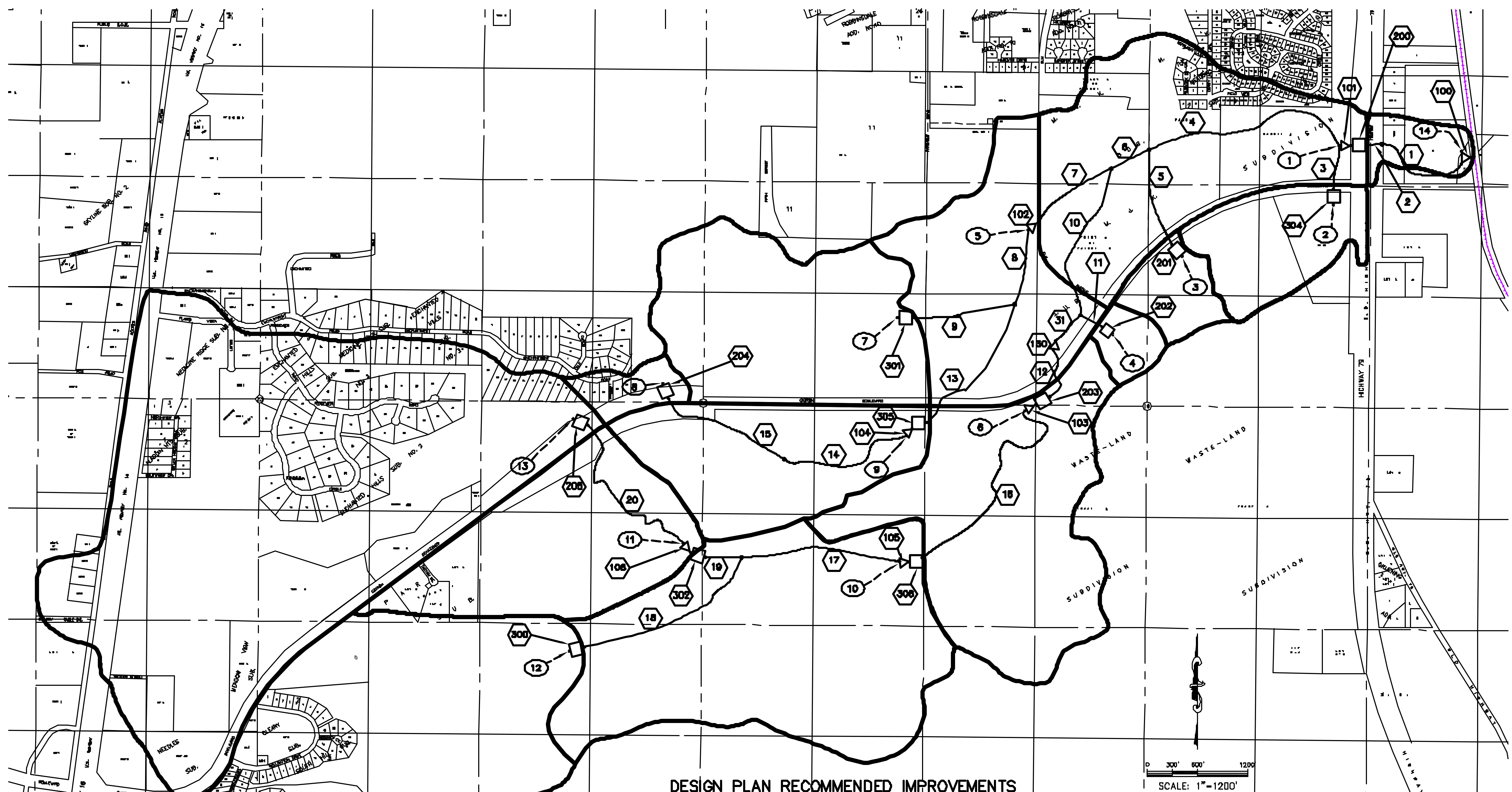
TABLE 2
PEAK SUB-BASIN FLOWS
SOUTH TRUCK ROUTE DRAINAGE BASIN DESIGN PLAN

SUB-BASIN NUMBER	SUB-BASIN SIZE (SM)	EXISTING 2 YEAR (CFS)	FUTURE 2 YEAR (CFS)	EXISTING 10 YEAR (CFS)	FUTURE 10 YEAR (CFS)	EXISTING 100 YEAR (CFS)	FUTURE 100 YEAR (CFS)
1	0.255	4	194	65	383	204	705
2	0.083	12	46	58	115	144	227
3	0.036	3	28	22	60	59	112
4	0.020	1	10	12	24	32	49
5	0.177	2	173	74	344	235	619
6	0.255	1	126	54	282	179	555
7	0.209	20	175	100	377	261	700
8	0.023	2	3	12	13	31	33
9	0.153	6	130	57	273	158	497
10	0.341	1	182	96	412	314	813
11	0.178	7	122	75	284	211	545
12	0.464	13	70	129	227	380	548
13	0.713	14	91	132	302	449	755
14	0.027	7	26	22	50	50	89

TABLE 3 - HYDRAULIC ELEMENT PEAK FLOWS (CFS) FOR SOUTH TRUCK ROUTE DRAINAGE BASIN DESIGN PLAN

ELEMENT NUMBER	EXISTING 2 YEAR (CFS)	FUTURE 2 YEAR W/O IMPROVEMENTS (CFS)	DESIGN PLAN 2 YEAR (CFS)	EXISTING 10 YEAR (CFS)	FUTURE 10 YR W/O IMPROVEMENTS (CFS)	DESIGN PLAN 10 YEAR (CFS)	EXISTING 100 YEAR (CFS)	FUTURE 100 YR W/0 IMPROVEMENTS (CFS)	DESIGN PLAN 100 YEAR (CFS)
1*	14	381	223	386	742	490	936	1,290	1,072
2*	15	384	236	389	744	506	938	1,295	1,073
3*	12	45	9	58	109	30	145	220	43
4*	14	365	137	368	769	401	1,008	1,442	957
5*	2	18	18	17	35	36	42	57	57
6*	14	381	139	372	784	398	1001	1,483	936
7*	11	223	147	184	504	295	612	1,116	564
8*	15	215	46	157	475	140	494	973	324
9*	15	136	31	90	302	81	249	603	121
10*	9	182	76	203	383	247	498	644	677
11*	1	6	4	8	14	7	23	25	8
12*	9	236	75	262	516	244	683	882	672
13*	4	84	16	50	180	62	165	374	207
14*	1	2	2	8	9	9	27	28	13
15*	2	2	2	10	11	9	30	32	13
16*	9	178	62	225	467	216	745	1,154	624
17*	13	116	42	177	337	107	577	830	391
18*	10	59	19	117	203	51	368	521	250
19*	6	114	28	73	262	66	215	521	228
20*	5	32	9	58	110	30	189	267	175
30*	0	52	NA	60	139	NA	191	249	NA
31*	9	184	75	202	377	243	492	633	672
100	15	384	230	386	746	504	936	1,295	1,077
101	15	413	247	408	887	530	1,151	1,763	1,118
102	15	272	174	198	605	347	651	1,304	629
103	9	249	134	270	621	321	898	1,490	882
104	6	130	130	59	273	274	178	499	500
105	13	263	186	257	661	419	860	1,482	833
106	7	122	122	75	284	284	216	546	545
130	9	236	75	262	516	244	683	882	672
200	15	384	236	388	743	505	938	1,294	1,073
201	3	19	19	17	16	36	42	57	57
202	1	6	4	8	14	7	23	25	8
203	9	236	75	263	516	244	683	882	672
204	2	3	3	12	13	9	31	33	13
205	6	32	9	59	111	30	190	269	177
300	NA	NA	19	NA	NA	52	NA	NA	252
301	NA	NA	32	NA	NA	82	NA	NA	121
302	NA	NA	29	NA	NA	66	NA	NA	229
304	NA	NA	9	NA	NA	30	NA	NA	43
305	NA	NA	16	NA	NA	66	NA	NA	216
306	NA	NA	62	NA	NA	252	NA	NA	635

EXISTING – This data is for existing land use and existing hydraulic conditions; FUTURE W/O IMPROVEMENTS – This data is for future land use and existing hydraulic conditions;
DESIGN PLAN – This data is for future land use and recommended design plan hydraulic improvements; * Denotes routed flow only. See Hydraulics Chapter or Appendixes for warning and explanation.



DESIGN PLAN RECOMMENDED IMPROVEMENTS

ELEMENT	IMPROVEMENT
1	CONSTRUCT NEW CHANNEL
2	EXTEND AND IMPROVE BOX CULVERT
3	CONSTRUCT NEW CHANNEL
4	CONSTRUCT NEW CHANNEL WITH DROP STRUCTURES
5	CONSTRUCT NEW CHANNEL WITH PARTIAL GEOTEXTILE LINING
6	CONSTRUCT NEW CHANNEL WITH DROP STRUCTURES
7	CONSTRUCT NEW CHANNEL WITH DROP STRUCTURES AND CONSTRUCT BOX CULVERT AT ELM AVENUE CROSSING
8	CONSTRUCT NEW CHANNEL WITH DROP STRUCTURES
9	CONSTRUCT NEW CHANNEL WITH DROP STRUCTURES
10	CONSTRUCT NEW CHANNEL WITH DROP STRUCTURES AND CONSTRUCT CROSSING AT ELM AVENUE
11	NO IMPROVEMENTS
12	CONSTRUCT NEW CHANNEL WITH DROP STRUCTURES
13	CONSTRUCT NEW CHANNEL WITH DROP STRUCTURES AND CONSTRUCT CROSSING AT FUTURE REARAGE ROAD
14	REPLACE CHANNEL WITH STORM SEWER
15	REGRADE CHANNEL AND LINE WITH GEOTEXTILE

ELEMENT	IMPROVEMENT
16	CONSTRUCT NEW CHANNEL WITH DROP STRUCTURES
17	CONSTRUCT NEW CHANNEL WITH DROP STRUCTURES
18	CONSTRUCT NEW CHANNEL WITH DROP STRUCTURES
19	CONSTRUCT NEW CHANNEL
20	REGRADE AND ARMOE UPPER SEGMENT OF CHANNEL
200	MODIFY EXISTING METERING POND
201	MODIFY EXISTING METERING POND
202	MODIFY EXISTING METERING POND
203	MODIFY EXISTING METERING POND
204	MODIFY EXISTING METERING POND
205	MODIFY EXISTING METERING POND
300	NEW METERING POND
301	NEW METERING POND
302	NEW METERING POND
304	NEW METERING POND
305	NEW METERING POND
306	NEW METERING POND

LEGEND

- STREET — JOE STREET
- SUB-BASIN INFLOW — 2
- DIRECT FLOW ELEMENT
- DETENTION POND ELEMENT
- CHANNEL OR PIPE FLOW CONVEYANCE ELEMENT
- FLOW ELEMENT IDENTIFIER — 200

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Drawn By: NDS
Checked By: JDF

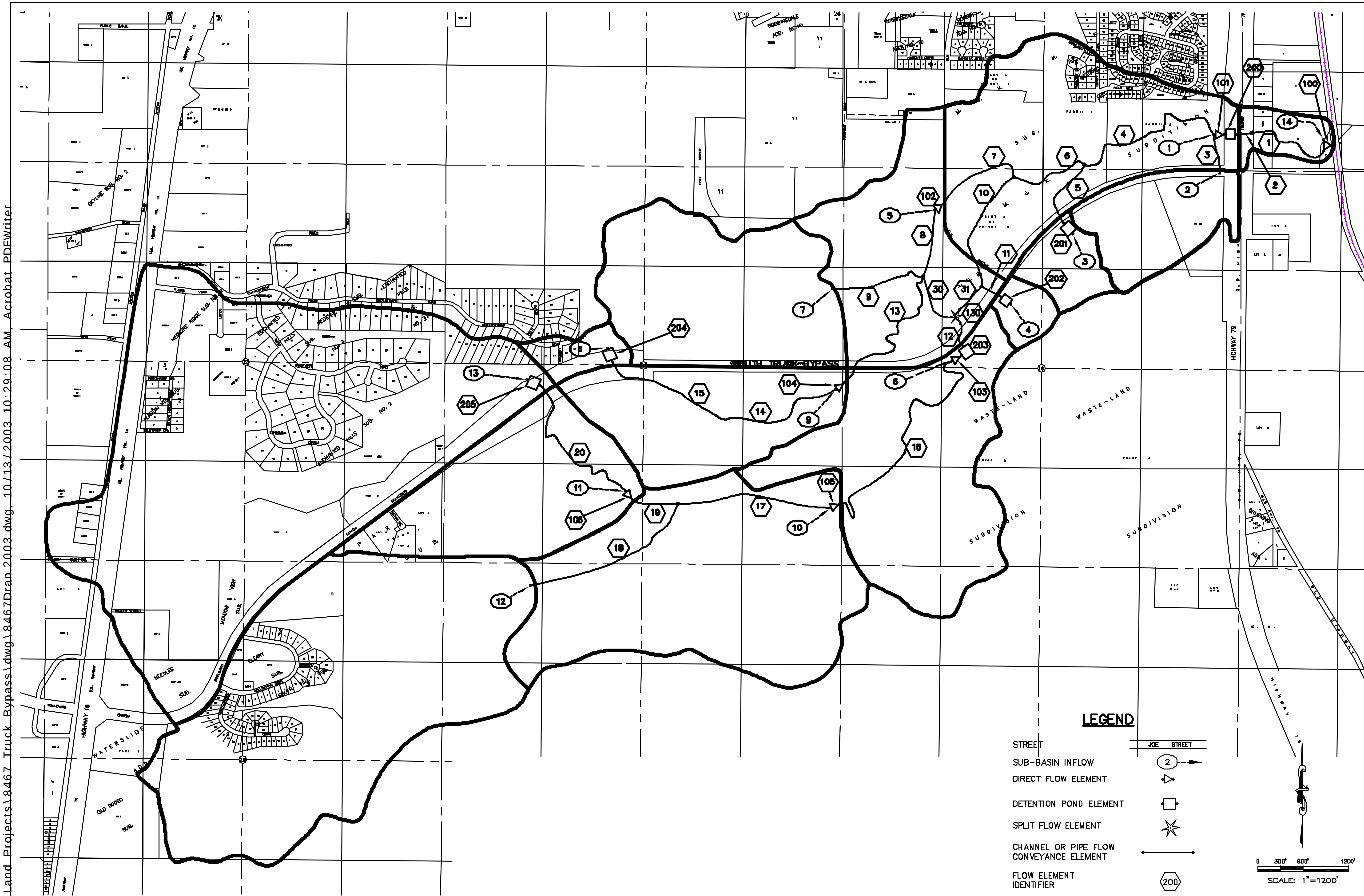
OCTOBER, 2003

SOUTH TRUCK ROUTE
DRAINAGE BASIN DESIGN PLAN
RAPID CITY, SOUTH DAKOTA

Revision / Date

Sheet Name: DESIGN PLAN HYDROLOGIC SCHEMATIC

Figure Number: 3



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SOUTH TRUCK ROUTE
DRAINAGE BASIN DESIGN PLAN
RAPID CITY, SOUTH DAKOTA

OCTOBER, 2003

Revision / Date

Sheet Name:
EXISTING HYDROLOGIC SCHEMATIC

Figure Number:
4

HYDROLOGY

METHODOLOGY

Before any drainage design can be performed it is necessary to determine runoff peaks and volumes from the various sub-basins. Numerous methods of making these determinations are available varying from the simple rational method to very complex statistical methods.

In accordance with the City of Rapid City Drainage Criteria Manual the method used for runoff determination in this design plan is a computerized version of the Colorado Urban Hydrograph Procedure (CUHPF95). This model allows the design plan to be easily updated should the conditions change from those assumed in this study.

It should be noted that a runoff/routing analysis is only an approximation since storms rarely follow ideal patterns and other factors such as ground cover, infiltration, and channel conditions may vary with time or from assumed conditions. The intent of a runoff/routing analysis is to provide a reasonably dependable and consistent approximation of rainfall-runoff characteristics.

INPUT PARAMETERS

1. Storm Recurrence Interval and Rainfall

In accordance with the City of Rapid City Drainage Criteria Manual, the design plan presented in this report is based on the 100 year one-hour storm with fully developed land use conditions. The 100 year one-hour storm used in Rapid City is 2.95 inches per hour. The CUHPF95 model converts the one-hour rain to a two-hour design storm hyetograph totaling 3.41 inches of precipitation for use in the CUHPF95 runoff calculations.

Two year and ten year flows were also calculated to help in evaluation of problems and proposed improvements. The 2 year one-hour storm is 1.10 inches per hour. The 2 year two-hour design storm hyetograph then calculated by CUHPF95 totals 1.27 inches of precipitation. The 10 year one-hour storm is 1.86 inches per hour. The 10 year two-hour design storm hyetograph then calculated by CUHPF95 totals 2.15 inches of precipitation.

2. Sub-basin Characteristics

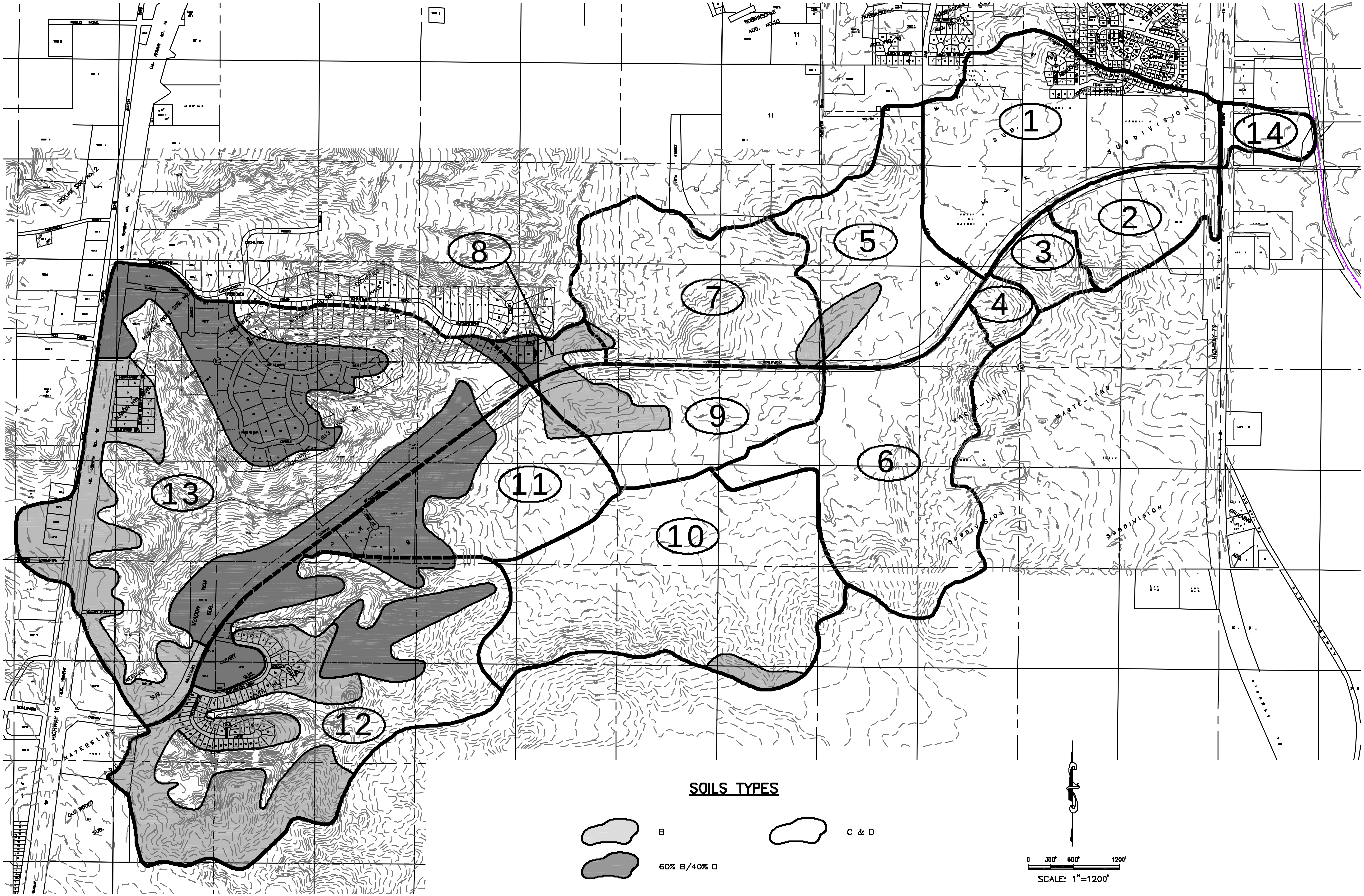
As previously mentioned the design plan is based on the anticipated future land use of the basin. Future land use is described in the BASIN DESCRIPTION section of the report.

The CUHPF95 program requires input of numerous parameters to represent sub-basin characteristics. The reader is referred to the program user's manual and the City of Rapid City Drainage Criteria Manual for a complete description of the input requirements. Input data was developed following guidelines in the manuals. Data sources included USGS topographic maps, 1"=200' aerial photos with 2 foot and 10 foot contours, SCS soil maps, field reconnaissance, engineering equations, and engineering judgment.

A complete listing of all data used for runoff analysis is included on the CUHPF95 printouts. Soils information is shown on Figure 5 at the rear of this chapter

SUB-BASIN FLOWS

Peak sub-basin flows with existing land use and future land use conditions for the 2 year, 10 year and 100 year storms are given on Table 1 in the DESIGN PLAN chapter. CUHPF95 computer printouts are located in the Appendices.



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SOUTH TRUCK ROUTE
DRAINAGE BASIN DESIGN PLAN
RAPID CITY, SOUTH DAKOTA

Revision / Date

Sheet Name:
SOILS

Figure Number:
5

HYDRAULICS

METHODOLOGY

In order to use peak flows and sub-basin hydrographs effectively and arrive at a realistic determination of time varied flows it is necessary to account for basin hydraulic characteristics. This process involves routing and combining hydrographs. This is a key step in the design process as it is where various design options are proposed and basinwide results investigated.

Numerous methods are available for performing these calculations ranging from simple hand approximations to complex computer modeling. In accordance with the City of Rapid City Drainage Criteria Manual the method used for the hydraulic routing is a computer model known as the Urban Drainage Storm Water Management Model (UDSWM95). This model allows the design plan to be easily updated should conditions change from those assumed in the design.

HYDRAULIC ROUTING NETWORK

Prior to routing and calculating combined hydrographs it is necessary to conceptually represent the drainage system as a system of interconnected hydraulic elements. Hydraulic properties of each element are then characterized by various parameters. The next step is then routing of flows through the elements.

It should be noted that the drainage system subdivision could be taken to infinitesimal detail in theory; however, computation and manpower requirements become prohibitive. No established rule is available for this subdivision and it is primarily based on engineering needs and judgment. The hydraulic subdivision used in this design provides a sufficient number of elements for suitable modeling. The network allows for sub-basin inflow at sub-basin design points and provides hydraulic flow elements between tributary junctions, between design points, at road crossings, at detention ponds, and at other locations judged necessary.

As with sub-basin delineation the hydraulic routing system was established following major flow patterns and unaccounted for sub-basin transfer could occur.

The Design Plan hydraulic network schematic is included as Figure 4 in DESIGN PLAN chapter. The schematic of the existing condition hydraulic system network is included as Figure 5 in the DESIGN PLAN chapter. The hydraulic routing elements are also shown on the 1" = 400" Hydrologic Schematic Drawings.

INPUT PARAMETERS

The UDSWM95 model requires input of numerous parameters to represent hydraulic element characteristics. The reader is referred to the program user's manual and the City of Rapid City Drainage Criteria Manual for a detailed explanation of input requirements and methods.

Input parameters were determined following guidelines in the program user's manual and the Drainage Criteria Manual. Data sources included aerial contour maps, as-built drawings, field reconnaissance, limited field surveys, engineering equations, and engineering judgment.

Input data used with the UDSWM95 model is included on the computer printouts in the appendices. An explanation of the various flow element types shown on the schematics and methods used for characterizing them follows. A description of each individual element is included in the DESIGN PLAN part of the report.

1. Direct Sub-basin Inflow

These are not hydraulic elements but rather denote inflow into the system from the various sub-basins. The computer model assumes that the inflow enters the hydraulic network at the sub-basin design point. It ignores the possibility that a portion of the sub-basin inflow may enter the adjacent hydraulic element above the sub-basin design point. Inflows used for these elements are the calculated hydrographs determined in the HYDROLOGY chapter of this report.

2. Detention Pond Elements

This element type allows the program to account for effects of storage at detention ponds. The flow calculated by the program for the referenced element is the outflow. The inflow to these elements is provided by other types of routing elements as shown on the routing schematic.

Input required for detention pond elements consists of a storage versus discharge data set. Data was determined from aerial contour maps, limited field surveys at certain ponds, and as-built engineering drawings. Design plan storage curves for expanded ponds or new ponds were developed using engineering judgment and were checked for reasonableness against existing ground contours.

Discharge curves were developed using applicable culvert discharge curves, storm sewer capacity, and standard engineering equations for orifices and weirs. Discharge curves assume unobstructed flow conditions.

Certain culverts, road crossings, and ponds were not modeled as detention pond elements, rather they were assumed simply to be a portion of the adjacent routing element. Modeling limitations, insignificant storage, minor flow lengths, and/or overtopping characteristics warranted this assumption. Existing stock dams were judged to have an insignificant effect on routing and were ignored during modeling.

3. Direct Flow Elements

Direct flow elements are not true hydraulic conveyance elements, rather they serve to provide summarized hydrographs. They are included in this study to summarize upstream flows and to provide inflow hydrographs for other elements.

4. Flow Conveyance Elements

These elements are trapezoidal open channels, storm sewer pipes, or combinations thereof. Flow conveyance elements may have overflow sections.

Overflow conveyance elements are used at various locations. Overflow elements are the same as pipe or channel elements except that an additional trapezoidal channel is specified to accept flows exceeding the capacity of the initial channel section or pipe. Bottom width of the overflow section does not include the top width of the initial section and therefore may be zero. Depth data required by the program is depth of initial channel and combined depth of the initial channel and overflow section.

Roughness coefficients were selected to represent conditions as they exist in the field or assumed design coefficients for new facilities. Roughness coefficients were then increased by 25% for use in UDSWM95 flow routing in accordance with the program user's manual. Unobstructed flow was assumed in all UDSWM95 elements, including pipes, unless otherwise reflected in the n value.

During input preparation it was assumed that certain channels would essentially remain in existing condition unless changed specifically by the design plan. Natural channels change shapes and slopes infinitely through the elements thus it is necessary to approximate a natural channel as a trapezoid and assume it as typical throughout the length of the element.

It should be noted that the program routes only flows entering the upstream end of the open channel or pipe and ignores the possibility that any adjacent sub-basin flow may be entering. Due to this program limitation the user should exercise caution when using channel or pipe peak flows and hydrographs for design. Flows for design should be increased appropriately using engineering judgment to reflect incoming sub-basin flows.

Additionally the user should not use conveyance element flow depths since flows are calculated as normal depth and effects of backwater, changing sections, etc., are not accounted for. The UDSWM95 calculations do not provide a flood boundary analysis.

5. Flow Element Numbers

Each hydraulic element is identified with a unique number. Element numbers are separated into a set of ranges for specific identification of types. Numbers 1-99 are used to represent channel or pipe flow elements, 100 series numbers represent direct flow elements, 200 series numbers represent existing detention ponds, and 300 series numbers represent recommended new design plan facilities.

HYDRAULIC ELEMENT FLOWS

Routed flows were calculated at all elements using methods and parameters presented above. Flows were calculated for 2 year, 10 year and 100 year storms.

Flows from the CUHPF95 model were initially routed with UDSWM95 using existing hydraulic conditions. This scenario provided the basis for problem identification and as a starting point for design planning.

The design process then consisted of numerous flow calculations using various design proposals. The result is the SOUTH TRUCK BYPASS DRAINAGE BASIN DESIGN PLAN as presented in the DESIGN PLAN section of this report.

Peak 2 year, 10 year and 100 year flows for existing and design plan hydraulic conditions are given on Table 2 in the DESIGN PLAN chapter of this report.

UDSWM95 printouts and hydrographs for direct flow elements and detention ponds are located in the Appendices

(Note: Appendix A Printouts on file at City Engineering, not included in PDF File)

APPENDIX A

DESIGN PLAN 100 YEAR HYDROGRAPHS

This appendix contains design plan hydrographs for sub-basins, direct flow elements and detention ponds. The hydrographs are for design plan conditions which are future land use and design plan hydraulic conditions. The hydrographs are in numerical order.

CAUTION STATEMENT

The user is advised to use caution when using flow conveyance element (channels and pipes) peak flows and hydrographs given in this report. The UDSWM2-PC model assumes that all adjacent sub-basin flow enters the flow conveyance element at the sub-basin design point or the downstream end of the element. The flow conveyance element is simply routing the upstream incoming flow and ignoring the possibility that additional flow may be entering from the adjacent sub-basin. Due to this model limitation flow used for channel or pipe design should be increased appropriately using engineering judgment to reflect incoming sub-basin flow.

(Note: Appendix B Printouts on file at City Engineering, not included in PDF File)

APPENDIX B

DESIGN PLAN COMPUTER PRINTOUTS

This appendix contains complete design plan computer printouts. Design plan printouts are for future land use and recommended design plan hydraulic conditions. Printouts for both the CUHPF95 and UDSWM95 models are included. 2 year, 10 year and 100 year runs are included.

(***Note: Appendix B Printouts on file at City Engineering, not included in PDF File)***

APPENDIX B – CUHPF95 - 2 YR

FULLY DEVELOPED LAND USE CONDITIONS

(Note: Appendix B Printouts on file at City Engineering, not included in PDF File)

APPENDIX B – CUHPF95 - 10 YR

FULLY DEVELOPED LAND USE CONDITIONS

(Note: Appendix B Printouts on file at City Engineering, not included in PDF File)

APPENDIX B – CUHPF95 - 100 YR

FULLY DEVELOPED LAND USE CONDITIONS

(*Note: Appendix B Printouts on file at City Engineering, not included in PDF File)*

APPENDIX B – UDSWM95 - 2 YR

DESIGN PLAN CONDITIONS

CAUTION STATEMENT

The user is advised to use caution when using flow conveyance element (channels and pipes) peak flows and hydrographs given in this report. The UDSWM95 model assumes that all adjacent sub-basin flow enters the flow conveyance element at the sub-basin design point or the downstream end of the element. The flow conveyance element is simply routing the upstream incoming flow and ignoring the possibility that additional flow may be entering from the adjacent sub-basin. Due to this model limitation flow used for channel or pipe design should be increased appropriately using engineering judgment to reflect incoming sub-basin flow.

(*Note: Appendix B Printouts on file at City Engineering, not included in PDF File)*

APPENDIX B – UDSWM95 – 10 YR

DESIGN PLAN CONDITIONS

CAUTION STATEMENT

The user is advised to use caution when using flow conveyance element (channels and pipes) peak flows and hydrographs given in this report. The UDSWM95 model assumes that all adjacent sub-basin flow enters the flow conveyance element at the sub-basin design point or the downstream end of the element. The flow conveyance element is simply routing the upstream incoming flow and ignoring the possibility that additional flow may be entering from the adjacent sub-basin. Due to this model limitation flow used for channel or pipe design should be increased appropriately using engineering judgment to reflect incoming sub-basin flow.

(Note: Appendix B Printouts on file at City Engineering, not included in PDF File)

APPENDIX B – UDSWM95 - 100 YR

DESIGN PLAN CONDITIONS

CAUTION STATEMENT

The user is advised to use caution when using flow conveyance element (channels and pipes) peak flows and hydrographs given in this report. The UDSWM95 model assumes that all adjacent sub-basin flow enters the flow conveyance element at the sub-basin design point or the downstream end of the element. The flow conveyance element is simply routing the upstream incoming flow and ignoring the possibility that additional flow may be entering from the adjacent sub-basin. Due to this model limitation flow used for channel or pipe design should be increased appropriately using engineering judgment to reflect incoming sub-basin flow.

(Note: Appendix C Printouts on file at City Engineering, not included in PDF File)

APPENDIX C

EXISTING CONDITION COMPUTER PRINTOUTS

This appendix contains existing condition computer printouts. Printouts are for existing land use and existing hydraulic conditions. Printouts for both the CUHPF95 and UDSWM95 models are included. 2 year, 10 year and 100 year runs are included.

(Note: Appendix C Printouts on file at City Engineering, not included in PDF File)

APPENDIX C – CUHPF95 - 2 YR

EXISTING LAND USE CONDITIONS

(Note: Appendix C Printouts on file at City Engineering, not included in PDF File)

APPENDIX C – CUHPF95 - 10 YR

EXISTING LAND USE CONDITIONS

(Note: Appendix C Printouts on file at City Engineering, not included in PDF File)

APPENDIX C – CUHPF95 - 100 YR

EXISTING LAND USE CONDITIONS

(*Note: Appendix C Printouts on file at City Engineering, not included in PDF File)*

APPENDIX C – UDSWM95 - 2 YR

EXISTING LAND USE AND EXISTING HYDRAULIC CONDITIONS

CAUTION STATEMENT

The user is advised to use caution when using flow conveyance element (channels and pipes) peak flows and hydrographs given in this report. The UDSWM95 model assumes that all adjacent sub-basin flow enters the flow conveyance element at the sub-basin design point or the downstream end of the element. The flow conveyance element is simply routing the upstream incoming flow and ignoring the possibility that additional flow may be entering from the adjacent sub-basin. Due to this model limitation flow used for channel or pipe design should be increased appropriately using engineering judgment to reflect incoming sub-basin flow.

(*Note: Appendix C Printouts on file at City Engineering, not included in PDF File)*

APPENDIX C – UDSWM95 – 10 YR

EXISTING LAND USE AND EXISTING HYDRAULIC CONDITIONS

CAUTION STATEMENT

The user is advised to use caution when using flow conveyance element (channels and pipes) peak flows and hydrographs given in this report. The UDSWM95 model assumes that all adjacent sub-basin flow enters the flow conveyance element at the sub-basin design point or the downstream end of the element. The flow conveyance element is simply routing the upstream incoming flow and ignoring the possibility that additional flow may be entering from the adjacent sub-basin. Due to this model limitation flow used for channel or pipe design should be increased appropriately using engineering judgment to reflect incoming sub-basin flow.

(***Note: Appendix C Printouts on file at City Engineering, not included in PDF File)***

APPENDIX C – UDSWM95 - 100 YR

EXISTING LAND USE AND EXISTING HYDRAULIC CONDITIONS

CAUTION STATEMENT

The user is advised to use caution when using flow conveyance element (channels and pipes) peak flows and hydrographs given in this report. The UDSWM95 model assumes that all adjacent sub-basin flow enters the flow conveyance element at the sub-basin design point or the downstream end of the element. The flow conveyance element is simply routing the upstream incoming flow and ignoring the possibility that additional flow may be entering from the adjacent sub-basin. Due to this model limitation flow used for channel or pipe design should be increased appropriately using engineering judgment to reflect incoming sub-basin flow.

(*Note: Appendix D Printouts on file at City Engineering, not included in PDF File)*

APPENDIX D

UDSWM95 PRINTOUTS

FUTURE LAND USE AND EXISTING HYDRAULIC CONDITIONS

This appendix contains UDSWM95 computer printouts for future land use and existing hydraulic conditions. Printouts are included for 2 year, 10 year, and 100 year runs.

(***Note: Appendix D Printouts on file at City Engineering, not included in PDF File)***

APPENDIX D – UDSWM95 - 2 YR

FUTURE LAND USE AND EXISTING HYDRAULIC CONDITIONS

(*Note: Appendix D Printouts on file at City Engineering, not included in PDF File)*

APPENDIX D – UDSWM95 - 10 YR

FUTURE LAND USE AND EXISTING HYDRAULIC CONDITIONS

(***Note: Appendix D Printouts on file at City Engineering, not included in PDF File)***

APPENDIX D – UDSWM95 - 100 YR

FUTURE LAND USE AND EXISTING HYDRAULIC CONDITIONS

(***Note: Appendix E Printouts on file at City Engineering, not included in PDF File)***

APPENDIX E

HY8 AND NORMAL DEPTH PRINTOUTS

APPENDIX F

DESIGN PLAN WITH OPTIONAL ROUTING

NARRATIVE
AND
UDSWM95 COMPUTER PRINTOUTS

DESIGN PLAN WITH OPTIONAL ROUTING

As directed, various alternates were reviewed during the preparation of the plan. This final report includes a Design Plan and a Design Plan With Optional Routing. The Design Plan generally follows historical flow routes. The Design Plan With Optional Routing has two modifications of the Design Plan. The Optional Routing modifications are (1) replacing one of the historical routes with a pipeline along a new route and (2) increasing the size of one of the Design Plan metering dams. The Optional Routing is described in Appendix F. **The City Council approved the Design Plan With Optional Routing on September 15, 2003.**

The Design Plan With Optional Routing described herein has certain features that vary significantly from the Design Plan. These features are:

3. Element 13 will be a storm sewer that follows the route of proposed 5th Street. Element 13 will convey flow from Metering Dam 305 to the upstream end of the Element 9 channel.

4. Increase storage and decrease discharge at Metering Dam 305.

A schematic of Design Plan With Optional Routing is included at the rear of this Appendix as Figure F1. Table F1 at the rear of this Appendix has 100 year flows for existing conditions, the Design Plan conditions, and the Design Plan With Option Routing conditions.

Table F2 at the rear of this Appendix has the 2 year, 10 year, and 100 year flows for the Design Plan With Optional Routing only. The reader can refer to Table 3 for existing condition flows, future condition flows assuming no improvements, and the Design Plan flows.

Table F3 at the rear of this Appendix provides a cost estimate for the Design Plan With Optional Routing.

Flows in various Elements will be slightly higher or lower than described in the Design Plan. Following is a description of the Elements that would be affected by the Design Plan With Optional Routing. All other Elements remain as described in the Design Plan section of this report.

Element 1

The 100 year routed flow will be reduced from 1,072 cfs to 1,027 cfs. Improvement recommendations remain as described in the Design Plan. Design flow should be 1,058 cfs as calculated at Element 100. Normal depth for 1,058 cfs will be about 4.1 cfs at a velocity of about 5 fps.

Element 2

The 100 year routed flow will be reduced from 1,073 cfs to 1,037 cfs. Improvement recommendations for the box culvert remain as described in the Design Plan.

The design flow approaching Element 2 is 1,117 cfs as calculated at Element 101. Final flow through the box culvert will be reduced to 1,037 cfs as a result of metering pond Element 200.

Element 4

The 100 year routed flow will be reduced from 957 cfs to 918 cfs. Improvement recommendations remain as described in the Design Plan. Design flow should be 1,117 cfs as calculated at Element 101. Normal depth for 1,117 cfs will be about 3.9 cfs at a velocity of about 5.7 fps.

Element 6

The 100 year routed flow will be reduced from 936 cfs to 909 cfs. Improvement recommendations remain as described in the Design Plan. It is recommended that the design discharge be increased to about 1,050 cfs same as in the Design Plan to account for added inflows from sub-basin 1. Normal depth for 1,050 cfs will be about 4.0 cfs at a velocity of about 5.7 fps.

Element 7

The 100 year routed flow of 565 cfs is essentially the same as the 564 cfs in the Design Plan. Improvement recommendations remain as described in the Design Plan. It is recommended that the design discharge be increased to about 800 cfs same as in the Design Plan to account for added inflows from sub-basin 1. Normal depth for 800 cfs will be about 4.1 cfs at a velocity of about 5.4 fps.

Improvement recommendations for the Elm Avenue crossing remain the same as described in the Design Plan. The 100 year design flow is 631 cfs as calculated at Element 102.

Element 8

The 100 year routed flow will be reduced from 324 cfs to 209 cfs. Improvement recommendations remain as described in the Design Plan. Since most of sub-basin 5 drains to Element 8 the recommended design discharge is 631 cfs as calculated at Element 102. Normal depth is about 3.9 feet and velocity is 5.2 fps.

Element 9

The 100 year routed flow will be increased from 121 cfs to 210 cfs. A certain amount of additional localized flow will also enter the channel from sub-basin 5. It will be necessary to determine the added flows when final development is proposed. A design discharge of 400 cfs has been assumed for the purpose of preliminary channel size recommendations. Normal depth using 400 cfs is about 3.6 feet and velocity is 4.9 fps.

Element 13

Element 13 is proposed as a 48" RCP storm sewer. Element 13 will convey flows from the Element 305 metering dam to near the upstream end of Element 9. Peak inflow to the pipe from Element 305 is 89 cfs.

Based on a normal depth analysis the proposed pipe would be a 48" RCP. Capacity is about 100 cfs assuming an n value of 0.012 and a recommended minimum slope of 0.004 ft/ft. Pipe depth (to flow line from proposed 5th Street centerline) would range from about 10' to 16' deep.

Note that it will be necessary to drop the proposed 15" sewer elevation about 1 foot from that shown on the preliminary 5th Street plans prepared by Ferber Engineering. This will allow the 48" RCP to cross over the sanitary sewer with clearance of about 1 foot.

Element 100

Optional Routing flow at Element 100 is 1,058 cfs compared to 1,077 cfs in the Design Plan.

Element 101

Optional Routing flow at Element 101 is 1,117 cfs compared to 1,118 cfs in the Design Plan.

Element 102

Optional Routing flow at Element 102 is 631 cfs compared to 629 cfs in the Design Plan.

Element 200

Improvements for Element 200 remain the same as described in the Design Plan.

Optional Routing inflow to Element 200 is 1,117 cfs and outflow is 1,039 cfs. The peak inflow is essentially the same as the 1,118 cfs in the Design Plan. The peak outflow of 1,039 cfs is smaller than the 1,073 cfs Design Plan peak outflow.

The 100 year water elevation is calculated at about elevation 3228.0 with storage of 7.0 acre foot.

Element 305

Storage will be increased and discharge reduced at Element 305.

Pond flow line is proposed at elevation 3314. Top of pond is proposed at elevation 3324 which provides about 1.5 feet of freeboard.

The proposed outlet is a 36" RCP with riser for low flow control. The riser will have one 18" round orifice at elevation 3314. Top of riser is proposed at elevation 3321. The riser needs to be sized such that the 36" RCP, rather than the riser overflow weir, controls high flows. Peak inflow is 500 cfs and peak outflow is 89 cfs. The 100 year water elevation is calculated at about elevation 3322.5 with 16.2 acre feet of storage.

Stage/storage/discharge data for Element 305 is given below.

STAGE/STORAGE/DISCHARGE DATA – ELEMENT 305

ELEVATION	STORAGE (AC-FT)	DISCHARGE (CFS)
3314	0	0
3316	0.7	9
3318	3.2	15
3320	8.1	18
3321	11.1	20
3322	15	87
3324	23	100

TABLE F1 - HYDRAULIC ELEMENT 100 YEAR PEAK FLOWS (CFS)

ELEMENT NUMBER	EXISTING 100 YEAR (CFS)	DESIGN PLAN 100 YEAR (CFS)	DESIGN PLAN OPTIONAL ROUTNG 100 YEAR (CFS)
1*	936	1,072	1,027
2*	938	1,073	1,037
3*	145	43	43
4*	1,008	957	918
5*	42	57	57
6*	1001	936	909
7*	612	564	565
8*	494	324	209
9*	249	121	210
10*	498	677	677
11*	23	8	8
12*	683	672	672
13*	165	207	89
14*	27	13	13
15*	30	13	13
16*	745	624	624
17*	577	391	391
18*	368	250	250
19*	215	228	228
20*	189	175	175
30*	191	NA	NA
31*	492	672	672
100	936	1,077	1,058
101	1,151	1,118	1,117
102	651	629	631
103	898	882	882
104	178	500	500
105	860	833	833
106	216	545	545
130	683	672	672
200	938	1,073	1,039
201	42	57	57
202	23	8	8
203	683	672	672
204	31	13	13
205	190	177	177
300	NA	252	252
301	NA	121	121
302	NA	229	229
304	NA	43	43
305	NA	216	89
306	NA	635	635

EXISTING – This data is for existing land use and existing hydraulic conditions; DESIGN PLAN – This data is per the Design Plan recommendations. DESIGN PLAN OPTIONAL ROUTING – This data is for the optional routing described in Appendix F.

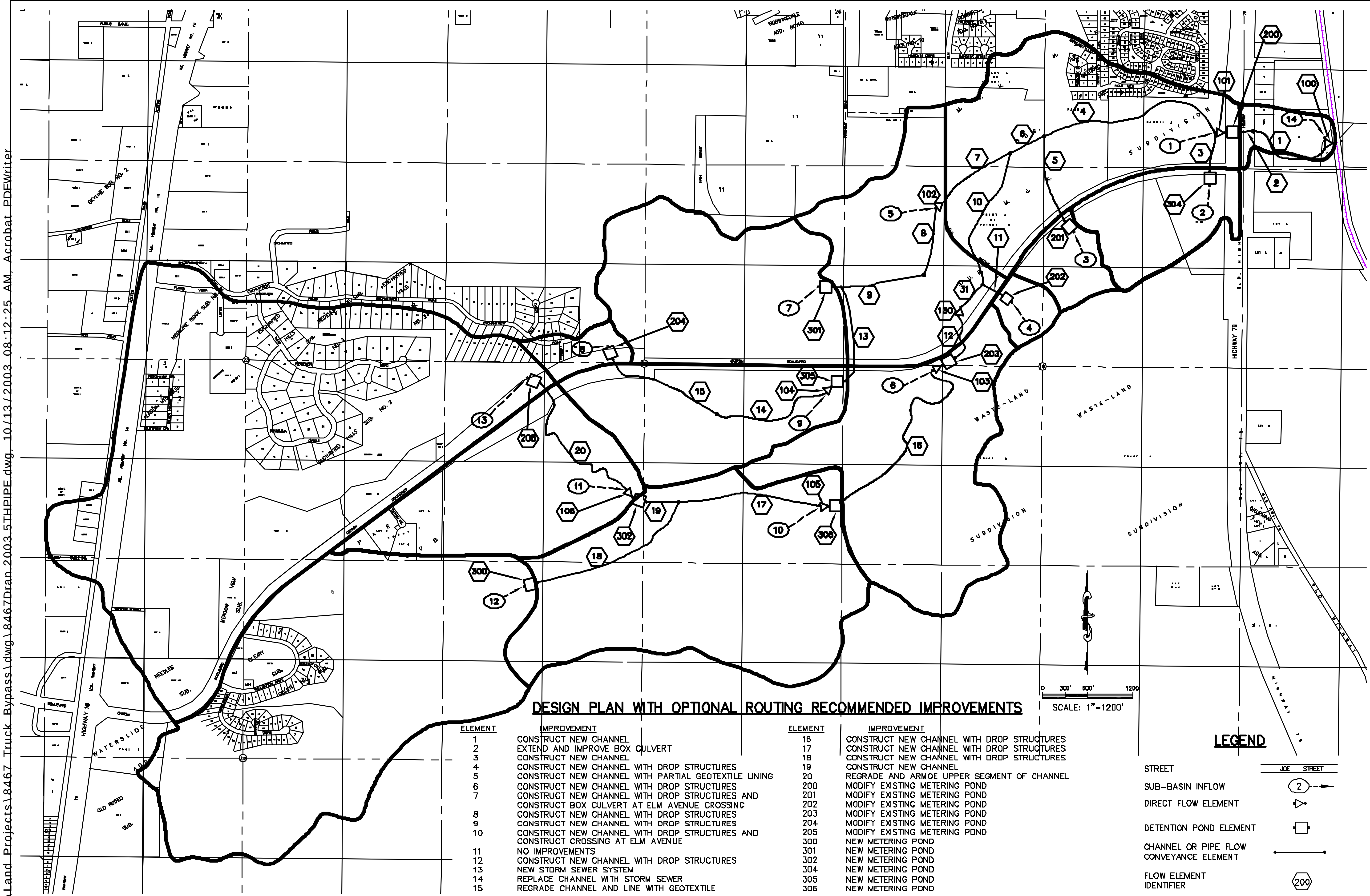
TABLE F2 - HYDRAULIC ELEMENT PEAK FLOWS (CFS) WITH OPTIONAL ROUTING

ELEMENT NUMBER	DESIGN PLAN OPTIONAL ROUTING 2 YEAR (CFS)	DESIGN PLAN OPTIONAL ROUTING 10 YEAR (CFS)	DESIGN PLAN OPTIONAL ROUTNG 100 YEAR (CFS)
1*	223	491	1,027
2*	236	506	1,037
3*	9	30	43
4*	137	366	918
5*	18	36	57
6*	139	363	909
7*	147	296	565
8*	47	99	209
9*	47	99	210
10*	76	247	677
11*	4	7	8
12*	75	244	672
13*	16	20	89
14*	2	9	13
15*	2	9	13
16*	62	216	624
17*	42	107	391
18*	19	51	250
19*	28	66	228
20*	9	30	175
30*	NA	NA	NA
31*	75	243	672
100	231	505	1,058
101	247	531	1,117
102	174	347	631
103	134	321	882
104	130	274	500
105	186	419	833
106	122	284	545
130	75	244	672
200	237	506	1,039
201	19	36	57
202	4	7	8
203	75	244	672
204	3	9	13
205	9	30	177
300	19	52	252
301	32	82	121
302	29	66	229
304	9	30	43
305	16	20	89
306	62	252	635

DESIGN PLAN OPTIONAL ROUTING – This data is for the optional routing described in Appendix F.

TABLE F3 - SUMMARY OF DESIGN PLAN OPTIONAL ROUTING
RECOMMENDED IMPROVEMENTS AND ESTIMATED COSTS

NUMBER	RECOMMENDED IMPROVEMENT	ESTIMATED COST
1	Construct new channel.	$50,000.00
2	Extend both ends of box culvert, side taper inlet.	$160,000.00
3	Construct new channel.	$10,000.00
4	Construct new channel with drop structures	$225,000.00
5	Construct new channel with partial geotextile lining.	$15,000.00
6	Construct new channel with drop structures	$75,000.00
7	Construct new channel with drop structures & construct box culvert at Elm Avenue crossing.	$155,000.00
8	Construct new channel with drop structures.	$140,000.00
9	Construct new channel with drop structures.	$75,000.00
10	Construct new channel with drop structures &. construct Elm Avenue/Rearage Road crossing	$265,000.00
11	No improvements	NA
12	Construct new channel with drop structures.	$60,000.00
13	Construct storm sewer	$200,000.00
14	Replace channel with storm sewer.	$220,000.00
15	Regrade channel and line with geotextile..	$40,000.00
16	Construct new channel with drop structures.	$110,000.00
17	Construct new channel with drop structures.	$175,000.00
18	Construct new channel with drop structures.	$225,000.00
19	Construct new channel.	$15,000.00
20	Line upper segment of channel with gabions.	$160,000.00
31	Construct new channel with drop structures	$45,000.00
200	Modify existing metering pond. (Costs Under Element 2)	NA
201	Modify existing metering pond.	$2,000.00
202	Modify existing metering pond.	$3,000.00
203	Modify existing metering pond.	$140,000.00
204	Modify existing metering pond.	$5,000.00
205	Modify existing metering pond..	$15,000.00
300	New metering pond.	$65,000.00
301	New metering pond.	$110,000.00
302	New metering pond.	$75,000.00
304	Install riser to create new metering pond.	$5,000.00
305	New metering pond	$85,000.00
306	New metering pond	$150,000.00
	IMPROVEMENTS SUBTOTAL TOTAL	$3,075,000.00
	5% CONTINGENCY	$155,000.00
	25% ENGINEERING/ADMINISTRATION	$770,000.00
	TOTAL COST OF DESIGN PLAN IMPROVEMENTS	$4,000,000.00



DESIGN PLAN WITH OPTIONAL ROUTING RECOMMENDED IMPROVEMENTS

ELEMENT	IMPROVEMENT
1	CONSTRUCT NEW CHANNEL
2	EXTEND AND IMPROVE BOX CULVERT
3	CONSTRUCT NEW CHANNEL
4	CONSTRUCT NEW CHANNEL WITH DROP STRUCTURES
5	CONSTRUCT NEW CHANNEL WITH PARTIAL GEOTEXTILE LINING
6	CONSTRUCT NEW CHANNEL WITH DROP STRUCTURES
7	CONSTRUCT NEW CHANNEL WITH DROP STRUCTURES AND CONSTRUCT BOX CULVERT AT ELM AVENUE CROSSING
8	CONSTRUCT NEW CHANNEL WITH DROP STRUCTURES
9	CONSTRUCT NEW CHANNEL WITH DROP STRUCTURES
10	CONSTRUCT NEW CHANNEL WITH DROP STRUCTURES AND CONSTRUCT CROSSING AT ELM AVENUE
11	NO IMPROVEMENTS
12	CONSTRUCT NEW CHANNEL WITH DROP STRUCTURES
13	NEW STORM SEWER SYSTEM
14	REPLACE CHANNEL WITH STORM SEWER
15	REGRADE CHANNEL AND LINE WITH GEOTEXTILE

ELEMENT	IMPROVEMENT
16	CONSTRUCT NEW CHANNEL WITH DROP STRUCTURES
17	CONSTRUCT NEW CHANNEL WITH DROP STRUCTURES
18	CONSTRUCT NEW CHANNEL WITH DROP STRUCTURES
19	CONSTRUCT NEW CHANNEL
20	REGRADE AND ARMOE UPPER SEGMENT OF CHANNEL
200	MODIFY EXISTING METERING POND
201	MODIFY EXISTING METERING POND
202	MODIFY EXISTING METERING POND
203	MODIFY EXISTING METERING POND
204	MODIFY EXISTING METERING POND
205	MODIFY EXISTING METERING POND
300	NEW METERING POND
301	NEW METERING POND
302	NEW METERING POND
304	NEW METERING POND
305	NEW METERING POND
306	NEW METERING POND

LEGEND

STREET	JOE STREET
SUB-BASIN INFLOW	2
DIRECT FLOW ELEMENT	
DETENTION POND ELEMENT	
CHANNEL OR PIPE FLOW CONVEYANCE ELEMENT	
FLOW ELEMENT IDENTIFIER	200

FMG, Inc.
3700 Sturgis Road
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File Number: 8467\8467SCHM.DWG

Location: BLACK HILLS MERIDIAN

Surveyed By:

Date:

Designed By: JDF

Drawn By: NDS

Checked By: JDF

OCTOBER 2003

SOUTH TRUCK ROUTE
DRAINAGE BASIN DESIGN PLAN
RAPID CITY, SOUTH DAKOTA

Revision / Date

Sheet Name: DESIGN PLAN WITH OPTIONAL ROUTING SCHEMATIC

Figure Number: F1

(*Note: Appendix F Printouts on file at City Engineering, not included in PDF File)*

APPENDIX F – UDSWM95 - 2 YR

DESIGN PLAN WITH OPTIONAL ROUTING CONDITIONS

CAUTION STATEMENT

The user is advised to use caution when using flow conveyance element (channels and pipes) peak flows and hydrographs given in this report. The UDSWM95 model assumes that all adjacent sub-basin flow enters the flow conveyance element at the sub-basin design point or the downstream end of the element. The flow conveyance element is simply routing the upstream incoming flow and ignoring the possibility that additional flow may be entering from the adjacent sub-basin. Due to this model limitation flow used for channel or pipe design should be increased appropriately using engineering judgment to reflect incoming sub-basin flow.

(Note: Appendix F Printouts on file at City Engineering, not included in PDF File)

APPENDIX F – UDSWM95 – 10 YR

DESIGN PLAN WITH OPTIONAL ROUTING CONDITIONS

CAUTION STATEMENT

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(Note: Appendix F Printouts on file at City Engineering, not included in PDF File)

APPENDIX F – UDSWM95 - 100 YR

DESIGN PLAN WITH OPTIONAL ROUTING CONDITIONS

CAUTION STATEMENT

The user is advised to use caution when using flow conveyance element (channels and pipes) peak flows and hydrographs given in this report. The UDSWM95 model assumes that all adjacent sub-basin flow enters the flow conveyance element at the sub-basin design point or the downstream end of the element. The flow conveyance element is simply routing the upstream incoming flow and ignoring the possibility that additional flow may be entering from the adjacent sub-basin. Due to this model limitation flow used for channel or pipe design should be increased appropriately using engineering judgment to reflect incoming sub-basin flow.