6.0 Collection System Evaluation

6.1 Hydraulic Model

The hydraulic capacity model of the sanitary sewer system was developed utilizing sewer network data, flow data, and a flow routing program. The model incorporated measured system parameters such as travel time, time of concentration, tributary acres for areas currently served, and rainfall duration and intensity to determine peak system flow rates. The model was developed using HYDRA software as the hydraulic engine. Data was processed using Sanitary Sewer Management System (SSMS) support modules developed by Black and Veatch to write to and read from HYDRA.

The drainage areas tributary to each monitoring point in the system and developed acres for each drainage area were obtained from existing maps. The developed areas relate to areas currently served. The ADDF determined from the flow monitoring program was used as the "base" flow component and was input into the model using the monitored diurnal flow variation observed at each flowmeter.

Infiltration was considered as a constant flow during high groundwater conditions, as observed infiltration flows were relatively constant over several days. The inflow component was observed to be highly variable over short periods, requiring dynamic analysis and modeling for accurate measurement and simulation. The inflow component was input into the model in a manner reflecting the dynamic nature of the flow. Input required to generate the inflow included the following:

?? Inflow coefficient determined from flow monitoring data
?? Developed acres for areas currently served for each subsystem
?? Historical rainfall intensity-duration curves for selected storm events
?? Estimated inlet time for each subsystem area

As flow was routed through the system, the model added the peak diurnal dry weather flow, the high groundwater infiltration, and the calculated inflow. Inflow for each segment was calculated using the inflow coefficient method. The model used the estimated inlet time, plus system travel time to determine time of concentration, which determined the appropriate rainfall intensity for each sewer to calculate inflow. The model accumulated the tributary areas and inflow coefficients to each sewer, and then applied the critical rainfall intensity to determine the peak inflow.

6.2 Model Calibration

An initial series of analyses were performed to calibrate the model against actual field data to insure accurate simulation. The model was calibrated against the projected 1-year flow rate determined from the flow monitoring data. The results of the calibration provided satisfactory agreement between model-generated and monitored flow. A summary of model calibration data is given in Table 6-1.

Table 6-1 shows that a good calibration was achieved for a 1-year storm event. Once the model was calibrated against monitored flow data, the analysis is based on modeled output; the results presented in the report and the capital improvement projects are based on the calibrated modeled output.

Table 6-1
Model Calibration – Peak 1-Year Storm Flows at Monitor Locations

Monitor	Expected Flow (mgd)	Modeled Flow (mgd)	Percentage Difference (%)
SF-041	0.54	0.38	-30
RS-002	0.35	0.35	0
SF-005	1.38	1.38	0
SF-003	1.74	1.56	-10
JC-002 or JC-003	1.27	1.24	-2
Total System	**2.76**	**2.75**	**0**

6.3 Collection System Improvement Criteria

The collection system improvement criteria, including the parameters used in the model for peak flow analyses, are included in the Appendix. The model improvement criteria include evaluation of information on existing sewers, relief sewers, force mains, and pumping stations. For existing sewers, an allowable peak flow to capacity ratio of 1:1 was used in the analysis. The total peak flow determined by the model for each sewer segment was compared to the full pipe sewer capacity. Parallel relief sewers were sized and costs assigned for any pipe with a peak flow greater than 100 percent of pipe capacity. Proposed relief sewers smaller than 18 inches in diameter were sized for a design flow-to-capacity ratio of 0.65. Proposed relief sewers larger than 18 inches in diameter were sized for a design flow-to-capacity ratio of 0.78. All improvements were sized as parallel relief sewers. Replacement force mains were assumed for all force main improvements. The following criteria were used in evaluating the pumping stations and force mains:

- ?? Station expansion, when ratio of flow/capacity is between 1.0 and 2.0
- ?? Station replacement, when flow/capacity ratio is more than 2.0
- ?? Force main replaced when maximum velocity at peak flow exceeds 12.0 ft/sec
- ?? Design velocity for new force main equals 6.0 ft/sec.

The decision to expand or replace a pumping station will be made by the District during detailed design. Similarly, the decision whether to replace or construct parallel force mains will be determined during detailed design.

6.4 Improvements Cost Basis

All collection system improvement costs are based on the unit construction costs presented in Tables 6-2 to 6-4. Capital costs were developed by adding a 40 percent service and contingency factor to the construction cost. This 40 percent includes 20 percent for contingency, 15 percent for engineering and 5 percent for legal and administrative. The costs are indexed to a current (April 2003) ENR – Construction Cost Index value of 6628.

Table 6-2 Wastewater Sewer Pipe Unit Construction Cost				
Pipe Diameter (in)	10 ft depth ($/ft)	15 ft depth ($/ft)	20 ft depth ($/ft)	25 ft depth ($/ft)
8	68.66	108.31	147.95	187.60
10	74.75	114.64	154.53	194.42
12	82.25	122.63	163.01	203.39
15	94.67	135.17	175.68	216.18
18	102.33	143.39	184.44	225.50
21	111.89	153.38	194.86	236.35
24	123.85	165.70	207.55	249.41
27	151.70	194.16	236.63	279.10
30	167.64	210.66	253.68	296.70
33	179.91	223.30	266.69	310.08
36	192.19	235.94	279.70	323.46
42	241.04	286.51	331.99	377.46
48	290.81	336.78	382.74	428.71
54	354.76	401.95	449.15	496.34
60	392.38	440.98	489.59	538.19

Table 6-3 Wastewater Force Main Construction Costs	
Force Main Diameter (in)	Construction Cost ($/ft)
4	20.00
6	30.00
8	40.00
10	50.00
12	60.00
16	80.00
20	100.00
24	120.00
27	135.00
30	150.00
33	165.00
36	180.00

Table 6-4
Wastewater Pump Station Construction Cost

Station Capacity		Replacement Construction Cost
(mgd)	(cfs)	($)
0.06	0.10	55,200
0.16	0.25	147,300
0.32	0.50	178,000
0.65	1.00	306,900
1.62	2.50	613,700
3.23	5.00	1,074,000
4.85	7.50	1,288,800
6.46	10.00	1,534,300
9.69	15.00	2,086,600
12.93	20.00	2,577,600
19.39	30.00	3,314,000
32.32	50.00	4,786,900

6.5 Existing System Analysis for Peak Flow Conditions

The existing collection system was modeled to determine the system response to current peak dry weather flow (PDF) and 5-year storm event peak wet weather flow (PWWF). All design analyses were performed using the calibrated model. Wastewater flow allocation to manholes and flow parameters for the existing system were the same as for the calibration analysis.

The peak dry weather analysis was selected by specifying zero inflow for the analysis. The PDF condition was simulated to determine whether any of the existing pipes are undersized for peak sanitary flow. The modeling indicated only one manhole section to be overloaded under existing PDF, from manhole CS-008 to CS-007. In the model inventory, this is an 8-inch line with slightly less than minimum slope.

To evaluate existing system performance under the design 5-year storm event a PWWF analysis was performed. The 5-year storm rainfall intensity curve was applied to the tributary areas and design inflow coefficient to produce the 5-year PWWF analysis. The results of the analysis show that parts of the system become overloaded during wet weather conditions. For the 5-year frequency event, 36 pipe segments (8.7 percent of the modeled trunk sewer length) had peak flows exceeding 100 percent of the full pipe capacity. Figure 6-1 shows the overloaded sewers for the 5-year storm event. Table 6-5 presents a summary of the overloaded sewers.

Insert Fig 6-1 Existing System Model Results 5-Year Storm Conditions

Following the hydraulic analysis, parallel relief sewers were sized and costed for those lines showing peak flows exceeding 100 percent of capacity.

Table 6-5
Pipe Surcharge and Overloading Summary
Existing System Analyses

Design Condition	Sewer Pipes Modeled	Length (ft)	Number of Pipes Overloaded	Overloaded Pipe Length (ft)	Percent Overloaded %
PDF	363	100,601	1	292	0.01
5-Year Storm PWWF	363	100,601	36	8,794	8.7

The existing condition analysis flows delivered to the Little Ranches pumping station were 0.85 mgd under PDF flows, and 1.65 mgd for the 5-year PWWF analysis. The existing station's firm pumping capacity of 2.1 mgd is sufficient for the existing flows.

6.6 Design Year 2010 and Build-out Hydraulic Capacity Evaluation

This section describes the hydraulic capacity evaluation of the FSD collection system under design year 2010 and build-out growth conditions. Extension trunk sewers were added to the model to extend service throughout the study area to the growth areas defined on Figure 3-3, Build-out Land Use. The extension sewers were assigned pipe elevations and slopes based on the existing ground slope, the pipe invert elevation at the connection to existing sewers, and a minimum sewer depth of 10 feet. Flow parameters were assigned to each growth area on Figure 3-3 according to the design flow curve. Each growth area was then assigned to specific manholes in the model as point loads. System expansion to year 2010 was assumed to correspond to the known subdivisions shown on Figure 3-2. The remaining extension sewers were assumed required at build-out.

Figure 6-2 shows the overloaded sewers for the year 2010 5-year storm PWWF. Table 6-6 presents a summary of the overloaded sewers under the year 2010 analyses.

Insert Fig 6-2 Year 2010 Model Results 5-Year Storm Conditions

Table 6-6
Pipe Surcharge and Overloading Summary
Design Year 2010 Analyses

Design Condition	Sewer Pipes Modeled	Length (ft)	Number of Pipes Overloaded	Overloaded Pipe Length (ft)	Percent Overloaded by Length %
PDF					
Existing Sewers	363	100,601		6,693	6.7
Extension Sewers	46	71,539	46	42,371	--
1-Year PWWF					
Existing Sewers	363	100,601		13,200	13.1
Extension Sewers	46	71,539	66	42,371	--
5-Year PWWF					
Existing Sewers	363	100,601		22,152	22.0
Extension Sewers	46	71,539	104	32,371	--

The year 2010 analysis shows that flows delivered to the Little Ranches pumping station will be 4.71 mgd for the 5-year PWWF condition. The existing station's firm pumping capacity of 2.1 mgd will require expansion to its planned 5.0 mgd ultimate capacity to be adequate for projected 2010 flows. Flow in the existing 10-inch force main would have a velocity of 14.2 fps at a flow of 5 mgd; this parameter exceeds the desirable velocity limit of 12 fps. The force main was originally planned for expansion by installing the 10-inch main inside a 12-inch main. After pulling out the 10-inch pipe, the 12-inch line will provide an acceptable velocity of 9.85 fps at 5 mgd.

Figure 6-3 shows the overloaded sewers for the build-out condition 5-year storm PWWF. Table 6-7 presents a summary of the build-out analyses overloaded sewers.

Insert Fig 6-3 Build-out Model Results

Table 6-7 Pipe Surcharge and Overloading Summary Build-out Analyses					
Design Condition	Sewer Pipes Modeled	Length (ft)	Number of Pipes Overloaded	Overloaded Pipe Length (ft)	Percent Overloaded by Length %
PDF					
Existing Sewers	363	100,601		25,839	25.6
Extension Sewers	58	89,553	126	76190	--
1-Year PWWF					
Existing Sewers	363	100,601		42,016	41.8
Extension Sewers	58	89,553	180	76,190	--
5-Year PWWF					
Existing Sewers	363	100,601		47,647	47.4
Extension Sewers	58	89,553	201	76,190	--

The build-out analysis shows that flows delivered to the Little Ranches pumping station will be 9.0 mgd for PDF and 22.2 mgd for the 5-year PWWF condition. After the existing station is expanded to 5 mgd for year 2010 conditions, a replacement station with 22.2 mgd firm capacity would be required to handle build-out conditions. Flow in the existing 10-inch force main would have a velocity of 62 fps at a flow of 22.2 mgd; thus for build-out the force main would require replacement with at minimum a 30 inch force main. The analysis is based on delivering all Jimmy Camp Creek flows to the existing treatment facility site. If a regional wastewater treatment plant is developed, the replacement for the Little Ranches pumping station and force main could be designed to deliver flows to the regional plant.

6.7 Compatibility of FSD’s Maintenance Program with SSO Rule and CMOM Requirements

This section provides a limited review of the FSD’s existing maintenance and Infiltration/inflow management activities, and a discussion of the compatibility of the FSD’s maintenance programs with the draft SSO rule and the Capacity, Management, Operation and Maintenance (CMOM) program.

6.7.1 Sanitary Sewer Overflow (SSO) Rule

Sanitary sewer overflows that discharge to surface waters have been prohibited under the Clean Water Act since 1972, and all current NPDES permits prohibit the discharge of untreated flows.

The proposed SSO Rule consists of regulations that will amend NPDES permit requirements to improve the operation of collection systems, reduce the frequency and severity of sewer overflows, and provide more effective public notification when overflows do occur.

The proposed SSO Rule addresses four issues related to collection systems overflows, as follows:

?? First, the Capacity Assurance, Management, Operation, and Maintenance (CMOM) Requirement will require that utilities;
  - Properly manage, operate, and maintain, the collection system;
  - Provide adequate capacity to convey base flows and peak flows;
  - Take all feasible steps to stop, and mitigate the impact of, sanitary sewer overflows;
  - Notify affected parties of the occurrence of overflows, and;
  - Develop a written summary of their CMOM program and make it available to the public upon request.

?? Second, the regulation reiterates the prohibition on unpermitted discharges and recognizes SSOs as a violation of the Clean Water Act

?? Third, recordkeeping and reporting requirements will require utilities to report the occurrence of SSOs, issue an annual report of all SSOs, and notify the public when SSOs occur.

?? Fourth, the regulations will address satellite systems that are operated by an entity other than the NPDES permit holder. The SSO rule will require these entities to comply with the same CMOM requirements that the NPDES holder is required to meet, or to apply for their own NPDES permits.

6.7.2 CMOM Regulations

The CMOM regulation will require that each collection system manager prepare a formal CMOM program to ensure that his collection system complies with the regulations. The major elements of any CMOM program will include:

?? Establishing Relevant Legal Authority: Does the operating entity have legal jurisdiction to enforce the measures that it deems are necessary for the prevention and elimination of overflows?

?? Assessing Current System Capacity: Does the operating entity know how much of the collection system capacity is utilized during dry and wet weather? Is there sufficient capacity to transport all flow to the treatment facility?

?? Addressing Structural Deficiencies: Is the operating entity taking steps to identify and repair structural deficiencies in the collection system?

?? Staff Training: Is the operating entity providing its staff with sufficient training to ensure that the CMOM program is properly and safely implemented?

The CMOM requirement will also require that operating entities prepare two subordinate plans that are components of the overall CMOM Plan. These are an Overflow Emergency Response Plan (OERP), and a System Evaluation and Capacity Assurance Plan (SECAP). The OERP will establish the specific steps that need to be taken when an overflow occurs. Such steps would, at a minimum consist of mitigating the health effects of the overflow whenever possible, notifying health officials, and notifying the public.

The SECAP will document the results of various evaluations and identify the measures that will be taken to ensure that the system has the capacity to transport peak flows. These measures may include the results of sewer evaluations, flow monitoring, and hydraulic modeling.

When the proposed regulations become law, operating entities will be required to evaluate their collection system programs and prepare the CMOM Program Plan at the renewal of their NPDES permits. Prior to subsequent permit renewals, the operating entity will conduct a self-audit and revise its CMOM program to ensure compliance with the permit conditions.

6.7.3 FSD System Evaluation

6.7.3.1 FSD Questionnaire Response

FSD personnel completed a questionnaire on the system operation and maintenance. Each area of the questionnaire is summarized below.

?? Financial - User rates are based on a cost of service evaluation performed bi-annually. The budget provides for annual operating costs, sufficient funding, and includes a fund for future equipment and infrastructure replacement. New construction is typically paid for by developers.

?? Public Education/Outreach - FSD communicates with the public through several venues including public meetings, a bi-annual newsletter, a website, and other communications.

?? Personnel - The FSD organization is documented. FSD has a documented safety program.

?? Equipment and Tools - The necessary equipment and tools to maintain and operate the collection system are available.

?? Legal - There is a sewer use and grease ordinance and a system in place for enforcement and inspection. There is no formal pretreatment program for industrial dischargers.

?? Engineering - A CAD system provides mapping and inventory. FSD's consulting engineer is relied on for capacity and design issues. A hydraulic model was prepared under this Master Plan project. This model provides for the capacity assurance component of the CMOM program.

?? Construction - New construction is inspected by FSD's consulting engineer and staff personnel. New sewers are air tested, video inspected, and warranted.

?? Sewer System Evaluation Survey (SSES) and Rehabilitation - FSD has not performed SSES surveys. Past rehabilitation work has included CIIP, brick manhole replacement, and sewer replacement.

?? Water Quality Monitoring - FSD does not have a program to monitor the local stream water quality.

?? Management Information System - Work reports for daily activities recorded by hand on a written log. No computer technology is used for the collection system. The treatment facility and administrative activities use computer technology.

?? Performance Indicators - EPA considers I/I nonexcessive if the total daily flow during high groundwater is below 120 gcd, and during wet weather does not exceed 275 gcd. The FSD average per capita wastewater flow is about 69 gcd. Annually FSD experiences about 1 to 3 overflows.

?? Complaints - FSD receives about 7 to 8 customer complaints per year, most commonly regarding odor, rates, or backups.

?? Public Relations - FSD has a public relations program.

?? Emergency Maintenance and Contingency Plans - No formal plan exists. There are written procedures for responses and for equipment operation.

?? Maintenance Scheduling - Maintenance is scheduled, and prioritized by system age.

?? Sewer Cleaning - The entire system is cleaned on a 2-year frequency. Problem segments that are identified are cleaned weekly. FSD has two vacuum units. There is no root control program.

?? Hydrogen Sulfide Monitoring and Control - There are odor complaints in certain areas, but FSD does not have a formal program for corrosion control.

?? Lift Stations - FSD has two personnel detailed to pump station operation and maintenance. The Little Ranches pump station is visited daily and the smaller stations twice per week.

?? Sewer System Evaluation - There is no formal flow monitoring program, sewer inspection program, or SSES program.

?? Rehabilitation - FSD has used Insituform sewer repair and point repairs. Manhole repairs have used epoxy coating, grouting, complete replacement, sewercoat, and replacement of castings.

?? Service Laterals - FSD does not have responsibility for service laterals. FSD has a procedure for approval and inspection of laterals.

6.7.3.2 FSD Evaluation

Based on comparison of the draft SSO Rule and CMOM requirements with FSD's questionnaire responses, it appears that the FSD incorporates most of the required elements in its current operations. Current SSO events are very few per year and are not typically I/I related. Potential weaknesses that seem to exist in the FSD's overall program are as follows:

?? Lack of a formal and written Overflow Emergency Response Plan (OERP)

?? Lack of an automated Maintenance Management Information System (MMIS) which would greatly facilitate the process of record keeping and reporting required by CMOM

?? Lack of a formal process for identification and prioritization of structural deficiencies

?? Lack of a formal short-term and long-term rehabilitation plan to address deficiencies

?? Legal issues related to satellite systems

?? Need to adopt procedures for formal review and evaluation of odor complaints

?? Need for review and assessment of whether FSD has adequate authority over private sector infiltration/inflow, and a program to provide construction inspection of private service connections

?? Need for enhancement of existing Floatable Oil and Grease (FOG) ordinance and activities to reduce the amounts of FOG received by the system

6.7.3.3 Impact of Proposed SSO Rule and CMOM Requirements on FSD's Operation

CMOM Regulations - Since FSD's collection system has very few SSO's per year and appears to have generally adequate capacity, the CMOM regulations are not expected to have a major impact on operations or on operational costs. It will be necessary to prepare a "CMOM Program Plan" for submittal to Colorado EPA following promulgation of the proposed SSO Rule. This will require only that the District summarize its existing activities and elements. The OERP will require that the District address the issue of public notification. The SECAP can be formulated from this study and previous collection system reports.

Satellite Systems - Regulations pertaining to satellite systems will require some attention on FSD's part. The Colorado Centre Metropolitan District would be a satellite system, since FSD is the permit holder. Any other entity with private sewers could fall under the designation of a satellite system, such as an apartment complex, mobile home park, or hospital. In some cases, private sewer systems are considered service lines and would not hinder FSD's efforts to control inflow and infiltration.

The regulations addressing satellite systems will require the District to identify the legal issues that limit its ability to effectively address overflows in satellite systems. Discussions will also need to be held with Colorado EPA to identify its position on smaller satellite systems. In most cases, it is expected that FSD will be required to implement CMOM requirements throughout the collection system. In that case, either FSD will require the satellite systems to submit a CMOM Program, or FSD will have to obtain legal authority to assume their systems and operate them.

CMOM Program Planning Report – FSD should prepare a detailed review, beyond the scope of this report, of the adequacy of current operations and maintenance activities with regard to upcoming regulations. An example report outline of a CMOM program planning report is shown below.

?? Executive Summary

?? Purpose and Goals

?? Collection System Description

- Service Area Characteristics

  Planning/ Demographic information

- Collection System Description

  Treatment Plant

  Pumping Stations

  Sewer System

  Satellites

?? Management Programs

- Organization Overview

  Fountain City Government Overview

  Fountain Sanitation District Organization

  Support Services

  Engineering Services

- Policies

- Training

- Safety Programs
- Vehicle and Equipment Management
- Inventory and Warehousing
- Information Management
- Budget and Finance
    - Operating Budget
    - Capital Budget
- Legal
    - Fats, Oils and Greases (FOG)
    - Pre-Treatment
    - Private Property I/I Control
    - Satellite Agreements
- Water Quality Monitoring
- O & M Programs
    - Preventive/Proactive Maintenance
        - Treatment Plant
        - Pumping Stations & Force Mains
            - Thermal scans
            - Vibration Analysis
            - Standby Power (Generators)
        - Pipe
            - Trunk Sewer
            - Gravity Sewer
            - Special Appurtenances (regulators, siphons, grinder pumps, etc.)
            - Easements & Right of Ways
            - Corrosion & Odor Control
            - Flow and Rainfall Monitoring
            - Sewer Surveys/ Condition Assessment
            - Sewer Cleaning
            - Rehabilitation Program
    - Emergency Maintenance
        - Emergency Response (Reference Plan)
            - WWTP
            - WWPS
            - Sewer Pipe/Manholes

Pumped Discharges
Manhole Overfllows
Backup
Monitoring & Reporting of SSDs (Reference Plan)
Overflow/Backup Analysis and Recommendations

?? Performance Review
- Performance Measures
- Annual Progress/Achievements
- O&M Plan Revisions
- Future Goals
- Schedule

?? Summary

?? Appendices