CHAPTER 4

WASTEWATER COLLECTION SYSTEM GEODATABASE

4.1. INTRODUCTION

The City of Helena currently uses a Geographic Information System (GIS) and a Computerized Maintenance Management System (CMMS) to store the mapping and attribute information for the wastewater collection system. The GIS is built within the Environmental Systems Research Institute (ESRI) software platform and uses ArcGIS as the interface with the information. The City's CMMS was developed within the Hansen software platform. The master planning efforts not only needed to use this existing information during the project but also supplemented this data so that upon completion of the master plan the City's wastewater collection system data would be more complete and robust as a result of the data collection and planning efforts.

This section of the report defines the existing data and data sources that were available for the wastewater collection system. In addition to defining the existing data sources, this section covers the design and loading of the new wastewater system geodatabase and future recommendations for the City's wastewater system data management.

4.2. EXISTING DATA

The following section describes the wastewater collection system data that was obtained from the City for the wastewater master planning process. Each data source is discussed with special attention being paid to the type and structure of the existing data sources available within the City that were fundamental to the completion of the wastewater master plan. The two main data sources, GIS and Hansen, are also described.

4.2.1. *GIS Data*

The City of Helena's GIS is built within an ESRI SQL Server geodatabase. The geodatabase is not only able to store the attribute data for each wastewater collection system feature but also the spatial or mapping information that allows the feature to be drawn on a map. The geodatabase format is a very efficient and robust means to store data. The SQL Server geodatabase is an enterprise database system in which many users may access the data at any given time and tools are available for multi-user editing of the data. At this point, the City is not using the multi-user editing functionality but may elect to use these tools in the future.

Data stored in the geodatabase is far more extensive than just the information defining the wastewater collection system. In addition to the wastewater data, the geodatabase contained base mapping (roads, parcels, streams, etc….), topography, and zoning data. The data that was extracted from the City's geodatabase can be found in Table 4-1.

Table 4-1
Existing GIS Data Collected For the Master Plan

File Name	Feature Type	Description
SewerLines	Feature Class	Sanitary sewer lines
SewerManhole	Feature Class	Sanitary sewer manholes
AddressPoints	Feature Class	Lewis & Clark County address location points
Roadways	Feature Class	Lewis & Clark County road centerlines
Streams	Feature Class	Lewis & Clark County stream centerlines
Lakes	Feature Class	Lewis & Clark County lakes
HelenaCityLimits	Feature Class	City limits for Helena
HelenaCityZoning	Feature Class	City zoning for Helena
EastHelenaCityLimits	Feature Class	City limits for East Helena
Hlshd1	Raster	Ground surface hill shade for Helena
Lc24kfdem	Raster	Digital elevation model for Helena
Breaklines	Feature Class	Topographic breaklines for Helena
Masspoints	Feature Class	Topographic spot elevations for Helena
Contours	Feature Class	Topographic contours (5ft Interval)

The wastewater data within the GIS contained many attributes that were useful during the master planning process. Attributes attached to the pipes and manholes in the GIS included manhole IDs, pipe diameters and pipe material. Tables 4-2 and 4-3 define the wastewater collection system attributes that were contained in the City's original GIS data layers. Additionally, the sanitary sewer system attributes that were mandatory for the completion of the master plan are noted in the tables.

Table 4-2
Manhole Attributes in GIS

Attribute	Required	Comments
Manhole ID	Yes	Unique manhole ID contained within Manhole_ID field
Source	No	Data collection source
Edit	No	
GPS_Date	No	Date of field GPS data collection

Table 4-3 Sewer Main Attributes in GIS		
Attribute	**Required**	**Comments**
ID	Yes	Unique ID contained within the ID field but all values were null in source data
Name	No	
Owner	No	Owning organization
Class	No	
Material	Yes	Pipe construction material
Diameter	Yes	Pipe diameter
Joint	No	Pipe joint type
Length	Yes	Length field contained lengths of pipes in mixed units. Some pipes were in feet and others in meters.
Year Built	Yes	Year of construction or installation
Cost	No	
County	No	County where the pipe is installed
Elevation	No	Elevation for pipe incomplete and does not define exact location for measurement.
Comment	No	Miscellaneous comments

As noted in Tables 4-2 and 4-3, the GIS data contained numerous data fields that were crucial for master planning but did lack some of the most important information regarding the actual elevation of features. When working with a gravity flow system, such as a wastewater collection system, the elevation data defining the vertical definition of the system is extremely important. The elevation data must be at an accuracy that is capable of tracking very gradual slope changes across stretches of sewer main. In order to fill the elevation gaps that were found in the GIS data, the Hansen CMMS data was analyzed for additional data.

4.2.2. *Hansen Data*

At the start of the wastewater master planning process the City's Hansen CMMS data was stored in a Microsoft Access database. The Microsoft Access format is a readily available database format and provided adequate data support for the CMMS. An initiative was begun by the City shortly after the start of the master planning process to convert all the Microsoft Access database information into a more expandable SQL Server database. This SQL Server database differed from the one used within the GIS environment because it did not contain any mapping information. The result was that all the features within the CMMS lacked an actual location in the real world that could be placed on a map.

The Hansen CMMS data contained over 600 tables of information including some data that was a duplicate of the GIS data. The majority of the data within the CMMS was related to the maintenance and operations of the wastewater and stormwater systems within the City; however, there were physical data for the wastewater collection system such as pipe materials, diameters, invert elevations. The physical information for the

manholes and sewer mains was housed in the COMPSMH and COMPSMN tables respectively within the Access database that supported the Hansen CMMS. Each table contained many fields that were important to maintenance management but not useful for master planning. Therefore, Tables 4-4 and 4-5 define only the key data fields fundamental to wastewater master planning that were found in the Hansen database. As with the GIS data layers, the data that was required during the master planning process is noted.

Table 4-4
Key Manhole Attributes in Hansen

Attribute	Required	Comments
BARLDIAM	Yes	Manhole diameter
COMPKEY	No	Unique ID used to link data within the Hansen database
DROPMH	Yes	Defines a manhole as drop or normal
MHDPTH	Yes	Depth of manhole. Approximately 400 manholes missing this data.
UNITID	Yes	Unique manhole ID

Table 4-5
Key Sewer Main Attributes in Hansen

Attribute	Required	Comments
COMPKEY	No	Unique ID used to link data within the Hansen database
DWNDPTH	Yes	Downstream pipe depth. Approximately 2,300 pipes missing this data
DWNELEV	Yes	Downstream pipe elevation. Approximately 2,300 pipes missing this data
INSTDATE	Yes	Pipe installation date
PIPEDIAM	Yes	Diameter of pipe
PIPELEN	No	Length of pipe
PIPETYPE	Yes	Pipe construction material
SLP	Yes	Pipe slope. Approximately 2,000 pipes missing this data
UNITID	Yes	Upstream manhole ID
UNITID2	Yes	Downstream manhole ID
UPSDPTH	Yes	Upstream pipe depth. Approximately 230 pipes missing this data
UPSELEV	Yes	Upstream pipe elevation. Approximately 2,300 pipes missing this data

4.3. GEODATABASE DEVELOPMENT

4.3.1. *Introduction*

Based on the City's existing information management tools, the decision was made to build the new wastewater system geodatabase within the ESRI environment. The

geodatabase was first built and tested using an ArcGIS 9.1 personal geodatabase. The personal geodatabase had all the same functionality of the final enterprise geodatabase and allowed for easy transport and delivery of the data. Geodatabase design tools were chosen based on City experience and ease of use so that the data structure could be edited by the City for any future needs. The geodatabase design and loading process is discussed in the following section.

4.3.2. *Geodatabase Design*

The first step in the development of the wastewater system geodatabase was to decide what tools would be used to design the data structure. The Microsoft Visio database design tool was chosen to design the geodatabase because of its accessibility and usability within the City. Visio creates a visual depiction similar to a flow chart of the data structure that can be exported to an Extensible Markup Language (XML) file that will create the geodatabase within the ESRI environment. The Visio tool also allows the City to make adjustments to the data model at any time and apply these changes to the wastewater system data structure.

With the geodatabase design tool and the existing data sources defined, the final step in the design of the geodatabase was to determine the existing and future needs of the wastewater data. The first and most obvious goal of the data was to facilitate the completion of the wastewater master plan. Secondary goals included the usage of the data within the Hansen CMMS and mapping of the wastewater collection system.

The main data driver for the wastewater collection system master plan was the development of the hydraulic model of the system. The hydraulic model was built directly from the geodatabase and required that all physical system data be present and accurate for any parts of the wastewater collection system that was modeled. In addition to the data defining the manholes and sewer mains, the lift stations, service lines, and flow monitoring data was integrated into the geodatabase design.

Figure 4-1 shows the wastewater collection system geodatabase design. The geodatabase includes four spatial features. The spatial features are actual points, lines or polygons that can be placed on a map. These features represent the physical locations of the manholes, sewer mains, service lines, and lift stations. Two other data tables are included in the geodatabase design to hold the flow meter data. The flow meter table represents the information about a particular flow meter. A spatial feature is not created for this entity because it can be moved around and is always tied to a manhole. Therefore, the feature is related to the manhole in which it is located by a geodatabase relationship. The data that is recorded by the flow meter is stored in the flow table and is related to the appropriate flow meter and manhole by a geodatabase relationship.

4.3.3. *Geodatabase Loading*

The geodatabase design shown in Figure 4-1 provided the empty database shell into which all the wastewater collection system data was loaded. Loading the data into the geodatabase was a multiple step process because of the varying data sources. The three main data sources were the GIS, Hansen, and flow meters.

Wastewater Collection System
Geodatabase Object Summary

- Line feature class **ww_line**
- Point feature class **ww_mh**
- Point feature class **ww_liftstation**
- Line feature class **ww_serviceline**
- Table **flow_meter**
- Table **flow**

Simple feature class ww_line

Geometry *Polyline*
Contains M values *No*
Contains Z values *No*

Field name	Data type	Allow nulls	Default value	Domain	Precision	Scale	Length	
OBJECTID	Object ID							
SHAPE	Geometry	Yes						
ww_id	String	Yes					7	Sewer Line ID
ww_name	String	Yes					30	Name
ww_owner	String	Yes		owner			25	Owner
ww_class	String	Yes					5	Class
ww_material	String	Yes		material			10	Material
ww_diameter	Long integer	Yes			0			Diameter (inches)
ww_joint	String	Yes		joint			25	Joint Type
ww_year	Long integer	Yes			0			Year Built
ww_cost	Long integer	Yes			0			Cost
ww_county	Long integer	Yes			0			County
ww_comment	String	Yes					100	Comment
ww_compkey	Long integer	Yes			0			Hansen ID
ww_mh_up	String	Yes					255	Upstream Manhole ID
ww_mh_dn	String	Yes					255	Downstream Manhole ID
ww_inv_up	Double	Yes			0	0		Upstream Invert Elevation (ft)
ww_inv_dn	Double	Yes			0	0		Downstream Invert Elevation (ft)
ww_shape	String	Yes					10	Shape
ww_condition	String	Yes					15	Condition
ww_roughness	Double	Yes			0	0		Roughness Coefficient
ww_modeled	String	Yes		boolean			3	Modeled?
ww_photopath	String	Yes					25	Photo Path
SHAPE_Length	Double	Yes			0	0		

Simple feature class ww_serviceline

Geometry *Polyline*
Contains M values *No*
Contains Z values *No*

Field name	Data type	Allow nulls	Default value	Domain	Precision	Scale	Length	
OBJECTID	Object ID							
SHAPE	Geometry	Yes						
ww_material	String	Yes		material			10	Service Line Material
ww_date	Date	Yes			0	0	8	Date Installed
ww_address	String	Yes					30	Service Line Address
ww_diameter	String	Yes					10	Diameter (inches)
SHAPE_Length	Double	Yes			0	0		

Simple feature class ww_liftstation

Geometry *Point*
Contains M values *No*
Contains Z values *No*

Field name	Data type	Allow nulls	Default value	Domain	Precision	Scale	Length	
OBJECTID	Object ID							
SHAPE	Geometry	Yes						
ww_ls_id	String	Yes					7	Liftstation ID
ww_name	String	Yes					30	Name
ww_owner	String	Yes		owner			25	Owner
ww_overflowalarm	String	Yes		boolean			5	Has overflow alarm installed
ww_elevationatbottom	Double	Yes			10	3		Elevation at bottom of liftstation (ft)
ww_avgflow	Double	Yes			8	2		Average liftstation flow (gpm)
ww_peakflow	Double	Yes			8	2		Peak liftstation flow (gpm)
ww_wetwellcapacity	Double	Yes			12	3		Liftstation wet well capacity (gal)
ww_wetwellrimelev	Double	Yes			10	3		Rim elevation of wet well (ft)
ww_wetwellbarscreen	String	Yes		boolean			5	Has a bar screen on the wet well
ww_wetwelldepth	Double	Yes			10	3		Depth of wet well (ft)
SHAPE_Length	Double	Yes			0	0		

Table flow_meter

Field name	Data type	Allow nulls	Default value	Domain	Precision	Scale	Length	
OBJECTID	Object ID							
meter_id	String	Yes					15	Flow Meter ID
meter_make	String	Yes					25	Manufacturer
meter_model	String	Yes					25	Model
meter_vendor	String	Yes					25	Meter Vendor
meter_ownership	String	Yes					10	Rent or Own?
meter_status	String	Yes					15	Meter Status
meter_pdate	Date	Yes			0	0	8	Purchase Date
comment	String	Yes					100	Comment

Relationship class FlowMeter_Flow

Type *Simple*
Cardinality *One to many*
Notification *Both*
Forward label *flow*
Backward label *flow_meter*

Origin table	Destination table
Name *flow_meter*	Name*flow*
Primary key *meter_id*	
Foreign key *meter_id*	

No relationship rules defined.

Table flow

Field name	Data type	Allow nulls	Default value	Domain	Precision	Scale	Length	
OBJECTID	Object ID							
meter_id	String	Yes					15	Flow Meter ID
comment	String	Yes					100	Comment
mh_id	String	Yes					10	Manhole ID
flow_date	Date	Yes			0	0	8	Reading Date
flow_time	Date	Yes			0	0	8	Reading Time
flow_velocity	Double	Yes			0	0		Velocity (fps)
flow_level	Double	Yes			0	0		Level (inches)
flow_nos	Long integer	Yes			0			NOS (val)
flow_pmr	Double	Yes			0	0		PMR (val)
battery_bak	Double	Yes			0	0		Battery Backup (vdc)
battery_mn	Double	Yes			0	0		Main Battery (vdc)
flow	Double	Yes			0	0		Flow (gpm)

Simple feature class ww_mh

Geometry *Point*
Contains M values *No*
Contains Z values *No*

Field name	Data type	Allow nulls	Default value	Domain	Precision	Scale	Length	
OBJECTID	Object ID							
Shape	Geometry	Yes						
ww_mh_id	String	Yes					10	Manhole ID
ww_source	String	Yes		mhsource			30	Data Source
ww_edit	String	Yes					20	Edit
ww_gps_date	Date	Yes			0	0	8	GPS Date
ww_compkey	Long integer	Yes			0			Hansen ID
ww_comment	String	Yes					100	Comment
ww_rimelev	Double	Yes			0	0		Rim Elevation (ft)

Relationship class MH_Flow

Type *Simple*
Cardinality *One to many*
Notification *Both*
Forward label *flow*
Backward label *ww_mh*

Origin feature class	Destination table
Name *ww_mh*	Name*flow*
Primary key *ww_mh_id*	
Foreign key *mh_id*	

No relationship rules defined.

Helena Wastewater Collection System Master Plan

City of Helena

N

Burns & McDonnell SINCE 1898

MORRISON MAIERLE, INC.

Figure 4-1
Wastewater Collection System Geodatabase Design

Helena Wastewater Collection System Master Plan

R:\0500\141 - WW Collection System Master Plan\DESIGN DOCS\Report\Figures\figure4-1.mxd

The GIS data was loaded into the geodatabase first because it contained the only spatial information of the three data sources. The tools within the ArcGIS environment were used to load all the City's manholes and sewer mains into the new geodatabase structure. As the legacy data was loaded into the new geodatabase, feature and attribute checks were completed to ensure that all legacy data was accurately loaded into the new geodatabase. The lift station data was loaded from the City's existing manhole GIS file. The manhole ID field in the existing manholes contained information that was used to separate the manhole features from the lift stations.

Once the GIS data had been loaded to the new geodatabase structure, additional information from the Hansen data and flow monitoring data sources could be added. The key to adding supplemental data was getting an identification number (ID) that could be used to link the different data sets. The manhole and pipe IDs in both the GIS and the Hansen data set were analyzed and adjusted so that all the data matched between the two data sets. It was imperative that a direct linkage between the two data sets be created so that the correct feature data could be added to the new geodatabase.

The final data that was loaded to the new geodatabase was the flow monitoring information. As the flow monitoring data was collected and compiled it was loaded to the geodatabase based on the appropriate manhole ID and flow monitoring ID. The data was checked to make sure that no records were lost during the loading process and the geodatabase relationships were checked to make sure the data linkage between meters, meter data, and manholes were working correctly.

4.4. GEODATABASE RECOMMENDATIONS

4.4.1. *Introduction*

This section provides recommendations for future wastewater collection system data management. It was not possible to determine all of the potential future needs or requirements for the wastewater collection system data during completion of this project, but these recommendations were developed with an emphasis on assisting the City in developing a system that is flexible and will allow adjustments to be easily made as new initiatives and needs arise.

4.4.2. *Geodatabase Structure*

The recommendations regarding the geodatabase structure are as follows:

- **Expand Wastewater Collection System Geodatabase Design to Allow Added Functionality.** As ESRI software evolves, new data structures are developed and one of these data structures is a geometric network. The geometric network is a data structure that is used within the geodatabase and allows a user to trace upstream and downstream within a pipe and manhole system. This type of data structure is highly useful in a gravity based system such as a wastewater collection system. The network also contains connectivity rules that make sure the system is always properly connected, thus eliminating small data snapping errors.

The downfall of the higher functionality of the geometric network is the requirement of an ESRI software license with additional functionality. As the City increases its usage of the geodatabase and begins to acquire more licenses of ESRI software, it is recommended that a geometric network be built for the wastewater collection system data. The added tracing and connectivity functionality of the geometric network would bring efficiencies and added data quality to the City's wastewater collection system data.

4.4.3. *GIS Data*

The City is currently doing a very good job of getting new wastewater collection system features into their GIS; however, some additional measures could be put in place. The recommendations are summarized as follows:

- **Additional Design Submittal Standards.** One key change that is recommended is the institution of design submittal standards that allow the City to receive a digital CAD file of all new wastewater collection system features. A CAD file that has feature and attribute standards can be easily imported into the City's geodatabase and automatically update the wastewater collection system data. The submittal standard would not only allow the City to get the location of the new collection system features but also the key maintenance and modeling information such as pipe diameters, pipe materials and the very important elevation information. This would relieve a large part of the data maintenance burden on the City and allow them to keep their wastewater collection system geodatabase up to date as new development occurs.

- **Adopt Data Accuracy Standards.** It is also recommended that the City keep in mind that there are many different uses for data that could benefit the City's other activities. While it is difficult to anticipate other future uses, the City should build that flexibility into their data collection activities. As an example, when the City is collecting manhole and invert depths, it is important to keep in mind that the accuracy required by the maintenance crew is different than the accuracy required for hydraulic modeling. It is recommended that the City refine their pipe invert and manhole depth collection methods to ensure that tenth of a foot or better accuracy is attained on these measurements. There are different tools available to accurately measure pipe invert depths ranging from a measurement rod to a laser measurement device that is mounted on the top of the manhole.

- **Increase GPS Accuracy Capability.** Additionally, the City should consider purchasing a survey grade GPS unit to use during the field data collection of manhole locations. The sub-meter GPS unit that is currently being used by City staff attains horizontal coordinate accuracies that are adequate for the manholes but does provide the accuracy recommended for the rim elevations. A survey grade GPS unit would attain adequate accuracies for both the horizontal and vertical coordinates of a manhole. It should be noted, though, that the cost of the survey grade GPS unit is quite high and it may be preferable to implement design submittal standards to attain the necessary vertical coordinate information.

- **Implement Standard Datum for all City Departments.** As part of the work for the master planning effort, a field survey of all manholes on pipe diameters 10-inch and greater was performed. An effort was made to utilize data from previously conducted surveys which included manhole rim elevations. It was observed that the City's Engineering Department maintains a "City Datum" which is believed to have originated from the NGVD29 (aka Mean Sea Level) Datum. This is inconsistent with the datum used in the City-County GIS geodatabase and is inconsistent with currently accepted surveying standards. The conversion of this data was felt to be of inadequate accuracy for use in the model. The datum shift from NGVD29 to NAVD88 is approximately 1.016 meters. It is recommended that the City convert to the NAVD88 datum and move toward elimination of any data referenced to the "City Datum".

4.4.4. *Hansen Data*

Recommendations for the Hansen data are as follows:

- **Integration of Hansen Data with City's GIS Data.** The City is currently implementing functionality that would allow them to use the GIS and Hansen data together and help eliminate duplicate information and duplicate effort to keep the data up to date. It is recommended that the City continue their program for the integration of the GIS data with the Hansen data because they will realize efficiencies and data quality improvements by removing duplicate data creation and maintenance processes.