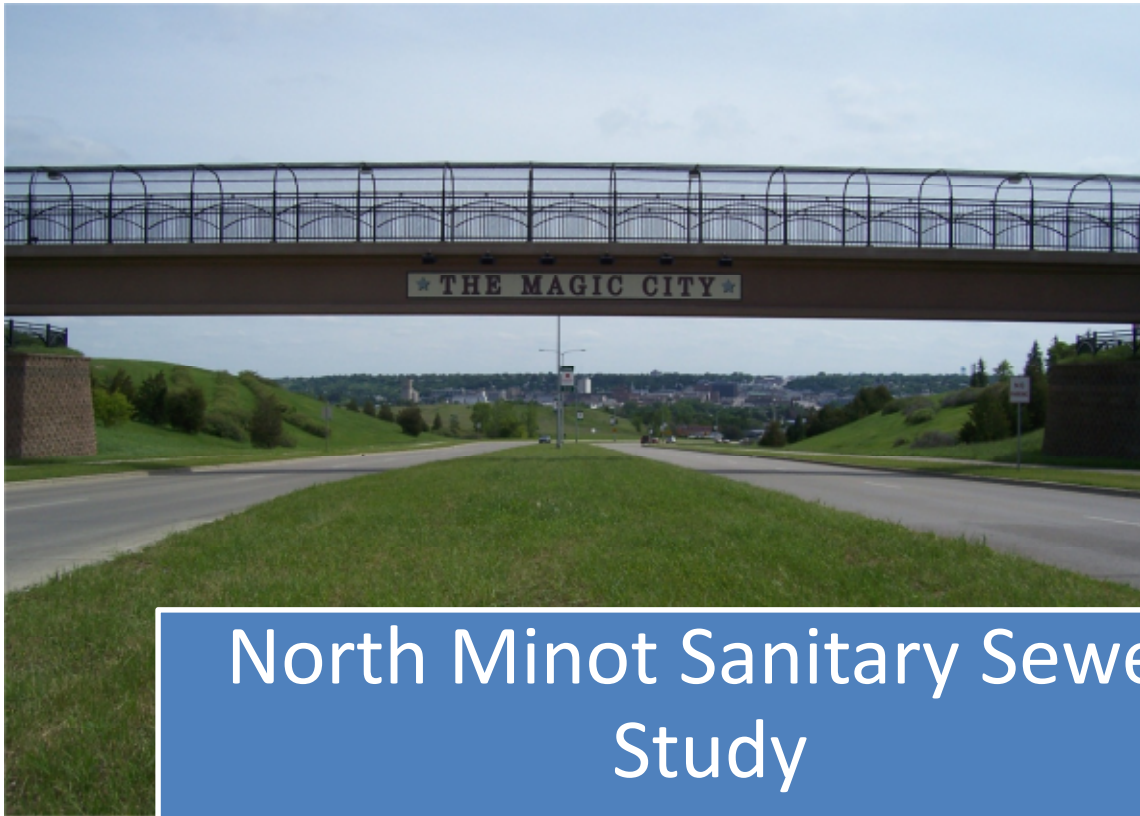




North Minot Sanitary Sewer Study July, 2011

City of Minot



City of Minot

Mr. Lance Meyer
City Engineer
515 2 Avenue SW
Minot, North Dakota 58701

Re: North Minot Sanitary Sewer Study
Ulteig File: 10.01288

Dear Lance,

With this letter we formally transmit the final report for the North Minot Sanitary Sewer Study. The information presented in this report is based on costs and data that were available in the spring of 2011. The plan was prepared in accordance with Ten States Standards.

We would be pleased to discuss the contents of this report with City Staff or other interested parties at any mutually convenient time.

Sincerely,
ULTEIG

Earth Evans, P.E.

Bob Barth

I hereby certify that this plan, specification, or report was prepared by me or under my direct supervision and that I am a duly Licensed Professional Engineer under the laws of the State of North Dakota.

Signature

Earth Evans
Typed or Printed Name

Date _____

License No. PE-7058

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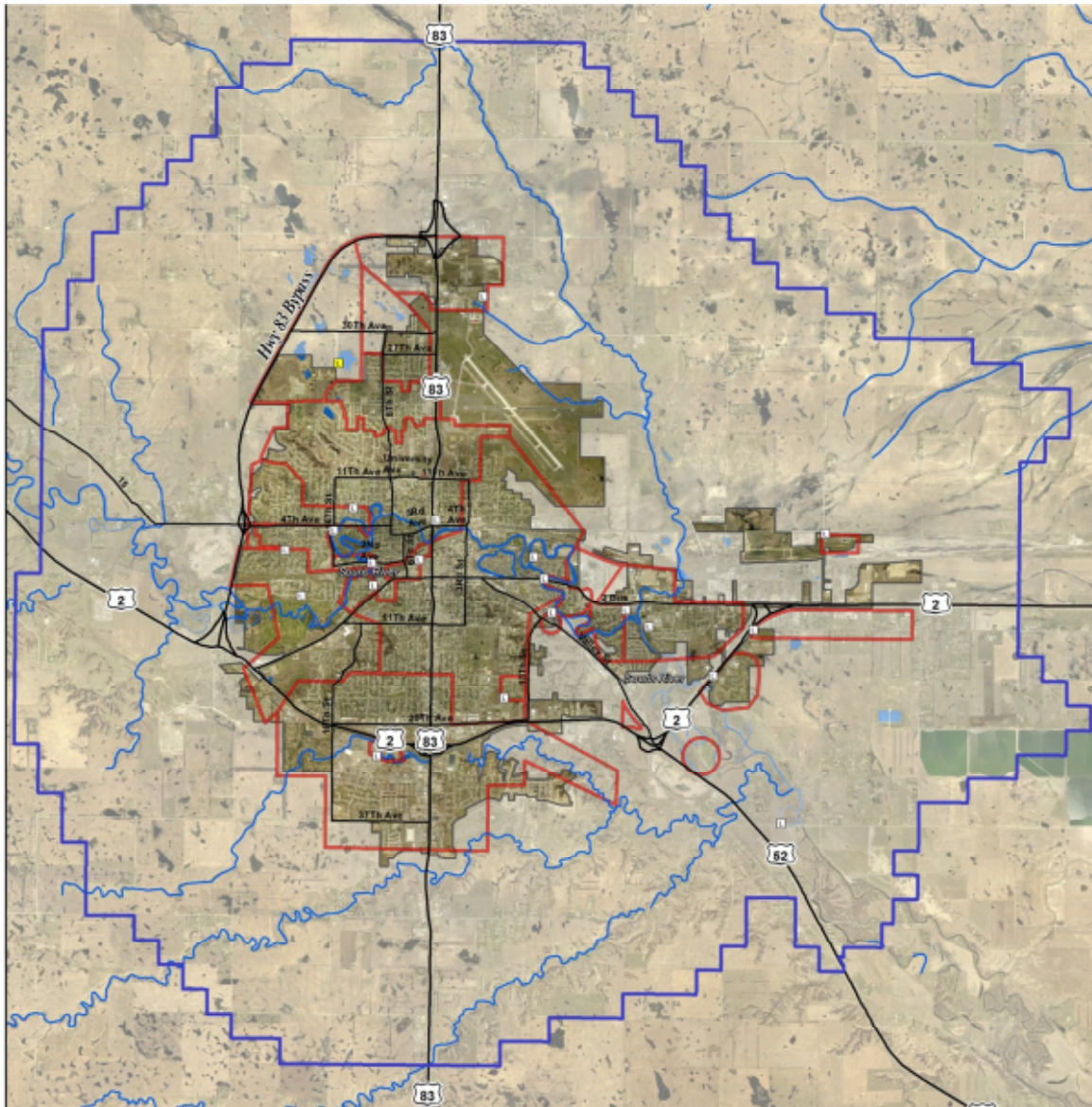
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1.0 INTRODUCTION AND PURPOSE

The purpose of this report is to provide the City of Minot with a comprehensive alternatives analysis and recommendations for the collection, conveyance, layout and capacity of the future trunk sanitary sewer system for North Minot. The study also determines future lift station locations and sizing criteria. Finally, a 20-year capital improvement plan is provided to assist the City in budgeting for the proposed improvements.

The scope of this study includes an evaluation of all existing facilities in the North Minot Sanitary Sewer System Area (NMSSSA). The NMSSSA is generally defined on the north, west and east by the 2-mile boundary as shown on Exhibit 1.

Exhibit 1 – Location Plan



The NMSSSA includes the majority of the existing collection system for the City of Minot, with the notable exception of the system tributary to the Puppy Dog Lift Station on the south side of the City. The existing facilities include the Valley Forcemain and 17 lift stations. No evaluation was made for the existing wastewater treatment facilities located in the southeast corner of the City.

A map of Minot's existing and proposed sanitary sewer trunk system is presented as Figure 1: North Minot Trunk Sanitary Sewer Map, at the back of this report. This map shows the trunk sanitary sewer, lift stations, existing and proposed sanitary sewersheds and 2 mile boundary.

The City is currently experiencing significant growth. As a result it is in the process of updating its Comprehensive Plan for the 2030 period. The flow projections utilized in this study are based on the forecasts from this draft document.

This North Minot Sanitary Sewer Study is intended to serve as an inventory of Minot's existing North trunk sewer system and a guide for the expansion and upgrading of the City's trunk sewer system to accommodate future growth. It presents an overall trunk layout for the City that will meet the immediate and future requirements of the City by accommodating anticipated growth.

2.0 EXISTING FACILITIES OVERVIEW

The North Trunk Sanitary Sewer Map (Figure 1 at the back of this report) depicts Minot's sanitary sewer districts. The map shows the layout of existing trunk sewer system and the general layout of the future sanitary sewer system. A distinction has been made between the collection system (mains 10 inches and smaller shown in light green) and the trunk system (gravity mains 12 inches and larger and forcemains).

There are 14 existing sewersheds in the NMSSSA.

2.1 Trunk System

Two key components to the NMSSSA existing trunk system are discussed in detail in this study.

- Valley Forcemain
- Nine Primary Lift Stations: Perkett, 16th Street, 13th Street, Walders, Roosevelt, Control, Master, Airport and Airport Industrial

A detailed analysis was also completed for the 21st Avenue system and Third Street NE collection system. Immediate development pressure in this location necessitated a specific analysis. This analysis is described in detail in Section 5.0

The system was modeled in InfoSWMM, software developed by Montgomery Watson Harza that simulates wastewater flow conditions by routing sewer flows through the developed sewer structure of pipes and lift stations. The model calculates the various hydraulic parameters during normal flow, surcharge, flooding and pumping conditions. Due to the complexity of the multiple connections into the Valley Forcemain, this modeling software was integral to the capacity assessment of the existing system.

The pump curves, wet well size and invert, forcemain size and invert, pump on/off elevations and other pertinent data for each of the primary lift stations in the NMSSSA was incorporated into the sewer system model to determine the existing system deficiencies and potential for expansion.

2.2 Valley Forcemain

The trunk system that serves the NMSSSA is primarily fed by a single interceptor line, the Valley Forcemain, which runs along the north side of the Souris River and ranges in size from 16 inches to 24 inches in diameter, as shown Figure 1. The Valley Forcemain is unique in that it conveys flows as a common forcemain for five different lift stations: Perkett, 16th Street, 13th Street, Walders and Roosevelt.

Construction of the Valley Forcemain began in 1950. Through the years, the City has completed numerous upgrades and expansions to the system. In the 1980's and early 1990's, for instance, several retrofits to the downstream system were constructed which

focused around the Control and Muus interceptors. Later, in 2000, Minot constructed upgrades that focused on the Valley Forcemain near the Walders Lift Station to just downstream of Roosevelt Lift Station. Generally, these upgrades consisted of minor capacity improvements and periodic rehabilitation, but no major capacity increases.

Due to the large number of lift stations directly connected to the Valley Forcemain, the pumps in directly connected lift stations do not operate at their design total dynamic head. In fact, individual lift stations usually encounter varying head conditions due to the presence of other pumps in the system. This aspect becomes important when considering future improvements to the system.

The primary constraint in the Valley Forcemain is the pipe diameter and lift station pump capacity. Increases in flow without increased pipe diameter result in velocities that exceed 10 feet-per-second (fps). The implications of increased forcemain velocities are corrosion in the pipe system, excessive head loss, forcemain transient pressure and pump cavitation, which in turn damages the impellers.

2.3 Primary Lift Stations

The five lift stations directly connected to the Valley Forcemain as well as 7 other lift stations were modeled: Carney, Kittleson, Control, Master, Verendrye, Airport and Airport Industrial. Drawdown tests and field inspections were completed for the primary lift stations for this study. A comparison of the draw/fill tests to the design flow is provided in Appendix J.

Table 1 includes the pertinent lift station data for each of the primary lift stations in the NMSSSA.

Table 1 – Existing Lift Station Data

Lift Station	hp	TDH (ft)	No. pumps	1 pump		Wet well (ft)	Imp size (in)
				gpm	MGD		
Perkett	25	45	2	900	1.3	12	12.5
16th Street	6.4	37	2	400	0.6	3.5 x 11.5	11.25
13th Street	7.5	39	2	600	0.9	3.5 x 11.5	10.5
Walders	30	47	2	1500	2.2	13	13
Roosevelt	40	48	2	2000	2.9	12	14 x 13
Control	185	84	3	5800	8.4	7.4 x 22	21.65
Master	500	210	2	6500*	9.4*	14 x 12	20.75
Airport	3.2	18	2	100	0.14	6	--
Airport Industrial	9.4	18	2	100	0.14	6	--

*Estimated capacity after impeller modifications based on pump curve, one pump operating

A brief discussion of each of the lift stations follows. Appendix A includes the land use acreages tributary to each lift station. Appendix B includes the estimated average flow to each lift station. Appendix E includes the average dry weather run time and flow data for each lift station based on the drawdown tests and lift station pump run times provided by the City. Finally, Appendix G includes the pump curves for several of the lift stations.

2.3.1 PERKETT, 13th STREET, 16th STREET, WALDERS and ROOSEVELT LIFT STATIONS

As described previously, these five lift stations pump directly into the Valley Forcemain. General information and specific field inspection information regarding each of the lift stations is provided.

The Perkett Lift Station is located at the intersection of 7th Avenue SW and 21st Street SW. It is the first lift station pumping into the Valley Forcemain and was constructed in 1963. Perkett pumps to a 16-inch forcemain.

The 16th and 13th Street lift stations are nearly identical. As their name indicates, they are located on 16th Street and 13th Street, respectively and near the Souris River. Both lift stations were constructed in 1954. The 16th Street Lift Station pumps to a 16-inch forcemain, 13th Street lift station pumps to a 20-inch forcemain.

Walders lift station is located at Walders Street and 5th Avenue NW and was also constructed in 1954. It pumps into a 24-inch forcemain. The lift station was upgraded and pumps replaced in 1991.

Roosevelt Lift Station is the final downstream lift station that pumps to the Valley Forcemain. It is located at 1st Avenue NE and 14th Street, east of a bend in the Souris River. It pumps to a 24-inch forcemain. Roosevelt was constructed in 1954, but completely rebuilt and expanded in 1984.

2.3.2 CONTROL AND MASTER LIFT STATIONS

The Control and Master Lift Stations are located on the downstream end of the Valley Forcemain. The Control Lift Station lies near 31st Street and 11th Avenue. Downstream of the Control station, the Master lift station lies on 16th Avenue, east of Highway 2. The Control lift station pumps to the Master lift station, which then pumps to the aeration ponds/lagoons. Both stations discharge into a 24-inch diameter forcemain. The lift stations were originally constructed in the 1950's with the Valley Forcemain. In 1982, the City upgraded both stations. The latest major improvements occurred in 2007 with upgrades to the Control Lift Station.

The City has highlighted several key issues with the Control and Master lift stations. These issues are discussed in further detail in the hydraulic assessment of the existing system later in this memo, but can be summarized as follows:

- The power available to the Master lift station is an issue. The current service only allows one pump to run and only after Public Works staff modified the impellers. The original impeller diameter was 24.25 inches but this was modified to 20.75 inches, to decrease the starts per hour. The maximum capacity of the Master lift station is restricted to 9.4 MGD based on one pump operating.
- Since electrical issues prevent the Master Lift Station from operating at full capacity, Public Works Staff must restrict the pumping from the Control Lift Station to avoid flooding the Master Lift Station wet well.

2.3.3 AIRPORT AND AIRPORT INDUSTRIAL LIFT STATION

The Airport and Airport Industrial lift stations are located on the northern limits of the developed area. The Airport Lift Station is downstream of the Airport Industrial lift station. However, there is only one 12-inch connection between the two lift stations so they both essentially convey the same flow. The capacity of these lift stations is 0.3 MGD with both pumps operating, which corresponds to the monitored flow. The calculated existing flow is considerably higher for these lift stations. The discrepancy is likely due to the low sewage generating industrial land use.

The Airport Industrial Lift Station is located at 35th Avenue NE and 5th Street NE. Airport Lift station is located along Highway 83, west of the Airport near 24th Avenue NW. Both lift stations were constructed in 1978.

3.0 FLOW AND RAINFALL MONITORING AND ANALYSIS

3.1 GENERAL

The purpose of flow monitoring is to collect accurate information on the characteristics of sanitary sewage flows for a particular study area. The collection of flow data is essential for conducting detailed analysis of a city's sanitary collection and conveyance system. For the Minot study, sanitary sewage flows and rainfall data were all monitored during the flow-monitoring program, which started August 11, 2010 and ended October 11, 2010. Results of the flow-monitoring program were used as the basis for hydraulic analysis of the City's north-side sanitary sewer system.

3.2 FLOW MONITORING AREAS AND SANITARY SEWER SUB-BASINS

The City of Minot's NMSSSA consists of gravity collector sewers, lateral sewers, force mains, and submersible pumping and lift stations. All of the existing collection and conveyance facilities act as one system for collection and conveyance of wastewater from the north side to the valley forcemain system and eventually to the wastewater treatment facility.

3.3 FLOW METER SITES AND INSTALLATION

Flow monitoring was the first task completed on this project. Temporary flow meters were installed on August 11, 2010 to better understand the flows, which will be used as the base line when evaluating the north sanitary sewer system with projected future flows. The data will also show any contribution from precipitation events.

Tech Sales, Inc., a subcontractor to Ulteig on this project, installed, monitored and downloaded data for two (2) flow meters and one (1) rain-gauging station. Some of the sub-basins were not monitored as shown on the previous page. Flow monitoring lasted approximately 60 days. The flow meter sites are shown in Figure A1 in the Appendix of this technical memorandum.

Exhibit 2: Flow Meter Installation



The meters used were manufactured by ISCO. Each meter records velocity and depth at pre-determined time intervals. The data points for velocity and depth, along with the time scale, are used to calculate a flow rate in gallons per minute.

3.4 RAINFALL DATA AND ANALYSIS

In order to study the magnitude and severity of wet weather events and the impact of wet weather events on the north side sanitary sewer system, rainfall data was collected. Each

wet weather event was monitored for rainfall intensity (inches of rain per hour) and rainfall total.

Rainfall data was collected on a continuous basis with a “tipping” type rain gauge mounted near the manhole with the flowmeters installed in it. The location of the rain gauge is shown in the Appendix. The rain event data for the study period is categorized as very good. There were numerous wet weather events in Minot during the monitoring period, which allowed for evaluation of the impact of rainfall on the City’s north side sanitary sewer system.

To determine peak collection system flows, it is essential that associated rainfall events have moderate intensities. High intensity rainfall events often result in peak wastewater flows that create surcharge, backups, and possibly overflows. The goal of the subsequent modeling effort is to evaluate the hydraulic behavior of the sewer system under open-channel flow conditions. Therefore, surcharges and backups produce non-representative data and must be used cautiously. In addition, projecting the theoretical peak wastewater flows under these conditions is virtually impossible since storage and other volumetric losses reduce measured peak flows.

There were five (5) rain events between August 11th and October 11th. The rain events are shown in Table 2.

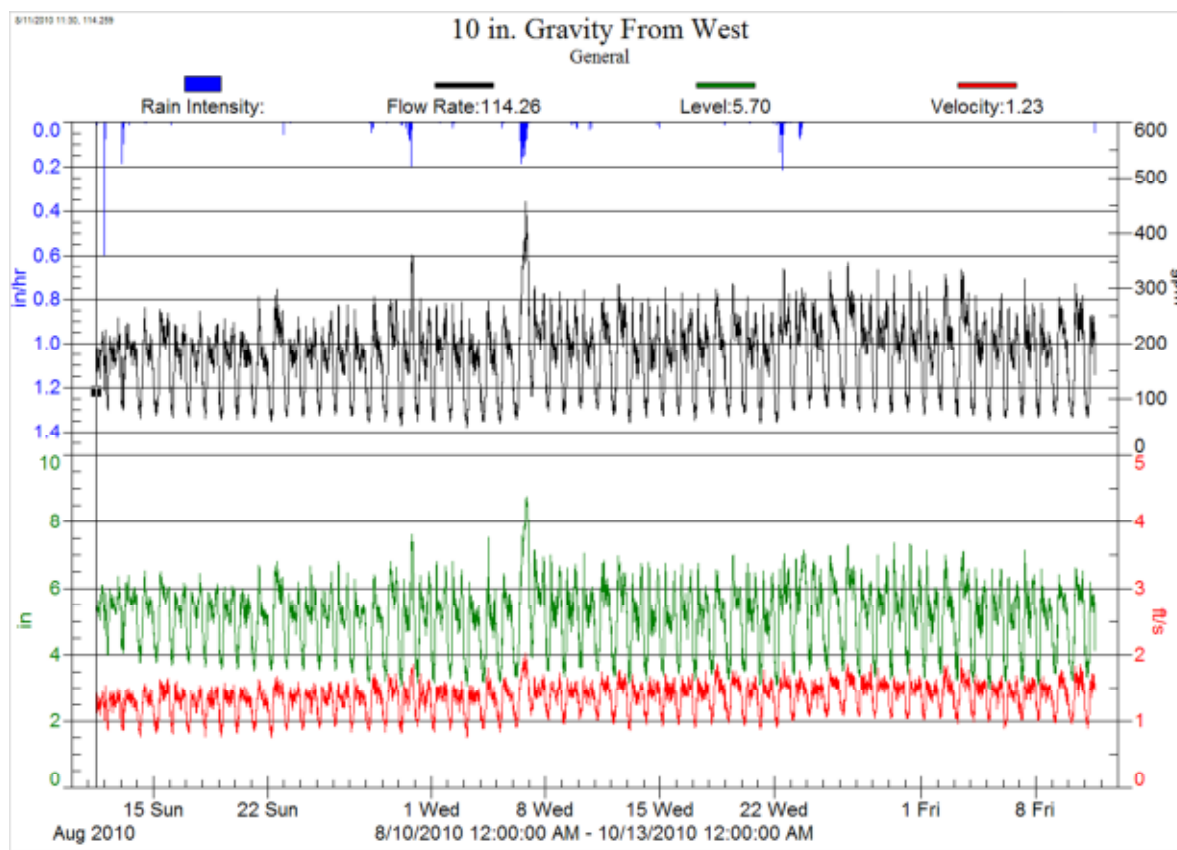
Table 2: Rain Events

Date	Rain Gauge	
	Total Storm Depth (in.)	60 min. Peak Intensity (in/HR)
8/12/2010	0.70	0.60
8/13/2010	0.36	0.19
9/6/2010	1.34	1.34
9/22/2010	0.63	0.22
9/23/2010	0.33	0.07

3.5 SANITARY SEWER FLOW MONITORING RESULTS

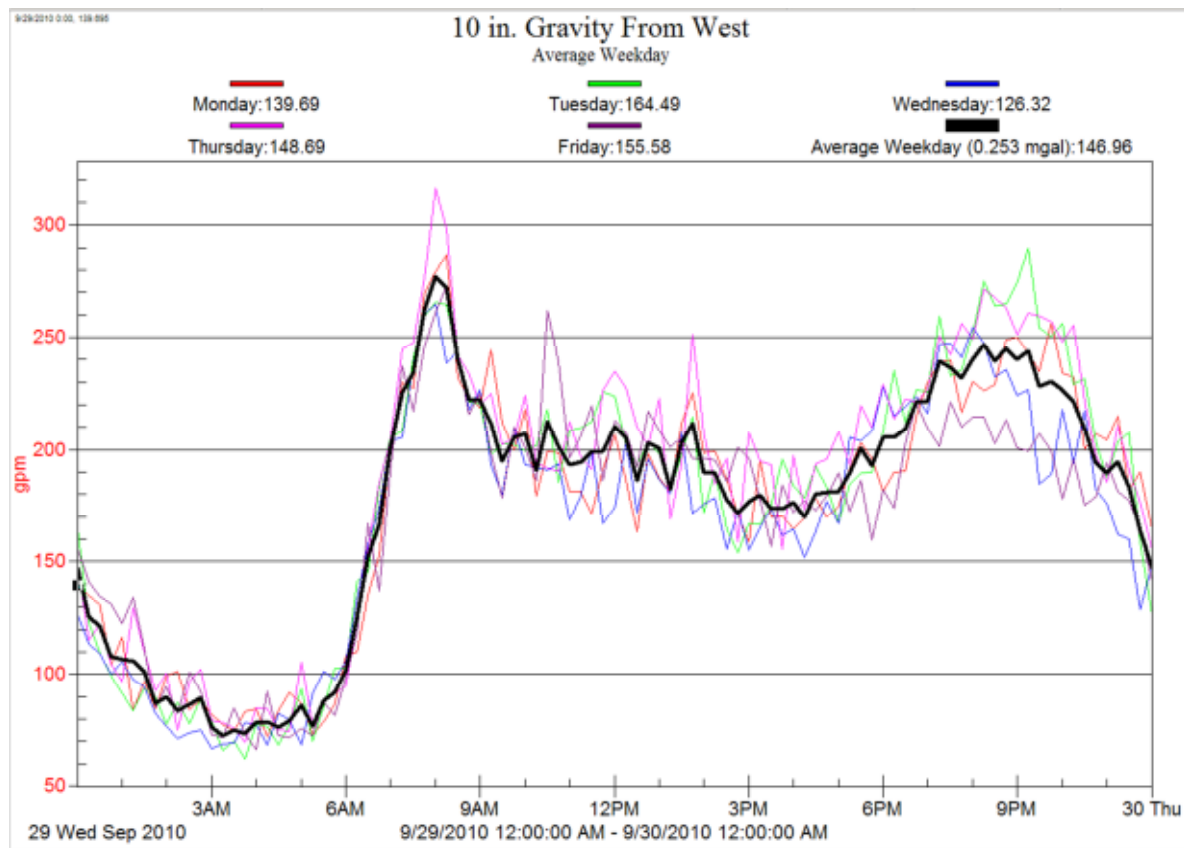
Flow patterns for the study area were evaluated using hydrographs generated from flow monitoring. Hydrographs identify the sewer’s total flow by measuring depth and velocity of flow over time (see Exhibit 3). Hydrographs can also help identify the amount of rainfall induced inflow and infiltration (I/I). The goal of these graphs is to quickly identify if the area has a problem with I/I and if so, to what magnitude.

Exhibit 3: Example Hydrograph



One of the objectives for flow monitoring on this project was to establish dry weather diurnal flow patterns for the study area. These flows are important for establishing base sanitary sewage flows with minor infiltration. Shown in Exhibit 4 is the diurnal flow for an average weekday in the 10-inch gravity line. Each day is represented on the graph, as well as the average weekday, shown with the heavy black line.

Exhibit 4: Typical Diurnal Flow Pattern for Study Area



The average diurnal flows for the 21st Avenue area vary from approximately 80 gpm to 280 gpm throughout the day.

3.6 Rainfall Derived Infiltration and Inflow (RDII)

Rainfall derived infiltration and inflow (RDII) is flow that enters the collection system due to rain events. This flow can be further separated into Infiltration and Inflow.

3.6.1 INFILTRATION

Rainfall Derived Infiltration is a result of rainfall that soaks through the soil and enters the collection system in the same manner as groundwater infiltration. Since Rainfall Derived Infiltration and Groundwater Infiltration enter the collection system in the same manner, the effects of Rainfall Derived Infiltration are reduced when the soil is already saturated. Rainfall Derived Infiltration is not considered when determining the peak basin flow rate since it usually occurs significantly after the inflow response has peaked.

3.6.2 INFLOW

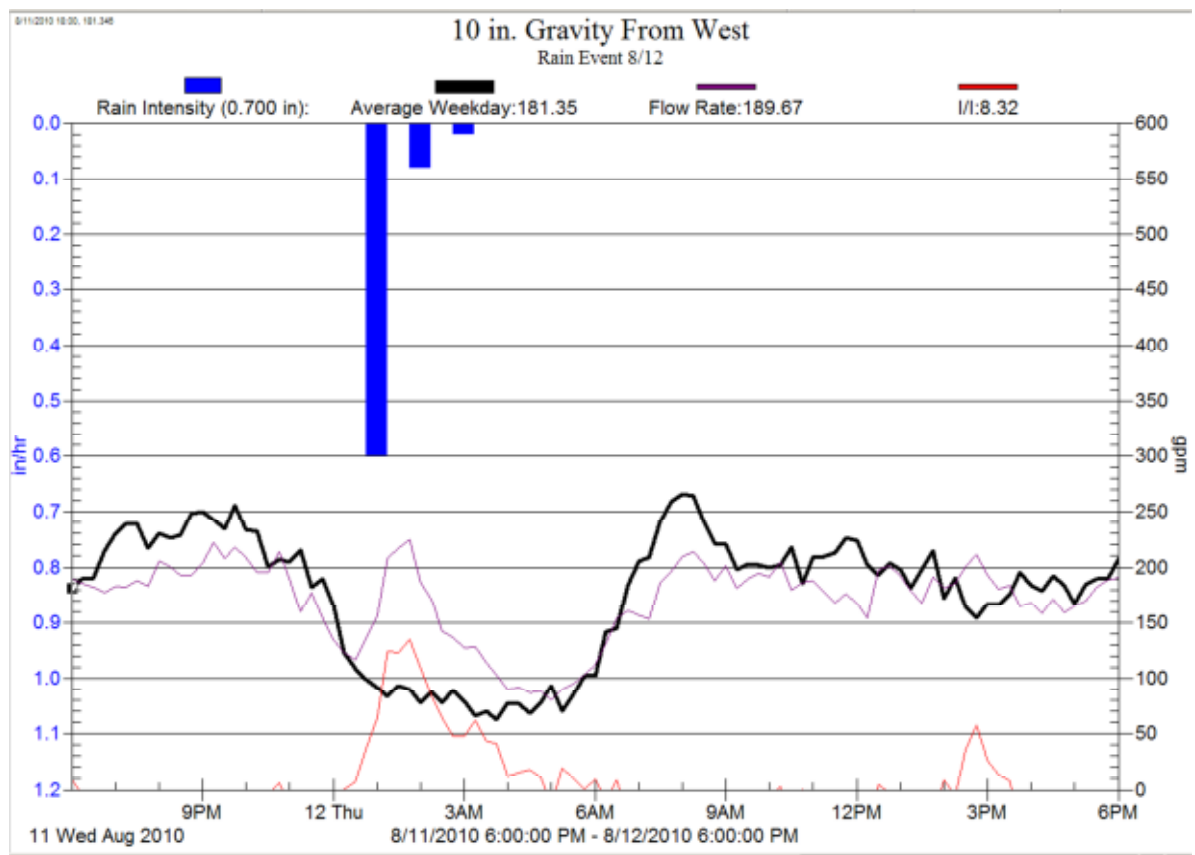
Rainfall derived inflow is the portion of rainfall that directly enters the collection system. Rainfall derived inflow results in a rapid rise in collection system flows during and immediately after a rain event.

Table 3: Typical Inflow Sources

Private Sector	Public Sector
Roof Downspout	Vented Cover (below grade)
Driveway Drain	Pick hole (below grade)
Exterior Stairwell Drain	Poor Manhole Cover Frame Seal
Uncapped Cleanout	Directly Connected Storm Inlet
Area/Yard Drain	Indirect Storm Sewer Connection
Exposed Service Lateral	Cross-Connected Storm Sewer

Flow patterns during each rainfall event discussed earlier were superimposed on the average diurnal curves to provide a snapshot of extraneous flows. An example is shown in the following figure from the 8/12 rain event.

Exhibit 5: Diurnal Flow Pattern During Rain Event versus Average



The heavy black line represents the average diurnal pattern. The purple line represents the actual flow pattern observed and the red line represents the difference between the actual and the average, or the I/I. The immediate spike following the start of the event represents inflow into the system. Subsequent smaller spikes typically represent infiltration. Graphs from the other rain events show similar tendencies and are included in the appendix.

4.0 SYSTEM CHARACTERISTICS

4.1 Land Use

The land use plan for the City of Minot served as the basis for the development of the sanitary sewer flow projections and analysis of the trunk system. Appendix F includes the existing land use map.

Using the land use map, the area of each land use was determined for each sewershed. Areas of each land use by sewer district are presented in Appendix A.

The existing land use is a mix of residential land use types and commercial. Residential land use is concentrated in the northwest and commercial/industrial to the northeast. South of the Souris River commercial development is focused along the corridor following South Broadway.

The City of Minot's Comprehensive Plan is being developed concurrently with this sanitary sewer study. The future area has been divided into two broad areas: northwest and northeast, generally split along Highway 83. Based on the Comprehensive Plan, the following land use percentages have been applied to future sewer service areas in the northwest. As shown in Table 4, the proposed land uses are largely residential west of Highway 83.

Table 4 – Proposed Land Use Percentages

Section	Right-of-way	Parks/Open Space	Low Density Residential	High Density Residential	Commercial	Industrial	Public/Semi-Public
NW	15%	15%	40%	10%	5%	5%	10%
NE	15%	10%	32%	5%	5%	28%	5%

The northeast area land use is largely industrial from south of 30th Avenue to Highway 2 and extending east to 72nd Street. Beyond the industrial land use, the northeast area is largely low density residential. A corridor of commercial and medium density residential follows 46th Avenue east to 55th Street. The areas listed in Appendix A follow these descriptions and guidance from the City based on the draft Comprehensive Plan.

A thirty percent reduction has been included for non-sewage generating land uses including right-of-way and parks/open space. The gross acreage was also reduced by existing wetlands and waterbodies as determined by the aerial photo.

4.2 Estimated Average Wastewater Flows

Municipal wastewater is made up of a mix of domestic sewage, commercial and industrial wastes, groundwater infiltration and surface water inflows. With proper design and construction, groundwater infiltration and surface water inflows, often called infiltration

and inflow (I/I) can be minimized. Actual monitored flows due to I/I are accounted for in this analysis and the proposed trunk sewer system presented in Figure 1.

The anticipated average wastewater flows from the various sewersheds were determined by applying a unit flow rate to each of the land use categories. The unit flow rate utilized by the City is 950 gallons per acre per day. This is based on the Puppy Dog Sanitary Sewer System Engineering Report. The unit rate is based on an average of 2.5 units per acre, 2.27 persons per unit, and 150 gallons per person per day. An additional factor of safety of 100 gallons per acre per day was included for unforeseen higher users.

Higher sewage generating industrial users are expected in the City's Agricultural Park located on County Road 12 and 42nd Street NE. A unit rate of 1,200 gallons/acre/day has been utilized in this specific area.

Existing wastewater flow rates were determined by two methods: flow monitoring data and pump run times. The flow monitoring data that was described in detail in Section 3.0 was used to generate existing flows for the 21st Avenue and Airport sewersheds. Based on the monitoring the average weekday diurnal flow is approximately 150 gpm (0.22 MGD) for the 21st Avenue sewershed. There were five rain events during the monitoring period; however these events did not generate significant rainfall. Therefore, a standard peaking factor was applied to this dry weather flow to better account for the bypass operations the City utilizes during heavy rain events.

The pump run times provided by the City were utilized to determine the average flow rate for the existing areas served by lift stations (which constitutes a large portion of the City). The average dry weather flow data is provided in Appendix E for each lift station. A standard peaking factor was applied to this dry weather flow, similar to the flow monitoring data, to better account for the effect of infiltration and inflow on the system.

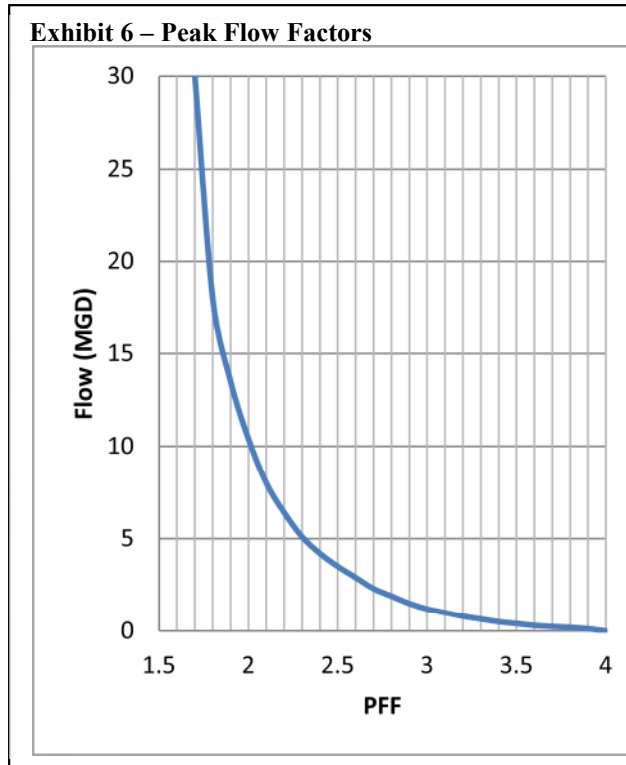
The unit rate of 950 gallons per acre per day was applied to the proposed land use to generate the average sewer flows. Non-sewage generating areas were removed from the total (i.e. existing wetlands, 15% for future right-of-way and parks/open space). Appendix B lists the average flow for each sewershed.

4.3 Peak Flow Factors

The sanitary sewer system must be capable of handling anticipated peak wastewater flow rate including any I/I. The design peak flow rate can be expressed as a variable ratio to the average flow rate. Curves used to describe this ratio, called the Peak Flow Factor (PFF), indicate a decreasing ratio of peak flow to average flow with increasing average flow.

The PFF values applied in this memo are shown in Exhibit 6 in curve form. Metropolitan Council Environmental Services (MCES) developed these peak flow factors, the regional sewer authority for the Twin Cities metropolitan area and follow directly from guidance in

Ten States Standards – Recommended Standards for Wastewater Facilities, 2004 Edition. They include a standard allowance for I/I, which is typical of new sanitary sewer construction as well as properly operating existing sewers. The design flows for each sewershed are provided in Appendix C.



5.0 21st AVENUE SEWERSHED ANALYSIS - EXISTING SYSTEM AND FUTURE DEVELOPMENT

The following section describes the specific analysis that was completed for the 21st Avenue sewershed. The purpose of the capacity analysis and this section was to determine whether cost feasible improvements to the existing system allow it to accommodate sewage from the growth areas north of 21st Avenue and whether investments in larger pipe under 21st Avenue thus make sense.

The impetus for this work was the potential to convey the flows from the northwest portion of Minot. The first phase of expansion lies within sewershed NW, the infill area bounded by Highway 83 bypass. Figure 2, which highlights the 21st Avenue Improvements and the adjacent sewer service areas, shows this infill area.

Portions of each of the four sewersheds – Airport, Airport Industrial, 21st Avenue, NW – is or has potential to be tributary to 21st Avenue at node 21.4 or upstream, independent of capacity constraints. Near term development potential is focused north of 30th Avenue between 8th and 12th Street and near 42nd Avenue and 8th Street.

The 21st Avenue system connects to the 3rd Street NE system at Airport Road. The 3rd Street NE system then connects to the Valley Forcemain at 5th Avenue NE between Walders and Roosevelt Lift Station.

The 21st Avenue sewershed is fully developed except for 58 acres west of the North Hill School. The Airport and Airport Industrial sewersheds are partially developed. Undeveloped land within these two sewersheds consists primarily of low density residential and industrial land uses (based on the Draft Land Use Plan.) Land use for the NW sewershed will consist predominantly of commercial and low density residential land uses. Table 5 provides summary information for the sewersheds in the northwest part of Minot that might be served by an expanded 21st Avenue system.

Table 5 – Areas for Full Development 21st Avenue System

Sewershed	Existing Developed Area (including wetlands) (ac)	Proposed Developable Area (ac)	Total Area (ac)
Airport Industrial	307	269	576
Airport	131	227	358
21 st Avenue	291	58	349
NW	187	467	654
TOTAL	646	1,021	1,937

The appendices include the average and peak wastewater flows for the four sewersheds.

5.1 Description of Existing 21st Avenue and 3rd Street NE System

5.1.1 21st AVENUE SYSTEM

A separate sewershed was developed for 21st Avenue for two reasons:

1. There exists a pending sanitary sewer system replacement project for 21st Avenue
2. Proximity to future growth areas in the northwest and potential to expand the 21st Avenue service area to accommodate this growth

The City of Minot has prepared construction plans for the 21st Avenue sanitary sewer replacement project, which extends from 3rd Street NE to 12th Street NW. The proposed sanitary sewer sizes are shown on Figure 1. The plans reviewed as a part of this memo are dated 1.7.08 and the sewer analysis report is dated December 2006. Currently, a 10-inch PVC sanitary sewer line runs under 21st Avenue. Based on City staff reports, the existing system has insufficient capacity and results in basement flooding during rain events. In the past, Public Works staff have had to bypass the sanitary sewer system and pump directly to the storm sewer system during heavy rain events. There are also reports of illicit sump pump connections.

The proposed design is based on a calculation of peak flow from existing and future development within the Airport, Airport Industrial, 21st Avenue and NW sewershed. However, this potential flow had not previously been analyzed as to its potential impact on downstream facilities such as 3rd Street system, Valley Forcemain and the Master Lift Station. That downstream evaluation is summarized in Section 4.0 of this report. Since the 21st Avenue sewer ties into the Valley Forcemain, the entire NMSSSA needs to be evaluated prior to determining whether it is feasible to expand the sewershed tributary to 21st Avenue.

5.1.2 THIRD STREET NE SYSTEM

Exhibit 7 shows the 3rd Street system downstream of node 21.5, which is located just south of Airport Road. There are two sanitary sewer pipes following 3rd Street starting at node 21.6, north of 11th Avenue. One 10 to 12-inch pipe, shown in light green, conveys the flow to the Roosevelt Lift Station. A 12-inch bypass pipe, shown in red, conveys the wastewater from the north to the Valley Forcemain at 5th Avenue and functions as a gravity/pressure system due to the pressure from the Valley Forcemain connection.

The system operates close to design, with the hydraulic modeling calculating one foot of surcharge at 3rd Street and 11th Avenue. There are approximately 80 properties directly connected to this line that would be affected by the surcharge. The sanitary sewer lies 13 to 15 feet below ground between 11th Avenue and 13th Avenue. The City provided approximate basement elevations for several of the low properties. Based on the LiDAR one-foot contour data, the properties on the east side of 3rd Street are 20 to 30 feet above 3rd Street. The controlling low properties are in the northwest and southwest quadrant of 11th Avenue and 3rd Street at 205 11th Avenue and 1023 3rd Street with basement elevations of 1588.27 and 1584.80, respectively. However, these properties would not be affected by the one-foot existing peak flow surcharge on the 3rd Street system. In fact, the basement elevations lie 3 feet above this surcharge elevation.

5.2 Hydraulic Assessment of the Existing System

The following sections describe the effects on the 21st Avenue, 3rd Street NE, Valley Forcemain, Control and Master Lift Stations due to the growth proposed in the Airport, Airport Industrial, 21st Avenue and NW sewersheds.

5.2.1 DEVELOPMENT SCENARIOS

Two development scenarios were considered as shown in Table 6.

Exhibit 7 – 3rd Street System



Table 6 – Development Scenarios

Scenario	Developable Area (ac)	Average Flow (MGD)	PFF	Peak Flow (MGD)
Partial Development	550	0.52	3.4	1.25
Full Development of Airport, Airport Industrial, 21 st Avenue and NW sewersheds	1,020	0.97	3.1	3.00

The 550 acre increment of development was chosen because that is the point where more substantial system upgrades need to occur.

5.2.2 CONTROL AND MASTER LIFT STATION

The Master Lift Station currently has an inadequate firm capacity (capacity with one pump out of service) for the existing peak flows. Adding a third pump identical to the two existing pumps would provide a firm capacity which is adequate for the existing peak flows but would not allow for the 1,020 acres of additional development. Three new pumps are recommended also due to the age of the pumps (installed in 1984). To convey the existing peak flows plus the peak flow from 1,020 acres of additional development the Master Lift Station will need a firm capacity of 12.7 MGD.

Table 7 – Master Lift Station Improvements

Description	Capacity (MGD)
Existing Firm Capacity (1 pump operating)	9.4
Existing Peak Flow	9.9
Peak flow with an additional 550 acres	11.2
Peak flow with an additional 1,020 acres	12.7

Increasing the firm capacity of the Master Lift Station to 12.7 MGD will require installing 3 new pumps with variable frequency drives (VFD). The improvements are a major upgrade to the Master Lift Station requiring temporary by-passing. Other improvements that are planned during this upgrade include a larger wet well, HVAC upgrades, valve and piping replacement, odor control, and an expanded control building. The budget cost for this upgrade is \$3,440,000 in 2011 dollars. This budget does not include fees that the electric utility may charge to upgrade the electrical service to the site. Note that these improvements are necessary regardless of the development scenario.

It is more economical to complete all the improvements at one time (largely due to the cost to bypass the lift station). However, there are options to spread these costs out depending on the rate of development.

The Control Lift Station firm capacity (one pump out of service) is 16.4 MGD based on the modeling. This is adequate for the existing peak flow of 9.9 MGD. This firm capacity is also adequate for the existing peak flow plus 550 acres of additional development.

The upgrades to the Control Lift Station are in two phases. The Phase I Control Lift upgrade is electrical only, adding VFDs and associated controls to eliminate on/off cycling of flow to the Master Lift Station. The VFDs would be sized to allow for future increases in pumping capacity. The Phase I upgrade budget for adding VFDs, controls, and integration is \$290,000 assuming that the VFDs can be located in the existing building and the existing switchgear is adequate.

The Phase II upgrade increases the firm capacity of the Control Lift Station to allow for 1,020 acres of development by installing new pumps. The existing forcemain from the Control Lift Station to the Master Lift Station has adequate capacity for the full 1,020 acres.

5.2.3 21st AVENUE TRUNK

The next step was to confirm that there is sufficient capacity in the proposed trunk line along 21st Avenue. Five nodes were selected for flow evaluation as shown on Figure 1 and 2.

Table 8 presents the proposed pipe sizes required to convey full development flows. Both inlet and outlet control were considered when determining the capacity of the pipe. Inlet control was based on the orifice equation. Outlet control was based on Manning's equation. A capacity to design flow ratio greater than one signifies that there is adequate capacity in the system to convey the peak flow.

Table 8 – Proposed Pipe Capacities Full Development (1,020 acres)

From	To	Pipe Size (in)	Slope (%)	Peak Design Flow (MGD)	Capacity (MGD)	Capacity/ Design Flow
NW.2	21.1	15	0.20	2.10 ¹	2.2	1.1
21.1	21.2	15	0.20	2.10 ²	2.2	1.1
21.2	21.3	18	0.20	2.34 ³	3.6	1.6
21.3	21.4	21	0.10	2.66 ⁴	3.9	1.4
21.4	21.5	24	0.11	4.95 ⁴	5.8	1.2
Airport Casing		23*	0.35	4.95 ⁴	9.2	2.1

*The steel casing pipe was assumed to be re-lined for this analysis

1) Peak design flow includes full development of NW and ¼ 21st Avenue sewershed

2) Peak design flow includes full development of NW and ½ 21st Avenue sewershed

- 3) Peak design flow includes full development of NW and all of 21st Avenue sewershed
- 4) Peak design flow includes full development of Airport, Airport Industrial, 21st Avenue and NW sewersheds

The proposed pipe sizes can carry flow from the 550 acre service area. For the 1,020 acre service area, only the pipe segment from node 21.3 to node 21.4 needed to be upsized (from an 18-inch to a 21-inch, shown highlighted in Table 8).

Two constraints control the pipe sizes shown in Table 7:

1. Existing 21-inch PVC at 0.10% slope that is to remain under Highway 83 (North Broadway), located between nodes 21.3 and 21.4
2. Existing 24-inch steel casing to remain under the airport taxiway between node 21.4 and 21.5. This casing is at 0.35% slope. The capacities listed in Table 7 assume the steel casing is re-lined, which reflects a 23" internal diameter.

These pipes lie within casings and cannot be replaced without also replacing the casings. It should be noted that the condition of these casings is not known. Therefore it was assumed that the casing under the Airport needed to be re-lined at a minimum. Also, as-builts were not available for either of these casings to verify the slope. The slopes shown in Table 8 were based on the analysis completed for the City in 2006 by KLJ. Based on these constraints, the system can convey 1,020 acres of new development into an expanded 21st Avenue system.

The engineer's cost estimate provided in 2009 for the 21st Avenue Improvements project is \$1,914,483, for the sanitary sewer related portion of the project including contingencies. This is for the proposed pipe sizes as shown in Table 8, not including the pipe from node NW.2 to 21.1. Based on a unit cost of \$90/lineal foot, the additional cost for NW.2 to 21.1 pipe segment is \$270,000. Therefore, the total estimated cost for the pipe sizes in Table 7 is \$2,184,483.

The cost increase to upsize the pipe from node 21.3 to node 21.4 is approximately \$37,000. The City must decide whether the additional flexibility warrants the additional investment.

5.2.4 VALLEY FORCEMAIN

No upgrades are required to the Valley Forcemain system (beyond the improvements to the Master and Control Lift Station) to convey the partial development 550 acre scenario.

This partial development scenario was also modeled against a "worst case" scenario for the Valley Forcemain. This "worst case" scenario was developed based on the lift station run times from the June 17, 2010 rainfall. Based on the North Dakota Agricultural Weather Network (NDAWN) station located 4 miles south of Minot, 2.85-inches of rainfall

occurred on this date. This rainfall occurred over several hours and necessitated bypass of the sanitary sewer system on 21st Avenue into the storm sewer system.

Table 9 lists the number of pumps running at each lift station for this event.

Table 9 – Valley Forcemain Pump Configuration for June, 2010 Event

Lift Station	Number of Pumps Running
Perkett	1
16 th Street	1
13 th Street	1
Walders	2
Roosevelt	2

The model was manipulated to run under these conditions. This results in a maximum forcemain velocity of 5.6 fps east of Roosevelt lift station and approximately 10 MGD peak flow. The Valley Forcemain system functions fairly well under this scenario (beyond the improvements to the Control and Master lift station).

Under full development of the four north sewersheds the maximum velocity in the Valley Forcemain is less than 8 fps. Therefore, the forcemain diameter is sufficient to convey this flow. The primary constraint is the capacity of the Master Lift station as described in section 4.2. With the upgrades to the Master and Control lift stations, the Valley Forcemain can convey the full development flow, even under “worst case” conditions. However, as shown in Table 9, the Walders and Roosevelt Lift Stations are running with two pumps. The firm capacity of these lift stations is based on one pump operating. Therefore both these lift stations exceed their firm capacity during the “worst case” scenario. Additional upgrades would be necessary at these lift stations in order for them to convey the full development flow with one pump running.

The existing firm capacity of the Roosevelt Lift Station based on its pump curve is 2.9 MGD (2000 gpm) at 48 feet total dynamic head (TDH). The proposed conditions (full development of the existing vacant lots within the sewershed) flow to the lift station is 3.6 MGD. Roosevelt Lift Station must pump against approximately 47 feet of TDH during normal conditions based on the model. Normal conditions represents each lift station on the Valley Forcemain operating at its firm capacity or one pump on. The required upgrades to the Roosevelt Lift Station include pump replacement to convey full development flow at normal operating conditions, bypass pumping and electrical improvements including replacement of the control panel. The estimated cost is \$470,000.

The firm capacity of the Walders Lift Station is 2.2 MGD. The existing conditions flow to the Walders Lift Station is 3.0 MGD and proposed conditions flow is 3.3 MGD. Walders Lift

Station must pump against approximately 36 feet of TDH during normal conditions based on the model. Increasing the firm capacity at Walders Lift Station will require installing two new pumps. The cost to replace the pumps at Walders Lift Station is \$450,000.

The improvements to Walders and Roosevelt Lift Station are necessary in order to convey existing conditions flow, regardless of the improvement scenario.

It is important to stress that improvements to the Valley Forcemain system cannot be prudently made without further evaluation of the flows. Flow monitoring was completed for one season for 21st Avenue and from the Airport. Additional monitoring is warranted throughout the system and in particular, at the junction of the Valley Forcemain and the gravity system upstream of the Control Lift Station to verify wet weather flows and I/I contribution. Since any improvements to the Valley Forcemain system would be costly, it is advisable to have a solid picture of the actual flows that reach the system.

5.2.5 THIRD STREET NE SYSTEM

As noted previously, the 3rd Street NE system is surcharged under existing conditions. The level of surcharge is within two feet of the low floor for the partial development scenario with 550 acres (1.25 MGD peak flow).

The most significant impediment to the 3rd Street system is the hydraulic grade line from the Valley Forcemain. The pressure in the forcemain directly affects the capacity of the 3rd Street system. Under the "worst case" scenario, the hydraulic grade line in the 3rd Street system rises 36 feet from 5th Avenue to approximately 10th Avenue due to the pressure in the Valley Forcemain. However, this reduced capacity is still sufficient to convey the wastewater from the 550 acre partial development scenario.

To convey the full development flow, several improvements to the 3rd Street system are necessary. The improvements have been defined both north and south of 11th Avenue.

5.2.5.1 3rd Street System North of 11th Avenue

Additional capacity is needed in the 3rd Street system north of 11th Avenue up to Airport Road (node 21.5), approximately 2,600 feet. Two options were considered:

1. a parallel 12-inch pipe (assuming a minimum of 2% slope)
2. replacement with an 18-inch pipe (assuming a minimum of 2% slope)

Note that north of Airport Road (upstream of node 21.5) a 24-inch pipe is proposed. An 18-inch pipe is adequate for the downstream section from Airport Road to 11th Avenue due to the steep slope.

Between 13th and 11th Avenues, the project would be tightly constrained by existing development. North of 13th Avenue, the construction limits are within the airport and ball fields thus reducing construction costs. A 25% increase in the unit cost was included for restoration in the fully developed portion. Table 10 provides the cost estimates for these two options.

Table 10 – 3rd Street from 11th Avenue to Airport Road Construction Cost Estimates

Description	Construction Cost (\$)	Contingencies, Engineering, Fiscal, Admin* (\$)	Total (\$)
PARALLEL PIPE			
11 th Ave to 13 th Ave	116,000	40,600	156,600
13 th Avenue to Airport Road	136,800	47,880	184,680
Total			341,280
REPLACEMENT PIPE			
11 th Ave to 13 th Ave	132,000	46,200	178,200
13 th Avenue to Airport Road	217,800	76,230	294,030
Total			472,230

*A 35% contingency has been applied

5.2.5.2 3rd Street System South of 11th Avenue

Several options were also considered for the 2,400 lineal feet south of 11th Avenue.

1. Replacement with a 24-inch pipe for the gravity/pressure system
2. Construct a lift station at 11th Avenue and replace existing gravity/pressure system with a forcemain

Both options present some significant constructability issues due to the existing development, infrastructure, right-of-way and utility crossings. Therefore, a range of cost estimates has been provided for each option. The estimated cost for the replacement pipe is \$650,000 - \$800,000. The estimated cost for the lift station and forcemain is \$1,000,000 - \$1,200,000. Contingencies of 35% have been applied to the estimated construction costs.

The range of total costs for providing the necessary capacity in the 3rd Street system for the full development scenario is a minimum of \$991,280 up to \$1,672,230.

5.2.6 AIRPORT AND AIRPORT INDUSTRIAL LIFT STATIONS

Both the Airport and the Airport Industrial Lift Station would need to be upgraded to convey the full development flows from these sewersheds. The capacity of these lift stations is 0.3 MGD with both pumps operating, which corresponds to the monitored flow. The flow to the lift station was also calculated using a unit rate of 950 gal/ac/day. Using the unit rate, the calculated flow to these lift stations is nearly three times the monitored flow. The discrepancy is likely due to the low sewage generating industrial land use. This difference also points to the benefit to flow monitoring for determining actual flows.

Based on the flow projections, the proposed Airport Industrial and Airport Lift Stations would need to convey 1.86 MGD peak flow (0.547 MGD average flow with a 3.4 PFF).

The 12-inch diameter gravity pipe downstream of the Airport Industrial Lift Station under Highway 83 (North Broadway) is surcharged for full development of the Airport Industrial sewershed. A 15-inch pipe is necessary to convey the flows. There is currently one 12-inch connection to this pipe and the area is proposed to be developed as low sewage generating industrial land uses. If this development pattern continues, flow monitoring is recommended prior to replacing this segment of pipe as the level of surcharge may be minimal and therefore acceptable.

The estimated cost to replace the Airport Industrial and Airport Lift Station is \$1,000,000.

5.3 Summary of Existing System with New Development

In summary, the following improvements allow the City to serve an additional 550 acres, or 1.25 MGD peak flow.

Table 11 – Summary of Improvements to Serve an Additional 550 Acres (1.25 MGD peak flow)

Improvement	Estimated Cost (\$)
21 st Avenue Improvements with extension to serve the NW sewershed	\$2,184,483
Master Lift Station Improvements	\$3,440,000
Control Lift Station VFD	\$290,000
Roosevelt Lift Station Improvements	\$470,000
Walders Lift Station Improvements	\$450,000
TOTAL	\$6,834,483

These improvements allow for the first phases of development in the northwest area.

In order to convey the full development flow from the northwest area (1,020 acres or 3.0 MGD peak flow) the following additional improvements are necessary.

Table 12 – Summary of Improvements to Serve an Additional 1,020 Acres (3.0 MGD peak flow)

Improvement	Estimated Cost (\$)
Additional capacity on 3 rd Street	\$991,280 - \$1,672,230
Upgrade Airport and Airport Industrial Lift Stations	\$1,000,000
Several seasons of flow monitoring on the Valley Forcemain system and associated lift stations to better calibrate model for wet weather flows	<i>Not estimated</i>
Control Lift Station Pump Replacement	<i>Not estimated</i>

The Valley Forcemain system is a key aspect of the City's sanitary sewer system. Prior to routing the full development flow to the Valley Forcemain, better calibration of the model to monitoring and a proactive I/I program is recommended.

6.0 SERVICE TO FUTURE GROWTH AREA

The previous section described options for serving future phases of growth within the Highway 83 bypass. This section focuses on service to the entire future North Minot growth area, approximately 17,780 gross acres. A new trunk interceptor is proposed to serve this area. The interceptor forms a loop around the north part of Minot in order to provide sewer service to the western sewersheds and connect to the existing lagoons.

The future trunk alignment was chosen based on natural topography, service area and growth phasing. Nine lift stations are required to serve the future growth area. For ease of constructability, a maximum depth of 20-feet is maintained for the entire future trunk alignment. This drives the need for the nine lift stations. The main trunk follows 30th Avenue NW and travels east to 55th Street as shown on Figure 1.

Additional wastewater treatment facility planning will be necessary to accommodate the future growth.

6.1 Service to Sewershed “W”

A pronounced ridgeline forms the border between the “NW” and “W” sewersheds. South of this ridgeline the topography changes significantly, with a 240-foot elevation change to the Souris River. In order to provide sewer service to the “W” sewershed, a large lift station is needed. Sewershed “W” includes 2,080 acres as shown on Figure 1. The “W” sewershed could feasibly be expanded to 4th Avenue NW, increasing the area to 2,700 acres. The additional 680 acres are partially developed with septic systems and are characterized by steep slopes that would be difficult to serve with sewer and to develop. Therefore, this area hasn’t been included in the sewershed at this stage.

There is development pressure north of 21st Avenue, adjacent to the Highway 83 Bypass. It is feasible to serve these immediate areas by a gravity system connected to the 21st Avenue Improvements at node 21.1. The proposed invert at 9th Street (where the 21st Avenue Improvements project terminates) is 1720.3. The ground surface at the intersection of 21st Avenue and the Highway 83 Bypass is approximately 1740.

In the interim, prior to full development of the “W” sewershed, the pumps will be cycling on and off frequently and for short bursts due to smaller flow levels than the ultimate design. This can lead to low velocities and the potential for deposits settling in the forcemain. Odor control may be necessary in the gravity sewer from node W2 to NW.3, and potentially downstream, until full development of the sewershed.

6.2 Flexibility

The interceptor has been strategically located to allow flexibility in the future growth patterns. It is sized to convey the full development flow from the future sewersheds, including the Airport, Airport Industrial and NW sewersheds. This redundant capacity

allows the City the flexibility to reroute both the Airport and Airport Industrial Lift Stations once the future interceptor is constructed up to node NW.4.

A potential interconnect was considered between the Valley Forcemain and the future interceptor at node NE5.2, on County Road 12, 3,500 feet east of County Road 19. This option was considered to allow flexibility and as a reliever for the Valley Forcemain. The invert where the Valley Forcemain connects to the 36-inch gravity pipe on 4th Avenue just east of the Fairgrounds is 1538.0. This is the most logical location to connect the two systems. The proposed invert at NE5.2 is 1615.0, 77 feet higher. While it is feasible to continue the forcemain to this location, it would require reevaluating the lift stations on the Valley Forcemain to determine if they can pump against this additional head.

7.0 FINANCIAL ANALYSIS

7.1 Cost Estimates

Cost estimates have been prepared for the proposed trunk facilities outlined in this report. The total estimated cost of all the proposed trunk facilities shown on figure 1 is \$42,674,000, including the improvements associated with the existing system (Master, Control, Roosevelt and Walders Lift Station improvements). Trunk facilities include lift stations, forcemains, and all gravity lines greater than 10 inches in diameter.

The cost estimates include the improvements to the existing system that are necessary to convey full development flow and the additional 550 acres from Phase I development in the northwest area within the Highway 83 bypass. Additional improvements that would be required to convey 1,020 acres are not included in the cost estimate tables. However, these additional costs are provided in Table 12, Section 5.3.

A breakdown of the cost estimates is presented in Table 13. The cost estimates include construction, design, legal, administration and planning contingency costs. Land and easement acquisition costs are estimated at \$50,000 per acre. The planning contingency costs are estimated at 35% and account for unexpected costs. Examples include route changes by the developer or difficulties in construction such as unexpected bedrock or the requirement of excessive dewatering. The cost estimates are based on February 2011 Engineering News Record Construction Cost Index of 8998.02. The costs in Table 13 are rounded to three significant figures.

Table 13 – Proposed Trunk Sewer and Lift Station Cost Estimates

Trunk Sewer Cost (\$)	Lift Station Cost* (\$)	Total Trunk Cost (\$)
25,389,000	17,285,000	42,674,000

*Includes costs for improvements to Master and Control Lift Station

The detailed cost estimates for each pipe segment and lift station are shown in Tables 14 and 15.

Table 14 – Detailed Cost Estimates Pipe System

From	To	Pipe Size (in)	Quantity	Cost/Unit	Construction Cost (\$)	Easement Acquisition (\$)	Cont., Eng., Admin., Fiscal (\$)	Total Cost (\$)
42.1	42.2	10	4,500	70	315,000	26,000	120,000	461,000
42.3	Master	10	2,500	70	175,000	15,000	67,000	256,000
Verendry	Master	8	3,000	59	178,000	18,000	69,000	263,000
NW1.1	NW3.1	12	4,200	76	318,000	25,000	120,000	462,000
NW2.1	NW3.1	10" FM	1,000	60	60,000	6,000	24,000	89,000
NW3.1	NW.3	21	6,000	139	834,000	35,000	304,000	1,172,000
W1	W2	18" FM	9,000	85	765,000	52,000	286,000	1,103,000
W2	NW.3	15	4,500	89	402,000	26,000	150,000	577,000
NW.2	NW.1	15	1,000	89	90,000	6,000	34,000	129,000
NW.1	NW.3	6" FM	1,700	40	68,000	10,000	28,000	105,000
NW.3	NW.4	27	5,500	168	924,000	32,000	335,000	1,290,000
NW.4	N5.3	27	9,000	168	1,511,000	52,000	547,000	2,110,000
N1.1	N2.1	12	6,300	76	477,000	37,000	180,000	693,000
N2.1	N4.1	18	3,700	121	449,000	22,000	165,000	635,000
N7.1	N8.1	18	3,300	121	401,000	19,000	147,000	566,000
N8.1	N4.1	15" FM	600	70	42,000	4,000	16,000	62,000
N3.1	N4.1	12	2,100	76	159,000	13,000	60,000	231,000
N4.1	N4.2	27	5,000	168	840,000	29,000	304,000	1,172,000
N4.2	N5.2	27	5,000	168	840,000	29,000	304,000	1,172,000
N5.2	N5.3	27	3,500	168	588,000	21,000	213,000	821,000
N5.3	N6.2	21" FM	1,500	89	134,000	9,000	50,000	192,000
NE1.1	N6.2	12" FM	4,500	66	297,000	26,000	113,000	436,000
N6.2	NE2.1	36	2,000	216	432,000	12,000	155,000	598,000
NE2.1	NE2.2	24" FM	2,200	95	209,000	13,000	78,000	300,000
NE2.2	NE6.1	33	6,780	198	1,343,000	39,000	484,000	1,865,000
NE6.1	NE6	36	5,280	216	1,139,000	31,000	409,000	1,578,000
NE4	NE5.1	10	6,000	70	420,000	35,000	160,000	614,000
NE5.1	NE5.2	6" FM	1,300	45	59,000	8,000	24,000	90,000
NE5.2	NE7	21	7,000	139	973,000	41,000	355,000	1,367,000
NE6	NE7	33	5,280	198	1,046,000	31,000	377,000	1,453,000
NE7	NE8	42	8,000	258	2,065,000	46,000	739,000	2,849,000
NE8	lagoons	27" FM	4,300	111	478,000	25,000	176,000	678,000

Table 15 – Detailed Cost Estimates Lift Stations

Lift Station	Construction Cost (\$)	Easement Acquisition (\$)	Cont., Eng., Admin., Fiscal (\$)	Total Cost (\$)
Lift Station W1	950,000	40,000	347,000	1,337,000
Lift Station NW2.1	440,000	20,000	161,000	621,000
Lift Station NW1	410,000	20,000	151,000	581,000
Lift Station N8.1	700,000	40,000	259,000	999,000
Lift Station NE2.1	1,640,000	40,000	588,000	2,268,000
Lift Station NE5.1	410,000	40,000	158,000	608,000
Lift Station NE8	2,000,000	40,000	714,000	2,754,000
Lift Station N5.3	1,640,000	40,000	588,000	2,268,000
Lift Station NE1.1	700,000	40,000	259,000	999,000
Master Lift Station Improvements				3,440,000
Control Lift Station Improvements				290,000
Roosevelt Lift Station Improvements				470,000
Walders Lift Station Improvements				450,000
Temporary Lift NW4				200,000

7.2 Capital Improvement Program

The City of Minot North Sanitary Sewer Capital Improvement Program is based on the phasing presented in Appendix I. The phasing shown on the figure was generated for the purposes of developing area charge estimates and is not an adopted phasing program. The phasing represents the trunk improvements required to bring service to areas as they open to development and are generally assumed to be in 5-year increments. The phasing of trunk elements and their associated costs are presented in Table 16 (rounded to three significant figures) in Appendix I. The CIP is intended to serve as a guide for future fiscal planning and should be reviewed annually as more current planning and cost data become available.

Tables 17-19 in Appendix I provide sample area charge estimates for three breakeven phases. Financing upfront trunk sewer costs with future growth results in a lower area charge, but also requires that the City bond or use other financing mechanisms to pay for the sewer construction. Whereas recovering the costs by Phase II results in roughly 1.7 times the Phase VI breakeven.

Appendix A
Areas for Full Development System

APPENDIX A: AREAS FOR FULL DEVELOPMENT SYSTEM

[illegible]

Appendix B

Average Flows for the Full Development System

APPENDIX B: AVERAGE FLOWS FOR THE FULL DEVELOPMENT SYSTEM

Sewershed	Existing (ac)								Proposed (ac)							EXISTING - no vacant lot development	TOTAL
	Low Density Residential	Medium Density Residential	High Density Residential	Mobile Home Park	Commercial	Industrial	Public/Semi-Public	Hospital	Vacant Lots (assume LDR)	Low Density Residential	Medium Density Residential	High Density Residential	Commercial	Industrial	Public/Semi-Public		
Airport Industrial	(MGD)	(MGD)	(MGD)	(MGD)	(MGD)	(MGD)	(MGD)	(MGD)	(MGD)	(MGD)	(MGD)	(MGD)	(MGD)	(MGD)	(MGD)	(MGD)	(MGD)
Airport	0.0000	0.0000	0.0000	0.0000	0.0456	0.2451	0.0006	0.0000	0.0000	0.1796	0.0000	0.0000	0.0000	0.0000	0.0000	0.0760	0.5468
Burdick Expressway	0.0417	0.0160	0.0000	0.0067	0.0317	0.0000	0.0005	0.0000	0.0000	0.2157	0.0000	0.0000	0.0000	0.0000	0.0000	0.0966	0.3123
Carney	0.0181	0.0034	0.0000	0.0000	0.0225	0.0010	0.0000	0.0000	0.0040	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0449	0.0489
Cloverdale	0.0124	0.0010	0.0000	0.0000	0.0059	0.0000	0.0000	0.0000	0.0024	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0193	0.0217
Control	0.0000	0.0000	0.0000	0.0000	0.0018	0.0031	0.0000	0.0000	0.0041	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0049	0.0090
Edgewood	0.1565	0.0303	0.0262	0.0720	0.1330	0.0855	0.1067	0.0000	0.1143	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.6102	0.7245
Forsberg	0.0000	0.0000	0.0036	0.0000	0.0000	0.0000	0.0000	0.0000	0.0240	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0036	0.0276
Kittelson	0.0100	0.0004	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0037	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0104	0.0141
Master	0.0257	0.0000	0.0000	0.0000	0.0000	0.0066	0.0000	0.0000	0.0063	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0323	0.0386
Muus	0.0068	0.0000	0.0000	0.0296	0.0217	0.0000	0.0000	0.0000	0.0420	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0581	0.1001
Park Street	0.0674	0.0028	0.0000	0.0000	0.0116	0.0133	0.0019	0.0000	0.0052	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0969	0.1021
Perkett	0.0006	0.0050	0.0000	0.0000	0.0034	0.0037	0.0142	0.0000	0.0016	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0269	0.0285
Roosevelt	0.2094	0.0432	0.0151	0.0106	0.0676	0.0342	0.0295	0.0000	0.0677	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.4097	0.4775
13th Street	0.5776	0.0823	0.0123	0.0123	0.1632	0.1348	0.1322	0.0076	0.1136	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	1.1222	1.2359
16th Street	0.1622	0.0000	0.0010	0.0000	0.0080	0.0000	0.0088	0.0000	0.0257	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.1800	0.2058
Verendrye	0.0744	0.0024	0.0000	0.0000	0.0138	0.0000	0.0000	0.0000	0.0122	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0905	0.1027
Walders	0.0000	0.0000	0.0000	0.0000	0.0122	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0122	0.0122
21st Avenue	0.4216	0.1783	0.0046	0.0000	0.0512	0.0032	0.2195	0.0000	0.0000	0.1079	0.0000	0.0000	0.0000	0.0000	0.0000	0.8784	0.9863
NW	0.1192	0.0312	0.0256	0.0000	0.0314	0.0000	0.0193	0.0000	0.0000	0.0551	0.0000	0.0000	0.0000	0.0000	0.0000	0.2267	0.2818
NW1	0.0116	0.0000	0.0000	0.0000	0.0834	0.0000	0.0000	0.0000	0.0000	0.1834	0.1045	0.0000	0.1463	0.0000	0.0095	0.0950	0.5387
NW2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.3249	0.0000	0.0812	0.0406	0.0406	0.0812	0.0000	0.5686
NW3	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.2929	0.0000	0.0732	0.0366	0.0366	0.0732	0.0000	0.5125
W	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.2158	0.0000	0.0539	0.0270	0.0270	0.0539	0.0000	0.3776
N1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.7904	0.0000	0.1976	0.0988	0.0988	0.1976	0.0000	1.3832
N2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.2027	0.0000	0.0507	0.0253	0.0253	0.0507	0.0000	0.3547
N3	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.2142	0.0000	0.0536	0.0268	0.0268	0.0536	0.0000	0.3749
N4	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.2827	0.0000	0.0707	0.0353	0.0353	0.0707	0.0000	0.4948
N5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.2461	0.0190	0.0000	0.0143	0.1520	0.0000	0.0000	0.4313
N6	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.1140	0.0361	0.0000	0.0323	0.0000	0.0000	0.0000	0.1824
N7	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0960	0.0000	0.0000	0.0000	0.5178	0.0000	0.0000	0.6137
N8	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.4446	0.0000	0.0000	0.0000	0.0000	0.0827	0.0000	0.5273
NE1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.5491	0.0333	0.0000	0.0333	0.0000	0.1663	0.0000	0.7819
NE2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.4988	0.1710	0.0000	0.1330	0.0000	0.0827	0.0000	0.8854
NE3	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.2470	0.0000	0.0000	0.0000	0.3116	0.0827	0.0000	0.6413
NE4	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0950	0.0000	0.0000	0.0000	0.0000	0.0000	0.0836	0.0000	0.0950	0.1786
NE5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.2252	0.0409	0.0000	0.2660
NE6	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0361	0.0000	0.0190	0.9107	0.0000	0.0000	0.9658
NE7	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.2565	0.1235	0.0000	0.0950	0.0380	0.0409	0.0000	0.5539
NE8	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.6080	0.0380	0.0000	0.0285	0.2850	0.0409	0.0000	1.0004
NE9	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.7325	0.0000	0.0000	0.7325
NE9	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.3335	0.0000	0.0000	0.3335

Accounts for 200 acres within Agricultural Park to develop as higher sewage generating industrial (1,200 gal/ac/day)

Appendix C

Design Flows for the Existing and Full Development System

APPENDIX C: DESIGN FLOWS FOR EXISTING SYSTEM

Point		Average Flow	Cum. Flow	PFF	Peak Design Flow*
From	To	(MGD)	(MGD)		(MGD)
Perkett	V-FM	0.4097	0.4097	3.5	1.4341
Forsberg	16th Street	0.0104	0.0104	4.0	0.0414
16th Street	V-FM	0.0905	0.1009	4.0	0.4036
13th Street	V-FM	0.1800	0.1800	3.9	0.7021
Walders	V-FM	0.8784	0.9568	3.2	3.0619
Park Street	W	0.0269	0.0269	4.0	0.1075
Kittleson	W	0.0323	0.0323	4.0	0.1292
Carney	W	0.0193	0.0193	4.0	0.0771
Airport Industrial	AI.1	0.2913	0.2913	3.7	1.0777
AI.1	Airport	0.0000	0.2913	3.7	1.0777
Airport	21.5	0.0966	0.3879	3.6	1.3964
21.5	V-FM	0.0000	0.3879	3.6	1.3964
Burdick Expressway	Roosevelt	0.0449	0.0449	4.0	0.1797
Cloverdale	Roosevelt	0.0049	0.0049	4.0	0.0198
Edgewood	Roosevelt	0.0036	0.0036	4.0	0.0144
Roosevelt	V-FM	1.1222	1.1757	3.1	3.6447
V-FM	36-inch gravity	0.0000	3.2111	2.6	8.3488
36-inch gravity	Control	0.0000	3.2111	2.6	8.3488
Muus	Control	0.0969	3.3080	2.6	8.6008
Control	Master	0.6102	3.9182	2.5	9.7955
Master	lagoons	0.0581	3.9763	2.5	9.9408

V-FM Valley Forcemain

*Based on 950 gal/ac/day unit rate (includes 100 gal/ac/day for inflow)

APPENDIX C: DESIGN FLOWS FOR FULL DEVELOPMENT SYSTEM

Point		Sewershed included	Average Flow	Cum. Flow	PFF	Peak Design Flow
From	To		(MGD)	(MGD)		(MGD)
Perkett	V-FM		0.4775	0.4775	3.5	1.6711
Forsberg	16th Street		0.0141	0.0141	4.0	0.0562
16th Street	V-FM		0.1027	0.1168	4.0	0.4670
13th Street	V-FM		0.2058	0.2058	3.8	0.7819
Walders	V-FM		0.9863	1.0750	3.1	3.3326
Park Street	Walders		0.0285	0.0285	4.0	0.1140
Kittleson	Walders		0.0386	0.0386	4.0	0.1543
Carney	Walders		0.0217	0.0217	4.0	0.0866
Airport Industrial	AI.1		0.5468	0.5468	3.4	1.8592
AI.1	Airport		0.0000	0.5468	3.4	1.8592
Airport	21.5		0.3123	0.8591	3.2	2.7491
NW	21.5		0.5387	0.5387	3.4	1.8314
21.5	V-FM		0.0000	1.3977	3.0	4.1932
Burdick Expressway	Roosevelt		0.0489	0.0489	4.0	0.1957
Cloverdale	Roosevelt		0.0090	0.0090	4.0	0.0361
Edgewood	Roosevelt		0.0276	0.0276	4.0	0.1106
Roosevelt	V-FM		1.2359	1.3215	3.0	3.9644
V-FM	36-inch gravity		0.0000	4.5942	2.4	11.0261
36-inch gravity	Control		0.0000	4.5942	2.4	11.0261
Muus	Control		0.1021	4.6963	2.4	11.2712
Control	Master		0.7245	5.4208	2.3	12.4678
Master	lagoons		0.1001	5.5209	2.3	12.6981

Future Growth Areas

NW1.1	NW3.1	NW1	0.5686	0.5686	3.4	1.9332
NW2.1	NW3.1	NW2	0.5125	0.5125	3.4	1.7426
NW3.1	NW.3	NW3	0.3776	1.4587	3.0	4.3760
W1	W2	W	1.3832	1.3832	3.0	4.1496
W2	NW.3		0	1.3832	3.0	4.1496
NW.2	NW.1	1/2 NW	0.2693	0.2693	3.7	0.9965
NW.1	NW.3	1/2 NW	0.2693	0.5387	3.4	1.8314
NW.3	NW.4	AI, Airport	0.8591	4.2396	2.4	10.1751
NW.4	N5.3		0.0000	4.2396	2.4	10.1751
N1.1	N2.1	N1	0.3547	0.3547	3.6	1.2770
N2.1	N4.1	N2	0.3749	0.7296	3.3	2.4076
N7.1	N8.1	N7	0.5273	0.5273	3.4	1.7927
N8.1	N4.1	N8	0.7819	1.3091	3.0	3.9273
N3.1	N4.1	N3	0.4948	0.4948	3.5	1.7317
N4.1	N4.2	1/2 N4	0.2157	2.7491	2.7	7.4225
N4.2	N5.1	1/2 N4	0.2157	2.9647	2.6	7.7083
N5.1	N5.2		0.0000	2.9647	2.6	7.7083
N5.2	N5.3	N5	0.1824	3.1471	2.6	8.1825
N5.3	N6.2	N6	0.6137	8.0004	2.1	16.8009
NE1.1	N6.2	NE1	0.8854	0.8854	3.2	2.8333
N6.2	NE2.1		0.0000	8.8858	2.1	18.6603
NE2.1	NE2.2	NE2	0.6413	9.5271	2.1	20.0069
NE2.2	NE2.3		0.0000	9.5271	2.1	20.0069
NE2.3	NE6		0.0000	9.5271	2.1	20.0069
NE4	NE5.2	NE4	0.2660	0.2660	3.7	0.9842
NE5.2	NE7	NE5	0.9658	1.2318	3.0	3.6954
NE6	NE7	NE6	0.5539	10.0809	2.1	21.1700
NE7	NE8	NE7	1.0004	12.3131	2.0	24.6262
NE8	lagoons	NE8 & NE9	1.0659	13.3790	2.0	26.7580

V-FM

Valley Forcemain

Appendix D
Existing/Proposed Pipe Capacities for the Full
Development System

APPENDIX D: EXISTING/PROPOSED PIPE CAPACITIES FOR THE FULL-DEVELOPMENT SYSTEM

Point		Design Flow (MGD)	Size (in)	Length (ft)	up Rim	down rim	Up cut	Down cut	Upstream Inv (ft)	Down Inv (ft)	Slope (%)	Capacity				Capacity (MGD)	Capacity/ Design Flow
												Inlet Control		Outlet Control			
From	To											(cfs)	(MGD)	(cfs)	(MGD)		
Future Growth Areas																	
NW1.1	NW3.1	1.93	12	4,200	1760	1730	20	13	1740	1717	0.55	3.7	2.4	3.1	2.0	2.0	1.0
NW2.1	NW3.1	1.74	10" FM	1,000	1710	1730	15	13	1695	1717	--						
NW3.1	NW.3	4.38	21	6,000	1730	1730	13	20	1717	1710	0.12	14.8	9.6	6.4	4.2	4.2	1.0
W1	W2	4.15	18" FM	9,000	1670	1780	20	20	1650	1760	--						
W2	NW.3	4.15	15	4,500	1780	1730	20	20	1760	1710	1.11	6.4	4.1	8.1	5.2	4.1	1.0
NW.2	NW.1	1.00	15	1,000	1750	1720	10	20	1740	1700	4.00	6.4	4.1	15.4	9.9	4.1	4.1
NW.1	NW.3	1.83	6" FM	1,700	1720	1730	20	20	1700	1710	--						
NW.3	NW.4	10.18	27	5,500	1730	1710	20	15	1710	1695	0.27	27.8	18.0	19.2	12.4	12.4	1.2
NW.4	N5.3	10.18	27	9,000	1710	1610	15	15	1695	1595	1.11	27.8	18.0	38.9	25.1	18.0	1.8
N1.1	N2.1	1.28	12	6,300	1710	1650	15	10	1695	1640	0.87	3.7	2.4	4.0	2.6	2.4	1.9
N2.1	N4.1	2.41	18	3,700	1650	1640	10	10	1640	1630	0.27	10.1	6.5	6.5	4.2	4.2	1.7
N7.1	N8.1	1.79	18	3,300	1632	1620	20	20	1612	1600	0.36	10.1	6.5	7.5	4.9	4.9	2.7
N8.1	N4.1	3.93	15" FM	600	1620	1640	20	10	1600	1630	--						
N3.1	N4.1	1.73	12	2,100	1690	1640	10	10	1680	1630	2.38	3.7	2.4	6.5	4.2	2.4	1.4
N4.1	N4.2	7.42	27	5,000	1640	1640	10	15	1630	1625	0.10	27.8	18.0	11.7	7.5	7.5	1.0
N4.2	N5.2	7.71	27	5,000	1640	1630	15	20	1625	1610.5	0.29	27.8	18.0	19.8	12.8	12.8	1.7
N5.2	N5.3	8.18	27	3,500	1630	1610	20	15	1610.5	1595	0.44	27.8	18.0	24.5	15.8	15.8	1.9
N5.3	N6.2	16.80	21" FM	1,500	1610	1622	15	10	1595	1612.5							
NE1.1	N6.2	2.83	12" FM	4,500	1620	1622	15	10	1605	1612.5							
N6.2	NE2.1	18.66	36	2,000	1622	1630	10	20	1612.5	1610	0.13	57	36.8	28.1	18.1	18.1	1.0
NE2.1	NE2.2	20.01	24" FM	2,200	1630	1660	20	15	1610	1645	--						
NE2.2	NE6.1	20.01	33	6,780	1660	1645	15	15	1645	1630	0.22	45.8	29.6	29.6	19.1	19.1	1.0
NE6.1	NE6	20.01	36	5,280	1645	1640	15	20	1630	1620	0.19	57	36.8	34.5	22.3	22.3	1.1
NE4	NE5.1	0.98	10	6,000	1635	1600	10	10	1625	1590	0.58	1.7	1.1	2.0	1.3	1.1	1.1
NE5.1	NE5.2	0.98	6" FM	1,300	1600	1615	10	10	1590	1605							
NE5.2	NE7	3.70	21	7,000	1615	1610	10	15	1605	1595	0.14	14.8	9.6	7.1	4.6	4.6	1.2
NE6	NE7	21.17	33	5280	1640	1610	20	15	1620	1595	0.47	45.8	29.6	43.3	28.0	28.0	1.3
NE7	NE8	24.63	42	8000	1610	1600	15	15	1595	1585	0.13	95	61.4	42.3	27.3	27.3	1.1
NE8	lagoons	26.76	27" FM	4300					1585	1646	--						

Appendix E

Lift Station Run Times and Dry Weather Flow

City of Minot Sewer lift run time report for June

Day	13 th Street		16th Street		Airport		Control			Master		Perkett		Roosevelt		Walders	
	Pump #1	Pump #2	Pump #1	Pump #2	Pump #1	Pump #2	Pump #1	Pump #2	Pump #3	Pump #1	Pump #2	Pump #1	Pump #2	Pump #1	Pump #2	Pump #1	Pump #2
1	2.23	2.61	0.98	0.70	1.56	1.43	3.26	3.15	3.63	6.07	5.80	2.46	2.46	8.20	6.07	3.94	4.43
2	1.86	2.41	1.02	0.68	1.40	1.34	3.20	2.98	3.30	5.91	5.56	2.44	2.44	5.90	8.70	3.76	4.46
3	2.12	2.71	1.08	0.74	1.58	1.44	3.30	3.20	3.74	6.08	5.94	2.71	2.71	5.80	9.26	4.01	4.55
4	1.91	2.22	1.00	0.72	1.48	1.48	3.12	2.98	3.32	5.64	5.57	2.49	2.49	5.58	8.56	3.62	4.28
5	1.54	1.94	0.94	0.68	1.20	1.22	3.00	2.82	3.20	5.33	5.40	2.41	2.41	6.77	6.65	3.68	4.15
6	1.86	2.00	1.16	0.76	1.23	1.16	2.98	2.74	3.34	5.46	5.23	2.43	2.43	11.54	0.24	3.82	4.29
7	2.08	2.48	0.96	0.76	1.23	1.26	3.04	2.92	3.30	5.34	5.79	2.40	2.40	7.42	6.22	3.66	4.33
8	2.04	2.26	1.08	0.86	1.32	1.36	3.20	3.02	3.34	5.60	6.04	2.40	2.40	5.53	9.16	3.78	4.19
9	1.98	2.40	0.90	0.68	1.28	1.16	2.86	2.84	3.21	5.44	5.48	2.30	2.30	5.50	8.35	3.64	4.12
10	1.94	2.30	0.94	0.78	1.28	1.29	2.96	2.90	3.01	5.02	5.78	2.40	2.40	5.82	9.21	3.48	4.10
11	1.68	2.14	1.06	0.72	1.34	1.19	2.80	2.69	3.30	5.22	5.33	2.34	2.34	5.06	8.97	3.55	4.02
12	1.48	1.92	1.02	0.68	1.50	1.40	2.70	2.87	2.84	5.11	4.86	2.26	2.26	5.23	7.35	3.58	4.01
13	1.68	2.01	1.15	0.84	1.18	1.16	2.74	2.76	3.00	5.20	4.95	2.34	2.34	5.23	7.54	3.51	4.10
14	1.83	2.36	1.13	0.80	1.32	1.38	2.82	2.84	3.04	5.16	5.38	2.31	2.31	5.28	8.36	3.73	4.22
15	1.81	2.29	1.10	0.74	1.24	1.18	2.70	2.86	3.00	5.30	4.93	2.18	2.18	5.39	8.23	3.66	4.12
16	1.89	2.15	1.10	0.66	1.28	1.20	2.65	2.88	3.17	5.07	5.25	2.35	2.35	5.37	8.33	3.63	4.15
17	4.24	5.23	2.06	1.56	3.50	2.78	7.64	3.00	8.09	4.41	9.82	7.31	7.31	9.75	12.41	6.93	7.04
18	2.50	3.25	1.02	0.72	3.52	3.00	9.95	6.15	12.81	9.92	13.08	3.78	3.78	9.86	22.06	4.90	6.38
19	1.98	2.59	1.06	0.76	1.96	1.82	3.52	3.64	7.99	9.46	8.29	2.92	2.92	6.89	17.21	4.42	5.09
20	2.05	2.61	1.12	0.84	2.11	1.88	3.84	4.10	4.34	9.57	6.91	2.88	2.88	9.38	13.66	4.47	5.13
21	2.68	3.33	1.14	0.88	2.14	2.08	4.20	4.51	5.03	9.13	7.76	3.26	3.26	4.76	18.31	4.86	5.74
22	2.24	2.84	1.12	0.86	1.92	1.86	3.06	3.12	6.51	8.29	7.32	3.12	3.12	9.41	13.15	4.60	5.18
23	2.12	2.52	0.96	0.76	1.92	1.68	3.64	3.88	4.14	7.46	7.13	2.76	2.76	16.53	4.58	4.28	5.03
24	2.10	2.56	1.02	0.78	1.64	1.48	3.58	3.84	4.06	7.37	6.72	2.88	2.88	5.33	13.72	4.34	5.01
25	2.08	2.69	0.96	0.76	1.87	1.76	3.46	3.76	3.92	7.01	6.90	2.72	2.72	5.08	12.87	4.24	4.98
26	2.04	2.48	0.98	0.72	1.62	1.42	3.40	3.56	3.53	6.65	6.18	2.66	2.66	5.60	10.37	4.17	4.47
27	1.84	2.24	0.96	0.74	1.32	1.34	3.25	3.50	3.60	6.26	6.08	2.58	2.58	5.73	9.76	4.15	4.78
28	1.94	2.31	0.99	0.74	1.74	1.78	3.13	3.54	3.46	6.19	6.09	2.56	2.56	5.48	10.40	4.04	4.47
29	2.04	2.39	0.99	0.66	1.48	1.46	3.02	3.32	3.55	5.87	6.05	2.61	2.61	5.47	10.36	3.99	4.46
30	2.08	2.46	1.02	0.78	1.50	1.44	3.19	3.25	3.43	6.06	5.84	2.54	2.54	5.62	10.43	4.03	4.42
31																	
total	61.85	75.70	32.00	23.34	49.65	46.44	106.18	99.61	126.21	190.63	191.45	82.80	82.80	204.50	300.50	122.48	139.73
average	2.06	2.52	1.07	0.78	1.66	1.55	3.54	3.32	4.21	6.35	6.38	2.76	2.76	6.82	10.02	4.08	4.66

Dry Weather (13th - 16th)	Four Day Pump	1.80	2.20	1.12	0.76	1.25	1.23	2.73	2.83	3.05	5.18	5.13	2.30	2.30	5.32	8.12	3.63	4.15
	Average Station	4.00		1.88		2.48		8.61			10.31		4.59		13.44		11.75	7.78
	Average Outflow from pump testing (gpm)	943		474		99		5,879			5,759		1,660		712		1,568	
	Dry Weather Outflow per Day (gal/day)	226,558		53,318		14,707		3,038,341			3,562,614		457,407		574,273		731,884	
Wet Weather	June 17th Pump Run Time (Station Total)	9.47		3.62		6.28		18.73			14.23		14.63		22.16		13.97	
	June 18th Pump Run Time (Station Total)	5.75		1.74		6.52		28.91			23.00		7.56		31.92		11.28	

Note: Field tests based on 1 pump operating during dry weather, field test flow rates will not be very accurate for determining high wet weather flows. A calibrated model will be more accurate.

Data used for dry weather hours
Data used for dry weather hours

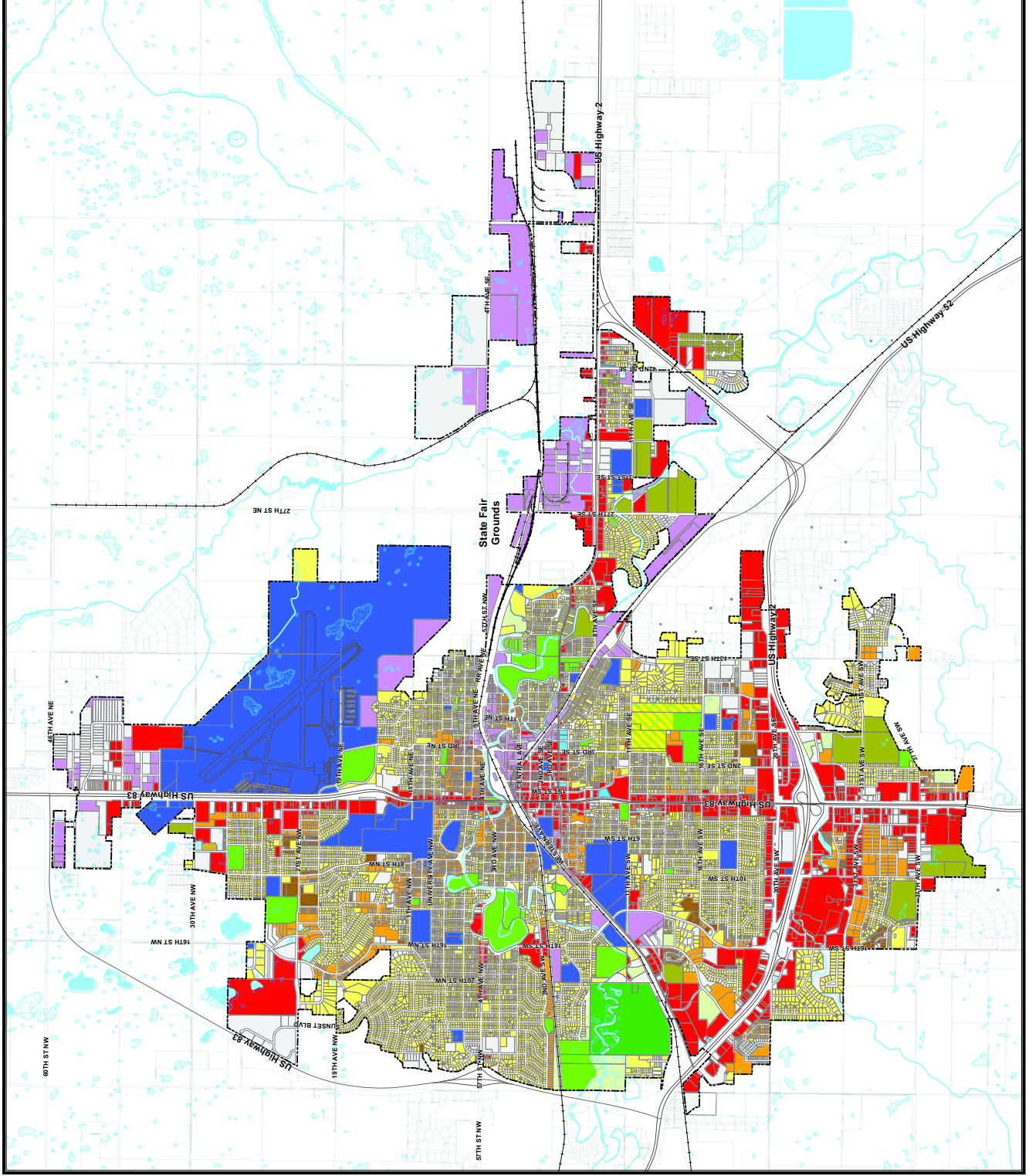
Appendix F

Existing Conditions Land Use Map

City of Minot 2011 Comprehensive Plan Existing Land Use Map



- City Boundary
- Low Density Residential
- Medium Density Residential
- High Density Residential
- Manufactured Home Park
- Commercial
- Industrial
- Public/Semi-Public
- Hospital
- Golf Course
- Parks and Open Space
- Cemetery
- Rural/Agricultural
- Vacant
- Open Water
- Wetlands
- Streams
- Railroad



October 8, 2010



K:\5459\54591000\10\GIS\Projects\leu new.mxd

Appendix G

Lift Station Pump Curves

Perkett School Lift No. 11

Pump No. 1 (North) (Aurora)

Serial No. 644377 - 2

GPM 900

Head 45'

RPM 1150

Type KU

Size 6DX6

GLAND No. T5819C same as 4 Ave. Lift

Bolts 3/8" x 3" Eye

Packing Size 7/16

Pump Top Bear. No. SMN203K, Bot - SM1203K

Frame 3270

Impellers changed from 11.125 to 12.50

Perkett School Lift No. 11

Pump No. 2 (South) (Aurora)

Serial No. 644377 - 1

GPM 900 Larger impellers installed 3/20/85 by Kemper Construction

Head 45'

RPM 1150

Type KU

Size 6DX6

GLAND no. T5819C same as 4 Ave. Lift

Bolts 3/8 x 3" eye bolt

Packing Size 7/16

Top Bear No. SMN203K, Bot SM1203K

Frame 3270

Impellers changed from 11.125 to 12.50

Perkett School Lift No. 11

Motor No. 1 (North) Marathon

Serial No. 280732

HP 25

PH 3

Volts 220 - 440

RPM 1180

Frame - 364 U

Type TSV BE

Model 1A364UTSV86AC

Perkett School Lift No. 11

Motor No. 2 Marathon

Serial No. 280731

HP 25

PH 3

Volts 220/440

RPM 1180

Frame - 364 U

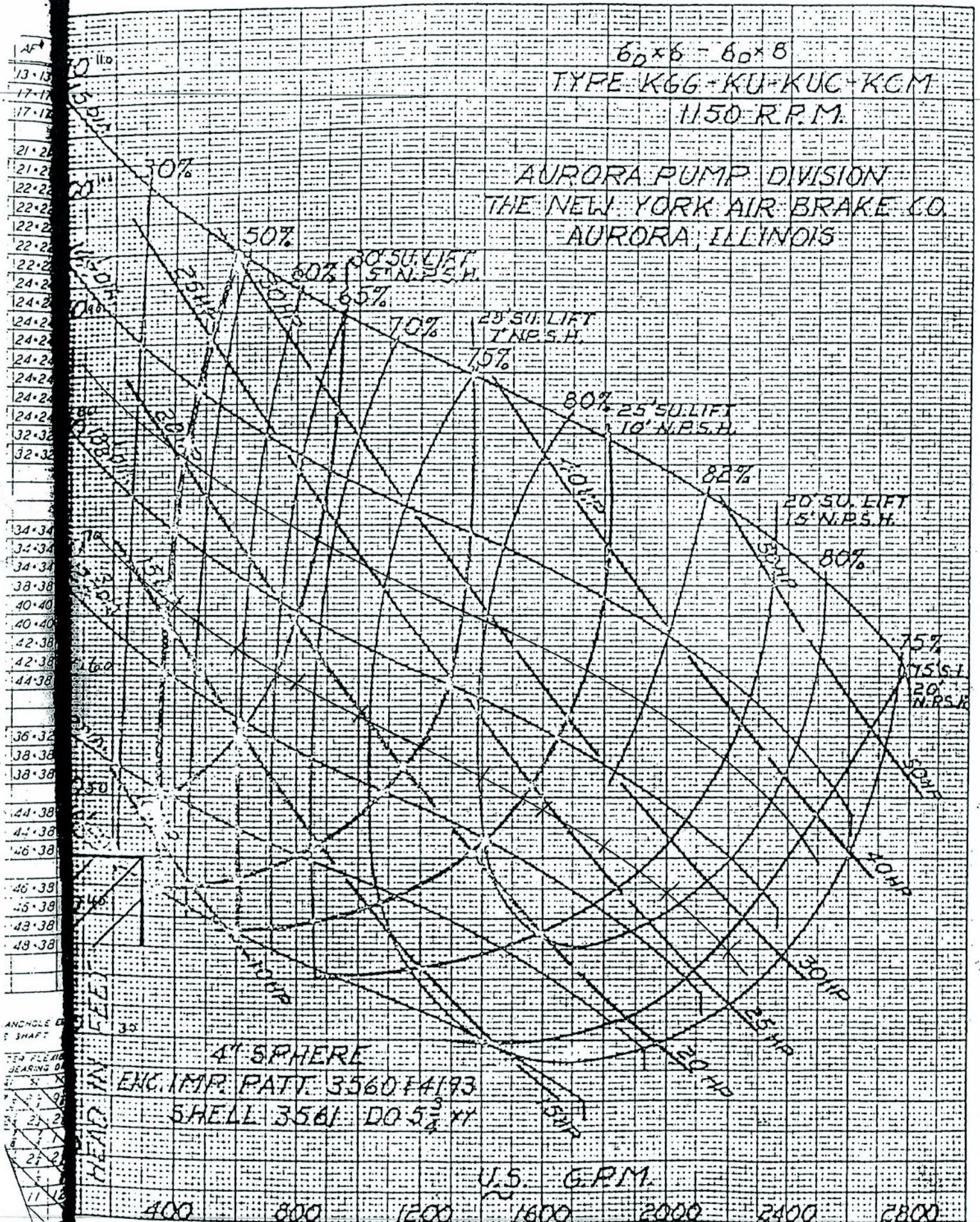
TYPE TSV BE

Model 1A364UTSV86AC

Peckets

CG 4-4211

SECTION 121.6 CURVE No. 330
DATED 7-1-57



PUMP DATA SHEET

Fairbanks Morse Pump, 60 Hz

Selection file: (untitled)

Catalog: FMCENT60.MPC v2.0

Curve: 130406AA

Design Point: Flow: 400 US gpm
Head: 37 ft

Fluid: Water Temperature: 60 °F
SG: 1

Viscosity: 1.122 cP
Vapor pressure: 0.2568 psi_a
Atm pressure: 14.7 psi_a

Pump: 5400BLADELES - 1200 Size: 4"5413K
Speed: 1150 rpm Dia: 11.25 in

Limits: Temperature: 150 °F Sphere size: 3 in
Pressure: 85 psi_g Power: --- bhp

NPSHa: --- ft

Specific Speed: Ns: 1421 Nss: 3892

Piping: --- System: ---
Suction: --- in
Discharge: --- in

Dimensions: Suction: 4 in Discharge: 4 in

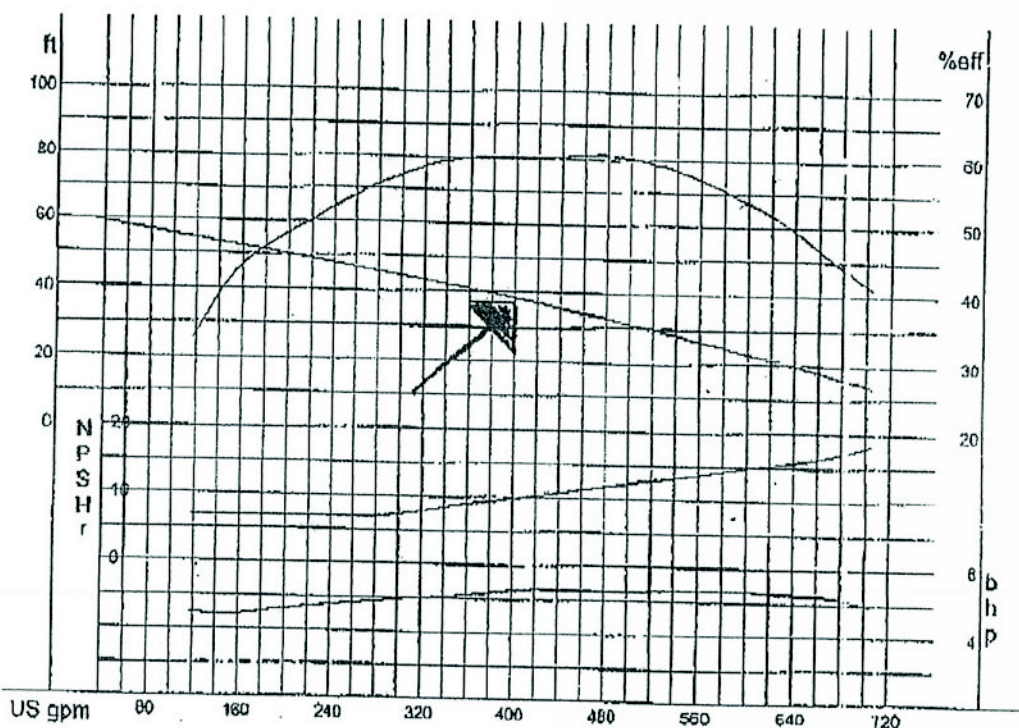
Motor: 7.5 hp Speed: 1200 Frame: 254T
NEMA Standard TEFC Enclosure
sized for Max Power on Design Curve

160th ST LIFT

— Data Point —
Flow: 400 US gpm
Head: 38.3 ft
Eff: 60%
Power: 6.42 bhp
NPSHr: 9.81 ft

-- Design Curve --
Shutoff Head: 80.7 ft
Shutoff dP: 26.3 psi
Min Flow: 118 US gpm
BEP: 60% eff
@ 419 US gpm
NOL Pwr: 6.62 bhp
@ 585 US gpm

-- Max Curve --
Max Pwr: 8.92 bhp
@ 732 US gpm



— PERFORMANCE EVALUATION —

Flow US gpm	Speed rpm	Head ft	Pump %eff	Power bhp	NPSHr ft	Motor %eff	Motor kW	Hrs/yr	Cost /kWh
480	1150	32.8	60	6.58	11.8				
400	1150	38.3	60	6.42	9.81				
320	1150	43.2	58	5.98	7.97				
240	1150	47.9	52	5.55	6.83				
160	1150	52.4	42	4.97	6.81				

FYI
1-20-03

13TH STREET LIFT STATION

Pump Model - Fairbanks Morse

FIG. 5413 T-30

Purchased: 09/18/95

Cost: \$5,185.00

From: Dakota Pump & Control

Serial Number: ~~K481-007~~ 3666-1

T3U C34A - 28 HC

Packing Size: $\frac{1}{2}$ " - 5 rings per box

Packing Length: 9 7/16"

Size: 4"

Impeller Weight: 65.9 lb . - 2 VANE 9/95 - came w/ 12" impeller - had to

Pump Weight: 650 lbs.

cut down to 10.5" at CMP

RPM: 1175

GPM: 600

TOH: 39'

3/08 - ordered new impeller. Came in at 12" - shaved to 10.5" at CMP

Note: in the future, order a 10.5" impeller!

13th St. NW Lift No. 7

Motor No. 1 (East) F.B. Morse

Serial No. F 433955

HP $7\frac{1}{2}$

PH 3

Volts 208 - 220 - 440

RPM 1170 - 975 Cont

TYPE - KZKU-1

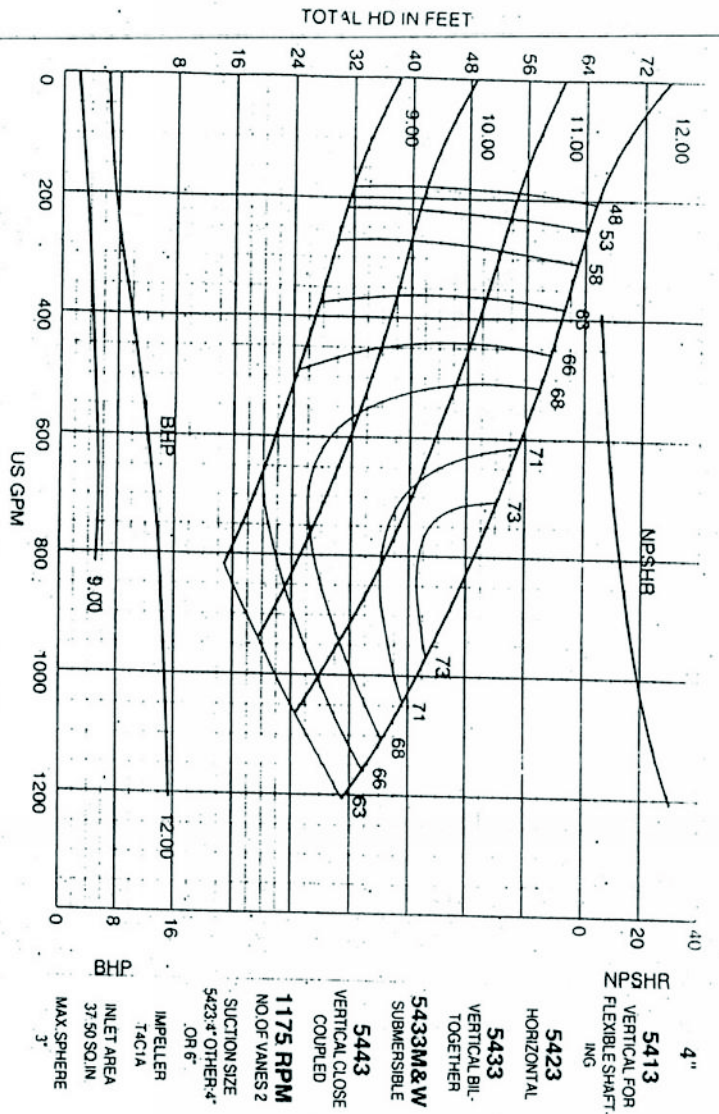
SPEC - #T1025-17

Frame - 256UPH

1/1/92

13 ST L.F.T

Fairbanks Morse Pump Corporation



HYDROMATIC SUBMERSIBLE SEWER PUMP

Model: S8L4000M4-6 09-04
Serial No: S78810

Item Number: 514440407

Imp: Dia: 14X13
HP: 40
V: 460
PH-HZ: 360
F.L. AMPS 60.2
S.F. AMPS 72.2
B.C. 11

Purchase Date: Received 9/27/04
Price: \$12,766.62
Acct: 140 6200 508 0793
GPM: 2000
RPM: 1150
TDH 48'

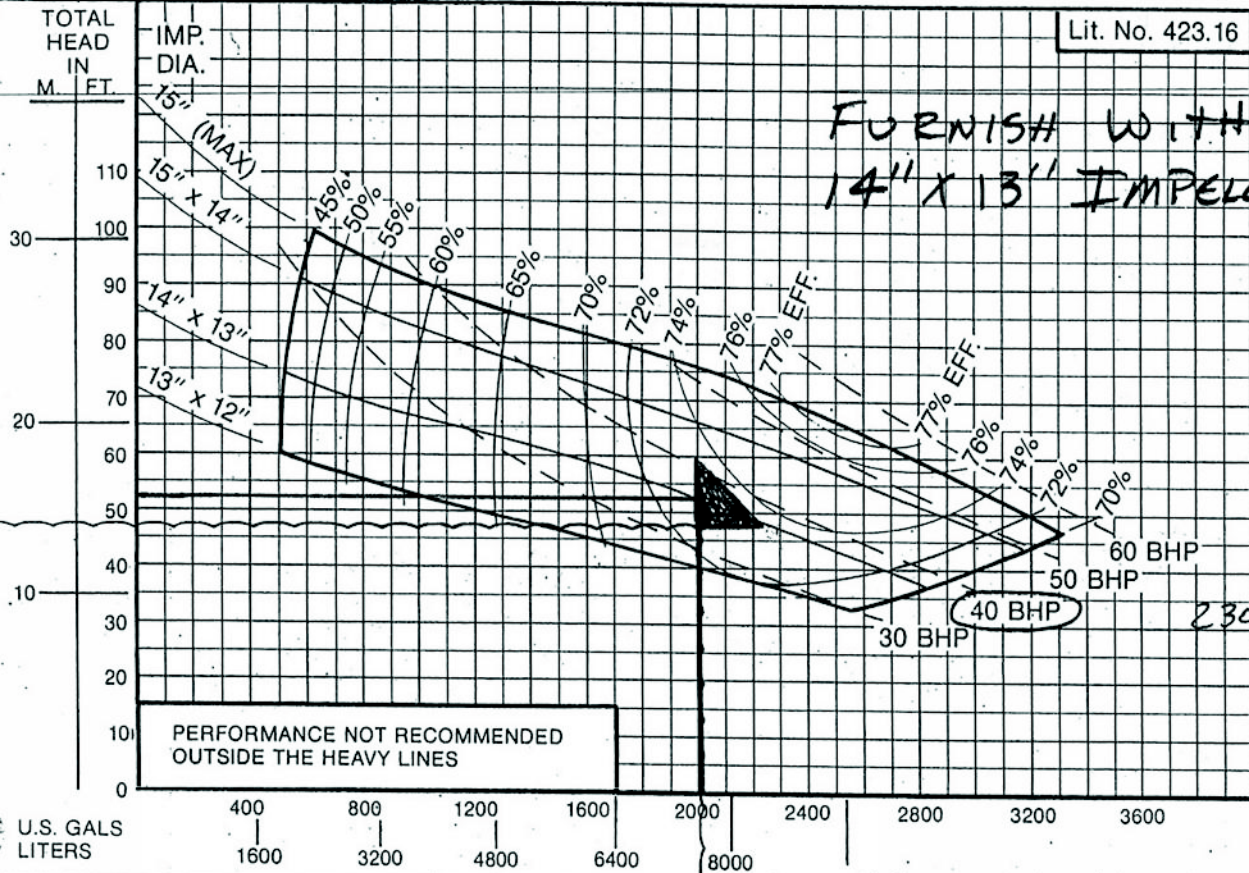
CERAMIC SEAL CI IMP HEAT SENSR
IMP 14.25 X 13.25
7395-003-2 @ 14" X 13" IMPELLER
460/3/60
BUILD W/60' CORD 8371-061-5

2000 GPM AT 48 TDH

MODEL: S8L SUBMERSIBLE SEWAGE PUMP — MAX. SOLIDS: 4" SPHERE — 1150 RPM

Lit. No. 423.16

8940



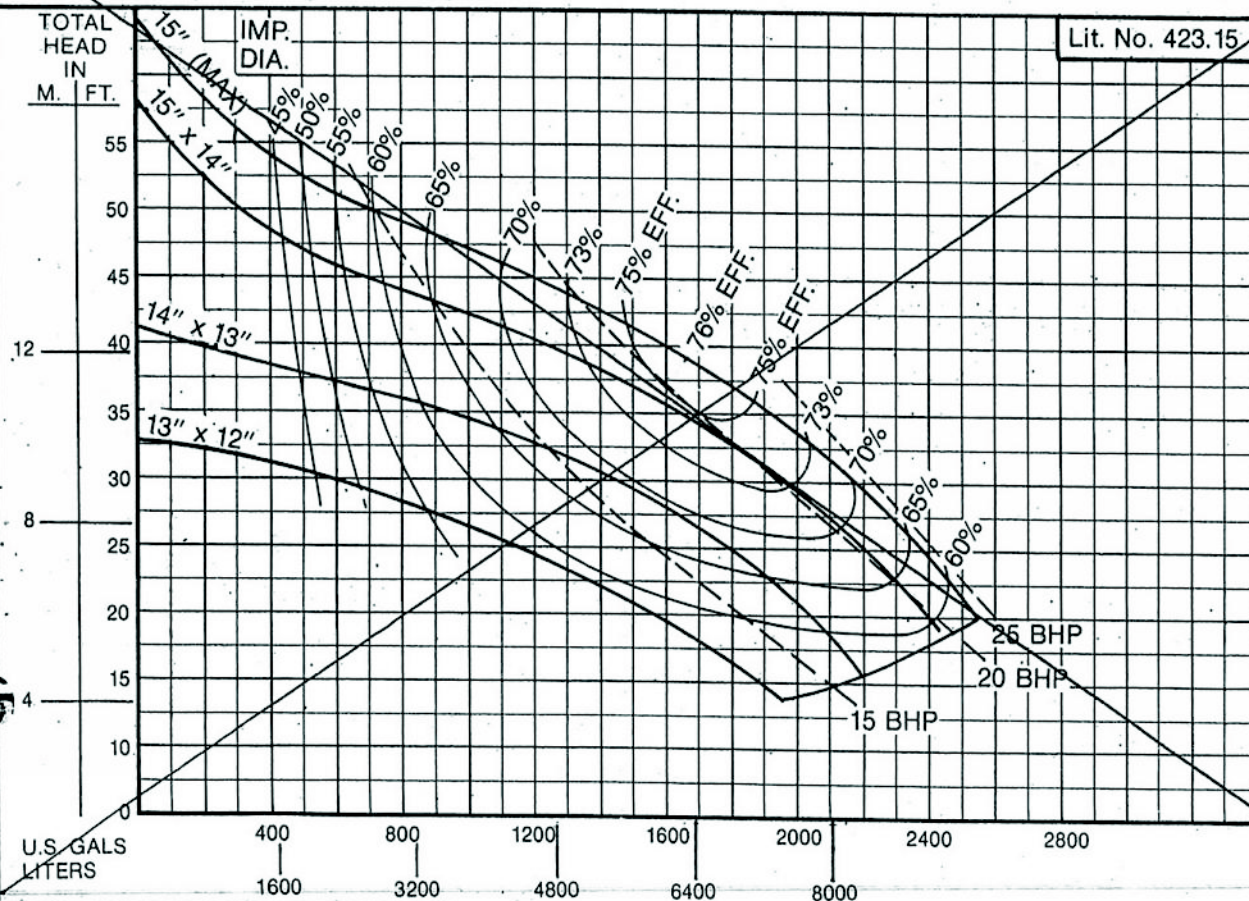
FURNISH WITH
14" x 13" IMPELLER

230/460 volt
3 ph. 60c.

MODEL: S8L SUBMERSIBLE SEWAGE PUMP — MAX. SOLIDS: 4" SPHERE — 870 RPM

Lit. No. 423.15

8939



WALDERS LIFT STATIONS

1

Fairbanks Morse Pumps

2

Serial # K3W1-070667-1

Model B5414

Serial # K3W1-070667-0

Frame Size - T40

Size - 5"

GPM - 1500

TDH - 47'

RPM - 1180

Rotation - one pump CW

- one pump CCW

Packing Size - $\frac{1}{2}$ "

Impeller DES - T5D1A

Impeller D1A - 13.00"

Pumps - Dakota Pump

Remodeled lift and installed
new pumps - SUMMER 1991

WALDERS LIFT STATION

#1

U.S. Motors

#2

H.P. 30 Ph. 3 60 HZ

Frame - 326 VP WP1

Volts - 240

AMPS 71

Type - RVE - 4

Design - B, Code - F, Insul Class B

Weight 570 #

Cont. Rating - 40, DEG.C-AMB

S.F. 1.15 R.P.M. - 1177

Upper Bearing - 7220 - M - oil cap $3\frac{1}{4}$ qts.

Lower Bearing - 6211-J

ID# G41454/T10T2320260 R-2

NRR over Temp Prot 2

Nema Nom. EFF 91.0

Fairbanks Morse Pumps

Serial # K3W1-070667-1

H.P. 30 Ph. 3 60 HZ

Frame 326 VP WP1

Volts - 240

AMPS 71

Type - RVE -4

Design - B, Code - F, Insul
Class B

Cont. Rating -40, DEG.C-AMB

S.F. 1.15 R.P.M. - 1177

Upper Bearing - 7220-M-oil cap $3\frac{1}{4}$ qts.

Lower Bearing - 6211 - J

ID# G41454/T10T2320260 R-1

NRR over Temp Prot 2

Nema Nom. EFF 91.0

Serial # K3W1-070667-0

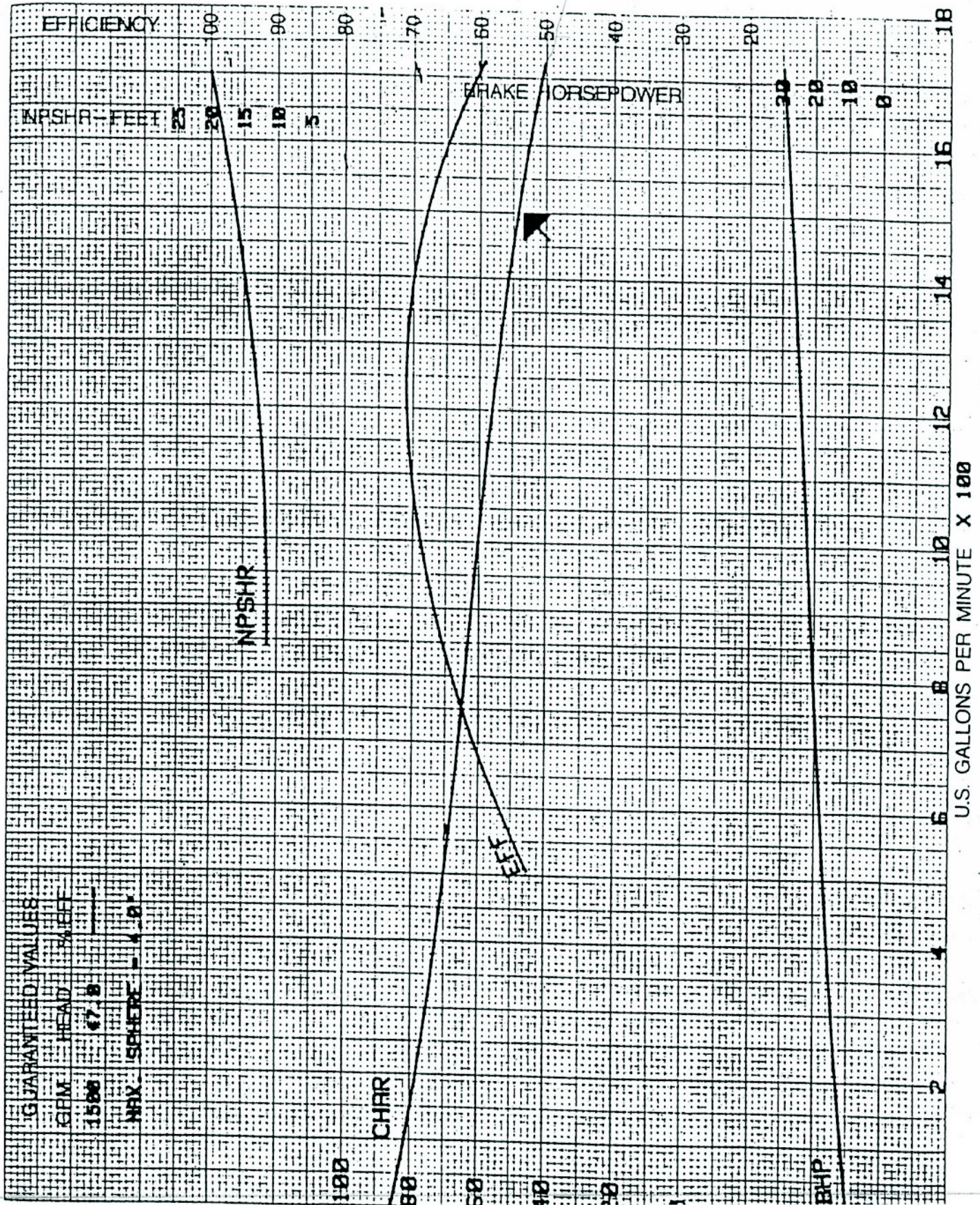
THIS CURVE IS BASED ON ACTUAL
TEST PERFORMANCE OF A SIMILAR
PUMP. ONLY THE INDICATED
POINT(S) IS GUARANTEED

NO. STAGES ONE
REFERENCE TL 85789
PLOTTED BY PTR
DATE 5/30/90

SIZE-MODEL 5-B5414
IMPELLER DES T5D1A
IMPELLER DIA 13.00"
RPM(S) 1180

PUMP PERFORMANCE CURVE

CURVE NO. CK3W1-070667



U.S. GALLONS PER MINUTE X 100

MASTER

0 NPSH-IN FEET

10

20

#2-4

14X12X25

CURVE NCP 37683-1

PUMP NSMV -2

G.P.M. 7350

FT. HD. 210.0

R.P.M. VAR

CUSTOMER ORDER

VAN BERGEN & MARKSON

1-5279-37683-2

DATE 10.19.82

APPROVED JPM

CALCULATED AND DRAWN BY COMPUTER

IMPELLER DWG.

1, 1180 RPM

Tag: Master Lift Station Pump

P.O. 2254-GAN

DIA. 24.25

VANE

HEAD IN FEET

PUMP EFF. %

B.H.P.

100. 300.

80. 200.

60. 100.

40. 0.

750.0

500.0 20.

250.0

0.0 0.

MINIMUM FLOW

HEAD

EFF

NPSH-R

BHP

U.S. GALLONS PER MINUTE

0. 2000. 4000. 6000. 8000. 10000. 12000. 14000. 16000.

IRVES SHOW APPROXIMATELY THE CHARACTERISTICS AT THE INDICATED SPEED WHEN PUMPING

WITH RESPECT TO PUMPING

Master Lift Pumps

33' deep

ALLIS CHALMERS CENTRIFUGAL PUMPS

Model 250

Serial #831-37683-1-1 #2 Pump (North)

Serial #831-37683-2-1 #1 Pump (South)

Size 14 x 12 x 25

Type NSMV

GPM 7350 Hd Ft 210 - *Est 6,500 GPM* *Trimmed Impeller*

Imp. Dia. 24.25*

Impeller Information:

RPM 1180

CC52- 324-945-035 (Pump #2)

Frame F8 K 1

CW52- 324-946-035 (Pump #1)

Inb Brgs 2222 4M

Parts: Attention: Patty

Outb Brgs HH926749/710TS

*Must be trimmed to 20.75 per
Van Bergen-Markson

HM624749/710TS

Sleeve # 52-118-447-03-001

Catalog # 1-009-0

Hard 500 BHN

Pump weight with impeller 2500 lbs.

CONTROL



PERFORMANCE FIELD at Constant nominal speed

PROD

C 3312

DATE
2007-06-11

ISSUE
10

FREQ.
60 HZ

NOMINAL HYDRAULIC-END SPEED
885 RPM

CURVE NO
63-830

IMPELLER PART

PUMPHOUSING PART

INLET/OUTLET
350/300

IMP.THROUGHLET
BALL 102 mm

NO. OF BLADES
3

AVAILABLE IMPELLER DIAMETERS
EVERY 5 mm FROM 450 TO 580

DRIVE UNIT
705

MOTOR
43-30-8FA

POLES
8

RATED POWER
90 HP / 67 kW

RATED SPEED
RPM

705

43-30-8AA

8

135 HP / 101 kW

735

43-44-8AA

8

185 HP / 138 kW

765

43-56-8AA

8

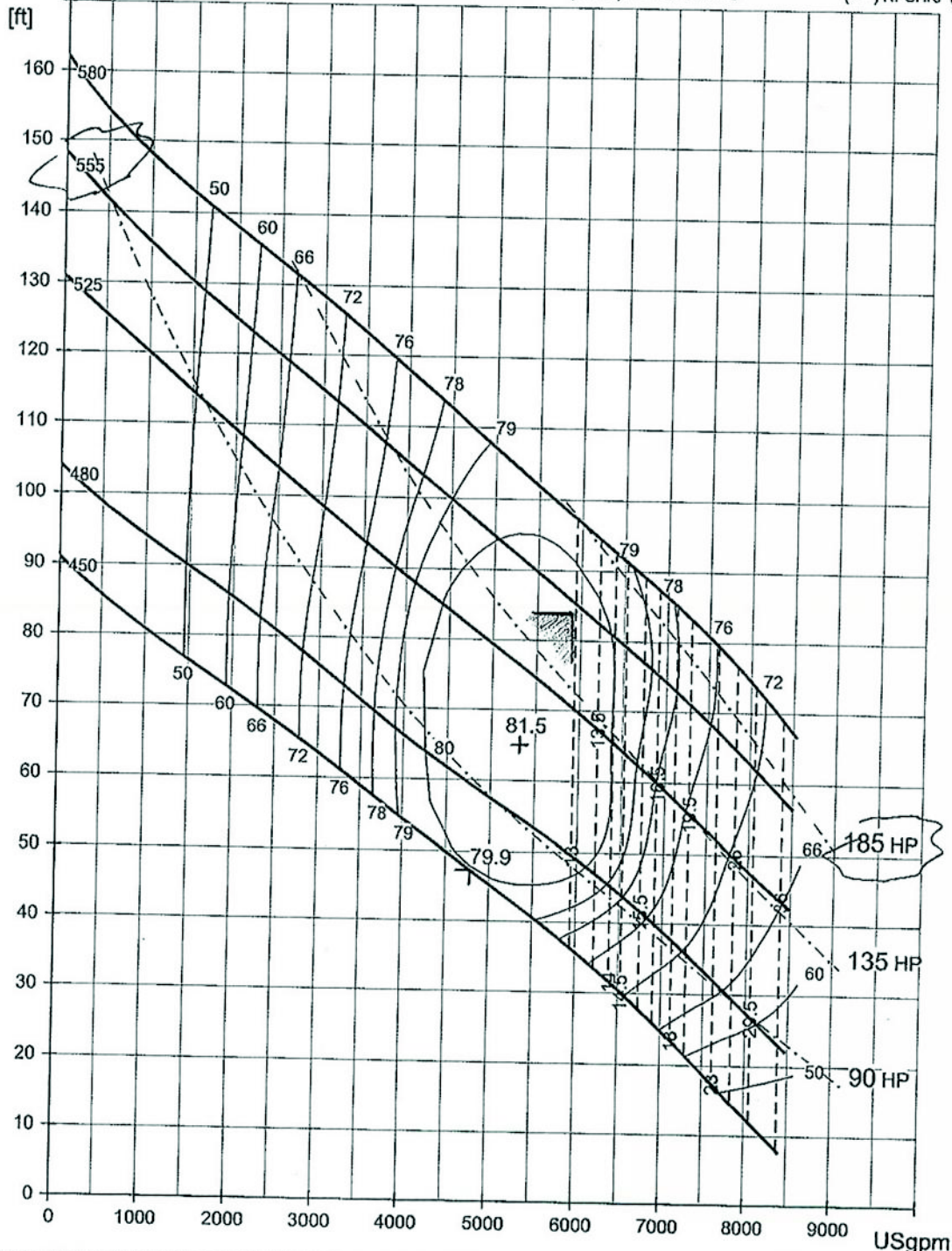
230 HP / 172 kW

HEAD

ISO-CURVES :

(-.-.-) POWER LIMITS

(-- --) NPSHre (ft)



NOTE:

CURVES ARE BASED ON NOMINAL CONSTANT HYDRAULIC-END SPEED.
and SHOW PERFORMANCE WITH CLEAR COLD WATER.

NPSHre = NPSH3% + in operational margins

FLOW

unix AUTHOR: FAS328 CUPF-C(rev:7.35)

USA

CONTROL



ITT

Flygt

C-3312

Impeller/Motor/ Nominal Sizes

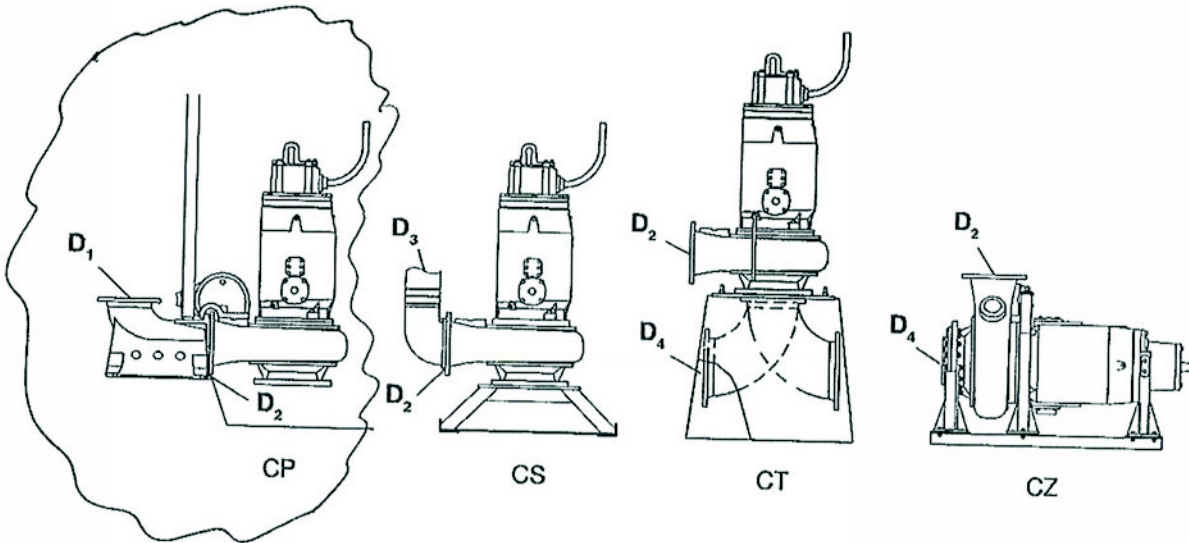
Issued: 8/00

Supersedes: 2/96

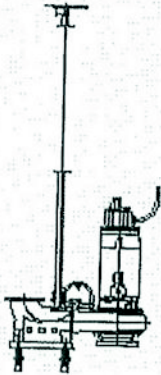
PUMP MODEL	IMPELLER CODE	HP RATING	VAC	D1	D2	D3	D4
		CP, CS, CT, CZ					
3312 3Ø	630 MT	215, 280, 385, 470	460,575	12"			
	830 MT	90	230,460 575	14"	12"	10"	*14"
		135, 185, 230	460,575	20"			16"

MT= Standard

* for CZ configuration

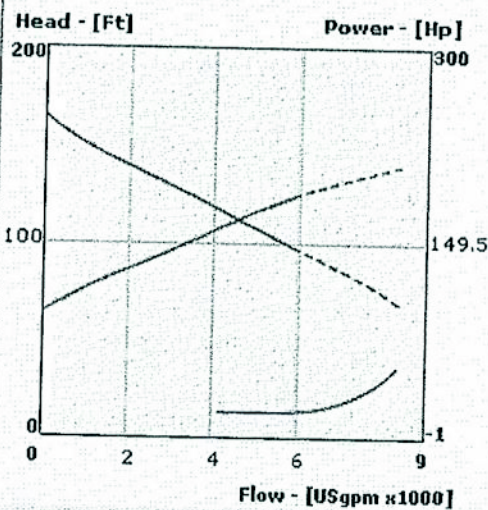


CONTROL

PRODUCT: CP 3312 / 735**Product picture**

Curves Enlarge

Available impeller diam: 580 mm *

☒ Performance☒ NPSHr☒ Shaft Power**Pump Data**

Curve id: 63-830 Impeller: 830 Poles: 8 - pole Motor: 43-44-8AA Frequency: 60 Hz

Motor Data

Rated output power Hp (kW)	Ø	Nominal voltage (V)	Full load current (A)	Locked rotor current (A)	Locked rotor kVA	Locked rotor code letter kVA/HP	Poles/rpm
185 (138)	3	460	231	1085	863	E	8/885
Pump motor Hp	Efficiency			Power factor			
	100% load	75% load	50% load	100% load	75% load	50% load	
	185	91.5	92	91	0.82	0.79	0.71

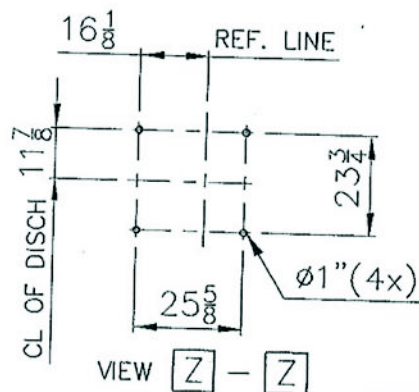
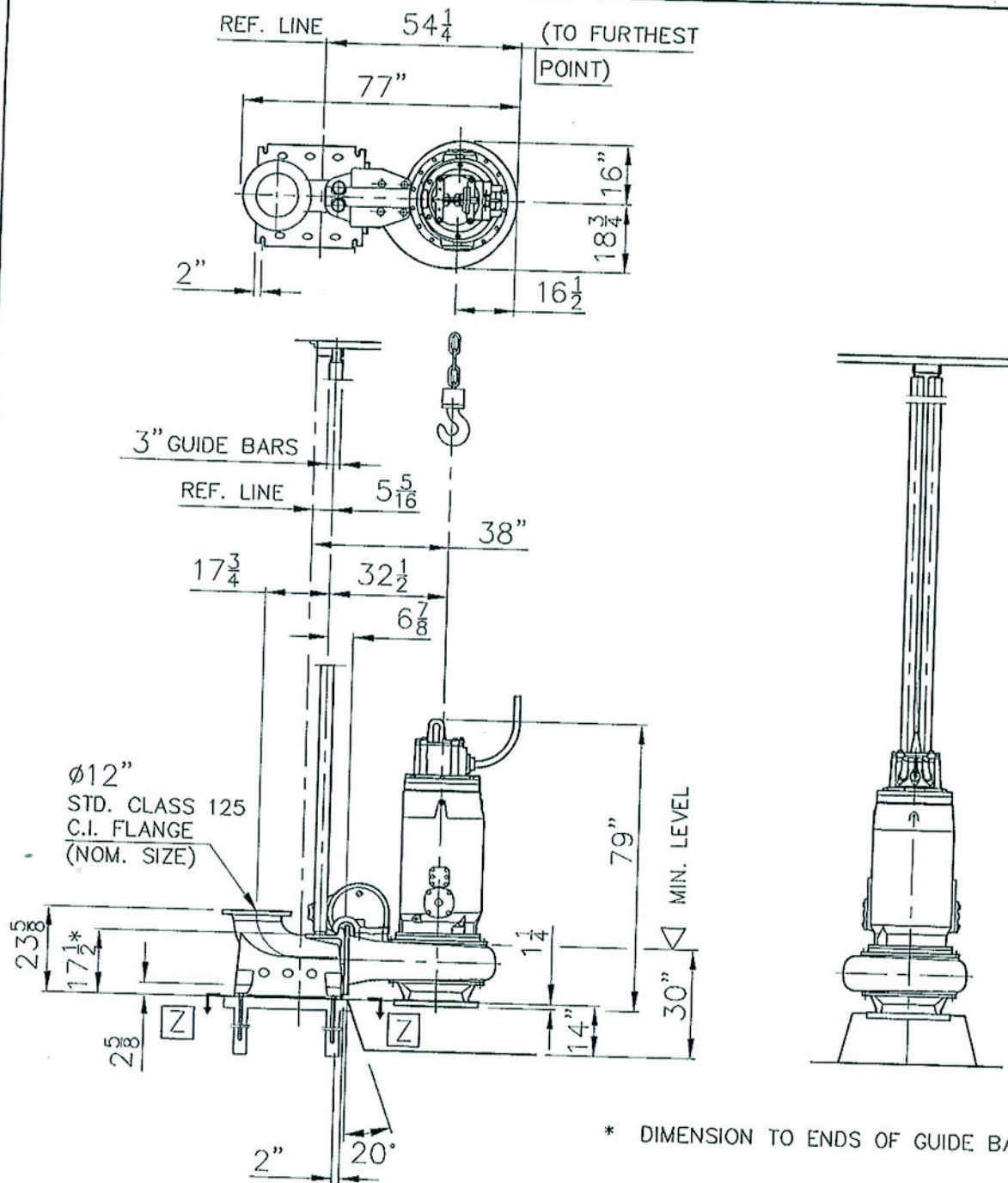
Cable Data

HP	Cables	Volts	Max. length (Ft)	Cable size/Nominal OD.	Conductors (In one cable)	Type	Part number
185	2	460	465	4 G 50 1.69"-(43mm)	(3) 50 mm ² (PWR) (1) 50 mm ² (GND)	STD	942066
Pilot cable				S12 X 1.5 30.0 mm (1.18")	(12) 1.5 (CTRL)		94 08 94

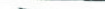
Available Discharge Connection Outlet Size

Outlet Drilled Flange	12" , 14"
-----------------------	-----------

CONTROL



Weight (lbs)	
Pump	Disch
4300	530

 AUTOCAD DRAWING	Denomination	4300	530	
	Dimensional drwg CP,NP 3312 735/745 ø12"	Drawn by KA	Checked by	Date 050701
		Scale 1: 40		Reg no 5399
		6444100		3



ITT

Flygt

AC Current Transformer

Model 2RL (with 1 amp secondary rating)

Monitoring and Controls

Issued: 9/07

Supersedes:

Typical Application:

Current Transformers (CT) are used with ITT Flygt Monitoring & Control products to read motor current levels. The CTs listed below are used specifically with the APP 521 Duplex pump controller P/N 40-501294 and MAS 711 system P/N 40-501141 & 40-501142. In either APP 521 or MAS 711 applications, only one CT is required per pump.

Frequency:

50 - 400 Hz

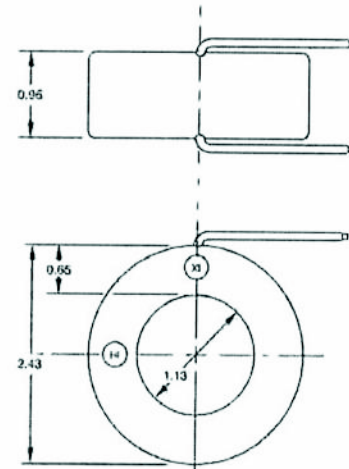
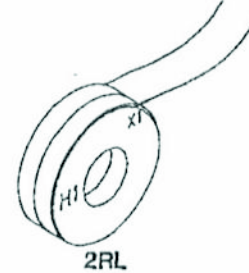
Insulation Level:

600 volts, 10kv BIL full wave

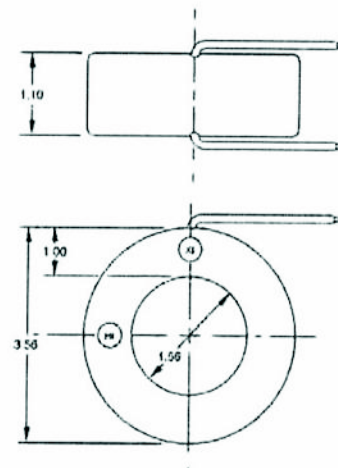
Rating Factor:

2.0 @ 30° C amb.

- Flexible leads are UL 1015 105°C, CSA approved # 16 AWG, 24" long.
- Approximate weight: 0.5 lb.



For Transformers rated
less than 400:1 or 400:5



For Transformers rated
greater than 400:1 or 400:5

Flygt Part #	Current Ratio	Accuracy at 60Hz	Burden VA at 60 Hz
14-404100	25:1	+/- 3%	2.0
14-404101	50:1	+/- 3%	2.0
14-404102	60:1	+/- 2%	2.0
14-404103	75:1	+/- 2%	2.0
14-404104	80:1	+/- 2%	2.0
14-404105	100:1	+/- 1%	2.0
14-404106	120:1	+/- 1%	2.5
14-404107	125:1	+/- 1%	2.5
14-404108	150:1	+/- 1%	4.0
14-404109	180:1	+/- 1%	4.0
14-404110	200:1	+/- 1%	4.0
14-404111	250:1	+/- 1%	7.5
14-404112	300:1	+/- 1%	10.0
14-404113	400:1	+/- 1%	10.0
14-404114	500:1	+/- 1%	25.0
14-404115	600:1	+/- 1%	25.0
14-404116	750:1	+/- 1%	25.0
14-404117	800:1	+/- 1%	30.0
14-404118	1000:1	+/- 1%	35.0
14-404119	1200:1	+/- 1%	40.0

**ITT****Flygt**

AC Current Transformer

Model 5RL (with 5 amp secondary rating)**Monitoring and Controls**

Issued: 9/07

Supersedes:

Typical Application:

Current Transformers (CT) are used with ITT Flygt Monitoring Control products to read motor current levels. The CTs listed below are used specifically with the PAN 311 Power analyzer P/N 40-501189. The PAN 311 application requires three CTs per pump for three phase motor current monitoring.

Frequency:

50 - 400 Hz

Insulation Level:

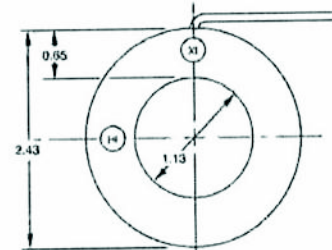
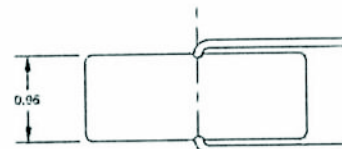
600 volts, 10kv BIL full wave.

Rating Factor:

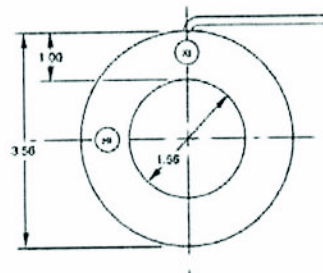
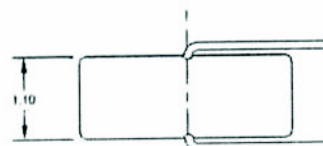
2.0 @ 30° C amb.

- Flexible leads are UL 1015 105°C, CSA approved # 16 AWG, 24" long.
- Approximate weight: 1.0 lb.

Flygt Part #	Current Ratio	Accuracy at 60Hz	Burden VA at 60 Hz
14-404120	25:5	+/- 2%	2.0
14-404121	50:5	+/- 3%	2.0
14-404122	60:5	+/- 2%	2.0
14-404123	75:5	+/- 2%	2.0
14-404124	80:5	+/- 2%	2.0
14-404125	100:5	+/- 1%	2.0
14-404126	120:5	+/- 1%	2.5
14-404127	125:5	+/- 1%	2.5
14-404128	150:5	+/- 1%	4.0
14-404129	180:5	+/- 1%	4.0
14-404130	200:5	+/- 1%	5.0
14-404131	250:5	+/- 1%	7.5
14-404132	300:5	+/- 1%	12.5
14-404133	400:5	+/- 1%	12.5
14-404134	500:5	+/- 1%	25.0
14-404135	600:5	+/- 1%	25.0
14-404136	750:5	+/- 1%	25.0
14-404137	800:5	+/- 1%	30.0
14-404138	1000:5	+/- 1%	35.0
14-404139	1200:5	+/- 1%	40.0

**5 RL**

For Transformers rated
less than 400:1 or 400:5



For Transformers rated
greater than 400:1 or 400:5

**ITT****Flygt**

MAS 711

*CONTROL***Monitoring and Controls**

Issued: 4/07

Supersedes: 10/04

MAS 711 is a pump monitoring system designed to remember, record and present pump events fast and easily. As part of a complete Flygt pumping system, it helps reduce costs over the pump's lifetime by facilitating maintenance and assuring safe operation, thereby increasing reliability and availability.

Detailed operation data can be accessed via MAS 711 for immediate analysis using a standard web browser on a PC (no special software required), or alternatively transferred to a higher level system such as a SCADA (Supervision Control and Data Acquisition) system.

Everything you need to know

MAS 711 monitors the pump's temperature, leakage, vibration, current and power (optional). In addition, it has a 'black box' function in case of pump failure.

• 'Plug-n-play' with back-up

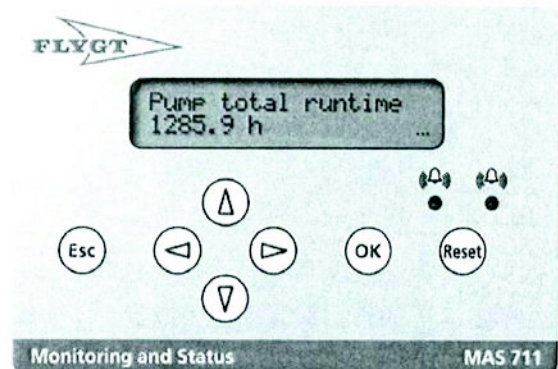
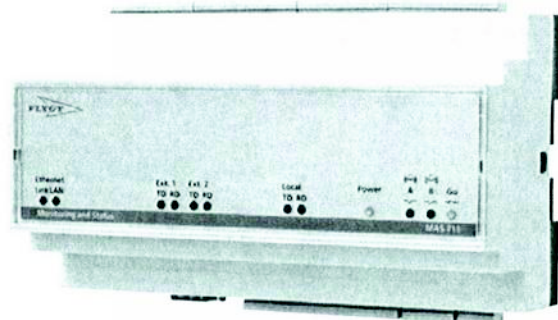
MAS 711 communicates with the pump's memory for fast and easy, 'plug-n-play' installation and routine back-up/synchronization of operation data and settings.

• Communication options

With its ethernet, Modbus and modem communications ports, MAS 711 can communicate with most Supervision Control and Data Acquisition (SCADA) systems on the market.

The MAS 711 also contains two relays that can be configured as normally - open or normally - closed, and indicate common pump - stop condition (A - Alarm) and pump - warning condition (B - Alarm).

With the many functions and features of MAS 711, you have Flygt's decades of knowledge and experience in monitoring and control of submersible pumps literally at your fingertips.





ITT

Flygt

MAS 711 Specifications

Monitoring and Controls

Issued: 10/04

Supersedes:

PUMP/MOTOR PROTECTION

All of the pump/motor unit protective and monitoring sensors shall be connected to a MAS, (Monitoring and Status) module. Each pump/motor unit shall be equipped with a MAS unit. The MAS shall be a two-piece product including the base module and an operator panel.

The operator panel shall be mounted on the dead-front panel. The operator panel shall include soft-touch type navigation keypad, alarm acknowledgement keypad, amber warning lamp, red alarm lamp and a 2-line by 20-character LCD digital display. The digital display shall provide the local readout of pump/motor sensor and alarm status and aid in navigation through the system during set-up.

The base module shall contain a processor unit having a minimum of 2Mb of memory for the logging of measurements and alarm events, two communications ports, sufficient terminals for pump/motor unit sensor connection and a Web tool. The Web tool shall be able to be accessed in the following manners; directly connected at the site with a personal computer, remotely accessed over the owner's LAN or internet or by the use of a telephone modem.

Base System Sensors

Each pump/motor unit(s) shall be equipped with the following Base Level protection and monitoring sensors:

1. Three (3) motor winding thermal switches, one installed in each motor phase winding, and connected in series to monitor and protect the winding from over temperature operation. The thermal switches shall open, activating an alarm and stopping the motor should a high temperature event occur.
2. One (1) PT-100 temperature probe shall be installed in the motor winding to provide direct stator temperature read-out.
3. One (1) PT-100 temperature probe shall be installed to directly contact the outer race of the thrust bearing to provide for accurate temperature monitoring of the bearing.
4. One (1) Float-type Leakage Sensor (FLS) shall be provided to detect water intrusion into the motor stator chamber. If activated, the FLS will activate an alarm and stop the motor.
5. One (1) Float-type Leakage Sensor (FLS) shall be provided to detect water intrusion into the power cable junction chamber of the pump/motor unit. If activated, the FLS will activate an alarm and stop the motor.

6. One (1) Pump Memory unit shall be installed in the cable junction chamber of the pump/motor unit. The Pump Memory with 32kb of memory shall store unit data plate information, listing of pump/motor unit installed sensors and statistical operational data including number of starts, unit accumulated running time, unit service data and histogram data of motor temperature.

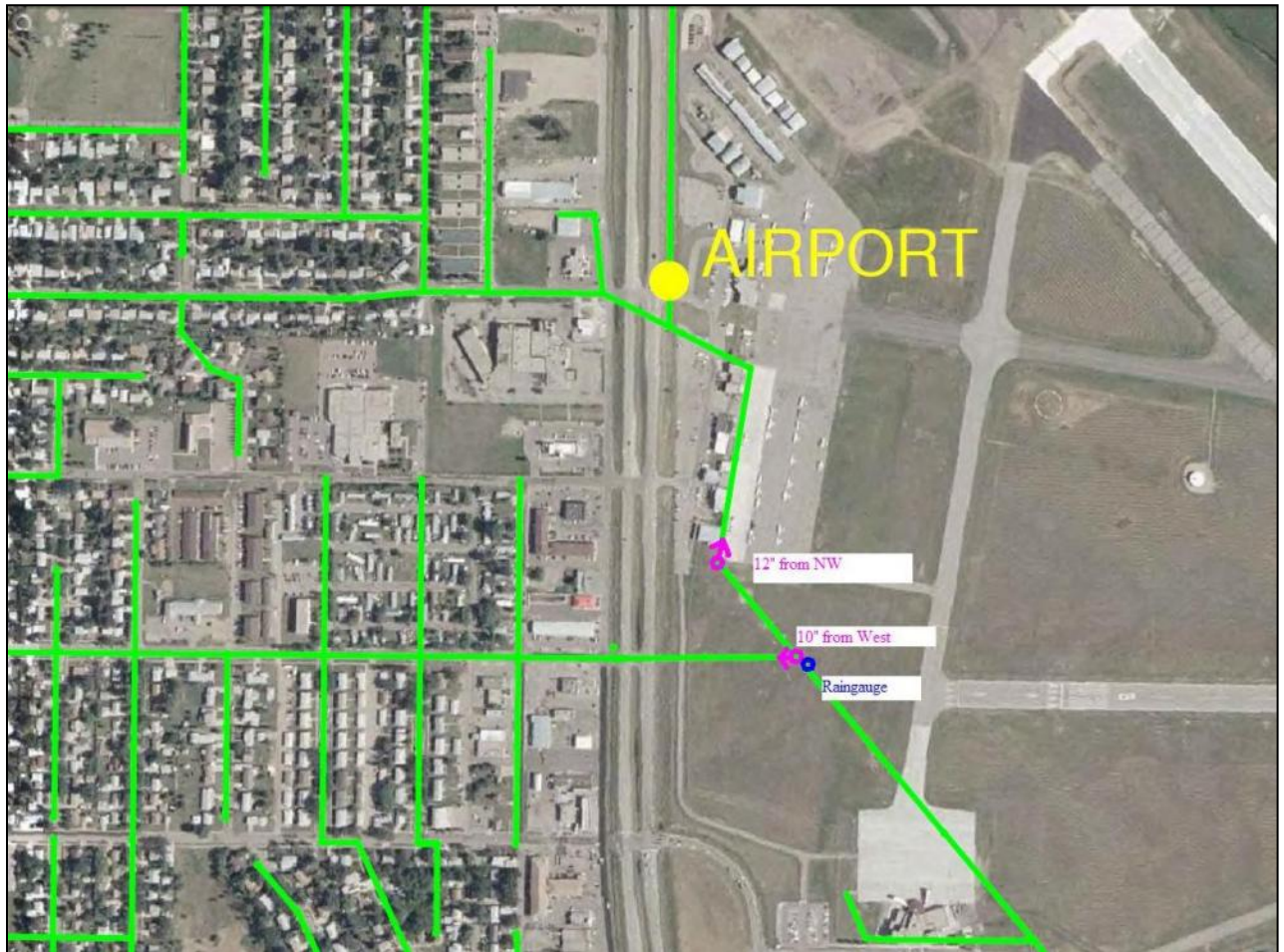
Optional System Sensors

Each pump/motor unit(s) can be further equipped with each of the following Optional sensors in addition to the Basic Level sensors listed above:

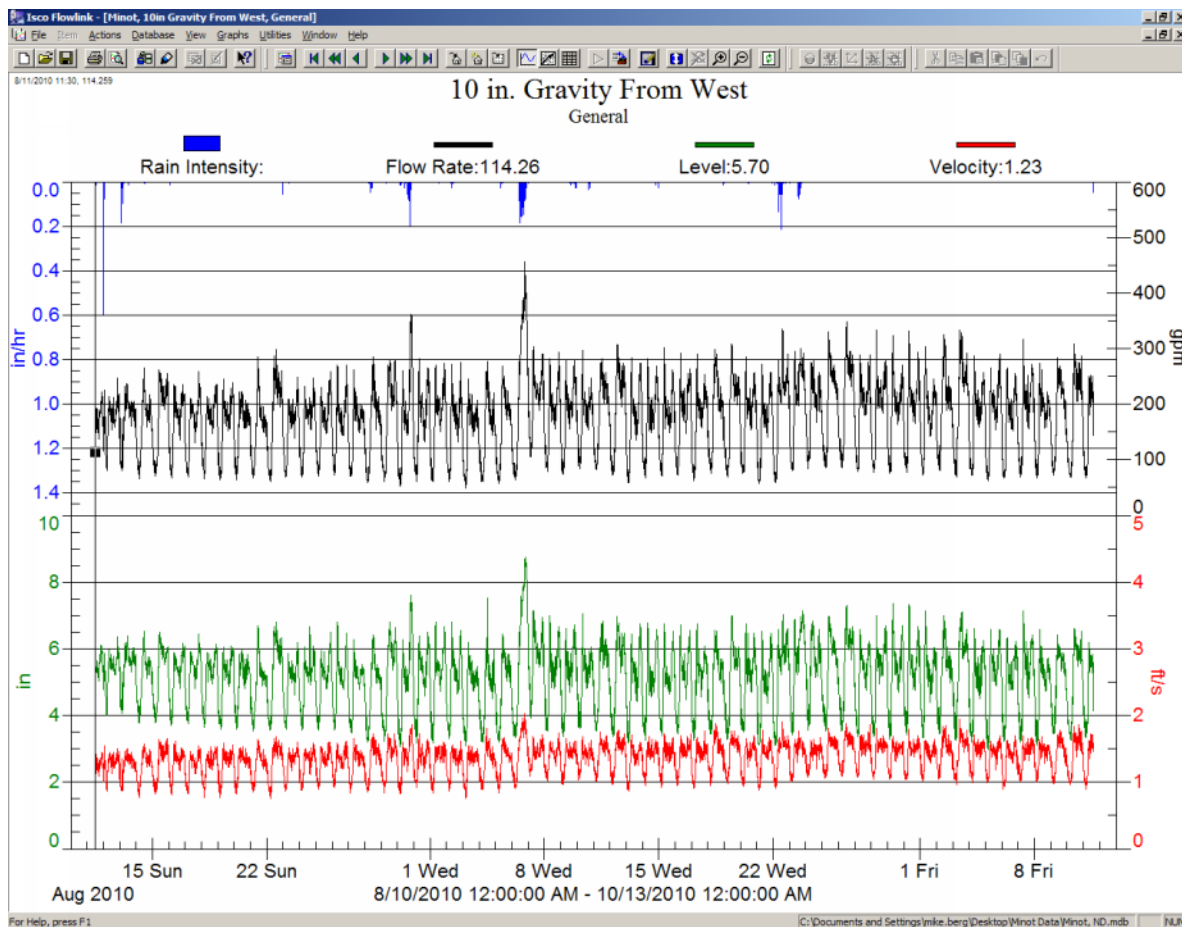
1. Three (3) PT-100 temperature probes, one installed in each motor stator phase winding, to provide direct stator temperature read-out of each phase winding.
2. One (1) PT-100 temperature probe shall be installed to directly contact the outer race of the upper support bearing to provide for accurate temperature monitoring of the bearing.
3. One (1) VIS-10 vibration sensor shall be installed in the power cable junction chamber of the pump/motor unit. The vibration sensor shall be capable of monitoring displacement in one plane.
4. One (1) CLS-10 water-in-oil sensor installed in the mechanical seal lubrication chamber to alarm should there be intrusion of water into the chamber.
5. One (1) Power Analyzer module. The Power analyzer shall provide additional input channels to monitor the following:
 - a. System pump/motor current
 - b. Individual phase pump/motor current (each of 3-phases)
 - c. Current imbalance
 - d. System voltage
 - e. Individual line voltage (each of 3-lines)
 - f. Voltage imbalance
 - g. System power
 - h. Power factor
 - i. Energy consumption

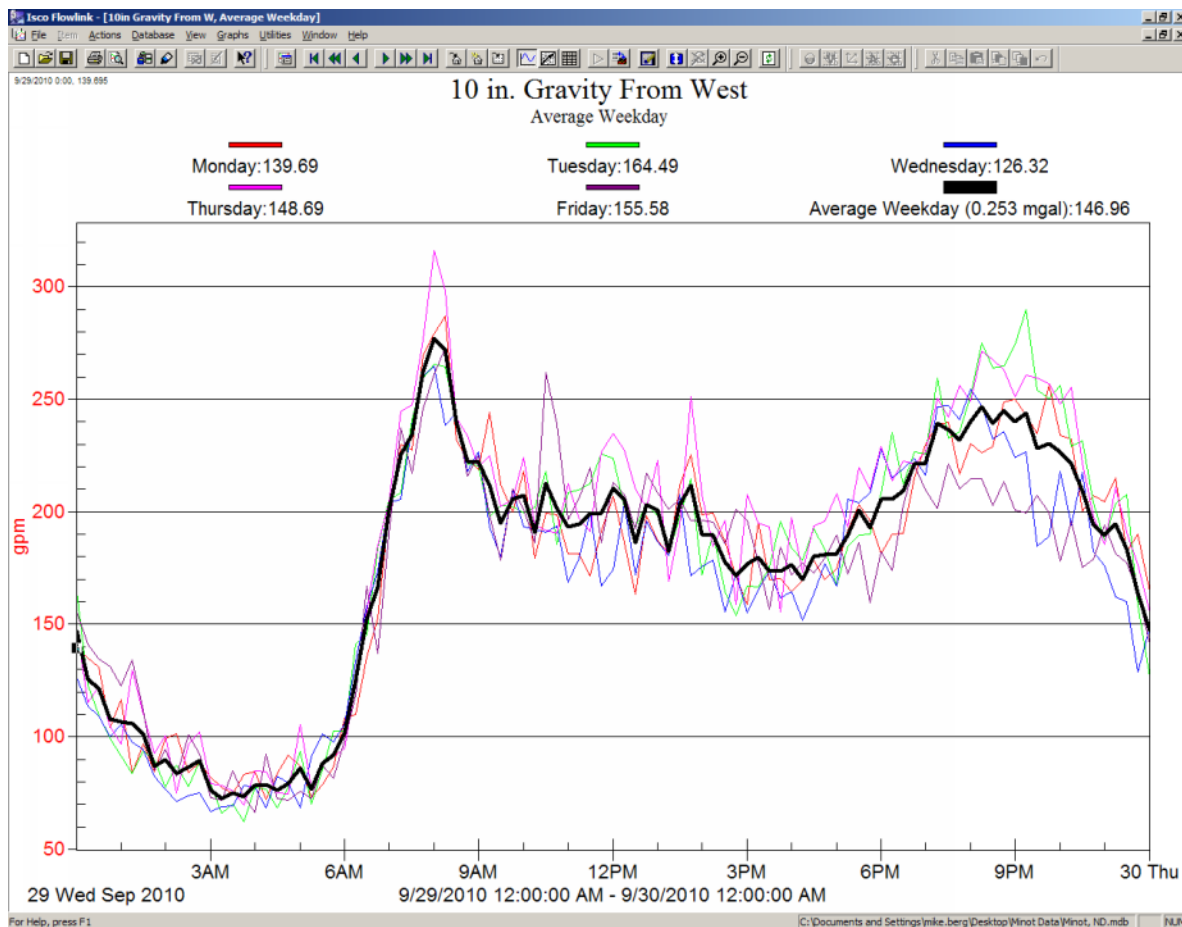
Appendix H

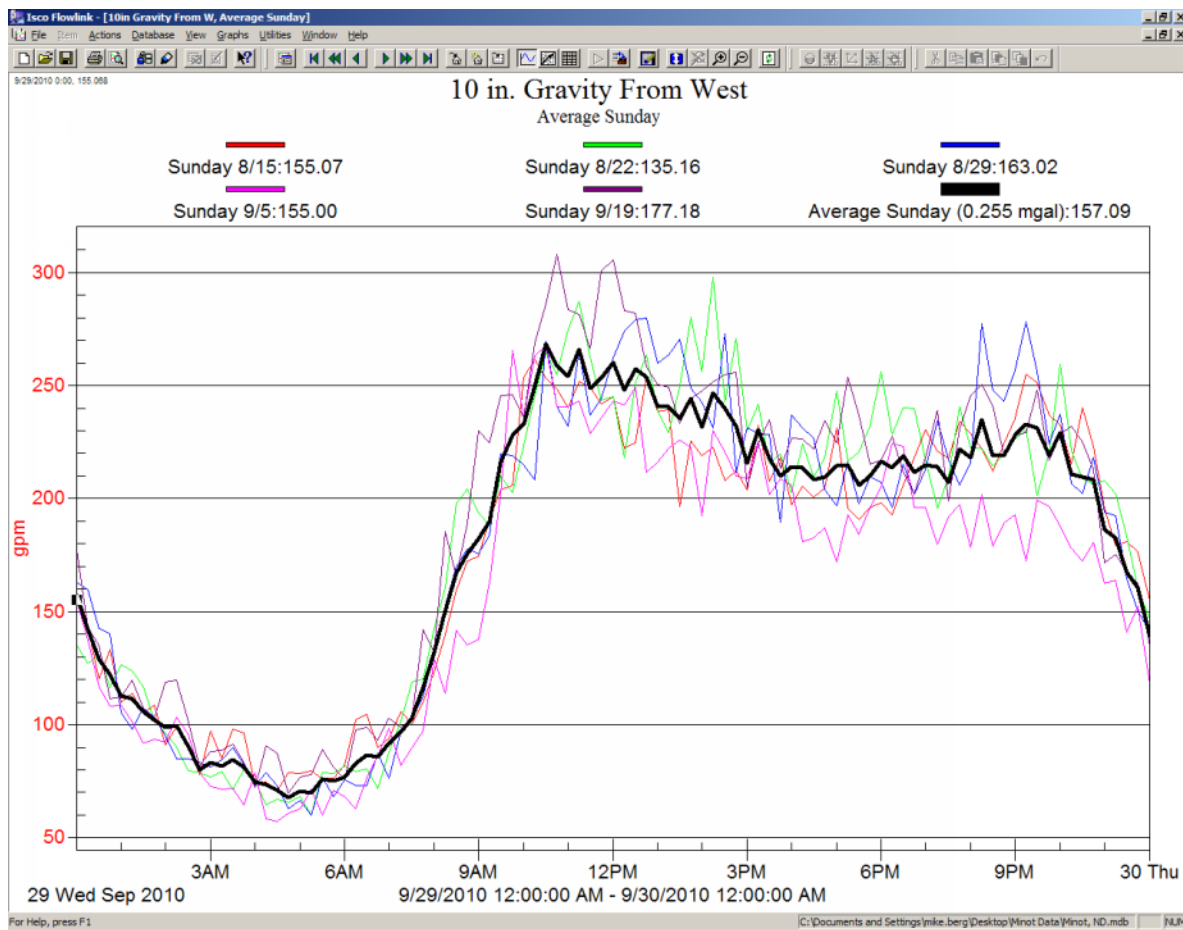
Rainfall Monitoring Results

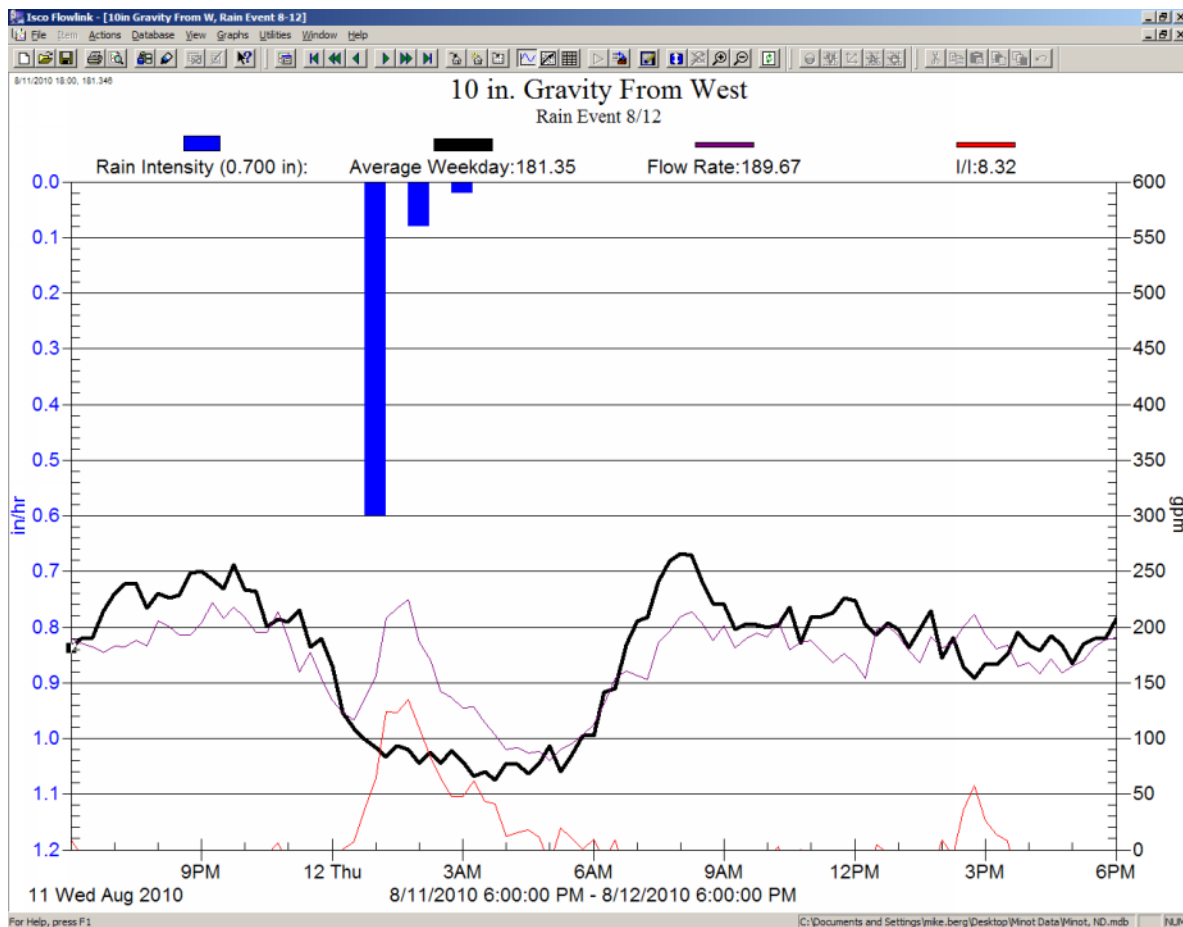


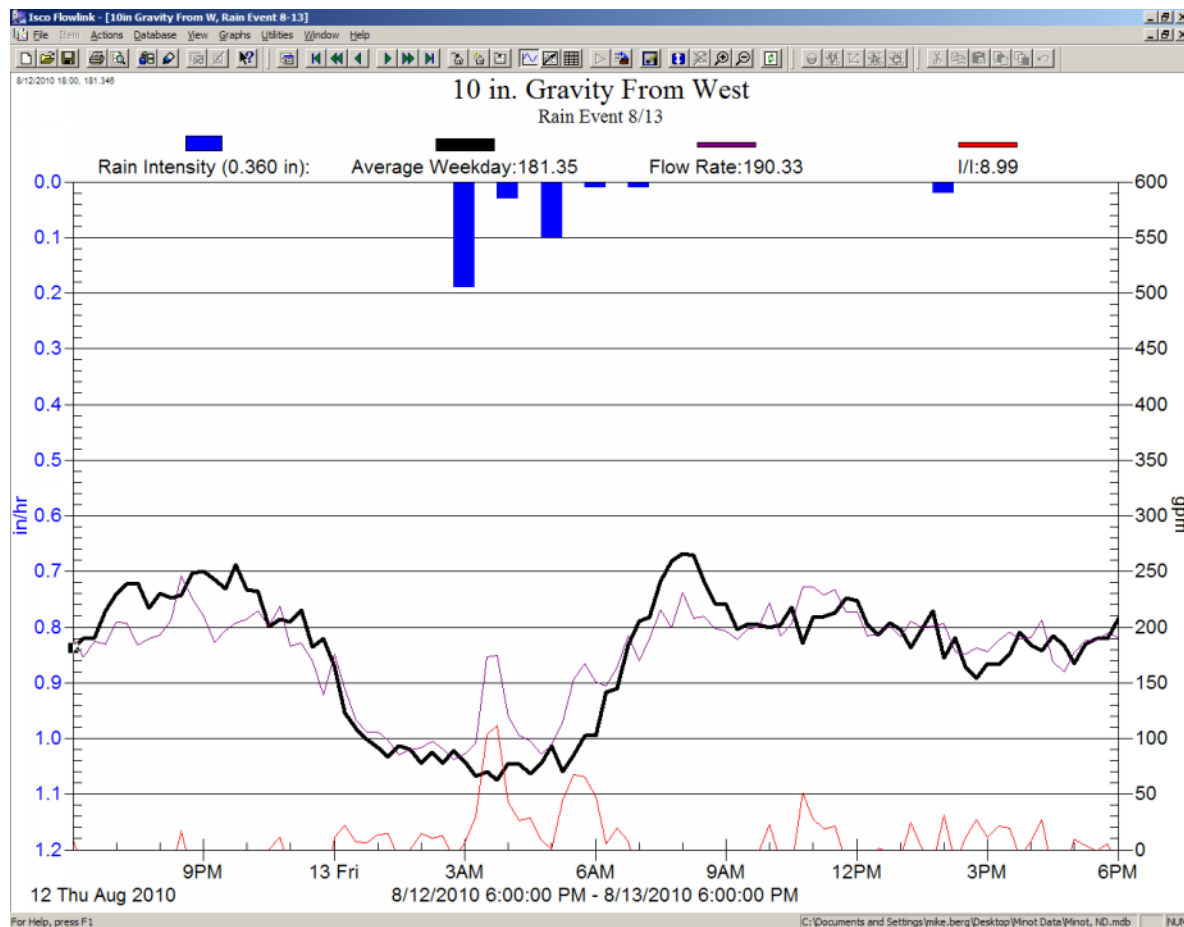
**Flow Meter and Raingauge Location
North Minot Sanitary Sewer Study
Minot, North Dakota**

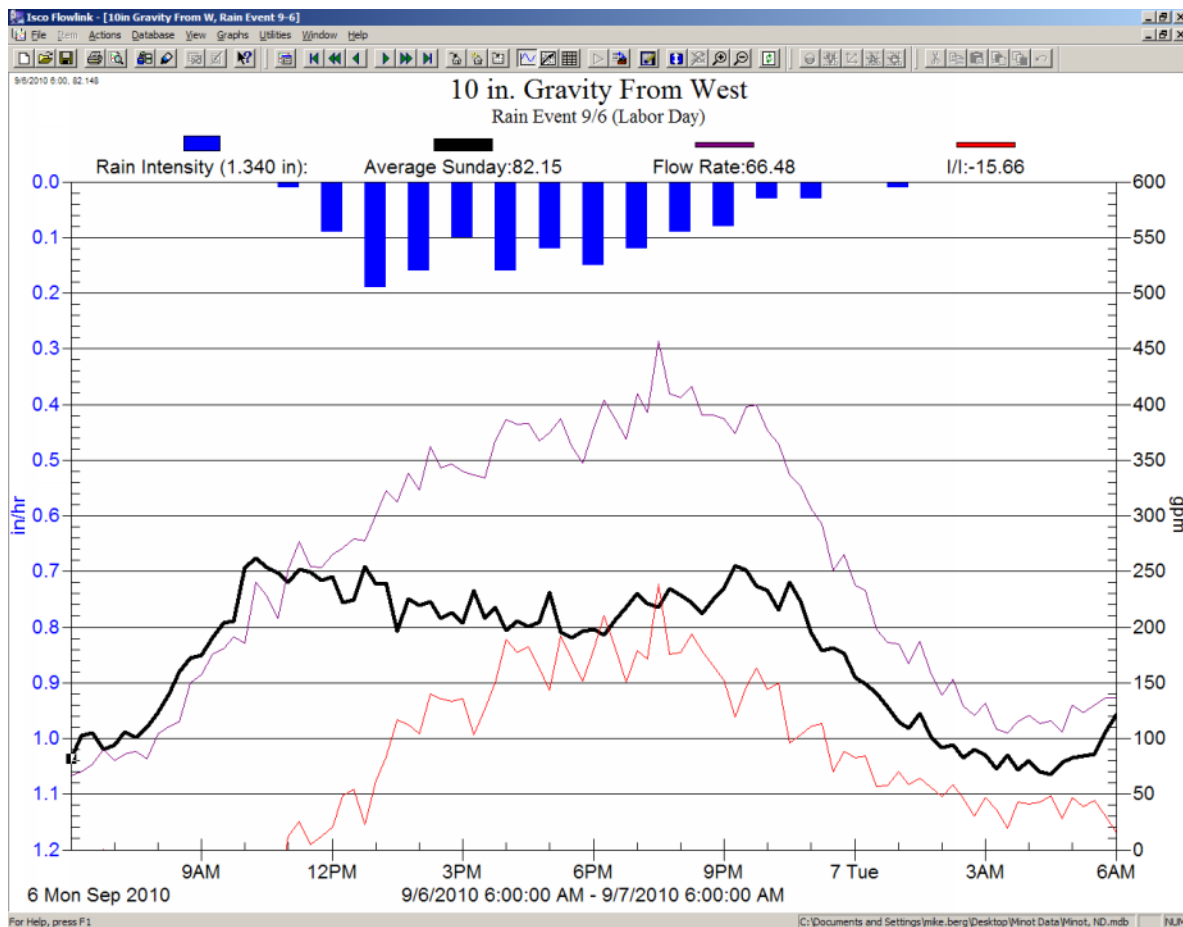


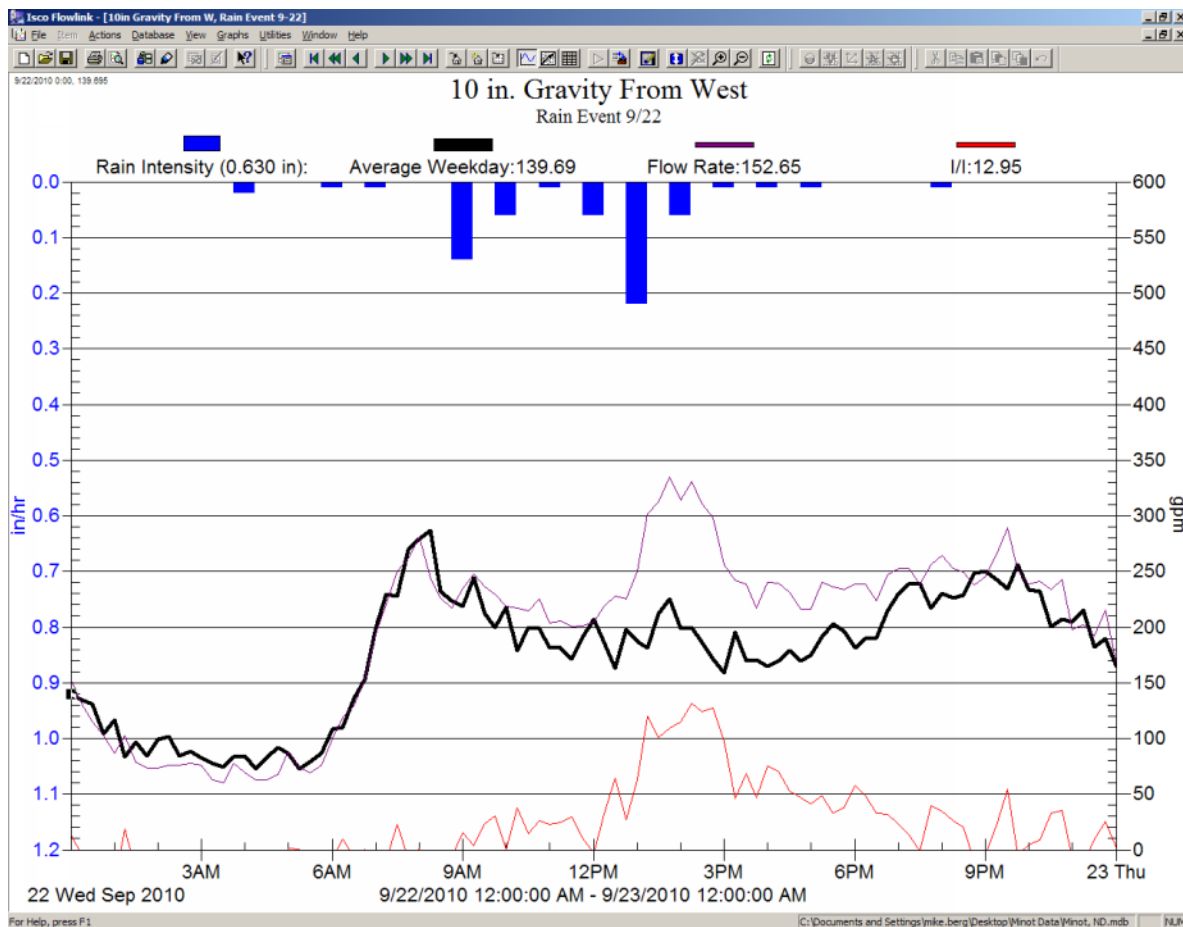


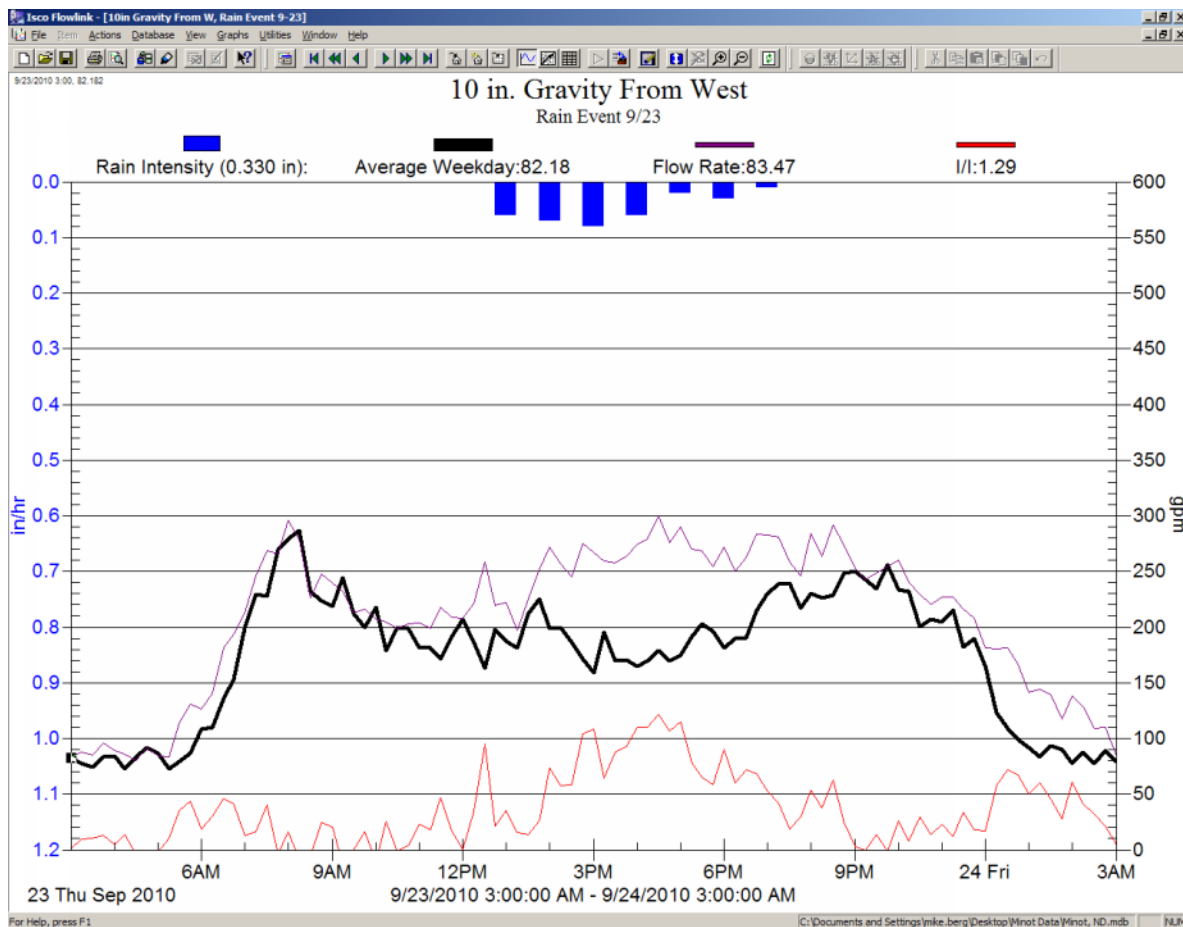


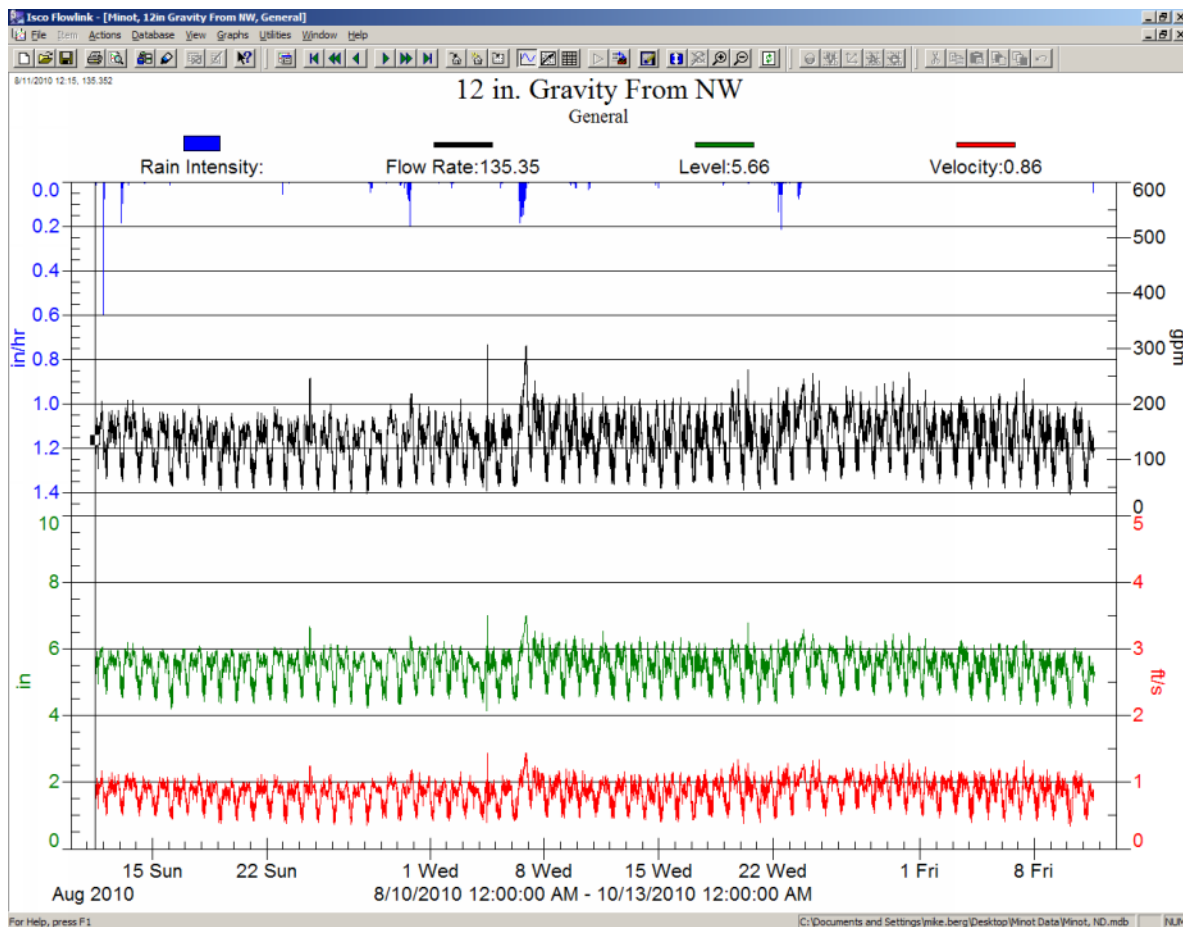


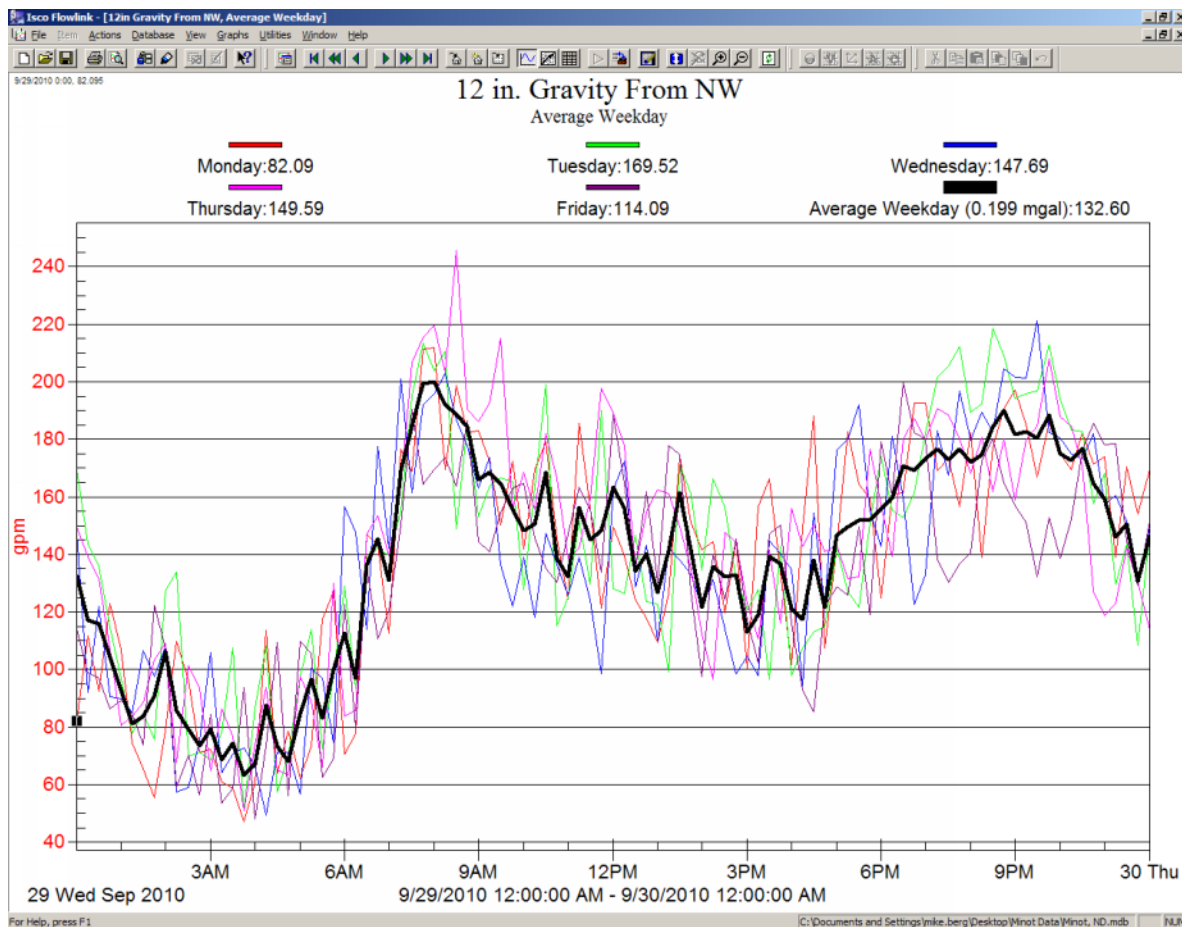


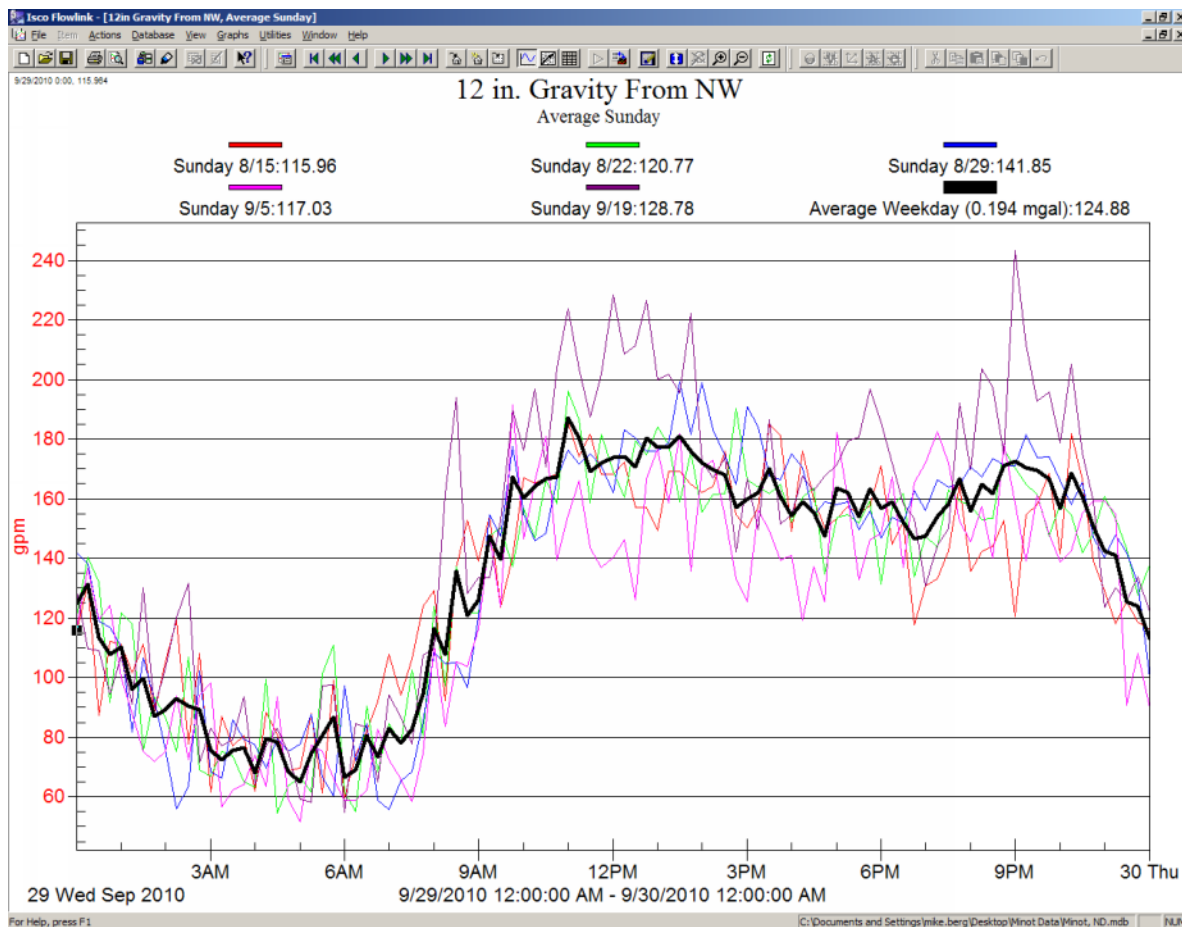


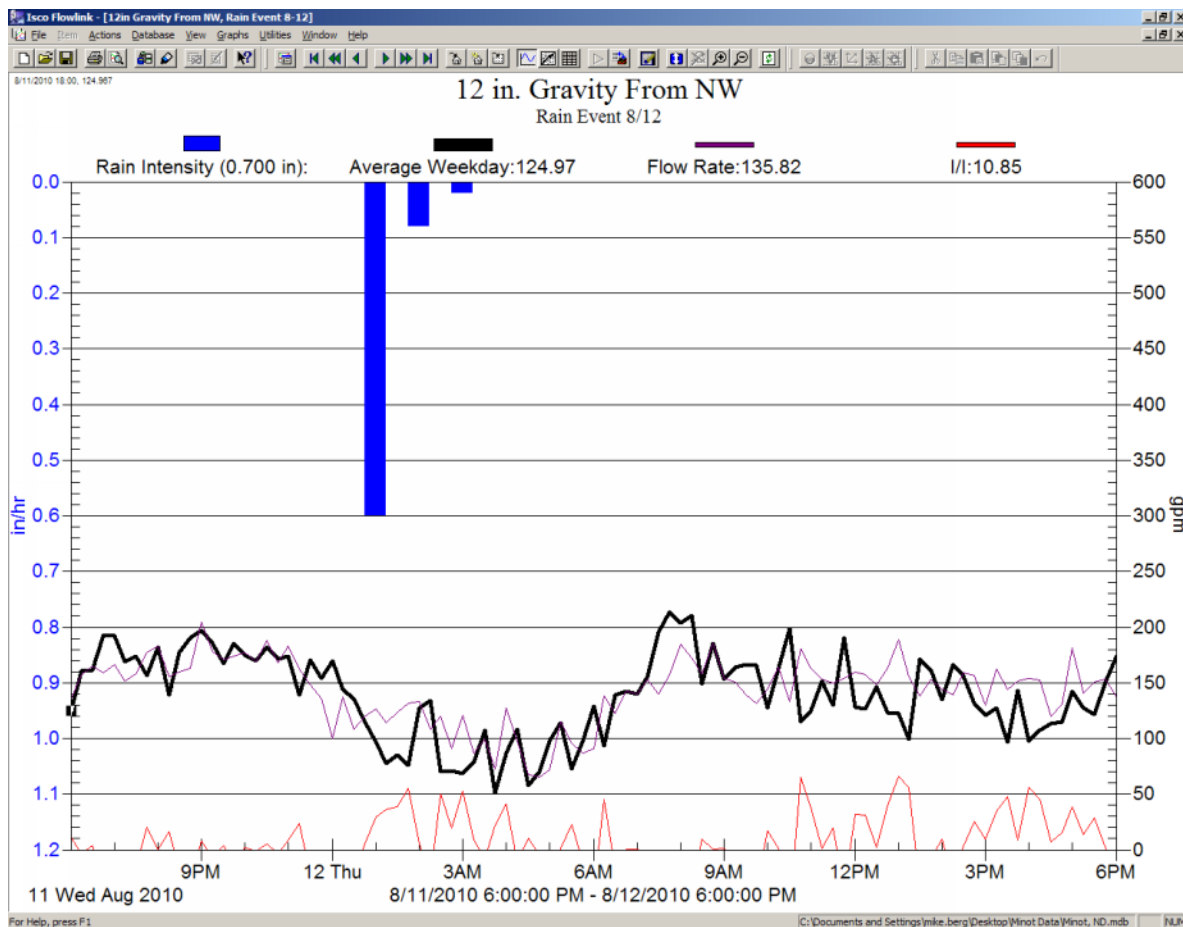


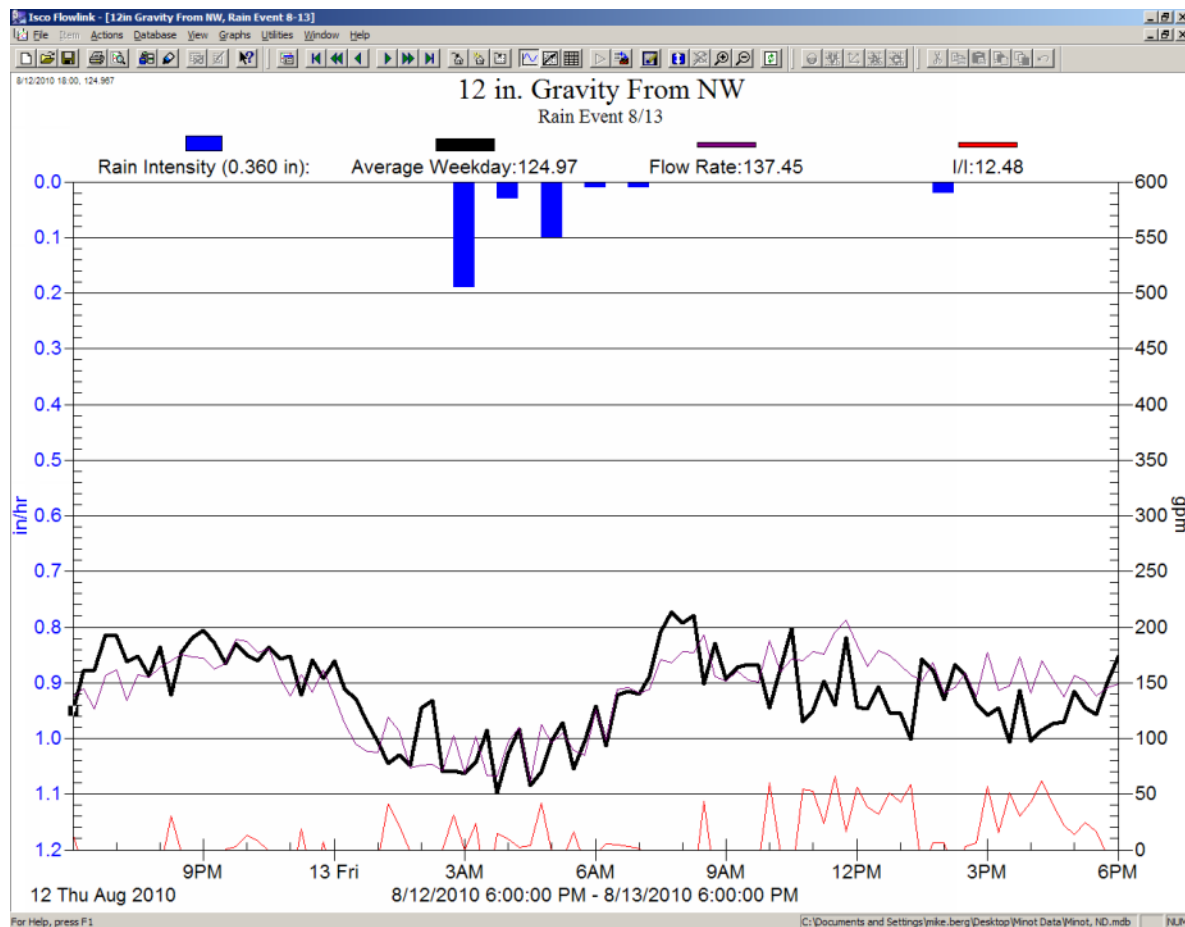


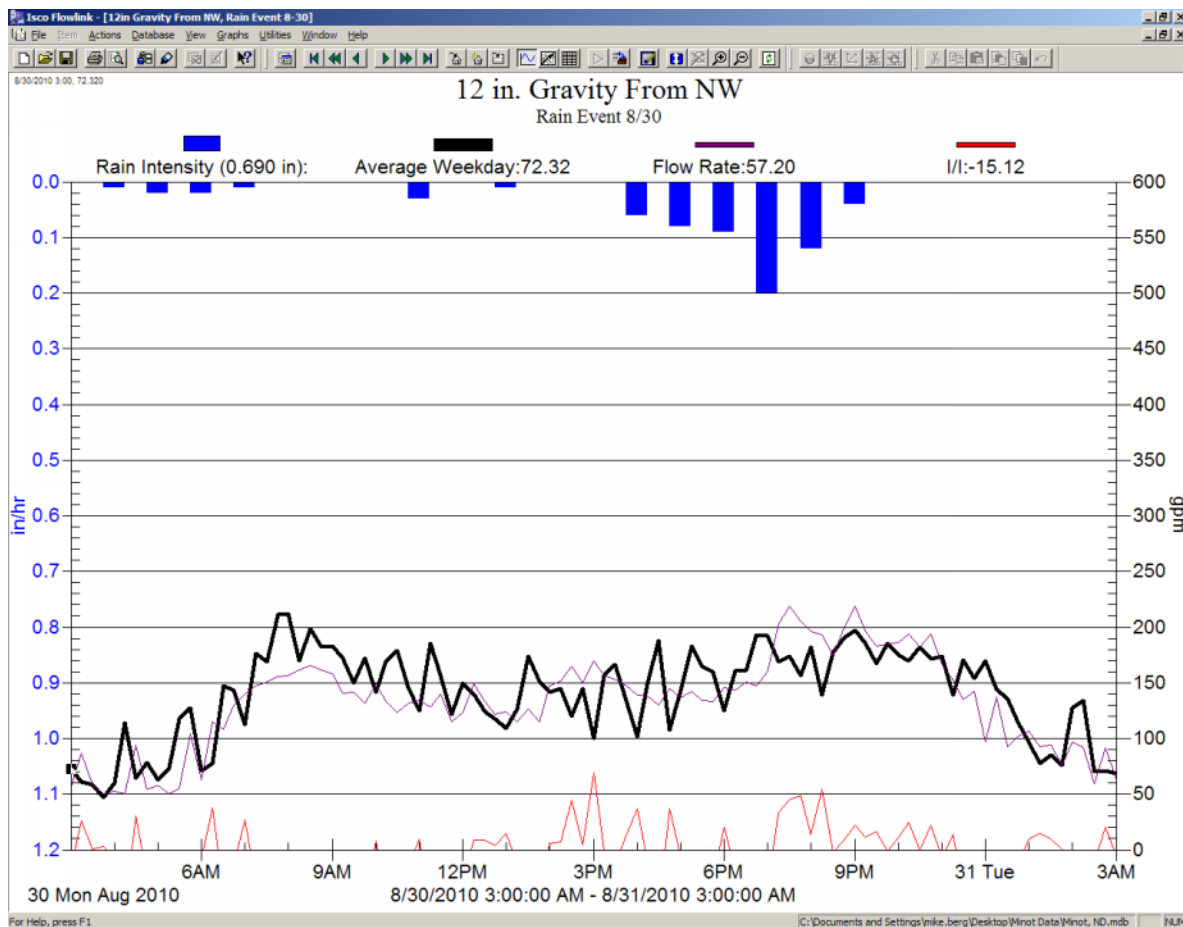


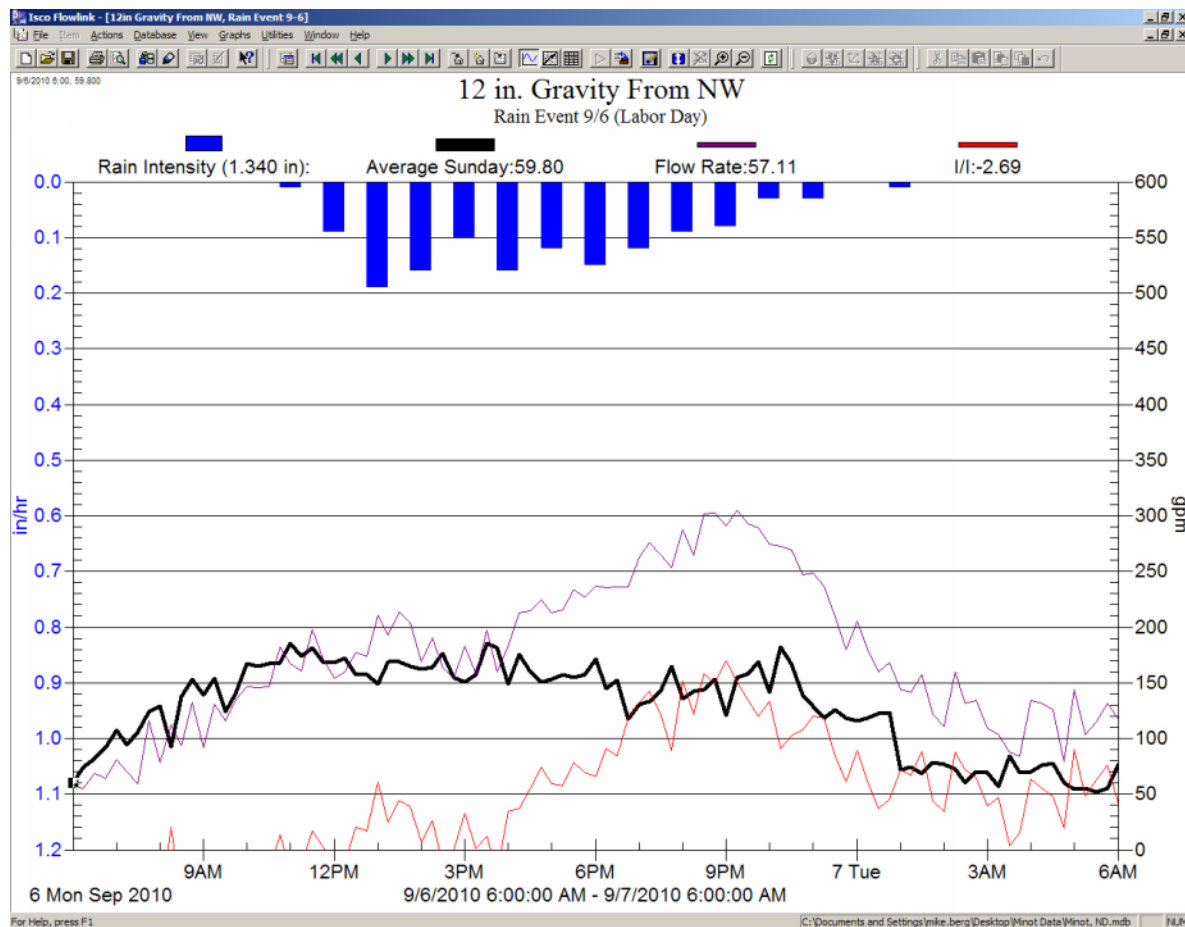


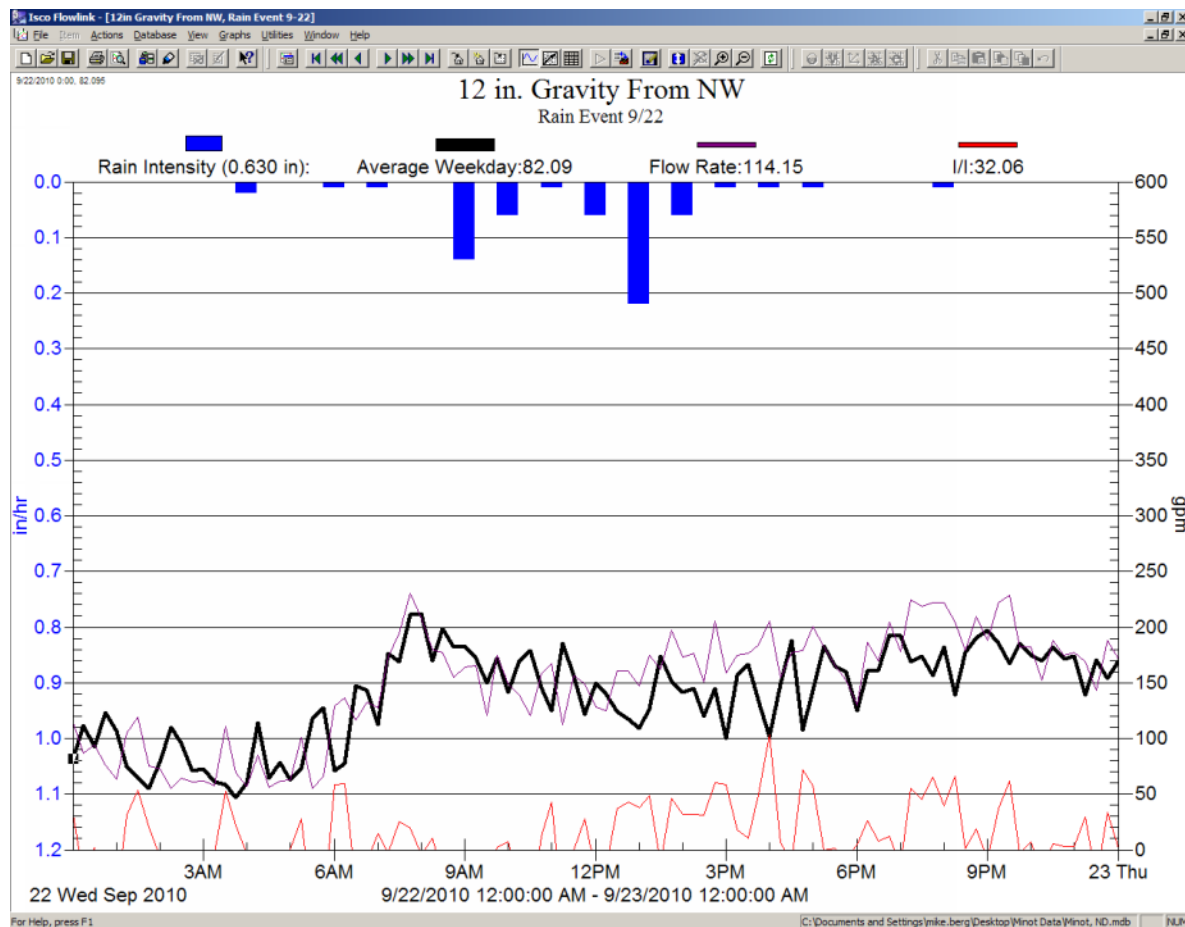


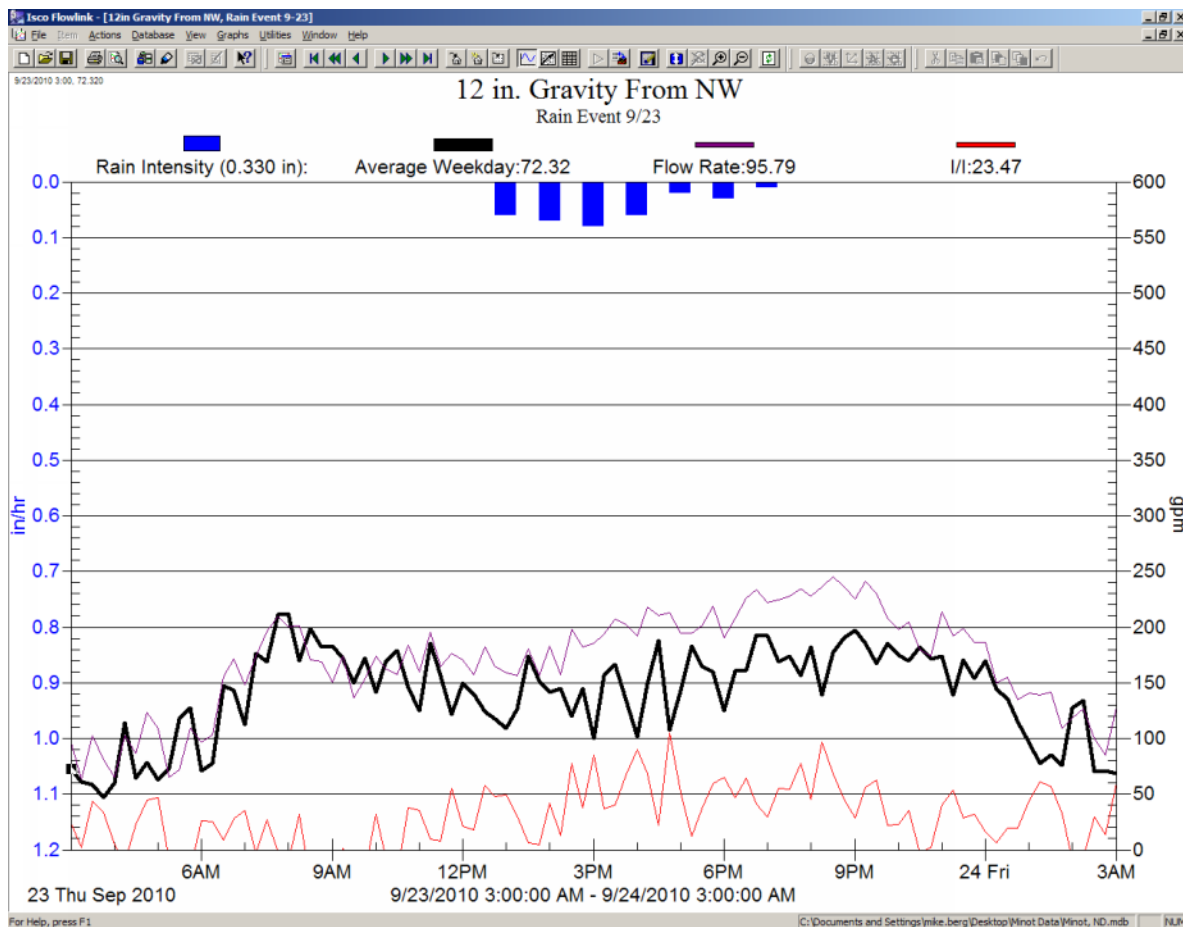












Appendix I

Capital Improvement Program

Table 16 - Capital Improvement Program

Phase	Trunk Sanitary Sewer Element				Trunk Sewer Cost (\$)	Total Trunk and Lift Station Cost (\$)
	Pipe			Lift Station Cost (\$)		
	From	To	Length (ft)			
I	Master Lift Improvements			3,440,000		3,440,000
	Control Lift Improvements			290,000		290,000
	NW.2	NW.1	1,000		129,000	129,000
	NW.1	NW.3	1,700		105,000	105,000
	Lift Station NW.1			581,000		581,000
	42.1	42.2	4,500		461,000	461,000
	42.3	Master	2,500		256,000	256,000
	Verendry	Master	3,000		263,000	263,000
	Roosevelt Lift Improvements			470,000		470,000
	Walders Lift Improvements			450,000		450,000
Subtotal Phase I*					6,445,000	
II	NW.3	NW.4	5,500		1,290,000	1,290,000
	Temporary Lift at NW.4			200,000		200,000
	NE8	lagoons	4,300		678,000	678,000
	Lift Station NE.8 (55th Street)			2,754,000		2,754,000
	Subtotal Phase II					4,922,000
III	NE2.2	NE6.1	6,780		1,865,000	1,865,000
	NE6.1	NE6	5,280		1,578,000	1,578,000
	NE4	NE5.1	6,000		614,000	614,000
	NE5.1	NE5.2	1,300		90,000	90,000
	NE5.2	NE7	7,000		1,367,000	1,367,000
	NE6	NE7	5,280		1,453,000	1,453,000
	NE7	NE8	8,000		2,849,000	2,849,000
	Lift Station NE5.1			608,000		608,000
Subtotal Phase III					10,424,000	
IV	W1	W2	9,000		1,103,000	1,103,000
	W2	NW.3	4,500		577,000	577,000
	NW.4	N5.3	9,000		2,110,000	2,110,000
	N5.2	N5.3	3,500		821,000	821,000
	N5.3	N6.2	1,500		192,000	192,000
	N6.2	NE2.1	2,000		598,000	598,000
	NE2.1	NE2.2	2,200		300,000	300,000
	Lift Station W1			1,337,000		1,337,000
	Lift Station NE2.1			2,268,000		2,268,000
	Lift Station N5.3			2,268,000		2,268,000
Subtotal Phase IV					11,574,000	
V	NW1.1	NW3.1	4,200		462,000	462,000
	NW2.1	NW3.1	1,000		89,000	89,000
	NW3.1	NW.3	6,000		1,172,000	1,172,000
	Lift Station NW2.1			621,000		621,000
	Subtotal Phase V					2,344,000
VI	N1.1	N2.1	6,300		693,000	693,000
	N2.1	N4.1	3,700		635,000	635,000
	N7.1	N8.1	3,300		566,000	566,000
	N8.1	N4.1	600		62,000	62,000
	N3.1	N4.1	2,100		231,000	231,000
	N4.1	N4.2	5,000		1,172,000	1,172,000
	N4.2	N5.2	5,000		1,172,000	1,172,000
	NE1.1	N6.2	4,500		436,000	436,000
	Lift Station NE1.1			999,000		999,000
	Lift Station N8.1			999,000		999,000
Subtotal Phase VI					6,965,000	
Total All Phases					42,674,000	

*21st Avenue Improvements project is underway and therefore not included in Phase I

City of Minot Sanitary Sewer Area Charge
Financing Table
Associated Costs and Areas

Gross Trunk Costs not reduced by lateral benefit

Table 17 - Break Even at Phase VI

A	B	C	D
Phase	Net Developable Acreage Added*	Column B X Area Charge of \$3137/AC	City Trunk Costs
(yr)	(ac)	(\$)	(\$)

I	901	2,826,437	6,445,000
II	1267	3,974,579	4,922,000
III	3555	11,152,035	10,424,000
IV	2294	7,196,278	11,574,000
V	1535	4,815,295	2,344,000
VI	4053	12,714,261	6,965,000
Totals	13,605	42,678,885	42,674,000

*Gross Acreage reduced by major waterbodies, 15% right-of-way and 5-15% parks and open space (per Comp Plan)

City of Minot Sanitary Sewer Area Charge
Financing Table
Associated Costs and Areas

Gross Trunk Costs not reduced by lateral benefit

Table 18 - Break Even at Phase IV

A	B	C	D
Phase	Net Developable Acreage Added*	Column B X Area Charge** of \$4162/AC	City Trunk Costs
(yr)	(ac)	(\$)	(\$)

I	901	3,749,962	6,445,000
II	1267	5,273,254	4,922,000
III	3555	14,795,910	10,424,000
IV	2294	9,547,628	11,574,000
V	1535	6,388,670	2,344,000
VI	4053	16,868,586	6,965,000
Totals	13,605	56,624,010	42,674,000

*Gross Acreage reduced by major waterbodies, 15% right-of-way and 5-15% parks and open space (per Comp Plan)

**Area charge derived from sum of column E divided by sum of column C through Phase V

City of Minot Sanitary Sewer Area Charge
Financing Table
Associated Costs and Areas

Gross Trunk Costs not reduced by lateral benefit

Table 19 - Break Even at Phase II

A	B	C	D
Phase	Net Developable Acreage Added*	Column B X Area Charge** of \$5244/AC	City Trunk Costs
(yr)	(ac)	(\$)	(\$)

I	901	4,724,844	6,445,000
II	1267	6,644,148	4,922,000
III	3555	18,642,420	10,424,000
IV	2294	12,029,736	11,574,000
V	1535	8,049,540	2,344,000
VI	4053	21,253,932	6,965,000

Totals	13,605	71,344,620	42,674,000
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*Gross Acreage reduced by major waterbodies, 15% right-of-way and 5-15% parks and open space (per Comp Plan)

**Area charge derived from sum of column E divided by sum of column C through Phase II

Appendix J

Existing Lift Station Pump Capacity Analysis

Appendix J

Existing Lift Station Pump Capacity Analysis

Lift stations are essential in a wastewater collection system to transfer wastewater from areas that cannot be serviced with a gravity sewer system. The primary objective of a lift station is to pump out inflow contributed by customers in a timely fashion to prevent sewer back-up in houses. Following are required at a minimum to ensure adequate lift station performance within a collection system.

- Quantify the total inflow into a lift station during the worst case condition (peak flow)
- Identify downstream conditions and calculate pump discharge head to size the pump for optimum performance
- Size the wet well and pump set points to ensure proper pump cycle times

As a part of this study, existing lift station pumps were analyzed for current performance using draw-fill field tests. Following summarizes the results of the draw-fill field testing performed at eight (8) of the nine (9) NMSSSA lift stations identified in Table 1 of the report. Airport Industrial lift station was not evaluated during the field testing. Table E-1 summarizes the comparative pump capacity analysis used to determine the adequacy of different lift station pumping capacities.

Table J-1: Pump Capacity Analysis based on Draw-Fill Test Results

Lift Station	(1) Original Design Flow (gpm)	(2) Avg. Current Observed Flow (gpm) ¹	(3) Difference between Current and Original Design Flow ² [(2)-(1)÷(1)] (%)	(4) Peak Design Flow From Appendix C (MGD/gpm)	(5) Additional Lift Station Pumping Capacity (gpm) ³ [(4)in gpm – (2)]
Master– Two (2) 500 hp pumps	6500	5,772	(-) 11.20	12.70/8,819	3,047
Control – Three (3) 185 hp pumps	5,800	5,893	(+) 1.58	11.27/7,826	Adequate
Walders – Two (2) 30 hp pumps	1,500	1,571	(+) 4.52	3.33/2,312.5	741
13 th – Two (2) 7.5 hp pumps	600	741	(+) 23.5	0.782/543	Adequate
16 th – Two (2) 6.4 hp pumps	400	454	(+) 13.5	0.467/324	Adequate
Perkett – Two (2) 25 hp pumps	900	1,498 ⁴	(+) 39.9 ⁴	1.67/1,159	Adequate ⁴
Roosevelt – Two (2) 40 hp pumps	2,000	1,429	(-) 28.5	3.96/2,750	1,321
Airport – Two (2) 3.2 hp pumps	100	96	(-) 4.0	2.75/1,909	1,813

¹Operation of one (1) pump is noted based on engineering judgment of the draw-fill testing results provided.

²(+) or (-) sign indicates if the current pumping observed are over or under respectively when compared with the original design flow

³Backup pump is not taken into consideration for a duplex pump station, while assessing the lift station's ability to keep up with incoming peak flow. For triplex pump station (Control), capacities of two pumps are taken into consideration while assessing lift station capacity.

⁴ It appears that the high flow observed in Perkett could have been caused by a possible non-operation of other lift stations in the valley forcemain. When other lift stations are in operation, the actual pump flow can be as low as 864 gpm (closer to the original design intent)

As a part of the draw-fill testing, discharge pressures at some of the lift stations were provided. However, for a multiple lift station system contributing to a common forcemain such as the valley forcemain system, it is challenging to perform a controlled testing to determine the relevance of discharge pressures observed. Challenges associated with controlled testing include the following.

- Ability to isolate one or a combination of lift stations for extended period of time to determine the effects of different lift stations on the line pressure.
- Synchronize pump starts and stops with other lift stations as required.

Based on the results observed in Table J-1, additional pumping capacity is required in four (4) lift stations when compared with the contributing peak flows for the proposed full development system. As noted above, other items such as wet well volume and downstream discharge conditions need to be evaluated prior to detailed design.