Sioux Falls Water System Master Plan

Finalized November 2023

Table of Contents

Preface

Executive Summary

List of Figures

List of Tables

Chapter 1: Water Rights

Table of Contents

List of Figures

List of Tables

Appendices

Chapter 2: Existing Wells Condition Assessment

Table of Contents

List of Figures

List of Tables

Appendices

Chapter 3: New Well Siting Plan

Table of Contents

List of Figures

List of Tables

Chapter 4: Groundwater Numerical Modeling of Drought Impacts

Table of Contents

List of Figures

List of Tables

Chapter 5: Water Transmission Mains

Table of Contents

List of Figures

List of Tables

Appendices

Chapter 6: Water Transmission Mains

Table of Contents

List of Figures

List of Tables

Appendices

Chapter 7: Water Purification Plant Treatment Evaluation

Table of Contents

List of Figures

List of Tables

Chapter 8: Future Growth and Peak Demand Solutions

Table of Contents

List of Tables

Appendices

Technical Memorandum

Water System Master Plan

Preface

HR Green Project No: 210506

Prepared For:

CITY OF
SIOUX FALLS

PREFACE

This document combines two master plans into one document. The first section addresses raw water supply and treatment. This section of the master plan was prepared using the team of HR Green, LRE, and Carollo. The second section covers distribution and storage. This section of the master plan was prepared by AE2S.

Purpose

The primary purpose of this master plan was to identify and prioritize needed capital improvement projects across the entire Water Division including water supply, treatment and distribution.

This endeavor identified numerous improvements that are worthwhile and beneficial to the long-term viability of the water system. However, the high number and cost of the projects quickly exceeded available budgets. Unreasonable rate increases would be required to pay for all of the identified projects. Therefore, the City scaled back the implementation of the proposed projects recommended in the Master Plans to more closely match the available funding allowed by the City's existing water rate financial model.

Flexibility is a key component of the recommendations within the Master Plan. The intent is a living document that can be adjusted up or down on a yearly basis to match funding while still accommodating anticipated robust growth.

Capital Improvement Plan

The City has made significant investments in the Lewis and Clark Rural Water System (LCRWS) which supplies the City with a redundant treated water source from the drought resistant Missouri River. A significant portion of the Water Division's CIP includes LCRWS payments to increase the City's allocation to 34 MGD.

Building the necessary infrastructure to allow the City to receive the full Lewis and Clark Rural Water System (LCRWS) treated water allocation gives the City the flexibility to delay the well field and water purification plant (WPP) capacity upgrades. However, maintenance projects at the existing well field and WPP are still required to ensure the plant and wells are well maintained throughout the design period.

Section I of the Master plan evaluates the existing well field and Water Purification Plant and provides a multi-year approach outlining prioritized improvements to meet the City's short and long-term goals. Major elements covered in Section I include the following:

- Water Rights
- Well Condition Assessment
- New Well and Well Field Siting Plan
- Drought Impacts Modeling
- Well Field Transmission Mains
- WPP Condition Assessment
- WPP Treatment Evaluation
- Future Growth and Peak Demand Solutions

The City's rapid growth necessitates expansion of the distribution system along with transmission improvements to replace and upsize existing transmission pipelines to meet future capacity requirements.

Additional water storage will be required for operational and emergency needs related to growth and expansion of the system.

Section II of the Master Plan evaluates the existing distribution system and provides a multi-year approach outlining prioritized improvements to meet the City's short and long-term goals. Major elements covered in Section II include the following.

- Existing System Overview
- Planning Horizons and Water Demands
- Water Distribution System Hydraulic Model
- Wate Conservation Efforts
- Design Parameters and Evaluation Criteria
- Existing System Evaluation
- Future System Evaluation
- Recommended System Improvements

A combined CIP plan from the two sections of the Master Plan is provided in the following Table.

Capital Improvement Project[1]	Funding Designation	Project Category	Project Year	OPPC
Water Supply - Well Field/BSR				
Replace 5-Pack Gravel Pack Wells	Water Driven	Supply	**2030**	$ 2,060,000
Proposed Collector Well 5 with Main Install	Water Driven	Supply	**2031**	$ 8,278,000
5-Pack Gravel Pack Wells	Water Driven	Supply	**2031**	$ 607,000
5-Pack Gravel Pack Wells - Upsize mains	Water Driven	Supply	**2032**	$ 3,877,000
Gravel Pack Wells 1, 2, and 3	Water Driven	Supply	**2033**	$ 1,346,000
Proposed Gravel Pack Wells 1, 2, and 3	Water Driven	Supply	**2034**	$ 528,000
Proposed Gravel Pack Wells 1, 2, and 3 - Upsize Main	Water Driven	Supply	**2035**	$ 2,461,000
Upsize Transmission Main from WPP to North of 258th Street	Water Driven	Supply	**2036**	$ 77,025,000
Replace 6-pack Gravel Pack Wells	Water Driven	Supply	**2037**	$ 3,025,000
6-pack Gravel Pack Wells	Water Driven	Supply	**2038**	$ 743,000
6-pack Gravel Pack Wells - Upsize mains	Water Driven	Supply	**2039**	$ 5,300,000
Proposed Collector Well 18 with Main Install	Water Driven	Supply	**2034**	$ 11,457,000
Install Parallel 36-Inch Transmission - 255th St: 257th to 255th	Water Driven	Supply	**2041**	$ 21,983,000
Install Cathodic Protection on Existing Ductile Iron Pipe	Water Driven	Supply	**2042**	$ 602,000
Water Supply - Lewis & Clark RWS				
L&C True-Up	Water Driven	Supply	**2031**	$ 10,000,000
L&C Expansion	Water Driven	Supply	**Yearly**	$ 57,990,990
L&C Raw Water Expansion	Water Driven	Supply	**Yearly**	$ 7,514,003
L&C Second Collector Well Payment	Water Driven	Supply	**2023**	$ 630,642
Water Treatment				
Filters: Redundant backwash blower; Backwash pump VFDs.	Water Driven	Treatment	**2024**	$ 227,000
Chemical Storage / Feed Systems: Add second service water line	Water Driven	Treatment	**2024**	$ 42,000
WPP Power Distribution: Replace gear in Power Room 2	Water Driven	Treatment	**2025**	$ 1,534,000
Backwash Reclaim Basin: Replace sludge scrapers & add scrapers	Water Driven	Treatment	**2025**	$ 1,562,000
Clearwell: Replace valves between clearwell & N transfer pumps	Water Driven	Treatment	**2025**	$ 174,000
Filters: Flow meters; Filter valves; Filter instrument upgrades	Water Driven	Treatment	**2027**	$ 5,388,000
Solids Contact Basins: Replace clarifier equipment in Basins 2 & 3	Water Driven	Treatment	**2027**	$ 7,740,000
High Service Pumps: Install additional VFDs	Water Driven	Treatment	**2028**	$ 4,139,000
Recarbonation Basins: Replace CO2 feeders	Water Driven	Treatment	**2029**	$ 2,216,000
High Service Pumps: Replace pumps 7, 8, 9	Water Driven	Treatment	**2029**	$ 976,000
Actiflo: Replace (6) sand pumps; Replace (2) influent flow meters	Water Driven	Treatment	**2029**	$ 459,000
Transfer Pumps: Install 480V motors & VFDs on transfer pumps	Water Driven	Treatment	**2030**	$ 914,000
Chemical Storage / Feed Systems: Life cycle replacement	Water Driven	Treatment	**2030**	$ 1,008,000
Lime System: Replace slakers 5 & 6	Water Driven	Treatment	**2031**	$ 1,868,000
Transmission Main Tunnel: Repair tunnel ceiling	Water Driven	Treatment	**2031**	$ -
Administrative & Personnel Facilities: Repair offices	Water Driven	Treatment	**2031**	$ 32,000
Laboratory: Replace lab cabinets, lab flooring	Water Driven	Treatment	**2032**	$ 270,000

Water Distribution - Defined Projects					
Minnesota Ave Corridor - Phase 2: 2nd St to 8th St - Material	Engineering Driven	Rehabilitation & Repair	**2023**	$	1,863,000
Minnesota Ave Corridor - Phase 2: 2nd St to 8th St	Engineering Driven	Rehabilitation & Repair	**2024**	$	2,310,000
Veterans Parkway Transmission from E 26th St to E 6th St	Engineering Driven	Transmission	**2024**	$	5,040,000
Minnesota Ave Corridor - Phase 3: 8th St. to 14th St.	Engineering Driven	Rehabilitation & Repair	**2025**	$	5,281,000
12th Street Connection to L&C RWS - Phase 2 - Meter Building	Water Driven	Supply	**2025**	$	1,798,000
12th Street Connection to L&C RWS - Phase 1 - Transmission	Water Driven	Supply	**2026**	$	5,978,000
West Reservoir Control Valve	Water Driven	Optimization	**2026**	$	452,000
Minnesota Ave Corridor - Phase 4: 14th St to 18th St	Engineering Driven	Rehabilitation & Repair	**2028**	$	3,902,000
Transmission to East Reservoir - East of WTP-Phase 1	Water Driven	Rehabilitation & Repair	**2029**	$	2,195,000
East Reservoir Transmission Upgrades - Hidden Hills	Water Driven	Rehabilitation & Repair	**2029**	$	2,290,000
West High Zone Transmission-La Mesa: Benson to Maple - Phase 1	Water Driven	Transmission	**2029**	$	5,384,000
Transmission to East Reservoir - East of WTP - Phase 2	Water Driven	Rehabilitation & Repair	**2030**	$	2,735,000
West High Zone Transmission-Ellis: Windmill to Madison - Phase 2	Water Driven	Transmission	**2030**	$	4,951,000
Transmission to East Reservoir - East of WTP - Phase 3	Water Driven	Rehabilitation & Repair	**2031**	$	3,011,000
West High Zone Transmission-Madison - Ellis to La Mesa - Phase 3	Water Driven	Transmission	**2031**	$	4,268,000
60th Street Tower	Water Driven	Storage	**2031**	$	10,175,000
Menlo Water Tower Fill Control Valve	Water Driven	Optimization	**2031**	$	548,000
West High Zone Transmission-La Mesa: Madison to Maple-Phase 4	Water Driven	Transmission	**2032**	$	6,066,000
Foundation Park - La Mesa Dr, Benson Rd to 54th St N	Water Driven	Transmission	**2033**	$	5,897,000
Foundation Park - La Mesa Dr, 54th St N to 62nd St N	Water Driven	Transmission	**2034**	$	5,233,000
Foundation Park - 260th St - La Mesa Dr to Marian Rd	Water Driven	Transmission	**2035**	$	4,130,000
Foundation Park - N La Mesa Dr - 62nd St N to 260th St	Water Driven	Transmission	**2036**	$	7,058,000
Powder House Road Tower	Water Driven	Storage	**2037**	$	12,374,000
Minnesota Ave Corridor - Phase 5: 18th St to 21st St	Engineering Driven	Rehabilitation & Repair	**2038**	$	5,175,000
East Reduced Zone Transmission - Six Mile Rd: E 26th to 41st	Water Driven	Transmission	**2038**	$	2,989,000
East Reduced Zone Transmission - 85th St: Southeastern to Cliff	Water Driven	Transmission	**2038**	$	4,750,000
41st St Pressure Reducing Station	Water Driven	Optimization	**2038**	$	679,000
East High Zone Transmission E 6th St: I-229 to Bahnson Ave	Water Driven	Transmission	**2039**	$	10,683,000
East Reduced Zone Transmission - Six Mile Rd: E 41st to E 57th	Water Driven	Transmission	**2040**	$	4,277,000
East High Zone Transmission: Bahnson Ave to Sycamore Ave	Water Driven	Transmission	**2040**	$	9,111,000
East High Zone Transmission: Sycamore Ave to N Foss Ave	Water Driven	Transmission	**2041**	$	10,262,000
East Reduced Zone Transmission - 85th St: Southeastern to Hwy 11	Water Driven	Transmission	**2042**	$	9,364,000
85th St Pressure Reducing Station	Water Driven	Optimization	**2042**	$	761,000
East Reduced Zone Transmission - Six Mile Rd: E 57th to E 85th	Water Driven	Transmission	**2043**	$	8,576,000
East Reduced Zone Transmission - 85th St: Hwy 11 to Six Mile Rd	Water Driven	Transmission	**2044**	$	5,031,000
Benson Rd Water Tower	Water Driven	Storage	**2045**	$	25,606,000
Water Distribution - Undefined Projects[2]					
Water Storage Rehabilitation	Water Driven	Rehabilitation & Repair	**Yearly**	$	16,323,000
City Wide Water Main Replacement Projects	Water Driven	Rehabilitation & Repair	**Yearly**	$	60,540,000
Water Pipe Trenchless Rehabilitation	Water Driven	Rehabilitation & Repair	**Yearly**	$	29,278,000
Transmission System Improvements - Replacement	Water Driven	Rehabilitation & Repair	**Yearly**	$	-
Transmission System Improvements - New Growth	Water Driven	Growth & Development	**Yearly**	$	-
Other Mains - Unforeseen Water Projects	Water Driven	Rehabilitation & Repair	**Yearly**	$	18,800,000
Neighborhood Reconstruction Program	Engineering Driven	Rehabilitation & Repair	**Yearly**	$	19,305,000
Major Street Reconstruction Program - Replacement	Engineering Driven	Rehabilitation & Repair	**Yearly**	$	1,404,000
Arterial Street Improvements - New Growth	Engineering Driven	Growth & Development	**Yearly**	$	75,436,000
Miscellaneous Water Main Project	Engineering Driven	Rehabilitation & Repair	**Yearly**	$	8,808,000
			Total Opinion of Probable Cost	**$**	**674,073,635**

[1] For more details on the project description and opinion of probable costs, refer to Appendix ?.

[2] Yearly undefined projects, OPPC is total through 2045.

[3] 2023 through 2045 Planning Years

Water Supply and Treatment Master Plan

Executive Summary

October 2022

(Revised September 2023)

HR Green Project No: 210506

Prepared For:

ES 1 Project Background and Objectives

The objective of the Water Supply and Treatment Master Plan is to provide a 10, 20, 50, and 100-year planning document to be used as a tool to outline and prioritize a Capital Improvement Plan (CIP) for the City of Sioux Falls' (City's) water supply and treatment facilities. Additional consideration is given to 10-year improvements and costs were provided with the assumption these projects will eventually be included in the City's upcoming CIP planning process. The following summarizes the objectives of the Master Plan:

- Maximize available water rights and explore feasible options for obtaining additional future water rights.
- Evaluate existing well field and collection system and identify areas for reconditioning and/or expansion.
- Evaluate sustainability of source water especially during drought conditions.
- Evaluate peak flow and sustainable flow rates of existing Water Purification Plant (WPP).
- Provide recommendations to maximize WPP capacity to meet current and future needs.
- Recommend WPP improvements to enhance efficiency and resiliency of operations.
- Provide summary of alternative viable water treatment methods and operational costs associated with each, including potential regulatory benefits and/or concerns of the proposed treatment process.
- Identify and provide summary of viable future growth solutions for additional study to match proposed growth.

To evaluate the water supply and treatment system operations and infrastructure, a proactive approach was followed that included valuable first-hand input from both the WPP and the City Engineering staff. Many field visits and meetings were held to gather information and gather input. Several Power Point presentations were held with the City to gather additional feedback and determine the direction of the Master Plan. Based on the input received, operations and maintenance data acquired, and detailed analysis by the project team, a Master Plan was developed. An overview of the of the major elements evaluated in the Master Plan and subsequent recommendations are summarized below.

ES 2 Water Rights

The City holds surface water rights and groundwater rights that not only supply the raw source water to the WPP, but also provide water for other uses, including irrigation, commercial, and industrial uses. Water rights in South Dakota are administered by the Water Rights Program (WRP) of the South Dakota Department of Agriculture and Natural Resources (DANR).

The City's surface water rights include appropriations from the Big Sioux River and the Missouri River. The City's groundwater rights include appropriations from three aquifers: the Sioux Falls management unit of the Big Sioux aquifer (Big Sioux:Sioux Falls aquifer), the Middle Skunk Creek management unit of the Big Sioux aquifer (Big Sioux:MSC aquifer), and the Southern Skunk Creek management unit of the Big Sioux aquifer (Big Sioux:Southern Skunk Creek aquifer).

The City has surface water intakes at the Big Sioux River Pumping station located at the Sioux Falls Regional Airport and three well fields: the North Well Field, the Airport Well Field, and the Middle Skunk Creek (MSC) Well Field. The North Well Field and the Airport Well Field are located within the Big Sioux:Sioux Falls aquifer. The MSC Well Field is located in the Big Sioux:MSC aquifer.

Due to water quality impacts associated with per-and polyfluoroalkyl substances (PFAS) at the Airport Well Field, no groundwater is being withdrawn from the 21 wells in the Airport Well Field and the wells are on “standby” status. The City is considering transferring the water rights associated with the Airport Well Field wells to wells located in the North Well Field (see new well siting plan). The WRP will allow existing permits and licenses to be amended by changing the diversion point locations if the following criteria are met: 1) no change in water source (same aquifer); 2) no increase in the amount of water (diversion rate and volume to remain the same); and 3) the change does not result in an added potential for unlawful impairment of senior or domestic water rights.

The total water rights held by the City for supplying raw water to the WPP are shown in Table ES-1. The water rights shown include permits and licenses for existing wells and intake structures and for surface and groundwater reserved by future use permits.

ES-2.1 Attributing Surface Water Rights to Groundwater Rights

Groundwater requires less treatment, and the City currently treats and distributes much more groundwater than surface water. For this reason, it may be advantageous to attribute some of the surface water rights held by the City to groundwater rights. The WRP has indicated that the only mechanism currently in place in South Dakota that could allow the City to potentially attribute current surface water rights to groundwater rights would be to divert surface water under an existing surface water permit (or future use permit) for the purpose of recharging the aquifer. The recharged water pumped from the aquifer would be pumped under a groundwater permit with a defensible amount of the well's production attributed to the infiltration of surface water. This type of undertaking would include amending, revising, or adding diversion point locations associated with the applicable permits, and would require sound hydrogeologic justification and investigation for review by the WRP. This process can be considered a managed aquifer recharge (MAR) system.

The City currently operates a MAR under an existing City water right (WR #5431-3, see Table 2, Water Right Technical Memorandum). Under this surface water permit, surface water from the Big Sioux River is diverted to a diversion ditch. This surface water recharges that portion of the aquifer located along the diversion ditch, increasing the available drawdown of wells near the ditch. An additional MAR, utilizing both the Big Sioux River and an existing diversion ditch, could be utilized as a mechanism to attribute some of the City's unused surface water rights to groundwater rights. A conceptual design for the proposed MAR system is shown in Figure 4 of the Water Rights Technical Memorandum. It is identical in concept to the MAR system the City currently employs. Surface water would be diverted from the Big Sioux River to an existing diversion ditch and wells designed to induce surface water infiltration would be installed along the ditch (see New Well Siting Plan Technical Memorandum).

ES-2.2 Maximizing Extraction through Existing Water Rights

It is recommended that the City focus future groundwater development in the near term (10 Years) in the North Well Field. This can be done by applying for water permits from Future Use Permits #5523-3 and #448-3. The total volume of groundwater remaining in these two future use permits is 7,892 acre-feet per year (ac-ft/yr), which is equivalent to an average annual daily withdrawal of 7.05 million gallons per day (MGD). This volume of water can be extracted with approximately four new horizontal collector wells, or 10 to 15 new vertical wells (gravel packs). Additional details regarding potential well locations are provided in the Well Siting Technical Memorandum.

To utilize more of the existing surface water rights, it is recommended that the City consider the MAR system described in Section ES-2.1 above. This MAR system would likely make it possible to attribute existing surface water rights to groundwater rights. A new MAR system extracting surface water from the Big Sioux River under the

City's existing surface water rights would have the same bypass restrictions that are currently a condition of the City's existing surface water future use permits and licenses (a minimum of 20 cubic feet per second must flow past the USGS gauging station on N. Cliff Avenue). The planning period for the conceptual design of the MAR system is near-term (10 years). The planning period for permitting and beginning construction of the MAR system is 20 years.

There is 5,430 ac-ft/yr (4.85 MGD) of groundwater reserved in the Big Sioux:Southern Skunk Creek aquifer (Future Use Permit #449-3). Development of groundwater resources in the Big Sioux:Southern Skunk Creek aquifer has not previously occurred due to water quality concerns. However, it is likely that well systems designed to infiltrate surface water from Skunk Creek could be developed that would produce water of suitable water quality for treatment and municipal use.

ES 3 Well Condition Assessment

The City has 66 wells of three different types: 1) horizontal collector well (HCW), 2) vertical well with a manufactured screen enclosed in an engineered filter pack (gravel pack well), and 3) a relatively large diameter (typically 40 feet) concrete casing sunk into the aquifer with an open bottom and no well screen (Bragstad well). A well condition assessment (WCA) was conducted for the purpose of providing the City with a recommendation, based on a well's performance history, regarding which wells to recondition and which wells to abandon and replace, along with recommended reconditioning methods. Due to water quality impacts associated with PFAS at the Airport Well Field, and ongoing litigation associated with the PFAS impacts, the 21 wells in the Airport Well Field were not included in the WCA.

Information utilized in the WCA was obtained from records provided by the City along with information obtained from two South Dakota Department of Agriculture and Natural Resources (DANR) online databases (water rights and well completion reports). This information was utilized to develop well performance metrics (WPMs), provided in tables, for the following three groupings of wells and well fields: 1) the HCWs in the North Well Field, 2) the gravel pack and Bragstad wells in the North Well Field; and 3) the gravel pack wells in the MSC Well Field.

Because the amount and quality of information varies between the well fields and the well types, information compiled for the WCAs and the WPMs developed from the WCA are different for each of the three well types and well field groupings. The WPMs are included in the three different well recondition decision (WRD) matrices (provided in tables) developed for each well type and well field grouping. The intent in constructing the WRD matrices was to utilize as much information as reasonably possible thereby enabling the decision to recondition or replace a well to be based on quantifiable data.

ES-3.1 HCW Condition Assessment Results

Due to the long length of the screens extending laterally from the HCWs and the consistent submergence of the lateral screens (laterals) beneath 5 or more feet of groundwater, decreases in yield of an HCW well is largely caused by plugging by sediment (primarily sand). Consequently, reconditioning methods employed by the City for the HCW laterals are designed to remove the sediment plugging the laterals.

The City has historically employed three general methods for reconditioning a HCW lateral (Method #1, Method #2, and Method #3), all of which are designed to remove, by mechanical methods, the sediments blocking or plugging the screen openings. Method #1, the highest level of reconditioning requiring the greatest level of effort and greatest cost, consists of installing new laterals within the caisson. Method #2, the second level of reconditioning, consists of high-pressure jetting of the lateral while simultaneously pumping the heavily sediment-laden water from the caisson to waste. Method #3, the third and lowest level of reconditioning, consists of isolating a lateral and surging water in the lateral by alternately turning the HCW pump on and off, and pumping that water to waste.

Six HCWs are recommended for reconditioning; (HCW #47, HCW #36, HCW #32, HCW #46, HCW #70 and HCW #39. According to the WRD Matrix, the HCW in most need of reconditioning is HCW #47. The HCWs with the least amount of performance degradation are HCW #62 and HCW#69, which are the two “newest” HCWs. Continued performance monitoring and yearly specific capacity testing are recommended for the other seven HCWs located in the North Well Field.

ES-3.2 North WF Field Gravel Pack and Bragstad Wells Cond. Assessment Results

The WRD Matrix developed for the North Well Field gravel pack and Bragstad wells utilizes WPMs and the construction details and hydrogeology at the well site to make one of three decisions: 1) the well is suitable for reconditioning; 2) the well is not suitable for reconditioning and should be replaced; and 3) the well requires further assessment prior to deciding on reconditioning or replacing.

Information regarding the hydrology includes the saturated thickness, static water level, and the aquifer transmissivity determined from aquifer pumping tests. The well yield history includes the reported yield when the well was constructed, the average monthly yield during the period from 2016 to 2021, the average yield during the period from 1991 to 2012, and the average yield reported for the well in 1989 (HDR,1991). The specific capacity determined from performance tests conducted when the well was constructed are compared to the most recently measured specific capacity. The WCA data for each individual well are provided in a table along with average values calculated for the North Well Field gravel pack and Bragstad wells.

The WRD Matrix is designed to determine if factors from the well construction, hydrogeology, WPMs, and maintenance history suggest that the well is a suitable candidate for reconditioning. There are 12 questions in the WRD Matrix and a yes answer favors reconditioning while a no answer favors abandonment and replacement. For example, inducing movement of fluids in two directions (in and out of the well screen and filter pack) is easier in a well with a larger slot size opening compared to a well with a smaller slot size opening, therefore, the WRD Matrix favors wells with larger slot size openings for reconditioning.

Based on the WRD Matrix, it is recommended that eight wells (#43, #51, #52, #54, #55, #56, #57, and #58) be abandoned and replaced, six wells (#42, #48, #49, #50, #53, and #63) be reconditioned, and two wells (#26 and #44), due to a relative lack of data, be further assessed. The additional assessment recommended for Well #26 is a detailed evaluation of the current yield capability. Due to the nearly equal number of yes and no responses in the WRD Matrix for Well #44, it is recommended that the effectiveness of the well reconditioning of Well #42 be used as a deciding factor on whether to recondition or replace Well #44.

ES-3.3 MSC Well Field Gravel Pack Wells Condition Assessment Results

Construction details for the MSC Wells include screen diameter, screen slot size opening, and the screen depth interval. Information regarding the hydrology includes the saturated thickness and static water level (when the well was constructed). The yield history includes the yield when the well was constructed, the average monthly yield during the period from 2016 to 2021, and the average yield during the period from 1991 to 2012. The WCA data for each individual well are provided in a table along with average values calculated for MSC Well Field gravel pack wells. The maintenance history of the Middle Skunk Creek gravel pack wells varies somewhat among the individual wells. In general, the wells were treated with acid in 2009, 2015 and 2020, were shock-chlorinated in 2003, 2004 and 2005, and were hydro-blasted (jetted with high-pressure air and water) in 2015 and 2019. Where the data allow, the improvement in well yield after treatment is a WPM included in the WRD Matrix.

The WRD Matrix is designed to determine if factors from the well construction, hydrogeology, WPMs, and maintenance history suggest that the well is a suitable candidate for reconditioning. There are 11 questions in the WRD Matrix and a “yes” answer favors reconditioning while a “no” answer favors abandonment and replacement.

Based on the WRD Matrix, it is recommended that six wells be abandoned and replaced (#102, #104, #105, #107, #111, and #114), five wells be reconditioned (#101, #106, #109, #110, and #112), and two wells (#103 and #113) be further assessed. The recommended protocol for reconditioning the MSC Well Field gravel pack wells is the same as that recommended for the North Well Field gravel pack wells.

ES 4 New Well Siting Plan

The new well siting plan describes the locations of 22 new wells (three gravel pack wells and 19 horizontal collector wells) proposed for the City’s North Well Field of the Big Sioux:Sioux Falls aquifer. The well locations are shown in Figures ES-1 (southern portion of North Well Field) and Figure ES-2 (northern portion of North Well Field).

Due to water quality impacts associated with PFAS at the Airport Well Field, no new wells are planned for the Airport Well Field. The City’s existing water rights support the construction of additional wells in the City’s MSC Well Field. However, it is recommended that reconditioning and replacement of existing wells in the MSC Well Field be conducted prior to siting new wells in the MSC Well Field. The City also holds water rights in the Big Sioux:Southern Skunk Creek aquifer. However, due to water quality concerns associated with past land uses and petroleum hydrocarbon releases, and it is recommended that a water quality evaluation be completed prior to constructing new wells in the Big Sioux:Southern Skunk Creek aquifer. For these reasons, the new well siting plan is focused solely on new wells to be constructed solely in the North Well Field.

The following four criteria were considered in selecting locations for the 22 new wells: 1) saturated thickness; 2) preference for land already owned by the City; 3) proximity to existing well water main transmission infrastructure; and 4) water rights availability. Other criteria included the proximity of other (non-City) water rights, the potential for well interference with existing City wells, the proximity to recharge-supplying surface water (primarily the Big Sioux River, but also including creeks and the diversion ditches), and draft locations selected by the United States Geological Survey (Cinotto, 2020).

The new well siting plan is designed to bring to beneficial use the 3,842 ac-ft/yr (3.43 MGD) remaining in Future Use Permit #448-3 and the 4,050 ac-ft/yr (3.62 MGD) remaining in Future Use Permit #5523-3. It is also assumed that the City’s existing water rights in the Airport Well Field (26,668.4 ac-ft/yr/23.81 MGD) will be successfully transferred to the new well locations within the North Well Field. This equates to a total water rights potential of the wells included in the new well siting plan of 34,560.4 ac-ft/yr, which is equivalent to an annual average daily withdrawal rate of approximately 29 MGD. It is important to recognize that given the number of variables associated with the new well siting plan (land-owner considerations, site-specific geology, the success, and timing of requested water right amendments) the specifics regarding well locations and total groundwater withdrawals possible from the proposed new wells will change. Consequently, the new well siting plan should be considered a road map for guiding future investment in wellfield infrastructure.

ES 5 Numerical Groundwater Modeling of Drought Impacts

A numerical groundwater model (Drought Model) of the Big Sioux aquifer was constructed to evaluate the effects that drought conditions will have on City groundwater withdrawals. The Drought Model was constructed from a numerical groundwater model previously developed for the City by the United States Geological Survey (hereafter referred to as the USGS 2019 Model), with revisions to recharge, river flow, and City well locations and groundwater withdrawals. The USGS 2019 Model (and the Drought Model) include that portion of the Big Sioux aquifer that extends from near Covell Lake in Sioux Falls to Dell Rapids, SD (Big Sioux:Sioux Falls aquifer). The Drought Model simulates well field withdrawals during four climate conditions 1) Normal, 2) Average Dry, 3) Drought, and 4) Extended Drought.

ES-5.1 Model Construction Summary

Historic precipitation data as measured at the Sioux Falls Regional Airport from 1950 to 2020 and the USGS 2019 Model recharge rates were evaluated utilizing a “binning” methodology (Jenks natural breaks) to define the recharge rate and corresponding approximate annual precipitation for each of the four climate conditions. Big Sioux River flow in the Drought Model is based on data from the USGS gauging station #648100 near Dell Rapids and assumptions regarding periods of low river flow typical in the Fall months. These low flows assumed for September, October and November were utilized to scale the river flows accordingly for the other 9 months of the year. The underlying assumptions for the Drought Model recharge are summarized in the following table. The groundwater recharge from precipitation and from the Big Sioux River was scaled to simulate seasonal variations.

Climate Condition	**Drought Model Recharge**	**Approximate Corresponding Precipitation**	**Mean Monthly Big Sioux River Flow in Fall Months (Sep/Oct/Nov)**
	(inches per year)	**(inches per year)**	**(cfs)**
Normal	4.04	26.75	240
Average Dry	2.61	22.27	50
Drought	1.83	16.87	20
Extended Drought	0.12	1.10	0

Each climate condition is simulated over a 7-year period. The Normal climate condition was modeled by simulating the Normal climate conditions over a period of 7 years. The Average Dry condition was modeled by simulating three years of Normal conditions (normal recharge) followed by four years of Average dry conditions. The Drought condition was modeled by simulating three years of Normal conditions followed by four years of Drought conditions. The Extended Drought condition was modeled by simulating three years of Normal conditions, followed by one year of Drought conditions, then three years of Extended Drought conditions.

The simulated City groundwater withdrawals are from the 31 existing wells in the North Well Field at two different pumping rates: 1) the City's approximate average annual withdrawals during the period from 2016 to 2021, and 2) 50% of the 2016-2021 average annual withdrawals. These two withdrawal rates are hereafter referred to as the average annual withdrawal rate and 50% of average annual withdrawal rate.

Simulations were also conducted at a withdrawal rate equal to the City's total water rights from the Big Sioux:Sioux Falls aquifer. The total water rights withdrawals simulations included pumping from the 31 existing wells in the North Well Field plus the 22 new wells included in the new well siting plan. The total water rights withdrawal simulations were conducted with the assumption that all the Airport Well Field water rights were transferred to the North Well Field.

ES-5.2 Model Results

The Drought Model was used to simulate twelve different climate and withdrawal scenarios. Simulations for each of the four climate conditions (Normal, Average Dry, Drought, and Extended Drought) were conducted at the three different withdrawal rates.

The four Drought Model climate conditions do not simulate any "wet" or "very wet" water years that, based on the binning analysis, occur fairly regularly in the Sioux Falls area (ten times between 2000 and 2020). The Drought Model is focused on continuous years of average or below average recharge. Consequently, the model-calculated withdrawals for the average annual withdrawals could potentially be slightly below the actual well field withdrawals over the period from 2016 to 2021.

The Drought Model automatically reduces the withdrawal rate of wells throughout the model area as the groundwater elevation approaches the bottom of a model cell (simulated aquifer bottom) during simulated pumping. This "automatic flow reduction" reduces the flow rate to maintain the groundwater elevation at a well above a minimum level and was utilized to estimate the maximum theoretical withdrawals possible from the North well field for a given climate or pumping condition.

The results of the 12 different simulations are provided in four graphs (Figures ES-3 through ES-6, Drought Model Technical Memorandum), with the y-axis representing groundwater withdrawals from the North Well Field in MGD and the x-axis representing time (in years) over the 7-year simulation period. Dashed lines in the graphs represent the input "requested" withdrawal rates (in MGD) and the solid lines in the graphs represent the model-calculated withdrawal rates.

ES-5.3 Model Results – Summary and Conclusions

The close match of the model-calculated withdrawals at the rate of the City's average annual withdrawals under Normal conditions to the actual withdrawals suggests that the model reasonably represents the Big Sioux: Sioux Falls aquifer. The Drought Model results agree reasonably well with previous modeling efforts. For example, the USGS 1982 Model (Koch, 1982) indicated the City could likely pump 28.8 MGD from the Big Sioux: Sioux Falls aquifer under equilibrium conditions, which agrees reasonably well with the model-calculated total water rights withdrawals of approximately 35 MGD on an average annual basis under the Normal climate condition. The HDR 1990 Model (HDR, 1990) calculated average monthly City withdrawals from the extended well field of 9.2 MGD at the end of 2 years of no recharge, which agrees reasonably well with the Drought Model-calculated withdrawals of 10 MGD by Year 7 of the Extended Drought climate condition (Figure 10).

Assuming continued operation (with the required maintenance) of the City's 31 existing wells with the addition of the 22 new wells, the estimated maximum withdrawals from the North well field vary from a short-term maximum of 50 MGD under Normal conditions to a long-term maximum of 10 MGD under Extended Drought conditions. Groundwater withdrawals at rates greater than those simulated by the Drought Model will be possible under wet or very wet conditions.

ES 6 Transmission Main

The Water Transmission Mains technical memorandum is prepared for the City of Sioux Falls WPP as part of the overall Water Distribution System Master Plan. This tech memo evaluated and addressed the existing well field transmission main and well lateral main infrastructure, along with addressing the proposed expansion of the Big Sioux aquifer well field infrastructure needs for 10-, 20-, 50-, and 100-year planning periods.

The transmission main technical memorandum provides a summary of an evaluation completed on the hydraulic capacities of the existing well field transmission mains and the proposed improvements based on the withdrawal rates of the existing and proposed wells. Historical withdrawal rates for each of the existing wells was gathered and analyzed to determine each well's average historical withdrawal rate. This average historical withdrawal rate was utilized along with the transmission main size and physical properties within a computerized hydraulic modeling software program to determine the hydraulic capacity and headloss of each segment of transmission main. Proposed improvements are recommended based on the transmission main age, material type, hydraulic capacity, and headloss based on the well field production capacity during each planning period.

It is assumed that the existing airport wells will not be recommissioned due to the contamination of PFAS. The airport well's permitted withdrawal rates are planned to be reallocated to the proposed new wells. The proposed wells are a mix of horizontal collector wells and vertical gravel pack wells. Both well types are currently utilized by the City with good success. The horizontal collector wells have the largest withdrawal rates and have the highest efficiency (gallons pumped per kilowatts of electricity used) of the two well types. The majority of the proposed wells are horizontal collector wells. The proposed 10-year well field improvements focused on improving the hydraulic capacity and reducing headloss in the larger transmission mains located closer to the WPP along with increasing the well field production with installing new wells in the southern portion of the well field where wells are near existing infrastructure. The 20-year proposed improvements focused on continued improvement of transmission main hydraulic capacity but with transmission mains further away from the WPP and with expanding the well field further north into the Big Sioux aquifer. The 50- and 100-year proposed improvements focus on the continued buildout of the well field in the northern portion of the Big Sioux aquifer along with replacement of extensively aged transmission mains. **Table ES-2** lists the prioritized recommended improvements in the four planning periods. The opinion of costs associated with the 10-year planning period improvements is detailed in **Table ES-3**.

ES 7 WPP Condition Assessment

The WPP Condition Assessment evaluates the age and condition of the Sioux Falls Water Purification Plant, including process equipment, piping, structures, electrical systems, instrumentation & control, and building facilities. The Condition Assessment considered the following:

- **Age & Condition:** The age of major process areas, structures, and equipment is summarized based on review of past plans and discussion with operations staff.
- **Reliability and Redundancy:** The condition assessment evaluates the consequence of failure for major process areas, and seeks to identify plant vulnerabilities if components of the plant fail.
- **Safety:** Safety of WPP operation & maintenance of the process areas were evaluated as part of the assessment. WPP staff maintain safety training and certifications where required for materials handling.
- **Maintaining Plant Capacity for Future Expansion:** The key focus of this condition assessment is evaluating the condition of existing facilities for the current plant capacity. However, as Sioux Falls grows, future water demand will require additional treatment capacity. If the WPP continues to operate, life cycle replacement of equipment will be required to maintain WPP operations and prepare for possible expansion.

Multiple site visits were conducted with City staff to evaluate the age, condition, and serviceability of each unit process throughout the WPP facility and the Big Sioux River Pump Station. The design team met with City operations, laboratory, maintenance, electrical, and instrumentation & controls staff to gain an understanding of daily operations of the WPP. Plant staff shared valuable first-hand input on the asset evaluation, including equipment age, ongoing maintenance concerns, and planned upgrades. The design team reviewed past plans to determine the date of installation of the WPP facilities.

After touring the WPP facilities, evaluating the age & condition, and speaking with operations staff, the design team determined recommended improvements that are needed at the facility to maintain current operations, and what options exist for expansion of the facility. Recommended improvements are summarized in the appendices of the Condition Assessment technical memorandum. The appendices describe the proposed improvement, project priority, and estimated project cost.

A summary of these recommendations is grouped by process area in tableES-4. Many process areas have critical-priority improvements that are needed to maintain current plant capacity. Further explanation of recommendations for each process area, the concerns identified, and recommended improvements are tabulated in a summary table included in Appendix A of the Condition Assessment.

Most recommendations in the Condition Assessment are within the 0 – 10-year timeframe. Determination of the timeline is as follows:

- 0 – 10 years: critical projects for equipment that is near failure, or life-cycle replacement of equipment beyond its useful life.
- 10 – 20 years: lower priority projects, or projects with a focus on future capacity increase.

To further rank the projects, a priority was assigned to the recommendations. While many of these recommendations are necessary for the operation and resiliency of the plant, **critical** priority projects include recommendations for processes or equipment that are near failure or where failure would significantly impact plant capacity or redundancy. The priorities are as follows:

- Critical: systems that have failed, are near failure, or where failure would have significant impact to plant capacity.
- Urgent: Life-cycle replacement of equipment beyond its useful life.
- Required: Required improvements to improve resiliency and update to current standards.
- Ad Hoc: Recommended improvements not necessary for plant capacity or functionality
- Maintenance / Monitoring: Ongoing monitoring or further study.

Recommendations in the summary tables follow the section numbering in the following report. Some of the recommended improvements are currently being planned by WPP staff as upcoming projects. These projects were included in the recommendations to capture current and planned projects in the Master Plan documents.

Overall the WPP staff continue to operate and maintain a well-appointed facility producing high-quality water. However, many process areas contain equipment that is beyond its useful life. For example, much of the mechanical equipment in the solids contact basins is original to the facility, and is over 50 years old. As water demand increases to serve a growing Sioux Falls, life cycle replacement of WPP equipment will be needed to provide sufficient capacity and maintain redundancy. The process areas with the costliest recommended improvements are the Solids Contact Basins, Filters, High Service Pumps, Building Roofs, and Power Distribution Systems. The recommended improvements from the condition assessment are provided in Table ES-4.

ES 8 WPP Treatment Evaluation

While there are several forthcoming and potential drinking water regulatory changes, there are a select few which are very pertinent to the City because of their potential to significantly impact future water treatment strategies. These future drinking water regulatory changes include:

- Lead and Copper Rule Revisions (LCRR)
- Per- and Polyfluroroalkyl Substances (PFAS)
- Unregulated Disinfection Byproducts (DBPs)
- Nitrosamines

A summary of the specific impacts that the LCRR will have on the City as they relate to the six focus areas of the new rule are presented below.

Lead and Copper Rule Revisions (LCRR)

<u>Relevance to the City</u>

- Lead Service Line Inventory (LSL): The City must develop an LSL inventory by October 16, 2024. If LSLs are identified, the inventory will need to be publicly available on a web-based platform and regularly updated.
- LSL Replacement (LSLR) Plan: An LSLR plan for LSLs, lead status unknown, and galvanized requiring replacement service lines will need to be finalized by October 16, 2024.
- Lead Trigger Level and Action Level: Historically the City has not had 90th percentile lead concentrations higher than 10 µg/L. If this does occur in the future, the City will have to re-optimize CCT and implement an LSLR program (goal based approach for trigger level exceedance, mandatory 3% annual replacement for action level exceedance). If new water sources are incorporated into the existing water system, a CCT study will likely be required.

- Sampling Requirements: Historically, the City has occasionally had individual lead sampling results above 15 µg/L. If a lead concentration above 15 ug/L is recorded after 2024, the City will have to follow "find-and-fix" protocol. The City will need to revisit its LCR compliance sampling pool and make changes as needed to comply with the revised tiering structure. The City will need to sample 20% of elementary schools and licensed childcare facilities within the service area annually, and all facilities over a five year period.
- Public Education: The City has identified four City-owned LSLs and nine unknown service lines as part of its initial LSL inventory. Customers served by these lines will need to be informed in accordance with USEPA and state guidance. Galvanized lines on both the public and private side, if discovered, will also trigger notification requirements unless information identified that confirms the pipes were never downstream of and LSL. City Consumer Confidence Reports must include the USEPA's required language on health impacts and include info on LSLR programs (if applicable).

Future, projected growth demands through 2045 will require the full rated capacity of the SFWPP. Hydraulic and treatment limitations must be considered when evaluating the capacity of a water treatment plant. Hydraulic modeling of the WPP demonstrated that the facility has a hydraulic capacity of approximately 55 MGD. The two major hydraulic bottlenecks are the over/under baffles in the recarbonation basin and the filter effluent piping from Filter Nos. 6-15. Demolition of the recarbonation basin baffles and installation of a 64-inch pipe from the combined filter effluent of Filter Nos. 6-10 to the Clearwell is recommended for a WPP hydraulic capacity of 75 mgd.

In addition to the overall facility hydraulic capacity, each treatment process was evaluated to determine improvements required to meet a 75 MGD treatment capacity. Several non-construction projects were identified to optimize WPP treatment operations and serve as the basis for preliminary design in support of future capital improvements projects:

- CFD Modeling of the Clearwell
- Corrosion Control Study
- Future Filter Pilot Study
- Existing Filter Media Configuration/Biofiltration Study
- Filter Wash Optimization
- Actiflo Chemical Optimization / Jar Testing Evaluation
- Pre-Oxidant Study
- Nitrosamine Formation Potential Study
- Future Water Purification Plant Siting Study

The following capital improvement projects are recommended for implementation over the next 10-25 years to ensure the WPP can reliably treat 75 MGD to meet demand from projected growth.

- Actiflo®
    - Construct parallel Actiflo® Treatment train(s) and sludge thickening basins (for additional surface water treatment capacity).
- Softening / Recarbonation
    - Replace the existing bubble diffuser carbon dioxide system with a side stream injection.
    - Demolish/modify over/under baffles in the recarbonation basins to alleviate hydraulic bottlenecks.
    - Refurbish solids contact basins.

    - Construct 2-3 new solids contact basins (may require site expansion and removal of the power plant).
- Filtration
    - Modify filter effluent piping to reduce headloss (addition of a 64-inch line directly from the north filters to the clearwell and removal of the static mixer and orifice pipe within the clearwell).
    - Increase media depth (pending the results of the pilot study).
    - Convert to biofiltration (pending the results of the pilot study).
    - Add a redundant air scour blower.
    - Filter backwash process optimization (add simultaneous air/water wash step).
- Disinfection
    - Add baffling to clearwell to increase baffle factor to at least 0.5 (pending results of CFD study).
    - Implement UV disinfection (only if the City's *Cryptosporidium* bin classification changes or if the clearwell is to be used for future treatment processes (beyond 75 MGD)).
- Solids Handling
    - Install a parallel sludge line to the lagoons to increase solids handling capacity.
    - Construct 2-3 additional sludge lagoons or implement mechanical dewatering to handle future solids production rates.
- Chemical Storage and Feed
    - Implement an alternative pre-oxidant (pending the results of the pre-oxidation study).
    - Place the potassium permanganate silo on load cells.
    - Replace existing diaphragm metering pumps with peristaltic pumps.
    - Utilize existing bulk chemical storage tanks to reduce operator handling of chemicals.
    - Modify the hydrofluorosilicic acid room to allow replacement of the bulk tank.

Figure ES-7 shows the proposed site layout with all of the recommended improvement projects implemented.

In lieu of process expansion at the WPP, the City could construct a second WPP on the west side of Sioux Falls; if a second WPP were constructed, several of the process expansion projects could be deferred beyond the 30 year planning horizon.

ES 9 Future Growth and Peak Demand Solutions

As part of the overall Water Distribution System Master Plan, evaluations were conducted to determine the overall water system’s peak day demand and the corresponding projected water supply capacity for the 10-, 20-, 50- and 100-year planning periods of 2035, 2045, 2066, and 2116, respectfully. Tables ES-5 And ES-6 illustrate how the various water sources available to the City could be engaged to attempt to meet the peak day demands for the different planning periods. Additionally, the estimated capacity available is adjusted downward as the assumed climatic conditions move from normal precipitation to extended drought conditions.

The estimated capacity for the Lewis & Clark Rural Water System (LCRWS) is based on the City’s water supply agreement with LCRWS and the anticipated increased water supply from the LCRWS Phase II improvements.

The deficit in water supply capacity for each planning period is indicated in the Required Future Water Source rows. The deficit indicates the City will not have a sufficient source water supply to meet the projected City peak day water demand. Table ES-5 shows the peak day water demand with no water restrictions implemented and should be considered as a worse-case scenario. In actuality, the City would likely implement water restrictions which would significantly decrease the peak day water demand. Table ES-6 displays the peak day water demand where the City's most stringent water restrictions are implemented. Table ES-6 illustrates the best-case scenario, which shows that nearly all of the planning periods would be capable of providing enough water during all four climatic conditions with the exception of the 100-year planning period at the extended drought condition. In reality, the City's peak day water demand will most likely fall in between the values provided in Tables ES-5 And ES-6.

The additional required future water source could come from a few different areas as summarized below:

- Missouri River Surface Water Rights
- Expansion of LCRWS
- Aquifers south of Sioux Falls
- Regional Water System

The City currently has a future use permit which would allow approximately 25.2 MGD continuous withdrawal from the Missouri River. This permit could serve as a starting point in developing an extension of the City's water system to bring this high quality water source to the City of Sioux Falls. Multiple options exist on how this could be done: 1) raw water could be pumped to Sioux Falls for treatment; 2) could be treated at a new plant adjacent to the Missouri River and treated water could be pumped to the City. Additionally, other regional partners could be added to share in the cost of the new infrastructure and ongoing operation and maintenance needed for a new source water system. It is recommended the City conduct a Feasibility Study to evaluate the pros, cons, and estimated planning level costs for this new system. The following is a list of suggested topics to evaluate in the Feasibility Study:

- Identify potential sites for new intake and pumping and/or treatment facilities
- Feasibility of obtaining additional surface water rights above the current 25 MGD
- Identify potential piping routes and associated pros and cons of each route
- Identify potential regional partners
- Identify potential funding options

Currently the City has agreements in place with LCRWS to deliver approximately 17 MGD of treated water to the City's system. There are also plans to increase this amount to 28 MGD in approximately 2025 and to 34 MGD by approximately 2030. As shown in Tables ES-5 and ES-6, these planned LCRWS allocations are already included and critical for Sioux Falls to meet future demands. Even with these planned allocations, additional water source quantities are needed to meet long-range growth. The LCRWS has begun conceptual planning to expand their system beyond what is currently allocated. This planning effort has been referred to as LCRWS II. The City of Sioux Falls should explore the feasibility of being involved in LCRWS II so it can effectively compare this option with other source water options being considered.

The City currently has approximately 4.85 MGD of water rights available in aquifers located south of the City. This water right is located within the Sioux Falls management unit of the Southern Skunk Creek Aquifer (Big Sioux:Southern Skunk Creek Aquifer). There are no City wells currently pumping water from this aquifer. As part of the Master Plan, a requested task was to provide a brief summary of other possible aquifers available as a water source in the area south of the City. Data regarding twelve of the major aquifers located in Minnehaha and Lincoln

County are summarized in Table ES-7. Three of the twelve aquifers are bedrock aquifers (Sioux Quartzite, Dakota, and Split Rock Creek aquifers), and the remaining nine are glacial or glacial/fluvial aquifers.

It is beyond the scope of the Master Plan to provide detailed conclusions or recommendations regarding which aquifer or aquifers to consider developing as a raw water source. None of the twelve can provide the volume of water needed to make up the shortfall in raw water source supply that is projected with the continued rapid population growth of the City. The aquifers that appear most suitable for augmenting the City's source supply are the Parker-Centerville aquifer and the Big Sioux:South Aquifer.

The final future water source option that was considered at a cursory level was the concept of a regional water system. Under this scenario the City would pool resources and facilities with other regional partners to develop a single administrative structure that would deliver treated water to the members of the newly formed regional water system. The advantage of a regional system is the costs for planning, design, construction, and operation and maintenance are split between the members. Regional systems can also improve efficiency of management by having a larger pool of resources to draw from. Additional funding may also be available to a larger group of users since a larger population will receive benefit. The challenge of regionalization and the primary reason they fail to occur is all parties need to be motivated to make a change at relatively the same time and be willing and able to invest into the new system from the onset.

This concept would likely focus on utilizing a groundwater source located as close to the City as feasible and offer a contrasting option to the Missouri River Feasibility Study. The following is a list of suggested topics to evaluate in the Regional Water Feasibility Study:

- Review options for pooling of water rights and where additional water rights are available
- Review how water from the regional water system would be delivered to the City and how it would enter the distribution system
- Identify potential regional partners likely within a 30 to 60 mile radius
- Identify new infrastructure needs
- Establish water quality goals
- Outline cost sharing concepts among the users of the system
- Outline how the new system would be governed, managed, and maintained

ES 10 Capital Improvement Recommendations

Table ES-8 shown below, summarizes the total recommended 10-year improvements for the water supply and Treatment System. This work primarily consists of adding new wells and transmission main piping to the City's well field and life cycle improvements to maintain capacity at the existing water purification plant. Due to capacity available via LCRWS, major WPP capacity upgrades can be delayed to near the end of the 20-year planning period. However, improvements are recommended at the existing plant to help ensure the existing equipment and structures are in reliable condition for both current and long-term operation.

Figures

FIGURE ES-7: SFWPP SITE PLAN WITH ALL RECOMMENDED IMPROVEMENTS IMPLEMENTED

Tables

Table ES-1. Total City Water Rights for Municipal Use

Water Source (Municipal Use Only)	Water Rights (Municipal Use Only)					Water Rights Comment
	No. of DPs	Maximum Diversion Rate		Annual Volume Limit		
	(Well or Intake)	(cfs)	(MGD)	(acre-feet/year)	MGD*	
BSA:Sioux Falls (Airport WF)	21	37.73	24.38	26,668.40	23.81	Includes 2/3 of diversion authority of WR #5710-3
BSA:Sioux Falls (North WF)	32	72.57	46.90	43,359.23	38.72	Includes 1/3 of WR #5710-3, includes DC-2
BSA:Middle Skunk Creek	13	14.92	9.64	4,883	4.36	
Subtotal Groundwater	66	125.22	80.93	74,911	66.90	Three existing well fields
Big Sioux River Surface Water	1	69.60	44.98	20,000	17.86	Big Sioux River Pumping Station (3 pumps)
Big Sioux River Surface Water WP#1	1	15.56	10.06	6,360	5.68	Wetland Pump #1 MAR System
Subtotal Surface Water	**2**	**85.16**	**55.04**	**26,360**	**23.54**	**Does not include Future Use Permits**
Big Sioux River (Surface Water)	NA	NA	NA	30,000	26.79	Future Use Permits #3981-3 & #3981A-3
Missouri River (Surface Water)				28,236	25.21	Future Use Permit #2042-3
Big Sioux Aquifer:Sioux Falls	NA	NA	NA	7,892	7.05	Future Use Permits #448-3 and #5523-3
Big Sioux Aquifer:Middle Skunk Creek	NA	NA	NA	183	0.16	Future Use Permit #5522-3
Big Sioux Aquifer:Southern Skunk Creek	NA	NA	NA	5,430	4.85	Future Use Permit #5523-3
Total Future Use Permit Reservations				**71,741**	**64.05**	
Total Groundwater Water - Municipal Use (Permits, Licenses & Future Use Permits)				88,416	78.95	
Total Surface Water - Municipal Use (Licenses & Future Use Permits)				84,596	75.53	Includes Missouri River Water Rights and MAR System
Total Water Rights for Municipal Use				**173,012**	**154.48**	Does not include Lewis & Clark RWS Connection

NOTES:

WP#1 - wetlant pump #1
WF - well field
MGD - million gallons per day
cfs - cubic feet per second
* - assumes continuous pumping
DP - diversion point

BSA - Big Sioux Aquifer
WR# - Water Right number
NA - not applicable
MAR - managed aquifer recharge
RWS - Regional Water System

TABLE ES-2: TRANSMISSION AND LATERAL MAIN IMPROVEMENT PRIORITIZATION

Improvement Description	Prioritization	Planning Period
New CW 25 with Main Install & Abandonment of Existing Well 25 Main	1	10 Year
Proposed Collector Well 5 with Main Install	2	10 Year
Replace the 5-Pack Gravel Pack Wells & Upsize Main	3	10 Year
Proposed Gravel Pack Wells 1, 2, and 3 with Upsized Main	4	10 Year
Upsize 24-, 36-, and 42-Inch Trans. Main from WPP to North of 258th Street	5	10 Year
Replace the 6-pack Gravel Pack Wells & Main Rehabilitation/Cleaning	6	10 Year
Proposed Collector Well 18 with Upsized Main	7	10 Year
Install Parallel 36-Inch Transmission Main from 257th Street to 255th Street	8	10 Year
Install Cathodic Protection on Existing Ductile Iron Pipe	9	10 Year
Install 24-, 30-, and 36-Inch Transmission Main from 2/3 Mile North of 255th Street to 252nd Street & Proposed Collector Well 16 with Main Install	10	20 Year
Proposed Collector Well 3 with Upsized Main	11	20 Year
Replace Collector Well 26 with Upsized Main	12	20 Year
Install 14-, 18-, 20-, and 24-Inch Trans. Main from 252nd Street to 249th Street	13	20 Year
Proposed Collector Well 14 with Main Install	14	20 Year
Proposed Collector Well 13 with Main Install	15	20 Year
Upsize 36-Inch Transmission Main North of Well 52 to 257th Street	16	20 Year
Upsize Main for Collector Well 69	17	20 Year
Proposed Collector Well 10 with Main Install	18	50 Year
Proposed Collector Well 7 with Main Install	19	50 Year
Proposed Collector Well 17 with Main Install	20	50 Year
Upsize 20-, 24-, 36-, and 42-Inch Trans. Main from WPP North to 84th Street	21	50 Year
Proposed Collector Well 9 with Main Install	22	50 Year
Proposed Collector Well 2 with Main Install	23	50 Year
Proposed Collector Well 1 with Main Install	24	50 Year
Upsize Mains South of Well 26 & on 257th Street	25	100 Year
Upsize 8-Inch Transmission Main South of Well 113 Near 250th Street	26	100 Year
Replace Wells 102, 104, 105, 107, 111, and 114	27	100 Year
Install Dual 36-Inch Trans. Main from 255th St. to 2/3 Mile North of 255th St.	28	100 Year
Proposed Collector Well 4 with Main Install	29	100 Year
Proposed Collector Well 8 with Main Install	30	100 Year
Proposed Collector Well 6 with Main Install	31	100 Year
Upsize 36-inch and Replace 42-Inch Trans.Main from WPP N. to Benson Rd	32	100 Year
Proposed Collector Well 12 with Main Install	33	100 Year
Proposed Collector Well 11 with Main Install	34	100 Year
Proposed Collector Well 15 with Main Install	35	100 Year
Replace and Install Dual the 24-Inch Main from Ditch Rd to 100 Series Wells[2]	36	100 Year

Notes: 1. Well main upsizing could be coupled with adjacent transmission main improvements.

2. The dual 24-inch main is not needed for hydraulics; however, it will provide additional redundancy to supply from the 100 Series Wells. The City has noted that this dual main maybe considered when the existing 24-inch main has come to the end of its useful life and will be replaced.

TABLE ES-3: 10-YEAR PLANNING PERIOD TRANSMISSION AND LATERAL MAIN IMPROVEMENT COSTS IN 2022 DOLLARS

Improvement Description	Improvement Costs[3]	Planning Period
New CW 25 with Main Install & Abandonment of Existing Well 25 Main	$7,900,000[1]	10 Year
Proposed Collector Well 5 with Main Install	$6,400,000	10 Year
Replace the 5-Pack Gravel Pack Wells & Upsize Main	$5,020,000	10 Year
Proposed Gravel Pack Wells 1, 2, and 3 with Upsized Main	$3,060,000	10 Year
Upsize 24-, 36-, and 42-Inch Trans. Main from WPP to North of 258th Street	$51,620,000[2]	10 Year
Replace the 6-pack Gravel Pack Wells & Main Rehabilitation/Cleaning	$5,700,000	10 Year
Proposed Collector Well 18 with Main Install	$8,130,000	10 Year
Install Parallel 36-Inch Trans.Main from 257th St to 255th St	$12,770,000[2]	10 Year
Install Cathodic Protection on Existing Ductile Iron Pipe	$340,000	10 Year

Notes: 1. Improvement costs are from the Water Supply and Distribution System Facility Plan, Transmission Redundancy Improvements and Well 25 Improvements, dated July 15, 2022. The cost opinion was prepared by HDR with the well design.

2. Improvement costs are from the HDR transmission improvements tech memo and are represented in 2022 dollars. The cost opinion was prepared by HDR with the transmission improvements tech memo.

3. Improvement costs include a 30% contingency which is an industry standard for a high level (broad) cost estimate. Actual project costs will vary upon market and bidding environment.

4. Refer to Appendix B for a breakdown of the opinion of costs for the recommended improvements.

TABLE ES-4: RECOMMENDED IMPROVEMENTS – CONDITION ASSESSMENT

Improvement Description	Improvement Costs	Planning Period
Actiflo: Replace (6) sand pumps; Replace (2) influent flow meters.	$317,800	10 Year
Solids Contact Basins: Replace clarifier equipment, sludge lines in Basins 2 & 3; update basin instruments/controls; influent flow meters.	$6,043,000	10 Year
Recarbonation Basins: Replace CO2 feeders.	$1,814,000	10 Year
Filters: Flow meters; Filter valves; Filter instrument upgrades; Redundant backwash blower; Backwash pump VFDs.	$4,123,700	10 Year
Backwash Reclaim Basin: Replace sludge scrapers and add additional.	$1,434,000	10 Year
Clearwell: Replace valves between clearwell & N. reservoir transfer pumps	$147,000	10 Year
High Service Pumps: Replace pumps 7, 8, 9; Install additional VFDs; Replace HVAC equipment; Replace slide gates in HS pump wet well.	$4,478,000	10 Year
Transfer Pumps: Install 480V motors & VFDs on transfer pumps.	$727,500	10 Year
North Reservoir: Re-paint North Reservoir (Big Blue).	$1,661,000	10 Year
Chemical Storage / Feed Systems: Add second service water line; Life cycle replacement of chemical feed systems & day tank scales; Replace Chemical Feed Building HVAC.	$736,400	10 Year
Lime System: Replace slakers 5 & 6; Replace slaker room HVAC; Replace control panel on lime transfer system.	$1,444,600	10 Year
Transmission Main Tunnel: Repair tunnel ceiling per inspection report.		10 Year
Administrative & Personnel Facilities: Repair offices with water damage; Thermal mixing valves at safety showers.	$25,000	10 Year
Laboratory: Replace lab cabinets, lab flooring; Replace laboratory surge protection & install UPS on analytical equipment.	$202,900	10 Year
Building Facilities: Replace roof - basin area; Replace North & South boilers.	$4,253,000	10 Year
Big Sioux River Pump Station: Replace pump discharge check valves; Automate bridge crane with motors & controls; Replace level, pressure & flow instruments; Update screen control system; Automate chemical feed system.	$525,800	10 Year
WPP Power Distribution: Replacement standby generator; Replace switchgear in Power Rooms 1 & 2. Replace MCCs in Power Rooms 3 & 4.	$6,350,600	10 Year
Big Sioux River Pump Station Power Distribution: Replace station MCC; Replace main breaker; Replace generator controller; Replace fire alarm communications.	$703,400	10 Year
Technology: Replace public address system; Replace fiber and complete fiber loop.	$871,700	10 Year

TABLE ES-5: PROJECTED WATER SOURCES FOR PLANNING PERIODS WITH NO WATER RESTRICTIONS

		Peak Day Capacity Req'd, MGD[1, 2]	Estimated Capacity Available			
			Normal Conditions, MGD	Average Dry Conditions, MGD	Drought Conditions, MGD	Extended Drought Conditions, MGD
10-Year Planning Period	Wellfield	71.6	22.0	19.0	17.0	11.0
	BS River Pump Station		23.0	23.0	0.0	0.0
	Lewis & Clark RWS		34.0	34.0	34.0	34.0
	Req Future Water Source		N/A	N/A	20.6	26.6
	Total		79.0	76.6	71.6	71.6
20-Year Planning Period	Wellfield	83.8	29.0	24.0	22.0	11.0
	BS River Pump Station		23.0	23.0	0.0	0.0
	Lewis & Clark RWS		34.0	34.0	34.0	34.0
	Req Future Water Source		N/A	2.8	27.8	38.8
	Total		86.0	83.8	83.8	83.8
50-Year Planning Period	Wellfield	90.7	31.0	26.0	23.0	12.0
	BS River Pump Station		23.0	23.0	0.0	0.0
	Lewis & Clark RWS		34.0	34.0	34.0	34.0
	Req Future Water Source		2.7	7.7	33.7	44.7
	Total		95.0	90.7	90.7	90.7
100-Year Planning Period	Wellfield	128.1	34.0	28.0	24.0	12.0
	BS River Pump Station		23.0	23.0	0.0	0.0
	Lewis & Clark RWS		34.0	34.0	34.0	34.0
	Req Future Water Source		37.1	43.1	70.1	82.1
	Total		128.1	128.1	128.1	128.1

Notes: 1. Peak day capacity required assumes no watering restrictions are implemented and the per capita demand is approximately 270 gpcd.

2. The value of peak day capacity required is provided from the AE2S's future water supply evaluation that was derived in Section 2 of the Master Plan.

TABLE ES-6: PROJECTED WATER SOURCES FOR PLANNING PERIODS WITH WATER RESTRICTIONS

		Peak Day Capacity Req'd, MGD^1	Estimated Capacity Available			
			Normal Conditions, MGD	Average Dry Conditions, MGD	Drought Conditions, MGD	Extended Drought Conditions, MGD
10-Year Planning Period	Wellfield	30.3	22.0	19.0	17.0	11.0
	BS River Pump Station		23.0	23.0	0.0	0.0
	Lewis & Clark RWS		28.0	28.0	28.0	28.0
	Req Future Water Source		N/A	N/A	N/A	N/A
	Total		73.0	70.0	45.0	39.0
20-Year Planning Period	Wellfield	35.5	29.0	24.0	22.0	11.0
	BS River Pump Station		23.0	23.0	0.0	0.0
	Lewis & Clark RWS		34.0	34.0	34.0	34.0.
	Req Future Water Source		N/A	N/A	N/A	N/A
	Total		86.0	81.0	56.0	45.0
50-Year Planning Period	Wellfield	39.1	31.0	26.0	23.0	12.0
	BS River Pump Station		23.0	23.0	0.0	0.0
	Lewis & Clark RWS		34.0	34.0	34.0	34.0
	Req Future Water Source		N/A	N/A	N/A	N/A
	Total		88.0	83.0	57.0	46.0
100-Year Planning Period	Wellfield	58.2	34.0	28.0	24.0	12.0
	BS River Pump Station		23.0	23.0	0.0	0.0
	Lewis & Clark RWS		34.0	34.0	34.0	34.0
	Req Future Water Source		N/A	N/A	N/A	12.2
	Total		91.0	85.0	58.0	58.2

Notes: 1. Peak day capacity required assumes watering restrictions are implemented and the per capita demand is approximately 115 gpcd.

2. The reduction in peak day capacity required from the water restrictions is taken from the City of Sioux Falls technical memorandum, Future Water Supply Needs, dated June 2020.

Table ES-7. Summary of Major Aquifers South of Sioux Falls

Aquifer	Distance* (miles)	Recoverable Water In Storage - Lincoln County (Hedges, et. al., 1982) (acre-feet)	Recoverable Water In Storage - Minnehaha County (Hedges, et. al., 1982) (acre-feet)	Identified Recharge Sources	Average Aquifer Thickness (feet)	Average Depth to Top of Aquifer (feet)	Iron (mg/L)	Manganese (mg/L)	Sulfate (mg/L)	Total Dissolved Solids (mg/L)	Hardness as CaCO3 (mg/L)	Water Quality Information Source	Estimated Amount Available for Appropriation (ac-ft/yr)	Estimated Amount Available for Appropriation (MGD)	Comment
Big Sioux:South	1	70,200	20,640	Precipitation, Big Sioux River, other aquifers	22	10	1.1	2.3	303 (d)	991	620	Niehus, 1994	5,490	4.9	Un-used water rights of nearly 1.9 MGD
Brule Creek	25	99,600	NP	Precipitation	33	46	0.675	0.075	430 (d)	1,285	690	Niehus, 1994	5,431	4.8	
Dakota	9	4,297,900	NP	Underlying Formations	216	281	1.76	0.19	360 (d)	1,800	480	Niehus, 1994	29,570	26.4	Regional aquifer, highly variable quality
Harrisburg	5	105,170	NA	Glacial Till	26	59	6	3.23	2,100 (d)	4,075	2,700	Niehus, 1994	Not Quantified	Not Quantified	
Lennox	10	43,830	NP	Possibly UVM aquifer, Glacial Till	NA	~300	3.4	1.5	1,164	2,296	1,357	Beffort, 1961	Not Quantified	Not Quantified	
Newton Hills	24	25,200	NP	Precipitation, possibly Brule Creek aquifer	36	72	0.18 (dM)	0.050 (dM)	570 (d)	1,230	1,050	Niehus, 1994	Not Quantified	Not Quantified	Limited data available
Parker-Centerville	27	6,600	NP	Precipitation, UVM aquifer, Vermillion River	35	17	1.49	1.2	360 (d)	777	600	Niehus, 1994	4,850	4.3	Aquifer extends further west into Turner County
Schindler	9	124,590	1,360	Harrisburg aquifer, Glacial Till	31	103	4.2	1.49	1,200 (d)	2,220	1,255	Niehus, 1994	Not Quantified	Not Quantified	Very poor water quality, limited data
Sioux Quartzite	0	NA	NA	Precipitation, Big Sioux River	NA	120	0.025 (d)	0.007 (d)	127	696	586	Lindgren & Niehus, 1992 (Table 8)	Not Quantified	Not Quantified	Wells dependant on intercepting fractures
Split Rock Creek	3	NP	99,400	Sioux Quartzite	48	160	0.31 (d)	0.19 (d)	271	853	637	Lindgren & Niehus, 1992 (Table 8)	None	None	In 2019 City withdrew a Future Use Permit application
Upper Vermillion Missouri	21	149,180	NP	Parker-Centerville aquifer, Glacial Till	41	162	3.6	2.2	1,400 (d)	2,400	1,300	Niehus, 1994	Not Quantified	Not Quantified	Recharge exceeds withdrawals (Buhler, 2015)
Wall Lake	0	70,400	75,690	Sioux Quartzite	33	105	0.37	2.69	757.1	1,086	977	Filipovic & Pence, 2001	Not Quantified	Not Quantified	Likely water available for appropriation

* Approximate, as measured from City's former filter plant along Skunk Creek following township boundaries (see text)

Water quality data are mean or average values of total recoverable concentrations unless otherwise indicated.

~	Approximated from data in Beffort (1961)	mg/L	milligrams per liter	UVM	Upper Vermillion Missouri aquifer	$CaCO_3$	calcium carbonate
NA	Not available	ac-ft/yr	acre-feet per year	(d)	dissolved		
NP	Not present	MGD	million gallons per day	(dM)	maximum dissolved concentration from limited sample number		

TABLE ES-8: 10-YEAR PLANNING PERIOD RECOMMENDATIONS & BUDGETARY PROJECT COSTS IN 2022 DOLLARS

Improvement Description	Improvement Costs[3]
New Collector Well 25 with Main Install & Abandonment of Existing Well 25 Main	$7,900,000
Replace the 5-Pack Gravel Pack Wells & Upsize Main	$5,020,000
Proposed Collector Well 5 with Main Install	$6,400,000
Proposed Gravel Pack Wells 1, 2, and 3 with Upsized Main	$3,060,000
Upsize 24-, 36-, and 42-Inch Trans. Main from WPP to North of 258th Street	$51,620,000
Replace the 6-pack Gravel Pack Wells & Main Rehabilitation/Cleaning	$5,700,000
Proposed Collector Well 18 with Main Install	$8,130,000
Install Parallel 36-Inch Trans. Main from 257th St. to 255th St.	$12,770,000
Install Cathodic Protection on Existing Ductile Iron Pipe	$340,000
Subtotal Well and Transmission Main Improvements	**$100,940,000**
Filters: Replace VFD for backwash pump (life cycle replacement)	$136,700
Filters: Add additional backwash blower (redundancy)	$77,500
Chemical Feed: Add second service water line	$39,300
Power Distribution: Replace gear in Power Room 2. Potentially relocate to another room	$1,408,000
Backwash Reclaim Basin: Replace sludge scrapers, Add additional scrapers to second side of basin	$1,434,000
Clearwell: Replace valves between clearwell & N. reservoir transfer pump wet well	$159,300
Filters: Install flow meters (mag meters) on Filters 1 – 10	$1,999,200
Filters: Replace filter valves on Filters 1 – 10	$2,669,900
Solids Contact Basins: Replace clarifier equipment in Basins 2 & 3. Update basin instruments/controls. Replace sludge lines on basins 2 & 3.	$6,252,000
Solids Contact Basins: Replace roof - basin area	$820,000
High Service Pumps: Install additional VFDs (Pumps 1, 2, 5, 6, 7, 8, 9)	$3,026,000
Recarbonation Basin: Replace CO2 feeders	$1,814,000
High Service Pumps: Replace pumps 7, 8, 9 (Cavitation). Change to lower flow pumps	$799,000
Actiflo: Replace (6) sand pumps	$227,800
Transfer Pumps: Replace medium voltage motors with 480V motors; Install 480V VFDs	$780,300
Chemical Storage: Replace analog equipment with digital/Ethernet chemical feed pumps. SCADA integration of day tank scales	$559,300
Chemical Storage: Replace Chemical Feed Building HVAC	$242,600
Lime System: Replace slakers 5 & 6	$1,368,100
Transmission Main Tunnel: Repair Pipe Tunnel Ceiling per inspection report	
Architectural/building maintenance improvements: Operations supervisor office floor. Process engineer office wall water damage.	$15,000
Laboratory: Replace cabinets & casework, Replace Lab Flooring	$112,300
Subtotal Improvements to Existing WPP	**$23,940,300**
Subtotal Capacity Imp.: Recarb – Side Stream CO2 Injection System	**$863,000**
Total Water Supply and Treatment 10-year Improvements	**$125,743,300**

Notes: 1. Improvement costs are from the Water Supply and Distribution System Facility Plan, Transmission Redundancy Improvements and Well 25 Improvements, dated July 15, 2022. The cost opinion was prepared by HDR with the well design.

2. Improvement costs are from the HDR transmission improvements tech memo and are represented in 2022 dollars. The cost opinion was prepared by HDR with the transmission improvements tech memo.

3. Improvement costs include a 30% contingency which is an industry standard for a high level (planning level) cost estimate. Actual project costs will vary upon market and bidding environment.

Technical Memorandum

Water Supply and Treatment Master Plan

Chapter 1:

Water Rights

November 2022

(Revised: September 2023)

HR Green Project No: 210506

Prepared For:

CITY OF
SIOUX FALLS

Table of Contents

List of Figures

List of Tables

Appendices

Section 1: Introduction

The City of Sioux Falls (City) holds surface water rights and groundwater rights that not only supply the raw source water to the Water Purification Plant (WPP), but also provide water for other uses, including irrigation, commercial, and industrial uses. Water rights in South Dakota are administered by the Water Rights Program (WRP) of the South Dakota Department of Agriculture and Natural Resources (DANR). Final decisions regarding permit applications are made by the South Dakota Water Management Board (WMB).

The City holds five types of water rights: 1) future use permits, 2) water permits, 3) licenses, 4) vested licenses, and 5) one temporary permit. Future use permits reserve water from a specific source and area, which can be later developed and brought to beneficial use through the water permit application process. Water permits are water rights that have been through the water permit application process and have been approved by the WMB. Water licenses are approved water permits for which the infrastructure has been constructed and the water has been placed into beneficial use. After inspection of the water withdrawal facility by the WRP, the water right diversion rate and annual volume is documented (licensed) and provides for a continuing right to use the water (as long as the water is used beneficially). The original permit is incorporated into the license, showing the original diversion rate and volume (as these can change during the licensing process). Vested licenses held by the City are water rights for which the water was applied for or brought to beneficial use prior to February 28, 1955, or water rights for which construction of the infrastructure was underway by February 28, 1955.

All water licenses incorporate the original permit, but often licenses will include other permits from transferred or amended water rights. If the incorporated permit or permits within a license held by the City have different priority dates, the incorporated permit, priority date, and diversion is shown along with the license in the water rights tables included in this Technical Memorandum (Tech. Memo).

WRP beneficial use categories include the following: 1) domestic, 2) municipal, 3) rural water system, 4) irrigation, 5) suburban housing/water distribution system, 6) commercial, 7) industrial, 8) recreation, 9) fish and wildlife, and 10) institutional. While the City has water rights under five different beneficial use categories; 1) municipal, 2) irrigation, 3) commercial, 4) industrial, and 5) fish and wildlife, the primary focus of the water rights work conducted for the Master Plan is water rights under the municipal use category.

The surface water and groundwater rights are presented separately (Sections 2 & 3, respectively). Section 4 provides information regarding the process for reallocating (transferring) water rights from one permitted or licensed diversion point location to another. Section 5 discusses the potential for attributing existing surface water rights to groundwater rights, primarily through managed aquifer recharge (MAR) activities. Section 6 concludes with recommendations for maximizing the municipal raw water available to the City through their existing water rights, along with the recommended timing relative to the Master Plan planning periods.

A listing of those water rights that provide water that is not pumped to the WPP is provided in Table A-1 of the Appendix. With the exception of water right #7037-3 authorizing the City's connection to the Lewis & Clark Regional Water System (RWS), the use categories for those water rights shown in Table A-1 are not municipal. City water rights that have been cancelled and water right permit applications that have been deferred or withdrawn are shown in Table A-2 of the Appendix.

Section 2: Surface Water Rights

Surface water rights data were obtained from the online water rights database maintained by the WRP of the DANR. The surface water rights data were also compared with information in a document titled Sioux Falls Water Rights (City of Sioux Falls Water Division, 2021). The surface water rights information provided in this Technical Memorandum (Tech Memo), with one minor exception (described in Section 2-2), is consistent with the information in the Sioux Falls Water Rights document. The surface water rights information is current through the date of this Tech. Memo.

2-1 Surface Water Future Use Permits

The future use permits reserving surface water for municipal use are listed in Table 1. Also included in Table 1 are details of the future use permits, including the source water, the future use permit area, the annual volume remaining, the priority date, the review date, and other details. The future use permit areas are shown in Figure 1.

To bring water reserved under a future use permit to beneficial use, the applicant must apply for a water permit providing details regarding the diversion point location, maximum discharge rate in cubic feet per second (cfs) or gallons per minute (gpm), and annual volume of water claimed in acre-feet/year (ac-ft/yr) or gallons. After a water permit is approved, the approved amount is subtracted from the future use permit.

Future Use Permit #2042-3 reserves 28,236 ac-ft/yr, which is equivalent (assuming continuous withdrawal) to 25.21 million gallons per day (MGD) of surface water from the Missouri River. Future Use Permits #3981-3 and #3981A-3 together reserve 30,000 ac-ft/yr (26.79 MGD) of surface water from the Big Sioux River from two diversion points located along the Big Sioux River in north Sioux Falls. Prior to bringing these surface water reservations to beneficial use, the City must first submit a water permit application to the DANR.

2-2 Surface Water Licenses

Surface water licenses held by the City Water Division are listed in Table 2. Also included in Table 2 are details regarding the license, including the source (the Big Sioux River or Skunk Creek), the diversion rate, the annual volume limit (in both ac-ft/yr and equivalent MGD), the number and location of the diversion points, the priority date, and other details. The locations of the diversion points are shown in Figure 2.

Water License #6210-3 permits the withdrawal of up to 20,000 ac-ft/yr (17.86 MGD) of surface water from the Big Sioux River. This surface water is pumped from the City's Big Sioux River Pumping Station to the WPP for treatment prior to municipal use. A condition of this license is that this diversion can only be made when there is a minimum of 20 cfs of flow in the Big Sioux River at the United States Geological Survey (USGS) gauging station (Site Number: 06482020) located on N. Cliff Avenue in Sioux Falls.

Water License #5431-3 permits transferring up to 6,360 ac-ft/yr (5.68 MGD) from the Big Sioux River to a Diversion Ditch (labeled as "Old Diversion Ditch" in Figure 2). The water flows south in the diversion ditch, providing recharge to the Sioux Falls Management Unit of the Big Sioux Aquifer (Big Sioux:Sioux Falls aquifer), some of which is then withdrawn by the City's groundwater water rights for municipal use. This is a managed aquifer recharge (MAR) system. A condition of this license is that this diversion can only be made when there is a minimum of 20 cfs of flow in the Big Sioux River at the USGS gauging station (Site Number: 06482020) located on N. Cliff Avenue in Sioux Falls.

Water License #5775-3 permits the withdrawal of up to 200 ac-ft/yr for fish and wildlife. This license originated during a wetland mitigation project. The surface water withdrawn under Water License #5775 3 is not pumped to the WPP and is not utilized as a municipal source water. As indicated previously, there is a slight discrepancy between the information in this Tech Memo and the Sioux Falls Water Rights document. The discrepancy is related to the applicable diversion rate for the period from July through February (July-Feb) and the annual volume limit. The Sioux Falls Water Rights document indicates the permitted diversion rate for July-Feb is 2 cfs (which was the amount approved in the permit). However, after inspection by the WRP, the July-Feb diversion rate was revised to 1 cfs. The Sioux Falls Water Right document suggests an annual volume limit of 6,630 ac-ft. The annual volume limit in the license is 200 ac-ft/yr.

Section 3: Groundwater Rights

Groundwater water rights data were obtained from the online water rights database maintained by the WRP of the DANR and were compared with information in the Sioux Falls Water Rights document (City of Sioux Falls Water Division, 2021). The groundwater water rights information provided in this Tech. Memo is generally consistent with the information in the Sioux Falls Water Rights document, although there are some differences. Most of the differences are because water rights not intended to supply raw water to the WPP are not included in the document, and some of the differences are due to amendments made to water rights after the Sioux Falls Water Rights document was written. The differences related to the groundwater rights are not significant and are not described individually in this Tech. Memo. The groundwater rights information is current through the date of this Tech. Memo.

3-1 Aquifers and Well Fields

The WRP administers groundwater rights by aquifer. Larger, regional aquifers are split into management units. Aquifer names in this Tech. Memo (and in WRP documents) include the regional aquifer and the management unit, separated by a colon. For example, most of the City's groundwater rights are within the Sioux Falls management unit of the Big Sioux aquifer (Big Sioux:Sioux Falls aquifer). The City divides the Big Sioux:Sioux Falls aquifer into two well fields;1) the Airport Well Field, and 2) the North Well Field.

The City also holds water rights in the Big Sioux:Middle Skunk Creek aquifer (Middle Skunk Creek Well Field), and in the Big Sioux:Southern Skunk Creek aquifer. There are no City wells currently pumping groundwater from the Big Sioux:Southern Skunk Creek aquifer.

3-2 Groundwater Future Use Permits

The future use permits reserving groundwater for municipal use are listed in Table 3. Also included in Table 3 are details of the future use permits, including the source water, the future use permit area, the annual volume remaining, the priority date, the review date, and other details. The groundwater future use permit areas are shown in Figure 3.

As indicated previously, to bring water reserved under a future use permit to beneficial use, the applicant must apply for a water permit providing details regarding the diversion point location, maximum discharge rate in cfs or gallons per minute (gpm), and annual volume of water claimed in ac-ft/yr or gallons. After a water permit is approved, the approved amount is subtracted from the future use permit.

The City, through Future Use Permits #448-3 and #5523-3, currently has 7,892 ac-ft/yr of groundwater reserved in the Big Sioux:Sioux Falls aquifer. Assuming continuous pumping, this is equivalent to 7.05 MGD. The City has 183 ac-ft/yr (0.16 MGD) reserved in the Big Sioux:Middle Skunk Creek aquifer and 5,430 ac-ft/yr (4.85 MGD) reserved in the Big Sioux:Southern Skunk Creek aquifer.

3-3 Groundwater Licenses Airport Well Field

Groundwater licenses in the Big Sioux:Sioux Falls aquifer Airport Well Field are listed in Table 4. Also included in Table 4 are details regarding the license, including the diversion rate, the annual volume limit (in both ac-ft/yr and equivalent MGD), the number and location of the diversion points, the priority date, any incorporated permits, and other details. There are 21 wells under 20 separate water licenses. The approximate locations of the wells are shown in Figure 3.

The allowable combined instantaneous maximum diversion rate for the groundwater rights in the Airport Well Field is 37.73 cfs. The combined annual volume limit for the groundwater rights in the Airport Well Field is 26,668.4 ac-ft/yr (23.81 MGD).

3-4 Groundwater Permits & Licenses North Well Field

Groundwater permits and licenses in the Big Sioux:Sioux Falls aquifer North Well Field are listed in Table 5. The City holds five types of groundwater rights in the Big Sioux:Sioux Falls aquifer North Well Field; 1) future use permits, 2) permits, 3) vested licenses, 4) licenses, and 5) a temporary permit. The future use permits have previously been described (Table 3 and Figure 3).

Included in Table 5 are details regarding the groundwater right, including the diversion rate, the annual volume limit (in both ac-ft/yr and equivalent MGD), the number and location of the diversion points, the priority date, the future use permit from which the permit was issued (if applicable), and incorporated permit details (if applicable).

There are 31 wells and one surface water intake (DC-2) permitted or licensed under 25 separate water rights. The approximate locations of the wells are shown in Figure 3. While DC-2 is a surface water intake located at the WPP that withdraws water from the flood control diversion channel, the water withdrawn by DC-2 is under a groundwater license. This is because it was concluded that excavation of the flood control diversion channel "exposed" the Big Sioux aquifer, and therefore water withdrawn from the channel could be considered groundwater (SD WRP files, Water License No. 1347-3).

The allowable combined instantaneous maximum diversion rate for the groundwater permits and licenses in the North Well Field is 72.569 cfs. The combined annual volume limit for the groundwater permits and licenses in the North Well Field is 43,359.23 ac-ft/yr (38.72 MGD).

3-5 Groundwater Licenses Big Sioux:Middle Skunk Creek Aquifer Well Field

Groundwater permits and licenses in the Big Sioux:Middle Skunk Creek aquifer Well Field are listed in Table 6. Included in Table 6 are details regarding the groundwater right, including the diversion rate, the annual volume limit (in both ac-ft/yr and equivalent MGD), the number and location of the diversion points, the priority date, the future use permit from which the permit was issued (if applicable), and incorporated permit details (if applicable).

There are 13 wells licensed under 5 separate water rights. The approximate locations of the wells are shown in Figure 3. The allowable combined instantaneous maximum diversion rate for the groundwater permits and licenses in the Middle Skunk Creek Well Field is 14.92 cfs. The combined annual volume limit for the groundwater licenses in the Middle Skunk Creek Well Field is 4,883 ac-ft/yr (4.36 MGD).

3-6 Total Water Rights for Municipal Use

The total water rights held by the City of Sioux Falls intended for municipal use (not including the Lewis & Clark RWS Connection) are summarized in Table 7. The water rights shown in Table 7 can be considered water rights for supplying raw water to the WPP. The total groundwater annual volume is 88,416 ac-ft/yr (78.95 MGD) and the total surface water annual volume is 84,596 ac-ft/yr (75.53 MGD). Therefore, the total water rights for municipal use are 173,012 ac-ft/yr (154.48 MGD).

Section 4: Reallocation of Groundwater Rights

The WRP will allow existing permits and licenses to be amended by changing the diversion point locations if the following criteria are met: 1) no change in water source (same aquifer); 2) no increase in the amount of water (diversion rate and volume to remain the same); and 3) the change does not result in an added potential for unlawful impairment of senior or domestic water rights.

Due to water quality impacts associated with per-and polyfluoroalkyl substances (PFAS) at the Airport Well Field, the City is considering reallocating some or all of the groundwater rights for the Airport Well Field to the North Well Field. However, the potential reallocation of City water rights is not limited solely to the Airport Well Field water rights. For example, the City has in the past (and will continue) to transfer water rights from an older, existing well that can no longer produce the volume of water associated with a specific water right to a newly constructed well that has greater production capacity. A specific example of this is Well #25. Well #25 is 71 years old and requires a degree of maintenance that is no longer practical. For this reason, the City is planning to replace Well #25 (a Bragstad well, which is a large diameter well with no screen) with a horizontal collector well. In this example, the City will submit an application to amend Water Right #274-3 (Table 5) by moving the diversion point location from Well #25 to the location of the new collector well.

Section 5: Attributing Surface Water Rights to Groundwater Rights

Groundwater requires less treatment, and the City currently treats and distributes much more groundwater than surface water. For this reason, it may be advantageous to attribute some of the surface water rights held by the City to groundwater rights. The WRP (LRE Water, 2021) has indicated that the only mechanism currently in place in South Dakota that could allow the City to potentially attribute current surface water rights to groundwater rights would be to divert surface water under an existing surface water permit (or future use permit) for the purpose of recharging the aquifer. The recharged water pumped from the aquifer would be pumped under a groundwater permit with a defensible amount of the well's production attributed to the infiltration of surface water. This type of undertaking would include amending, revising, or adding diversion point locations associated with the applicable permits, and would require sound hydrogeologic justification and investigation for review by the WRP. This process can be considered a MAR system.

The City currently operates a MAR under WR #5431-3 (Table 2) where surface water from the Big Sioux River is diverted to what is labeled the Old Diversion Ditch on Figure 2. This surface water recharges that portion of the aquifer located along the Old Diversion Ditch, increasing the available drawdown of wells near the ditch. An additional MAR, utilizing both the Big Sioux River and an old diversion ditch, could be utilized as a mechanism to attribute some of the City's unused surface water rights to groundwater rights. A conceptual design for the proposed MAR system is shown in Figure 4. It is identical in concept to the MAR system the City currently employs. Surface water would be diverted from the Big Sioux River (near the north boundary of Future Use Permit #5523-3) to an existing diversion ditch. Wells designed to induce surface water infiltration (likely horizontal collector wells) would be installed along the ditch.

Section 6: Maximizing Extraction through Existing Water Rights

It is recommended that the City focus future groundwater development in the near term (10-20 Years) in the North Well Field. This can be done by applying for water permits from Future Use Permits #5523-3 and #448-3 (shown in Table 3). The total volume of groundwater remaining in these two future use permits is 7,892 ac-ft/yr (7.05 MGD). This volume of water can be extracted with approximately four new horizontal collector wells, or 10 to 15 new vertical wells (gravel packs). Additional details regarding potential well locations are provided in the Well Siting Technical Memorandum (LRE, HRG & Carollo, 2022).

To utilize more of the existing surface water rights, it is recommended that the City consider another MAR system as briefly described in Section 5. This added MAR system would make it possible to attribute existing surface water rights (Table 2) to groundwater rights. A new MAR system extracting surface water from the Big Sioux River under the City's existing surface water rights would have the same bypass restrictions that are currently a condition of the existing surface water future use permits and licenses (a minimum of 20 cfs must flow past the USGS gauging station on N. Cliff Avenue). The planning period for the conceptual design of the MAR system is near-term (10 years). The planning period for permitting and beginning construction of the MAR system is 20 years.

There is 5,430 ac-ft/yr (4.85 MGD) of groundwater reserved in Future Use Permit #449-3 (Table 3). Development of groundwater resources in the Big Sioux:Southern Skunk Creek aquifer has not previously occurred primarily due to water quality concerns. However, it is likely that well systems designed to infiltrate surface water from Skunk Creek could be developed that would produce water of suitable water quality for treatment and municipal use. A former filtration plant located in the southeastern portion of Future Use Permit #449-3 Area could potentially be updated to treat groundwater produced from the Big Sioux:Southern Skunk Creek aquifer.

To provide more information with which to evaluate the suitability of the groundwater reserved under Future Use Permit #449-3 for City use, a detailed water quality assessment is recommended. The water quality assessment would include mapping the pollution sources, identifying potential contaminants of concern (COCs), identifying existing wells suitable for water quality sampling, and perhaps constructing new small-diameter wells for water quality sampling. These wells would be sampled for the COCs and the results of the water quality assessment could be utilized to provide a conceptual design of a Big Sioux: Southern Skunk Creek well field. The planning period for the water quality assessment and conceptual well field design is Near Term (10 years). Should the City elect to proceed with the development of a Big Sioux:Southern Skunk Creek well field, the recommended planning period for constructing the well field is 20 to 50 years.

The remaining water in Big Sioux:Middle Skunk Creek aquifer Future Use Permit #5522-3 (183 ac-ft/yr, 0.16 MGD, Table 3) could be produced by one vertical well. However, it may be advantageous to add additional wells to more efficiently produce the current permitted amount shown in Table 6. The planning period for adding additional gravel pack wells to the Big Sioux:Middle Skunk Creek aquifer is 20 years.

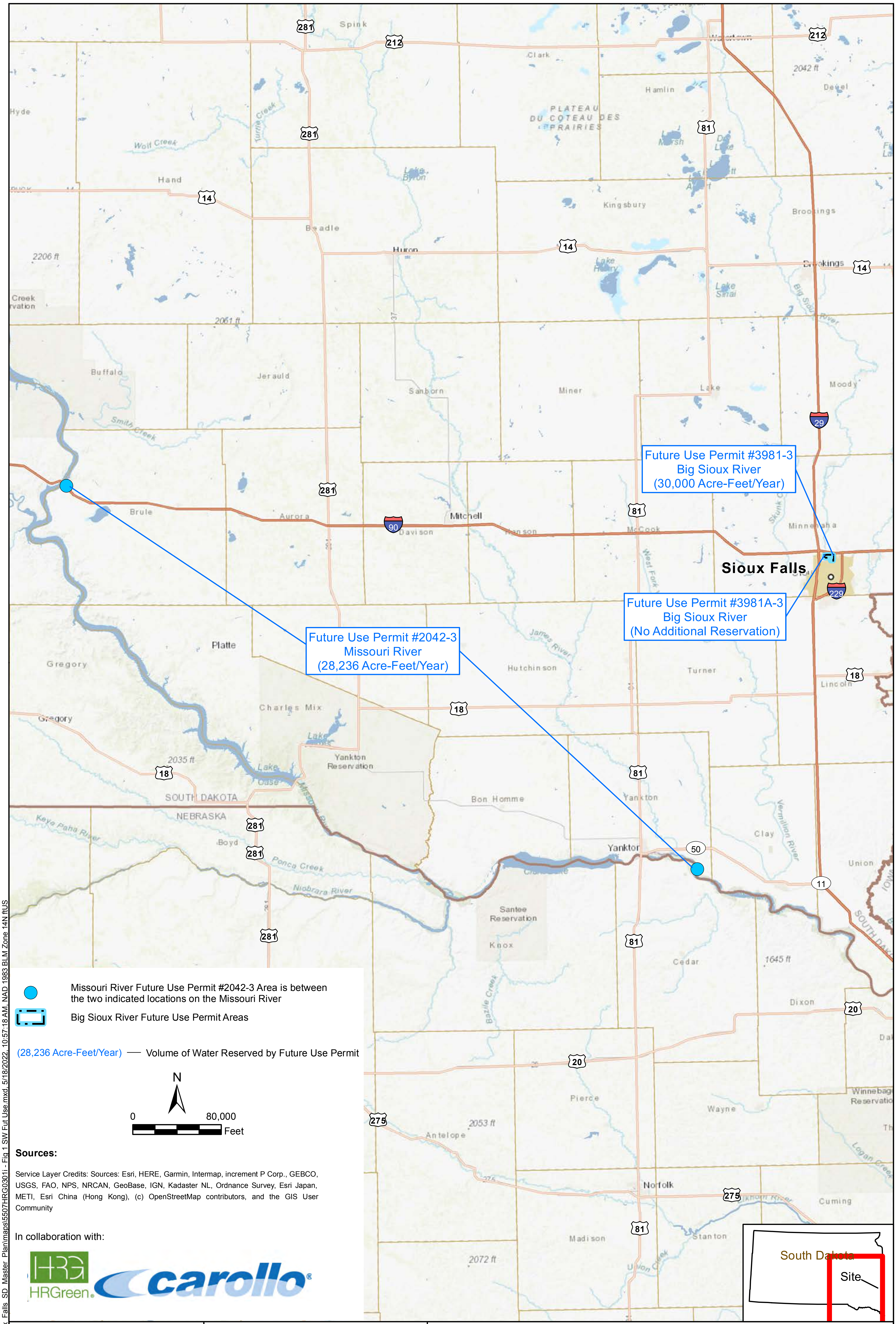
Section 7: References Cited

City of Sioux Falls Water Division, 2021. Sioux Falls Water Rights. Undated Microsoft Word document provided by City Water Purification Plant Personnel (no author indicated).

LRE, 2021. Memorandum to City, dated December 6, 2021, documenting a conversion with Mr. Ron Duvall of the South Dakota Water Rights Program.

LRE, HRG & Carollo, 2022. Well Siting Plan Technical Memorandum, Water Purification Master Plan.

Figures



Sources:

Service Layer Credits: Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community

In collaboration with:

HRGreen carollo

C:\GIS\GIS\HR_Green_Sioux_Falls_SD_Master_Plan\maps\5507HRG0301i - Fig 1 SW Fut Use.mxd, 5/18/2022, 10:57:18 AM, NAD 1983 BLM Zone 14N ftUS

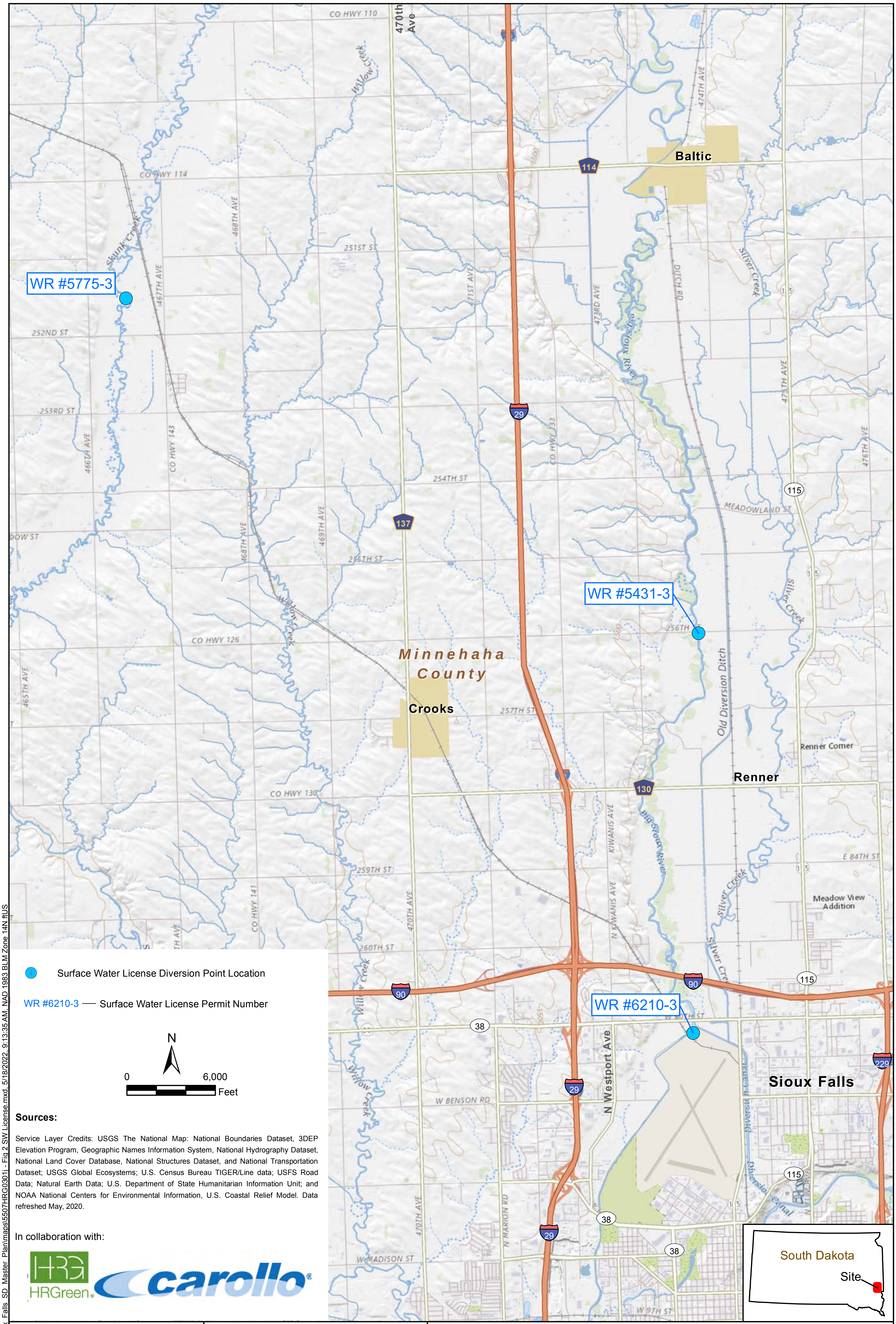
LRE WATER
CONNECTING WATER TO LIFE

Prepared By:
LRE Water
Innovative Water Resource Solutions
South Dakota Office
Sioux Falls, South Dakota
(605) 310-1721

CITY OF SIOUX FALLS
WATER PURIFICATION MASTER PLAN
SIOUX FALLS, SOUTH DAKOTA

SURFACE WATER FUTURE USE PERMIT AREAS

FILE:5507HRG0301i - Fig 1 SW Fut Use.MXD	DATE: 5/18/2022	FIGURE: 1



● Surface Water License Diversion Point Location

WR #6210-3 — Surface Water License Permit Number

Sources:

Service Layer Credits: USGS The National Map: National Boundaries Dataset, 3DEP Elevation Program, Geographic Names Information System, National Hydrography Dataset, National Land Cover Database, National Structures Dataset, and National Transportation Dataset; USGS Global Ecosystems; U.S. Census Bureau TIGER/Line data; USFS Road Data; Natural Earth Data; U.S. Department of State Humanitarian Information Unit; and NOAA National Centers for Environmental Information, U.S. Coastal Relief Model. Data refreshed May, 2020.

In collaboration with:

HRGreen.

carollo®

LRE WATER
CONNECTING WATER TO LIFE

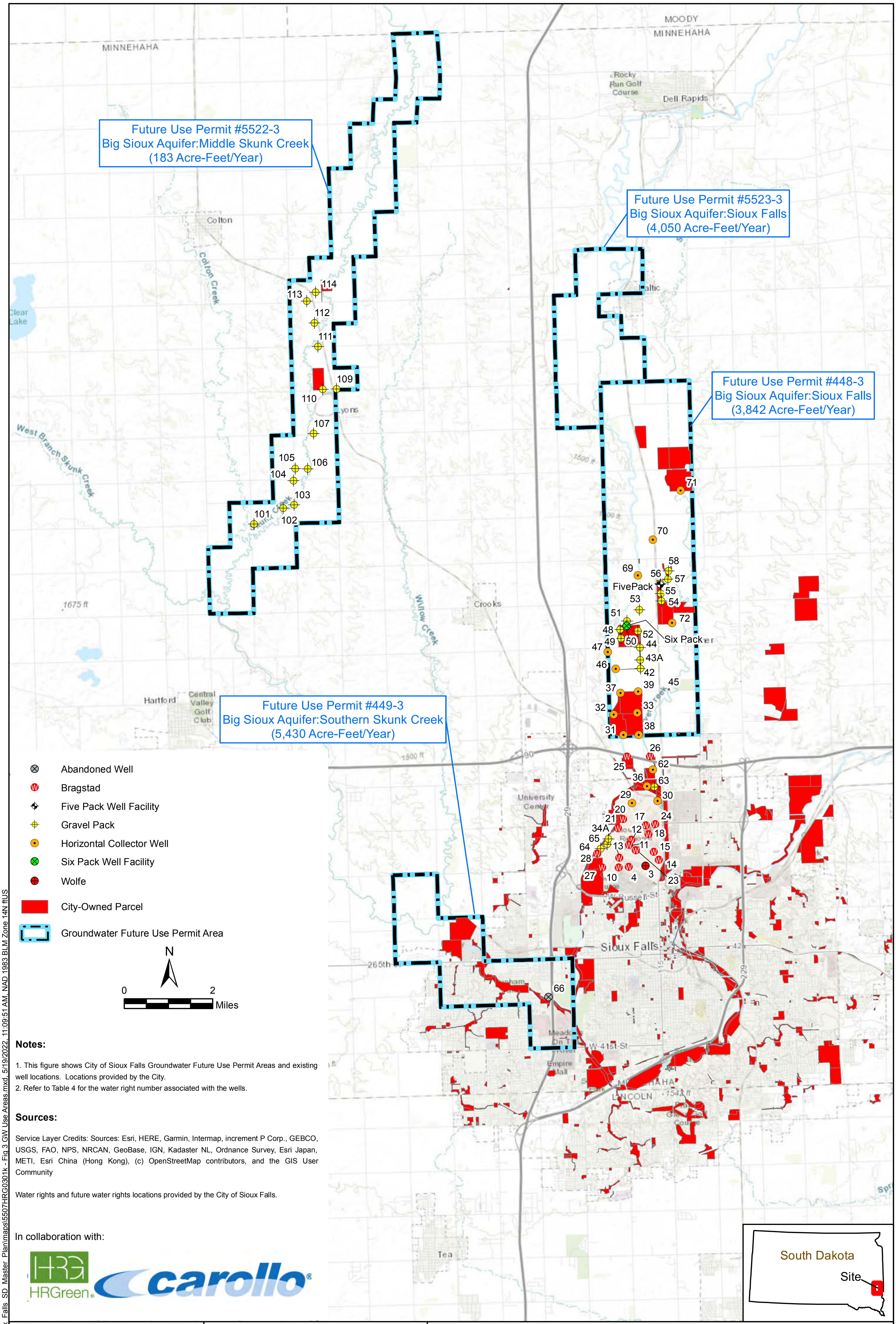
Prepared By:
LRE Water
Innovative Water Resource Solutions
South Dakota Office
Sioux Falls, South Dakota
(605) 310-1721

CITY OF SIOUX FALLS
WATER PURIFICATION MASTER PLAN
SIOUX FALLS, SOUTH DAKOTA

SURFACE WATER LICENSES DIVERSION POINT LOCATIONS

FILE:5507HRG0301j - Fig 2 SW License.MXD
DATE: 5/18/2022
FIGURE: 2

C:\GIS\GIS\HR Green Sioux Falls SD Master Plan\maps\5507HRG0301j - Fig 2 SW License.mxd, 5/18/2022, 9:13:35 AM, NAD 1983 BLM Zone 14N ftUS



Notes:

1. This figure shows City of Sioux Falls Groundwater Future Use Permit Areas and existing well locations. Locations provided by the City.
2. Refer to Table 4 for the water right number associated with the wells.

Sources:

Service Layer Credits: Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community

Water rights and future water rights locations provided by the City of Sioux Falls.

In collaboration with:

HRGreen. carollo®

C:\GIS\GIS\HR_Green_Sioux_Falls_SD_Master_Plan\maps\5507HRG0301k - Fig 3 GW Use Areas.mxd, 5/19/2022, 11:09:51 AM, NAD 1983 BLM Zone 14N ftUS

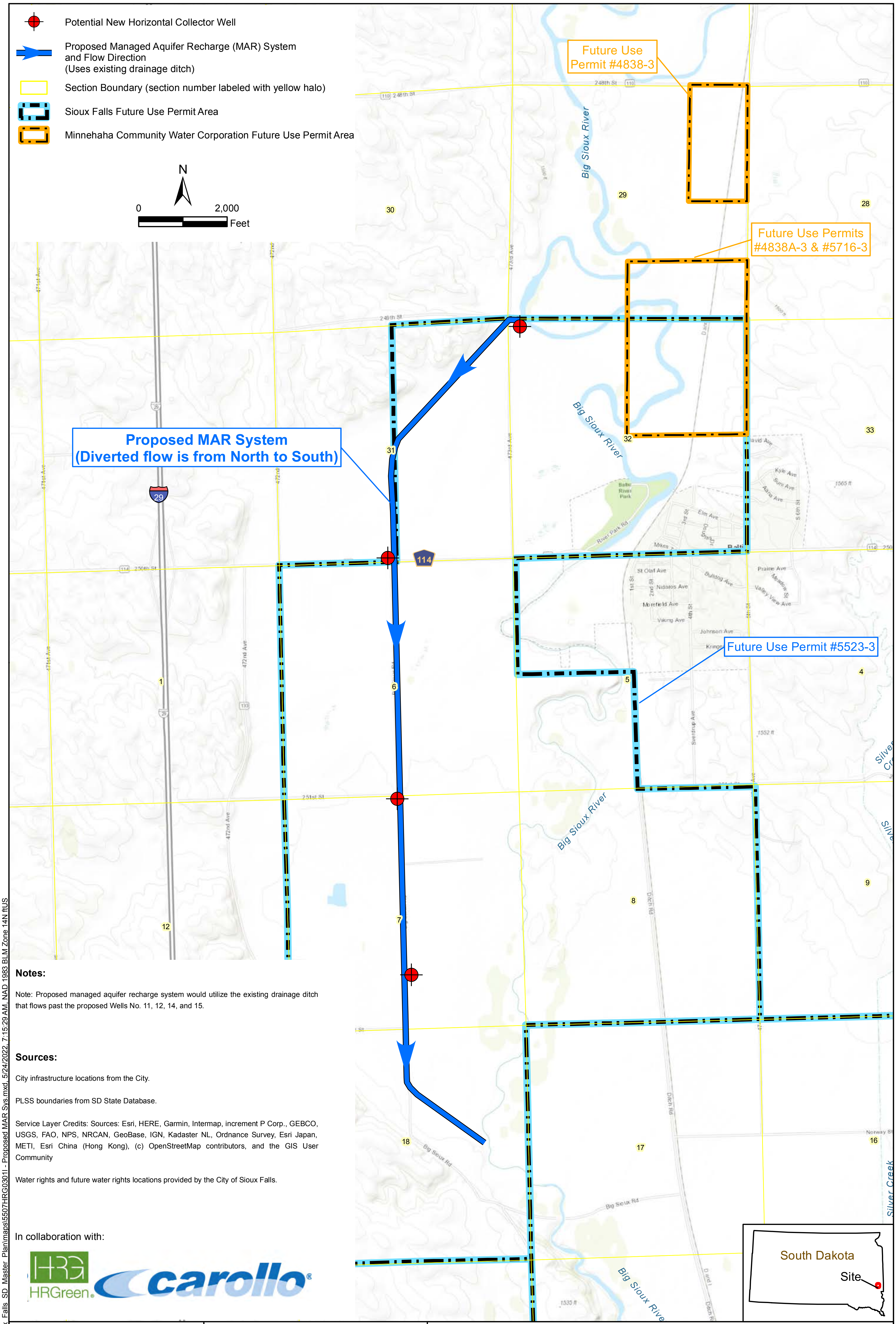
LRE WATER
CONNECTING WATER TO LIFE

Prepared By:
LRE Water
Innovative Water Resource Solutions
South Dakota Office
Sioux Falls, South Dakota
(605) 310-1721

CITY OF SIOUX FALLS
WATER PURIFICATION MASTER PLAN
SIOUX FALLS, SOUTH DAKOTA

GROUNDWATER FUTURE USE PERMIT AREAS AND CITY WELL LOCATIONS

FILE:5507HRG0301k - Fig 3 GW Use Areas.MXD | DATE: 5/19/2022 | FIGURE: 3



- Potential New Horizontal Collector Well
- Proposed Managed Aquifer Recharge (MAR) System and Flow Direction (Uses existing drainage ditch)
- Section Boundary (section number labeled with yellow halo)
- Sioux Falls Future Use Permit Area
- Minnehaha Community Water Corporation Future Use Permit Area

Notes:

Note: Proposed managed aquifer recharge system would utilize the existing drainage ditch that flows past the proposed Wells No. 11, 12, 14, and 15.

Sources:

City infrastructure locations from the City.

PLSS boundaries from SD State Database.

Service Layer Credits: Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community

Water rights and future water rights locations provided by the City of Sioux Falls.

In collaboration with:

HRGreen

carollo

LRE WATER
CONNECTING WATER TO LIFE

Prepared By:
LRE Water
Innovative Water Resource Solutions
South Dakota Office
Sioux Falls, South Dakota
(605) 310-1721

CITY OF SIOUX FALLS
WATER PURIFICATION MASTER PLAN
SIOUX FALLS, SOUTH DAKOTA

PROPOSED MANAGED AQUIFER RECHARGE SYSTEM

FILE:5507HRG0301I - Proposed MAR Sys.MXD | DATE: 5/24/2022 | FIGURE: 4

C:\GIS\GIS\HR Green Sioux Falls SD Master Plan\maps\5507HRG0301I - Proposed MAR Sys.mxd, 5/24/2022, 7:15:29 AM, NAD 1983 BLM Zone 14N ftUS

Tables

Table 1. Surface Water Future Use Permits

Water Right No.	Water Right Status	Priority Date	Use	Diversion Annual Volume Remaining	Diversion Annual Volume Remaining	Future Use Permit Area	Water Source	Next Review Date	Comment
				(ac-ft/yr)	(MGD)*				
2042-3	Future Use	12/28/1973	Municipal	28,236	25.21	Missouri River between Chamberlain (Section 21, T104N, R70W) and Yankton (Section 34, T93N, R54W)	Missouri River	2026	Original reservation was for 65 csf. In 1990, it was converted to the volume equal to pumping at 65 cfs for 60% of the year (28,236 ac-ft).
3981-3	Future Use	6/6/1977	Municipal	30,000	26.79	West 1/2 of Section 33, T102N, R49W	Big Sioux River	2023	Original reservation was 50,000 ac-ft (10,000 ac-ft applied to WR #5334-3, 10,000 ac-ft applied to WR #6210-3).
3981A-3	Future Use	6/6/1977	Municipal	0	0	North 1/2 of Section 32, T102N, R49W	Big Sioux River	2023	This amends WR #3981-3 by increasing the diversion area (N1/2 of Section 32)
Total Reservation				**58,236**	**52.00**				

NOTES: T&R - township and range
ac-ft/yr - acre-feet per year
ac-ft - acre-feet

* assumes continuous pumping
WR = water right
cfs = cubic feet per second

Table 2. Surface Water Licenses

Intake Name	Water Right No.	Water Right Status	Use	Water Right Maximum Diversion Rate	Water Right Diversion Annual Volume	Water Right Diversion Annual Volume	No. of DPs	Water Right Diversion Point Locations					Current Use	Future Use Permit	Incorp. Permit	Priority Date	Incorp. Permit Diversion Rate	Incorp. Permit Diversion Volume	Incorp. Permit No. of DPs	Water Source	Infrastructure Comment	Water Right Comment
				cfs	ac-ft/yr	MGD*		Quarter Section	Sec	T&R	LAT.	LONG.					cfs	ac-ft/yr				
BSR PS	6210-3	License	Municipal	69.60	20,000	17.86	1	NW1/4 of NE1/4	32	102N-49W	43.59966	-96.74053	In Use	3981-3 & 3981A-3	5334-3	6/6/1977	13.80	10,000	2	Big Sioux River	WR #5334-3 included 2 diversion points - existing Big Sioux River Pumping Station intake in NE1/4 of Section 32 & a proposed intake in W1/2 of Section 33, T102N, R50W.	A minimum flow of 20 cfs must be flowing past the USGS gauging station No. 06482020 at North Cliff Avenue
															6210-3	6/6/1977	55.80	10,000	1	Big Sioux River		
WP#1	5431-3	License	Municipal	15.56	6,360	5.68	1	NW1/4 of NE1/4	5	102N-49W	43.67404	-96.73638	In Use			3/26/1990				Big Sioux River	Water is pumped to the Big Ditch to recharge Big Sioux aquifer. This is a MAR system.	Surface water diversion to recharge the Big Sioux Aquifer:Sioux Falls. A minimum flow of 20 cfs must be flowing past the USGS gauging station No. 06482020 at North Cliff Avenue
WP#2	5775-3	License	F&W Propagation	15	200	0.179	1	NE1/4 of SW1/4	7	103N-50W	43.73874	-96.88124	Intermittent			5/17/1993				Skunk Creek	Authorizes storage of up to 50 acre-feet of water.	No diversion allowed unless 10 cfs bypasses (while diverting up to 15 cfs) guage at S. Marion Rd from March 1 to June 30, or at a diversion rate of up to 1 cfs the remainder of year.
Totals				**100.16**	**26,560**	**23.7**	3															

NOTES:

WPP - water purification plant	No. - number	ac-ft/yr - acre-feet per year	WP - wetland pump
T&R - township and range	LAT. - latitude	BSR PS - Big Sioux River Pumping Station	MGD - million gallons per day
F&W - fish & wildlife	LONG. - longitude	Incorp. - Incorporated	* assumes continuous pumping
cfs - cubic feet per second	DP - diversion point	MAR - managed aquifer recharge	

Table 3. Groundwater Future Use Permits

Water Right No.	Water Right Status	Priority Date	Use	Diversion Annual Volume Remaining	Diversion Annual Volume Remaining	Future Use Permit Area	Water Source	Next Review Date	Comment
				(ac-ft/yr)	(MGD)*				
448-3	Future Use	4/8/1957	Municipal	3,842	3.43	Sections 4, 5, 8, 9, 16, 17, 20, and 21 of T102N, R49W, and Sections 16, 17, 20, 21, 28, 29, 32, and 33, of T103N, R49W.	Big Sioux Aquifer:Sioux Falls	2026	Originally issued for 46.8 cfs. In 1991, WRP record keeping was switched to volume in units of ac-ft/yr.
449-3	Future Use	4/8/1957	Municipal	5,430	4.85	Sections 9, 15, 16, 22, 23, 24 and 25, in T101N, R50W.	Big Sioux Aquifer:Southern Skunk Creek	2023	Originally issued for 15.6 cfs. In 1995, WRP record keeping was switched to volume in units of ac-ft/yr.
5522-3	Future Use	8/22/1991	Municipal	183	0.16	Section 2, T102N, R51W, E1/2, SW1/4,Section 35, Section 36, E1/2, SW1/4, Section 25, SE1/4 Section 26, E1/2 Section 24, all in T103N, R51W, Sections 30, 19, 18, 7, 6, SW1/4 Section 8, NW1/4 Section 5, all in T103N, R50W, E1/2, SW1/4, Section 31, W1/2 Section 32, Sections 29, 20, W1/2 Section 21, E1/2 Section 17, W1/2 Section 16, E1/2, SW1/4 Section 9, NW1/4 Section 10, W1/2 Section 3, E1/2 Section 4, all in T104N, R50W.	Big Sioux Aquifer:Middle Skunk Creek	2027	Original reservation was for 5,000 ac-ft/yr.
5523-3	Future Use	8/22/1991	Municipal	4,050	3.62	SW1/4 Section 5, Sections 6, 7, 8, 18 all in T103N, R49W, and the E1/2 Section 31 and Section 32 of T104N, R49W	Big Sioux Aquifer:Sioux Falls	2027	Original reservation was for 4,050 ac-ft/yr.
Total Groundwater Reservation				**13,505**	**12.06**				

NOTES:	T&R - township and range	* assumes continuous pumping
	ac-ft/yr - acre-feet per year	MGD - million gallons per day
	ac-ft - acre-feet	cfs - cubic feet per second
	WRP- Water Rights Program	

Table 4. Big Sioux:Sioux Falls Aquifer Groundwater Licenses - Airport Well Field

Well No.	Water Right No.	Water Right Status	Water Right Maximum Diversion Rate	Water Right Diversion Annual Volume	Water Right Diversion Annual Volume	No. of DPs	Water Right Diversion Point Locations					Current Use	Incorp. Permit	Priority Date	Incorp. Permit Diversion Rate	Incorp. Permit Diversion Volume	DP Type	Comment	Agree with WPP's Water Rights Document?
			(cfs)	(ac-ft/yr)	(MGD)*		Quarter Section	Sec	T&R	LAT.	LONG.				(cfs)	(ac-ft/yr)			
3	256-3	License (Vested)	1.11	803.60	0.72	1	SW1/4 of SE1/4	5	101N-49W	43.57360	-96.73699	PFAS Standby		1/1/1911			Wolfe		yes
4	257-3	License (Vested)	2.67	1,932.99	1.73	1	SE1/4 of SW1/4	5	101N-49W	43.57338	-96.74446	PFAS Standby		1/1/1913			HCW		yes
10	259-3	License (Vested)	1.33	962.88	0.86	1	SW1/4 of SW1/4	5	101N-49W	43.57328	-96.74898	PFAS Standby		1/1/1934			Bragstad		yes
11	260-3	License (Vested)	1.33	962.88	0.86	1	SE1/4 of NW1/4	5	101N-49W	43.58060	-96.74409	PFAS Standby		1/1/1934			Bragstad		yes
12	261-3	License (Vested)	1.33	962.88	0.86	1	SE1/4 of NW1/4	5	101N-49W	43.58222	-96.74305	PFAS Standby		1/1/1941			Bragstad		yes
13	262-3	License (Vested)	1.55	1,122.15	1.00	1	SW1/4 of SW1/4	5	101N-49W	43.57652	-96.74871	PFAS Standby		1/1/1942			Bragstad		yes
14	263-3	License (Vested)	1.55	1,122.15	1.00	1	SW1/4 of SW1/4	4	101N-49W	43.57549	-96.73086	PFAS Standby		1/1/1943			Bragstad		yes
15	264-3	License (Vested)	1.55	1,122.15	1.00	1	NE1/4 of SE1/4	5	101N-49W	43.57806	-96.73299	PFAS Standby		1/1/1943			Bragstad		yes
17	266-3	License (Vested)	1.55	1,122.15	1.00	1	NE1/4 of NE1/4	5	101N-49W	43.58398	-96.73522	PFAS Standby		1/1/1943			Bragstad		yes
18	267-3	License (Vested)	1.55	1,122.15	1.00	1	NE1/4 of NE1/4	5	101N-49W	43.58682	-96.73636	PFAS Standby		1/1/1943			Bragstad		yes
20	269-3	License (Vested)	1.78	1,288.66	1.15	1	SW1/4 of SW1/4	32	102N-49W	43.58907	-96.74646	PFAS Standby		1/1/1944			Bragstad		yes
21	270-3	License (Vested)	1.67	1,209.02	1.08	1	NW1/4 of NW1/4	5	101N-49W	43.58622	-96.74894	PFAS Standby		1/1/1946			Bragstad		yes
23	272-3	License (Vested)	1.44	1,042.51	0.93	1	NW1/4 of SE1/4	5	101N-49W	43.57877	-96.74118	PFAS Standby		1/1/1950			Bragstad		yes
24	273-3	License (Vested)	1.67	1,209.02	1.08	1	NE1/4 of NE1/4	5	101N-49W	43.58721	-96.73204	PFAS Standby		1/1/1950			Bragstad		yes

Table 4. Big Sioux:Sioux Falls Aquifer Groundwater Licenses - Airport Well Field

Well No.	Water Right No.	Water Right Status	Water Right Maximum Diversion Rate	Water Right Diversion Annual Volume	Water Right Diversion Annual Volume	No. of DPs	Water Right Diversion Point Locations					Current Use	Incorp. Permit	Priority Date	Incorp. Permit Diversion Rate	Incorp. Permit Diversion Volume	DP Type	Comment	Agree with WPP's Water Rights Document?
			(cfs)	(ac-ft/yr)	(MGD)*		Quarter Section	Sec	T&R	LAT.	LONG.				(cfs)	(ac-ft/yr)			
27	276-3	License (Vested)	1.78	1,288.66	1.15	1	SW1/4 of SE1/4	6	101N-49W	43.57340	-96.75643	PFAS Standby		1/1/1954			Bragstad		yes
28	298-3	License	1.78	1,288.66	1.15	1	NW1/4 of SE1/4	6	101N-49W	43.57802	-96.75858	PFAS Standby		9/17/1956			Bragstad		yes
29	7363-3	License	4.57	2,978	2.66	1	NE1/4 of SW1/4	32	102N-49W	43.59433	-96.74227	PFAS Standby	299-3	9/17/1956	3.12	2,259	HCW	Includes diversion authority transferred from WR #5710-3 due to abandonment of 3 wells (60, 61, 62)	yes
													5710-3	1/4/1989	1.45	719			
30	300-3	License	3.21	2,323.93	2.08	1	SW1/4 of NW1/4	33	102N-49W	43.59475	-96.73063	PFAS Standby		9/17/1956			HCW		yes
34A	1305-3	License	1.57	1,136.63	1.02	1	SE1/4 of NE1/4	6	102N-49W	43.58279	-96.75332	PFAS Standby		9/8/1966			Gravel Pack	Replacement for original well #34, constructed 15 feet south of original well.	yes
64	5710-3	License	1.37	833.66	0.74	1	NW1/4 of SE1/4	6	101N-49W	43.57963	-96.75689	PFAS Standby	5235-3, 5710-3	1/4/1989 & 9/4/92	2.10 & 2.02		Gravel Pack		yes
65			1.37	833.66	0.74	1	SE1/4 of NE1/4	6	101N-49W	43.58104	-96.75390	PFAS Standby	5235-3, 5710-3	1/4/1989 & 9/4/92	2.10 & 2.02		Gravel Pack		
Totals			**37.73**	**26,668.40**	**23.81**	**21**													

NOTES:

Water Licenses #7363-3 and #5710-3 annual volume limits are specifically set by license. The annual volumes for all other Airport Well Field groundwater licenses are the amount calculated assuming continuous pumping at the permitted diversion rate.

All wells in the Airport Well Field are currently out of service due to water quality concerns associated with the detection of per-and polyfluoroalky substances (PFAS).

All licenses are permitted for municipal use.

T&R - township and range
cfs - cubic feet per second
ac-ft/yr - acre-feet per year
MGD - million gallons per day
Incorp. - Incorporated
WPP - Water Purification Plant

Sec. - section
LAT. - latitude
LONG. - longitude
DP - diversion point
* assumes continuous pumping

Gravel Pack - vertical well with screen and filter pack
HCW - horizontal collector well
Bragstad or Wolfe - large diameter well with no screen

Table 5. Big Sioux:Sioux Falls Aquifer Groundwater Permits and Licenses - North Well Field

Well No.	Water Right No.	Water Right Status	Water Right Maximum Diversion Rate	Water Right Diversion Annual Volume	Water Right Diversion Annual Volume	No. of DPs	Water Right Diversion Point Locations					Current Use	Future Use Permit	Incorp. Permit	Priority Date	Incorp. Permit Name	Incorp. Permit Diversion Rate	Incorp. Permit Diversion Volume	DP Type	Comment	Agree with WPP's Water Rights Document?
			(cfs)	(ac-ft/yr)	(MGD)*		Quarter Section	Sec	T&R	LAT.	LONG.						(cfs)	(ac-ft/yr)			
25	274-3	License (Vested)	2.00	1,447.93	1.29	1	SE1/4 of NW1/4	29	102N-49W	43.60949	-96.74399	In Use			1/1/1952				Bragstad		Yes
26	275-3	License (Vested)	1.78	1,288.66	1.15	1	SE1/4 of NE1/4	29	102N-49W	43.60938	-96.73359	In Use			1/1/1952				Bragstad		Yes
31	7361-3	License	4.57	2,978	2.66	1	SE1/4 of SW1/4	20	102N-49W	43.61673	-96.74523	In Use		395-3 1347-3 5710-3	1/22/1957 1/10/1967 1/4/1989	Sioux Falls Sioux Falls Sioux Falls	3.12 0.00 1.45	2,259 719 0	HCW		Yes
32	7362-3	License	4.57	2,978	2.66	1	NW1/4 of SW1/4	20	102N-49W	43.62341	-96.74936	In Use		396-3 1347-3 5710-3	1/22/1957 1/10/1967 1/4/1989	Sioux Falls Sioux Falls Sioux Falls	3.12 0.00 1.45	2,259 719 0	HCW		Yes
33	397-3	License	3.12	2,258.78	2.02	1	NW1/4 of SE1/4	20	102N-49W	43.62376	-96.73883	In Use			1/22/1957				HCW		Yes
36	2018-3	License	3.10	2,244.30	2.00	1	NE1/4 of NE1/4	32	102N-49W	43.59973	-96.73532	In Use			10/1/1973				HCW		Yes
37	2019-3	License	3.10	2,244.30	2.00	1	NW1/4 of NW1/4	20	102N-49W	43.63042	-96.74609	In Use	448-3		4/8/1957				HCW		Yes
38	2747-3	License	3.10	2,244.30	2.00	1	SW1/4 of SE1/4	20	102N-49W	43.61657	-96.73844	In Use	448-3		4/8/1957				HCW		Yes
39	2886-3	License	3.10	2,244.30	2.00	1	NW1/4 of NE1/4	20	102N-49W	43.63071	-96.73810	In Use	448-3		4/8/1957				HCW		Yes
42	4098-3	License	1.00	723.97	0.65	1	SW1/4 of NE1/4	17	102N-49W	43.63823	-96.73679	In Use	448-3		4/8/1957				Gravel Pack		Yes
43A	4099-3	License	1.00	723.97	0.65	1	SW1/4 of NE1/4	17	102N-49W	43.64111	-96.73680	In Use	448-3		4/8/1957				Gravel Pack		Yes
44	4100-3	License	1.00	723.97	0.65	1	NW1/4 of NE1/4	17	102N-49W	43.64508	-96.73680	In Use	448-3		4/8/1957				Gravel Pack		Yes
45	4101-3	License	0.00	0.00	0.00	0	SE1/4 of SW1/4	16	102N-49W	43.63102	-96.72445	In Use	448-3		4/8/1957				Gravel Pack	In April 2021, entire diversion authority of 1 cfs and 724 ac-ft/yr transferred to WR #8497-3. Water rights will likely cancel this permit.	No - document prepared prior to transfer.
46	4812-3	License	4.01	2,903.11	2.59	1	NW1/4 of SW1/4	17	102N-49W	43.63839	-96.74791	In Use	448-3		4/8/1957				HCW		Yes

Table 5. Big Sioux:Sioux Falls Aquifer Groundwater Permits and Licenses - North Well Field

Well No.	Water Right No.	Water Right Status	Water Right Maximum Diversion Rate	Water Right Diversion Annual Volume	Water Right Diversion Annual Volume	No. of DPs	Water Right Diversion Point Locations					Current Use	Future Use Permit	Incorp. Permit	Priority Date	Incorp. Permit Name	Incorp. Permit Diversion Rate	Incorp. Permit Diversion Volume	DP Type	Comment	Agree with WPP's Water Rights Document?
			(cfs)	(ac-ft/yr)	(MGD)*		Quarter Section	Sec	T&R	LAT.	LONG.						(cfs)	(ac-ft/yr)			
47	4811-3	License	2.67	1,932.99	1.73	1	NW1/4 of NW1/4	17	102N-49W	43.64392	-96.75136	In Use	448-3		4/8/1957				HCW		Yes
48	5115-3	License	5.00	1,140	1.02	5	SE1/4 of SW1/4	8	102N-49W	43.64824	-96.74516	DNR	448-3	5115-3	4/8/1957		6.70	2,244	Gravel Pack	In a letter dated 8/24/92, City requested annual use limit be reduced to 1,140 ac-ft, returning the unused 1,104 ac-ft/yr to WR #448-3.	Yes
49							NE1/4 of SW1/4	8	102N-49W	43.65121	-96.74540	DNR	448-3	5115-3	4/8/1957				Gravel Pack		
50							NE1/4 of SW1/4	8	102N-49W	43.65204	-96.74262	DNR	448-3	5115-3	4/8/1957				Gravel Pack		
51							SE1/4 of NW1/4	8	102N-49W	43.65394	-96.74225	DNR	448-3	5115-3	4/8/1957				Gravel Pack		
52							NW1/4 of SE1/4	8	102N-49W	43.65056	-96.73749	DNR	448-3	5115-3	4/8/1957				Gravel Pack		
53	5127A-3	License	5.50	1,600	1.43	6	NW1/4 of NE1/4	8	102N-49W	43.65751	-96.73662	In Use	448-3	5127-3	4/8/1957	Sioux Falls	8.00	2160	Gravel Pack	WR #5127-3 was amended solely to correct a publication error (added W1/2 of Section 4 - no additional diversion). City voluntarily reduced annual volume to 1600 ac-ft.	Yes
54							SW1/4 of SW1/4	4	102N-49W	43.66019	-96.72645	DNR	448-3	5127-3	4/8/1957	Sioux Falls			Gravel Pack		
55							SW1/4 of SW1/4	4	102N-49W	43.66258	-96.72674	In Use	448-3	5127-3	4/8/1957	Sioux Falls			Gravel Pack		
56							NW1/4 of SW1/4	4	102N-49W	43.66593	-96.72674	DNR	448-3	5127-3	4/8/1957	Sioux Falls			Gravel Pack		
57							SE1/4 of NW1/4	4	102N-49W	43.66728	-96.72331	In Use	448-3	5127-3	4/8/1957	Sioux Falls			Gravel Pack		
58							SE1/4 of NW1/4	4	102N-49W	43.66995	-96.72293	DNR	448-3	5127-3	4/8/1957	Sioux Falls			Gravel Pack		
62	7232-3	Permit	4.476	3,247	2.90	1	SE1/4 of SE1/4	29	102N-49W	43.60502	-96.73240	In Use		1306-3	9/8/1966	Sioux Falls	2.65	1,918	HCW	Includes diversion authority transferred from WR #1306-3 (DC-1) and WR #1347-3 (DC-2).	Yes
														1347-3	1/10/1967	Sioux Falls	1.837	1,329			
63	5710-3	License	1.37	833.67	0.74	1	NE1/4 of NE1/4	32	102N-49W	43.59934	-96.73193	In Use		5235-3, 5710-3	1/4/1989 & 9/4/92	Sioux Falls	2.10 & 2.02		Gravel Pack	Portion of original diversion authority transferred to WR #7361-3 when Wells 61 & 62 abandoned.	Yes
69	7170-3	License	4.33	2,988	2.67	1	SW1/4 of NE1/4	5	102N-49W	43.66881	-96.73681	In Use	448-3	6214-3	4/8/1957	Sioux Falls	0.78	418	HCW	Diversion authority for WR #7170-3 transferred from now cancelled WR #1306-3 and WR #6214-3.	Yes
														1306-3	9/8/1966	Sioux Falls	3.55	2,570			
70	6215-3	License	2.22	1,193	1.07	1	NW1/4 of SW1/4	33	102N-49W	43.68033	-96.72957	In Use	448-3		4/8/1957				HCW		Yes

Table 5. Big Sioux:Sioux Falls Aquifer Groundwater Permits and Licenses - North Well Field

Well No.	Water Right No.	Water Right Status	Water Right Maximum Diversion Rate	Water Right Diversion Annual Volume	Water Right Diversion Annual Volume	No. of DPs	Water Right Diversion Point Locations					Current Use	Future Use Permit	Incorp. Permit	Priority Date	Incorp. Permit Name	Incorp. Permit Diversion Rate	Incorp. Permit Diversion Volume	DP Type	Comment	Agree with WPP's Water Rights Document?
			(cfs)	(ac-ft/yr)	(MGD)*		Quarter Section	Sec	T&R	LAT.	LONG.						(cfs)	(ac-ft/yr)			
71	6475-3	License	3.20	1,475	1.32	1	SE1/4 of NE1/4	28	103N-49W	43.69620	-96.71643	In Use	448-3		4/8/1957				HCW	Well 71 has two water rights associated with it - WR #6475-3 & WR #2047A-3.	Yes
71	2047A-3	Permit (Temp.)	1.44	378	0.34		SW1/4 of NE1/4	28	103N-49W	43.69620	-96.71643	In Use		2047-3	2/13/1974	Beckman/ Midway Farms/SF	1.44		HCW	Water only to be used from May 1 to September 30. Original permit was for an agriculture irrigation well (Val Beckman), which has since been abandoned.	Yes
72	8497-3	Permit	4.927	2,600	2.32	1	SE1/4 of SW1/4	16	102N-49W	43.65306	-96.72191	Under Cons.	448-3	4101-3	4/8/1957	Sioux Falls	1.00	724	HCW	Includes 1.0 cfs diversion authority and 724 ac-ft transferred from WR #4101-3 and 3.927 cfs and 1,876 ac-ft from WR #1347-3.	No - document prepared prior to transfer.
														1347-3	1/10/1967	Sioux Falls	3.927	1,876			
DC-2	1347-3	License	1.986	968	0.86	1	SW1/4 of SW1/4	4	101N-49W	43.57323	-96.72736	In Use			1/10/1967				SW Intake	Portions of the original diversion authoritiy of 7.75 cfs transferred to WR #7232-3, WR #7361-3, WR #7362-3 and WR #8497-3.	Yes, except for recent transfers
Totals			**72.569**	**43,359.23**	**38.72**	**32**															

NOTES:

Annual volume limits shown without decimal fraction indicate that the limit shown is specified in the permit or license. Those shown with a decimal fraction are calculated from the diversion rate assuming continuous pumping (except Well 63).

Well 63 is part of Water License #5710-3, which also includes wells 64 and 65 in the Airport Well Field. The total annual volume limit for 5710-3 is 2,500 ac-ft/yr.

T&R - township and range
Sec - section
cfs - cubic feet per second
ac-ft/yr - acre-feet per year
Incorp. - Incorporated
WR# - water right number

LAT. - latitude
LONG. - longitude
DP - diversion point
SW - surface water
DNR - do not run
WPP - Water Purification Plant

Gravel Pack - vertical well with screen and filter pack
HCW - horizontal collector well
Bragstad - large diameter well with no screen

Table 6. Big Sioux:Middle Skunk Creek Aquifer Well Field Groundwater Licenses

Well No.	Water Right No.	Water Right Status	Water Right Maximum Diversion Rate	Water Right Diversion Annual Volume	Water Right Diversion Annual Volume	No. of DPs	Water Right Diversion Point Locations					Current Use	Future Use Permit	Incorp. Permit	Priority Date	Incorp. Permit Diversion Rate	Incorp. Permit Diversion Volume	Incorp. Permit No. of DPs	DP Type	Comment	Agree with WPP's Water Rights Document?
			(cfs)	(ac-ft/yr)	(MGD)*		Quarter Section	Sec	T&R	LAT.	LONG.					(cfs)	(ac-ft/yr)				
101	5611-3	License	3.78	1,460	1.30	4	SW1/4 of SW1/4	25	103N-51W	43.68889	-96.90946	In Use	5522-3		8/22/1991				Gravel Pack		Yes
102							NW1/4 of SE1/4	25	103N-51W	43.69388	-96.89608	In Use	5522-3		8/22/1991				Gravel Pack		Yes
103							NE1/4 of SE1/4	25	103N-51W	43.69478	-96.89104	In Use	5522-3		8/22/1991				Gravel Pack		Yes
104							NE1/4 of NE1/4	25	103N-51W	43.70275	-96.89112	In Use	5522-3		8/22/1991				Gravel Pack		Yes
105	5612-3	License	3.00	1,275	1.14	3	SW1/4 of SW1/4	19	103N-50W	43.70667	-96.89009	In Use	5522-3		8/22/1991				Gravel Pack		Yes
106							SE1/4 of SW1/4	19	103N-50W	43.70646	-96.88455	In Use	5522-3		8/22/1991				Gravel Pack		Yes
107							SE1/4 of SW1/4	19	103N-50W	43.71799	-96.88152	DNR	5522-3		8/22/1991				Gravel Pack		Yes
110	5726-3	License	3.00	671	0.60	2	SW1/4 of SE1/4	7	103N-50W			In Use		2923-3	8/24/1976	0.97	66	1	Gravel Pack	Transferred irrigation permit, diversion limited to April 1 to October 31.	Yes
109							SW1/4 of SW1/4	8	103N-50W			In Use	5522-3	5613-3	8/22/1991	2.03	605	1	Gravel Pack	This is change in point of diversion from WR #5613-3 to WR #5726-3.	Yes
111	5614-3	License	2.14	570	0.51	2	NW1/4 of NE1/4	7	103N-50W	43.74645	-96.87850	In Use	5522-3		8/22/1991				Gravel Pack		Yes
112							SW1/4 of NE1/4	6	103N-50W	43.75427	-96.87986	In Use	5522-3		8/22/1991				Gravel Pack		Yes
113	5615-3	License	3.00	907	0.81	2	SE1/4 of SW1/4	31	104N-50W	43.76142	-96.88305	In Use	5522-3		8/22/1991				Gravel Pack		Yes
114							SW1/4 of SE1/4	31	104N-50W	43.76421	-96.87893	In Use	5522-3		8/22/1991				Gravel Pack		Yes
Totals			**14.92**	**4,883**	**4.36**	**13**															

NOTES:

T&R - township and range
Sec - section
cfs - cubic feet per second
ac-ft/yr - acre-feet per year
MGD - million gallons per day
Incorp. - Incorporated

LAT. - latitude
LONG. - longitude
DP - diversion point
* assumes continuous pumping
WR # - water right number
WPP - Water Purification Plant

Gravel Pack - vertical well with screen and filter pack

Table 7. Total City Water Rights for Municipal Use

Water Source (Municipal Use Only)	Water Rights (Municipal Use Only)					Water Rights Comment
	No. of DPs	Maximum Diversion Rate		Annual Volume Limit		
	(Well or Intake)	(cfs)	(MGD)	(acre-feet/year)	MGD*	
BSA:Sioux Falls (Airport WF)	21	37.73	24.38	26,668.40	23.81	Includes 2/3 of diversion authority of WR #5710-3
BSA:Sioux Falls (North WF)	32	72.57	46.90	43,359.23	38.72	Includes 1/3 of WR #5710-3, includes DC-2
BSA:Middle Skunk Creek	13	14.92	9.64	4,883	4.36	
Subtotal Groundwater	66	125.22	80.93	74,911	66.90	Three existing well fields
Big Sioux River Surface Water	1	69.60	44.98	20,000	17.86	Big Sioux River Pumping Station (3 pumps)
Big Sioux River Surface Water WP#1	1	15.56	10.06	6,360	5.68	Wetland Pump #1 MAR System
Subtotal Surface Water	**2**	**85.16**	**55.04**	**26,360**	**23.54**	**Does not include Future Use Permits**
Big Sioux River (Surface Water)	NA	NA	NA	30,000	26.79	Future Use Permits #3981-3 & #3981A-3
Missouri River (Surface Water)				28,236	25.21	Future Use Permit #2042-3
Big Sioux Aquifer:Sioux Falls	NA	NA	NA	7,892	7.05	Future Use Permits #448-3 and #5523-3
Big Sioux Aquifer:Middle Skunk Creek	NA	NA	NA	183	0.16	Future Use Permit #5522-3
Big Sioux Aquifer:Southern Skunk Creek	NA	NA	NA	5,430	4.85	Future Use Permit #5523-3
Total Future Use Permit Reservations				**71,741**	**64.05**	
Total Groundwater Water - Municipal Use (Permits, Licenses & Future Use Permits)				88,416	78.95	
Total Surface Water - Municipal Use (Licenses & Future Use Permits)				84,596	75.53	Includes Missouri River Water Rights and MAR System
Total Water Rights for Municipal Use				**173,012**	**154.48**	Does not include Lewis & Clark RWS Connection

NOTES:

WP#1 - wetlant pump #1
WF - well field
MGD - million gallons per day
cfs - cubic feet per second
* - assumes continuous pumping
DP - diversion point

BSA - Big Sioux Aquifer
WR# - Water Right number
NA - not applicable
MAR - managed aquifer recharge
RWS - Regional Water System

Appendix – Table A-1 and Table A-2

Table A-1. Other City Water Rights not piped to the Water Purification Plant

Well No. or Other ID.	Water Right No.	Water Right Status	Name	Use	Water Right Maximum Diversion Rate	Water Right Diversion Annual Volume	No. of DPs	Water Right Diversion Point Locations			Future Use Permit	Incorp. Permit	Priority Date	Incorp. Permit Name	Incorp. Permit Diversion Rate	Incorp. Permit Diversion Volume	Incorp. Permit No. of DPs	SW or GW	Water Source	DP Type	Comment	Agree with WPP's Water Rights Document?
					(cfs)	(ac-ft/yr)		Quarter Section	Sec	T&R					cfs	ac-ft/yr						
W1	2244-3	License	City of Sioux Falls	Irrigation	1.33	123*	3?		21	103N-49W			4/8/1975	Mrs. Dale Swartz	1.33		3	GW	Big Sioux Aquifer:Sioux Falls	Gravel Pack	Land with irrigation permit purchased by City in 2009. License is for "one well." Number of wells and locations uncertain - no well logs.	Not in Document
W2									21	103N-49W			4/8/1975	Mrs. Dale Swartz				GW		Gravel Pack		
W3									21	103N-49W			4/8/1975	Mrs. Dale Swartz				GW		Gravel Pack		
EGC SWI	6210A-3	Permit	City of Sioux Falls	Irrigation	No additional water		1	SE1/4 of SW1/4	6	101N-49W	3981-3		6/6/1977					SW	Big Sioux River	SW Intake	Elmwood Golf Course.	Not in Document
KGC	4231-3	License	City of Sioux Falls - Kuehn GC	Irrigation	0.71	50*	1	NE1/4 of SW1/4	26	101N-50W			2/13/1978					GW	Wall Lake Aquifer?	Gravel Pack	Uncertain if still in use.	Not in Document
EGC #1	5556-3	License	City of Sioux Falls - Elmwood GC	Irrigation	2.13	238*	3	N1/2	7	101N-49W		5556-3	3/21/1991	Sioux Falls	1.42	188	2	GW	Big Sioux Aquifer:Sioux Falls	Gravel Pack	Elmwood Golf Course	Not in Document
EGC #2																		GW		Gravel Pack	Elmwood Golf Course	Not in Document
EGC #3												4232-3	2/13/1978	Elmwood GC	0.71	50	1	GW		Gravel Pack	Elmwood Golf Course	Not in Document
MQ	5242-3	License	City of Sioux Falls	Industrial	1.56	110		SW1/4 of SE1/4	9	101N-49W			9/19/1988					SW	Sioux Quartzite	SW Intake	Dewatering permit, pump water from abandoned Morrell Quarry to Big Sioux River	Yes
DP	5416-3	License	City of Sioux Falls	Irrigation	0.286	20*	1	NE1/4 of SE1/4	23	101N-50W			3/8/1990					GW	Big Sioux Aquifer:Southern Skunk Creek	Gravel Pack	Dunham Park irrigation.	Not in Document
YT SWI	5512-3	License	City of Sioux Falls	Irrigation	0.50	35*	1	SW1/4 of SE1/4	32	101N-49W			2/27/1991					SW	Big Sioux River	SW Intake	No diversion allowed unless there is a minimum flow of 20 cfs must be flowing past the USGS gauging station No. 06482020 at North Cliff Avenue	Not in Document
TP1	5698-3	License	City of Sioux Falls	Irrigation	1.67	117*	3	NW1/4	33	101N-49W		5605-3	12/26/1991	Sioux Falls	1.50	117*	2	GW	Big Sioux Aquifer: South	Gravel Pack	Permit includes both groundwater and surface water sources for irrigating Prairie Green Golf Course and Soccer Fields at Tomar Park.	Not in Document
TP2								NW1/4	33	101N-49W		5605-3	12/26/1991	Sioux Falls			2	GW	Big Sioux Aquifer: South	Gravel Pack		
TP SWI								NW1/4	33	101N-49W		5698-3	7/20/1992	Sioux Falls	2.40	605	1	SW	Big Sioux River	SW Intake	No diversion allowed unless there is a minimum flow of 20 cfs must be flowing past the USGS gauging station No. 06482020 at North Cliff Avenue	
LF	5691-3	License	City of Sioux Falls	Commercial	0.03	21.72	1	SW1/4 of SW1/4	35	101N-51W		5691-3	7/16/1992	Sioux Falls				GW	Wall Lake Aquifer	Gravel Pack	Sioux Falls Sanitary Landfill Well Dust Control and Compost Operation	Not in Document
PP	6157-3	License	City of Sioux Falls	Irrigation	0.17	38	1	NW1/4 of SE1/4	27	101N-49W			11/24/1999					GW	Big Sioux Aquifer: South	Gravel Pack	Pasley Park	Not in Document
WA	7805-3	License	City of Sioux Falls	Irrigation	0.16	24	1	NW1/4 of NW1/4	28	101N-48W			3/1/2013					GW	Sioux Quartzite	Open Hole	Mary Jo Wegner Arboretum	Not in Document

Table A-1. Other City Water Rights not piped to the Water Purification Plant

Well No. or Other ID.	Water Right No.	Water Right Status	Name	Use	Water Right Maximum Diversion Rate	Water Right Diversion Annual Volume	No. of DPs	Water Right Diversion Point Locations			Future Use Permit	Incorp. Permit	Priority Date	Incorp. Permit Name	Incorp. Permit Diversion Rate	Incorp. Permit Diversion Volume	Incorp. Permit No. of DPs	SW or GW	Water Source	DP Type	Comment	Agree with WPP's Water Rights Document?
					(cfs)	(ac-ft/yr)		Quarter Section	Sec	T&R					cfs	ac-ft/yr						
FP	8234-3	License	City of Sioux Falls	Commercial	1.11	803.60	1	NW1/4 of NE1/4	15	101N-50W			8/5/2016					SW	Skunk Creek	SW Intake	Purchased by City - located in dog park at Family Park	Not in Document
Lewis & Clark Connection	7037-3	License	City of Sioux Falls	Municipal			1											GW	Lewis & Clark Regional Water System (Missouri:Elk Point Aquifer)	NA	This authorizes City's connection to Lewis & Clark Regional Water System.	Yes

NOTES:

* annual volume listed for irrigation wells is the amount of acres irrigated and assumes an application rate of 1 ft of water per acre irrigated (i.e. 40 acres = 40 ac-ft/yr)

T&R - township and range
Sec - section
cfs - cubic feet per second
ac-ft/yr - acre-feet per year
Incorp. - Incorporated
WR# - water right number

LAT. - latitude
LONG. - longitude
DP - diversion point
SW - surface water
WPP - Water Purification Plant

Table A-2. CIty of Sioux Falls Cancelled Water Rights and Deferred or Withdrawn Applications

Well No. or Other ID.	Water Right No.	Water Right Status	Use	Water Right Maximum Diversion Rate	Water Right Diversion Annual Volume	No. of DPs	Water Right Diversion Point Locations			Current Use	Future Use Permit	Priority Date	SW or GW	Water Source	DP Type	Comment	Agree with WPP's Water Rights Document?
				(cfs)	(ac-ft/yr)		Quarter Section	Sec	T&R								
8	258-3	Cancelled Vested License	Municipal	0.44	318.55	1	NE1/4	7	101N-49W	Cancelled		1/1/1926	GW	Big Sioux Aquifer:Sioux Falls			Not in Document
8	218-3	Cancelled Vested License	Irrigation	1.55	1,122.15	2		33	101N-49W	Cancelled		1/1/1941	SW	Big Sioux River	SW Intake	Pre-existing irrigation permit transferred to City after City purchased land in 1981. In 1992, WRP cancelled due to non-use/forfeiture.	Not in Document
16	265-3	Cancelled Vested License	Municipal	1.55	1,122.15	1	SE1/4 of NE1/4	5	101N-49W	Cancelled		1/1/1943	GW	Big Sioux Aquifer:Sioux Falls	Bragstad	WRP cancelled license due to abandonment/forfeiture in 1991.	Not in Document
19	268-3	Cancelled Vested License	Municipal	1.00	723.97	1	NW1/4 of NW1/4	9	101N-49W	Cancelled		1/1/1943	GW	Big Sioux Aquifer:Sioux Falls	Gravel Pack	WRP cancelled license due to abandonment/forfeiture in 1991.	Not in Document
22	271-3	Cancelled Vested License	Municipal	1.33	962.88	1	SE1/4 of SW1/4	32	102N-49W	Cancelled		1/1/1948	GW	Big Sioux Aquifer:Sioux Falls	Bragstad	WRP cancelled license due to abandonment/forfeiture in 1991.	Not in Document
WPS #1	254-3	Cancelled Vested License	Municipal	1.55	1,122.15	49	SW1/4 of SW1/4	32	102N-49W	Cancelled		6/1/1955	GW	Big Sioux Aquifer:Sioux Falls	Well Point System	49 wells connected to 8-inch header. License cancelled due to abandonment/forfeiture in 1991.	Not in Document
WPS #2	255-3	Cancelled Vested License	Municipal	1.55	1,122.15	40	NE1/4 of NW1/4	5	101N-49W	Cancelled		6/1/1955	GW	Big Sioux Aquifer:Sioux Falls	Well Point System	40 wells connected to 8-inch header. WRP cancelled license due to abandonment/forfeiture in 1991.	Not in Document
35	1579-3	Cancelled License	Municipal	0.72		1	SE1/4 of SE1/4	29	102N-49W	Cancelled	448-3	4/25/1968	GW	Big Sioux Aquifer:Sioux Falls	Gravel Pack	WRP cancelled license due to abandonment/forfeiture in 1991.	Not in Document
66A	5214-3	Cancelled License	Municipal	1.22	883.30	1	SE1/4 of NW1/4	8	102N-49W	Cancelled	449-3	4/8/1957	GW	Big Sioux Aquifer:Southern Skunk Creek	Gravel Pack	Cancelled in 2010 due to levee construction.	Yes
69A	6214-3	Cancelled License	Municipal	0.78	418.00		WW1/4 of NE1/4	5	102N-49W	Cancelled	448-3	4/8/1957	GW	Big Sioux Aquifer:Sioux Falls	Gravel Pack	Entire diverrsion authority (0.78 cfs, 418 ac-ft/yr) transferred to #7170-3	Yes
DC-1	1306-3	Cancelled License	Municipal	6.20	4,488.60	1	NW1/4 of NW1/4	9	101N-49W	Cancelled		9/8/1966	GW	Big Sioux Aquifer:Sioux Falls	SW Intake	Entire diversion authority transferred to WR #7170-3 (#69) & WR #7232-3 (#62). Cancelled in 2012	Yes
	1947-3	Cancelled License	Suburban Housing Dev.	0.33		>1	NE1/4	32	102N-49W	Cancelled		6/23/1972	GW	Big Sioux Aquifer:Sioux Falls	Treated water from WPP	Intended to provided treated water from City to EROS Data Center. Cancelled after Minnehaha Community Water System began serving the facility.	Yes
40	3587-3	Cancelled Permit	Municipal	3.1	2,244.30		SW1/4	4	101N-49W	Cancelled		2/18/1977	GW	Big Sioux Aquifer:Sioux Falls	Monitoring Well	Well was never constructed and permit cancelled for non-construction in 1981.	Yes
Sand Point System	3588-3	Cancelled Permit	Municipal	18.60	13,465.79		Five "Sand-Point" Systems near Diversion Canal near Airport			Cancelled		2/18/1977	GW	Big Sioux Aquifer:Sioux Falls	Sand Points	Permit cancelled due to non-use in 1981.	Not in Document
41	3589-3	Cancelled Permit	Municipal	3.1	2,244.30		SW1/4	4	101N-49W	Cancelled		2/18/1977	GW	Big Sioux Aquifer:Sioux Falls	Monitoring Well	Well was never constructed and permit cancelled for non-construction in 1981.	Yes
	3980-3	Deferred	Municipal							Deferred			SW	Slip Up Creek		Approved by Legislature, even though recommended for denial by then State Water Commission.	Not in Document
	5202-3	Cancelled Permit	Municipal	4.60	552		NE1/4 NE1/4 Section 32 and SE1/4SE1/4 Section 29, in 102N-			Cancelled		6/24/1988	SW	Big Sioux River and Silver Creek	SW Intake	Emergency supply during Summer of 1988, pumped SW into raw water transmission line.	Yes

Table A-2. CIty of Sioux Falls Cancelled Water Rights and Deferred or Withdrawn Applications

Well No. or Other ID.	Water Right No.	Water Right Status	Use	Water Right Maximum Diversion Rate	Water Right Diversion Annual Volume	No. of DPs	Water Right Diversion Point Locations			Current Use	Future Use Permit	Priority Date	SW or GW	Water Source	DP Type	Comment	Agree with WPP's Water Rights Document?
				(cfs)	(ac-ft/yr)		Quarter Section	Sec	T&R								
67	5213-3	Cancelled License	Municipal	1.42	1,028.03	2	SW/14 of NE1/4	36	102N-49W	Cancelled		8/18/1988	GW	Split Rock Creek Aquifer	Drilled	City forfeited water rights. Wells likely still exist.	Yes
68							SE1/4 & SW1/4	36	102N-49W	Cancelled		8/18/1988	GW	Split Rock Creek Aquifer	Drilled		Yes
	8356-3	Cancelled Permit	Geothermal	0.33	38.9	4	NW1/4 of SW1/4	16	101N-49W	CDF		5/9/2018	GW	Sioux Quartzite	Open Hole	City ceased useage - no mention of why, but likely due to operational problems.	Not in Document
	8399-3	Withdrawn FUPA	Municipal	11.61	4,142.88	10	Various locations within townships 103N-50W, 102N-49W, and 101N-			Withdrawn by City			GW	Split Rock Creek Aquifer		City rescinded after learning from Water Rights Program that aquifer is nearly fully appropriated.	Not in Document
201P	5521-3	Withdrawn Permit Application	Municipal	1.34	720.0	1	NE1/4 of SW1/4	28	102N-49W	Withdrawn by City		5/9/2018	GW	Big Sioux Aquifer:Sioux Falls		Withdrawn. Significant number of intervenors.	Not in Document
202P	5533-3	Withdrawn Permit Application	Municipal	0.78	480.0	1	NE1/4 of SW1/4	28	102N-49W	Withdrawn by City	448-3		GW	Big Sioux Aquifer:Sioux Falls		Withdrawn. Significant number of intervenors.	Not in Document
	5699-3	Withdrawn Permit Application	Irrigation	2.40	170.0	1	NE1/4 of NW1/4	16	101N-49W	Withdrawn by City			SW	Skunk Creek		WRP had concerns of transporting water through creek and river for 10 miles. City withdrew application.	Not in Document

NOTES:

Annual volume limits shown without decimal fraction indicate that the limit shown is specified in the permit or license. Those shown with a decimal fraction are calculated from the diversion rate assuming continuous pumping.

T&R - township and range
Sec - section
cfs - cubic feet per second
ac-ft/yr - acre-feet per year
WR# - water right number
WRP - Water Rights Program

LAT. - latitude
LONG. - longitude
DP - diversion point
SW - surface water
GW - groundwater

Gravel Pack - vertical well with screen and filter pack
HCW - horizontal collector well
Bragstad - large diameter well with no screen
FUPA - future use permit application
WPP - water purification plant

Technical Memorandum

Water Supply and Treatment Master Plan

Chapter 2:

Well Condition Assessment

November 2022

HR Green Project No: 210506

Prepared For:

CITY OF
SIOUX FALLS

Table of Contents

List of Figures

List of Tables

Appendices

Section 1: Introduction

The purpose of the well condition assessment (WCA) is to provide the City with a recommendation regarding which wells to recondition and which wells to abandon and replace, along with recommended reconditioning methods. An additional purpose is assessing the sizing, Hazen-Williams roughness coefficient, and material of the raw water transmission infrastructure (RWTI) associated with each well, and using the data obtained from the assessment along with each well's historical withdrawal rates to provide recommendations for modifications to the RWTI and well pumping equipment (WPE).

The City has a total of three well fields located in two different aquifers; the Big Sioux:Sioux Falls (BS:SF) aquifer, and the Big Sioux:Middle Skunk Creek (BS:MSC) aquifer. The City's 66 wells are categorized into the following three well types: 1) horizontal collector well (HCW), 2) vertical well with a manufactured screen enclosed in an engineered filter pack (gravel pack well), and 3) a relatively large diameter (40 feet) concrete casing sunk into the aquifer with an open bottom and no well screen (Bragstad well).

The City has two well fields located in the BS:SF aquifer. The Airport Well Field consists of 21 wells (gravel packs, HCWs, and Bragstads) completed within or near the boundaries of the airport shared by the City and the Air National Guard (Sioux Falls Regional Airport/Joe Foss Field). The North Well Field consists of 32 wells (gravel packs, HCWs, and Bragstads) completed in a portion of the BS:SF aquifer that is located north of the Airport Well Field. These 32 wells include two wells that are not included in this condition assessment: 1) new HCW #72, and 2) gravel pack well #45, which the City had already decided to abandon.

The City has one well field located in the BS:MSC aquifer, that is referred to as the Middle Skunk Creek Well Field. There are 13 gravel pack wells in the Middle Skunk Creek Well Field. The locations of the well fields are shown in Figure 1.

1-1 Project Approach

Information utilized in the WCA was obtained from records provided by the City along with information obtained from two South Dakota Department of Agriculture and Natural Resources (DANR) online databases (water rights and well completion reports). This information was utilized to develop well performance metrics (WPMs) for the following three groupings of wells and well fields: 1) the HCWs in the North Well Field, 2) the gravel pack and Bragstad wells in the North Well Field; and 3) the gravel pack wells in the Middle Skunk Creek Well Field. Due to water quality impacts associated with per-and polyfluoroalkyl substances (PFAS) at the Airport Well Field, the 21 wells in the Airport Well Field were not included in the WCA.

Because the amount and quality of information varies between the well fields and the well types, information compiled for the WCAs (Tables 1a, 2a, and 3a) for each of the three well types and well field groupings differ. Average values (bottom row of the WCA tables) calculated for each specific well type within the well field were utilized to determine the WPMs. An attempt was made to utilize a fairly large number of different WPMs to reduce the impacts of the varying amount and quality of available data. The WPMs are included in the three different well recondition decision (WRD) matrices (Tables 1b, 2b and 3b) developed for each well type and well field grouping. The intent in constructing the WRD matrices was to utilize as much information as reasonably possible thereby enabling the decision to recondition or replace a well to be based on quantifiable data.

Information utilized in the RWTI and the WPE evaluations was also obtained from records provided by the City along with the calibrated well field model. The Calibrated well field model is discussed in-depth within the Water Transmission Mains Technical Memorandum (HRG, et. al.., 2022). The information was used to determine where the RWTI fit within the parameters specified below.

- Raw water transmission main velocities less than 2 feet per second (fps) are recommended to be cleaned and considered for decreasing the main diameter.
- Raw water transmission main velocities between 6 fps and 2 fps are considered ideal.
- Raw water transmission main velocities greater than 6 fps are recommended to be considered for increasing the main diameter.
- Raw water transmission main's less than 16-inch diameter with headloss greater than 7 feet per thousand feet and a Hazen-Williams roughness coefficient less than 100 are recommended to be cleaned or rehabilitated. If the Hazen-Williams roughness coefficient is significantly less than 100, it is recommended to rehabilitate the main.

The WPE was evaluated based on historical well withdrawal rates, variations in seasonal withdrawal rates, City provided pump curves, percent of throttled flow as reported with each well's specific capacity checks, and status of WPE from the City well service logs. This data was considered when recommending if improvements should be considered along with what type of improvements. The results of the RWTI and WPE condition assessment for the three well types and well field groupings are summarized in Tables 1c, 2c, and 3c.

The historical electrical efficiency for each well within the well field was also summarized as gallons of raw water withdrawal per kilowatt hour (KWH) energy use. The electrical efficiency was also grouped into efficiency per each type of well. The results of the electrical efficiency are summarized in Tables 5a and 5b.

Over the years the City has utilized varied methods to recondition or rehabilitate a well to improve the yield. These methods are collectively referred to as "treatment" in Tables 1 through 3. The types of treatment employed are discussed briefly for each well type and well field grouping.

1-2 Reasons for Decreased Well Performance

Excluding pump performance or raw water transmission hydraulics, reduced well yield is caused by one or more of the following three factors: 1) plugging of the well screen, 2) plugging of the pore spaces in the filter pack, or 3) plugging of the pore spaces in the aquifer matrix near the well. It is common for all three to incrementally occur simultaneously over time, and this is referred to generally as "well plugging."

Well plugging can be separated into three different categories (Mansuy, 1999): 1) physical or mechanical blockage, 2) bacteriological plugging or biofouling; and 3) mineral encrustation. Mechanical blockage is caused by the transport and accumulation of silt and sand particles, which can be exacerbated by high well entrance velocities. The recommended maximum limit for the average entrance velocity into a traditional vertical well (gravel pack well) is 6 feet per minute (ft/min), or 0.1 feet per second (Driscoll, 1986). This entrance velocity limit is also cited in the South Dakota Well Construction Standards (Administrative Rules of South Dakota, Chapter 74:02:04:51). For a HCW, a lower entrance velocity is recommended, typically 1 to 2 ft/min. Entrance velocities greater than these recommended limits can be caused by improper well design, improper pump sizing, or by incremental well plugging, which decreases the open areas through which water can be transmitted into the well, thereby requiring greater entrance velocities through the remaining pore spaces to maintain a design pumping rate.

Biofouling is the plugging caused by the bacteria-produced films and slimes accumulating in the screen, filter pack or aquifer matrix openings, and the plugging is often exacerbated by the entrapment of fine-grained sediments by those films and slimes. Well plugging caused by biofouling is common in shallow alluvial aquifers. It has been estimated that as much as 80% of well problems are caused by biofouling (Mansuy, 1999). The results of testing by HDR in 1989 (HDR, 1991) indicate a nearly universal distribution of slime-forming bacteria and iron-reducing bacteria in City wells located in both the Airport and North well fields.

Mineral encrustation is caused by chemical precipitation of minerals due to equilibrium changes in the dissolved gases and constituents in the groundwater induced by pumping. Deposits caused by mineral encrustation include iron, calcium carbonate, and magnesium carbonate deposits (Mansuy, 1999).

The term well reconditioning in this Tech Memo refers specifically to removing the substances that are causing the well plugging. Well reconditioning as used herein as has also historically been referred to in the industry as “well rehabilitation.”

Section 2: HCWs in the North Well Field

Information compiled for the WCA for the HCWs in the North well field is summarized in Table 1a. There are 13 HCWs in the North well field. Three of the 13 HCWs were constructed in the late 1950’s (#31, #32, and #33) and six of the 13 HCWs were constructed in the mid to late 1970’s and in 1980 (#36, #37, #38, #39, #46 and #47). These nine HCWs have been retrofitted with a second set of lateral screens (laterals), and the information in Table 1a is for the time period after the second set of laterals were installed. Four of the 13 HCWs were constructed in the 2000’s (#62, #69, #70, and #71). Each of these four HCWs are operating with the originally installed laterals.

An underlying assumption for the HCWs WRD Matrix is that the City will not choose to abandon an existing HCW. For this reason, the WRD Matrix for the HCWs has only two decision categories: 1) recondition, or 2) monitor performance.

2-1 WCA for the HCWs in the North Well Field

The WCA information in Table 1a includes information in the following four categories: 1) construction details, 2) hydrogeology, 3) yield history, and 4) maintenance history. Construction details include diameter of the laterals, depth to the top of the laterals, and number of laterals. Construction details including drawings showing the orientation of the laterals and information regarding the soil profile at the well are provided in Appendix A.

Information regarding the hydrology includes the saturated thickness and static water level (when the well was constructed) and the aquifer transmissivity determined from aquifer pumping tests. The yield history includes the reported yield when the well was constructed, the most recent average monthly yield (sometime during 2021 for all except HCW #33), and the average monthly yield during the period from January 2016 through November 2021 (hereinafter simply referred to as “2016 to 2021”). The most recently measured specific capacity is compared to the specific capacity determined from performance tests conducted when the current laterals where installed. The average values for the applicable construction, hydrogeology and yield information are also shown in Table 1a.

The primary maintenance affecting yield for a HCW is cleaning the laterals (removing accumulated sediment and biofilm) and pump maintenance. Cleaning the laterals is accomplished by isolating the lateral and removing the sediment (and biofilm) by inserting a jetting tool into the lateral and pumping water under high pressure into the lateral while simultaneously removing the water from the caisson. This removes the sediment accumulation in the laterals. Surging is accomplished by isolating a lateral (closing the valves of all but one of the laterals), then cycling the pump on and off, which causes the water level in the HCW to rise and fall (surge). Surging removes sediment from the laterals, but not as effectively as high-pressure jetting with simultaneous pumping. The pumps are manually cleaned by removing the pump from the HCW caisson and cleaning the impellers. The approximate dates when the laterals were cleaned or surged, and when the pumps were cleaned or replaced, are shown in Table 1a.

2-2 WPMs for the HCWs in the North Well Field

The four WPMs developed for the HCWs consist of apparent yield reduction, specific capacity reduction, average monthly yield from 2016 to 2021, and the rate of yield reduction. Each of these WPMs is included in Table 1a.

The apparent yield reduction was calculated by comparing the yield measured when the current generation of laterals was installed with the most recent average monthly yield. This WPM is termed “apparent” yield reduction in recognition that there is some error in the value. The data for the yield when the laterals were installed are from performance testing (usually over a period of 24 to 72 hours) after the laterals were installed. The average monthly yield was determined from 71 months (January 2016 to November 2021) of average monthly yields as recorded by the City. These average monthly yields are measured over a longer period of operation than are the installed yields; consequently, the two yields are not compared under the same operating conditions, which is the reason for the term “apparent” yield reduction. The apparent yield reduction for the 13 HCWs ranges from 37% (HCW #69) to 74% (HCW #47), with an average apparent yield reduction of 48%.

The specific capacity reduction was calculated by comparing the specific capacity measured when the current generation of laterals was installed with the most recently measured specific capacity. For HCW #31 and HCW #62, the most recent specific capacity is greater than the specific capacity measured when the laterals where installed. Typically, this is not the case and may indicate an error in one or both of the reported values; therefore, the specific capacity reduction values for HCW #31 and HCW #62 were not included in the average shown in Table 1a. No specific capacity data for when the laterals were installed in HCW #38 and #39 were identified in the information reviewed. Consequently, the specific capacity information from HCW #38 and HCW #39 are not included in the average specific capacity reduction value. The specific capacity reduction ranges from 11% in HCW #69 to 75% in HCW #46, with an average of 41%.

The average monthly yield values shown in Table 1a for the period from 2016 to 2021 do not include data from months when the well was not in operation. In other words, the average monthly yields shown in Table 1a were calculated only from those months that the well was in operation. For example, for HCW #71, there are 31 months when the well was not operated (likely due to relatively low static water levels). Those 31 months where the average monthly yield is indicated as 0 gpm are not included in the average monthly yield of 1,558 gpm reported for HCW #71 in Table 1a. The average monthly yield for the HCWs ranges from 711 gpm for HCW #33 to 1,558 gpm for HCW #71. The average monthly yield for the HCWs is 901 gpm.

The average monthly yield data for 2016 to 2021 were plotted versus time, and a linear trendline was applied to the data as a measure of the rate of change in yield. The slope of the trendline is recorded in Table 1a. The linear trendline slopes range from -21.89% (HCW #71) to +1.86% (HCW #36), with the average slope of -8.87%. Copies of the yield trendline graphs are provided in Appendix B.

2-3 WRD Matrix for HCWs in the North Well Field

The WRD Matrix for the HCWs in the North Well Field is provided in Table 1b. The WPMs in the WRD Matrix are designed to indicate those HCWs exhibiting the greatest degree of performance degradation. The WRD Matrix is comprised of one question with a yes or no answer; is the WPM for a particular HCW less than the average value for that WPM? The yes and no answers are tallied. A greater percentage of yes answers favors reconditioning. According to the WRD Matrix, the HCW in most need of reconditioning is HCW #47. The HCWs with the least amount of performance degradation are HCW #62 and HCW#69, which are the two “newest” HCWs.

The City has indicated that an approximate schedule for HCW reconditioning is two HCWs per calendar year. Those HCWs for which the reconditioning is recommended are prioritized with a numerical ranking (Table 1b), with #1 indicating the highest priority (recondition soonest) and #6 indicating the lowest priority (recondition later).

2-4 HCW Reconditioning Methods

This discussion on recondition methods is focused on the laterals. The City has historically employed three general methods for reconditioning a HCW lateral (Method #1, Method #2, and Method #3), all of which are designed to remove, by mechanical methods, the sediments blocking or plugging the screen openings. Method #1, the highest level of reconditioning requiring the greatest level of effort and greatest cost, consists of installing new laterals within the caisson. Method #2, the second level of reconditioning, consists of high-pressure jetting of the lateral while simultaneously pumping the heavily sediment-laden water from the caisson to waste. Method #3, the third and lowest level of reconditioning, consists of isolating a lateral and surging water in the lateral by alternately turning the HCW pump on and off, and pumping that water to waste. The City typically performs Methods 2 and 3 using City employees and City-owned equipment. The City hires a contractor to install new laterals under Method #1.

As previously indicated, nine of the HCWs (#31, #32, #33, #36, #37, #38, #39, #46 and #47) have been reconditioned by adding new laterals. In all nine cases, the old laterals were abandoned, and the new laterals were installed at a slightly higher elevation within the caisson. Some caissons have spare ports, which are holes in the concrete caisson wall through which a new lateral can be installed. By examining the spacing of the existing laterals, and considering those HCWs with spare ports, it appears that 10 of the 13 HCWs have space for additional laterals. The estimated number of laterals that could potentially be added if Method #1 is employed as a reconditioning method is shown in Table 1b. Please note that these estimates are based on the drawings provided in Appendix A, and a detailed inspection of the HCW caisson is recommended before deciding on adding laterals to an existing HCW.

2-5 Raw Water Transmission Infrastructure at the HCWs

Areas of improvement have been identified for the existing RWTI for the HCWs. Two of the HCWs (#36 and #47) experience velocities of less than 2 fps during an average historical withdrawal rate. To increase the main velocity above 2 fps to help push sediment buildup within the pipe, Table 1c provides the recommended minimum withdrawal rate to achieve a velocity greater than 2 fps. Four of the HCWs (#31, #32, #33, and #38) have high velocities and in some instances high headloss as a result of low Hazen-Williams roughness coefficients. All four of these HCWs mains are also impacted by proposed new HCWs. It is at that time that the proposed new HCWs are installed that the existing RWTI be upsized. Two of the HCWs (#37 and #46) have velocities within the ideal range but indicate a high headloss from low Hazen-Williams roughness coefficients. It is assumed that the mains have sediment and buildup within the mains which could be restricting pipe internal diameter and/or increasing the roughness of the pipe interior. Both HCW #37 and #46 are recommended to be cleaned and have the RWTI pressures check. If the pressure and headloss stays elevated the mains should be considered for rehabilitation or replacement.

All of the HCWs have VFD driven pumps, which is beneficial to the operation of the wells with the overall seasonal withdrawal needs of the wellfield. Well #36 has a steep pump curve that exhibits significant change in pumping rate from the small variations in system pressure. A pump with a flatter pump curve should be considered to help improve the wells' operation. Well #38 has experienced limitations from high pump amp draw but the well itself is capable of higher withdrawal rates. The well service and electrical components should be checked for available pump motor horsepower and a new pump with higher withdrawal rates should be considered. After reconditing of Well #39, the withdrawal rate and main pressure should be compared to the existing pump curve to determine if a larger pump is needed. Wells #46 and #47 have pumps with pump curves that appear to exceed the total dynamic head at the pumps and may operate outside of the ideal pumping range on the pump curves. These wells should have pumps considered with pump curves that closer match the hydraulics experienced at the pumps. Well #70 is known to over pump during dryer climatic conditions. After the well is reconditioned and over pumping still occurs, consideration should be given to modifying the bowl assembly to better match the withdrawal rate at dry conditions.

The results of the condition assessment of the RWTI and WPE at the HCWs in the North Well Field are summarized in Table 1c. Additional evaluation of the RWTI is provided in the Water Transmission Mains Technical Memorandum (HRG, et. al, 2022).

The historical electrical efficiency of HCWs is the highest of the three well types with average of 2,088 gallons per KWH and a median rate of 2,015 gallons per KWH. The electrical efficiency for each well for the period from 2015 to 2021 (excluding 2018) is summarized in Tables 5a and 5b.

Section 3: Gravel Pack Wells in the North Well Field

Information compiled for the WCA for the 15 gravel pack wells and one Bragstad well located in the North Well Field is summarized in Table 2a. The raw water transmission lines from five of the gravel pack wells (#54 through #58, inclusive) are manifolded at a single facility referred to as the FivePack facility. The raw water transmission lines from six of the gravel pack wells (#48 through #53, inclusive) are manifolded at a single facility referred to as the SixPack facility. The City has indicated that the equipment at the FivePack and SixPack facilities (controls, valves, etc.) is generally in good condition. Gravel pack wells #42, #43 and #44 are located adjoining the west bank of the irrigation ditch referred to as the Big Ditch. The single Bragstad well (Well #26) was constructed in approximately 1951.

The WRD Matrix developed for the North Well Field gravel pack and Bragstad wells utilizes WPMs and the construction details and hydrogeology at the well site to make one of three decisions: 1) the well is suitable for reconditioning; 2) the well is not suitable for reconditioning and should be replaced; and 3) the well requires further assessment prior to deciding on reconditioning or replacing.

3-1 WCA for Gravel Pack and Bragstad Wells in the North Well Field

The WCA information in Table 2a includes information in the following four categories: 1) construction details, 2) hydrogeology, 3) yield history, and 4) maintenance history. Construction details include diameter and slot opening size of the screen and the screen depth interval. Copies of the well completion reports (well logs) are provided in Appendix C.

Information regarding the hydrology includes the saturated thickness and static water level (when the well was constructed) and the aquifer transmissivity determined from aquifer pumping tests. The yield history includes the reported yield when the well was constructed, the average monthly yield during the period from 2016 to 2021, the average yield during the period from 1991 to 2012, and the average yield reported for the well in 1989 (HDR,1991). The specific capacity determined from performance tests conducted when the well was constructed are compared to the most recently measured specific capacity. The average values for the applicable construction, hydrogeology and yield history information are shown in Table 2a.

The maintenance history for the gravel packs appears to consist mostly of periodic cleaning of the pumps with occasional reconditioning of the well screen with acid treatment or hydroblasting (application of high-pressure water and air to scour the screen and remove sediment). In 1991, the FivePack and SixPack facility wells were treated with the application of acid. Wells #42 and #44 were treated with acid in 1989, and Well #43 was treated with acid in 1992. In 2018, there was a significant effort expended on the FivePack and SixPack facility wells, during which the wells were hydroblasted and fitted with new pumps and pump motors.

3-2 WPMs for the Gravel Pack and Bragstad Wells in the North Well Field

WPMs developed from yield history, specific capacity reduction, and treatment improvement, were assigned for the 16 wells. An average for each WPM was calculated based on the data from the wells. The yield history is from three periods: 1) 2016 to 2021, 2) 1991 to 2012, and 3) 1989. The specific capacity reduction compares the original specific capacity with the most recently determined specific capacity. For those periods when it is possible to determine the yield of the well before and after treatment, the percent improvement in yield after treatment was calculated. Each of these WPMs is included in Table 2a along with the average values calculated from the 16 wells.

3-3 WRD Matrix for Gravel Pack and Bragstad Wells in the North Well Field

The WRD Matrix for the gravel pack wells in the North Well Field is provided in Table 2b. The WRD Matrix is designed to determine if factors from the well construction, hydrogeology, WPMs, and maintenance history suggest that the well is a suitable candidate for reconditioning. There are 12 questions in the WRD Matrix and a yes answer favors reconditioning while a no answer favors abandonment and replacement. For example, inducing movement of fluids in two directions (in and out of the well screen and filter pack) is easier in a well with a larger slot size opening compared to a well with a smaller slot size opening, therefore, the WRD Matrix favors wells with larger slot size openings for reconditioning.

Based on the WRD Matrix, it is recommended that eight wells be abandoned and replaced, six wells be reconditioned, and two wells (Well #26 and Well #44), due to a relative lack of data, be further assessed. The additional assessment recommended for Well #26 is a detailed evaluation of the current yield capability. Due to the nearly equal number of yes and no responses in the WRD Matrix for Well #44, it is recommended that the effectiveness of the well reconditioning of Well #42 be used as a deciding factor on whether to recondition or replace Well #44.

3-4 Recommended Reconditioning Protocol for Gravel Pack & Bragstad Wells

The recommended protocol for reconditioning a Bragstad well consists of three general tasks: 1) assess condition of pumping equipment, 2) assess condition of concrete caisson and well house, and 3) assess amount of aquifer matrix that has moved up into the bottom of the well. If the amount of sand, gravel and fines has accumulated to a height in the well that results in the well pumping sediment, the material at the bottom of the well can be removed with a clamshell. The City is currently operating only one Bragstad well (Well #26). As indicated previously, further evaluation of Well #26 current yield capability is recommended.

A recommended protocol for reconditioning the gravel pack wells is provided in Table 4. The protocol consists of three principal tasks; Task #1 - preparation and well screen assessment (Table 4, Items 1 through 6), Task #2 - well reconditioning (Table 4, Items 7, 8 and 9), and Task #3 - post-reconditioning performance monitoring (Table 4, Items 10 and 11).

Task #1 consists of preparing the well site for handling the wastes produced by the reconditioning in an efficient and environmentally appropriate manner and inspecting the well screen and casing. If there is significant corrosion of the screen or casing, it is recommended that the well be abandoned and replaced. Task #2 is the well reconditioning, including physical and chemical methods for removing biofilm and sediment. Task #3 documents the efficacy of the reconditioning and includes monitoring the well performance for the purpose of scheduling additional well maintenance activity or possibly scheduling well replacement.

3-5 Raw Water Transmission Infrastructure for the North Well Field Gravel Pack & Bragstad Wells

The velocities of the existing raw RWTI for the gravel packs and Bragstad wells mainly operate within the ideal range or below 2 fps. As discussed with the HCWs, the main velocity should be operated above 2 fps to help push sediment buildup within the pipe, Table 2c provides the recommended minimum withdrawal rate to achieve a velocity greater than 2 fps. The gravel packs wells with RWTI velocities under 2 fps are #42, #44, #50, #51, #52, #53, and #54. Bragstad well #26 has a high headloss from a low Hazen-Williams roughness coefficient for the main and is impacted by a proposed new HCW. It is at that time that the proposed new HCW is installed that the existing RWTI be replaced. Gravel pack well #53 should have the RWTI cleaned every few years if the well is incapable of producing withdrawal rates of 310 gpm for a period of time. This withdrawal rate is needed to increase the main velocity above 2 fps. Well #53 is also potentially impacted by the recommended replacement of the FivePack facilities.

WPE improvements such as adding a VFD to the pump motor would benefit well #26. New pumps and drives would also benefit Wells #43 and #5, however, both of these wells are recommended to be replaced and will have new pumping equipment and hydraulics at the time of replacement, so it is recommended to defer WPE changes at this time. The results of the condition assessment of the RWTI and WPE associated with the gravel pack and Bragstad Wells in the North Well Field are summarized in Table 2c. Additional evaluation of the RWTI is provided in the Water Transmission Mains Technical Memorandum (HRG, et. al, 2022).

The historical electrical efficiency of gravel pack wells is the lowest of the three well types with average for the North Well Field Wells of 1,102 gallons per KWH and a median rate of 1,069 gallons per KWH. The Bragstad Wells are in the middle of the three well types in terms of electrical efficiency with an average of 1,501 gallons per KWH and a median rate of 1,445 gallons per KWH. The historical electrical efficiency for each well during the period from 2015 to 2021 (excluding 2018) is summarized in Tables 5a and 5b.

Section 4: Wells in the Middle Skunk Creek Well Field

Information compiled for the WCA for the 13 gravel pack wells located in the Middle Skunk Creek well field is summarized in Table 3a. All but Well #110 were constructed by Layne Christenson Company in 1993. Well #110 is a former private irrigation well that was transferred to the City (along with the water right) when the City purchased the property on which the well is located.

4-1 WCA for Middle Skunk Creek Well Field Gravel Pack Wells

As with the gravel pack wells in the North well field, the WCA information in Table 3a includes information in the following four categories: 1) construction details, 2) hydrogeology, 3) yield history, and 4) maintenance history. Construction details include screen diameter, screen slot size opening, and the screen depth interval. Information regarding the hydrology includes the saturated thickness and static water level (when the well was constructed). The yield history includes the yield when the well was constructed, the average monthly yield during the period from 2016 to 2021, and the average yield during the period from 1991 to 2012. The average values for the applicable construction, hydrogeology and yield history information are shown in Table 3a.

The maintenance history of the Middle Skunk Creek gravel pack wells varies somewhat among the individual wells, but an overall summary is provided herein. The Middle Skunk Creek gravel pack wells have been treated with acid (the type and strength of acid is not indicated in the well service record file provided to LRE). The three main acid treatment programs were conducted in 2009, 2015 and 2020. The MSC gravel pack wells were shock chlorinated in 2003, 2004 and 2005, and were hydro-blasted (jetted with high-pressure air and water) in 2015 and 2019. Where the data allow, the improvement in well yield after treatment is shown in Table 3a.

4-2 WPMs for the Middle Skunk Creek Gravel Pack Wells

WPMs based on yield history, specific capacity reduction, and treatment improvement, were assigned for the 13 wells and an average value for each WPM was calculated. The yield history includes average and maximum values from four periods: 1) yield when constructed, 2) monthly maximum yield from 2016 to 2021, 3) average monthly yield from 2016 to 2022, and 4) average yield from 1991 to 2012. The specific capacity reduction compares the original specific capacity with the most recently determined specific capacity. For those periods when it is possible to determine the yield of the well before and after treatment, the percent improvement in yield after treatment was calculated.

4-3 WRD Matrix for Middle Skunk Creek Gravel Pack Wells

The WRD Matrix for the gravel packs wells in the Middle North Well Field is provided in Table 3b. The WRD Matrix is designed to determine if factors from the well construction, hydrogeology, WPMs, and maintenance history suggest that the well is a suitable candidate for reconditioning. There are 11 questions in the WRD Matrix and a "yes" answer favors reconditioning while a "no" answer favors abandonment and replacement. For example, inducing movement of fluids in two directions (in and out of the well screen and filter pack) is easier in a well with a larger slot size opening compared to a well with a smaller slot size opening, therefore, the WRD Matrix favors wells with larger slot size openings for reconditioning.

Based on the WRD Matrix, it is recommended that six wells be abandoned and replaced, five wells be reconditioned, and two wells (Well #103 and Well #113 be further assessed.

4-4 Recommended Reconditioning Protocol for Middle Skunk Creek Wells

The recommended protocol for reconditioning the Middle Skunk Creek gravel pack wells is the same protocol recommended for the gravel pack wells located in the North Well Field (Table 4). While it is likely that the groundwater geochemistry and microbial population in the Middle Skunk Creek Well Field differ somewhat from the North Well Field, it is likely that slime and iron reducing bacteria are present in significant quantities in the Middle

Skunk Creek aquifer. Consequently, the protocol in Table 4 is suitable for reconditioning a Middle Skunk Creek gravel pack well. It is recommended that the protocol in Table 4 be utilized to guide the reconditioning of Well #112. If the yield improvement is deemed suitable (greater than 100%), then the same protocol can be used for reconditioning other Middle Skunk Creek gravel pack wells. If the reconditioning of Well #112 using the protocol outlined in Table 4 is deemed ineffective, it can be revised.

4-5 Raw Water Transmission Infrastructure for the Middle Skunk Creek Wells

The velocities of the existing RWTI for the gravel packs mainly operates within the ideal range or below 2 fps and in some instances significantly below 2 fps (noted as oversized mains). As discussed with the HCWs, the main velocity should be operated above 2 fps to help push sediment buildup within the pipe, Table 3c provides the recommended minimum withdrawal rate to achieve a velocity greater than 2 fps. The gravel packs wells with RWTI velocities under 2 fps and do not have oversized mains are #101, #103, #109, and #114. Wells #102, #104, #105, #110, #111, and #112 have oversized mains and are unable to reach velocities of 2 fps or greater with the current well withdrawal rates. All of these wells are recommended to be either reconditioned or replaced. The RWTI velocities should be re-evaluated after the recommended reconditioning or replacement. In the meantime, the RWTI for these wells should be cleaned ever couple of years in an effort to remove sediment buildup.

All of the Middle Skunk Creek Wells have VFD driven pumps, which is beneficial to the operation of the wells with the overall seasonal withdrawal needs of the wellfield. After reconditioning of Middle Skunk Creek well #101, the withdrawal rate and main pressure should be compared to the existing pump curve to determine if a larger pump is needed. Wells #102, #104, #105, and #111 would all benefit from consideration for new pumps; however, these wells are recommended to be replaced and will have new pumping equipment and hydraulics at the time of replacement, no WPE changes are recommended at this time. Well #113 should have the hydraulics evaluated with new pump curves to determine if a smaller horsepower pump and motor assembly is capable of meeting the withdrawal rates. The results of the condition assessment of the RWTI and WPE associated with the Middle Skunk Creek Wells is summarized in Table 3c. Additional evaluation of the RWTI is provided in the Water Transmission Mains Technical Memorandum (HRG, et. al., 2022).

The historical electrical efficiency of gravel pack wells is the lowest of the three well types with average for the Middle Skunk Creek Wells of 504 gallons per KWH and a median rate of 445 gallons per KWH. The result of the historical electrical efficiency is summarized in Tables 5a and 5b.

Section 5: Reconditioning and Replacement Prioritization

This section provides a discussion of the overall recommended reconditioning and replacement prioritization for the entire well field. The HCWs typically have the highest production values and have the highest historical electrical efficiency of the three types of wells. For those reasons the HCWs are prioritized over the gravel pack and Bragstad Wells. As discussed previously in this tech memo, the HCWs have a reconditioning prioritization provided in Table 1b. The gravel pack and Bragstad Wells reconditioning and replacement prioritization along with the HCWs is listed in Table 6. Table 7 summarizes the opinion of cost for the improvements within the 10- year planning period.

Section 6: Recommended Non-Construction Projects

To assist the City with evaluating future needs, the following studies are recommended:

- Structural evaluation of HCW's including caissons, walkways, beams, and well house structures

- Electrical service evaluation at individual wells
- SCADA review and conversion from radio telemetry to fiber
- Optimization of pump hydraulics in raw water transmission main

Section 7: References Cited

Driscoll, Fletcher G., 1986. Groundwater and Wells, 2nd Edition, Johnson Filtration Systems, Inc., St. Paul, MN 55112.

HDR Engineering, Inc., 1991: Big Sioux Aquifer Study, Part 1 Evaluation of Existing Well Field, July 1990, and Part 2 Future Well Field Development, February 1991, prepared in association with Layne GeoSciences, Inc. and Stockwell Engineers, Inc.

HRG, LRE, & Carollo, 2022. Water Transmission Mains Technical Memorandum, Water Purification Master Plan.

Mansuy, Neil, 1999. Water Well Rehabilitation: A practical guide to understanding well problems and solutions CRC Press LLC, 2000 Corporate Blvd., N.W., Boca Raton, Florida 33431.

Figure

Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community

HRGreen

In collaboration with:

carollo

LRE WATER
CONNECTING WATER TO LIFE

Figure 1
Existing Wells & Water Mains

N
W
E
S

0 1 2
Miles

1 inch = 1.25 miles

Tables

Table 1a. Condition Assessment
North Well Field Horizontal Collector Wells - Page 1 of 2

Well	Year Placed in Operation	Screen Diameter	Saturated Thickness	Number of Lateral Screens	Depth to Top of Screen	Static	Year Current Laterals Installed	Yield When Laterals Installed	Specific Capacity (When Laterals Installed)	Available Drawdown	Theoretical Yield New	T (from Pumping Test
	(years)	(inch)	(feet)		(ft bgs)	(ft bgs)		(gpm)	(gpm/ft)	(feet)	(gpm)	(gpd/ft)
31	1957	8	38	4	38	12	1990	2,200	107	16	1,712	
32	1957	8	32	4	42	11	1989	1,800	191	21	4,011	100,334
33	1957	8	32.5	3	38	15.5	1989	1,500	150	12.5	1,875	134,101
36	1974	8	27.5	3	36	17	1999	2,000	180	9	1,620	147,673
37	1975	12	28	3	33	10	2009	*1,400*	143	13	1,859	62,050
38	1975	12	25	3	31	10	2004	*1,400*		11		88,582
39	1977	12	24	3	33	13	2016	*1,400*		10		176,671
46	1980	12	32.5	3	37	10	2005	1,590	275	17	4,675	82,970
47	1980	12	28	4	33	12	2005	1,245	178	11	1,958	135,825
62	2010	12	26.3	4	31	8.7	2010	1,800	112	12.3	1,378	
69	2009	12	31.5	4	37	8	2009	1,380	183	19	3,477	
70	2000	8	25	4	27	8	1999	1,600	107	9	963	
71	2005	12	32	4	*33*	*10*	2005	2,112	176	13	2,288	119,800
Averages			**29.4**	**3.5**	**35**	**11.2**	**2002**	**1,648**	**164**	**13**	**2,347**	**116,445**

🟨 Monitor and assess

🟥 Recondition

* Does not include December 2021

** Average does not include data from Well #31 and Well #62

ft bgs	feet below ground surface
gpm	gallons per minute
gpm/ft	gallons per minute per foot
T	transmissivity
gpd/ft	gallons per day per foot

1,400 number in italics font indicates estimated from limited available data

Table 1a. Condition Assessment
North Well Field Horizontal Collector Wells - Page 2 of 2

Well	Average Monthly Yield 2016-2021*	Most Recent Average Monthly Yield	Most Recent Specific Capacity	Specific Capacity Reduction	2016-2021* Yield Linear Trendline Slope	Apparent Yield Reduction	Maintenance History Summary
	(gpm)	(gpm)	(gpm/ft)	(%)	(%)	(%)	
31	1,101	1,144	141.0	-32	-11.67%	48	Laterals cleaned 2009, surged 2014, 2016, 2017, new column pipe 2021
32	1,052	963	107.0	44	-10.10%	47	Laterals cleaned in 2004, new pump 2014
33	711	895	96.0	36	Insuf Data	40	Laterals cleaned in 2008 and 2021 (scheduled)
36	786	887	99.4	45	1.86%	56	Laterals cleaned in 2013 & 2014, surged in 2015 & 2016
37	818	845	98.1	31	-4.50%	40	Laterals surged 2014 & 2015, pump cleaned 2019
38	555	638	152		-6.11%	54	Laterals cleaned in 2014, pump cleaned in 2020
39	812	788	158		-10.38%	44	Laterals surged 2017, pump cleaned 2019
46	1,057	884	69.1	75	-11.73%	44	Laterals surged 2009 & 2014
47	512	327	68.9	61	-13.85%	74	New laterals 2005, surged 2009, 2016, pump cleaned 2020
62	923	984	268	-139	-4.36%	45	No Maintenance Activity
69	1,080	874	162	11	-5.98%	37	Pump cleaned August 2015, no lateral maintenance
70	749	890	60.3	44	-7.71%	44	Laterals cleaned 2016, pump cleaned & laterals surged 2020
71	1,558	1,028	141	20	-21.89%	51	New pump June 2014, laterals Cleaned November 2016
Averages	**901**	**857**	**125**	**41****	**-8.87%**	**48**	

🟨 Monitor and assess

🟥 Recondition

* Does not include December 2021

** Average does not include data from Well #31 and Well #62

ft bgs
gpm feet below ground surface
gpm/ft gallons per minute
T gallons per minute per foot
gpd/ft transmissivity
gallons per day per foot

Table 1b. Well Recondition Decision Matrix
North Well Field Horizontal Collector Wells - Page 1 of 1

Well	Apparent Yield Reduction ≥ 48%	Specific Capacity Reduction ≥ 41%	Average Monthly Yield 2016-2021* < 901 gpm	Yield Linear Trendline Slope < -9%	Yes	No	No Data	Recondition Priority	Recommendation	Potentially space to add another lateral? (number of laterals that could potentially be added)
31	Y	N	N	Y	2	2	0		Monitor Performance	No
32	N	Y	N	Y	2	2	0	3	Clean Laterals	No
33	N	N	Y		1	2	1		Monitor Performance	Possibly (1)
36	Y	Y	Y	N	3	1	0	2	Assess yield trend, Clean Laterals	Yes (1-3)
37	N	N	Y	N	1	3	0		Monitor Performance	Yes (1-3)
38	Y		Y	N	2	1	1		Monitor Performance	Yes (1)
39	N		Y	Y	2	1	1	6	Schedule Lateral Clean	Yes (2)
46	N	Y	N	Y	2	2	0	4	Clean Laterals	Yes (2)
47	Y	Y	Y	Y	4	0	0	1	Clean Laterals	Yes (1)
62	N	N	N	N	0	4	0		Monitor, Check Specific Capacity	Yes (3-4)
69	N	N	N	N	0	4	0		Monitor Performance	Yes (2-3)
70	N	Y	Y	N	2	2	0	5	Schedule Lateral Clean	Yes (3-4)
71	Y	N	N	Y	2	2	0		Monitor Performance	Yes (3)

🟨 Monitor and assess

🟥 Recondition

* Does not include December 2021

Table 1c. Raw Water Transmission Condition Assessment
North Well Field Horizontal Collector Wells - Page 1 of 1

Well	% Flow Throttled	Modifications to Pump	Well's Raw Water Lateral Main Capacity Adequate	Clean/Rehabilitate Well's Raw Water Lateral Main
31	0	No	Increase Main to 16" with Addition of Proposed Collector Well 18	Yes but Replacement Main via Upsize Instead
32	0	No	If Well Withdrawal Rate gets Back Above 1,600 GPM, Upsize Main to 14". Increase Main to 16" with Addition of Proposed Collector Well 3.	No
33	0	No	Increase Main to 18" with Addition of Proposed Collector Well 3	No
36	54.7	Review Flatter Pump Curves	Consider Operating Well Above 1,250 GPM for Period of Time to Increase Velocity Above 2 FPS	No
37	0	No	Within Ideal Range	Yes, Clean and Recheck Main Pressures
38	0	New Pump & Motor, Review Electrical Service	Increase Main to 20" with Addition of Proposed Collector Well 18	Yes but Replacement Main via Upsize Instead
39	0	Review for Larger Pump After Reconditioning	Within Ideal Range	No
46	0	Consider New Pump with Pump Curve Closer Matching Hydraulics	Within Ideal Range	Yes, Clean and Recheck Main Pressures
47	0	Consider New Pump with Pump Curve Closer Matching Hydraulics	Consider Operating Well Above 700 GPM for Period of Time to Increase Velocity Above 2 FPS	No
62	0	No	Within Ideal Range	No
69	0	Consider Cleaning Pump	Within Ideal Range	No
70	22.5	Review Pump Curve After Reconditioning	Within Ideal Range	No
71	23.2	No	Within Ideal Range	No

🟨	Monitor and Assess
🟥	Recondition

gpm	gallons per minute
"	inches

Table 2a. Condition Assessment
North Well Field Gravel Pack & Bragstad Wells Page 1 of 1

Well	Type	Year Const.	Screen Diameter	Saturated Thickness	Well Log (Y/N)	Screen Type	Screen Slot Size	Depth to Screen Top	Depth to Screen Bottom	Static	Installed Yield	Max Yield 2016-2021	Average Yield (2016-2021*)	Average Yield (1991-2012)	Average Yield (1989)	Specific Capacity (Installed)	Most Recent Specific Capacity	Specific Capacity Reduction	Available Drawdown	Theoretical Yield New	T (from Pumping Test)	Yield Improvement after Treatment
			(inches)	(feet)			(Inch)	(ft. bgs)	(ft. bgs)	(ft. bgs)	(gpm)	(gpm)	(gpm)	(gpm)	(gpm)	(gpm/ft)	(gpm/ft)	(%)	(feet)	(gpm)	(gpd/ft)	(%)
26	Bragstad	1951		28.5	N	None		8.5	37	8.5	*900*	760	334	437	322		59.9			*900*	95,842	Insuf. Data
42	GP	1977	36	28	N	Stainless		36	40	12	*450*	265	193	471	311		18.2		21		8,982	83
43	GP	1977	30	25	N	Stainless		29	35	10	*450*	200	46	393	137		12.2		16		10,728	No Treatment
44	GP	1977	36	25	N	Stainless		26	32	7	*450*	223	138	386	313		9.9		16			106
48	GP	1986	12	33.6	Y	Stainless	0.125	31.5	43.6	10	600	507	354	325	311	60.0	19.0	68.3	18.5	1,110	59,166	36
49	GP	1986	12	33.5	Y	Stainless	0.090	31	43	9.5	700	0	NA	438	201	67.0	30.0	55.2	18.5	1,240	111,051	74
50	GP	1986	12	31	Y	Stainless	0.090	29	41	10	400	401	237	262	194	40.0	22.1	44.8	16	640	101,317	1115
51	GP	1987	12	30	Y	Stainless	0.090	27.5	39.5	9.5	400	307	158	222	185	38.1	19.7	48.3	15	572	94,670	28
52	GP	1986	12	26	Y	Stainless	0.120	24	32	6	400	229	158	268	180	36.4	19.1	47.5	15	546	126,669	8
53	GP	1987	12	37.5	Y	Stainless	0.080	33.5	43.5	6	600	396	299	400	350	26.1	72.9		24.5	639	163,076	Insuf. Data
54	GP	1988	12	27	Y	Stainless	0.100	28	36	9	500	241	86	237	250	33.3	35.9		16	533	100,829	139
55	GP	1988	12	26.7	Y	Stainless	0.100	26	36	9.3	450	389	65	262	187	32.8	13.1	60.1	13.7	449	168,569	81
56	GP	1988	12	25.6	Y	Stainless	0.100	25	35	9.4	500	310	110	242	208	34.2	6.3	81.6	12.6	431	92,309	153
57	GP	1988	12	26.7	Y	Stainless	0.100	26	36	9.3	450	292	216	337	267	32.8	11.5	64.9	13.7	449	175,140	Inconclusive
58	GP	1987	12	30.5	Y	Stainless	0.100	25.5	35.5	5	350	NA	NA	266	246	17.5	6.0	65.7	17.5	306		41
63	GP	1988	12	31	Y		Hand Slot	28	38	7	500	312	227	471	374	27.8	16.3	41.4	18	500		7
	Averages			**29.1**			**0.100**	**27.2**	**37.7**	**8.6**	**506**	**322**	**187**	**339**	**252**	**37**	**23**	**58**	**16.8**	**640**	**100,642**	**156**

🟩 Assess

🟨 Recondition

🟥 Replace

ft bgs	feet below ground surface	Insuf.	insufficient	*1,400*	number in italics font indicates estimated from limited available data
gpm	gallons per minute	SC	specific capacity		
gpm/ft	gallons per minute per foot	Y	yes		
T	transmissivity	N	no		
gpd/ft	gallons per day per foot	*	Does not include December 2021		
Const.	constructed	GP	gravel pack		

Table 2b. Well Recondition Decision Matrix
North Well Field Gravel Pack & Bragstad Wells Page 1 of 1

Well	Specific Capacity Reduction % < Average	Saturated Thickness >30 feet	Available Drawdown > 17 feet	Slot Size >0.100 inch	Installed Yield > 500 gpm	Average Yield (2016-2021) > 190 gpm	Avg. Yield (1991-2012) > 350 gpm	Average Yield (1989) > 250 gpm	Installed SC > 37 gpm/ft	Theoretical Yield (New) > 650 gpm	T > 100,000 gpd/ft	Treatment Improvement > 70%	Yes	No	No Data	Recommendation
26		N		Y	Y	Y	Y	Y		Y	N		6	2	4	Assess Yield Reduction
42		N	Y		N	Y	Y	Y			N	Y	5	3	4	Recondition & Assess
43		N	N		N	N	Y	N			N		1	6	5	Replace
44		N	N		N	N	Y	Y				Y	3	4	5	Assess after #42 recondition
48	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	N	9	3		Recondition
49	Y	Y	Y	N	Y		Y	N	Y	Y	Y	Y	9	2	1	Recondition
50	Y	Y	N	N	N	Y	N	N	Y	N	Y	Y	6	6		Recondition & Assess
51	Y	N	N	N	N	N	N	N	Y	N	N	N	2	10		Replace
52	Y	N	N	Y	N	N	N	N	N	N	Y	N	3	9		Replace
53	Check SC	Y	Y	N	Y	Y	Y	Y	N	N	Y		7	3	2	Recondition
54	Check SC	N	N	N	Y	N	N	N	N	N	Y	Y	3	8	1	Replace
55	N	N	N	N	N	N	N	N	N	N	Y	Y	2	10		Replace
56	N	N	N	N	Y	N	N	N	N	N	N	Y	2	10		Replace
57	N	N	N	N	N	Y	N	Y	N	N	Y		3	8	1	Replace
58	N	Y	Y	N	N		N	N	N	N		N	2	8	2	Replace
63	Y	Y	Y	N	Y	Y	Y	Y	N	N		N	7	4	1	Recondition

🟩 Assess
🟨 Recondition
🟥 Replace

ft bgs	feet below ground surface	Insuf.	insufficient	*1,400*	number in italics font indicates estimated from limited available data
gpm	gallons per minute	SC	specific capacity		
gpm/ft	gallons per minute per foot	Y	yes		
T	transmissivity	N	no		
gpd/ft	gallons per day per foot				

Table 2c. Raw Water Transmission Condition Assessment
North Well Field Gravel Pack & Bragstad Wells Page 1 of 1

Well	% Flow Throttled	Modifications to Pump	Well's Raw Water Lateral Main Capacity Adequate	Clean/Rehabilitate Well's Raw Water Lateral Main
26	19.4	Put Pump on VFD	Within Ideal Range	Yes but Replace with New Horizontal Collector Well #26
42	51.4	No	Consider Operating Well above 310 gpm for Period of Time to Increase Velocity Above 2 FPS	No
43	0	Yes but Well is Recommended to be Replaced	No but Well is Recommended to be Replaced	No
44	63.3	No	Consider Operating Well above 310 gpm for Period of Time to Increase Velocity Above 2 FPS	No
48	9.2	No	Within Ideal Range	No
49	OOS	OOS	OOS	No
50	36.5	No	Consider Operating Well above 310 gpm for Period of Time to Increase Velocity Above 2 FPS	No
51	Insuff. Data	Yes but Well is Recommended to be Replaced	Consider Operating Well above 310 gpm for Period of Time to Increase Velocity Above 2 FPS	No
52	18.7	No	Consider Operating Well above 310 gpm for Period of Time to Increase Velocity Above 2 FPS	No
53	0	No	Consider Operating Well Above 310 gpm for Period of Time to Increase Velocity Above 2 FPS	Yes, if Well Cannot Produce 310 gpm, Clean Main Every Couple of Years
54	0	No	Consider Operating Well Above 175 gpm for Period of Time to Increase Velocity Above 2 FPS	No
55	0	No	Within Ideal Range	No
56	0	No	Within Ideal Range	No
57	9	No	Increase Main to 8" with Well Replacement	No
58	OOS	OOS	OOS	OOS
63	57	No	Within Ideal Range	No

Assess	VFD	variable frequency drive
Recondition	OOS	out of service
Replace	gpm	gallons per minute

Table 3a. Condition Assessment
Middle Skunk Creek Well Field Gravel Pack Wells - Page 1 of 1

Well	Year Const.	Screen Diameter	Saturated Thickness	Screen Slot Size	Depth to Screen Top	Depth to Screen Bottom	Static	Yield when Constructed	Maximum Monthly Yield (2016-2021)	Average Monthly Yield (2016-2021)	Average Yield (1991-2012)	Most Recent Yield	Specific Capacity (Installed)	Most Recent Specific Capacity	Specific Capacity Reduction	Available Drawdown	Theoretical Yield New	Apparent Yield Reduction	Yield Improvement after Treatment
		(inch)	(feet)	(inch)	(ft. bgs)	(ft. bgs)	(ft. bgs)	(gpm)	(gpm)	(gpm)	(gpm)	(gpm)	(gpm/ft)	(gpm/ft)	(%)	(feet)	(gpm)	(%)	(%)
101	1993	30	26.5	0.100	19	29.5	3	500	427	158	327	174	64.9	59.4	8.5	13	844	65	251
102	1993	30	21.6	0.090	13.6	24	2.4	449	488	67	247	123	47.3	107.8		8.2	388	73	Assess
103	1993	36	29	0.100	21	31	2	450	283	138	326	254	59.2	44.9	24.2	16	947	44	24
104	1993	36	30	0.070	16	31.5	1.5	350	234	72	242	234		25.4		11.5		33	103
105	1993	36	24.6	0.080	15.4	25.8	1.2	300	237	70	163	141	24.2	15.5	36.0	11.2	271	53	43
106	1993	30	29.8	0.100	17.1	32.5	2.7	635	562	266	497	432	129.5	60.9	53.0	11.4	1,476	32	13
107	1993	36	31	0.090	17.5	32.9	1.9	528	170	125	252	137	40.6	20.3	50.0	12.6	512	74	Insufficient Data
109	1993	36	34.9	0.090	16.1	36.5	1.6	606	814	83	308	333	43.6	46.6		11.5	501	45	249
110	1976	14	29	0.080	25	35	6	600	612	284	448	347		25.5		16		42	321
111	1993	30	22.3	0.090	14.5	24.9	2.6	354	245	95	167	92	38.6	36.7	4.9	8.9	344	74	50
112	1993	30	39.2	0.080	21.9	42.2	3	715	441	195	545	250	96.6	26.3	72.8	15.9	1,536	65	Likely >50%
113	1993	36	43.5	0.035	21.2	47	3.5	850	750	284	522	344		52.4		14.7		60	36
114	1993	36	35	0.070	16.6	37	2	500	298	122	228	234		24.8		11.6		53	54
Averages		**32**	**30.5**	**0.083**	**18.07**	**33.06**	**2.57**	**526**	**428**	**151**	**329**	**238**	**61**	**42**	**36**	**13**	**758**	**55**	**114**

🟨 Recondition
🟩 Monitor
🟥 Replace

ft. bgs	feet below ground surface
gpm	gallons per minute
gpm/ft	gallons per minute per foot
Const.	constructed

Table 3b. Well Recondition Decision Matrix
Middle Skunk Creek Aquifer Gravel Pack Wells - Page 1 of 1

Well	Specific Capacity Reduction < 36%	Saturated Thickness > 30 feet	Available Drawdown > 13 feet	Slot Size >0.080 inch	Installed Yield >525 gpm	Maximum Monthly Yield (2016-2021*) > 425 gpm	Average Monthly Yield (2016-2021*) > 150 gpm	Average Yield (1991-2012) >325 gpm	Installed Specific Capacity >60 gpm/ft	Theoretical Yield ≥ 750 gpm	Treatment Improvement >100%	Yes	No	No Data	Recommendation
101	Y	N	N	Y	N	Y	Y	Y	Y	Y	Y	8	3	0	Recondition
102		N	N	Y	N	Y	N	N	N	N		2	7	2	Replace
103	Y	N	Y	Y	N	N	N	Y	N	Y	N	5	6	0	Assess yield reduction/monitor
104		N	N	N	N	N	N	N			Y	1	7	3	Replace
105	N	N	N	N	N	N	N	N	N	N	N	0	11	0	Replace
106	N	N	N	Y	Y	Y	Y	Y	Y	Y	N	7	4	0	Recondition
107	N	Y	N	Y	Y	N	N	N	N	N		3	7	1	Replace
109		Y	N	Y	Y	Y	N	N	N	N	Y	5	5	1	Check Specific Capacity/Recondition
110		N	Y	N	Y	Y	Y	Y			Y	6	2	3	Recondition
111	Y	N	N	Y	N	N	N	N	N	N	N	2	9	0	Replace
112	N	Y	Y	N	Y	Y	Y	Y	Y	Y		8	2	1	Recondition
113		Y	Y	N	Y	Y	Y	Y			N	6	2	3	Check Specific Capacity/Monitor
114		Y	N	N	N	N	N	N			N	1	7	3	Replace

Recondition
Monitor
Replace

ft. bgs	feet below ground surface
gpm	gallons per minute
gpm/ft	gallons per minute per foot
*	does not include December 2021

Table 3c. Raw Water Transmission Condition Assessment
Middle Skunk Creek Aquifer Gravel Pack Wells - Page 1 of 1

Well	% Flow Throttled	Modifications to Pump	Well's Raw Water Lateral Main Capacity Adequate	Clean/Rehabilitate Well's Raw Water Lateral Main
101	0	Review for Larger Pump After Reconditioning	Consider Operating Well Above 500 gpm for Period of Time to Increase Velocity Above 2 FPS	Yes
102	61.8	Yes but Well is Recommended to be Replaced	Main is Oversized Should be 8", Evaluate After Replacement	Yes
103	44.9	No	Consider Operating Well Above 310 gpm for Period of Time to Increase Velocity Above 2 FPS	Yes, if Well Cannot Produce 310 gpm, Clean Main Every Couple of Years
104	80.8	Yes but Well is Recommended to be Replaced	Main is Oversized Should be 6", Evaluate After Replacement	Yes, Clean Main Every Couple of Years
105	58.2	Yes but Well is Recommended to be Replaced	Main is Oversized Should be 6", Evaluate After Replacement	Yes, Clean Main Every Couple of Years
106	11.9	No	Within Ideal Range	Yes, Clean and Recheck Main Pressures
107	OOS	OOS	OOS	OOS
109	20.7	No	Consider Operating Well Above 700 gpm for Period of Time to Increase Velocity Above 2 FPS	No
110	3.9	No	Main is Oversized Should be 8", Evaluate After Reconditioning	Yes, Clean Main Every Couple of Years
111	69.4	Yes but Well is Recommended to be Replaced	Main is Oversized Should be 6", Evaluate After Replacement	Yes, Clean Main Every Couple of Years
112	23.4	No	Main is Oversized Should be 8", Evaluate After Reconditioning	Yes, Clean Main Every Couple of Years
113	8.5	Consider Pump with Less Horsepower	Within Ideal Range	No
114	14	No	Consider Operating Well Above 310 gpm for Period of Time to Increase Velocity Above 2 FPS	Yes, if Well Cannot Produce 310 gpm, Clean Main Every Couple of Years

Assess	"	inches
Recondition	OOS	out of service
Replace	gpm	gallons per minute

Table 4. Recommended Protocal for Reconditioning of Gravel Pack Wells

No.	Task	Purpose	Comment
1	Prepare well site for reconditioning	Construct shallow pit for disposal of reconditioning wastes	Use to evaporate liquids and dispose of biosolids and sediment
2	Conduct 1-hour specific capacity test	Develop well performance benchmark	Conduct test under easily reproduceable conditions
3	Remove pump	Facilitate reconditioning of well & pump maintenance	Pump and column pipe can be cleaned after removal
4	Air-lift well	Remove loose material	Inject air under pressure into well
5	Let well sit idle for minimum 24 hours	Allow suspended material to settle and water to clear	Will facilitate obtaining a high quality video record of well
6	Conduct video survey	Assess screen and casing condition	If screen or casing is damaged, cease reconditioning and replace well
7	Conduct mechanical screen cleaning	Utilize a manufactured or purchased steel brush	Remove deposits on screen to enable application of chemicals & energy to filter pack
8	Apply liquid descaler chemical	Mixture of acid & other chemicals designed to remove biolfilm	Leave in well for 36 hours, periodically agitate and check pH
9	Develop well (air-lift & surge block)	Remove dislodged sediment and biofilm from pore spaces	Continue developing until discharge is sediment free
10	Conduct 1-hour specific capacity test	Document improvement in yield	Keep records of test results and type and volume of materials used in reconditioning
11	Reinstall pump & operate	Resume operation of well	Conduct 1-hour specific capacity test at least once per 12 months

Table 5a. Individual Well Historical Electrical Efficiency - Page 1 of 5

Well No.		2015	2016	2017	2018	2019	2020	2021*	Well Type
3	Million Gallons	0.523	0	0	Insufficient Data	0	0	0	Wolfe/Gravel Pack
	KWH	988	0	0		0	0	1	
	Gal/KWH	529.35	0.00	0.00		0.00	0.00	0.00	
4	Million Gallons	2.16	0	0	Insufficient Data	0	0	0	Bragstad/Gravel Pack
	KWH	4,057	746	0		0	2,716	414	
	Gal/KWH	532.41	0.00	0.00		0.00	0.00	0.00	
10	Million Gallons	0	0	0	Insufficient Data	0	0	0	Bragstad/Gravel Pack
	KWH	1,242	727	0		0	3,256	410	
	Gal/KWH	0.00	0.00	0.00		0.00	0.00	0.00	
11	Million Gallons	0.56	0	0	Insufficient Data	0	0	0	Bragstad/Gravel Pack
	KWH	3,657	2,904	0		0	14,225	559	
	Gal/KWH	153.13	0.00	0.00		0.00	0.00	0.00	
12	Million Gallons	0.07	0	0	Insufficient Data	0	0	0	Bragstad/Gravel Pack
	KWH	3,364	2,346	0		0	20,003	3,214	
	Gal/KWH	20.81	0.00	0.00		0.00	0.00	0.00	
13	Million Gallons	10.31	0	0	Insufficient Data	0	0	0	Bragstad/Gravel Pack
	KWH	5,195	1,767	0		0	11,945	0	
	Gal/KWH	1,984.60	0.00	0.00		0.00	0.00	0.00	
14	Million Gallons	103.46	14.35	0	Insufficient Data	0	0	0	Bragstad/Gravel Pack
	KWH	27,811	6,416	0		0	3,243	490	
	Gal/KWH	3,720.11	2,236.60	0.00		0.00	0.00	0.00	
15	Million Gallons	55.28	11.79	0	Insufficient Data	0	0	0	Bragstad/Gravel Pack
	KWH	35,315	6,201	0		0	2,985	425	
	Gal/KWH	1,565.34	1,901.31	0.00		0.00	0.00	0.00	
17	Million Gallons	55.42	17.78	0	Insufficient Data	0	0	0	Bragstad/Gravel Pack
	KWH	20,920	8,037	0		0	21,373	2,876	
	Gal/KWH	2,649.14	2,212.27	0.00		0.00	0.00	0.00	
18	Million Gallons	60.92	9.75	0	Insufficient Data	0	0	0	Bragstad/Gravel Pack
	KWH	32,950	6,786	0		535	639	140	
	Gal/KWH	1,848.86	1,436.78	0.00		0.00	0.00	0.00	
20	Million Gallons	185.76	39.37	8.07	Insufficient Data	4.43	10.773	0	Bragstad/Gravel Pack
	KWH	80,907	19,700	7,883		10,653	11,807	423	
	Gal/KWH	2,295.97	1,998.48	1,023.72		415.85	912.42	0.00	

Table 5a. Individual Well Historical Electrical Efficiency - Page 2 of 5

21	Million Gallons	38.04	31.7	0	Insufficient Data	0	0	0	Bragstad/Gravel Pack
	KWH	14,654	16,254	0		0	11,143	1,004	
	Gal/KWH	2,595.88	1,950.29	0.00		0.00	0.00	0.00	
23	Million Gallons	7.11	3.84	0	Insufficient Data	0	0	0	Bragstad/Gravel Pack
	KWH	6,961	2,657	0		0	3,048	4,637	
	Gal/KWH	1,021.40	1,445.24	0.00		0.00	0.00	0.00	
24	Million Gallons	33.66	0.03	0	Insufficient Data	0	0	0	Bragstad/Gravel Pack
	KWH	17,501	941	0		3,284	1,196	290	
	Gal/KWH	1,923.32	31.88	0.00		0.00	0.00	0.00	
25	Million Gallons	6.7	24.75	23.5	Insufficient Data	Insufficient Data	18.02	0	Bragstad/Gravel Pack
	KWH	8,581	39,228	28,112			24,169	9,607	
	Gal/KWH	780.79	630.93	835.94			745.58	0.00	
26	Million Gallons	65.66	76.95	75.04	Insufficient Data	32.09	6.414	0	Bragstad/Gravel Pack
	KWH	27,936	31,395	36,062		15,257	5,693	11,184	
	Gal/KWH	2,350.37	2,451.03	2,080.86		2,103.30	1,126.65	0.00	
27	Million Gallons	0.69	0.21	0	Insufficient Data	0	0	0	Bragstad/Gravel Pack
	KWH	1,529	991	0		0	2,489	393	
	Gal/KWH	451.28	211.91	0.00		0.00	0.00	0.00	
28	Million Gallons	22.97	7.49	0	Insufficient Data	0	0	0	Bragstad/Gravel Pack
	KWH	18,489	6,424	0		0	6,479	1,294	
	Gal/KWH	1,242.36	1,165.94	0.00		0.00	0.00	0.00	
29	Million Gallons	169.24	112.08	0	Insufficient Data	0	0	0	Collector
	KWH	96,137	67,739	0		0	9,801	1,164	
	Gal/KWH	1,760.40	1,654.59	0.00		0.00	0.00	0.00	
30	Million Gallons	48.94	12.75	0	Insufficient Data	0	0	0	Collector
	KWH	90,554	50,142	0		0	10,357	0	
	Gal/KWH	540.45	254.28	0.00		0.00	0.00	0.00	
31	Million Gallons	117.26	167.61	471.44	431.94	151.93	258.681	0	Collector
	KWH	76,057	86,643	216,430	217,413	67,674	175,399	347	
	Gal/KWH	1,541.74	1,934.49	2,178.26	1,986.73	2,245.03	1,474.81	0.00	
32	Million Gallons	105.04	176.6	224.45	138.683	89.17	397.336	100.26	Collector
	KWH	63,429	92,018	109,085	64,025	35,973	214,657	54,351	
	Gal/KWH	1,656.02	1,919.19	2,057.57	2,166.08	2,478.80	1,851.03	1,844.68	

Table 5a. Individual Well Historical Electrical Efficiency - Page 3 of 5

33	Million Gallons	225.94	243.03	217.28	Insufficient Data	Insufficient Data	216.007	0	Collector
	KWH	93,286	91,512	93,883			92,467	48,332	
	Gal/KWH	2,422.01	2,655.72	2,314.37			2,336.04	0.00	
34A, 64, 65	Million Gallons	2.59	7.13	0	0	0	0	0	Gravel Packs
	KWH	21,150	22,429	0	0	0	222	0	
	Gal/KWH	122.46	317.89	0.00	0.00	0.00	0.00	0.00	
36	Million Gallons	205.89	221.68	155.08	73.67	141.24	210.934	75.54	Collector
	KWH	106,251	118,172	79,376	35,351	50,760	79,159	24,593	
	Gal/KWH	1,937.77	1,875.91	1,953.74	2,083.96	2,782.51	2,664.69	3,071.61	
37	Million Gallons	225.5	291.74	225.49	225.49	116.85	270.467	120.69	Collector
	KWH	112,321	185,885	69,755	69,755	46,379	100,969	47,370	
	Gal/KWH	2,007.64	1,569.46	3,232.60	3,232.60	2,519.46	2,678.71	2,547.82	
38	Million Gallons	98.21	74.72	50.34	41.16	47.75	83.392	12.81	Collector
	KWH	29,626	31,612	29,122	23,478	36,528	42,208	3,448	
	Gal/KWH	3,314.99	2,363.66	1,728.59	1,753.13	1,307.22	1,975.74	3,715.20	
39	Million Gallons	61.84	80.69	69.04	108.09	168.66	81.234	16	Collector
	KWH	32,967	48,907	27,628	33,179	58,136	39,534	9,051	
	Gal/KWH	1,875.82	1,649.87	2,498.91	3,257.78	2,901.13	2,054.79	1,767.76	
42	Million Gallons	24.9	48.1	42.49	66.07	15.72	0	0	Gravel Pack
	KWH	23,137	37,884	44,420	69,201	18,847	310	0	
	Gal/KWH	1,076.20	1,269.67	956.55	954.75	834.09	0.00	0.00	
43	Million Gallons	0	0.33	0.12	38.01	0	0	0	Gravel Pack
	KWH	9,135	7,802	18,389	37,113	4,160	352	0	
	Gal/KWH	0.00	42.30	6.53	1,024.17	0.00	0.00	0.00	
44	Million Gallons	29.84	60.49	59.23	34.16	0.09	0	0	Gravel Pack
	KWH	39,175	69,038	69,342	49,835	5,089	0	0	
	Gal/KWH	761.71	876.18	854.17	685.46	17.69	0.00	0.00	
46	Million Gallons	21.85	224.04	237.45	161.5	65.88	275.842	30.95	Collector
	KWH	14,621	114,832	123,502	83,635	38,082	182,203	27,697	
	Gal/KWH	1,494.43	1,951.02	1,922.64	1,931.01	1,729.95	1,513.93	1,117.45	
47	Million Gallons	151.41	178.93	164.96	88.62	56.31	166.554	72.18	Collector
	KWH	69,843	90,121	65,932	34,615	22,586	76,813	25,568	
	Gal/KWH	2,167.86	1,985.44	2,501.97	2,560.16	2,493.14	2,168.30	2,823.06	

Table 5a. Individual Well Historical Electrical Efficiency - Page 4 of 5

48-53	Million Gallons	0	15.95	97.87	174.001	363.81	256.64	Insufficient Data	Gravel Packs
	KWH	18,960	65,466	123,924	64,280	283,650	241,500		
	Gal/KWH	0.00	243.64	789.76	2,706.92	1,282.60	1,062.69		
54-58	Million Gallons	0	0.42	59.81	196.54	205.6	Insufficient Data	0.634	Gravel Packs
	KWH	452	381	47,380	150,870	175,600		325	
	Gal/KWH	0.00	1,102.36	1,262.35	1,302.71	1,170.84		1,950.77	
62	Million Gallons	196.25	307.79	315.75	401.59	268.5	353.272	Insufficient Data	Collector
	KWH	83,400	125,372	134,200	174,300	132,000	175,300		
	Gal/KWH	2,353.12	2,455.01	2,352.83	2,304.02	2,034.09	2,015.24		
63	Million Gallons	2.29	17.03	13.33	43.86	Insufficient Data	27.58	0	Gravel Pack
	KWH	1,746	17,353	12,621	29,502		25,581	273	
	Gal/KWH	1,311.57	981.39	1,056.18	1,486.68		1,078.14	0.00	
69	Million Gallons	203	358	240	129	126.1	236.55	0	Collector
	KWH	109,120	195,680	126,368	78,000	91,060	192,320	0	
	Gal/KWH	1,860.34	1,829.52	1,899.21	1,653.85	1,384.80	1,229.98	0.00	
70	Million Gallons	42.99	12.88	120.16	79.7	190.37	74.5	0	Collector
	KWH	34,576	15,137	44,255	30,843	85,205	39,336	0	
	Gal/KWH	1,243.35	850.90	2,715.17	2,584.05	2,234.26	1,893.94	0.00	
71	Million Gallons	226.41	282.04	284.65	390.27	205.14	229.99	0	Collector
	KWH	104,300	128,900	104,900	159,200	116,200	153,500	0	
	Gal/KWH	2,170.76	2,188.05	2,713.54	2,451.44	1,765.40	1,498.31	0.00	
101	Million Gallons	45.46	52.68	32.37	24.76	10.1	42.52	0	Gravel Pack
	KWH	74,897	75,268	52,951	39,168	26,487	70,637	0	
	Gal/KWH	606.97	699.90	611.32	632.15	381.32	601.95	0.00	
102	Million Gallons	13.49	16.09	9.95	3.8	18.53	22.171	0	Gravel Pack
	KWH	43,523	54,579	40,019	24,027	64,126	68,385	0	
	Gal/KWH	309.95	294.80	248.63	158.16	288.96	324.21	0.00	
103	Million Gallons	32.57	37.29	21.78	15.18	32.45	34.401	0	Gravel Pack
	KWH	53,346	55,470	37,525	32,862	58,439	60,169	0	
	Gal/KWH	610.54	672.26	580.41	461.93	555.28	571.74	0.00	
104	Million Gallons	15.756	10.217	6.9	6.74	20.39	17.69	0	Gravel Pack
	KWH	39,000	41,215	33,713	29,134	53,223	45,094	0	
	Gal/KWH	404.00	247.90	204.67	231.34	383.11	392.29	0.00	

Table 5a. Individual Well Historical Electrical Efficiency - Page 5 of 5

105	Million Gallons	23.9	18.15	7.48	18.45	17.93	21.401	0	Gravel Pack
	KWH	58,216	54,407	32,991	52,062	42,094	39,472	0	
	Gal/KWH	410.54	333.60	226.73	354.39	425.95	542.18	0.00	
106	Million Gallons	56.51	49.7	112.29	105.67	63.23	80.042	0	Gravel Pack
	KWH	86,385	80,066	148,877	146,180	90,259	73,828	0	
	Gal/KWH	654.16	620.74	754.25	722.88	700.54	1,084.17	0.00	
107	Million Gallons	30.52	44.49	0	0	0	0	0	Gravel Pack
	KWH	71,287	102,586	11,244	6,925	9,969	20,425	0	
	Gal/KWH	428.13	433.68	0.00	0.00	0.00	0.00	0.00	
109	Million Gallons	4.91	0	0	0	19.74	36.03	0	Gravel Pack
	KWH	25,003	13,607	16,114	8,513	20,582	52,804	0	
	Gal/KWH	196.38	0.00	0.00	0.00	959.09	682.33	0.00	
110	Million Gallons	4.78	54.06	23.89	13.62	94.12	92.18	0	Gravel Pack
	KWH	26,189	71,401	45,413	31,630	100,783	119,091	0	
	Gal/KWH	182.52	757.13	526.06	430.60	933.89	774.03	0.00	
111	Million Gallons	9.17	28.09	15.57	21.481	50.05	49.17	0	Gravel Pack
	KWH	27,595	37,361	41,576	48,255	90,436	84,370	0	
	Gal/KWH	332.31	751.85	374.49	445.16	553.43	582.79	0.00	
112	Million Gallons	31.05	40.23	24.72	61.47	82.27	59.92	0	Gravel Pack
	KWH	64,175	93,768	59,838	136,925	76,594	70,879	0	
	Gal/KWH	483.83	429.04	413.12	448.93	1,074.11	845.38	0.00	
113	Million Gallons	35.37	36.05	33.82	11.975	126.97	129.06	0	Gravel Pack
	KWH	80,163	89,233	92,971	46,168	209,009	230,798	0	
	Gal/KWH	441.23	404.00	363.77	259.38	607.49	559.19	0.00	
114	Million Gallons	8.31	29.11	23.55	18.316	37.07	57.8	0	Gravel Pack
	KWH	24,525	62,495	55,873	45,289	92,280	76,814	0	
	Gal/KWH	338.84	465.80	421.49	404.42	401.71	752.47	0.00	

Notes:

* The total million gallons and KWH for the year 2021 are partial year values and should not be viewed as the total values for the year.

Table 5b. Summary of Historical Electrical Efficiency - Page 1 of 1

Well Type	Min, Gal/KWH	Max, Gal/KWH	Median, Gal/KWH	Average, Gal/KWH
Bragstad/Gravel Pack	153	3,720	1,445	1,501
Collector	254	3,715	2,015	2,088
North Well Field Gravel Pack	122	2,707	1,069	1,102
Middle Skunk Creek Gravel Pack	158	1,084	445	504

Notes:

* Years with withdrawal rates less than 0.5 MG were not included.

Table 6. Reconditioning and Replacement Prioritization - Page 1 of 1

Reconditioning & Replacement Description	Prioritization	Planning Period
Recondition Horizontal Collector Well #47	1	10 Year
Recondition Horizontal Collector Well #36	2	10 Year
Recondition Horizontal Collector Well #32	3	10 Year
Recondition Horizontal Collector Well #46	4	10 Year
Recondition Horizontal Collector Well #70	5	10 Year
Recondition Horizontal Collector Well #39	6	10 Year
Replace FivePack Gravel Wells	7	10 Year
Recondition Gravel Pack Well #42	8	10 Year
Recondition Gravel Pack Well #101	9	10 Year
Recondition Gravel Pack Well #106	10	10 Year
Recondition Gravel Pack Well #109	11	10 Year
Recondition Gravel Pack Well #110	12	10 Year
Recondition Gravel Pack Well #112	13	10 Year
Replace SixPack Gravel Wells	14	10 Year
Remove Gravel Pack Well #43	15	10 Year
Recondition Gravel Pack Well #63	16	20 Year
Replace 100 Series Wells	17	100 Year

Table 7. 10-Year Planning Period Improvement Cost Opinion in 2022 Dollars - Page 1 of 1

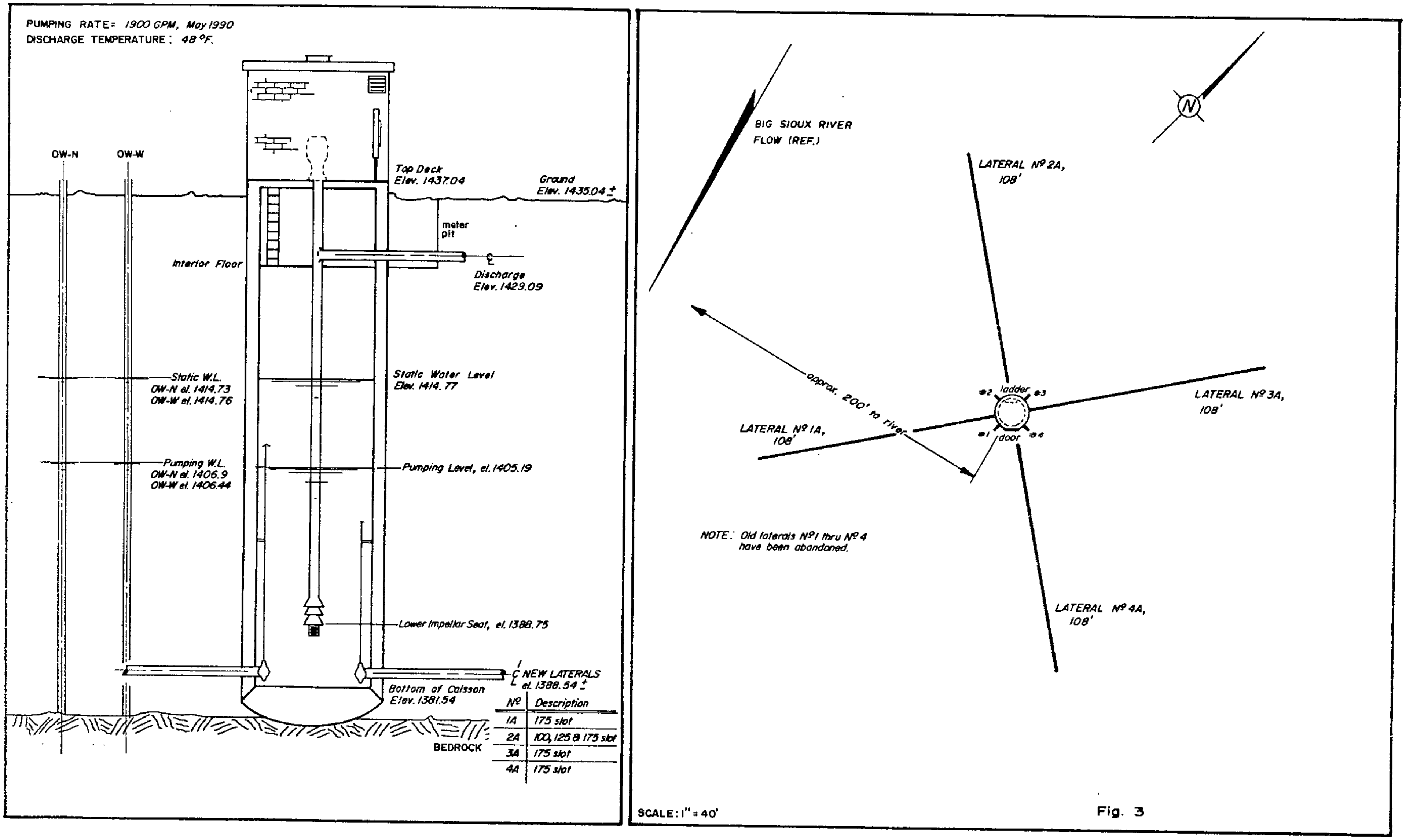
Reconditioning & Replacement Description	Improvement Costs	Planning Period
Recondition Horizontal Collector Well #36 & #47	$422,000	10 Year
Recondition Horizontal Collector Well #32 & #46	$365,000	10 Year
Recondition Horizontal Collector Well #39 & #70	$423,000	10 Year
Replace FivePack Gravel Wells	$5,020,000	10 Year
Recondition Gravel Pack Well #42	$32,000	10 Year
Recondition Gravel Pack Well #101, #106, #109, #110, & #112	$123,000	10 Year
Replace SixPack Gravel Wells	$5,700,000	10 Year
Remove Gravel Pack Well #43	$20,000	10 Year

Notes:

1. Improvement costs are represented in 2022 dollars.
2. Improvement costs for the replacement of the FivePack and SixPack gravel wells are taken from the Water Transmission Mains tech memo.
3. Refer to Appendix E for a breakdown of the opinion of costs for the recommended improvements.

Appendix A Horizontal Collector Well Construction Details

№ 7361-3
SF WELL No 31



PUMPING RATE= 1900 GPM, May 1990
DISCHARGE TEMPERATURE: 48 °F.

№	Description
1A	175 slot
2A	100, 125 & 175 slot
3A	175 slot
4A	175 slot

NOTE: Old laterals №1 thru №4 have been abandoned.

SCALE: 1" = 40'

Fig. 3

SECTION & PLAN VIEWS
RANNEY WELL NO. 31
Sioux Falls, South Dakota

Lithologic Logs Database

Lithologic Logs Search for: *lithhead.location like 102N49W20CD*

Page 1 of 1 New Search Printer Friendly Download Options **Page:** Prev 1 Next

---

Record 1 of 1

Location Information

Legal Location: SE SW SEC. 20, T. 102 N., R. 49 W.
County: MINNEHAHA
Location: 102N49W20CD
Latitude: 43.618056
Hydrologic Unit Code: 10170203
Longitude: - 96.743333
Land Owner:
Ground Surface Elev. (ft.): 1428 T

Test Hole Information

Project: BIG SIOUX DRAINAGE BASIN
Drill Date: 01/01/1944
Geologist:
Company: SDGS
Geologist's Log: X
Drilling Method:
Driller:
Test Hole Number: 25
Driller's Log:
Geophysical Log: NO
Total Drill Hole Depth (ft.): 50.0

NEAR HCW #31

Lithologic Information

Elevation (ft.)	Depth (ft.)	Description
1428.0 - 1419.0	0.0 - 9.0	SOIL AND LOAM
1419.0 - 1413.0	9.0 - 15.0	SAND AND GRAVEL
1413.0 - 1408.0	15.0 - 20.0	GRAVEL
1408.0 - 1403.0	20.0 - 25.0	SAND
1403.0 - 1383.0	25.0 - 45.0	GRAVEL
1383.0 - 1378.0	45.0 - 50.0	SAND AND GRAVEL

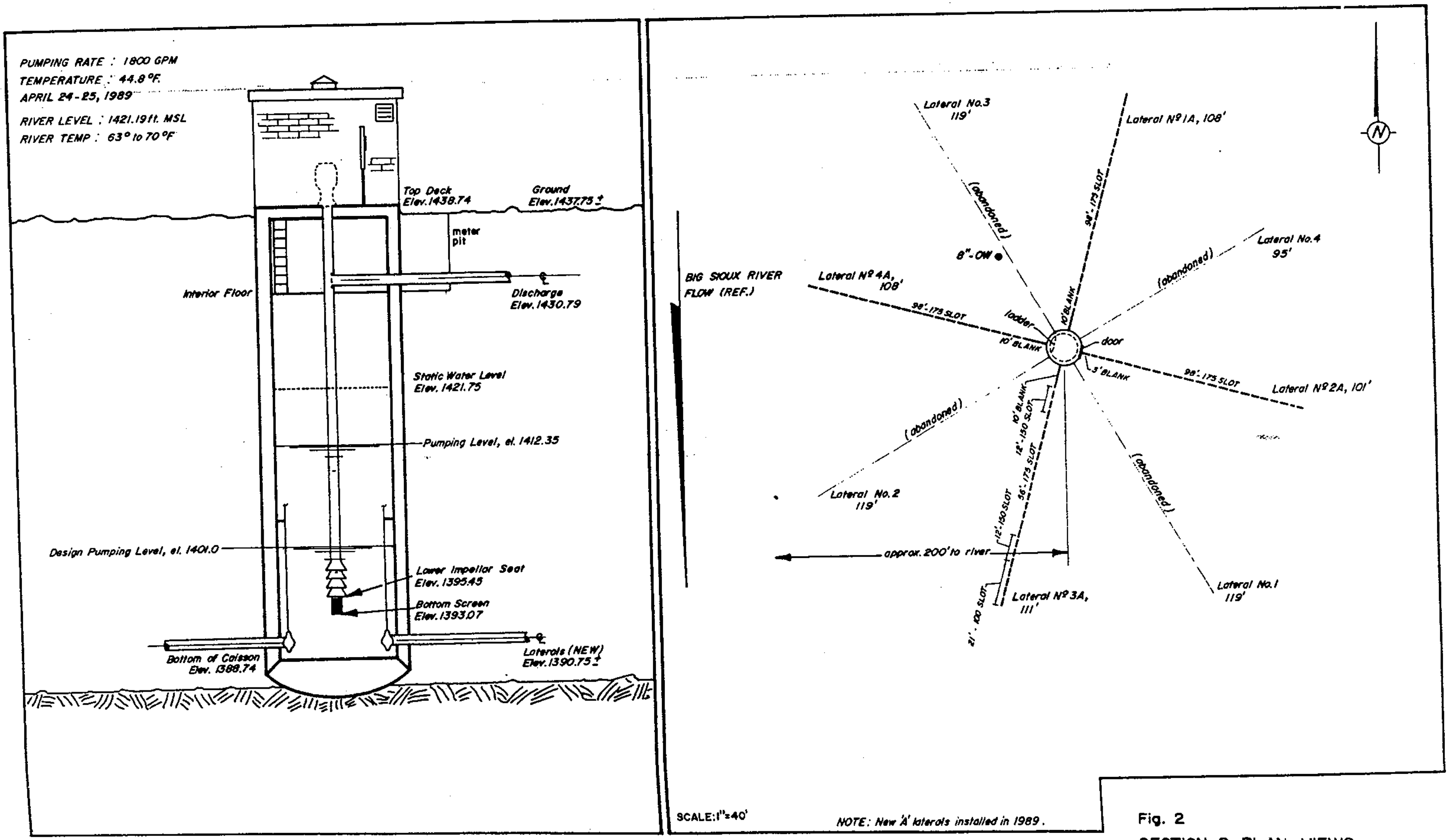


Fig. 2

SECTION & PLAN VIEWS
RANNEY WELL NO. 32
Sioux Falls, South Dakota

Lithologic Logs Database

Lithologic Logs Search for: *lithhead.location like 102N49W20BDCC*

Page: Prev 1 Next

Page 1 of 1 New Search Printer Friendly Download Options

Record 1 of 1

Location Information

Legal Location: SW SW SE NW SEC. 20, T. 102 N., R. 49 W.
County: MINNEHAHA
Location: 102N49W20BDCC
Latitude: 43.623790
Hydrologic Unit Code: 10170203
Longitude: - 96.745860
Land Owner: CITY OF SIOUX FALLS
Ground Surface Elev. (ft.): 1430 T

Test Hole Information

Project:
Drill Date: 08/08/1969
Geologist:
Company: USGS
Geologist's Log: X
Drilling Method:
Driller:
Test Hole Number:
Driller's Log:
Geophysical Log: NO
Total Drill Hole Depth (ft.): 34.0

Well Information

SDGS Well Name:
Aquifer:
Water Rights Well:
Management Unit:
Other Well Name: USGS
Casing Top Elev. (ft.): 1430.3 T
Casing Type: GALVANIZED IRON
Casing Diameter (in.): 3.0
Screen Type: STAINLESS STEEL
Screen Length (ft.): 0.0
Total Casing and Screen (ft.): 32.0
Casing Stick-up (ft.): 0.30

Lithologic Information

Elevation (ft.)	Depth (ft.)	Description
1430.0 - 1418.0	0.0 - 12.0	TOPSOIL, BLACK; ALLUVIAL
1418.0 - 1411.0	12.0 - 19.0	SAND, FINE TO MEDIUM; WITH SILT AND CLAY
1411.0 - 1397.0	19.0 - 33.0	GRAVEL, FINE TO MEDIUM; WITH SAND AND SOME CLAY
1397.0 - 1396.0	33.0 - 34.0	TILL, MEDIUM-GRAY

Page 1 of 1 (goto top)

Page: Prev 1 Next

NEAR HCW #32

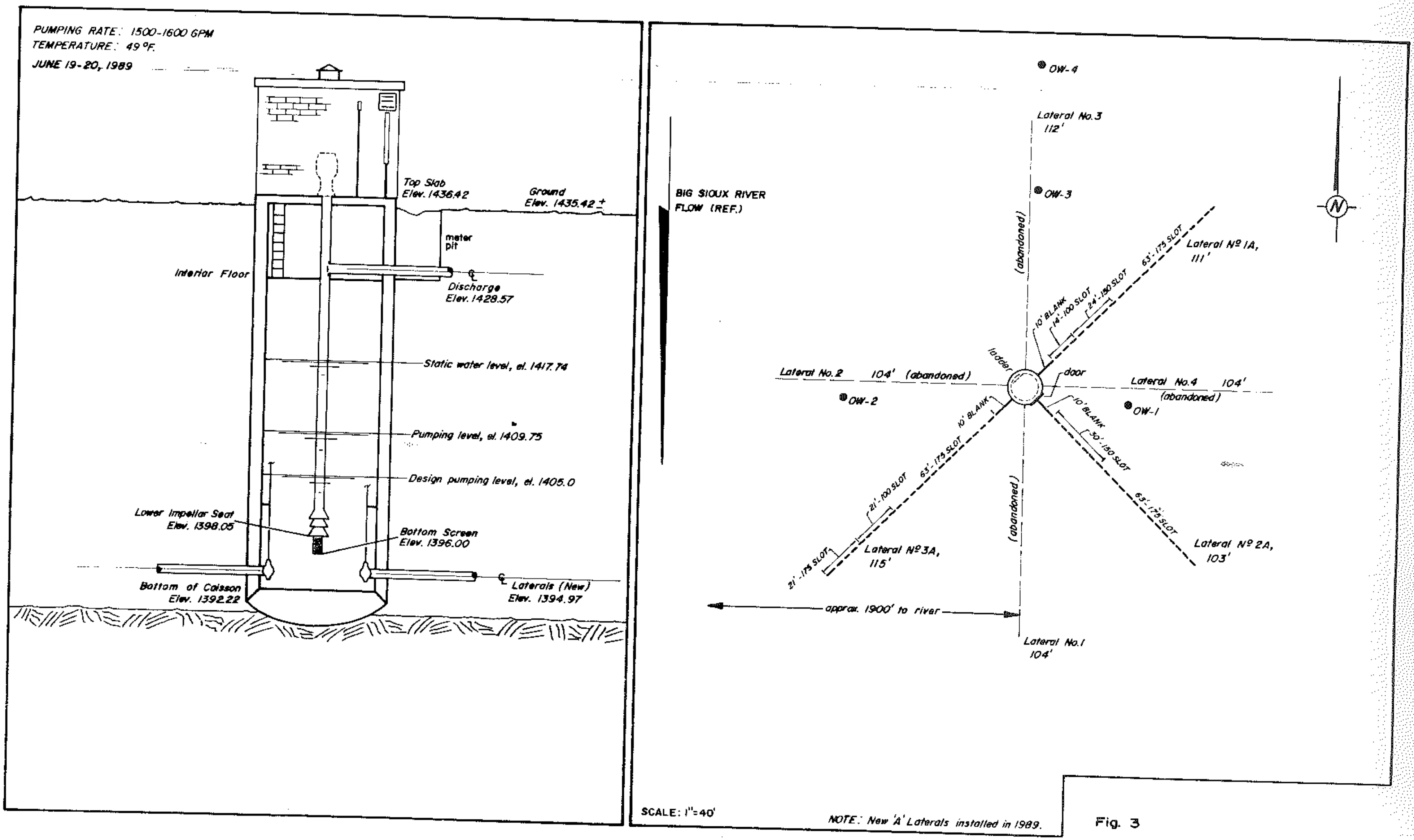
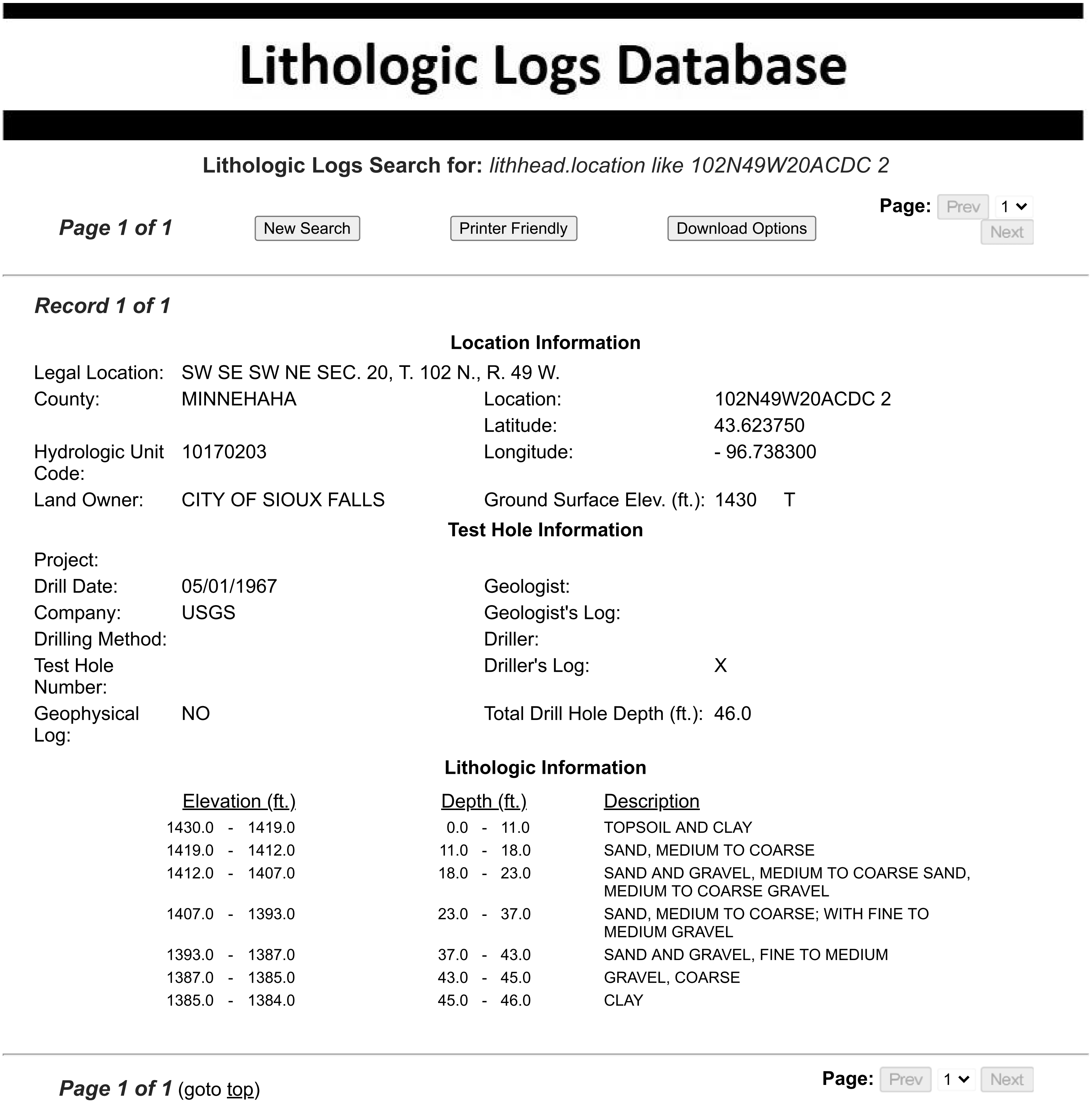


Fig. 3

SECTION & PLAN VIEWS
RANNEY WELL NO. 33
Sioux Falls, South Dakota



Lithologic Logs Database

Lithologic Logs Search for: *lithhead.location like 102N49W20ACDC 2*

Record 1 of 1

Location Information

Legal Location:	SW SE SW NE SEC. 20, T. 102 N., R. 49 W.		
County:	MINNEHAHA	Location:	102N49W20ACDC 2
		Latitude:	43.623750
Hydrologic Unit Code:	10170203	Longitude:	- 96.738300
Land Owner:	CITY OF SIOUX FALLS	Ground Surface Elev. (ft.):	1430 T

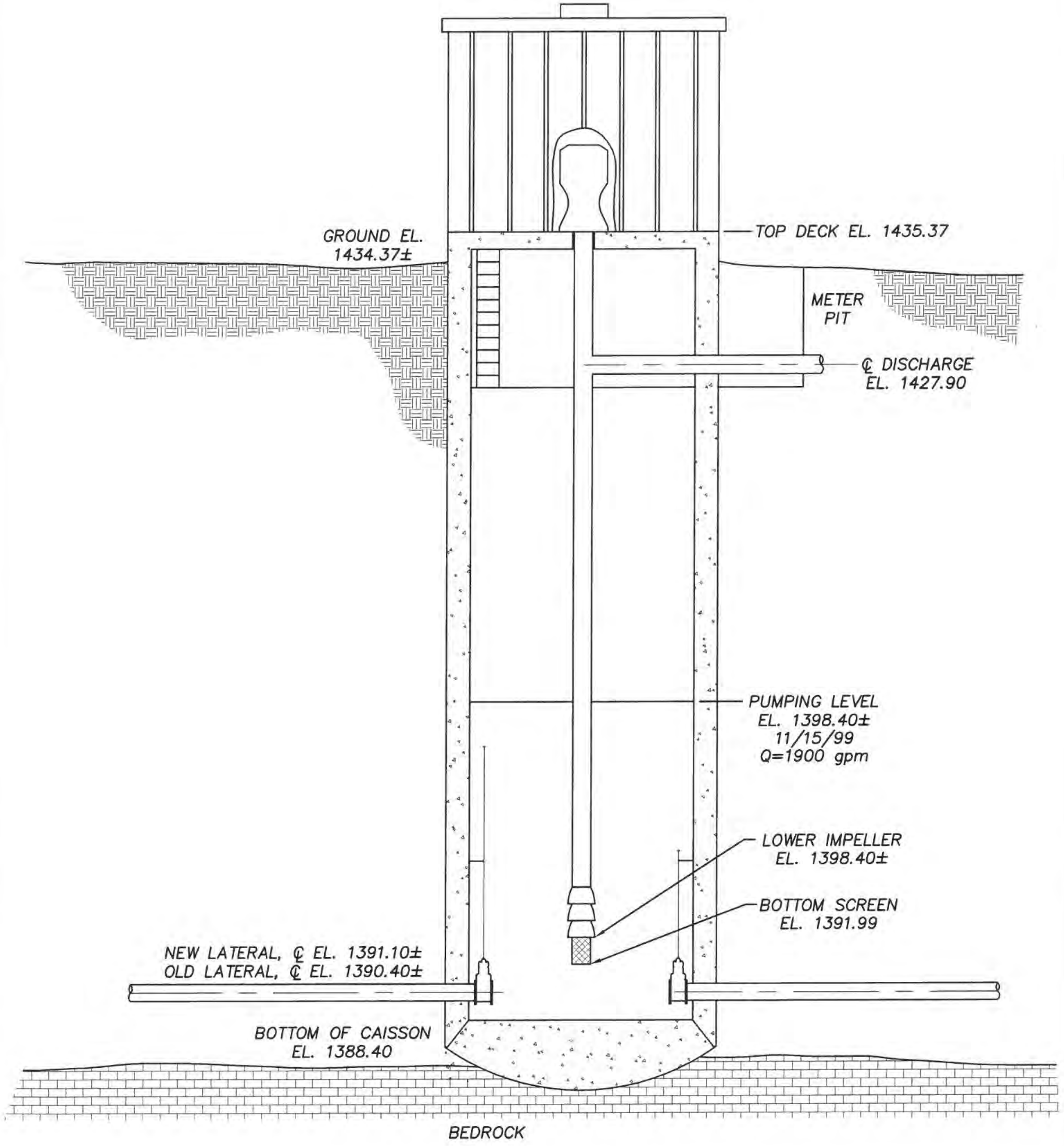
Test Hole Information

Project:			
Drill Date:	05/01/1967	Geologist:	
Company:	USGS	Geologist's Log:	
Drilling Method:		Driller:	
Test Hole Number:		Driller's Log:	X
Geophysical Log:	NO	Total Drill Hole Depth (ft.):	46.0

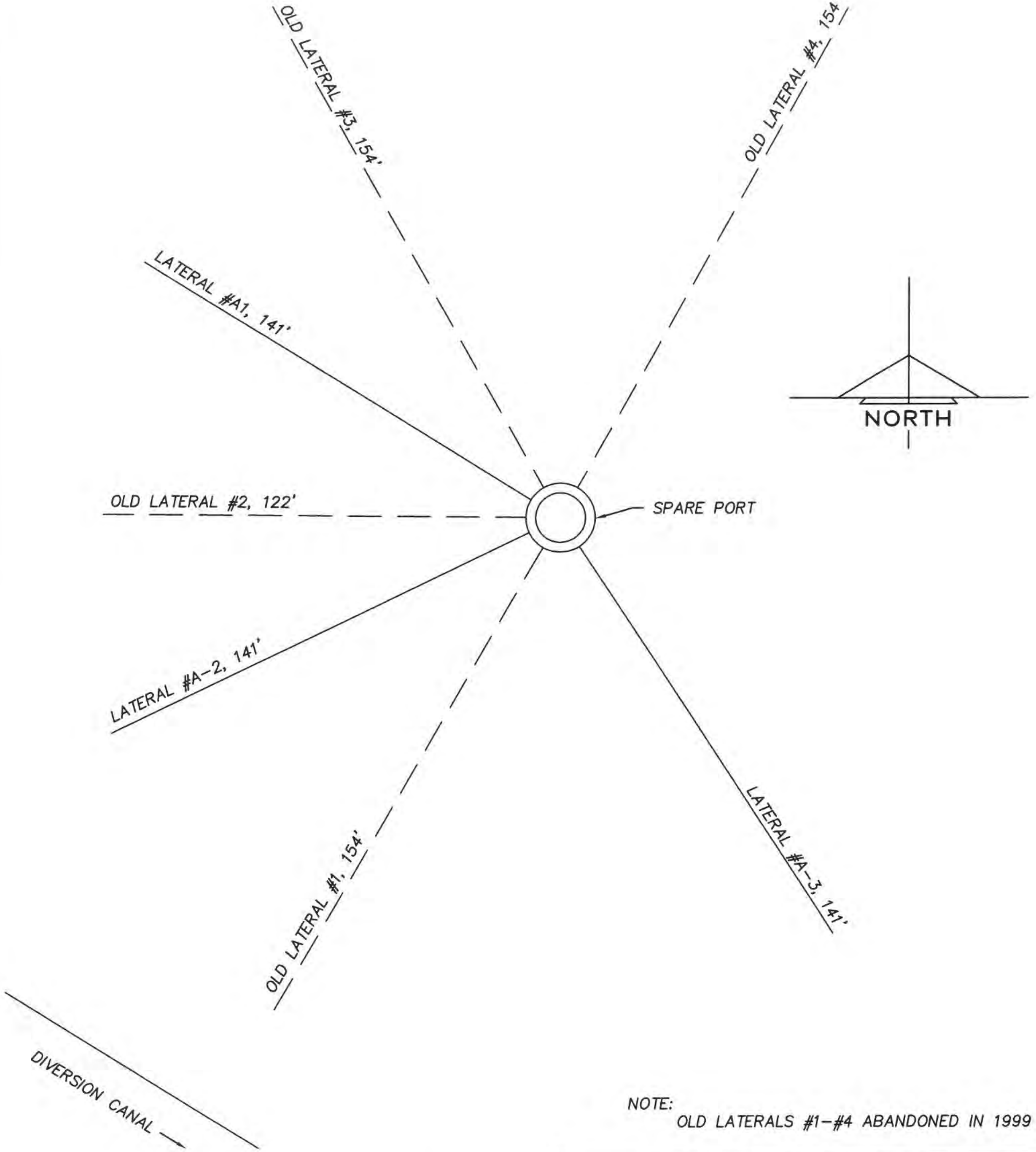
Lithologic Information

Elevation (ft.)	Depth (ft.)	Description
1430.0 - 1419.0	0.0 - 11.0	TOPSOIL AND CLAY
1419.0 - 1412.0	11.0 - 18.0	SAND, MEDIUM TO COARSE
1412.0 - 1407.0	18.0 - 23.0	SAND AND GRAVEL, MEDIUM TO COARSE SAND, MEDIUM TO COARSE GRAVEL
1407.0 - 1393.0	23.0 - 37.0	SAND, MEDIUM TO COARSE; WITH FINE TO MEDIUM GRAVEL
1393.0 - 1387.0	37.0 - 43.0	SAND AND GRAVEL, FINE TO MEDIUM
1387.0 - 1385.0	43.0 - 45.0	GRAVEL, COARSE
1385.0 - 1384.0	45.0 - 46.0	CLAY

NEAR HCW #33



SECTION



NOTE:
OLD LATERALS #1–#4 ABANDONED IN 1999

PLAN
N.T.S.

SECTION & PLAN VIEW
OF COLLECTOR WELL #36
SIOUX FALLS, SOUTH DAKOTA

COLLECTOR WELLS INTERNATIONAL, INC.

DRAWN BY: RJM	FILE NAME: 198–114–11	DATE: 1/26/00	FIGURE: 8

2012-1 2018-3

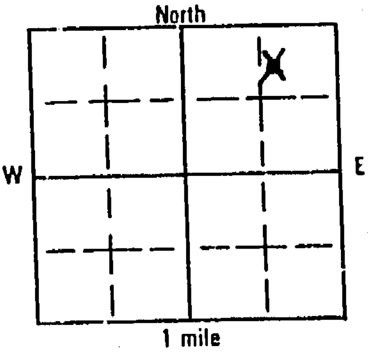
SOUTH DAKOTA WELL REHABILITATION REPORT

10-85

Location NE ¼ NE ¼ Sec 32 Twp 102N Rg 49W

County Minnehaha

Please mark well location with an "X"



Rehabilitation Completion Date 12/99

PROPOSED USE:
☐ Domestic ☒ Municipal ☐ Stock
☐ Irrigation ☐ Industrial

Well Owner: City of Sioux Falls, S.D.

Name

Address 224 West Ninth St., Sioux Falls

Describe original construction if possible?
(Attach original log if known)
Well 36 - Horizontal collector well constructed in 1975. Well log and plan and section view attached.

Description of condition of well before rehabilitation: Low carbon steel perforated lateral screens last cleaned in 1993. By 1998 specific capacity had declined to 120 gpm/ft. of downdraw.

Description of rehabilitation work completed: Installed three new 8-inch ID stainless steel laterals, each 141 feet in length. Each lateral equipped with 134 feet of stainless steel wire-wound screen (slot opening 0.080 to 0.125 inches) orientation of laterals is shown on attached figure.

Recasing information: Material N/A Diameter ______ Inches Depth ______ Feet

Describe screen or perforations 8-inch PS stainless steel Screen Location From 7' To 141' (horizontal)
From ______ To ______

Grout: ☐ YES ☒ NO Describe grouting procedure and grout Not application - only new screens installed.

JAN 2000
WATER RIGHTS
PROGRAM
PIERRE, SD

Well Test Data: 200 gpm, 11 feet of drawdown

Specific capacity 180 gpm/ft. Static water level 20 feet

If a flowing well GPM ______ Shut in ______ PSI

This well rehabilitation was completed under license # 673 And this report is true and accurate.

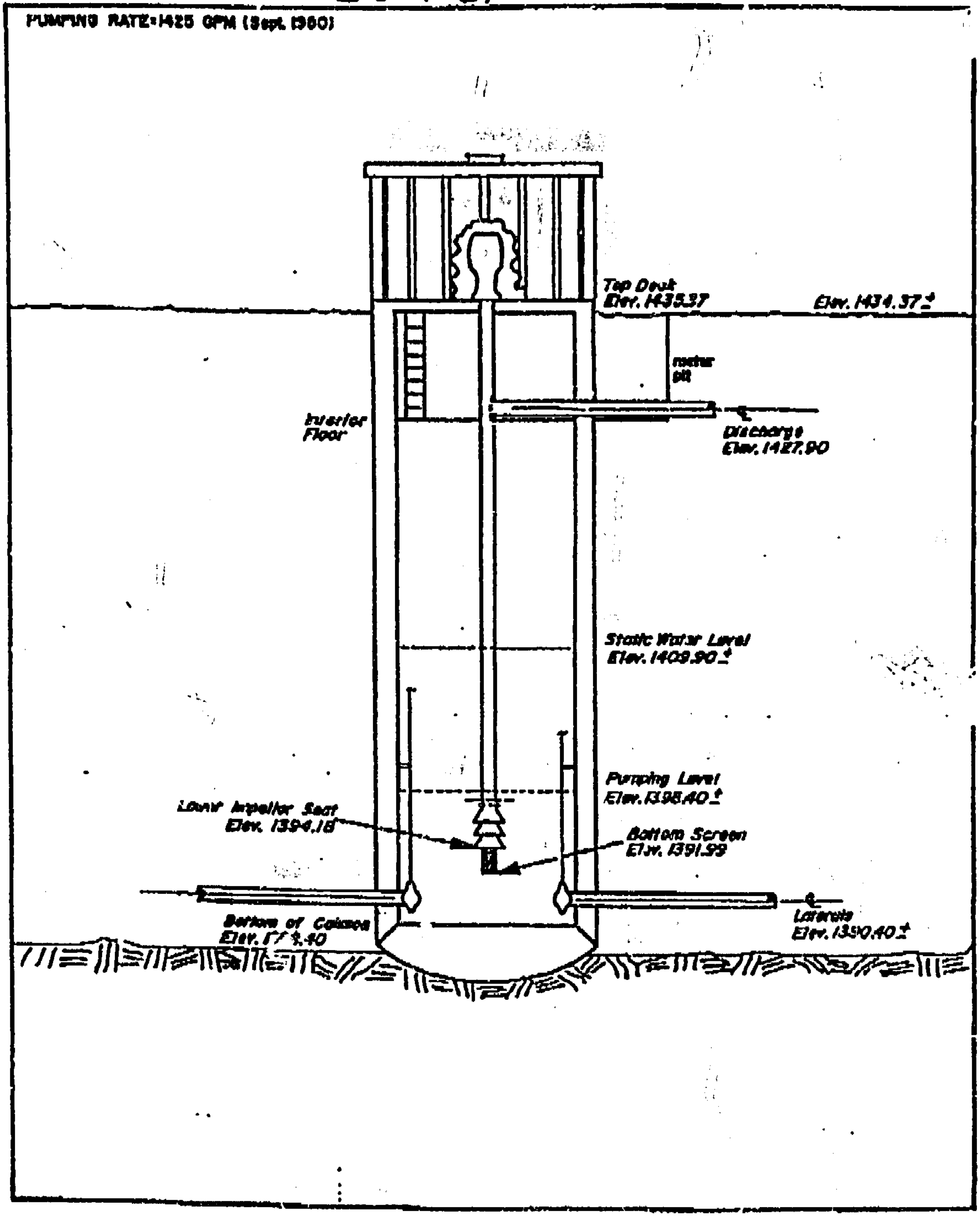
Drilling firm Collector Wells International, Inc.

Signature of Licensed Representative

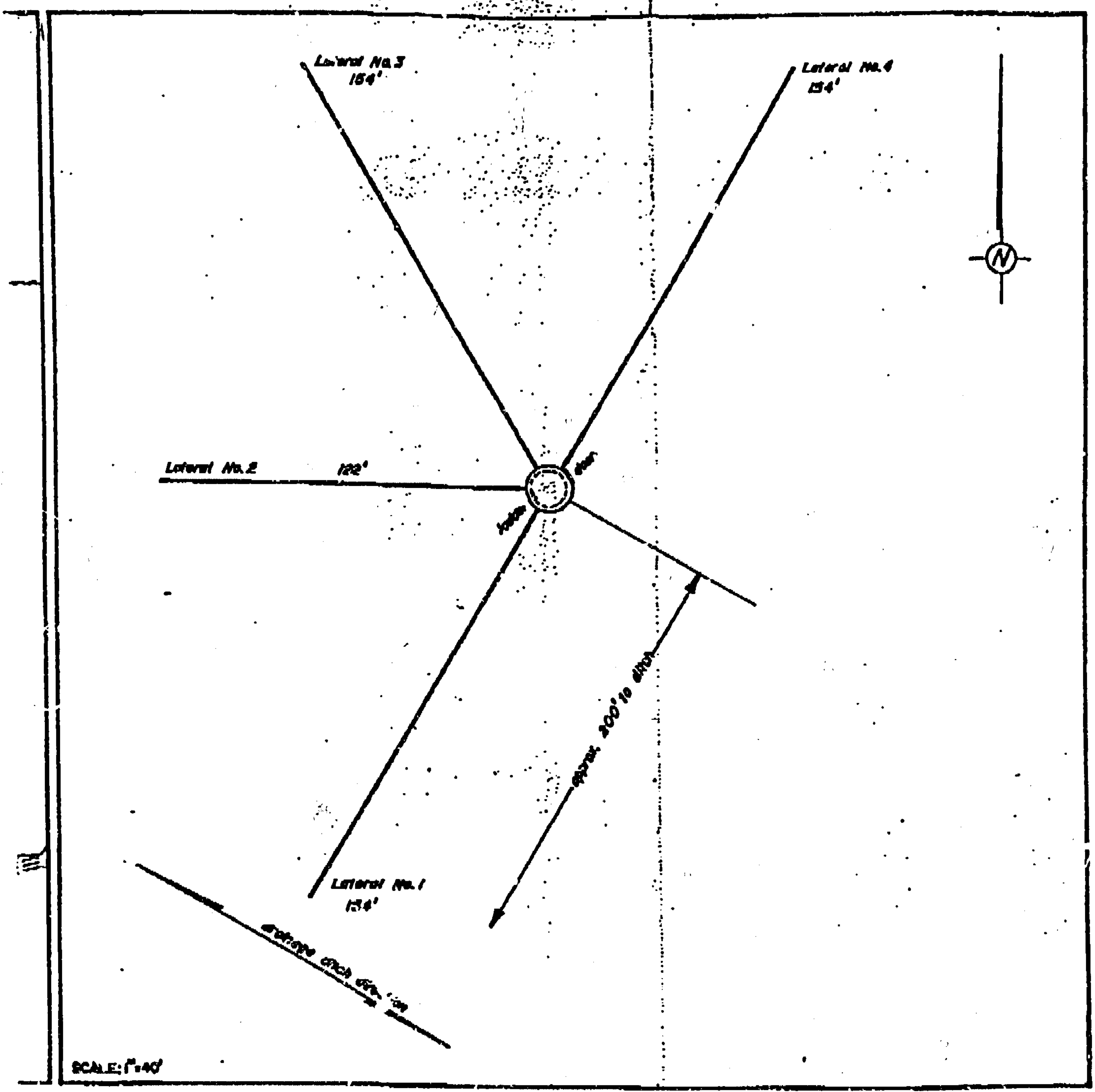
Signature of Well Owner R Jansen Water Supt City of Sioux Falls

Date December 16, 1999

#36 Well


PUMPING RATE=1425 GPM (Sept. 1980)
Top Deck Elev. 1435.37
Elev. 1434.37 ±
motor pit
Interior Floor
Discharge Elev. 1427.90
Static Water Level Elev. 1409.90 ±
Pumping Level Elev. 1398.40 ±
Lower Impeller Seat Elev. 1394.18
Bottom Screen Elev. 1391.99
Bottom of Caisson Elev. 1[illegible]9.40
Laterals Elev. 1390.40 ±

2018-3



SECTION & PLAN VIEWS
WELL NO.36
Sioux Falls, South Dakota

34

RAMSEY WATER SYSTEMS

WELL LOG

Date Drilled: 12/19/72

Geologist: A. Kiefer

Sheet 1 of 2 Sheets

Project: PI 1151

Location: Sioux Falls, South Dakota

Well No. TH36-72-1 Size: 5" Total Depth 43'6"

Elevation (land surface at well) 1427.3 Approx: x Measured:

Elevation (source of recharge) 1421 Approx: x Measured:

Drilled By Minnehaha Waters, Inc. Static: 12.5' below l.s.

Material Description	Time	From	To
Top Soil		0	3
Drift		3	10
Fine Soil		10	12
Fine-coarse sand		12	27
Detailed Description of Bottom Samples			
Sand & gravel: cs.-very fine sand;		27	30
granule-fine pebble gravel (5%)			
gray, subrounded, mostly clastic			
& carb. rxs.			
Sand & Gravel: coarse-very fine sand,		36	39
granule-fine pebble gravel,			
3%; coarse gravel. 1%; gray-brown			
subround, mostly clastic & carb. Rxs.			
Sand and Gravel: Medium-very coarse		42	possible heave
sand, mostly quartz grains;			
granule-fine pebble gravel,			
gray-brown, subround, 50%, mostly			
clastic & carb. Rxs.			
Sand and Gravel: fine-coarse sand,		42	44
mostly quartz; granule-medium (continued)			

[illegible] WATER SYSTEMS

Date Drilled: 12/19/72

WELL LOG

Geologist: A. Kiefer

Sheet 2 of 2 Sheets

Project: PJ 1151

Location: Sioux Falls, South Dakota

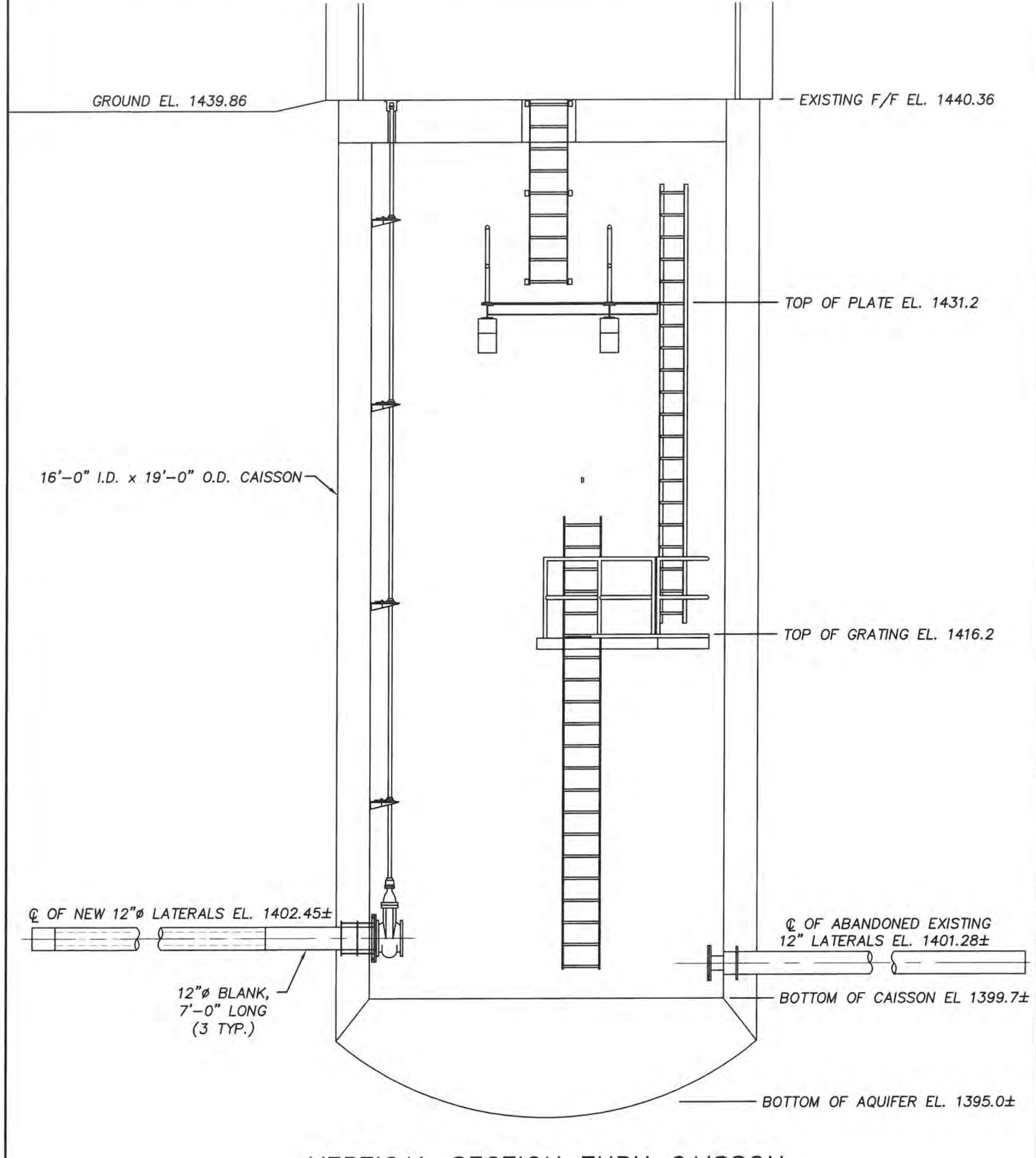
Well No. TH36-72-1 Size: 5" Total Depth 43'6"

Elevation (land surface at well) 1427.3 Approx: x Measured:

Elevation (source of recharge) 1421 Approx: x Measured:

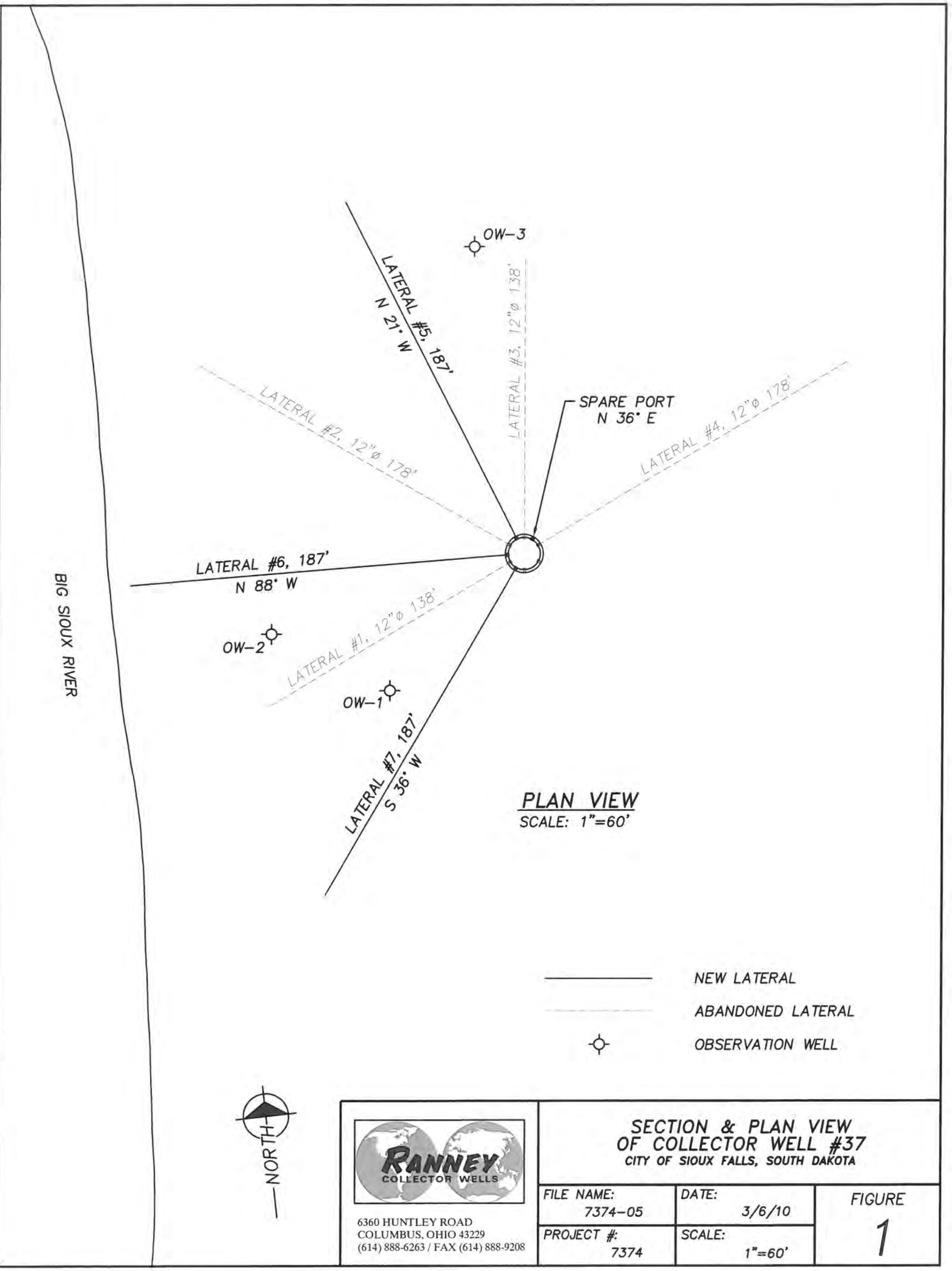
Drilled By Minnehaha Waters, Inc. Static: 12.5' below l.s.

Material Description	Time	From	To
pebble gravel, gray, brown			
subround, 40%, clastic and			
carbonacious Rxs; 5% coarse pebble		42	44 cont
gravel .			
Sand: fine-very coarse sand		43.5	
mostly quartz, light brown			
subround; 5% granule gravel			



VERTICAL SECTION THRU CAISSON

SCALE: N.T.S.



PLAN VIEW

SCALE: 1"=60'

RANNEY COLLECTOR WELLS

6360 HUNTLEY ROAD
COLUMBUS, OHIO 43229
(614) 888-6263 / FAX (614) 888-9208

SECTION & PLAN VIEW OF COLLECTOR WELL #37

CITY OF SIOUX FALLS, SOUTH DAKOTA

FILE NAME: 7374-05	DATE: 3/6/10	FIGURE 1
PROJECT #: 7374	SCALE: 1"=60'	

37

RANNEY WATER SYSTEMS

WELL LOG

Date Drilled: May 23, 1973

Geologist: T.C.

Sheet 1 of 1 Sheets

Project: Sioux Falls, South Dakota PJ 1151

Location: Site No. 37-A

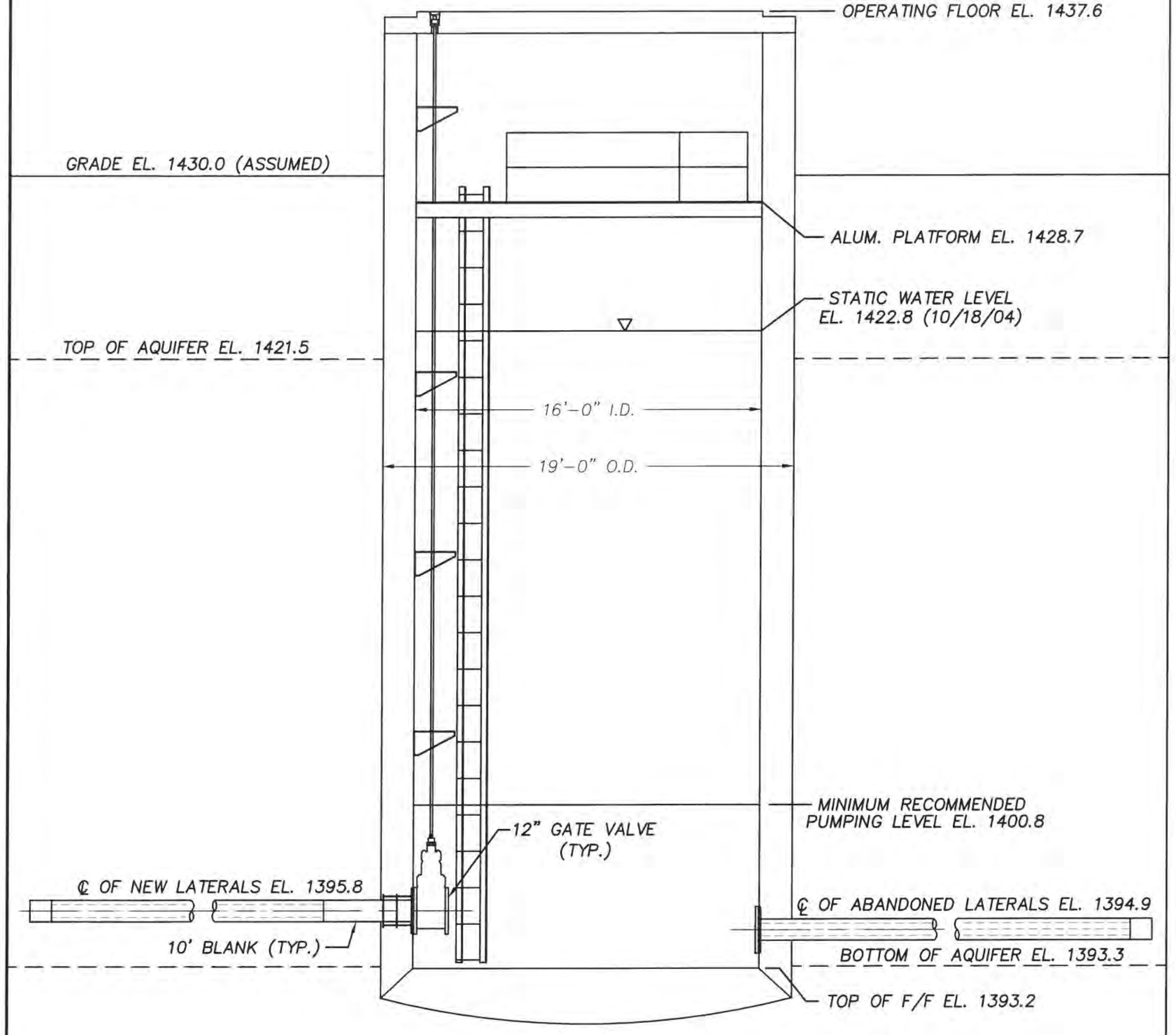
Well No. TH 37-A-73-3 Size: 6" Total Depth 40

Elevation (land surface at well) ______ Approx: ______ Measured: ______

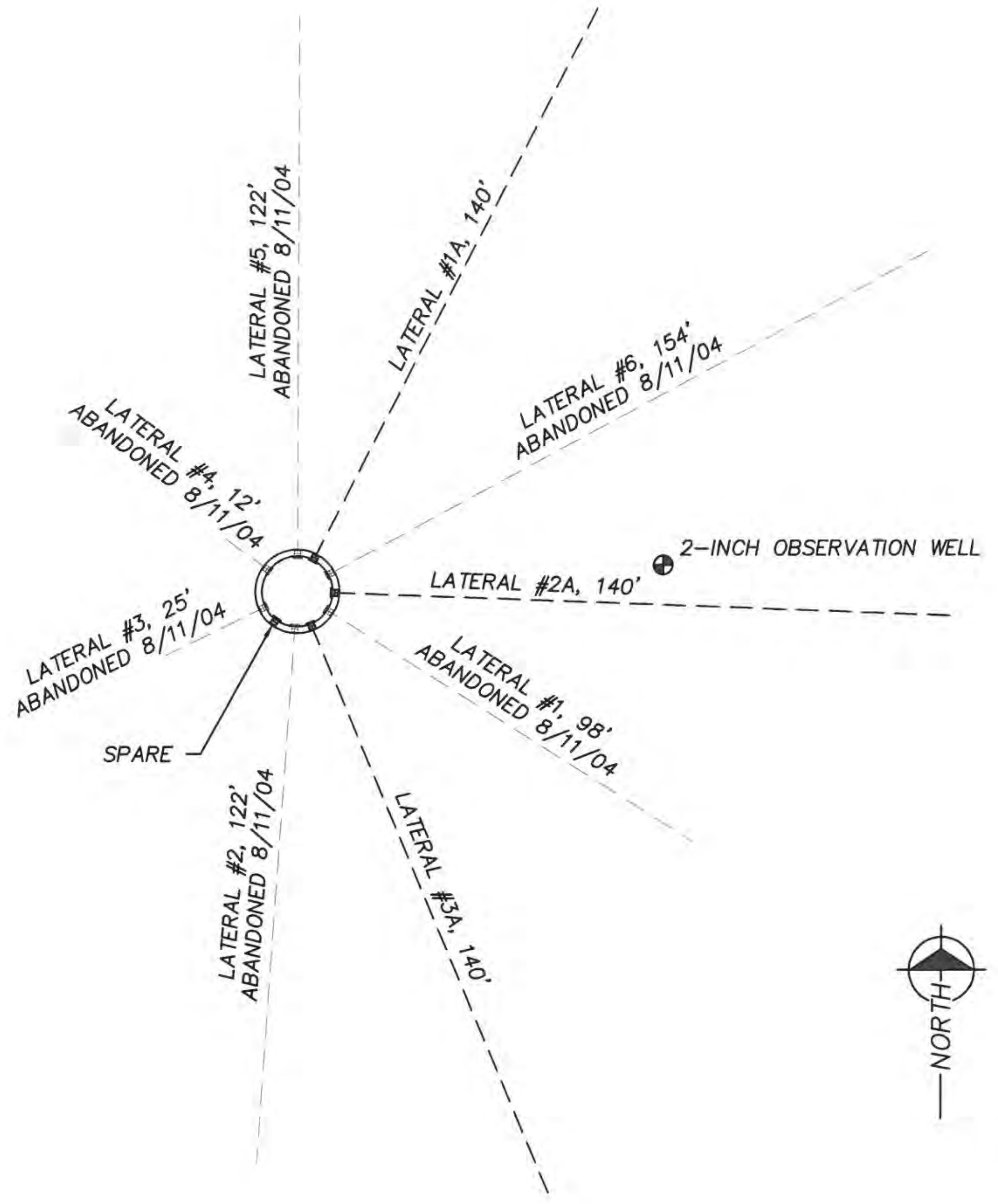
Elevation (source of recharge) ______ Approx: ______ Measured: ______

Drilled By Minnehaha Waters, Inc. Static: 10' below L.S.

Material Description	Time	From	To
Top Soil		0	5
Silt		5	9
SAND AND GRAVEL with silt, medium to coarse sand, light brown with fine to medium gravel		9	13
SAND AND GRAVEL, fine to coarse sand, light brown, medium subrounded gravel		13	36
SAND, fine to medium with some clay		36	38
CLAY, blue		38	40



VERTICAL SECTION THRU CAISSON
SCALE: N.T.S.



PLAN VIEW
SCALE: 1"=40'

NOTE:
ELEVATIONS BASED ON ASSUMED GRADE ELEVATION OF 1430.0 FEET AND WELL #38 SECTION & PLAN VIEWS (RANNEY COMPANY, 1977).

Collector Wells International, Inc.
6360 HUNTLEY ROAD
COLUMBUS, OHIO 43229
(614) 888-6263 / FAX (614) 888-9208

PLAN & SECTION VIEW COLLECTOR WELL #38

REHABILITATION OF COLLECTOR WELL #38
SIOUX FALLS, SOUTH DAKOTA

FILE NAME: 104–244–3	DATE: 11/3/04	FIGURE 2
PROJECT #: 104–244	SCALE: 1"=40'	

Lithologic Logs Database

Lithologic Logs Search for: *lithhead.location like 102N49W20DCD 9*

Page 1 of 1 New Search Printer Friendly Download Options **Page:** Prev 1 Next

---

Record 1 of 1

Location Information

Legal Location: SE SW SE SEC. 20, T. 102 N., R. 49 W.
County: MINNEHAHA
Location: 102N49W20DCD 9
Latitude: 43.616421
Hydrologic Unit Code: 10170203
Longitude: - 96.736744
Land Owner:
Ground Surface Elev. (ft.): 1430 T

Test Hole Information

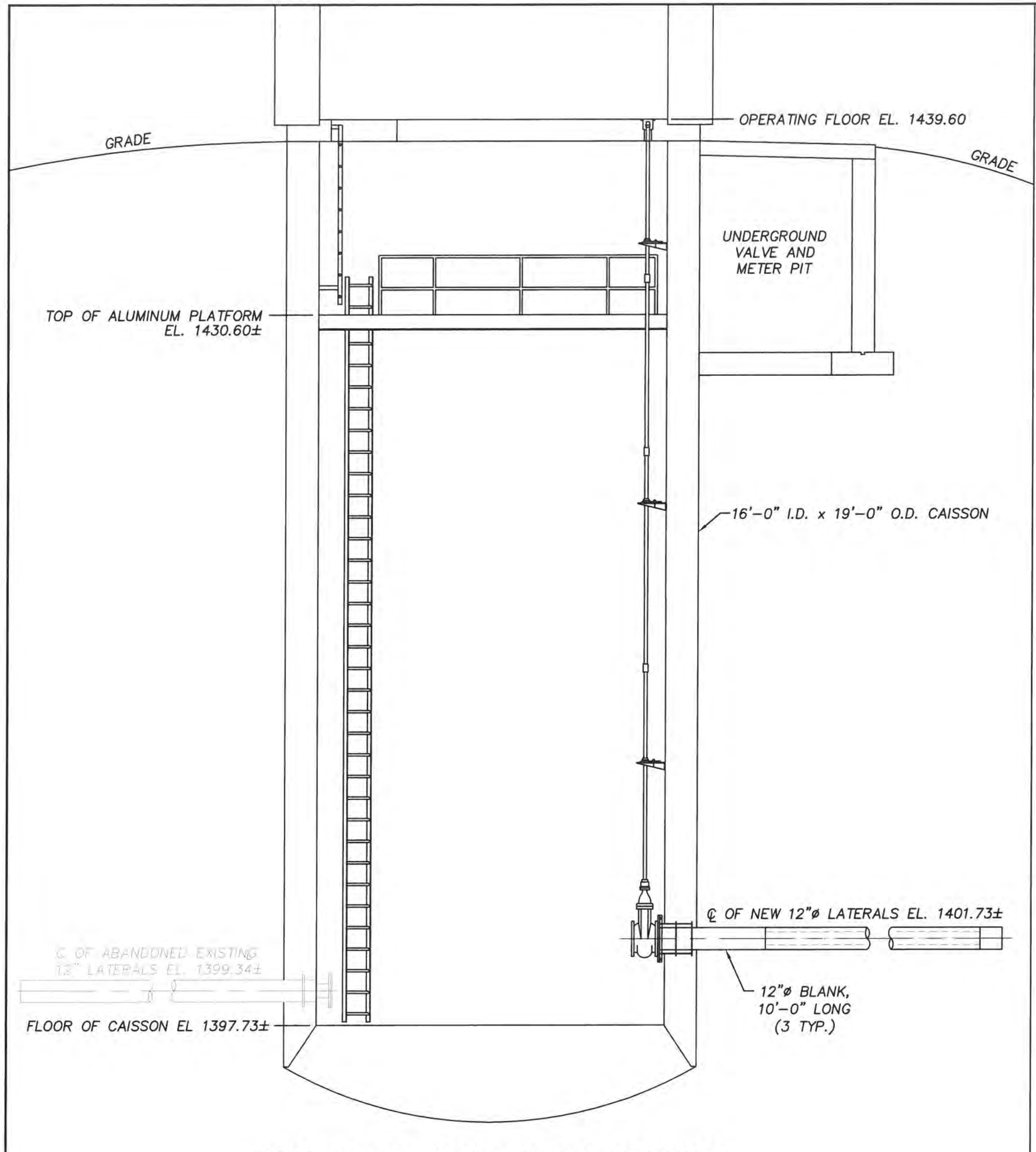
Project:
Drill Date: 05/27/1976
Geologist:
Company: RANNEY COMPANY
Geologist's Log:
Drilling Method:
Driller:
Test Hole Number:
Driller's Log: X
Geophysical Log: NO
Total Drill Hole Depth (ft.): 36.0

Lithologic Information

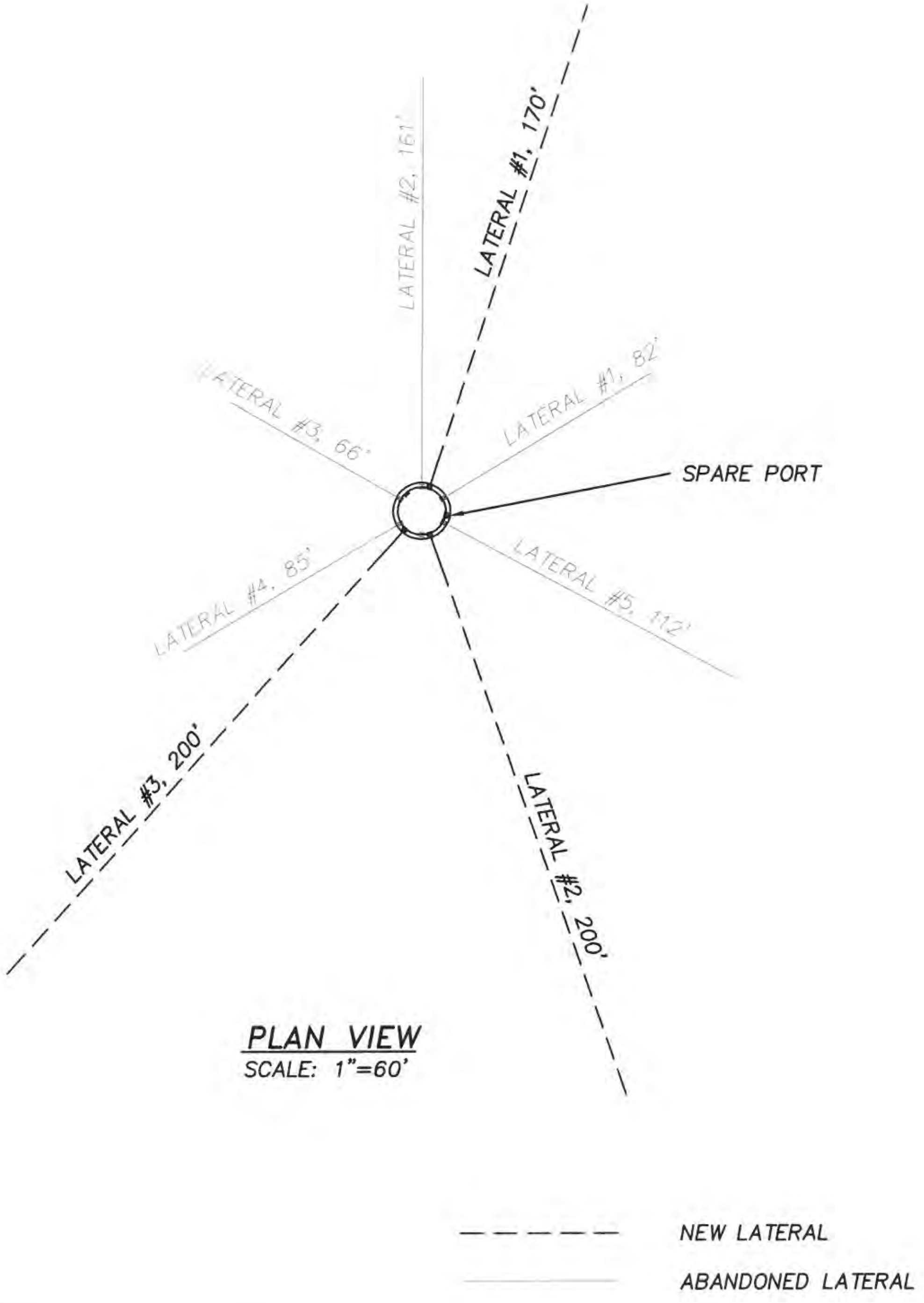
Elevation (ft.)	Depth (ft.)	Description
1430.0 - 1423.0	0.0 - 7.0	TOPSOIL AND CLAY, BLACK CLAY
1423.0 - 1407.0	7.0 - 23.0	SAND AND GRAVEL, FINE TO COARSE SAND, FINE TO MEDIUM GRAVEL
1407.0 - 1395.0	23.0 - 35.0	SAND AND GRAVEL, FINE TO COARSE SAND, FINE TO COARSE GRAVEL
1395.0 - 1394.0	35.0 - 36.0	CLAY, GRAY

Page 1 of 1 (goto top) **Page:** Prev 1 Next

Near HCW #38



VERTICAL SECTION THRU CAISSON
SCALE: N.T.S.



PLAN VIEW
SCALE: 1"=60'

Layne
Ranney Collector Wells
6360 HUNTLEY ROAD
COLUMBUS, OHIO 43229
(614) 888-6263 / FAX (614) 888-9208

SECTION & PLAN VIEW
OF COLLECTOR WELL #39
CITY OF SIOUX FALLS, SOUTH DAKOTA

FILE NAME: 37064-02	DATE: 12/9/15	FIGURE
PROJECT #: 37064	SCALE: 1"=60'	2

RANNEY WATER SYSTEMS NW ¼, NE ¼, Sec 20
Mapleton

WELL LOG

a Drilled: May 21, 1973
eologist: T.C.

Sheet 1 of 1 Sheets

Project: Sioux Falls, So. Dak. PJ 1151

Location: Site No. 37-A

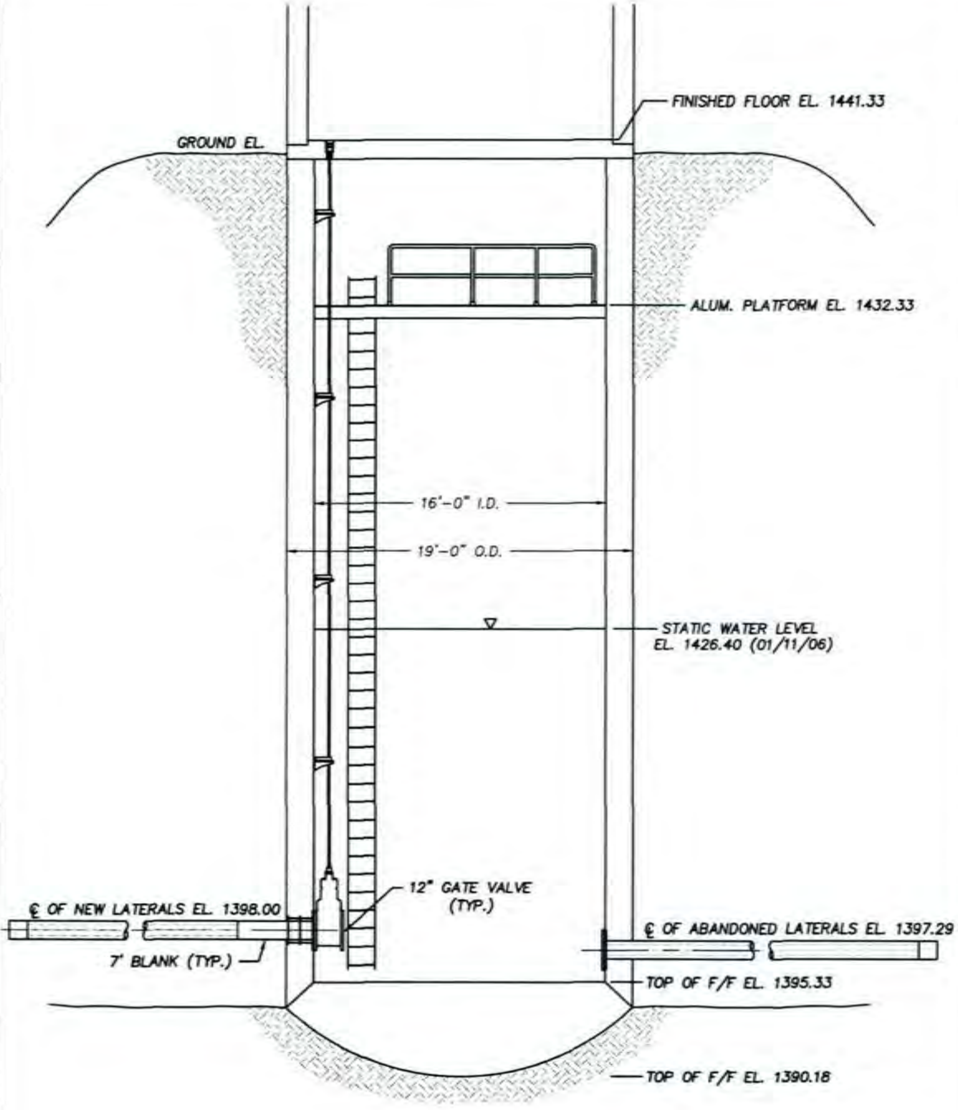
Well No. TH 37-A-73-1 Size: 6" Total Depth: 39'

Elevation (land surface at well) ________ Approx: ______ Measured: ______

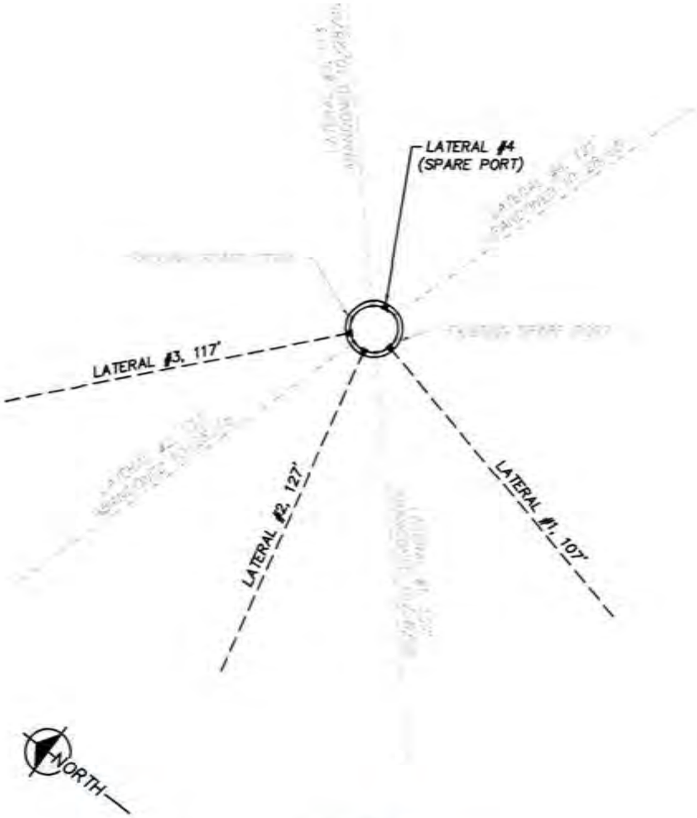
Elevation (source of recharge) ________ Approx: ______ Measured: ______

Drilled By Minnehaha Waters, Inc. Static: ________

Material Description	Time	From	To
Top Soil		0	6
Silty Clay		6	8
SAND & GRAVEL, medium sand,			
light brown, mostly quartz			
with some fine to coarse gravel		8	26
SAND, fine to medium light			
brown sand		26	32
SAND AND GRAVEL, fine to coarse			
sand, light brown, subangular			
with some yellow clay; fine to			
medium subangular gravel		32	35
SAND AND GRAVEL, fine to			
coarse light brown subrounded			
sand and gravel		35	37
CLAY, Blue		37	39



VERTICAL SECTION THRU CAISSON
SCALE: N.T.S.



PLAN VIEW
SCALE: 1"=40'

Collector Wells International, Inc.
6360 HUNTLEY ROAD
COLUMBUS, OHIO 43229
(614) 888-6263 / FAX (614) 888-9208

PLAN & SECTION VIEW
COLLECTOR WELL #46
REHABILITATION OF COLLECTOR WELLS #46 and 47
SIOUX FALLS, SOUTH DAKOTA

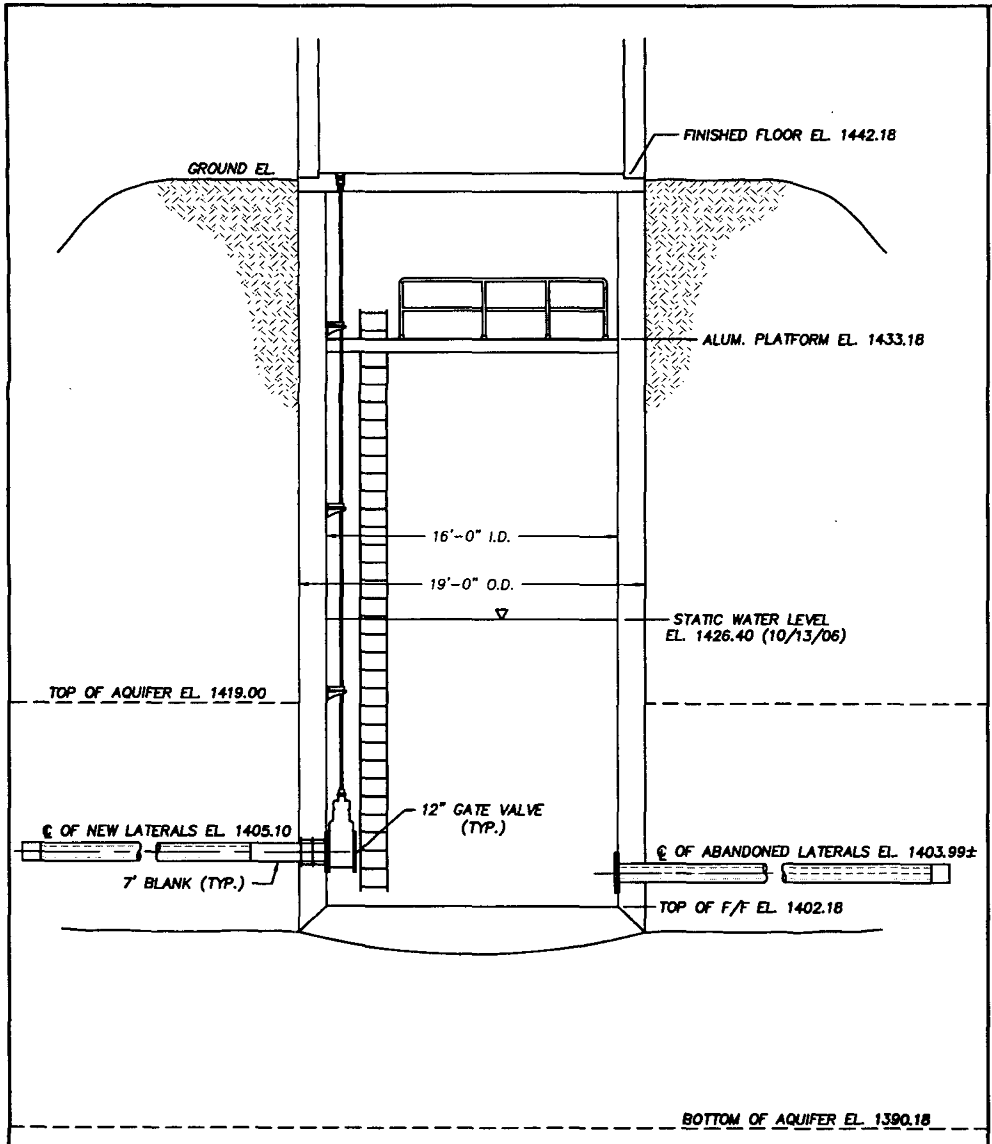
FILE NAME: 105-270-4	DATE: 2/24/06	FIGURE 2
PROJECT #: 105-270	SCALE: 1"=40'	

THE RANNEY COMPANY
Westerville Ohio

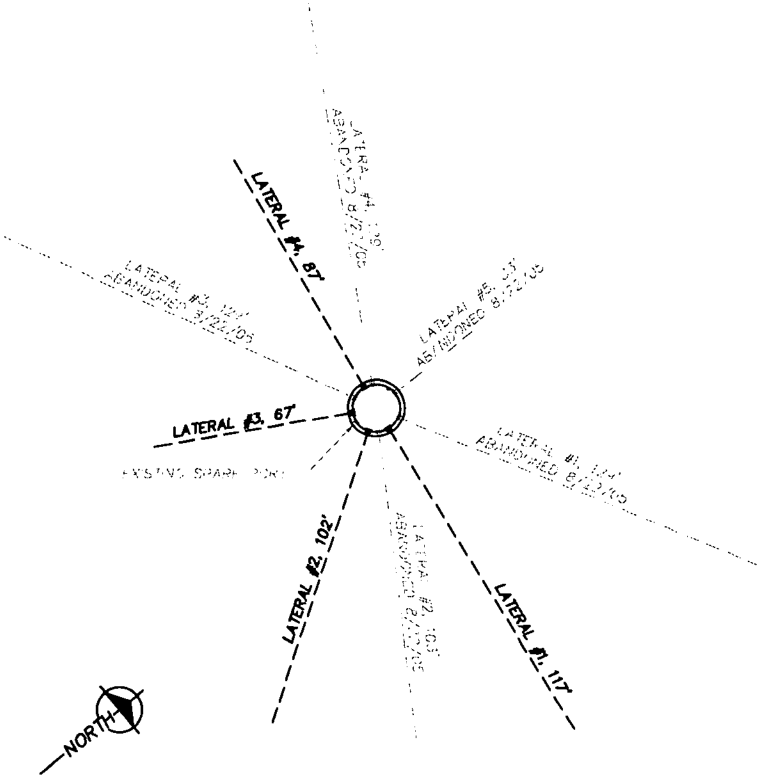
WELL LOG

Client: CITY OF SIOUX FALLS
JOB NO. RLC-2463
Location: NORTH WELL FIELD
Well No. OW78-2-6(R-3)
Date 11-2-78
Well Dia. 6 inch Total Depth 42'-6" Drill Method Cable Tool
Screen: 40 slot PVC From 39'-6" To 42'-6" Casing steel From +3 To 39'-6"
Elevation: Top of Casing Ground
(Log in feet from ground level) Static From

FROM	TO	MATERIAL	REMARKS
0	18	Dark gray brown sandy SILT/CLAY.	
18	22	Dark gray-brown very silty fine-very coarse SAND, 30% Birdseye-Pea GRAVEL, 10% medium GRAVEL, 5% coarse GRAVEL, CLAYBALLS.	
22	28	Dark gray very silty fine-very coarse SAND, 20% Birdseye GRAVEL, 23-28 No sample.	
28	32	Dark gray very silty fine-very coarse SAND, 30% Birdseye-Pea GRAVEL, scattered medium GRAVEL.	
32	36	Dark gray silty fine-very coarse SAND, 50% Birdseye Pea Gravel, 20% medium coarse GRAVEL.	
36	39	Dark gray very silty fine-very coarse SAND, 50% Birdseye-Pea GRAVEL, scattered medium coarse GRAVEL.	
39	42	Dark gray very silty fine-very coarse SAND, 50% Birds-Pea GRAVEL, 10% medium-coarse GRAVEL.	
42	42'-6"	Dark gray fine-very coarse SAND,60% Birdseye GRAVEL 25% medium-coarse GRAVEL, scattered pieces SAND/gravel loosely cemented congolomerate, COBBLES.	Bottom foot cement Not suitable for Lateral Projection
	42'-6"	Gray CLAY.	



VERTICAL SECTION THRU CAISSON
SCALE: N.T.S.



PLAN VIEW
SCALE: 1"=40'

Collector Wells International, Inc.

[illegible] HUNTLEY ROAD
COLUMBUS, OHIO [illegible]
(614) [illegible] / FAX (614) [illegible]

PLAN & SECTION VIEW
COLLECTOR WELL #47
REHABILITATION OF COLLECTOR WELLS #46 and 47
SIOUX FALLS, SOUTH DAKOTA

FILE NAME: 105-270-3	DATE: 2/24/06	FIGURE 3
PROJECT #: 105-270	SCALE: 1"=40'	

THE RANNEY COMPANY

Westerville Ohio

WELL LOG

Client: CITY OF SIOUX FALLS JOB NO. RLC-2463

Location: NORTH WELL FIELD Well No. TH78-1-2 (R-3)

Date October 16, 1978

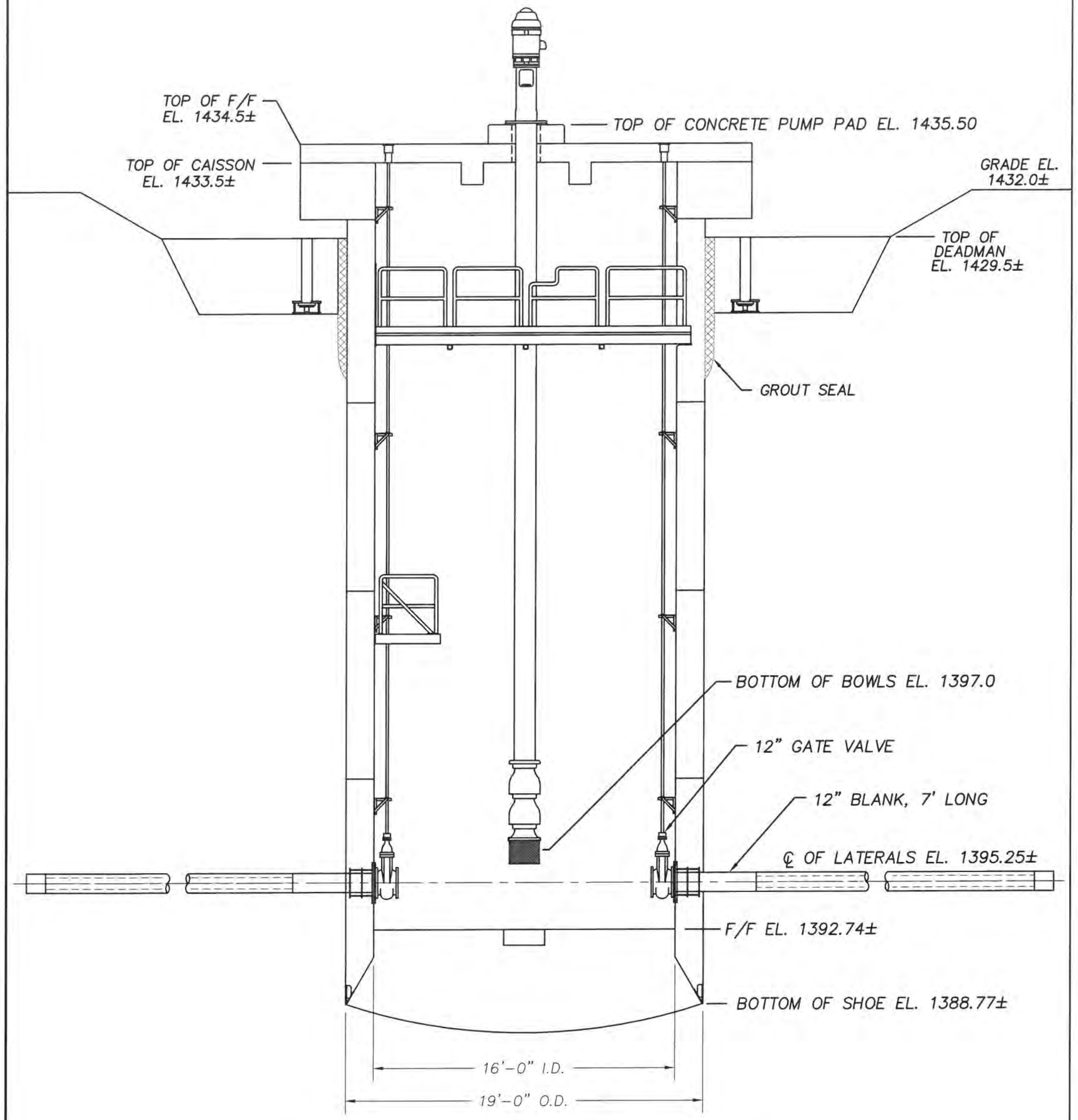
Well Dia. 6 inch Total Depth 40 feet Drill Method Cable-Tool

Screen: 40 slot PVC From 37 To 40 Casing steel From +3 To 37

Elevation: Top of Casing _____ Ground _____

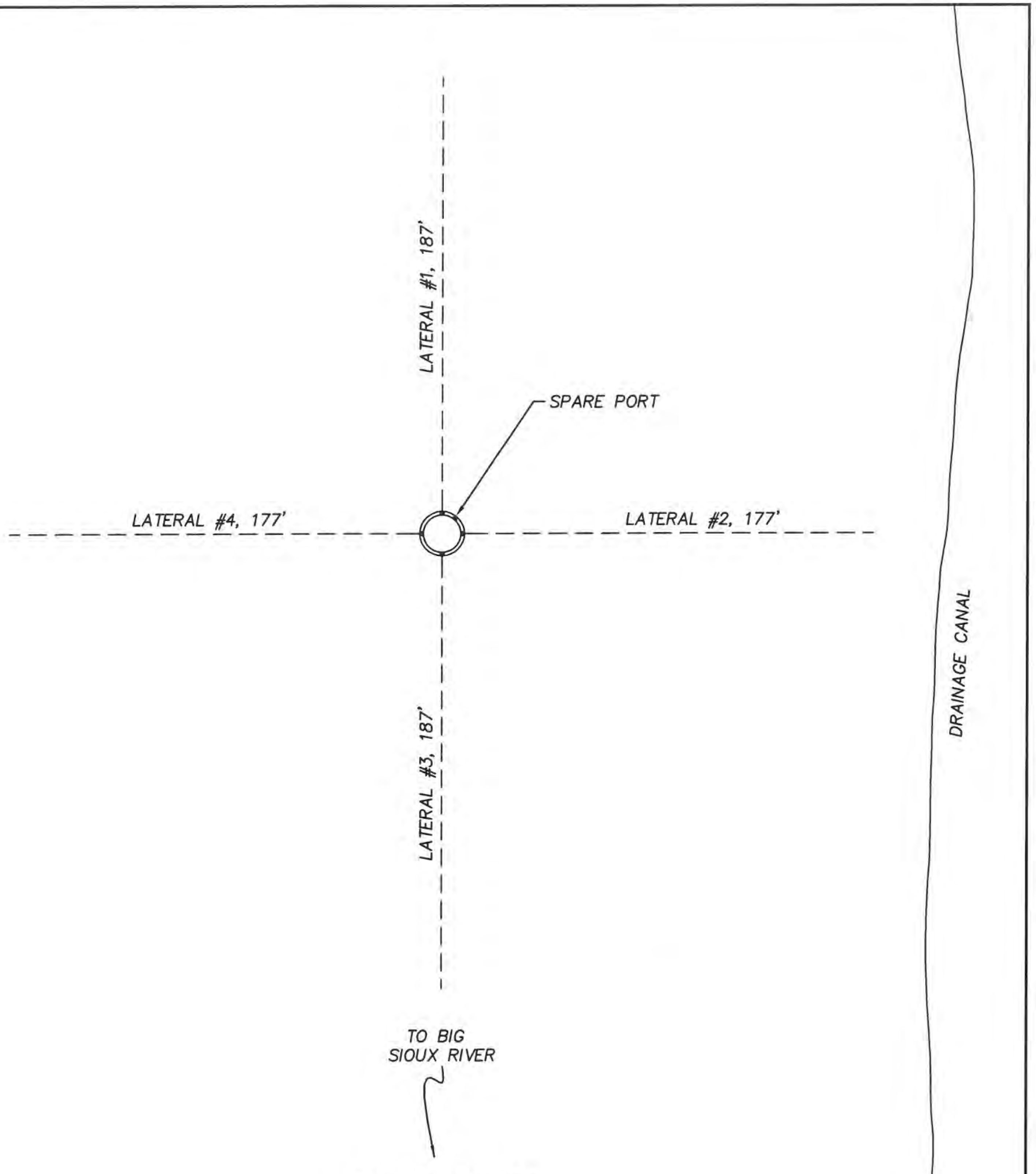
(Log in feet from ground level) _____ Static _____ From _____

FROM	TO	MATERIAL	REMARKS
0	16	Dark brown, sandy SILT/CLAY.	
16	20	Dark brown, sandy clayey SILT with 10% fine-coarse GRAVEL.	
20	23	Dark brown, silty fine-medium SAND with 10% birdseye GRAVEL.	
23	26	Dark gray-brown, silty fine-coarse SAND with 20% birdseye GRAVEL.	
26	31	Dark gray-brown, silty fine-very coarse SAND with 30% birdseye-pea GRAVEL, 15% medium GRAVEL.	
31	34	Dark gray-brown, lightly silty fine-very coarse SAND, 40% birdseye-medium GRAVEL, 10% coarse GRAVEL.	
34	38	Dark gray-brown, lightly silty SAND, with 30% birdseye-pea GRAVEL, 30% medium-coarse GRAVEL.	
38	40	Dark gray-brown, medium-coarse SAND with 40% birdseye-pea GRAVEL, 40% medium-coarse GRAVEL.	Bottom foot cemented - Not suitable for later
	40	Gray CLAY.	projection.



VERTICAL SECTION THRU CAISSON

SCALE: N.T.S.



PLAN VIEW

SCALE: 1"=60'

REYNOLDS, INC.

6360 HUNTLEY ROAD
COLUMBUS, OHIO 43229
(614) 888-6263 / FAX (614) 888-9208

SECTION & PLAN VIEW
OF COLLECTOR WELL #62
CITY OF SIOUX FALLS, SOUTH DAKOTA

FILE NAME: 10034-150-06	DATE: 11/23/10	FIGURE 2
PROJECT #: 10034-150	SCALE: 1"=60'	

SD EForm - 1621LD V1

SOUTH DAKOTA WATER WELL COMPLETION REPORT

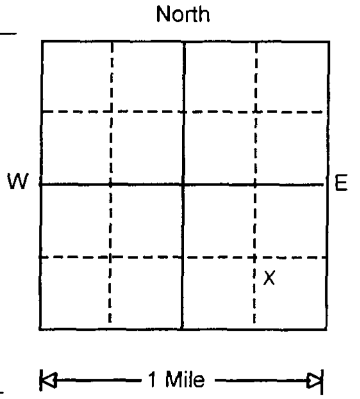
11-02

Location SE ¼ SE ¼ Sec 29 Twp 102N Rg 49W

County Minnehaha

Please mark well location with an "X"

HCW #62



Well Completion Date
16 October 2010

Distance to nearest potential pollution source (septic tank, abandoned well, feed lot, etc.)?
800.0 ft. from Farm (identify source)

PROPOSED USE:
☐ Domestic/Stock ☑ Municipal ☐ Business ☐ Test holes
☐ Irrigation ☐ Industrial ☐ Institutional ☐ Monitoring well

METHOD OF DRILLING:
Caisson sinking; vertical
Lateral projection, Horizontal

CASING DATA: ☐ Steel ☐ Plastic ☑ Other
If other describe Reinforced concrete caisson 16' x 19'

PIPEWEIGHT	DIAMETER	FROM	TO	HOLE DIAMETER
12,37 LB/FT	228.00 IN	0.0 FT	43.0 FT	228.00 IN
LB/FT	IN	FT	FT	IN
LB/FT	IN	FT	FT	IN

GROUTING DATA:

Grout Type	No. of Sacks	Grout Weight	From	To
		Lb/gal	Ft	Ft
		Lb/gal	Ft	Ft

Describe grouting procedure
Bentonite slurry was added as caisson was sunk

SCREEN: ☐ Perforated pipe ☑ Manufactured
Diameter 12.75 inches Length 400.0 Feet
Material 304 Stainless Steel
Slot Size 30-150 Set From 37.0 Feet to 38.0 Feet
Other information 4 laterals were installed, 2 - 177' overall length; 2 - 187' overall length; 7' blank pipe, each

WAS A PACKER OR SEAL USED? ☐ Yes ☑ No
If so, what material?
Describe packer(s) and location

DISINFECTION: Was well disinfected upon completion?
☑ Yes, How? Calcium Hypochlorite
☐ No, Why Not?
Lab to which water quality sample sent for analysis
Energy Lab
Rapid City, South Dakota

Well Owner: City of Sioux Falls, South Dakota
Business Name: Water Department
Address: 224 West 9th Street
City, State, Zip: Sioux Falls SD 57117

WELL LOG:

FORMATION	DEPTH FROM	DEPTH TO
Lean Clay, top soil	0	6
Sand, Medium Grained, Brown	6	20
Sand, Tr. Gravel, Med Gr., Grey	20	30
Sand w/Gr. Med Grained, Brown	30	40
Lean Clay	40	43

STATIC WATER LEVEL 8.7 FEET
If flowing: closed in pressure PSI
GPM flow through Inch pipe
Controlled by ☐ Valve ☐ Reducers ☐ Other
Reduced flow rate GPM
Can well be completely shut in?

RECEIVED
MAR 2 1 2011
WATER RIGHTS PROGRAM

WELL TEST DATA:
☑ Pumped ☐ Bailed ☐ Other
Describe: 8 Hour step Test and 72 hour constant rate test run with vertical turbine pump

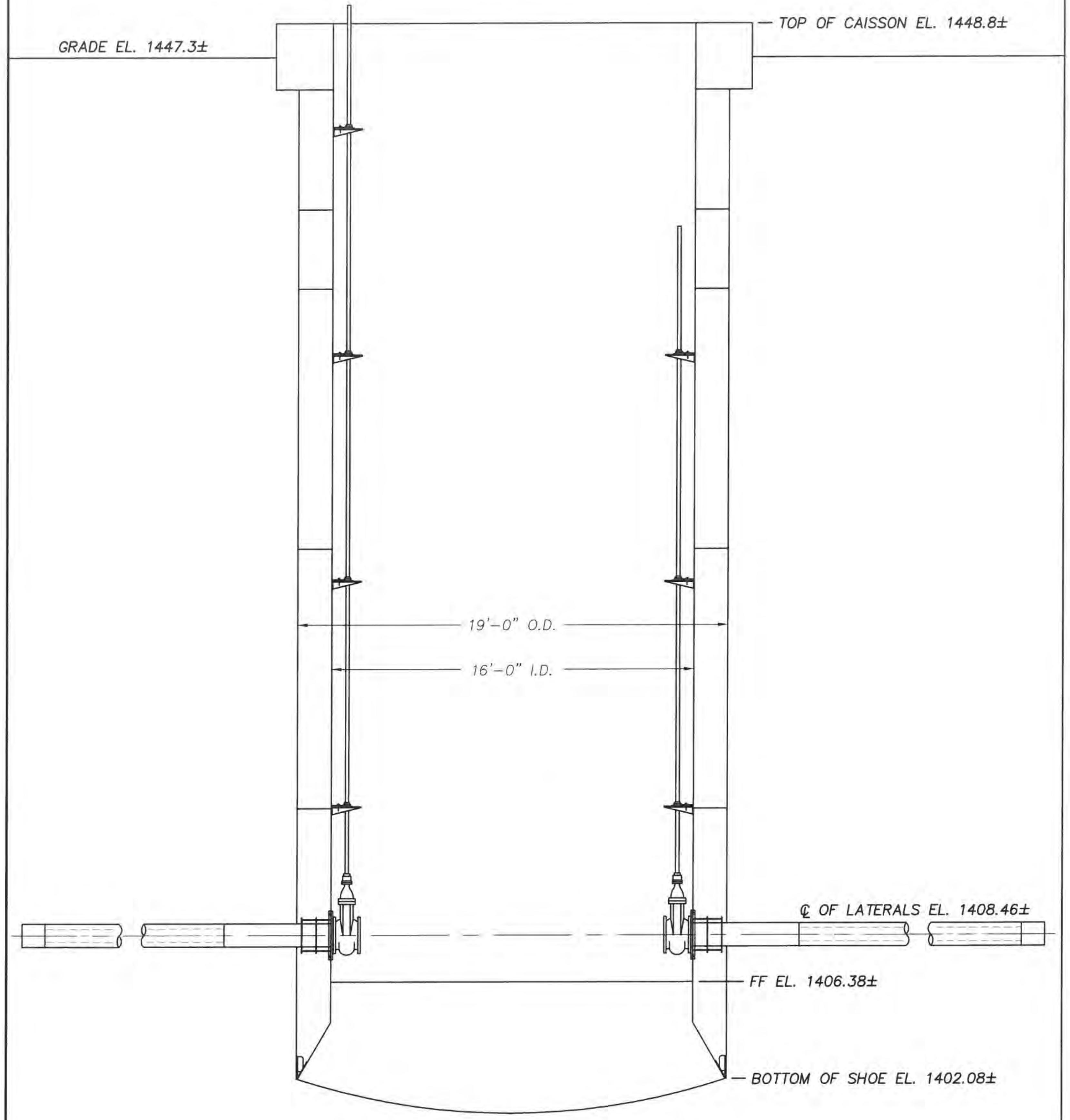
Pumping Level Below Land Surface
15.3 Ft. After 24.0 Hrs. pumped 1,800.0 GPM
1,608.0 Ft. After 72.0 Hrs. pumped 1,800.0 GPM
If pump installed, pump rate: 1,250.0 GPM

REMARKS
This is Sioux Falls Well #62. It is a horizontal collector well; 16' ID x 19' OD. 4 horizontal laterals are installed 90 degrees apart near the bottom of the well shaft.

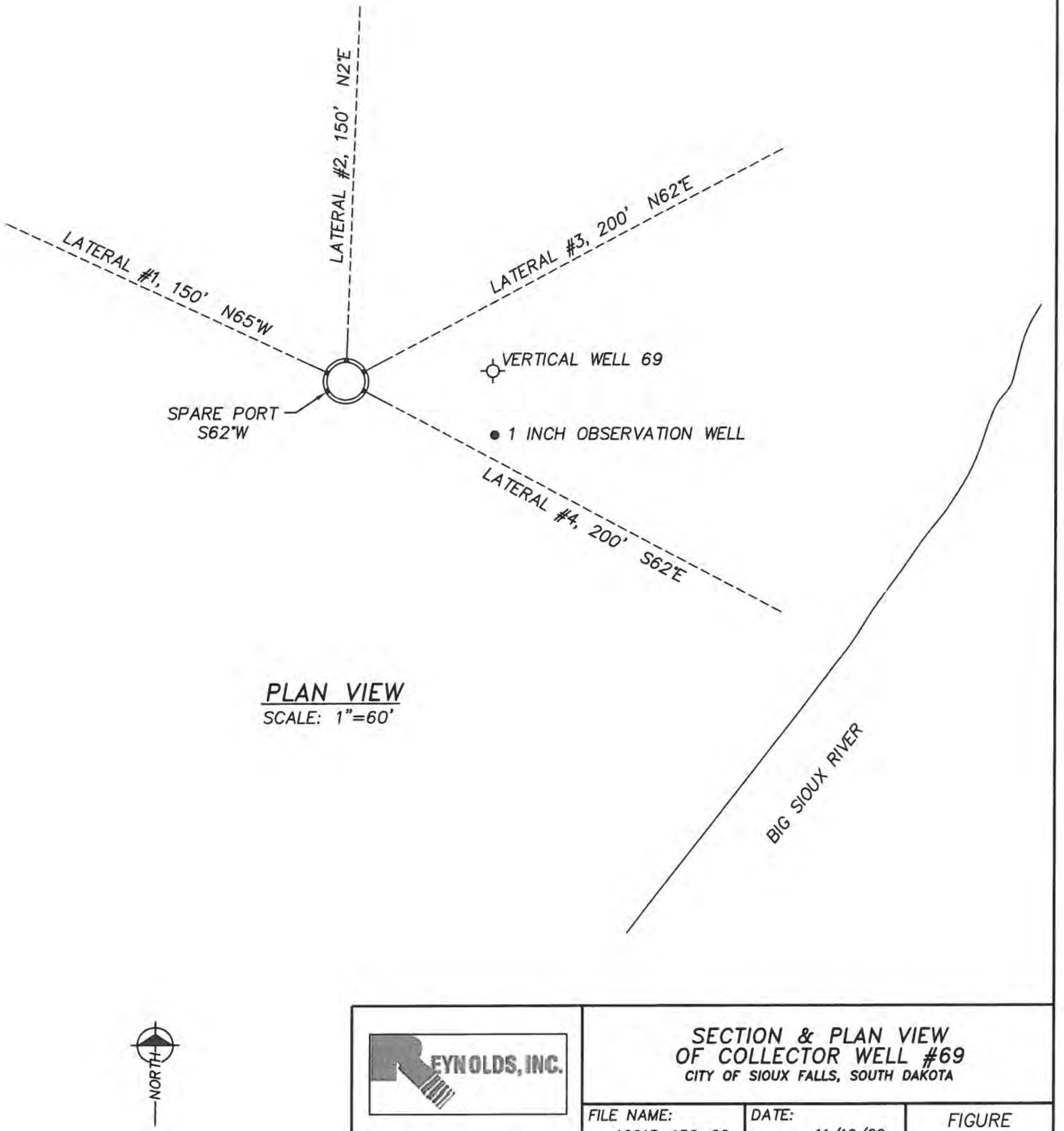
This well was drilled under license # 716 and this report is true and accurate.
Drilling firm: Ranney Collector Wells, John Reynolds & Sons
Signature of License Representative:

Signature of Well Owner or Equitable Property Holder:

Date: 3-15-11



VERTICAL SECTION THRU CAISSON
SCALE: N.T.S.



PLAN VIEW
SCALE: 1"=60'

REYNOLDS, INC.

6360 HUNTLEY ROAD
COLUMBUS, OHIO 43229
(614) 888-6263 / FAX (614) 888-9208

SECTION & PLAN VIEW OF COLLECTOR WELL #69
CITY OF SIOUX FALLS, SOUTH DAKOTA

FILE NAME: 10015-150-06	DATE: 11/10/09	FIGURE 2
PROJECT #: 10015-150	SCALE: 1"=60'	

GEOTEK ENGINEERING
& TESTING SERVICES, INC.
909 E. 50th Street North
Sioux Falls, SD 57104
605-335-5512 Fax 605-335-0773
www.geotekeng.com

GEOTECHNICAL TEST BORING LOG

HCW #69

GEOTEK # 08-781 Ground Elev = 1440.5 BORING NO. 1 (1 of 2)

PROJECT Well #69, Sioux Falls, SD

DEPTH in FEET	DESCRIPTION OF MATERIAL	GEOLOGIC ORIGIN	N	WL	SAMPLE NO.	SAMPLE TYPE	LABORATORY TESTS WC	D	LL	PL	QU
	LEAN CLAY: black, moist, (CL)	TOPSOIL			1	FA					
4½	**SAND**: poorly graded fine grained, brown, moist to waterbearing, loose to very loose, (SP)	COARSE ALLUVIUM	5		2	SPT					
			3	▼	3	SPT					
9½	**SAND**: with gravel, poorly graded fine to coarse grained, brown, waterbearing, (SP)	COARSE ALLUVIUM			4	SS					
					5	SS					
					6	SS					

WATER LEVEL MEASUREMENTS

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	WATER LEVEL
7-10-08	11:25 am	–	–	–	▼ 8
–	–	–	–	–	–
–	–	–	–	–	–
–	–	–	–	–	–

START 7-10-08 COMPLETE 7-10-08 11:24 am

METHOD
Rotary Mud Drilling

CREW CHIEF Gordy Hawkey

GEOTEK ENGINEERING
& TESTING SERVICES, INC.
909 E. 50th Street North
Sioux Falls, SD 57104
605-335-5512 Fax 605-335-0773
www.geotekeng.com

GEOTECHNICAL TEST BORING LOG

GEOTEK # **08-781**

BORING NO. **1 (2 of 2)**

PROJECT **Well #69, Sioux Falls, SD**

DEPTH in FEET	DESCRIPTION OF MATERIAL	GEOLOGIC ORIGIN	N	WL	SAMPLE NO.	SAMPLE TYPE	WC	D	LL	PL	QU
	SAND: with gravel, poorly graded fine to coarse grained, brown, waterbearing, (SP) *(Continued from previous page)*	COARSE ALLUVIUM									
					7	SS					
					8	SS					
					9	SS					
39½	**LEAN CLAY WITH SAND**: a little gravel, dark gray, moist, (CL)	TILL			10	SS					
41	Bottom of borehole at 41 feet.										

START 7-10-08 COMPLETE 7-10-08 11:24 am

METHOD
Rotary Mud Drilling

WATER LEVEL MEASUREMENTS

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	WATER LEVEL
7-10-08	11:25 am	–	–	–	▼ 8
–	–	–	–	–	–
–	–	–	–	–	–
–	–	–	–	–	–

CREW CHIEF Gordy Hawkey

7170-3 **SD EForm - 1621LD V1**

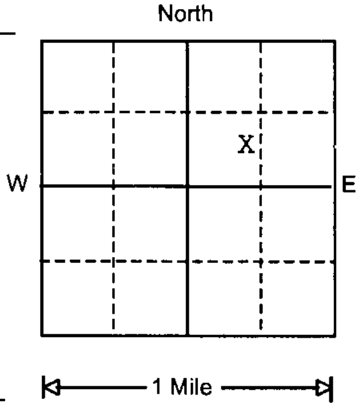
SOUTH DAKOTA WATER WELL COMPLETION REPORT

11-02

Location SW ¼ NE ¼ Sec 5 Twp 102N Rg 49W

County Minnehaha

Please mark well location with an "X"



Well Completion Date
10 June 2009

Distance to nearest potential pollution source (septic tank, abandoned well, feed lot, etc.)?
1200 ft. from Farm to NE (identify source)

PROPOSED USE:
☐ Domestic/Stock ☒ Municipal ☐ Business ☐ Test holes
☐ Irrigation ☐ Industrial ☐ Institutional ☐ Monitoring well

METHOD OF DRILLING:
Caisson Sinking; Vertical
Lateral Projection: horizontal

CASING DATA: ☐ Steel ☐ Plastic ☒ Other
If other describe Concrete Caisson; 16' x 19'

PIPEWEIGHT	DIAMETER	FROM	TO	HOLE DIAMETER
12,370 LB/FT	228 IN	0 FT	45.5 FT	228.0 IN
LB/FT	IN	FT	FT	IN
LB/FT	IN	FT	FT	IN

GROUTING DATA:

Grout Type	No. of Sacks	Grout Weight	From	To
		Lb/gal	Ft	Ft
		Lb/gal	Ft	Ft

Describe grouting procedure

SCREEN: ☐ Perforated pipe ☒ Manufactured
Diameter 12.75 Inches Length 600.0 Feet
Material 304 St. Steel; 0.03" slot to
Slot Size 0.15" Set From 39 Feet to 38 Feet
Other information 4 laterals installed; 2-200' 2-150' OAL; 10' blank pipe, each

WAS A PACKER OR SEAL USED? ☐ Yes ☒ No
If so, what material?
Describe packer(s) and location

DISINFECTION: Was well disinfected upon completion?
☒ Yes, How? CA Hypochlorite
☐ No, Why Not?

Lab to which water quality sample sent for analysis
Energy Lab; Rapid City, SD

Well Owner: City of Sioux Falls, SD
Business Name: Water Department
Address: 224 West 9th Street
City, State, Zip: Sioux Falls, SD 57117

WELL LOG:

FORMATION	DEPTH FROM	DEPTH TO
Lean Clay, top soil	0	4.5
Brn Sand, poorly graded, loose	4.5	9.5
Brn Sand, w/Gravel; fine to coarse	9.5	39.5
Lean Clay	39.5	45

STATIC WATER LEVEL 15.5' FEET
If flowing: closed in pressure PSI
GPM flow 1380 through 8" Inch pipe
Controlled by ☒ Valve ☐ Reducers ☐ Other
Reduced flow rate GPM
Can well be completely shut in?

WELL TEST DATA:
☒ Pumped ☐ Bailed ☐ Other
Describe: Temporary submersible pump installed; pumped to Water treatment plant

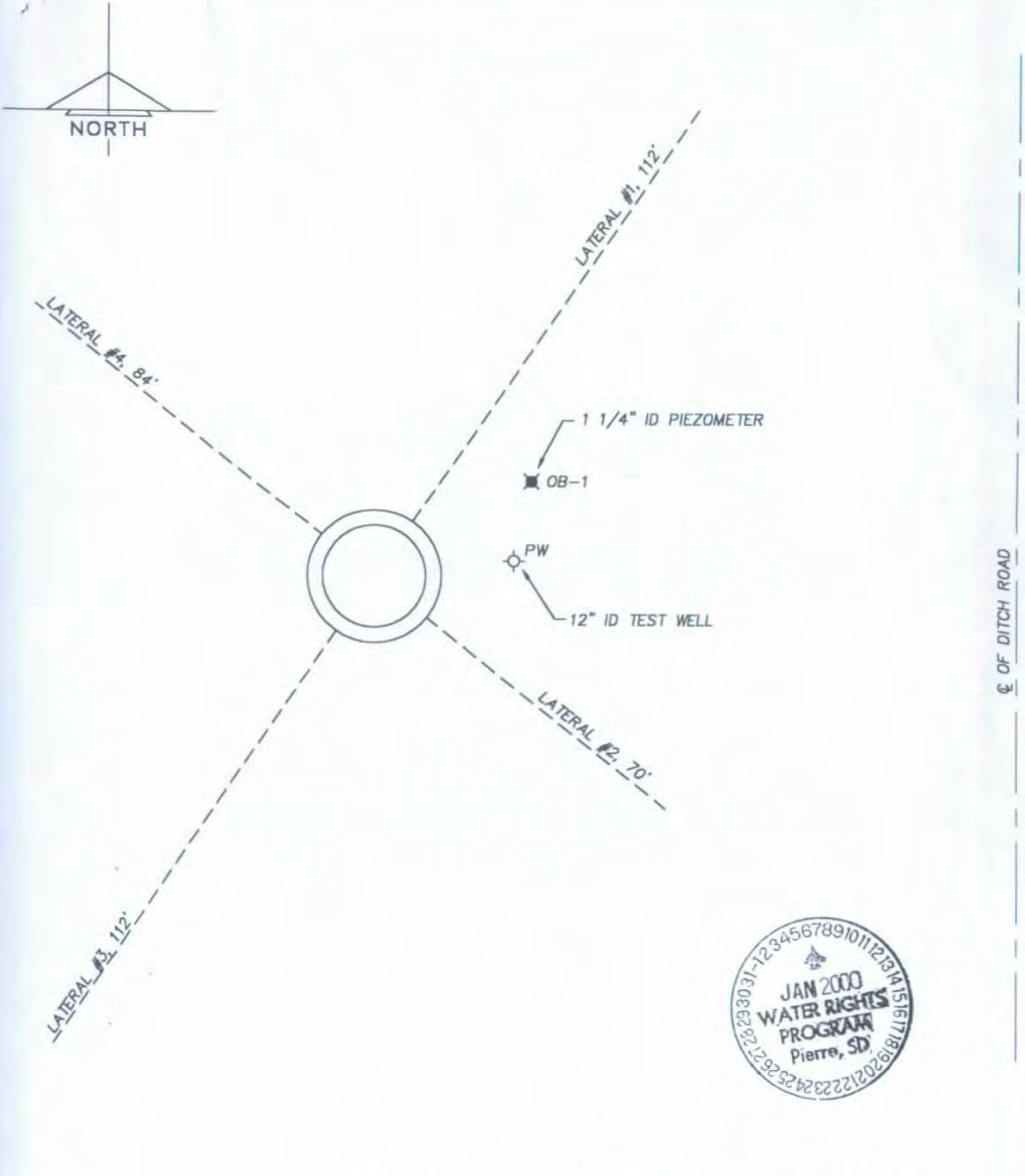
Pumping Level Below Land Surface
21.9 Ft. After 24 Hrs. pumped 1380 GPM
23 Ft. After 72 Hrs. pumped 1380 GPM
If pump installed, pump rate: 1390 GPM

REMARKS This is Sioux Falls' well 69. A Horizontal collector well; 16'ID x 19'OD. 4 Horizontal laterals installed over 180 deg; NE to SW, near the bottom of the well shaft

This well was drilled under license # 716 and this report is true and accurate.
Drilling firm: Ranney Collector Wells; ~~John Reynolds & Sons~~
Signature of License Representative:

Signature of Well Owner or Equitable Property Holder:

Date:



PLAN
N.T.S.

SECTION & PLAN VIEW
OF COLLECTOR WELL 70, FERNSDALE SITE
SIOUX FALLS, SOUTH DAKOTA

COLLECTOR WELLS INTERNATIONAL, INC.

DRAWN BY:	FILE NAME:	DATE:	FIGURE:
RJM	198-114-9	12/20/99	1

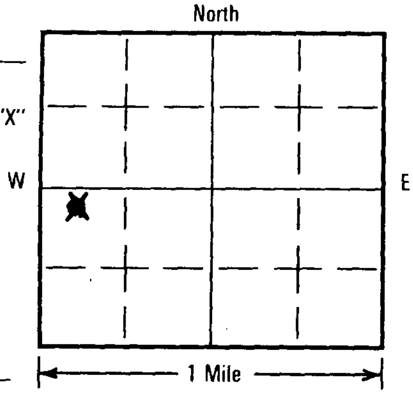
SOUTH DAKOTA WATER WELL COMPLETION REPORT

07-92

Location NW ¼ SW ¼ Sec 33 Twp 103N Rg 49W

County Minnehaha

Please mark well location with an "X"



HCW #70

Well Completion Date 11-29-99

Well Owner: City of Sioux Falls, S.D.

Business Name:

Address: 224 West Ninth Street
Sioux Falls, South Dakota 57104

WELL LOG:

FORMATION	DEPTH FROM	DEPTH TO
clay	0	14
sand and gravel	14	33
clay	33	35

LOCATION:

Distance from nearest potential pollution source (septic tank, abandoned well, feed lot, etc.)? 120 ft. from Ditch Road (identify source).

PROPOSED USE:

☐ Domestic/Stock ☒ Municipal ☐ Business ☐ Test Holes
☐ Irrigation ☐ Industrial ☐ Institutional ☐ Monitoring well

JAN 2000
WATER RIGHTS PROGRAM
Pierre, SD

METHOD OF DRILLING: Completed by the open caisson method. Caisson was sunk and laterals were jacked

STATIC WATER LEVEL 8 ft. below grade - 1434.4 elevation Feet

If flowing: closed in pressure N/A PSI

GPM flow ____ through ____ inch pipe

Controlled by ☐ Valve ☐ Reducers ☐ Other ____

Reduced Flowrate N/A GPM

Can well be completely shut in? yes

CASING DATA: ☐ Steel ☐ Plastic ☒ Other

If other describe Reinforced concrete caisson

PIPEWEIGHT	DIAMETER	FROM	TO	HOLE DIAMETER
8129 LB/FT	156 IN	0 FT	33 FT	120 IN
LB/FT	IN	FT	FT	IN
LB/FT	IN	FT	FT	IN

WELL TEST DATA:

☒ Pumped Describe: 72 hour constant rate test @ 1600 gpm
☐ Bailed
☐ Other

GROUTING DATA

Grout Type	No. of Sacks	Grout Weight	From	To
		lb./gal	ft.	ft
		lb./gal	ft.	ft

Describe grouting procedure N/A

Pumping Level Below Land Surface

21 ft. After 24 Hrs. pumped 1600 GPM
23 ft. After 72 Hrs. pumped 1600 GPM

If pump installed, pump rate N/A GPM

SCREEN: ☐ Perforated pipe ☒ Manufactured

Diameter 8 IN Length 350 FEET

Material Stainless steel

Slot Size 40-100 Set From 26 Feet to 27 Feet

Other information Screen was installed horizontally - See plan.

REMARKS

This is a collector well

WAS A PACKER OR SEAL USED? ☐ YES ☒ NO

If so, what material?

Describe packer(s) and location?

This well was drilled under license # 673

And this report is true and accurate.

Drilling firm Collector Wells International, Inc.

Signature of License Representative:

DISINFECTION: Was well disinfected upon completion?

X YES, How: calcium Hypochloride

____ NO, Why Not?

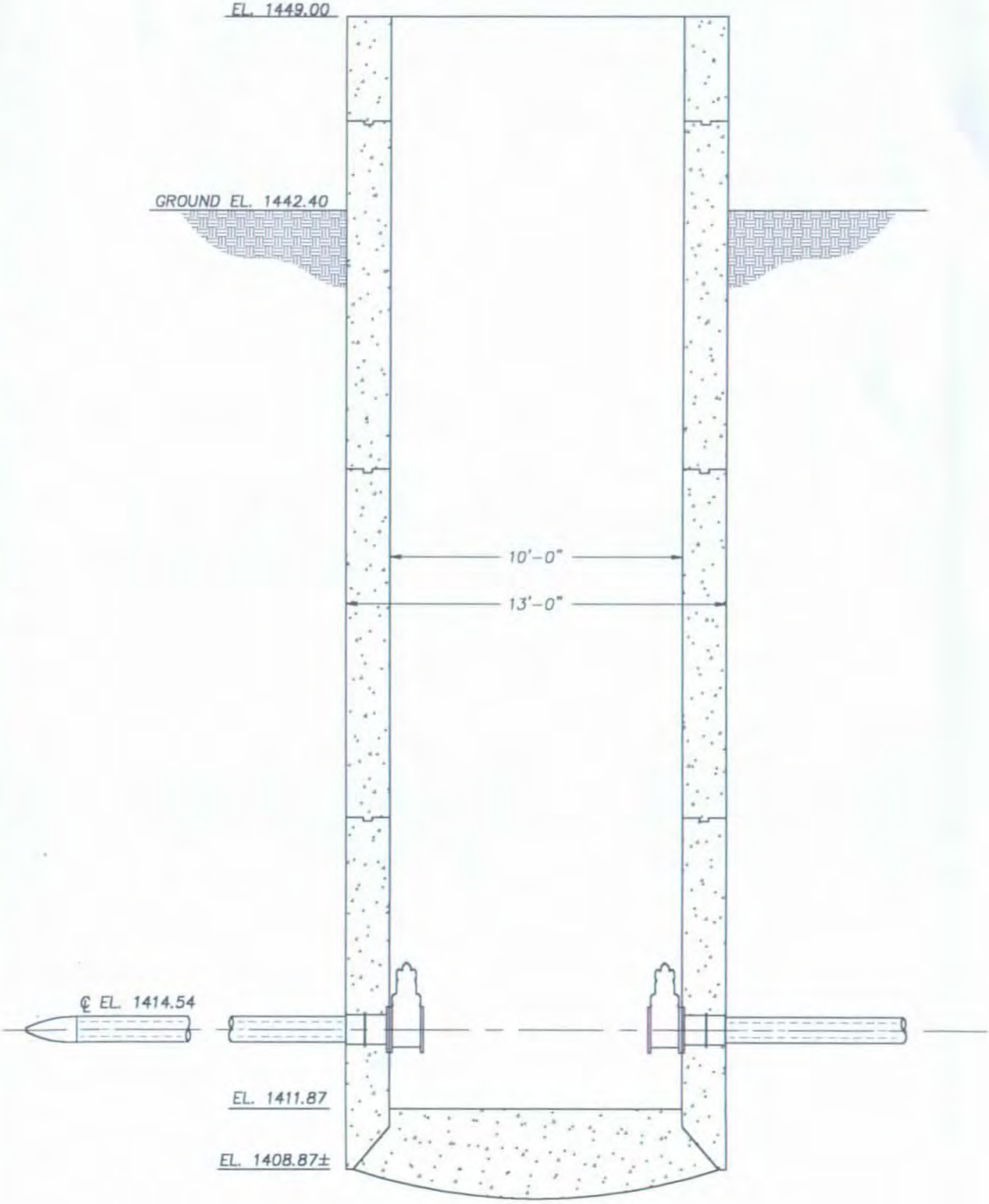
Laboratory sent to for water quality analysis

City of Sioux Falls

Signature of Well Owner or Equitable Property Holder:

x R Jansen (water Supt City of Sioux Falls)

Date: December 16, 1999



SECTION

HCW #70

UTILITY NOTE:

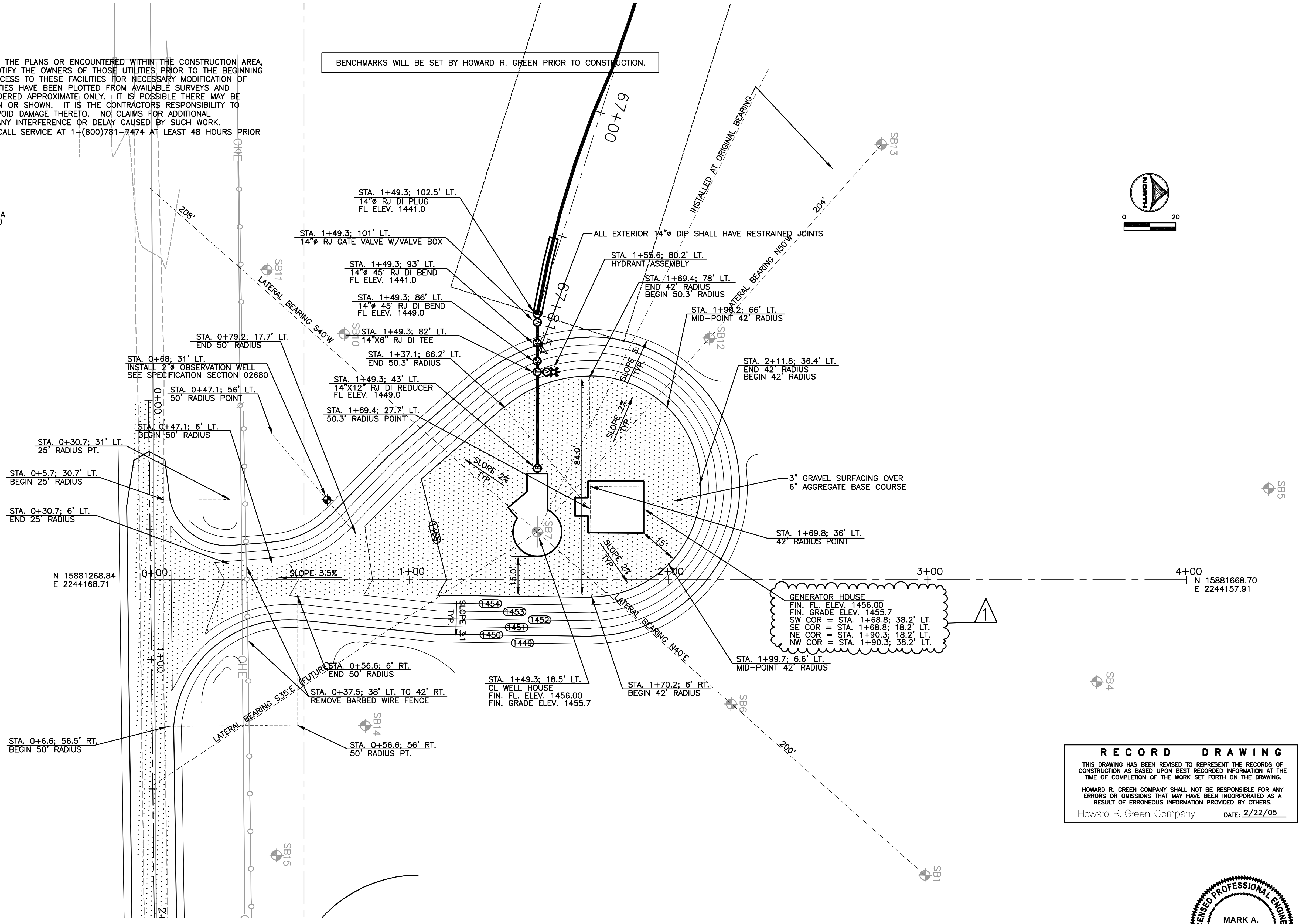
WHERE PUBLIC UTILITY FIXTURES ARE SHOWN AS EXISTING ON THE PLANS OR ENCOUNTERED WITHIN THE CONSTRUCTION AREA, IT SHALL BE THE RESPONSIBILITY OF THE CONTRACTOR TO NOTIFY THE OWNERS OF THOSE UTILITIES PRIOR TO THE BEGINNING OF ANY CONSTRUCTION. THE CONTRACTOR SHALL AFFORD ACCESS TO THESE FACILITIES FOR NECESSARY MODIFICATION OF SERVICES. UNDERGROUND FACILITIES, STRUCTURES AND UTILITIES HAVE BEEN PLOTTED FROM AVAILABLE SURVEYS AND RECORDS, AND THEREFORE THEIR LOCATIONS MUST BE CONSIDERED APPROXIMATE ONLY. IT IS POSSIBLE THERE MAY BE OTHERS, THE EXISTENCE OF WHICH IS PRESENTLY NOT KNOWN OR SHOWN. IT IS THE CONTRACTORS RESPONSIBILITY TO DETERMINE THEIR EXISTENCE AND EXACT LOCATION AND TO AVOID DAMAGE THERETO. NO CLAIMS FOR ADDITIONAL COMPENSATION WILL BE ALLOWED TO THE CONTRACTOR FOR ANY INTERFERENCE OR DELAY CAUSED BY SUCH WORK.
THE CONTRACTOR IS REQUIRED TO UTILIZE THE UTILITY ONE-CALL SERVICE AT 1-(800)781-7474 AT LEAST 48 HOURS PRIOR TO EXCAVATING ANYWHERE ON THE PROJECT.

SPECIFICATIONS TO BE USED:

THE CITY OF SIOUX FALLS GENERAL CONDITIONS FOR PUBLIC IMPROVEMENTS AND SUPPLEMENTAL STANDARD SPECIFICATIONS ARE HEREBY MADE PART OF THESE SPECIFICATIONS IN THEIR ENTIRETY UNLESS OTHERWISE REVISED, DELETED OR SUPPLEMENTED HEREIN.

THE CITY OF SIOUX FALLS ENGINEER'S OFFICE WILL PROVIDE A COPY OF THE STANDARD SPECIFICATIONS FREE OF CHARGE TO ALL PROSPECTIVE BIDDERS UPON REQUEST. THE STANDARD SPECIFICATIONS CAN ALSO BE DOWNLOADED FROM THE CITY OF SIOUX FALLS WEBSITE AT ADDRESS http://siouxfalls.org/publicworks/bidtabsdocs.asp.

BENCHMARKS WILL BE SET BY HOWARD R. GREEN PRIOR TO CONSTRUCTION.



RECORD DRAWING

THIS DRAWING HAS BEEN REVISED TO REPRESENT THE RECORDS OF CONSTRUCTION AS BASED UPON BEST RECORDED INFORMATION AT THE TIME OF COMPLETION OF THE WORK SET FORTH ON THE DRAWING.

HOWARD R. GREEN COMPANY SHALL NOT BE RESPONSIBLE FOR ANY ERRORS OR OMISSIONS THAT MAY HAVE BEEN INCORPORATED AS A RESULT OF ERRONEOUS INFORMATION PROVIDED BY OTHERS.

Howard R. Green Company DATE: 2/22/05

MARK A. HARDIE
6819

Xrefs: XCT-DSGN.DWG XCS-BASE.DWG

DRAWN BY: TLK JOB DATE: 11/5/03
APPROVED: MAH JOB NUMBER: 603050
CAD DATE: March 22, 2004 4:39:38 p.m.
CAD FILE: 603050\Dwgs\C\C100A.DWG (TKUIPER)

NO.	DATE	BY	REVISION DESCRIPTION
1	3/15/04	TLK	MOVED GENERATOR BLDG. 10.3' TO THE EAST
2	3/15/04	TLK	ROTATE NW LATERAL TO N65°W

Howard R. Green Company

BIG SIOUX AQUIFER EXPANSION
CITY OF SIOUX FALLS
SIOUX FALLS, SD

CIVIL
SITE LAYOUT AND GRADING PLAN

SHEET NO.
C100A

GEOTEK ENGINEERING
& TESTING SERVICES, INC.
909 EAST 50TH STREET NORTH
SIOUX FALLS, SOUTH DAKOTA 57104
605-335-5512 FAX 605-335-0773

GEOTECHNICAL TEST BORING LOG

JOB # 03-990 BORING # SB7

PROJECT PROPOSED CITY WELL, HWY 115 & 254TH ST, MINNEHAHA COUNTY, SD

DEPTH IN FEET	DESCRIPTION OF MATERIAL SURFACE ELEVATION ______	GEOLOGIC ORIGIN	SAMPLE DATA				LABORATORY TESTS			
			WL	N	NO	TYPE	W	D	LL/PL	QU
	SILTY CLAY, black (CL)	TOPSOIL								
5	SILTIY CLAY, gray (CL)	FINE ALLUVIUM								
10	SAND, medium & fine grained, a little gravel, gray (SP)	COARSE ALLUVIUM								
			▽							
					1	SB				
					2	SB				
					3	SB				
28	SAND, medium grained, a little gravel, gray (SP)									
30	CONTINUED ON NEXT PAGE									

HCW #71

SD WELL DRILLER'S
LICENSE No 552

FORMG4A

GEOTEK ENGINEERING
& TESTING SERVICES, INC.
909 EAST 50TH STREET NORTH
SIOUX FALLS, SOUTH DAKOTA 57104
605-335-5512 FAX 605-335-0773

GEOTECHNICAL TEST BORING LOG

JOB # 03-990

BORING # SB7 CONT

PROJECT PROPOSED CITY WELL, HWY 115 & 254TH ST, MINNEHAHA COUNTY, SD

DEPTH IN FEET	DESCRIPTION OF MATERIAL	GEOLOGIC ORIGIN	SAMPLE DATA				LABORATORY TESTS			
	SURFACE ELEVATION		WL	N	NO	TYPE	W	D	LL PL	QU
					4	SB				
					5	SB				
					6	SB				
42	LEAN CLAY, a little gravel, dark gray (CL)	TILL								
45	END OF BORING									

WATER LEVEL MEASUREMENT

DATE	TIME	WATER LEVEL	WATER ELEV.	CAVE-IN DEPTH
10-15-03	12:50	14.0'		

DATE STARTED 10-15-03

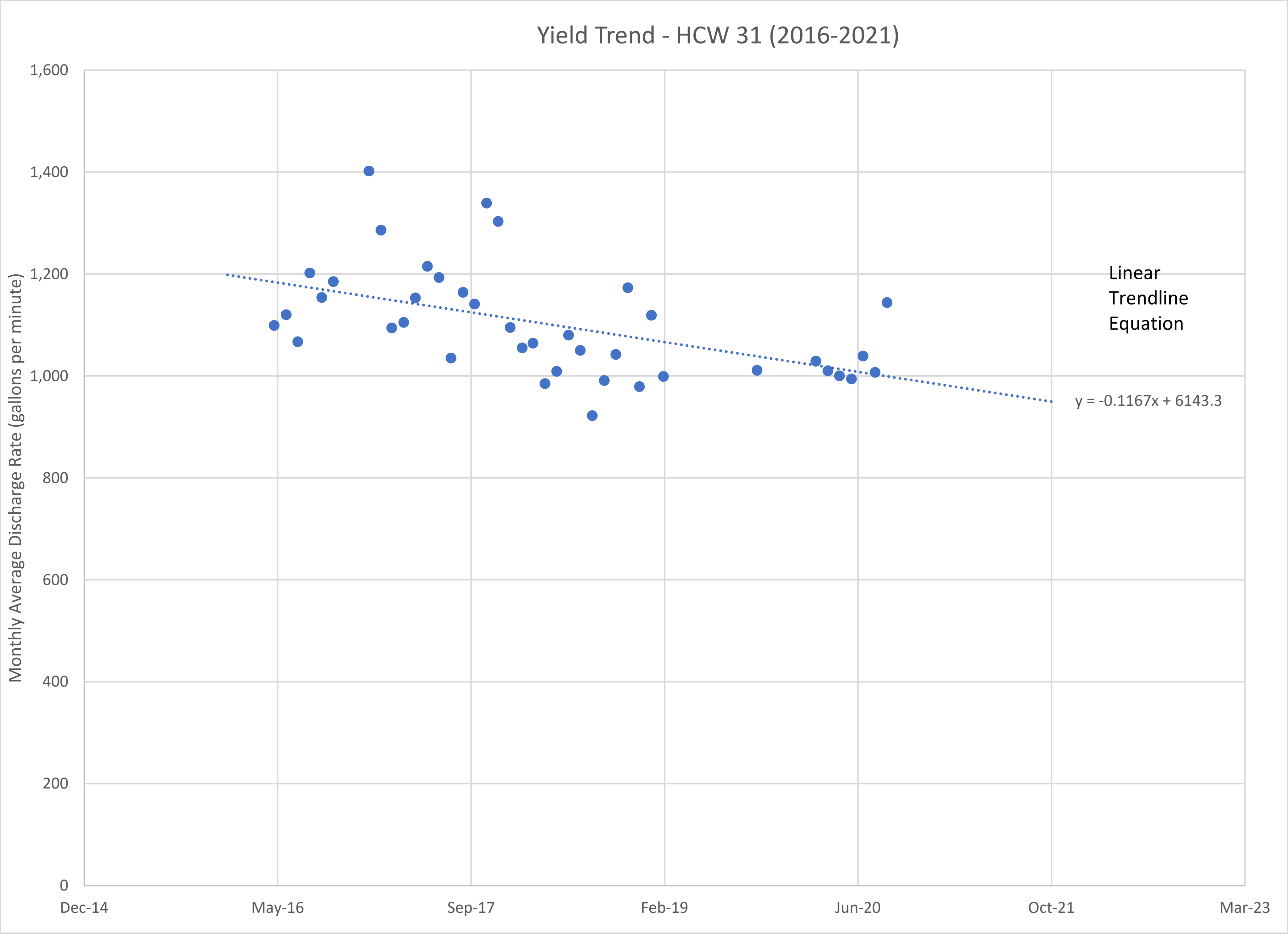
DATE FINISHED 10-15-03 @ 2:35

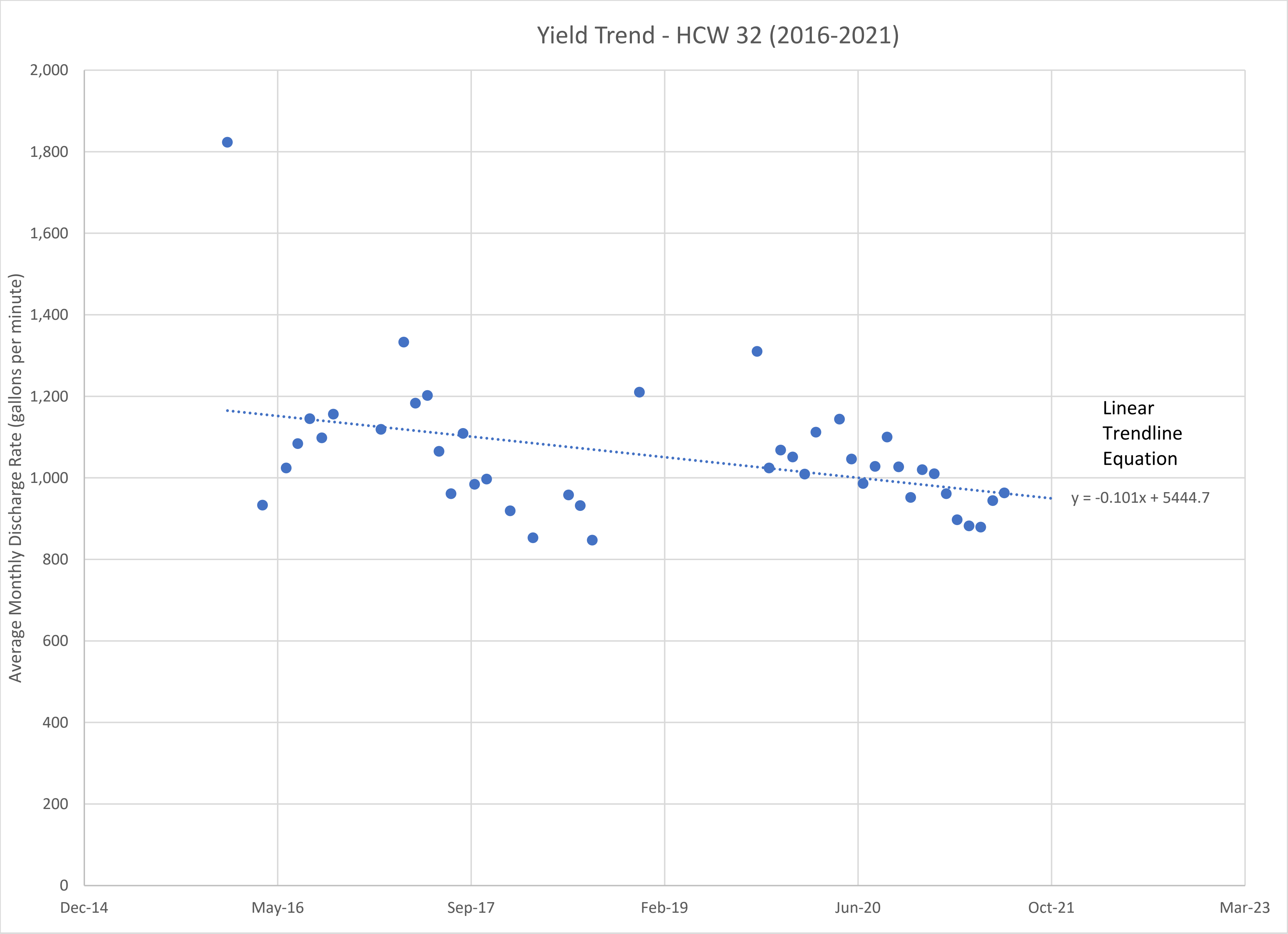
METHOD OF DRILLING 3 1/4" HSA: 0'-44.5'

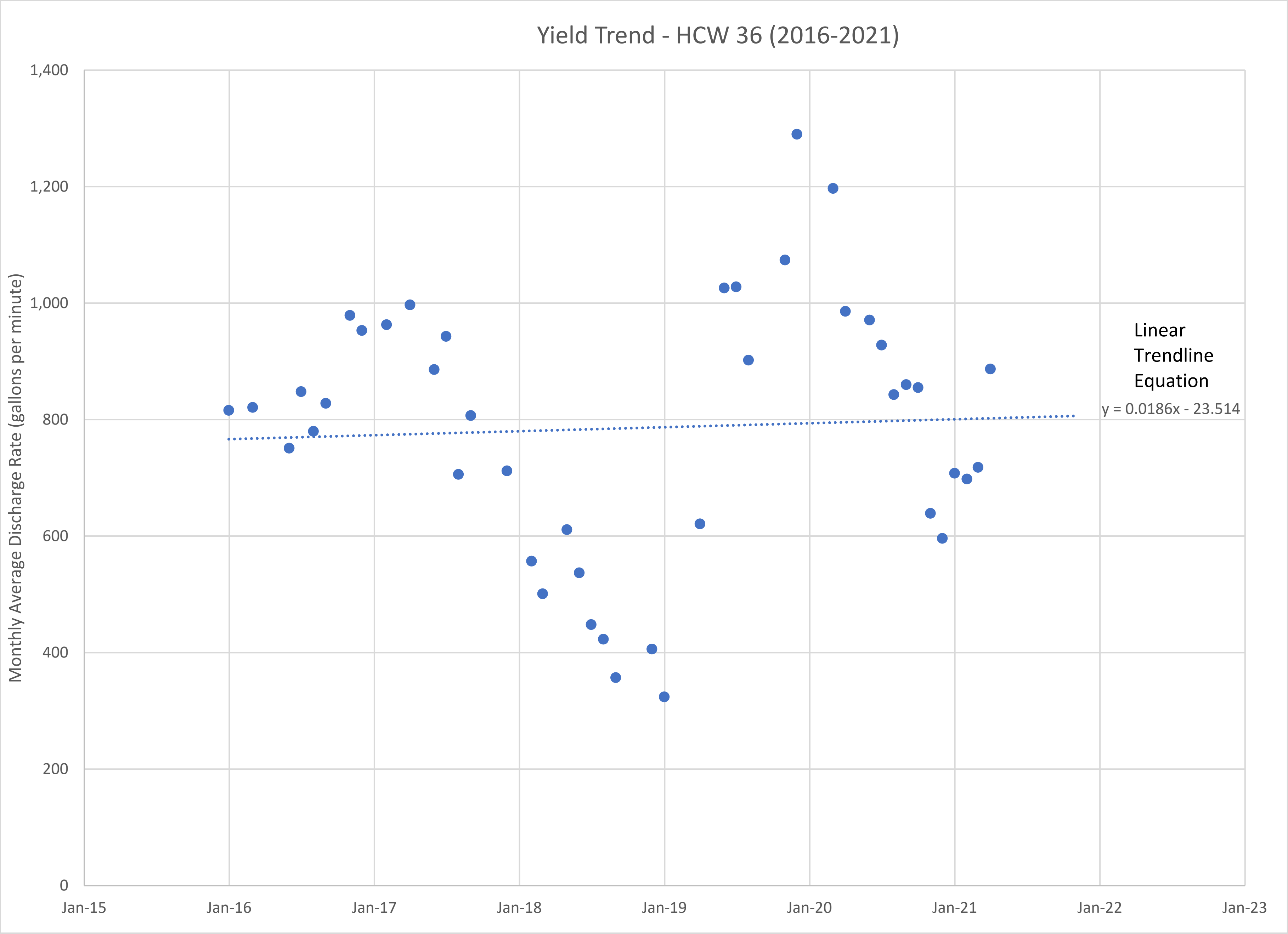
CREW CHIEF OLLERICH

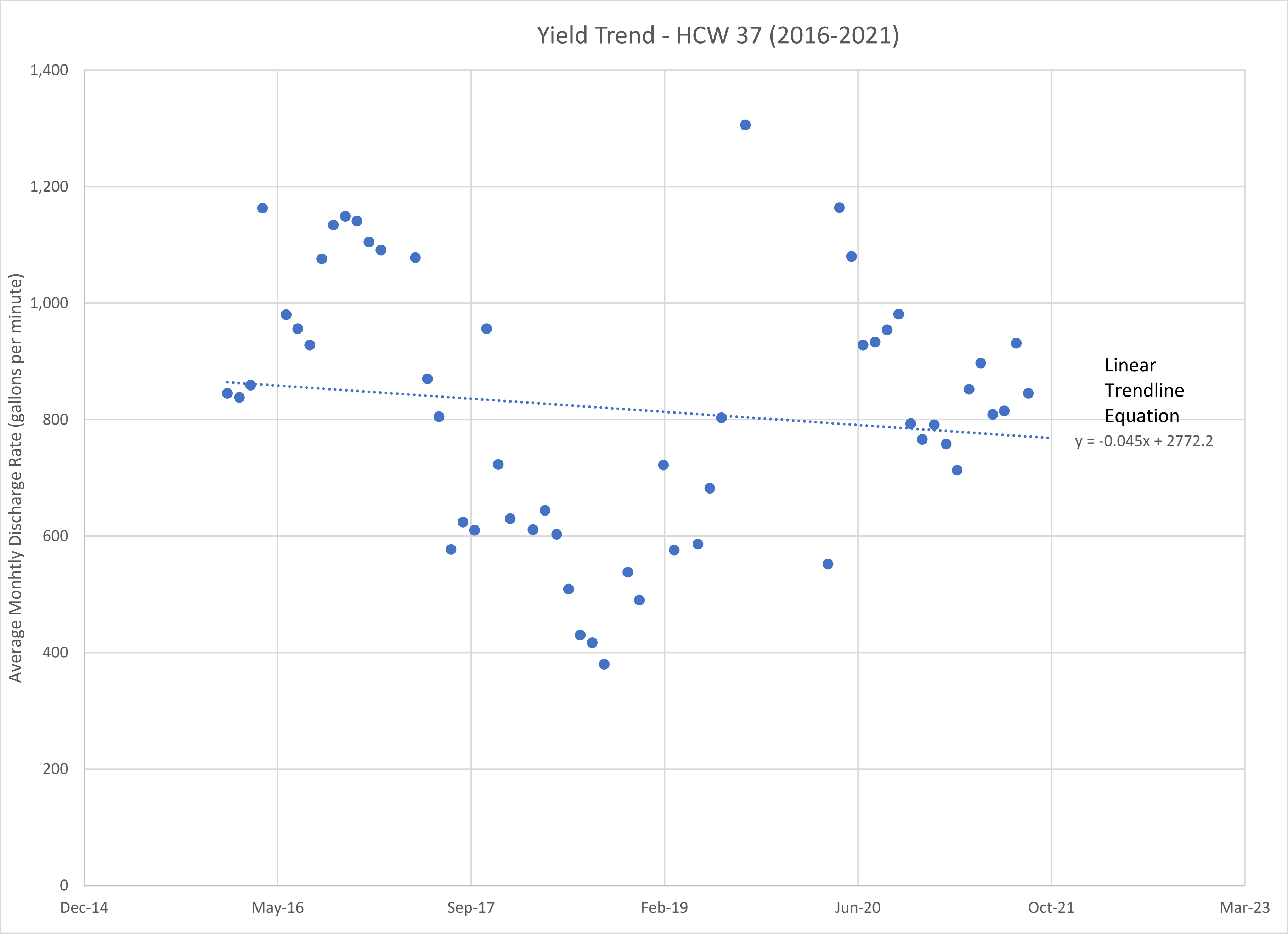
FORMG4JEFF

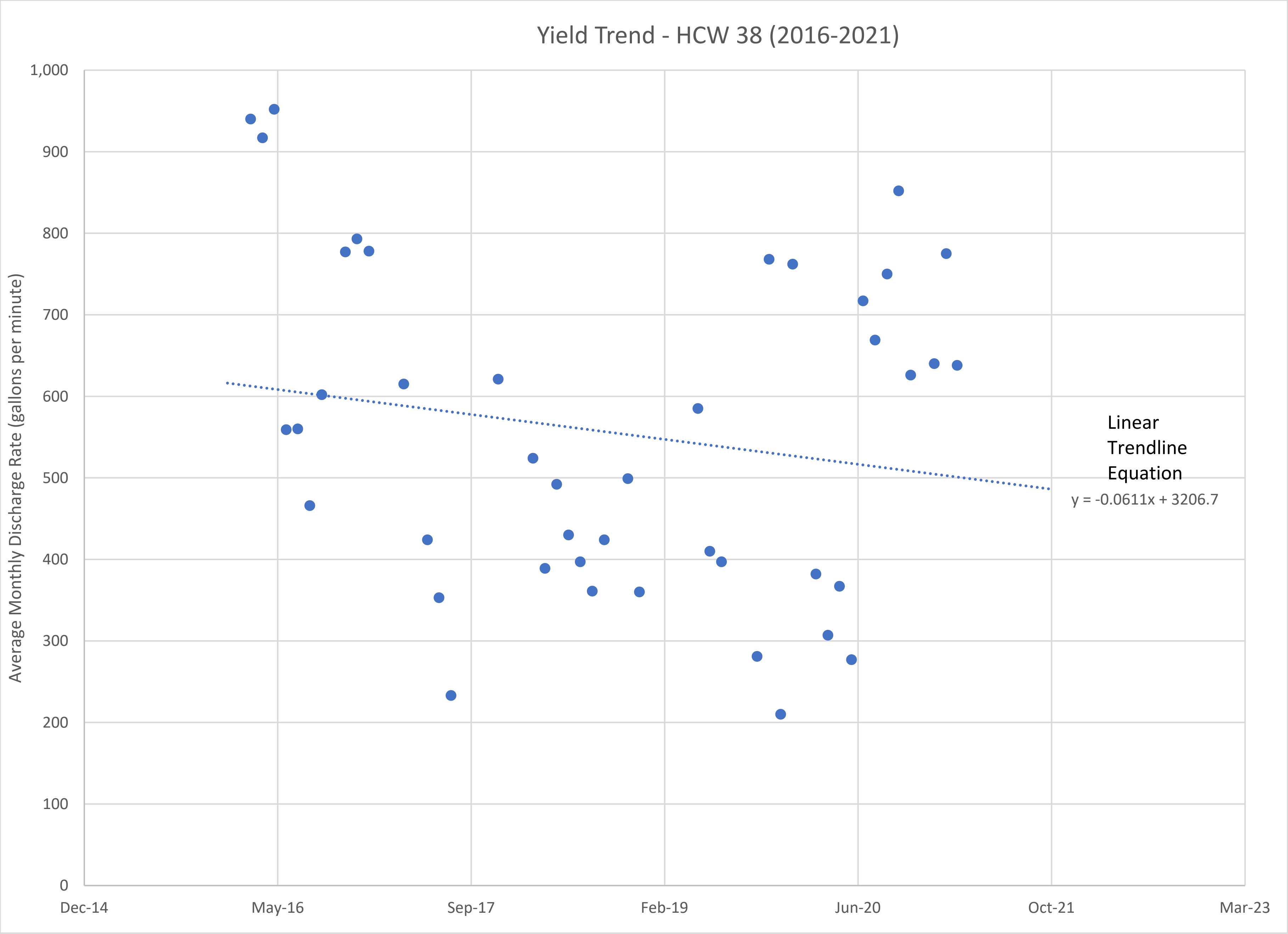
Appendix B Horizontal Collector Well Yield Trendlines

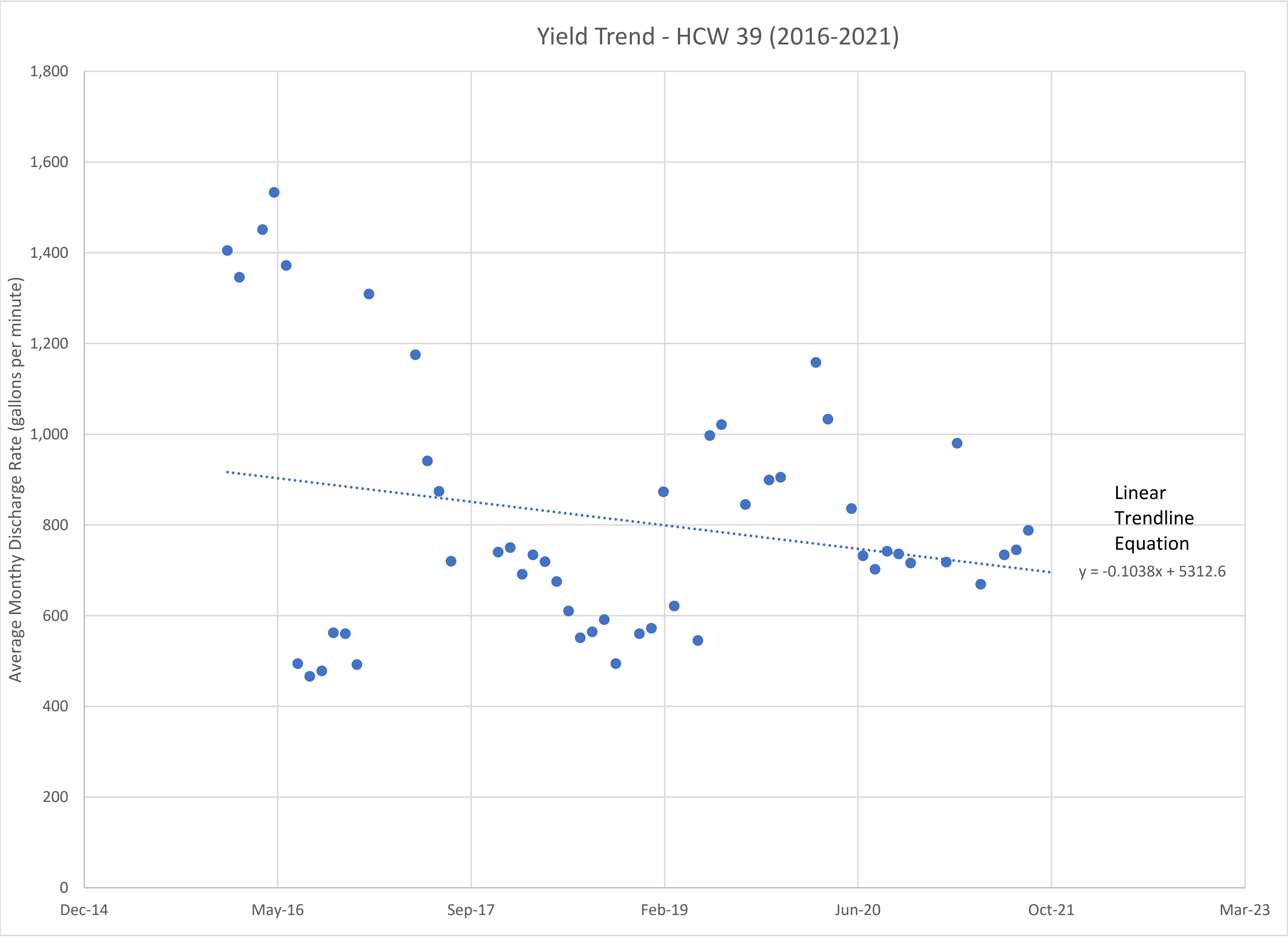

Yield Trend - HCW 31 (2016-2021)
Monthly Average Discharge Rate (gallons per minute)
1,600
1,400
1,200
1,000
800
600
400
200
0
Dec-14
May-16
Sep-17
Feb-19
Jun-20
Oct-21
Mar-23
Linear Trendline Equation
y = -0.1167x + 6143.3

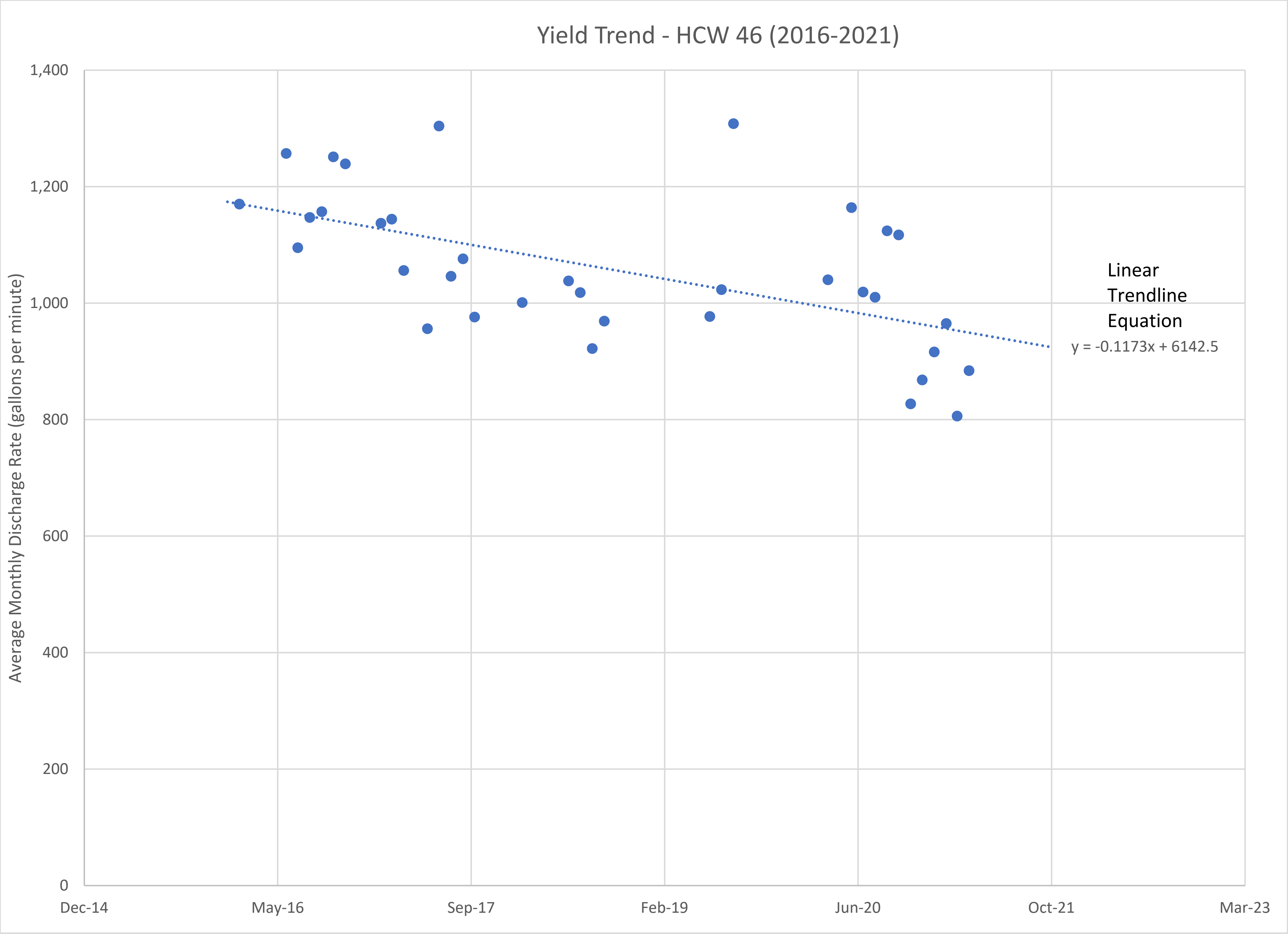

Yield Trend - HCW 32 (2016-2021)
Average Monthly Discharge Rate (gallons per minute)
2,000
1,800
1,600
1,400
1,200
1,000
800
600
400
200
0
Dec-14
May-16
Sep-17
Feb-19
Jun-20
Oct-21
Mar-23
Linear Trendline Equation
y = -0.101x + 5444.7

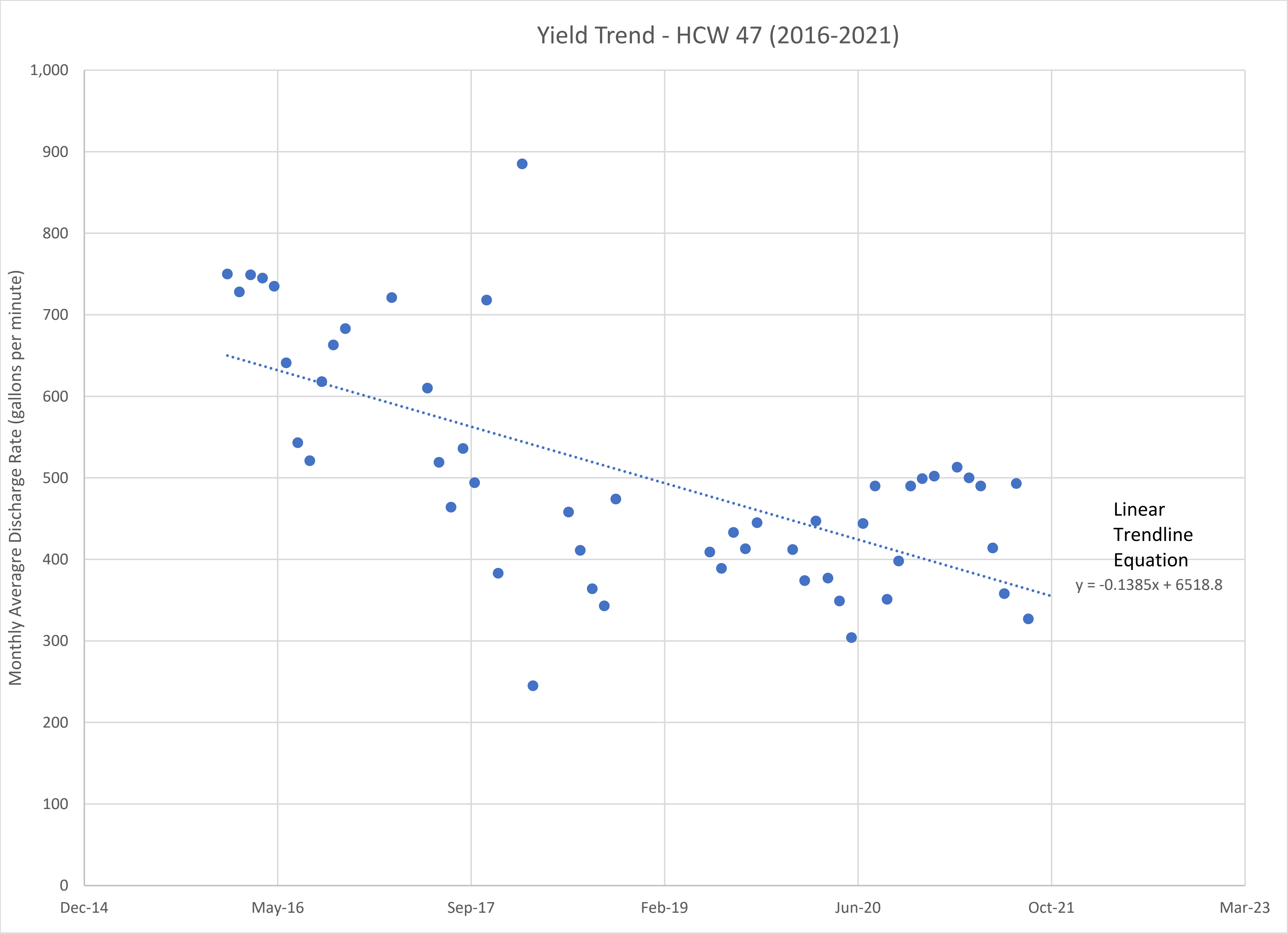

Yield Trend - HCW 36 (2016-2021)
Monthly Average Discharge Rate (gallons per minute)
1,400
1,200
1,000
800
600
400
200
0
Jan-15
Jan-16
Jan-17
Jan-18
Jan-19
Jan-20
Jan-21
Jan-22
Jan-23
Linear Trendline Equation
y = 0.0186x - 23.514

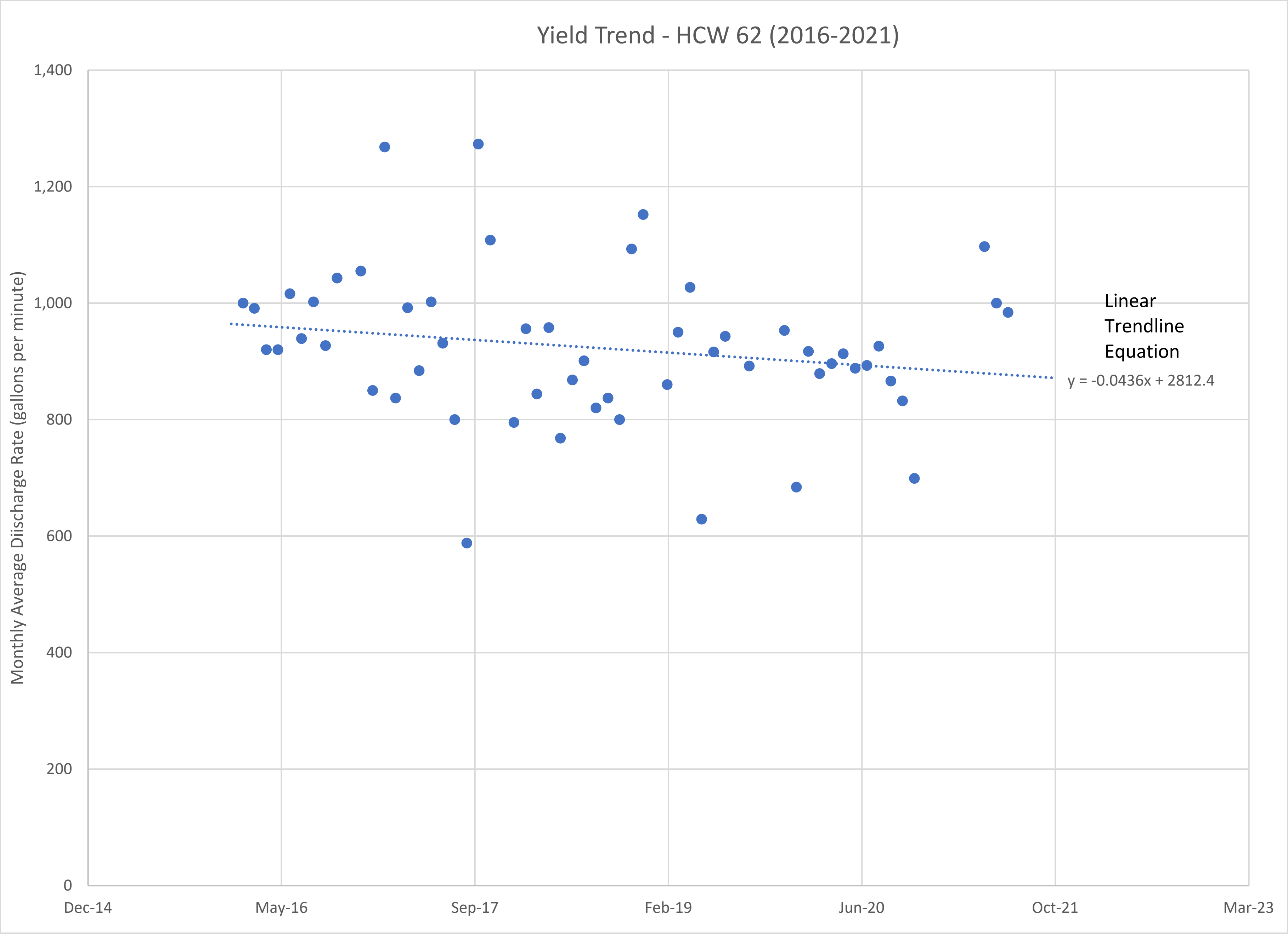

Yield Trend - HCW 37 (2016-2021)
Average Monhtly Discharge Rate (gallons per minute)
1,400
1,200
1,000
800
600
400
200
0
Dec-14
May-16
Sep-17
Feb-19
Jun-20
Oct-21
Mar-23
Linear Trendline Equation
y = -0.045x + 2772.2


Yield Trend - HCW 38 (2016-2021)
Average Monthly Discharge Rate (gallons per minute)
1,000
900
800
700
600
500
400
300
200
100
0
Dec-14
May-16
Sep-17
Feb-19
Jun-20
Oct-21
Mar-23
Linear Trendline Equation
y = -0.0611x + 3206.7

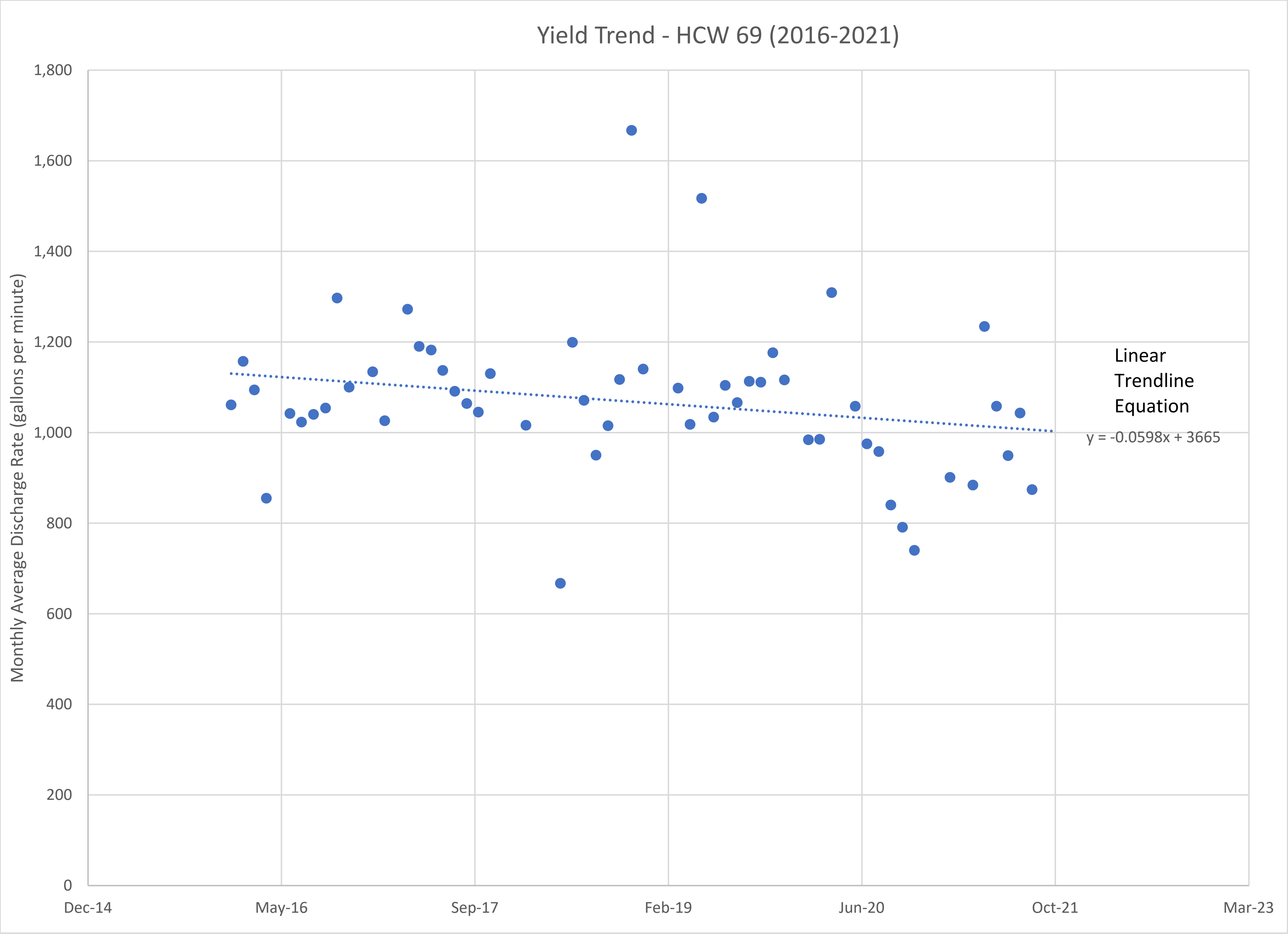

Yield Trend - HCW 39 (2016-2021)
Average Monthy Discharge Rate (gallons per minute)
1,800
1,600
1,400
1,200
1,000
800
600
400
200
0
Dec-14
May-16
Sep-17
Feb-19
Jun-20
Oct-21
Mar-23
Linear Trendline Equation
y = -0.1038x + 5312.6


Yield Trend - HCW 46 (2016-2021)
Average Monthly Discharge Rate (gallons per minute)
1,400
1,200
1,000
800
600
400
200
0
Dec-14
May-16
Sep-17
Feb-19
Jun-20
Oct-21
Mar-23
Linear Trendline Equation
y = -0.1173x + 6142.5

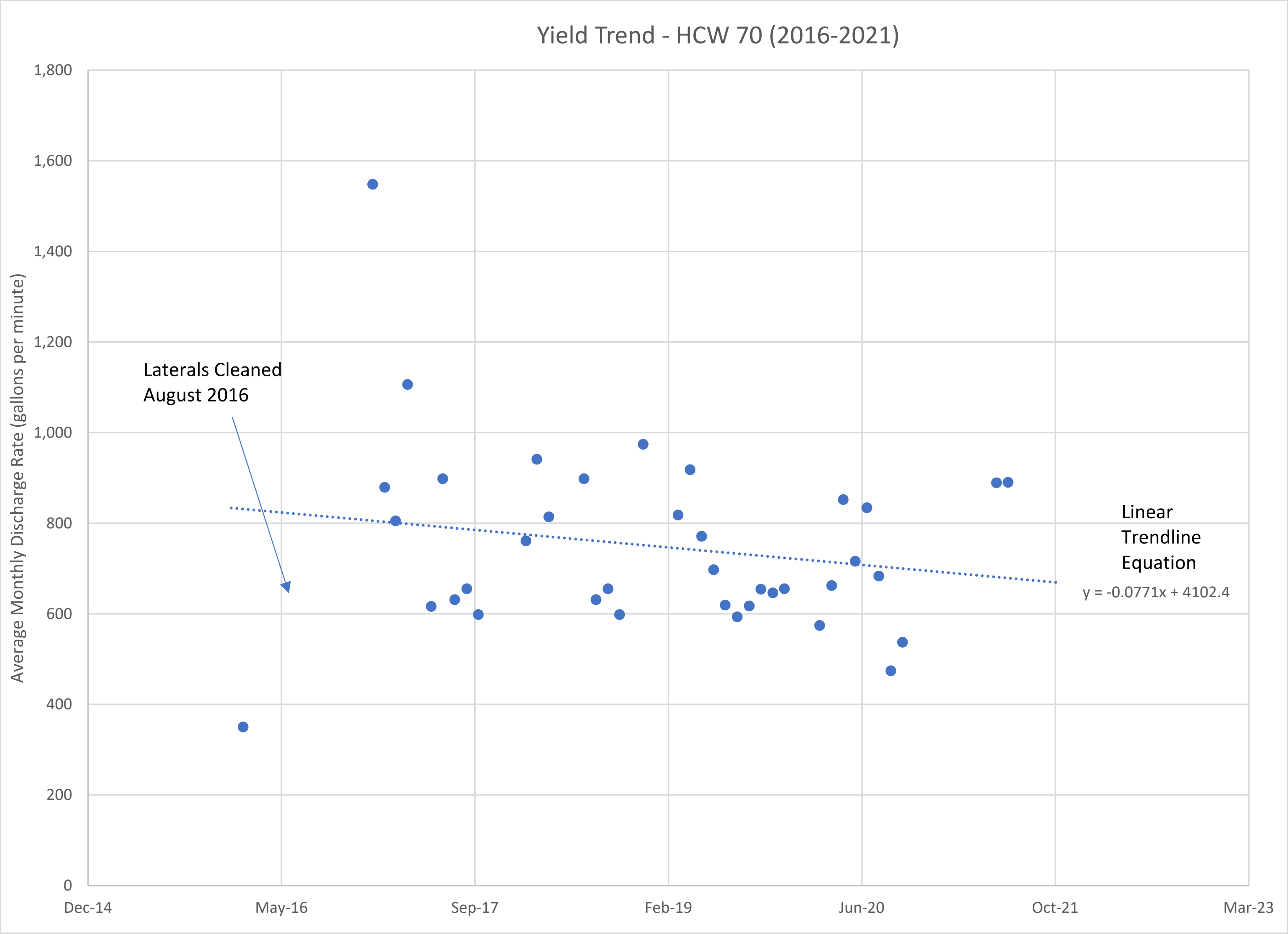
Yield Trend - HCW 47 (2016-2021)
Monthly Averagre Discharge Rate (gallons per minute)
1,000
900
800
700
600
500
400
300
200
100
0
Dec-14
May-16
Sep-17
Feb-19
Jun-20
Oct-21
Mar-23
Linear Trendline Equation
y = -0.1385x + 6518.8



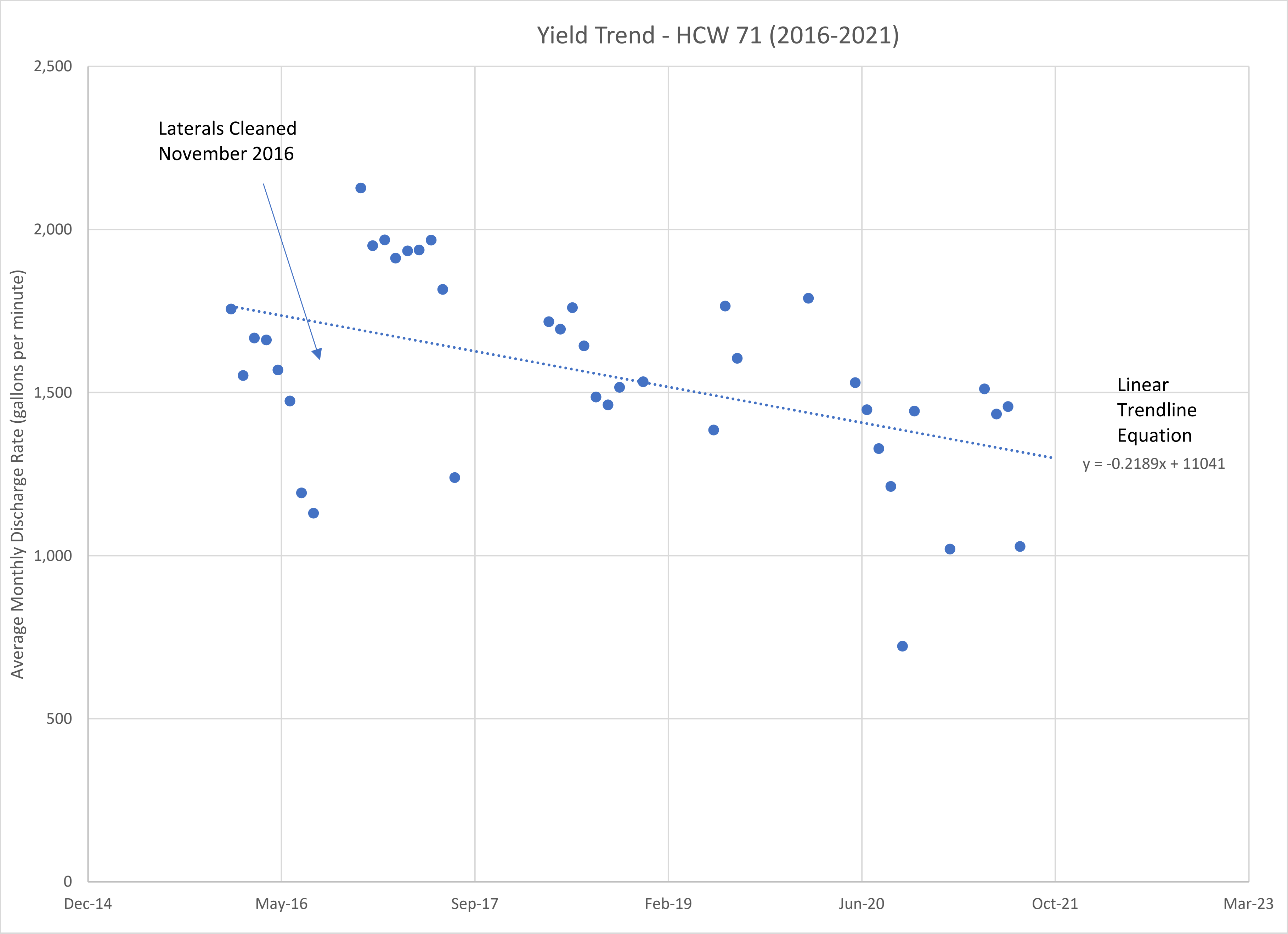
Yield Trend - HCW 62 (2016-2021)
Monthly Average Discharge Rate (gallons per minute)
1,400
1,200
1,000
800
600
400
200
0
Dec-14
May-16
Sep-17
Feb-19
Jun-20
Oct-21
Mar-23
Linear Trendline Equation
y = -0.0436x + 2812.4



Yield Trend - HCW 69 (2016-2021)
Monthly Average Discharge Rate (gallons per minute)
1,800
1,600
1,400
1,200
1,000
800
600
400
200
0
Dec-14
May-16
Sep-17
Feb-19
Jun-20
Oct-21
Mar-23
Linear Trendline Equation
y = -0.0598x + 3665



Yield Trend - HCW 70 (2016-2021)
Average Monthly Discharge Rate (gallons per minute)
1,800
1,600
1,400
1,200
1,000
800
600
400
200
0
Dec-14
May-16
Sep-17
Feb-19
Jun-20
Oct-21
Mar-23
Laterals Cleaned
August 2016
Linear
Trendline
Equation
y = -0.0771x + 4102.4


Yield Trend - HCW 71 (2016-2021)
Average Monthly Discharge Rate (gallons per minute)
2,500
2,000
1,500
1,000
500
0
Dec-14
May-16
Sep-17
Feb-19
Jun-20
Oct-21
Mar-23
Laterals Cleaned November 2016
Linear Trendline Equation
y = -0.2189x + 11041

Appendix C North Well Field Gravel Pack Well Logs

Well #26

Form 2A — Wells (Supplement to Form 2)

9. (Continued)

III. Well Specifications

(a) Hole and casing

Size of drill hole or excavation 40.0', Depth 37.0'

Type of casing Concrete (wood, concrete, steel, etc.)

Size of casing 40.0', Thickness of casing 15"

Length of casing 37.0'. If collection gallery, length, size and depth of gallery

(b) Screens

Type of perforated screen None

Size of perforated screen (diameter), (length).

Thickness of gravel pack, length of gravel pack

(c) Water Bearing Materials

Distance to water. Character of water bearing materials

Water bearing sand & gravel.

Thickness of water bearing material

(d) Pump and Motor

Type of pump Deep well turbine (centrifugal, propeller, mixed flow, etc.)

Name of pump Pomona, size 1,200GPM

Kind of motor Electric (gasoline, electric, diesel, etc.)

Horsepower 40 Name of Motor F.M.

(e) Complete well

Capa[illegible] GPM at drawdown of 12-14 Ft. Estimated cost $30,125

(f) Own[illegible] on which well is located City of Sioux Falls, South Dakota, Name

Sioux Falls, South Dakota Address

(g) Distance to nearest existing wells

On same owner's property 73 rods. On property owned by others 110+ rods

Well #42

Well # 42 FIELD DATA SHEET

Boring No. ① Job No. 660-999 Crew Chief Hagedorn

Vehicle Required: Truck All Terrain

Depth of Layer	Sample No/Depth	BLOWS Set	1st ½FT	2nd ½FT	Total	Rec. in Inch	SOIL CLASSIFICATION
0-.5	/						Fat clay, black (CH)
	/						
-12½	/10-11	1	1	3	4		Fat clay, brownish gray
	/						
12½-14½	/12½-14½	4	4	3	7	—	Sand, med. grained, a little
	/						gravel, gray, wls., loose [illegible]
	/						
14½-40	/15-17	2	2	3	5		Sand, course grained, some
	/20-22	8	14	17	31		gravel, light brownish gray,
	/25-27	9	10	10	20		loose to dense, a few lenses of
	/30-32	9	9	10	19		gravel below 25', a few lenses
	/35-37	10	9	9	18		of medium sand between 30'
	/						(SP)
	/						
40-42	/						Lean clay, a little gravel, gray
	/						(CL)
	/						
	/						
	/						
	/						
	/						
	/						
	/						
	/						
	/						
	/						
	/						
	/						

SF-1 (73-C)

Well #42

Boring No. 1	Date	Time
Boring Started	5-11-77	8:50
Boring Completed	5-11-77	12:15
Finished Pulling Casing	5-11-77	2:05
Boring Filled		
Depth to Frost		

Water Level Information

Water level at ______ ft. After Sampling

To ______ ft. Before Casing

W.L. Checks During Boring Progress

Date	Time	Casing In	Sampled To	W.L.	Depth To Cave In
5-11	9:40	14½	17	12.2	10

Date		Time		Bailed From		To	
Date		Time		Bailed From		To	
Date		Time		Bailed From		To	

W.L. Rechecks After Completion of Boring

	Date	Time	Casing in Grnd	W.L.	C
At Completion					
1st Recheck					
2nd Recheck					

Method of Advancing Boring

Continuous Sampling From ______ To ______

Pipe Drill To ______

______ In. Flite Auger To ______

7¼ In. Hollow Stem Auger To 39½

______ In. Casing To ______

______ In. Casing To ______

C.O. Tube From ______ To ______

Jet With Water From ______ To ______

Jet With Drilling Mud From 19½ To 39½

W.L. Remarks ______

Depth of Layer	Depth Sample Taken	Blows Set	Blows 1st ½ft	Blows 2nd ½ft	Blows Total	Rec in Inch	LOG CONTINUED SOIL CLASSIFICATION

(J-57) 1-82

Form 2A - Wells, Dugouts or Water Storage Dams (Supplement to form 2)

Well #42

12. Principal Features of the Proposed Water Supply System (continued.)

D. Well Information or Estimates

(1) Drill Hole, Diameter 42", Depth 43'

(2) Casing, Type Steel (wood, concrete, steel, etc) Diameter 36" Thickness .50" minimum

(3) Perforated Screen.

Type Stainless Steel, Diameter 36", Length 6'

(4) Gravel Pack, Thickness 7", Length of gravel pack 22'

E. Dugout Information or Estimates. N/A

(1) Surface dimensions ________, Depth ________

F. Fill out for Either a Well or a Dugout

(1) Water Bearing Materials. (Please attach a copy to test well log if available.)

Character of Water bearing materials Fine to coarse sand and gravel

Depth to top of water bearing material 12

Depth to bottom of water bearing material 40

Thickness of water bearing material 28

Depth to water (ground surface to water level) 12

(2) Distance to nearest existing household or livestock watering wells.

On same owner's property 182 rds. On property owned by others 24 rds.

G. Water Storage Dams. N/A

If the proposed water use system contains one or more water storage dams, please show in the space below, the height, maximum water depth, surface area and storage capacity of each storage dam. The location of each water storage dam should be shown on the water right map.

Lis Haal

Signature of Applicant

$3\text{-}0^{22}$

Form 12. **Well #42**

Permit No. 4098-3

Water Division 3 Big Sioux River Water District

REPORT OF EXAMINATION OF WORKS
AND/OR APPLICATION OF WATER TO BENEFICIAL USE

TO: WATER RIGHTS, WATER MANAGEMENT BOARD / FOSS BLDG., PIERRE, SOUTH DAKOTA 57501

I have this day made a thorough examination of the water use system constructed by City of Sioux Falls of Sioux Falls holder of Permit No. 4098-3, bearing date of priority of April 8, 1957 authorizing the diversion of 1.0 cu. ft. per second of the waters of Groundwater for Municipal purposes, in Minnehaha County.

I have to report on the condition of the same as follows:

The Water Use System consists of,

A. Works used to divert the water:
WELL #42 - 43' DEEP WITH 30" STEEL CASING - 6' SS SCREEN FLOWWAY 8" BYRON JACKSON PUMP - (NO TAG) POWERED BY 25HP REULAND ELECTRIC MOTOR

B. Works used to transport water to place of use,
10" BURIED [illegible] STEEL LINE TO EXISTING 24" PIPELINE TO TREATMENT PLANT - APPROX 50'

C. Works used to apply water to beneficial use.
WATER IS USED FOR VARIOUS MUNICIPAL PURPOSES WITHIN THE CITY OF SIOUX FALLS THROUGH THE CITY DISTRIBUTION SYSTEM

The system is in the following condition: GOOD

The point of diversion is located 2200'W & 2600'S OF THE NE CORNER, SECTION 17, T102N, R49W

The works are capable of diverting and conveying to the place of use 1.0 (450 GPM) cu. ft. per second of water which is to be used for MUNICIPAL USE

Water has been put to beneficial use to the maximum extent as follows: __________

comprising a total of __________ acres of land.

Date SEPTEMBER 8, 1981

Burton [illegible] Jones
(Signature)

BEST IMAGE POSSIBLE FROM POOR ORIGINAL

Well #43

FIELD DATA SHEET

g No. [illegible] Job No. 626-999 Crew Chief Hagedorn

Vehicle Required: Truck - All Terrain

Depth of Layer	Sample No./Depth	Set	BLOWS 1st ½FT	BLOWS 2nd ½FT	Total	Rec. in Inch	SOIL CLASSIFICATION
0-4	/						Fat clay, black (CH)
	/						
4-7½	/						Fat clay, brownish gray (CH)
	/						
7½-9½	/8-9½	6	6	8	14	—	Sand, med., a little gravel, br.
	/						to light br., moist, med. dense
	/						
9½-12	/10-12	3	3	3	6		Sand, med. to coarse grained
	/						a little gravel, br., [illegible]
	/						10' then w.B., loose to [illegible]
	/						lenses of fine to [illegible]
	/						
12-34½	/12-14	3	3	5	8		Sand, coarse grained, some
	/15-17	5	5	5	10		gravel, light brownish gray,
	/20-22	7	10	7	17		w.B., loose to dense, a few
	/25-27	10	7	7	14		lenses of gravel below 23' (SP)
	/30-32	8	8	8	16		
	/						
34½-37	/35-37	18	11	7	18		Lean clay, a little gravel,
	/						gray, stiff (CL)
	/						
	/						
	/						
	/						
	/						
	/						
	/						
	/						

SF-1 [illegible]

Well #43

Boring No. 2	Date	Time
Boring Started	5-11-77	2:30
Boring Completed	5-12-77	10:00
Finished Pulling Casing	5-12-77	10:10
Boring Filled	5-12	10:15
Depth to Frost		

Water Level Information

Water level at ~~_______ ft. After Sampling~~

To _______ ft. Before Casing

W.L. Checks During Boring Progress

Date	Time	Casing In	Sampled To	W.L.	Depth T Cave In
5-11	3:05	9½	14	10	10.4

Date		Time		Bailed From		To
Date		Time		Bailed From		To
Date		Time		Bailed From		To

Method of Advancing Boring

Continuous Sampling From ______ To ______

Pipe Drill To

______ In. Flite Auger To ______

3¼ In. Hollow Stem Auger To 14½

______ In. Casing To ______

______ In. Casing To ______

C.O. Tube From ______ To ______

Jet With Water From ______ To ______

Jet With Drilling Mud From 14½ To 34½

W.L. Rechecks After Completion of Boring

	Date	Time	Casing in Grnd	W.L.	C
At Completion					
1st Recheck					
2nd Recheck					

W.L. Remarks

Depth of Layer	Depth Sample Taken	Blows Set	Blows 1st ½ft	Blows 2nd ½ft	Blows Total	Rec in Inch	LOG CONTINUED SOIL CLASSIFICATION

Form 2A - Wells, Dugouts or Water Storage Dams (Supplement to form 2)

Well #43

17. Principal Features of the Proposed Water Supply System (continued.)

D. Well Information or Estimates

(1) Drill Hole, Diameter 42", Depth 37'

(2) Casing, Type Steel (wood, concrete, steel, etc), Diameter 36" Thickness .50" minimum

(3) Perforated Screen.

Type Stainless Steel, Diameter 36", Length 6'

(4) Gravel Pack. Thickness 7", Length of gravel pack 20'

E. Dugout Information or Estimates. N/A

(1) Surface dimensions ____, Depth ____

F. Fill out for Either a Well or a Dugout.

(1) Water Bearing Materials. (Please attach a copy to test well log if available.)

Character of Water bearing materials Fine to coarse sand and gravel

Depth to top of water bearing material 8

Depth to bottom of water bearing material 34

Thickness of water bearing material 26

Depth to water (ground surface to water level) 10

(2) Distance to nearest existing household or livestock watering wells.

On same owner's property 167 rds. On property owned by others 91 rds.

G. Water Storage Dams. N/A

If the proposed water use system contains one or more water storage dams, please show in the space below, the height, maximum water depth, surface area and storage capacity of each storage dam. The location of each water storage dam should be shown on the water right map.

Liz [illegible]

Signature of Applicant

BEST IMAGE POSSIBLE FROM POOR ORIGINAL

Well #44

FIELD DATA SHEET

Well # 44

Boring No. 3 Job No. 620-009 Crew Chief [illegible]

Vehicle Required: Truck - All Terrain

Depth of Layer	Sample No./Depth	BLOWS Set	BLOWS 1st ½FT	BLOWS 2nd ½FT	BLOWS Total	Rec. in Inch	SOIL CLASSIFICATION
[illegible] - 6½							Silty clay, dk. br., soft (CL)
[illegible]-32½	7-9	5	8	8	16		Sand, coarse grained, some
	10-12	6	8	8	16		gravel, light brownish gray,
	15-17	9	8	7	15		w/B, dense, a few lenses of
	20-22	7	7	7	14		med. sand above 27', a few
	25-27	Lost		Sample			lenses of gravel below 27½'
	27-29	7	7	8	15		(SP)
	30-32	8	12	13	25		

SF-1 (73-D)

BEST IMAGE POSSIBLE FROM POOR ORIGINAL

Well #44

Boring No. 3	Date	Time
Boring Started	5-12-77	10:45
Boring Completed	5-12-77	1:30
Finished Pulling Casing	5-12-77	1:45
Boring Filled	5-12	1:41
Depth to Frost		

Water Level Information

Water level at ______ ft. After Sampling

To ______ ft. Before Casing

W.L. Checks During Boring Progress

Date	Time	Casing In	Sampled To	W.L.	Depth To Cave In
5-12	11:10	9½	12	6.5	9.5

Date		Time		Bailed From		To	
Date		~~Time~~		Bailed ~~From~~		To	
Date		Time		Bailed From		To	

Method of Advancing Boring

Continuous Sampling From ______ To ______

Pipe Drill To ______

______ In. Flite Auger To ______

3¼ In. Hollow Stem Auger To 14½

______ In. Casing To ______

______ In. Casing To ______

C.O. Tube From ______ To ______

Jet With Water From ______ To ______

Jet With Drilling Mud From 14½ To 25'

W.L. Rechecks After Completion of Boring

	Date	Time	Casing in Grnd	W.L.	Cave In
At Completion					
1st Recheck					
2nd Recheck					

W.L. Remarks ______

Depth of Layer	Depth Sample Taken	Blows Set	Blows 1st ½ft	Blows 2nd ½ft	Blows Total	Rec in Inch	LOG CONTINUED SOIL CLASSIFICATION

Form 2A · Wells, Dugouts or Water Storage Dams (Supplement to form 2)

Well #44

12. Principal Features of the Proposed Water Supply System (continued.)

D. Well Information or Estimates

(1) Drill Hole, Diameter 42", Depth 35'

(2) Casing, Type Steel (wood,concrete, steel,etc), Diameter 36" Thickness .50" minimum

(3) Perforated Screen.

Type Stainless Steel, Diameter 36", Length 6'

(4) Gravel Pack. Thickness 7", Length of gravel pack 10'

E. Dugout Information or Estimates. N/A

(1) Surface dimensions ________, Depth ________

F. Fill out for Either a Well or a Dugout.

(1) Water Bearing Materials. (Please attach a copy to test well log if available.)

Character of Water bearing materials Fine to coarse sand and gravel

Depth to top of water bearing material 7

Depth to bottom of water bearing material 32

Thickness of water bearing material 25

Depth to water (ground surface to water level) 7

(2) Distance to nearest existing household or livestock watering wells.

On same owner's property 182 rds. On property owned by others 164 rds.

G. Water Storage Dams. N/A

If the proposed water use system contains one or more water storage dams, please show in the space below, the height, maximum water depth, surface area and storage capacity of each storage dam. The location of each water storage dam should be shown on the water right map.

Signature of Applicant

SOUTH DAKOTA WATER WELL COMPLETION REPORT

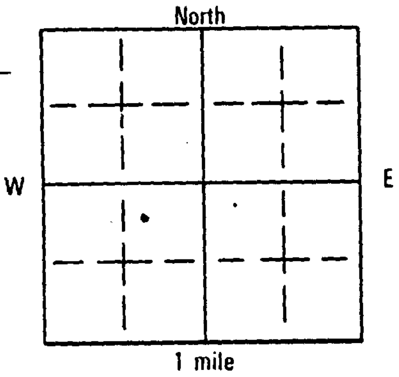
10-85

Location SE ¼ SW ¼ Sec 8 Twp 102-N Rg 49-W

County Minnehaha

Please mark well location with an "X"

Well #48



Well Completion Date 12-10-86

PROPOSED USE:
☐ Domestic ☑ Municipal ☐ Test Holes
☐ Irrigation ☐ Industrial ☐ Stock

Method of Drilling:
Bucket- Boring-False casing

CASING DATA:
☑ Steel ☐ Plastic ☐ Other
If other describe

PIPEWEIGHT	DIAMETER	FROM	TO	HOLE DIAMETER
LB/FT	IN	0 FT	31'6" FT	12" IN
LB/FT	IN	FT	FT	IN
LB/FT	IN	FT	FT	IN
LB/FT	IN	FT	FT	IN

GROUT:
Was the well grouted? ☑ YES ☐ NO
To what depth? 0-10' FEET
What is grouting material? Bentonite
If cement, number of sacks?
Describe grouting procedure
What was grout weight? LB/GAL

SCREEN: ☐ Perforated pipe ☑ Manufactured
Diameter 12" IN Length 12' FEET
Material Stainless Steel
Slot Size .125 Set From 31'6" Feet To 43'6" Feet
Slot Size Set From Feet To Feet
Slot Size Set From Feet To Feet
Other information

Was a packer or seal used? ☐ YES ☑ NO
If so, what material?
Describe packer(s) and location?

Was well disinfected upon completion? ☑ YES ☐ NO
Explain Chlorinated
Bacteriological analysis ☐ YES ☐ NO
Laboratory sent to [illegible]

Well Owner:
Name City of Sioux Falls
Address

Well Log: A

Formation	Depth From	Depth To
Topsoil	0	4
Clay + Mud	4	10
Sand	10	12
Clay lens	12	13
Grey Sand	13	20
Gravel	20	35
Coarse Gravel	35	38
Good Sand	38	43'6"

STATIC WATER LEVEL 10' Feet
If flowing: closed in pressure PSI
GPM flow through inch pipe
Controlled by ☐ Valve ☐ Reducers ☐ Other
If other; specify
Can well be completely shut in?

WELL TEST DATA:
☑ Pumped
☐ Bailed Describe:
☐ Other
Pumping Level Below Land Surface
20' ft. After 72 Hrs. pumped 600 GPM
ft. After Hrs. pumped GPM
ft. After Hrs. pumped GPM

REMARKS: - Fairly good well-

MAR 1987
DIVISION OF WATER RIGHTS
Pierre, SD

This well was drilled under license # 447
And this report is true and accurate.
Drilling firm Lacey Well Drilling
Signature of License Representative: James J. Lacey
Signature of Well Owner:
Date [illegible]

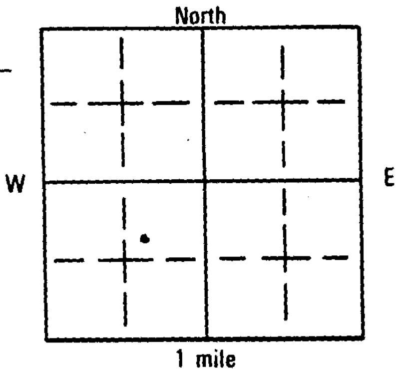
SOUTH DAKOTA WATER WELL COMPLETION REPORT

10-85

Location NE ¼ SW ¼ Sec 8 Twp 102-N Rg 49-W

County
Minnehaha

Please mark well location with an "X"



Well #49

Well Completion Date 12-6-86

PROPOSED USE:
☐ Domestic ☑ Municipal ☐ Test Holes
☐ Irrigation ☐ Industrial ☐ Stock

Method of Drilling:
Bucket-Boring-Falsecasing

CASING DATA:
☑ Steel ☐ Plastic ☐ Other
If other describe

PIPEWEIGHT	DIAMETER	FROM	TO	HOLE DIAMETER
LB/FT	IN	0 FT	31' FT	12" IN
LB/FT	IN	FT	FT	IN
LB/FT	IN	FT	FT	IN
LB/FT	IN	FT	FT	IN

GROUT:
Was the well grouted? ☑ YES ☐ NO
To what depth? 0-9'6" FEET
What is grouting material? Bentonite
If cement, number of sacks?
Describe grouting procedure
What was grout weight? LB/GAL

SCREEN: ☐ Perforated pipe ☑ Manufactured
Diameter 12" IN Length 12' FEET
Material Stainless Steel
Slot Size 090 Set From 31' Feet To 43' Feet
Slot Size Set From Feet To Feet
Slot Size Set From Feet To Feet
Other information

Was a packer or seal used? ☐ YES ☑ NO
If so, what naterial?
Describe packer(s) and location?

Was well disinfected upon completion? ☑ YES ☐ NO
Explain Chlorinated
Bacteriological analysis ☑ YES ☐ NO
Laboratory sent to City of Sioux Falls

Well Owner:
Name City of Sioux Falls
Address

Well Log: B

Formation	Depth From	Depth To
Topsoil	0	2
Brown Clay	2	9
Grey Gravel	9	14
Mud Streak	14	14
Grey Fine Sand	14	16
Grey Sand	16	20
Grey Gravel	20	43

STATIC WATER LEVEL 9'6" Feet
If flowing: closed in pressure PSI
GPM flow through inch pipe
Controlled by ☐ Valve ☐ Reducers ☐ Other
If other; specify
Can well be completely shut in?

WELL TEST DATA:
☑ Pumped
☐ Bailed Describe:
☐ Other
Pumping Level Below Land Surface
20' ft. After 72 Hrs. pumped 700 GPM
ft. After Hrs. pumped GPM
ft. After Hrs. pumped GPM

REMARKS:

MAR 1987
DIVISION OF WATER RIGHTS
PIERRE, SD

This well was drilled under license # 447
And this report is true and accurate.
Drilling firm Lacey Well Drilling
Signature of License Representative: James J. Lacey
Signature of Well Owner: Douglas T. [illegible]
Date 2-25-87

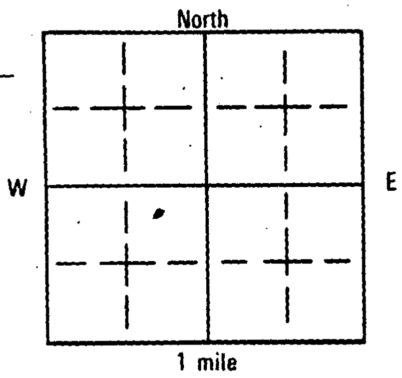
SOUTH DAKOTA WATER WELL COMPLETION REPORT

10-85

Location NE ¼ SW ¼ Sec 8 Twp 102-N Rg 49-W

County ______

Please mark well location with an "X"



Well #50

Well Completion Date 12-29-86

PROPOSED USE:
☐ Domestic ☑ Municipal ☐ Test Holes
☐ Irrigation ☐ Industrial ☐ Stock

Method of Drilling:
Bucket - Bored - False casing

CASING DATA:
☑ Steel ☐ Plastic ☐ Other
If other describe ______

PIPEWEIGHT	DIAMETER	FROM	TO	HOLE DIAMETER
LB/FT	IN	0 FT	29 FT	12" IN
LB/FT	IN	FT	FT	IN
LB/FT	IN	FT	FT	IN
LB/FT	IN	FT	FT	IN

GROUT:
Was the well grouted? ☑ YES ☐ NO
To what depth? Bentonite FEET
What is grouting material? 10'
If cement, number of sacks? ______
Describe grouting procedure ______
What was grout weight? ______ LB/GAL

SCREEN: ☐ Perforated pipe ☑ Manufactured
Diameter 12" IN Length 12' FEET
Material Stainless Steel
Slot Size .090 Set From 29' Feet To 41' Feet
Slot Size ______ Set From ______ Feet To ______ Feet
Slot Size ______ Set From ______ Feet To ______ Feet
Other information ______

Was a packer or seal used? ☐ YES ☑ NO
If so, what naterial? ______
Describe packer(s) and location? ______

Was well disinfected upon completion? ☑ YES ☐ NO
Explain Chlorinated
Bacteriological analysis ☑ YES ☐ NO
Laboratory sent to [illegible]

Well Owner:
Name Sioux Falls City
Address ______

Well Log: C

Formation	Depth From	Depth To
Black Topsoil	0	5
Grey Sandy Clay	5	9
Sand + Gravel	9	12
Mudlens	12	12'6"
Fine Grey Sand	12'6"	15
Gravel - Layered	15	41
Medium to Coarse		

STATIC WATER LEVEL 10' Feet
If flowing: closed in pressure ______ PSI
GPM flow ______ through ______ inch pipe
Controlled by ☐ Valve ☐ Reducers ☐ Other
If other; specify ______
Can well be completely shut in? ______

WELL TEST DATA:
☑ Pumped
☐ Bailed Describe: ______
☐ Other

Pumping Level Below Land Surface
20' ft. After 72 Hrs. pumped 400 GPM
______ ft. After ______ Hrs. pumped ______ GPM
______ ft. After ______ Hrs. pumped ______ GPM

REMARKS:

MAR 1987
DIVISION OF WATER RIGHTS
Pierre, SD

This well was drilled under license # 447
And this report is true and accurate.
Drilling firm Lacey Well Drilling
Signature of License Representative: James Lacey
Signature of Well Owner: Douglas J. Holl
Date 3-25-87

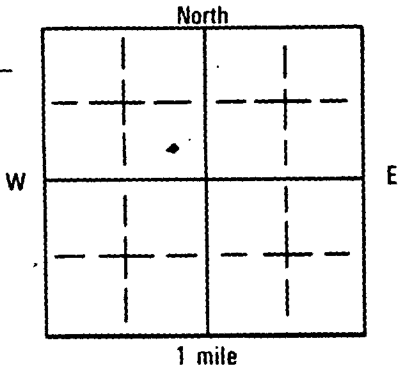
SOUTH DAKOTA WATER WELL COMPLETION REPORT

10-85

Location SE ¼ NW ¼ Sec 8 Twp 102-N Rg 49-W

County Minnehaha

Please mark well location with an "X"



Well #51

Well Completion Date 1-8-87

PROPOSED USE:
☐ Domestic ☑ Municipal ☐ Test Holes
☐ Irrigation ☐ Industrial ☐ Stock

Method of Drilling: Bucket-Boring-False casing

CASING DATA:
☑ Steel ☐ Plastic ☐ Other
If other describe -

PIPEWEIGHT	DIAMETER	FROM	TO	HOLE DIAMETER
LB/FT	IN	27'6" FT	0 FT	12 IN
LB/FT	IN	FT	FT	IN
LB/FT	IN	FT	FT	IN
LB/FT	IN	FT	FT	IN

GROUT:
Was the well grouted? ☑ YES ☐ NO
To what depth? 9'6" FEET
What is grouting material? Bentonite
If cement, number of sacks?
Describe grouting procedure
What was grout weight? LB/GAL

SCREEN: ☐ Perforated pipe ☑ Manufactured
Diameter 12 IN Length 12" FEET
Material Stainless Steel
Slot Size .090 Set From 27'6" Feet To 39'6" Feet
Slot Size Set From Feet To Feet
Slot Size Set From Feet To Feet
Other information

Was a packer or seal used? ☐ YES ☑ NO
If so, what material?
Describe packer(s) and location?

Was well disinfected upon completion? ☑ YES ☐ NO
Explain Chlorinated
Bacteriological analysis ☑ YES ☐ NO
Laboratory sent to City of Sioux Falls

Well Owner:
Name City of Sioux Falls
Address
Well Log:

D

Formation	Depth From	Depth To
Topsoil	0	2
Clay	2	8
Brown Sand	8	11
Mud Streak	11	11
Good Sand	11	16
Coarse Gravel	16	25
Good Sand	25	39'6"

STATIC WATER LEVEL 9'6" Feet
If flowing: closed in pressure PSI
GPM flow through inch pipe
Controlled by ☐ Valve ☐ Reducers ☐ Other
If other; specify
Can well be completely shut in? -

WELL TEST DATA:
☑ Pumped
☐ Bailed Describe:
☐ Other

Pumping Level Below Land Surface
20 ft. After 72 Hrs. pumped 400 GPM
ft. After Hrs. pumped GPM
ft. After Hrs. pumped GPM

REMARKS:

MAR 1987
DIVISION OF WATER RIGHTS
Pierre, SD

This well was drilled under license # 447
And this report is true and accurate.
Drilling firm Lacey Well Drilling
Signature of License Representative: James J. Lacey
Signature of Well Owner: Douglas T. [illegible]
Date 3-25-87

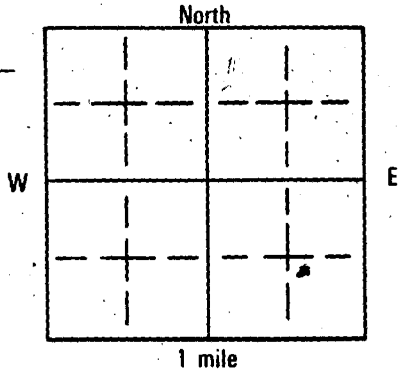
SOUTH DAKOTA WATER WELL COMPLETION REPORT

10-85

Location SE ¼ SE ¼ Sec ~~[illegible]~~ 8 Twp ~~[illegible]~~ 102-N Rg 49-W

County Minnehaha

Please mark well location with an "X"



Well #52

Well Completion Date 12-19-86

PROPOSED USE:
☐ Domestic ☑ Municipal ☐ Test Holes
☐ Irrigation ☐ Industrial ☐ Stock

Method of Drilling: Bucket-Boring-False casing

CASING DATA:
☑ Steel ☐ Plastic ☐ Other
If other describe

PIPEWEIGHT	DIAMETER	FROM	TO	HOLE DIAMETER
LB/FT	IN	24 FT	8 FT	12 IN
LB/FT	IN	FT	FT	IN
LB/FT	IN	FT	FT	IN
LB/FT	IN	FT	FT	IN

GROUT:
Was the well grouted? ☑ YES ☐ NO
To what depth? 6' FEET
What is grouting material? Bentonite
If cement, number of sacks?
Describe grouting procedure
What was grout weight? LB/GAL

SCREEN: ☐ Perforated pipe ☑ Manufactured
Diameter 12" IN Length 8' FEET
Material Stainless Steel
Slot Size .120 Set From 24 Feet To 32 Feet
Slot Size Set From Feet To Feet
Slot Size Set From Feet To Feet
Other information

Was a packer or seal used? ☐ YES ☑ NO
If so, what material?
Describe packer(s) and location?

Was well disinfected upon completion? ☑ YES ☐ NO
Explain Chlorinated
Bacteriological analysis ☑ YES ☐ NO
Laboratory sent to City of Sioux Falls

Well Owner:
Name City of Sioux Falls
Address
Well Log: E

Formation	Depth From	Depth To
Black Topsoil	0	4
Brown Clay	4	6
Fine Brown Sand	6	16
Grey Gravel	16	19
Good Coarse Grey Gravel	19	32

STATIC WATER LEVEL 6' Feet
If flowing: closed in pressure PSI
GPM flow through inch pipe
Controlled by ☐ Valve ☐ Reducers ☐ Other
If other; specify
Can well be completely shut in?

WELL TEST DATA:
☑ Pumped
☐ Bailed Describe:
☐ Other
Pumping Level Below Land Surface
17' ft. After 72 Hrs. pumped 400 GPM
ft. After Hrs. pumped GPM
ft. After Hrs. pumped GPM

REMARKS: Very good production for the depth

MAR 1987
DIVISION OF
WATER RIGHTS
PIERRE, SD

This well was drilled under license # 447
And this report is true and accurate.
Drilling firm Lacey Well Drilling
Signature of License Representative: James J. Lacey
Signature of Well Owner: Douglas J. [illegible]
Date 3-25-87

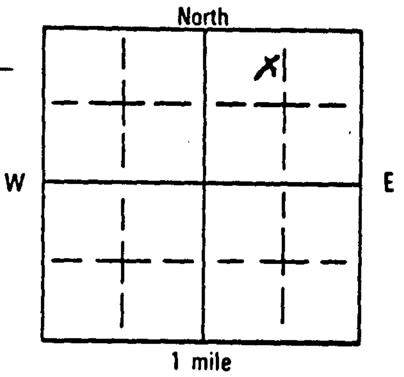
SOUTH DAKOTA WATER WELL COMPLETION REPORT

10-85

Location NW ¼ NE ¼ Sec 8 Twp 102-N Rg 49-W

County Minnehaha

Please mark well location with an "X"



Well #53

Well Completion Date May 19, 1987

PROPOSED USE:
☐ Domestic ☑ Municipal ☐ Test Holes
☐ Irrigation ☐ Industrial ☐ Stock

Method of Drilling:

CASING DATA:
☑ Steel ☐ Plastic ☐ Other
If other describe

PIPEWEIGHT	DIAMETER	FROM	TO	HOLE DIAMETER
LB/FT	IN	FT	FT	IN
LB/FT	IN	FT	FT	IN
LB/FT	IN	FT	FT	IN
LB/FT	IN	FT	FT	IN

GROUT:
Was the well grouted? ☑ YES ☐ NO
To what depth? 12' FEET
What is grouting material? Bentonite
If cement, number of sacks?
Describe grouting procedure
What was grout weight? LB/GAL

SCREEN: ☐ Perforated pipe ☐ Manufactured
Diameter 12' IN Length 10' FEET
Material Stainless Steel
Slot Size 080 Set From 39'6" Feet To 48'6" Feet
Slot Size Set From Feet To Feet
Slot Size Set From Feet To Feet
Other information

Was a packer or seal used? ☐ YES ☑ NO
If so, what material?
Describe packer(s) and location?

Was well disinfected upon completion? ☑ YES ☐ NO
Explain
Bacteriological analysis ☐ YES ☐ NO
Laboratory sent to

Well Owner:
Name City of Sioux Falls
Address

Well Log:

Formation	Depth From	Depth To
Topsoil	0	4
Brown Clay	4	8
mud	8	10
Fine Sand	10	14
Grey Sand	14	16
Mud lens	16'	16'6"
Uniform Sand	16'6"	19'
Coarse Sand	19	40
Medium Sand	40	44

STATIC WATER LEVEL 6' Feet
If flowing: closed in pressure PSI
GPM flow through inch pipe
Controlled by ☐ Valve ☐ Reducers ☐ Other
If other; specify
Can well be completely shut in?

WELL TEST DATA:
☑ Pumped
☐ Bailed Describe:
☐ Other

Pumping Level Below Land Surface
29 ft. After 4 Hrs. pumped 600 GPM
ft. After Hrs. pumped GPM
ft. After Hrs. pumped GPM

REMARKS: - will be finished with A 12" Baker Pitless beined up

JUN 1987
DIVISION OF WATER RIGHTS
Pierre, SD

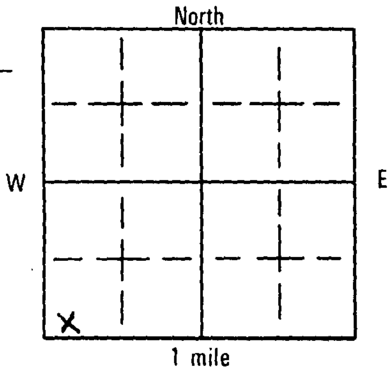
This well was drilled under license # 111
And this report is true and accurate.
Drilling firm Lacey Well Drilling
Signature of License Representative:
Signature of Well Owner:
UTILITIES DIRECTOR
Date 5-20-87

SOUTH DAKOTA WATER WELL COMPLETION REPORT 5127-3 10-85

Location ____ ¼ SW ¼ Sec 4 Twp 102N Rg 49W

County Minnehaha

Please mark well location with an "X"



Well #54

Well Completion Date May 88

PROPOSED USE:
☐ Domestic ☒ Municipal ☐ Test Holes
☐ Irrigation ☐ Industrial ☐ Stock

Method of Drilling: false casing

CASING DATA:
☒ Steel ☐ Plastic ☐ Other
If other describe

PIPEWEIGHT	DIAMETER	FROM	TO	HOLE DIAMETER
49.56 LB/FT	12 IN	0 FT	28 FT	20 IN
LB/FT	IN	FT	FT	IN
LB/FT	IN	FT	FT	IN
LB/FT	IN	FT	FT	IN

GROUT:
Was the well grouted? ☒ YES ☐ NO
To what depth? 12' FEET
What is grouting material? cement
If cement, number of sacks? 7
Describe grouting procedure tremmie pipe gravity feed.
What was grout weight? LB/GAL

SCREEN: ☐ Perforated pipe ☒ Manufactured
Diameter 12" IN Length 8 FEET
Material Stainless Steel
Slot Size .100 Set From 28 Feet To 36 Feet
Slot Size Set From Feet To Feet
Slot Size Set From Feet To Feet
Other information

Was a packer or seal used? ☐ YES ☒ NO
If so, what material?
Describe packer(s) and location?

Was well disinfected upon completion? ☒ YES ☐ NO
Explain Chlorine solution
Bacteriological analysis ☒ YES ☐ NO
Laboratory sent to City

Well Owner:
Name City of Sioux Falls,
Address

Well Log:

Formation	Depth From	Depth To
Top soil	0	2
Clay	2	9
Sand F-M	9	12
sand M-C	12	36
Clay	36	40

STATIC WATER LEVEL 9'-1" Feet
If flowing: closed in pressure PSI
GPM flow through inch pipe
Controlled by ☐ Valve ☐ Reducers ☐ Other
If other; specify
Can well be completely shut in?

WELL TEST DATA:
☒ Pumped Describe: gas driven turbine
☐ Bailed
☐ Other
Pumping Level Below Land Surface
24 ft. After 72 Hrs. pumped 500 GPM
ft. After Hrs. pumped GPM
ft. After Hrs. pumped GPM

REMARKS: Well #54

JAN 1989
DIVISION OF WATER RIGHTS
Pierre, SD

This well was drilled under license # 129
And this report is true and accurate.
Drilling firm Sioux Well Drilling
Signature of License Representative: Wayne H Wagner
Signature of Well Owner:
Date

Well #55

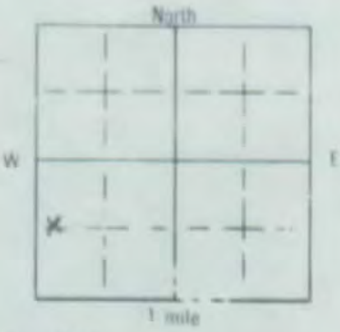
SOUTH DAKOTA WATER WELL COMPLETION REPORT

2127-3 10-85

Location ¼ SW ¼ Sec 4 Twp 102N Rg 49W

County Minnehaha

Please mark well location with an "X"



Well Completion Date May 88

PROPOSED USE
☐ Domestic ☒ Municipal ☐ Test Holes
☐ Irrigation ☐ Industrial ☐ Stock

Method of Drilling
false casing

CASING DATA
☒ Steel ☐ Plastic ☐ Other
If other describe

PIPEWEIGHT	DIAMETER	FROM	TO	HOLE DIAMETER
49.56 LB/FT	12 IN	0 FT	26 FT	20 IN
LB/FT	IN	FT	FT	IN
LB/FT	IN	FT	FT	IN
LB/FT	IN	FT	FT	IN

GROUT
Was the well grouted? ☒ YES ☐ NO
To what depth? 12' FEET
What is grouting material? Cement
If cement, number of sacks? 7
Describe grouting procedure gravity feed with tremmaie pipe
What was grout weight? LB/GAL

SCREEN ☐ Perforated pipe ☐ Manufactured
Diameter 12 IN Length 10' FEET
Material Steinless Steel
Slot Size .100 Set From 26 Feet To 36 Feet
Slot Size Set From Feet To Feet
Slot Size Set From Feet To Feet
Other information

Was a packer or seal used? ☐ YES ☒ NO
If so, what material?
Describe packer(s) and location?

Was well disinfected upon completion? ☒ YES ☐ NO
chlorine soultion 50PPM

Well Owner
Name City of Sioux Falls.
Address

Well Log

Formation	Depth From	Depth To
top soil	0	2
clay	2	10
silt	10	12
Sand M	12	16
Sand M C	16	22
Sand M	22	36
Clay	36	40

STATIC WATER LEVEL 9'-4 Feet
If flowing: closed in pressure PSI
GPM flow through inch pipe
Controlled by ☐ Valve ☐ Reducers ☐ Other
If other, specify
Can well be completely shut in?

WELL TEST DATA
☒ Pumped Describe gas driven turbine
☐ Bailed
☐ Other

Pumping Level below Land Surface
23 ft After 72 Hrs pumped 450 GPM
ft After Hrs pumped GPM
ft After Hrs pumped GPM

REMARKS Well #55

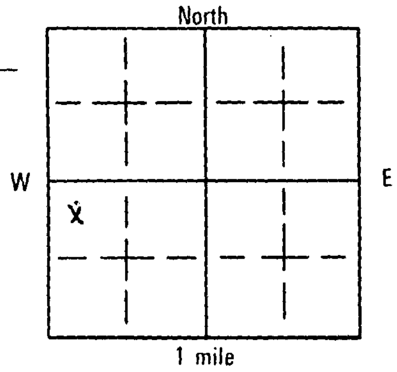
This well was drilled under license # 129
And this report is true and accurate.
Drilling firm Sioux Well Drilling
Signature of License Representative
Wayne H Wagner
Signature of Well Owner

SOUTH DAKOTA WATER WELL COMPLETION REPORT 5127-3 10-85

Location ____ ¼ SW ¼ Sec 4 Twp 102N Rg 49W

County Minnehaha

Please mark well location with an "X"



Well #56

Well Completion Date June 88

PROPOSED USE:

☐ Domestic ☒ Municipal ☐ Test Holes
☐ Irrigation ☐ Industrial ☐ Stock

Method of Drilling: false casing

CASING DATA:

☒ Steel ☐ Plastic ☐ Other

If other describe

PIPEWEIGHT	DIAMETER	FROM	TO	HOLE DIAMETER
49.56 LB/FT	IN	0 FT	25 FT	20 IN
LB/FT	IN	FT	FT	IN
LB/FT	IN	FT	FT	IN
LB/FT	IN	FT	FT	IN

GROUT:

Was the well grouted? ☒ YES ☐ NO

To what depth? 12 FEET

What is grouting material? cement

If cement, number of sacks? 8

Describe grouting procedure gravity feed with tremmie pipes

What was grout weight? ____ LB/GAL

SCREEN: ☐ Perforated pipe ☒ Manufactured

Diameter 12 IN Length 10 FEET

Material Stainless Steel

Slot Size .100 Set From 25 Feet To 35 Feet

Slot Size ____ Set From ____ Feet To ____ Feet

Slot Size ____ Set From ____ Feet To ____ Feet

Other information

Was a packer or seal used? ☐ YES ☒ NO

If so, what material?

Describe packer(s) and location?

Was well disinfected upon completion? ☒ YES ☐ NO

Explain Chlorine Solution 50 PPM

Bacteriological analysis ☒ YES ☐ NO

Laboratory sent to City

Well Owner:

Name City of Sioux Falls.

Address

Well Log:

Formation	Depth From	Depth To
top soil	0	2
clay	2	11
sand M-C	11	24
sand M	24	35
clay	35	40

STATIC WATER LEVEL 9'-5 Feet

If flowing: closed in pressure ____ PSI

GPM flow ____ through ____ inch pipe

Controlled by ☐ Valve ☐ Reducers ☐ Other

If other; specify

Can well be completely shut in?

WELL TEST DATA:

☒ Pumped
☐ Bailed Describe: gas driven turbine
☐ Other

Pumping Level Below Land Surface

24 ft. After 72 Hrs. pumped 500 GPM

____ ft. After ____ Hrs. pumped ____ GPM

____ ft. After ____ Hrs. pumped ____ GPM

REMARKS: Well # 56

JAN 1989
DIVISION OF WATER RIGHTS
Pierre, SD

This well was drilled under license # 129

And this report is true and accurate.

Drilling firm Sioux Well Drilling

Signature of License Representative: Wayne H Wagner

Signature of Well Owner:

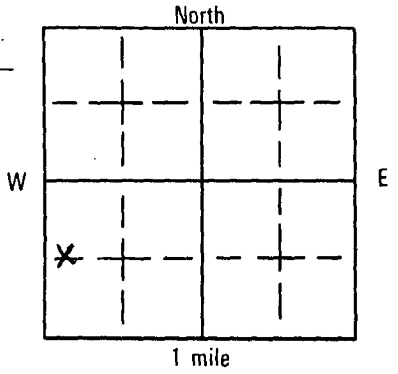
Date

SOUTH DAKOTA WATER WELL COMPLETION REPORT 5127-3 10-85

Location ____¼ 5W ¼ Sec 4 Twp 102N Rg 49W

County
Minnehaha

Please mark well location with an "X"



Well #57

Well Completion Date May 88

PROPOSED USE:
☐ Domestic ☒ Municipal ☐ Test Holes
☐ Irrigation ☐ Industrial ☐ Stock

Method of Drilling:
false casing

CASING DATA:
☒ Steel ☐ Plastic ☐ Other
If other describe ____

PIPEWEIGHT	DIAMETER	FROM	TO	HOLE DIAMETER
49.56 LB/FT	12 IN	0 FT	26 FT	20 IN
LB/FT	IN	FT	FT	IN
LB/FT	IN	FT	FT	IN
LB/FT	IN	FT	FT	IN

GROUT:
Was the well grouted? ☒ YES ☐ NO
To what depth? 12' FEET
What is grouting material? cement
If cement, number of sacks? 7
Describe grouting procedure gravity feed with tremmaie pipe
What was grout weight? ____ LB/GAL

SCREEN: ☐ Perforated pipe ☐ Manufactured
Diameter 12 IN Length 10' FEET
Material Stainless Steel
Slot Size .100 Set From 26 Feet To 36 Feet
Slot Size ____ Set From ____ Feet To ____ Feet
Slot Size ____ Set From ____ Feet To ____ Feet
Other information ____

Was a packer or seal used? ☐ YES ☒ NO
If so, what material? ____
Describe packer(s) and location? ____

Was well disinfected upon completion? ☒ YES ☐ NO
Explain Chlorine soultion 50PPM
Bacteriological analysis ☒ YES ☐ NO
Laboratory sent to City

Well Owner:
Name City of Sioux Falls,
Address ____

Well Log:

Formation	Depth From	Depth To
top soil	0	2
clay	2	10
silt	10	12
sand M	12	16
sand M C	16	22
sand M	22	36
clay	36	40

STATIC WATER LEVEL 9'-4 Feet
If flowing: closed in pressure ____ PSI
GPM flow ____ through ____ inch pipe
Controlled by ☐ Valve ☐ Reducers ☐ Other
If other; specify ____
Can well be completely shut in? ____

WELL TEST DATA:
☒ Pumped
☐ Bailed Describe: gas driven turbine
☐ Other

Pumping Level Below Land Surface
23 ft. After 72 Hrs. pumped 450 GPM
____ ft. After ____ Hrs. pumped ____ GPM
____ ft. After ____ Hrs. pumped ____ GPM

REMARKS: Well #55

JAN 1989
DIVISION OF
WATER RIGHTS
Pierre, SD

This well was drilled under license # 129
And this report is true and accurate.
Drilling firm Sioux Well Drilling
Signature of License Representative:
Wayne H Wagner
Signature of Well Owner:
Date ____

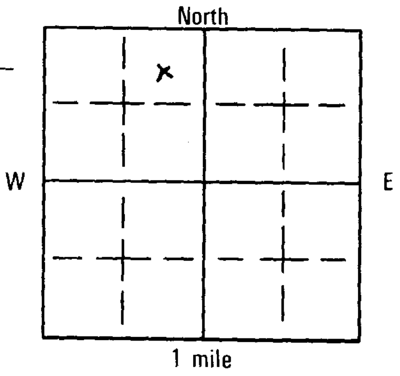
SOUTH DAKOTA WATER WELL COMPLETION REPORT

10-85

Location SE ¼ NW ¼ Sec 4 Twp 102N Rg 49W

County Minnehaha

Please mark well location with an "X"



Well #58

Well Completion Date Aug 87

PROPOSED USE:
☐ Domestic ☒ Municipal ☐ Test Holes
☐ Irrigation ☐ Industrial ☐ Stock

Method of Drilling:
false casing method

CASING DATA:
☒ Steel ☐ Plastic ☐ Other
If other describe

PIPEWEIGHT	DIAMETER	FROM	TO	HOLE DIAMETER
49.56 LB/FT	12 IN	0 FT	25'-6 FT	20 IN
LB/FT	IN	FT	FT	IN
LB/FT	IN	FT	FT	IN
LB/FT	IN	FT	FT	IN

GROUT:
Was the well grouted? ☒ YES ☐ NO
To what depth? 8' to 11' FEET
What is grouting material? cement.
If cement, number of sacks?
Describe grouting procedure gravity feed with tremmie pipe
What was grout weight? LB/GAL

SCREEN: ☐ Perforated pipe ☒ Manufactured
Diameter 12" PS IN Length 10 FEET
Material Stainless steel
Slot Size .100 Set From 25'-6" Feet To 35'-6" Feet
Slot Size Set From Feet To Feet
Slot Size Set From Feet To Feet
Other information

Was a packer or seal used? ☐ YES ☒ NO
If so, what material?
Describe packer(s) and location?

Was well disinfected upon completion? ☒ YES ☐ NO
Explain 50PPM chlorine solution
Bacteriological analysis ☒ YES ☐ NO
Laboratory sent to City of Sioux Falls

Well Owner:
Name City of Sioux Falls
Address

Well Log:

Formation	Depth From	Depth To
top soil	0	2
clay	2	8
sand M-C	8	35'-6"
sand F	35'-6"	36
clay	36	

STATIC WATER LEVEL 5 Feet
If flowing: closed in pressure PSI
GPM flow through inch pipe
Controlled by ☐ Valve ☐ Reducers ☐ Other
If other; specify
Can well be completely shut in?

WELL TEST DATA:
☒ Pumped
☐ Bailed
☐ Other
Describe: test pumped with gas driven turbine pump.

Pumping Level Below Land Surface
25 ft. After 72 Hrs. pumped 350 GPM
ft. After Hrs. pumped GPM
ft. After Hrs. pumped GPM

REMARKS: Well # I

This well was drilled under license # 129
And this report is true and accurate.
Drilling firm Sioux Well Drilling
Signature of License Representative:
Wayne H Wagner
Signature of Well Owner:

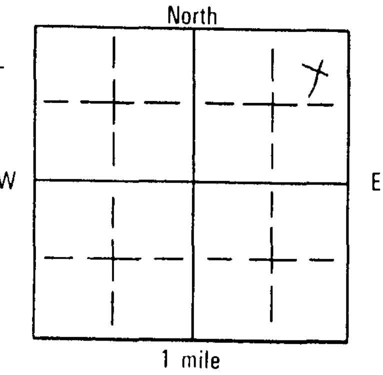
Date Feb 88

SOUTH DAKOTA WATER WELL COMPLETION REPORT

10-85 Ⓓ

Location ne ¼ ne ¼ Sec 32 Twp 102N Rg 49W

County Minnehaha



Please mark well location with an "X"

63

Well #63

Well Completion Date 11-3-88

PROPOSED USE:

☐ Domestic ☑ Municipal ☐ Test Holes
☐ Irrigation ☐ Industrial ☐ Stock

Method of Drilling: Bucket

CASING DATA:

☐ Steel ☑ Plastic ☐ Other

If other describe

PIPEWEIGHT	DIAMETER	FROM	TO	HOLE DIAMETER
LB/FT	IN	FT	FT	IN
LB/FT	IN	FT	FT	IN
LB/FT	IN	FT	FT	IN
LB/FT	IN	FT	FT	IN

GROUT:

Was the well grouted? ☑ YES ☐ NO

To what depth? 0-6 FEET

What is grouting material? Cement

If cement, number of sacks?

Describe grouting procedure

What was grout weight? LB/GAL

SCREEN: ☐ Perforated pipe ☑ Manufactured

Diameter 12" IN Length 10' FEET

Material Hand Slotted

Slot Size Set From 28 Feet To 38 Feet

Slot Size Set From Feet To Feet

Slot Size Set From Feet To Feet

Other information

Was a packer or seal used? ☐ YES ☑ NO

If so, what material?

Describe packer(s) and location?

Was well disinfected upon completion? ☑ YES ☐ NO

Explain

Bacteriological analysis ☑ YES ☐ NO

Laboratory sent to Sioux Fall

Well Owner:

Name City of Sioux Falls

Address

Well Log:

Formation	Depth From	Depth To
Topsoil	0	2
Clean Sand	2	6
Clean Gravel	6	35
Rocks + Gravel	35	38

STATIC WATER LEVEL 7' Feet

If flowing: closed in pressure PSI

GPM flow through inch pipe

Controlled by ☐ Valve ☐ Reducers ☐ Other

If other; specify

Can well be completely shut in?

WELL TEST DATA:

☑ Pumped
☐ Bailed Describe:
☐ Other

Pumping Level Below Land Surface

25' ft. After 6 Hrs. pumped 500 GPM

ft. After Hrs. pumped GPM

ft. After Hrs. pumped GPM

REMARKS:

This well was drilled under license # 111

And this report is true and accurate.

Drilling firm Lacey Well Drilling

Signature of License Representative: Joan Redder

Signature of Well Owner:

Date 11-30-88

Appendix D Middle Skunk Creek Well Field Well Logs

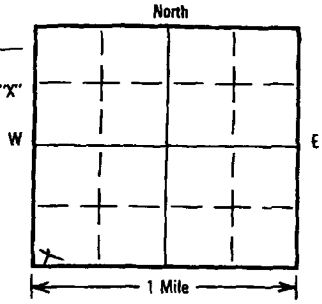
SOUTH DAKOTA WATER WELL COMPLETION REPORT

07-92

Location SW cor SW¼ Sec 25 Twp 103N Rg 51W

County
MINNEHAHA

Please mark well location with an "X"



Well Completion Date 3-2-93

Well Owner: City of Sioux Falls.
Business Name:
Address: 1400 No Minnesota Ave
Sioux Falls SD 57102

WELL LOG:

FORMATION	DEPTH FROM	DEPTH TO
See Attached Log		
Well #101		

APR 1993
DIVISION OF WATER RIGHTS
Pierre, SD

LOCATION:
Distance from nearest potential pollution source (septic tank, abandoned well, feed lot, etc.)? ______ ft. from ______ (identify source).

PROPOSED USE:
☐ Domestic/Stock ☒ Municipal ☐ Business ☐ Test Holes
☐ Irrigation ☐ Industrial ☐ Institutional ☐ Monitoring well

METHOD OF DRILLING:
Reverse Rotary

CASING DATA:
☒ Steel ☐ Plastic ☐ Other
If other describe

PIPEWEIGHT	DIAMETER	FROM	TO	HOLE DIAMETER
119 LB/FT	30 IN	19 FT	GL FT	54" IN
142 LB/FT	36 IN	13 FT	GL FT	54" IN
LB/FT	IN	FT	FT	IN

GROUTING DATA

Grout Type	No. of Sacks	Grout Weight	From	To
Slurry	46	lb./gal	10 ft	7 ft
		lb./gal	ft	ft

Describe grouting procedure 2 cu Yds. 23 bags p/yd with 6 gal p/Bag H2O. TREMIED IN on top of Bentonite Seal Just above Gravel Pack

SCREEN: ☐ Perforated pipe ☒ Manufactured
Diameter 30 IN Length 10'4" FEET
Material 304 SS
Slot Size .100 Set From 29.5 Feet to 19 Feet
Other information 3" STEEL Sump on Bottom of 30" 3/8 wall with 3/8 Plate Bottom

WAS A PACKER OR SEAL USED? ☐ YES ☒ NO
If so, what material?
Describe packer(s) and location?

DISINFECTION:
Was well disinfected upon completion? ____ YES, How:
X NO, Why Not? Contractor to use For Dewatering Will Be Disinfected at time of New Pump Install

Laboratory sent to for water quality analysis City LAB

STATIC WATER LEVEL 3 Feet
If flowing: closed in pressure ______ PSI
GPM flow ______ through ______ inch pipe
Controlled by ☐ Valve ☐ Reducers ☐ Other
Reduced Flowrate ______ GPM
Can well be completely shut in?

WELL TEST DATA:
☒ Pumped Describe: 16 HRS Step test AT 4 Rates then 24 HRs Constant Test AT 500gpm
☐ Bailed
☐ Other

Pumping Level Below Land Surface
7.1 ft. After 4 Hrs. pumped 310 GPM
10.7 ft. After 12 Hrs. pumped 500 GPM
If pump installed, pump rate ______ GPM

REMARKS
Complete Date Available From City Files or H.D.R Engineering
ALSO 2 MONITORING WELLS ON SITE

This well was drilled under license # 513
And this report is true and accurate.
Drilling firm LAYNE-WESTERN CO.
Signature of License Representative:
W. G. Grear
Signature of Well Owner or Equitable Property Holder:

Date: 4-11-93

Layne-Western Company, Inc.

Well Information

Omaha, Nebraska

1. Contract RICE LAKE CONTRACTING Date 3-2-93

2. City and State SIOUX FALLS, SOUTH DAKOTA Driller GARY MCCRACKEN

3. Well No. 101 at test hole No. .... Well location (attach map) ....

4. Work completed .... No of man hours as charged to job on time sheet ....

5. MATERIAL:

	LENGTH	DIA.	GAUGE OR WALL THICKNESS	MATERIAL	TYPE	NO. OF OPENINGS
6. Screen	10.4	30	.375	STAINLESS STEEL	WIRE WRAP	.100
7. Inner Casing	27.1	30	.375	BLACK	BLANK	
8. Outer Casing	21.5	36	.375	BLACK	BLANK	

9. 13 tons of gravel used in the well. Size "AA" LUTHER MADDOX

10. Test of well. Did you use test or permanent pump? .... Size of Bowl .... Stages

11. Size of orifice .... inch by .... inch. Orifice tube reading .... inches.

12. Pumping test — measurements from ground level:

TIME	G.P.M.	STATIC	DRAWDOWN	PUMPING LEVEL

13. Recovery in 5 minutes ...., in 30 minutes ....

14. Did you seal bottom of well? YES Thickness .375 inches, material STEEL

15. Well underreamed? NO From .... feet to .... feet, ... feet to .... feet.

16. If all screen was not placed at bottom, state how it was spaced.

From 29.5 feet to 19 feet; from .... feet to .... feet; from .... feet to .... feet.

17. Depth of well from ground level to top of plug 32.5 Size of drilled hole 54"

18. Was cement placed around or between any of the casings? YES

19. If so, state where, how much and method used. 7-10 FT 1.5 YARDS

Layne-Western Company, Inc. **Well Information**

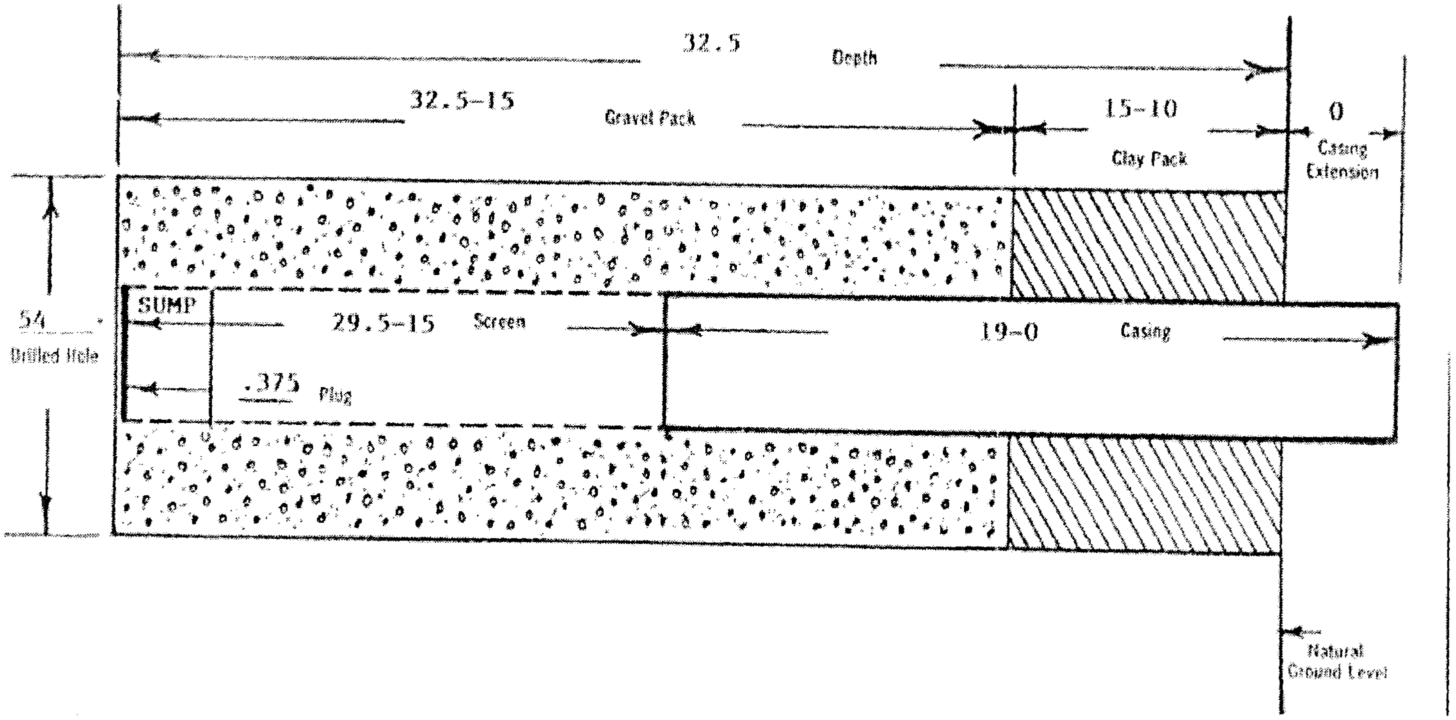
Omaha, Nebraska

CONTRACT RICE LAKE CONTRACTING-CITY OF SIOUX FALLS, SD

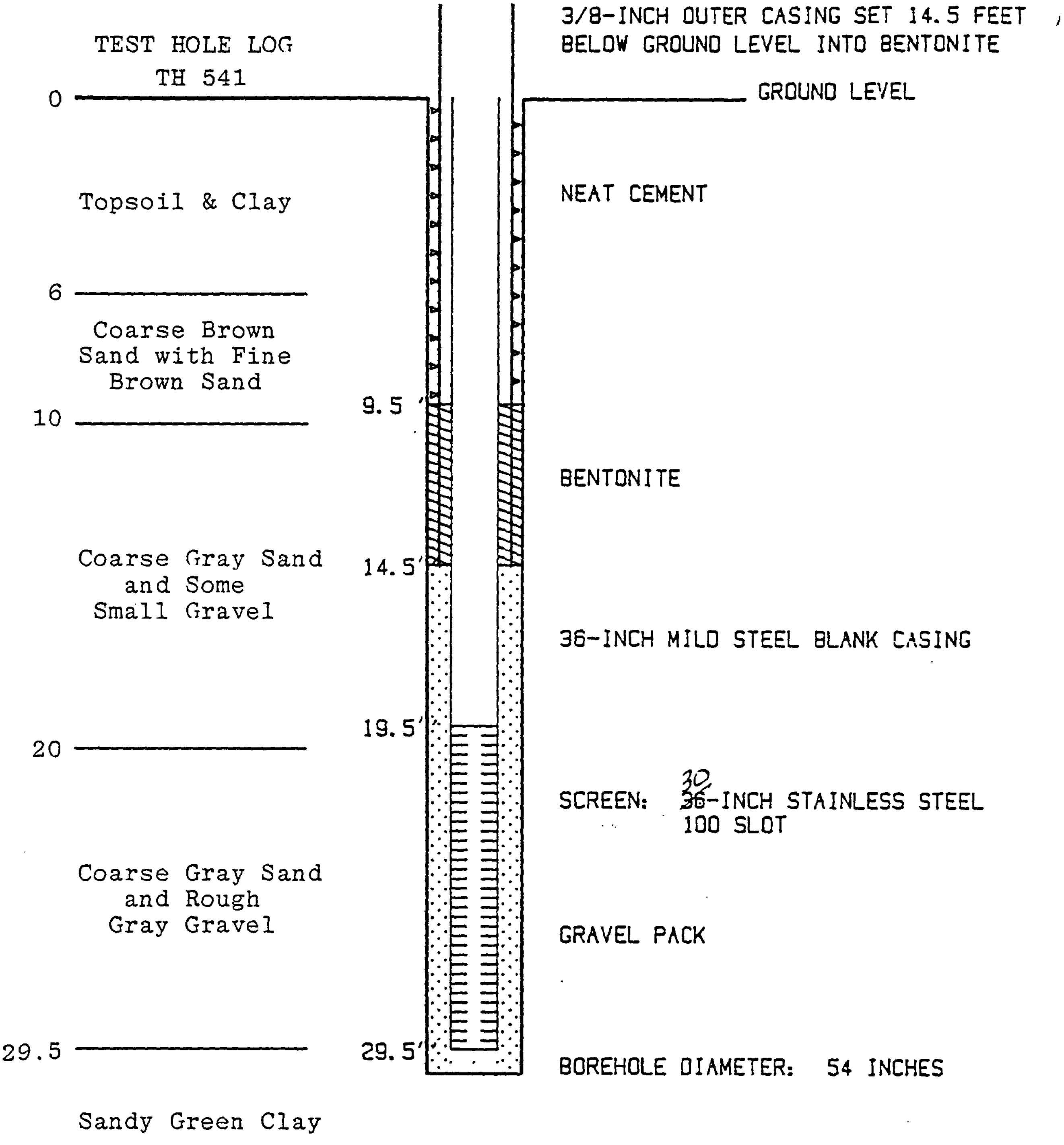
Well No. 101

Log of well from ground level:

Feet		Feet	Formation
0	to	2	TOP SOIL
2	to	5	CLAY
5	to	15	FINE SAND
15	to	22	MEDIUM TO COARSE SAND
22	to	29.5	MEDIUM TO COARSE GRAVEL SOME BOULDERS
29.5	to	35	CLAY
	to		
	to		
	to		
	to		
	to		
	to		
	to		
	to		
	to		
	to		



WELL NO: 101



LAYNE GEOSCIENCES, INC.

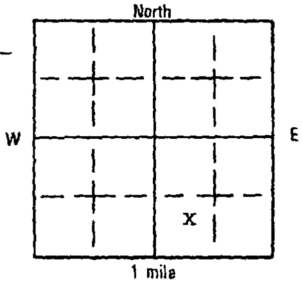
SOUTH DAKOTA WATER WELL COMPLETION REPORT

10-85

Location W ¼ SE ¼ Sec 25 Twp 103N Rg 51W

County
Minnehaha

Please mark well location with an "X"



Well Completion Date 10/9/93

PROPOSED USE:
☐ Domestic ☒ Municipal ☐ Test Holes
☐ Irrigation ☐ Industrial ☐ Stock

Method of Drilling:
Reverse Circulation Rotary

CASING DATA:
☒ Steel ☐ Plastic ☐ Other
If other describe

PIPEWEIGHT	DIAMETER	FROM	TO	HOLE DIAMETER
118 LB/FT	30 IN	14 FT	GL FT	42 IN
142 LB/FT	36 IN	11.5 FT	GL FT	42 IN
LB/FT	IN	FT	FT	IN
LB/FT	IN	FT	FT	IN

GROUT:
Was the well grouted? ☒ YES ☐ NO
To what depth? 6.5' to 2' FEET
What is grouting material? Slurry
If cement, number of sacks? 23 bags p/cu yd
Describe grouting procedure Hopper and tremmie pipe from bottom up
What was grout weight? 15.4 LB/GAL

SCREEN: ☐ Perforated pipe ☒ Manufactured
Diameter 30 IN Length 10.4 FEET
Material Stainless Steel
Slot Size .090 Set From 24 Feet To 13.6 Feet
Slot Size Set From Feet To Feet
Slot Size Set From Feet To Feet
Other information

Was a packer or seal used? ☐ YES ☒ NO
If so, what material?
Describe packer(s) and location?

Was well disinfected upon completion? ☐ YES ☒ NO
Explain Contractor to use for dewatering. ~~Chlor at time of pump setting.~~
Bacteriological analysis ☒ YES ☐ NO
Laboratory sent to Sioux Falls City Lab

Well Owner:
Name City of Sioux Falls
Address 1400 No. Minnesota
Sioux Falls, SD.

Well Log:

Formation	Depth From	Depth To
See Attached Log		
Well No. 102		

STATIC WATER LEVEL 2.42 Feet
If flowing: closed in pressure PSI
GPM flow through inch pipe
Controlled by ☐ Valve ☐ Reducers ☐ Other
If other: specify
Can well be completely shut in?

WELL TEST DATA:
☒ Pumped 16 hr step & 24 hr covstant
☐ Bailed Describe:
☐ Other

Pumping Level Below Land Surface
11.4 ft. After 4 Hrs. pumped 449 GPM
11.8 ft. After 12 Hrs. pumped 449 GPM
11.9 ft. After 23 Hrs. pumped 449 GPM

REMARKS:
ALSO 2 MONITORING WELLS ON SITE

DEC 1993
DIVISION OF WATER RIGHTS

This well was drilled under license # 513
And this report is true and accurate.
Drilling firm Layne-Western Company
Signature of License Representative:
W. J. Grear
Signature of Well Owner:

Date ~~12/8/93~~
1-21-94

Layne-Western Company, Inc. **Well Information**
Omaha, Nebraska

1. Contract Rice Lake Contracting Date 10/8/93
2. City and State Sioux Falls, SD. Driller Dave Deaver
3. Well No. (102) at test hole No. 102 Well location (attach map)
W 1/2 of SE 1/4 SEC 25 TWP 103N RG 51W
4. Work completed 10/8/93 No of man hours as charged to job on time sheet

5. MATERIAL:	LENGTH	DIA.	GAUGE OR WALL THICKNESS	MATERIAL	TYPE	NO. OF OPENINGS
6. Screen	10.4'	30"	.375	SS	WR	.090
7. Inner Casing	13.6'	30"	.375	Black	Blank	
8. Outer Casing	22'	36"	.375	Black	Blank	

9. 8 tons of gravel used in the well. Size 1/4 x 10 Northern Gravel Co.
10. Test of well. Did you use test or permanent pump? ______ Size of Bowl ______ Stages ______
11. Size of orifice ______ inch by ______ inch. Orifice tube reading ______ inches.
12. Pumping test — measurements from ground level:

TIME	G.P.M.	STATIC	DRAWDOWN	PUMPING LEVEL

13. Recovery in 5 minutes ______, in 30 minutes ______
14. Did you seal bottom of well? Yes Thickness .375 inches, material Black - 3' x 30" Sump
15. Well underreamed? No From ______ feet to ______ feet, ______ feet to ______ feet.
16. If all screen was not placed at bottom, state how it was spaced.
From 24' feet to 13.6' feet; from ______ feet to ______ feet; from ______ feet to ______ feet.
17. Depth of well from ground level to top of plug 27.4' Size of drilled hole 42"
18. Was cement placed around or between any of the casings? Yes
19. If so, state where, how much and method used. 6.5' to 2', 1 cu. yd. by tremmie pipe

LW 65

Layne-Western Company, Inc.

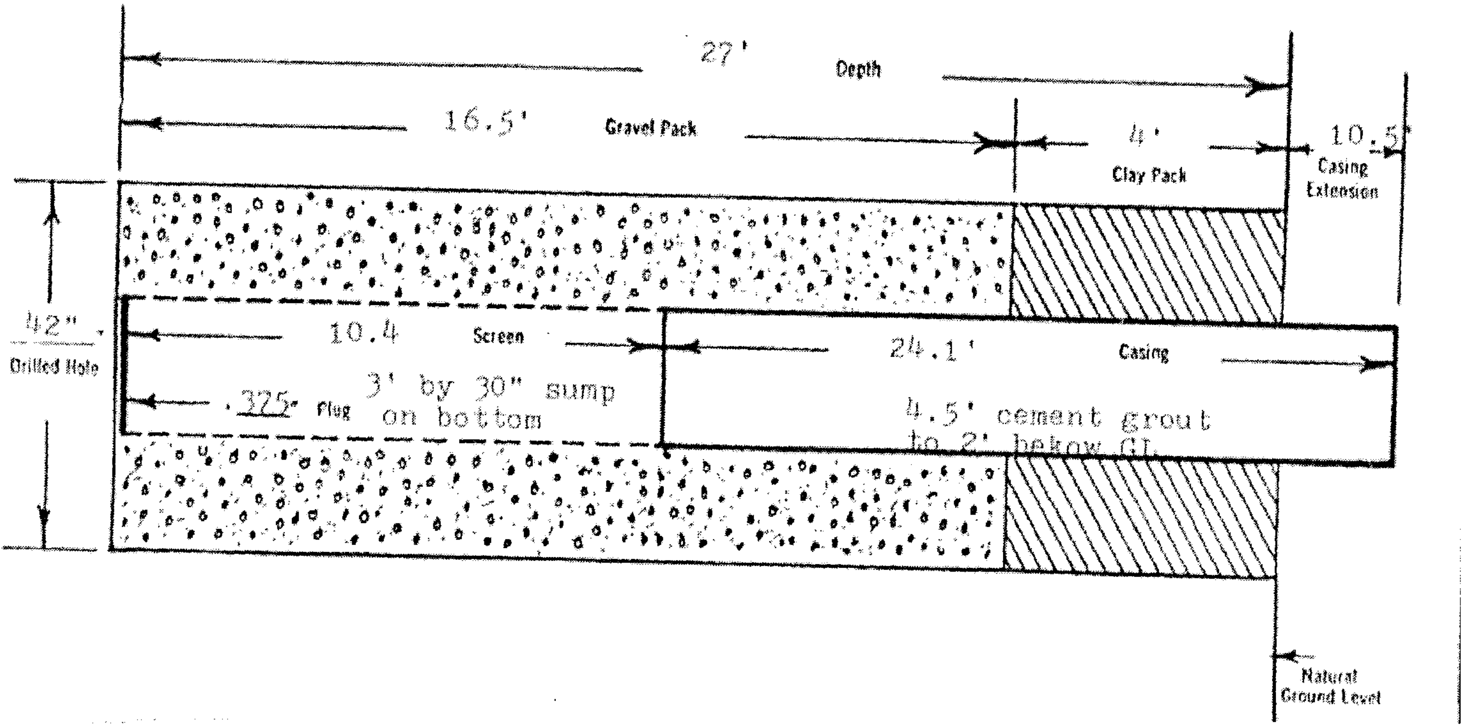
Well Information

Omaha, Nebraska

CONTRACT Rice Lake Covtracting - Sioux Falls, SD. Well No. 102

Log of well from ground level:

Feet		Feet	Formation
0	to	2	Topsoil
2	to	5	Brown clay
5	to	16	Sand and gravel
16	to	24	Sand, large gravel and boulders
24	to	27	Sandy grey clay and large rocks



Contract 4 - Sioux Falls, South Dakota
HDR Project No.: 01450-077-135

Construction of Well No. 102

Method used: Reverse

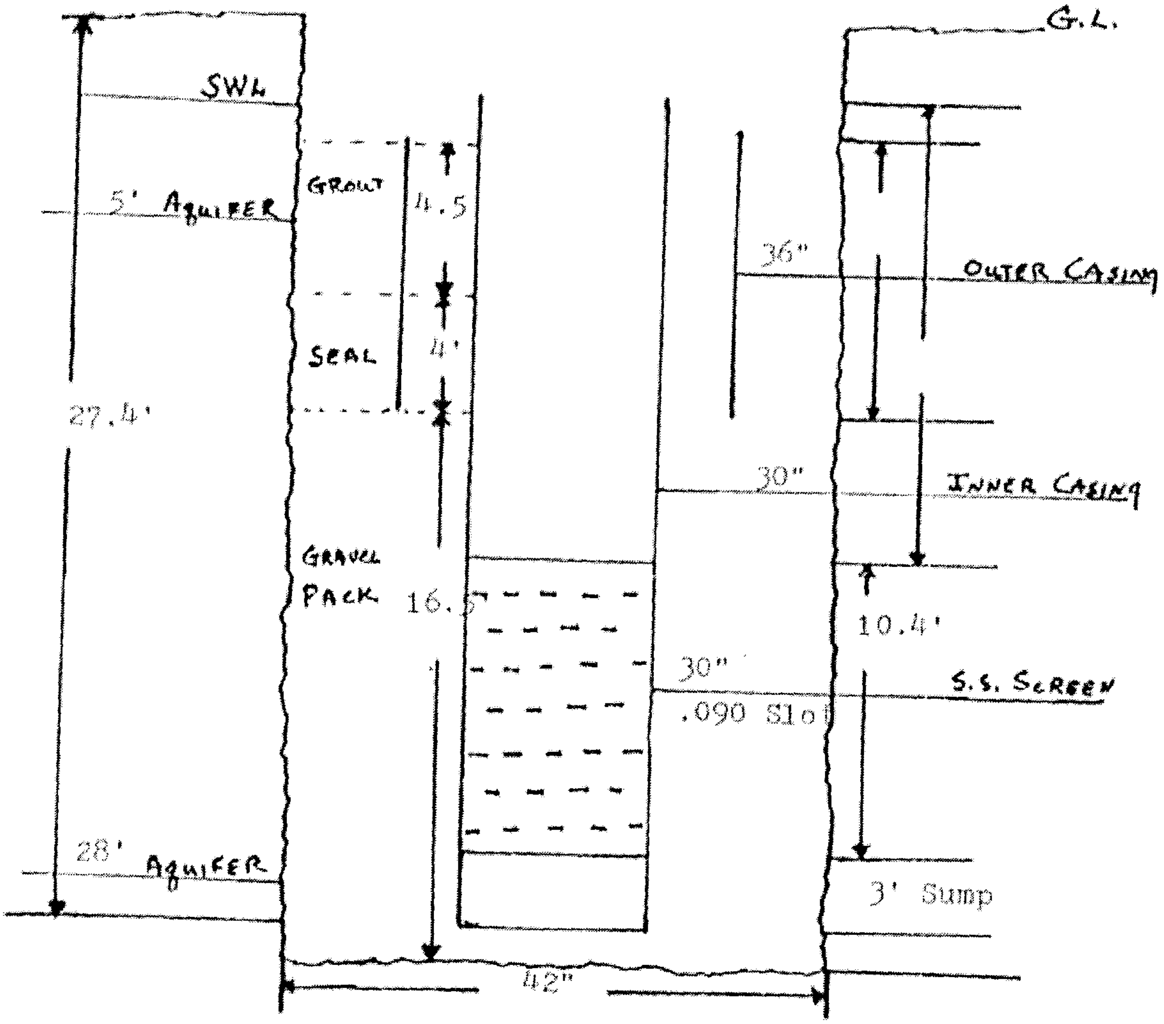
Date Started: 10/5/93

Drilling date(s): 10/6/93 10/7/93 10/8/93

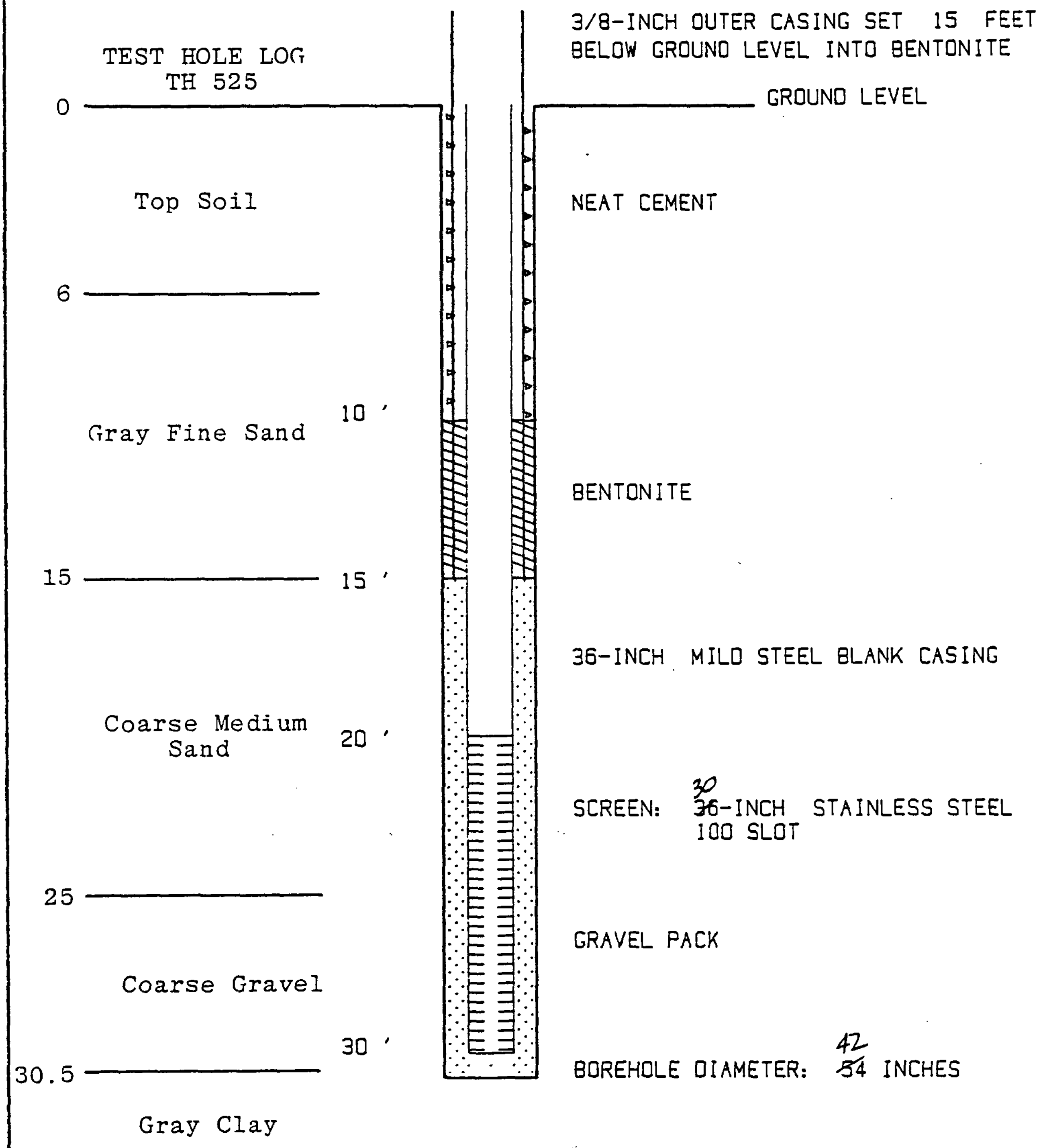
Date casing and screen installed: 10/8/93

Date cement grouted: 10/9/93 No. cu. yards: 1
(Cement slurry - 23 bags per cubic yard with 6 gallons H_2O weighing 15.6 # per gallons)
(Method - Hopper with tremie pipe)

Construction completion date: 10/9/93



WELL NO: 102



LAYNE GEOSCIENCES, INC.

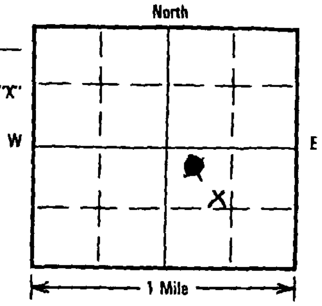
SOUTH DAKOTA WATER WELL COMPLETION REPORT

07-92

Location NE ¼ SE ¼ Sec 25 Twp 103N Rg 51W

County
Minnehaha

Please mark well location with an "X"



Well Completion Date 3-5-93

Well Owner: City of Sioux Falls
Business Name:
Address: 1400 No Minnesota
Sioux Falls SD 57102

WELL LOG:

FORMATION	DEPTH FROM	DEPTH TO
See Attached log		
Well #103		

APR 1993
DIVISION OF WATER RIGHTS

LOCATION:
Distance from nearest potential pollution source (septic tank, abandoned well, feed lot, etc.)? ______ ft. from ______ (identify source).

PROPOSED USE:
☐ Domestic/Stock ☒ Municipal ☐ Business ☐ Test Holes
☐ Irrigation ☐ Industrial ☐ Institutional ☐ Monitoring well

METHOD OF DRILLING:
Reverse Rotary

CASING DATA:
☒ Steel ☐ Plastic ☐ Other
If other describe

PIPEWEIGHT	DIAMETER	FROM	TO	HOLE DIAMETER
~~119 LB/FT~~	~~30 IN~~	~~19 FT~~	~~GL FT~~	~~54 IN~~
142 LB/FT	36 IN	19 FT	GL FT	54 IN
167 LB/FT	42 IN	13 FT	GL FT	94 IN

GROUTING DATA

Grout Type	No. of Sacks	Grout Weight	From	To
Slurry	46	lb./gal	ft.	ft
		lb./gal	ft.	ft

Describe grouting procedure 2 cu yds - 23 bags p/yd w/ 6 gal p/bag H2O. Tremied in on Top of Bentonite Seal Just Above gravel Pack

SCREEN: ☐ Perforated pipe ☒ Manufactured
Diameter 36 IN Length 10.4 FEET
Material 304 Stainles Steel
Slot Size .100 Set From 31 Feet to 21 Feet
Other information 3' Steel Sump on Bottom of 36" 3/8 wall w/ 3/8" plate Bottom

WAS A PACKER OR SEAL USED? ☐ YES ☒ NO
If so, what material?
Describe packer(s) and location?

DISINFECTION:
Was well disinfected upon completion? ____ YES, How:
X NO, Why Not? Contractor to use For Dewatering Will be Disinfected At Time of New Pump Install

Laboratory sent to for water quality analysis City LAB

STATIC WATER LEVEL 2' Feet
If flowing: closed in pressure ______ PSI
GPM flow ______ through ______ inch pipe
Controlled by ☐ Valve ☐ Reducers ☐ Other
Reduced Flowrate ______ GPM
Can well be completely shut in?

WELL TEST DATA:
☒ Pumped
☐ Bailed
☐ Other

Describe: 16 HRS Step test AT 4 Rates, Then 24 HRs Constant Test AT 450gpm

Pumping Level Below Land Surface
6.4 ft. After 8 Hrs. pumped 340 GPM
9.6 ft. After 32 Hrs. pumped 450gpm GPM
If pump installed, pump rate ______ GPM

REMARKS
Complete DATA Available From City Files OR H.D.R Engineering ALSO 1 MONITORING WELL ON SITE

This well was drilled under license # 513
And this report is true and accurate.
Drilling firm Layne-Western Co
Signature of License Representative: W. G. Grear
Signature of Well Owner or Equitable Property Holder:

Date: 4-13-93

Layne-Western Company, Inc.

Well Information

Omaha, Nebraska

1. Contract RICE LAKE CONTRACTING Date 3-5-93

2. City and State SIOUX FALLS, SD Driller GARY MCCRACKEN

3. Well No. 103 at test hole No. Well location (attach map)

4. Work completed No of man hours as charged to job on time sheet

5. MATERIAL:

	LENGTH	DIA.	GAUGE OR WALL THICKNESS	MATERIAL	TYPE	NO. OF OPENINGS
6. Screen	10.4	36"	.375	STAINLESS STEEL	WIRE WRAP	.100
7. Inner Casing	28.0	36"	.375	BLACK	BLANK	
8. Outer Casing	23.0	42"	.375	BLACK	BLANK	

9. 13 tons of gravel used in the well. Size "AA" LUTHER MADDOX

10. Test of well. Did you use test or permanent pump? Size of Bowl Stages

11. Size of orifice inch by inch. Orifice tube reading inches.

12. Pumping test — measurements from ground level:

TIME	G.P.M.	STATIC	DRAWDOWN	PUMPING LEVEL

13. Recovery in 5 minutes , in 30 minutes

14. Did you seal bottom of well? YES Thickness .375 inches, material STEEL

15. Well underreamed? NO From feet to feet, feet to feet.

16. If all screen was not placed at bottom, state how it was spaced.

From 31 feet to 21 feet; from feet to feet; from feet to feet.

17. Depth of well from ground level to top of plug 34' Size of drilled hole 54"

18. Was cement placed around or between any of the casings? YES

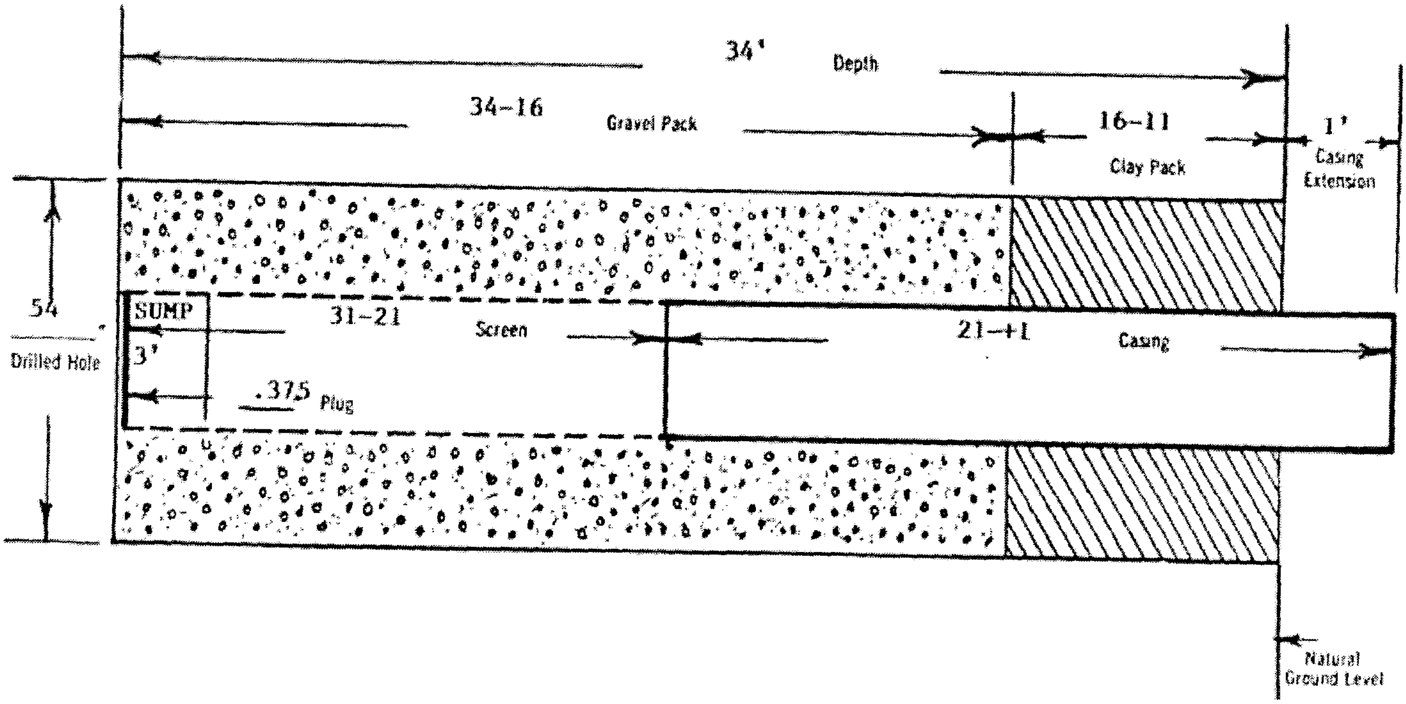
19. If so, state where, how much and method used. 11-6' 2 YARDS TREMIE

LW-66

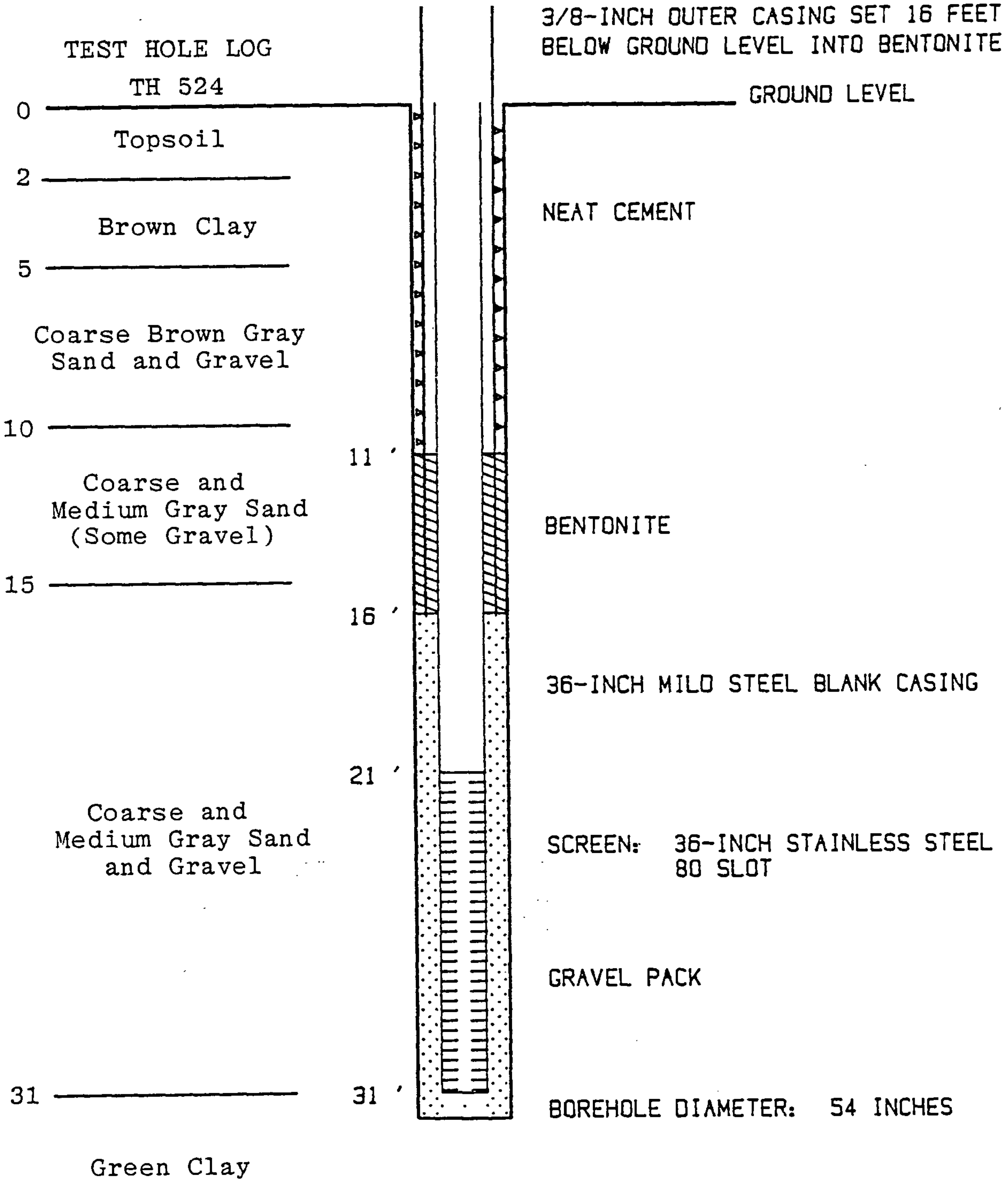
CONTRACT RICE LAKE CONTRACTING-CITY OF SIOUX FALLS, SD Well No. 103

Log of well from ground level:

Feet		Feet	Formation
0	to	3	TOP SOIL
3	to	6	CLAY
6	to	12	MEDIUM GRAVEL AND SAND
12	to	31	MEDIUM TO COARSE GRAVEL WITH A FEW BOULDERS
	to		
	to		
	to		
	to		
	to		
	to		
	to		
	to		
	to		
	to		
	to		
	to		



WELL NO: 103



LAYNE GEOSCIENCES, INC.

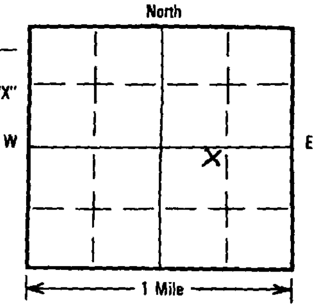
SOUTH DAKOTA WATER WELL COMPLETION REPORT

07-92

Location NE ¼ SE ¼ Sec 25 Twp 103N Rg 51W

County Minnehaha

Please mark well location with an "X"



Well Completion Date 3-7-93

Well Owner: City of Sioux Falls

Business Name:

Address: 1400 No. Minnesota
Sioux Falls SD 57102

LOCATION:

Distance from nearest potential pollution source (septic tank, abandoned well, feed lot, etc.)? ______ ft. from ______ (identify source).

PROPOSED USE:

☐ Domestic/Stock ☒ Municipal ☐ Business ☐ Test Holes
☐ Irrigation ☐ Industrial ☐ Institutional ☐ Monitoring well

METHOD OF DRILLING:

Reverse Rotary

CASING DATA:

☒ Steel ☐ Plastic ☐ Other

If other describe

PIPEWEIGHT	DIAMETER	FROM	TO	HOLE DIAMETER
142 LB/FT	36 IN	16 FT	GL FT	54 IN
167 LB/FT	42 IN	13 FT	GL FT	IN
LB/FT	IN	FT	FT	IN

GROUTING DATA

Grout Type	No. of Sacks	Grout Weight	From	To
Slurry	35	lb./gal	ft	ft
		lb./gal	ft	ft

Describe grouting procedure 1½ cu yds - 23 bag p/yd 7 6gal H2O/BAG. TREMIED IN ON top of Bentonite SEAL Just ABOVE gRAVel PACK

SCREEN: ☐ Perforated pipe ☒ Manufactured

Diameter 36 IN Length 15.4 FEET

Material 304 SS

Slot Size .070 Set From 31.5 Feet to 16 Feet

Other information 3' STEEL Sump on Bottom of 36" 3/8 wall W/ 3/8" Plate Bottom

WAS A PACKER OR SEAL USED? ☐ YES ☒ NO

If so, what material?

Describe packer(s) and location?

DISINFECTION:

Was well disinfected upon completion? ____ YES, How:

X NO, Why Not? Contractor To use For Dewatering Will be Disinfected at Time of New Pump Install

Laboratory sent to for water quality analysis City LAB

WELL LOG:

FORMATION	DEPTH FROM	DEPTH TO
See Attached Log		
Well #104		

APR 1993
DIVISION OF WATER RIGHTS
Pierre, SD

STATIC WATER LEVEL 1½ Feet

If flowing: closed in pressure ______ PSI

GPM flow ______ through ______ inch pipe

Controlled by ☐ Valve ☐ Reducers ☐ Other

Reduced Flowrate ______ GPM

Can well be completely shut in?

WELL TEST DATA:

☐ Pumped Describe:
☐ Bailed
☐ Other

Pumping Level Below Land Surface

______ ft. After ______ Hrs. pumped ______ GPM

______ ft. After ______ Hrs. pumped ______ GPM

If pump installed, pump rate ______ GPM

REMARKS

Pump test Data when Completed
ALSO 1 MONITORING WELL ON SITE

This well was drilled under license # 513

And this report is true and accurate.

Drilling firm LAyne-Western Co

Signature of License Representative: W. G Grear

Signature of Well Owner or Equitable Property Holder:

Date: 4-14-93

Layne-Western Company, Inc.

Well Information

Omaha, Nebraska

1. Contract RICE LAKE CONTRACTING Date 3-7-93

2. City and State SIOUX FALLS, SOUTH DAKOTA Driller GARY MCCRACKEN

3. Well No. 104 at test hole No. Well location (attach map)

4. Work completed No of man hours as charged to job on time sheet

5. MATERIAL:

	LENGTH	DIA.	GAUGE OR WALL THICKNESS	MATERIAL	TYPE	NO. OF OPENINGS
6. Screen	15.4	36"	.375	STAINLESS STEEL	WIRE WRAP	.070
7. Inner Casing	25	36"	.375	BLACK	BLANK	
8. Outer Casing	19	42"	.375	BLACK	BLANK	

9. 14 tons of gravel used in the well. Size #2 NORTHERN

10. Test of well. Did you use test or permanent pump? Size of Bowl Stages

11. Size of orifice inch by inch. Orifice tube reading inches.

12. Pumping test — measurements from ground level:

TIME	G.P.M.	STATIC	DRAWDOWN	PUMPING LEVEL

13. Recovery in 5 minutes , in 30 minutes

14. Did you seal bottom of well? YES Thickness .375 inches, material STEEL

15. Well underreamed? NO From feet to feet, feet to feet.

16. If all screen was not placed at bottom, state how it was spaced.

From 31.5 feet to 16 feet; from feet to feet; from feet to feet.

17. Depth of well from ground level to top of plug 34.5 Size of drilled hole 54"

18. Was cement placed around or between any of the casings? YES

19. If so, state where, how much and method used. 14-8 1.5 YARDS TREMIE

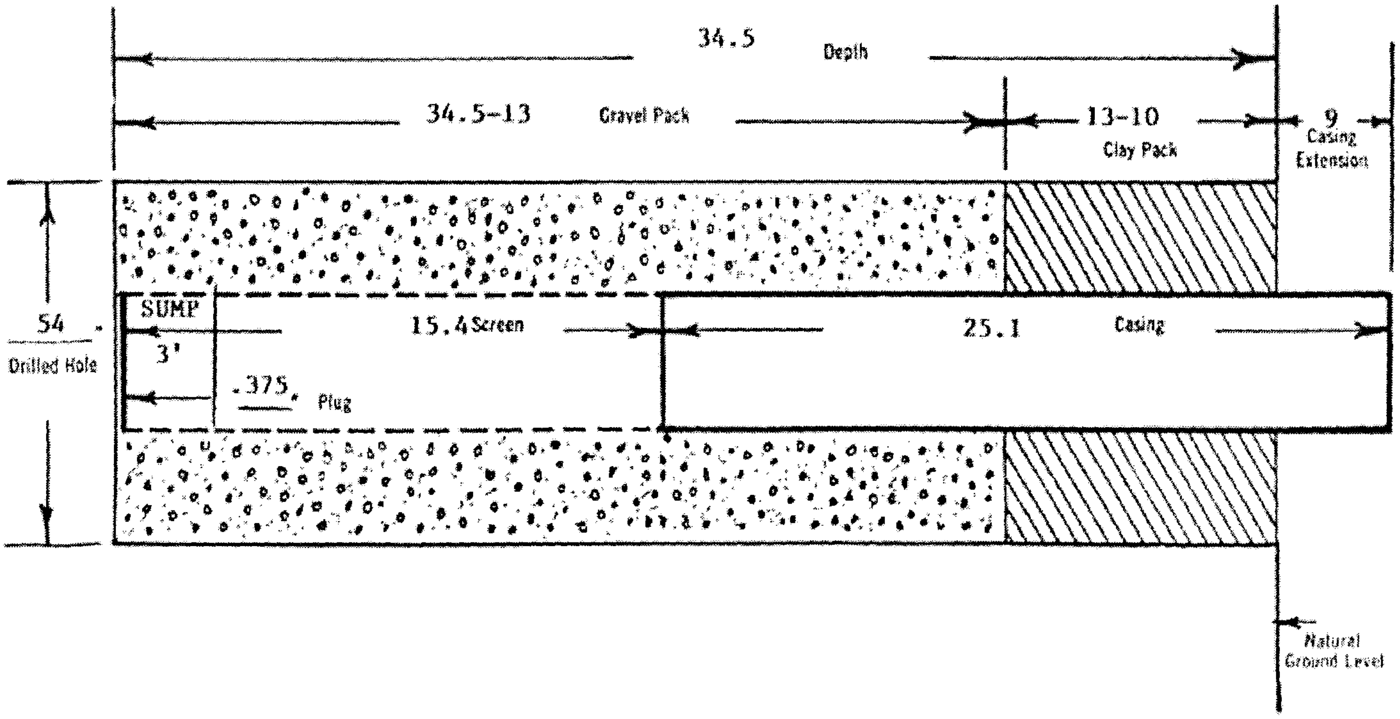
LW-65

Layne-Western Company, Inc. **Well Information**
Omaha, Nebraska

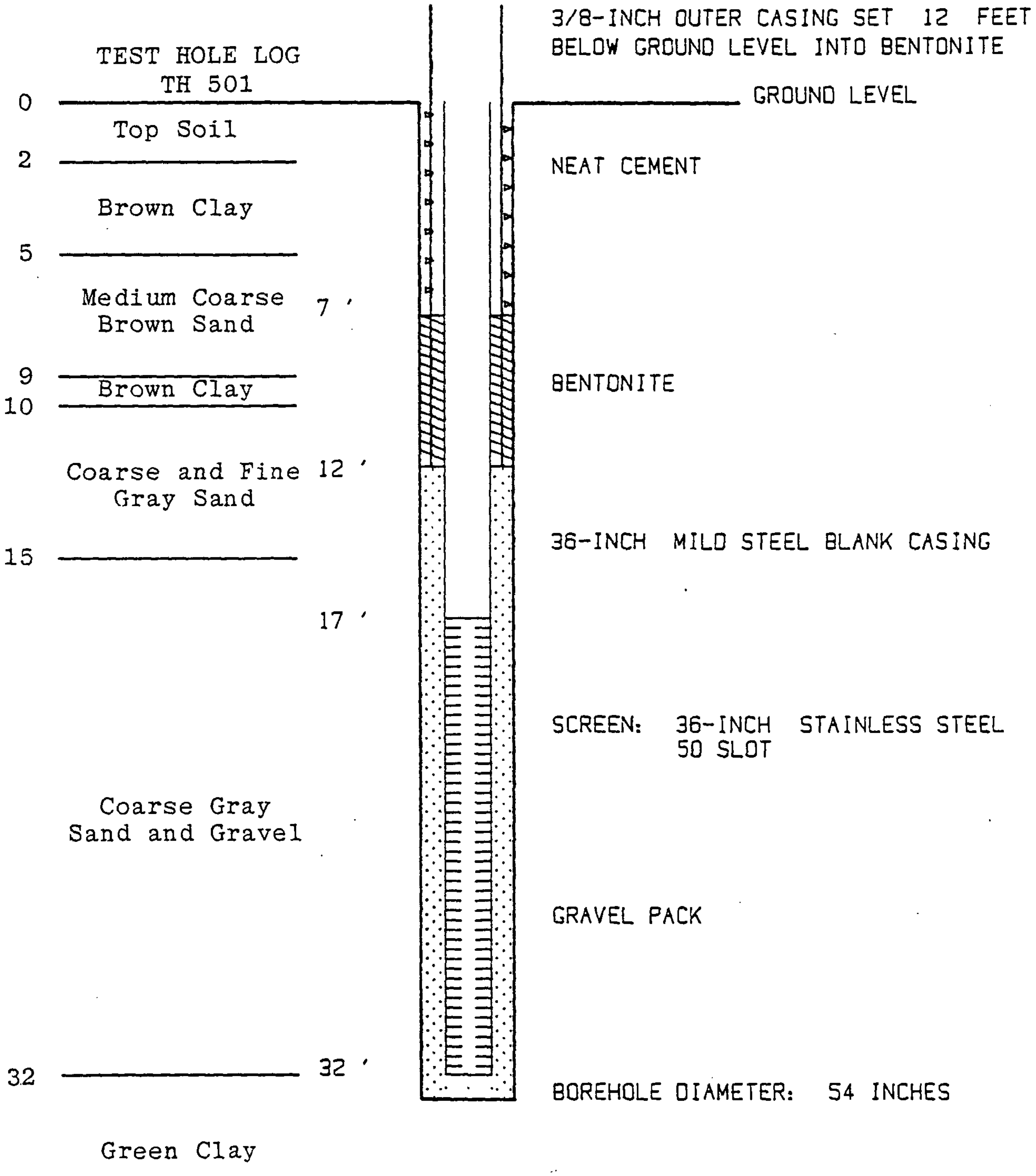
CONTRACT RICE LAKE CONTRACTING-CITY OF SIOUX FALLS, SD Well No. 104

Log of well from ground level:

Feet		Feet	Formation
0	to	16	BERM
16	to	12	CLAY
12	to	17	MEDIUM SAND
17	to	31.5	MEDIUM GRAVEL
31.5	to	35	CLAY



WELL NO: 104



LAYNE GEOSCIENCES, INC.

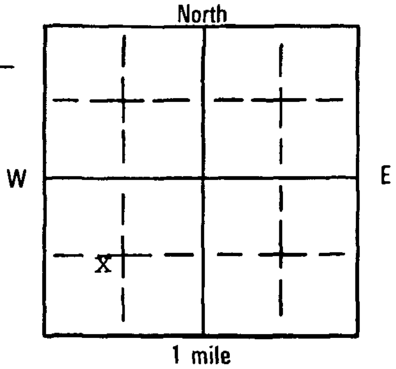
SOUTH DAKOTA WATER WELL COMPLETION REPORT

10-85

Location ¼ SW ¼ Sec 19 Twp 103N Rg 50W

County
Minnehaha

Please mark well location with an "X"



Well Completion Date 10/13/93

PROPOSED USE:
☐ Domestic ☒ Municipal ☐ Test Holes
☐ Irrigation ☐ Industrial ☐ Stock

Method of Drilling:
Reverse Circulation Rotary

CASING DATA:
☒ Steel ☐ Plastic ☐ Other
If other describe

PIPEWEIGHT		DIAMETER		FROM		TO		HOLE DIAMETER	
142	LB/FT	36	IN	15.4	FT	GL	FT	48	IN
166	LB/FT	42	IN	12	FT	GL	FT	48	IN
	LB/FT		IN		FT		FT		IN
	LB/FT		IN		FT		FT		IN

GROUT:
Was the well grouted? ☒ YES ☐ NO
To what depth? 7' to 2' FEET
What is grouting material? Slurry
If cement, number of sacks? 23 bags p/ cu yd
Describe grouting procedure Hopper and tremmie pipe from bottom uo
What was grout weight? 15.4 LB/GAL

SCREEN: ☐ Perforated pipe ☒ Manufactured
Diameter 36 IN Length 10.4 FEET
Material Stainless Steel
Slot Size .080 Set From 25.8 Feet To 15.4 Feet
Slot Size Set From Feet To Feet

Well Owner:
Name City Of Sioux Falls
Address 1400 No. Minnesota
Sioux Falls, SD

Well Log:

Formation	Depth From	Depth To
See Attached Log		
Well No. 105		

STATIC WATER LEVEL 1.2 Feet
If flowing: closed in pressure PSI
GPM flow through inch p
Controlled by ☐ Valve ☐ Reducers ☐ Other
If other; specify
Can well be completely shut in?

WELL TEST DATA:
☒ Pumped 16 hr & 24 hr constant
☐ Bailed Describe:
☐ Other

Pumping Level Below Land Surface
13.24 ft. After 4 Hrs. pumped 300 G
13.50 ft. After 12 Hrs. pumped 300 G
13.62 ft. After 24 Hrs. pumped 300 G

REMARKS: ALSO 2 MONITORING WELLS ON SITE

DEC 1993

Layne-Western Company, Inc. **Well Informatio**

Omaha, Nebrask

1. Contract Rice Lake Contracting Date 10/12/93
2. City and State City of Sioux Falls, SD. Driller Dave Deaver
3. Well No (105) at test hole No. 105 Well location (attach map)

So. ½ lot 2 SW 1/4 Sec 19 Twp 103N R50W

4. Work completed No of man hours as charged to job on time sheet

5. MATERIAL:	LENGTH	DIA.	GAUGE OR WALL THICKNESS	MATERIAL	TYPE	NO. OF OPENINGS
6. Screen	10.4'	36"	.375	SS	WR	.08
7. Inner Casing	15.4'	36"	.375	Black	Blank	
8. Outer Casing	19.5'	42"	.375	Black	Blank	

9. 10 tons of gravel used in the well. Size No. 3 Northern Gravel Company
10. Test of well. Did you use test or permanent pump? Size of Bowl Stages
11. Size of orifice inch by inch. Orifice tube reading inches.
12. Pumping test — measurements from ground level:

TIME	G.P.M.	STATIC	DRAWDOWN	PUMPING LEVEL

13. Recovery in 5 minutes , in 30 minutes
14. Did you seal bottom of well? Yes Thickness .375inches, material Black Plate
15. Well underreamed? No From feet to feet, feet to feet.
16. If all screen was not placed at bottom, state how it was spaced.

From 25.8feet to 15.4'feet; from feet to feet; from feet to feet.

17. Depth of well from ground level to top of plug 29' Size of drilled hole 48"
18. Was cement placed around or between any of the casings? Yes
19. If so, state where, how much and method used. 7' to 2', 1 yard tremmied

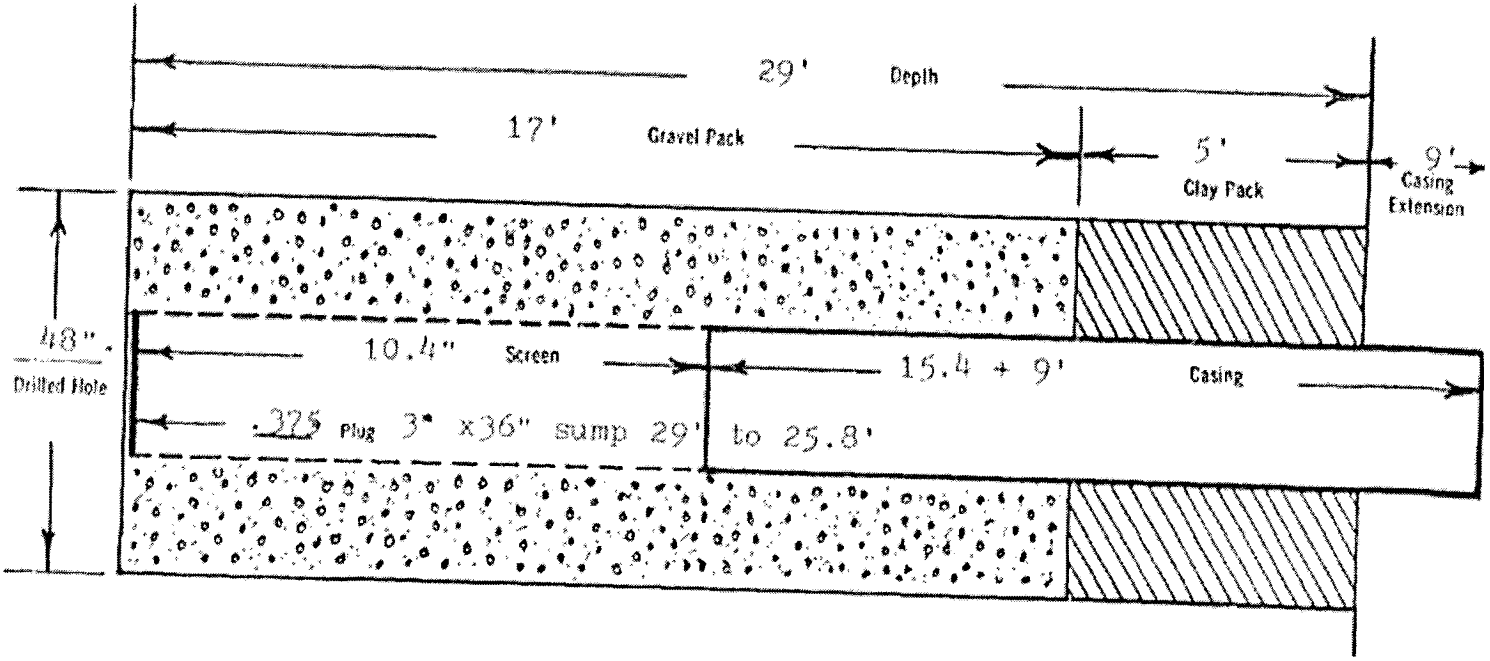
Layne-Western Company, Inc. **Well Information** Page

Omaha, Nebraska

CONTRACT Rice Lake Contracting - City of Sioux Falls, SD Well No. 105

Log of well from ground level:

Feet		Feet	Formation
0	to	5	Topsoil and clay
5	to	15	Sand and gravel
15	to	20	Sand and Large gravel
20	to	28	Sand and gravel
28	to	33	Sandy green clay



Contract 4 - Sioux Falls, South Dakota
HDR Project No.: 01450-077-135

Construction of Well No. 105

Method used: Reverse

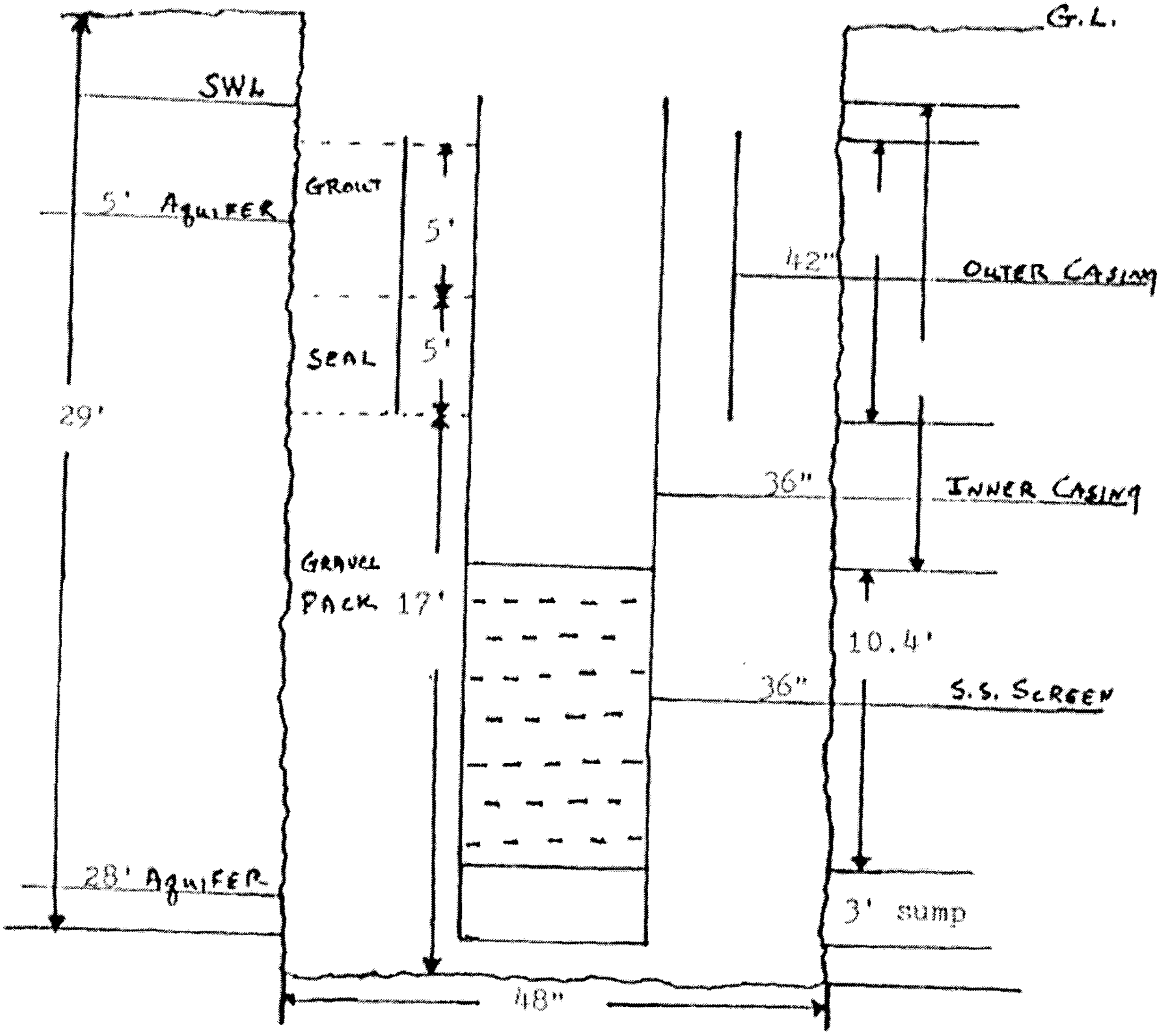
Date Started: 10/9/93

Drilling date(s): 10/10/93 10/11/92 10/12/93

Date casing and screen installed: 10/12/93

Date cement grouted: 10/13/93 No. cu. yards: one (1)
(Cement slurry - 23 bags per cubic yard with 6 gallons H_2O weighing 15.6 # per gallons)
(Method - Hopper with tremie pipe)

Construction completion date: 10/13/93



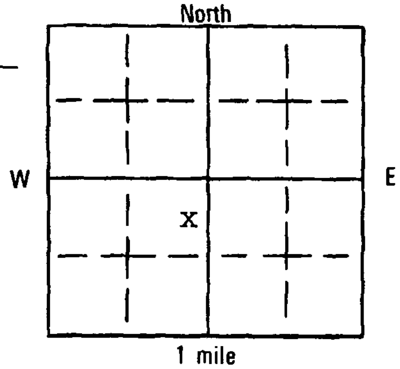
SOUTH DAKOTA WATER WELL COMPLETION REPORT

10-85

Location E½ ~~¼~~SW ¼ Sec 19 Twp 103N Rg 50W

County Minnehaha

Please mark well location with an "X"



Well Completion Date 10/16/93

PROPOSED USE:

☐ Domestic ☒ Municipal ☐ Test Holes
☐ Irrigation ☐ Industrial ☐ Stock

Method of Drilling:

Reverse Circulation Rotary

CASING DATA:

☒ Steel ☐ Plastic ☐ Other

If other describe

PIPEWEIGHT	DIAMETER	FROM	TO	HOLE DIAMETER
118 LB/FT	30 IN	17.1 FT	GL FT	54 IN
142 LB/FT	36 IN	14 FT	GL FT	54 IN
LB/FT	IN	FT	FT	IN
LB/FT	IN	FT	FT	IN

GROUT:

Was the well grouted? ☒ YES ☐ NO

To what depth? 9' to 5' FEET

What is grouting material? Slurry 2 cu yds

If cement, number of sacks? 23 bags p/ cu yd

Describe grouting procedure Hopper and tremmie pipe from bottom up.

What was grout weight? 15.4 LB/GAL

SCREEN: ☐ Perforated pipe ☒ Manufactured

Diameter 30 IN Length 15.4 FEET

Material Stainless Steel

Slot Size .100 Set From 32.5 Feet To 17.1 Feet

Slot Size Set From Feet To Feet

Well Owner:

Name City of Sioux Falls

Address 1400 No. Minnesota
Sioux Falls, SD.

Well Log:

Formation	Depth From	Depth To
See Attached Log		
Well No. 106		

STATIC WATER LEVEL 2.66 Feet

If flowing: closed in pressure PSI

GPM flow through inch p

Controlled by ☐ Valve ☐ Reducers ☐ Other

If other; specify

Can well be completely shut in?

WELL TEST DATA:

☒ Pumped 16 hr and 24 hr constar
☐ Bailed Describe:
☐ Other

Pumping Level Below Land Surface

7.29 ft. After 4 Hrs. pumped 635 G
7.43 ft. After 12 Hrs. pumped 635 G
7.56 ft. After 24 Hrs. pumped 635 G

REMARKS: ALSO 2 MONITORING WELLS ON SITE

DEC 1993

Layne-Western Company, Inc.

Well Information
Omaha, Nebraska

1. Contract Rice Lake Contracting Date 10/15/93

2. City and State Sioux Falls, SD Driller Dave Deaver/Harold Sta

3. Well No. 106 at test hole No. 106 Well location (attach map)
E 1/2 SW 1/4 SEC 19 TWP 103N R50W

4. Work completed No of man hours as charged to job on time sheet

5. MATERIAL:	LENGTH	DIA.	GAUGE OR WALL THICKNESS	MATERIAL	TYPE	NO. OF OPENINGS
6. Screen	15.4'	30"	.375	SS	WR	.100
7. Inner Casing	17.1'	30"	.375	Black	Blank	
8. Outer Casing	22.3'	36"	.375	Black	Blank	

9. 13 tons of gravel used in the well. Size 3/16 x 6 x 8 x 10 Northern Gravel Company

10. Test of well. Did you use test or permanent pump? Size of Bowl Stages

11. Size of orifice inch by inch. Orifice tube reading inches.

12. Pumping test — measurements *from ground level:*

TIME	G.P.M.	STATIC	DRAWDOWN	PUMPING LEVEL

13. Recovery in 5 minutes , in 30 minutes

14. Did you seal bottom of well? Yes Thickness .375 inches, material Black Plate

15. Well underreamed? No From feet to feet, feet to feet.

16. If all screen was not placed at bottom, state how it was spaced.
From 32.5' feet to 17.1' feet; from feet to feet; from feet to feet.

17. Depth of well from ground level to top of plug 35.5' Size of drilled hole 54"

18. Was cement placed around or between any of the casings? Yes

19. If so, state where, how much and method used. 9' to 5' 2 cu. yds. tremmied

Layne-Western Company, Inc. **Well Information**

Omaha, Nebraska

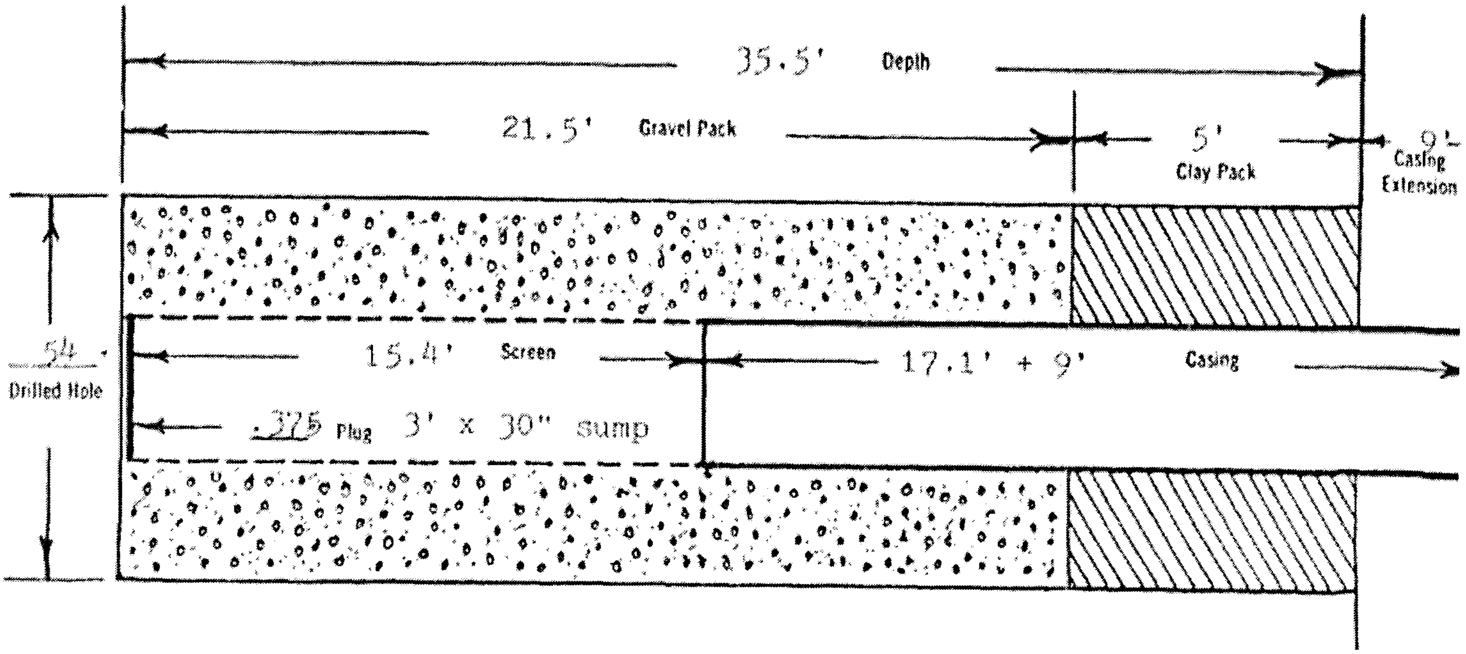
Page

CONTRACT Rice Lake Contracting

Well No. 106

Log of well from ground level:

Feet		Feet	Formation
0	to	6	Topsoil and clay
6	to	20	Sand and gravel
20	to	28	Sand and large gravel
28	to	33	Sand, gravel and cobbles
33	to	36	Sandy green clay and cobbles



Contract 4 - Sioux Falls, South Dakota
HDR Project No.: 01450-077-135

Construction of Well No. 106

Method used: Reverse

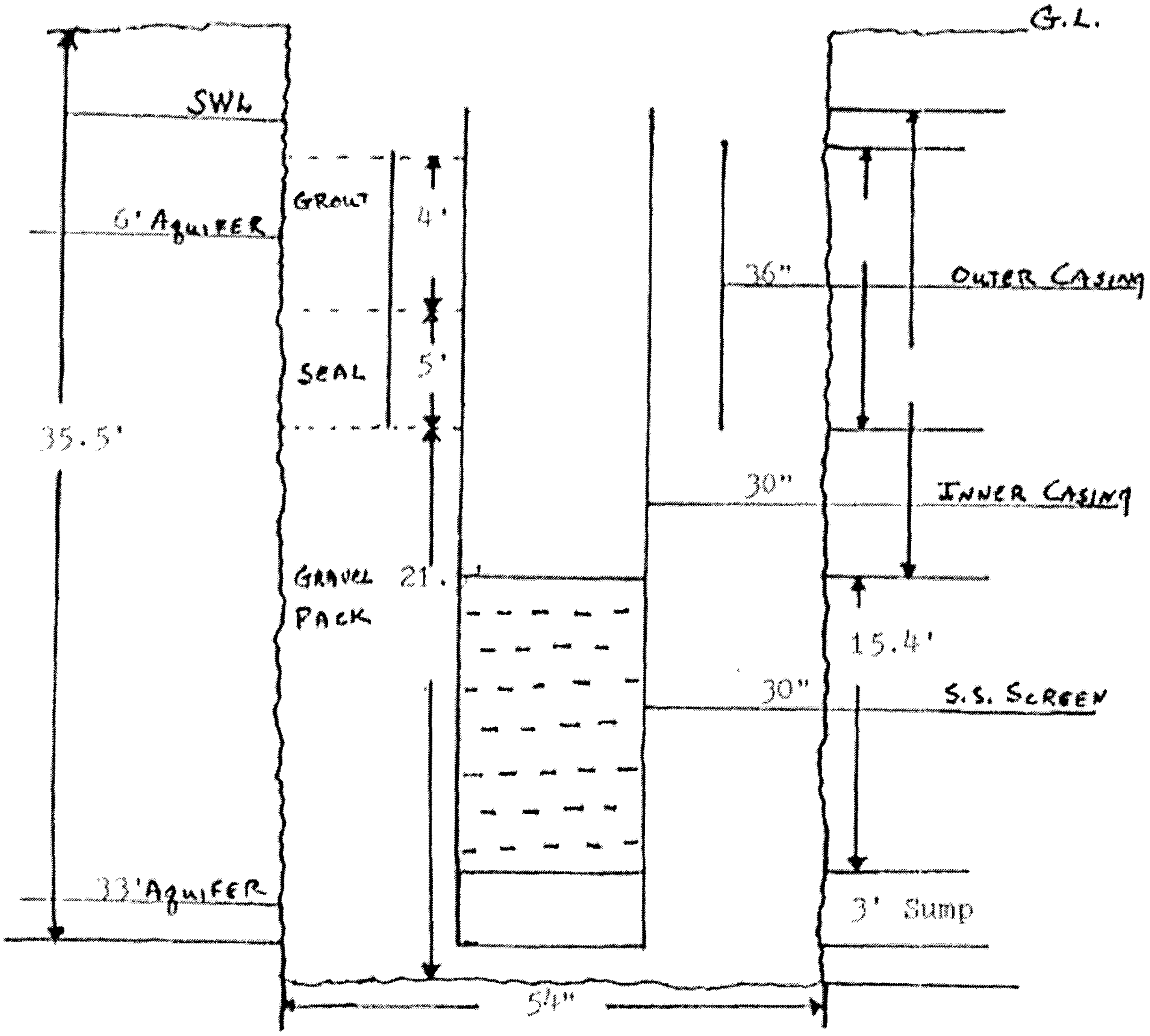
Date Started: 10/13/93

Drilling date(s): 10/14/93 10/15/93 10/16/93

Date casing and screen installed: 10/15/93

Date cement grouted: 10/16/93 No. cu. yards: 2
(Cement slurry - 23 bags per cubic yard with 6 gallons H_2O weighing 15.6 # per gallons)
(Method - Hopper with tremie pipe)

Construction completion date: 10/16/93



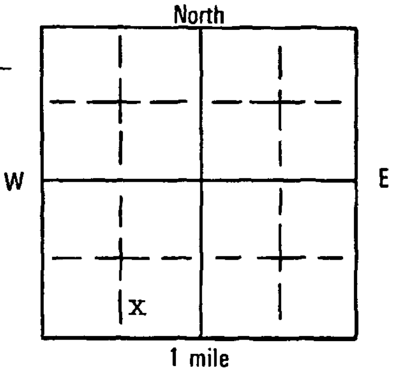
SOUTH DAKOTA WATER WELL COMPLETION REPORT

10-85

Location E½ ~~¼~~SW ¼ Sec 18 Twp 103N Rg 50W

County
Minnehaha

Please mark well location with an "X"



Well Completion Date 11/3/93

PROPOSED USE:
☐ Domestic ☒ Municipal ☐ Test Holes
☐ Irrigation ☐ Industrial ☐ Stock

Method of Drilling:
Reverse Circulation Rotary

CASING DATA:
☒ Steel ☐ Plastic ☐ Other
If other describe

PIPEWEIGHT	DIAMETER	FROM	TO	HOLE DIAMETER
142 LB/FT	36" IN	17.5 FT	GL FT	54 IN
166 LB/FT	42 IN	12 FT	GL FT	54 IN
LB/FT	IN	FT	FT	IN
LB/FT	IN	FT	FT	IN

GROUT:
Was the well grouted? ☒ YES ☐ NO
To what depth? 6' to 2' 1.5 cu yds FEET
What is grouting material? Slurry
If cement, number of sacks? 23bags p/ cu yd
Describe grouting procedure Hopper and tremmie pipe from bottom up.
What was grout weight? 15.4 LB/GAL

SCREEN: ☐ Perforated pipe ☒ Manufactured
Diameter 36 IN Length 15.4 FEET
Material Stainless Steel
Slot Size .090 Set From 32.9 Feet To 17.5 Feet
Slot Size Set From Feet To Feet

Well Owner:
Name City of Sioux Falls
Address 1400 No. Minnesota
Sioux Falls, SD

Well Log:

Formation	Depth From	Depth To
See Attached Log		
Well No. 107		

STATIC WATER LEVEL 1.92 Feet
If flowing: closed in pressure PSI
GPM flow through inch p
Controlled by ☐ Valve ☐ Reducers ☐ Other
If other; specify
Can well be completely shut in?

WELL TEST DATA:
☒ Pumped 16 hr step and 24 hr co
☐ Bailed Describe:
☐ Other

Pumping Level Below Land Surface
14.43 ft. After 4 Hrs. pumped 528 G
14.67 ft. After 12 Hrs. pumped 528 G
14.94 ft. After 24 Hrs. pumped 528 G

REMARKS: ALSO 2 MONITORIN WELLS ON SITE

DEC 1993
DIVISION OF

Layne-Western Company, Inc. **Well Information**
Omaha, Nebraska

1. Contract Rice Lake Contracting Date 11/2/93

2. City and State Sioux Falls, SD. Driller Dave Deaver

3. Well No. 107 at test hole No. 107 Well location (attach map)

E 1/2 of SW 1/4 SEC 18 TWP 103N RG 50W

4. Work completed ______ No of man hours as charged to job on time sheet ______

5. MATERIAL:

	LENGTH	DIA.	GAUGE OR WALL THICKNESS	MATERIAL	TYPE	NO. OF OPENINGS
6. Screen	15.4	36"	.375	SS	WR	.090
7. Inner Casing	17.5	36"	.375	Black	Blank	
8. Outer Casing	20.1	42"	.375	Black	Blank	

9. 15 tons of gravel used in the well. Size 1/4 x 10 Northern Gravel ompany

10. Test of well. Did you use test or permanent pump? ______ ______ Size of Bowl ______ Stages

11. Size of orifice ______ inch by ______ inch. Orifice tube reading ______ inches.

12. Pumping test — measurements from ground level:

TIME	G.P.M.	STATIC	DRAWDOWN	PUMPING LEVEL

13. Recovery in 5 minutes ______, in 30 minutes ______

14. Did you seal bottom of well? Yes Thickness .375 inches, material Black

15. Well underreamed? No From ______ feet to ______ feet, ______ feet to ______ feet.

16. If all screen was not placed at bottom, state how it was spaced.

From 32.9 feet to 17.5 feet; from ______ feet to ______ feet; from ______ feet to ______ feet.

17. Depth of well from ground level to top of plug 16' Size of drilled hole 54"

18. Was cement placed around or between any of the casings? Yes

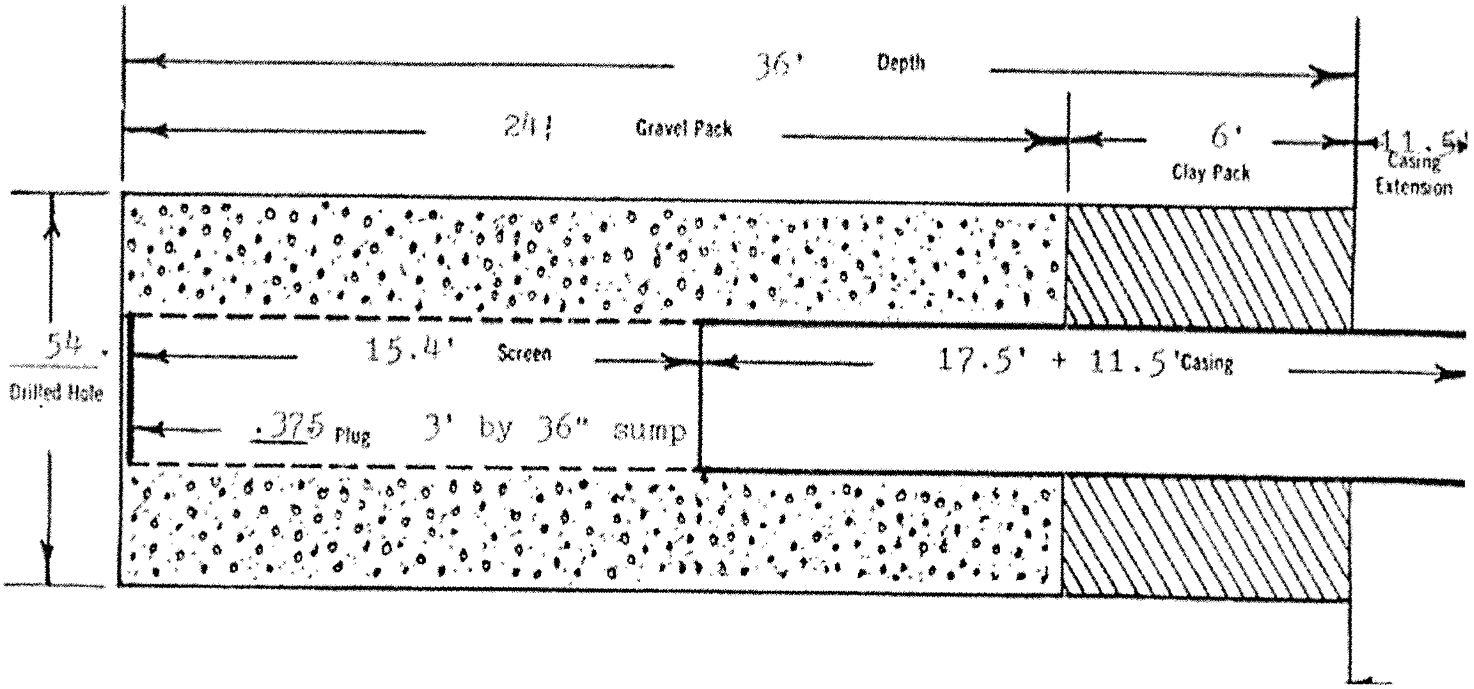
19. If so, state where, how much and method used. 6' to 2' 1.5 cu yds Tremmied

Layne-Western Company, Inc. **Well Information** Page 1
Omaha, Nebraska

CONTRACT Rice Lake Contracting Well No. 107

Log of well from ground level:

Feet		Feet	Formation
0	to	4	Topsoil and clay
4	to	13	Sand and gravel
13	to	15	Sand and Large gravel
15	to	20	Sand and gravel
20	to	31	Sand and large gravel
31	to	33	sand and cobbles
33	to	36	Sandy green clay and cobbles



Contract 4 - Sioux Falls, South Dakota
HDR Project No.: 01450-077-135

Construction of Well No. 107

Method used: Reverse

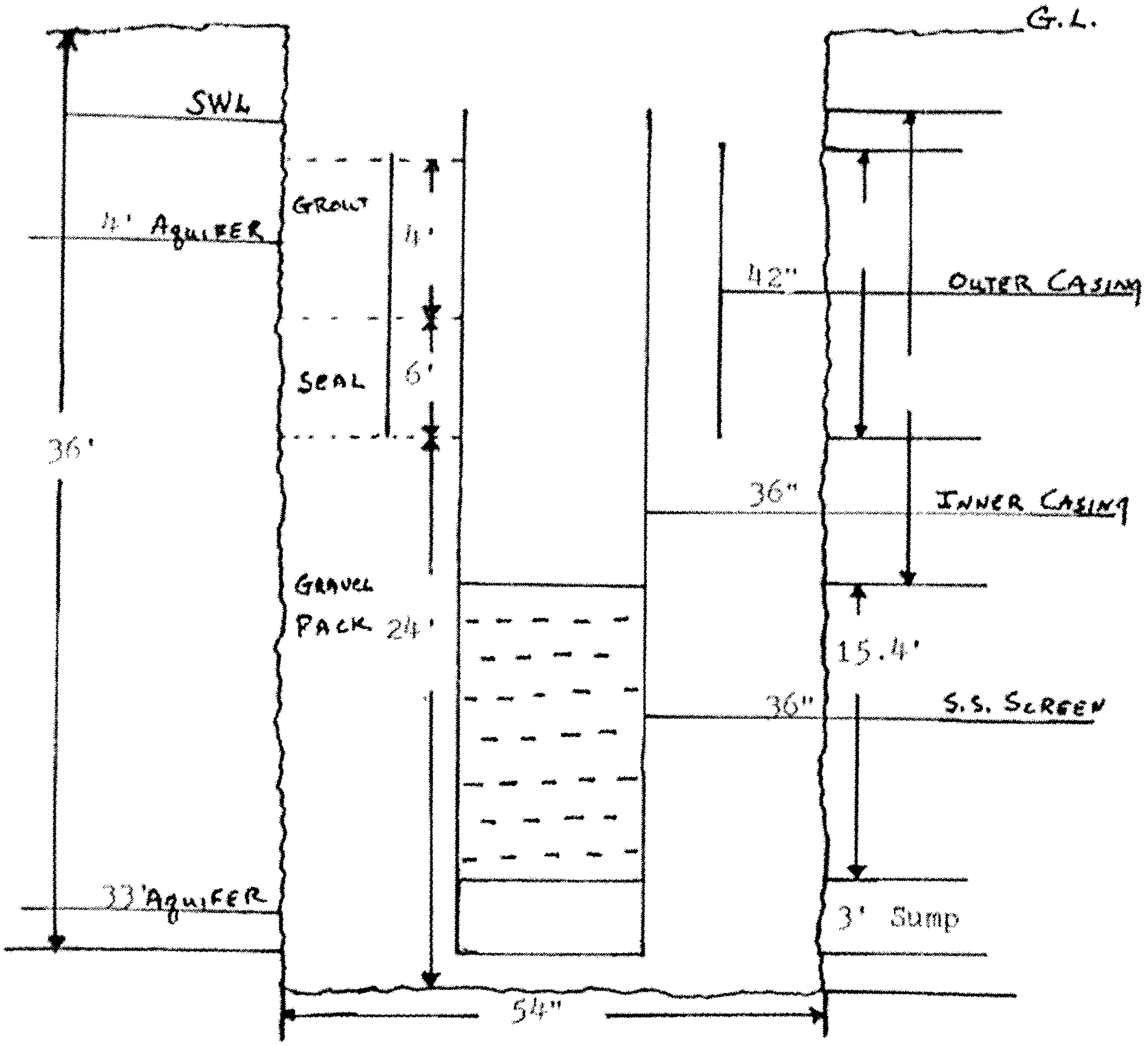
Date Started: 10/29/93

Drilling date(s): 10/30/93 10/31/93 11/1/93 11/2/93

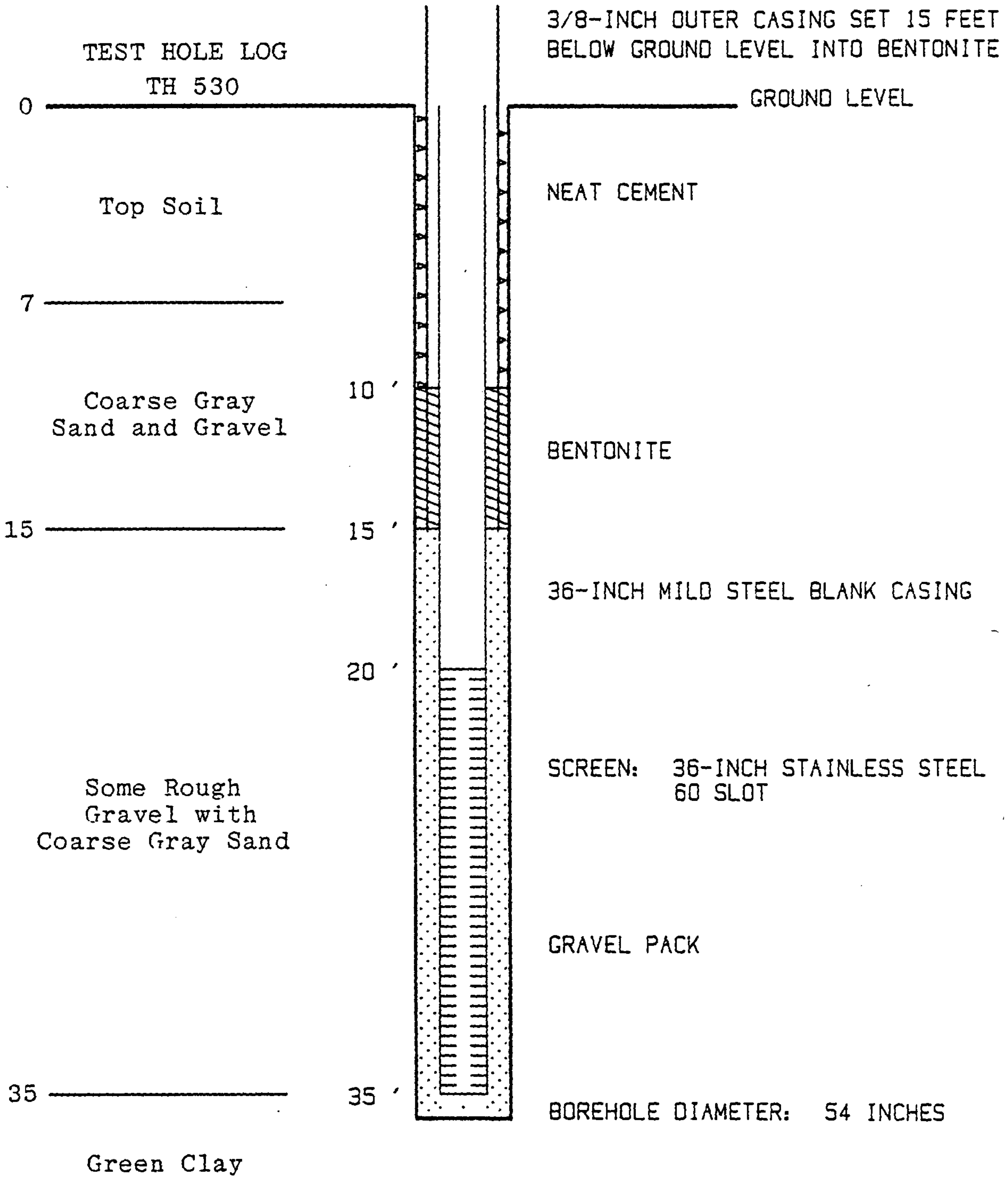
Date casing and screen installed: 11/2/93

Date cement grouted: 11/3/93 No. cu. yards: 1.5
(Cement slurry - 23 bags per cubic yard with 6 gallons H_2O weighing 15.6 # per gallons)
(Method - Hopper with tremie pipe)

Construction completion date: 11/3/93



WELL NO: 107



LAYNE GEOSCIENCES, INC.

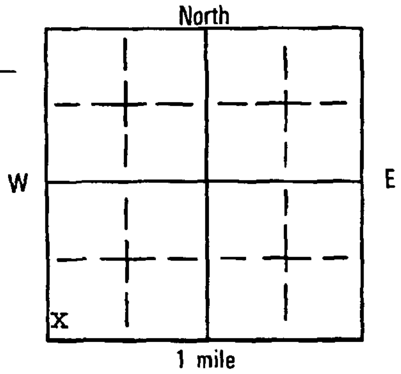
SOUTH DAKOTA WATER WELL COMPLETION REPORT

10-85

Location SW ¼ SW ¼ Sec 8 Twp 103N Rg 50W

County Minnehaha

Please mark well location with an "X"



Well Completion Date 6/19/93

PROPOSED USE:

☐ Domestic ☒ Municipal ☐ Test Holes
☐ Irrigation ☐ Industrial ☐ Stock

Method of Drilling:

Reverse Circulation Rotary

CASING DATA:

☒ Steel ☐ Plastic ☐ Other

If other describe

PIPEWEIGHT	DIAMETER	FROM	TO	HOLE DIAMETER
142 LB/FT	36 IN	16.1 FT	GL FT	54 IN
166 LB/FT	42 IN	11.5' FT	GL FT	54 IN
LB/FT	IN	FT	FT	IN
LB/FT	IN	FT	FT	IN

GROUT:

Was the well grouted? ☒ YES ☐ NO

To what depth? 6' to 2' 1.5 cu yds FEET

What is grouting material? Slurry

If cement, number of sacks? 23 bags p/cu yd

Describe grouting procedure Hopper and tremmie pipe from bottom up.

What was grout weight? 15.4 LB/GAL

SCREEN: ☐ Perforated pipe ☒ Manufactured

Diameter 36 IN Length 20.4 FEET

Material Stainless Steel

Slot Size .090 Set From 36.5 Feet To 16.1 Feet

Slot Size Set From Feet To Feet

Well Owner:

Name City of Sioux Falls

Address 1400 No. Minnesota
Sioux Falls, SD.

Well Log:

Formation	Depth From	Depth To
See Attached Log		
Well No. 109		

STATIC WATER LEVEL 1' 7" Feet

If flowing: closed in pressure PSI

GPM flow through inch

Controlled by ☐ Valve ☐ Reducers ☐ Other

If other; specify

Can well be completely shut in?

WELL TEST DATA:

☒ Pumped 16 hr step and 24 hr const

☐ Bailed Describe:

☐ Other

Pumping Level Below Land Surface

13 ft. After 4 Hrs. pumped 622

13.3 ft. After 12 Hrs. pumped 610

15.5 ft. After 24 Hrs. pumped 606

REMARKS: ALSO 2 MONITORING WELLS ON SI

DEC 1993
DIVISION OF
WATER RIGHTS
SD

Layne-Western Company, Inc.

Well Information
Omaha, Nebrask

1. Contract RICE LAKE CONTRACTING Date 6-18-93

2. City and State SIOUX FALLS, SOUTH DAKOTA Driller DAVE DEAVER

3. Well No 109 at test hole No. 109 Well location (attach map)

SW 1/4 of SW 1/4 SEC 8 TWP 103N RG 50W

4. Work completed No of man hours as charged to job on time sheet

5. MATERIAL:	LENGTH	DIA.	GAUGE OR WALL THICKNESS	MATERIAL	TYPE	NO. OF OPENINGS
6. Screen	20.4	36"	.375	SS	WR	.09
7. Inner Casing	24.1	36"	.375	BLACK	BLANK	
8. Outer Casing	21.5	42"	.375	BLACK	BLANK	

9. 12 tons of gravel used in the well. Size 1/4 x 10 NORTHERN

10. Test of well. Did you use test or permanent pump? Size of Bowl Stages

11. Size of orifice inch by inch. Orifice tube reading inches.

12. Pumping test — measurements from ground level:

TIME	G.P.M.	STATIC	DRAWDOWN	PUMPING LEVEL

DEC 1993
DIVISION OF
WATER RIGHTS
Pierre, SD.

13. Recovery in 5 minutes , in 30 minutes

14. Did you seal bottom of well? YES Thickness .375 inches, material 55

15. Well underreamed? NO From feet to feet, feet to feet.

16. If all screen was not placed at bottom, state how it was spaced.

From feet to feet; from feet to feet; from feet to feet.

17. Depth of well from ground level to top of plug 36.5 Size of drilled hole 54"

18. Was cement placed around or between any of the casings? YES

19. If so, state where, how much and method used. 1.5 YARDS - TREMMIE 6' to 2'

Layne-Western Company, Inc. **Well Information** Page 2

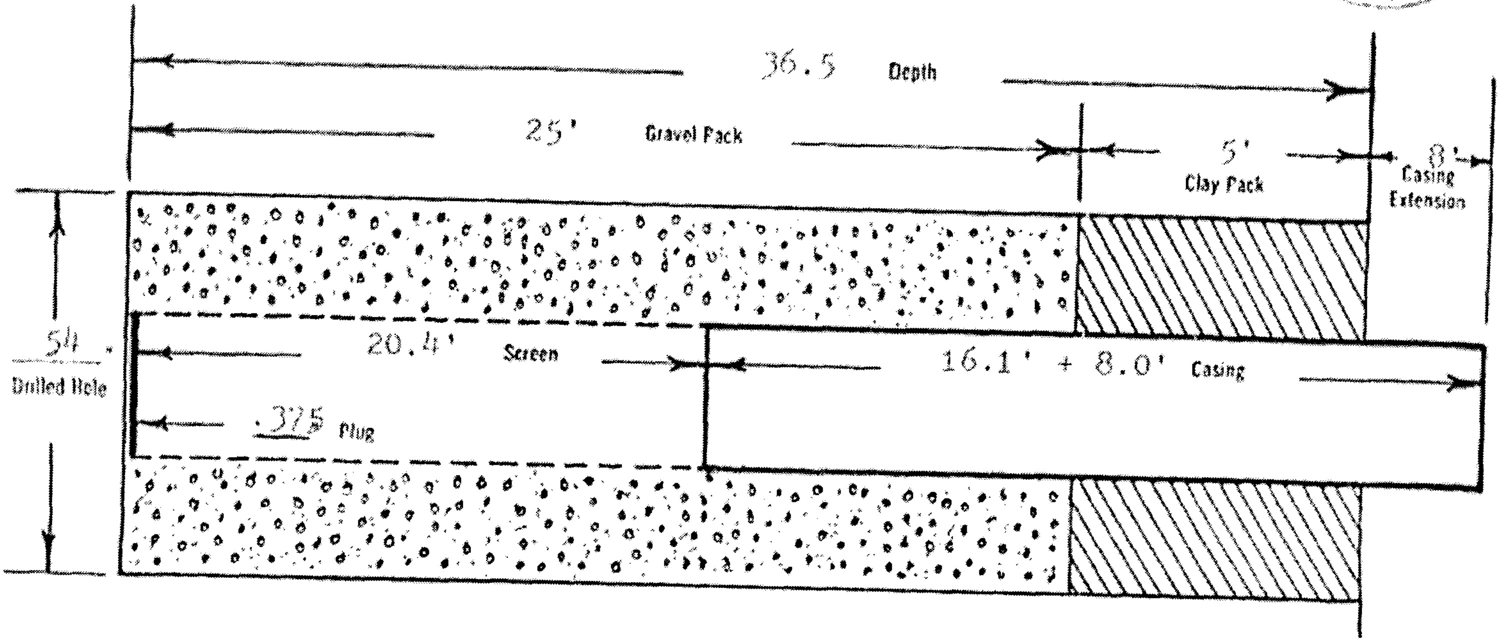
Omaha, Nebraska

CONTRACT Rice Lake Contracting

Well No. 109

Log of well from ground level:

Feet		Feet	Formation
	to		
0	to	2	Topsoil
2	to	5	Sandy brown clay
5	to	34	Brown sand and gravel
34	to	36.5	Gravel with large rock
36.5	to	37	Sandy green clay
	to		
	to		
	to		
	to		
	to		
	to		
	to		
	to		
	to		
	to		



Contract 4 - Sioux Falls, South Dakota
HDR Project No.: 01450-077-135

Construction of Well No. 109

Method used: REVERSE

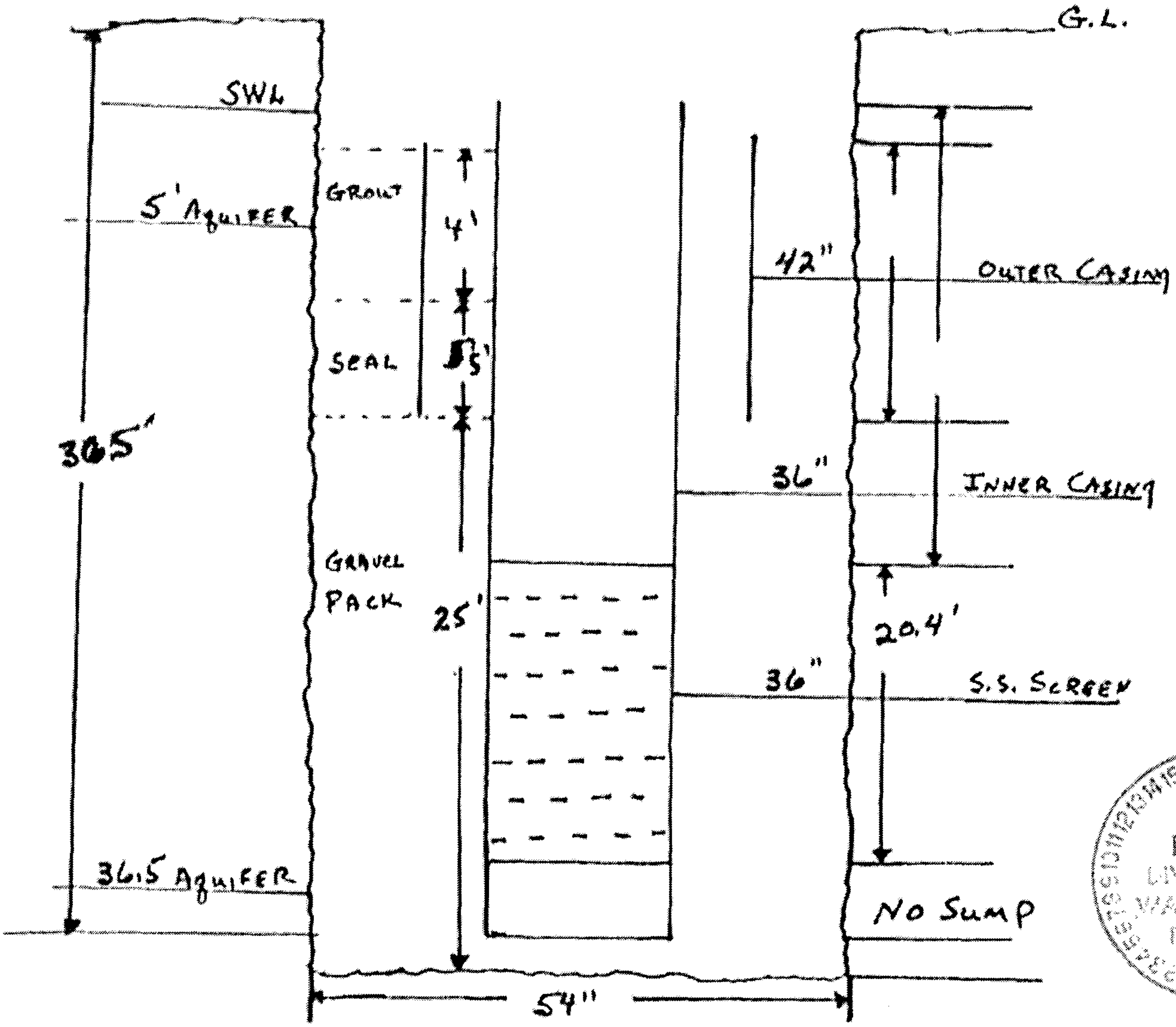
Date Started: 6-15-93

Drilling date(s): 6-16-93 6-17-93

Date casing and screen installed: 6-18-93

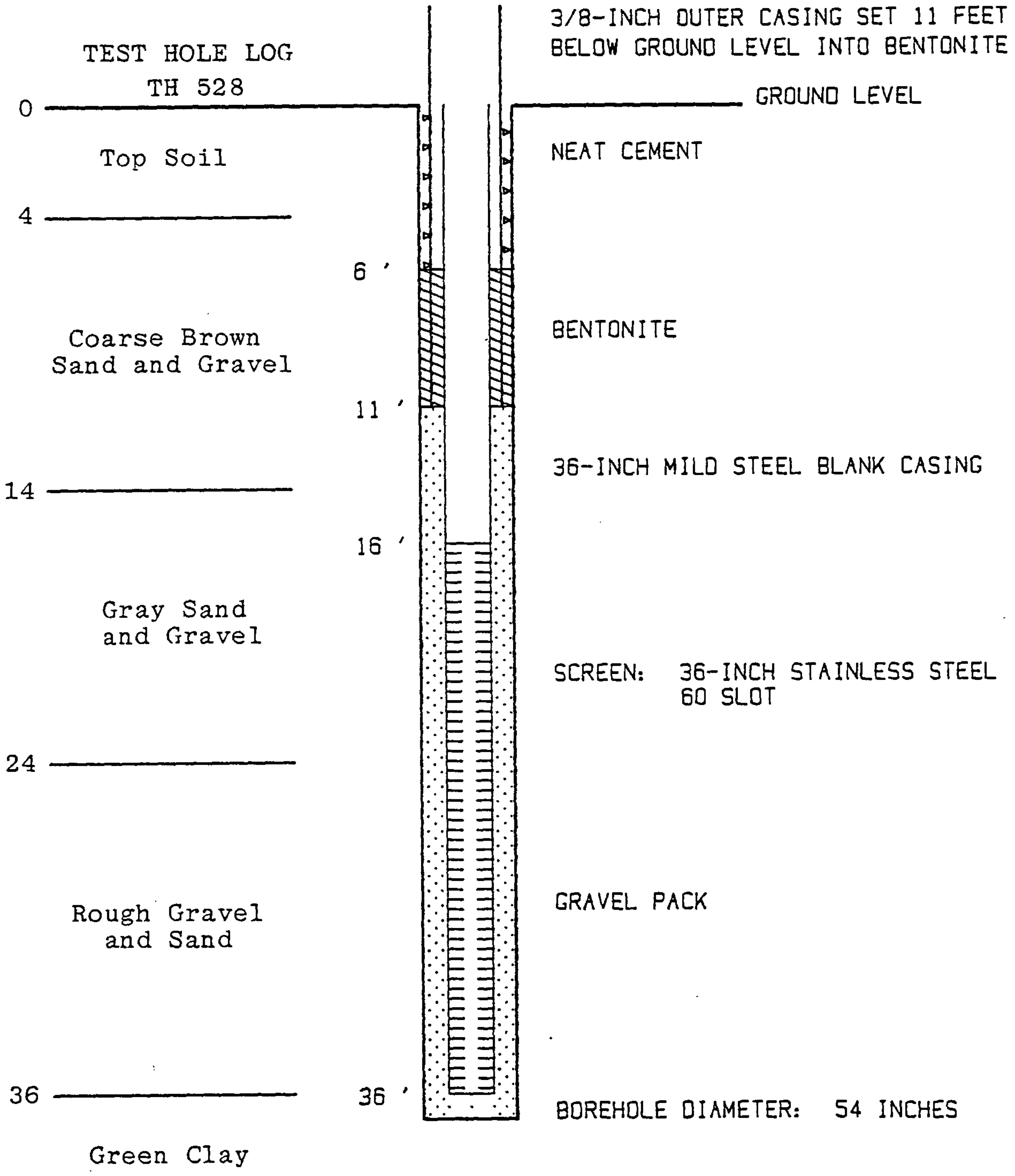
Date cement grouted: 6-19-93 No. cu. yards: 1 ½
(Cement slurry - 23 bags per cubic yard with 6 gallons H_2O weighing 15.6 # per gallons)
(Method - Hopper with tremie pipe)

Construction completion date: 6-19-93



Layne

WELL NO: 109



LAYNE GEOSCIENCES, INC.

2923-3

NOTICE OF WELL CONSTRUCTION

(1) WELL CONSTRUCTION SE 40 ac N ¼

Location of well ~~SW~~ 1/4 NW 1/4 SW ¼ Section 7 Township 103 Range 50-W

Well owner Wayne Tellinghuisen (Name) Lyon, South Dakota (Address)

Date well drilling completed 11-26-76 Purpose of well Irrigation (domestic, irrigation, municipal, industrial, other)

WELL LOG

Layers, from - to (top in feet)	Description of layer
0-2	Topsoil
2-4	yellow clay
4-7	brown sand
7-11	Gravel w/silt
11-21	Fine gray sand
21-36'8"	Good gravel

Attach sheet if more space is needed

Depth to top of water producing aquifer 6 ft.

Depth to static water level 6' ft.

Name of producing aquifer (if known) ____

Total depth of drill hole 36'8" ft.

Depth to bottom of casing 36'8" ft.

Casing information: in the space below show kind, size, weight, lengths per diameter, etc., for production casing and surface casing, if used.

27' x 14", 1/4" steel casing

Screen information: in the space below show length of screen below bottom of casing, diameter and kind of screen or casing perforations.

10' x 14" x CEC Johnson

If a flowing well, flow of completed well ____ G.P.M.

Ed H. Losey & Sons
Name of Drilling Contractor

(2) PUMP INSTALLATION

Company name and size of pump ____ HP ____

Type of pump ____ Capacity of installed pump ____ G.P.M.

Depth of pump placement ____ ft., Date of pump installation ____

(3) WATER SURFACE MEASURING TUBE

Irrigation wells an air-tight water surface measuring tube is required: See Section 46.408 of Chapter 46.4, MINIMUM WELL CONSTRUCTION STANDARDS.

Show total vertical length of water surface measuring tube, when installed ____ ft, tube diameter ____, tube material ____.

Name of Pump Installation Contractor

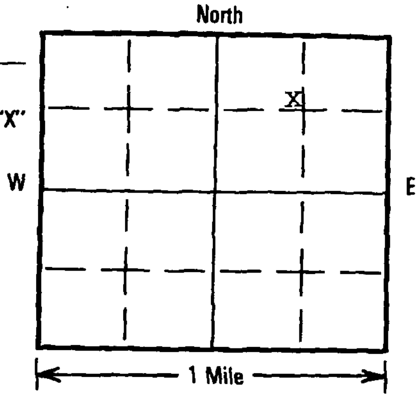
SOUTH DAKOTA WATER WELL COMPLETION REPORT

07-92

Location NW ¼ NE ¼ Sec 7 Twp 103N Rg 50W

County
Minnehaha

Please mark well location with an "X"



Well Completion Date 11/11/93

Well Owner: City of Sioux Falls

Business Name:

Address: 1400 No. Minnesota
Sioux Falls, SD.

WELL LOG:

FORMATION	DEPTH FROM	TO
See Attached Log		
Well No. 111		

LOCATION:

Distance from nearest potential pollution source (septic tank, abandoned well, feed lot, etc.)? ______ ft. from ______ (identify source).

PROPOSED USE:

☐ Domestic/Stock ☒ Municipal ☐ Business ☐ Test Holes
☐ Irrigation ☐ Industrial ☐ Institutional ☐ Monitoring well

METHOD OF DRILLING:

Reverse Circulation Rotary

CASING DATA:

☒ Steel ☐ Plastic ☐ Other

If other describe

PIPEWEIGHT	DIAMETER	FROM	TO	HOLE DIAMETER
118 LB/FT	30 IN	14.5 FT	GL FT	42 IN
142 LB/FT	36 IN	11.5 FT	GL FT	42 IN
LB/FT	IN	FT	FT	IN

GROUTING DATA

Grout Type	No. of Sacks	Grout Weight	From	To
1Slurry	23p/cuyd	15.4 lb./gal	5.5 ft	1.5 ft
		lb./gal	ft	ft

Describe grouting procedure Hopper and tremmie pipe from bottom up.

SCREEN: ☐ Perforated pipe ☒ Manufactured

Diameter 30 IN Length 10.4 FEET

Material Stainless Steel

Slot Size .090 Set From 24.9 Feet to 14.5 Feet

Other information

STATIC WATER LEVEL 2.61

If flowing: closed in pressure

GPM flow ______ through ______ inch

Controlled by ☐ Valve ☐ Reducers ☐ Other

Reduced Flowrate

Can well be completely shut in?

WELL TEST DATA:

☒ Pumped Describe: 16 hr step and 24
☐ Bailed constant
☐ Other

Pumping Level Below Land Surface

10.21 ft. After 4 Hrs. pumped 357

11.78 ft. After 14 Hrs. pumped 354

If pump installed, pump rate

REMARKS ALSO 2 MONITORING WELLS ON

Layne-Western Company, Inc.

Well Information

Omaha, Nebraska

1. Contract Rice Lake Contracting, Inc. Date 11/10/93

2. City and State Sioux Falls, SD. Driller Dave Deaver

3. Well No. 111 at test hole No. 111 Well location (attach map)
NW 1/4 of NE 1/4 SEC 7 TWP 103N RG 50W

4. Work completed No of man hours as charged to job on time sheet

5. MATERIAL:

	LENGTH	DIA.	GAUGE OR WALL THICKNESS	MATERIAL	TYPE	NO. OF OPENINGS
6. Screen	10.4'	30"	.375	SS	WR	.090
7. Inner Casing	14.5'	30"	.375	Black	Blank	
8. Outer Casing	19"	36"	.375	Black	Blank	

9. 8 tons of gravel used in the well. Size 1/4 x 10 Northern Gravel Company

10. Test of well. Did you use test or permanent pump? Size of Bowl Stages

11. Size of orifice inch by inch. Orifice tube reading inches.

12. Pumping test — measurements from ground level:

TIME	G.P.M.	STATIC	DRAWDOWN	PUMPING LEVEL

13. Recovery in 5 minutes , in 30 minutes

14. Did you seal bottom of well? Yes . Thickness .375 inches, material Black

15. Well underreamed? No From feet to feet, feet to feet.

16. If all screen was not placed at bottom, state how it was spaced.
From 24.9 feet to 14.5 feet; from feet to feet; from feet to feet.

17. Depth of well from ground level to top of plug 28' Size of drilled hole 42"

18. Was cement placed around or between any of the casings? Yes

19. If so, state where, how much and method used. 5.5' to 1.5' 1.25 cu yds Tremmied

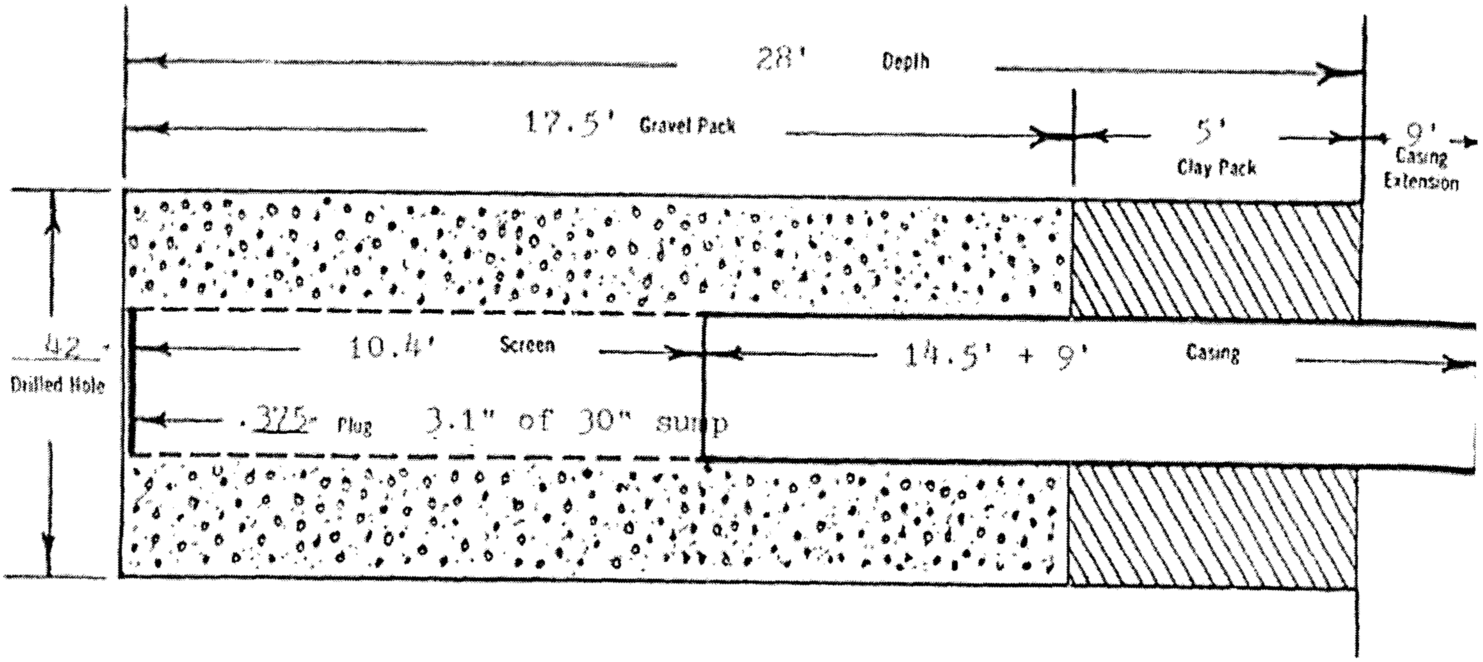
Layne-Western Company, Inc. **Well Information** Omaha, Nebraska

CONTRACT Rice Lake Contracting, Inc.

Well No. 111

Log of well from ground level:

Feet		Feet	Formation
0	to	3	Top soil and clay
3	to	6	Sand and gravel
6	to	7	Sandy green clay
7	to	22	Sand and gravel
22	to	24.5	Sand, gravel, cobbles and boulders
24.5	to	28	Sandy green clay with cobbles



Contract 4 - Sioux Falls, South Dakota
HDR Project No.: 01450-077-135

Construction of Well No. 111

Method used: Reverse

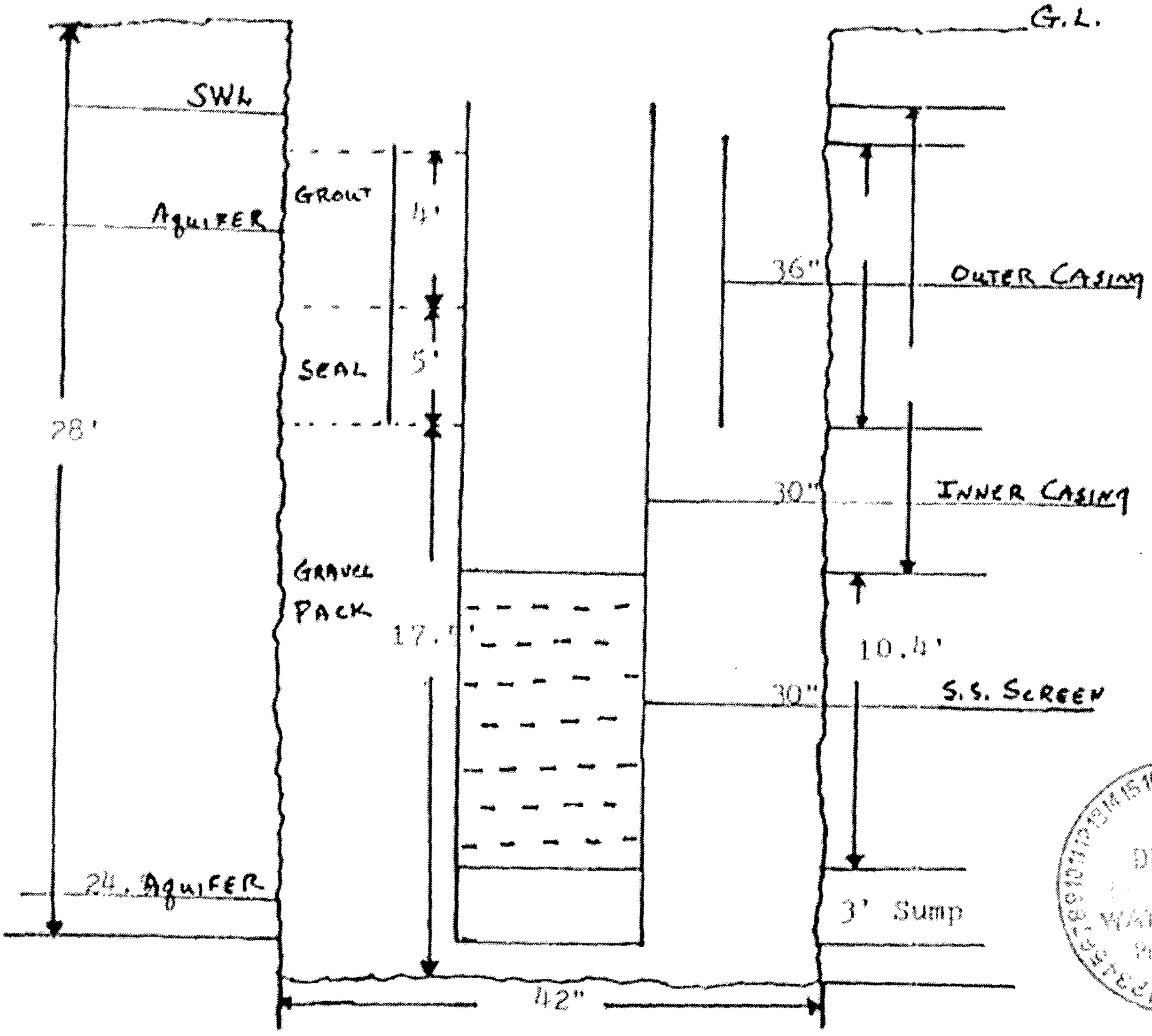
Date Started: 11/3/93

Drilling date(s): 11/4/93 11/8/93 11/9/93

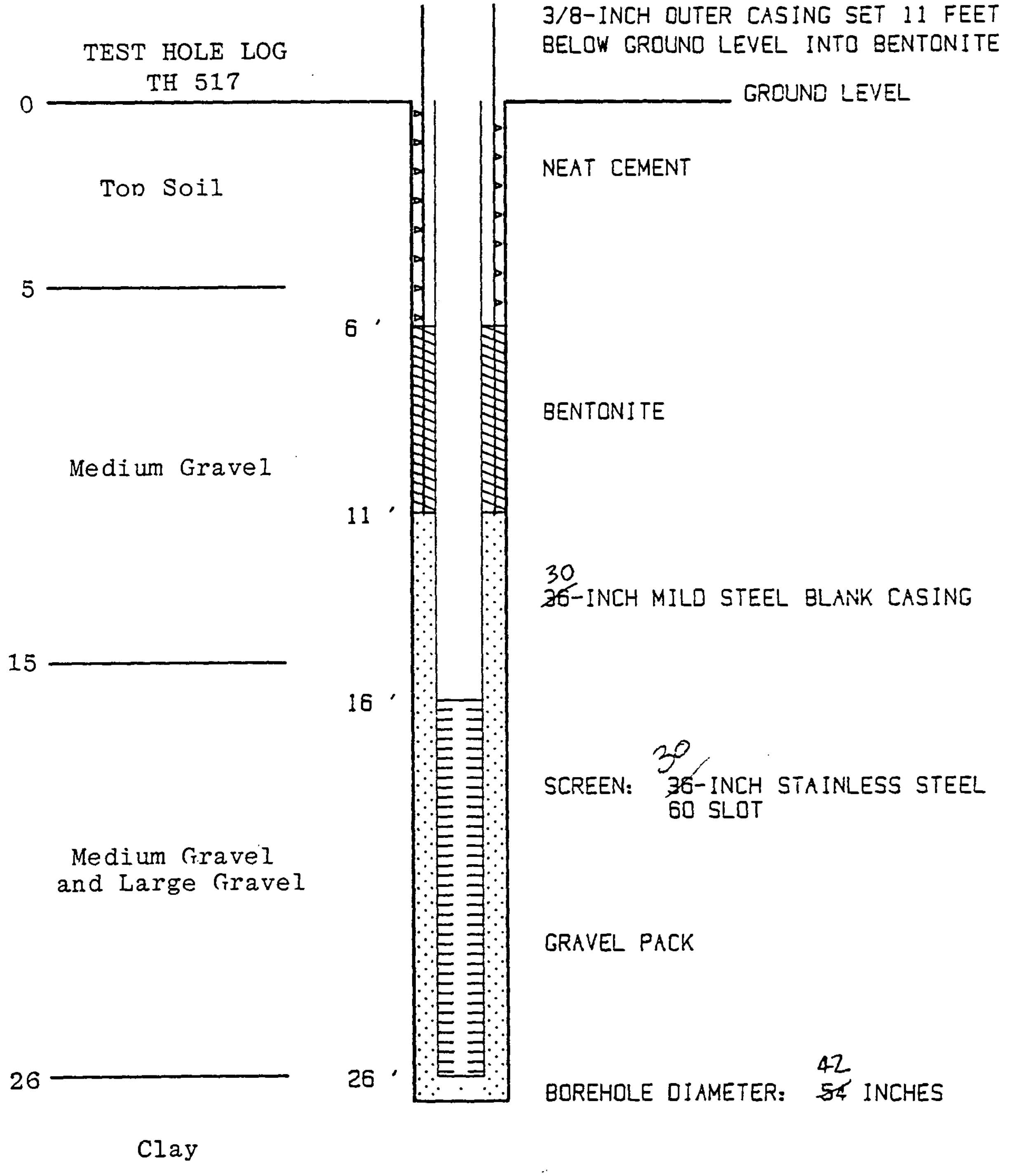
Date casing and screen installed: 11/10/93

Date cement grouted: 11/11/93 No. cu. yards: 1.25
(Cement slurry - 23 bags per cubic yard with 6 gallons H_2O weighing 15.6 # per gallons)
(Method - Hopper with tremie pipe)

Construction completion date: 11/11/93



WELL NO: 111


TEST HOLE LOG
TH 517
0
Top Soil
5
Medium Gravel
15
Medium Gravel and Large Gravel
26
Clay
6 ′
11 ′
16 ′
26 ′
3/8-INCH OUTER CASING SET 11 FEET BELOW GROUND LEVEL INTO BENTONITE
GROUND LEVEL
NEAT CEMENT
BENTONITE
~~36~~ 30-INCH MILD STEEL BLANK CASING
SCREEN: ~~36~~ 30-INCH STAINLESS STEEL 60 SLOT
GRAVEL PACK
BOREHOLE DIAMETER: ~~54~~ 42 INCHES

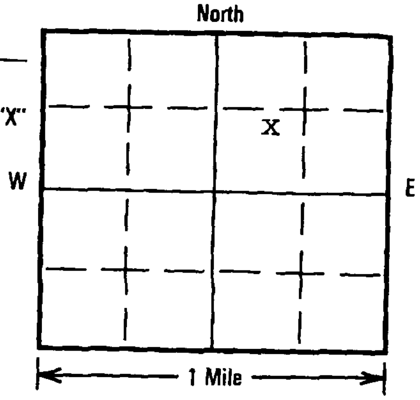
SOUTH DAKOTA WATER WELL COMPLETION REPORT

07-92

Location SW ¼ NE ¼ Sec 6 Twp 103N Rg 50W

County
Minnehaha

Please mark well location with an "X"



Well Completion Date 10/29/93

Well Owner: City of Sioux Falls
Business Name:
Address: 1400 No. Minnesota
Sioux Falls, SD.

WELL LOG:

FORMATION	DEPTH FROM	DEPTH TO
See Attached Log		
Well No. 112		

LOCATION:
Distance from nearest potential pollution source (septic tank, abandoned well, feed lot, etc.)? ____ ft. from ____ (identify source).

PROPOSED USE:
☐ Domestic/Stock ☒ Municipal ☐ Business ☐ Test Holes
☐ Irrigation ☐ Industrial ☐ Institutional ☐ Monitoring well

METHOD OF DRILLING:
Reverse Circulation Rotary

CASING DATA:
☒ Steel ☐ Plastic ☐ Other
If other describe

PIPEWEIGHT	DIAMETER	FROM	TO	HOLE DIAMETER
118 LB/FT	30 IN	21.9 FT	GL FT	54 IN
142 LB/FT	36 IN	14.2 FT	GL FT	54 IN
LB/FT	IN	FT	FT	IN

GROUTING DATA

Grout Type	No. of Sacks	Grout Weight	From	To
Slurry	23p/cuyd	15.6 lb./gal	9.2 ft	4.2 ft
		lb./gal	ft	ft

Describe grouting procedure Hopper and tremmie pipe from bottom up.

SCREEN: ☐ Perforated pipe ☒ Manufactured
Diameter 30 IN Length 20.3 FEET
Material Stainless Steel
Slot Size .080 Set From 42.2 Feet to 21.9 Feet
Other information

STATIC WATER LEVEL 2.98'
If flowing: closed in pressure
GPM flow ____ through ____ inch
Controlled by ☐ Valve ☐ Reducers ☐ Other
Reduced Flowrate
Can well be completely shut in?

WELL TEST DATA:
☒ Pumped Describe: 16 hr step and 24 hr constant
☐ Bailed
☐ Other

Pumping Level Below Land Surface
9.32 ft. After 4 Hrs. pumped 715
10.40 ft. After 24 Hrs. pumped 715
If pump installed, pump rate

REMARKS ALSO 2 MONITORING WELLS ON SITE

11 12 13 14 15 16 17 18 19 20 21 22 23
DEC 1993

Layne-Western Company, Inc.

Well Information

Omaha, Nebraska

1. Contract Rice Lake Contracting, Inc. Date 10/28/93

2. City and State Sious Falls, SD Driller Dave Deaver

3. Well No. 112 at test hole No. 112 Well location (attach map)

NE 1/4 SEC 6 TWP 103N RG 50W

4. Work completed .... No of man hours as charged to job on time sheet ....

5. MATERIAL:	LENGTH	DIA.	GAUGE OR WALL THICKNESS	MATERIAL	TYPE	NO. OF OPENINGS
6. Screen	20.3'	30"	.375	SS	WR	.080
7. Inner Casing	21.9"	30"	.375	Black	Blank	
8. Outer Casing	14.2'	36"	.375	Black	Blank	

9. 20 tons of gravel used in the well. Size No. 3 Northern Gravel Company

10. Test of well. Did you use test or permanent pump? .... Size of Bowl .... Stages

11. Size of orifice .... inch by .... inch. Orifice tube reading .... inches.

12. Pumping test -- measurements from ground level:

TIME	G.P.M.	STATIC	DRAWDOWN	PUMPING LEVEL

DEC 1993
DIVISION OF
WATER RIGHTS
Pierre, SD

13. Recovery in 5 minutes ...., in 30 minutes ....

14. Did you seal bottom of well? Yes Thickness .375 inches, material Black

15. Well underreamed? No From .... feet to .... feet, ... feet to .... feet.

16. If all screen was not placed at bottom, state how it was spaced.

From 42.2 feet to 21.9 feet; from .... feet to .... feet; from .... feet to .... feet.

17. Depth of well from ground level to top of plug 45' Size of drilled hole 54"

18. Was cement placed around or between any of the casings? Yes

19. If so, state where, how much and method used. 9.2' to 4.2' 2 cu yds Tremmied

Layne-Western Company, Inc. Well Information

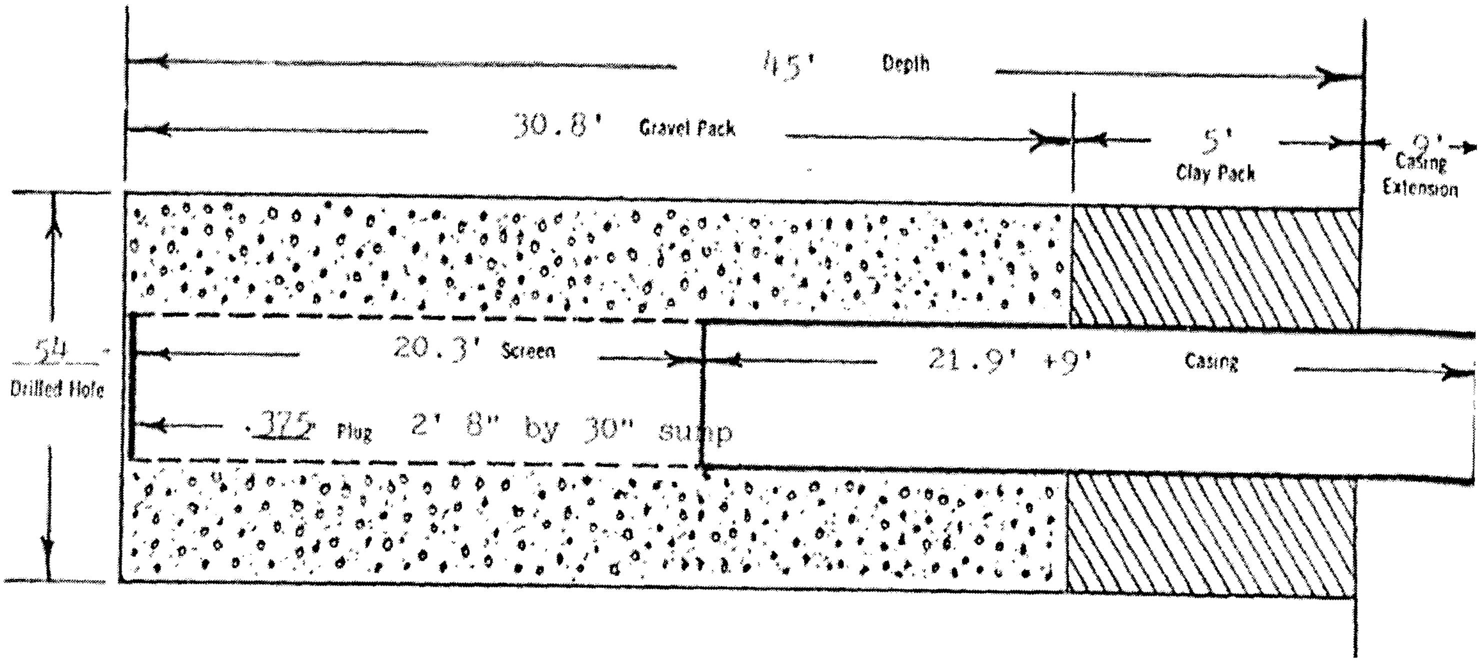
Omaha, Nebraska

CONTRACT Rice Lake Contracting, Inc.

Well No. 112

Log of well from ground level:

Feet		Feet	Formation
0	to	3	Top soil and Clay
3	to	15	Sand and gravel
15	to	19	Sand, gravel and cobbles
19	to	35	Sand and gravel
35	to	41.5	Sand, large gravel and cobbles
41.5	to	45	Sandy green clay and cobbles



Contract 4 - Sioux Falls, South Dakota
HDR Project No.: 01450-077-135

Construction of Well No. 112

Method used: Reverse

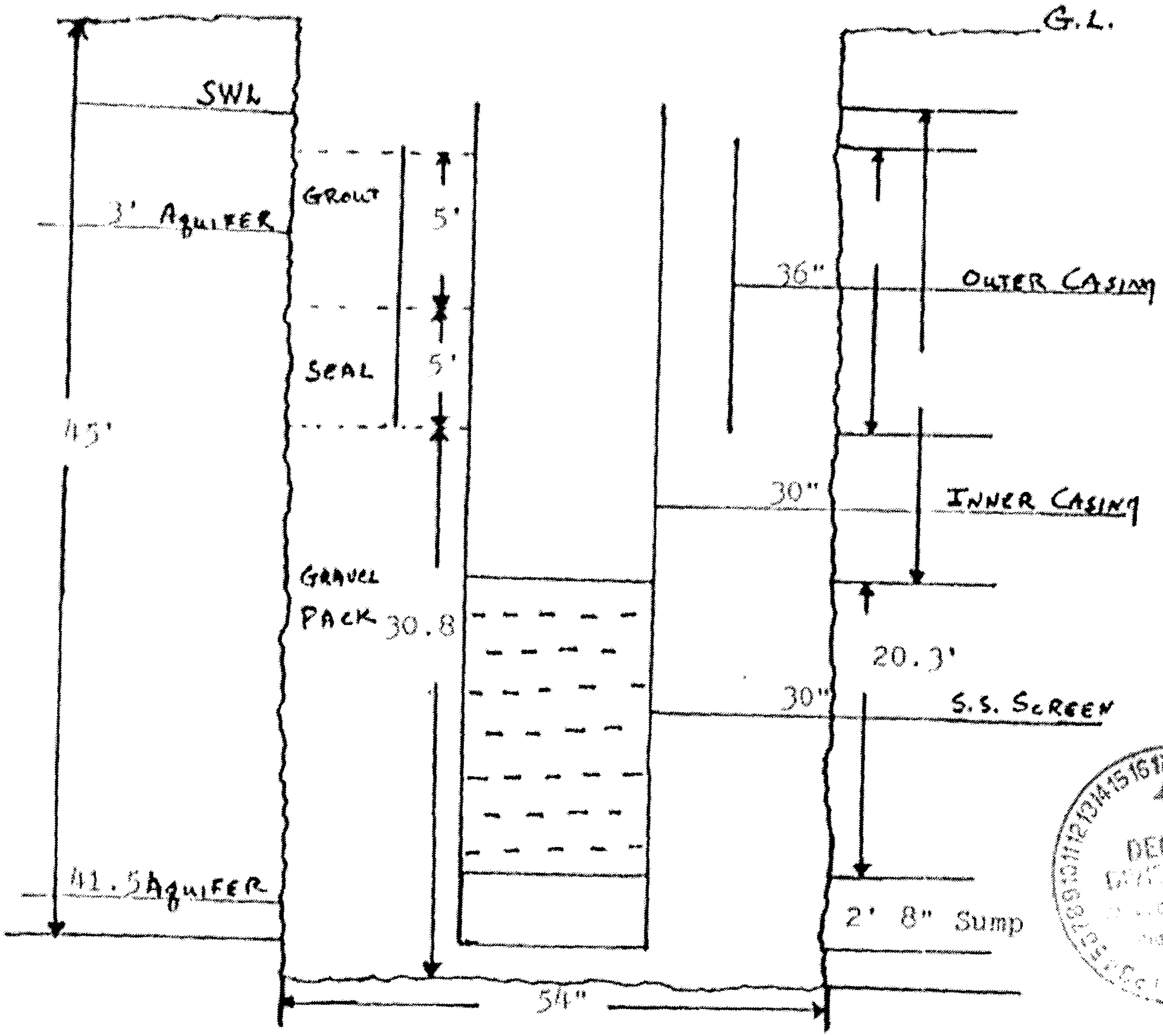
Date Started: 10/24/93

Drilling date(s): 10/25/93 10/26/93 10/27/93

Date casing and screen installed: 10/28/93

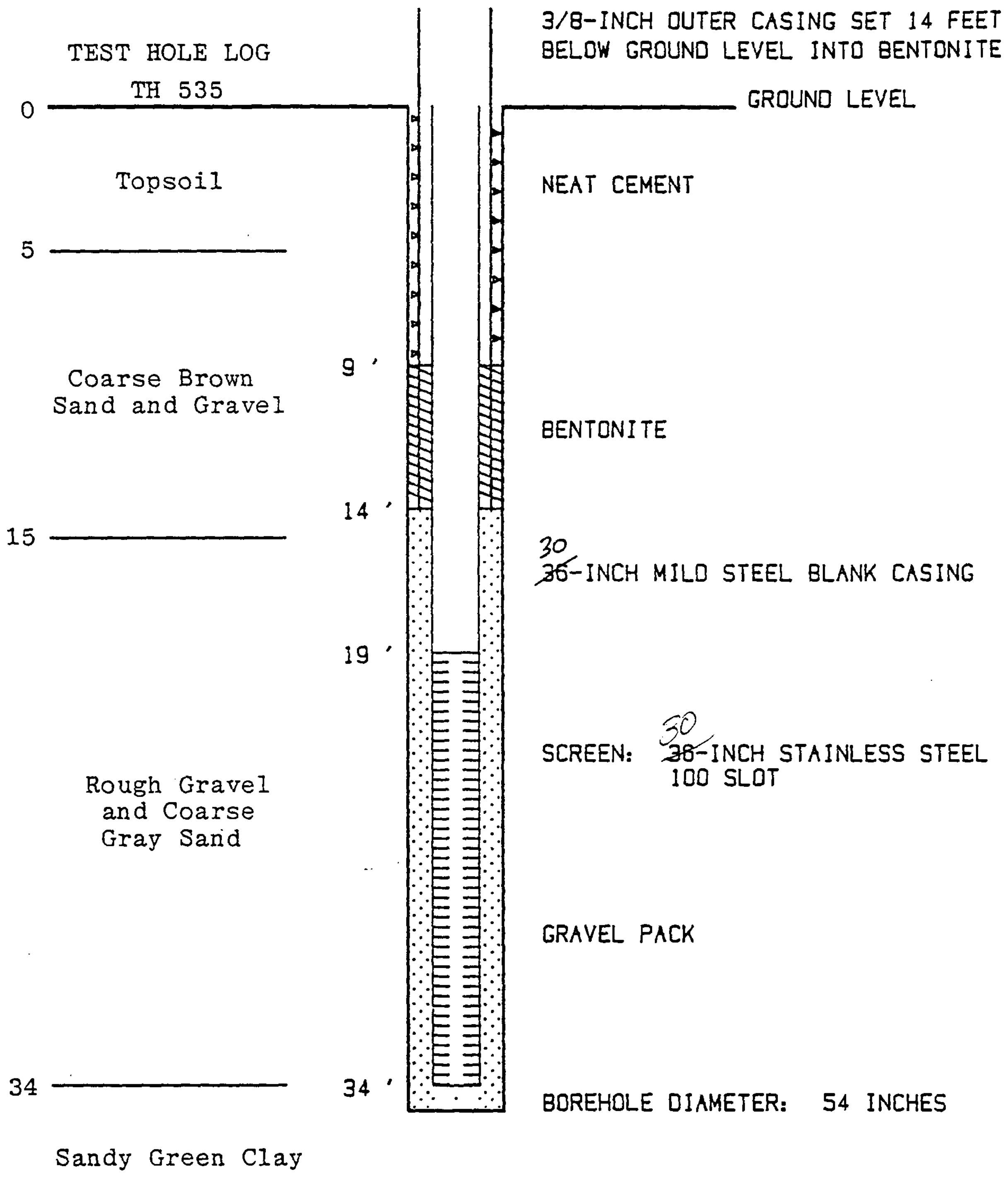
Date cement grouted: 10/29/92 No. cu. yards: 2
(Cement slurry - 23 bags per cubic yard with 6 gallons H_2O weighing 15.6 # per gallons)
(Method - Hopper with tremie pipe)

Construction completion date: 10/29/93



layne

WELL NO: 112



LAYNE GEOSCIENCES, INC.

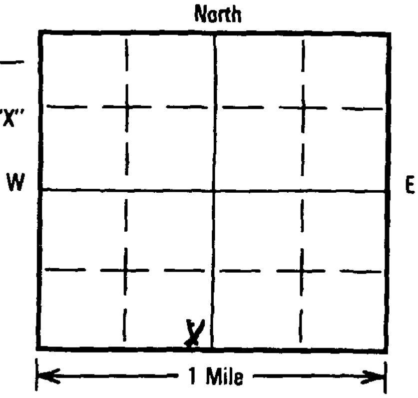
SOUTH DAKOTA WATER WELL COMPLETION REPORT

07-92

Location SEcor ¼ SW ¼ Sec 31 Twp 104N Rg 50W

County
Minnehaha

Please mark well location with an "X"



Well Completion Date 3-20-93

Well Owner: City of Sioux Falls

Business Name:

Address: 1400 No. Minnesota
Sioux Falls SD 57102

WELL LOG:

FORMATION	DEPTH FROM	DEPTH TO
See Attached Log		
Well #113		

APR 1993
DIVISION OF WATER RIGHTS
PIERRE, SD

LOCATION:
Distance from nearest potential pollution source (septic tank, abandoned well, feed lot, etc.)? ______ ft. from ______ (identify source).

PROPOSED USE:
☐ Domestic/Stock ☒ Municipal ☐ Business ☐ Test Holes
☐ Irrigation ☐ Industrial ☐ Institutional ☐ Monitoring well

METHOD OF DRILLING:

Reverse Rotary

CASING DATA:
☒ Steel ☐ Plastic ☐ Other
If other describe

PIPEWEIGHT	DIAMETER	FROM	TO	HOLE DIAMETER
142 LB/FT	36 IN	212 FT	GL FT	54 IN
167 LB/FT	42 IN	16 FT	GL FT	54 IN
LB/FT	IN	FT	FT	IN

GROUTING DATA

Grout Type	No. of Sacks	Grout Weight	From	To
Slurry	23	lb./gal	ft.	ft
		lb./gal	ft.	ft

Describe grouting procedure 1 cu yd - 23 bags/yd w/ 6gal H2O/bag. TREMIED IN ON top of Bentonite SEAl Just Above gRAvel PACK

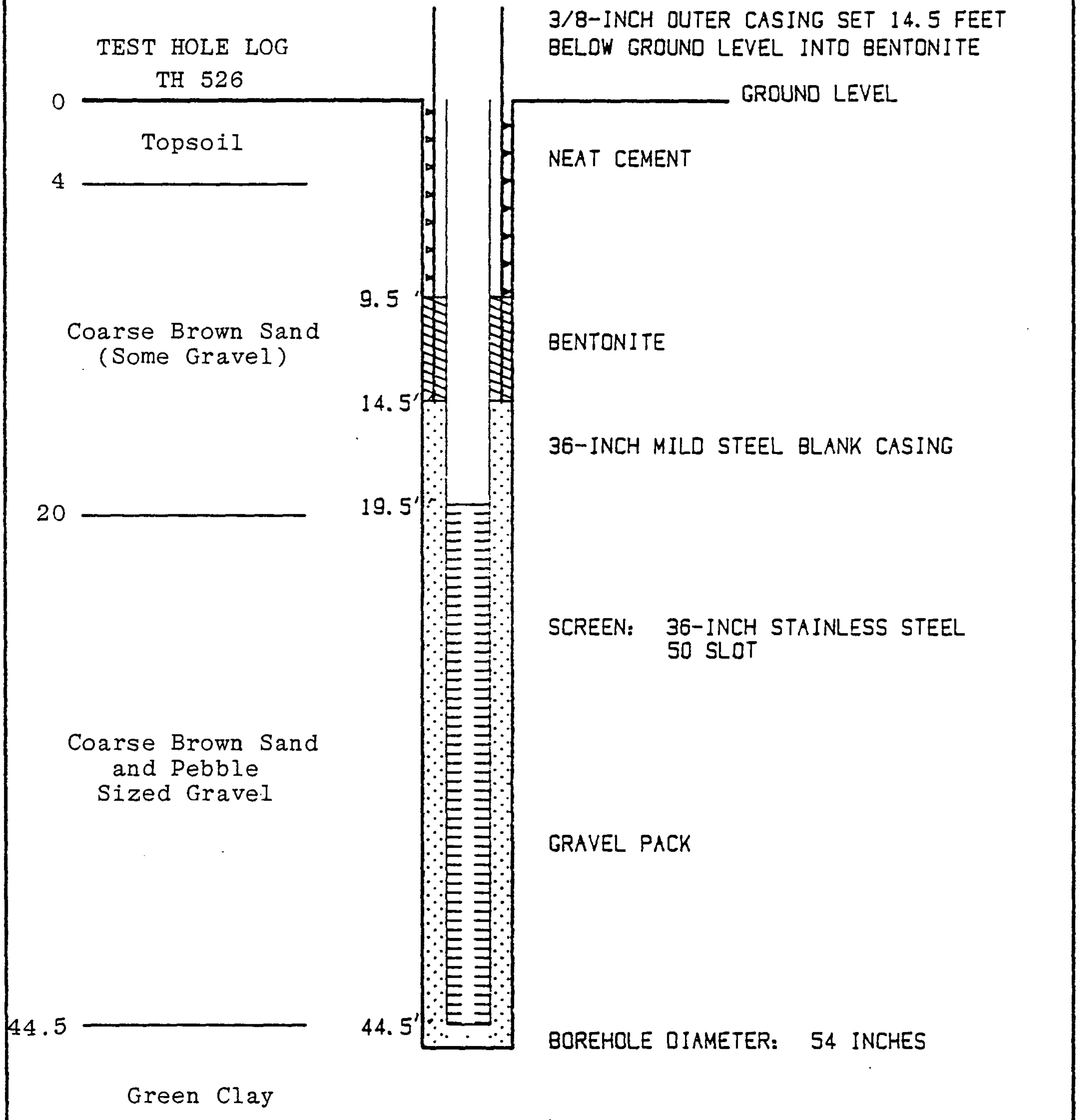
SCREEN: ☐ Perforated pipe ☒ Manufactured
Diameter 36 IN Length 25.8 FEET
Material 304 STAINless STEEL
Slot Size .035 Set From 47 Feet to 212 Feet
Other information

STATIC WATER LEVEL 3.5
If flowing: closed in pressure
GPM flow ______ through ______ inch
Controlled by ☐ Valve ☐ Reducers ☐ Other
Reduced Flowrate
Can well be completely shut in?

WELL TEST DATA:
☐ Pumped Describe:
☐ Bailed
☐ Other
Pumping Level Below Land Surface
______ ft. After ______ Hrs. pumped
______ ft. After ______ Hrs. pumped
If pump installed, pump rate

REMARKS
Test Pumping Data When Complete
ALSO 1 MONITORING

WELL NO: 113



LAYNE GEOSCIENCES, INC.

Layne-Western Company, Inc.

Well Information

Omaha, Nebraska

1. Contract RICE LAKE CONTRACTING Date 3-20-93

2. City and State SIOUX FALLS, SOUTH DAKOTA Driller DAVID DEAVER

3. Well No. 113 at test hole No. Well location (attach map)

4. Work completed . No of man hours as charged to job on time sheet

5. MATERIAL:

	LENGTH	DIA.	GAUGE OR WALL THICKNESS	MATERIAL	TYPE	NO. OF OPENINGS
6. Screen	25.8	36"	.375	S.S.	WIRE WRAP	.035
7. Inner Casing	28	36"	.375	BLACK	BLANK	
8. Outer Casing	23	42"	.375	BLACK	BLANK	

9. 22 tons of gravel used in the well. Size COARSE O NORTHERN

10. Test of well. Did you use test or permanent pump? Size of Bowl Stages

11. Size of orifice inch by inch. Orifice tube reading inches.

12. Pumping test — measurements from ground level:

TIME	G.P.M.	STATIC	DRAWDOWN	PUMPING LEVEL

13. Recovery in 5 minutes , in 30 minutes

14. Did you seal bottom of well? YES Thickness .375 inches, material S.S.

15. Well underreamed? NO From feet to feet, feet to feet.

16. If all screen was not placed at bottom, state how it was spaced.

From 47 feet to 21.2 feet; from feet to feet; from feet to feet.

17. Depth of well from ground level to top of plug 47' Size of drilled hole 54'

18. Was cement placed around or between any of the casings? AROUND

19. If so, state where, how much and method used. 1 YARD TREMMIE

Layne-Western Company, Inc. **Well Information** Page 2

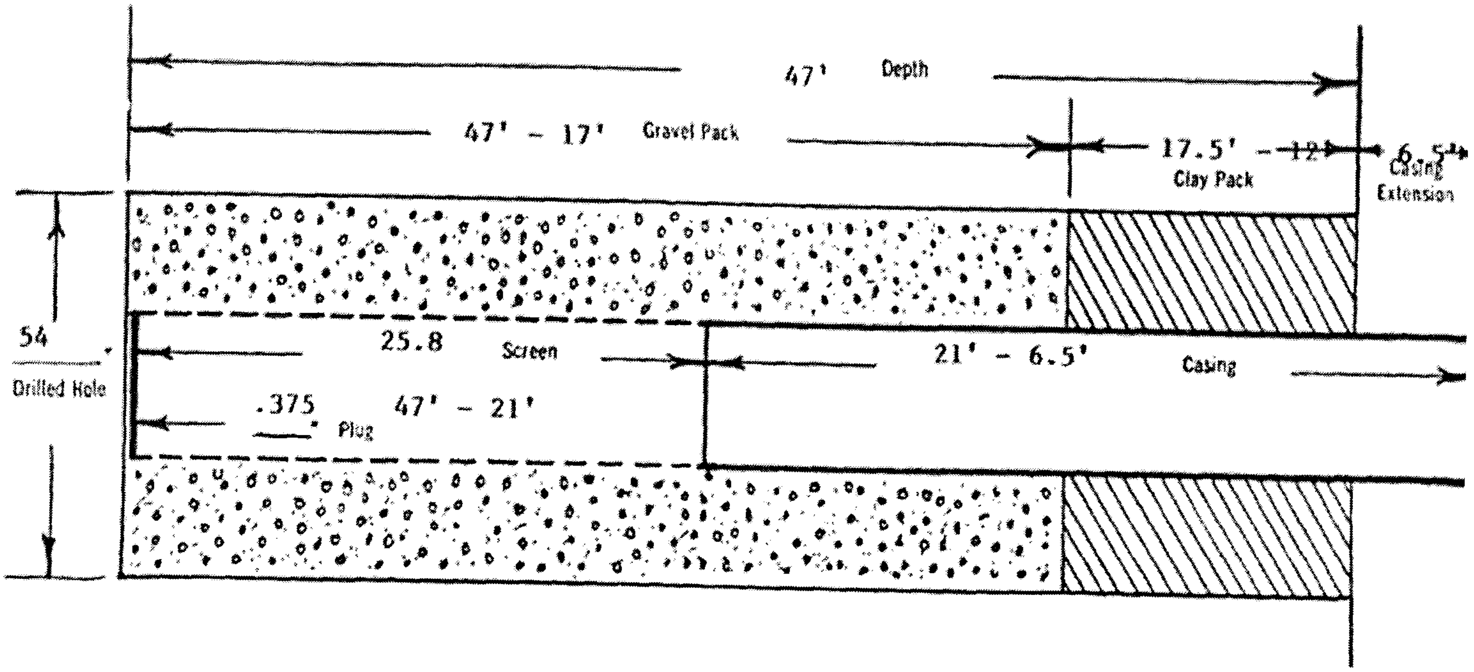
Omaha, Nebraska

CONTRACT RICE LAKE CONTRACT--SIOUX FALLS SD

Well No. 113

Log of well from ground level:

Feet		Feet	Formation
0	to	2	TOP SOIL
2	to	5	SAND BROWN CLAY
5	to	10	MEDIUM GRAVEL W/SAND
10	to	15	MEDIUM GRAVEL W/SAND
15	to	20	MEDIUM GRAVEL W/SAND
20	to	22	LARGE GRAVEL W/SAND
22	to	47	GRAVEL W/SAND
47	to	48	SANDY GREEN CLAY
	to		
	to		
	to		
	to		
	to		
	to		
	to		
	to		



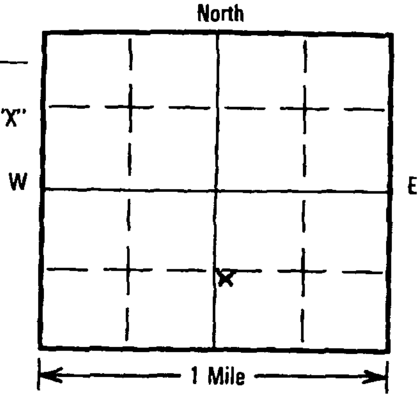
SOUTH DAKOTA WATER WELL COMPLETION REPORT

07-92

Location ½ mi N½ SE ¼ Sec 31 Twp 104N Rg 50W

County
Minnehaha

Please mark well location with an "X"



Well Completion Date 3-12-93

Well Owner: City of Sioux Falls
Business Name:
Address: 1400 No. Minnesota
Sioux Falls SD 57102

WELL LOG:

FORMATION	DEPTH FROM	DEPTH TO
See Attached Log		
Well #11		

APR 1993
DIVISION OF WATER RIGHTS
Pierre, SD

LOCATION:
Distance from nearest potential pollution source (septic tank, abandoned well, feed lot, etc.)? ______ ft. from ______ (identify source).

PROPOSED USE:
☐ Domestic/Stock ☒ Municipal ☐ Business ☐ Test Holes
☐ Irrigation ☐ Industrial ☐ Institutional ☐ Monitoring well

METHOD OF DRILLING:
Reverse Rotary

CASING DATA:
☒ Steel ☐ Plastic ☐ Other
If other describe

PIPEWEIGHT	DIAMETER	FROM	TO	HOLE DIAMETER
142 LB/FT	34 IN	166 FT	GL FT	54 IN
167 LB/FT	36 IN	13 FT	GL FT	54 IN
LB/FT	IN	FT	FT	IN

GROUTING DATA

Grout Type	No. of Sacks	Grout Weight	From	To
Slurry	35	lb./gal	ft	ft
		lb./gal	ft	ft

Describe grouting procedure 1½ cu yds - 23 Bags p/yd w/ 6 gal H2O p/bag. Tremied in on top of Bentonite Seal Just Above gravel Pack

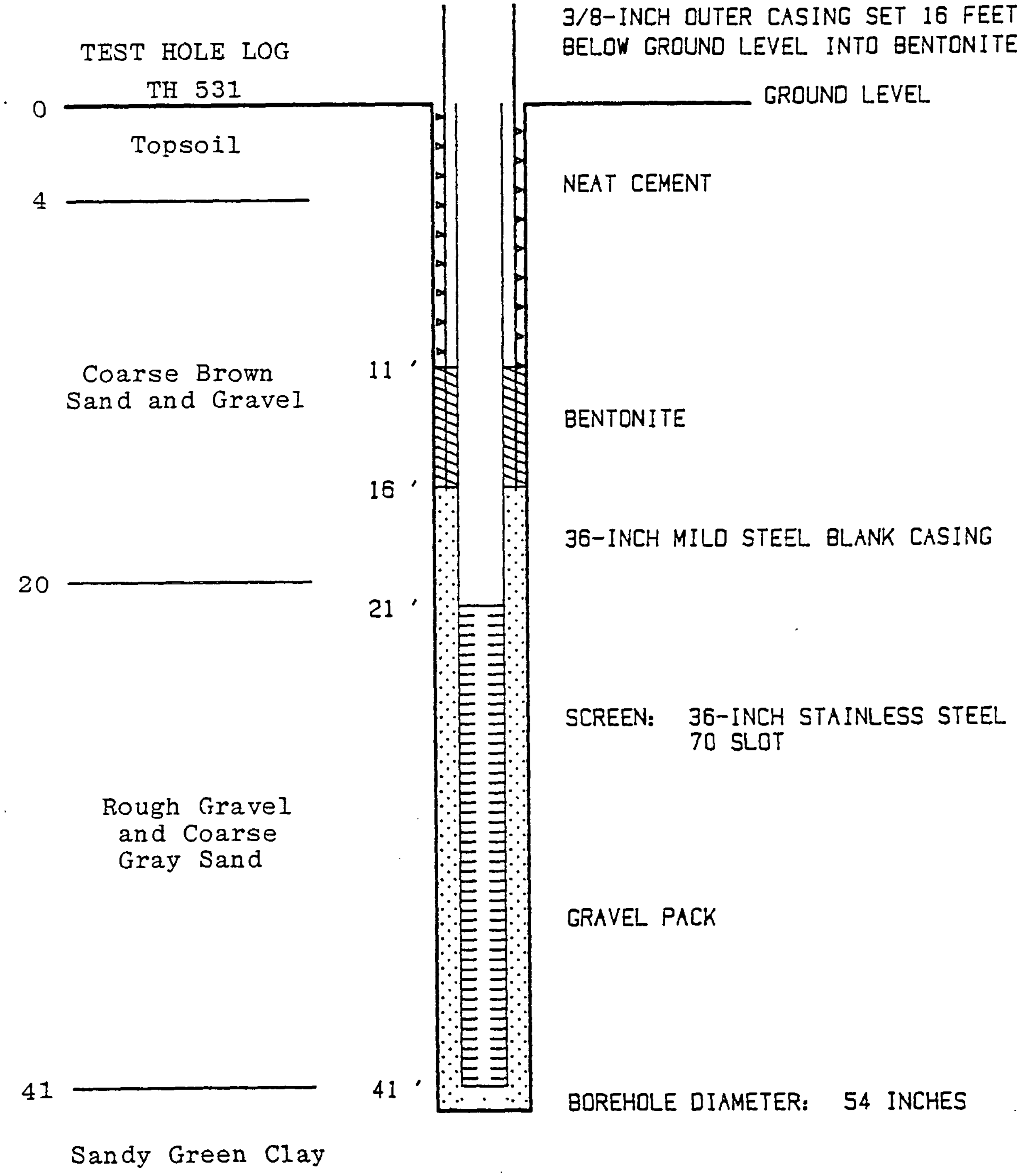
SCREEN: ☐ Perforated pipe ☒ Manufactured
Diameter 36 IN Length 20.4 FEET
Material 304 S.S
Slot Size .070 Set From 37 Feet to 166 Feet
Other information

STATIC WATER LEVEL 2'
If flowing: closed in pressure
GPM flow ______ through ______ inch
Controlled by ☐ Valve ☐ Reducers ☐ Other
Reduced Flowrate
Can well be completely shut in?

WELL TEST DATA:
☐ Pumped Describe:
☐ Bailed
☐ Other
Pumping Level Below Land Surface
______ ft. After ______ Hrs. pumped
______ ft. After ______ Hrs. pumped
If pump installed, pump rate

REMARKS
Pump test data when Complete

WELL NO: 114



LAYNE GEOSCIENCES, INC.

Layne-Western Company, Inc.

Well Information

Omaha, Nebraska

1. Contract RICE LAKE CONTRACTING Date 3-12-93
2. City and State CITY OF SIOUX FALLS, SOUTH DAKOTA Driller GARY MCCRACKEN
3. Well No. 114 at test hole No. ______ Well location (attach map) ______
4. Work completed ______ No of man hours as charged to job on time sheet ______
5. MATERIAL:

	LENGTH	DIA.	GAUGE OR WALL THICKNESS	MATERIAL	TYPE	NO. OF OPENINGS
6. Screen	20.4	36	.375	STAINLESS STEEL	WIRE WRAP	.070
7. Inner Casing	26.1	36	.375	BLACK	BLANK	
8. Outer Casing	23.0	42	.375	BLACK	BLANK	

9. 22 tons of gravel used in the well. Size #2 NORTHERN
10. Test of well. Did you use test or permanent pump? ______ ______ Size of Bowl ______ Stages
11. Size of orifice ______ inch by ______ inch. Orifice tube reading ______ inches.
12. Pumping test — measurements from ground level:

TIME	G.P.M.	STATIC	DRAWDOWN	PUMPING LEVEL

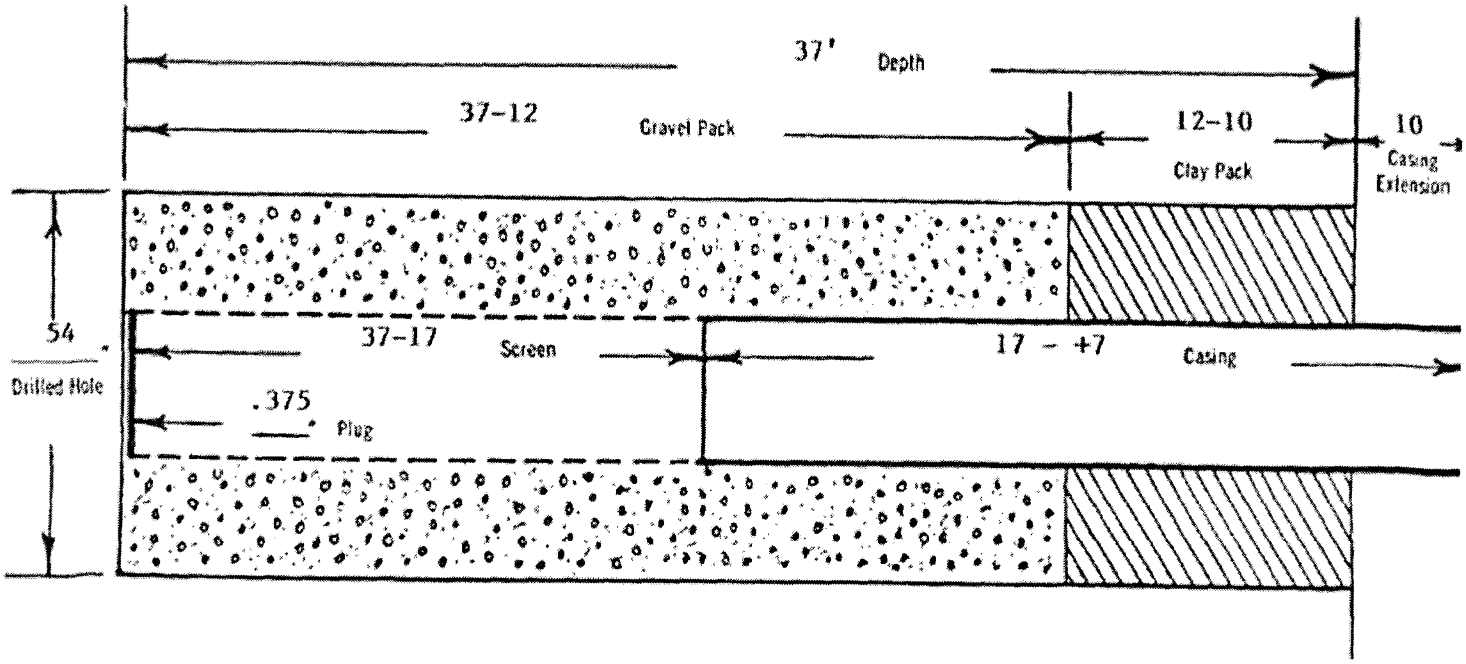
13. Recovery in 5 minutes ______, in 30 minutes ______
14. Did you seal bottom of well? YES Thickness .375 inches, material STAINLESS STEEL
15. Well underreamed? NO From ______ feet to ______ feet, ______ feet to ______ feet.
16. If all screen was not placed at bottom, state how it was spaced.
    From 37 feet to 16.4 feet; from ______ feet to ______ feet; from ______ feet to ______ feet.
17. Depth of well from ground level to top of plug 37' Size of drilled hole 54"
18. Was cement placed around or between any of the casings? YES
19. If so, state where, how much and method used. 5-10 1.5 YARDS TREMIE

CONTRACT RICE LAKE CONTRACTING-CITY OF SIOUX FALLS, SD

Well No. 114

Log of well from ground level:

Feet		Feet	Formation
0	to	2	TOP SOIL
2	to	8	CLAY
8	to	23	SAND AND GRAVEL
23	to	37	GRAVEL AND BOULDERS
	to		
	to		
	to		
	to		
	to		
	to		
	to		
	to		
	to		
	to		
	to		
	to		



Technical Memorandum

Water Supply and Treatment Master Plan

Chapter 3:

New Well Siting Plan

November 2022

(Revised: September 2023)

HR Green Project No: 210506

Prepared For:

CITY OF
SIOUX FALLS

Table of Contents

List of Figures

List of Tables

Section 1: Introduction

The purpose of this Technical Memorandum is to provide the results of a new well siting plan. The new well siting plan was developed by the Sioux Falls Master Plan Project Team (LRE Water, Inc., HR Green, Inc., and Carollo Engineers, Inc).

The City of Sioux Falls holds groundwater rights that supply source water to the Water Purification Plant (WPP). The City's groundwater rights include appropriations (permits, licenses and future use permits) from the Sioux Falls Management Unit of the Big Sioux Aquifer (Big Sioux:Sioux Falls aquifer) and the Middle Skunk Creek Management Unit of the Big Sioux Aquifer (Big Sioux:Middle Skunk Creek aquifer). The City also holds a future use permit (FUP) for groundwater from the Southern Skunk Creek Management unit of the Big Sioux Aquifer (Big Sioux:Southern Skunk Creek aquifer). Additional details regarding the City's water rights are provided in the Water Rights Technical Memorandum (LRE, et. al., 2022).

The City's Big Sioux:Sioux Falls aquifer groundwater rights include licenses (a groundwater appropriation for which the well has been constructed and the water brought to beneficial use) and future use permits (FUPs). After the groundwater withdrawal works (primarily wells) have been constructed and the water brought to beneficial use, the works are inspected by the Water Rights Program (WRP) of the South Dakota Department of Agriculture and Natural Resources (DANR) and a final water right (license) is issued. The FUPs reserve a specified groundwater volume from a defined area. The new well siting plan provides recommendations for new well locations designed to maximize the groundwater withdrawals under the existing licenses and remaining FUP reservations in the Big Sioux:Sioux Falls aquifer.

1-1 Aquifers and Well Fields and Wells

This new well siting plan is focused on the Big Sioux:Sioux Falls aquifer. There are options for new well sites in two other nearby aquifers; the Big Sioux:Middle Skunk Creek aquifer, and the Big Sioux:Southern Skunk Creek aquifer.

The remaining water rights reserved in a FUP held by the City in the Big Sioux:Middle Skunk Creek aquifer could be extracted by one (possibly two) properly designed and constructed wells installed at locations near the existing well field. Prior to constructing wells in the Big Sioux:Southern Skunk Creek aquifer, and as described in the Water Rights Technical Memorandum (LRE et. al., 2022), a water quality investigation is recommended to determine if several potential sources of contamination pose a water quality risk.

The City has two well fields located in the Big Sioux:Sioux Falls aquifer; the Airport Well Field and the North Well Field. Due to water quality impacts associated with per-and polyfluoroalkyl substances (PFAS) at the Airport Well Field, no new wells are planned for the Airport Well Field.

1-2 Well Types

The City operates wells of three types: 1) horizontal collector well (HCW), 2) vertical well with a manufactured screen enclosed in an engineered filter pack (gravel pack well), and 3) a relatively large diameter (typically 40 feet) concrete casing sunk into the aquifer with an open bottom and no well screen (Bragstad well). The North Well Field has at least one well of each of these three types.

New wells recommended for the North Well Field include HCWs and gravel pack wells. The City has expressed a preference for HCWs. There are good reasons for this preference, as the thickness of Big Sioux:Sioux Falls aquifer is relatively limited. Based on the results of a detailed review of the City's existing wells (LRE et. al., 2022), the average saturated thickness of the City's wells in the North Well Field is approximately 29 feet and the average static water level is approximately 10 feet below ground surface. This limits the available drawdown. An HCW, with lateral screens of lengths typically greater than 100 feet that are installed near the bottom of the aquifer, has a definite production advantage over a gravel pack well in both screen length and available drawdown.

Section 2: Well Siting Approach

As described in Progress Meeting #4 (January 11, 2022), four criteria were considered in selecting locations for new wells. The four criteria are: 1) saturated thickness; 2) preference for land already owned by the City; 3) proximity to existing well water main transmission infrastructure; and 4) water rights availability. Other criteria considered in selecting the new well locations included the proximity of other (non-City) water rights, potential for well interference with existing City wells, proximity to recharge-supplying surface water (primarily the Big Sioux River, but also including creeks and the diversion ditches), and draft locations selected by the United States Geological Survey (Cinotto, 2020).

2-1 Saturated Thickness

The United States Geological Survey (USGS), on behalf of the City, constructed a numerical groundwater flow model (USGS Model) for the Big Sioux:Sioux Falls aquifer (Davis, et. al, 2019). Within the USGS Model, the elevation of the base of the aquifer (in most places, clay-rich glacial till) was estimated based on airborne electromagnetic (AEM) data (Valseth, et. al., 2018). Saturated thickness is calculated within the USGS Model by subtracting the elevation of the base of the aquifer from the groundwater elevation during a specific model time step (Eldridge, USGS, personal communication, 2021).

The North Well field is shown in two figures, with the southern portion of the well field shown in Figure 1 and the northern portion of the well field shown in Figure 2. The saturated thickness calculated by the USGS Model, based on the groundwater elevations from the December 2017 model time step, is shown in both figures with a "color-flood" format, with colors of lighter shades (light green to yellow) indicating greater saturated thickness and colors of darker shades (dark green to blue to dark blue) indicating lesser saturated thickness. It should be noted that due to the source of the data (a regional AEM survey and a numerical groundwater elevation calculation), there is error in the saturated thickness maps shown in Figures 1 and 2. The inherent error in the AEM-based saturated thickness is occasionally evident when comparing AEM-based aquifer thicknesses to site specific well log data. For example, at HCW #71, the saturated thickness exported from the USGS Model is in the 40 to 60 feet range, but the site specific well log indicates a saturated thickness of 32 feet. However, the saturated thickness data exported from the USGS Model are reasonably accurate and are very useful for relative comparisons between locations within the North Well Field.

Another source of saturated thickness data is water well completion reports (well logs). Well logs for the North Well Field obtained from the well completion report database and the water rights database maintained by the DANR were utilized to estimate the saturated thickness at specific well locations. At those locations in Figures 1 and 2 where the saturated thickness was calculated based on a well log, the saturated thickness value at that location is labeled.

2-2 City Owned Parcels and Well Water Main Transmission Pipeline Locations

Those parcels of land owned by the City as of September 2021 are shown in Figures 1 and 2. A greater percentage of City-owned parcels are located in the southern portion of the North Well Field. New well locations were selected for most, but not all, of the City-owned parcels shown in Figures 1 and 2.

The existing well water main transmission pipelines (well water mains) are shown in Figures 1 and 2. The locations of proposed well water mains for the new proposed well locations are shown in Figure 3. The existing well water main locations and the City-owned parcel locations were provided to the Project Team in geographic information system shapefiles. The data are current as of September 2021. The proposed well water mains are discussed in greater detail in the Water Transmission Mains Technical Memorandum (HRG, et. al, 2022).

2-3 Water Rights Availability

The water rights availability considered for the new well siting plan includes FUP #448-3 and FUP #5523-3. As indicated in the Water Rights Technical Memorandum (LRE, et. al., 2022), there is 3,842 acre-feet per year remaining in FUP #448-3 and 4,050 acre-feet per year remaining in FUP #5523-3. Assuming continuous withdrawals, these volumes are equivalent to approximately 3.43 million gallons per day (MGD) and 3.62 MGD, respectively.

Also included in the water rights availability analysis was an assumption that it will be possible to re-allocate the water rights in the Airport Well Field (26,668.40 acre-feet per year, or approximately 23.81 MGD) to the North Well Field. This would require amending the Airport Well Field groundwater licenses by changing the points of diversion from the Airport Well Field to the North Well Field.

The WRP will allow existing permits and licenses to be amended by changing the diversion point locations if the following criteria are met: 1) no change in water source (same aquifer); 2) no increase in the amount of water (diversion rate and volume to remain the same); and 3) the change does not result in an added potential for unlawful impairment of senior or domestic water rights.

Should the City choose to amend the existing Airport Well Field water rights by transferring the diversion point locations to the North Well Field, criteria #1 will be met, as both well fields are located in the same aquifer (Big Sioux:Sioux Falls aquifer). It is assumed (and recommended) that should the City choose to amend the existing Airport Well Field water rights, it will do so on a case-by-case basis for each existing water right and the amendment request will not include a request for additional water beyond that already allowed within the existing groundwater license.

Regarding the unlawful impairment criteria, while the City holds the majority of the water rights within the North Well Field, other entities, including Minnehaha Community Water Corporation (MCWC) as well as individuals with irrigation permits, hold water rights within the area represented by the North Well Field. The approximate locations of the wells associated with these non-City water rights are shown in Figure 1 and 2. These non-City water rights were considered when selecting the new well locations.

2-4 Potential for Well Interference and Recharge Considerations

HCW well spacing was evaluated by reviewing the existing HCW well spacing (Table 1) and by reviewing drawdown and observation well data from historical HCW performance test data (those data that had drawdown measured in at least two observation wells). The spacing between the existing HCWs ranges from approximately 1,800 feet to

6,800 feet, with an average of approximately 2,925 feet. Utilizing historical performance test data (from HCWs #46, #47, #71 and #72), the average radial distance from a HCW to a point where the drawdown caused by pumping during the test would be 0.5 feet ranges from approximately 400 feet to 2,300 feet, with an average of approximately 1,300 feet. These distances were considered when identifying potential locations for HCWs and new vertical gravel pack wells (NGPs) utilized in the well siting plan. Further monitoring and assessment of the drawdown caused by pumping from the City's HCWs is recommended to provide additional information regarding the radius of influence of an HCW.

An additional assumption for new HCWs located near an existing HCW, is that the new HCW be designed and constructed in a way to maximize the amount of induced surface water infiltration and thereby minimize drawdown in the direction perpendicular to (away from) the surface water body. This would be accomplished by constructing the lateral screens in a direction toward or under the surface water body (as indicated previously, usually the Big Sioux River, but also Silver Creek or a diversion ditch) and not constructing lateral screens in the direction away from the surface water body.

Constructing the new HCW near a surface water body increases the potential yield (relative to HCWs not located near a surface water body) by taking advantage of the recharge from the surface water body. This also reduces the propagation of the drawdown in the aquifer in the direction opposite from (away from) the surface water body.

2-5 Need for Site Specific Investigation

The Big Sioux:Sioux Falls aquifer is a glacio-fluvial aquifer composed of glacial outwash overlain by more recent alluvial sediments. While the outwash is comprised primarily of sand and gravel, it can include a significant percentage of finer-grained sediments (silt and clay), as well as coarser sediments including cobbles and boulders. Due to the variability associated with the depositional environment of a glacio-fluvial aquifer, there can be significant variations of grain sizes in both the horizontal and vertical directions, as well as differences in the thickness of the sand and gravel deposits. These differences in grain size and aquifer thickness can significantly impact the yield and water quality of a well.

The locations for wells recommended in this Technical Memorandum are intended to guide future site investigation efforts and should be considered approximate and subject to change. At a minimum, it is recommended that soil borings be advanced at each potential new well site prior to proceeding with well and well water main design activities, and prior to purchasing land or developing easements associated with the new well locations. Additional soil borings are recommended when a site is selected to aid in well design.

Section 3: New Well Siting Plan

The new well siting plan includes three gravel pack wells and 19 HCWs. The locations of the wells are shown in Figure 1 and Figure 2. This mix of well types is somewhat arbitrary, with the three new gravel pack wells being located near existing gravel pack wells. An example distribution of water rights from the FUPs and from the Airport Well Field to the new wells is shown in Table 2. The information in Table 2 compares the estimated long-term average yield of the new wells with available water rights. The total of the two numbers (estimated well yields and available water rights) shown in Table 2 do not match exactly but are reasonably close and provide an example distribution or assignment of water rights with a specific well. The information shown in Table 2 is subject to change, depending on actual well locations and the timing of water right amendments.

The proposed well improvements have been prioritized within the 10-, 20-, 50- and 100-year planning periods of 2035, 2045, 2066, and 2116, respectfully. This prioritization and near term planning period opinion of probable costs are summarized in Tables 6 and 7 of the Water Transmission Main Technical Memorandum (HRG, et. al., 2022).

Section 4: Recommended Non-Construction Projects

Below are several recommended studies that will enable the City to better evaluate future needs associated with the well field. The recommended studies include:

- Managed Aquifer Recharge (MAR)
- New (western) wellfield siting study
- Individual well siting study for recommended near term wells

Section 5: References Cited

Cinotto, Peter, 2020. Letter to Nick Borns from United States Geological Survey Acting Director Peter Cinotto, dated February 27, 2020.

Davis, K.W., Eldridge, W.G., Valder, J.F., and Valseth, K.J., 2019. Groundwater-flow model and analysis of groundwater and surface-water interactions for the Big Sioux aquifer, Sioux Falls, South Dakota: U.G. Geological Survey Scientific Investigations Report 2019-5117, 86 p., https://doi.org/10.3133/sir20195117.

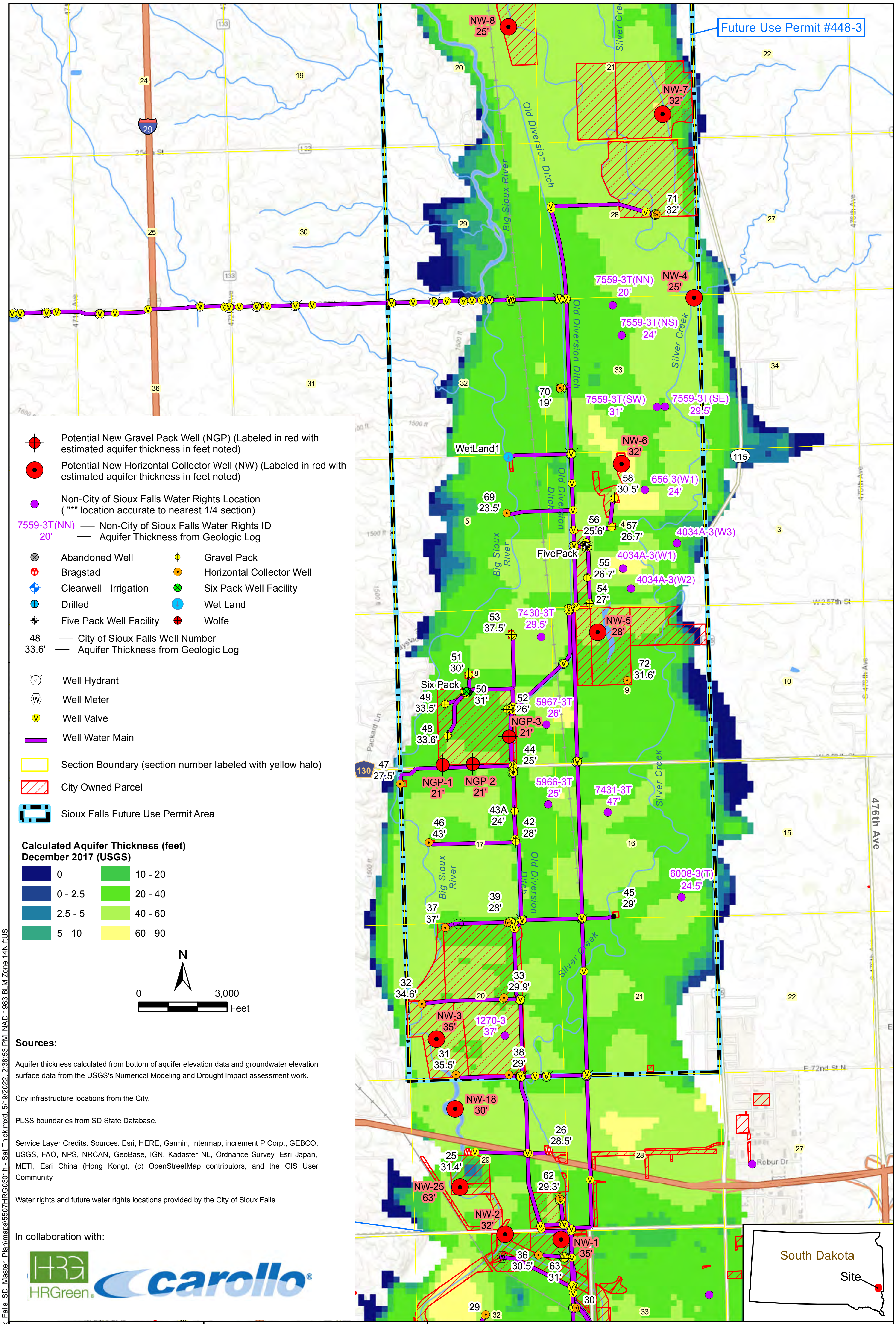
HRG, LRE & Carollo, 2022. Water Transmission Mains Technical Memorandum, Water Purification Master Plan.

LRE, HRG & Carollo, 2022. Water Rights Technical Memorandum, Water Purification Master Plan.

LRE, HRG & Carollo, 2022. Well Condition Assessment, Water Purification Master Plan.

Valseth, K.J., Delzer, G.C., and Price, C.V., 2018, Delineation of the hydrogeologic framework of the Big Sioux aquifer near Sioux Falls, South Dakota, using airborne electromagnetic data: U.S. Geological Survey Scientific Investigations Map 3393, 2 sheets, accessed August 2018 at https://doi.org/10.3133/sim3393.

Figures



Potential New Gravel Pack Well (NGP) (Labeled in red with estimated aquifer thickness in feet noted)

Potential New Horizontal Collector Well (NW) (Labeled in red with estimated aquifer thickness in feet noted)

Non-City of Sioux Falls Water Rights Location
("*" location accurate to nearest 1/4 section)

7559-3T(NN) — Non-City of Sioux Falls Water Rights ID
20' — Aquifer Thickness from Geologic Log

Abandoned Well
Bragstad
Clearwell - Irrigation
Drilled
Five Pack Well Facility
Gravel Pack
Horizontal Collector Well
Six Pack Well Facility
Wet Land
Wolfe

48 — City of Sioux Falls Well Number
33.6' — Aquifer Thickness from Geologic Log

Well Hydrant
Well Meter
Well Valve
Well Water Main

Section Boundary (section number labeled with yellow halo)
City Owned Parcel
Sioux Falls Future Use Permit Area

Calculated Aquifer Thickness (feet)
December 2017 (USGS)

0	10 - 20
0 - 2.5	20 - 40
2.5 - 5	40 - 60
5 - 10	60 - 90

Sources:

Aquifer thickness calculated from bottom of aquifer elevation data and groundwater elevation surface data from the USGS's Numerical Modeling and Drought Impact assessment work.

City infrastructure locations from the City.

PLSS boundaries from SD State Database.

Service Layer Credits: Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community

Water rights and future water rights locations provided by the City of Sioux Falls.

In collaboration with:

C:\GIS\GIS\HR Green Sioux Falls SD Master Plan\maps\5507HRG0301h - Sat Thick.mxd, 5/19/2022, 2:38:53 PM, NAD 1983 BLM Zone 14N ftUS

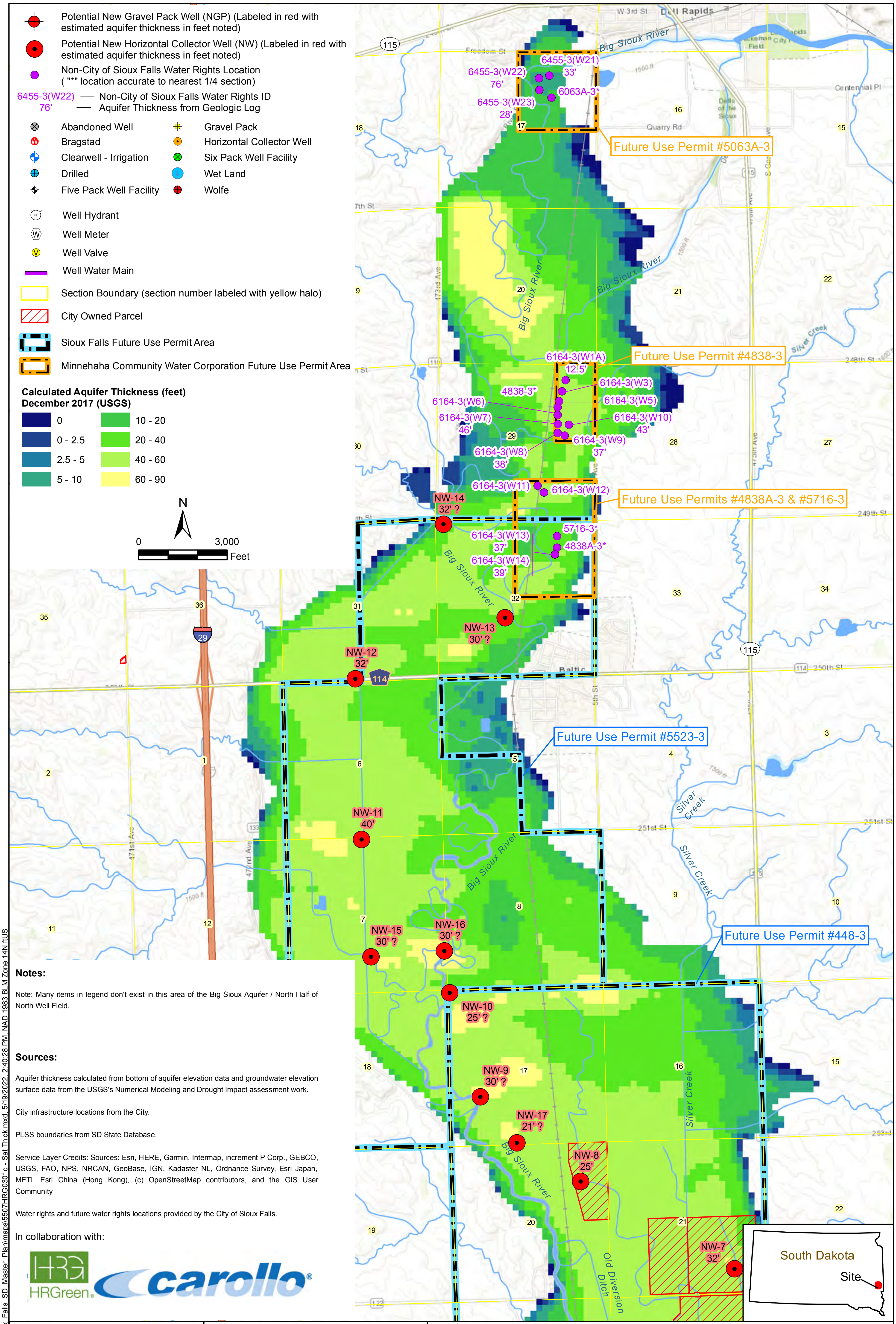
CONNECTING WATER TO LIFE

Prepared By:
LRE Water
Innovative Water Resource Solutions
South Dakota Office
Sioux Falls, South Dakota
(605) 310-1721

CITY OF SIOUX FALLS
WATER PURIFICATION MASTER PLAN
SIOUX FALLS, SOUTH DAKOTA

POTENTIAL NEW WELL LOCATIONS AND
SATURATED THICKNESS (SOUTH-HALF OF NORTH WELL FIELD)

FILE:5507HRG0301h - Sat Thick.MXD | DATE: 5/19/2022 | FIGURE: 1



Notes:

Note: Many items in legend don't exist in this area of the Big Sioux Aquifer / North-Half of North Well Field.

Sources:

Aquifer thickness calculated from bottom of aquifer elevation data and groundwater elevation surface data from the USGS's Numerical Modeling and Drought Impact assessment work.

City infrastructure locations from the City.

PLSS boundaries from SD State Database.

Service Layer Credits: Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community

Water rights and future water rights locations provided by the City of Sioux Falls.

In collaboration with:

C:\GIS\GIS\HR_Green_Sioux_Falls_SD_Master_Plan\maps\5507HRG0301g - Sat Thick.mxd, 5/19/2022, 2:40:28 PM, NAD 1983 BLM Zone 14N ftUS

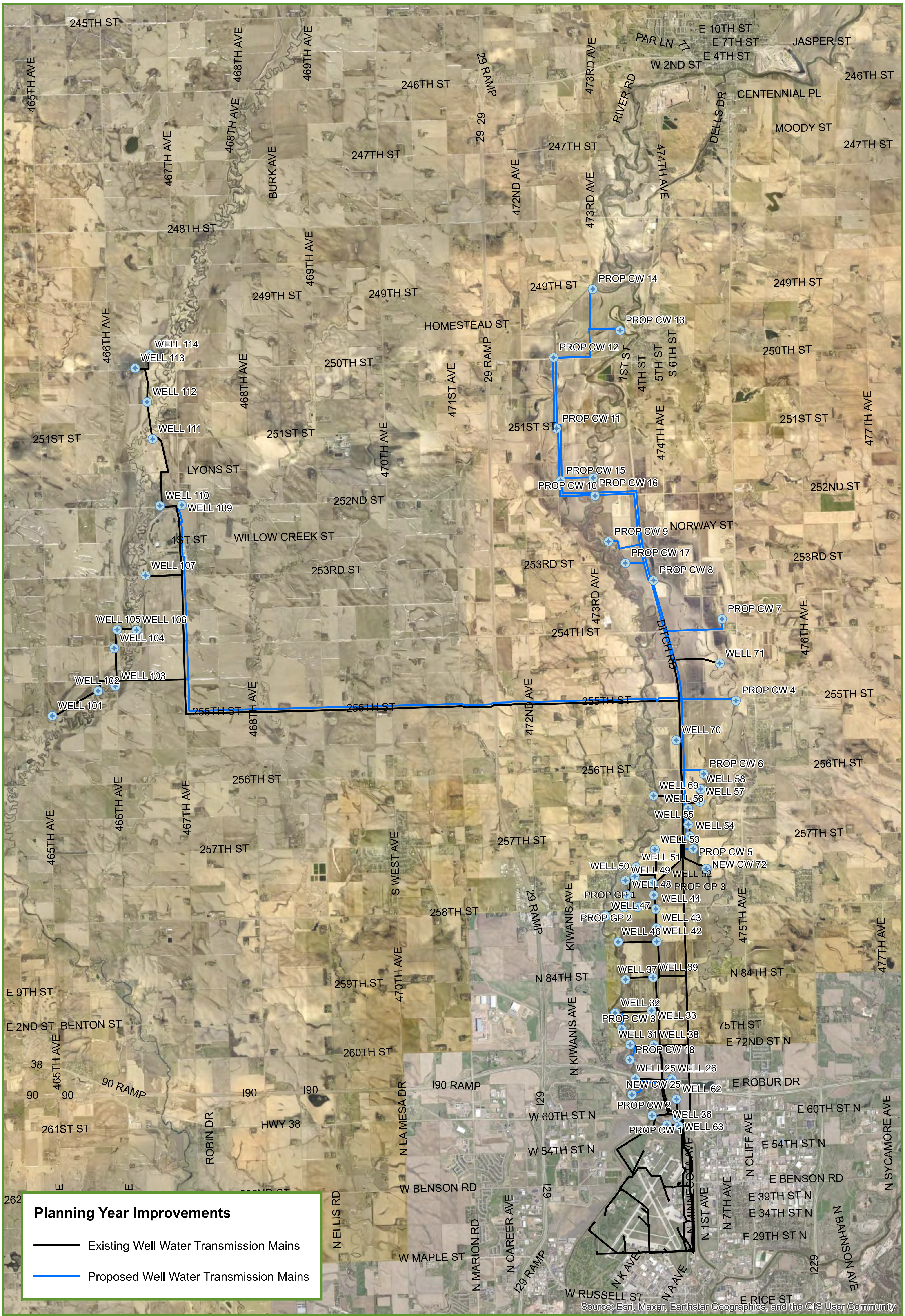
CONNECTING WATER TO LIFE

Prepared By:
LRE Water
Innovative Water Resource Solutions
South Dakota Office
Sioux Falls, South Dakota
(605) 310-1721

CITY OF SIOUX FALLS
WATER PURIFICATION MASTER PLAN
SIOUX FALLS, SOUTH DAKOTA

POTENTIAL NEW WELL LOCATIONS AND
SATURATED THICKNESS (NORTH-HALF OF NORTH WELL FIELD)

FILE:5507HRG0301g - Sat Thick.MXD | DATE: 5/19/2022 | FIGURE: 2



In collaboration with:

Figure 3
Existing & Proposed Well Water Mains

Tables

Table 1. North Well Field Horizontal Collector Well Spacing

Well	Closest HCW	Radial Distance (feet)
HCW 36	HCW62	2,070
HCW 36	HCW30	2,200
HCW 31	HCW 38	1,800
HCW 31	HCW 32	2,660
HCW 32	HCW 33	2,800
HCW 32	HCW 37	2,700
HCW 37	HCW 39	2,125
HCW 37	HCW 46	2,950
HCW 46	HCW 47	2,200
HCW 69	HCW 70	4,600
HCW 70	HCW 71	6,800
HCW 36	HCW 30	2,190
Average		2,925

Note:

Radial distances are approximate and are based on aerial photograph measurements.

Table 2. Example Water Rights Distribution among New Well Locations in North Well Field

Well ID	Average Withdrawal Rate	Average Withdrawal Rate	From FUP #5523-3	From FUP #5523-3	From FUP #448-3	From FUP #448-3	From Reallocation	From Reallocation
	(ac-ft/yr)	(MGD)	(ac-ft/yr)	(MGD)	(ac-ft/yr)	(MGD)	(ac-ft/yr)	(MGD)
NGP-1	645.28	0.58					645.28	0.58
NGP-2	645.28	0.58					645.28	0.58
NGP-3	645.28	0.58					645.28	0.58
NW-1	1,774.52	1.58					1,774.52	1.58
NW-2	1,774.52	1.58					1,774.52	1.58
NW-3	1,774.52	1.58					1,774.52	1.58
NW-4	1,451.88	1.30			1,451.88	1.30		
NW-5	1,451.88	1.30			1,451.88	1.30		
NW-6	1,451.88	1.30			1,451.88	1.30		
NW-7	1,451.88	1.30					1,451.88	1.30
NW-8	1,451.88	1.30					1,451.88	1.30
NW-9	1,935.84	1.73					1,935.84	1.73
NW-10	1,935.84	1.73					1,935.84	1.73
NW-11	1,613.20	1.44					1,613.20	1.44
NW-12	1,613.20	1.44					1,613.20	1.44
NW-13	1,935.84	1.73					1,935.84	1.73
NW-14	1,935.84	1.73	1,935.84	1.73				
NW-15	1,613.20	1.44					1,613.20	1.44
NW-16	1,935.84	1.73	1,935.84	1.73				
NW-17	1,613.20	1.44					1,613.20	1.44
NW-18	1,935.84	1.73					1,935.84	1.73
NW-25	2,258.48	2.02					2,258.48	2.02
Totals	**34,845.12**	**31.10**	**3,872**	**3.46**	**4,355.64**	**3.89**	**26,617.80**	**23.76**
Available Water Rights			**4,050**	**3.62**	**3,842.00**	**3.43**	**26,668.40**	**23.81**

Reallocation = amending a water right for a well located in the Airport Well Field by changing the point of diversion to a well located in the North Well Field
Totals assume all Airport Well Field water rights are transferred to North Well Field
Information is provided as an example showing the distribution of available water rights among the new wells.
ac-ft/yr - acre-feet per year
MGD - million gallons per day (assuming continuous withdrawal)
FUP - future use permit

Technical Memorandum

Water Supply and Treatment Master Plan

Chapter 4:

Groundwater Numerical Modeling of Drought Impacts

November 2022

HR Green Project No: 210506

Prepared For:

CITY OF SIOUX FALLS

Table of Contents

List of Figures

List of Tables

Appendices

Electronic copies of model files.

Section 1: Introduction

LRE modified an existing numerical groundwater model of the Big Sioux aquifer for the purpose of evaluating the effects that drought conditions will have on the City of Sioux Falls (City) groundwater withdrawals. During a drought, the volume of the City's groundwater withdrawals will be reduced due to decreased available drawdown. The decreased available drawdown is a direct result of groundwater elevation decreases as a natural result of decreased groundwater recharge (precipitation and stream recharge) during drought conditions.

This work relied heavily on a numerical groundwater model developed on behalf of the City by the United States Geological Survey (USGS). The USGS model (hereafter referred to as the USGS 2019 Model) includes that portion of the Big Sioux aquifer that extends from near Covell Lake in Sioux Falls to Dell Rapids, SD. This portion of the Big Sioux aquifer is bounded by local bedrock topographical highs, one near Covell Lake, and one near Dell Rapids, formed by the Pre-Cambrian Sioux Quartzite. This portion of the aquifer is known as the Sioux Falls Management Unit of the Big Sioux Aquifer (Hedges, et. al., 1982).

The model developed by LRE for this project is hereinafter referred to as the Drought Model. The model area for the Drought Model is identical to the model area of the USGS 2019 Model (Figure 1). The City has two well fields in the Big Sioux: Sioux Falls aquifer. The Airport Well Field is comprised of 21 wells located within the boundaries of the Sioux Falls Regional Airport. The North Well Field is comprised of 31 wells located between the Airport Well Field and the City of Baltic, SD. The City's wells are categorized into the following three well types: 1) horizontal collector well (HCW), 2) vertical well with a manufactured screen enclosed in an engineered filter pack (gravel pack well), and 3) a relatively large diameter (40 feet) concrete casing sunk into the aquifer with an open bottom and no well screen (Bragstad well).

This Technical Memorandum does not include a description of the hydrogeologic conceptual model of the Big Sioux: Sioux Falls aquifer, nor are the assumptions and inputs associated with the USGS 2019 Model completely described. For added detail regarding hydrogeological conceptual model and elements, inputs and assumptions associated with the USGS 2019 Model, please refer to Davis, et. al. (2019).

Section 2: Previous Numerical Groundwater Models

In addition to the USGS 2019 Model, there are two other numerical groundwater models that have been previously constructed for the Big Sioux: Sioux Falls aquifer. One was developed by HDR Engineering, Inc. (HDR 1990 Model) and one was developed by the USGS (Koch, 1982).

2-1 USGS 2019 Model

The USGS 2019 Model simulated the period between 1949 and 2017, with the year 1949 as a steady state "wind up" stress period, and the following years simulated with monthly steps (time steps) incorporating representative climate and river stage data. Actual groundwater withdrawals were incorporated into the USGS 2019 Model based on pumping data provided by the City for 45 wells over the period from 1995 to 2017. City groundwater withdrawals during the period from 1950 to 1994 were estimated based on population. The estimated mean monthly withdrawal rate for the City from 1950 to 2017 ranged from 0.2 to 22.8 million gallons per day (MGD). The estimated mean monthly withdrawal rate for Minnehaha Community Water Corporation (MCWC) from 1979 to 2017 ranged from 0.3 to 4.4 MGD. MCWC is a rural water system with two well fields; one located just southwest of Dell Rapids, and one located just north of Baltic.

The USGS 2019 Model did not include 12 wells located in the North Well Field, and 2 wells located in the Airport Well Field. The 14 wells not included in the USGS 2019 Model are as follows: #45, #48, #49, #50, #51, #52, #54, #55, #56, #57, #58, #64, #65, and #70. Additionally, City Well #72 was not included in the USGS 2019 Model as it had not yet been constructed. Thirteen of the 15 wells not included in the USGS 2019 Model are gravel pack wells, and two of the wells not included in the USGS 2019 Model are HCWs (Well #70 and Well #72).

The USGS 2019 Model incorporated the results of an airborne electromagnetic survey (Valseth, 2018) conducted for the purpose of further delineating the Big Sioux: Sioux Falls aquifer. These results were utilized in the USGS 2019 Model at various locations to estimate the elevation of the bottom of the aquifer (William Eldridge, USGS, personal communication, 2021). In Davis, et. al. (2019), the USGS states “The final calibrated parameter values of horizontal and vertical conductivity, specific yield, specific storage, streambed hydraulic conductivity, recharge and evapotranspiration were considered reasonable for hydrogeologic materials and conditions in the model area for 1950 – 2017.” None of these calibrated parameter values, except recharge (discussed in a later section), were changed in the Drought Model.

The USGS conducted simulations to evaluate groundwater capture in the Big Sioux: Sioux Falls aquifer. Capture is that portion of the water pumped by a well that is derived from induced recharge during pumping and decreased natural discharge (in this case, primarily discharge to the Big Sioux River). The results indicated that areas of higher streamflow capture were adjacent to the Big Sioux River north of the City and along the lower part of the Sioux Falls Diversion Channel (Davis, et. al., 2019). These results were considered when proposing new well locations (LRE, et. al., 2022). In the USGS 2019 Model report (Davis, et. al, 2019) the USGS concludes that one of the uses of the model is to “to simulate hydrologic scenarios…” which is what the Drought Model does.

2-2 HDR 1990 Model

Layne Geosciences, Inc. and HDR (HDR, 1990) constructed a groundwater model (HDR 1990 Model) as part of an investigation intended to guide the City’s future well field development. The HDR 1990 Model was constructed using the USGS MODFLOW package (an earlier version), and the model area was nearly identical to the USGS 2019 Model and Drought Model. The northern boundary of the Big Sioux: Sioux Falls aquifer in the HDR 1990 Model was approximately one mile south of the northern boundary of the USGS 2019 Model and the Drought Model.

Recharge in the 1990 Model was from infiltration of precipitation and leakage from the Big Sioux River. Direct infiltration recharge was assigned at 25% of precipitation, and the value was confirmed through calibration (HDR, 1990). Other aquifer parameters in the HDR 1990 Model inputs included horizontal hydraulic conductivity (K_h) at 300 feet/day and specific yield of 0.2. These parameters are similar to the final calibrated parameter values in the USGS 2019 Model (mean K_h of approximately 158 feet/day and specific yield of 0.10).

Groundwater withdrawals in the HDR 1990 Model included pumping from City wells, Baltic municipal wells, and a few irrigation wells and did not include withdrawals from MCWC. The HDR 1990 Model was utilized to simulate two City well field configurations: the then-existing well field, and the “extended well field.” The then-existing well field consisted of 51 wells including all of the City’s currently existing Big Sioux: Sioux Falls aquifer wells except HCWs #69, #70 and #71, plus two temporary gravel pack wells. The extended well field consisted of a conceptual well field design that included the existing wells with the addition of approximately 27 new gravel pack wells to be located in the North Well Field.

City groundwater withdrawals in the HDR 1990 Model were simulated based on the actual pumping from the 51 City wells in 1989. Each of the 51 wells was assigned a factor calculated by the total annual production of that well divided by the total production of the 51 wells. This factor was used as a multiplier in simulations in which the total well field production was either more or less than the 1989 production. For the simulated extended well field, each of the City wells was assumed to pump at equal rates. The production of the extended well field was assumed to be the total simulated well field production minus the simulated production of the 51 existing wells. Seasonal multipliers were developed to simulate the seasonal variations in withdrawal volume.

Transient simulations (models in which the aquifer storage is allowed to change with time due to withdrawals and changes in recharge conditions) were conducted under three climate scenarios: 1) average normal conditions (no dry or wet years, precipitation at approximately 24-inches per year), 2) average dry (defined as conditions when precipitation is 20% less than average conditions, or approximately 19½-inches per year), and 3) extreme dry (no precipitation and no flow in the Big Sioux River for two years). The results are summarized in Table 1, and the results from the extreme dry simulation are shown in Figure 2. The results in Table 1 show simulated withdrawals while maintaining the aquifer in equilibrium (i.e., no net change in aquifer storage). The withdrawals shown in Figure 2 are from transient simulations that allow groundwater to be removed from storage by pumping: by the end of 24 months, the maximum simulated withdrawals from the extended well field were 9.2 MGD.

2-3 USGS 1982 Model

A two-dimensional finite-difference model was constructed for the Big Sioux: Sioux Falls aquifer by the USGS, and the estimated volume of groundwater in the aquifer was approximately 100,000 acre-feet (Koch, 1982). The estimated recharge rate determined during model calibration was 6.9 inches per year. The 1982 model simulated three hypothetical simulations briefly described below.

Pumping from aquifer under extreme drought conditions

Koch (1982) simulated recharge from precipitation at the 1976 rate (a very dry year with annual precipitation of 11.42 inches), City groundwater withdrawals of 17,500 ac-ft/yr (~15.6 MGD), and no flow in the Big Sioux River. After 16 months, the simulated withdrawals from the City wells had to be decreased by 40% to prevent the aquifer storage from reaching zero at any location within the model area.

Increased City withdrawals while maintaining aquifer equilibrium (no net change in groundwater storage)

A steady-state (equilibrium) simulation during which the City withdrawal rates were increased to 32,200 ac-ft/yr (~28.8 MGD) from a total of 60 wells distributed throughout the Big Sioux: Sioux Falls aquifer. The simulation water budget consisted of a total inflow to the aquifer (from precipitation and stream recharge) of 35,300 acre-feet and a total discharge of 35,340 acre-feet (32,300 acre-feet from pumping, 2,830 acre-feet to streams, and 310 acre-feet to evapotranspiration). These results suggested that withdrawals from the aquifer by the City of approximately 28.8 MGD could be possible while maintaining equilibrium conditions (no net change in aquifer storage).

Increased City withdrawals under 1976 conditions and mostly dry Big Sioux River

Simulations were conducted with City groundwater withdrawals at 32,200 ac-ft/yr (~28.8 MGD) from 60 wells, and the pumping had to be decreased by 44% during a simulation conducted with no recharge and generally no flow in the Big Sioux River. This simulation indicated that 63% of groundwater being pumped was capture from the Big Sioux River (groundwater that would under equilibrium conditions be discharged to the river but was instead captured by a pumping well).

Section 3: Model Approach

As indicated previously, the Drought Model is the USGS 2019 Model (Davis, et. al., 2019) with revisions to recharge, river input volumes, pumping well locations, and pumping rates. The Drought Model simulates well field operations during four climate conditions as referenced in the City's Request for Proposals (RFP) for Water Purification Division Master Plan (RFP No. 21-0078). The four climate conditions are 1) Normal, 2) Average Dry, 3) Drought, and 4) Extended Drought.

Each climate condition is simulated over a 7-year period by altering the respective monthly climate conditions in the final 7 years of the USGS 2019 Model (January 2011- December 2017). The previous USGS 2019 inputs were not changed for model years 1949-2010, and act as a prolonged "wind-up" period for each climate condition scenario.

3-1 Drought Model Recharge

Recharge in the USGS 2019 Model was determined using a separate Soil Water Balance (SWB) model (Davis et. al., 2019) The recharge in the USGS 2019 Model was compared to actual inches of precipitation measured at the Sioux Falls regional airport over the corresponding USGS 2019 Model timesteps from 1950 to 2017. There is little correlation between precipitation and the USGS 2019 Model recharge which indicates that recharge depends on multiple factors including precipitation patterns, soil water storage, temperature, and vegetation.

The USGS 2019 Model recharge files were averaged for individual months over the simulated 68 transient model years (1950-2017) with the spatial variation in recharge rates over each model cell preserved in the process. This process produced a Drought Model input file with the average monthly recharge for each month of the year.

To scale the input recharge to one of the four climate conditions requested by the RFP, the model recharge was separated into five categories using a "binning" methodology called Jenks Natural Breaks. Binning is a process for separating more or less continuous values into representative groups or "bins." These data were used to develop the recharge amounts to simulate in the four climate conditions, which are shown in Table 2. The binning process highlighted two categories of climate conditions that could be referred to as "wet" or "very wet" recharge years, and these climate categories were not simulated in the Drought Model. The Extended Drought climate recharge (Table 2) is the minimum recharge year in the USGS 2019 Model dataset. It is noted that the binning process selected an average yearly recharge total of 4.04 inches/year to represent the Normal climate condition which is slightly above the mean recharge rate of the entire dataset of 3.70 inches/year.

A reference precipitation was achieved by "binning" the historic precipitation data at the Sioux Falls Regional Airport, from 1950 to 2020, (NOAA climate station USW00014944, Joe Foss Field, South Dakota) in a similar method to the model recharge binning process. The precipitation (inches/year) was paired with the model recharge in the same "bins" to provide the approximate annual precipitation corresponding to the Drought Model recharge for each of the four climate conditions (Table 2).

Each month's average recharge input file for model simulations was created by scaling the seasonal variations in average recharge according to the annual inches of recharge shown in Table 2 for a given climate condition. The monthly input precipitation recharge in the Drought Model for each climate condition is shown in Figure 3.

3-2 Big Sioux River Flow in the Drought Model

The USGS 2019 Model largely used the Stream Flow Routing package (SFR) in MODFLOW to simulate the flow in the Big Sioux River. The data from the USGS Stream gauging station #06481000 near Dell Rapids represents the largest input of water in the SRF package for the Big Sioux River. This gauging station is near the northern boundary of the model area (Figure 1). The flow in Skunk Creek at USGS gauging station #06481500 at Marion Road is also used as a river input to the model. While the river (RIV) package was used in the USGS 2019 Model, the proportion of water contributed to the model was very small compared to the SFR Package and the RIV package was not altered in the Drought Model.

The USGS 2019 Model SFR model inputs were averaged for individual months over the 68 transient model years simulated (1950-2017). This average input per month was then scaled according to the climate conditions shown in Table 2. Big Sioux River discharge for the four climate conditions was estimated based on historical river flow data from the USGS gauging station near Dell Rapids and on the description of the Average Dry climate condition in the *Future Water Supply Needs Technical Memorandum* (City of Sioux Falls Water Division, 2020). In this technical memorandum, the Average Dry climate condition describes the Big Sioux River flow as dropping down to "as low as 50 cubic feet per second (cfs)". Big Sioux River flow in the Drought Model is controlled by inputting flow data in the SFR Package at the USGS gauging station #648100 near Dell Rapids. Big Sioux River flows during the fall months of September, October, and November are 50 cfs in the Average Dry climate condition, 240 cfs in the Normal climate condition, and 20 cfs in the Drought climate condition. The Extended Drought climate condition simulations assume no flow in the Big Sioux River.

These low flows assumed for September, October and November were utilized to scale the river flows accordingly for the other 9 months of the year. The Drought Model SFR package inputs for Big Sioux River flows at USGS gauging station #06481000 near Dell Rapids are shown in Figure 4. Big Sioux River flow SFR package input in the southern portion of the Drought Model at USGS gauging station #06482020 at N. Cliff Avenue were also averaged in a seasonal/monthly fashion and then scaled in the same fashion for each climate condition. The SFR model input volumes at USGS gauging station #06481500 at Dell Rapids are about 20% of those at USGS gauging station #06482020 at N. Cliff Avenue. This is because the Big Sioux River south of Dell Rapids is a gaining stream until the River enters the North Well Field. The surface water flows simulated at the USGS gauging station #06482020 at N. Cliff Avenue in the Drought Model do not supply water to the Big Sioux: Sioux Falls aquifer at the North or Airport well fields and therefore have little to no impact to the simulated Drought Model well field withdrawals.

3-3 Climate Conditions Simulations

Simulations for the four climate conditions were conducted with 84-time steps (months) for each simulation. The Normal climate condition was modeled by simulating the Normal climate conditions over a period of 7 years. The Average Dry condition was modeled by simulating three years of Normal conditions (normal recharge) followed by four years of Average dry conditions. The Drought condition was modeled by simulating three years of Normal conditions followed by four years of Drought conditions. The Extended Drought condition was modeled by simulating three years of Normal conditions, followed by one year of Drought conditions, then three years of Extended Drought conditions.

3-4 Groundwater Withdrawals in the Drought Model

The USGS 2019 Model (Davis, et. al., 2019) included simulated groundwater withdrawals from the City and Minnehaha Community Water Corporation (MCWC) production wells, but did not include simulated withdrawals from irrigation, domestic, or livestock supply wells "because previous investigators (Koch, 1982) indicated that these withdrawals were less than 0.05 percent of total groundwater outflow in the model area." The Big Sioux: Sioux Falls aquifer was the City's primary raw water source prior to 2012, when the City began receiving water from the Lewis

& Clark Regional Water System (RWS). According to the MCWC website (https://www.minnehahacommunitywater.com/about-us), the rural water system began providing water in 1978.

Due to the detection of Per-and Polyfluoroalkyl Substances (PFAS) in the Airport Well Field, the City largely ceased production from the Airport Well Field at the end of 2016. Therefore, no pumping from the Airport Well Field was simulated in the Drought Model.

The simulated City groundwater withdrawals are from the 31 existing wells in the North Well Field (including the 11 wells not included in the USGS 2019 Model) during the period from January 2016 through November 2021 (hereafter referred to as 2016 to 2021). Simulations also include withdrawals from the existing wells in the North well field plus the addition of 22 proposed new wells.

The locations of the City's existing wells in the North Well Field and proposed new wells (LRE, et. al., 2022) for the North Well Field are shown in Figure 5 (north portion of North Well Field) and Figure 6 (south portion of the North Well Field). Also shown in Figure 5 and Figure 6 is the saturated thickness from the USGS 2019 Model, the approximate locations of MCWC wells (water right numbers 6455-3 and 6164-3), the approximate locations of irrigation wells, the locations of raw water transmission mains, and the locations of land parcels owned by the City.

The *Future Water Supply Needs Technical Memorandum* (City of Sioux Falls Water Division, 2020) references general protocols for source water pumping reductions related to climate conditions. Under Normal conditions, groundwater withdrawals up to the maximum rated capacity are allowed. Under Average Dry conditions, utilization of groundwater sources is "reduced." Under Drought conditions, groundwater withdrawals equal to the average annual yield are planned. During Extended Drought conditions, groundwater withdrawals equal to 50% of the average annual yield are planned.

Pumping from the City wells in the Drought Model was simulated for three different groundwater withdrawal levels: 1) withdrawals equal to the City's total Big Sioux: Sioux Falls aquifer water rights, 2) The City's average annual withdrawals from the Big Sioux: Sioux Falls aquifer during the period from 2016 to 2021, and 3) 50% of the City's average withdrawals during the period from 2016 to 2021. The simulations conducted at the average annual (2016-2021) withdrawal rates and 50% average annual withdrawal rates were conducted using only the 31 existing wells (Table 3). The simulations conducted at the total water rights withdrawal rates included the 31 existing wells (Table 3) and the 22 proposed new wells (Table 4).

3-4.1 Total Water Rights Withdrawals

The total water rights withdrawals simulate pumping from each of the 31 existing wells at the maximum annual permitted water rights for the individual well incorporating the seasonal variations in pumping, and from 22 proposed new wells pumping at the rates shown in Table 4. The total water withdrawal rates assume that all the water rights from the Airport Well field will be transferred to the North Well Field, and all of the remaining water rights under the future use permits will be developed. This equates to a total groundwater withdrawal from the North Well Field of approximately 69 MGD. The withdrawal rates were simulated incorporating seasonal variations in the withdrawal rates.

3-4.2 Average Annual Withdrawals (2016-2021)

The average annual withdrawal rates for the 31 existing wells were calculated from City data over the period from 2016 to 2021 (not including December of 2021) and are shown in Table 3. This represents the average withdrawals from the North Well field period after utilization of the Airport Well Field had effectively ceased. The average annual withdrawals from each well were simulated to incorporate seasonal variations in withdrawal rates.

3-4.3 50% of Average Annual Withdrawals (2016-2021)

The average annual withdrawal rates for each existing City well were reduced by half and incorporated the seasonal variations. These simulations provide information regarding the potential groundwater withdrawals under the planned reductions as described in the *Future Water Supply Needs Technical Memorandum* (City of Sioux Falls Water Division, 2020).

3-4.4 MCWC Withdrawals

The maximum water rights for MCWC withdrawals were determined in the same way as the City's maximum water rights withdrawals, including all MCWC's groundwater licenses and also including the remaining (undeveloped) future use permit reservations. The average annual withdrawals for MCWC were calculated from the five years with the highest withdrawal rates in the USGS model dataset over the period from 1980 to 2017. The five years with the highest withdrawal rates are 2001, 2002, 2003, 2004 and 2012. The MCWC average annual withdrawals were included in the simulations modeling the City's average annual withdrawals (2016-2021) and 50% of the City's average annual withdrawals (2016-2021). The MCWC total water rights withdrawals were included in the simulations modeling the City's total water rights groundwater withdrawals.

3-4.5 Maximum Theoretical Withdrawal

The Drought Model uses a MODFLOW package option to reduce the withdrawal rate of wells throughout the model area as the groundwater elevation approaches the bottom of a cell during simulated pumping. The flow reduction limits pumping to the volume that will occur when the water table is at 25% of the total cell thickness. This "automatic flow reduction" in MODFLOW 6 iteratively reduces the flow rate to maintain the groundwater elevation at a well above the 25% cell thickness level. This MODFLOW option was incorporated into the Drought Model for the purpose of estimating the maximum theoretical withdrawals possible from individual wells and the North well field for a given climate or pumping condition.

Section 4: Model Results

The Drought Model was used to simulate twelve different climate and withdrawal scenarios. Simulations for each of the four climate conditions (Normal, Average Dry, Drought, and Extended Drought) were conducted at the three different withdrawal rates. The results of these simulations are plotted on four figures (Figures 7 through 10). The y-axis in each figure is the amount of City groundwater withdrawals in MGD from the North Well Field. The x-axis in each figure represents seven years.

The dashed lines on Figures 7 through 10 represent the groundwater withdrawal rates, summarized in Tables 3 and 4, input into the Drought Model. The solid lines represent the withdrawal rates calculated by the Drought Model incorporating the automatic pumping rate reductions at affected wells when the saturated thickness drops to 25% of the cell thickness. The dashed lines can be thought of as the withdrawals rates requested from the Drought Model and the solid lines can be thought of as the maximum theoretical withdrawals produced at the requested withdrawal rates.

For the average annual withdrawals (2016-2021) and 50% average annual withdrawals (2016-2021) scenarios, pumping is only simulated for the 31 existing wells in the North Well Field (at the rates shown in Table 3). For the total water rights withdrawals, pumping is simulated from the 31 existing wells, at the total water rights withdrawals rates shown in Table 3, plus the 22 new wells at the withdrawal rates shown in Table 4.

It should be kept in mind that the four Drought Model climate conditions do not simulate any “wet” or “very wet” water years (as discussed in Section 3-1) that, based on the binning analysis, occur fairly regularly in the Sioux Falls area (ten times between 2020 and 2000). The Drought Model is focused on continuous years of average or below average recharge. Consequently, the model-calculated withdrawals for the average annual withdrawals (2016-2021) could potentially be slightly below the actual well field withdrawals.

4-1 Normal Climate Conditions Simulation Results

The estimated North Well Field withdrawals under the Normal condition are shown in Figure 7. The percent reduction in simulated withdrawal rates made by the Drought Model in the four climate conditions and three withdrawal rate options are shown in Table 5. For the Normal condition, there were only very slight reductions in simulated individual well withdrawals, and this is evident in Figure 7 with the blue line indicating the requested withdrawal rates and the solid blue line indicating the model-calculated withdrawal rates coincident. This result is as expected with the Drought Model results indicating that the 31 existing wells in the North Well Field can be pumped at 50% of the average annual withdrawals (2016-2021) without experiencing enough reduction in saturated thickness to significantly reduce withdrawal capacity.

The percent reduction in simulated withdrawal rates for the average annual withdrawals scenario (gray lines in Figure 7) range from 5.9% in Year 1 to 11.2% in Year 7 (Table 5). This result indicates that pumping at the 2016-2021 average annual withdrawal rates could potentially result in reduced yields from some individual wells, particularly after 7 years. Table 6 lists the wells for which the automatic reduction in pumping was activated.

The input (or requested) total water rights withdrawal rates range from approximately 60 MGD to 94 MGD per month (dashed orange line in Figure 7). The model calculated withdrawal rates start in Year 1 above 50 MGD but decrease relatively quickly at the end of Year 1, and then generally vary between approximately 29 and to 38 MGD per month over the next six years. The precent reductions shown in Table 5 range from 36.7% to 53.9% and the automatic reduction in pumping was activated for 27 of the existing wells and 18 of the new wells (Table 6), indicating a widespread decrease in saturated thickness in the North Well Field.

4-2 Average Dry Climate Conditions Simulation Results

The estimated North Well Field withdrawals under the Average Dry climate condition are shown in Figure 8. As with the Normal climate condition, there were only slight reductions in simulated individual well withdrawals at the 50% of average annual withdrawal rate (2016-2021).

The percent reduction in simulated withdrawal rates for the average annual withdrawals (2016-2021) scenario range from 5.9% in Year 1 to 23.9% in Year 7 (Table 5). These results indicate that existing wells in the North Well Field pumping at the average annual withdrawals (2016-2021) are likely to experience decreased production during Average Dry conditions. The automatic reduction in pumping was activated for ten wells (Table 6).

In Year 7, after three years at the Normal condition followed by four years of Average Dry conditions, the model-calculated monthly withdrawal rate under the total water rights withdrawals varies from approximately 24 MGD to 31 MGD. The automatic reduction in pumping was activated for 27 existing wells and 18 new wells (Table 6).

4-3 Drought Climate Conditions Simulation Results

The model-calculated North Well Field withdrawals under the Drought climate condition are shown in Figure 9. As with the Normal and Average Dry climate conditions, there were only slight reductions (0 to 2.5%) in simulated individual well withdrawals at the 50% of average annual withdrawal rate (2016-2021). This indicates that the City's plan for reduced groundwater withdrawals during periods of drought, as described in the *Future Water Supply Needs Technical Memorandum* (City of Sioux Falls Water Division, 2020), is sound, at least for the near future.

The percent reduction in simulated withdrawal rates for the average annual (2016-2021) withdrawals scenario range from 5.9% in Year 1 to 29.8% in Year 7 (Table 5). The model-calculated monthly production from the existing wells under the average annual (2016-2021) withdrawals rate scenario during Year 7 are approximately 10 MGD. The automatic reduction in pumping was activated for 13 of the existing wells (Table 6).

In the total water rights withdrawals scenario, the model calculated monthly withdrawal rates in the first year of drought conditions (Year 3, Figure 9) are approximately 31 MGD mid-year (after the spring recharge) but then decrease to approximately 23 MGD in the fall and winter. By Year 7, the monthly withdrawal rate varies from approximately 20 MGD to 26-27 MGD. The percent reduction in simulated withdrawal rates for the total water rights withdrawals scenario range from 36.7% in Year 1 to 67% in Year 7 (Table 5). and the automatic reduction in pumping was activated for the 31 existing wells and 21 of the new wells (Table 6) , indicating a widespread reduction in saturated thickness in the North Well Field.

4-4 Extended Drought Climate Conditions Simulation Results

The model-calculated North Well Field withdrawals under the Extended Drought climate Condition are shown in Figure 10. Reductions in simulated withdrawals at the 50% average annual withdrawal rate (2016-2021) reach nearly 7% in Year 7 (Table 5).

The percent reduction in simulated withdrawal rates for the average annual (2016-2021) withdrawals scenario range from 5.9% in Year 1 to 47.6% in Year 7 (Table 5). The model-calculated monthly production from the existing wells under the average annual (2016-2021) withdrawals rate scenario during Year 7 are approximately 8 MGD. The automatic reduction in pumping was activated for 21 of the existing wells (Table 6).

In the total water rights withdrawals scenario, the model calculated monthly withdrawal rates in the first year of drought conditions (Year 3, Figure 9) are approximately 30 MGD mid-year (after the spring recharge), but then begin decreasing significantly in Year 4 to approximately 15 MGD and by the end of Year 7 the total water rights withdrawal rate is at 10 MGD. The percent reduction in simulated withdrawal rates for the total water rights withdrawals scenario range from 36.7% in Year 1 to 84.5% in Year 7 (Table 5), and the automatic reduction in pumping was activated for the 31 existing wells and the 22 new wells (Table 6).

4-5 Summary and Conclusions

The close match of the model-calculated withdrawals at the rate of the City's average annual withdrawals (2016 to 2021) under Normal conditions to the actual withdrawals suggests that the model reasonably represents the Big Sioux: Sioux Falls aquifer. The Drought Model results agree reasonably well with previous modeling efforts. For example, the USGS 1982 Model (Koch, 1982) indicated the City could likely pump 28.8 MGD from the Big Sioux: Sioux Falls aquifer under equilibrium conditions, which agrees reasonably well with the model-calculated total water rights withdrawals of approximately 35 MGD on an average annual basis under the Normal climate condition (Figure 7). The HDR 1990 Model (HDR, 1990) calculated average monthly City withdrawals from the extended well field of

9.2 MGD at the end of 2 years of no recharge, which agrees reasonably well with the Drought Model-calculated withdrawals of 10 MGD by Year 7 of the Extended Drought climate condition (Figure 10).

The total water rights withdrawal scenario is intended to simulate the long-term groundwater production capacity from the North Well Field assuming all of the City's available water rights from the Big Sioux: Sioux Falls aquifer are developed and brought online. The Drought Model simulations for the total water rights withdrawal rates from the 31 current wells and the 22 planned new wells indicate that significant reductions in well field production can be expected to occur within the first year of each of the four climate conditions, with production continuing to decrease throughout each consecutive year. At the end of the 7th year of the Extended Drought climate condition, the total well field production appears to flatten around 10 MGD. This indicates that even after several years of extended drought approximately 10 MGD may still be possible from the North Well Field assuming all the Airport water rights are successfully transferred to the North Well Field, and assuming new wells with a total production capacity during Normal climate conditions of approximately 31 MGD are constructed.

The USGS estimated amount of groundwater in storage in the Big Sioux: Sioux Falls aquifer is approximately 100,000 acre-feet (Koch, 1982). The City holds total water rights from the Big Sioux: Sioux Falls aquifer of 77,919 acre-feet (LRE, et. al., 2022), or approximately 78% of the total storage. The DANR is not accepting any further applications for groundwater permits from the Big Sioux: Sioux Falls aquifer. Assuming continued operation (with the required maintenance) of the City's 31 existing wells with the addition of the 22 new wells pumping at the rates shown in Table 4, the estimated maximum withdrawals from the North well field vary from a short-term maximum of 50 MGD under Normal conditions to a long-term maximum of 10 MGD under Extended Drought conditions. Increased groundwater withdrawals will be possible under wet or very wet conditions. Additionally, the construction and operation of managed aquifer recharge systems as described in the New Well Siting Plan (LRE, et. al., 2022) can increase the total well field withdrawals (except during the Drought or Extended Drought conditions).

Section 5: References Cited

City of Sioux Falls Water Division, 2020, City of Sioux Falls Water Division Technical Memorandum, Future Water Supply Needs, February 2015, Updated June 2020.

Davis, K.W., Eldridge, W.G., Valder, J.F., and Valseth, K.J., 2019. Groundwater-flow model and analysis of groundwater and surface-water interactions for the Big Sioux aquifer, Sioux Falls, South Dakota: U.G. Geological Survey Scientific Investigations Report 2019-5117, 86 p., https://doi.org/10.3133/sir20195117.

HDR, 1990. Big Sioux Aquifer Study; City of Sioux Falls, South Dakota, Part 1 Evaluation of Existing Well Field July 1990, and Part 2 Future Well Field Development February 1991, HDR Engineering, Inc. in association with: Layne Geosciences, Inc. and Stockwell Engineers, Inc.

Hedges, Lynn S., Burch, Stephen L., Iles, Derric L., Barari, Rachel A., and Schoon, Robert A, 1982. Evaluation of Ground-Water Resources Eastern South Dakota and Upper Big Sioux River, South Dakota and Iowa, Final Report, March 1982, prepared for Planning Division, U.S. Army Corps of Engineers, 215 N. 17th Street, Omaha, Nebraska, 68102.

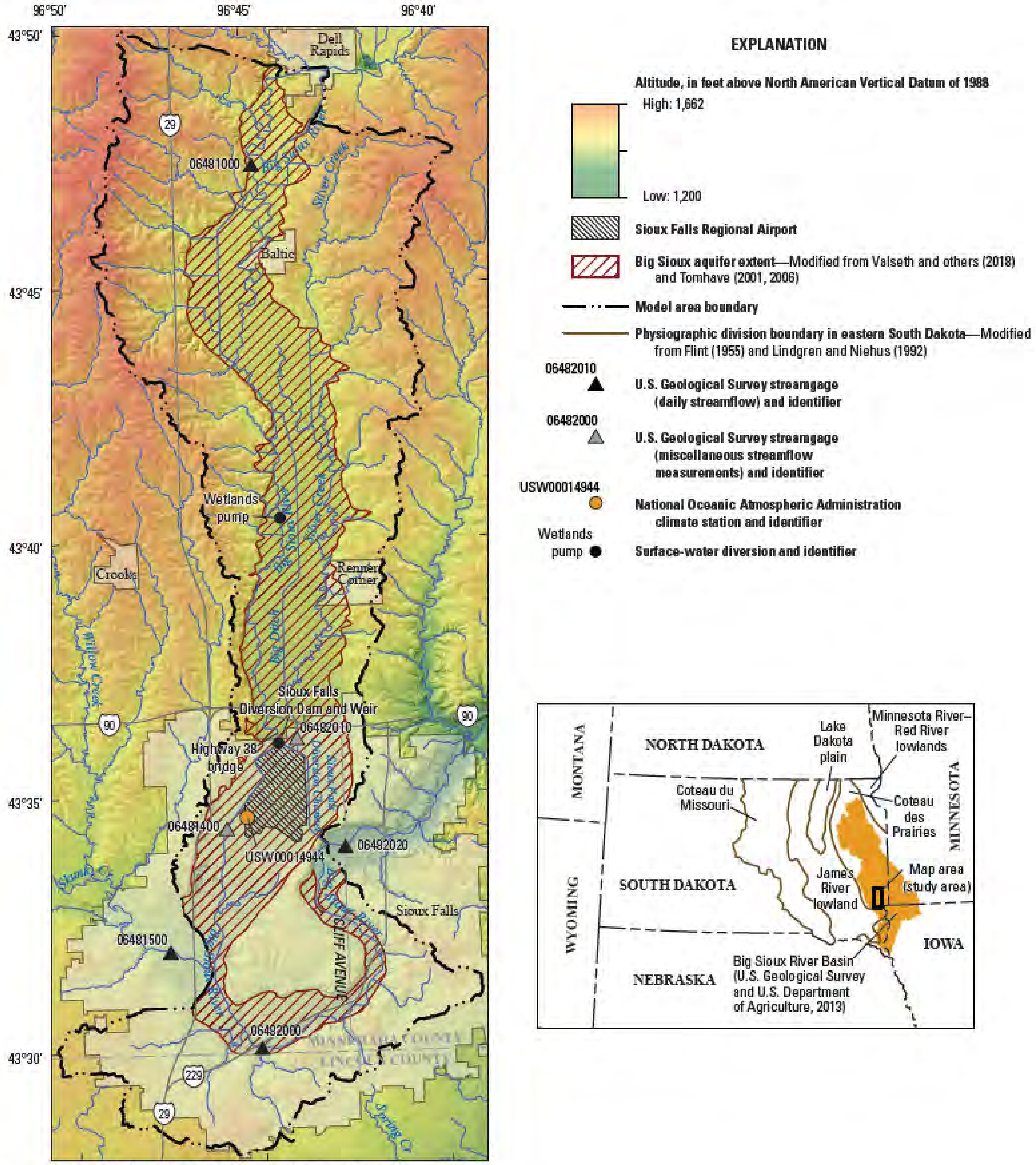
Koch, Neil C., 1982. A Digital-Computer Model of the Big Sioux Aquifer in Minnehaha County, South Dakota: U.S. Geological Survey Water-Resources Investigations Report 82-4064, 49 p.

LRE, HRG & Carollo, 2022. Water Rights Technical Memorandum, Water Purification Master Plan.

LRE, HRG & Carollo, 2022. Well Siting Plan Technical Memorandum, Water Purification Master Plan.

Valseth, K.J., Delzer, G.C., and Price, C.V., 2018, Delineation of the hydrogeologic framework of the Big Sioux aquifer near Sioux Falls, South Dakota, using airborne electromagnetic data: U.S. Geological Survey Scientific Investigations Map 3393, 2 sheets, accessed August 2018 at https://doi.org/10.3133/sim3393

Figures

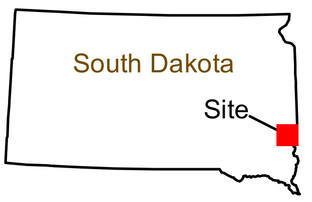


Base modified from U.S. Geological Survey digital data, various scales
Universal Transverse Mercator projection, zone 14 N.

Sources:

Service Layer Credits: Davis, K.W., Eldridge, W.G., Valder, J.F., and Valseth, K.J., 2019. Groundwater-flow model and analysis of groundwater and surface-water interactions for the Big Sioux aquifer, Sioux Falls, South Dakota: U.G. Geological Survey Scientific Investigations Report 2019-5117, 86 p., https://doi.org/10.3133/sir20195117.

In collaboration with:



CONNECTING WATER TO LIFE

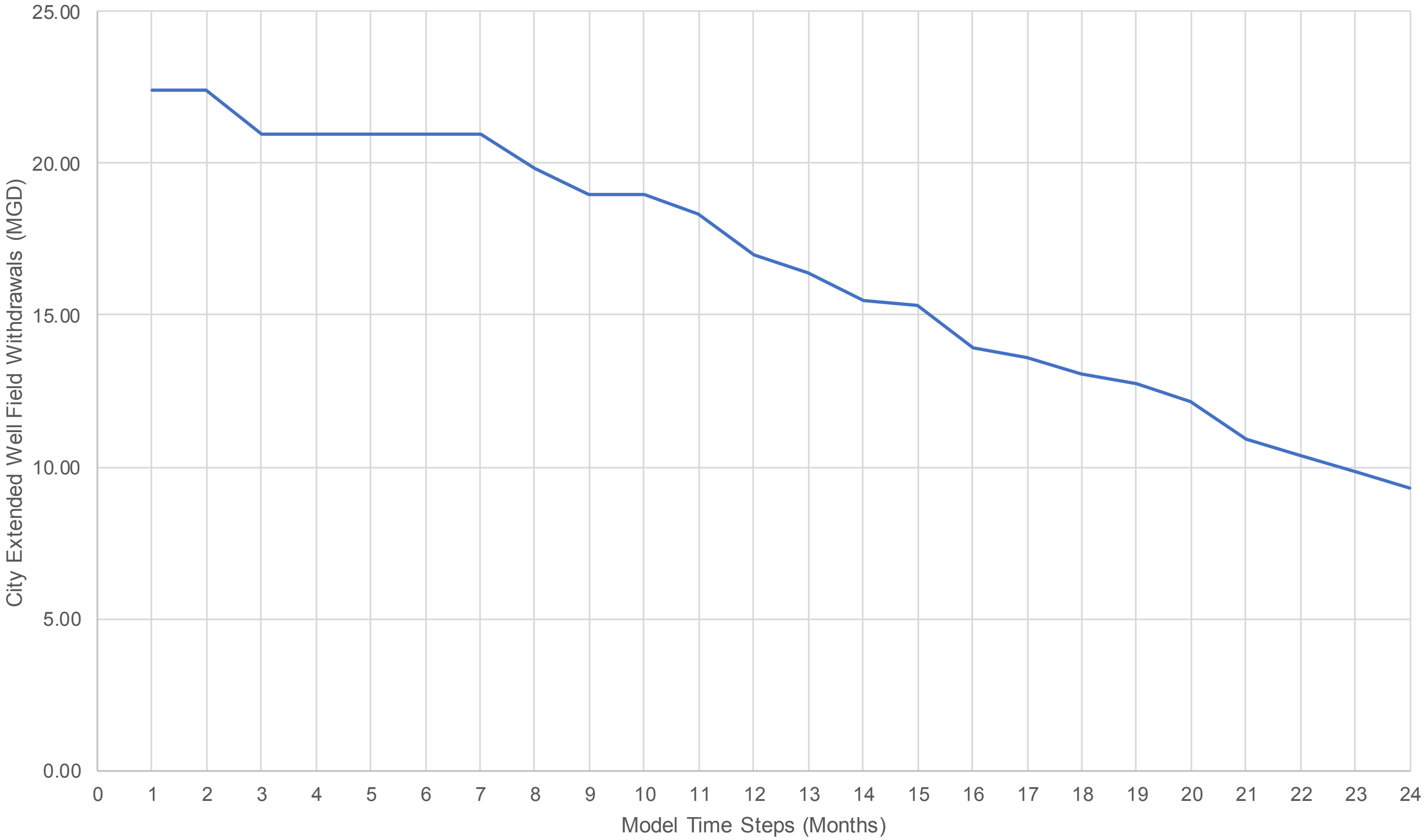
Prepared By:
LRE Water
South Dakota Office
Sioux Falls, South Dakota
(605) 310-1721

CITY OF SIOUX FALLS
DROUGHT MODEL REPORT
SIOUX FALLS, SOUTH DAKOTA

LOCATION OF MODEL AREA AND U.S. GEOLOGICAL SURVEY STREAM GAUGING STATIONS (MODIFIED FROM DAVIS, E. AL., 2019)

FILE:5507HRG0301m - Fig 1 Model Area.MXD	DATE: 8/17/2022	FIGURE: 1

C:\GIS\GIS\HR_Green_Sioux_Falls_SD_Master_Plan\maps\5507HRG0301m - Fig 1 Model Area.mxd, 8/17/2022, 12:52:14 PM, NAD 1983 BLM Zone 14N ftUS



In collaboration with:

Prepared By:
LRE Water
South Dakota Office
Sioux Falls, South Dakota
(605) 310-1721

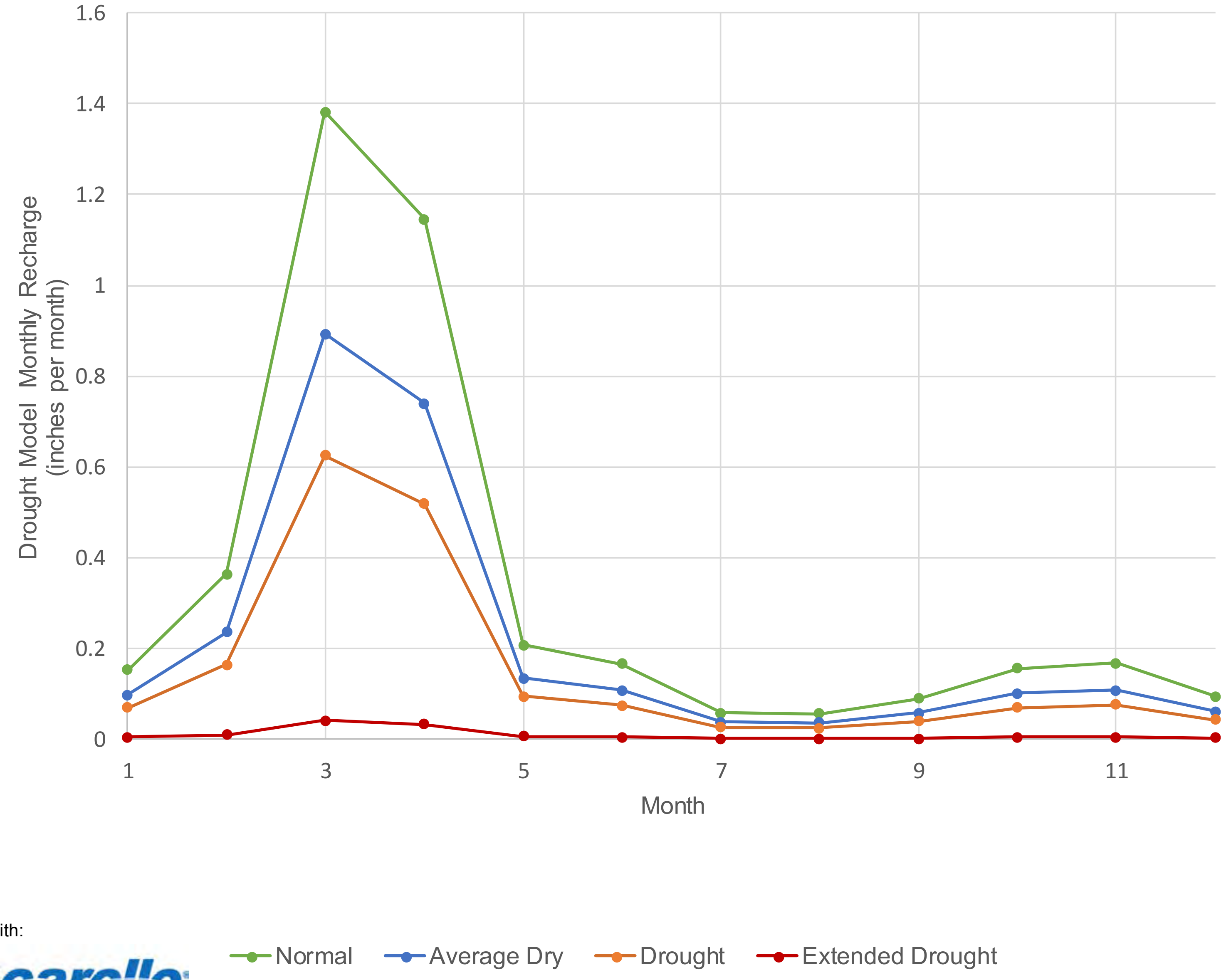
CITY OF SIOUX FALLS
DROUGHT MODEL REPORT
SIOUX FALLS, SOUTH DAKOTA

HDR 1990 MODEL SIMULATED CITY WELL FIELD
WITHDRAWALS UNDER EXTREME DRY CONDITIONS

FILE: 5507HRG0301n - Fig 2 Model Withdrawals.MXD
DATE: 8/18/2022
FIGURE: 2

C:\GIS\GIS\HR Green Sioux Falls SD Master Plan\maps\5507HRG0301n - Fig 2 Model Withdrawals.mxd, 8/18/2022, 11:33:13 AM, NAD 1983 UTM Zone 15N

C:\GIS\GIS\HR Green Sioux Falls SD Master Plan\maps\5507HRG0301o - Fig 3 Precip Rchrg.mxd, 8/18/2022, 11:34:21 AM, NAD 1983 UTM Zone 15N



In collaboration with:

HRGreen. carollo

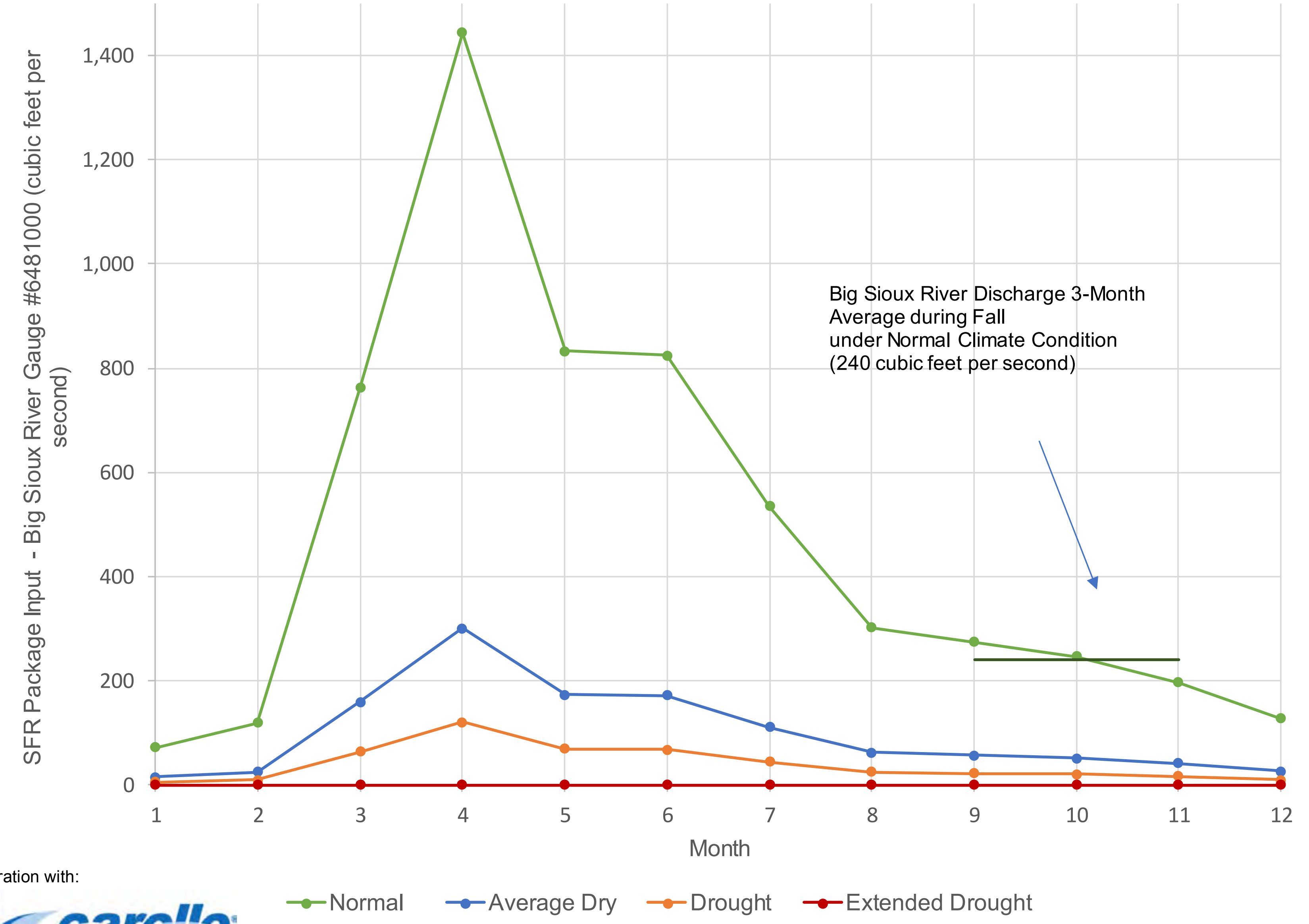
LRE WATER
CONNECTING WATER TO LIFE

Prepared By:
LRE Water
South Dakota Office
Sioux Falls, South Dakota
(605) 310-1721

CITY OF SIOUX FALLS
DROUGHT MODEL REPORT
SIOUX FALLS, SOUTH DAKOTA

DROUGHT MODEL PRECIPITATION RECHARGE
FOR FOUR CLIMATE CONDITIONS

FILE: 5507HRG0301o - Fig 3 Precip Rchrg.MXD	DATE: 8/18/2022	FIGURE: 3



Big Sioux River Discharge 3-Month
Average during Fall
under Normal Climate Condition
(240 cubic feet per second)

In collaboration with:

CONNECTING WATER TO LIFE

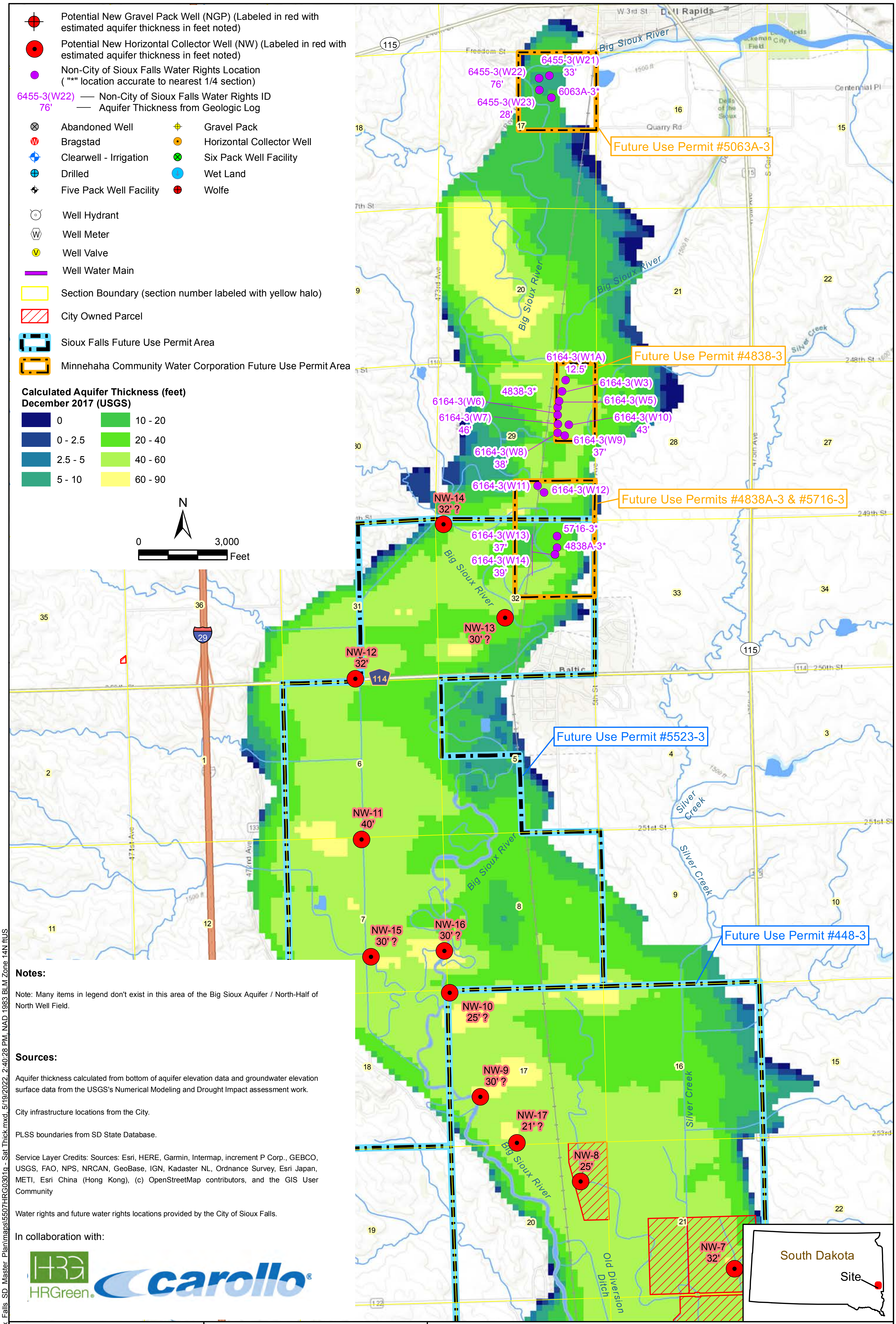
Prepared By:
LRE Water
South Dakota Office
Sioux Falls, South Dakota
(605) 310-1721

CITY OF SIOUX FALLS
DROUGHT MODEL REPORT
SIOUX FALLS, SOUTH DAKOTA

DROUGHT MODEL SFR PACKAGE INPUT FOR BIG SIOUX RIVER USGS GAUGING STATION #06481000 NEAR DELL RAPIDS

FILE: 5507HRG0301p - Fig 4 SFR Pckg.MXD | DATE: 8/18/2022 | FIGURE: 4

C:\GIS\GIS\HR_Green_Sioux_Falls_SD_Master_Plan\maps\5507HRG0301p - Fig 4 SFR Pckg.mxd, 8/18/2022, 11:35:21 AM, NAD 1983 UTM Zone 15N



Potential New Gravel Pack Well (NGP) (Labeled in red with estimated aquifer thickness in feet noted)

● Potential New Horizontal Collector Well (NW) (Labeled in red with estimated aquifer thickness in feet noted)

● Non-City of Sioux Falls Water Rights Location ("*" location accurate to nearest 1/4 section)

6455-3(W22) — Non-City of Sioux Falls Water Rights ID
76' — Aquifer Thickness from Geologic Log

⊗ Abandoned Well
Bragstad
Clearwell - Irrigation
⊕ Drilled
Five Pack Well Facility
Gravel Pack
Horizontal Collector Well
⊗ Six Pack Well Facility
● Wet Land
Wolfe

Well Hydrant
W Well Meter
V Well Valve
Well Water Main

☐ Section Boundary (section number labeled with yellow halo)

▨ City Owned Parcel

Sioux Falls Future Use Permit Area

Minnehaha Community Water Corporation Future Use Permit Area

Calculated Aquifer Thickness (feet)
December 2017 (USGS)

🟦	0	🟩	10 - 20
🟦	0 - 2.5	🟩	20 - 40
🟦	2.5 - 5	🟩	40 - 60
🟩	5 - 10	🟨	60 - 90

Notes:

Note: Many items in legend don't exist in this area of the Big Sioux Aquifer / North-Half of North Well Field.

Sources:

Aquifer thickness calculated from bottom of aquifer elevation data and groundwater elevation surface data from the USGS's Numerical Modeling and Drought Impact assessment work.

City infrastructure locations from the City.

PLSS boundaries from SD State Database.

Service Layer Credits: Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community

Water rights and future water rights locations provided by the City of Sioux Falls.

In collaboration with:

HRGreen. carollo

C:\GIS\GIS\HR_Green_Sioux_Falls_SD_Master_Plan\maps\5507HRG0301g - Sat Thick.mxd, 5/19/2022, 2:40:28 PM, NAD 1983 BLM Zone 14N ftUS

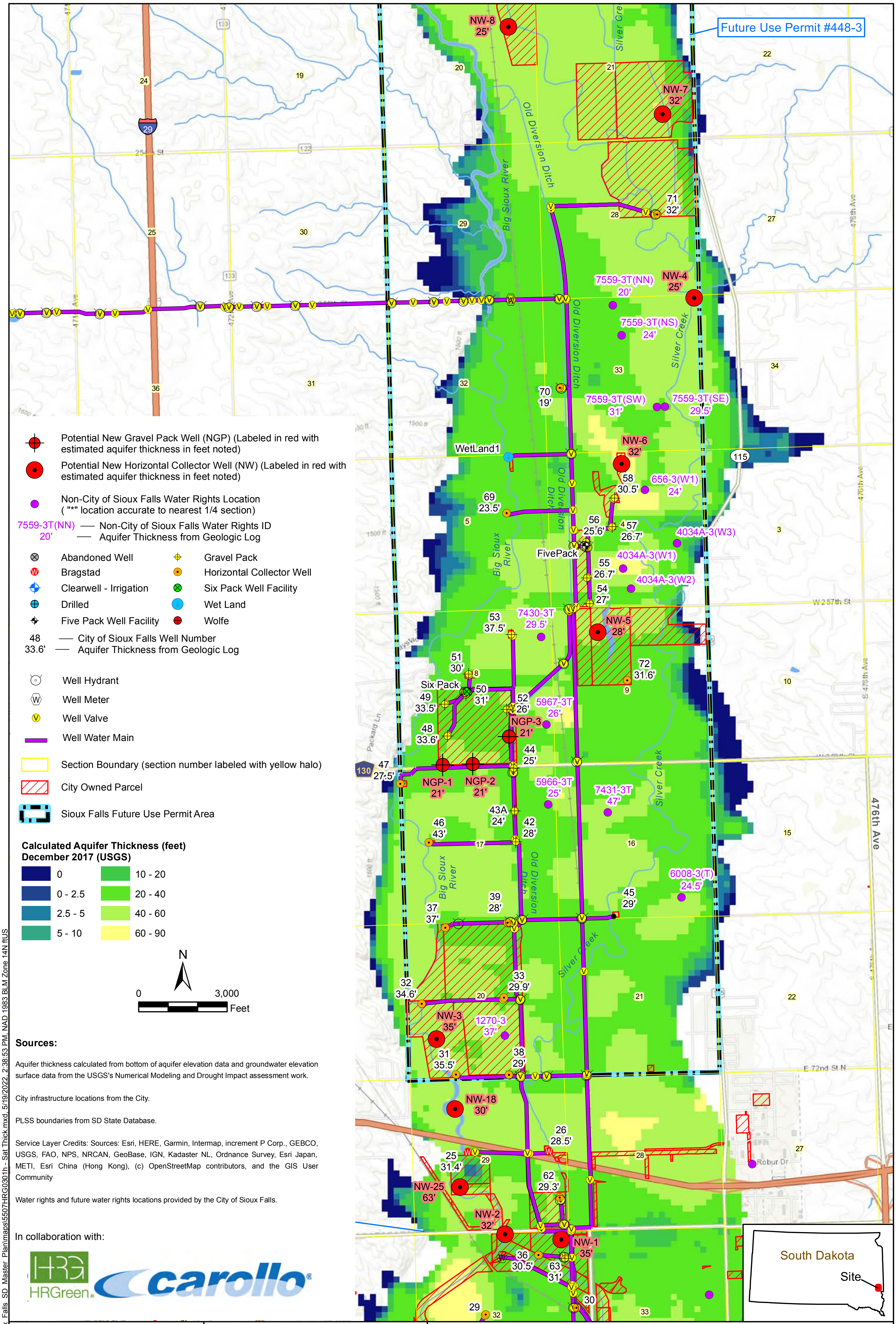
LRE WATER
CONNECTING WATER TO LIFE

Prepared By:
LRE Water
Innovative Water Resource Solutions
South Dakota Office
Sioux Falls, South Dakota
(605) 310-1721

CITY OF SIOUX FALLS
WATER PURIFICATION MASTER PLAN
SIOUX FALLS, SOUTH DAKOTA

POTENTIAL NEW WELL LOCATIONS AND
SATURATED THICKNESS (NORTH-HALF OF NORTH WELL FIELD)

FILE:5507HRG0301g - Sat Thick.MXD | DATE: 5/19/2022 | FIGURE: 5



- ⊕ Potential New Gravel Pack Well (NGP) (Labeled in red with estimated aquifer thickness in feet noted)
- ● Potential New Horizontal Collector Well (NW) (Labeled in red with estimated aquifer thickness in feet noted)
- ● Non-City of Sioux Falls Water Rights Location ("*" location accurate to nearest 1/4 section)

7559-3T(NN) — Non-City of Sioux Falls Water Rights ID
20' — Aquifer Thickness from Geologic Log

⊗	Abandoned Well	⊕	Gravel Pack
Ⓦ	Bragstad	⊙	Horizontal Collector Well
⊕	Clearwell - Irrigation	⊗	Six Pack Well Facility
⊕	Drilled	●	Wet Land
✦	Five Pack Well Facility	⊕	Wolfe

48 — City of Sioux Falls Well Number
33.6' — Aquifer Thickness from Geologic Log

- ⊙ Well Hydrant
- Ⓦ Well Meter
- Ⓥ Well Valve
- — Well Water Main
- ☐ Section Boundary (section number labeled with yellow halo)
- ▨ City Owned Parcel
- ▭ Sioux Falls Future Use Permit Area

Calculated Aquifer Thickness (feet)
December 2017 (USGS)

■	0	■	10 - 20
■	0 - 2.5	■	20 - 40
■	2.5 - 5	■	40 - 60
■	5 - 10	■	60 - 90

Sources:

Aquifer thickness calculated from bottom of aquifer elevation data and groundwater elevation surface data from the USGS's Numerical Modeling and Drought Impact assessment work.

City infrastructure locations from the City.

PLSS boundaries from SD State Database.

Service Layer Credits: Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community

Water rights and future water rights locations provided by the City of Sioux Falls.

In collaboration with:

HRGreen. carollo

C:\GIS\GIS\HR_Green_Sioux_Falls_SD_Master_Plan\maps\5507HRG0301h - Sat Thick.mxd, 5/19/2022, 2:38:53 PM, NAD 1983 BLM Zone 14N ftUS

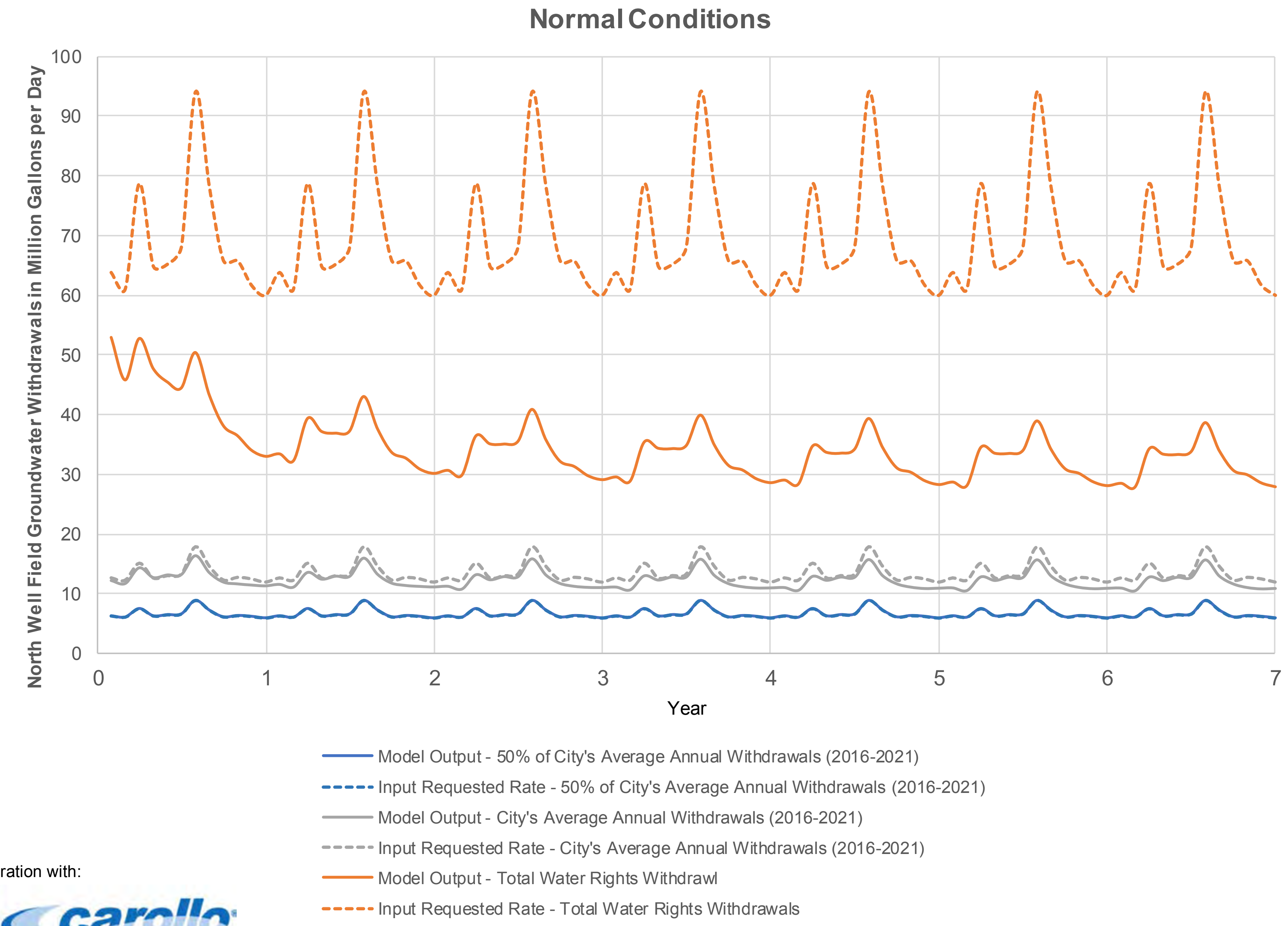
LRE WATER
CONNECTING WATER TO LIFE

Prepared By:
LRE Water
Innovative Water Resource Solutions
South Dakota Office
Sioux Falls, South Dakota
(605) 310-1721

CITY OF SIOUX FALLS
WATER PURIFICATION MASTER PLAN
SIOUX FALLS, SOUTH DAKOTA

POTENTIAL NEW WELL LOCATIONS AND
SATURATED THICKNESS (SOUTH-HALF OF NORTH WELL FIELD)

FILE:5507HRG0301h - Sat Thick.MXD | DATE: 5/19/2022 | FIGURE: 6



In collaboration with:

Prepared By:
LRE Water

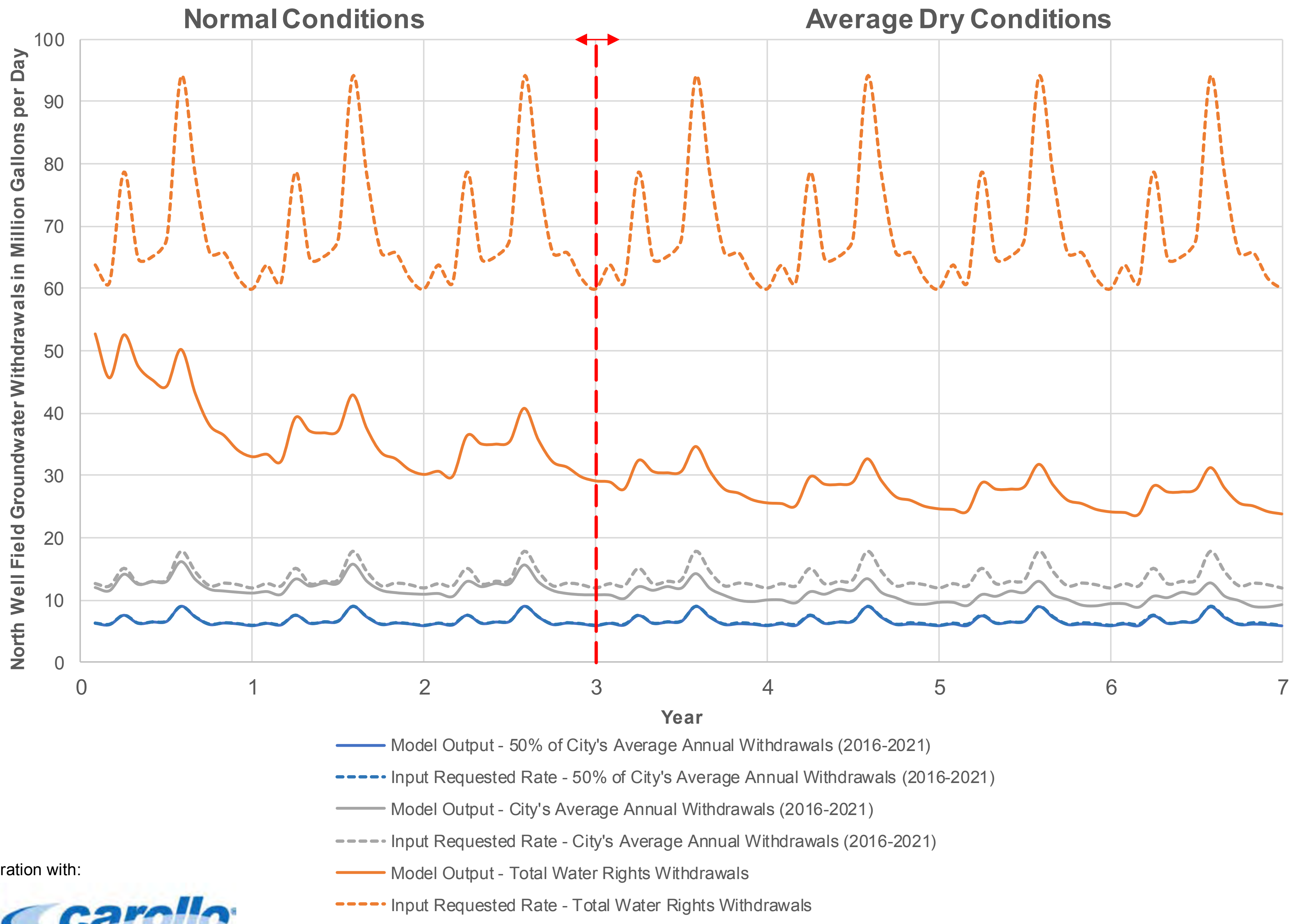
South Dakota Office
Sioux Falls, South Dakota
(605) 310-1721

CITY OF SIOUX FALLS
DROUGHT MODEL REPORT
SIOUX FALLS, SOUTH DAKOTA

DROUGHT MODEL SIMULATED GROUNDWATER WITHDRAWALS
NORMAL CLIMATE CONDITIONS

FILE: 5507HRG0301q - Fig 7.MXD
DATE: 8/18/2022
FIGURE: 7

C:\GIS\GIS\HR_Green_Sioux_Falls_SD_Master_Plan\maps\5507HRG0301q - Fig 7.mxd, 8/18/2022, 10:51:41 AM, NAD 1983 UTM Zone 15N



In collaboration with:

HRGreen. carollo

LRE WATER
CONNECTING WATER TO LIFE

Prepared By:
LRE Water

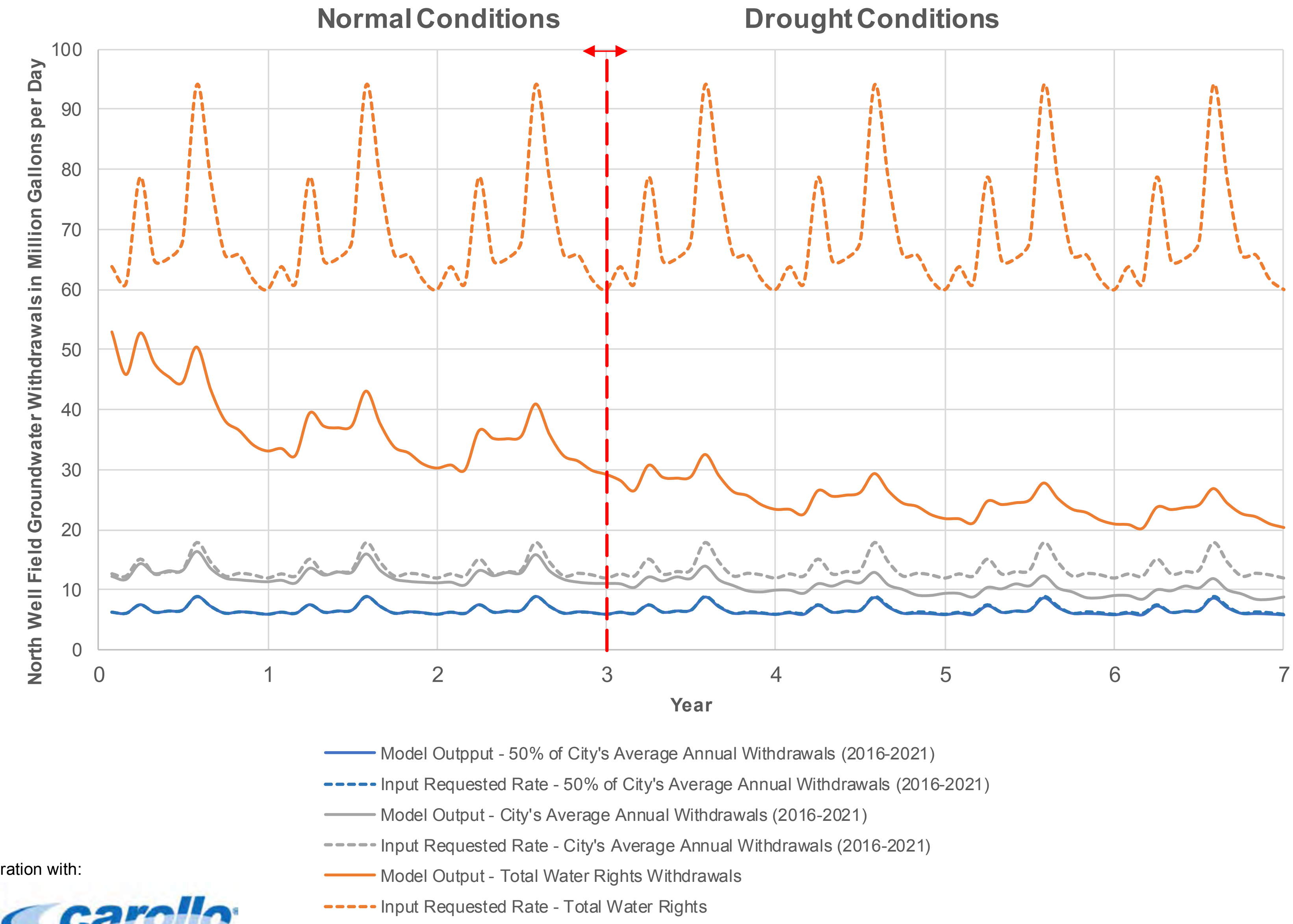
South Dakota Office
Sioux Falls, South Dakota
(605) 310-1721

CITY OF SIOUX FALLS
DROUGHT MODEL REPORT
SIOUX FALLS, SOUTH DAKOTA

DROUGHT MODEL SIMULATED GROUNDWATER WITHDRAWALS
AVERAGE DRY CONDITIONS

FILE: 5507HRG0301r - Fig 8.MXD	DATE: 8/18/2022	FIGURE: 8

C:\GIS\GIS\HR Green Sioux Falls SD Master Plan\maps\5507HRG0301r - Fig 8.mxd, 8/18/2022, 10:53:57 AM, NAD 1983 UTM Zone 15N



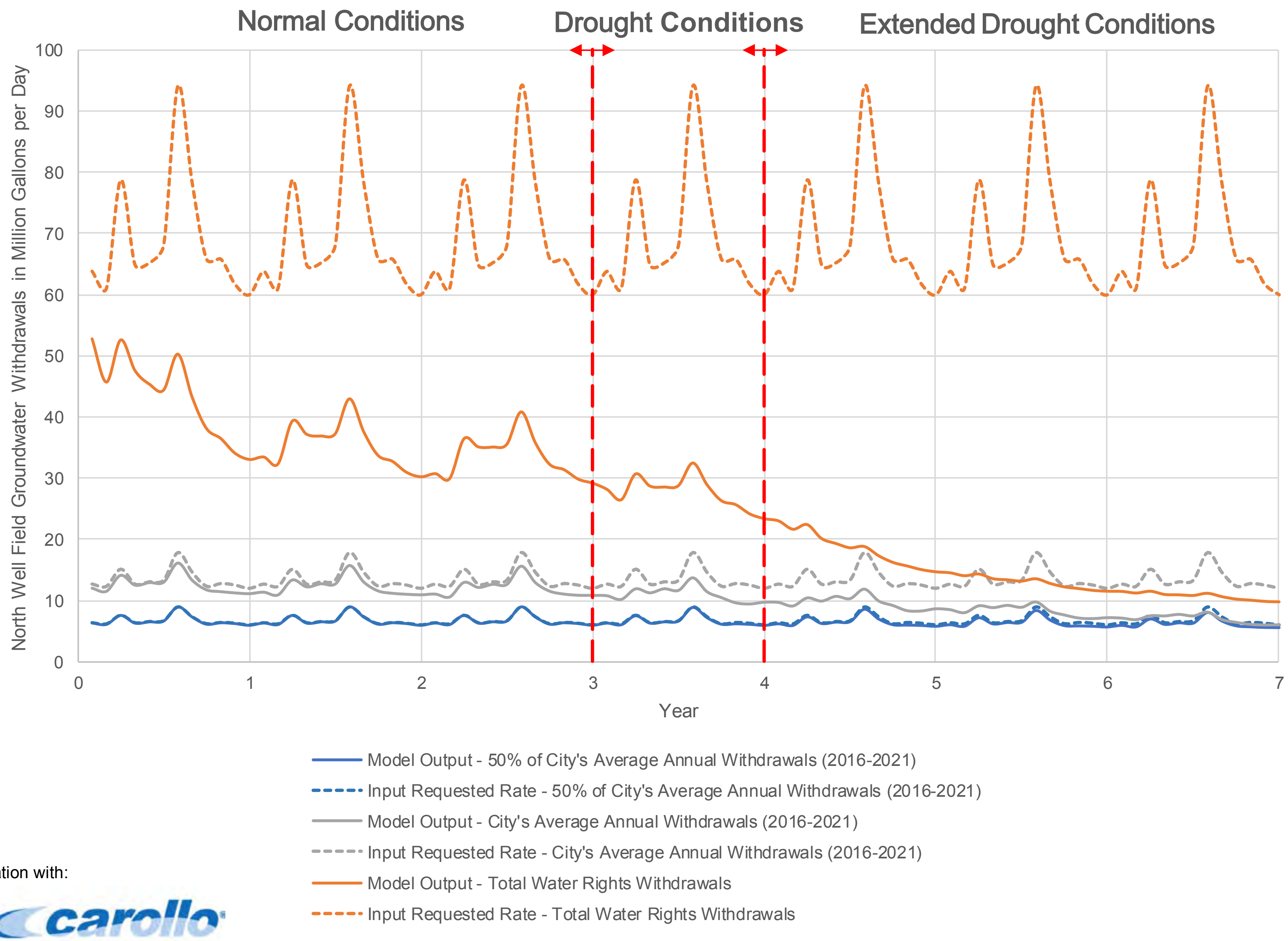
In collaboration with:

Prepared By:
LRE Water
South Dakota Office
Sioux Falls, South Dakota
(605) 310-1721

CITY OF SIOUX FALLS
DROUGHT MODEL REPORT
SIOUX FALLS, SOUTH DAKOTA
DROUGHT MODEL SIMULATED GROUNDWATER WITHDRAWALS
DROUGHT CONDITIONS

FILE: 5507HRG0301s - Fig 9.MXD	DATE: 8/18/2022	FIGURE: 9

C:\GIS\GIS\HR_Green_Sioux_Falls_SD_Master_Plan\maps\5507HRG0301s - Fig 9.mxd, 8/18/2022, 10:54:44 AM, NAD 1983 UTM Zone 15N



In collaboration with:

HRGreen. carollo

LRE WATER
CONNECTING WATER TO LIFE

Prepared By:
LRE Water

South Dakota Office
Sioux Falls, South Dakota
(605) 310-1721

CITY OF SIOUX FALLS
DROUGHT MODEL REPORT
SIOUX FALLS, SOUTH DAKOTA

DROUGHT MODEL SIMULATED GROUNDWATER WITHDRAWALS
EXTENDED DROUGHT CONDITIONS

FILE: 5507HRG0301t - Fig 10.MXD | DATE: 8/18/2022 | FIGURE: 10

C:\GIS\GIS\HR Green Sioux Falls SD Master Plan\maps\5507HRG0301t - Fig 10.mxd, 8/18/2022, 10:55:32 AM, NAD 1983 UTM Zone 15N

Tables

Table 1. Summary of HDR 1990 Model Results

Climate Scenario	Simulated Period	Simulated Annual Precipitation (inches)	Extended Wellfield Withdrawals (MGD)	Total Aquifer Withdrawals (MGD)	Comment
Average Normal	12 months	~24	22	22.4	Maximum average yearly withdrawal was evaluated such that net change in storage was approximately zero (steady state).
Average Dry	12 months	~20 (80% of normal)	14.6	15	Net change in storage for the four season simulation period remained at or near zero (steady state).
Extreme Dry	24 months	none	9.3 (see Figure 2)		Withdrawals shown are for month 24.

Note:
Climate scenarios in HDR 1990 Model differ from the four climate conditions in the Drought Model.
MGD - million gallons per day
~ - approximately
No withdrawals associated with Minnehaha Community Water Corporation

Table 2. Climate Conditions Summary

Climate Condition	Drought Model Recharge	Approximate Corresponding Precipitation[1]	Mean Monthly Big Sioux River Flow in Fall Months (Sep/Oct/Nov)	Comments From Future Water Supply Needs Technical Memorandum (February 2015/June 2020)
	(inches per year)	(inches per year)	(cfs)	
Normal	4.04	26.75	240	Groundwater withdrawals up to "maximum rated capacity"
Average Dry	2.61	22.27	50	"Reduced utilization of groundwater sources"
Drought	1.83	16.87	20	Surface water not available. Groundwater withdrawals "reduced to average annual yield."
Extended Drought	0.12	1.10	0	Surface water not available. Groundwater withdrawals "reduced to 50% of average annual yield."

Notes: Future Water Supply Needs Technical Memorandum (Water Purification Plant, June 2020)

cfs - cubic feet per second

Big Sioux River flow as measured at the United States Gauging Station near Dell Rapids (Site Number 06481000)

1 - Based on the "Binning" process for categorizing precipitation and model recharge to each climate condition

Table 3. Simulated Groundwater Withdrawal Rates from Existing Wells

Existing Wells	Water Right Annual Maximum	Water Right Annual Maximum	Water Right Annual Maximum	Average Annual Yield	Average Annual Yield	Average Annual Yield	50% Average Annual Yield	50% Average Annual Yield	50% Average Annual Yield
Well #	**(ac-ft/yr)**	**(MGD)**	**(gpm)**	**(ac-ft/yr)**	**(MGD)**	**(gpm)**	**(ac-ft/yr)**	**(MGD)**	**(gpm)**
25	1447.93	1.29	895.83	22.99	0.02	14.25	11.49	0.01	7.13
26	1288.66	1.15	798.61	83.36	0.07	51.68	41.68	0.04	25.84
31	2978.00	2.66	1847.22	1204.54	1.08	746.68	602.27	0.54	373.34
32	2978.00	2.66	1847.22	1075.12	0.96	666.45	537.56	0.48	333.23
33	2258.78	2.02	1402.78	161.48	0.14	100.10	80.74	0.07	50.05
36	2244.30	2.00	1388.89	767.54	0.69	475.79	383.77	0.34	237.89
37	2244.30	2.00	1388.89	1022.38	0.91	633.76	511.19	0.46	316.88
38	2244.30	2.00	1388.89	542.56	0.48	336.32	271.28	0.24	168.16
39	2244.30	2.00	1388.89	941.20	0.84	583.44	470.60	0.42	291.72
42	723.97	0.65	451.39	166.39	0.15	103.14	83.19	0.07	51.57
43A	723.97	0.65	451.39	9.45	0.01	5.86	4.73	0.00	2.93
44	723.97	0.65	451.39	103.22	0.09	63.99	51.61	0.05	31.99
46	2903.11	2.59	1798.61	840.84	0.75	521.23	420.42	0.38	260.61
47	1932.99	1.73	1201.39	670.32	0.60	415.52	335.16	0.30	207.76
48	228.00	0.20	141.67	340.45	0.30	211.04	170.23	0.15	105.52
49*	228.00	0.20	141.67	168.73	0.15	104.59	84.36	0.08	52.30
50	228.00	0.20	141.67	280.43	0.25	173.84	140.22	0.13	86.92
51	228.00	0.20	141.67	81.42	0.07	50.47	40.71	0.04	25.23
52	228.00	0.20	141.67	141.34	0.13	87.62	70.67	0.06	43.81
53	266.67	0.24	165.51	135.65	0.12	84.08	67.82	0.06	42.04
54	266.67	0.24	165.51	139.27	0.12	86.33	69.64	0.06	43.17
55	266.67	0.24	165.51	104.44	0.09	64.74	52.22	0.05	32.37
56	266.67	0.24	165.51	176.96	0.16	109.69	88.48	0.08	54.85
57	266.67	0.24	165.51	127.44	0.11	79.00	63.72	0.06	39.50
58**	266.67	0.24	165.51	113.96	0.10	70.64	56.98	0.05	35.32
62	3247.00	2.90	2013.89	1160.53	1.04	719.39	580.26	0.52	359.70
63	833.67	0.74	513.89	92.95	0.08	57.62	46.48	0.04	28.81
69	2988.00	2.67	1854.17	1373.61	1.23	851.48	686.80	0.61	425.74
70	1193.00	1.07	743.06	728.19	0.65	451.39	364.09	0.33	225.70
71	1853.00	1.66	1152.78	1416.39	1.26	878.00	708.19	0.63	439.00
72	2600.00	2.32	1611.11	921.44	0.82	571.19	460.72	0.41	285.60
Totals	**42,391.23**	**37.86**	**26,292**	**15,114.60**	**13.50**	**9,369**	**7,557.30**	**6.75**	**4,685**

Notes:

Average annual yield based on actual pumping data from 2016 to 2021

* Simulated average annual yield (AAY) is the average single well AAY based on total AAY for the 5-Pack wells (#48 through #52)

** Simulated average annual yield (AAY) is the average single well AAY based on total AAY for the 6-Pack wells (#53 through #58)

ac-ft/yr - acre-feet per year
MGD - million gallons per day
gpm - gallons per minute

Table 4. Simulated Groundwater Withdrawal Rates from New Wells

New Wells	Estimated Saturated Thickness from Well Log Data	Simulated Withdrawal Rate	Simulated Withdrawal Rate	Simulated Withdrawal Rate
Well #	**(feet)**	**(ac-ft/yr)**	**(MGD)**	**(gpm)**
NGP-1	21	645.28	0.58	400.00
NGP-2	21	645.28	0.58	400.00
NGP-3	21	645.28	0.58	400.00
NW-1	35	1,774.52	1.58	1,100.00
NW-2	32	1,774.52	1.58	1,100.00
NW-3	35	1,774.52	1.58	1,100.00
NW-4	32	1,451.88	1.30	900.00
NW-5	28	1,451.88	1.30	900.00
NW-6	26	1,451.88	1.30	900.00
NW-7	32	1,451.88	1.30	900.00
NW-8	25	1,451.88	1.30	900.00
NW-9	30	1,935.84	1.73	1,200.00
NW-10	25	1,935.84	1.73	1,200.00
NW-11	40	1,613.20	1.44	1,000.00
NW-12	32	1,613.20	1.44	1,000.00
NW-13	30	1,935.84	1.73	1,200.00
NW-14	32	1,935.84	1.73	1,200.00
NW-15	30	1,613.20	1.44	1,000.00
NW-16	30	1,935.84	1.73	1,200.00
NW-17	21	1,613.20	1.44	1,000.00
NW-18	30	1,935.84	1.73	1,200.00
NW-25	63	2,258.48	2.02	1,400.00
Total Simulated Withdrawals		**34,845.12**	**31.10**	**21,600**

Notes:

ac-ft/yr = acre feet per year
MGD = million gallons per day
gpm = gallons per minute

Well log data from DANR water well completion report & lithologic log databases.
DANR - South Dakota Department of Agriculture & Natural Resources
NGP - new gravel pack well
NW - new horizontal collector well

Table 5. Percent Reduction of Requested Groundwater Withdrawals

Withdrawal Rates	**Climate Condition/ Year**	**1**	**2**	**3**	**4**	**5**	**6**	**7**
50% of Average Annual Withdrawals (2016-2021)	Normal	0.0%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%
	Average Dry	0.0%	0.1%	0.1%	0.4%	0.7%	0.9%	1.0%
	Drought	0.0%	0.1%	0.1%	0.8%	1.6%	2.2%	2.5%
	Extended Drought	0.0%	0.1%	0.1%	0.8%	3.0%	4.9%	6.9%
Average Annual Withdrawals (2016-2021)	Normal	5.9%	8.6%	9.8%	10.4%	10.8%	11.1%	11.2%
	Average Dry	5.9%	8.6%	9.8%	15.6%	19.8%	22.4%	23.9%
	Drought	5.9%	8.6%	9.8%	17.7%	23.7%	27.3%	29.8%
	Extended Drought	5.9%	8.6%	9.8%	17.7%	27.4%	37.8%	47.6%
Total Water Rights Withdrawals	Normal	36.7%	48.7%	51.4%	52.5%	53.3%	53.6%	53.9%
	Average Dry	36.7%	48.7%	51.4%	57.3%	60.0%	61.0%	61.7%
	Drought	36.7%	48.7%	51.4%	59.9%	64.0%	65.8%	67.0%
	Extended Drought	36.7%	48.7%	51.4%	59.9%	73.1%	81.1%	84.5%

Table 6. Wells for which Simulated Withdrawal Rates were Reduced by Drought Model Automatic Flow Reduction for Four Climate Conditions and Three Withdrawal Rates

Normal Climate Condition				Average Dry Climate Condition				Drought Condition				Extended Drought Condition			
50% of AAW	**AAW**	**Total Water Rights (Existing Wells)**	**Total Water Rights (New Wells)**	**50% of AAW**	**AAW**	**Total Water Rights (Existing Wells)**	**Total Water Rights (New Wells)**	**50% of AAW**	**AAW**	**Total Water Rights (Existing Wells)**	**Total Water Rights (New Wells)**	**50% of AAW**	**AAW**	**Total Water Rights (Existing Wells)**	**Total Water Rights (New Wells)**
Well #47	Well #31	Well #25	NGP-1	Well #47	Well #31	Well #25	NGP-1	Well #47	Well #31	Well #25	NGP-1	Well #31	Well #25	Well #25	NGP-1
Well #69	Well #37	Well #26	NGP-2	Well #69	Well #32	Well #26	NGP-2	Well #69	Well #32	Well #26	NGP-2	Well #37	Well #31	Well #26	NGP-2
	Well #39	Well #31	NGP-3	Well #70	Well #37	Well #31	NGP-3	Well #70	Well #37	Well #31	NGP-3	Well #46	Well #32	Well #31	NGP-3
	Well #46	Well #32	NW-1		Well #39	Well #32	NW-1		Well #38	Well #32	NW-1	Well #47	Well #36	Well #32	NW-1
	Well #47	Well #33	NW-2		Well #46	Well #33	NW-2		Well #39	Well #33	NW-2	Well #69	Well #37	Well #33	NW-2
	Well #69	Well #36	NW-3		Well #47	Well #36	NW-3		Well #46	Well #36	NW-3	Well #70	Well #38	Well #36	NW-3
	Well #70	Well #37	NW-4		Well #69	Well #37	NW-4		Well #47	Well #37	NW-4	Well #72	Well #39	Well #37	NW-4
	Well #72	Well #38	NW-5		Well #70	Well #38	NW-5		Well #50	Well #38	NW-5		Well #42	Well #38	NW-5
		Well #39	NW-7		Well #71	Well #39	NW-7		Well #62	Well #39	NW-7		Well #44	Well #39	NW-7
		Well #42	NW-8		Well #72	Well #42	NW-8		Well #69	Well #42	NW-8		Well #46	Well #42	NW-8
		Well #43	NW-9			Well #43	NW-9		Well #70	Well #43	NW-9		Well #47	Well #43	NW-9
		Well #44	NW-11			Well #44	NW-11		Well #71	Well #44	NW-11		Well #48	Well #44	NW-10
		Well #46	NW-12			Well #46	NW-12		Well #72	Well #46	NW-12		Well #49	Well #46	NW-11
		Well #47	NW-13			Well #47	NW-13			Well #47	NW-13		Well #50	Well #47	NW-12
		Well #48	NW-14			Well #48	NW-14			Well #48	NW-14		Well #52	Well #48	NW-13
		Well #49	NW-15			Well #49	NW-15			Well #49	NW-15		Well #62	Well #49	NW-14
		Well #50	NW-6			Well #50	NW-6			Well #50	NW-16		Well #63	Well #50	NW-15
		Well #51	NW-25			Well #51	NW-25			Well #51	NW-17		Well #69	Well #51	NW-16
		Well #52				Well #52				Well #52	NW-18		Well #70	Well #52	NW-17
		Well #54				Well #54				Well #53	NW-6		Well #71	Well #53	NW-18
		Well #57				Well #57				Well #54	NW-25		Well #72	Well #54	NW-6
		Well #62				Well #62				Well #55				Well #55	NW-25
		Well #63				Well #63				Well #56				Well #56	
		Well #69				Well #69				Well #57				Well #57	
		Well #70				Well #70				Well #58				Well #58	
		Well #71				Well #71				Well #62				Well #62	
		Well #72				Well #72				Well #63				Well #63	
										Well #69				Well #69	
										Well #70				Well #70	
										Well #71				Well #71	
										Well #72				Well #72	

Notes:
AAW = Average Annual Withdrawals by City (2016-2021)

Technical Memorandum

Water Supply and Treatment Master Plan

Chapter 5:

Water Transmission Mains

November 2022

(Revised: September 2023)

HR Green Project No: 210506

Prepared For:

CITY OF
SIOUX FALLS

Table of Contents

List of Figures

List of Tables

Appendices

Section 1: Background

The City of Sioux Falls has an extensive well field which is made up of Bragstad, Collector, Wolfe, and Gravel Pack wells. The majority of the Bragstad and Wolfe wells are located in and near the Sioux Falls Regional Airport and have been impacted by PFAS. The City has previously performed transmission main modeling for the well field to analyze the capacity and reliability of the existing transmission mains. This technical memorandum (tech memo) further analyzes the existing and prior proposed transmission main improvements based on the anticipated rate of existing wells and proposed new wells. Evaluation of the well field transmission mains and individual well lateral mains operated on the assumption that the airport wells impacted by PFAS would no longer be operated. When determining the proposed improvements, they were based on the 10-, 20-, 50-, and 100-year planning periods which requires peak day water production from the WPP of 37.6 MGD, 49.8 MGD, 56.7 MGD, and 94.1 MGD, respectfully. The peak day water production values do not factor in water restriction reductions.

Section 2: Evaluation of Prior Transmission Main Improvements

HDR's previous tech memo, Raw Water Transmission Improvements dated January 7, 2022, evaluated the well field transmission mains based on the best available data at the time. Additional data was acquired for the evaluation performed with HR Green's tech memo. This additional data impacts some of the prior recommendations made by HDR as described below. HR Green utilized the same basic well field infrastructure data points used by HDR in the prior tech memo. However, several infrastructure data points were updated with well field pipe material along with historical withdrawal rates, proposed wells, reconditioned wells, and new improvements as outlined in this tech memo. The hydraulic modeling software used by HR Green is Bentley's WaterGEMS CONNECT Edition. Lastly, HDR's model evaluated well field flows of up to 75 MGD; however, the 100-year planning period now has an estimated peak day demand need of 94.1 MGD from the WPP (i.e. the well field and the River Pump Station). The hydraulic modeling was completed to error on the conservative side of well field flows is an assumed peak day withdrawal rate of 73.0 MGD. The peak day withdrawal rate assumed that each of the wells within the well field would operate at their assumed peak withdrawal rates (not to be confused with the permitted withdrawal rate) with all of the improvements having been made through those recommended with all four planning periods. The 73.0 MGD is higher than what the well field is projected to produce at the 100-year planning period of 43.0 MGD at normal climatic conditions. It is anticipated that the well field will be able to produce high single peak day flows under wet climatic conditions, thus the conservative hydraulic modeling approach. This tech memo evaluated the well field hydraulics with the 73.0 MGD production.

For consistency with the HDR, Raw Water Transmission Improvements tech memo, the segments A, B, C and D are utilized for this memo as well. Two additional segments E and F have been added to incorporate the well field. These segments are visible on the figures included within Appendix A.

HDR recommended that the existing 24-, 36-, and 42-inch concrete transmission main located within Segment A be upsized with a 42-inch ductile iron transmission main. For Segment B, it was recommended to upsize the existing 24- and 36-inch concrete and ductile iron mains with 36- and 42-inch ductile iron mains. Segment C included the addition of a parallel 36-inch ductile iron main, and Segment D also included an addition of a parallel 24-inch ductile iron main. Refer to Appendix A, HDR Raw Water Transmission Improvements Technical Memorandum, Figures for illustration of the HDR recommended improvements and segment areas.

2-1 Existing Well Withdrawal Rate

Thru this evaluation, additional historical well withdrawal data was gathered and assessed. As outlined in the Well Condition Assessment tech memo, the vast majority of the existing wells have had historical (between the years of 2016-2021) withdrawal rates below and in many instances significantly below their permitted water rights withdrawal rate. The recommended improvements included with the HDR tech memo were further reviewed with individual well average historical withdrawal rates. The proposed improvements and subsequent hydraulic analysis outlined in the tech memo utilized both the full permitted withdrawal rate and the historical withdrawal rates to determine the likelihood of each individual wells withdrawal rate and impacts on hydraulics. Using only the permitted water rights withdrawal rate produces inaccurately high main flows, velocities, and headloss. These higher than likely flows, velocities, and headloss can result worse velocity and headloss conditions within existing mains than what is more likely to be experienced and can result in oversized main improvement recommendations. Therefore, the average historical withdrawal rates were also evaluated and considered within the recommended improvements.

2-2 Improvement Adjustments

In Segment B, based on proposed new well locations as detailed in the New Well Siting Plan tech memo, the previously recommended improvement of replacing the existing 24-inch main north of Well 33 and south of 258th Street with 36-inch main. With the full development of the well field within the 100-year planning period, a 36-inch main is hydraulically undersized and induces excess headloss, for that reason the main shall be adjusted to a 42-inch main. **Figure 14** in Appendix A illustrates this recommendation.

The recommended improvement of adding a parallel 36-inch within Segment C north of 255th Street to Collector Well 71 shall not be recommended for installation until the existing 36-inch main has come to the end of its useful life and needs to be replaced. The City has noted that new transmission mains north of 255th Street should be single transmission mains sized to handle the withdrawal rates of the proposed new wells. The City has had minimal maintenance issues with the existing transmission mains and would prefer to initially install a single transmission main north of 255th Street to the proposed new wells with the exception where the transmission main crosses under the railroad, ditches, channels, and other problematic locations. The City would consider installing a parallel main significantly later in time when the proposed single main has come to the end of its useful life and needs to be replaced. Since the installation of a parallel main would be significantly in the future, the parallel main is recommended in the 100-year planning period. Refer to **Figure 14** in Appendix A for the recommended adjustments in pipe diameter.

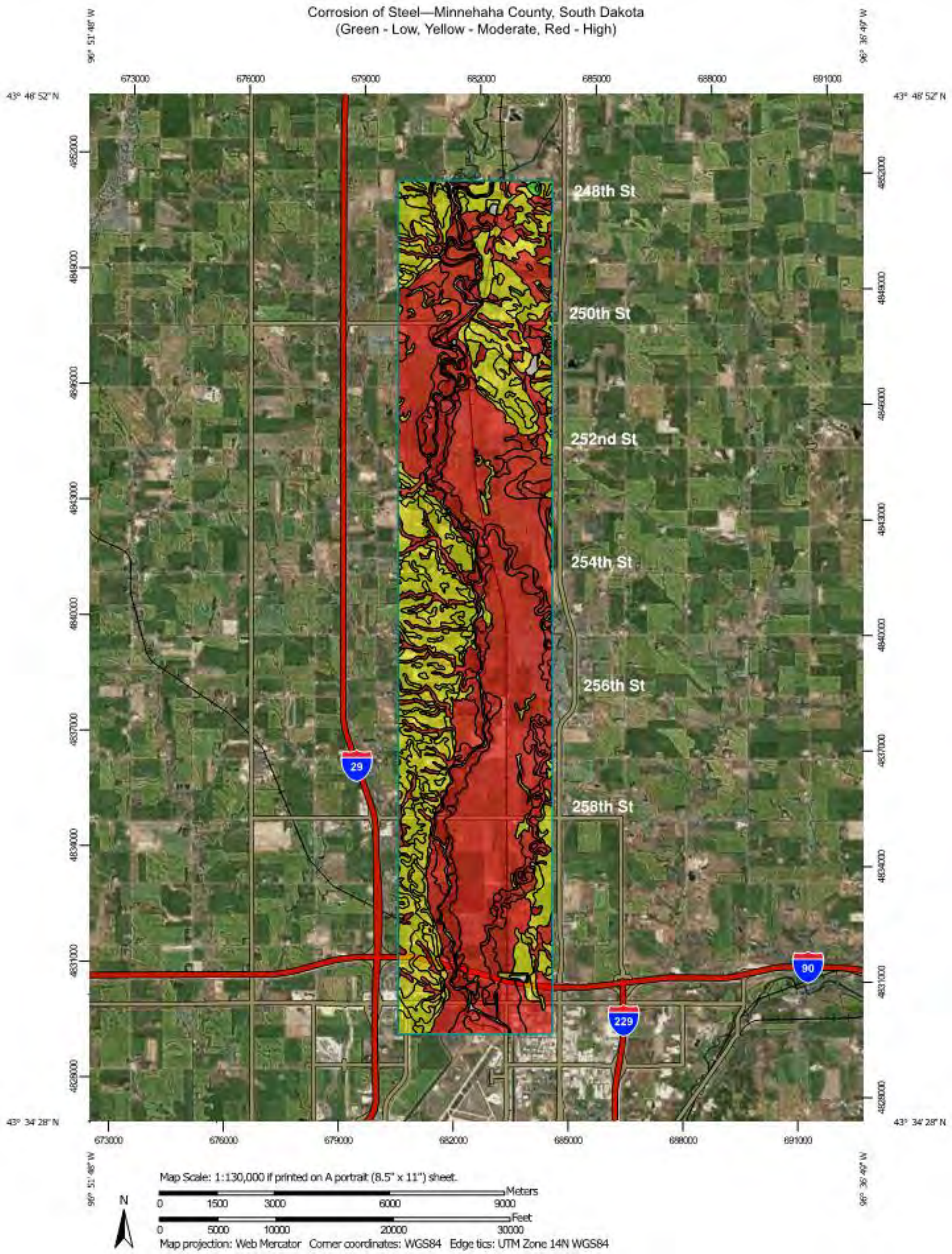
Within Segment D, the proposed additional parallel 24-inch transmission main from Ditch Road west to 467th Avenue and north on 467th Avenue to 252nd Street was proposed to provide redundancy and address reliability to the 100 series wells. The parallel main is not needed for hydraulic capacity, thus the parallel main would primarily serve as a redundancy and reliability to the 100 series wells. The City has noted that they view the proposed wells north of 255th Street within the Big Sioux aquifer as being the redundancy to the 100 series wells, thus the parallel main is not needed. Refer to **Figure 14** in Appendix A for the recommended single transmission main.

Segment E as displayed in **Figure 14** in Appendix A and just south of 250th Street is a short 95-ft run of 8-inch transmission main that is undersized and inducing significant headloss back to Wells 113 and 114. This short section of transmission main should be upsized from 8-inch to 12-inch. This segment of transmission main was not flagged on the HDR tech memo for improvement but similar to HR Green's review, the segment of main does indicate excessive headloss.

The USDA has a service (Web Soil Survey) that publishes properties of soil corrosivity to steel within the State. The well field transmission mains are located within soils that are classified as having a high corrosivity to steel, as seen by the red color within **Figure 1** and **Figure 2**. For this reason, it is recommended that either plastic pipe such as PVC or HDPE pipe be utilized for the new mains on the well field or corrosion protection measures be taken with ductile iron main. This study evaluated hydraulic properties of the proposed new mains and improvement adjustments with the assumption that the new mains would be plastic pipe. The City has noted that they historically haven't had many issues with corrosion on the existing transmission mains but are in agreement that going forward plastic pipe would be preferred.

In addition to being corrosion resistant to the corrosive soils located within the majority of the well field, plastic pipe also has a lower internal pipe roughness coefficient than ductile iron pipe. This lower roughness coefficient reduces headloss experienced within the transmission mains, which is critical with the peak flows in the 50- and 100-year buildout of the well field. In some cases, the reduced headloss has allowed for smaller diameter mains. The decreased headloss within the transmission mains is detailed later in the memo.

The larger diameter main, 36-inch to 48-inch, maybe challenging to acquire in the near-term due to the current market conditions and supply chain restrictions. When plastic mains are unable to be acquired or financially more expensive than ductile iron pipe, the ductile iron pipe should have measures installed for corrosion resistance, to extend the life of the main. The proposed improvements will be listed as plastic pipe but ductile iron pipe should be considered as noted above.



Corrosion of Steel—Minnehaha County, South Dakota
(Green - Low, Yellow - Moderate, Red - High)

Map Scale: 1:130,000 if printed on A portrait (8.5" x 11") sheet.

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 14N WGS84

Figure 1: USDA Soil Corrosivity to Steel Map, Big Sioux Aquifer

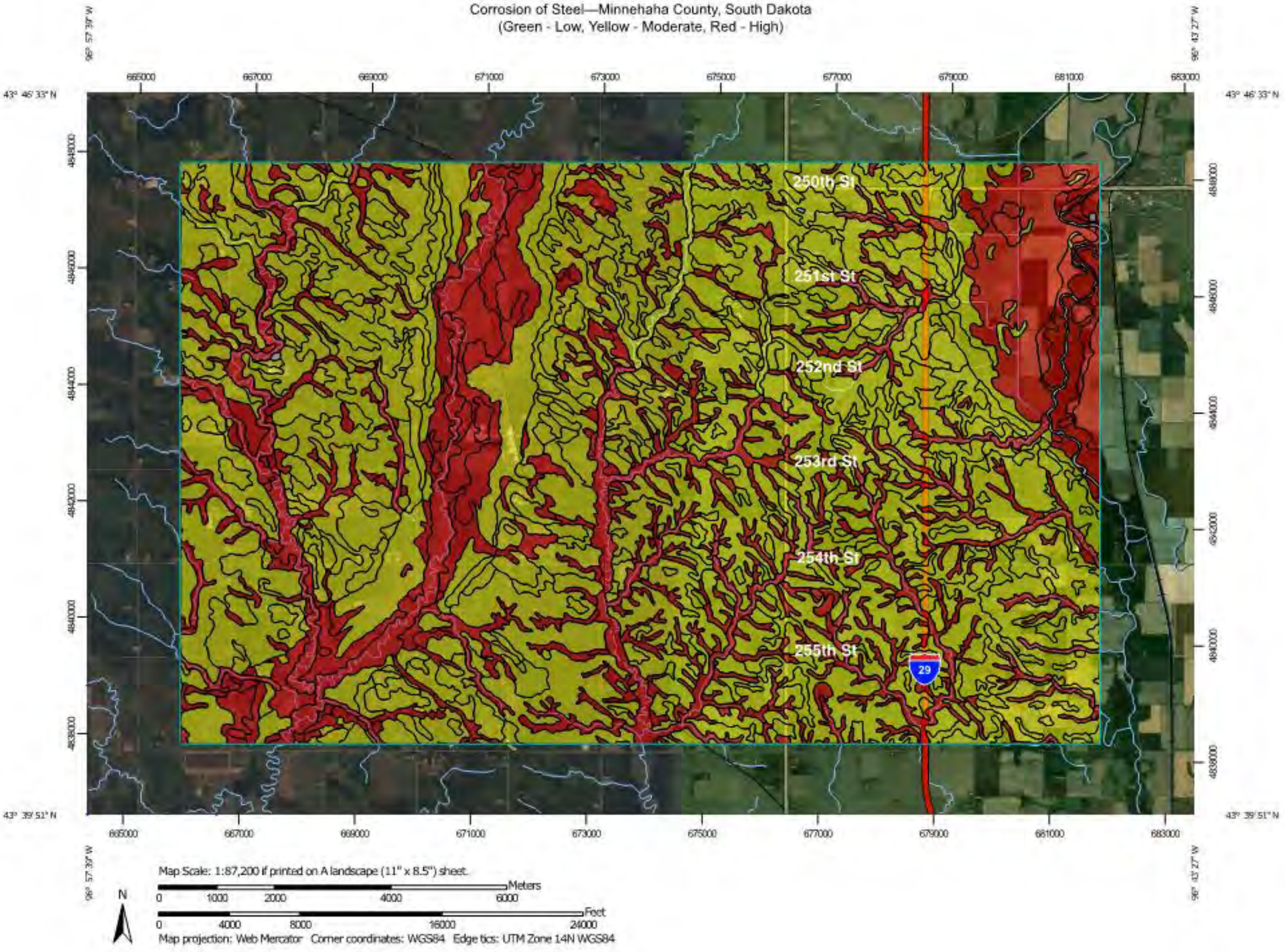


Figure 2: USDA Soil Corrosivity to Steel Map, Middle Skunk Creek Aquifer

Section 3: Transmission Main Modeling

3-1 Dynamic Modeling

The current well field hydraulic model is limited to static conditions and is currently unable to model system impacts from select wells being turned on or off. The City has asked what the next steps should be to move the hydraulic model from a limited static model to a more dynamic model, which can identify how variations in specific parameters such as groundwater level and pressure in the transmission main can impact the pumping capacity of individual wells. The following steps of gathering additional data and model correlations, will increase the model's capabilities to be more dynamic. There will still be limitations to the capabilities of the dynamic model as it will be challenging to include all the differing aquifer impacts at each well with differing groundwater levels.

- Gather pressure data from data loggers at hydrants in strategic locations within the well field system. During the same period of time also gather system pressures at each well location (where pressure sensors are connected to SCADA) and gather system pressure at each well that is operating. For the wells that are operating, also gather the withdrawal rate, VFD speed, well drawdown levels, and percent open on valve throttling. Gather this data in 15-minute intervals for 1 month during each of the Winter, Spring, Summer, and Fall operational periods.
- Gather all well pump curves for the pumps currently installed at the wells.
- At each well, perform a flow step test in which the well withdrawal rates are recorded along with the drawdown levels. If able, have the well discharge isolated from influence of other well operations during the testing and make sure that the drawdown levels equalize at each withdrawal rate before moving on to the next withdrawal rate. Perform the flow step testing each time a well has maintenance performed and adjust model as needed.
- Correlate the ground water levels at each well in relation to the aquifer modeling performed for the Drought Impacts Modeling tech memo. Create modeling scenarios for normal, average dry, drought, and extended drought conditions.

3-2 Evaluation of Existing Well Lateral Mains

Each of the existing well lateral mains from the well to the transmission main were evaluated with both the maximum permitted withdrawal rate and the average historical withdrawal rate to determine the main's velocity and headloss. As previously stated, the maximum permitted withdrawal rate is overly conservative and will inaccurately predict velocities and headloss with a withdrawal rate that is too high. In accordance with the American Water Works Association (AWWA) Manual M32 – Computer Modeling of Water Distribution Systems, the Fourth Edition, the following are recommended guidelines to achieve an operationally efficient water transmission system.

- All main velocities should be less than 4–6 fps during normal operation.
- All mains with a dimeter less than 16-inch should have a headloss of less than 5–7 feet per thousand feet of headloss during normal operation. All mains with a diameter greater than or equal to 16-inch should have a headloss that does not exceed 2–3 feet per thousand feet of headloss during normal operation.

Headloss values discussed below are based on Hazen-Williams C values determined during the calibration of the water model. Some segments of main have very low C values which result in excessive headloss even when velocities within the main are low or within the ideal range. The C values were a best estimate of the main's characteristics; however, actual C values may vary either higher or lower than those in the model. **Table 1** shows each of the well lateral mains that exceed the recommended maximum velocity or headloss at either or both the maximum permitted withdrawal rate and the average historical withdrawal rate. **Table 2** shows each of the well lateral mains that have velocities of less than 2 fps. **Figures 1** through **4** in Appendix A is a visual representation of the well lateral mains velocity and headloss for the maximum permitted withdrawal rate and average historical withdrawal rate.

When the velocity and headloss at the maximum permitted withdrawal rate exceeds the ideal range, the withdrawal rate was reviewed for the likelihood that the velocity would approach the maximum permitted withdrawal rate versus the average historical withdrawal rate. The main size was evaluated with the more likely withdrawal rate and if the velocity still exceeded the ideal range, the main was proposed for modifications as noted in **Table 4**. If the velocity was within the ideal range but the headloss exceeded the ideal range, the main was recommended for rehabilitation/cleaning to reduce excess headloss from internal debris and buildup. Rehabilitation/cleaning of mains is discussed further in the Well Condition Assessment. Mains that indicated velocities less than 2 fps at the maximum permitted withdrawal rate have proposed modifications as noted in **Table 4**.

Several existing collector wells have indications of potential for additional laterals and increased withdrawal rates; however, additional aquifer analysis, including soil borings will need to be conducted to determine if these wells could indeed have increased withdrawal rates. For the purpose of this tech memo, the existing withdrawal rates were utilized. If these wells are evaluated later for additional laterals, the well lateral main should also be reevaluated to determine if the main will be properly sized.

Table 1: Well Lateral Mains Exceeding Velocity and Headloss Recommendation

Well No.	Maximum Permitted Withdrawal Rate		Average Historical Withdrawal Rate		Most Restrictive Main Diameter in Lateral, inch
	Velocity, fps	Headloss, ft/1000 ft	Velocity, fps	Headloss, ft/1000 ft	
No. 26	3.26	12.8	1.36	2.5	10
No. 31	5.82	30.1	3.12	9.5	12
No. 32	5.73	8.1	2.98	2.4	12
No. 33	5.46	15.0	2.81	4.4	16
No. 37	3.95	19.6	2.32	7.3	12
No. 38	9.76	78.7	4.70	20.3	12
No. 42	2.87	13.0	1.23	2.7	8
No. 46	5.11	23.7	3.00	8.8	12
No. 54	4.66	19.5	0.98	1.1	6
No. 55	4.66	19.5	0.74	0.6	6
No. 56	4.66	19.5	1.25	1.7	6
No. 57	4.66	19.5	2.45	5.9	6
No. 58	4.66	19.5	--	--	6
No. 62	8.17	19.4	3.77	4.6	10
No. 63	6.99	41.2	2.58	6.5	6
No. 69	7.94	18.4	4.41	6.2	10
No. 70	4.07	5.3	3.06	3.1	10

Table 2: Well Lateral Mains Less Than 2 FPS Velocity

Well No.	Maximum Permitted Withdrawal Rate		Average Historical Withdrawal Rate		Least Restrictive Main Diameter in Lateral, inch
	Velocity, fps	Headloss, ft/1000 ft	Velocity, fps	Headloss, ft/1000 ft	
No. 37	1.97	0.8	1.16	0.3	24
No. 101	1.73	15.9	0.65	2.6	10
No. 102	1.73	15.9	0.27	0.5	10
No. 104	1.20	1.6	0.20	>0.1	12
N0. 105	1.83	4.4	0.29	>0.1	10
No. 107	1.83	1.2	0.51	>0.1	10
No. 109	1.91	1.7	0.24	>0.1	12
No. 110	0.48	0.2	0.20	>0.1	24
No. 111	0.61	0.3	0.12	>0.1	18
No. 112	0.61	0.3	0.25	>0.1	18

The mains for the 6-pack series wells (gravel pack Wells 48 through 53) have velocities within the ideal range but generally exhibit a headloss of 5.7 ft/1000 ft at the maximum permitted withdrawal rate. As detailed in the Well Condition Assessment tech memo, all of these wells are recommended for replacement. The well lateral mains would benefit from rehabilitation/cleaning to reduce excess headloss from internal debris and buildup.

The mains for the 5-pack series wells (gravel pack Wells 54 through 58) have velocities on the high side of the ideal range and generally exhibit a headloss of 19.5 ft/1000 ft at the maximum permitted withdrawal rate of 411 gpm. See **Table 1** and **Figure 2** for the for the main velocities and headloss at both the maximum permitted withdrawal rate and the average historical withdrawal rate. As detailed in the Well Condition Assessment tech memo, all of these wells are recommended for replacement. New wells with a withdrawal rate similar to the original designed withdrawal rate for the 5-pack wells should have all of the individual mains upsized to 8-inch and the header main should be upsized to 14- to 16-inch depending on the total withdrawal capacities.

The 100 series wells generally have well lateral mains that are oversized, even on a maximum permitted withdrawal rate, as indicated in **Table 2**. As the 100 series wells are replaced and reconditioned, the withdrawal rate of the new well(s) should be considered in determining if the lateral main is properly sized or should be downsized. **Table 4** factors in withdrawal rates of new and reconditioned wells attaining near the maximum permitted withdrawal rate.

3-3 Evaluation of New Big Sioux Aquifer Transmission Main

As the well field is developed north of 255th Street within the Big Sioux aquifer, the transmission main will be extended north. Within the 20-year planning period, a single transmission main will be capable of carrying the combined withdrawal rate of the proposed wells. As noted earlier in the tech memo, the City would prefer to install a single transmission main in lieu of dual mains with the exception of where main crosses under the railroad, ditches, channels, and other problematic locations. The City would consider installing a parallel main significantly later in time when the proposed single main has come to the end of its useful life and needs to be replaced. Since the installation of a parallel main would be significantly in the future, the dual transmission main is recommended for installation past the 100-year planning period. The dual transmission main will provide redundancy, operational flexibility, and resilience to the well field if one transmission main is offline for repairs. **Table 3** shows the total footage of transmission main for the well field expansion north. These quantities include only the total footage for the initial single transmission mains. **Figures 6** and **7** in Appendix A visually show the transmission main size.

Table 3: Big Sioux Transmission Main Expansion

Pipe Diameter	Quantity, ft
14-Inch[1]	5,600
18-Inch	5,000
20-Inch	5,370
24-Inch	4,210
30-Inch	13,750
36-Inch	6,250

Notes: 1. The 14-inch main footage includes the lateral mains for proposed Collector Wells 13 and 14.

Section 4: Proposed Improvements

The proposed transmission main and well lateral main improvements are summarized below within the 10-, 20-, 50- and 100-year planning periods of 2035, 2045, 2066, and 2116, respectfully. The prioritization of these proposed improvements is discussed in the Improvement Prioritization Section located at the end of this tech memo. **Tables 4** and **5** detail the recommended well lateral main improvements.

Table 4: Existing Well Lateral Main Diameter Modifications

Well No.	New Well Added to Lateral	Average Historical Withdrawal Rate, gpm	Current Diameter, inch	Proposed Diameter, inch	Average Historical Withdrawal Rate		Planning Period
					Proposed Velocity, fps	Proposed Headloss, ft/1000 ft	
No. 54	Yes[2]	425	6	8	2.71	2.9	10 Year
No. 55	Yes[2]	400	6	8	2.55	2.6	10 Year
No. 56	Yes[2]	425	6	8	2.71	2.9	10 Year
No. 57	Yes[2]	400	6	8	2.55	2.6	10 Year
No. 58	Yes[2]	400	6	8	2.55	2.6	10 Year
No. 69	No	1,080	10	14	2.25	1.1	20 Year
No. 101[1]	Yes[2]	424	10	8	2.71	2.9	100 Year
No. 102[1]	Yes[2]	424	10	8	2.71	2.9	100 Year
No. 104[1]	Yes[2]	425	12	8	2.71	2.9	100 Year
N0. 105[1]	Yes[2]	449	10	8	2.87	3.2	100 Year
No. 107[1]	Yes[2]	449	10	8	2.87	3.2	100 Year
No. 109[1]	Yes[2]	673	12	10	2.75	2.3	100 Year
No. 110	Yes[2]	673	24	10	2.75	2.3	100 Year
No. 111	Yes[2]	479	18	8	3.06	3.6	100 Year
No. 112	Yes[2]	480	18	8	3.06	3.6	100 Year

Notes: 1. Main diameter may not need reduction to obtain 2 fps velocity with additional well(s) discharging into the main. Further evaluation of aquifer is needed to determine the withdrawal potential of proposed wells.

2. Existing wells are proposed to be replaced.

Table 5: Proposed Well Lateral Main Diameters

Well No.	Anticipated Total Lateral Flow, gpm	Diameter, inch	Velocity, fps	Headloss, ft/1000 ft	Planning Period
GP No. 1[1]	400 – 1,671	8 – 14	2.55 – 3.48	2.6 – 2.4	10 Year
GP No. 2	400	8	2.55	2.6	10 Year
GP No. 3	400	8	2.55	2.6	10 Year
CW No. 1	1,100	12	3.12	2.3	20 Year
CW No. 2	1,100	12	3.12	2.3	10 Year
CW No. 3[1]	1,100 – 3,071	12 – 18	3.12 – 3.87	2.3 – 2.2	50 Year
CW No. 4	900	10	3.68	3.9	100 Year
CW No. 5	900	10	3.68	3.9	10 Year
CW No. 6	900	10	3.68	3.9	100 Year
CW No. 7	900	10	3.68	3.9	50 Year
CW No. 8	900	10	3.68	3.9	100 Year
CW No. 9	1,200	14	2.50	1.3	50 Year
CW No. 10	1,200	14	2.50	1.3	50 Year
CW No. 11	1,000	12	2.84	1.9	100 Year
CW No. 12	1,000	12	2.84	1.9	100 Year
CW No. 13	1,200	14	2.50	1.3	20 Year
CW No. 14	1,200	14	2.50	1.3	20 Year
CW No. 15	1,000	12	2.84	1.9	100 Year
CW No. 16	1,200	14	2.50	1.3	10 Year
CW No. 17	1,000	12	2.84	1.9	50 Year
CW No. 18[1]	1,200 – 2,856	12 – 20	2.92 – 3.67	1.1 – 2.7	20 Year
New No. 25[2]	2,500	16	3.99	2.6	10 Year
CW No. 26	1,100	12	3.12	2.3	20 Year

Notes:
1. Well values include the direct lateral main and the adjacent existing mains. The anticipated total lateral flow has the lowest value listed first which is the anticipated proposed well withdrawal rate. The higher value is the anticipated proposed well withdrawal rate plus the average historical withdrawal rate of the existing adjacent wells connected to the lateral main.
2. Well 25 is currently under design with withdrawal rate assumed at 2,500 gpm and the design 16-inch lateral main.

4-1 10-Year Planning Period

In Segment A, the existing western parallel 24-inch transmission main along Minnesota Ave from the Water Purification Plant (WPP) to 60th Street shall be replaced with a proposed 42-inch plastic main.

For Segment B, the existing 20- and 24-inch transmission mains along Ditch Road from 60th Street to 258th Street shall be replaced with a proposed 42-inch plastic mains. Additionally, the existing 24-inch transmission main along Ditch Road from 258th Street to Well 52 shall be replaced with a proposed 36-inch plastic main. The existing 24-inch transmission main north of Well 52 within Segment B, hydraulically does not need to be replaced until the 20-year planning period. With the addition of the proposed gravel pack Wells 1 and 2, the header main that is shared with collector Well 47 and the two proposed gravel pack wells shall be replaced with a 14-inch main. Also, the segment includes the installation of proposed Collector Well 18, installation of Collector Well 25 that is currently under design, and installation of new Gravel Pack Wells 1, 2, and 3. With the installation of proposed Collector Well 18, the lateral main shall be a 12-inch main and upsizing the adjacent existing mains to 16- and 20-inch plastic mains. With the installation of the new gravel pack wells, the lateral mains shall also be upsized to a 14-inch plastic main.

Within Segment C, installation of a new 36-inch parallel transmission main along Ditch Road from 257th Street to 255th Street is recommended. The 36-inch main will provide redundancy and added reliability to the well field north of 255th Street. From a hydraulic standpoint, the new 36-inch parallel transmission main is not needed until the end of the 20-year planning period. With the replacement of the 5-pack series wells it is anticipated that the new wells will be capable of withdrawal rates similar to the rates of the existing wells when originally constructed. Hydraulically, each of the well laterals shall be replaced with 8-inch mains and the header main shall be replaced with a 16-inch main. Additionally, the segment includes the installation of the proposed Collector Well 5. Depending on the withdrawal rate of proposed Collector Well 5, the 12-inch shared header pipe with Collector Well 72 should be evaluated to determine if the existing 12-inch size is adequate.

Figures 6 and **10** in Appendix A show the velocity and headloss of the transmission and well lateral mains with the proposed improvements within the 10-year planning period. **Figure 15** in Appendix A displays the improvements within the planning period.

4-2 20-Year Planning Period

Within Segment B, the remaining parallel 24-inch existing transmission main along Ditch Road north of Well 52 to 257th Street shall be replaced with a proposed 36-inch plastic main. Within this segment is the inclusion of the installation of proposed Collector Wells 3 and 26. With the installation of proposed Collector Well 3, the lateral main shall be a 12-inch main and upsizing the adjacent existing mains to 16- and 18-inch plastic mains. The installation of proposed Collector Well 26, the lateral main shall be upsized to a 12-inch plastic main.

For Segment C, the lateral main for existing Collector Well 69 should be replaced with 14-inch main for more ideal hydraulic operation.

Segment F has the installation of the proposed Collector Well 16 along with the proposed 24-, 30-, and 36-inch transmission mains that extend from existing Well 71 to proposed collector Well 16. The segment also has the installation of the proposed Collector Wells 13 and 14 at the very north end of the well field within the Big Sioux aquifer. With the installation of these proposed collector wells it is recommended that 14-, 18-, 20- and 24-inch transmission mains be installed from 252nd Street north to Collector Wells 13 and 14.

Figures 7 and **11** in Appendix A show the velocity and headloss of the transmission and well lateral mains with the proposed improvements within the 20-year planning period. **Figure 16** in Appendix A displays the improvements within the planning period.

4-3 50-Year Planning Period

For Segment A, the existing eastern parallel 36-inch transmission main along Minnesota Ave from the WPP to 60th Street shall be replaced with a proposed 42-, and 48-inch plastic main. Although the existing eastern parallel 42-inch transmission main south of Benson Road hydraulicly does not need to be replaced within the 50-year planning period, the ductile iron and concrete pipes will have extensive age and exposure to the corrosive native soil. Prior to replacing the ductile iron and concrete pipes, evaluate the structural integrity of the pipes. If the integrity is acceptable push the transmission main replacement down on the improvement prioritization. Hydraulically, the transmission mains should be replaced by the 100-year planning period. The ductile iron pipe and concrete pipe should be replaced with 42-inch plastic pipe to the WPP. Likewise, the existing 36-inch concrete and cast-iron main that feeds into the WPP should be replaced with 42-inch plastic pipe. Install the proposed Collector Well 1 and 12-inch lateral main. Prior to installation of the proposed Collector Well 1, an evaluation should be completed on the location of the PFAS plume to determine if it will have an interaction with the location of the proposed collector well.

Within Segment B, the existing ductile iron and concrete eastern dual 36-inch existing transmission main along the railroad half a mile east of Ditch Road shall be replaced with a proposed 42- and 48-inch plastic mains. The 24-inch concrete transmission main along 72nd Street North and 20-inch concrete transmission main along 84th Street North shall be replaced with the proposed 42-inch plastic main and recommended 36-inch plastic main, respectfully. Also in Segment B, the remainder of the eastern dual 36-inch existing concrete transmission main north of 72nd Street hydraulicly does not need to be replaced until the 100-year planning period, but similar to the comments with the concrete mains within Segment A, it is recommended that the 36-inch concrete main be replaced with 36-inch plastic main. Prior to replacing the concrete pipe, evaluate the structural integrity of the pipe. If the integrity is acceptable push the transmission main replacement down on the improvement prioritization. Also, within the segment, it is recommended to install proposed Collector Well 2 and lateral main. Further evaluation of the existing 20-inch main for proposed Collector Well 2 should be completed to determine if the existing main should be reduced to a 12-inch main. Prior to installation of the proposed Collector Well 2, an evaluation should be completed on the location of the PFAS plume to determine if it will have an interaction with the location of the proposed collector well.

Segment F has the installation of proposed Collector Wells 7, 9, 10, and 17 and are planned with the wells discharging into the transmission main that is recommended in the 20-year planning period.

Figures 8 and **12** in Appendix A show the velocity and headloss of the transmission and well lateral mains with the proposed improvements within the 50-year planning period. **Figure 17** in Appendix A displays the improvements within the planning period.

4-4 100-Year Planning Period

For Segment A, if the existing eastern parallel 42-inch transmission main on Minnesota Ave south of Benson Road was not replaced within the 50-year planning period (as noted above), then it shall be replaced with the proposed 42-inch plastic pipe.

Within Segment B, the existing 20-inch ductile iron and concrete transmission mains along Ditch Road south of Well 26 to Minnesota Avenue shall be replaced with a 24-inch plastic pipe, which reduces the flow through the 42-inch transmission main installed within the 10-year planning period and brings both transmission mains to an ideal hydraulic loading. The 20-inch concrete transmission main along Ditch Road that crosses under 60th Street North shall be abandoned.

In Segment C, replace the short run of existing 24-inch ductile iron pipe at the intersection of Ditch Road and 257th Street that runs under the railroad with a 36-inch plastic pipe. Replace the existing 36-inch ductile iron transmission main along Ditch Road from 255th Street to Well 71 with 36-inch plastic pipe along with the installation of a proposed parallel 36-inch transmission main. Installation of proposed Collector Wells 4 and 6 are planned with the wells discharging into the north dual transmission mains that was recommended in the 10-year planning period.

For Segment D, replace the significantly aged 24-inch ductile iron transmission main along 255th Street and 467th Ave with the proposed 24-inch plastic pipe along with the installation of a proposed parallel 24-inch transmission main. Replace Wells 102, 104, 105, and 107 out of the Series 100 wells. Reduce lateral main diameters per **Table 4** if Series 100 well withdrawal rates remain near estimated values within the table.

Within Segment E, the existing 8-inch transmission main south of 250th Street shall be replaced with a proposed 12-inch main. Replace Wells 111 and 114 out of the Series 100 wells. Reduce lateral main diameters per **Table 4** if Series 100 well withdrawal rates remain near estimated values within the table.

Segment F has the installation of proposed Collector Wells 8, 11, 12, and 15 and are planned with the wells discharging into the transmission main that is recommended in the 20-year planning period.

Figures 9 and **13** in Appendix A show the velocity and headloss of the transmission and well lateral mains with the proposed improvements within the 50-year planning period. **Figure 18** in Appendix A displays the improvements within the planning period.

4-5 Improvement Prioritization

The transmission main and well lateral main proposed improvements have been prioritized within the 10-, 20-, 50- and 100-year planning periods of 2035, 2045, 2066, and 2116, respectfully. Prioritization is based on the ability to utilize existing infrastructure, City improvement preference, and obtaining industry recommended operational velocity and headloss ranges. **Table 6** lists the prioritization of the improvements and **Table 7** summarizes the opinion of cost for the improvements within the 10- year planning period. The prioritized improvements will provide an anticipated maximum well and well field production rate of 42.4 MGD for the 10-year period, 50.2 MGD for the 20-year period, 59.6 MGD for the 50-year period, and 73.0 MGD for the 100-year period. The anticipated production is based on the existing historical well withdrawal rates, anticipated withdrawal gains from well reconditioning and proposed new wells.

Table 6: Transmission and Lateral Main Improvement Prioritization

Improvement Description	Prioritization	Planning Period
New Collector Well 25 with Main Install & Abandonment of Existing Well 25 Main	1	10 Year
Replace the 5-Pack Gravel Pack Wells & Upsize Main	2	10 Year
Proposed Collector Well 5 with Main Install	3	10 Year
Proposed Gravel Pack Wells 1, 2, and 3 with Upsized Main	4	10 Year
Upsize 24-, 36-, and 42-Inch Transmission Main from WPP to North of 258th Street	5	10 Year
Replace the 6-pack Gravel Pack Wells & Main Rehabilitation/Cleaning	6	10 Year
Proposed Collector Well 18 with Upsized Main	7	10 Year
Install Parallel 36-Inch Transmission Main from 257th Street to 255th Street	8	10 Year
Install Cathodic Protection on Existing Ductile Iron Pipe	9	10 Year
Install 24-, 30-, and 36-Inch Transmission Main from 2/3 Mile North of 255th Street to 252nd Street & Proposed Collector Well 16 with Main Install	10	20 Year
Proposed Collector Well 3 with Upsized Main	11	20 Year
Replace Collector Well 26 with Upsized Main	12	20 Year
Install 14-, 18-, 20-, and 24-Inch Transmission Main from 252nd Street to 249th Street	13	20 Year
Proposed Collector Well 14 with Main Install	14	20 Year
Proposed Collector Well 13 with Main Install	15	20 Year
Upsize 36-Inch Transmission Main North of Well 52 to 257th Street	16	20 Year
Upsize Main for Collector Well 69	17	20 Year
Proposed Collector Well 10 with Main Install	18	50 Year
Proposed Collector Well 7 with Main Install	19	50 Year
Proposed Collector Well 17 with Main Install	20	50 Year
Upsize 20-, 24-, 36-, and 42-Inch Transmission Main from WPP North to 84th Street	21	50 Year
Proposed Collector Well 9 with Main Install	22	50 Year
Proposed Collector Well 2 with Main Install	23	50 Year
Proposed Collector Well 1 with Main Install	24	50 Year
Upsize Mains South of Well 26 & on 257th Street	25	100 Year
Upsize 8-Inch Transmission Main South of Well 113 Near 250th Street	26	100 Year
Replace Wells 102, 104, 105, 107, 111, and 114	27	100 Year
Install Dual 36-Inch Transmission Main from 255th Street to 2/3 Mile North of 255th Street	28	100 Year
Proposed Collector Well 4 with Main Install	29	100 Year
Proposed Collector Well 8 with Main Install	30	100 Year
Proposed Collector Well 6 with Main Install	31	100 Year
Upsize 36-inch and Replace 42-Inch Transmission Main from WPP North to Benson Road	32	100 Year
Proposed Collector Well 12 with Main Install	33	100 Year
Proposed Collector Well 11 with Main Install	34	100 Year
Proposed Collector Well 15 with Main Install	35	100 Year
Replace and Install Dual the 24-Inch Main from Ditch Road to 100 Series Wells[2]	36	100 Year

Notes: 1. Well main upsizing could be coupled with adjacent transmission main improvements.

2. The dual 24-inch main is not needed for hydraulics; however, it will provide additional redundancy to supply from the 100 Series Wells. The City has noted that this dual main maybe considered when the existing 24-inch main has come to the end of its useful life and will be replaced.

4-6 10-Year Planning Improvement Cost Opinion

Table 7: 10-Year Planning Period Transmission and Lateral Main Improvement Costs in 2022 Dollars

Improvement Description	Improvement Costs[3]	Planning Period
New Collector Well 25 with Main Install & Abandonment of Existing Well 25 Main	$7,900,000[1]	10 Year
Replace the 5-Pack Gravel Pack Wells & Upsize Main	$5,020,000	10 Year
Proposed Collector Well 5 with Main Install	$6,400,000	10 Year
Proposed Gravel Pack Wells 1, 2, and 3 with Upsized Main	$3,060,000	10 Year
Upsize 24-, 36-, and 42-Inch Transmission Main from WPP to North of 258th Street	$51,620,000[2]	10 Year
Replace the 6-pack Gravel Pack Wells & Main Rehabilitation/Cleaning	$5,700,000	10 Year
Proposed Collector Well 18 with Main Install	$8,130,000	10 Year
Install Parallel 36-Inch Transmission Main from 257th Street to 255th Street of 255th Street	$12,770,000[2]	10 Year
Install Cathodic Protection on Existing Ductile Iron Pipe	$340,000	10 Year

Notes: 1. Improvement costs are from the Water Supply and Distribution System Facility Plan, Transmission Redundancy Improvements and Well 25 Improvements, dated July 15, 2022. The cost opinion was prepared by HDR with the well design.

2. Improvement costs are from the HDR transmission improvements tech memo and are represented in 2022 dollars. The cost opinion was prepared by HDR with the transmission improvements tech memo.

3. Improvement costs include a 30% contingency which is an industry standard for a high level (broad) cost estimate. Actual project costs will vary upon market and bidding environment.

4. Refer to Appendix B for a breakdown of the opinion of costs for the recommended improvements.

Section 5: Recommended Non-Construction Projects

Below are several recommended studies that will enable the City to better evaluate future needs associated with the well field transmission mains. The recommended studies include:

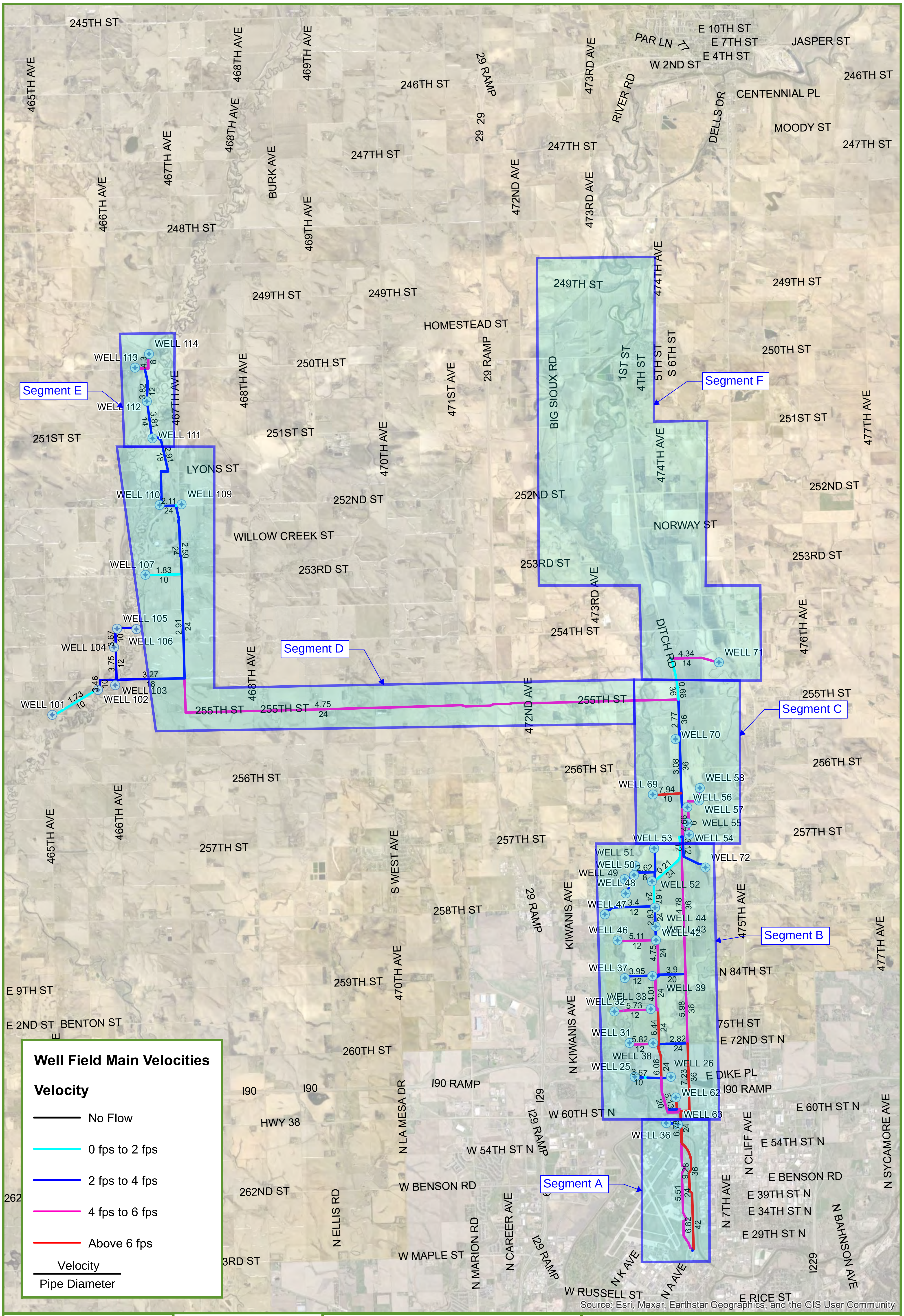
- Study the structural integrity evaluation of the ductile iron and concrete mains

The recommended project is briefly discussed in the following section.

5-1 Structural Integrity Evaluation

An evaluation of the structural integrity of the existing ductile iron and concrete mains would provide useful information if the corrosive soil conditions that the mains are mainly located in, as discussed in Section 2-2. The information would also help fine tune if certain portions of transmission mains should be moved up or down on the priority list and planning periods.

Appendix



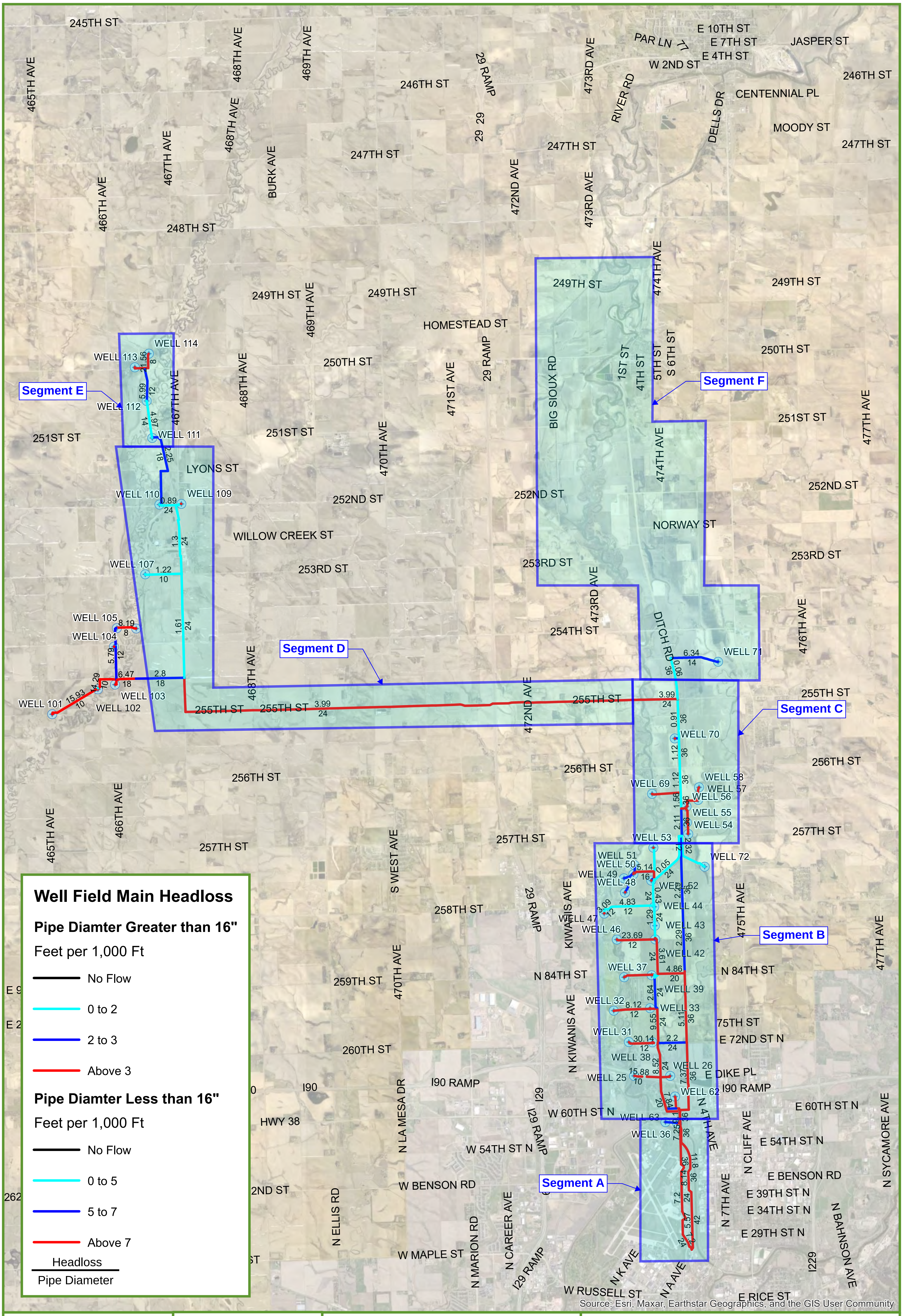
In collaboration with:

Figure 1
Existing Transmission Main Velocities Permitted Water Rights

N
W E
S

0 1 2
Miles
1 inch = 1.25 miles

HRG FILE: J:\2021\210506\Design\Report\Water Transmission Mains TM\Figures\Figure 1-Revised.mxd



HRGreen

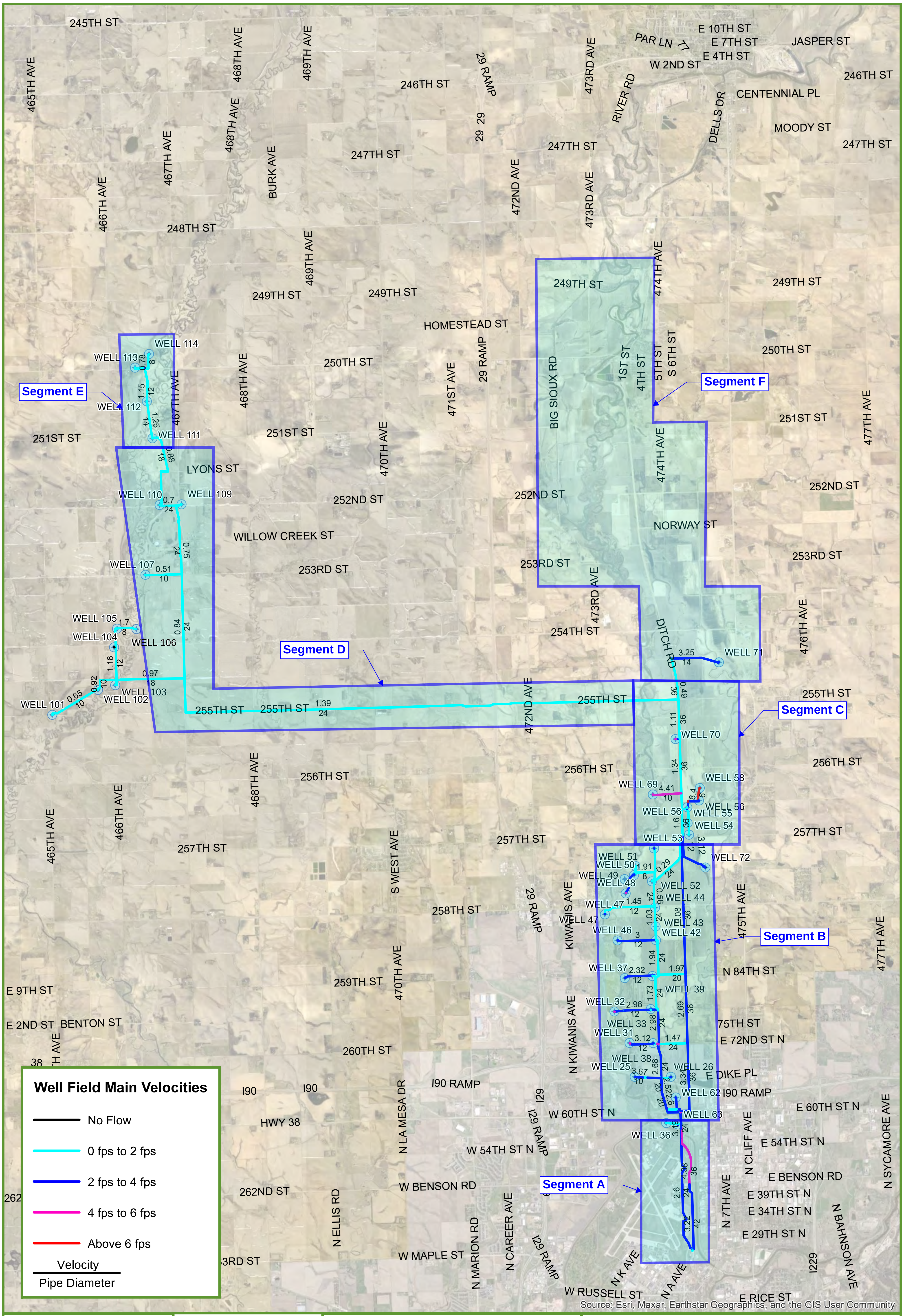
In collaboration with:
carollo
LRE WATER CONNECTING WATER TO LIFE

Figure 2
Existing Transmission Main Headloss Permitted Water Rights

N
W E
S

0 1 2
Miles
1 inch = 1.25 miles

HRG FILE: J:\2021\210506\Design\Report\Water Transmission Mains TM\Figures\Figure 2-Revised.mxd



HRGreen

In collaboration with:

carollo

LRE WATER
CONNECTING WATER TO LIFE

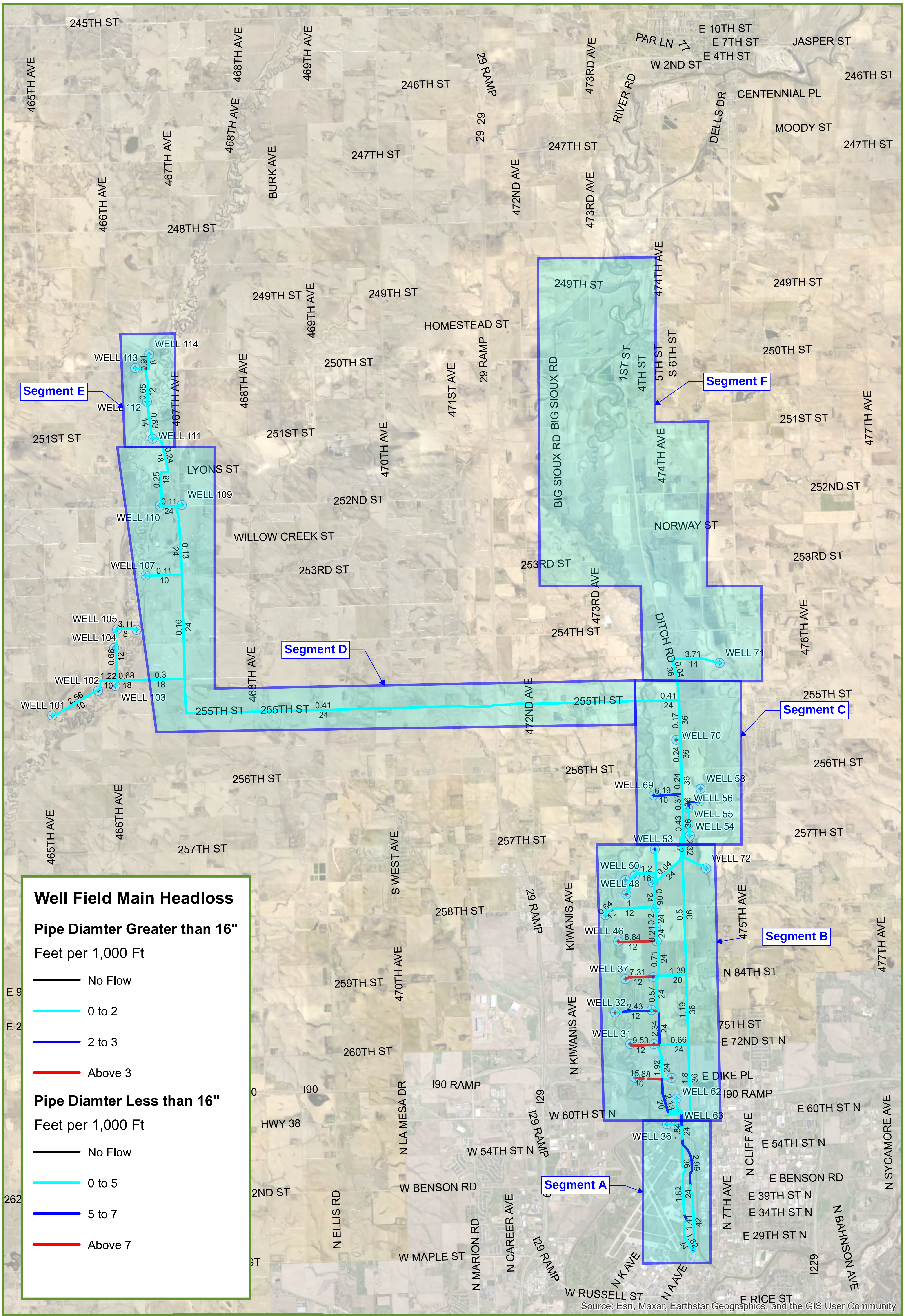
Figure 3
Existing Transmission Main Velocities Peak Day Historical Withdrawal

N
W E
S

0 1 2
Miles

1 inch = 1.25 miles

HRG FILE: J:\2021\210506\Design\Report\Water Transmission Mains TM\Figures\Figure 3-Revised.mxd



In collaboration with:

carollo

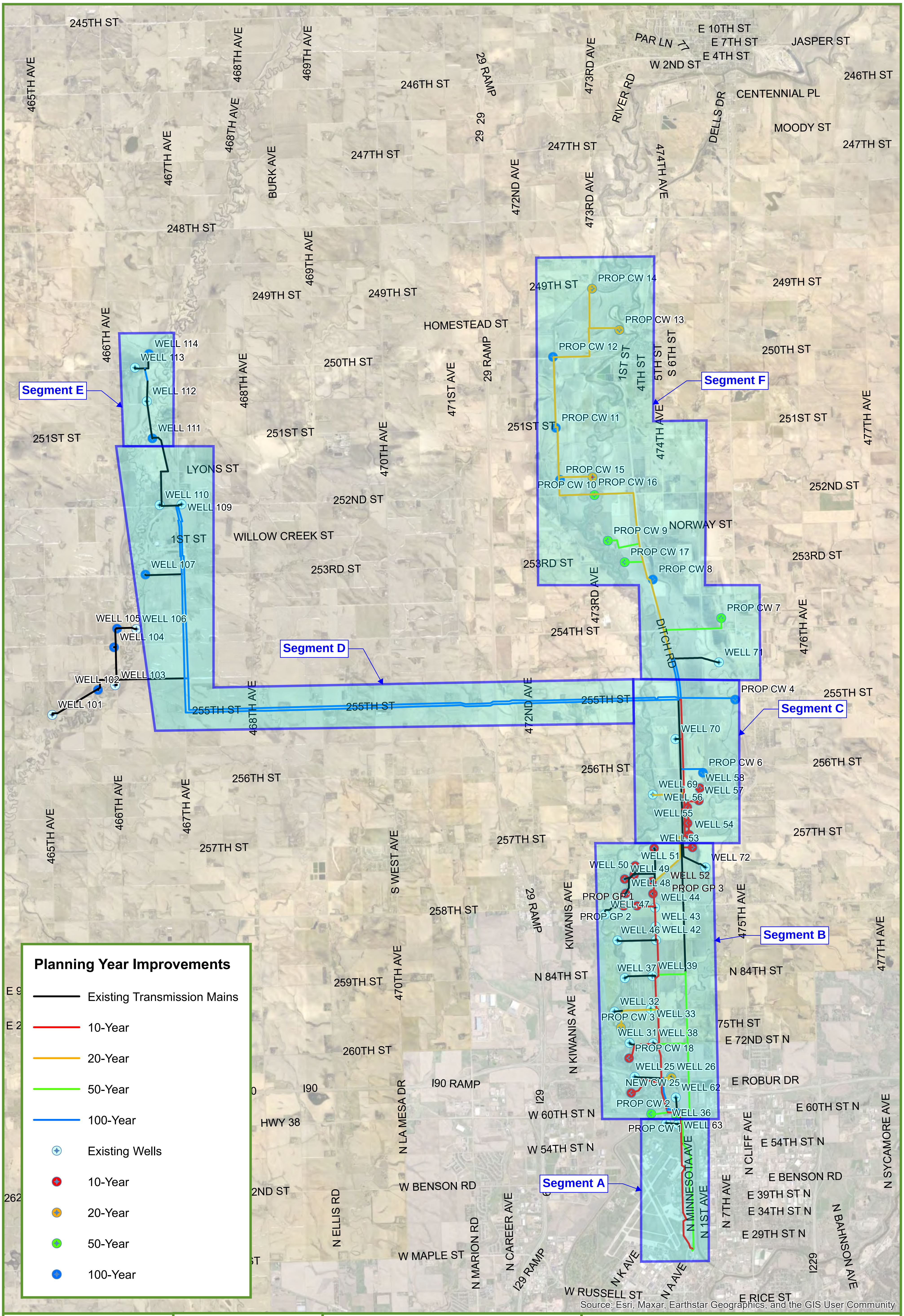
LRE WATER CONNECTING WATER TO LIFE

HRGreen

Figure 4
Existing Transmission Main Headloss Peak Day Historical Withdrawal

1 inch = 1.25 miles

HRG FILE: J:\2021\210506\Design\Report\Water Transmission Mains TM\Figures\Figure 4-Revised.mxd



HRGreen

In collaboration with:

carollo

LRE WATER
CONNECTING WATER TO LIFE

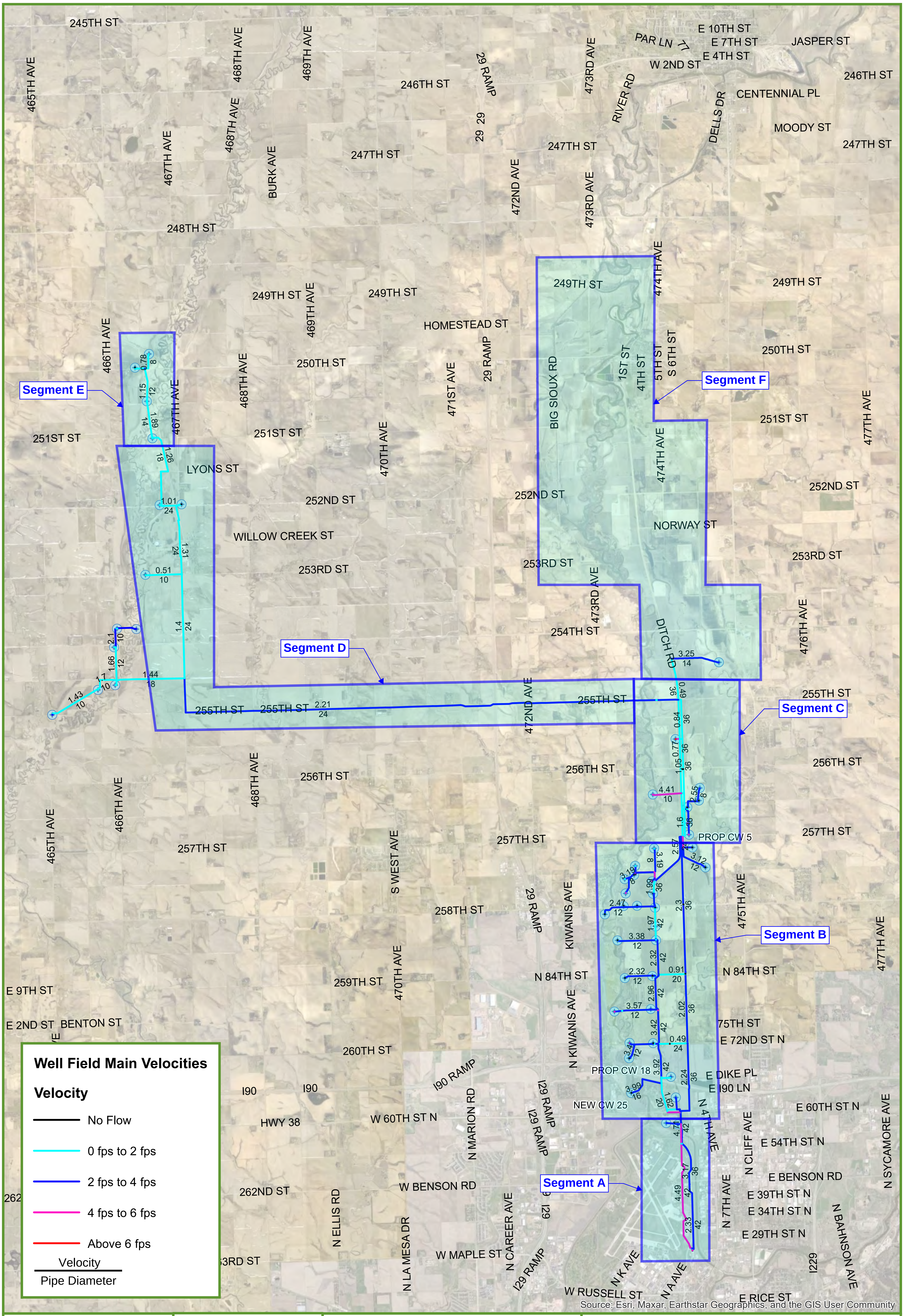
Figure 5
Proposed Main & Well Improvements

N
W
E
S

0 1 2
Miles

1 inch = 1.25 miles

HRG FILE: J:\2021\210506\Design\Report\Water Transmission Mains TM\Figures\Figure 5-Revised.mxd



In collaboration with:

carollo

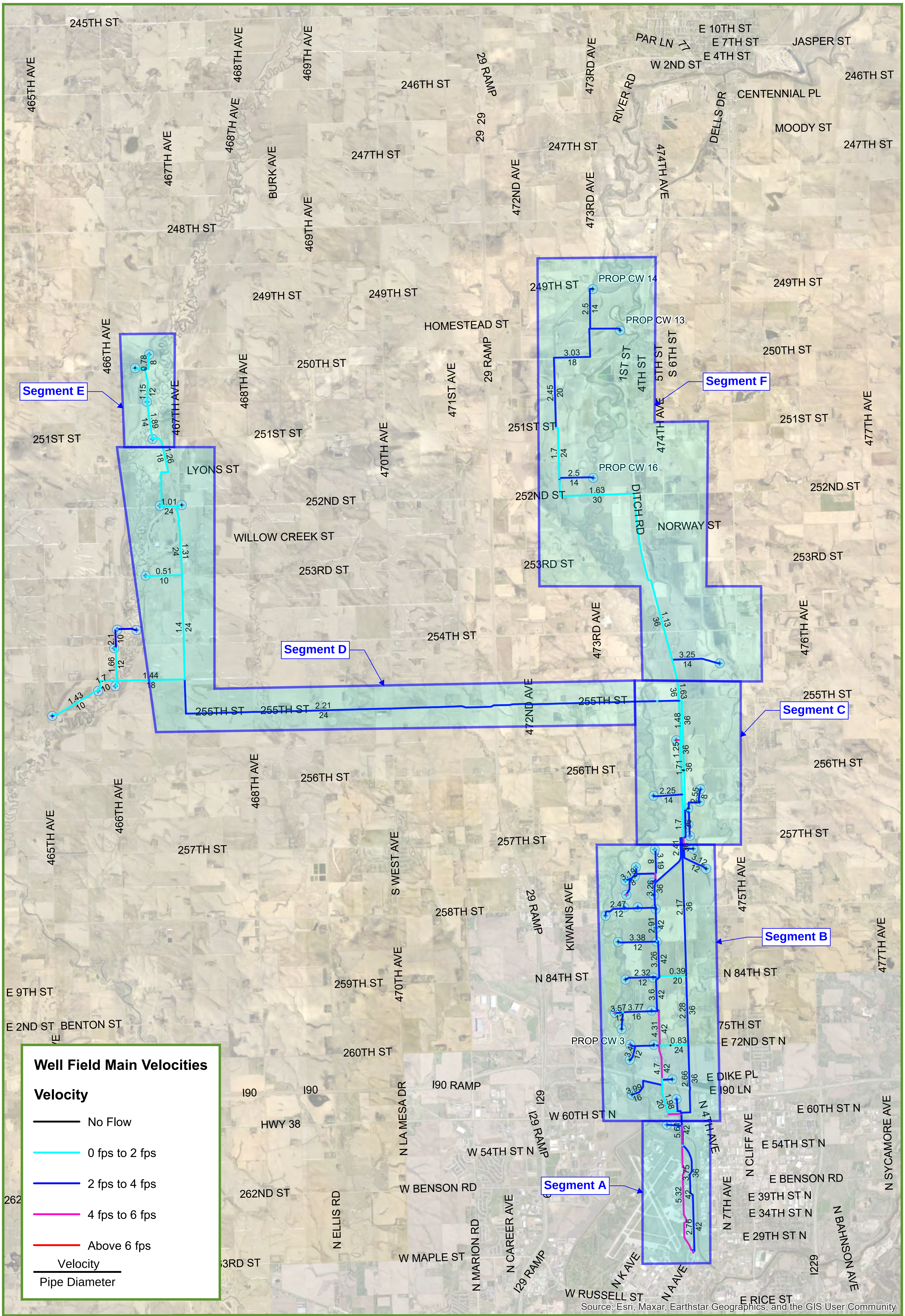
LRE WATER
CONNECTING WATER TO LIFE

HRGreen

Figure 6
Peak Day 10-Year Planning Period Main Vel, Historical Withdrawal

N
W E
S

0 1 2
Miles
1 inch = 1.25 miles



In collaboration with:

carollo

LRE WATER
CONNECTING WATER TO LIFE

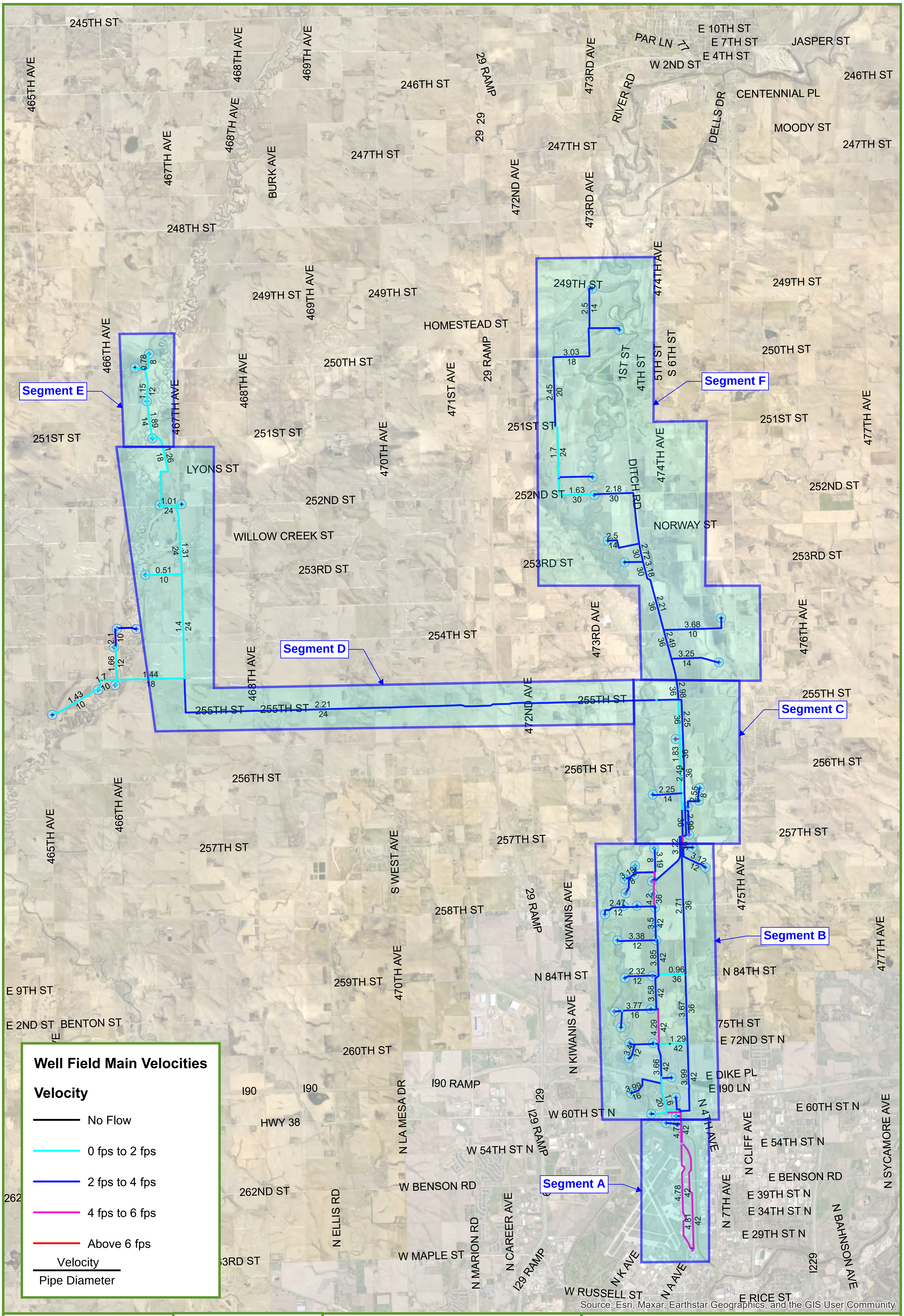
Figure 7
Peak Day 20-Year Planning Period Main Vel, Historical Withdrawal

N
W
E
S

0 1 2
Miles

1 inch = 1.25 miles

HRG FILE: J:\2021\210506\Design\Report\Water Transmission Mains TM\Figures\Figure 6-Revised.mxd



Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community

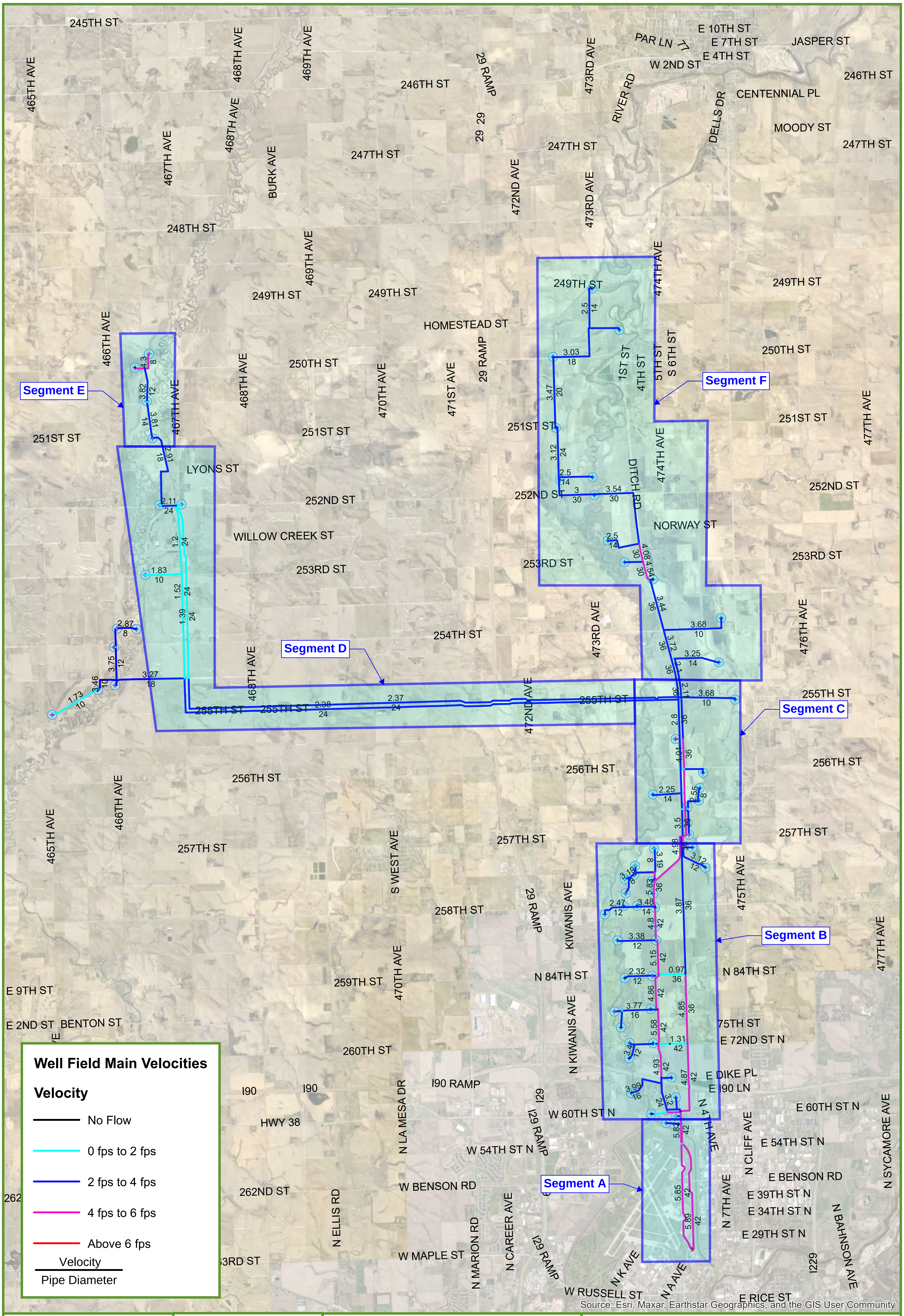
HRGreen

In collaboration with:

Figure 8
Peak Day 50-Year Planning Period Main Vel, Historical Withdrawal

1 inch = 1.25 miles

HRG FILE: J:\2021\210506\Design\Report\Water Transmission Mains TM\Figures\Figure 6-Revised.mxd



HRGreen

In collaboration with:

carollo

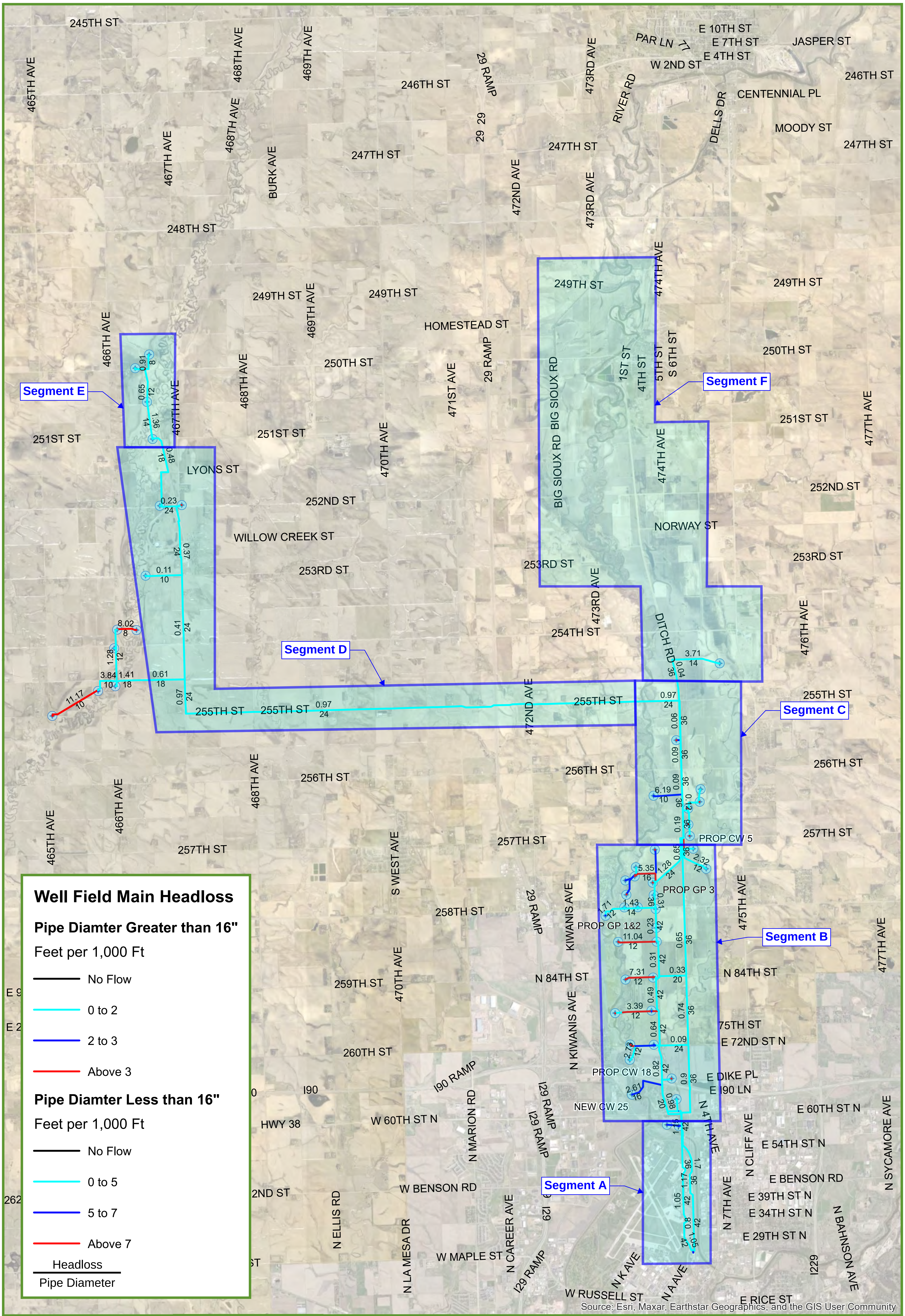
LRE WATER CONNECTING WATER TO LIFE

Figure 9
Peak Day 100-Year Planning Period Main Vel, Historical Withdrawal

N
W E
S

0 1 2
Miles
1 inch = 1.25 miles

HRG FILE: J:\2021\210506\Design\Report\Water Transmission Mains TM\Figures\Figure 6-Revised.mxd



Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community

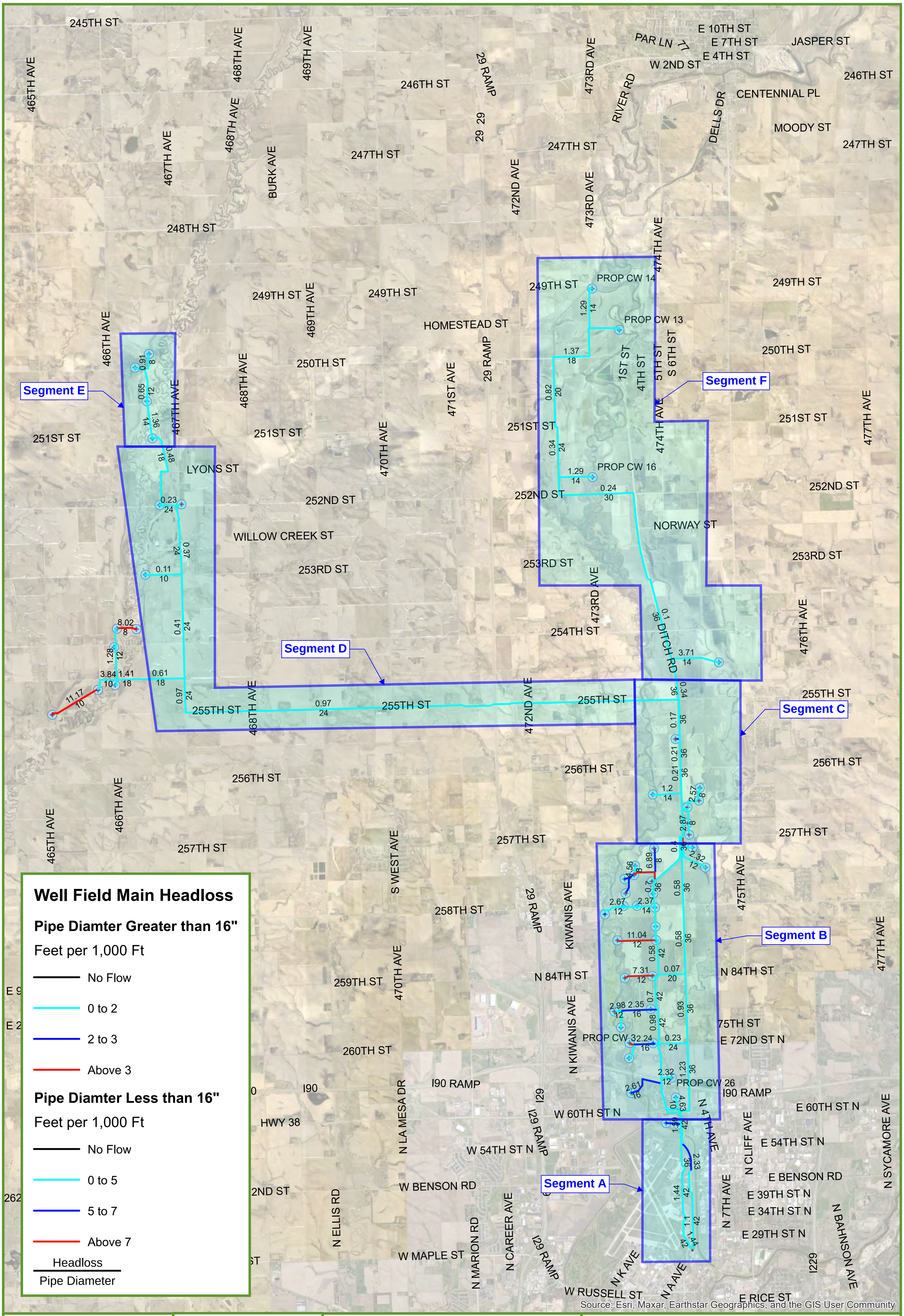
HRGreen

In collaboration with:

carollo

LRE WATER
CONNECTING WATER TO LIFE

Figure 10
Peak Day 10-Year Planning Period Main Headloss, Historical Withdrawal



Well Field Main Headloss

Pipe Diamter Greater than 16"

Feet per 1,000 Ft

━	No Flow
━	0 to 2
━	2 to 3
━	Above 3

Pipe Diamter Less than 16"

Feet per 1,000 Ft

━	No Flow
━	0 to 5
━	5 to 7
━	Above 7

Headloss
Pipe Diameter

Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community

HRGreen

In collaboration with:
carollo
LRE WATER
CONNECTING WATER TO LIFE

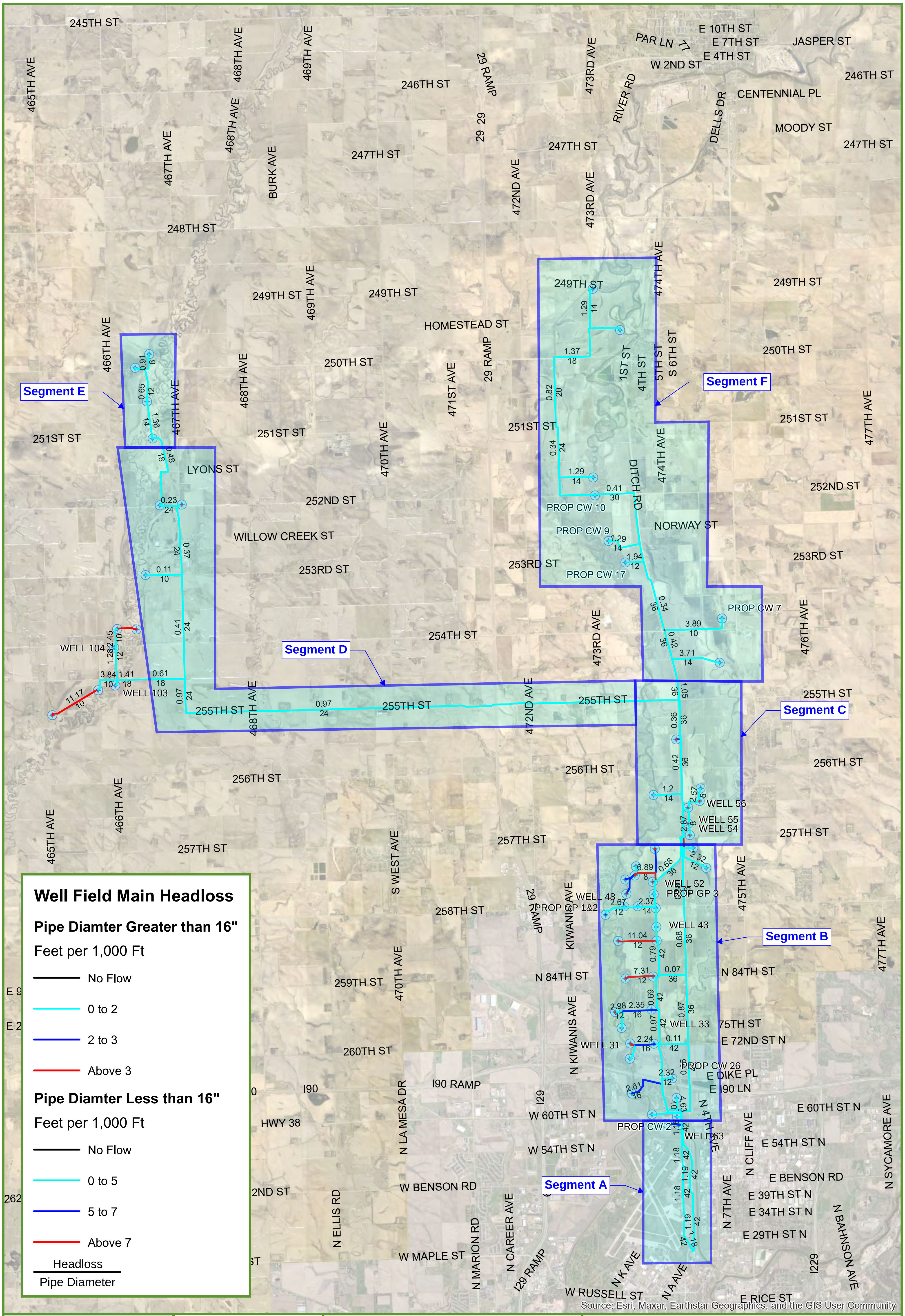
Figure 11
Peak Day 20-Year Planning Period Main Headloss, Historical Withdrawal

N
W E
S

0 1 2
Miles

1 inch = 1.25 miles

HRG FILE: J:\2021\210506\Design\Report\Water Transmission Mains TM\Figures\Figure 11-Revised.mxd



Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community

HRGreen

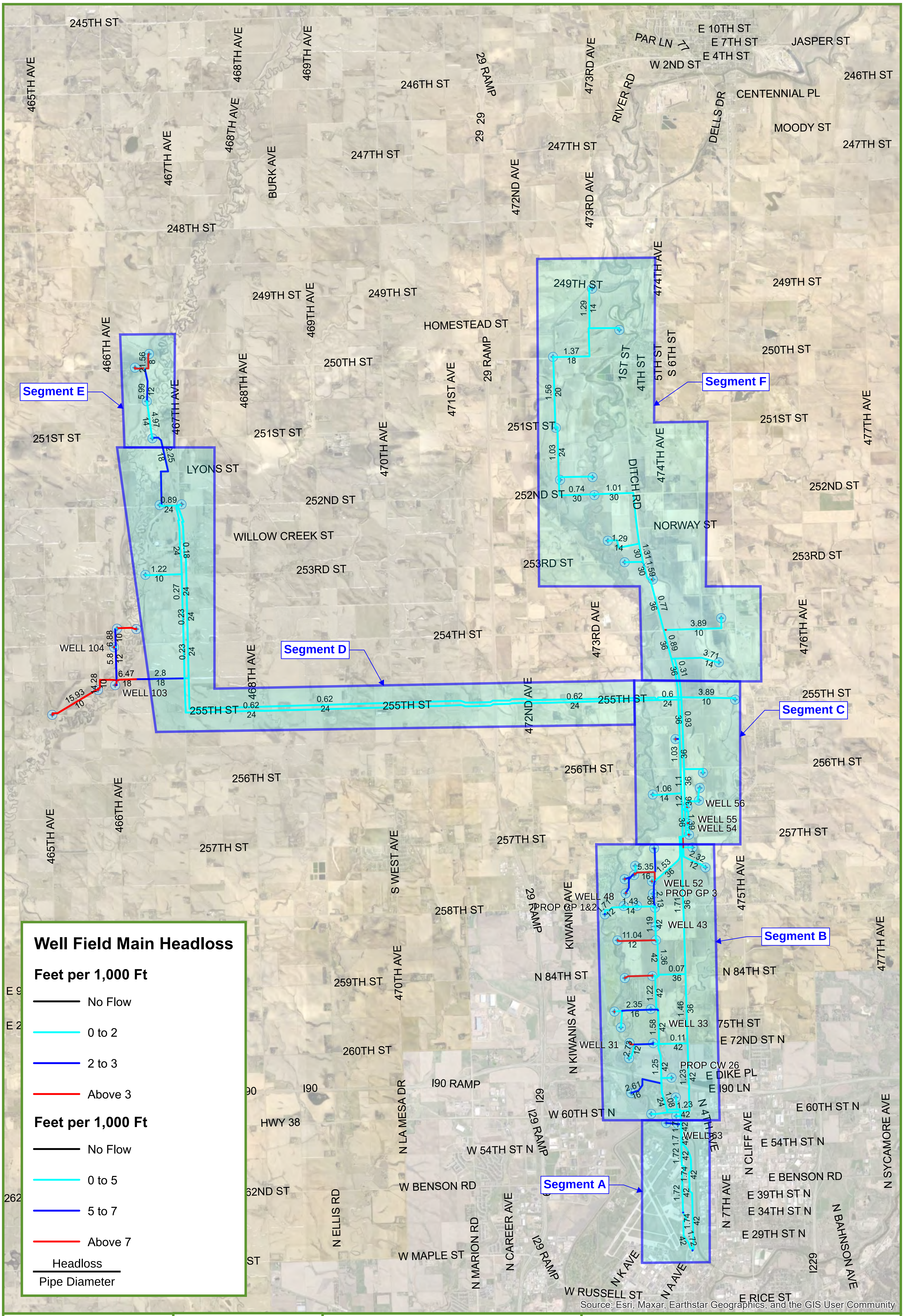
In collaboration with:

carollo

LRE WATER
CONNECTING WATER TO LIFE

Figure 12
Peak Day 50-Year Planning Period Main Headloss, Historical Withdrawal

0 1 2
Miles
1 inch = 1.25 miles



In collaboration with:

carollo

LRE WATER
CONNECTING WATER TO LIFE

HRGreen

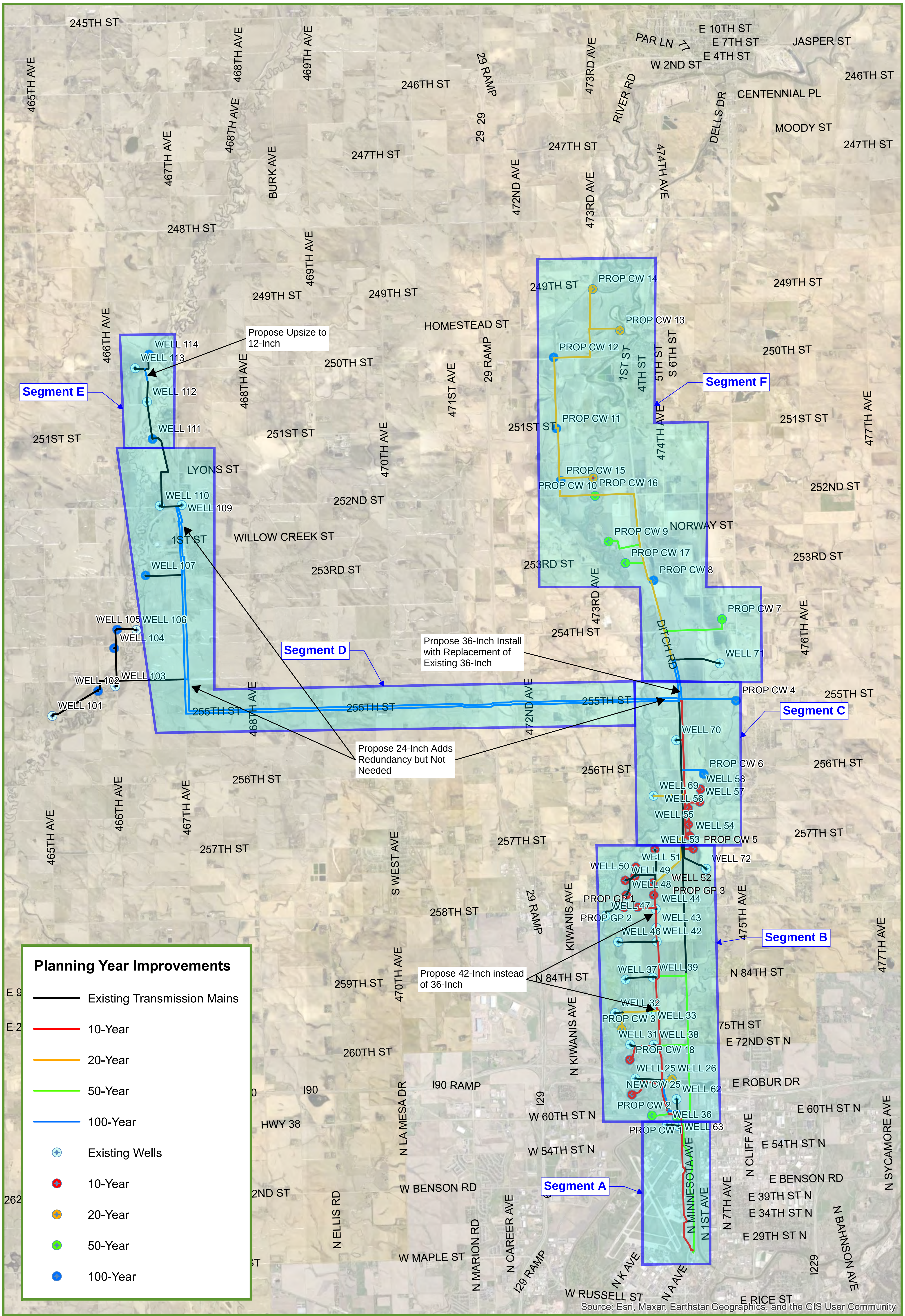
Figure 13
Peak Day 100-Year Planning Period Main Headloss, Historical Withdrawal

N
W E
S

0 1 2
Miles

1 inch = 1.25 miles

HRG FILE: J:\2021\210506\Design\Report\Water Transmission Mains TM\Figures\Figure 13-Revised.mxd



HRGreen

In collaboration with:

carollo

LRE WATER
CONNECTING WATER TO LIFE

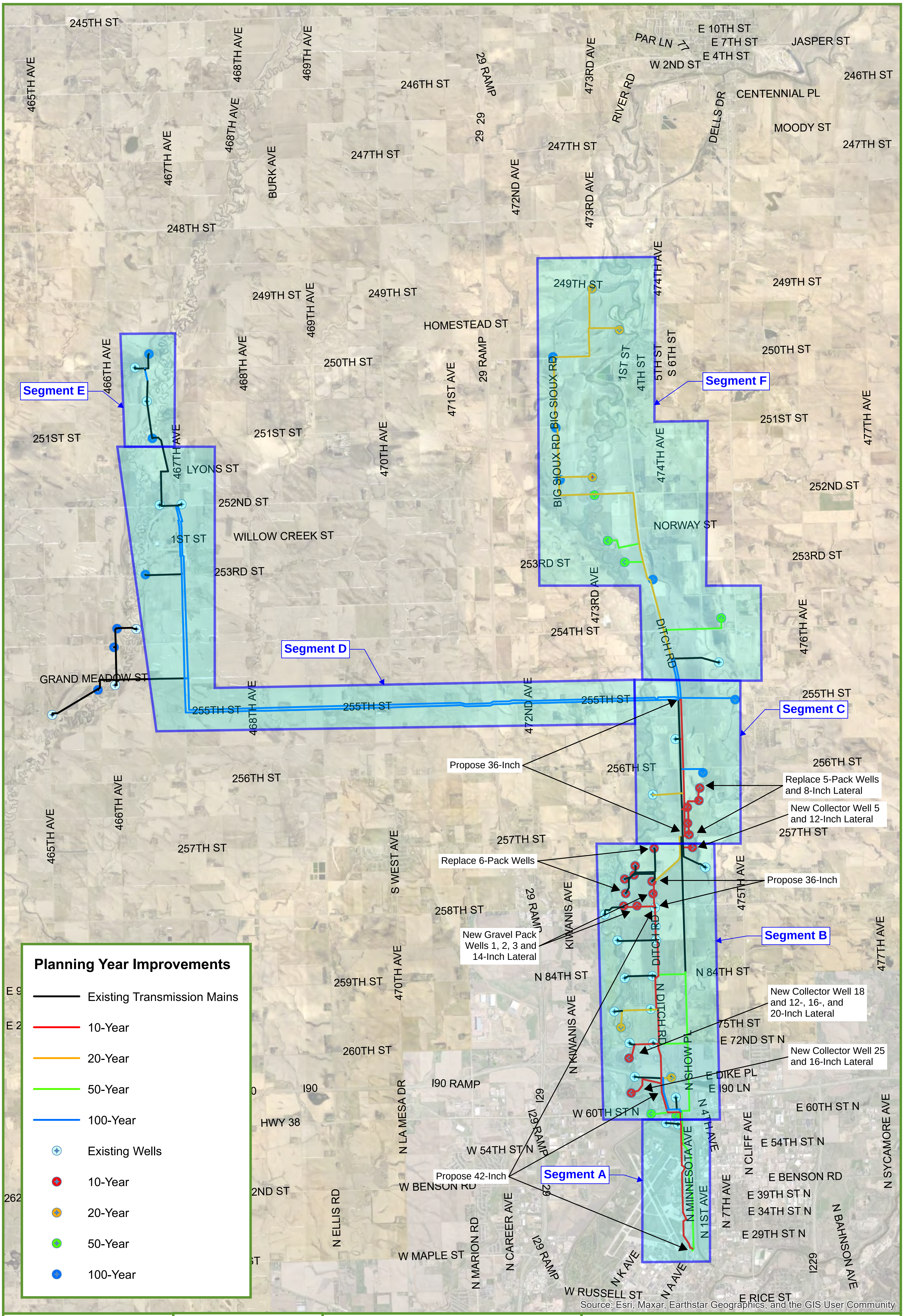
Figure 14
Adjustments to HDR Proposed Improvements

N
W E
S

0 1 2
Miles

1 inch = 1.25 miles

HRG FILE: J:\2021\210506\Design\Report\Water Transmission Mains TM\Figures\Figure 14.mxd



Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community

HRGreen

In collaboration with:

carollo

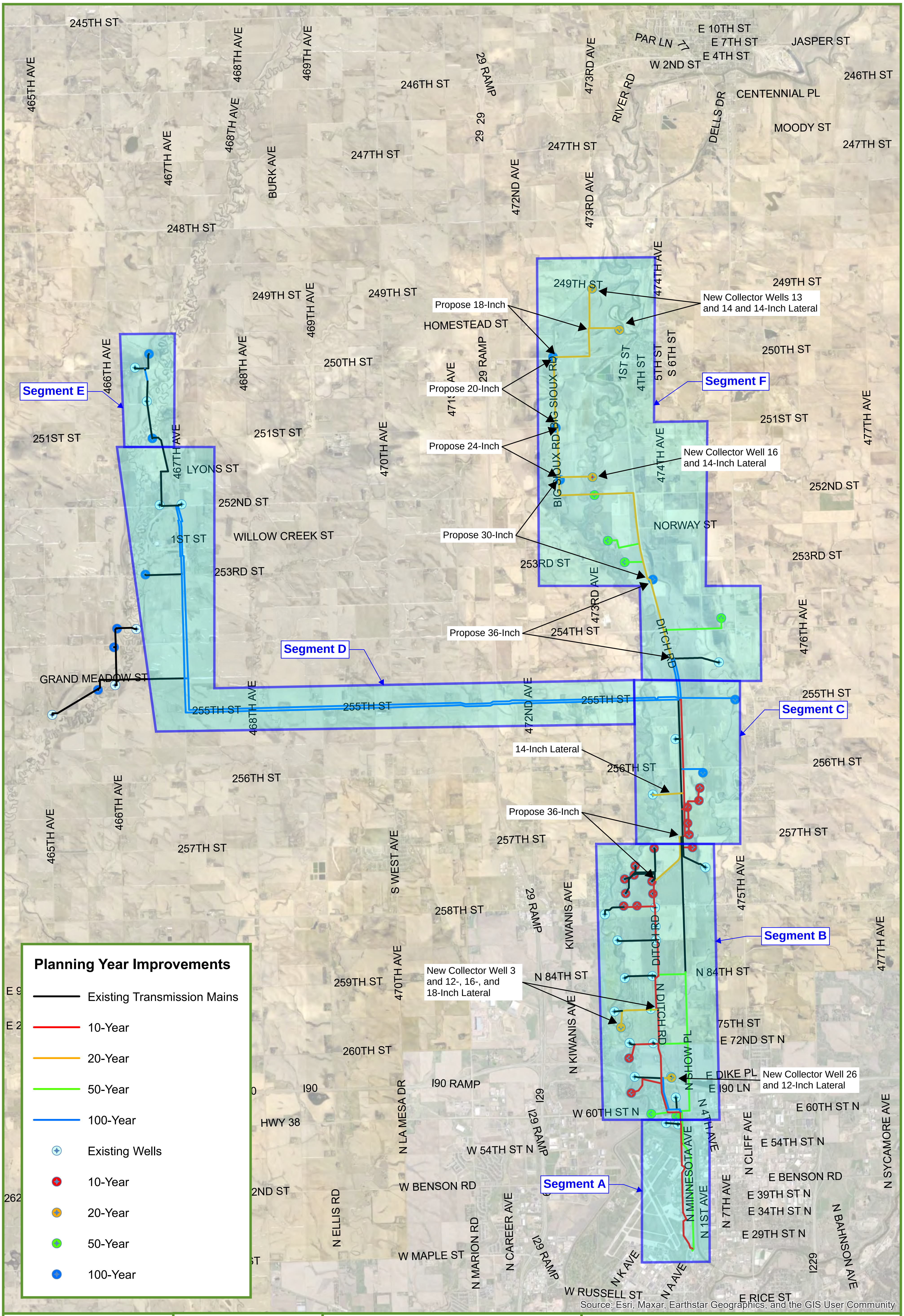
LRE WATER CONNECTING WATER TO LIFE

Figure 15
10-Year Planning
Proposed Improvements

N
W E
S

0 1 2
Miles

1 inch = 1.25 miles



HRGreen

In collaboration with:

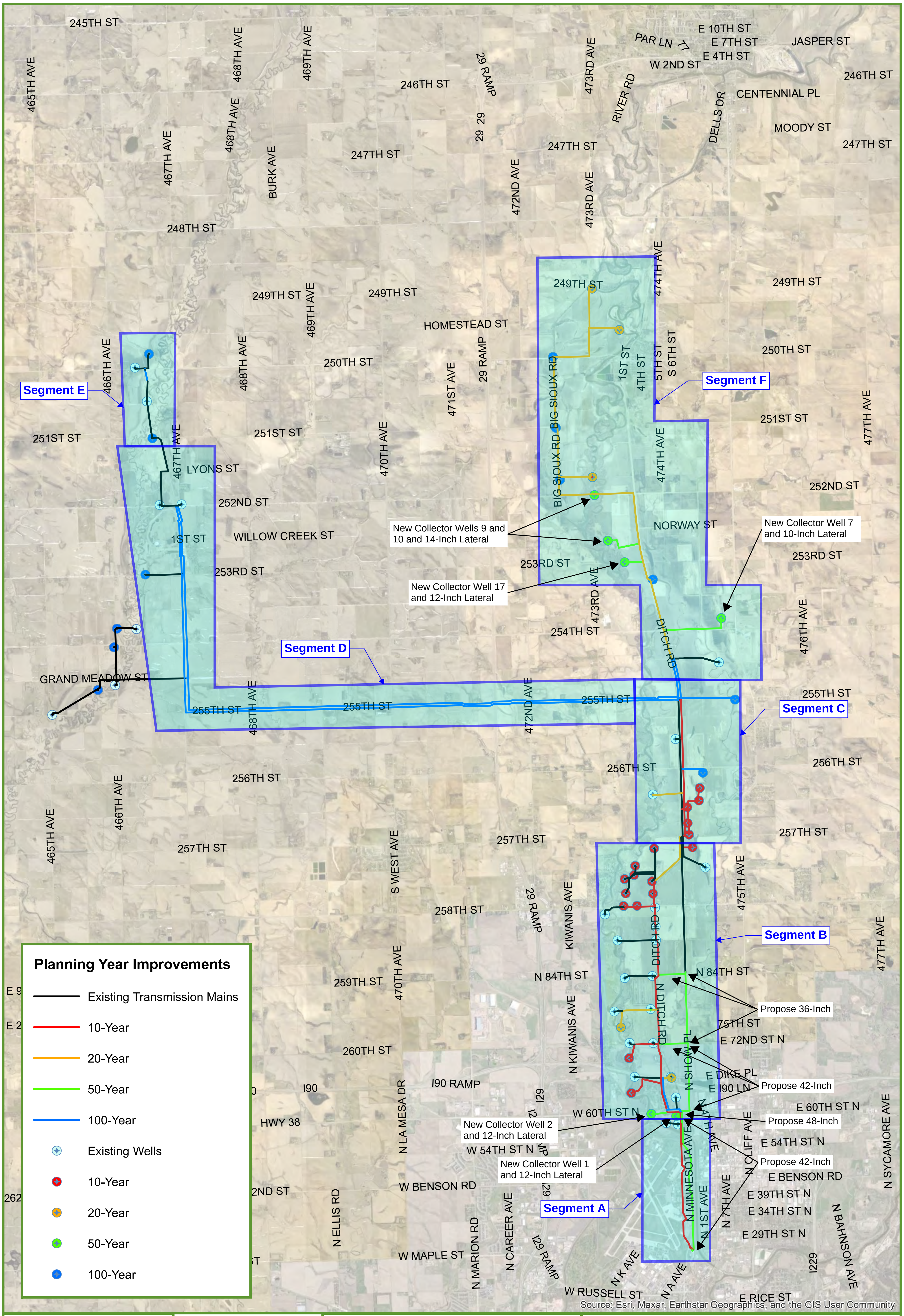
carollo

LRE WATER
CONNECTING WATER TO LIFE

Figure 16
20-Year Planning Proposed Improvements

N
W E
S

0 1 2
Miles
1 inch = 1.25 miles



Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community

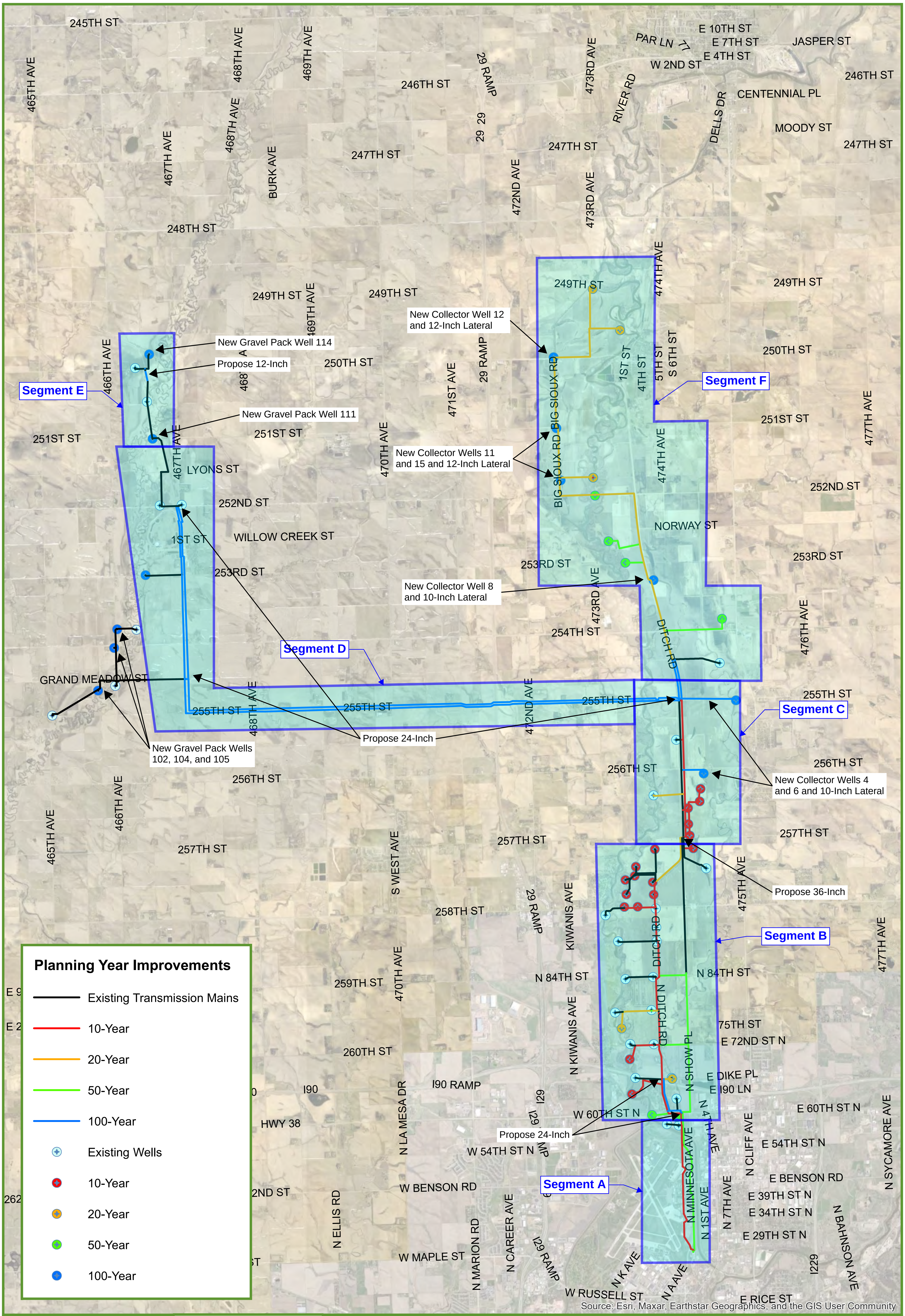
HRGreen

In collaboration with:

carollo

LRE WATER
CONNECTING WATER TO LIFE

Figure 17
50-Year Planning
Proposed Improvements



Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community

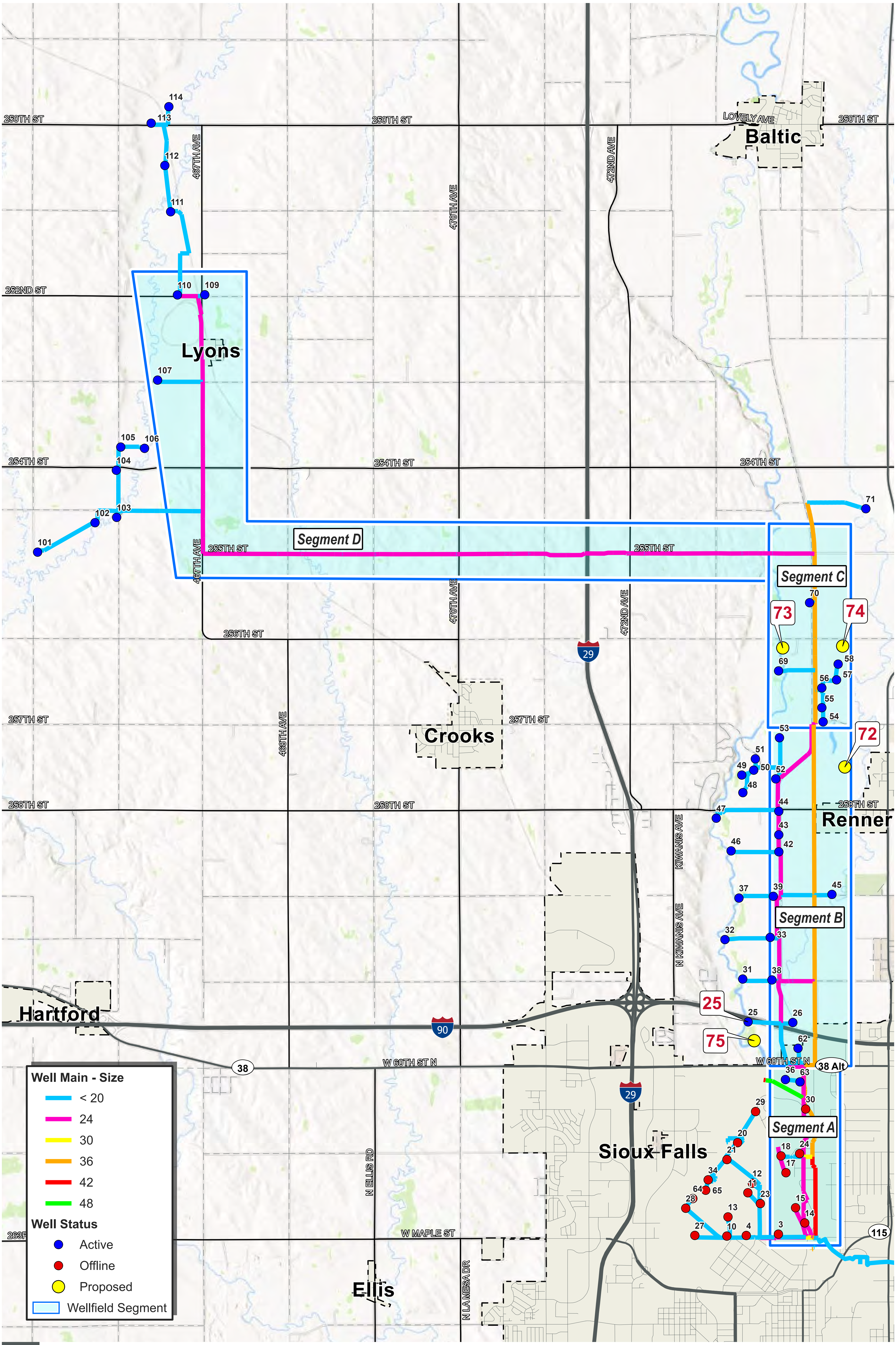
In collaboration with:

Figure 18
100-Year Planning Proposed Improvements

N
W E
S

0 1 2
Miles

1 inch = 1.25 miles

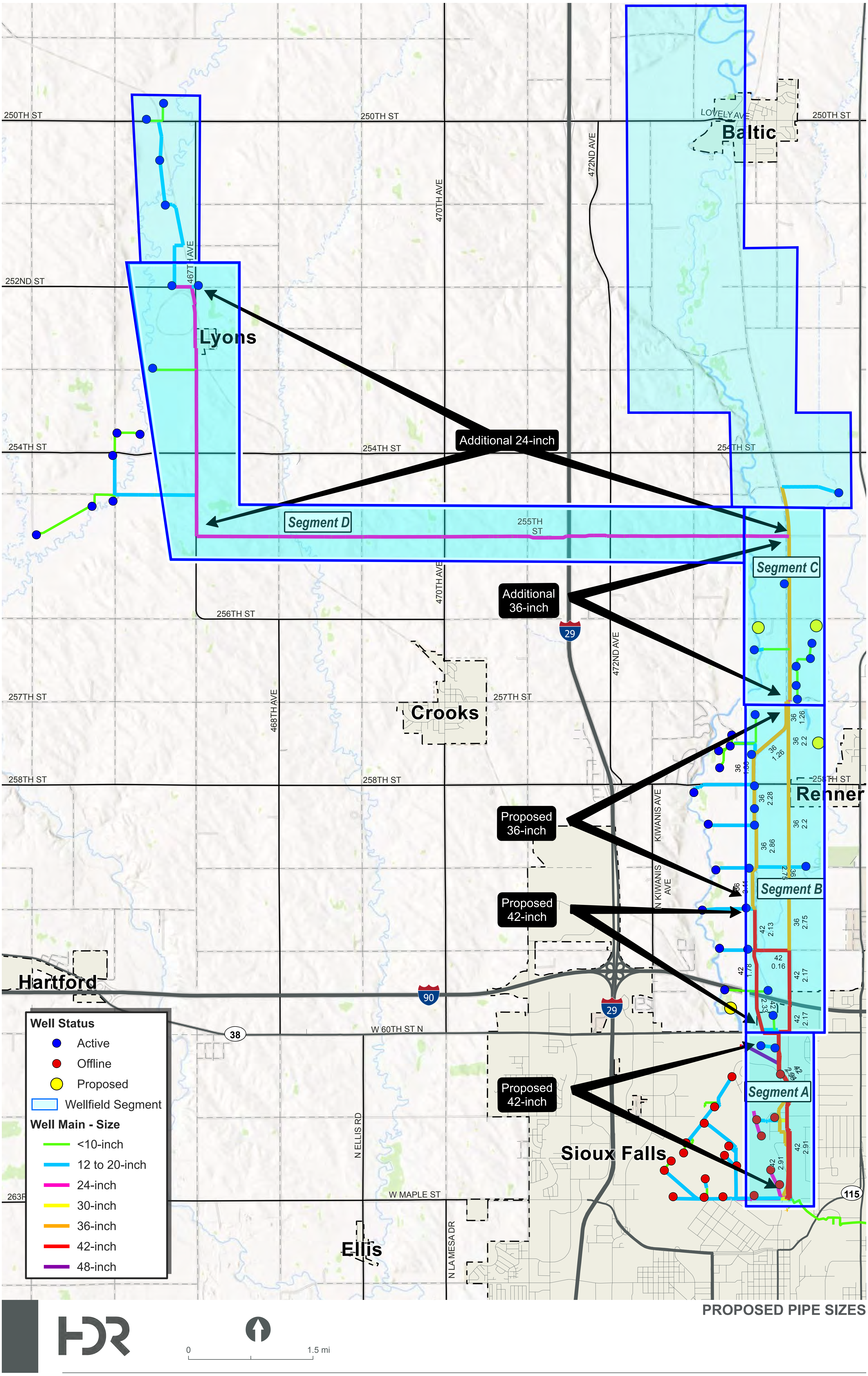


EXISTING WELLFIELD AND RAW WATER MAINS WITH PROPOSED WELLS

Figure 2-1

SIOUX FALLS RAW WATER

\\SXF-SRV01\ENG\GIS\PROJECTS\CITY_SIOUX_FALLS\CRITICAL_ASSETS_10195834\MAP_DOCS\CRITCAL_ASSETS.APRX DATE: 10/11/2021



PROPOSED PIPE SIZES

\\SXF-SRV01\ENG\GIS\PROJECTS\CITY_SIOUX_FALLS\CRITICAL_ASSETS_10195834\MAP_DOCS\CRITCAL_ASSETS.APRX DATE: 1/11/2022

SIOUX FALLS RAW WATER

COLLECTOR WELL 25 AND LATERAL
ESTIMATE OF CONSTRUCTION AND PROJECT COSTS IN 2022 DOLLARS

	ITEM DESCRIPTION	QTY	UNITS	UNIT COST	COST
1	Collector Well	1	LS	$ 4,298,000	$ 4,298,000
2	Raw Water Main	1	LS	$ 1,722,000	$ 1,722,000
3	Contingecy, Engineering, Legal, Admin & Testing	1	LS	$ 1,875,000	$ 1,875,000
				Estimated Construction Cost	$ 7,900,000

PROPOSED COLLECTOR WELL 5 AND LATERAL
ESTIMATE OF CONSTRUCTION AND PROJECT COSTS IN 2022 DOLLARS

	ITEM DESCRIPTION	QTY	UNITS	UNIT COST	COST
1	Collector Well Construction	1	LS	$ 3,000,000	$ 3,000,000
2	Sitework, Access Road, Electrical Utilities	1	LS	$ 220,000	$ 220,000
3	Well Lateral Main, 10"	700	LF	$ 280	$ 196,000
Contingency (30%)					$ 1,024,800
Estimated Construction Cost					$ 4,440,800
Contractor General Conditions (5%)					$ 222,100
Contractor Overhead/Profit/Mobilization (15%)					$ 666,200
Engineering Design (14%)					$ 621,800
Construction Administration (6%)					$ 266,500
Funding - Legal / Admin (4%)					$ 177,700
Estimated Project Cost					$ 6,400,000

5-PACK SERIES REPLACEMENT AND LATERAL
ESTIMATE OF CONSTRUCTION AND PROJECT COSTS IN 2022 DOLLARS

	ITEM DESCRIPTION	QTY	UNITS	UNIT COST	COST
1	Gravel Pack Well Construction	5	EA	$ 175,000	$ 875,000
2	Sitework, Access Road, Electrical Utilities	1	LS	$ 250,000	$ 250,000
3	Well Lateral Main, 8"	6,850	LF	$ 210	$ 1,438,500
4	Well Lateral Main, 12"	360	LF	$ 325	$ 117,000
Contingency (30%)					$ 804,200
Estimated Construction Cost					$ 3,484,700
Contractor General Conditions (5%)					$ 174,300
Contractor Overhead/Profit/Mobilization (15%)					$ 522,800
Engineering Design (14%)					$ 487,900
Construction Administration (6%)					$ 209,100
Funding - Legal / Admin (4%)					$ 139,400
Estimated Project Cost					$ 5,020,000

PROPOSED GRAVEL PACK WELLS 1, 2, 3, AND LATERAL
ESTIMATE OF CONSTRUCTION AND PROJECT COSTS IN 2022 DOLLARS

	ITEM DESCRIPTION	QTY	UNITS	UNIT COST	COST
1	Gravel Pack Well Construction	3	EA	$ 175,000	$ 525,000
2	Sitework, Access Road, Electrical Utilities	1	LS	$ 200,000	$ 200,000
3	Well Lateral Main, 8"	270	LF	$ 210	$ 56,700
4	Well Lateral Main, 14"	2,360	LF	$ 360	$ 849,600
Contingency (30%)					$ 489,400
Estimated Construction Cost					$ 2,120,700
Contractor General Conditions (5%)					$ 106,100
Contractor Overhead/Profit/Mobilization (15%)					$ 318,200
Engineering Design (14%)					$ 296,900
Construction Administration (6%)					$ 127,300
Funding - Legal / Admin (4%)					$ 84,900
Estimated Project Cost					$ 3,060,000

UPSIZE 24-, 36-, AND 42-INCH TRANSMISSION MAIN
FROM WPP TO NORTH OF 258TH STREET
ESTIMATE OF CONSTRUCTION AND PROJECT COSTS IN 2022 DOLLARS

	ITEM DESCRIPTION	QTY	UNITS	UNIT COST	COST
1	Segment A Cost	1	LS	$ 19,745,000	$ 19,745,000
2	Segment B Cost Partial	1	LS	$ 26,670,000	$ 26,670,000
				Estimated Construction Cost	$ 46,500,000
				Contractor General Conditions (5%)	$ 2,325,000
				Construction Administration (6%)	$ 2,790,000
				Estimated Project Cost	$ 51,620,000

6-PACK SERIES REPLACEMENT AND LATERAL
ESTIMATE OF CONSTRUCTION AND PROJECT COSTS IN 2022 DOLLARS

	ITEM DESCRIPTION	QTY	UNITS	UNIT COST	COST
1	Gravel Pack Well Construction	6	EA	$ 175,000	$ 1,050,000
2	Sitework, Access Road, Electrical Utilities	1	LS	$ 250,000	$ 250,000
3	Well Lateral Main Rehabilitation, 8"	8,800	LF	$ 130	$ 1,144,000
4	Well Lateral Main Rehabilitation, 16"	2,170	LF	$ 275	$ 596,750
Contingency (30%)					$ 912,300
Estimated Construction Cost					$ 3,953,100
Contractor General Conditions (5%)					$ 197,700
Contractor Overhead/Profit/Mobilization (15%)					$ 593,000
Engineering Design (14%)					$ 553,500
Construction Administration (6%)					$ 237,200
Funding - Legal / Admin (4%)					$ 158,200
Estimated Project Cost					$ 5,700,000

PROPOSED COLLECTOR WELL 18 AND LATERAL
ESTIMATE OF CONSTRUCTION AND PROJECT COSTS

	ITEM DESCRIPTION	QTY	UNITS	UNIT COST	COST
1	Collector Well Construction	1	LS	$ 3,000,000	$ 3,000,000
2	Sitework, Access Road, Electrical Utilities	1	LS	$ 240,000	$ 240,000
3	Well Lateral Main, 12"	1,180	LF	$ 325	$ 383,500
4	Well Lateral Main, 16"	1,500	LF	$ 390	$ 585,000
5	Well Lateral Main, 20"	300	LF	$ 440	$ 132,000
				Contingency (30%)	$ 1,302,200
				Estimated Construction Cost	$ 5,642,700
				Contractor General Conditions (5%)	$ 282,200
				Contractor Overhead/Profit/Mobilization (15%)	$ 846,500
				Engineering Design (14%)	$ 790,000
				Construction Administration (6%)	$ 338,600
				Funding - Legal / Admin (4%)	$ 225,800
				Estimated Project Cost	$ 8,130,000

PARALLEL 36-INCH TRANSMISSION MAIN FROM 257TH STREET TO 255TH STREET
ESTIMATE OF CONSTRUCTION AND PROJECT COSTS

	ITEM DESCRIPTION	QTY	UNITS	UNIT COST	COST
1	Segment C Cost	1	LS	$ 13,302,000	$ 13,302,000
2	Segment C Cost Reduction Less 3,500'	1	LS	$ (1,900,000)	$ (1,900,000)
				Estimated Construction Cost	$ 11,500,000
				Contractor General Conditions (5%)	$ 575,000
				Construction Administration (6%)	$ 690,000
				Estimated Project Cost	$ 12,770,000

CATHODIC PROTECTION ON EXISTING
DUCTILE IRON PIPE
ESTIMATE OF CONSTRUCTION AND PROJECT COSTS

	ITEM DESCRIPTION	QTY	UNITS	UNIT COST	COST
1	Cathodic Protection	1	LS	$ 300,000	$ 300,000
Estimated Construction Cost					$ 300,000
Contractor General Conditions (5%)					$ 15,000
Construction Administration (6%)					$ 18,000
Estimated Project Cost					$ 340,000

Technical Memorandum

Water Supply and Treatment Master Plan

Chapter 6:

Water Purification Plant Condition Assessment

November 2022

(Revisions September 2023)

HR Green Project No: 210506

Prepared For:

CITY OF
SIOUX FALLS

Table of Contents

List of Figures

List of Tables

Appendices

Section 1: Introduction

This Condition Assessment technical memorandum is prepared for the City of Sioux Falls Water Purification Plant (WPP) as part of the Water Purification Master Plan. This memo assesses the current age, condition, and consequence of failure of the equipment and infrastructure of the WPP facility.

Water treatment facilities have been located at 2100 N. Minnesota Ave. for nearly 90 years. The original treatment plant and clearwell were constructed in the 1930's. Since then, multiple additions have been constructed to expand treatment, storage, and distribution capacity.

The WPP facilities have been well-maintained. Through skilled operation and maintenance by WPP staff, the facility reliably provides good quality water to the City of Sioux Falls. The addition of the Lewis & Clark Regional Water System has helped meet Sioux Falls' demand. However, as Sioux Falls grows, the capacity of the system must increase accordingly.

Though the treatment facility continues to effectively treat a combination of groundwater and surface water, some components of the WPP infrastructure require life cycle replacement due to age and mechanical wear.

Summary of Equipment Age

This memo evaluates the age and condition of the process equipment, structures, and building facilities. A summary of the major process areas and corresponding recommendations are included in the table below.

Process Area	Recommendations	Year Constructed	Age of Structure / Equipment
Actiflo	Replace sand pumps	2004	18
Solids Contact Basins	Basins 1 – 6: Replace mechanical equipment	1952 / 1969	70 / 53
Recarbonation Basins	Evaluate side stream CO2 Remove baffles from structure	1952 / 1969	70 / 53
Filters	Replace valves & flow meters: Filters 1 – 10	1952 / 1969 / 2011	70 / 53 / 11
Backwash reclaim basin	Replace sludge scrapers Add sludge scrapers to East side of basin	2011	11
Clearwell	Monitor structural condition	1935	87
High Service Pumping	Add VFDs to all pumps		
North Reservoir / Transfer Pumps	Add VFDs to transfer pumps Replace medium voltage motors with 480V		
Lime Storage	Replace lime transfer control system	1953	69
Lime Slakers	Replace slakers 5 & 6		
Chemical Storage / Feed Systems	Replace fluoride tank Evaluate chemical feed pumps	1995	27
Facilities	Replace Basin area roof Replace freight elevator Replace facility boilers		
Electrical	Replace Power Room 1 Switchgear Replace Power Room 2 MCCs & Equipment Replace Power Room 3 MCC Replace Power Room 4 MCC Replace Standby Generator	2003 - 2004 2011 1997	19 - 18 11 25
Instrumentation / Controls	Replace Analog Chemical Area Equipment Replace Chemical Area Flow Meters Replace PA System Upgrade & Loop Fiber	1993 1993 - -	29 29 - -

1-1 Background

The City of Sioux Falls currently owns, operates, and maintains the Water Purification Plant (WPP) to treat surface water and ground water to serve Sioux Falls. In order to review system viability HR Green, Carollo, and LRE were contracted to evaluate the existing water purification plant to develop a Master Plan to help the City plan for future improvements. As the City moves forward and continues to grow, it will be critical for the existing facility to reliably maintain its current capacity in combination with additional proposed improvements to meet projected long-term demands The intent of this Chapter/Technical Memo is to assist in documenting capital improvements to address age, condition, and capacity of the existing facilities.

Multiple site visits were conducted with City staff to evaluate the age, condition, and serviceability of each unit process throughout the WPP facility. The design team met with City operations, laboratory, maintenance, electrical, and instrumentation & controls staff to gain an understanding of daily operations of the WPP. Plant staff shared valuable first-hand input on the asset evaluation, including equipment age, ongoing maintenance concerns, and planned upgrades. The design team reviewed past plans to determine the date of installation of the WPP facilities.

The condition assessment seeks to evaluate the facility condition for reliability, and provide recommendations based on the near-term (10 years) and mid-term (20 years) outlooks. Considerations include the following:

- **Age & Condition:** The age of major process areas, structures, and equipment is summarized based on review of past plans and discussion with operations staff.
- **Reliability and Redundancy:** The condition assessment evaluates the consequence of failure for major process areas, and seeks to identify plant vulnerabilities if components of the plant fail.
- **Maintaining Plant Capacity for Future Expansion:** As Sioux Falls grows, future water demand will require additional treatment capacity. If the WPP continues to operate, life cycle replacement of equipment will be required to maintain WPP operations and prepare for possible expansion. Options for expanding the existing processes are discussed in Chapter 7 – WPP Treatment Evaluation.

After evaluating the plant facilities, touring the facility, and speaking with operations staff, the design team determined what improvements are needed at the facility to maintain current operations, and what options exist for expansion of the facility.

1-2 Evaluation Summary

A summary of each process area, the concerns identified, and recommended improvements are tabulated in a summary table included in Appendix A. Excerpts of this table are included throughout this memo with additional discussion of each process area in the facility.

A recommended timeline is included in Appendix A and the following sections. Most recommendations in the Condition Assessment are within the 0 – 10 year timeframe. Determination of the timeline is as follows:

- 0 – 10 years: critical projects for equipment that is near failure, or life-cycle replacement of equipment beyond its useful life.
- 10 – 20 years: lower priority projects, or projects with a focus on future capacity increase.

Many of the projects are recommended to be completed within 0 – 10 years. To further classify the projects, a priority was assigned to the recommendations. While many of these recommendations are necessary for the operation and resiliency of the plant, **critical** priority projects include recommendations for processes or equipment that are near failure or where failure would significantly impact plant capacity or redundancy. The priorities are as follows:

- Critical: systems that have failed, are near failure, or where failure would have significant impact to plant capacity.
- Urgent: Life-cycle replacement of equipment beyond its useful life.
- Required: Required improvements to improve resiliency and update to current standards.
- Ad Hoc: Recommended improvements not necessary for plant capacity or functionality
- Maintenance / Monitoring: Ongoing monitoring or further study.

Recommendations in the summary tables follow the section numbering in the following report. Some of the recommended improvements are currently being planned by WPP staff as upcoming projects. These projects were included in the recommendations to capture current and planned projects in the Master Plan documents.

Appendix A includes a list of the proposed projects, ranked by priority. The initial portion of this table is shown in Table 1 below to reflect the priorities of a 10-year capital improvement plan.

Table 1: 10-year CIP Recommended Improvements

#	Recommended Improvements	Priority	Cost
2-4.D	Filters: Replace VFD for backwash pump (life cycle replacement)	Critical	$136,700
2-4.C	Filters: Add additional backwash blower (redundancy)	Critical	$77,500
2-10.B	Chemical Feed: Add second service water line	Critical	$39,300
3-1.C	Power Distribution: Replace gear in Power Room 2. Potentially relocate to another room	Critical	$1,408,000
2-5.A/B	Backwash Reclaim Basin: Replace sludge scrapers, Add additional scrapers to second side of basin	Critical	$1,434,000
2-6.A	Clearwell: Replace valves between clearwell & N. reservoir transfer pump wet well	Critical	$159,300
2-4.A	Filters: Install flow meters (mag meters) on Filters 1 – 10	Urgent	$1,999,200
2-4.B	Filters: Replace filter valves on Filters 1 – 10	Urgent	$2,669,900
2-2.A	Solids Contact Basins: Replace clarifier equipment in Basins 2 & 3. Update basin instruments/controls. Replace sludge lines on basins 2 & 3.	Critical	$6,252,000
2-15.A	Solids Contact Basins: Replace roof - basin area	Critical	$820,000
2-7.B	High Service Pumps: Install additional VFDs (Pumps 1, 2, 5, 6, 7, 8, 9)	Urgent	$3,026,000
2-3.A	Recarbonation Basin: Replace CO2 feeders	Urgent	$1,814,000
2-7.A	High Service Pumps: Replace pumps 7, 8, 9 (Cavitation). Change to lower flow pumps	Critical	$799,000
2-1.A	Actiflo: Replace (6) sand pumps	Critical	$227,800
2-8.A	Transfer Pumps: Install 480V VFDs	Urgent	$780,300
2-8.B	Transfer Pumps: Replace medium voltage motors with 480V motors	Urgent	

#	Recommended Improvements	Priority	Cost
2-10.C	Chemical Storage: Replace analog equipment with digital/Ethernet chemical feed pumps. SCADA integration of day tank scales	Urgent	$559,300
2-10.D	Chemical Storage: Replace Chemical Feed Building HVAC	Urgent	$242,600
2-11.A	Lime System: Replace slakers 5 & 6	Urgent	$1,368,100
2-12.A	Transmission Main Tunnel: Repair Pipe Tunnel Ceiling per inspection report	Critical	Refer to Midwest Engineering structural report
2-13.A	Architectural/building maintenance improvements: Operations supervisor office floor. Process engineer office wall water damage.	Ad Hoc	$15,000
2-14.A	Laboratory: Replace cabinets & casework	Ad Hoc	$112,300
2-14.B	Laboratory: Lab Flooring	Ad Hoc	

1-3 Asset Condition Summary

The condition assessment is summarized in a summary table included in Appendix B. This is an important appendix to identify age, condition, and consequence of failure for process and mechanical systems throughout the facilities.

WPP staff are committed to maintaining the facilities, and have done an excellent job extending the life of this facility. Throughout the plant evaluation, WPP staff noted there has been less demand on the plant demand in recent years due to the addition of supply from the Lewis & Clark Regional Water System. This lower demand has allowed the WPP to defer certain upgrades and expansion. However, maintaining the capacity of the treatment plant is essential to meeting future water demand. No matter how well a facility is maintained, there is no escaping the fact that mechanical equipment will wear out and building components will deteriorate due to age and mechanical wear.

The summary tables in Appendix A include an evaluation of the estimated life expectancy. The need or life cycle replacement of equipment and building facilities is dependent on many factors, such as operating environment, duty cycle of mechanical equipment, and performance of routine maintenance. General guidelines for life cycle replacement of equipment and structures are summarized in Table 2 below.

Table 2: Asset Estimated Life Expectancy

Asset	Estimated Life Expectancy
Mechanical Equipment	30 years
Pumps	25 years
Piping	60 years
Valves	35 years
Instruments / Controls	10 years
Filters	50 years
Concrete Tanks	75 years
HVAC	25 years

The condition of the assets summarized in the table are categorized by the current age, estimated life expectancy, condition, and consequence of failure. The asset condition is given a ranking between 1 and 5 (1 is new, 5 is unserviceable). The description of the condition is categorized as follows:

- Excellent or New Condition
- Minor defects only
- Moderate deterioration
- Significant deterioration
- Virtually unserviceable

The consequence of failure column indicates how the WPP facility would be impacted if the individual asset were to fail. The descriptions are categorized as follows:

- Minor Impact: Equipment failure will is not expected to impact WPP capacity or operation of other systems.
- Process Impacted / Redundancy Available: The capacity of the individual process is reduced, but redundancy is available and the WPP capacity is not affected.
- Intermediate Impact / No Redundancy: The capacity of the individual process is reduced and no redundancy is available. The process must be bypassed for service, or the WPP capacity will be affected.
- Reduced Plant Capacity: Failure of the process will reduce plant capacity.
- Major Impact: Equipment failure will lower WPP capacity and impact operation of other processes
- Building / Facility Impact: Facilities impact that does not immediately affect WPP capacity.

1-4 Treatment System Description

The treatment system is described in detail in Chapter 7 – WPP Treatment Evaluation. In summary, the treatment process consists of the following major process areas, with water flowing through the plant generally in this order:

- Raw Water Source: The WPP raw water supply comes from two sources: surface water from the Big Sioux River pump station, and groundwater from an extensive network of wells north of Sioux Falls.
- Surface Water Pretreatment: Actiflo System.
- Softening: Lime softening, with six (6) solids contact basins.
- Filtration: Fifteen (15) dual-media filters.
- Chemical addition
- Clearwell: 4 million gallon clearwell.
- High service pumping

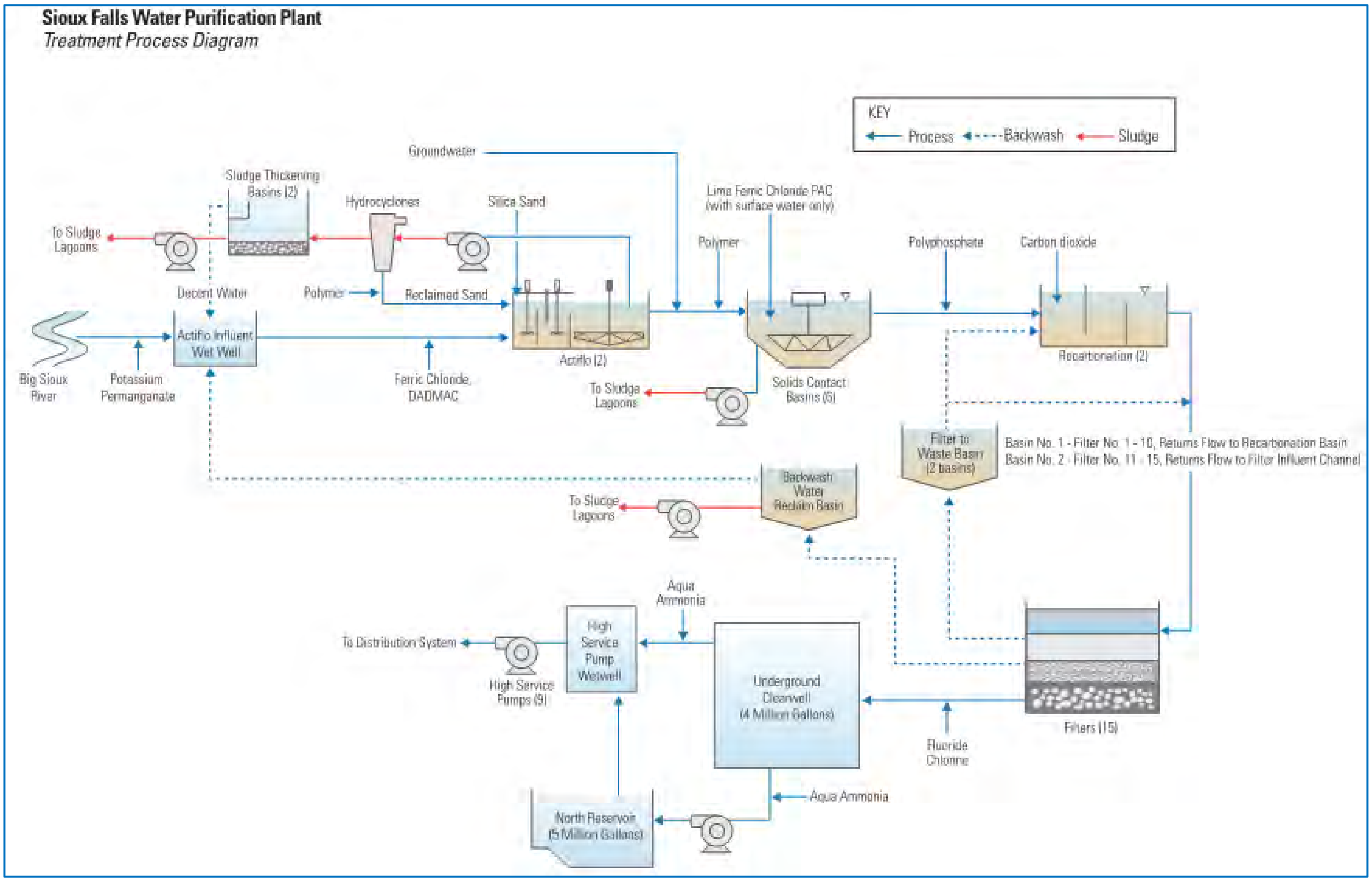


Figure 1: WPP Treatment Process Diagram

Other processes at the WPP serve to support these major process areas, such as chemical storage, sludge handling, backwash basins, and maintenance areas. The age and condition of each treatment system component is detailed in the following sections.

Section 2: Equipment & Facilities Condition Assessment

The current Sioux Falls WPP facility was initially constructed in 1952, but consists of multiple building additions that were added to improve treatment processes and expand capacity over the life of the plant.

Figure 2: WPP Site Plan

2-1 Actiflo

The Actiflo system is used as a pretreatment process for surface water. Filter backwash reclaim water is also pumped to the Actiflo system. The Actiflo system consists of flocculation with polymer and a microsand ballast, followed by a rapid clarifier with lamella plate settlers. The Actiflo system has two trains, each with a capacity of 15 mgd. Under current operation, the WPP typically operates one Actiflo train. Staff indicated two Actiflo trains have been operated during summer high demand seasons from June to August.

Table 3: Actiflo Equipment

Equipment	Description	Year Constructed
Piping	Good condition	2004
Valves	Good condition	2004
Actiflo Sand Pumps	Rubber lined volute Sand piping is glass lined	2004
Sludge Pumps	Moyno progressive cavity pumps	2004
Structure	Good condition	2004

Photo 1: ACTIFLO SAND PUMPS

Identified Concerns:

- Actiflo sand pumps have leaking seals, abrasive sand causes wear in these pumps. Sand pumps are original to the Actiflo system (2004).
- Life cycle replacement of influent flow meters (original to Actiflo system in 2004).
- Life cycle replacement of Actiflo sand silo weighing system (original to Actiflo system in 2004).

Actiflo Recommendations:

	Recommendation	Timeline	2022 Estimated Project Cost
2-1.A	Replace (6) sand pumps	0 - 10 years	$227,800
2-1.B	Actiflo Instrumentation: Replace (2) influent flow meters, Replace sand silo weight system	0 – 10 years	$148,000

2-2 Solids Contact Basins

Influent groundwater comes to the treatment plant through two 36-inch lines at the northeast corner of the solids contact basin area. The untreated influent groundwater is combined with the Actiflo pretreated surface water in the influent channel serving the solids contact basins. The WPP treatment softening process consists of six solids contact softening basins. Lime softening is achieved with slaked lime added to the solids contact basin influent. The basins consist of a 56-ft x 56-ft square concrete basin, with a 16-ft water depth. Water flows into the basins through a 30-inch influent pipe under each basin to the upflow center column of the basin. Effluent launders convey basin effluent to a 36" effluent pipe that flows to an effluent channel and flows to the recarbonation basins.

Basins 2 through 6 contain Dorr-Oliver upflow clarifier equipment. Basin 1 has WesTech equipment with radial launders. A sludge blanket is maintained in these basins. Sludge is collected from the basins with sludge scrapers in the bottom of the basin. Sludge drain lines convey sludge to a common sludge collection structure. Basin 2 & 3 have 4-inch sludge drain line while basins 1, 4, 5, 6 have 6-inch sludge drain lines. The sludge drain line in Basin 1 was upsized when the clarifier equipment was replaced.

The City periodically services mechanical equipment in the solids contact basins by sandblasting and repainting the metal components in the basin. Cracks in the concrete walls of the basin have been repaired in the past with injection of polyurethane. Operations staff identified issues with maintaining the sludge blanket density when the alkalinity in the basin changes.

Table 4: Solids Contact Basin Equipment

Equipment	Notes	Year Constructed
Basin 1 (Westech eqpt.)	New Westech eqpt. - 1997	1952
Basin 2 (Dorr-Oliver eqpt.)	Undersized 4" sludge line	1952
Basin 3 (Dorr-Oliver eqpt.)	Undersized 4" sludge line	1952
Basin 4 (Dorr-Oliver eqpt.)		1969
Basin 5 (Dorr-Oliver eqpt.)		1969
Basin 6 (Dorr-Oliver eqpt.)		1969
Piping		1969
Valves		1969

Photo 2: INFLUENT FLOW METERS (36-INCH DIAMETER)

Identified Concerns:

- Life cycle replacement of influent flow meters on North and South influent pipes.
- Life cycle replacement of influent flow meters on each basin. Existing venturi meters are to be replaced with magnetic flow meters.
- Life cycle replacement of influent valve actuators.
- Life cycle replacement of (1) lime sludge pump and associated VFD.
- Corroded mechanical equipment inside basin 2 & 3.
- Condition of basin influent piping and sludge drain piping is unknown on basins 2 & 3.
- Basin 2 & 3 have 4-inch sludge piping. Plant staff indicated sludge discharge restricts the basin flow.
- The south wall of Basin 1 has leaked in the past, leaking into the auditorium. Repairs were made to the south wall; the basin is no longer leaking.
- Controls for basins 2 & 3 have not been recently updated.

Photo 3: Solids Contact Basin Sludge Scrapers

Solids Contact Basin Recommendations:

	Recommendation	Timeline	2022 Estimated Project Cost
2-2.A	Replace clarifier equipment in Basin 2 & Basin 3. Update basin controls as part of this project. Replace sludge lines on basins 2 & 3 with larger pipes	0 - 10 years	$6,252,000
2-2.B	Televise basin piping to determine condition and risk of failure	0 - 10 years	Study / Evaluation
2-2.C	Replace influent flow meters on N / S pipes (36-inch diameter)	0 - 10 years	$92,000
2-2.D	Basin concrete has leaked in the past. Continue to monitor concrete structure and repair / seal concrete as necessary.	0 - 10 years	Routine Inspection / Monitoring
2-2.E	Basin Controls Improvements: Replace influent flow meters, influent valve actuators and lime sludge pump	0 – 10 years	$365,000

Photo 4: Solids Contact Basin 1

Photo 5: Solids Contact Basin 2

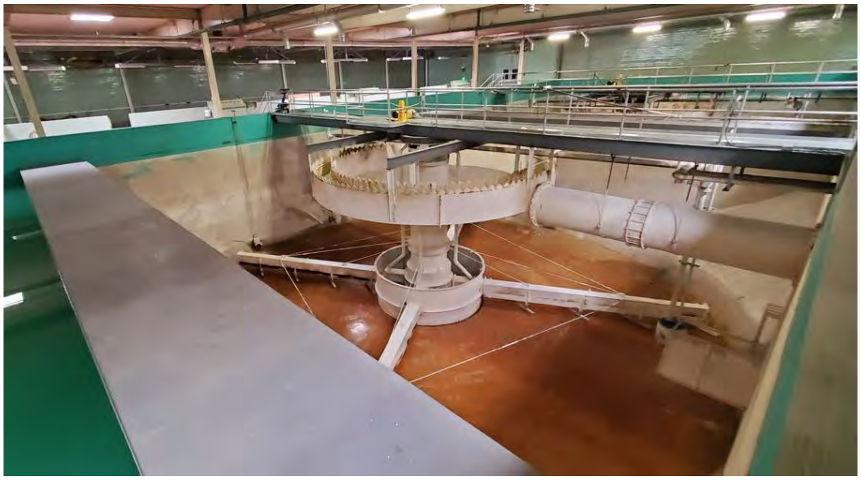


Photo 6: Solids Contact Basin 5

2-3 Recarbonation Basins

Following lime softening, water flows through the recarbonation basins for pH adjustment prior to filtration. Recarbonation basins are located between solids contact basins #3 & #4. Water flows from the solids contact basins to the recarbonation basins. Carbon dioxide gas is diffused with bubble diffusers into the water to lower the pH that has been raised in the lime softening process. Baffles within the recarbonation basin improve transfer efficiency of the bubble diffusers. From the recarbonation basin, water flows to the filters.

Refer to Chapter 7 - WPP Treatment Evaluation memo for recommendations related to improving headloss through the recarbonation basins and improving carbon dioxide transfer efficiency.

Table 5: Recarbonation Equipment

Equipment	Description	Year Constructed
Recarbonation Basin (Train 1)	South Train 12-ft x 62-ft tank 15-ft water depth	1952
Recarbonation Basin (Train 2)	North Train 12-ft x 62-ft tank 15-ft water depth	1969
CO_2 Feed System	Updated w/ Chem bldg. Feed rate: 22 mg/L	1995

Photo 7: CO_2 Feeder Equipment

Identified Concerns:

- Aging CO_2 feed equipment.
- Life cycle replacement of instruments for level & pH.

Recarbonation Basins Recommendations:

	Recommendation	Timeline	2022 Estimated Project Cost
2-3.A	Life cycle replacement of CO2 feeders Replace recarbonation basin instrumentation & control	0 - 10 years	$1,814,000
2-3.B	Evaluate CO2 alternatives (i.e. pressurized solution feed, side stream CO2.	0 - 10 years	Study / Evaluation

Photo 8: Recarbonation Basins

2-4 Filters

The filtration system consists of 15 dual-media filters. Filters 1 through 10 consists of a 25-ft by 33-ft footprint. A 1993 project improved filters 1 through 10: underdrains were replaced, surface wash was added, washwater troughs were replaced. The footprint of filters 11 through 15 are very similar to filters 1 – 10, at 25'-9" x 32'-4" with surface wash, nozzle underdrains. Filter underdrains consist of block laterals that allow for air scour and water backwash of the filter media. Filter piping and valves convey and control flow for filter influent, backwash supply, filter to waste, surface wash, and air scour.

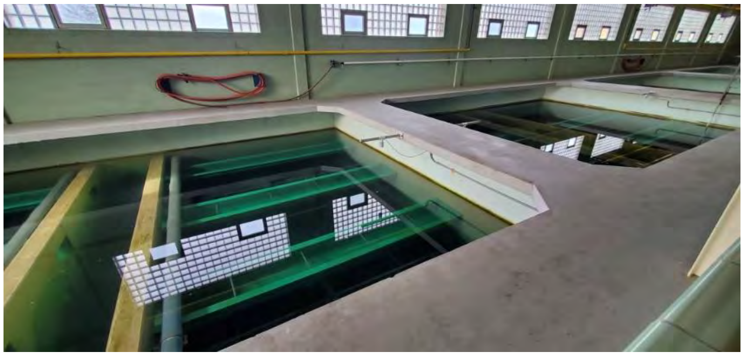


Photo 9: Filters 1 - 10

Filter backwash water is provided by two 150-HP backwash pumps which pump from the corner of the clearwell. Only one backwash pump operates at a time, backwashing redundancy is provided by a second pump. However, motor control is provided by a single variable frequency drive (VFD), with a selector switch between the two pumps. If the VFD fails, the system will not be able to backwash. The VFD itself also has some built-in redundancy with an internal bypass starter that can be selected instead of using the variable frequency drive. Filter backwash is performed automatically through the SCADA system. However, an operating procedure is in place to backwash filters manually if needed.

Photo 10: Filters 11 - 15

The WPP staff operates each filter at a flow rate of 3 mgd each. The plant always operates with one filter and turns on additional filters as needed to meet water demand. During filter operation, the process uses filter-to-waste during the startup of a filter cycle after backwashing. Surface wash is available on the filters but is not used during every backwash cycle. Reviewing water quality data, filter effluent water quality is consistently below 0.1 ntu turbidity.

Table 6: Filters & Equipment

Equipment	Notes	Year Constructed
Filter 1-5	1993: Replaced filter underdrain, air scour, surface wash, filter to waste.	1952
Filter 6-10	1993: Replaced filter underdrain, air scour, surface wash, filter to waste. Sealed cracks w/ polyurethane sealant.	1969
Filter 11-15		2011
Backwash Pumps (2)	VFD is over 10 years old. (2) 150 HP pumps, rated for 8500 gpm each	2011
Backwash Blower	Surface wash added in mid-1990's	1993
Piping	Paint is chipped, need to check thickness of pipe remaining	1969

Identified Concerns:

- Backwash blower for air scour does not have redundancy
- Life cycle replacement of filter flow meters. Basins 1 – 10 have aging orifice plate flow meters that warrant replacement.
- Filters 1 – 10: Aging condition of valve actuators
- Life cycle replacement of aging turbidimeters.
- Backwash pump VFD: Out-of-date VFD beyond typical life cycle replacement. No second VFD for redundant pump.
- Piping paint is cracked or deteriorating on filter gallery piping on filters 1 – 10.
- Life cycle replacement of filter instruments and controls I/O hardware that is outdated and will soon be obsolete.

Filter Recommendations:

	Recommendation	Timeline	2022 Estimated Project Cost
2-4.A	Filter Instrumentation Improvements (meters, pressure transducers, solenoids, radar sensors, and I/O hardware).	0 - 10 years	$1,999,200
2-4.B	Replace filter valves on Filters 1 – 10	0 - 10 years	$2,669,900
2-4.C	Add additional backwash blower (redundancy)	0 - 10 years	$77,500
2-4.D	(2) VFDs for backwash pumps (life cycle replacement)	0 - 10 years	$136,700

Photo 11: Filter 12 Backwash Troughs

Photo 12: Filter Gallery (Filters 1 - 10) – Concrete Wall Repairs

Photo 13: Filter Gallery (Filters 1 - 10) – Filter Effluent Flow Metering & Control Valves

2-5 Backwash Reclaim Basin & Filter to Waste Basins

Filter operation relies on periodic backwashing and filter-to-waste upon returning the filter to service. Storage basins for the backwash and filter to waste water are located west of the WPP, below grade in the yard.

The backwash basin was constructed in 2011 and consists of 96-ft by 66-ft concrete basin located outside the WPP building in the yard, west of Filters 11-15. The basin is divided into two chambers; the tank contains a sloped floor and operates at a high water level depth between 4 and 11 feet. Backwash water is introduced to the west chamber and then flowing to the east chamber where recycle water pumps discharge the reclaimed water to the Actiflo system. The west chamber contains sludge scrapers to collect settled solids. Cross collectors convey settled sludge to a pit with submersible sludge pumps. Sludge is pumped to the lime lagoons with the softening basin sludge.

A recent site visit was by the manufacturer (Brentwood) on March 1 2022 to inspect the backwash reclaim basin sludge collectors. The site visit determined that the existing chain-and-rake sludge collection system is showing indications of significant wear due to the abrasive nature of the accumulated solids in the backwash reclaim basin. The chain tension was low, and the chain was misaligned leading to failure of the mechanism. Brentwood drafted a report recommending component replacement and upgrades to the existing sludge scrapers.

Filter-to-waste effluent is sent to a basin to be reclaimed. Filter wasting is performed based on the initial turbidity spike upon returning the filter to service after backwashing. Two filter-to-waste basins are used during filter startup following backwash operations. Filter-to-Waste Basin No. 1 is located under the auditorium and Basin No. 2 is located west of the WPP.

The filter to waste basin west of the WPP was constructed in 1993 and consists of an 80-ft by 40-ft concrete basin with a sloped floor, 12-ft deep. Filter-to-waste water enters the basin at the southeast corner of the basin, and flows into the basin through a baffled inlet chamber that distributes the water. The basin does not contain sludge scrapers.

Table 7: Backwash & Filter-to-waste Basins

Equipment	Location	Year Constructed
Filter-to-waste basin No. 1 (Filters 1-10)	Under Auditorium	1969
Filter-to-waste basin No. 2 (Filters 11-15)	West of Actiflo	1993
Backwash reclaim basin (South)	West of Filters 11-15	2011

Identified Concerns:

- Sludge accumulates at the influent of the Backwash Reclaim Basin and flows over the center wall and accumulates on both sides of the divider wall. It accumulates up to 5 ft deep with sludge. This requires the sludge to be hosed down every 200 backwashes (roughly every +/- 2-3 months).
- Existing chain-and-rake sludge collection system is showing indications of significant wear due to the abrasive nature of the accumulated solids in the backwash reclaim basin. Some of the backwash reclaim basin sludge collectors have been removed due to equipment failure.
- The existing system requires periodic maintenance to repair chains and flights.
- Life cycle replacement of filter-to-waste basin return pumps & control panel.

Backwash Reclaim Basin & Filter to Waste Basins Recommendations:

	Recommendation	Timeline	2022 Estimated Project Cost
2-5.A	Replace existing sludge scrapers	0 - 10 years	$1,434,000
2-5.B	Add additional scrapers to east side of the reclaim basin	0 - 10 years	
2-5.C	Visual inspection of basin	0 – 10 years	Routine Inspection / Monitoring
2-5.D	Replace return pumps & control panel at filter-to-waste basin	0 - 10 years	$142,000

2-6 Clearwell

The WPP operates a clearwell with a storage volume of 4.0 million gallons. The clearwell was constructed in the 1930’s and is constructed of a concrete tank with concrete columns with fabric baffle curtains throughout the structure. The fabric baffle curtains were installed in 2001. Plant staff access the clearwell through hatches in the roof. Water from the filter effluent flows through the clearwell and is then pumped to the north reservoir or to distribution through the high service pumps. The WPP operates the clearwell at a typical depth of 10.7 feet.

Past maintenance and improvements of the clearwell includes installing a static mixer, sealing of cracks in the floor, replacement of pipe hangers, and upgrades to chemical feed lines.

AE2S conducted a condition assessment on the clearwell when it was drained recently. AE2S submitted a technical memorandum dated February 24, 2022 summarizing the findings. The risk of failure was determined to be low. Recommendations of this memo include continued monitoring of cracks, sealing larger cracks, patching exposed rebar, and replacing effluent valves. Previous photos taken in 2011 by HR Green staff were discovered in past project files. Where photos were taken in similar locations, the 2022 photos were compared to the 2011 photos. This is included in **Appendix C**.

In our site evaluation, the effluent valves were identified as a concern and are recommended for replacement. Valves between the clearwell and the north reservoir transfer pump wet well, and between the clearwell and high service pump wet well need to be replaced. These are buried valves and in some cases are encased in concrete. They were leaking back into the clearwell from the high service pump wet well.

It should be noted that additional piping improvements upstream and inside the clearwell are recommended in Chapter 7 – WPP Treatment Evaluation to improve headlosses at high flows. These proposed improvements should be considered when developing both near- and long-term projects.

A discussion of the clearwell baffling and CT time is included in the WPP Treatment Evaluation tech memo. The CT evaluation assumed a baffling factor of the current configuration of 0.41. The evaluation determined that the CT was sufficient to meet the required CT value at the planned flowrate of 75 mgd.

Clearwell Recommendations:

	Recommendation	**Timeline**	2022 Estimated Project Cost
2-6.A	Replace valves between clearwell & N. reservoir transfer pump wet well	0 - 10 years	$159,300
2-6.B	Replace clearwell baffle curtains	10 - 20 years	--

2-7 High Service Pumping

The high service pumping station was constructed in 1969. This area was constructed as an expansion to the previous high service pump room containing three pumps. Nine high service pumps draw water from the wet well and pump to the transmission system. The wet well is located along the west wall of the high service pump room, between the clearwell and the high service pumps. Wet well sections can be isolated with gate valves on the wet well influent pipes, as well as slide gates between wet well chambers and the clearwell.

WPP staff indicated a desire to replace high service pumps 7, 8, and 9 with lower-flow pumps. These pumps currently experience cavitation and must be replaced. WPP staff identified the need to pump at a lower flow rate with these pumps. WPP staff have installed a trimmed impeller in Pump #7 as a trial to determine is trimmed impellers can resolve the cavitation concerns.

High service pumps are split-case pumps and vary in horsepower from 600 HP to 900 HP. The pump motors are located on the ground floor, with a shaft running to the pump in the lower level. A 5-ton bridge crane operates in the high service pump area for maintenance.


Photo 14: High Service Pump

HVAC in the high service pump area includes a Kathabar dehumidifier system. The Kathabar system has not been operated recently since air conditioning system was installed within the past 10 years. The air conditioner adequately dehumidifies the space.

Photo 15: High Service Pump 3 & 4 Motors

High service pumping system has recently been evaluated by AE2S using the distribution system hydraulic model. The evaluation includes both near- and long-term pumping scenarios. The high service pumping improvements are important to the WPP's ability to meet future demands within the current footprint. In this report, various demand conditions for the near-term and long-term planning horizons were evaluated. Hydraulic modeling determined the peak water demand and the required WPP capacity for these conditions. The 2066 modeled condition identified a peak water demand of 90.7 mgd, requiring a WPP capacity of 56.7 mgd and operational storage at the WPP of 5.3 million gallons, provided by the North Reservoir and the clearwell. This condition required high service pumps 1, 2, 3, 4, 5, and 6 operating. This leaves pumps 7, 8, and 9 (600 HP pumps) out of service. However, this modeled condition requires all large pumps (Pump # 3, 5, & 6, all 900 HP pumps) to be in-service.

The modeling assumed continuous operation of the WPP, utilization of 1.5 million gallons of storage at 60th Street North, and future capacity increases in the distribution to upsize pipes. Additional planning horizons were modeled. The modeling determined that VFDs on additional pumps would benefit plant efficiency and optimize use of available water storage for planning horizon 2035 and beyond. For more details of this study, refer to the AE2S report included in Section 2 of this Master Plan.

Table 8: High Service Pumps

Equipment	Description	Year Constructed
Pump 1	600 hp (soft start)	2001
Pump 2	600 hp (soft start)	2001
Pump 3	900 hp - VFD 10 yr old	2001
Pump 4	600 hp - VFD 10 yr old	2001
Pump 5	900 hp (soft start)	2001
Pump 6	900 hp (soft start)	2001
Pump 7	600 hp (soft start)	2001
Pump 8	600 hp (soft start)	2001
Pump 9	600 hp (soft start)	2001
Structure	Roof replaced 2012	1969
Electrical		2003
HVAC	Makeup Air Unit is original. Needs replacement	1969

Photo 16: Kathabar Dehumidification System

Identified Concerns:

- WPP staff identified the need for low-flow pumps to serve low-flow periods. Pumps 7, 8, & 9 are 600-HP pumps with lower capacity than other high service pumps. These pumps have issues with cavitation.
- Slide gates between Clearwell and High Service Pump wet well do not seal completely.

High Service Pumping Recommendations:

	Recommendation	Timeline	2022 Estimated Project Cost
2-7.A	Replace pumps 7, 8, 9 (Cavitation). Change to lower flow pumps	0 – 10 years	$799,000
2-7.B	Install additional VFDs (Pumps 1, 2, 5, 6, 7, 8, 9)	0 – 10 years	$3,026,000
2-7.C	Evaluate age & condition of VFDs on pumps 3 & 4	0 – 10 years	Study / Evaluation
2-7.D	Replace HVAC	0 – 10 years	$461,000
2-7.E	Remove Kathabar	0 – 10 years	Demolish with electrical or HVAC improvements
2-7.F	Replace slide gates in high service pump wet well	0 – 10 years	$192,000

2-8 Transfer Pumping

The North Reservoir transfer pumps are located between the Clearwell and the North Reservoir.

Identified Concerns:

- Pump motors do not have VFDs.
- Pump motors are medium-voltage, but 150-HP size can be accomplished with 480V motors. 480V motors would be easier for plant staff to operate and maintain.
- Life cycle replacement of transfer pump flow meter.
- Life cycle replacement of North Reservoir effluent flow meter.

Photo 17: Transfer Pumps (North Reservoir)

Transfer Pumping Recommendations:

	Recommendation	Timeline	2022 Estimated Project Cost
2-8.A	Install 480V VFDs on transfer pumps. Replace transfer pump flow meter & N. Reservoir effluent flow meter.	0 - 10 years	$780,300
2-8.B	Replace medium voltage motors with 480V motors	0 - 10 years	

2-9 North Reservoir

Photo 18: North Reservior ("Big Blue")

The north reservoir is a 5 million gallon steel tank located south of the clearwell. The north reservoir was constructed in 1987. The reservoir provides storage for the distribution system, and also serves as a backup to the clearwell when the clearwell is offline for servicing and cleaning. The exterior of the tank was last painted in 2008. The date of interior coating is unknown.

City staff plan to recondition the interior and exterior of the tank, and had an inspection of the tank coating done in September 2022 by KLM. The KLM inspection report is attached to this chapter in Appendix I. The KLM inspection report recommends replacing all interior and exterior coatings in the next one to two years.

For the exterior coating, the KLM inspection report found that the exterior coating is in overall fair good condition, with some coating failures. The report recommends replacing vents, caulking & sealing, and installing safety features such as handrail toe boards, horizontal cable lifeline systems, and other safety modifications to remain OSHA-compliant.

The interior coating has experienced more failure, and in some areas the condition may not be known until scale or flaking coating is removed from the steel. The report recommends abrasive blasting of the interior and repairing roof rafters where steel loss has occurred due to corrosion. The report also makes other recommendations for operation & maintenance of the tank, such as seal welding at bolted connections and installing a silt stop to prevent sediment from entering the distribution system.

North Reservoir Recommendations:

	Recommendation	Timeline	2022 Estimated Project Cost
2-9.A	Re-paint reservoir. Replace reservoir level sensor.	0 – 10 years	$ 2,998,100

2-10 Chemical System Overview

Section 2-8-1 of the WPP Treatment Evaluation provides a summary of the existing chemical feed systems. Additionally, Section 2-8-2 provides several improvement recommendations. This section provides a summary of additional comments that were received from staff during the condition assessment walkthrough. As stated previously, this information is summarized in Appendix A and B. The chemical building addition was constructed in 1995 and includes bulk storage tanks and chemical feed pumps for the chemicals summarized in the table below. Chemical feed pumps are rebuilt annually.

Table 9: Chemical System

Equipment	Description	Year Constructed
Phosphate	No longer use the phosphate bulk tank. Went to 275 gal. totes Feed rate: 0.15 mg/L	1995
Polydadmac	Feed rate: 2mg/L	1995
Polymer	No longer use the polymer bulk tank. Went to 55 gal drums Feed rate: 0.1 - 0.4mg/L	1995
Ferric Chloride		1995
Powder Activated Carbon		1995
Hydrofluorosilicic Acid	Fluoride tank needs to be replaced Feed rate: 0.35 mg/L	1995
Ammonium Hydroxide	No longer used - New ammonia addition	1995
Chemical Feed Pumps	Pulsafeeders. Motors replaced with AC drives 10 years ago	1995
Chemical Feed Piping	All pumps have automatic valves that open when the pump turns on	1995

Chemical Building:

The WPP uses fluosilicic acid for fluoridation. The fiberglass fluoride storage tank was exhibiting signs of failure. An inspection was conducted in June 2022. Fiberglass delamination and cracks in the liner were observed, and were causing the fluoride to penetrate the liner and be in direct contact with the structural wall of the tank. The cracks were in the internal floor and side wall seams and ports. These cracks were repaired in June 2022 with a fiberglass patch, and the fluoride tank concern has ben resolved. The inspection report recommends inspecting the exterior of the tank every 5 years and the interior of the tank every 10 years.

Identified Concerns:

- Fluoride tank cracks were resolved June 2022. The inspection report advised continuing to monitor for cracks and leaks.
- Service water line: No redundancy. A recent service water line emergency repair impacted the chemical feed system.
- Polymer day tank scales: Limited SCADA integration and outdated scale equipment for the day tanks. Pumps and polymer day tank scales do not have up-to-date SCADA integration.

Chemical System Recommendations:

	Recommendation	**Timeline**	2022 Estimated Project Cost
2-10.A	Monitor Fluoride Tank	0 – 10 years	Routine Inspection / Monitoring
2-10.B	Add second service water line	0 – 10 years	$39,300
2-10.C	Replace analog equipment with digital/Ethernet chemical feed pumps. SCADA integration of day tank scales.	0 – 10 years	$559,300
2-10.D	Replace Chemical Feed Building HVAC	0 – 10 years	$242,600

2-11 Lime Handling & Lime Feed Systems

The WPP treats with lime softening, added to the solids contact basins. The lime handling equipment consists of multiple components for delivery, storage, and chemical feed. Lime is delivered to the facility by railcar. Rail cars are transferred to the storage system through a bucket elevator or a vacuum transfer system. Lime is stored in a bunker facility with five (5) cells each with an 80-ton capacity. For daily use, lime is then transferred to day bins over each lime slaker. Six lime slakers provide a lime feed rate of 250 to 450 mg/L and transfer the lime to the solids contact basins. Two of these slakers (slakers 5 & 6) batch a lime slurry to a storage tank. This lime slurry can be fed with hose pumps to the solids contact basins.

The WPP has recently completed maintenance repairs on the bunker auger system. WPP staff have additional projects planned to maintain the lime storage system. Plant staff have identified the need to upgrade the existing vacuum system to increase the capacity. The current control system is a relay-based system that is outdated, unreliable, and does not conform to the City standards for instrumentation & control.

Table 10: Lime Handling & Feed Equipment

Equipment	Description	Year Constructed
Lime Transfer - Bucket Elevator	Control System is outdated	1953
Lime Transfer - Vacuum System		1953
Lime Storage - Bunker	(5) 80 ton bunkers - Replacing augers	1953
Lime Storage - Day Bins		1953
Lime Slaker 1		2020
Lime Slaker 2		2020
Lime Slaker 3		2016
Lime Slaker 4		2018
Lime Slaker 5	Batch Slaker Needs Replacement	2003
Lime Slaker 6	Batch Slaker Needs Replacement	2003
Slurry Tank	1000 gallon tank from slaker 5 & 6	2003
HVAC	HVAC Ducts are corroded	2003

Photo 19: Lime Slakers

Photo 20: Lime Slaker Room – HVAC Corrosion

Photo 21: Lime Slaker Room - HVAC Corrosion

Identified Concerns:

- HVAC exhaust ducts are corroded in lime slaker area.
- City priority to enclose lime unloading area to minimize dust, provide a weatherproof enclosure for working around the railcars.
- Controls system for lime transfer system is outdated. Controls for the screw conveyor and bucket elevator are hard-wired analog controls. A study of the required input & output is recommended to determine the cost of this improvement.

Lime Handling Recommendations:

	Recommendation	**Timeline**	2022 Estimated Project Cost
2-11.A	Replace slakers 5 & 6	0 – 10 years	$1,368,100
2-11.B	Replace exhaust fans & HVAC ducts for slaker room	0 – 10 years	$76,500
2-11.C	Enclose lime railcar area	10 – 20 years	--
2-11.D	Replace control system on screw conveyor and bucket elevator	0 – 10 years	Study for Cost Estimate

2-12 Transmission Main Tunnel

Photo 22: Transmission Main Tunnel

Discharge transmission mains connect the WPP to the distribution system. Two transmission mains are located in a subgrade tunnel located west of the Light & Power building. This tunnel is below the driveway surface adjacent to the chlorine delivery area. A 42-inch header pipe feeds the central main distribution system and a 20-inch header pipes feeds to Western Avenue.

Coating on the pipe appears to be well-maintained. No visible defects or concerns with the pipes were identified. The WPP is currently conducting a project to replace the flow meters on these two transmission mains. There are structural concerns with the existing ceiling (driveway surface). Visual observation of the tunnel ceiling identified exposed rebar and cracks. Mineral deposits are visible along the cracks, indicating water intrusion. Corrosion may be caused by salting the driveway surface above the tunnel. WPP staff have recently prohibited wintertime salt application on the driveway above the transmission tunnel in an effort to reduce this corrosion.

A structural assessment of this area was conducted by Midwest Engineering in July 2022. This assessment determined that concrete deterioration is present around areas that experience moisture, but overall the concrete appears to be structurally sound. Steel beams are rusting and paint is failing due to humidity. The report analyzed acceptable loads for the driveway area, and recommended immediate repair of loose concrete to resolve the safety concerns of possible falling concrete. The report also recommended dehumidifying the space and sealing the hatches to be watertight.

Another alternative is filling in this pipe tunnel area, but welded steel pipe would need to be protected prior to backfilling. This would require wrapping/protecting the transmission pipes and adding cathodic protection. There are flow meters on the two transmission mains in this area. Vaults would need to be constructed around the valves and meters.

Identified Concerns:

- Tunnel area ceiling structure exhibits signs of corrosion and loose concrete.

Photo 23: Transmission Main Tunnel - Corrosion

Transmission Main Tunnel Recommendations:

	Recommendation	Timeline	2022 Estimated Project Cost
2-12.A	Repair pipe tunnel ceiling as recommended by Midwest Engineering report: Repair loose concrete; evaluate dehumidification; seal hatches to be watertight.	0 – 10	Refer to Midwest Engineering structural report

2-13 Administrative, Maintenance & Personnel Facilities

The plant evaluation included a walkthrough of administrative offices and support facilities for plant staff. Through discussions with plant staff, the treatment plant has adequate staff and space for the current needs. Life cycle updates and renovations are recommended for staff comfort and aesthetics.

Overview of restroom and locker rooms include:

- Main locker room / restroom (near break room): Men's facility. Size/amenities are adequate.
- Maintenance shop locker room / restroom: Men's facility. Size/amenities are adequate.
- Administrative restrooms: Men's restroom has lockers and shower. Women's restroom does not have lockers or shower. There is also a unisex ADA-accessible restroom.

A deficiency identified in the walkthrough is that the plant currently has no female shower facilities on-site within the locker room areas. Recommendations include installing female locker room facilities with a shower.

Staff facilities also include a break room. The break room was expanded within the past 2 years. Break room facilities are large enough for the current staff. The break room ceiling is showing signs of leaks. Plant staff indicated the ceiling leaks are from flooding that can occur in the slaker area. The cause of these leaks has been operational, these leaks are not an architectural concern.

The auditorium is used for training and conference calls. The size and space meet the WPP needs.

The WPP has administrative offices for plant staff distributed throughout the plant. These offices include the following:

- Superintendent & receptionist office: This office area has adequate space.
- Water program coordinator office: This office is a small space with no room to expand.
- Conservation coordinator office: This is a small temporary cubicle space that could be walled off to create a separate office.
- Operations supervisor office: Needs new floor. Roof leak has been repaired, but water damaged walls and ceiling and should be repaired. HVAC was recently replaced.
- Process engineer office: The wall was damaged by a roof leak. The roof leak has been repaired, but water damage has not been repaired. HVAC was recently replaced.
- Maintenance supervisor office: Office space is adequate.
- Lab Supervisor office: This office is located next to the laboratory, the office space is adequate.
- Controls technician office: Office space is adequate.
- IT office: The network rack is located in this office. Recommendations include evaluating construction of a separate room to house network equipment.
- Need space for one more office.


Photo 24: Operations Supervisor Office - **Flooring**

WPP staff expressed a need for one additional office in case additional staff is added. If a project expands the WPP facility, staff expressed a desire to relocate staff offices to a central location to encourage collaboration of the WPP team.

Operations & Maintenance Facilities

The maintenance facility was constructed in 2003. WPP staff operate a maintenance shop that is capable of supporting operations at the WPP and related operations in the well field. The addition included a 133’ by 55’ building expansion on the east side of the WPP building.

The maintenance area includes overhead doors opening to a general maintenance bay, wash bay, prep bay, and grit loading bay. The facility also includes a parts room, storage rooms, locker room, administrative offices, and workshop space for fabrication and repair including tools and equipment for fabrication. A bridge crane and monorail hoists allow for maintenance of equipment.

No plans for additional storage/garage space are being considered since WPP will take over entire garage/ storage building that is currently shared with Power & Light when Power & Light moves out.

Personal Protective Equipment

Plant staff participate in routine training and orientation for safety and health. Maintenance staff who work with chlorine and ammonia systems are trained by the HAZWOPER program and are trained to use self-contained breathing apparatus (SCBA) equipment. The plant staff have also worked to eliminate confined spaces wherever possible by adding ships ladders. Remaining confined spaces are entering the clearwell, backwash basin, and filter-to-waste basins. The staff follow confined space entry protocols for entering these spaces.

Plant staff noted that safety eyewash stations and showers are located in areas with the risk of chemical contact. This includes the chlorine area, ammonia area, chemical storage area, and laboratory.

Identified Concerns:

- Safety showers do not have tempered water.

Photo 25: Typical Emergency Eye Wash / Shower

Administrative, Maintenance & Personnel Facilities Recommendations:

	Recommendation	**Timeline**	2022 Estimated Project Cost
2-13.A	Architectural/building maintenance improvements: Operations supervisor office floor. Process engineer office wall water damage.	0 – 10 years	$15,000
2-13.B	Evaluate future office needs.	10 – 20 years	Study
2-13.C	Install thermal mixing valves at eye wash / safety showers for tempered water.	0 – 10 years	$10,000

2-14 Laboratory

Laboratory staff support the operation and regulatory compliance of the facility. The laboratory facilities include fume hoods, chemical storage, refrigerators, lab countertops and cabinets, and analytical equipment. Adjacent rooms support the lab operations, including lab manager offices and an organics lab containing gas chromatography / mass spectrometry equipment. The laboratory has replaced cabinets at the water sample area and fume hoods in recent projects. However, other cabinets and the laboratory flooring are in need of replacement.

Photo 26: Laboratory Fume Hoods

Identified Concerns:

- Age & condition of existing laboratory cabinets.
- Age & condition of laboratory flooring.
- Analytical equipment requires surge protection devices and battery backup.
- Age & condition of HVAC equipment.

Laboratory Recommendations:

	Recommendation	Timeline	2022 Estimated Project Cost
2-14.A	Replace cabinets & casework	0 – 10 years	$112,300
2-14.B	Lab flooring	0 – 10 years	
2-14.C	Laboratory UPS & Surge Protection	0 – 10 years	$90,600

Photo 27: Laboratory Cabinets

2-15 Building Facilities

HVAC

The HVAC systems throughout the facility operate with a boiler system. There are two boilers that serve the facility, a North boiler serving the solids contact unit area, and a South boiler in the High Service Pump area.

WPP staff want to go from a steam system to a hot water system in the basin area. Unit heaters in the plant are currently steam, with local controls only. Plant staff desires to replace the unit heaters with hot water units that operate off of the heating water boilers.

The two boilers in the WPP require replacement. Many condensate return lines are showing signs of corrosion. WPP staff is budgeting $50k per year to replace rooftop units and upgrade HVAC control systems. WPP staff plan to replace make up air units (MAUs) and associated temperature controls in chemical feed area in 2023.

Photo 28: Facility Boiler (High Service Pump Area)

Roofs

Roof over the basin/filter area is oldest on the WPP campus and needs to be replaced. It is currently a rock ballasted roof. (All newer roofs are membrane roofs with no ballast rock). It is recommended the roof over contact basins 2 & 3 be replaced when basin 2 & 3 equipment is replaced. It is assumed the roof will need to be removed to replace basin equipment. The Actiflo area roof is next-oldest roof, the roof is original to Actiflo addition in 2004.

Recent roof replacements include: Chemical Building Addition, Admin Building roof (2007), Filter addition roof (2011), High service pump building, Lime storage/feed building.

Photo 29: Basin Area Roof

Freight Elevator

The WPP has one freight elevator located in the east portion of the plant, east of the operator station and north of the lime storage area. The freight elevator was constructed with the 1953 portion of the facility. Structural and electrical/controls components of the elevator are original to the facility.

Photo 30: Freight Elevator

Identified Concerns:

- Age & condition of freight elevator and elevator electrical/controls.

Building Facilities Recommendations:

	Recommendation	Timeline	2022 Estimated Project Cost
2-15.A	Replace roof – basin area	0 – 10 years	$3,433,000
2-15.B	Replace North boiler Replace South boiler	0 – 10 years	$820,000
2-15.C	Evaluate hot water heaters instead of steam	0 – 10 years	Evaluation
2-15.D	Replace elevator	10 – 20 years	--

2-16 Big Sioux River Pump Station

The Big Sioux River Pump Station (BSRPS) draws raw water for treatment from the Big Sioux River. The BSRPS is located north of the Sioux Falls Regional Airport along the Big Sioux River. The BSRPS was constructed in 1990. City staff reported the maximum flow achievable is 36 mgd. A walk-through of the BSRPS was conducted in July 2022 to review age and condition of pump station components.

The building is cast-in-place concrete below grade and masonry construction above grade with a precast concrete roof. The building appears to be in serviceable condition. The roof was replaced in 2019.Process equipment includes screens, pumps, and potassium permanganate chemical feed system. Coarse screens are installed at the intake structure, and fine screens are located inside the building. The fine screens consist of two traveling screens with approximately ¼” screen openings. Screens are washed when operating to remove collected debris. Screens can be isolated with stop logs. The screen room includes a monorail crane for removing stop logs.

Pumping equipment consists of one (1) 100-HP pump and three (3) 300-HP pumps. Space is available for installing a 4th pump in the future. Pumps are single-stage vertical turbine pumps drawing from a split wet well structure. The wet well structure is divided into two sides that can be isolated with a slide gate. Pumps discharge through 24-inch pump discharge control valves that are hydraulically-actuated with the service water system (potable water). A booster pump is located in the pump room to boost this service water pressure to a suitable pressure for actuating these valves. Other process equipment in the pump room includes a seal water system for each pump, bridge crane, surge relief valves, and a wash sink. The electrical service equipment, MCC, and VFDs are also located in the pump room.

Potassium permanganate ($KMnO_4$) is fed for odor control. The chemical is stored in a storage silo with a baghouse for dust control. To prevent clumps in the chemical, the silo has a constant air supply from the pump station air compressor that has been dried through a desiccant drier. The bottom of the silo is divided into two sections serving the chemical feeders. Dry potassium permanganate is fed with a screw feeder into a mixing cone and drawn into solution by an eductor fed with service water (potable water). The chemical feed rate is manually set and verified by operators. The floor drain from the potassium permanganate room drains to a holding tank on-site. A fire sprinkler system is located in the chemical room.

Identified Concerns:

- Hydraulically-actuated pump check/control valves cause frequent maintenance concerns.
- Bridge crane trolley and gantry are not motorized. Trolley must be pulled back and forth. Under load this is difficult and can cause unsafe operation.
- Outdated instrumentation & controls components for level, pressure, screen controls, and chemical feed controls.

Big Sioux River Pump Station Recommendations:

	Recommendation	**Timeline**	2022 Estimated Project Cost
2-16.A	Replace pump discharge check valves	0 – 10 years	$135,900
2-16.B	Bridge crane: Add trolley and gantry motors and controls	0 – 10 years	$20,600
2-16.C	Instrumentation Improvements: Replace discharge pressures transducer; Replace wet well level sensor; Replace screen was valve	0 – 10 years	$102,200
2-16.D	Controls Improvements: Replace screen automatic controls; Automate chem feed system; Automation of chemical feed system to more accurately feed potassium permanganate.	0 – 10 years	$292,000

Section 3: Electrical Evaluation

3-1 Site Evaluation - Electrical

Electric Service

The electric utility provider is Sioux Falls Municipal Power & Light.

A 1387/2400V electric service comes from a 2500 kVA utility transformer located to the east of the plant, on the opposite side of the railroad tracks. Utility transfer relay status is monitored through an interface PLC. A communication module talks to the ControlLogix PLC at the transformer to communicate alarms and status. No communication is present to the master PLC at the medium voltage switchgear in the plant.

The 2400V electric service is routed to the medium voltage switchboard in Power Room No. 1 at the south end of the plant via an underground vault [see photo E-1, Appendix E]. The medium voltage switchgear contains vacuum circuit breakers which distribute medium voltage power to various areas of the plant. The City owns and maintains the medium voltage switchboard and all downstream equipment. Plant staff has indicated that they rely on Sioux Falls Municipal Utilities, or on outside contractor such as Malloy or Protech Power, to maintain the 2400 volt equipment. The plant is currently working with Protech Power of Minneapolis to upgrade medium voltage feeders.

Power is purchased at medium voltage. A single electrical metering equipment is present at the medium voltage switchboard [see photo E-2]. The plant is on a Large Commercial Service rate. The customer charge is $16.78 per month. Energy usage (kWH) is charged at a rate of $0.0431/kWH. The demand charge (billed for all kW) is $20.26. Demand is established as the maximum kilowatt demand for any 15-minute period during the month. The demand billed each month is the adjusted demand for the month, but not less than 50% of the highest demand amount billed during the preceding 11 months.

Generator

One Caterpillar 1800 kW/2250 kVA, 1387/2400 volt, three phase, four wire, diesel engine generator provides standby power to the medium voltage switchboard in Power Room No. 1. It has the capacity to power the entire plant’s load and, via some switching, can send power to the wells.

The generator is housed in a walk-in enclosure located south of the ground storage reservoir [see photo E-3]. A sub-base double-wall fuel tank is present, which plant staff indicated has a 2500 gallon capacity.

The generator was installed in 1997 and appears to be in good condition. As of November 2021, it had almost 600 runtime hours on it. Plant staff reports that the generator is exercised monthly.

The generator has one 1200A, 1387/2400 volt output vacuum circuit breaker which provides power to the medium voltage switchgear in Power Room No. 1. The breaker was replaced in 2017. The generator’s PLC controls were replaced in 2019 with a ControlLogix processor. The PLC communicates via a ModBus gateway and Molex card. The generator is used purely for standby (backup) power and is not used for load shedding or demand response purposes.

Site Lighting

The building perimeter is lit with wall-mounted HID fixtures [see photo E-4]. These provide light for the parking areas and driveways adjacent to the building. There is no pole-mounted lighting dedicated to parking lots and driveways. The exterior lighting is controlled by outdoor photocells in conjunction with lighting contactors. The lighting appears to be in good condition. Plant staff indicated they are working on replacing the exterior lighting with LED fixtures.

Site Issues/Recommendations

While the generator's operating hours are not especially high, and the unit appears to have been regularly maintained, it is getting older and its remaining service life is questionable. Rust is becoming visible on certain areas of the enclosure. It is recommended that the generator be evaluated by a manufacturer's service technician to determine adequate functionality, any needed repairs, and expected remaining life.

The existing site lighting is HID, a legacy light source which is not as efficient as modern LED. It is recommended that the existing HID fixtures be replaced one-by-one with similar-style LED fixtures as existing lamps fail, or altogether as part of an energy efficiency improvement project. It should be investigated as to whether power company incentives are available for this work.

Recommendations:

	Recommendation	**Timeline**	2022 Estimated Project Cost
3-1.A	Life cycle replacement of standby generator	0 – 10 years	$2,947,000
3-1.B	Replace switchgear in Power Room 1	0 – 10 years	$936,000
3-1.C	Replace gear in Power Room 2. Potentially relocate to another room	0-10 years	$1,408,000
3-1.D	Replace MCC in Power Room 3	0 – 10 years	$588,400
3-1.E	Replace MCC in Power Room 4	0 – 10 years	$488,200
3-1.F	Evaluate smart MCCs where replacing MCCs	0 – 10 years	Study/Evaluation
3-1.G	Evaluate capacity of standby generator to operate WPP facility and high service pump station	0 – 10 years	Study/Evaluation

3-2 Building Evaluation - Electrical

Lighting

Interior lighting in administration/office areas has mostly been upgraded to natively LED fixtures [see photo E-5]. Troffer style fixtures are present in offices, conference rooms, labs, and other spaces with lay-in ceilings. Most manual switches have been replaced with occupancy sensor switches [see photo E-6], or occupancy sensors used in conjunction with manual switches. The lighting appears to be in excellent condition.

Interior lighting in process areas consists primarily of fixtures containing 4' linear fluorescent lamps [see photo E-7]. Fixtures are lensed or vapor tight, as appropriate for the environment. Suspended industrial fixtures are present in electrical and mechanical spaces. Where fixtures are in good condition, plant staff has been replacing linear fluorescent lamps (as they burn out) with tubular LED lamps (TLEDs) utilizing the existing lamp ballasts. Several process areas have metal halide fixtures [see photo E-8]. Newer process areas contain fixtures that are natively LED [see photo E-9].

Plant staff has indicated that current projects include new LED lighting for the high service pump room in 2022, and installing tubular LED lamps in existing light fixtures that are in good condition.

Power for lighting is predominantly 120 volts, although lighting in certain areas is 277 volt powered. Control consists of mainly of manual switches; although plant staff has been installing occupancy sensors in certain areas [see photo E-10]. In general, the lighting fixtures and controls appear to be in good condition.

Power

Electrical power distribution equipment is located throughout the plant, but is concentrated in four main locations, identified as “Power Rooms”.

2400 volt utility power enters the building into a medium voltage switchboard within Power Room 1 [see photo E-11]. This switchboard in turn provides medium voltage power to Power Rooms 2 and 4. Power Room 2 then feeds Power Room 3. The medium voltage switchgear in Power Room 1 was replaced in 2003 and circuit breaker components were replaced in 2006. Plant staff has expressed concern with the age and condition of the medium voltage switch gear in Power Room 1.

A battery bank is present in Power Room 1 that serves the Schweitzer gear and the backup controls for the generator. Plant staff reports that the batteries are tested and replaced regularly. The plant has a maintenance contract for annual assessment and maintenance of UPS equipment.

Power Room 2 contains obsolete Square D Model 5 and GE 8000 Line MCCs [see photo E-12]. Liebert UPS equipment is present in the room which provide 120/208V power to the Backwash Power Room and network equipment. Additionally, multiple dry transformers are present in the room [see photo E-13]. Plant staff has indicated that they would like to replace all the electrical distribution gear in Power Room 2. The MCCs could possibly be combined into one new MCC. One option staff suggested was moving the equipment to an existing storage room on the upper level.

Power Room 3 serves the Actiflo area. The room contains a Mitsubishi UPS and an obsolete GE 8000 Line MCC [see photo E-14].

The Transfer Pump Power Room contains three 2400 volt soft starters with capacitor banks for the 150 HP transfer pumps [see photo E-15]. Plant staff desires to change the transfer pump soft starters to 480 volt active front end VFD’s (Allen-Bradley PowerFlex 6000, or equal) controlled via a network connection. A 112.5 KVA dry transformer in this room provides 120/240 volt power to receptacles and equipment. Plant staff has expressed concern over the life expectancy of the transformer.

Power Room 4 is in the 2011 filter expansion area. The room is powered from an exterior oil-filled transformer at the northwest corner of the plant which receives 2400V power from a feeder which is routed across the roof from Power Room 1 via an exterior disconnect switch near Power Room 1. The transformer provides 480V, 3 phase power to the MCC in Power Room 4. The MCC is an Allen-Bradley Centerline 2100 MCC with integral VFDs [see photo E-16]. The MCC has been retrofitted, and replacement parts are still currently available. The room contains one UPS, which was installed in 2004. Plant staff has expressed concerns about its age and life expectancy. The electrical gear in Power Room 4 was installed in 2004.

Nine High Service Pumps are present in the plant. A transformer in the Battery Room serves the high service pumps. HSPs 3 (900HP) and 4 (600HP) are connected via obsolete Toshiba VFDs [see photo E-17]. All other HSPs are on soft starters. Plant staff desires to put the seven HSPs (that are not currently on VFDs) onto active front end combination VFDs and remove the existing soft starters. Staff indicated that the two HSPs currently on VFDs can remain as is. For the HSPs currently on VFDs, power is fed through the disconnect switch of its former soft starter (the soft starter is bypassed). Plant staff would like to use Allen-Bradley PowerFlex 6000 drives, or equivalent drives from ABB, Schneider, or Eaton.

Two 150 HP, 480V backwash pumps are on a common VFD with a manual switch to select which pump will operate [see photo E18]. The VFD has a bypass contact on it.

An exterior oil-filled pad-mount transformer near the parking lot serves the shop area.

Interstates performed an arc flash study approximately three years ago on all facilities (plant, reservoirs, wells) and provided arc flash labels for equipment.

Allen-Bradley PowerFlex 70 VFDs are present in certain areas, such as the Lie Slaker room [See photo E-20]. These are obsolete and should be upgraded as they fail.

Plant staff wants to locate all VFDs outside of MCCs. Additionally, plant staff would like to consider smart MCCs where MCCs are being replaced.

Fire Alarm System

A Kidde VS-1 addressable fire alarm system is present in the chlorine area. The system connects wirelessly to the plant network and is remotely monitored by the City's third-party monitoring company. The system is independent of other fire alarm systems at the plant. The system primarily monitors the sprinkler system in the chlorine area. It was installed in 2021 and is in excellent condition.

The fire alarm control panel is located in the chlorine building garage [see photo E-19]. Initiation devices consist of a smoke detector at the panel and a manual pull station. Notification devices consist of a horn/strobe at the fire department connection (FDC) outdoors.

A fire alarm system is present in the ammonia area.

No fire alarm system is present in other areas of the plant.

Building Issues/Recommendations

Overall, the building is in good condition electrically. However, there are a few areas that have been identified where improvements could be made.

Some of the existing interior lighting is fluorescent and metal-halide, light sources which are not as efficient as modern LED. It is recommended that fixtures be replaced one-by-one with similar-style LED fixtures as existing lamps fail, or altogether as part of an energy efficiency improvement project. It should be noted that power company incentives are not available for this work, as the power company only incentivizes non-City customers.

It is recommended that the medium voltage switchgear in Power Room 1 be replaced due to age and life expectancy. Circuit breaker components have already failed and been replaced.

Several of the MCCs throughout the plant are obsolete and parts are becoming hard to obtain. It is recommended that the MCCs in Power Rooms 2, 3, and 4 be replaced with digital (smart) MCCs. For Power Room 2, it should be evaluated whether the electrical gear remains in its current location or whether the gear is replaced in another location. It should further be evaluated whether the equipment currently served from the MCCs in Power Room 2 could be fed from a common MCC.

It is recommended that VFDs be installed for the seven HSPs that are not currently connected to VFDs, and the existing soft starters should be removed. Replacing the existing Toshiba VFDs for the other two HSPs should be evaluated. All new VFDs should be combination active-front end type for harmonics mitigation.

In the Transfer Pump Power Room, it is recommended that the medium voltage MCC be removed along with the medium voltage transfer pump VFDs. 480V active front end VFDs should be provided for the three 150 HP transfer pumps.

Where VFDs are currently installed inside of MCCs, they should be relocated to outside of the MCCs for ease of maintenance and better heat dissipation. The basis of design for VFDs should be Allen-Bradley PowerFlex, per staff preference. Digital communication should be provided for control of VFDs.

Electrical Evaluation Recommendations:

	Recommendation	Timeline	2022 Estimated Project Cost
3-2.A	Replace MCC with digital (smart) MCC. Replace main breaker.	0 – 10 years	$667,600
3-2.B	Replace Generator controller for SCADA integration. Evaluate generator by a manufacturer’s service technician to determine adequate functionality, any needed repairs, and expected remaining life.	0 – 10 years	$31,000
3-2.C	Replace fire alarm panel communication card.	0 – 10 years	$4,800

3-3 Big Sioux River Pump Station – Electrical Evaluation

Electric Service

The electric utility provider for the BSRPS is Sioux Falls Municipal Power & Light. A 750 kVA utility transformer is located north of the pump station building. The primary feed voltage to the utility transformer is 13.8 kV. A utility meter is located inside the BSRPS building, near the electrical distribution equipment.

Generator

One Caterpillar 500 kW/625 kVA, 480/277 volt, three phase, four wire, diesel engine generator provides standby power to a 480V Square D I-Line distribution panelboard in the walk-in generator enclosure [see photo E-21]. The standby generator serves the BSRPS and also wells #20, 21, 29, 30, and 36. The generator was installed in 2004 and appears to be in good condition.

The generator has a local control panel inside the walk-in enclosure, and also a remote annunciator panel located in the BSRPS. City staff recommended upgrades to the generator monitoring and control system to add communication via Modbus-TCP/IP for SCADA monitoring of the generator.

The standby generator has capacity to power the wells and one of the BSRPS 300 HP pumps. However, wells 20, 21, and 29, and 30 are no longer used due to PFAS contamination, giving the standby generator additional capacity to power the BSRPS.

An automatic transfer switch is located outside the pump station, adjacent to the utility transformer.

Power

A 2000A Square D QED solid state main circuit breaker is located in the pump room. Power distribution inside the pump station consists of an obsolete Square D Model 5 MCC [see photo E-22]. The MCC contains feeder breakers to serve the pump VFDs, along with a 277/480V panelboard, 30 KVA step-down transformer and 120/208V panelboard, and miscellaneous starters for HVAC and other equipment.

Pump motors consist of one (1) 100 HP motor and two (2) 300 HP motors. These 480 V motors are controlled by Allen-Bradley PowerFlex 753 VFDs located in the pump room, in stand-alone cabinets adjacent to the MCC. The VFDs are still a current product offering and were last replaced in 2014.

Lighting

Stem-mounted LED industrial high-bay fixtures are present in the pump and filter rooms. Wall-mounted fixtures containing 4’ linear fluorescent lamps are also present in the pump and chemical rooms. Fixtures are lensed or vapor tight, as appropriate for the environment. Exterior LED wall packs are present above entry doors.

Power for lighting is predominantly 120 volts. Control consists of mainly of manual switches. In general, the lighting fixtures and controls appear to be in good condition.

Fire Alarm System

The facility has a fire sprinkler system in the potassium permanganate room. The sprinkler system is monitored by a Gamewell Flex Series fire alarm panel. City staff recommended updating the fire alarm panel to add a communication card to connect it to their network, to match other City facilities.

Electrical/Recommendations

Overall, the facility is in good condition electrically. However, there are a few areas that have been identified where improvements could be made.

While the generator's operating hours are not especially high, and the unit appears to have been regularly maintained, it is getting older and its remaining service life is questionable. It is recommended that the generator be evaluated by a manufacturer's service technician to determine adequate functionality, any needed repairs, and expected remaining life. It is further recommended that the generator monitoring and control system be upgraded to add communication via Modbus-TCP/IP for SCADA monitoring of the generator.

The MCC is obsolete and parts are becoming hard to obtain. It is recommended that the MCC be replaced with a digital (smart) MCC. At the time when the MCC is replaced, it is recommended that the main circuit breaker also be replaced due to its age and life expectancy.

Some of the existing interior lighting is fluorescent, a light source not as efficient as modern LED. It is recommended that fluorescent fixtures be replaced one-by-one with similar-style LED fixtures as existing lamps fail, or altogether as part of an energy efficiency improvement project. It should be noted that power company incentives are not available for this work, as the power company only incentivizes non-City customers.

It is recommended that the fire alarm panel be updated to add a communication card, and that it be connected to the network.

Section 4: Instrumentation & Control Evaluation

4-1 Building Evaluation – Instrumentation & Control

Overall, the plant instrumentation and control system is well-maintained and in good working condition. The main process control panels have had PLC upgrades and are generally of current technology. However, there are several areas where instrumentation and process equipment panels are in poor condition and/or contain obsolete technology. Much of the instrumentation throughout the plant is still analog and does not provide all the status and alarm communication that modern digital instruments do. Plant staff has expressed a desire to pursue a “digital transformation” for the plant. In general, City staff consider life cycle for controls systems to be 10 years for replacement of obsolete or unsupported components.

The table below outlines the conditions, concerns, and recommendations for key areas and systems throughout the facility.

Location or Item	Existing Conditions/Concerns	Recommended Improvements
High Service Pump VFDs	• The existing Toshiba VFDs for two of the HSPs have CompactLogix PLCs in them • The local PLC controls the valves and is on a segmented network to the main PLC • Staff wants to control related valves with relay logic through the associated VFD, not by PLC logic as current VFDs have. RTD inputs would be needed. (Similar to Main PS and PS 240.)	• When VFDs are upgraded, revise valve control to be by VFDs
Power Room 3 (Actiflo)	• Control panel in room with I/O back to existing panel • Bigger flow meters are older series that need to be replaced • Old ultrasonic level transducers should be converted to radar level transducers	• Replace flow meters • Upgrade ultrasonic transducers to radar (plant staff indicated they can do this in house)
Actiflo	• An ABB ultrasonic level transmitter is present, which is obsolete and in fair condition [See photo IC-01] • Two Rosemount flow meters are present • Two GLI pH sensors are present [See photo IC-01]. This company was purchased by Hach several years ago and these are obsolete • A sand silo scale indicator is present	• Upgrade level transmitter with radar type • Upgrade flow meters with E&H Ethernet flow meters • Replace pH sensors when they fail • Replace sand silo scale with load cells when equipment fails
Solids Contact Basins	• Controls have been updated • Controlled from Power Room 2 (located behind operating station) • Slakers 5 & 6 have not been replaced recently	
Filters	• Have differential pressure transducers • Have flex I/O in each filter controller • Flow meters are 4-20ma Hart – not obsolete. • Valve positioners are analog only – Staff is considering digital ¼-turn positioners • Have 20 flow meters	• Upgrade all valves and instrumentation on the filters to digital—positioners, K-Tork vane actuators, effluent valves, and Ethernet flow meters

	• Controlling effluent valves on Filters 1-10 should be completely replaced, along with orifice plate differential flow meters (need to be 0 dimension). • Existing flow meters have integral display and are hard wired • Remote I/O connects to LCP-22 (main control panel) via Ethernet. All filter control panels currently have Allen-Bradley Flex I/O • Hach CL17 chlorine analyzer present and in good condition, which is no longer an active product [see photo IC-02] • A Hach CL17sc chlorine analyzer is present and in good condition [See photo IC-03]. This is the current model. • A Hach 1720E turbidimeter is present, which is an older model (5300 is current model) [See photo IC-03] • Hach sc100 and sc200 display units are present, and in good condition [See photo IC-03]. These are not current modes (sc4500 is current model) • A Magnetrol 341 flow meter readout is present, which is obsolete and in fair condition [See photo IC-04] • A Hach surface scatter turbidimeter is present for monitoring high range turbidity, and is obsolete by 2+ generations [see photo IC-05] • A Hach 1720E turbidimeter with sc100 controllers is present, which are obsolete [See photo IC-06] • Two pressure transmitters or differential pressure transducers are present which appear to be either obsolete E&H or Foxboro [See photo IC-06]. They appear to be corroded • A Hach 1720E turbidimeter with sc200 controller is present, which are obsolete [See photo IC-07] • A Chemtrack PC3400 particle counter is present, which is in good condition and a current model [See photo IC-07] • An E&H differential pressure transmitter is present, which is in good condition [See photo IC-07]	• Upgrade I/O in all filter control panels to Allen-Bradley Flex 5000 I/O • Upgrade turbidimeters to Hach 5300 with sc450 controllers • Replace leaking pressure transmitters/ transducers
Recarbonation	• All process controllers are up to date – ControlLogix	
Open Channel	• Have done level updates	
Day Tanks	• North of operator stations	• Upgrade old flow meters to Ethernet mag meters

	• Feeders – Want Wallace & Tiernan Ethernet feeders • Old chrome flow meters present • Room full of analog devices – staff wants to go digital	• Upgrade analog scales, flow meters, etc. to digital/Ethernet
Power Room 4	• Filter 5 – A-B MCC has VFDs in MCC. Has been retrofitted. Can get replacements for 2100 Series MCC. • Open network switch panel present • LCP-23 – I/O is obsolete	• Upgrade MCC • Provide enclosed network panel • Upgrade LCP-23 I/O to Flex 5000 I/O
Generator	• Has new PLC interface – been updated recently • ControlLogix processor • Multimode fiber to generator currently • No fiber loop present in plant • Generator not included in fiber loop • Uses Modbus gateway and Molex card • Butler controller – still current • Generator feeder runs through vault near Big Blue tank	• Upgrade generator network connection to single mode fiber • Provide fiber network loop for generator
Fiber Optic Network	• There are separate process and building networks • The industrial control network is a totally separate network and does not connect to internet • Whole spine is multimode fiber currently. • All switches are Cisco managed switches – up to date and use single mode fiber • Actiflo has a managed switch • Fiber routes from Power Room 2 to Filter Control Panel to Power Room 4. Fiber routes to server room and to Big Blue control room. Fiber routes from server room to generator directly • No network connection is present in Power Room 3 currently. • The plant is fed from three directions- two fiber, one radio • The oldest fiber backbone is multi-mode and connects to the power and light department • All new network drops are CAT6; older CAT5 drops are still present • Most fiber is single mode, but some multimode still exists • Fiber connects to every network switch and every control panel • Fiber routes into some control panels	• Upgrade all multimode fiber to single mode • Link Big Blue (transfer pump area) to Actiflo (Power Room 3) with fiber to create an overall loop. (Daisy chained currently.) • Relocate fiber out of control panels and into CubeIT panels
Phones	• The plant is currently moving to a Cisco phone system.	

PA System	• The existing PA system is wireless and operates on a licensed frequency. Coverage is poor.	• Upgrade PA system to a wired system providing full coverage
Cameras	• The existing camera system is a few years old • It covers the chlorine area and exterior areas • It is in good condition • The camera system is POE • The camera software is Milestone • Plant staff would like to go to a combination wired/ wireless system	• Move toward a combination wired/wireless system
Turbidimeters	• One chlorinator replacement purchased in 2022. New analog one from Vessco	
Chlorine Area	• Control panel for scrubber is in poor condition- shuts off exhaust fan and runs scrubber • Ultima XA chlorine gas detectors are present and in good condition [See photos IC-08 & IC-09] • MSA X5000 CO & NO_2 sensors for diesel exhaust are present in the loading area and are modern equipment in excellent condition [See photos IC-10 & IC-11] • A ventilation control panel is present, which is obsolete and in poor condition [See photo IC-12]	• Replace control panel for scrubber • Upgrade ventilation panel
Lime System	• The old relay logic for the lime system is in poor condition and needs to be redone	• Replace lime system control panel/wiring
PLC-001	• PLC-001 controls the lime slakers and CO_2 system • Slakers have their own PLCs that control them and communicate to PLC-001 • The PLC-001 panel contains three separate PLCs to handle analog I/O, discrete I/O, and communication	
PLC-002	• PLC-002 panel contains 2 PLCs; one for the lime system and one for the well master • The lime system PLC has extended I/O	
PLC-003	• PLC-003 contains 2 PLCs, one of which is an Allen-Bradley SLC-5/05, which is in the sunset of its product lifecycle.	• Replace SLC-5/05 PLC
Panel 12	• Panel 12 is the lime transfer panel which is in poor condition and needs to be replaced • The vacuum system needs to be replaced within 10 years	• Replace the lime transfer panel along with the lime transfer system
PLC-900 (Chemical Feeders)	• The chemical feed area was redone in 1993 • The chemical feed pumps are controlled by VFDs	

	• The MAU's and temperature controls for the chemical area are planned to be replaced within the next year	
Big Sioux River Pump Station	• Main station control panel was recently updated [see photo IC-13]. • Flow meter is located in a vault east of the pump station [see photo IC-14]. It is 42" diameter mag meter and is 20-years old. • Screen control system is antiquated. • IT system includes security cameras, door access security, and a UPS backup. • Pump station is connected by radio telemetry (900 MHz & Microwave radio) MDS Orbit radio. No internet connection is present. • A bubbler system is present for level measurement in the wet well • Pneumatic actuators are present on screen wash water lines • $KMnO_4$ feed rate requires daily manual calibration • Rotameters present on pump seal water lines	• Replace the 42" flow meter transmitter and flow tube • Remove existing screen control panels and connect screens to main station control panel • Add camera to potassium permanganate room. • Replace bubbler system with radar level sensor in wet well • Install electric open/close actuated valves on screen wash water lines • Modernize controls on $KMnO_4$ feeders • Replace rotameters with mini mag-meters tied to SCADA

Instrumentation & Control Recommendations:

	Recommendation	**Timeline**	2022 Estimated Project Cost
4-1.A	Replace public address system with wired system	0 – 10 years	$453,000
4-1.B	Replace remaining multimode segments with single mode fiber and complete the loop	0 – 10 years	$491,300

Appendix A: Recommended Improvements

Unit Process	Concerns	#	Recommended Improvements	Recommendation Timeline	Priority	2022 Improvements Estimated Project Cost
Actiflo	♦Sand pumps - Leaking seals - Sand wears packing ♦Lifecycle replacement of influent flow meters	1-1.A	Replace (6) sand pumps	0 - 10 years	Critical	$227,800
		1-1.B	Actiflo Instrumentation: Replace (2) influent flow meters. Replace sand silo weight system	0 - 10 years	Urgent	$148,000
Solids Contact Basins	♦Challenge to maintain sludge blankent when alkalinity changes ♦Sludge discharge line size varies between basins ♦Basin 1 has leaked in the past ♦Corrosion on mechanical equipment in basin ♦Condition of basin influent piping and sludge drain piping is unknown. ♦Lifecycle replacement of influent flow meters	1-2.A	Replace clarifier equipment in Basins 2 & 3. Update basin instruments/controls. Replace sludge lines on basins 2 & 3.	0 - 10 years	Critical	$6,252,000
		1-2.B	Televise basin piping to determine condition and risk of failure	0 - 10 years	Maintenance / Monitoring	Study / Evaluation
		1-2.C	Replace influent flow meters on N / S pipes (36" dia.)	0 - 10 years	Urgent	$92,000
		1-2.D	Monitor concrete structure and repair / seal concrete	0 - 10 years	Maintenance / Monitoring	Routine Inspection / Monitoring
		1-2.E	Basin Controls Improvements: Replace basin flow meters, influent valve actuators and lime sludge pump	0 - 10 years	Required	$365,000
Recarbonation Basins	♦CO2 Feeders - Life cycle replacement ♦Baffles create high headloss through basin.	1-3.A	Replace CO2 feeders & Replace recarbonation instruments & controls	0 - 10 years	Urgent	$1,814,000
		1-3.B	Evaluate CO2 alternatives (i.e. pressurized solution feed, side stream CO2.	0 - 10 years	Maintenance / Monitoring	Study / Evaluation
Filters	♦Filters 1-10: Aging orifice plate flow meters ♦Filters 1-10: Aging condition of valve actuators ♦Backwash blower (air scour) - No redundancy	1-4.A	Filter Instrumentation Improvements (meters, pressure transducers, solenoids, radar sensors, and I/O hardware).	0 - 10 years	Urgent	$1,999,200
		1-4.B	Replace filter valves & actuators on Filters 1 – 10	0 - 10 years	Urgent	$2,669,900
		1-4.C	Add additional backwash blower (redundancy)	0 - 10 years	Critical	$77,500
		1-4.D	(2) VFDs for backwash pumps (life cycle replacement)	0 - 10 years	Critical	$136,700
Backwash Reclaim Basin	♦Sludge accumulation in basin ♦Sludge scraper flights are broken ♦Sludge buildup on the side with no scrapers: Need to add sludge scrapers.	1-5.A	Replace sludge scrapers	0 - 10 years	Critical	$1,434,000
		1-5.B	Add additional scrapers to second side of basin	0 - 10 years	Urgent	
Filter to waste basins	♦Review condition of filter to waste basin under auditorium ♦Life cycle replacement of filter to waste return pumps	1-5.C	Visual Inspection of basin	0 - 10 years	Maintenance / Monitoring	Routine Inspection / Monitoring
		1-5.D	Replace return pumps & control panel at filter-to-waste basin	0 - 10 years	Required	$142,000
Clearwell	♦Valves between clearwell and N. reservoir transfer pump wet well do not seal ♦Valves between clearwell and high service pump wet well do not seal	1-6.A	Replace valves between clearwell & N. reservoir transfer pump wet well	0 - 10 years	Critical	$159,300
		1-6.B	Replace clearwell baffle curtains	10-20 years	Ad Hoc	--

Unit Process	Concerns	#	Recommended Improvements	Recommendation Timeline	Priority	2022 Improvements Estimated Project Cost
High Service Pumps	♦Cavitation on pumps 7, 8, 9. ♦Existing pumps too large to meet lower flows ♦Only (2) VFDs on the high service pumps ♦Valves in wet well do not seal completely	1-7.A	Replace pumps 7, 8, 9 (Cavitation). Change to lower flow pumps	0 - 10 years	Critical	$799,000
		1-7.B	Install additional VFDs (Pumps 1, 2, 5, 6, 7, 8, 9)	0 - 10 years	Urgent	$3,026,000
		1-7.C	Evaluate age & condition of VFDs on pumps 3 & 4	0 - 10 years	Maintenance / Monitoring	Study / Evaluation
		1-7.D	Replace HVAC equipment	0 - 10 years	Urgent	$461,000
		1-7.E	Remove Kathabar dehumidifier	0 - 10 years	Ad Hoc	Demolish with electrical or HVAC improvements
		1-7.F	Replace slide gates in high service pump wet well.	0 - 10 years	Urgent	$192,000
Transfer Pumps	♦Transfer pumps are medium-voltage ♦No VFDs on transfer pumps	1-8.A	Install 480V VFDs on transfer pumps. Replace Transfer Pump flow meter & N. Reservoir effluent flow meter.	0 - 10 years	Urgent	$780,300
		1-8.B	Replace medium voltage motors with 480V motors	0 - 10 years	Urgent	
North Reservoir	♦Life cycle maintenance of tank coatings	1-9.A	Re-paint North Reservoir (Big Blue). Replace reservoir level sensor	0 - 10 years	Critical	$1,925,900
Chemical Storage / Feed Systems	♦Fluoride Tank cracks were repaired, but require ongoing monitoring. ♦Service water line - No redundancy ♦Chemical feed equipment (scales, feeders, etc.) are aging and analog. ♦Krohne flow meters are aging	1-10.A	Monitor Fluoride Tank	0 - 10 years	Maintenance / Monitoring	Routine Inspection / Monitoring
		1-10.B	Add second service water line	0 - 10 years	Critical	$39,300
		1-10.C	Replace analog equipment with digital/Ethernet chemical feed pumps. SCADA integration of day tank scales	0 - 10 years	Urgent	$559,300
		1-10.D	Replace Chemical Feed Building HVAC	0 - 10 years	Urgent	$242,600
Lime System	♦Life cycle replacement of lime conveyance systems and condition of associated control panel ♦Ventilation in slaker room is corroded	1-11.A	Replace slakers 5 & 6	0 - 10 years	Urgent	$1,368,100
		1-11.B	Replace exhaust fans & HVAC ducts for slaker room	0 - 10 years	Urgent	$76,500
		1-11.C	Enclose lime railcar area	10 - 20 Years	Ad Hoc	--
		1-11.D	Replace control system on screw conveyor and bucket elevator	0 - 10 years	Critical	Study for Cost Estimate
Transmission Main Tunnel	♦Structural concerns with pipe tunnel ceiling	1-12.A	Repair Pipe Tunnel Ceiling per inspection report	0 - 10 years	Critical	Refer to Midwest Engineering structural report
Administrative & Personnel Facilities	♦Conservation coordinator office: Small temporary cubicle space. Operations supervisor office: Needs new floor. Walls and ceilings have water damage. ♦Process engineer office: Wall has water damage. ♦IT office: Needs separate room to house network equipment. ♦Plant staff need space for one more office.	1-13.A	Architectural/building maintenance improvements: Operations supervisor office floor. Process engineer office wall water damage.	0 - 10 years	Ad Hoc	$15,000
		1-13.B	Evaluate future office needs.	10-20 years	Ad Hoc	Study
		1-13.C	Install thermal mixing valves at eye wash / safety showers for tempered water.	0 - 10 years	Urgent	$10,000
Laboratory	♦Age & Condition of lab cabinets ♦Wear on lab flooring	1-14.A	Replace cabinets & casework	0 - 10 years	Ad Hoc	$112,300
		1-14.B	Lab Flooring	0 - 10 years	Ad Hoc	
		1-14.C	Laboratory Surge Protection & UPS	0 - 10 years	Urgent	$90,600

Unit Process	Concerns	#	Recommended Improvements	Recommendation Timeline	Priority	2022 Improvements Estimated Project Cost
Building Facilities	♦Basin area roof - Life cycle replacement ♦Age & condition of boilers. Boilers are in need of replacement. Condensate lines are corroded. ♦Chemical feed area: Age & condition of HVAC ♦High Service Pump area: Age & condition of	1-15.A	Replace roof - basin area	0 - 10 years	Critical	$3,433,000
		1-15.B	Replace North boiler Replace South boiler	0 - 10 years	Urgent	$820,000
		1-15.C	Evaluate hot water heaters instead of steam	0 - 10 years	Maintenance / Monitoring	Evaluation
		1-15.D	Replace service elevator	10 - 20 years	Required	--
Big Sioux River Pump Station	♦Hydraulically-actuated pump check/control valves cause frequent maintenance concerns. ♦Bridge crane trolley must be manually pulled back and forth. Under load this is difficult and can cause unsafe operation. ♦Outdated instrumentation & controls components for level, pressure, screen controls, and chemical feed controls.	1-16.A	Replace pump discharge check valves	0 - 10 years	Urgent	$135,900
		1-16.B	Bridge crane: Add trolley and gantry motors and controls.	0 - 10 years	Critical	$20,600
		1-16.C	Instrumentation Improvements: Replace discharge pressures transducer; Replace wet well level sensor; Replace screen wash valve. Replace 42" Flow Meter	0 - 10 years	Urgent	$102,200
		1-16.D	Controls Improvements: Replace screen automatic controls; Automate chem feed system; Automation of chemical feed system to more accurately feed potassium permanganate.	0 - 10 years	Urgent	$292,000
WPP Power Distribution	♦Generator is approximately 25 years old. Age is a concern ♦Power Room 1 - Medium voltage switchgear age is a concern. ♦Power Room 2 - Move VFDs out of buckets. Needs HVAC system replaced. City staff wants to replace equipment/gear in power room 2 and combine MCCs ♦Power Room 3 - GE MCC is obsolete ♦Power Room 4 - GE MCC is obsolete	2-1.A	Life cycle replacement of standby generator	0 - 10 years	Required	$2,947,000
		2-1.B	Replace switchgear in Power Room 1	0 - 10 years	Urgent	$936,000
		2-1.C	Replace gear in Power Room 2. Potentially relocate to another room	0 - 10 years	Critical	$1,408,000
		2-1.D	Replace MCC in Power Room 3	0 - 10 years	Urgent	$588,400
		2-1.E	Replace MCC in Power Room 4	0 - 10 years	Urgent	$488,200
		2-1.F	Evaluate smart MCCs where replacing MCCs	0 - 10 years	Maintenance / Monitoring	Study / Evaluation
		2-1.G	Evaluate capacity of standby generator to operate WPP facility and high service pump station	0 - 10 years	Ad Hoc	Study / Evaluation
Big Sioux River Pump Station Power Distribution	♦MCC is obsolete and parts are becoming hard to obtain ♦Standby generator service life ♦Fire alarm panel is outdated, does not have updated communication.	2-2.A	Replace MCC with digital (smart) MCC. Replace main breaker.	0 - 10 years	Urgent	$667,600
		2-2.B	Replace Generator controller for SCADA integration. Evaluate generator by a manufacturer's service technician to determine adequate functionality, any needed repairs, and expected remaining life.	0 - 10 years	Urgent	$31,000
		2-2.C	Replace fire alarm panel communication card.	0 - 10 years	Urgent	$4,800
Technology	♦Plant public address system has coverage issues ♦Multimode fiber present and network is not looped	3-1.A	Replace public address system with wired system	0 - 10 years	Urgent	$453,000
		3-1.B	Replace remaining multimode segments with single mode fiber and complete the loop	0 - 10 years	Urgent	$491,300
				Total Recommended Improvements		$38,034,300

Project Priority List

Recommended improvements ranked by priority

#	Recommended Improvements	Priority	Cost
2-4.D	Filters: Replace VFD for backwash pump (life cycle replacement)	Critical	$136,700
2-4.C	Filters: Add additional backwash blower (redundancy)	Critical	$77,500
2-10.B	Chemical Feed: Add second service water line	Critical	$39,300
3-1.C	Power Distribution: Replace gear in Power Room 2. Potentially relocate to another room	Critical	$1,408,000
2-5.A/B	Backwash Reclaim Basin: Replace sludge scrapers, Add additional scrapers to second side of basin	Critical	$1,434,000
2-6.A	Clearwell: Replace valves between clearwell & N. reservoir transfer pump wet well	Critical	$159,300
2-4.A	Filters: Install flow meters (mag meters) on Filters 1 – 10	Urgent	$1,999,200
2-4.B	Filters: Replace filter valves on Filters 1 – 10	Urgent	$2,669,900
2-2.A	Solids Contact Basins: Replace clarifier equipment in Basins 2 & 3. Update basin instruments/controls. Replace sludge lines on basins 2 & 3.	Critical	$6,252,000
2-15.A	Solids Contact Basins: Replace roof - basin area	Critical	$820,000
2-7.B	High Service Pumps: Install additional VFDs (Pumps 1, 2, 5, 6, 7, 8, 9)	Urgent	$3,026,000
2-3.A	Recarbonation Basin: Replace CO2 feeders	Urgent	$1,814,000
2-7.A	High Service Pumps: Replace pumps 7, 8, 9 (Cavitation). Change to lower flow pumps	Critical	$799,000
2-1.A	Actiflo: Replace (6) sand pumps	Critical	$227,800
2-8.A	Transfer Pumps: Install 480V VFDs	Urgent	$780,300
2-8.B	Transfer Pumps: Replace medium voltage motors with 480V motors	Urgent	
2-10.C	Chemical Storage: Replace analog equipment with digital/Ethernet chemical feed pumps. SCADA integration of day tank scales	Urgent	$559,300
2-10.D	Chemical Storage: Replace Chemical Feed Building HVAC	Urgent	$242,600

#	Recommended Improvements	Priority	Cost
2-11.A	Lime System: Replace slakers 5 & 6	Urgent	$1,368,100
2-12.A	Transmission Main Tunnel: Repair Pipe Tunnel Ceiling per inspection report	Critical	Refer to Midwest Engineering structural report
2-13.A	Architectural/building maintenance improvements: Operations supervisor office floor. Process engineer office wall water damage.	Ad Hoc	$15,000
2-14.A	Laboratory: Replace cabinets & casework	Ad Hoc	$112,300
2-14.B	Laboratory: Lab Flooring	Ad Hoc	
2-9.A	Re-paint North Reservoir (Big Blue).	Critical	$2,998,100
2-11.D	Lime System: Replace control system on screw conveyor and bucket elevator	Critical	Study for Cost Estimate
2-16.B	BSRPS: Bridge crane: Add trolley and gantry motors and controls.	Urgent	$20,600
2-1.B	Actiflo: Life cycle replacement of influent flow meters	Urgent	$148,000
2-2.C	Basins: Replace influent flow meters on N / S pipes (36" dia.)	Urgent	$92,000
2-7.D	High Service Pumps: Replace HVAC equipment	Urgent	$461,000
2-7.F	High Service Pumps: Replace slide gates in high service pump wet well.	Urgent	$192,000
2-11.B	Lime System: Replace exhaust fans & HVAC ducts for slaker room	Urgent	$76,500
2-13.C	Personnel Facilities: Install thermal mixing valves at eye wash / safety showers for tempered water.	Ad Hoc	$10,000
2-14.C	Laboratory: Surge Protection & UPS	Urgent	$90,600
2-15.B	Building Facilities: Replace North boiler, Replace South boiler	Urgent	$820,000
2-16.A	BSRPS: Replace pump discharge check valves	Urgent	$135,900
2-16.C	BSRPS: Instrumentation Improvements: Replace discharge pressures transducer; Replace wet well level sensor; Replace screen wash valve. Replace 42" Flow Meter	Urgent	$102,200
2-16.D	BSRPS: Controls Improvements: Replace screen automatic controls; Automate chem feed system; Automation of chemical feed system to more accurately feed potassium permanganate.	Urgent	$292,000
3-1.B	Replace switchgear in Power Room 1	Urgent	$936,000
3-1.D	Replace MCC in Power Room 3	Urgent	$588,400
3-1.E	Replace MCC in Power Room 4	Urgent	$488,200

#	Recommended Improvements	Priority	Cost
3-2.A	BSRPS: Replace MCC with digital (smart) MCC. Replace main breaker.	Urgent	$667,600
3-2.B	BSRPS: Replace Generator controller for SCADA integration. Evaluate generator by a manufacturer's service technician to determine adequate functionality, any needed repairs, and expected remaining life.	Urgent	$31,000
3-2.C	BSRPS: Replace fire alarm panel communication card.	Urgent	$4,800
4-1.A	Technology: Replace public address system with wired system	Urgent	$453,000
4-1.B	Technology: Replace remaining multimode segments with single mode fiber and complete the loop	Urgent	$491,300
2-2.E	Basin Controls Improvements: Replace basin flow meters, influent valve actuators and lime sludge pump	Required	$365,000
2-5.D	Filter-to-waste basin: Replace return pumps & control panel	Required	$142,000
2-15.D	Building Facilities: Replace service elevator	Required	--
3-1.A	Power Distribution: Life cycle replacement of standby generator	Required	$2,947,000
2-6.B	Clearwell: Replace clearwell baffle curtains	Ad Hoc	--
2-7.E	High Service Pumps: Remove Kathabar dehumidifier	Ad Hoc	Demolish with electrical or HVAC improvements
2-11.C	Lime System: Enclose lime railcar area	Ad Hoc	--
2-13.B	Evaluate future office needs.	Ad Hoc	Study
3-1.G	Power Distribution: Evaluate capacity of standby generator to operate WPP facility and high service pump station	Ad Hoc	Study / Evaluation
2-2.B	Solids Contact Basins: Televise basin piping to determine condition and risk of failure	Maintenance / Monitoring	Study / Evaluation
2-2.D	Solids Contact Basins: Monitor concrete structure and repair / seal concrete	Maintenance / Monitoring	Routine Inspection / Monitoring
2-3.B	Recarbonation Basin: Evaluate CO2 alternatives (i.e. pressurized solution feed, side stream CO2.	Maintenance / Monitoring	Study / Evaluation
2-5.C	Backwash Reclaim Basin: Visual Inspection of basin	Maintenance / Monitoring	Routine Inspection / Monitoring
2-7.C	High Service Pumps: Evaluate age & condition of VFDs on pumps 3 & 4	Maintenance / Monitoring	Study / Evaluation
2-10.A	Chemical Storage: Monitor Fluoride Tank	Maintenance / Monitoring	Routine Inspection / Monitoring
2-15.C	Building Facilities: Evaluate hot water heaters instead of steam	Maintenance / Monitoring	Evaluation
3-1.F	Power Distribution: Evaluate smart MCCs where replacing MCCs	Maintenance / Monitoring	Study / Evaluation

Appendix B: Condition Assessment Summary Tables

Sioux Falls WPP
Condition Assessment

Sioux Falls Water Purification Plant 2022 5/25/2022

Process Area / Asset Description		Notes/Comments	Year put in service	Calc. Actual Age	Estimated Life Expectancy		Calc. life (years) remaining	Condition Assessment		Consequence of Failure
								1 new - 5 unserviceable		Component
Unit Process	Process Area				**Equipment**	**Years**				
Actiflo										
	Piping	Good condition	2004	18	Pipe work Pressure	60	42	Excellent or New Condition	1	Intermediate Component Failure
	Valves	Good condition	2004	18	Pipe work Pressure	60	42	Excellent or New Condition	1	Intermediate Component Failure
	Actiflo Sand Pumps	Rubber lined volute Sand piping is glass lined Leaking seals - Requires replacement	2004	18	Pump Centrifugal	25	7	Significant Deterioration	4	Intermediate Component Failure
	Sludge Pumps	Moyno progressive cavity pumps	2004	18	Pump Progressive Cavity	35	17	Minor Defects Only	2	Intermediate Component Failure
	Structure		2004	18	Tanks - Concrete	75	57	Minor Defects Only	2	Intermediate Component Failure
	Sludge Tanks	Tank 1 / Tank 2	2004	18	Tanks - Concrete	75	57	Minor Defects Only	2	Intermediate Component Failure
	Sludge Collection Equipment		2011	11	Clarifier Mechanism	35	24	Excellent or New Condition	1	Minor Component Failure
Solids Contact Units										
	Basin 1 (Westech eqpt.)	Westech eqpt. - 1997 Also upsized sludge line to 6"	1952	70	Clarifier	35	-35	Moderate Deterioration	3	Intermediate Component Failure
	Basin 2 (Dorr-Oliver eqpt.)	4" sludge line	1952	70	Clarifier	35	-35	Significant Deterioration	4	Intermediate Component Failure
	Basin 3 (Dorr-Oliver eqpt.)	4" sludge line	1952	70	Clarifier	35	-35	Significant Deterioration	4	Intermediate Component Failure
	Basin 4 (Dorr-Oliver eqpt.)		1969	53	Clarifier	35	-18	Significant Deterioration	4	Intermediate Component Failure
	Basin 5 (Dorr-Oliver eqpt.)		1969	53	Clarifier	35	-18	Significant Deterioration	4	Intermediate Component Failure
	Basin 6 (Dorr-Oliver eqpt.)		1969	53	Clarifier	35	-18	Significant Deterioration	4	Intermediate Component Failure
	Piping		1969	53	Pipe work Pressure	60	7	Moderate Deterioration	3	Intermediate Component Failure
	Valves		1969	53	Valves	35	-18	Moderate Deterioration	3	Intermediate Component Failure
	Roof	Roof needs to be replaced over Basins 1 through 6	1969	53	Roof	25	-28	Significant Deterioration	4	Intermediate Component Failure
Recarbonation Basins										
	Train 1	South Train	1952	70	Tanks - Concrete	75	5	Minor Defects Only	2	Intermediate Component Failure
	Train 2	North Train	1969	53	Tanks - Concrete	75	22	Minor Defects Only	2	Intermediate Component Failure
	CO2 Feed System	Updated w/ Chem bldg	1995	27	Equipment Misc	30	3	Moderate Deterioration	3	Intermediate Component Failure
Filters										
	Filter 1-5	1993 Filter underdrain, air scour, surface wash, filter to waste	1952	70	Filters	50	-20	Moderate Deterioration	3	Intermediate Component Failure
	Filter 6-10	1993 Filter underdrain, air scour, surface wash, filter to waste. Sealed structural leaks/cracks w/ polyurethane sealant	1969	53	Filters	50	-3	Moderate Deterioration	3	Intermediate Component Failure
	Filter 11-15		2011	11	Filters	50	39	Minor Defects Only	2	Intermediate Component Failure
	Backwash Pumps (2)	VFDs > 10 yrs old. 150-HP pumps, rated for 8500 gpm each	2011	11	Pump Centrifugal	25	14	Minor Defects Only	2	Intermediate Component Failure
	Backwash Blower	Surface wash added in mid-1990's	1993	29	Blowers	50	21	Minor Defects Only	2	Minor Component Failure
	Piping	Paint is chipped, need to check thickness of pipe remaining	1969	53	Pipe work Pressure	60	7	Moderate Deterioration	3	Intermediate Component Failure
	Valves	City staff want to replace all filter valve actuators with vane actuators	1969	53	Valves	35	-18	Moderate Deterioration	3	Intermediate Component Failure

Process Area / Asset Description		**Notes/Comments**	**Year put in service**	**Calc. Actual Age**	**Estimated Life Expectancy**		**Calc. life (years) remaining**	**Condition Assessment**		**Consequence of Failure**
Unit Process	Process Area				**Equipment**	**Years**		1 new - 5 unserviceable		Component
Filter to waste basin (Filters 1-10)		Under Auditorium	1969	53	Tanks - Concrete	75	22			Intermediate Component Failure
Filter to waste basin (Filters 11-15)		West of Actiflo	1993	29	Tanks - Concrete	75	46			Intermediate Component Failure
Backwash reclaim basin (South)		West of Filters 11-15	2011	11	Tanks - Concrete	75	64			Major Component Failure
Clearwell			1935	87	Tanks - Concrete	75	-12	Minor Defects Only	2	Major Component Failure
High Service Pumping										
	Pump 1	600 hp (soft start)	2001	21	Pump Centrifugal	25	4	Minor Defects Only	2	Intermediate Component Failure
	Pump 2	600 hp (soft start)	2001	21	Pump Centrifugal	25	4	Minor Defects Only	2	Intermediate Component Failure
	Pump 3	900 hp - VFD 10 yr old	2001	21	Pump Centrifugal	25	4	Minor Defects Only	2	Intermediate Component Failure
	Pump 4	600 hp - VFD 10 yr old	2001	21	Pump Centrifugal	25	4	Minor Defects Only	2	Intermediate Component Failure
	Pump 5	900 hp (soft start)	2001	21	Pump Centrifugal	25	4	Minor Defects Only	2	Intermediate Component Failure
	Pump 6	900 hp (soft start)	2001	21	Pump Centrifugal	25	4	Minor Defects Only	2	Intermediate Component Failure
	Pump 7	600 hp (soft start) (Not used often. Need to be replaced)	2001	21	Pump Centrifugal	25	4	Moderate Deterioration	3	Intermediate Component Failure
	Pump 8	600 hp (soft start) (Not used often. Need to be replaced)	2001	21	Pump Centrifugal	25	4	Moderate Deterioration	3	Intermediate Component Failure
	Pump 9	600 hp (soft start) (Not used often. Need to be replaced)	2001	21	Pump Centrifugal	25	4	Moderate Deterioration	3	Intermediate Component Failure
	Structure	Roof replaced 2012	1969	53	Building	100	47	Minor Defects Only	2	Major Component Failure
	Electrical		2003	19	Electrical	35	16	Moderate Deterioration	3	Major Component Failure
	HVAC	Makeup Air Unit is original. Needs replacement	1969		HVAC	25	-28	Significant Deterioration	4	Intermediate Component Failure
Lime Storage / Feed Systems										
	Lime Transfer - Bucket Eleva	Control System is outdated	1953	69	Equipment Misc	30	-39	Significant Deterioration	4	Major Component Failure
	Lime Transfer - Vacuum System		1953	69	Equipment Misc	30	-39	Significant Deterioration	4	Intermediate Component Failure
	Lime Storage - Bunker	(5) 80 ton bunkers - Replacing augers	1953	69	Chemical Storage	50	-19	Significant Deterioration	4	Major Component Failure
	Lime Storage - Day Bins		1953	69	Chemical Storage	50	-19	Significant Deterioration	4	Intermediate Component Failure
	Lime Slaker 1		2020	2	Chemical Feed	15	13	Excellent or New Condition	1	Minor Component Failure
	Lime Slaker 2		2020	2	Chemical Feed	15	13	Excellent or New Condition	1	Minor Component Failure
	Lime Slaker 3		2016	6	Chemical Feed	15	9	Minor Defects Only	2	Minor Component Failure
	Lime Slaker 4		2018	4	Chemical Feed	15	11	Minor Defects Only	2	Minor Component Failure
	Lime Slaker 5	Batch Slaker- Needs replacement	2003	19	Chemical Feed	15	-4	Significant Deterioration	4	Minor Component Failure
	Lime Slaker 6	Batch Slaker- Needs replacement	2003	19	Chemical Feed	15	-4	Significant Deterioration	4	Minor Component Failure
	Slurry Tank	1000 gallon tank from slaker 5 & 6	2003	19	Tanks - Concrete	75	56	Minor Defects Only	2	Intermediate Component Failure
	HVAC	HVAC Ducts are corroded	2003	19	HVAC	25	6	Significant Deterioration	4	Intermediate Component Failure
Chemical Storage / Feed Systems										
	Phosphate	No longer use the phosphate bulk tank. Went to 275 totes	1995	27	Chemical Storage	50	23	Minor Defects Only	2	NA / No Impact
	Polydadmac		1995	27	Chemical Storage	50	23	Minor Defects Only	2	Intermediate Component Failure
	Polymer	No longer use the polymer bulk tank. Went to 55 gal drums	1995	27	Chemical Storage	50	23	Minor Defects Only	2	NA / No Impact
	Ferric Chloride		1995	27	Chemical Storage	50	23	Minor Defects Only	2	Intermediate Component Failure
	Powder Activated Carbon		1995	27	Tanks - Concrete	75	48	Minor Defects Only	2	Intermediate Component Failure
	Hydrofluorosilicic Acid	Fluoride tank needs to be replaced	1995	27	Chemical Storage	50	23	Virtually Unserviceable	5	Intermediate Component Failure
	Ammonium Hydroxide	No longer used - New ammonia addition	1995	27	Chemical Storage	50	23	Minor Defects Only	2	Intermediate Component Failure
	Chemical Feed Pumps	Pulsafeeders. Motors replaced with AC drives 10 years ago Pumps are rebuilt annually	1995	27	Chemical Feed	15	-12	Moderate Deterioration	3	Intermediate Component Failure
	Chemical Feed Piping	All pumps have automatic valves that open when the pump turns on	1995	27	Chemical Feed	15	-12	Moderate Deterioration	3	Intermediate Component Failure
	Structure	Roof replaced 2010	2010	12	Building	100	88	Excellent or New Condition	1	Major Component Failure
	Instruments		1995	27						

Process Area / Asset Description		**Notes/Comments**	**Year put in service**	**Calc. Actual Age**	**Estimated Life Expectancy**		**Calc. life (years) remaining**	**Condition Assessment**		**Consequence of Failure**
Unit Process	Process Area				**Equipment**	**Years**		1 new - 5 unserviceable		Component
Chlorination System										
	Chlorine Feeders	Replacing one feeder in 2022	2022	0	Chemical Feed	15	15	Minor Defects Only	2	Intermediate Component Failure
	Structure	2011 Bldg addition	1987	35	Building	100	65	Minor Defects Only	2	Intermediate Component Failure
	Instruments	New gas detectors installed in building addit	2021	1	Controls	15	14	Excellent or New Condition	1	Minor Component Failure
	Chemical Unloading Area	Enlcosed garage for unloading	2021	1	Building	100	99	Excellent or New Condition	1	Intermediate Component Failure
Ammonia Building										
	Equipment	Project constructed in 2021	2021	1	Equipment Misc	30	29	Excellent or New Condition	1	Intermediate Component Failure
	Structure		2021	1	Building	100	99	Excellent or New Condition	1	Major Component Failure
	Electrical		2021	1	Electrical	35	34	Excellent or New Condition	1	Intermediate Component Failure
	Instrumentation/Controls		2021	1	Controls	15	14	Excellent or New Condition	1	Intermediate Component Failure
Facilities										
	Freight Elevator	Controls are open contacts, controls should be updated	1955	67	Building Asset	30	-37	Significant Deterioration	4	
	Boiler - North (Basin area)	City wants to replace steam boiler with hot water system			HVAC	25		Significant Deterioration	4	Major Component Failure
	Boiler - South (High Service Pump Area)	City wants to replace steam boiler with hot water system			HVAC	25		Significant Deterioration	4	Major Component Failure
	Pipe Tunnel	Structural concernswith the existing ceiling (	1953	69				Significant Deterioration	4	

Appendix C: Clearwell Condition: Photo Comparison

WPP Clearwell:
Photo comparison

February 2022 photos vs. 12/9/2011 photos

Note: 2011 were not necessarily take in exactly the same location as 2022 photos. We attempted to match them up as best as possible for comparison.

Markups by Sam Cotter, HR Green

AE2S Photo
February 2022

HRGreen Photo:
12/9/2011

Figure 4 Mineral intrusion at crack in roof slab

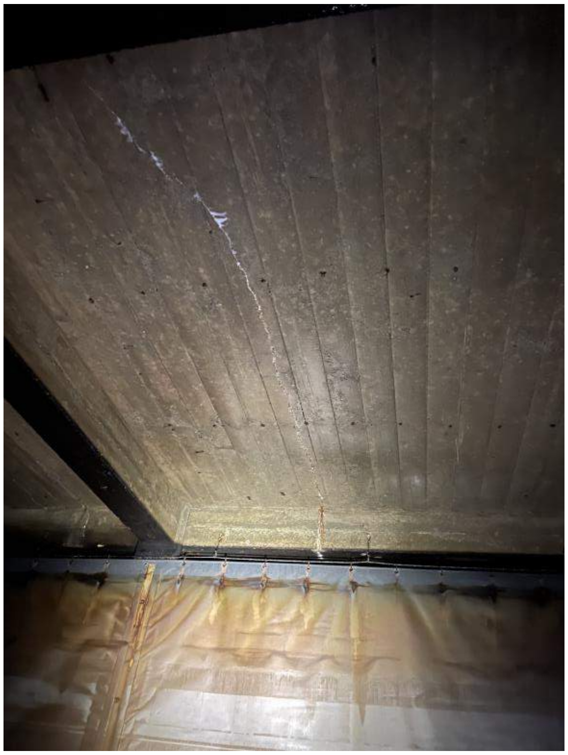


Figure 5 Mineral intrusion at roof slab crack

AE2S Photo
February 2022

HRGreen Photo:
12/9/2011

Figure 8 Unconsolidated concrete and exposed aggregate

AE2S Photo
February 2022

HRGreen Photo:
12/9/2011

Figure 9 Unconsolidated concrete at beam

AE2S Photo
February 2022

HRGreen Photo:
12/9/2011

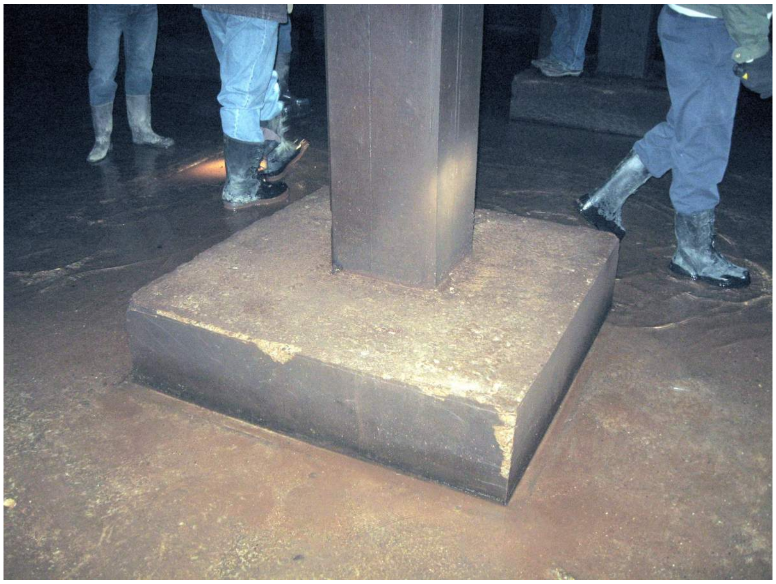
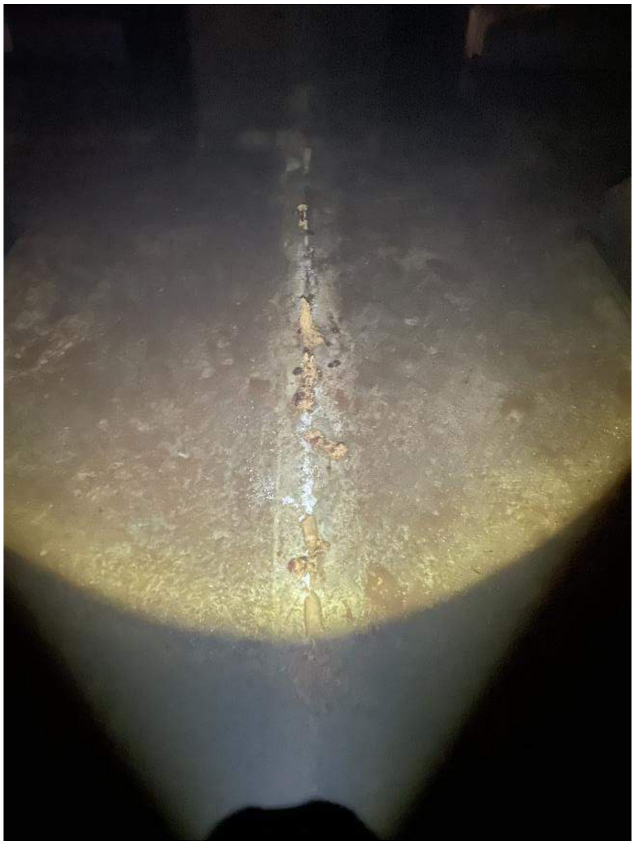


Figure 10 Spalling at concrete column pedestal

AE2S Photo
February 2022



HRGreen Photos:
12/9/2011

Figure 11 Joint sealant in mat slab

AE2S Photo
February 2022

HRGreen Photo:
12/9/2011

Figure 16 Influent piping concrete supports

AE2S Photo
February 2022

HRGreen Photo:
12/9/2011

Figure 20 Clearwell effluent pipe (valve closure issue)

AE2S Photo
February 2022

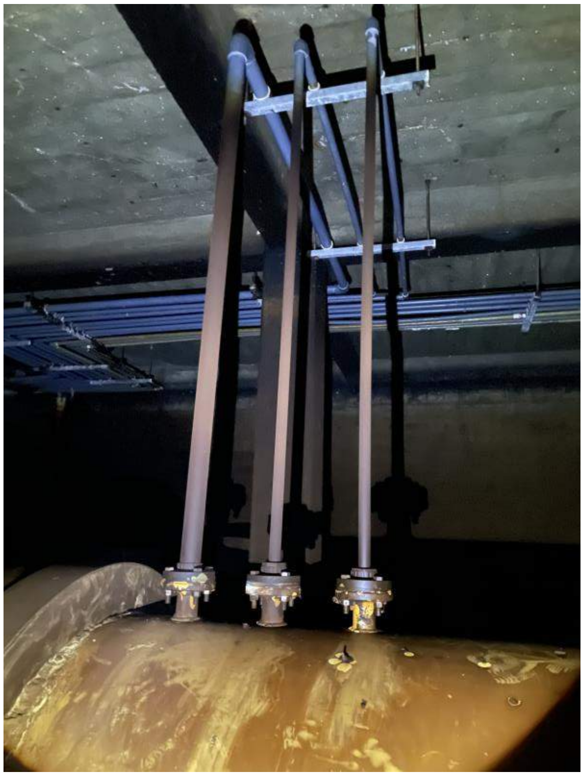


Figure 26 Clearwell influent chemical feed

HRGreen Photo:
12/9/2011

AE2S Photo
February 2022

HRGreen Photo:
12/9/2011

Figure 27 Clearwell effluent chemical feed

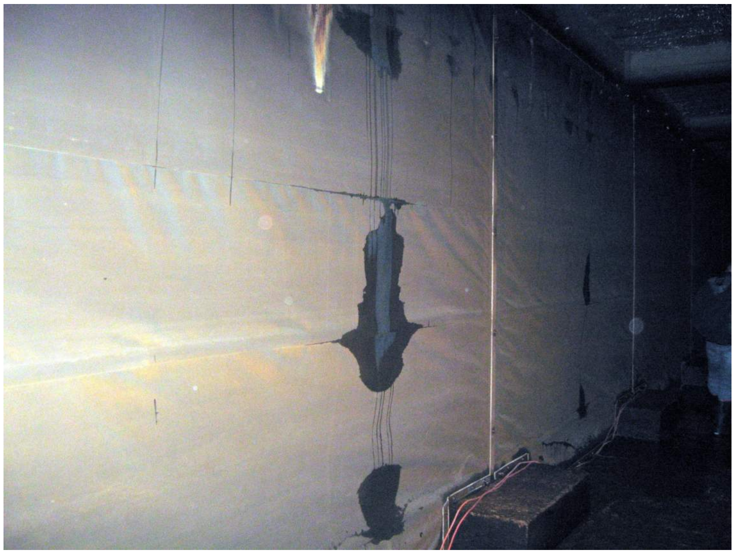
Figure 19 Effluent piping tuberculation

AE2S Photo
February 2022

Figure 30 Baffle curtain (bottom connection)

Figure 31 Baffle curtain (top connection)

HRGreen Photo:
12/9/2011



Appendix D: Engineer's Opinion of Probable Cost

Actiflo - 1-1.A: Replace Sand Pumps
ESTIMATE OF CONSTRUCTION AND PROJECT COSTS

	ITEM DESCRIPTION	QTY	UNITS	UNIT COST	COST
1	Replace Actiflo Sand Pumps	6	EA	$ 16,896	$ 101,377
2	Electrical & IC - Incidental for pump replacement (20%)	1	LS	$ 20,275	$ 20,275
				Contingency (30%)	$ 36,496
				Estimated Construction Cost	$ 158,200
				Contractor General Conditions (5%)	$ 7,910
				Contractor Overhead/Profit/Mobilization (15%)	$ 23,730
				Engineering Design (14%)	$ 22,148
				Construction Administration (6%)	$ 9,492
				Funding - Legal / Admin (4%)	$ 6,328
				Estimated Project Cost	$ 227,800

Solids Contact Basins - 1-1.B: Actiflo Instrumentation: Flow Meters, Silo Weight System
ESTIMATE OF CONSTRUCTION AND PROJECT COSTS

	ITEM DESCRIPTION	QTY	UNITS	UNIT COST	COST
1	Influent Flow Meter: 36" Diameter	2	EA	$ 18,630	$ 37,260
2	Demolition	2	EA	$ 1,500	$ 3,000
3	Piping Connection	2	EA	$ 500	$ 1,000
4	Sand Silo Weight System	1	LS	$ 11,970	$ 11,970
5	Sand Silo Weight System - Installation	1	LS	$ 17,955	$ 17,955
6	Electrical & IC - Incidental for equipment replacement (20% of equipment cost)	1	LS	$ 8,052	$ 8,052
				Contingency (30%)	$ 23,771
				Estimated Construction Cost	$ 103,100
				Contractor General Conditions (5%)	$ 5,155
				Contractor Overhead/Profit/Mobilization (15%)	$ 15,465
				Engineering Design (14%)	$ 14,434
				Construction Administration (6%)	$ 6,186
				Funding - Legal / Admin (4%)	$ 4,124
				Estimated Project Cost	$ 148,000

Solids Contact Basins - 1-2.A: Replace Mechanical Equipment - Basins 2 & 3
ESTIMATE OF CONSTRUCTION AND PROJECT COSTS

	ITEM DESCRIPTION	QTY	UNITS	UNIT COST	COST
1	Solids Contact Clarifier Equipment: Basin 2 & 3	2	EA	$ 866,667	$ 1,733,333
2	Crane Rental	1	LS	$ 500,000	$ 500,000
3	Roof modifications for basin work	1	LS	$ 500,000	$ 500,000
	Replace sludge lines on Basins 2 & 3	2	EA	$ 80,000	$ 160,000
4	Electrical & IC - Incidental for equipment replacement (20% of equipment cost)	1	LS	$ 446,667	$ 446,667
				Contingency (30%)	$ 1,002,000
				Estimated Construction Cost	$ 4,342,000
				Contractor General Conditions (5%)	$ 217,100
				Contractor Overhead/Profit/Mobilization (15%)	$ 651,300
				Engineering Design (14%)	$ 607,880
				Construction Administration (6%)	$ 260,520
				Funding - Legal / Admin (4%)	$ 173,680
				Estimated Project Cost	$ 6,252,000

Solids Contact Basins - 1-2.C: Replace Influent Flow Meters
ESTIMATE OF CONSTRUCTION AND PROJECT COSTS

	ITEM DESCRIPTION	QTY	UNITS	UNIT COST	COST
1	Header Pipe Magnetic Flow Meters: 36" Diameter	2	EA	$ 18,630	$ 37,260
2	Demolition	2	EA	$ 1,500	$ 3,000
3	Piping Connection	2	EA	$ 500	$ 1,000
4	Electrical & IC - Incidental for equipment replacement (20% of equipment cost)	1	LS	$ 8,052	$ 8,052
				Contingency (30%)	$ 14,794
				Estimated Construction Cost	$ 64,200
				Contractor General Conditions (5%)	$ 3,210
				Contractor Overhead/Profit/Mobilization (15%)	$ 9,630
				Engineering Design (14%)	$ 8,988
				Construction Administration (6%)	$ 3,852
				Funding - Legal / Admin (4%)	$ 2,568
				Estimated Project Cost	$ 92,000

Solids Contact Basins - 1-2.E: Basin Control Equipment

ESTIMATE OF CONSTRUCTION AND PROJECT COSTS

	ITEM DESCRIPTION	QTY	UNITS	UNIT COST	COST
1	Basin Influent Magnetic Flow Meters:	6	EA	$ 10,230	$ 61,380
2	Influent Valve Actuators	6	EA	$ 13,500	$ 81,000
3	Lime Sludge Pump w/VFD	1	EA	$ 20,000	$ 20,000
4	Electrical & IC - Incidental for equipment replacement (20% of equipment cost)	1	LS	$ 32,476	$ 32,476
				Contingency (30%)	$ 58,457
				Estimated Construction Cost	$ 253,400
				Contractor General Conditions (5%)	$ 12,670
				Contractor Overhead/Profit/Mobilization (15%)	$ 38,010
				Engineering Design (14%)	$ 35,476
				Construction Administration (6%)	$ 15,204
				Funding - Legal / Admin (4%)	$ 10,136
				Estimated Project Cost	$ 365,000

Solids Contact Basins - 1-3.A: Replace CO2 Feeders
ESTIMATE OF CONSTRUCTION AND PROJECT COSTS

	ITEM DESCRIPTION	QTY	UNITS	UNIT COST	COST
1	CO2 Feed Panels (2) with pH control	1	LS	$ 538,294	$ 538,294
2	Incidental Piping (50% of equipment	1	LS	$ 269,147	$ 269,147
3	Electrical & IC - Incidental for equipment replacement (20% of equipment cost)	1	LS	$ 161,488	$ 161,488
				Contingency (30%)	$ 290,679
				Estimated Construction Cost	$ 1,259,700
				Contractor General Conditions (5%)	$ 62,985
				Contractor Overhead/Profit/Mobilization (15%)	$ 188,955
				Engineering Design (14%)	$ 176,358
				Construction Administration (6%)	$ 75,582
				Funding - Legal / Admin (4%)	$ 50,388
				Estimated Project Cost	$ 1,814,000

Filters - 1-4.A: Filter Instrumentation Improvements

ESTIMATE OF CONSTRUCTION AND PROJECT COSTS

	ITEM DESCRIPTION	QTY	UNITS	UNIT COST	COST
1	Flow meter: Demolition	30	EA	$ 130	$ 3,900
2	Filter Flow meter - 20"	30	EA	$ 8,630	$ 258,900
3	Installation - Flow Meters	30	EA	$ 500	$ 15,000
4	Life Cycle Replacment: Turbidimeters	17	EA	$ 7,000	$ 119,000
5	Pressure Transducers (Filters)	45	EA	$ 3,200	$ 144,000
6	Flushing solenoids & Installation	45	EA	$ 750	$ 33,750
7	Radar Level Sensors (Filters)	30	EA	$ 1,500	$ 45,000
8	Update filter I/O hardware (Allen Bradley Flex5000)	15	EA	$ 17,500	$ 262,500
9	Incidental piping (10%)	1	LS	$ 61,955	$ 61,955
10	Electrical & IC - Incidental for valve replacement (20%)	1	LS	$ 123,910	$ 123,910
				Contingency (30%)	$ 320,375
				Estimated Construction Cost	$ 1,388,300
				Contractor General Conditions (5%)	$ 69,415
				Contractor Overhead/Profit/Mobilization (15%)	$ 208,245
				Engineering Design (14%)	$ 194,362
				Construction Administration (6%)	$ 83,298
				Funding - Legal / Admin (4%)	$ 55,532
				Estimated Project Cost	$ 1,999,200

Filters - 1-4.B: Filter Gallery Valve Replacement

Filters 1 - 10

ESTIMATE OF CONSTRUCTION AND PROJECT COSTS

	ITEM DESCRIPTION	QTY	UNITS	UNIT COST	COST
1	Valve: Demolition	40	EA	$ 130	$ 5,200
2	Valve: 20" Butterfly	20	EA	$ 22,232	$ 444,640
3	Valve: 24" Butterfly	10	EA	$ 25,900	$ 259,000
4	Valve: 30" Butterfly	10	EA	$ 37,800	$ 378,000
5	Installation - Valves	40	EA	$ 1,500	$ 60,000
6	Recoating process piping	1	LS	$ 50,000	$ 50,000
7	Electrical & IC - Incidental for valve replacement (20%)	1	LS	$ 229,368	$ 229,368
				Contingency (30%)	$ 427,862
				Estimated Construction Cost	$ 1,854,100
				Contractor General Conditions (5%)	$ 92,705
				Contractor Overhead/Profit/Mobilization (15%)	$ 278,115
				Engineering Design (14%)	$ 259,574
				Construction Administration (6%)	$ 111,246
				Funding - Legal / Admin (4%)	$ 74,164
				Estimated Project Cost	$ 2,669,900

Filters - 1-4.C: Add additional backwash blower

ESTIMATE OF CONSTRUCTION AND PROJECT COSTS

	ITEM DESCRIPTION	QTY	UNITS	UNIT COST	COST
1	Backwash Blower	1	EA	$ 30,300	$ 30,300
2	Freight & Field Service	1	LS	$ 5,000	$ 5,000
3	Incidental piping (10%)	1	LS	$ 3,030	$ 3,030
4	Electrical & IC - Incidental (10%)	1	LS	$ 3,030	$ 3,030
				Contingency (30%)	$ 12,408
				Estimated Construction Cost	$ 53,800
				Contractor General Conditions (5%)	$ 2,690
				Contractor Overhead/Profit/Mobilization (15%)	$ 8,070
				Engineering Design (14%)	$ 7,532
				Construction Administration (6%)	$ 3,228
				Funding - Legal / Admin (4%)	$ 2,152
				Estimated Project Cost	$ 77,500

Filters - 1-4.D: Backwash Pump VFD Life Cycle Replacement / Redundancy

ESTIMATE OF CONSTRUCTION AND PROJECT COSTS

	ITEM DESCRIPTION	QTY	UNITS	UNIT COST	COST
1	Backwash Pump: 480V VFD - Equipment & Labor	2	EA	$ 29,000	$ 58,000
2	Conductors & Raceways - Equipment & Labor	1	LS	$ 8,600	$ 8,600
3	Distribution Equipment - Equipment & Labor	1	LS	$ 3,800	$ 3,800
4	Demolition (Incidental to equipment replacement)	1	LS	$ 2,600	$ 2,600
				Contingency (30%)	$ 21,900
				Estimated Construction Cost	$ 94,900
				Contractor General Conditions (5%)	$ 4,745
				Contractor Overhead/Profit/Mobilization (15%)	$ 14,235
				Engineering Design (14%)	$ 13,286
				Construction Administration (6%)	$ 5,694
				Funding - Legal / Admin (4%)	$ 3,796
				Estimated Project Cost	$ 136,700

Reclaimation Basin - 1-5.A: Replace Sludge Scrapers
ESTIMATE OF CONSTRUCTION AND PROJECT COSTS

	ITEM DESCRIPTION	QTY	UNITS	UNIT COST	COST
1	Replace existing: Reclaim basin sludge collectors & cross-collector	1	LS	$ 291,900	$ 291,900
2	Additional reclaim basin sludge collectors	1	LS	$ 277,300	$ 277,300
3	Add scraper drive unit	1	LS	$ 69,325	$ 69,325
4	Electrical & IC - Incidental for equipment installation (20% of equipment cost)	1	LS	$ 127,705	$ 127,705
				Contingency (30%)	$ 229,869
				Estimated Construction Cost	$ 996,100
				Contractor General Conditions (5%)	$ 49,805
				Contractor Overhead/Profit/Mobilization (15%)	$ 149,415
				Engineering Design (14%)	$ 139,454
				Construction Administration (6%)	$ 59,766
				Funding - Legal / Admin (4%)	$ 39,844
				Estimated Project Cost	$ 1,434,000

Reclaimation Basin - 1-5.D: Filter-to-waste Basin: Replace Pumps & Control
ESTIMATE OF CONSTRUCTION AND PROJECT COSTS

	ITEM DESCRIPTION	QTY	UNITS	UNIT COST	COST
1	Filter-to-waste return pumps	2	EA	$ 10,000	$ 20,000
2	Pump VFDs (10 HP)	2	EA	$ 6,500	$ 13,000
3	Pump Control Panel	1	LS	$ 30,000	$ 30,000
4	Electrical & IC - Incidental for equipment installation (20% of equipment cost)	1	LS	$ 12,600	$ 12,600
				Contingency (30%)	$ 22,680
				Estimated Construction Cost	$ 98,300
				Contractor General Conditions (5%)	$ 4,915
				Contractor Overhead/Profit/Mobilization (15%)	$ 14,745
				Engineering Design (14%)	$ 13,762
				Construction Administration (6%)	$ 5,898
				Funding - Legal / Admin (4%)	$ 3,932
				Estimated Project Cost	$ 142,000

Clearwell 1-6.A: Replace valves between clearwell & N. reservoir transfer pump wet well
ESTIMATE OF CONSTRUCTION AND PROJECT COSTS

	ITEM DESCRIPTION	QTY	UNITS	UNIT COST	COST
1	Replacement valves	2	EA	$ 38,670	$ 77,340
2	Incidental Piping Modifications (10%)	1	LS	$ 7,734.00	$ 7,734
Contingency (30%)					$ 25,522
Estimated Construction Cost					$ 110,600
Contractor General Conditions (5%)					$ 5,530
Contractor Overhead/Profit/Mobilization (15%)					$ 16,590
Engineering Design (14%)					$ 15,484
Construction Administration (6%)					$ 6,636
Funding - Legal / Admin (4%)					$ 4,424
Estimated Project Cost					$ 159,300

High Service Pump: - 1-7.A: Pump Replacment
ESTIMATE OF CONSTRUCTION AND PROJECT COSTS

	ITEM DESCRIPTION	QTY	UNITS	UNIT COST	COST
1	900 HP High Service Pump	0	EA	$ 95,718	$ -
2	600 HP High Service Pump	3	EA	$ 83,748	$ 251,244
3	Demolition of Existing	1	LS	$ 50,000	$ 50,000
4	Incidental Piping Modifications (50%)	1	LS	$ 125,622	$ 125,622
				Contingency (30%)	$ 128,060
				Estimated Construction Cost	$ 555,000
				Contractor General Conditions (5%)	$ 27,750
				Contractor Overhead/Profit/Mobilization (15%)	$ 83,250
				Engineering Design (14%)	$ 77,700
				Construction Administration (6%)	$ 33,300
				Funding - Legal / Admin (4%)	$ 22,200
				Estimated Project Cost	$ 799,000

High Service Pump - 1-7.B: Electrical Improvements
ESTIMATE OF CONSTRUCTION AND PROJECT COSTS

	ITEM DESCRIPTION	QTY	UNITS	UNIT COST	COST
1	VFD (600 HP) - Equipment & Labor	6	EA	$ 145,000	$ 870,000
2	VFD (900 HP) - Equipment & Labor	1	EA	$ 215,000	$ 215,000
3	Medium Voltage Wiring	1	LS	$ 461,875	$ 461,875
4	Demolition	1	LS	$ 41,600.00	$ 41,600
5	Disconnect / Reconnect Pumps	1	LS	$ 28,000	$ 28,000
				Contingency (30%)	$ 484,943
				Estimated Construction Cost	$ 2,101,500
				Contractor General Conditions (5%)	$ 105,100
				Contractor Overhead/Profit/Mobilization (15%)	$ 315,200
				Engineering Design (14%)	$ 294,200
				Construction Administration (6%)	$ 126,100
				Funding - Legal / Admin (4%)	$ 84,100
				Estimated Project Cost	$ 3,026,000

High Service Pump - 1-7.D: Replace High Service Pump HVAC Equipment
ESTIMATE OF CONSTRUCTION AND PROJECT COSTS

	ITEM DESCRIPTION	QTY	UNITS	UNIT COST	COST
1	High Service Pump Area: HVAC Equipment	1	LS	$ 205,000	$ 205,000
2	Electrical & IC - Incidental for equipment replacement (20%)	1	LS	$ 41,000	$ 41,000
				Contingency (30%)	$ 73,800
				Estimated Construction Cost	$ 319,800
				Contractor General Conditions (5%)	$ 16,000
				Contractor Overhead/Profit/Mobilization (15%)	$ 48,000
				Engineering Design (14%)	$ 44,800
				Construction Administration (6%)	$ 19,200
				Funding - Legal / Admin (4%)	$ 12,800
				Estimated Project Cost	$ 461,000

High Service Pump - 1-7.F: Replace Slide Gates in High Service Pump Wet Well
ESTIMATE OF CONSTRUCTION AND PROJECT COSTS

	ITEM DESCRIPTION	QTY	UNITS	UNIT COST	COST
1	48"x48" Slide Gate	2	EA	$ 33,275	$ 66,550
2	36"x36" Slide Gate	1	EA	$ 26,620	$ 26,620
3	Incidental piping modifications (10%)	1	LS	$ 9,317	$ 9,317
				Contingency (30%)	$ 30,746
				Estimated Construction Cost	$ 133,300
				Contractor General Conditions (5%)	$ 6,700
				Contractor Overhead/Profit/Mobilization (15%)	$ 20,000
				Engineering Design (14%)	$ 18,700
				Construction Administration (6%)	$ 8,000
				Funding - Legal / Admin (4%)	$ 5,300
				Estimated Project Cost	$ 192,000

Transfer Pumps 1-8.A/B: Rehabilitation
ESTIMATE OF CONSTRUCTION AND PROJECT COSTS

	ITEM DESCRIPTION	QTY	UNITS	UNIT COST	COST
1	Pump VFDs	3	EA	$ 34,500	$ 103,500
2	Pump motors (480V / 150 HP)	3	EA	$ 20,950.00	$ 62,850
3	Conductors & Raceways - Labor & Equipment	1	LS	$ 107,868	$ 107,868
4	Distribution Equipment - Labor & Equipment	1	LS	$ 54,480.00	$ 54,480
5	Wiring	1	LS	$ 40,500	$ 40,500
6	Demolition	1	LS	$ 10,400.00	$ 10,400
7	Disconnect / Reconnect Pumps	3	EA	$ 3,000	$ 9,000
8	Transfer Flow Meter - 30"	1	EA	$ 22,400	$ 22,400
9	North Reservoir Effluent Flow Meter - 24"	1	EA	$ 14,322	$ 14,322
				Contingency (30%)	$ 116,579
				Estimated Construction Cost	$ 541,900
				Contractor General Conditions (5%)	$ 27,095
				Contractor Overhead/Profit/Mobilization (15%)	$ 81,285
				Engineering Design (14%)	$ 75,866
				Construction Administration (6%)	$ 32,514
				Funding - Legal / Admin (4%)	$ 21,676
				Estimated Project Cost	$ 780,300

North Reservoir - 1-9.A: Repaint North Reservoir, Instrumentation Improvements
ESTIMATE OF CONSTRUCTION AND PROJECT COSTS

	ITEM DESCRIPTION	QTY	UNITS	UNIT COST	COST
1	Recoat: Tank interior - Surface prep & coating	31,809	SF	$ 12.00	$ 381,704
2	Recoat: Tank exterior - Surface prep & coating	31,809	SF	$ 15.00	$ 477,129
3	Containment	1	LS	$ 75,000	$ 75,000
4	Incidental expenses (roof vent replacement, piping repairs as needed) - 10%	1	LS	$ 93,383	$ 93,383
5	Level Sensor (radar)	1	EA	$ 1,500	$ 1,500
					$ -
				Contingency (30%)	$ 308,615
				Estimated Construction Cost	$ 1,337,400
				Contractor General Conditions (5%)	$ 66,870
				Contractor Overhead/Profit/Mobilization (15%)	$ 200,610
				Engineering Design (14%)	$ 187,236
				Construction Administration (6%)	$ 80,244
				Funding - Legal / Admin (4%)	$ 53,496
				Estimated Project Cost	$ 1,925,900

Chemical Feed System: 1-10.B - Service Water Line
ESTIMATE OF CONSTRUCTION AND PROJECT COSTS

	ITEM DESCRIPTION	QTY	UNITS	UNIT COST	COST
	2" Diameter Copper pipe	400	Ft	$ 53	$ 21,000
				Contingency (30%)	$ 6,300
				Estimated Construction Cost	$ 27,300
				Contractor General Conditions (5%)	$ 1,365
				Contractor Overhead/Profit/Mobilization (15%)	$ 4,095
				Engineering Design (14%)	$ 3,822
				Construction Administration (6%)	$ 1,638
				Funding - Legal / Admin (4%)	$ 1,092
				Estimated Project Cost	$ 39,300

Chemical Feed System: 1-10.C - Chemical Feed Pumps
ESTIMATE OF CONSTRUCTION AND PROJECT COSTS

	ITEM DESCRIPTION	QTY	UNITS	UNIT COST	COST
1	Chemical Feed Pumps - Low Flow (Peristaltic Pumps)	24	EA	$ 7,000	$ 168,000
2	Replace polymer day tank scales	6	EA	$ 5,300	$ 31,800
3	Day tank scale digital indicator	3	EA	$ 3,115	$ 9,345
4	Polymer Chemical Feed Pumps	8	EA	$ 7,000	$ 56,000
5	Electrical & IC - Incidental for pump replacement (20%)	1	LS	$ 33,600	$ 33,600
				Contingency (30%)	$ 89,624
				Estimated Construction Cost	$ 388,400
				Contractor General Conditions (5%)	$ 19,420
				Contractor Overhead/Profit/Mobilization (15%)	$ 58,260
				Engineering Design (14%)	$ 54,376
				Construction Administration (6%)	$ 23,304
				Funding - Legal / Admin (4%)	$ 15,536
				Estimated Project Cost	$ 559,300

Chemical Feed System: 1-10.D - Chemical Feed Area HVAC
ESTIMATE OF CONSTRUCTION AND PROJECT COSTS

	ITEM DESCRIPTION	QTY	UNITS	UNIT COST	COST
1	Chemical Feed Area: HVAC	1	LS	$ 108,000	$ 108,000
2	Electrical & IC - Incidental for HVAC (20%)	1	LS	$ 21,600	$ 21,600
				Contingency (30%)	$ 38,880
				Estimated Construction Cost	$ 168,500
				Contractor General Conditions (5%)	$ 8,425
				Contractor Overhead/Profit/Mobilization (15%)	$ 25,275
				Engineering Design (14%)	$ 23,590
				Construction Administration (6%)	$ 10,110
				Funding - Legal / Admin (4%)	$ 6,740
				Estimated Project Cost	$ 242,600

Lime Slakers: 1-11.A - Replace Slakers 5 & 6
ESTIMATE OF CONSTRUCTION AND PROJECT COSTS

	ITEM DESCRIPTION	QTY	UNITS	UNIT COST	COST
1	Lime Slaker (#5 & #6): Screw Feeder; Lime Slaker (2,000 PPH); Water Supply Panel; Grit Remover; PLC Control Panel	2	EA	$ 304,500	$ 609,000
2	Electrical & IC - Incidental for pump replacement (20%)	1	LS	$ 121,800	$ 121,800
				Contingency (30%)	$ 219,240
				Estimated Construction Cost	$ 950,100
				Contractor General Conditions (5%)	$ 47,505
				Contractor Overhead/Profit/Mobilization (15%)	$ 142,515
				Engineering Design (14%)	$ 133,014
				Construction Administration (6%)	$ 57,006
				Funding - Legal / Admin (4%)	$ 38,004
				Estimated Project Cost	$ 1,368,100

Lime Slakers: 1-11.B - Replace Slaker Area HVAC
ESTIMATE OF CONSTRUCTION AND PROJECT COSTS

	ITEM DESCRIPTION	QTY	UNITS	UNIT COST	COST
1	Lime Slaker HVAC Replacement	1	EA	$ 34,000	$ 34,000
2	Electrical & IC - Incidental for pump replacement (20%)	1	LS	$ 6,800	$ 6,800
				Contingency (30%)	$ 12,240
				Estimated Construction Cost	$ 53,100
				Contractor General Conditions (5%)	$ 2,655
				Contractor Overhead/Profit/Mobilization (15%)	$ 7,965
				Engineering Design (14%)	$ 7,434
				Construction Administration (6%)	$ 3,186
				Funding - Legal / Admin (4%)	$ 2,124
				Estimated Project Cost	$ 76,500

Laboratory 1-14.A/B: Improvements
ESTIMATE OF CONSTRUCTION AND PROJECT COSTS

	ITEM DESCRIPTION	QTY	UNITS	UNIT COST	COST
1	Laboratory Furniture	1	LS	$ 50,000	$ 50,000
2	Epoxy Flooring Replacment	1	LS	$ 10,000.00	$ 10,000
				Contingency (30%)	$ 18,000
				Estimated Construction Cost	$ 78,000
				Contractor General Conditions (5%)	$ 3,900
				Contractor Overhead/Profit/Mobilization (15%)	$ 11,700
				Engineering Design (14%)	$ 10,920
				Construction Administration (6%)	$ 4,680
				Funding - Legal / Admin (4%)	$ 3,120
				Estimated Project Cost	$ 112,300

Laboratory 1-14.C: Laboratory UPS & Surge Protection
ESTIMATE OF CONSTRUCTION AND PROJECT COSTS

	ITEM DESCRIPTION	QTY	UNITS	UNIT COST	COST
1	Surge Protection Devices	1	LS	$ 3,800	$ 3,800
2	Laboratory UPS System - 30 KVA	1	LS	$ 35,000.00	$ 35,000
3	Incidental circuit breakers / panels	1	LS	$ 4,400	$ 4,400
4	Incidental conductors / conduit	1	LS	$ 6,700	$ 6,700
				Contingency (30%)	$ 12,960
				Estimated Construction Cost	$ 62,900
				Contractor General Conditions (5%)	$ 3,145
				Contractor Overhead/Profit/Mobilization (15%)	$ 9,435
				Engineering Design (14%)	$ 8,806
				Construction Administration (6%)	$ 3,774
				Funding - Legal / Admin (4%)	$ 2,516
				Estimated Project Cost	$ 90,600

Building Facilities 1-15.A: Basin Area Roof Replacement
ESTIMATE OF CONSTRUCTION AND PROJECT COSTS

	ITEM DESCRIPTION	QTY	UNITS	UNIT COST	COST
1	Basin Area Roof: Basins 1 - 6, Filters 1 - 10	48,655	SF	$ 35	$ 1,702,925
2	Roof Accessories - Curbs for ventilation, fill in skylights (10% of roof cost)	1	LS	$ 170,293	$ 170,293
				Contingency (30%)	$ 510,878
				Estimated Construction Cost	$ 2,384,100
				Contractor General Conditions (5%)	$ 119,205
				Contractor Overhead/Profit/Mobilization (15%)	$ 357,615
				Engineering Design (14%)	$ 333,774
				Construction Administration (6%)	$ 143,046
				Funding - Legal / Admin (4%)	$ 95,364
				Estimated Project Cost	$ 3,433,000

Building Facilities: 1-15.B - Replace North and South Boilers
ESTIMATE OF CONSTRUCTION AND PROJECT COSTS

	ITEM DESCRIPTION	QTY	UNITS	UNIT COST	COST
1	Replace North boiler	1	LS	$ 211,000	$ 211,000
2	Replace South Boiler	1	LS	$ 211,000	$ 211,000
3	Electrical & IC - Incidental for equipment replacement (20%)	1	LS	$ 84,400	$ 84,400
				Contingency (30%)	$ 63,300
				Estimated Construction Cost	$ 569,700
				Contractor General Conditions (5%)	$ 28,485
				Contractor Overhead/Profit/Mobilization (15%)	$ 85,455
				Engineering Design (14%)	$ 79,758
				Construction Administration (6%)	$ 34,182
				Funding - Legal / Admin (4%)	$ 22,788
				Estimated Project Cost	$ 820,000

Big Sioux River Pump Station 1-16.A: Replace Pump Discharge Check Valves
ESTIMATE OF CONSTRUCTION AND PROJECT COSTS

	ITEM DESCRIPTION	QTY	UNITS	UNIT COST	COST
1	Check Valves	3	EA	$ 22,000	$ 66,000
2	Incidental piping modifications (10%)	1	LS	$ 6,600.00	$ 6,600
Contingency (30%)					$ 21,780
Estimated Construction Cost					$ 94,400
Contractor General Conditions (5%)					$ 4,720
Contractor Overhead/Profit/Mobilization (15%)					$ 14,160
Engineering Design (14%)					$ 13,216
Construction Administration (6%)					$ 5,664
Funding - Legal / Admin (4%)					$ 3,776
Estimated Project Cost					$ 135,900

Big Sioux River Pump Station 1-16.B: Add Trolley and Gantry Motors and Controls
ESTIMATE OF CONSTRUCTION AND PROJECT COSTS

	ITEM DESCRIPTION	QTY	UNITS	UNIT COST	COST
1	Bridge crane: Trolly & gantry motors and controls	1	LS	$ 10,980	$ 10,980
Contingency (30%)					$ 3,300
Estimated Construction Cost					$ 14,300
Contractor General Conditions (5%)					$ 715
Contractor Overhead/Profit/Mobilization (15%)					$ 2,145
Engineering Design (14%)					$ 2,002
Construction Administration (6%)					$ 858
Funding - Legal / Admin (4%)					$ 572
Estimated Project Cost					$ 20,600

Big Sioux River Pump Station 1-16.C: Instrumentation Improvements

ESTIMATE OF CONSTRUCTION AND PROJECT COSTS

	ITEM DESCRIPTION	QTY	UNITS	UNIT COST	COST
1	Pressure Transducer (Instrument, Labor, Incidental wiring)	2	EA	$ 3,100	$ 6,200
2	Wet Well Level Sensor: (Radar instrument, Labor, Wiring)	2	EA	$ 3,595	$ 7,190
3	Screen Wash Valve	2	EA	$ 1,936	$ 3,872
4	Seal water flow meters	3	EA	$ 4,437	$ 13,310
5	42" Flow Meter	1	LS	$ 24,000.00	$ 24,000
Contingency (30%)					$ 16,372
Estimated Construction Cost					$ 71,000
Contractor General Conditions (5%)					$ 3,550
Contractor Overhead/Profit/Mobilization (15%)					$ 10,650
Engineering Design (14%)					$ 9,940
Construction Administration (6%)					$ 4,260
Funding - Legal / Admin (4%)					$ 2,840
Estimated Project Cost					$ 102,200

Big Sioux River Pump Station 1-16.D: Controls Improvements

ESTIMATE OF CONSTRUCTION AND PROJECT COSTS

	ITEM DESCRIPTION	QTY	UNITS	UNIT COST	COST
1	Screen Automatic Controls	2	LS	$ 20,000	$ 40,000
2	Chem Feed System Automation	2	LS	$ 58,000.00	$ 116,000
Contingency (30%)					$ 46,800
Estimated Construction Cost					$ 202,800
Contractor General Conditions (5%)					$ 10,140
Contractor Overhead/Profit/Mobilization (15%)					$ 30,420
Engineering Design (14%)					$ 28,392
Construction Administration (6%)					$ 12,168
Funding - Legal / Admin (4%)					$ 8,112
Estimated Project Cost					$ 292,000

WPP Power Distribution 2-1.A: Standby Generator Replacement
ESTIMATE OF CONSTRUCTION AND PROJECT COSTS

	ITEM DESCRIPTION	QTY	UNITS	UNIT COST	COST
1	Standby Generator (2MW)	1	LS	$ 1,525,000	$ 1,525,000
2	Conductors and Raceways	1	LS	$ 29,026	$ 29,026
3	Demolition	1	LS	$ 20,000	$ 20,000
				Contingency (30%)	$ 472,300
				Estimated Construction Cost	$ 2,046,400
				Contractor General Conditions (5%)	$ 102,320
				Contractor Overhead/Profit/Mobilization (15%)	$ 306,960
				Engineering Design (14%)	$ 286,496
				Construction Administration (6%)	$ 122,784
				Funding - Legal / Admin (4%)	$ 81,856
				Estimated Project Cost	$ 2,947,000

WPP Power Distribution 2-1.B: Power Room 1
ESTIMATE OF CONSTRUCTION AND PROJECT COSTS

	ITEM DESCRIPTION	QTY	UNITS	UNIT COST	COST
1	Medium Voltage Switchgear: Equipment & Labor	1	LS	$ 468,747	$ 468,747
2	Demolition	1	LS	$ 31,200	$ 31,200
				Contingency (30%)	$ 150,000
				Estimated Construction Cost	$ 650,000
				Contractor General Conditions (5%)	$ 32,500
				Contractor Overhead/Profit/Mobilization (15%)	$ 97,500
				Engineering Design (14%)	$ 91,000
				Construction Administration (6%)	$ 39,000
				Funding - Legal / Admin (4%)	$ 26,000
				Estimated Project Cost	$ 936,000

WPP Power Distribution 2-1.C: Power Room 2
ESTIMATE OF CONSTRUCTION AND PROJECT COSTS

	ITEM DESCRIPTION	QTY	UNITS	UNIT COST	COST
1	Conductors & Raceways: Equipment & Labor	1	LS	$ 55,234	$ 55,234
2	Distribution Equipment: Equipment & Labor	1	LS	$ 101,008	$ 101,008
3	Motor Control: Equipment & Labor	1	LS	$ 540,000	$ 540,000
4	Replace Air Conditioner (Power Room #2)	1	LS	$ 9,100	$ 9,100
5	Demolition	1	LS	$ 46,800	$ 46,800
Contingency (30%)					$ 225,643
Estimated Construction Cost					$ 977,800
Contractor General Conditions (5%)					$ 48,890
Contractor Overhead/Profit/Mobilization (15%)					$ 146,670
Engineering Design (14%)					$ 136,892
Construction Administration (6%)					$ 58,668
Funding - Legal / Admin (4%)					$ 39,112
Estimated Project Cost					$ 1,408,000

WPP Power Distribution 2-1.D: Power Room 3
ESTIMATE OF CONSTRUCTION AND PROJECT COSTS

	ITEM DESCRIPTION	QTY	UNITS	UNIT COST	COST
1	Conductors & Raceways: Equipment & Labor	1	LS	$ 16,991	$ 16,991
2	Motor Control: Equipment & Labor	1	LS	$ 281,700	$ 281,700
3	Demolition	1	LS	$ 15,600	$ 15,600
Contingency (30%)					$ 94,287
Estimated Construction Cost					$ 408,600
Contractor General Conditions (5%)					$ 20,430
Contractor Overhead/Profit/Mobilization (15%)					$ 61,290
Engineering Design (14%)					$ 57,204
Construction Administration (6%)					$ 24,516
Funding - Legal / Admin (4%)					$ 16,344
Estimated Project Cost					$ 588,400

WPP Power Distribution 2-1.E: Power Room 4

ESTIMATE OF CONSTRUCTION AND PROJECT COSTS

	ITEM DESCRIPTION	QTY	UNITS	UNIT COST	COST
1	Conductors & Raceways: Equipment & Labor	1	LS	$ 13,655	$ 13,655
2	Distribution Equipment: Equipment & Labor	1	LS	$ 27,683	$ 27,683
3	Motor Control: Equipment & Labor	1	LS	$ 203,775	$ 203,775
4	Demolition	1	LS	$ 15,600	$ 15,600
				Contingency (30%)	$ 78,214
				Estimated Construction Cost	$ 339,000
				Contractor General Conditions (5%)	$ 16,950
				Contractor Overhead/Profit/Mobilization (15%)	$ 50,850
				Engineering Design (14%)	$ 47,460
				Construction Administration (6%)	$ 20,340
				Funding - Legal / Admin (4%)	$ 13,560
				Estimated Project Cost	$ 488,200

Big Sioux River Pump Station 2-2.A: Replace MCC and Replace Main Breaker
ESTIMATE OF CONSTRUCTION AND PROJECT COSTS

	ITEM DESCRIPTION	QTY	UNITS	UNIT COST	COST
1	Conductors & Raceways: Equipment & Labor	1	LS	$ 16,991	$ 16,991
2	Motor Control: Equipment & Labor	1	LS	$ 323,955	$ 323,955
3	Demolition	1	LS	$ 15,600	$ 15,600
Contingency (30%)					$ 106,964
Estimated Construction Cost					$ 463,600
Contractor General Conditions (5%)					$ 23,180
Contractor Overhead/Profit/Mobilization (15%)					$ 69,540
Engineering Design (14%)					$ 64,904
Construction Administration (6%)					$ 27,816
Funding - Legal / Admin (4%)					$ 18,544
Estimated Project Cost					$ 667,600

ig Sioux River Pump Station 2-2.B: Replace Generator Controller and Evaluate Generator and make repair
ESTIMATE OF CONSTRUCTION AND PROJECT COSTS

	ITEM DESCRIPTION	QTY	UNITS	UNIT COST	COST
1	SCADA Generator Controller	1	LS	$ 15,000	$ 15,000
2	Generator Evaluation	1	LS	$ 1,500.00	$ 1,500
Contingency (30%)					$ 4,950
Estimated Construction Cost					$ 21,500
Contractor General Conditions (5%)					$ 1,075
Contractor Overhead/Profit/Mobilization (15%)					$ 3,225
Engineering Design (14%)					$ 3,010
Construction Administration (6%)					$ 1,290
Funding - Legal / Admin (4%)					$ 860
Estimated Project Cost					$ 31,000

Big Sioux River Pump Station 2-2.C: Replace Fire Alarm Panel Communication Cards
ESTIMATE OF CONSTRUCTION AND PROJECT COSTS

	ITEM DESCRIPTION	QTY	UNITS	UNIT COST	COST
1	Fire Alarm Panel Communication Card	1	LS	$ 2,500	$ 2,500
Contingency (30%)					$ 750
Estimated Construction Cost					$ 3,300
Contractor General Conditions (5%)					$ 165
Contractor Overhead/Profit/Mobilization (15%)					$ 495
Engineering Design (14%)					$ 462
Construction Administration (6%)					$ 198
Funding - Legal / Admin (4%)					$ 132
Estimated Project Cost					$ 4,800

Technology 3-1.A: Replace PA System
ESTIMATE OF CONSTRUCTION AND PROJECT COSTS

	ITEM DESCRIPTION	QTY	UNITS	UNIT COST	COST
1	PA System Equipment	1	LS	$ 15,000	$ 15,000
2	PA Speaker	250	EA	$ 514	$ 128,500
3	Amplifier	6	EA	$ 7,500	$ 45,000
4	Startup & Testing	1	LS	$ 7,500	$ 7,500
5	Conductors and Raceways	1	LS	$ 40,910	$ 40,910
6	Demolition	1	LS	$ 5,000	$ 5,000
				Contingency (30%)	$ 72,600
				Estimated Construction Cost	$ 314,600
				Contractor General Conditions (5%)	$ 15,730
				Contractor Overhead/Profit/Mobilization (15%)	$ 47,190
				Engineering Design (14%)	$ 44,044
				Construction Administration (6%)	$ 18,876
				Funding - Legal / Admin (4%)	$ 12,584
				Estimated Project Cost	$ 453,000

Technology 3-1.B: Fiber Optic System Upgrades
ESTIMATE OF CONSTRUCTION AND PROJECT COSTS

	ITEM DESCRIPTION	QTY	UNITS	UNIT COST	COST
1	Conductors and Raceways	10,000	LF	$ 19	$ 188,700
2	48 Strand Single Mode Fiber	15,000	LF	$ 4.22	$ 63,300
3	Demolition	1	LS	$ 10,400	$ 10,400
				Contingency (30%)	$ 78,800
				Estimated Construction Cost	$ 341,200
				Contractor General Conditions (5%)	$ 17,060
				Contractor Overhead/Profit/Mobilization (15%)	$ 51,180
				Engineering Design (14%)	$ 47,768
				Construction Administration (6%)	$ 20,472
				Funding - Legal / Admin (4%)	$ 13,648
				Estimated Project Cost	$ 491,300

Appendix E: Electrical Site Visit Photos

PHOTO E- 1

PHOTO E- 2

PHOTO E- 3

PHOTO E- 4

PHOTO E- 5

PHOTO E- 6

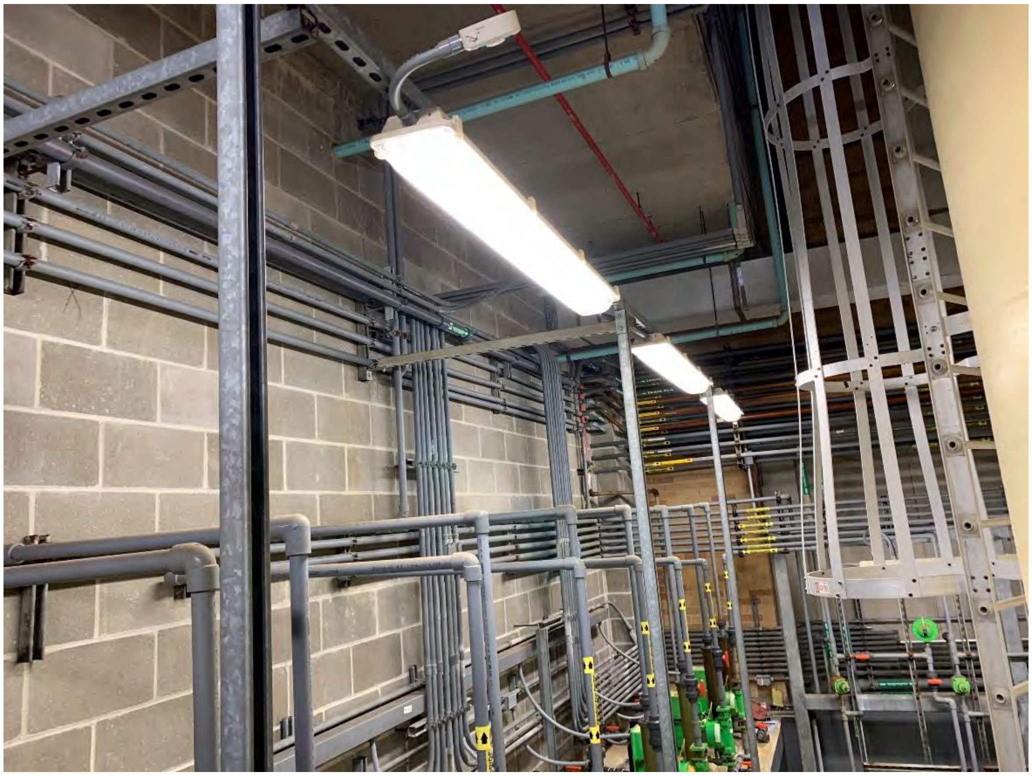


PHOTO E- 7

PHOTO E- 8

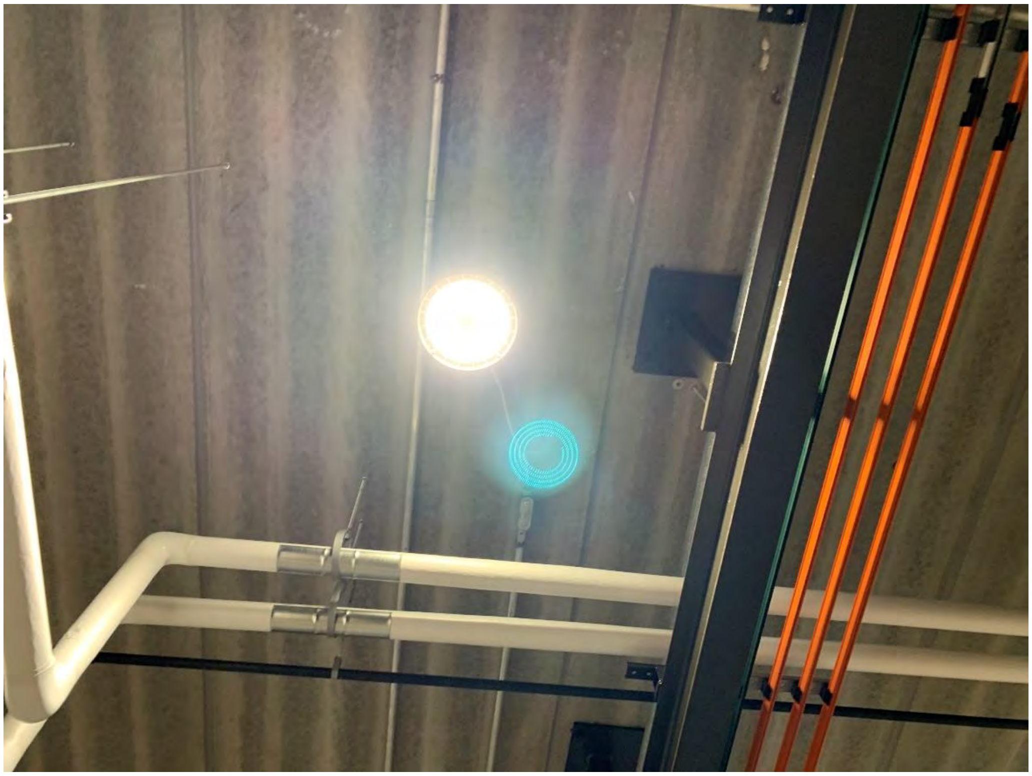


PHOTO E- 9

PHOTO E- 10

PHOTO E- 11

PHOTO E- 12

PHOTO E- 13

PHOTO E- 14

PHOTO E- 15

PHOTO E- 16

PHOTO E- 17

PHOTO E- 18

PHOTO E- 19

PHOTO E- 20

PHOTO E- 21

PHOTO E- 22

PHOTO IC - 1

PHOTO IC - 2

PHOTO IC - 3

PHOTO IC - 4

PHOTO IC - 5

PHOTO IC - 6

PHOTO IC - 7

PHOTO IC - 8

PHOTO IC - 9

PHOTO IC - 10

PHOTO IC - 11

PHOTO IC - 12

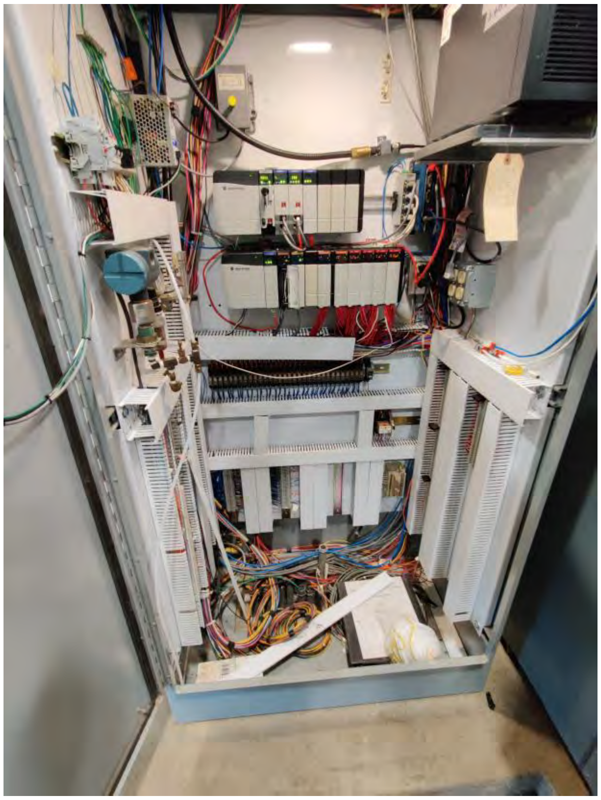


PHOTO IC - 13

PHOTO IC - 14

Appendix F: Clearwell Inspection Report

TECHNICAL MEMORANDUM

To: Gavin Graverson, Water Superintendent
Chris Myers, Water Operations Manager
City of Sioux Falls, SD

From: Matt Erickson, PE
Mike Siewert, EIT
AE2S

Re: **Sioux Falls WPP Clearwell Observation Report**

Date: February 24, 2022

EXECUTIVE SUMMARY

The Water Purification Plant's (WPP) clearwell is an important asset for the City of Sioux Falls distribution and WPP operations; it is one of two primary finished water storage facilities at the WPP. Having been built in the late 1930's, this asset is nearing 90-years of operation and has had some rehabilitation improvements completed within the last 20 years. The City recognizes that additional improvements may be required for reliable operations into the future. AE2S was hired to complete a condition observation report and to identify potential needed improvements.

Within this document, the City will learn of the existing conditions of the WPP Clearwell as well as receive updated record drawings of the structure and the process piping and equipment within it.

Upon completion of the clearwell observation and evaluation, it is the opinion of AE2S that the risk to potential failure posed by the observations noted is low. The concrete roof condition appears adequate to continue to support the loads it was designed for. The concrete beams and columns show areas where it is likely that unconsolidated concrete remains as it was installed during initial construction however, substantial fatigue due to time variable loading is not present.

The concrete exterior and concrete baffle walls all show various localized cracking and substantial amounts of a dark mineral/gaseous coating. The cracking extents appear to indicate this is a result of shrinkage and not of structural failure, but further observations should be taken to document whether additional modifications are needed to ensure structural stability. The pedestals and mat slab supporting the concrete columns show substantial amounts of spalling and large amounts of residual sediment, but neither are expected to pose a risk to global stability of the structure.

We recommend the City take considerations in the future to periodically observe, when permissible, the inside of the clearwell and monitor the structural components to ensure that no further damage presents itself as cyclical weather events persist. Documentation of periodic maintenance observations should be performed in accordance with this report to gauge if any further damage has occurred and if so, appropriate actions shall be taken accordingly.

BACKGROUND

Project Background

The Sioux Falls WPP Clearwell is a fully-buried concrete reservoir tank for potable water dating back to the late 1930's and is located west of the existing WPP, between North Minnesota Ave and the High Service Pump Station addition of the WPP. The concrete tank shape is trapezoidal, with the wall nearest North Minnesota Ave angled to run parallel to what was the previous rail spur along Minnesota Ave. The location of the Clearwell is shown in Figure 1.

Figure 1 Sioux Falls WPP Clearwell Location

The tank is approximately 192 feet wide, north to south, with a north wall length of ~258 feet, a south wall length of ~203 feet, an overall height of ~13 feet (operating water height of 10'-7") and a nominal storage volume of 4.0 million gallons. Due to the lack of design and construction documents and record drawings, there is little original design information regarding the structural components of the floor and roof slab and concrete walls, columns, and beams.

The structure has one double door hatch (main access), 1 single door hatch, 6 manhole access points, and three vent openings located atop the structure. The Clearwell has two influent pipes which receive filter effluent water from the WPP's fifteen (15) gravity filters. One (1) 36-inch pipe which enters the clearwell near the southeast corner delivers water from Filters 1-5 and one (1) 48-inch pipe which enters the structure along the north wall from Filters 6-15. The two pipes travel through the clearwell and combine near the northeast corner into a single 54-inch pipe. The water then travels through the 54-inch pipe past several chemical feed points prior to entering the Clearwell through five (5) orifices in the 54-inch pipe, spaced 8 feet on center. Interior baffling consists of fabric baffles which were installed in 2001 and a concrete baffle through the center of the clearwell, installed as part of the original construction. Two (2) 48-inch effluent pipes with static mixers and chemical injection points are located on the east wall and direct water to the wet well for pumping into the distribution system. One (1) 36-inch effluent pipe with no static mixer or chemical feed is also located on the east wall, south of the two static mixers and also directs water into the wet well. One (1) 24-inch effluent pipe connects the clearwell to the transfer pump building wet well and the above ground storage reservoir. A 24-inch overflow pipe exits the south wall of the Clearwell, in the southeast corner, to an unknown location.

City Concerns

- The City currently has limited construction or record drawings of the existing Clearwell structure, or the original piping located within it.
- City operators have the knowledge and ability for the clearwell to be taken offline, however there is considerable planning and coordination needed.
- Existing valves located outside the clearwell are in poor condition, hindering the ability to prevent all water from being diverted away from the clearwell and completely draining the water.
- The clearwell is approaching the end of its useful life and the City, currently in development of a system wide water master plan, would like to understand the remaining life and recommended next steps for the clearwell.
- The clearwell is infrequently taken offline and accessed and previous inspections by City staff have not been well documented.
- The WPP clearwell is an instrumental facility for the City's WPP operating philosophies. WPP operations can continue with the clearwell down, but only seasonally during low flow periods.

Past Maintenance and Repairs

Over the life of the clearwell, City Operations and Maintenance staff have conducted basic maintenance and contracted for minor repairs – each requiring the clearwell to have been isolated from distribution. Based on observations from this inspection of the tank, since its construction in the late 1930's, there appear to be several influent and effluent pipe connections that have been plugged and abandoned over the years as the overall WPP has been expanded and operations reconfigured. A fabric baffling system was added to the clearwell in 2001 to improve the detention time to meet the surface water treatment rule disinfection contact time (CT). The chemical feed systems and piping in the clearwell has been updated twice since 1993 and a recent 2021 improvements project has upgraded and replaced the existing Ammonia chemical feed system and chemical lines within the Clearwell.

The following is a list of known construction and repair activities:

- 1937 – Original Clearwell Construction
- 1969 – Improvements to the Filter Effluent/Clearwell Influent Piping and Clearwell Overflow
- 1987 – Improvements to the Effluent Piping to the Ground Storage Reservoir
- 1993 – Improvements to the Chemical Feed Piping within the Clearwell
- 2001 – Installation of Fabric Baffle Walls on north half of Clearwell
- 2001 – Floor Slab Joint/Crack Repair
- 2011 – Improvements to Filter Effluent Piping / Clearwell Influent

Visual Assessment

Visual assessment can help identify obvious areas of concern such as the following: cracked or peeling coating systems; spalling concrete; debris on the reservoir floor; exposed and corroded reinforcing steel; interior and exterior appurtenance condition; efflorescence; etc. The quantitative data gleaned from a visual inspection alone comprises only part of the data necessary for a more comprehensive assessment. Obvious improvements required are discussed and included in the proposed scope of rehabilitation, but the City should also be aware of how collecting additional quantitative data through more invasive methods can identify deficiencies that are not obvious from visual inspection alone.

Structure Overview

Structural discipline drawings of the original late 1930's clearwell construction either do not exist or have not been made available. City staff has record of and has made available construction drawings from a 1969 improvements project that includes section details of the existing clearwell, including wall, floor, and roof thickness and rebar spacing, although the information indicated in these drawings has not been field verified. Various process engineering renovations are generally known to have taken place since original construction but have not modified the original intent of the structure and have been mainly performance and sustainability focused, to our knowledge.

The existing structure is primarily concrete composed. The structure possesses a 6-inch-thick concrete slab roof supported on a 12-foot N-S by 12-foot E-W grid of 10-inch-wide by 18-inch-deep concrete beams which frame into the concrete roof slab. The 12-foot by 12-foot grid of concrete beams are supported at grid intersections by 14-inch square concrete columns. The concrete columns run down to a concrete mat slab and bear on 4-foot square concrete pedestals which extend above the mat slab approximately 1-foot. The thickness of the mat slab is assumed to be 12-inches, based on section details of WPP improvement projects throughout the years, however it was not verified in the field.

The roof slab possesses six (6) 30-inch diameter openings and three (3) vent openings in various locations over the entirety of the roughly 258’ x 192’ footprint of the structure. An additional main access hatch opening lies in the north portion of the structure, approximately 13-feet off the inside face of the north structure wall and 49-feet off the inside face of the east structure wall. Additionally, an approximate 3-foot by 4-foot rectangular hatch exists on the east edge of the clearwell, above the sump area, although it is not confirmed if this opening has been abandoned. Three (3) concrete influent boxes lie at the southeast, east, and northwest portions of the structure respectively. The influent boxes are comprised of 8-inch thick concrete walls along each side and frame into the assumed 12-inch thick exterior structure walls. The influent box walls run from the mat slab up to 10-inches below the concrete roof slab and possess unique interior dimensions ranging from 4-feet to 7-feet in width. A concrete baffle wall which extends full height runs in the E-W direction and lies about halfway through the N-S dimension of the entire structure.

Clearwell Structure Evaluation

Exterior of Concrete Roof Slab

The structure exists underground, and it is thus not feasible to investigate the entirety of the exterior side of the roof slab. The portion made accessible to AE2S for observation on site by the stripping of soil and exposing the concrete surface showed exceptional concrete quality and showed no signs of cracking as shown in Figure 2 below. The concrete roof slab was lined with a membrane roofing that was removed and inspected and appeared to be in good condition. A concrete core of the roof was gathered from a separate construction project and is shown in Figure 3.

Figure 2 Exposed exterior of roof slab

Figure 3 Roof slab core

Interior of Concrete Roof Slab

The concrete roof slab exists in a generally serviceable condition with substantial amounts of a gaseous/mineral coating visible. Form lines from initial construction are very visible and minor cracking is apparent in numerous areas with relatively small extents. Few areas show signs of mineral intrusion through cracks as shown in Figures 4 and 5 below. Exposed rebar exists in one area and could be attributed to initial construction mistakes, chemical damage over time, and/or any combination of time derived actions. See Figure 6 below.

Figure 4 **Mineral intrusion at crack in roof slab**

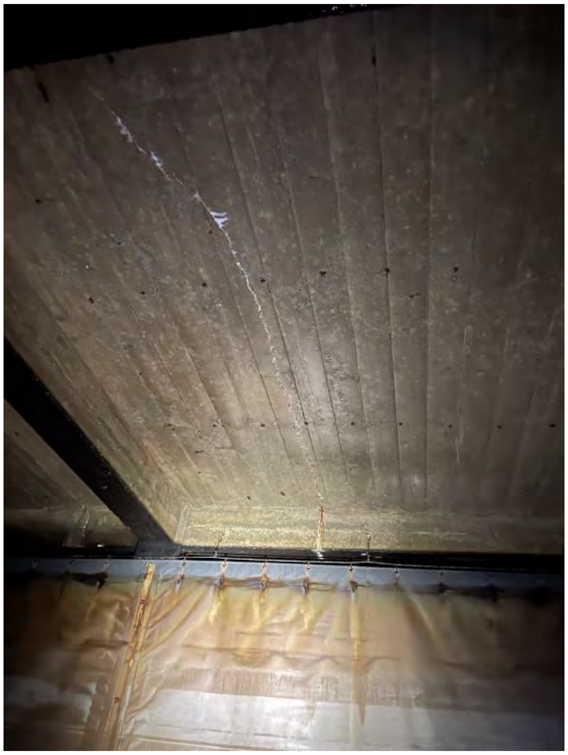


Figure 5 Mineral intrusion at roof slab crack

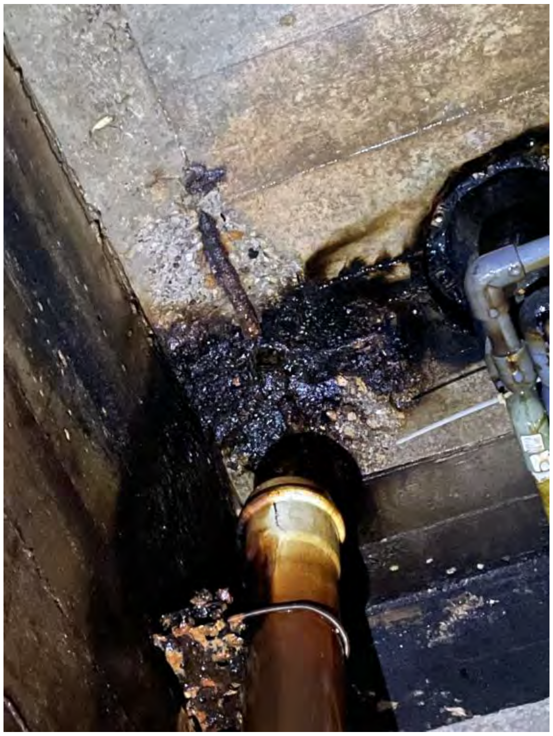


Figure 6 Exposed rebar in roof slab

Interior Concrete Walls, Beams, Columns and Floor

The concrete walls of the structure appear to be in generally adequate condition with minor shrinkage cracking but show significant signs of gaseous/mineral coating. Few larger cracks run nearly vertical in the interior concrete baffle wall as shown in Figure 7 below.

The columns and beams show few localized instances where concrete was likely not installed adequately and left residual unconsolidated areas and exposed aggregate as shown in Figures 8 and 9 below. The beams and columns appear to remain in adequate condition showing little to no signs of structural fatigue.

The condition of the pedestals supporting the concrete beams show signs of time derived damage where concrete has experienced spalling as shown in Figure 10. The mat slab floor of the structure appears to possess a fine layer of sediment from the settlement of water constituents over the years of operation, however the sediment was not tested. The general condition for structural stability can be considered adequate with signs of spalling appearing universally and wear of joint sealant being very visible as shown in Figure 11.

Figure 7 Vertical crack in concrete baffle wall

Figure 8 Unconsolidated concrete and exposed aggregate

Figure 9 Unconsolidated concrete at beam

Figure 10 Spalling at concrete column pedestal

Figure 11 Joint sealant in mat slab

Chemical Feed Piping and Various Supports

Many chemical and sample feed lines tie to the structure via threaded rod and unistrut connections which show signs of significant rust and corrosion as shown in Figure 12. Additional framing supports for retrofit pipe openings show signs of rust and residual mineral deposits likely from modifications to the roof structure as shown in Figure 13 below.

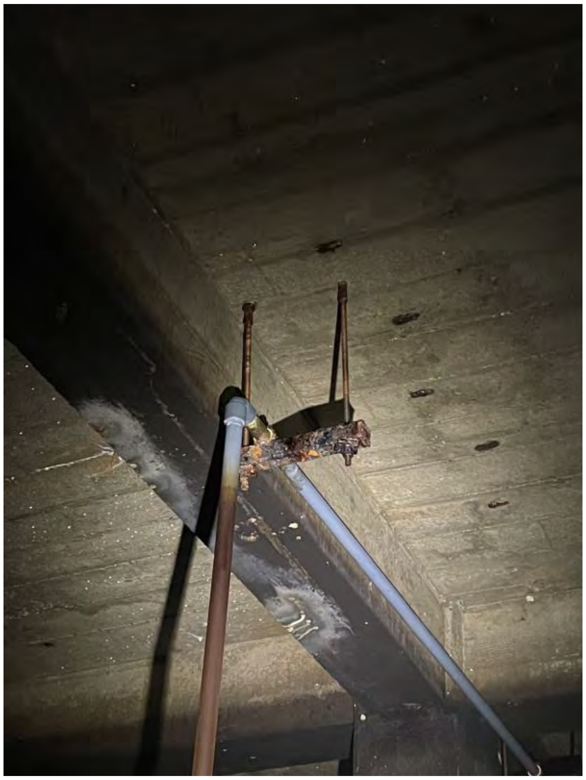


Figure 12 Chemical feed line support damage

Note: The City has replaced the hangers, brackets, and clamps with stainless steel components following the clearwell inspection and prior to completion of the report.

Figure 13 Rust at retrofit pipe opening framing

Interior Appurtenances

Inside the Clearwell, process piping and appurtenances have been modified over the life of the clearwell to best serve the operations of the WPP. Many old pipes have been either abandoned in place, plugged, or removed as indicated by concrete patches or signs of prior installation (bolt holes, pipe supports, etc.). An example of an abandoned pipe connection is shown in Figure 14.

Figure 14 Example of an abandoned pipe

Piping Systems

The influent piping within the clearwell appears to be in good condition. The pipe connections at the influent box are also in good visual condition as shown in Figure 15.

Figure 15 Influent box and influent piping

Concrete supports on the influent piping, shown in Figure 16, were observed in good condition and shows no signs of deterioration.

Figure 16 **Influent piping concrete supports**

The influent piping, once combined into one (1) 54-inch pipe, enters the clearwell through five (5) 24-inch diameter openings spaced 8-feet on center. The openings appear in good condition as shown in Figure 17.

Figure 17 **Influent piping openings**

The overflow piping shows significant amounts of tuberculation as observed in Figure 18, and the location of the overflow outlet is unknown, and possibly suspected to no longer have an outlet.

Figure 18 Overflow piping tuberculation

The two (2) 48-inch effluent pipes with static mixers and chemical injection points are located on the east end of the clearwell and are experiencing significant tuberculation, as shown in Figure 18. New ammonia chemical lines have recently been constructed and will replace the current chemical feed lines also observed in Figure 19.

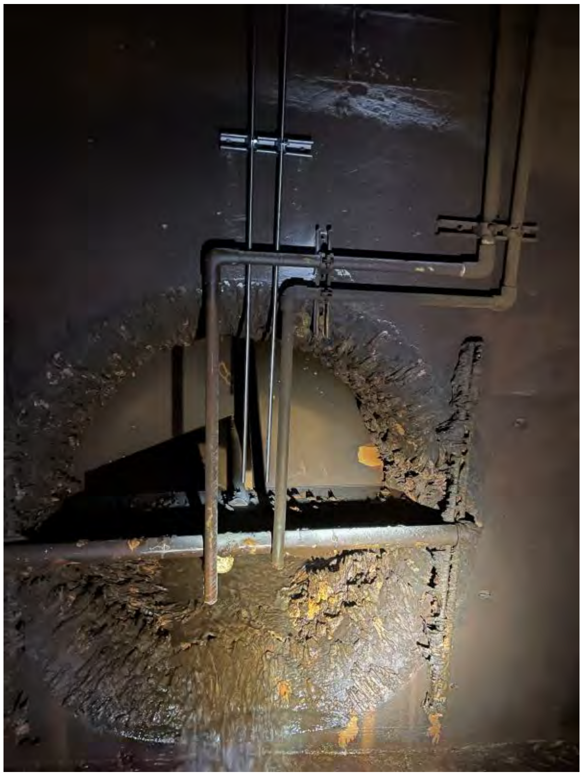


Figure 19 Effluent piping tuberculation

The effluent pipe connecting the transfer pump wet well to the clearwell shows signs of tuberculation but otherwise appears to be in good condition. The valve (located outside of the clearwell) is in poor condition and cannot fully close to prevent water from flowing back into the clearwell, when drained, as shown in Figure 20.

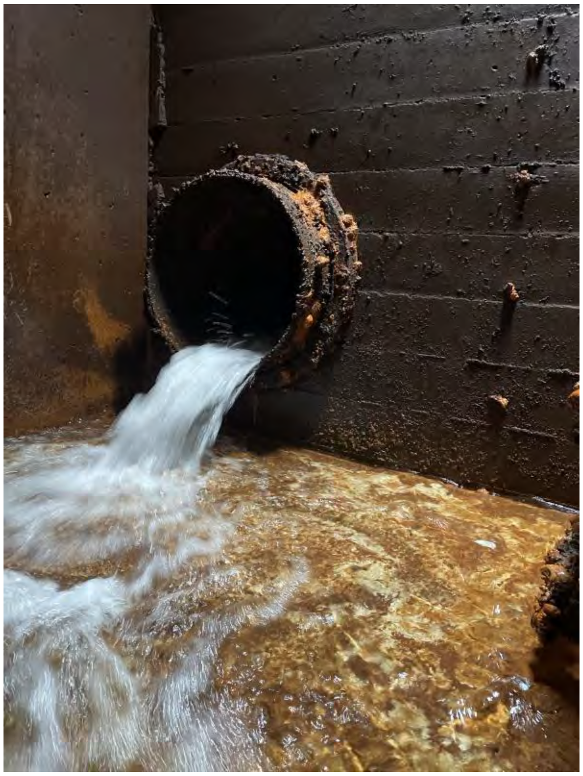


Figure 20 Clearwell effluent pipe (valve closure issue)

The backwash pumps shaft and bowl assemblies appear in good condition, indicated by Figure 21.

Figure 21 Backwash supply pumps

A concrete sump exists near the middle of the east wall and includes a pipe connection from the bottom of the sump and approximately 4-inch PVC piping that routes through the clearwell to the main access hatch intended for draining the clearwell by pumping. The PVC pipe shows signs of aging and discoloration, see Figures 22 and 23, although the pipe itself appears to be in good working condition.

Figure 22 Drain pipe (sump location)

Figure 23 Drain pipe (end/exterior connection)

Chemical Systems

The chemical feed system and sample line piping enters the clearwell in the northeast corner, from the backwash pump room above. The chemical and sample line piping is mounted from the roof slab, as described in the above section, and generally runs south to the multiple feed locations. Figure 24 and 25 shows the piping as it enters the clearwell from above (Figure 24) and runs south to each of the feed points (Figure 25).

Figure 24 Chemical piping (above clearwell)

Figure 25 Chemical piping (within clearwell)

As mentioned in above sections, the pipe supports are in poor condition with significant rust and corrosion. The piping is in average condition and still serves their intended purpose. Figure 26 shows the chemical feed locations of chlorine (the two smaller lines are no longer in use). These connections to the influent piping are in average condition.

Figure 26 Clearwell influent chemical feed

Figure 27 shows one of the high service pump influent static mixer and chemical (ammonia) feed points which includes one (1) pvc pipe, which is abandoned, one (1) green thread fiberglass, which is the current feed, and two (2) stainless steel pipes which have just been installed and will be in operation within the next few months, replacing the existing feeds.

Figure 27 Clearwell effluent chemical feed

The sample piping, located within the 54-inch influent pipe downstream of the chemical feed and on a column in front of each static mixer, shows signs of aging, but appears to remain in working condition as indicated in Figures 28 and 29.

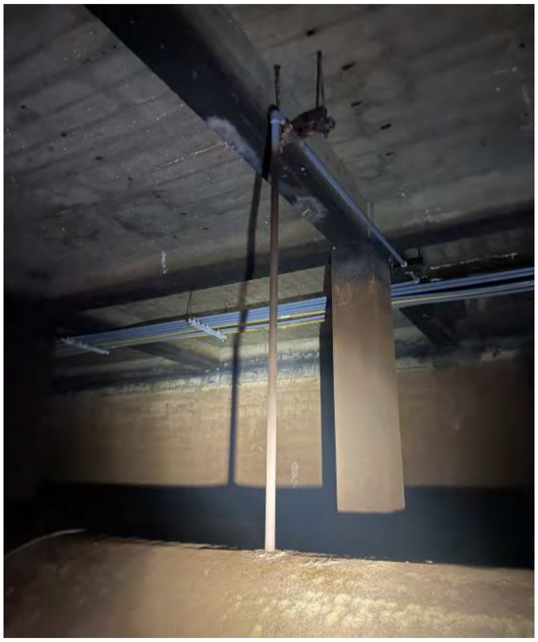


Figure 28 Clearwell influent sample piping

Figure 29 Clearwell effluent sample piping

Baffle Curtains

The curtain baffles were installed in 2001 in the northern half of the clearwell. The baffling is supported on the top by wire connected to the clearwell walls and on the bottom and sides by stainless brackets. Figures 30, 31, and 32 show the baffling and its connections. The condition of the bottom and side brackets is good, while the top support wire shows signs of rust and corrosion.

Figure 30 Baffle curtain (bottom connection)

Figure 31 Baffle curtain (top connection)

Figure 32 **Baffle curtain (side/end connection)**

Structure Recommendations and Summary

It is the opinion of AE2S that the risk to potential failure posed by the observations noted is low. The concrete roof condition appears adequate to continue to support the loads it was designed for but considerations may need to be taken in the future to account for mineral intrusion, and/or gaseous coating which presents itself as a black covering in most of the structure. AE2S recommends monitoring the roof and any cracks when accessible to ensure that no further damage presents itself as cyclical weather events persist.

The concrete beams and columns showed areas where it is likely that unconsolidated concrete remains as it was installed during initial construction however, substantial fatigue due to time variable loading is not present. We advise that observations, when permissible, be utilized to document any further damage and actions be taken accordingly.

The concrete exterior and baffle walls all show various localized cracking and substantial amounts of a dark mineral/gaseous coating. The cracking extents appear to indicate this is a result of shrinkage and not of structural failure, but further observations should be taken to document whether additional modifications are needed to ensure structural stability. The dark coating is unknown and any future service plans should include additional observation and possible testing to monitor this substance.

The pedestals and mat slab supporting the concrete columns show signs of spalling and large amounts of residual sediment, but neither are expected to pose a risk to global stability of the structure.

Process piping and appurtenances do display signs of significant tuberculation, however, the intended operation of the clearwell should not be impacted. Since the clearwell inspection and prior to completion of the report, the City has replaced the chemical piping supports. Consideration should be given to remove the abandoned chemical piping the next time the clearwell is taken offline.

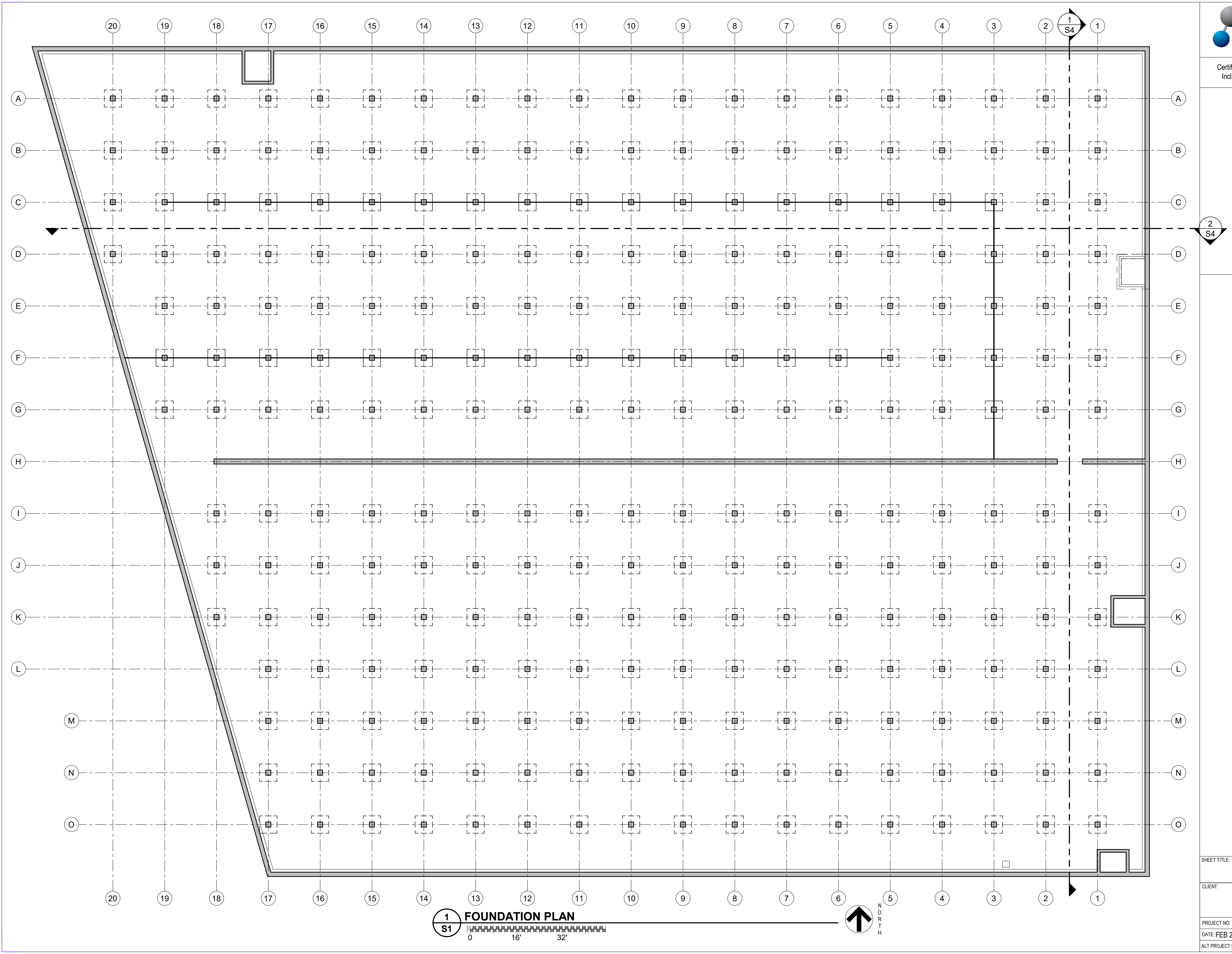
Table 1 provides a summary of the clearwell components, their general observed condition, and recommended actions.

Table 1 Summary of Clearwell Observation

Component	Observed Condition	Recommended Action
Exterior Concrete Roof Sab	Good	None
Interior Concrete Roof Slab	Fair, Minor Cracking, Small area of exposed rebar	Continued monitoring of cracking, patching of exposed rebar
Interior Concrete Walls	Fair, General Minor Cracking, Localized areas of moderate cracking	Continued monitoring of cracking, sealing of larger cracks in concrete baffle wall
Interior Beams and Columns	Fair, Areas of Unconsolidated Concrete and Exposed Aggregate	Continued monitoring
Interior Column Pedestals	Fair, Signs of Time Derived Damage/Spalling	Continued monitoring
Floor Mat Slab	Fair, Contains Settled Sediment, Wear of Joint Sealant Observed	Continued monitoring, sealing of floor joints
Chemical Feed Pipe Supports	Poor, Significant Rust and Corrosion	None (City has replaced the pipe hangers, brackets, and clamps prior to completion of this report)
Filter Influent Pipe	Good	None
Filter Influent Pipe Supports	Good	None
Effluent Pipe (Static Mixers)	Fair, Significant Tuberculation	None
Overflow Pipe	Fair, Significant Tuberculation	Confirm overflow piping connection/outfall
Effluent Pipe (To Reservoir)	Fair	External butterfly valve replacement
Backwash Supply Pumps	Good	None
Sump Area Drain Pipe	Good	None
Chemical Feed Piping	Good	Remove abandoned pipe at earliest convenience
Sample Piping	Fair	None
Baffle Curtains	Bottom Support - Good, Top Support - Fair, Signs of Rust and Corrosion	Continue to monitor

AE2S appreciates the opportunity to assist the City with this effort and is eager to help the City on other efforts such as this. If there are any questions regarding information within this Technical Memorandum, please do not hesitate to contact me at (605) 275-5620.

File: C:sers\SSeibert\OneDrive - AE2S\Desktop\Revit_2022_G1_Win_64bit_dlmaster_Titleblock.dwg



1 S1 **FOUNDATION PLAN**

Certification of Individual Project Design Disciplines Are Included On Their Individual Drawings, Respectively

SYM	DATE	DESCRIPTION	APPR

STATUS: PRELIMINARY

PROJECT TITLE:

WPP CLEARWELL OBSERVATION REPORT

Advanced Engineering and Environmental Services, LLC www.ae2s.com

SHEET TITLE: FOUNDATION PLAN

CLIENT:
CITY OF SIOUX FALLS
SIOUX FALLS, SD

PREPARED BY: MTS
CHECKED BY: MTS
APPROVED BY: MTS

PROJECT NO: P00834-2021-009
DATE: FEB 2022
ALT PROJECT NO: 00000-0000

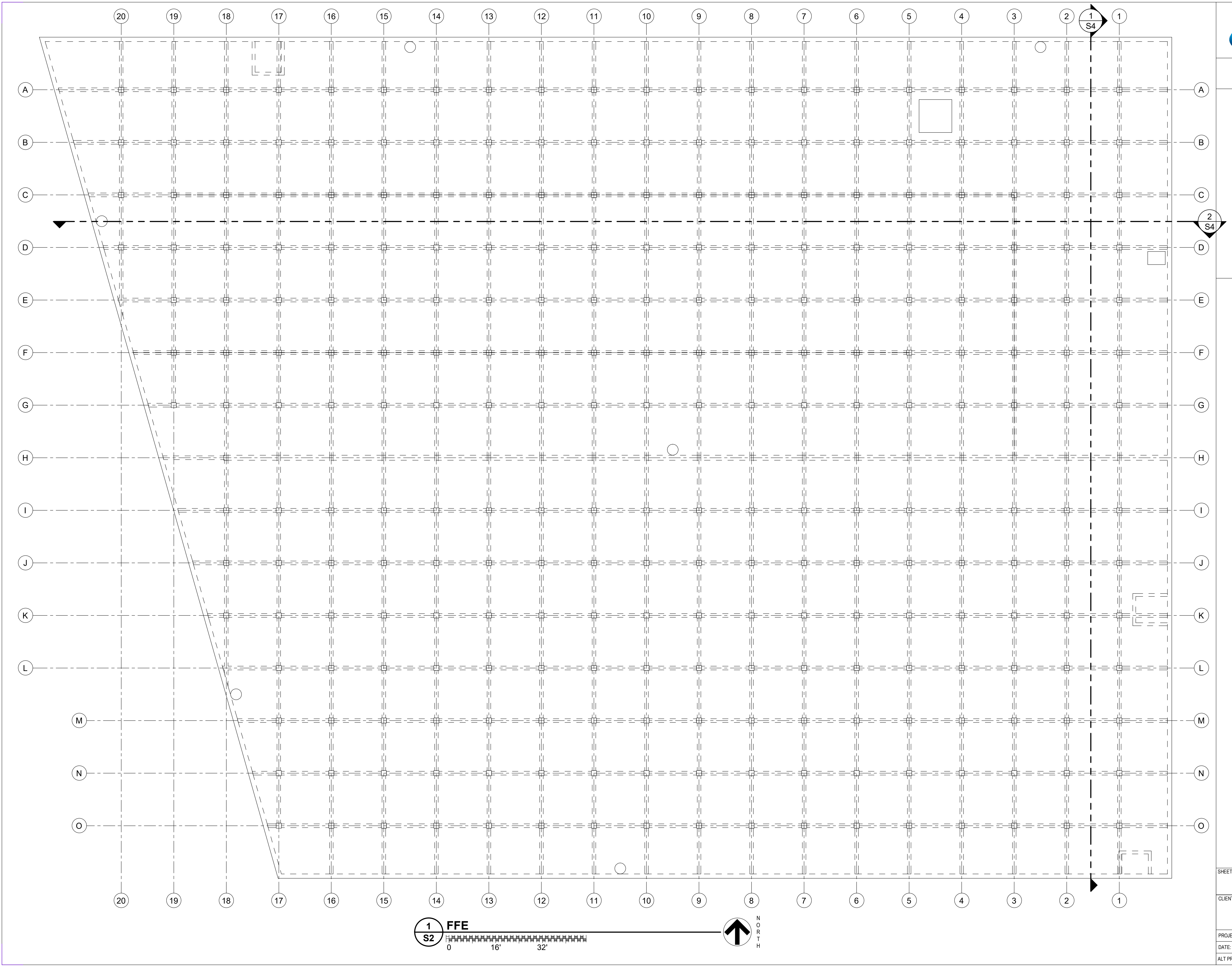
SHEET DESIGNATOR: **CLW**

SHEET NO: **S1**

Plotted: By: Steve Seibert Date: Thursday, March 18, 2021

File: C:sers\SSeibert\OneDrive - AE2S\Desktop\Revit_2022_G1_Win_64bit_dlmaster_Titleblock.dwg

Plotted: By: Steve Seibert Date: Thursday, March 18, 2021



1
S2
FFE

Certification of Individual Project Design Disciplines Are Included On Their Individual Drawings, Respectively

STATUS: PRELIMINARY

SYM	DATE	DESCRIPTION	APPR

PROJECT TITLE:

WPP CLEARWELL OBSERVATION REPORT

Advanced Engineering and Environmental Services, LLC www.ae2s.com

SHEET TITLE:
ROOF PLAN

CLIENT:
CITY OF SIOUX FALLS
SIOUX FALLS, SD

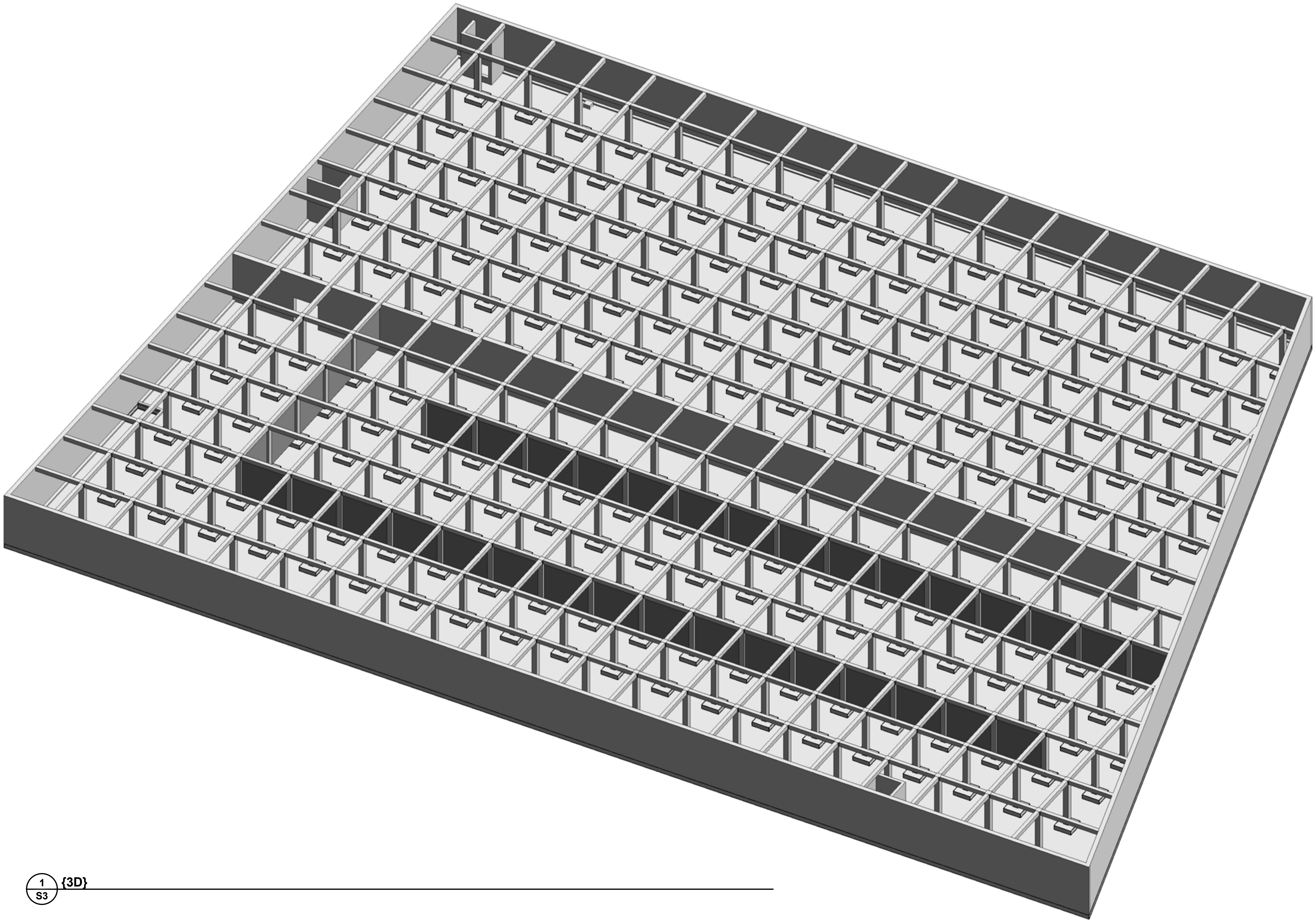
PREPARED BY: MTS
CHECKED BY: MTS
APPROVED BY: MTS

PROJECT NO: P00834-2021-009
DATE: FEB 2022
ALT PROJECT NO: 00000-0000

SHEET DESIGNATOR:
CLW

SHEET NO:
S2

File: C:sers\SSeibert\OneDrive - AE2S\Desktop\Revit_2022_G1_Win_64bit_dlmaster_Titleblock.dwg



1
S3
{3D}

Plotted: By: Steve Seibert Date: Thursday, March 18, 2021

AE2S

Certification of Individual Project Design Disciplines Are Included On Their Individual Drawings, Respectively

STATUS: PRELIMINARY

SYM	DATE	DESCRIPTION	APPR

PROJECT TITLE:

WPP CLEARWELL OBSERVATION REPORT

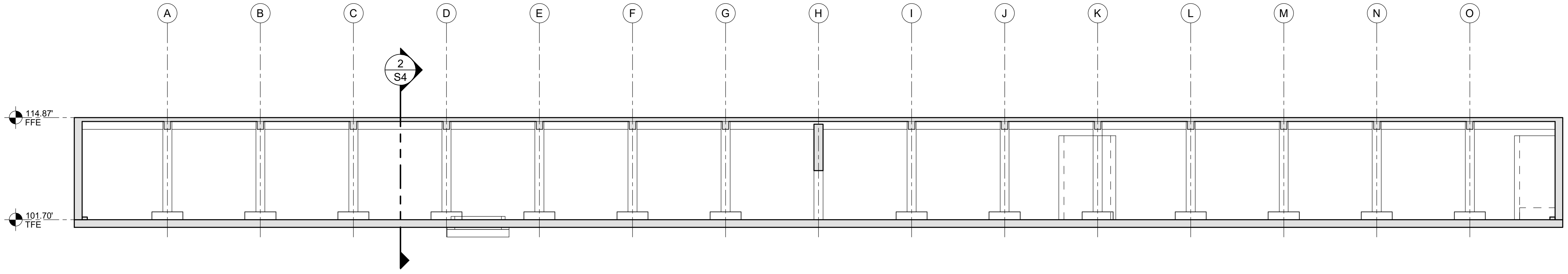
Advanced Engineering and Environmental Services, LLC www.ae2s.com

SHEET TITLE: 3D VIEWS

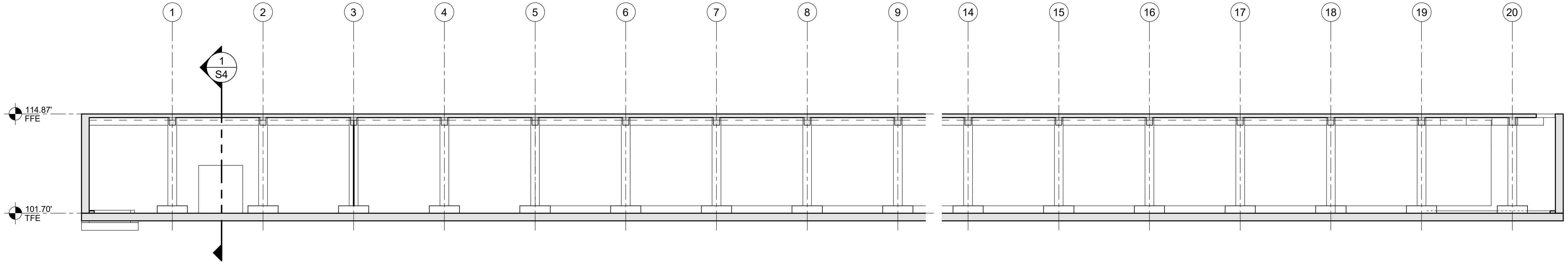
CLIENT: CITY OF SIOUX FALLS
SIOUX FALLS, SD

PREPARED BY: MTS
CHECKED BY: MTS
APPROVED BY: MTS

PROJECT NO: P00834-2021-009
DATE: FEB 2022
ALT PROJECT NO: 00000-0000
SHEET DESIGNATOR: CLW
SHEET NO: S3



1
S4
BUILDING SECTION



2
S4
BUILDING SECTION

Certification of Individual Project Design Disciplines Are Included On Their Individual Drawings, Respectively

STATUS: PRELIMINARY

SYM	DATE	DESCRIPTION	APPR

PROJECT TITLE:
WPP CLEARWELL OBSERVATION REPORT

Advanced Engineering and Environmental Services, LLC www.ae2s.com

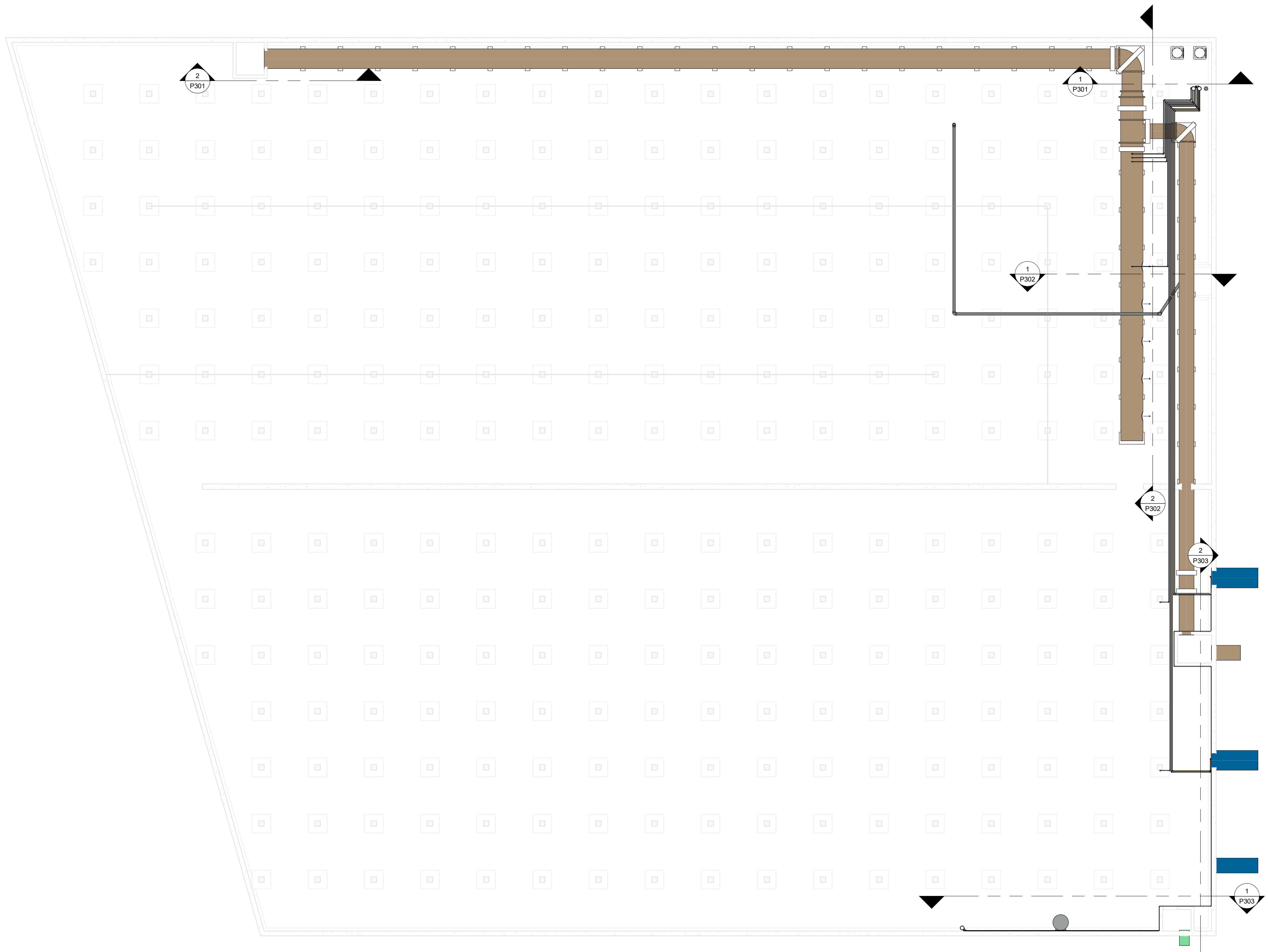
SHEET TITLE: BUILDING SECTIONS

CLIENT:
CITY OF SIOUX FALLS
SIOUX FALLS, SD

PREPARED BY: MTS
CHECKED BY: MTS
APPROVED BY: MTS

PROJECT NO: P00834-2021-009
DATE: FEB 2022
ALT PROJECT NO: 00000-0000
SHEET DESIGNATOR: CLW
SHEET NO: S4

File: C:sers\SSeibert\OneDrive - AE2S\Desktop\Revit_2022_G1_Win_64bit_dlmaster_Titleblock.dwg



1
P101
TFE - OVERALL PLAN
0 4' 8' 12' 16' 20' 24' 28'
NORTH

Certification of Individual Project Design Disciplines Are Included On Their Individual Drawings, Respectively

STATUS: PRELIMINARY

SYM	DATE	DESCRIPTION	APPR

PROJECT TITLE:
WPP CLEARWELL OBSERVATION REPORT

Advanced Engineering and Environmental Services, LLC www.ae2s.com

SHEET TITLE: CLEARWELL - OVERALL PLAN

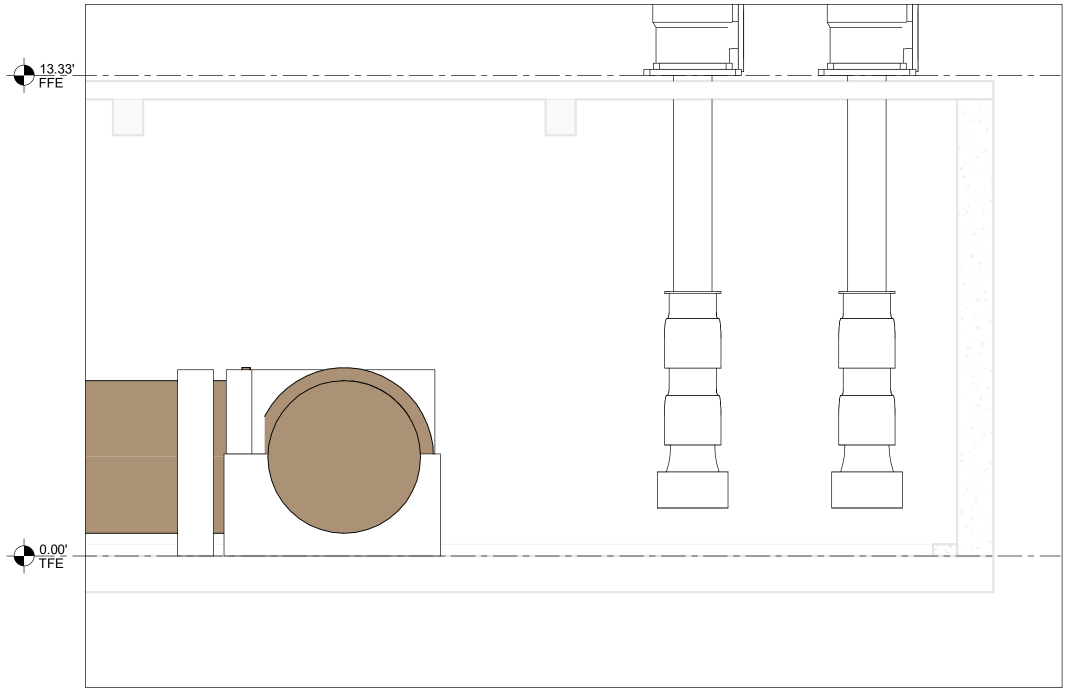
CLIENT: CITY OF SIOUX FALLS
SIOUX FALLS, SD

PREPARED BY: SAS
CHECKED BY: MGE
APPROVED BY: MGE

PROJECT NO: 00834-2021-009
DATE: FEB. 2022
ALT PROJECT NO: 00000-0000
SHEET DESIGNATOR: CLW
SHEET NO: P101

Plotted: By: Steve Seibert Date: Thursday, March 18, 2021

File: C:sers\SSeibert\OneDrive - AE2S\Desktop\Revit_2022_G1_Win_64bit_dlmaster_Titleblock.dwg



1
P301
SECTION - BACKWASH PUMPS - LOOKING NORTH

12" 0 1' 2' 3' 4' 5' 6' 7'

2
P301
SECTION - FILTER INFLUENT (FILTERS 6-15) - LOOKING NORTH

12" 0 1' 2' 3' 4' 5' 6' 7'

Plotted: By: Steve Seibert Date: Thursday, March 18, 2021

AE2S

Certification of Individual Project Design Disciplines Are Included On Their Individual Drawings, Respectively

STATUS: PRELIMINARY

SYM	DATE	DESCRIPTION	APPR

PROJECT TITLE:
WPP CLEARWELL OBSERVATION REPORT

Advanced Engineering and Environmental Services, LLC www.ae2s.com

SHEET TITLE:
SECTIONS

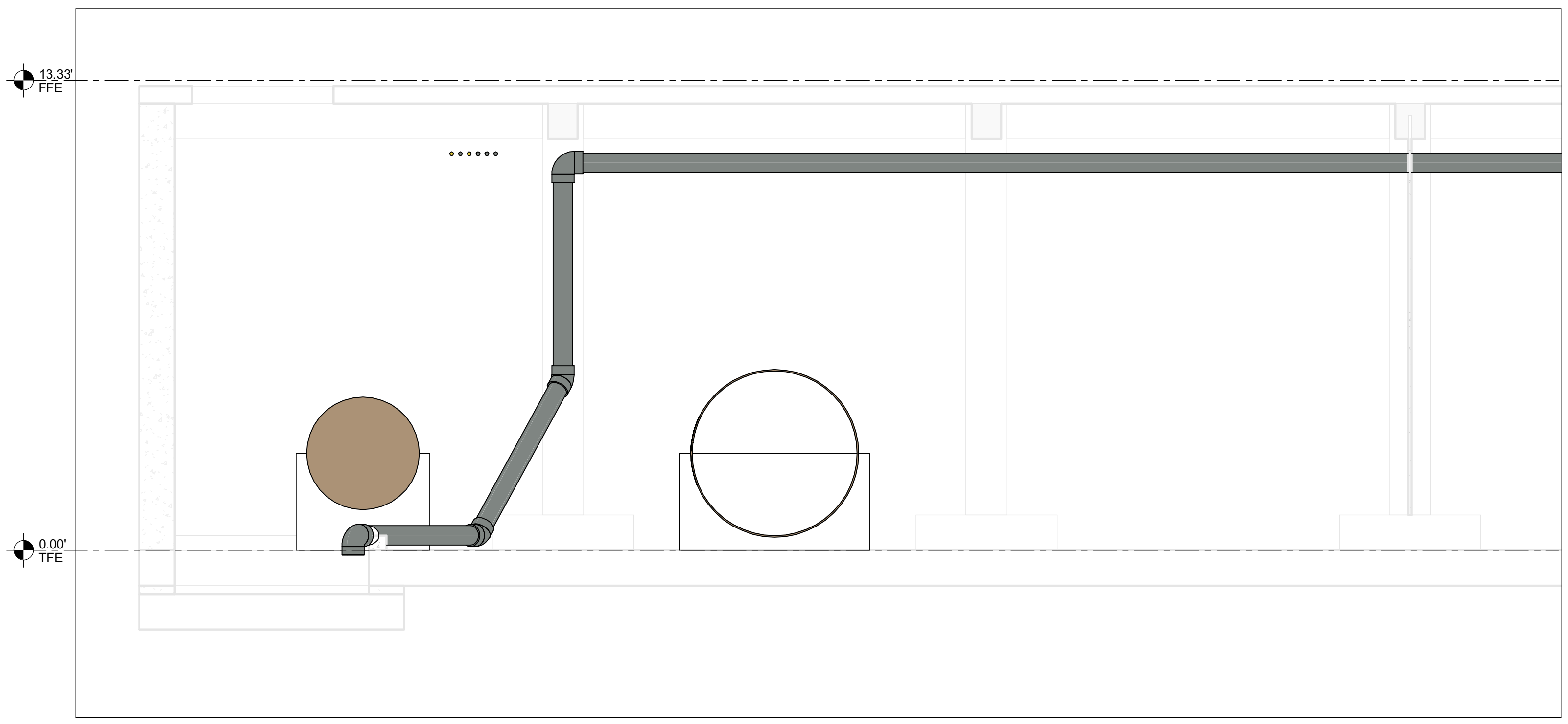
CLIENT:
CITY OF SIOUX FALLS
SIOUX FALLS, SD

PREPARED BY: SAS
CHECKED BY: MGE
APPROVED BY: MGE

PROJECT NO: 00834-2021-009
DATE: FEB. 2022
ALT PROJECT NO: 00000-0000

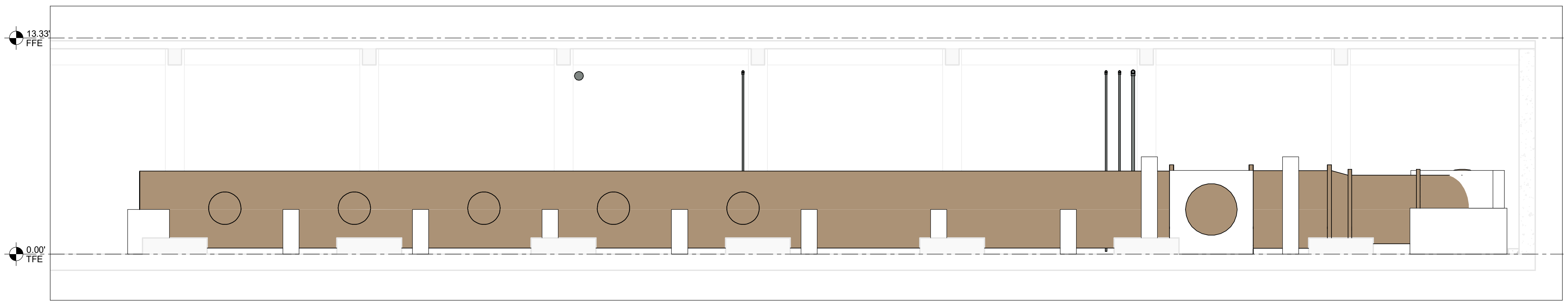
SHEET DESIGNATOR:
CLW

SHEET NO:
P301



1 P302 SECTION - DRAIN PIPING - LOOKING SOUTH

12" 0 1' 2' 3' 4' 5' 6' 7'



2 P302 SECTION - COMBINED FILTER INFLUENT - LOOKING WEST

12" 0 2' 4' 6' 8' 10'

File: C:sers\SSeibert\OneDrive - AE2S\Desktop\Revit_2022_G1_Win_64bit_dlmaster_Titleblock.dwg

Plotted: By: Steve Seibert Date: Thursday, March 18, 2021

Certification of Individual Project Design Disciplines Are Included On Their Individual Drawings, Respectively

STATUS: PRELIMINARY

SYM DATE DESCRIPTION APPR

PROJECT TITLE:

WPP CLEARWELL OBSERVATION REPORT

Advanced Engineering and Environmental Services, LLC www.ae2s.com

SHEET TITLE:
SECTIONS

CLIENT:
CITY OF SIOUX FALLS
SIOUX FALLS, SD

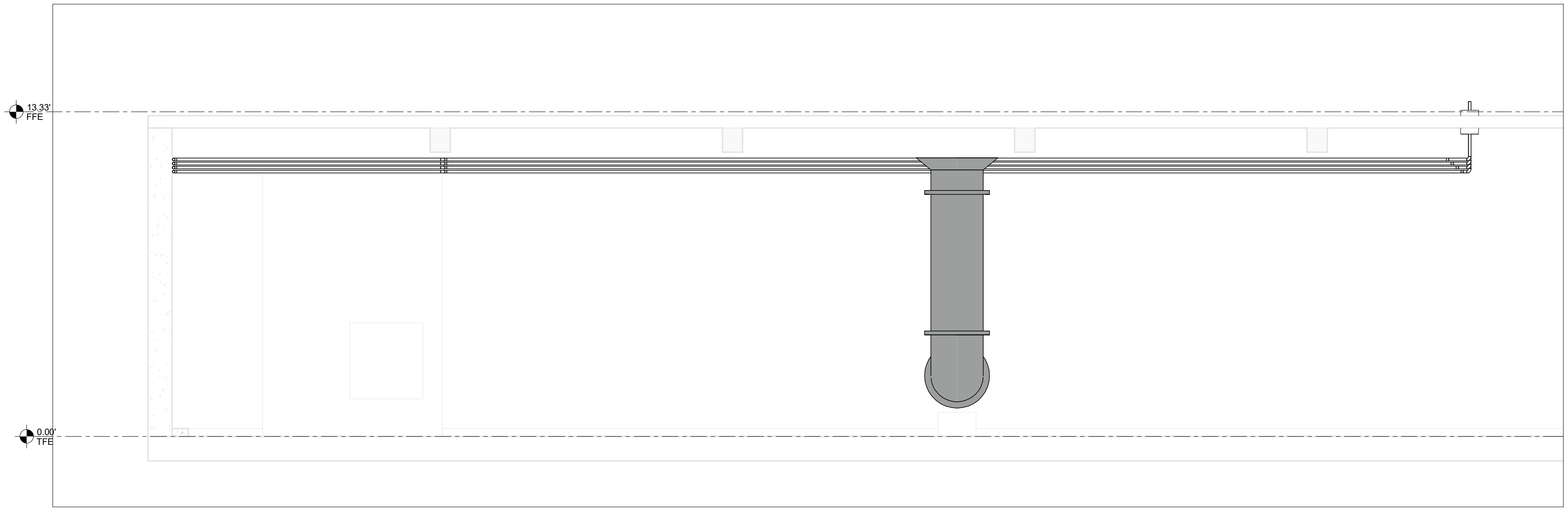
PREPARED BY: Author
CHECKED BY: Checker
APPROVED BY: Approver

PROJECT NO: 00834-2021-009
DATE: FEB. 2022
ALT PROJECT NO: 00000-0000

SHEET DESIGNATOR: CLW

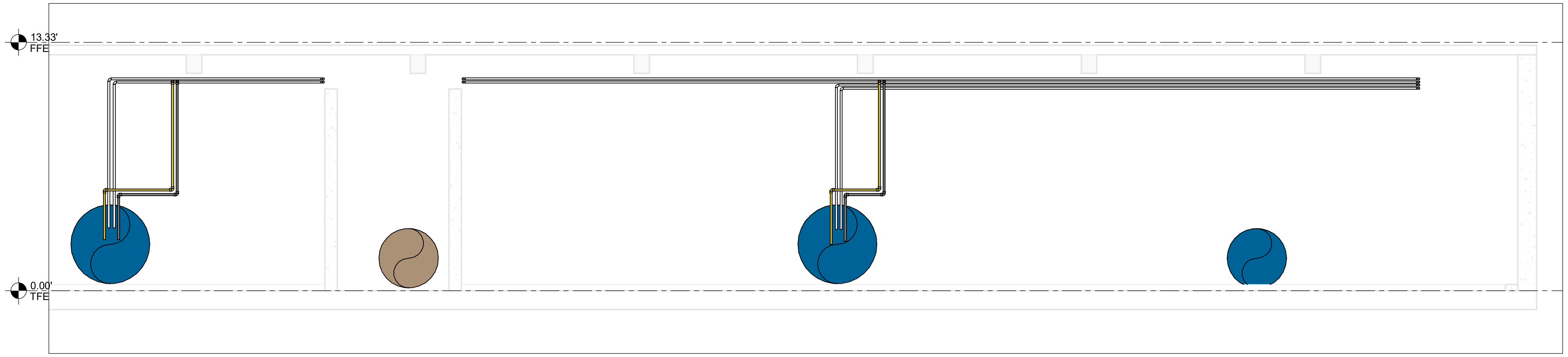
SHEET NO: P302

File: C:sers\SSeibert\OneDrive - AE2S\Desktop\Revit_2022_G1_Win_64bit_dlmaster_Titleblock.dwg



1 P303 SECTION - OVERFLOW AND AMMONIA PIPING - LOOKING SOUTH

12" 0 1' 2' 3' 4' 5' 6' 7'



2 P303 SECTION - CLEARWELL EFFLUENT - LOOKING EAST

12" 0 2' 4' 6' 8' 10'

Plotted: By: Steve Seibert Date: Thursday, March 18, 2021

AE2S®

Certification of Individual Project Design Disciplines Are Included On Their Individual Drawings, Respectively

STATUS: PRELIMINARY

SYM	DATE	DESCRIPTION	APPR

PROJECT TITLE:

WPP CLEARWELL OBSERVATION REPORT

Advanced Engineering and Environmental Services, LLC www.ae2s.com

SHEET TITLE: SECTIONS

CLIENT:
CITY OF SIOUX FALLS
SIOUX FALLS, SD

PREPARED BY: Author
CHECKED BY: Checker
APPROVED BY: Approver

PROJECT NO: 00834-2021-009
DATE: FEB. 2022
ALT PROJECT NO: 00000-0000

SHEET DESIGNATOR: CLW

SHEET NO: P303

Appendix G: Reclaim Basin Inspection Report

BRENTWOOD®
Polychem SOLUTIONS
500 Spring Ridge Drive
Ph: 610-374-5109 Reading PA - 19610 Fax: 610-685-0127

Project Name: Sioux Falls SD WTP	**Address:** 2100 N. Minnesota Ave
Polychem Solutions Tech: Richard Pirino	**Plant Contact:** Dan Lewis
Phone: 610.347.8573	**Phone:** 605-261-8395
Email: richard.pirino@brentwoodindustries.com	**Email:** DLewis@siouxfalls.org
Mfg Rep: Matt Madson	**Org:** Vessco, Inc.
Phone: 612-269-4859	**Email:** mmadson@vessco.com
Date on Site: 03/01/2022	**Tank(s) Inspected:** Backwash Basin Tanks #1 & #2

Observations/Findings
Brentwood's evaluation is general and does not portray every possible condition.

Scope: Purpose of visit was general tank inspection. Customer was looking for evaluation of existing equipment and replacement recommendations. These recommendations will also be representative of the other tanks onsite as they are all similar vintage and size.

Professional Summary:

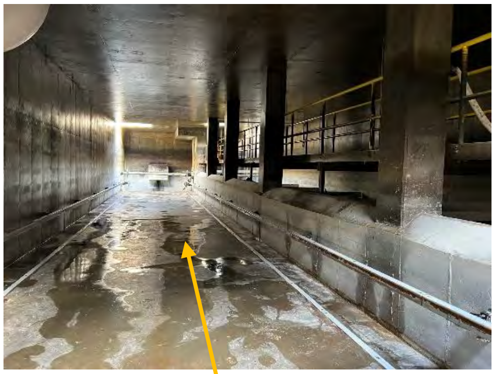
On 01/22/2022 Backwash Basin Tanks #1 & #2 were inspected. Tank #1 had experienced a recent "crash" and all the chain and flights had been removed. Tank #2 was complete and operational the characteristics observed there will be considered similar to those which would have been found in Tank #1 for the components which had been removed. The longitudinal collectors for each tank consists of 1-3 shaft measuring approx. 86 Ft Long x 14.75 Ft Wide x 5 Ft AWD and a single 3 shaft shared cross collector measuring approx. 27 Ft Long x 6 Ft Wide x 9.5 Ft AWD. A brief description of the plants rectangular clarifiers would note that Tanks #1 & #2 are part of a 2010 installation/upgrade. They act as backwash clarifiers primarily to remove the solids that collect in the plants filters. The plant doses with lime as part of their standard process for purification/clarification this lime collects and ultimately blocks the filters. The backwash sends the accumulated solids including the lime to these tanks where the solids can be concentrated and removed from the system. During the winter months the plant draws from subterranean water reserves as surface waters are frozen. The backwash activities increase significantly during the times when surface waters are utilized. There is also a "stilling" basin adjacent to the collectors which is approximately the same size as the collector area. They are hydraulically connected at the rear end of the tanks and separated by a approx. 4' knee-wall. This was likely designed to allow for quiescent final settling of solids. Plant staff indicated that this vault collects significant amounts of solids and w/o any sort of mechanism for concentration requires many man hours to manually hose the solids to the collection pumps at the opposite end of the tank. This report focuses primarily on Tanks #1 & #2, options can be offered for the settling area as required at a later date.

Observations and Findings:

Tank #1 has been in a crashed state since early of 2022. As noted above the chain and flights had been removed but Tank #2 chain was available and it indicated significant wear. It is apparent that the accumulated solids have a fairly abrasive nature which is evidenced in the wear patterns on the chain and the sprockets/bearings. There was an notable misalignment in both tanks and the chain tension was well below manufacturers recommendations. It is likely that the wear on the chain in combination with the misalignment, compounded by the excessive slack in the mechanism led to the failure. These conditions are present in both Tank #2 and the cross collector pointing towards a similar fate. It is recommended that Polychem Grit Shield Chain be installed. “GRITSHIELD” stainless steel banded chain which is best suited for primary tanks with aggressive solids/grit. This chain provides exceptional durability and longevity reducing nuisance failures and thus minimizing normal maintenance requirements to annual PM’s. It is also recommended that “Half-Links” be provided to assist with proper tensioning as part of the plant annual maintenance evaluations. Observation of the collector sprockets indicated tooth wear on the headshaft 23-tooth sprockets. The 17-tooth idler sprockets had similar wear on the teeth in addition they had significant wear on their bore (ID) as well as on the stub shaft bearings themselves. Fortunately, the wear had not progressed into the nylon stubshaft itself. It is recommended that the bearings and 17-tooth sprockets be replaced at each of the four locations per mechanism (#1, #2 & CC). It should be noted that since the idler bearings were worn to the point of mandated replacement the headshaft bearings should also be replaced. The 23-tooth driven sprockets are of the same vintage as the idler sprockets and have similar wear and should be replaced to properly fit to the new Polychem Grit Shield Chain recommended earlier. The bull sprocket on the headshaft showed indications of tooth “hooking” this is in part due to the nature of the solids noted early as well as inadequate tensioning of the drive chain. These 40-tooth sprockets should be replaced along with the drive chain and the “snap idler” tensioners. The drive chain should be replaced with Polychem NH78 “GRITSHIELD” stainless steel barrel wrapped chain for increased chain life and sprocket protection. Proper tension must be maintained on these mechanisms to maximize performance and longevity. PM training with both plant operations and maintenance staff should be considered.

SIOUX FALLS
SOUTH DAKOTA

Surface View of Tank Location



Tank #1 Equipment Removed

Grit Wear on Chain

Idler Bearing Wear

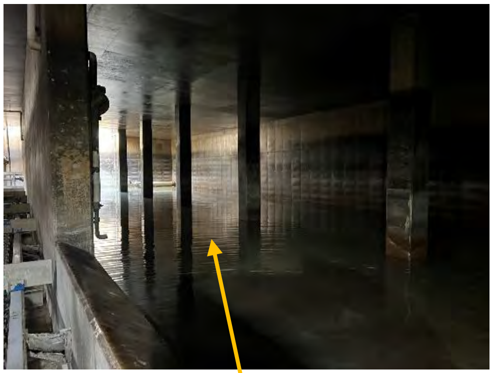
Sprocket ID Heavy Scoring

Sprocket Tooth Scoring

Bull Sprocket Tooth Hooking

Extreme Slack Drive Chain

Improper Tension Collector Chain

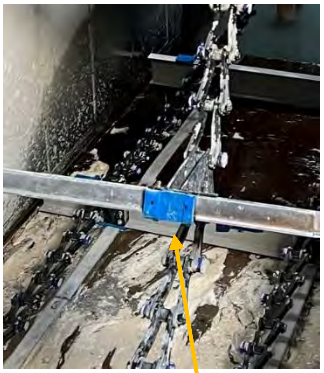


Settling Basin (Vault)

As noted earlier, the flights from the crashed tank #1 mechanism had been removed. Inspection of tank #2 flights as well as the cross collector flights found a number with fractures in the FRP this is likely due to previous crashes and/or interference from the tank walls or floor. It is unclear as to how many flights can be salvaged from those removed from Tank #1. For the sake of this report and to be sure a reasonable budget is planned it is recommended that all flights (approx. 19) for Tanks #1 and 20% for Tank #2 and the cross collector be included. Additionally, the wear shoes affixed to the flights have worn to the point requiring replacement, these are Polychem NSF61 certified wear shoes. We recommend placing the floor wear strip with ½" UHMW wear strip the existing wear strip on the return rails was in acceptable condition but should be evaluated at each annual PM. Additionally, we would recommend that 2 squeegee flights be installed to more effectively "wipe" the tank floor of solids in both tank #1 and #2.

The drive is a SEW Eurodrive dating back to the initial installation. It seems to be in good working order. I always recommend the vents be renewed to maintain proper pressures helping prevent premature shaft seal replacement. The plant should be changing oil in accordance with the manufactures specifications as noted in the O&M manual. As noted above the drive chain should be replaced with Polychem NH78 "GRITSHIELD" stainless steel barrel wrapped chain, in addition the shear pin assemblies exhibit wear both on the sprockets themselves but also the actual shear pin mechanism. Each of the 3 assemblies need to be replaced. This would a good time for the plant to consider replacing them with stainless steel torque limiters. Torque Limiters are a great maintenance friendly option/solution. The mechanism can be "tuned" to the specific "load" for each mechanism and provide an easy reset in the event that a "trip" condition is encountered. Either way replacement is required.

Typical Sludge/Grit



Excessively Worn Shoe

Failed Shear Pin Assembly

Notes:

1. Sprocket Motion Monitoring (SMM) is recommended to help guard against in-tank failures. Whereas the torque limiter mechanism helps prevent excessive loads from damaging the above deck components SMM monitors the in-tank mechanisms, specifically sprocket rotation/chain travel. If one side or the other of a mechanisms chain stops the non-contact sensors send an alert to a deck level box. This can be configured to have stand-alone functionality or dry contacts for the plants SCADA. Each NEMA box can handle up to 6 mechanisms. Depending on the plant's requirements or level of customization budgetary costing can be provided.

2. Brentwood can provide a certificate training for maintenance and operations staff. This training incorporates 3hrs of in class work and then 2hrs of in tanks hands-on training after a lunch provided by the manufacturers rep. All aspects of chain and flight mechanisms is covered but it is tailored to the equipment and PM requirements at the specific plant.

3. Brentwood can provide yearly inspection contracts to provide onsite technical assistance during scheduled Periodic Maintenance (PM). The technician will work in conjunction with maintenance personnel to inspect and adjust equipment in line with manufacturers recommendations. As required, technician will provide updated product information and training of new employees. Incorporating these contracts into yearly budgets and renewal annually makes PM a simple but important aspect of plant performance. Brentwood can provide a quote for this option if desired.

4. Brentwood can provide manufacturers training on Periodic Maintenance procedures, product familiarization, and new product updates. This training is recommended every other year to keep technicians up to date and new technicians trained to insure product longevity.

Questions regarding this report should be directed to Richard Pirino at
Richard.Pirino@brentwoodindustries.com or 610-347-8573

Regards,
Rich

Appendix H: Pipe Gallery Structural Report

July 12, 2022

City of Sioux Falls
Nick Borns
2100 N Minnesota Ave
Sioux Falls, SD, 57104

Nick,

Midwest Engineering completed an ongoing investigation of the existing Pipe Gallery at 2100 N Minnesota Ave, Sioux Falls, SD, 57104. The purpose of the visit was to analyze the existing structural capacity.

OBSERVATIONS/DISCUSSION

1. Concrete Decking
    - Globally the concrete appears to be structurally sound
    - Areas of deterioration are present, primarily around conduits and areas that experience moisture issues.
    - Concrete assumptions are listed on S1
    - One area of concrete decking appeared to have been infilled in after original construction. This area was noted on the plans, as it does not appear to be structurally adequate. This loose concrete presents a structural safety issue and should be addressed.
2. Roof System:
    - 10" concrete deck over steel structure
    - 10" concrete slab supporting deck, acting non-compositely (Figure 1)
    - W18x77 steel beams (AISC 7th edition), (Figure 2)
    - HSS 7x0.25 steel column (Figure 3)
    - S1 was put together utilizing field measurements
3. Analysis
    - Design Load Assumptions:
        - DL: 300 psf (roadway, fill, and decking)
        - LL: 250 psf (Heavy Industrial)
        - See S1 for all noted structural elements and assumptions
    - The existing concrete slab, steel beams, and steel columns can withstand a live load of 250 psf with the assumed 300 psf dead load.
    - Existing footings not visible and their sizes are unknown and cannot be analyzed.

CONCLUSIONS/RECOMMENDATIONS

1. It is of our opinion that the structure is adequate to sustain a load classified as heavy industrial (250psf).
2. The loose replaced slab should be removed and replaced immediately as it is a life safety issue to occupants below it.
3. Future Work that should be completed (Work completed in the next 5 years)
   a. The steel beams in areas have heavy corrosion, they should be cleaned and repainted
   b. The conduits in the ceiling have been exposed to water infiltration. These conduits should be removed, and the concrete repaired.
   c. Loose concrete is present on the ceiling throughout, this should be removed and repaired as it presents a safety concern.
   d. The room has high humidity, which may be the cause of some of the steel deterioration, consideration for a dehumidifier should be explored.
   e. The hatches to the exterior are not waterproof and do allow water into this area. Consideration should be made to make these watertight.

This report was prepared by Midwest Engineering, LLC, for the exclusive use of City of Sioux Falls. Our opinions are based on experience, education, industry references, and work performed. Any repair methods discussed are deemed general recommendations of repairs only and no warranty is expressed or implied. We reserve the right to modify or supplement our opinions and conclusions should other information become available.

Please contact us with any questions, comments, or concerns.

Regards,

Robbie Veurink, Partner
SD License # 12466
Structural Engineer, PE

Figure 1. Existing Concrete Decking

Figure 2. Existing W18x77 (AISC 7th edition) beams

Figure 3. Existing HSS 7x0.25 column

Appendix I: North Reservoir Inspection Report

Sioux Falls, South Dakota

Inspection Report on:
5,000,000-Gallon Capacity
Big Blue Reservoir

Prepared by:

KLM Engineering, Inc.
1976 Wooddale Drive, Suite 4 | Woodbury, MN 55125
651.773.5111 | www.klmengineering.com

October 2022

Project No.: 4714-22

Table of Contents

1.0| PROJECT INFORMATION

KLM Project No.: 4714-22 **Customer P. O. Number:** N/A
Tank Owner: Sioux Falls, South Dakota **Phone:** 605-373-6971
Street/City/State/Zip: 2100 North Minnesota Avenue, Sioux Falls, SD 57104
Tank Owner Contact: Darin Freese, Water Program Coordinator
Owner's Tank Designation: Big Blue Reservoir
Tank Description: Ground Storage Reservoir
Tank Street Location: 2100 North Minnesota Avenue, Sioux Falls, SD 57104
Purpose of Inspection: Condition assessment
Date of Inspection: September 22, 2022
Inspected By: Devin Severson NACE #78234 and Matt Finley
Type of Inspection: KLM Standard In-Service Visual Inspection
Manufacturer: Advance Tank Co. **Construction Date:** 1988
Serial No.: 11587 **Design Code:** AWWA D100-84
Capacity: 5,000,000 Gallons
Type of Construction: Welded
Tank Diameter: 150’-0”
Height to: Overall 39’-8”
Height to: HWL ~35-feet LWL Grade
Tank Construction Drawings: Unavailable to KLM
Previous Inspection Records: Unavailable to KLM

EXISTING COATING INFORMATION

	Interior Wet	Exterior
Date Last Coated	Unknown	~2008
Full or Spot Repair	Full	Overcoat
Coating Contractor	Unknown	Unknown
Surface Preparation	Blast	Unknown
Paint System	Epoxy	Epoxy/Urethane
Paint Manufacturer	Unknown	Unknown
Paint Chip Samples	N/A	Taken/filed

Sioux Falls, South Dakota

5,000,000-GALLON CAPACITY
BIG BLUE RESERVOIR

2.0| REFERENCES

The tank interior and exterior areas were evaluated in conformance with the following:

a. KLM Engineering, Inc. Proposal.

b. General guidelines of AWWA Manual M42 Appendix C "Inspecting and Repairing Steel Water Tanks, and Elevated Tanks for Water Storage."

c. KLM "Procedures and Guidelines for Inspecting Existing Steel and Concrete Water Storage Tanks."

d. AWWA Standard D100-11; Welded Carbon Steel Tanks for Water Storage.

3.0| COATINGS EVALUATION

3.1| Lead and Chromium Content Analysis

KLM recommends testing the exterior coatings prior to the next reconditioning to determine if existing coatings contain chromium in excess of current federal recommended limits. KLM has a sample on file should testing be pursued. Lead levels are not considered a concern given the age of the tank and restrictions already in place at the time of its construction. Coatings exceeding the recommended chromium limit may be considered hazardous and require additional safety measures to protect public and contractor health. Removal and disposal of chromium-based paints must be performed in accordance with applicable local, state, and federal regulations. Proprietary products or other commercial methods are available to contractors to incorporate into their removal process to mitigate risks and convert the waste to a non-hazardous material allowing for more disposal options.

3.2| Interior Wet Coating

The reservoir was constructed and originally coated by Advance Tank Co. in 1988. The presence of a "door sheet" having been cut in the shell to allow for larger size equipment such as a skid steer to enter the wet area indicates the reservoir has been reconditioned at least once since its original construction.

The interior wet coating is in overall fair to poor condition above the high-water line (HWL) with approximately ten percent visible coating failures. Failures above the HWL consist of surface corrosion along unwelded roof plate overlap connections, along the supporting cross beams, and along roof plates and rafter connections. Severe corrosion with loss of steel on the flanges and webs is also visible on many roof rafters. The most severe appears primarily at the bolted end supports, which has resulted in rust-colored streaking down the shell and significant scale build-up on the rafter. Corrosion is also present along the connecting weld seams of manways to roof plates and some connecting welds within the overflow corridor area. Surfaces below the HWL were not observed as part of this inspection. However, KLM anticipates the coating below the HWL is in similar fair to poor condition. Similar peeling paint and surface corrosion was observed on the shell plates along the water level. See photos in Appendix A.

3.3| Exterior Coating

There is evidence from field data collected that the exterior may have the original coating and been overcoated at least once since it was constructed. The exterior coating is in overall fair good condition, with approximately two percent visible coating failures. Failures consist of typical UV deterioration on the roof and pinhole corrosion at some deterioration locations, on the finial vent, ventilation manway, and roof handrails. Additional failures include widespread areas of topcoat delamination on the roof edges and minor topcoat delamination on the shell. As the topcoat delaminates, it exposes the underlying epoxy coating. This epoxy coating is more susceptible to UV exposure and will degrade at a faster rate than the topcoat, eventually leading to pinhole corrosion. See photos in Appendix A.

3.4| Replacement Coating Systems

When the next full reconditioning is required, KLM recommends preparing surfaces in accordance with NACE guidance and applying a coating system for each area according to the following.

3.4.1| Interior Wet Coating

Surface preparation should be performed according to SSPC-SP10 Near White Metal Blast criteria.
Apply a three-coat system:

1. moisture cured zinc-rich
2. polyamidoamine epoxy
3. 100% solids, high-build epoxy

3.4.2| Exterior Coating

Surface preparation should be performed according to SSPC-SP6 Commercial Blast Clean criteria.
Apply a four-coat system:

1. moisture cured zinc-rich
2. polyamidoamine epoxy
3. aliphatic acrylic urethane
4. fluoropolymer

4.0| STRUCTURE MODIFICATIONS

Structure modifications and repairs serve to bring the reservoir into compliance with OSHA regulations, AWWA standards, and Department of Health regulations. They also improve areas of the reservoir that are prone to premature development of corrosion, repair surface defects resultant from reservoir construction, remove abandoned and unnecessary equipment, and improve reservoir maintenance capabilities.

The following is a list of recommended modifications and repairs to be included during the next reservoir reconditioning. Detailed information important to each item will be determined when developing the project specifications. Additional minor modifications, not impacting the estimated project cost, may be identified and incorporated at that time.

Photographs referred to in this section are in Appendix A.

4.1| Interior Wet Modifications

4.1.1 Rafter condition is unknown at this time. As noted in the coating condition assessment, some bolted rafter to shell connections have significant scale build-up. There may be enough steel loss that repairs are required. Actual condition won't be known until they have been abrasive blasted. See photos 2, 3, 6 through 10, and 14.

4.1.2 Assuming rafter ends have significant steel loss, seal weld a plate between the web of each rafter and the shell to strengthen the connection. See photos 8, 9, and 10.

4.1.3 Seal weld around all roof access and ventilation manways. See photo 4.

4.1.4 Seal weld all bolted roof-framing and structural support connections. After welding, remove all nuts and bolts. Welding these connections is required for conformance with AWWA D100-11. See photos 2, 3, 6 through 10, and 14.

4.1.5 Seal weld the base of each roof support column to the floor to comply with AWWA D100-11.

4.1.6 Weld a sump pit into the floor to improvement maintenance cleanout processes in the future.

4.1.7 Install a silt stop on the outlet pipe to prevent sediment from entering the distribution system. Include two bars welded to the top to reduce the risk of foreign objects entering the pipe during maintenance activities.

4.1.8 Grind off all weld spatter and erection scab marks below the HWL for compliance with AWWA D100-11.

4.2| Exterior Modifications

4.2.1 Replace the finial vent with an aluminum pressure pallet style vent. The new vent and vent screen design should meet AWWA D100-11 and Department of Health regulations. The removable top will also improve ventilation of the interior during reconditioning. See photos 15 and 16.

4.2.2 Install toe boards on the sections of roof handrail that do not have them installed. See photos 17 and 24.

4.2.3 Install a horizontal cable lifeline system conforming to OSHA regulations from the roof access manway to the finial vent collar. See photos 15 and 24.

4.2.4 Install a self-closing gate to the ladder access handrail to comply with OSHA requirements. See photo 24.

4.2.5 Replace the double aviation light and sensor with a new double LED style aviation light and sensor. See photo 20.

4.2.6 Replace the pipe-style safety climb device on the access ladder with a cable-style safety climb device conforming to OSHA regulations. See photos 25 and 26.

4.2.7 Replace the existing overflow pipe screen with corrosion-resistant, heavy-gauge #24 and #4 mesh screens. See photo 34.

4.2.8 Caulk around the perimeter of the reservoir where the steel meets the concrete foundation. See photos 30 through 33.

4.3| Cathodic Protection (CP) System

4.3.1 The reservoir interior does not have a cathodic protection system, and one is not required if the coating is applied and maintained properly.

5.0| PROPERTY CONSIDERATIONS

5.1| Site and Environmental Considerations

5.1.1 The reservoir is located adjacent to the Sioux Falls Water Purification Plant and Light Department. The Light Department building is only approximately five feet to the north of the reservoir. The site consists of maintained grass, accessible hydrants, and a paved driveway surrounding.

5.1.2 Given the proximity of the reservoir to the surrounding structures, pollution control methods such as a full containment system will be required during reconditioning. Reconditioning specifications should employ environmental standards to maintaining air quality and to prevent the drift of dust and fugitive emissions.

5.2| Telecommunications Considerations

5.2.1 The reservoir has no telecommunications equipment, either antennas or other associated equipment. Antennas generally have the effect of dramatically increasing the cost of reconditioning water storage reservoirs. If the owner is considering allowing antennas to be installed on the reservoir, lease agreements should be written to ensure the antenna owners are responsible for increase maintenance costs due to their presence. Installations should be reviewed to ensure that they do not interfere with normal use or maintenance of the reservoir, present safety hazards, or violate state or federal regulations.

6.0| RECONDITIONING SUMMARY

6.1| Reconditioning Summary and Cost Estimate

Due to conditions observed within the interior wet area, KLM recommends planning to replace all interior and exterior coatings in their entirety in the next one to two years to prevent additional corrosion damage within the wet area, maintain a uniform life cycle for the coatings, and develop the most cost-effective repair plan.

Market conditions are anticipated to continue fluctuating considerably over the next couple years, but if structure repairs and interior and exterior coating replacements were to be performed today, the estimated current cost would be between $1,500,000 and $1,600,000. This estimate does not include the cost of engineering and inspection services. For competitive bids, the project should be bid approximately 9 to 12 months before the desired starting date.

An experienced tank-coating contractor with proper crew and equipment should be able to complete the project in 20 weeks. At the time of reconditioning, the reservoir will need to be drained and remain off-line during interior structure modifications, abrasive blasting, and painting. However, most of the exterior modifications can be performed prior to draining, with the reservoir in-service.

KLM ENGINEERING, INC.

Report prepared by:

Thomas Brown

Thomas Amarvi-Brown, P.E.
Civil Engineer
MN License No. 58770

Report reviewed and certified by:

Rodney Ellis

Rodney Ellis
Vice President/COO
NACE Certified Coatings Inspector No. 1686
AWS/CWI 04040311

APPENDIX A

PHOTOGRAPHS

Photo No. 1
Overall view of reservoir

Photo No. 2
Interior conditions

Photo No. 3
Interior conditions

Photo No. 4
Manway access on roof

Photo No. 5
Condition of roof plates

Photo No. 6
Condition of roof and rafters

Photo No. 7
Condition of rafter

Photo No. 8
Typical condition of rafter and support angle

Photo No. 9
Typical roof rafter to shell connection

Photo No. 10
Condition of rafter connections

Photo No. 11
Overflow corridor

Photo No. 12
Overflow pipe condition

Photo No. 13
Overflow corridor condition

Photo No. 14
Shell conditions

Photo No. 15
Overall roof conditions

Photo No. 16
Roof and finial vent conditions

Photo No. 17
Roof and manways conditions

Photo No. 18
Manway condition

Photo No. 19
Ventilation manway

Photo No. 20
Aviation lights on roof

Photo No. 21
Roof conditions

Photo No. 22
Coating conditions on roof

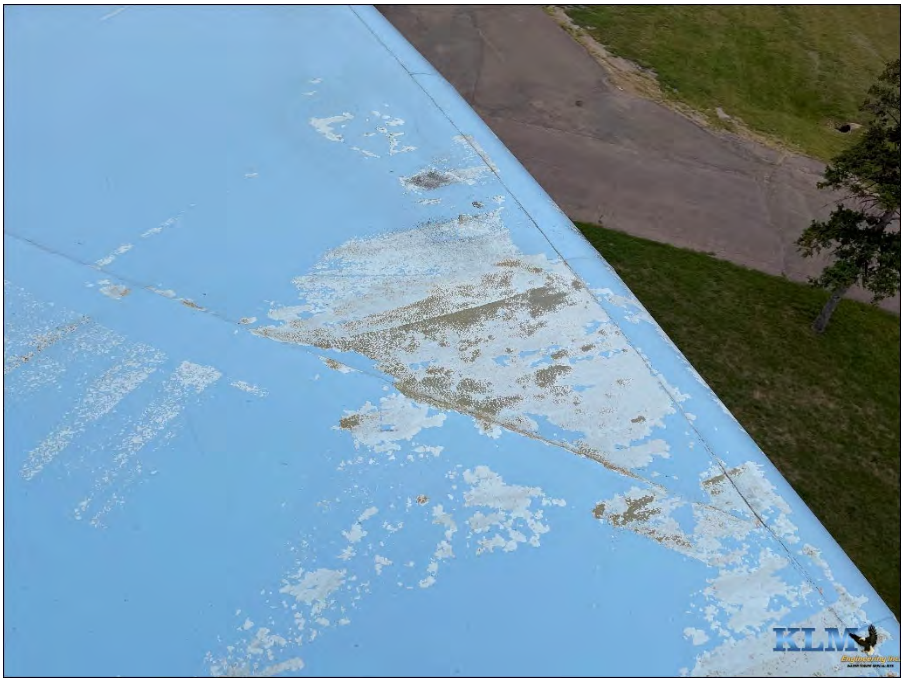


Photo No. 23
Coating conditions on roof

Photo No. 24
Roof ladder access and manway on roof

Photo No. 25
Exterior roof ladder access and cage conditions

Photo No. 26
Exterior ladder and cage conditions

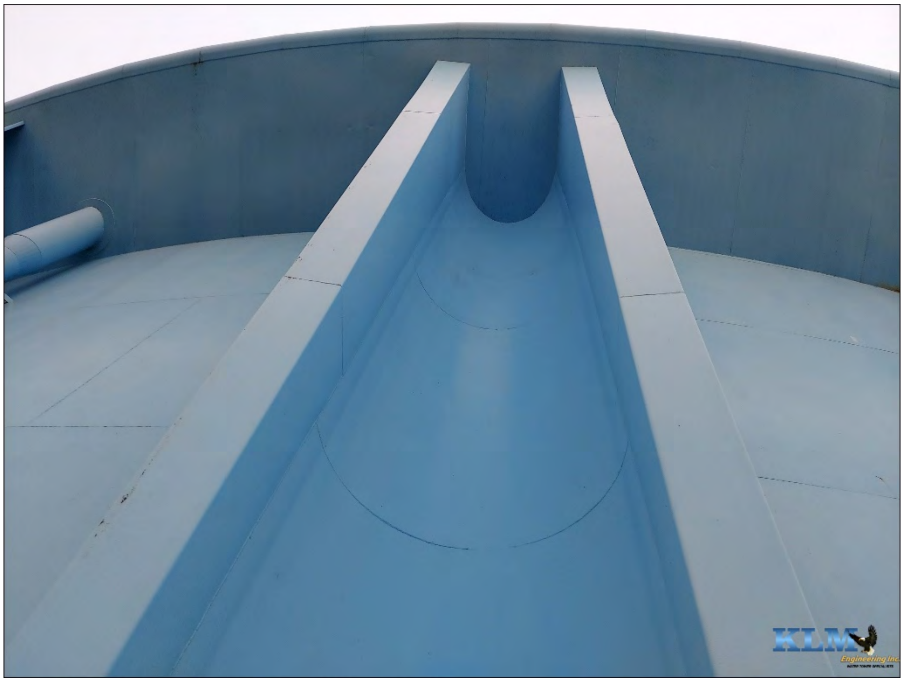


Photo No. 27
Shell exterior conditions

Photo No. 28
Shell exterior conditions

Photo No. 29
Shell exterior conditions with dirt accumulation visible

Photo No. 30
Shell exterior conditions with dirt accumulation visible

Photo No. 31
Layers of exterior coating shown at damage location

Photo No. 32
Manway on shell exterior

Photo No. 33
Overflow pipe on shell exterior

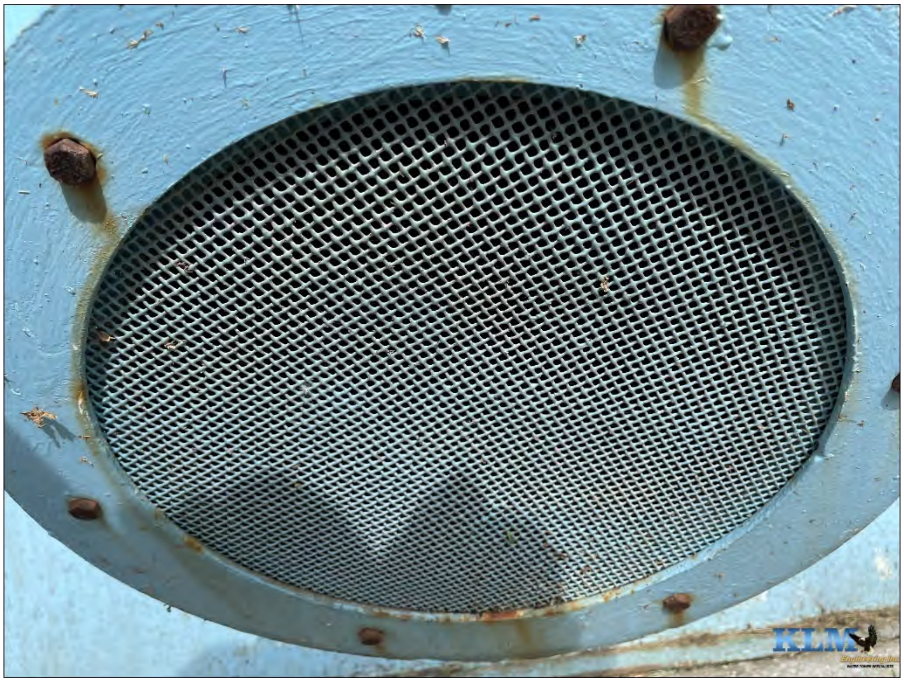


Photo No. 34
Overflow pipe screen conditions

APPENDIX B

INSPECTION AND EVALUATION METHODS

1.0| INSPECTION AND EVALUATION METHODS

Some or all of the following procedures were performed as applicable.

1.1| Methods

1.1.1 The inspection of the base metal and coatings on interior and exterior surfaces included only areas accessible without scaffolding or special rigging. Where possible, the base metal and coating on the interior wet surfaces were examined from either a rubber raft while the tank was being drained, by a Remote Operated Vehicle (ROV) with the tower in service, or with both.

1.1.2 Tank plate thickness was measured at random locations on the liquid holding shell. The overall structural condition of the tank was visually examined.

1.1.3 No structural analysis was done to determine if the tank design complies with the AWWA D100-11 Standard for “Welded Carbon Steel Tanks for Water Storage.” However, any observed non-conformance to the AWWA D100-11 standard is noted in this report.

1.1.4 Although compliance with OSHA regulations was not a part of this inspection, any unsafe conditions or violations of current OSHA regulation that were observed are noted in this report.

1.2| Examination and Evaluation Techniques

Some or all of the following procedures were performed as applicable.

1.2.1| Site

The tank site was evaluated for proper drainage conditions affecting access and lead paint abatement during reconditioning.

Also, the following site dimensions were obtained: distance to fence(s), power lines, owner buildings, public property, private property/buildings, school/playgrounds, public parks, and other property.

1.2.2| Foundations

The tank concrete foundation(s) were/was visually examined for cracks, spalling, conditions of grout, indications of distress/settlement, and elevation above grade.

1.2.3| Tank Plate Thickness

Plate thickness measurements were taken using ultrasonic methods (UTM). The readings were taken using a digital readout Elcometer MTG6 Ultrasonic Thickness Gage that has a dual element probe (transducer). The probe’s transmitter element sends a short ultrasonic pulse through the material. The pulse gets reflected as an echo from the opposite side of the plate and returns to the probe’s receiver element. The round-trip time is directly related to the material’s thickness.

1.2.4| Coating Thickness

Interior and exterior coatings, where accessible, were tested in accordance with Steel Structures Painting Council SSPC-PA2-18 “Procedure for Determining Conformance to Dry Coating Thickness Requirements” using PosiTector-6000-F1 Type 2 gages.

1.2.5| Coating Adhesion

Adhesion testing of the coating to the steel, and inner coat adhesion, was performed by ASTM D-3359: Shear Adhesion Test, Measuring Adhesion by Tape Test. In addition, subjective coating adhesion evaluation was performed using a penknife.

1.2.6| Coating Serviceability

The estimated remaining coating life or serviceability evaluation was performed using a wide variety of inspection instruments such as dry film thickness gauge, pen knife, Tooke gauge, adhesion tester(s), 30x microscope and serviceability evaluation experience (minimum experience 10 years).

The instrument inspection was combined with a close visual inspection of all accessible coatings. This was done to detect any holidays (misses), skips, runs, sags, surface containments, overspray, dry spray, poor coating cohesion, inter-coat delamination, loss of adhesion to the substrate, adverse conditions of the steel underneath the coating, or any other defects affecting the intended service.

1.2.7| Coating Lead and Chromium Content Analysis

Samples may have been taken of the various types of coatings present on the interior and exterior surfaces. GPI Laboratories, Inc. of Grand Rapids, Michigan tests these coatings in conformance with ASTM D-3335 Standard Test Methods for Concentrations of Lead and Chromium in Paint.

Appendix J: Fluoride Tank Inspection Report

Hydrofluosilicic Acid FRP Tank – 921

Internal and External Inspection Report

City of Sioux Falls – Water Purification
2100 N Minnesota Ave.
Sioux Falls, SD 57104

June 1, 2022

Manufacturer	Raven Industries	**Code of Construction**	ASTM D-3299
Serial #	G6-3165	**Capacity**	6,385 Gal. max
Date Manufactured	12/06/94	**Dimensions**	17' x 8'
Structural Resin	Vinyl Ester		

Inspector:

Sven C. Jasinski
Certified FTPI 2007-1 Inspector

Prepared by:

Sven C.

June 02, 2022

Darin Granum
Lead Maintenance Mechanic
City of Sioux Falls – Water Purification
2100 N Minnesota Ave.
Sioux Falls, SD 57104

RE: Hydrofluosilicic Acid FRP Tank 921 - Internal & External Inspection

Dear Darin,

In accordance with your request, Aero-Tec has evaluated the Hydrofluosilicic Acid tank 921. The areas of non-destructive testing, visual review, photographic documentation, and conclusions are as follows:

Completed Inspection

Aero-Tec has provided inspection services in connection with the 6,300-gallon FRP tank; located at your Sioux Falls, SD facility, in accordance with FTPI 2007-1, ASTM D-3299-10 and ASTM D-4097-01. Services provided include the following:

- *Formal Internal Inspection (FII)*: A documented internal inspection conducted by a certified inspector to assess the condition of the tank and determine its suitability for continued service.

- *Formal External Inspection (FEI)*: A documented external inspection conducted by a certified inspector to assess the condition of the tank and determine its suitability for continued service.

This report shall be added to previous inspection records for the purposes of determining suitability for continued service, according to recommended practices of FTPI 2007-1 and ASTM D-3299-10 and ASTM D-4097-01.

If you have any questions regarding this report, or if we may be of any further service, please contact me at (402) 319-1139.

Respectfully Submitted;

Sven C.

Sven C. Jasinski

6,300 Gallon HYDROFLUOSILICIC ACID FRP Tank 921 - INSPECTION SUMMARY

PREVIOUS INSPECTION RECORDS

NA

GLOBAL INSPECTION

General Appearance

Good

Prior to the inspection, the tank was in use and completely functional

Distortion

None

Resin Discoloration

None

Subsurface Disbonding or Blister and Surface Cracking or Crazing

None

Stripping

None

Internal Erosion/Surface Smoothness

Other

- The corrosion liner has been previously renewed and is still in good condition (see photo log 13)
- There are smaller delamination areas around the lower knuckle seam and drainage ports (see photo log 15, 16, 17)
- In addition there is one smaller area (6’ from the floor between the 2 down pipes) with a corrosion liner crack (see photo log 14)

VISUAL INSPECTION FOR LOCAL DEFECTS (Shell Penetrations)

Nozzles

Present

There are 5 tank fittings on the top/dome that are all in working condition. There are 2 fittings on the lower side wall and 1 on the upper side wall. All are in working condition (see photo log 9, 10, 11, 12).

Man-Ways
Present

- The 24” top manway is in overall working condition (see photo log 8).
- The 24” lower side manway is in overall working condition (see photo log 7).

Pipe Penetrations
None

Other Penetrations and/or Seams
None

FLANGE FLATNESS/OVER-TORQUED BOLTS

None

SOUNDING FOR VOIDS

None

CRACKING & CRAZING

None

GEOMETRIC DISTORTION: VERTICLE CIRCUMFERENCE

None

a. 18 Inches from foundation	**25’2”**
b. 5 Feet from foundation	**25’1”**
c. Wall bulging	**None**

SURFACE HARDNESS

Calibrated Barcol Impresser Model GYZJ-934-001 using Test Disc **Yes**
(readings above 42 are satisfactory for this type of resin)

Test Location	Internal Readings	External Readings
Floor North	73	NA
Floor East	72	NA
Floor South	69	NA
Floor West	69	NA
Side Wall North	70	74
Side Wall East	70	73
Side Wall South	71	71
Side Wall West	70	71
Dome North	NA	69
Dome East	NA	74
Dome South	NA	73
Dome West	NA	72
Average	**71**	**72**

BOTTOM FLATNESS

Good

HELIX WIND ANGLE

NA

Helix Wind Angle	Degrees
Manufacturer Spec.	Degrees

INSULATED TANK ELECTRICAL HEAT AMPERAGE/CICUIT BREAKER PROTECTION

None

VENT OPERATION

Good

- There is a 6" vent flange installed in the dome center (see photo log 9, 10).
- The vent system operation was not tested (see photo log 10)

SURFACE DRAINAGE

Good

FOUNDATION/SUPPORT CONDITION

Good

See photo log

HOLD DOWN & LIFTING LUGS

Present

- There are 4 hold down lugs. Each of them is in working condition. (see photo log 5).
- There are 5 lifting down lugs – all are in working condition (see photo log 6).

PRESSURE TEST

No

ACOUSTIC EMISSION TEST

No

INTERSTITIAL VACUUM TEST

No

CONCLUSIONS AND RECOMMENDATIONS SUMMARY

It is my opinion this vessel can be put back into service. It is fully functional and safety & environmental hazard free. However to assure the functionality over the mid- and long term of the tank, the following areas of concern need to be addressed ASAP.

Tank Subject	Issue	Recommendation
Internal Corrosion Liner	○ There are smaller delaminated areas around the lower knuckle seam and drainage ports ○ In addition there is one smaller area with a corrosion liner crack ○ Due to these openings, acid has direct contact with the structural wall. If not addressed, the wall will eventually weaken, crack and leak	○ **Repair all identified delaminated and cracked areas by overlaying new material as per OEM specs – as soon as possible**

INSPECTION INTERVALS

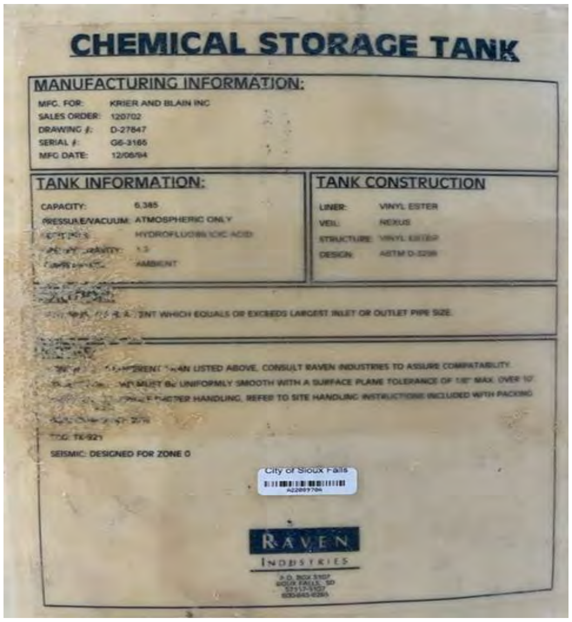
External Inspection

Due to its age and content, the next FEI (formal external inspection) should be conducted every 5 years thus no later than June 2027.

Internal Inspection

An FII (formal internal inspection) should be conducted after 10 years, or no later than June 2032.

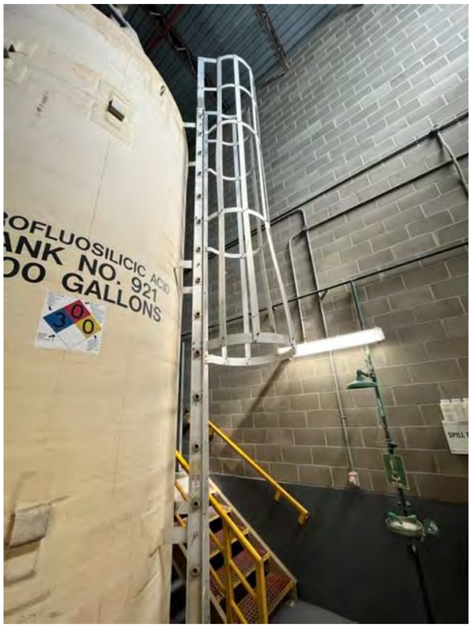
SECTION IV: PHOTOGRAPHS

TANK INSPECTION PHOTO LOG –HYDROFLUORISTICIC Acid FRP Tank 921	
PHOTO #1 DATE: 06/01/22 Description: **Full Tank View**	
PHOTOS #2 DATE: 06/01/22 Description: **Manufacturer Label**	CHEMICAL STORAGE TANK MANUFACTURING INFORMATION: MFC. FOR: KRIER AND BLAIN INC SALES ORDER: 120702 DRAWING #: D-27647 SERIAL #: G6-3165 MFG DATE: 12/06/94 TANK INFORMATION: CAPACITY: 6,385 PRESSURE/VACUUM: ATMOSPHERIC ONLY [illegible] HYDROFLUOSILICIC ACID [illegible] GRAVITY: 1.3 [illegible] AMBIENT TANK CONSTRUCTION LINER: VINYL ESTER VEIL: NEXUS STRUCTURE: VINYL ESTER DESIGN: ASTM D-3299 [illegible] ENT WHICH EQUALS OR EXCEEDS LARGEST INLET OR OUTLET PIPE SIZE. [illegible] DIFFERENT THAN LISTED ABOVE, CONSULT RAVEN INDUSTRIES TO ASSURE COMPATABILITY [illegible] MUST BE UNIFORMLY SMOOTH WITH A SURFACE PLANE TOLERANCE OF 1/8" MAX. OVER 10' [illegible] HANDLING. REFER TO SITE HANDLING INSTRUCTIONS INCLUDED WITH PACKING [illegible] TAG: TK-921 SEISMIC: DESIGNED FOR ZONE 0 City of Sioux Falls RAVEN INDUSTRIES P.O. BOX 5107 SIOUX FALLS, SD 57117-5107

<table>
<tr><th colspan="3">TANK INSPECTION PHOTO LOG –HYDROFLUORISTICIC Acid FRP Tank 921</th></tr>
<tr>
<td>PHOTO #3 & 4

DATE: 06/01/22

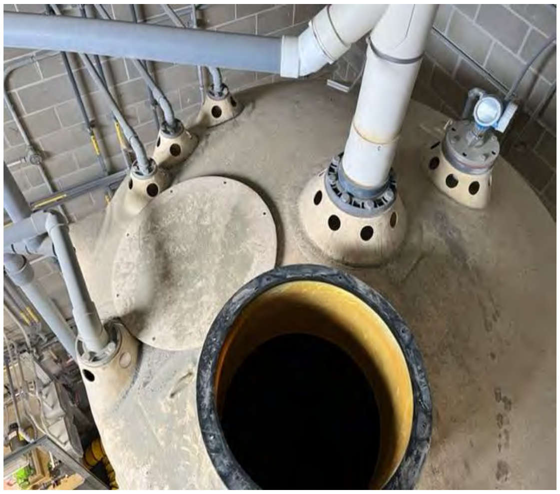
Description:

Tank Labeling and Tank Ladder</td>
<td>
</td>
<td>
</td>
</tr>
<tr>
<td>PHOTOS #5 & 6

DATE: 06/01/22

Description:

Tank Hold-Down Lug and Lifting Lug</td>
<td></td>
<td></td>
</tr>
</table>

<table>
<tr><th colspan="3">TANK INSPECTION PHOTO LOG –HYDROFLUORISTICIC Acid FRP Tank 921</th></tr>
<tr><td>PHOTO #7 & 8
DATE: 06/01/22
Description:
Side and Top Manway</td><td></td><td></td></tr>
<tr><td>PHOTO #9 & 10
DATE: 06/01/22
Description:
Tank Dome View and Tank Ventilation System</td><td></td><td></td></tr>
</table>

<table>
<tr><th colspan="3">TANK INSPECTION PHOTO LOG –HYDROFLUORISTICIC Acid FRP Tank 921</th></tr>
<tr><td>PHOTO #11 & 12

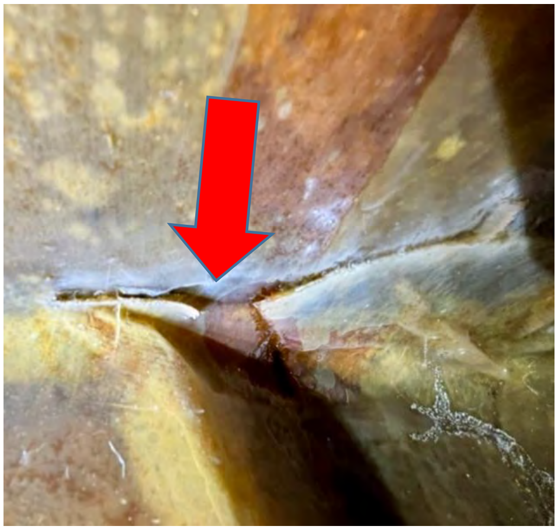
DATE:
06/01/22

Description:

Tank Dome and Bottom Inside View</td><td></td><td></td></tr>
<tr><td>PHOTO #13 & 14
DATE:
06/01/22

Description:

Corrosion Liner and Crack 6’ up the Floor btw the Down Pipes</td><td></td><td></td></tr>
</table>

<table>
<tr><th colspan="3">TANK INSPECTION PHOTO LOG –HYDROFLUORISTICIC Acid FRP Tank 921</th></tr>
<tr><td>PHOTO #15 & 16
DATE:
06/01/22
Description:
Corrosion Liner Cracking Around the 2 Drain Flanges</td><td></td><td></td></tr>
<tr><td>PHOTO #17
DATE:
06/01/22
Description:
Close-up Sample of the One of the Knuckle Seam Delaminations</td><td colspan="2"></td></tr>
</table>

Repair Work Report – City of Sioux Falls, SD – Water Purification Fluosilicic Acid Tank 921

Repair Date: 06/08/22

Repair Done By:
Aero-Tec, Inc., 2324 S 102 Street; Omaha, NE 68124
Sven Jasinski, President, Certified FTPI 2007-1 Tank Inspector
(402) 310-1139

Purpose: To address and correct 3 issues identified at an inspection done in June 2022

Repair Scope:

1. Internal floor/sidewall knuckle seam – various smaller liner cracks
2. Internal floor/sidewall drainage ports – various liner cracks
3. Internal sidewall 6’ off the floor btw. down pipes – one longer liner crack

Materials Used:

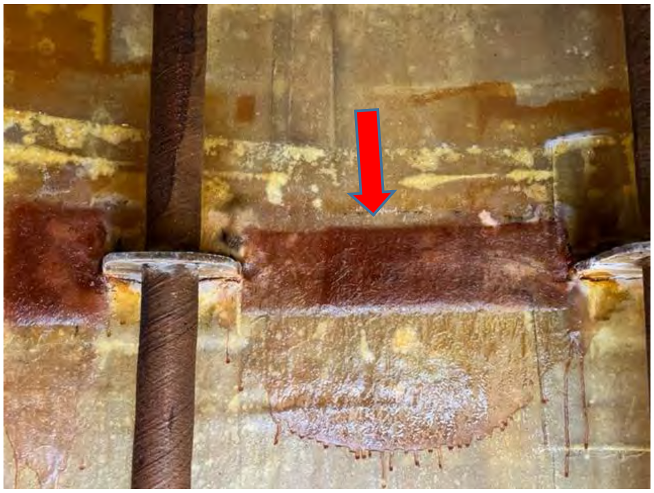
- Resin – Corve 8100 Vinyl Ester
- Glass mat – 3oz random woven
- Corrosion liner – Nexus, 8% was solution

Issues Addressed:

1. ***Internal Floor/Sidewall Knuckle Seam***
    - Situation: There were multiple smaller openings (cracks) through which fluoride was penetrating causing direct contact with structural wall
    - Actions taken:
        - Ground/sanded around cracks
        - Overlaid with 2 layers random woven mat
        - Laid single Nexus veil with 8% wax solution as corrosion liner

2. ***Internal Floor/Sidewall Drainage Ports***
    - Situation: Lamination around the ports had cracks through which fluoride was penetrating causing direct contact with structural wall
    - Actions taken:
        - Ground/sanded around ports
        - Overlaid with 2 layers random woven mat
        - Laid single Nexus veil with 8% wax solution as corrosion liner

3. ***Internal Sidewall 6' off the Floor btw Down Pipes***
    - Situation: Corrosion liner had longer crack through which fluoride was penetrating causing direct contact with structural wall
    - Actions taken:
        - Ground/sanded around crack
        - Overlaid with 2 layers random woven mat
        - Laid single Nexus veil with 8% wax solution as corrosion liner



Technical Memorandum

Water Supply and Treatment Master Plan

Chapter 7:
Water Purification Plant Treatment Evaluation

November 2022

HR Green Project No: 210506

Prepared For:

CITY OF
SIOUX FALLS

Table of Contents

List of Figures

List of Tables

Section 1 Introduction

1-1 Overview

The Sioux Falls Water Purification Plant (SFWPP) is the City of Sioux Falls' (City) sole drinking water treatment facility. The plant treats surface water and groundwater sources and has an effective treatment capacity of approximately 55 MGD. The gravity filters were updated in 2009 and have a treatment capacity of approximately 75 million gallons per day (MGD). The treatment process includes Actiflo® ballasted flocculation (for surface water only), lime softening, recarbonation, filtration, and chlorine disinfection. The City also utilizes the Lewis and Clark Regional Water System to provide treated drinking water to the residents of Sioux Falls through its utility membership with the wholesale water provider.

The purpose of the 2022 Water Purification Master Plan is to develop a holistic, cost-effective, long-term capital improvement plan for providing exceptional drinking water that will meet future growth and regulatory requirements through 2045.

This technical memorandum (TM) is organized into the following sections:

1. Regulatory Review: Present recent and anticipated regulatory changes that may impact the City's future water treatment strategies.
2. SFWPP Hydraulic Capacity: Determine the current hydraulic capacity of the SFWPP and identify improvements to reliably treat 75 MGD.
3. SFWPP Treatment Evaluation: Evaluate each treatment process of the SFWPP in detail with special emphasis on areas where the existing treatment infrastructure limits the effective treatment capacity.
4. Recommendations: Develop alternatives for expanding the City's drinking water treatment capacity, including expansion of either the surface water treatment or combined treatment processes at the SFWPP.

1-2 Summary of Previous Studies

The City has a long history of developing planning documents for drinking water treatment, illustrating the foresight and necessity of updated Master Plans to reflect increases in population and increasingly stringent treatment standards. The following planning documents and reports were provided by the City and reviewed for this 2022 Master Plan update.

- 1992 Master Plan for Sioux Falls WPP Improvements
- 2001 Sioux Falls Water Purification Plant Master Plan Update
- 2008 Water Purification Plant Filter Upgrade TM
- 2020 City of Sioux Falls Future Water Supply Needs TM
- 2022 Sioux Falls WPP Clearwell Observation Report

Section 2 Regulatory Review

2-1 Overview

This section presents recent and anticipated regulatory changes that may impact the City's future water treatment strategies. The Safe Drinking Water Act (SDWA) and its amendments require the U.S. Environmental Protection Agency (USEPA) to reevaluate existing drinking water regulations on a periodic basis and develop new standards and regulations as necessary to protect public health. At any given time, there may be many contaminants at various stages of the rulemaking and revision process. The regulatory review cycle includes periods for information gathering, regulation development, and public comment before new rules and regulations are promulgated.

While there are several forthcoming and potential drinking water regulatory changes to be aware of, this TM only presents those which could potentially impact the City. The pertinent drinking water quality regulatory changes include:

- Lead and Copper Rule Revisions (LCRR)
- Per- and Polyfluroroalkyl Substances (PFAS)
- Unregulated Disinfection Byproducts (DBPs)
- Nitrosamines

2-1-1 LEAD AND COPPER RULE REVISIONS

The USEPA published the LCRR in the Federal Register on January 15, 2021 with an effective date of December 16, 2021. Public water systems will be required to comply with the rule by October 16, 2024. The LCRR focused on six key areas for reducing exposure to lead and copper in drinking water and improving public education:

- Identifying areas most impacted
- Strengthening treatment requirements
- Systematically replacing lead service lines
- Increasing sample reliability
- Improving risk communication
- Protecting children in schools and childcare facilities

The LCRR amended the original Lead and Copper Rule (LCR) requirements in several ways:

1. Requires water systems to maintain a lead service line (LSL) inventory
2. Requires water systems to establish a lead service line replacement (LSLR) plan
3. Establishes a 90th percentile lead trigger level, and amends the actions to be taken in the event of an action level exceedance
4. Revises sampling requirements for lead, copper, and water quality parameter (WQP) monitoring
5. Establishes sampling requirements and outreach initiatives for schools and childcare facilities
6. Modifies public education and outreach requirements

Each of these components is discussed below. At the end of this section, a summary of LCRR impacts on the City is provided.

LSL Inventory

All water systems must develop a publicly accessible LSL inventory by January 16, 2024 (three years after the LCRR was originally published). The inventory must include all service lines in the distribution system and must be updated over time to reflect changes (i.e., identification of unknowns, LSL replacement, etc.). The publicly accessible inventory must include general location identifiers for all LSLs. Water systems serving populations greater than 50,000 people, must publish their LSL inventory online (i.e., websites, cloud-based file sharing, social media, etc.). Systems with no LSLs only have to conduct an initial inventory but are not required to provide inventory updates; these systems may fulfill the requirement to make the inventory publicly accessible with a statement that there are no LSLs, along with a general description of the methods used to make that determination.

Relevance to the City

- The City must develop an LSL inventory by October 16, 2024. If LSLs are identified, the inventory will need to be publicly available on a web-based platform and regularly updated.

LSL Replacement Plan

All water systems that have LSLs or service lines of unknown lead status must submit an LSLR plan to their state primacy agency by October 16, 2024. The purpose of developing a LSLR plan is to proactively prepare water systems to implement an LSLR program in the event that they have a lead trigger level or action level exceedance (discussed further in the next section). The plan must include the following:

1. A strategy for determining the composition of service lines with unknown lead status in its inventory.
2. Procedures to conduct full LSLR.
3. A strategy for informing customers before a full or partial LSLR is conducted.
4. A recommended LSLR goal rate (only applies to systems with service populations greater than 10,000). This rate includes replacement of galvanized service lines that currently are, or were previously, downstream of an LSL.
5. A procedure for customers to flush service lines and premise plumbing of particulate lead.
6. An LSLR prioritization strategy based on factors including but not limited to the targeting of known LSLs and replacing LSLs for disadvantaged consumers and populations most sensitive to the effects of lead.
7. A funding strategy for conducting full LSLRs which considers ways to accommodate customers that are unable to pay to replace the portion they own.

In addition to developing an LSLR plan, the LCRR also requires that all lead goosenecks, pigtails, and connectors be replaced any time they are encountered in the water system. In order to mitigate the impacts of partial LSLR (i.e., replacement of just the system-owned portion or just the customer-owner portion), only full LSLR is allowed under the LCRR. When notified of a customer initiated LSLR, the system must complete a full LSLR within 45 days, with the possibility of an extension to 180 days after notification to the state. Because of the potential for partial LSLR to contribute higher levels of lead into drinking water, water systems must also provide the customer with a filter (free pitcher filter or point of use device) within 24 hours of learning of a customer replacement that left a system-owned LSL in place within the past six months. Lead tap samples must be collected at locations served by replaced lines within three to six months after replacement.

Relevance to the City

- An LSLR plan for LSLs, lead status unknown, and galvanized requiring replacement service lines will need to be finalized by October 16, 2024.

Lead Trigger Level and Action Level

The LCRR establishes a new 10 microgram per liter (μg/L) trigger level for lead; this is in addition to the existing 15 μg/L lead action level from the current LCR. Both of these are based on the 90th percentile lead concentration measured from tap sampling in the distribution system. For medium and large water systems that have a lead exceedance between the trigger level and action level, the following actions must be taken:

- Systems with an established corrosion control treatment (CCT) in place are required to reoptimize CCT and conduct annual tap sampling. States can approve existing CCT modifications without requiring a formal CCT study (however a state can still require a CCT study if it so choses).
- Systems without CCT must conduct a CCT study, obtain state approval for designated CCT, and conduct annual tap sampling.
- Regardless of whether CCT is in place, community water systems serving more than 3,300 people that have LSLs or service lines of unknown lead status in the distribution system must notify customers and implement a goal-based LSLR program in accordance with the aforementioned LSLR plan and primacy agency requirements. The LSLR program must be implemented for a minimum of two consecutive one-year monitoring periods. Only full LSLR (i.e., replacing the customer-owned portion as well as the system-owned portion) counts towards this goal-based rate.

After an action level exceedance, lead and coper monitoring frequency is increased to every six months. The LCRR removed the previous requirement for source water monitoring following an action level exceedance. This was done because the source water monitoring is not necessary to protect public health because lead and copper are rarely found in source waters in significant quantities.

The LCRR further requires that any water system serving more than 3,300 people that has an action level exceedance must conduct a flow-through pipe loop study to evaluate optimal CCT within one year of the violation. These systems must also undergo a LSLR program with a minimum replacement rate of 3% per year (based on a rolling two-year average). The number of LSLRs required under the mandatory LSLR program must be calculated using the number of LSLs and galvanized service lines requiring replacement at the time the system first exceeds the action level plus the number of unknowns at the beginning of each year of the system's LSLR program. Only full LSLR counts towards this mandatory rate. The mandatory LSLR program must be implemented until the water system's 90th percentile lead levels are at or below the action level for two years and the cumulative percentage of LSLs replaced by the system is greater than or equal to 3% times the number of years that elapsed since the system's first violation.

Relevance to the City

- Historically the City has not had 90th percentile lead concentrations higher than 10 µg/L. If this does occur in the future, the City will have to re-optimize CCT and implement an LSLR program (goal based approach for trigger level exceedance, mandatory 3% annual replacement for action level exceedance).
- If new water sources are incorporated into the existing water system, a CCT study will likely be required.

Sampling Requirements

The LCRR modified sampling requirements for lead and copper, as well as monitored WQPs. The tiered criteria for selection of lead and copper sampling sites have been revised to better target locations expected to have higher levels of lead in drinking water. With this, five tiers of sampling sites were defined as outlined in Table 1 below.

TABLE 1: LCRR SAMPLING SITE TIERS

Tier	Description
1	Single family structures served by and LSL. When multiple-family structures comprise at least 20 percent of the structures served by a water system, the water system may include these in the Tier 1 sampling pool.
2	Buildings (including multiple-family residences) that are served by an LSL.
3	Single family structures with galvanized service lines currently downstream of an LSL or known to be downstream of an LSL in the past.
4	Single family structures that contain copper pipes with lead solder installed before the effective date of the state's lead ban.
5	Representative sample where the plumbing is similar to that used at other sites served.

Under the LCRR, water systems are required to collect all lead and copper samples from all Tier 1 and Tier 2 sites. If there are not enough Tier 1 and Tier 2 sites in the system, the system must use Tier 3, 4, or 5 sites, in that order. To the extent feasible, the same sample sites must be used for each monitoring period. If a customer chooses to discontinue participation in the sampling program, a similarly tiered site must take its place.

The LCRR also updated lead and copper sample collection protocol. The new rule maintains the required 6-hour stagnation period before sample collection. For LSL sites (Tiers 1 and 2) a first liter sample must be collected and analyzed for copper; a fifth liter sample must be collected and analyzed for lead. For non-LSL sites (Tiers 3,4 and 5) the first liter sample is used for both copper and lead analysis. All samples must be collected in wide-mouth samples bottles so that collection is occurring when the faucet is flowing at a high rate. Sampling instructions that include recommendations for aerator cleaning and removal and pre-stagnation flushing prior to sample collection are prohibited.

Whenever a new source water or long-term change in treatment is implemented, tap sampling for lead and copper must occur every six months unless the state determines that the change is not significant and therefore does not warrant more frequent monitoring.

The previous LCR required that systems serving more than 50,000 people conduct regular WQP monitoring at the entry points to the distribution and at sample taps within the distribution system to ensure effective CCT is being achieved. The LCRR modifies these requirements in a number of ways. CCT and WQP monitoring must be evaluated during sanitary surveys to ensure they meet the most recent CCT guidance issued by the USEPA. Calcium carbonate stabilization has been eliminated as a CCT option, therefore the WQPs associated with this have also been eliminated (calcium, conductivity, and water temperature). That LCRR also clarified that orthophosphate must be measured as PO_4^-.

If an individual tap sample has a lead level greater than 15 µg/L, a "find-and-fix" process is initiated wherein another sample must be collected at the same tap within 30 days. If the high lead level occurs in a system with established CCT, within 5 days WQP monitoring must take place either at the same tap, or at a location within the same pressure zone that is on the same size water main and within a half-mile from the tap sample site. Water systems then use the follow-up lead and WQP samples to assess whether the cause of the high lead tap sample is due to a source of lead at the sampling location, corrosive water quality parameters, or is unknown. If the water system determines the cause of the elevated level of lead is solely due to a source of lead at the sampling location, or is unknown, the system is not required to recommend an action to fix the cause of the elevated lead. If the water system finds that corrosive water quality parameters are the cause, the system must determine if distribution system management changes such as flushing to reduce water age or adjustment of the CCT are necessary to restore optimal water quality parameters in that portion of the system.

The number of WQP monitoring sites that must be added through the find-and-fix process is limited to two times the standard number of sites. States can determine which sites will be retained if a system exceeds the find-and-fix threshold as outlined in Table 2.

TABLE 2: WQP MONITORING SITE REQUIREMENTS

Population Served	Number of Sites for Standard Monitoring	Number of Sites for Reduced Monitoring	Find and Fix Threshold
>100,000	25	10	50
10,001 – 100,000	10	7	20
3,301 – 10,000	3	3	6
501 – 3,300	2	2	4
101 - 500	1	1	2
≤ 100	1	1	2

WQP monitoring must occur every six months. A system which does not have an action level lead or copper exceedance, does not exceed the lead trigger level, and meets all of its optimal WQPs for two consecutive six-month monitoring periods is eligible for reduced monitoring.

Relevance to the City

- Historically, the City has occasionally had individual lead sampling results above 15 µg/L. If a lead concentration above 15 ug/L is recorded after 2024, the City will have to follow "find-and-fix" protocol.
- The City will need to revisit its LCR compliance sampling pool and make changes as needed to comply with the revised tiering structure.

Sampling at Schools and Childcare Facilities

The LCRR requires community water systems to sample for lead in all elementary schools and childcare facilities that they serve within the first five years after the compliance date. Each year, 20 percent of these facilities must be contacted for sampling. After all elementary schools and childcare facilities have been tested once, the water system must conduct additional sampling when requested by a facility. Sampling must also be provided at secondary schools upon request.

Relevance to the City

- The City will need to sample 20% of elementary schools and licensed childcare facilities within the service area annually, and all facilities over a five year period.

Public Education

The LCRR modified public education requirements in several ways. First, the USEPA modified the requirements of public education materials to include a mandatory statement explaining the health effects of lead exposure. The LCRR also requires systems to notify and provide education materials to customers served by LSLs, service lines of unknown lead status, or galvanized piping requiring replacement. Furthermore, water systems that cause a disturbance to a lead, galvanized requiring replacement, or lead status unknown service line must notify persons at the service connection and provide them with information on how to reduce their exposure to potentially elevated lead levels. Community water systems serving more than 10,000 people that do not meet their LSLR goal must conduct additional public outreach activities. Systems must also conduct annual outreach to state and local health agencies to discuss sources of lead in drinking water, health effects of lead, steps to reduce exposure to lead in drinking water, and information on find-and-fix activities.

The LCRR requires that water systems notify customers at the sample site of any individual tap sample that exceeds 15 µg/L no later than three days after receiving the sample results. For samples that do not exceed 15 µg/L, the existing LCR requirement to send customers individual sample tap results within 30 days is still applicable.

Relevance to the City

- The City has identified four City-owned LSLs and nine unknown service lines as part of its initial LSL inventory. Customers served by these lines will need to be informed in accordance with USEPA and state guidance.
- Galvanized lines on both the public and private side, if discovered, will also trigger notification requirements unless information identified that confirms the pipes were never downstream of and LSL.
- City Consumer Confidence Reports must include the USEPA's required language on health impacts and include info on LSLR programs (if applicable).

LCRR Impacts on the City of Sioux Falls

Table 3 summarizes the specific impacts that the LCRR will have on the City of Sioux Falls as they relate to the six focus areas of the new rule.

TABLE 3: SUMMARY OF LCRR IMPACTS TO THE CITY

Focus Area	Rule Requirement	Impact to City
Identifying areas most impacted	- Complete an LSL inventory within 3 years of rule promulgation. - Systems without LSLs must demonstrate their absence. - If an individual tap sample exceeds 15 μg/L, systems must collect a follow-up sample, WQP monitoring at or near the site (0.5 mile radius, similar pressure zone, same water main size) and perform a corrective action. This is termed a "find-and-fix" approach.	- City must develop an LSL inventory by October 16, 2024. The inventory will need to be publicly available on a web-based platform and regularly updated. - Historically, the City has had individual lead sampling results above 15 μg/L. If a lead concentration above 15 ug/L is recorded after 2024, the City will have to follow "find-and-fix" protocol.
Strengthening treatment requirements	- 10 μg/L trigger level for lead in addition to the current 15 μg/L action level. - If the trigger level is exceeded based on 90th percentile lead concentrations, systems must re-optimize CCT or conduct a CCT study if CCT is not currently in place. - Calcium hardness adjustment is no longer a lead CCT option and phosphate inhibitors must be orthophosphate. - Calcium, conductivity, and temperature analyses are no longer required as part of the water quality parameter sampling.	- Historically the City has not had 90th percentile lead concentrations higher than 10 μg/L. If this does occur in the future, the City will have to re-optimize CCT and implement an LSLR program (goal based approach for trigger level exceedance, mandatory 3% annual replacement for action level exceedance). - If new sources are incorporated into the water system, a CCT study will likely be required.
Systematically replacing lead service lines	- Systems with lead above the trigger level must develop a goal for LSLR; 3% replacement per year for systems with a lead action level exceedance - No partial LSL replacements can be conducted. - Utilities must replace their portion of an LSL within 45 days if the customer replaces their portion.	- The City is subject to public notification requirements for any identified LSL or lead status unknown locations. Galvanized lines on both the public and private side, if discovered, will also trigger notification requirements unless information identified that confirms the pipes were never downstream of and LSL. - An LSLR plan for LSLs, lead status unknown, and galvanized requiring replacement service lines will need to be finalized by 2024.
Increasing sample reliability	- Prioritize sample collection from sites served by LSLs (Tiers 1 and 2), galvanized requiring replacement (Tier 3), and copper pipes with lead solder installed before the effective date of South Dakota's lead ban (Tier 4). - For sites with LSLs and galvanized piping requiring replacement, lead sample should be collected on the 5th liter. - Collect samples in wide-mouth bottles with no cleaning, flushing, etc. prior to sample collection.	- The City will need to revisit its LCR compliance sampling pool and make changes as needed to comply with the revised tiering structure and sampling protocol.
Improving risk communication	- Utilities must notify customers with individual tap sample results greater than 15 μg/L within 3 days of detection. - Utilities must inform customers served by an LSL or lead status unknown service line. - Consumer Confidence Reports must provide updated health effects language and info on LSLR programs. - Utilities must notify system-wide customers of lead action level exceedance within 24 hours. - Systems must improve public access to lead information, including LSL locations, and respond to request for LSL information, deliver educational materials to customers during water-related work that could disturb LSLs and provide increased information to health care providers. - Systems must provide information to schools and childcare facilities.	- The City has identified 4 city-owned LSLs and 9 unknown service lines as part of its initial LSL inventory. Customers served by these lines will need to be informed in accordance with USEPA and state guidance. - City Consumer Confidence Reports will need to include the USEPA's required language on health impacts and include info on LSLR programs (if applicable)
Protecting children in schools and childcare facilities	- Provide information and communicate results to users of the facility, parents, primacy agency, and the local or state health department. - Test 20% of licensed childcare facilities and elementary schools each year. - Provide testing to secondary schools on request.	- The City will need to sample 20% of elementary schools and licensed childcare facilities within the service area annually, and all facilities over a five year period.

2-1-2 FUTURE PFAS REGULATIONS

PFAS are a class of chemicals consisting of perfluorooctanesulfonic acid (PFOS), perfluorooctanoic acid (PFOA), and many other per- and polyfluoronated chemical compounds. These compounds are manufactured and used in a variety of industries, most notably for stain- and water-repellent fabrics, nonstick products such as Teflon, and firefighting foam used by aircrafts. As part of a series of phase-outs, the United States no longer manufactures certain PFAS, including PFOS and PFOA. However, these compounds are still produced internationally and can enter the United States through imported consumer goods.

PFAS have been classified through research as probable human carcinogens and linked to other additional health-related risks such as obesity, immune system suppression, and endocrine disruption. Most notably, the chemical structures of long-chain PFAS make them bioaccumulative in humans and wildlife, and persistent in the environment.

The following is a brief summary of the actions that the USEPA has taken to date regarding PFAS:

- In January 2009, USEPA established a Provisional Health Advisory of 400 parts per trillion (ppt) for PFOA and 200 ppt for PFOS to assess the potential risk from short-term exposure of these chemicals through drinking water.
- On May 19, 2016, USEPA released its final Health Advisory Level for PFOA and PFOS in drinking water (70 ppt total).
- On February 20, 2020, USEPA announced and requested public comment on the preliminary regulatory determinations for eight Candidate Contaminant List (CCL) 4 contaminants. USEPA made preliminary determinations to regulate PFAS in drinking water.
- On February 22, 2021, the USEPA reissued the final regulatory determinations for CCL4, making the determination to regulate both PFOS and PFOA in drinking water. USEPA will move forward with the rule development process.
- On July 19, 2021, the USEPA draft CCL5 also incorporated five additional PFAS for consideration and the proposed Unregulated Contaminant Monitoring Rule (UCMR) 5 includes 29 PFAS compounds.

With Regulatory Determination 4, the USEPA has 24 months to propose potential maximum contaminant levels (MCLs) for PFOA and/or PFOS. In October 2021, the USEPA released its PFAS Strategic Roadmap, which laid out the following priorities and dates:

- **Drinking Water**— MCLs for PFOA and PFOS are to be proposed in Fall 2022 and finalized in Fall 2023. 29 PFAS are to be measured in 2023-2025 as part of UCMR5.
- **Cleanup**—PFOA and PFOS are to be designated Superfund (CERCLA) hazardous substances by Summer 2023.
- **Toxics**—more toxicity tests for PFAS (particularly new PFAS) are to be conducted under the Toxic Substances Control Act.
- **Monitoring**—USEPA Method 1633 can measure up to 40 PFAS in eight environmental matrices and was released in September 2021 (multi-lab validation expected Fall 2022). "Total PFAS" quantification methods are to be developed (2021-2022). The National Lakes Assessment will evaluate PFAS in fish tissue in Summer 2022.

- **Research**—funding is to be directed to treatment, environmental justice, and quantifying toxicity, exposure, and ecological effects.
- **Wastewater**—ambient water quality criteria are to be released in Winter 2022; industrial effluent limits are to be proposed in Summer 2023.

The PFAS Strategic Roadmap emphasizes full consideration of the lifecycle of PFAS and multiple exposure pathways, holding polluters accountable (including enhanced reporting requirements), and preventing future PFAS pollution.

Currently, South Dakota follows the regulatory requirements established by the USEPA and is not anticipated to establish regulatory or guidance PFAS concentrations that are lower than USEPA established concentrations or Health Advisory Levels. It is recommended the City identify whether concentrations are below target levels for PFAS compounds in the potable water system. To do so, the City will need to collect samples and analyze for the 29 PFAS compounds included on UCMR5 which will determine if changes to source water or additional treatment are necessary to address these components.

2-1-3 UNREGULATED DISINFECTION BYPRODUCTS

The USEPA continually considers whether additional regulation of DBPs is warranted, as illustrated by the inclusion of several unregulated DBPs on CCL4, the decision to consider revisions to the Stage 1 and 2 D/DBPRs based on the Third Six Year Review cycle, and inclusion of several classes of unregulated DBPs through the UCMR. Unregulated brominated haloacetic acids (HAAs), haloacetonitriles, halonitromethanes, haloketones, and nitrosamines are among the most common non-regulated DBPs. Research into these nonregulated DBPs has indicated a potential for greater toxicity than some of the currently regulated DBPs. Since brominated DBPs can be more toxic, USEPA required monitoring for HAA9 under UCMR4. Currently there are no forthcoming changes to DBP regulations, however future regulations could include regulations on groupings of the six brominated HAA species (HAA6Br) and/or all nine HAA species (HAA9). Table 4 outlines the differences between these HAA categories.

TABLE 4: HALOACETIC ACID SPECIES GROUPINGS

HAA Specie	HAA5	HAA6Br	HAA9
Monochloroacetic acid	X		X
Dichloroacetic acid	X		X
Trichloroacetic acid	X		X
Monobromoacetic acid	X	X	X
Dibromoacetic acid	X	X	X
Tribromoacetic acid		X	X
Bromochloroacetic acid		X	X
Bromodichloroacetic acid		X	X
Bromodichloroacetic acid		X	X
Chlorodibromoacetic acid		X	X

2-1-4 NITROSAMINES

Nitrosamines are a group of chemical compounds, a number of which are classified by the USEPA as probable human carcinogens. Nitrosamines are a byproduct of manufacturing products such as rocket fuels, foods, and beverages. They can enter the treatment plant from upstream industrial and wastewater treatment plant discharges. These compounds can also be formed within the treatment plant or distribution system as a byproduct of chloramines and chlorine reacting with organic nitrogen precursors. Nitrosamines can also be an unintentional by-product of quaternary ammonium cationic polymer coagulants during chloramine disinfection.

A total of six nitrosamines were monitored as part of the UCMR2. UCMR2 data indicated that *N*-nitrosodimethylamine (NDMA) is the predominant nitrosamine occurring in drinking water. Further, NDMA was detected three times more frequently in surface waters than groundwaters and ten times more frequently in surface water plants using chloramines as a secondary disinfectant. NDMA was also detected at higher concentrations at maximum residence time locations in the distribution system as compared to entry points.

The USEPA has considered regulating the nitrosamines as a group since most of them have common treatment/control processes and considered setting the maximum contaminant level goal (MCLG) at non-detectable since all the nitrosamines are probable carcinogens. With the publication of the draft CCL5, the USEPA added six of the nitrosamines under the category of unregulated disinfection by-products, five of which were monitored under the UCMR2. The following six nitrosamines are in the draft CCL5:

- Nitrosodibutylamine (NDBA).
- N-Nitrosodiethylamine (NDEA).
- N-Nitrosodimethylamine (NDMA).
- N-Nitrosodi-n-propylamine (NDPA).
- N-Nitrosodiphenylamine (NDPhA).
- Nitrosopyrrolidine (NPYR).

While the USEPA has not yet indicated a timeline or whether it will move forward at all on regulatory action for nitrosamines, the City should be aware that MCLs for these compounds could be established in the future. The City may be impacted by these future MCLs since the SFWPP uses cationic polymers in the treatment process and chloramines as a secondary disinfectant in the distribution system.

Section 3 Water Purification Plant Treatment Evaluation

3-1 Sioux Falls Water Purification Plant Overview

The SFWPP treats both surface water from the Big Sioux River (BSR) as well as groundwater from the City's wellfields. BSR water is first treated using an Actiflo® ballasted flocculation process for solids removal. Actiflo® effluent is blended with groundwater and sent to upflow solids contact basins for conventional lime softening. Softened contact basin effluent goes to recarbonation basins for pH adjustment and then to dual media filters. Final disinfection of filter effluent occurs in the 4-MG clearwell from which finished water is pumped to the North Reservoir for distribution.

Figure Nos. 1 and 2 illustrate the SFWPP treatment process flow schematic and site layout, respectively.

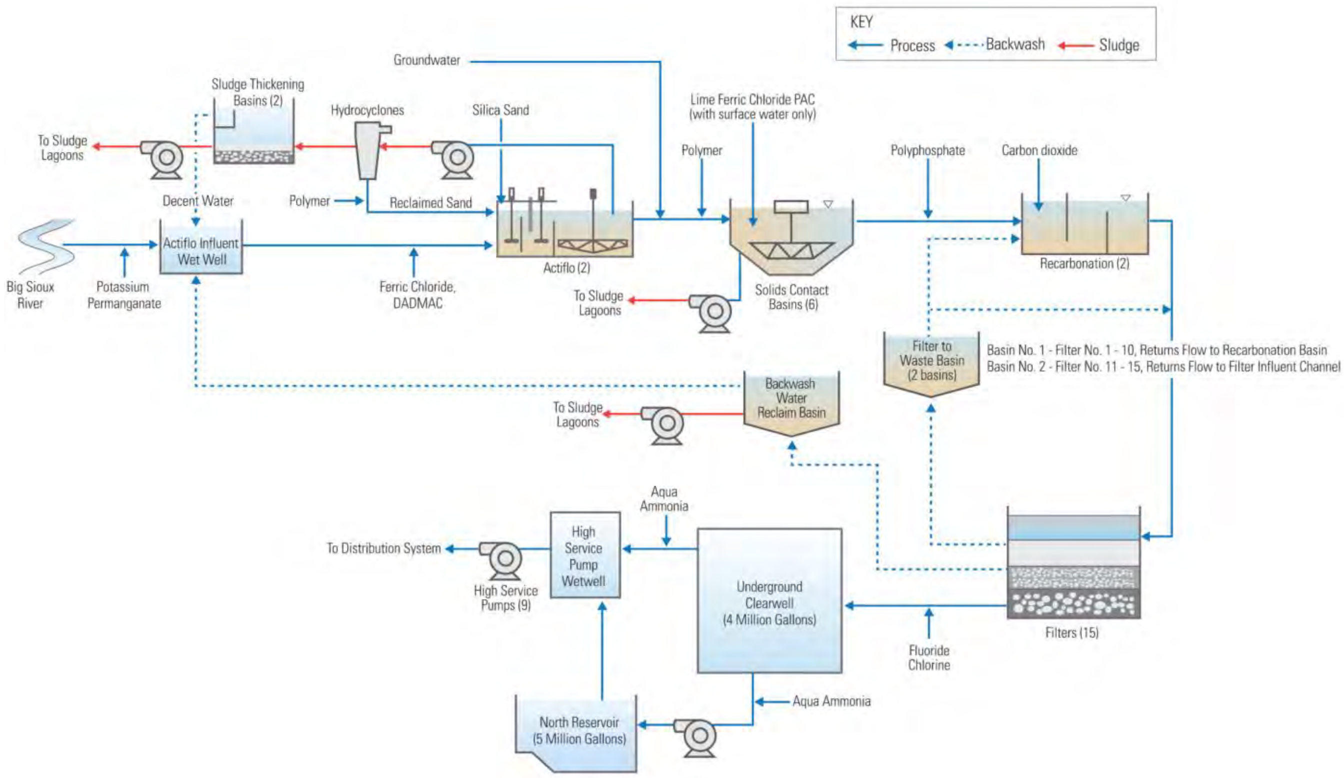


FIGURE 1: SFWPP TREATMENT PROCESS SCHEMATIC

FIGURE 2: SFWPP SITE LAYOUT

Table 5 outlines the water quality for the SFWPP's groundwater and BSR sources.

TABLE 5: SFWPP AVERAGE SOURCE WATER QUALITY PARAMETERS

Parameter	North Wells	South Wells	BSR
pH	7.3	7.3	8.3
Turbidity (NTU)	7.9	8.4	26.6
Temperature (deg C)	12.0	10.5	16.9
Hardness (mg/L as $CaCO_3$)	482.8	505.7	522.5
Ca Hardness (mg/L as $CaCO_3$)	292.7	308.6	272.2
Alkalinity (mg/L as $CaCO_3$)	295.8	307.5	267.6
Total Dissolved Solids (mg/L)	582.5	591.1	647.0
Total Organic Carbon (mg/L)	5.8	5.0	11.8

Per City staff, 52 MGD has been the highest historical flowrate the SFWPP has treated. A maximum treatment capacity of 75 MGD is based on simultaneous operation of all 15 filters (each rated at 5 MGD at a loading rate of 5 gpm/sq ft). This operational approach does not account for at least one filter out of production for backwashing, resulting in a firm capacity of 70 MGD. Additionally, this firm capacity does not account for loses associated with other treatment processes such as Actiflo® and softening (due to approximately 5% water loss in solids removal) and filtration (due to the filter-to-waste process).

3-2 SFWPP Hydraulic Capacity Overview

Hydraulic modeling for the SFWPP was performed using Carollo's Hydraulix® software. The hydraulic calculations account for friction losses in piping, channels, and conduits, as well as minor losses in typical system components (e.g., bends, valves, tees, etc.). A baseline model was established for a 38.5 MGD treatment scenario, which corresponds to the calibrated hydraulic modeling efforts completed by HR Green during a 2008 hydraulic evaluation. The calibration scenario assumes Filter Nos. 1-10 were in operation since Filter No. 11-15 were not constructed until 2009. Actiflo® data was not included in the 2008 hydraulic evaluation and for the purposes of this evaluation it was assumed that the Actiflo® process was operating at its 30 MGD design capacity.

The calibrated baseline model was used to evaluate flowrates of 50, 55, 60, and 75 MGD. Table 6 outlines the assumed operating conditions for each of these baseline modeling scenarios. Note that for all scenarios, the assumed clearwell operating level was 1421.07 feet (11.07-foot operating depth) to match the conditions of the 2008 calibration data. Normally the clearwell is operated at a maximum level of 1420.70 feet (10.70-foot operating depth), so the approach used here provides a safety factor of approximately 4-inches.

TABLE 6: BASELINE HYDRAULIC MODELING ASSUMPTIONS

Parameter	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5
Treatment Plant Flowrate (MGD)	38.5	50.0	55.0	60.0	75.0
Number of Filters in Service	9 (3)	10 (4)	11 (5)	12 (6)	15 (7)
North Filter Flowrate (MGD) (2)	16.9	25.0	30.0	35.0	50.0

Notes:

1) Assumed clearwell operating level is 1421.07. This equates to an operating depth of 11.07 feet.
2) North filters are Filter No. 6 – 15.
3) Scenario 1 filters in service = Filter No. 1 – 6 and Filter No. 8 – 10.
4) Scenario 2 filters in service = Filter No. 1 – 10
5) Scenario 3 filters in service = Filter No. 1 – 11.
6) Scenario 4 filters in service = Filter No. 1 – 12.
7) Scenario 5 assumes all filters are in service.

Figure 3 shows the SFWPP hydraulic profile for the various flowrates modeled. Note that the Actiflo® process was modeled at 30 MGD while the remainder of the treatment plant was modeled at the specified treatment flowrates.

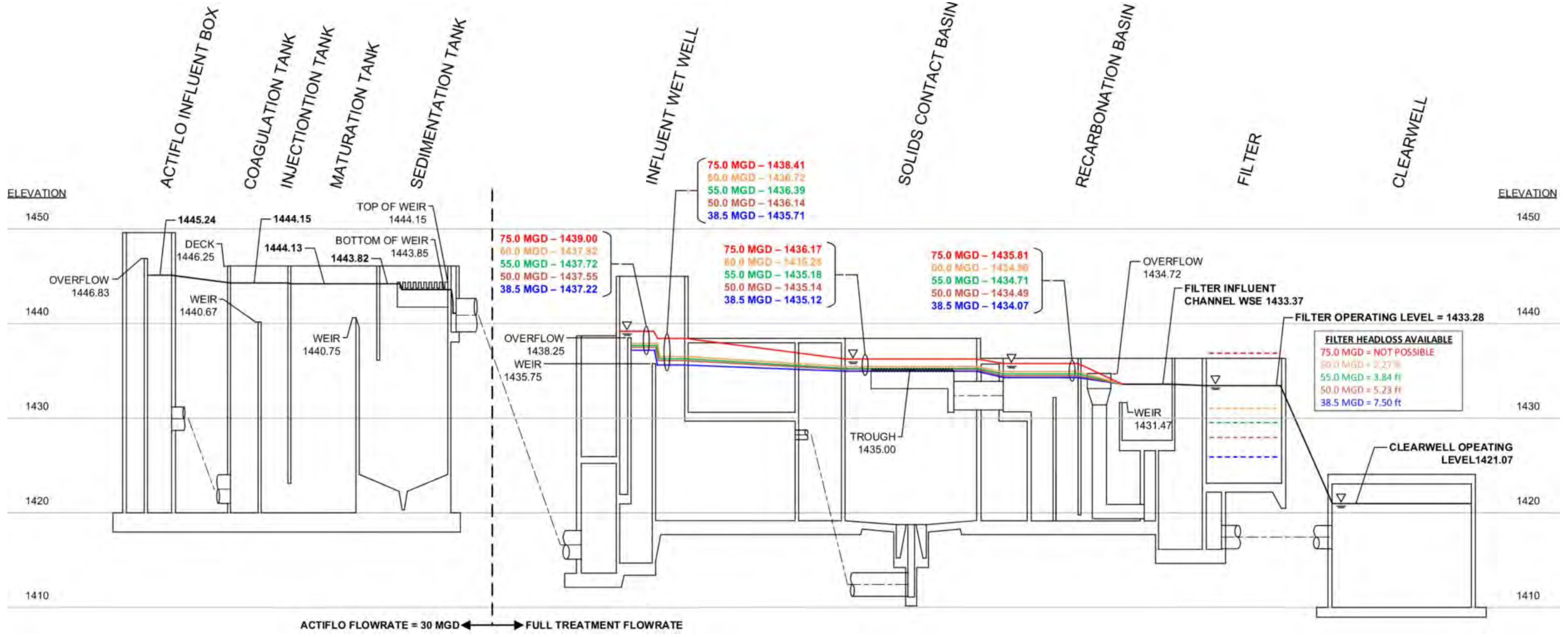


FIGURE 3: SFWPP HYDRAULIC PROFILE

Based on this hydraulic analysis, the SFWPP is currently hydraulically limited to approximately 55 MGD. In order to operate at its design capacity of 75 MGD, improvements are required upstream of the filters to prevent the influent wet wells, solids contact basins, and recarbonation from overflowing. Furthermore, modification of the filter effluent piping is recommended to alleviate the hydraulic restrictions at higher flows and to allow 5-7.5 feet of headloss accumulation in the filters.

3-3 SFWPP Treatment Process Evaluation

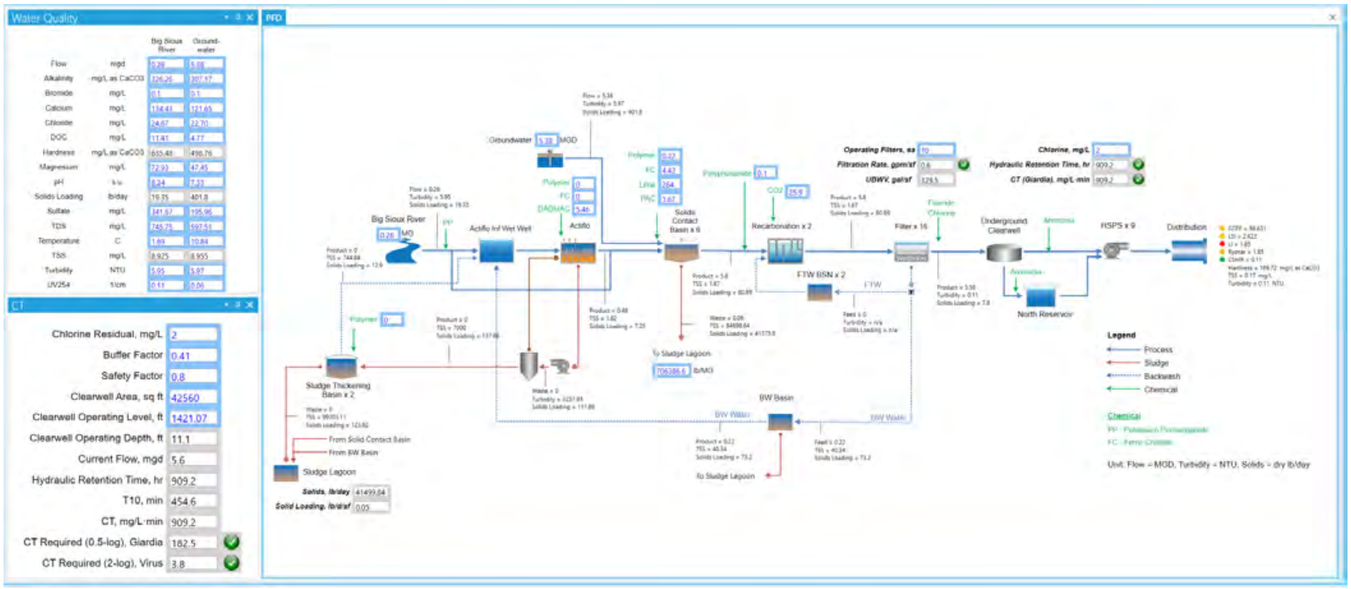
When evaluating the overall capacity of a water treatment plant, both hydraulic limitations as well as treatment process limitations must be considered. The following section describes each treatment process in detail, presents the main contributing factors inhibiting the SFWPP's ability to effectively treat water, and offers proposed treatment and hydraulic modifications to overcome limitations.

The treatment process evaluation utilized Carollo's Blue Plan-it® software for treatment process modeling. Blue Plan-it® is a simulation-based modeling system developed to support decision making efforts. The model can be customized to model different operational scenarios and provide a sensitivity analysis for utility planning purposes.

Two different Blue Plan-it® models were developed for this evaluation:

- A steady state model to simulate water treatment where the user can alter the raw water quality, flow rate, chemical feed, and treatment parameters to assess impacts on solids production, disinfection, and finished water corrosivity.
- A time series model used to simulate different solids production, drying, operations, and lagoon cycling options in order to determine the number of passive lagoons required.

Figure 4 shows the Blue Plan-It® model user interface established for the SFWPP.



		Big Sioux River	Ground-water
Flow	mgd	0.28	5.38
Alkalinity	mg/L as CaCO3	326.26	307.17
Bromide	mg/L	0.1	0.1
Calcium	mg/L	134.43	121.65
Chloride	mg/L	24.67	22.70
DOC	mg/L	11.41	4.77
Hardness	mg/L as CaCO3	635.48	490.76
Magnesium	mg/L	72.93	47.45
pH	s.u.	8.24	7.33
Solids Loading	lb/day	19.35	401.8
Sulfate	mg/L	341.67	195.96
TDS	mg/L	745.75	597.51
Temperature	C	1.69	10.84
TSS	mg/L	8.925	8.955
Turbidity	NTU	5.95	5.97
UV254	1/cm	0.11	0.06

Chlorine Residual, mg/L	2	
Buffer Factor	0.41	
Safety Factor	0.8	
Clearwell Area, sq ft	42560	
Clearwell Operating Level, ft	1421.07	
Clearwell Operating Depth, ft	11.1	
Current Flow, mgd	5.6	
Hydraulic Retention Time, hr	909.2	
T10, min	454.6	
CT, mg/L·min	909.2	
CT Required (0.5-log), Giardia	182.5	✓
CT Required (2-log), Virus	3.8	✓

FIGURE 4: BLUE PLAN-IT USER INTERFACE

3-3-1 Actiflo®

3-3-1-1 PROCESS SUMMARY

Potassium permanganate is added to BSR raw water as an iron and manganese pre-oxidant; this chemical application occurs off-site at the surface water intake. By having the permanganate injection far upstream of the downstream treatment process, a long oxidation reaction time is provided. Once BSR flow reaches the SFWPP, it goes to an inlet wet well for blending with filter backwash waste and decant water from the sludge thickening tanks. Ferric chloride and polydiallyldimethylammonium chloride (polyDADMAC) polymer are injected into the blended Actiflo® feed.

The plant has two parallel Actiflo® (ballasted flocculation process) trains which split flow evenly (15 MGD capacity per train). Actiflo® is a settling process that utilizes silica sand (microsand) and high molecular weight polymer to promote settling. While conventional gravity sedimentation basins are designated with hydraulic surface loading rates of 0.5 to 1.0 gpm/sq ft, Actiflo® settling basins are designed with hydraulic surface loading rates of 20 to 30 gpm/sq ft.

The Actiflo® includes a coagulation tank where the chemicals are mixed into solution, an injection tank where microsand is mixed into the process stream, a maturation tank where settleable floc is formed, and a sedimentation chamber which utilizes lamella tubes to enhance solids settling; settled water is collected via a series of launder troughs. A sludge scraper assembly continually removes settled solids from the bottom of the basin and sludge is pumped to a series of six hydrocyclones (three per train) that separate the microsand from the flocculated sludge. Sand is then recycled back to the maturation tank and the separated sludge is sent to a thickening tank for solids separation; cationic polymer is added to the reclaimed sand slurry prior to recycling it back into the process.

Occasionally, surface water is not available but the Actiflo® system remains in service and treats recycled filter backwash water. When this occurs, the backwash water is recycled into the Actiflo® Train No. 1 coagulation tank to prevent solids from building up in the wet well.

Typically, only one Actiflo® train is operated at a time with both trains having been operated simultaneously once (both operated far below their 15 MGD capacity). Table 7 summarizes the Actiflo® treatment process criteria.

TABLE 7: ACTIFLO TREATMENT PROCESS CRITERIA

Parameter	Unit	Value	Notes
Number of Actiflo® Trains	-	2	
Actiflo® Design Capacity, each Train	MGD	15	30 MGD total
Coagulation Tank Volume, each Train	gallons	23,400	
Coagulation Tank Minimum Retention Time	mins	2.2	At 15 MGD per train
Coagulation Tank Mixer Power	hp	10	
Injection Tank Volume, each Train	gallons	23,400	
Injection Tank Minimum Retention Time	mins	2.2	At 15 MGD per train
Injection Tank Mixer Power	hp	10	
Maturation Tank Volume, each Train	gallons	84,500	

Maturation Tank Minimum Retention Time	mins	8.0	At 15 MGD per train
Maturation Tank Mixer Power	hp	20	
Sedimentation Tank Volume, each Train	gallons	100,200	
Sedimentation Tank Minimum Retention Time	mins	9.6	At 15 MGD per train
Sedimentation Tank Loading Rate	gpm / sq ft	22.1	
Microsand Feed Rate	g/L	3,000 – 6,000	Operations has observed 5-10 lbs of sand loss / MGD treated

3-3-1-2 ACTIFLO® HYDRAULIC CONSIDERATIONS

The hydraulic profile assumes that the Actiflo® process can operate up to its design capacity of 30 MGD (assuming an even flow split between the two trains). The Actiflo® process was designed to operate at 30 MGD, which is the maximum capacity of the process from a hydraulic and process performance perspective.

3-3-1-3 PROCESS LIMITING FACTORS AND IMPROVEMENT RECOMMENDATIONS

Hydraulic Limitations

The Actiflo® basins are designed to treat flows up to 30 MGD, which equals the maximum surface water supply currently available. If additional surface water sources are developed in the future, the SFWPP's surface water treatment capacity will require expansion; options for this are discussed below in the Treatment Expansion Alternatives section of this TM.

Water Rights

The City currently has 30 MGD of BSR water rights. The BSR utilization is typically far below this limit. However, as demands increase in the future, additional surface water may be required to supplement groundwater flow. As previously noted, this will require the SFWPP's surface water treatment to be expanded.

Surface Water Treatment Cost

Operators primarily rely on the groundwater wells to provide base flow at the SFWPP. The amount of BSR water that is utilized is limited to only what is needed to supplement the base flow because surface water treatment costs are 3-4 times higher than the cost of treating groundwater.

3-3-2 Lime Softening and Recarbonation

3-3-2-1 PROCESS SUMMARY

Actiflo® effluent combines with the East and West groundwater headers. Flow in both of these lines is metered and then sent to two influent wet wells (the East groundwater header feeds the South contact basins, and the West header feeds the North contact basins). From the wet wells, water flows through the contact basin influent conduits. Flow splits from these conduits to six up-flow solids contact lime softening basins. Flow to each individual basin is controlled by a modulating butterfly valve. Cationic polymer, ferric chloride, powdered activated carbon (PAC), and lime are added to each basin's influent. The three oldest basins in the South treatment train have influent aeration boxes; influent flow in the North treatment train is directly piped to the contact basins with no upstream aeration. Plant operators report that there is no difference in performance between the basins with and without influent aeration.

The softening process targets calcium and magnesium removal at a pH of approximately 10.4. Operators maintain a sludge blanket depth between six to nine feet in the contact basins, with a target of eight feet. Daily settling tests are manually conducted in graduated cylinders to monitor the sludge blanket in each basin. The SFWPP has the ability to recirculate sludge, but this is normally only performed to accelerate solids formation when a new basin is brought online. During basin startup the pH is increased to accelerate the solids inventory formation.

At the current average flows treated at the SFWPP, only two solids contact basins run concurrently. A third basin is brought online when system demands increase and during periods of low flow only one solids contact basin is used.

Softened water from the contact basins is sent to a series of two recarbonation basins for pH adjustment (one basin for the North treatment train and one for the South treatment train). Polyphosphate is added in this line to prevent scaling in the filters downstream. The recarbonation basins have a series of over/under baffles. Carbon dioxide gas is bubbled through the water column downstream of the over baffles (upstream of the under baffles) to bring the pH down to 8.2. Recarbonation basin effluent flows over a weir into the filter influent conduit.

Figure 5 illustrates shows the treatment schematic for this process.

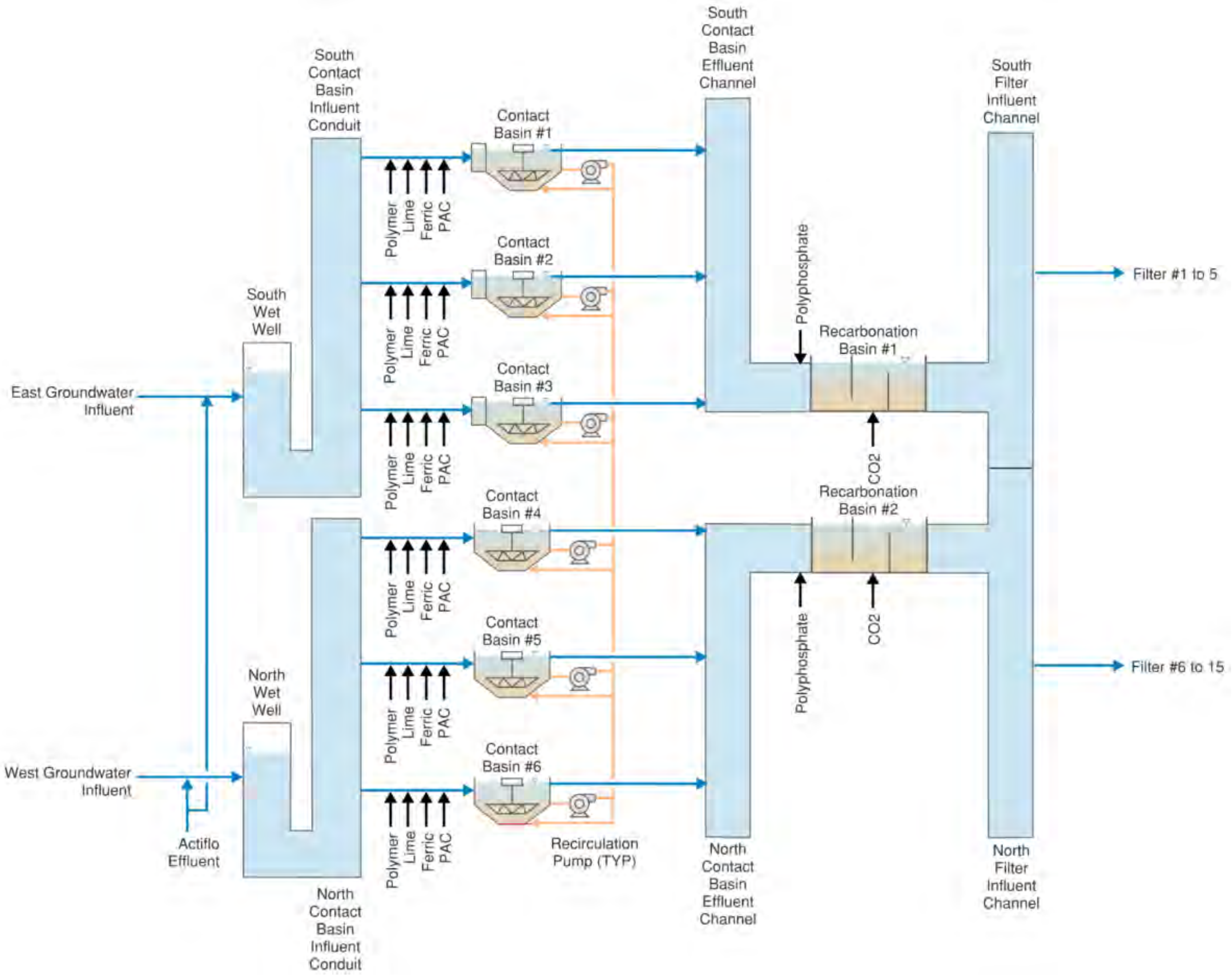


FIGURE 5: SFWPP SOFTENING AND RECARBONATION SCHEMATIC

Treatment process design criteria for the lime softening and recarbonation systems are outlined in Table 8.

TABLE 8: LIME SOFTENING AND RECARBONATION TREATMENT PROCESS CRITERIA

Parameter	Unit	Value	Notes
Lime Softening			
Number of Contact Basins	-	6	
Contact Basin Diameter	ft-in	56"-0"	
Contact Basin Volume, each Basin	gallons	295,000	
Contact Basin Loading Rate @ 55 MGD	gpm / sq ft	2.6	55 MGD split across 6 basins. Additional basins required to treat 75 MGD

Parameter	Unit	Value	Notes
Contact Basin Retention Time @ 55 MGD	mins	46	55 MGD split across 6 basins. Additional basins required to treat 75 MGD
Sludge Blanket Depth	ft	6-9	8 feet is the optimal level, per plant staff
Recarbonation			
Number of Recarbonation Basins	-	2	
Recarbonation Basin Volume, each Basin	gallons	86,300	
Recarbonation Basin Retention Time	mins	3.3	75 MGD split across both basins

3-3-2-2 SOFTENING AND RECARBONATION HYDRAULIC CONSIDERATIONS

The SFWPP can currently operate at flowrates up to 55 MGD. At 60 MGD and above, the recarbonation basins, solids contact basins, and the influent wet wells will overflow. The major area where headloss occurs upstream of the filters is at the under baffle in the recarbonation basins which imparts approximately 2.2 feet of headloss at 75 MGD.

3-3-2-3 PROCESS LIMITING FACTORS AND IMPROVEMENT RECOMMENDATIONS

Carbon Dioxide Gas Inefficiency

Counter current bubble diffuser systems have poorer gas transfer efficiency compared to other forms of gaseous chemical addition. Thus, the use rate of carbon dioxide added to the recarbonation basins is higher than if a carbonic acid solution were used.

Replacement of the existing carbon dioxide bubble diffuser system in the recarbonation basins with a side stream carbon dioxide injection system will improve chemical efficiency. In this scenario, the existing carbon dioxide tanks are maintained and carbon dioxide feed skids and carrier water booster pumps are installed. The skids create a carbonic acid feed solution by dissolving carbon dioxide gas in carrier water which is injected into the main process flow. While this is essentially what currently occurs in the recarbonation basins, the solution skids create the conditions that maximize the gas transfer efficiency. This is a widely used technology with variations on how it is implemented but improved recarbonation will benefit process performance by making the pH control more stable and efficient.

Hydraulic Limitations

As noted above, the biggest hydraulic constraint upstream of the filters is the baffling in the recarbonation basins. The over/under baffles are required for the existing carbon dioxide gas diffuser system in order to provide counter current flow (water traveling down, gas traveling up) which enhances gas transfer efficiency. Utilization of a side stream carbon dioxide injection system allows removal of both baffles thereby reducing headloss by 2.2 feet and allowing the softening and recarbonation processes to operate at 75 MGD without overflowing. Note that even with this hydraulic bottleneck removed, the treatment capacity is limited to 55-60 MGD based on the maximum acceptable surface loading rate for each basin.

Surface Loading Rate

At 75 MGD the surface loading rate of the contact basins is 3.5 gpm/sq ft (assuming an even flow split across all 6 basins; equivalent to 12.5 MGD per basin). Typically, it is recommended to operate these type of softening basins at a maximum of 1.5 gpm/ sq ft, which equates to a total treatment flowrate of 37.2 MGD for the SFWPP (6.2 MGD per basin).

Operators report that the basins can be operate at approximately 7-10 MGD per basin (surface loading rate of 2.8 gpm/sq ft) without a loss in treatment performance. At this rate the maximum treatment capacity of the existing basins is approximately 55 to 60 MGD. Even at the higher loading rates, the softening process must be expanded to treat flows greater than 60 mgd. Treatment expansion options are discussed further in the Treatment Expansion Alternatives section of this TM.

Aging Infrastructure

The north solids contact basins (Basin Nos. 4-6) and recarbonation basin are over 50 years old; the south solids contact basins (Basin Nos. 1-3) are 70 years old. While the basins are still functional, over time the concrete and metal components of those structures have deteriorated. Additional details on the condition of this infrastructure can be found in the SFWPP Condition Assessment TM.

To ensure the solids contact basins can reliably operate into the future these should be refurbished to mitigate the impacts of concrete and metal deterioration. Refurbishing likely entails the following elements:

- Concrete repair and sealing.
- Sandblasting/recoating and/or replacing metal components.
- Gear box replacement.

3-3-3 Filtration

3-3-3-1 PROCESS SUMMARY

Filtration Process

Softened water from the recarbonation basins is sent to a series of 15 filters. Each filter contains two cells separated by a central gullet to collect backwash waste. The oldest filters (Filter Nos. 1-5) were constructed in 1952. Filter Nos. 6-10 were implemented in 1969 with a slightly larger footprint; Filter Nos. 11-15 were constructed in 2010 with an identical footprint to that of Filter Nos. 6-10. Each filter has 20 inches of granular activated carbon (GAC) over ten inches of sand. All filters have nozzle style underdrains (the block underdrains in Filter Nos. 1-10 were replaced in 1994). All filters operate at a constraint rate with flow control provided by modulating valves on each of the filter cell effluent pipes.

Table 9 outlines the filtration treatment process criteria.

TABLE 9: FILTRATION TREATMENT PROCESS CRITERIA

Parameter	Unit	Value	Notes
Number of Filters	-	15	

Number of Cells per Filter	-	2	
Filter No. 1-5 Area, each Filter	sq ft	700.0	
Filter No. 6-15 Area, each Filter	sq ft	712.5	
GAC Depth	inches	20	
GAC Effective Size	mm	0.8	
GAC Uniformity Coefficient	-	2	
GAC L/d Ratio	-	635	
Sand Depth	inches	10	
Sand Effective Size	mm	0.5	
Sand Uniformity Coefficient	-	< 1.4	
Sand L/d Ratio	-	510	
SFWPP Treatment Capacity @ 3 gpm/sq ft	MGD	42	14 filters online, 1 filter offline for backwash
SFWPP Treatment Capacity @ 5 gpm/ sq ft	MGD	70	14 filters online, 1 filter offline for backwash
Empty Bed Contact Time	mins	2.30	

The filters are operated at a maximum loading rate of 3 gpm/sq ft (3 MGD per filter) although the maximum design loading rate is 5 gpm/sq ft (5 MGD per filter). As shown above, with one filter in backwash the maximum treatment capacity at 3 gpm/sq ft is 42 MGD. Operation of the filters at their rated capacity results in a firm treatment capacity of approximately 70 MGD (with one filter offline in backwash mode).

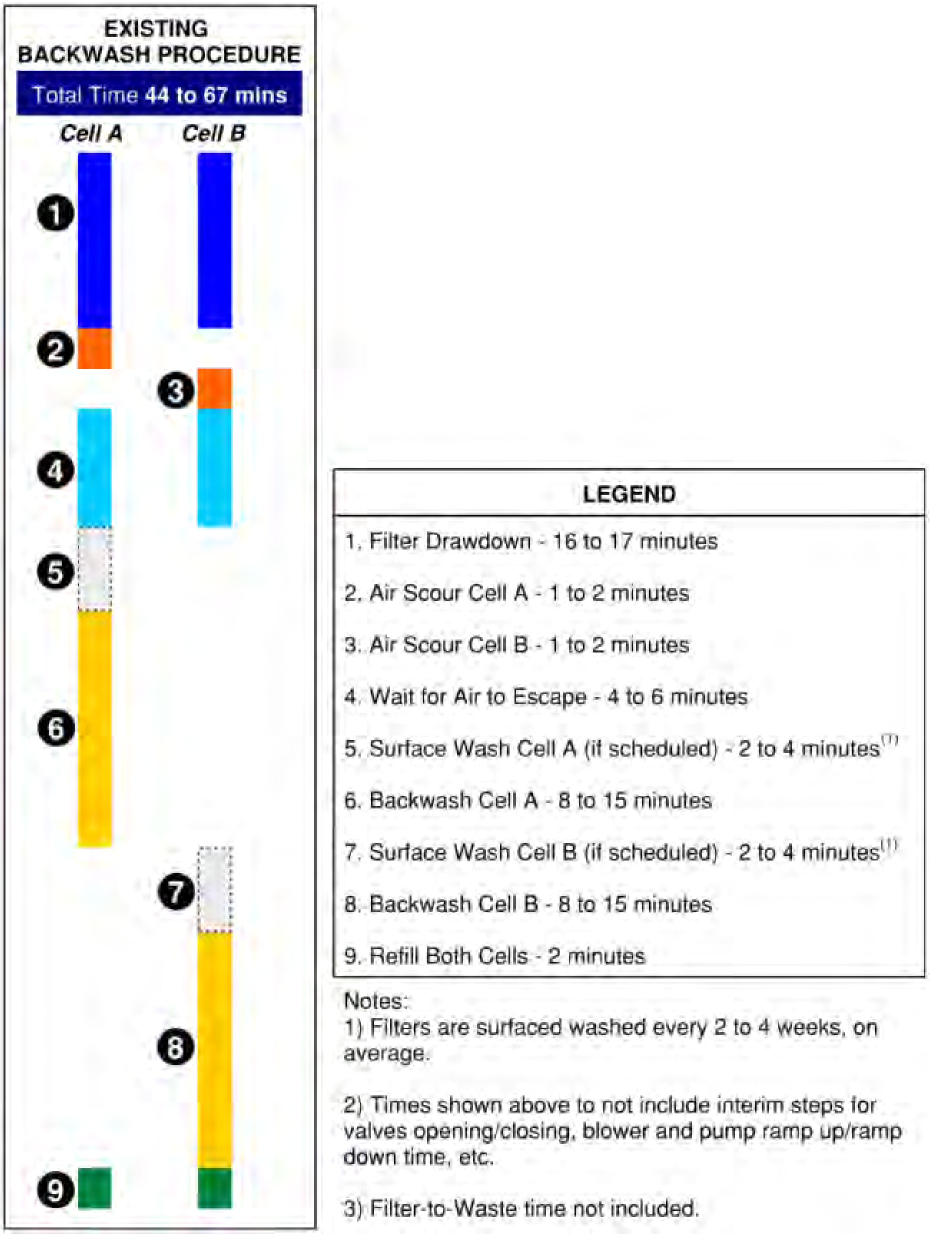
Based on operating data from 2021, the average unit filter run volume (UFRV) is approximately 9,000 gal/sq ft. As shown in Table 10, UFRV is generally higher in the fall and winter and slightly lower in the spring and summer. The industry standard UFRV is approximately 10,000 gal/sq ft. While the SFWPP UFRV values are slightly lower than this, they are still considered acceptable. The average filter runtime is 65 hours with filters typically taken offline when turbidity is roughly 0.1 NTU. Filter headloss accumulation over the course of a filter run is generally 2 – 3 feet. Hydraulic modeling suggests that at a flowrate of 38.5 MGD, the filters should be able to handle up to 7.5 feet of headloss (this is significantly reduced at higher flowrates – see Section 3-2 for additional details).

TABLE 10: FILTER UFRV AND RUNTIME SUMMARY

Season	Avg. UFRV (gal/sq ft)	Avg. Runtime (hours)
Winter (January – March)	9,071	70
Spring (April – June)	8,815	62
Summer (July – September)	8,560	58
Fall (October – December)	9,763	70
Overall Average	9,039	65

__Filter Washing Process__

The SFWPP filter washing process utilizes air scour and surface washing as outlined in Figure 6. Air scour is performed for every wash cycle while surface wash is only done once every 2 to 4 weeks. The facility does not utilize a simultaneous air scour/backwash process. The total backwash time for an individual filter can range from approximately 44 minutes to 67 minutes (not including filter-to-waste time), depending on the duration of each step and whether or not surface wash is performed. Based on operations data from 2021, the average volume of water used per backwash is 244,000 gallons resulting in an average filter efficiency of 96% (not including losses from filter drawdown and filter-to-waste). A summary of the filter washing process criteria is presented in Table 11.



LEGEND

1. Filter Drawdown - 16 to 17 minutes
2. Air Scour Cell A - 1 to 2 minutes
3. Air Scour Cell B - 1 to 2 minutes
4. Wait for Air to Escape - 4 to 6 minutes
5. Surface Wash Cell A (if scheduled) - 2 to 4 minutes(1)
6. Backwash Cell A - 8 to 15 minutes
7. Surface Wash Cell B (if scheduled) - 2 to 4 minutes(1)
8. Backwash Cell B - 8 to 15 minutes
9. Refill Both Cells - 2 minutes

Notes:
1) Filters are surfaced washed every 2 to 4 weeks, on average.

2) Times shown above to not include interim steps for valves opening/closing, blower and pump ramp up/ramp down time, etc.

3) Filter-to-Waste time not included.

FIGURE 6: FILTER WASHING TIMING DIAGRAM

TABLE 11: FILTER WASHING PROCESS CRITERIA

Parameter	Unit	Value	Notes
Number of Backwash Pumps	-	2	
Backwash Pump No. 1 Capacity	gpm	8,500	
Backwash Pump No. 1 Power	hp	150	
Backwash Pump No. 2 Capacity	gpm	6,800	
Backwash Pump No. 2 Power	hp	75	
Maximum Backwash Rate	gpm / sq ft	19 or 24	Rate depends on which pump is used.
Surface Wash Rate	gpm / sq ft	3	Surface wash provided by SFWPP water supply. Surface wash only done periodically.
Number of Air Scour Blowers	-	1	
Air Scour Blower Capacity	scfm	1,280	
Air Scour Blower Power	hp	50	
Air Scour Rate	scfm / sq ft	3	

3-3-3-2 FILTRATION HYDRAULIC CONSIDERATIONS

Table 12 presents the headloss available for solids accumulation in the filters for the baseline modeling scenarios. Note that for all scenarios, it is assumed that the filter operating level is sustained at 1433.28 feet in order to maintain and maximize filter driving head.

TABLE 12: FILTER HEADLOSS AVAILABLE FOR BASELINE HYDRAULIC MODELING SCENARIOS

Parameter	Scenario 1 (38.5 MGD)	Scenario 2 (50.0 MGD)	Scenario 3 (55.0 MGD)	Scenario 4 (60.0 MGD)	Scenario 5 (75.0 MGD)
Filter Headloss Available (ft) (1)	7.50	5.23	3.84	2.27 (2)	N/A (3)

Notes:

1) Assumed filter operating level is 1433.28 feet.
2) At 60 MGD, the solids contact and recarbonation basins upstream overflows. Filter headloss available shown is hypothetical.
3) It is not possible to operate at 75 MGD (headloss accumulation available is negative, indicating the filters cannot operate at their current level for this condition).

Based on an analysis of historic operating data, the filter headloss accumulation rate varies seasonally. The lower the accumulation rate, the longer the potential filter runtime would be. The winter and fall accumulation rates are lower than the spring and summer. This is likely due to water quality characteristics and treatment efficacy of variations in source water blends with the SFWPP treating more surface water during the spring and summer months. The seasonal SFWPP filter headloss accumulation is summarized in Table 13.

TABLE 13: FILTER HEADLOSS ACCUMULATION RATE

Season	Avg. Headloss Accumulation Rate (ft/MG)
Winter (January – March)	0.29
Spring (April – June)	0.42
Summer (July – September)	0.68
Fall (October – December)	0.28
Overall Average	0.42

Figure 7 and Figure 8 show headloss accumulation in an individual filter at flowrates of 3 MGD (current operations) and 5 MGD (maximum condition) per filter, respectively.

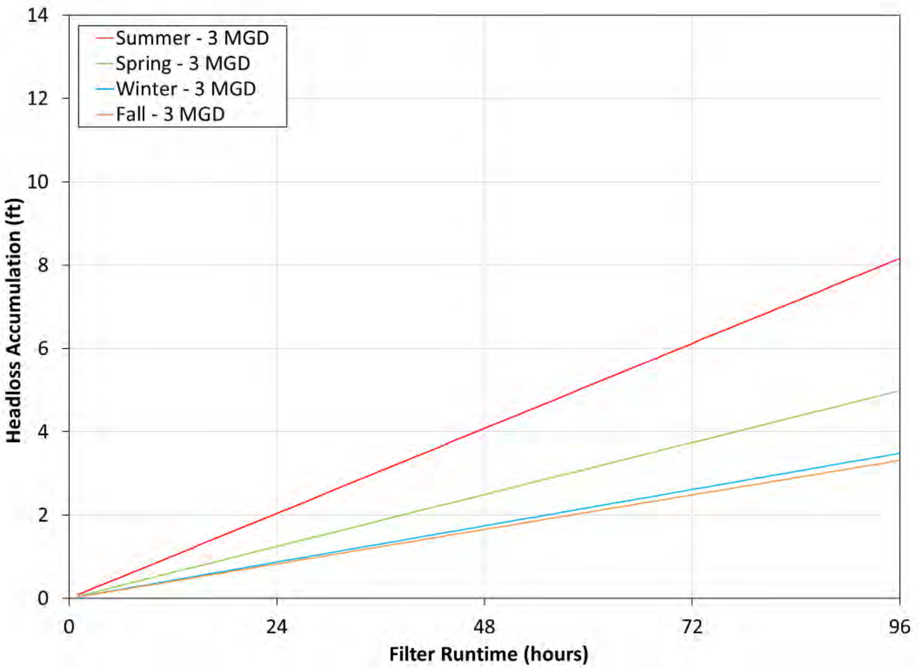


FIGURE 7: SFWPP FILTER HEADLOSS ACCUMULATION AT 3 MGD

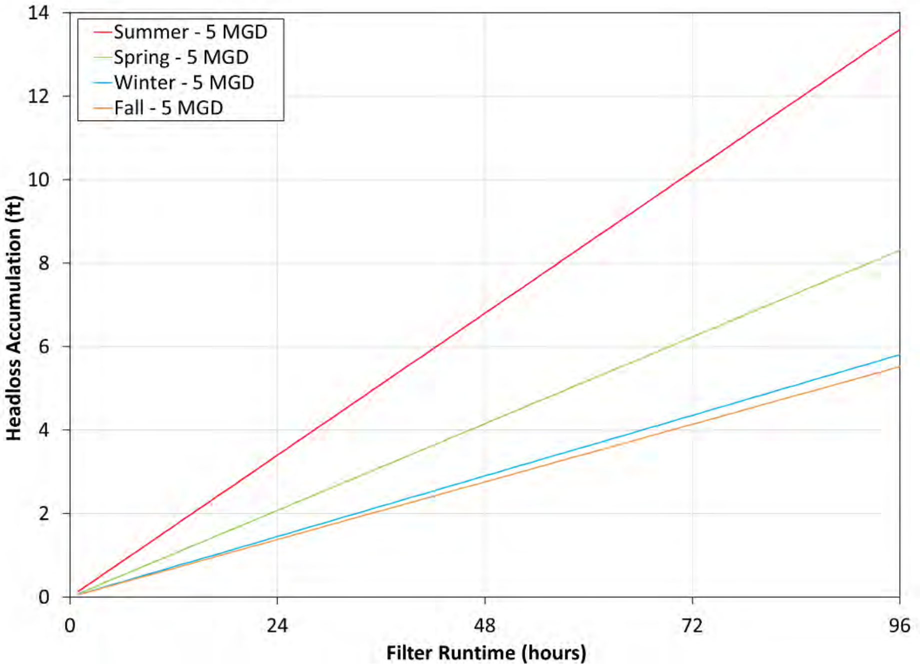


FIGURE 8: SFWPP FILTER HEADLOSS ACCUMULATION AT 5 MGD

Typically, SFWPP filter runtimes are 72 hours or less when operated at 3 MGD. At the higher loading rates (5 MGD per filter), the same amount of water is filtered in 43 hours. At these runtimes, filter headloss accumulation is generally less than four feet, with the exception of summer operating conditions when headloss accumulation is closer to six feet. In order to ensure the facility can operate at 75 MGD without filters stacking up due to high headloss, at least five feet should be available for headloss accumulation. Operation of the filters with approximately 7.5 feet of headloss is recommended to accommodate more challenging summer water quality conditions.

3-3-3-3 PROCESS LIMITING FACTORS AND RECOMMENDATIONS

Hydraulic Limitations

The current configuration of the filter effluent piping does not allow the facility to operate at its design capacity of 75 MGD. As previously noted, filter effluent hydraulic improvements are recommended to allow for 5 - 7.5 feet of headloss accumulation at 75 MGD.The following sections describe a systematic approach to modifying the filter effluent piping to alleviate the hydraulic restrictions.

Improvement 1 – Demolish Clearwell Inlet Orifice Pipe and Static Mixer

The first step in addressing the filter effluent hydraulic restrictions is to demolish the 48-inch clearwell inlet orifice pipe and static mixer and install an energy dissipation plate to prevent water from jetting out the end of the pipe and short-circuiting the disinfection volume. This serves the same purpose as the orifices on the existing discharge pipe but has very low headloss. Figure 9 illustrates Filter Effluent Improvement 1.

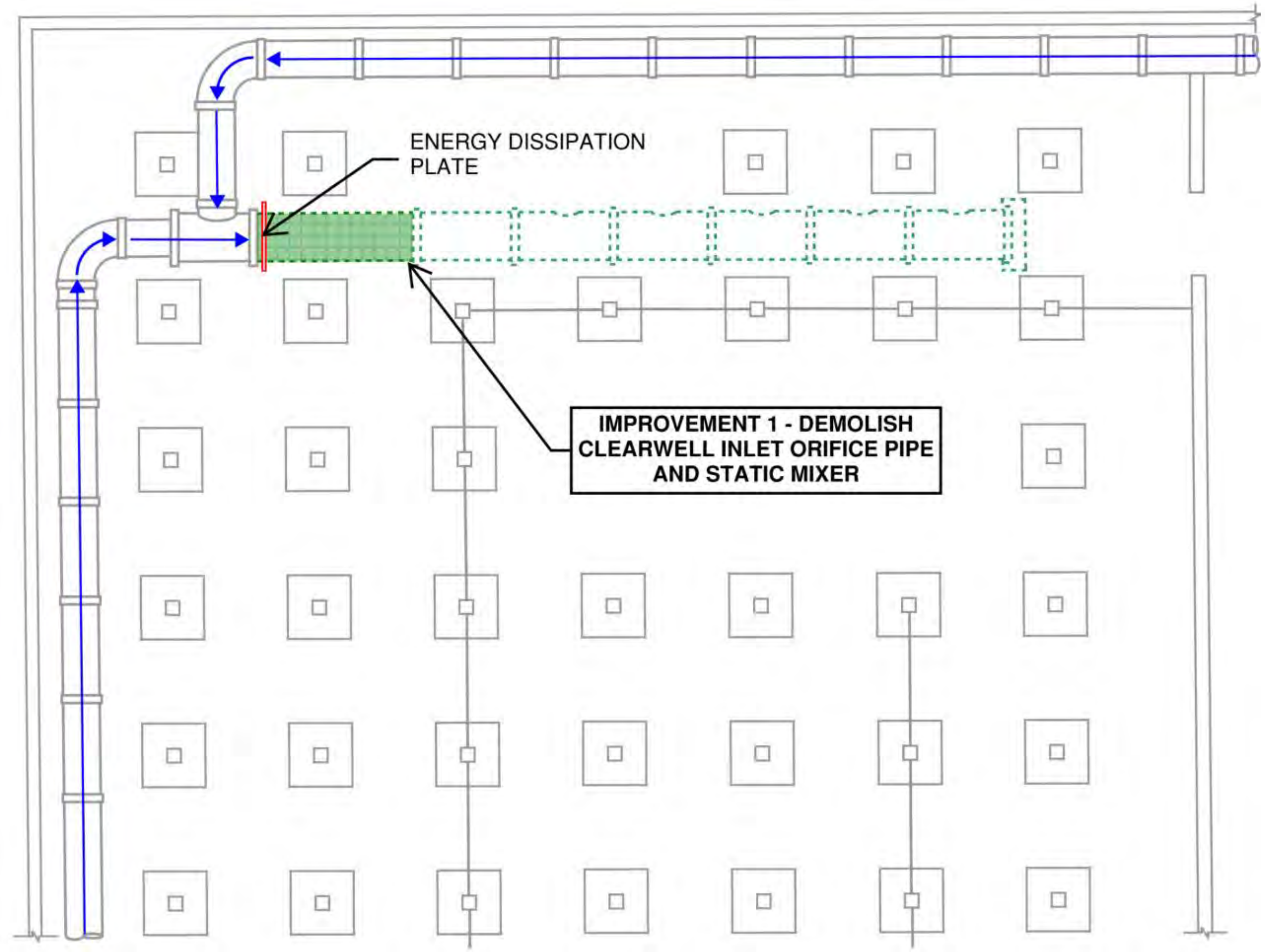


FIGURE 9: FILTER EFFLUENT IMPROVEMENT 1 - DEMOLISH CLEARWELL INLET ORIFICE PIPE AND STATIC MIXER

Removal of the piping elements reduces the headloss in the filter effluent piping by 4.68 feet at 75 MGD. Although this allows the filters to operate at 75 MGD, only 1.20 feet of filter headloss accumulation is available which limits the duration the SFWPP could operate at this flowrate. An alternate means of mixing chlorine and fluoride into solution is recommended to further improve hydraulics. Several low-headloss chemical mixing options are available for implementation including pump diffusion flash mixing and impeller flash mixing.

Improvement 2 – Upsize North Filter Clearwell Inlet Pipe to 48-inches

The second proposed filter effluent improvement is to upsize the clearwell inlet pipe from the north filters from 36-inches to 48-inches, as illustrated by Figure 10.

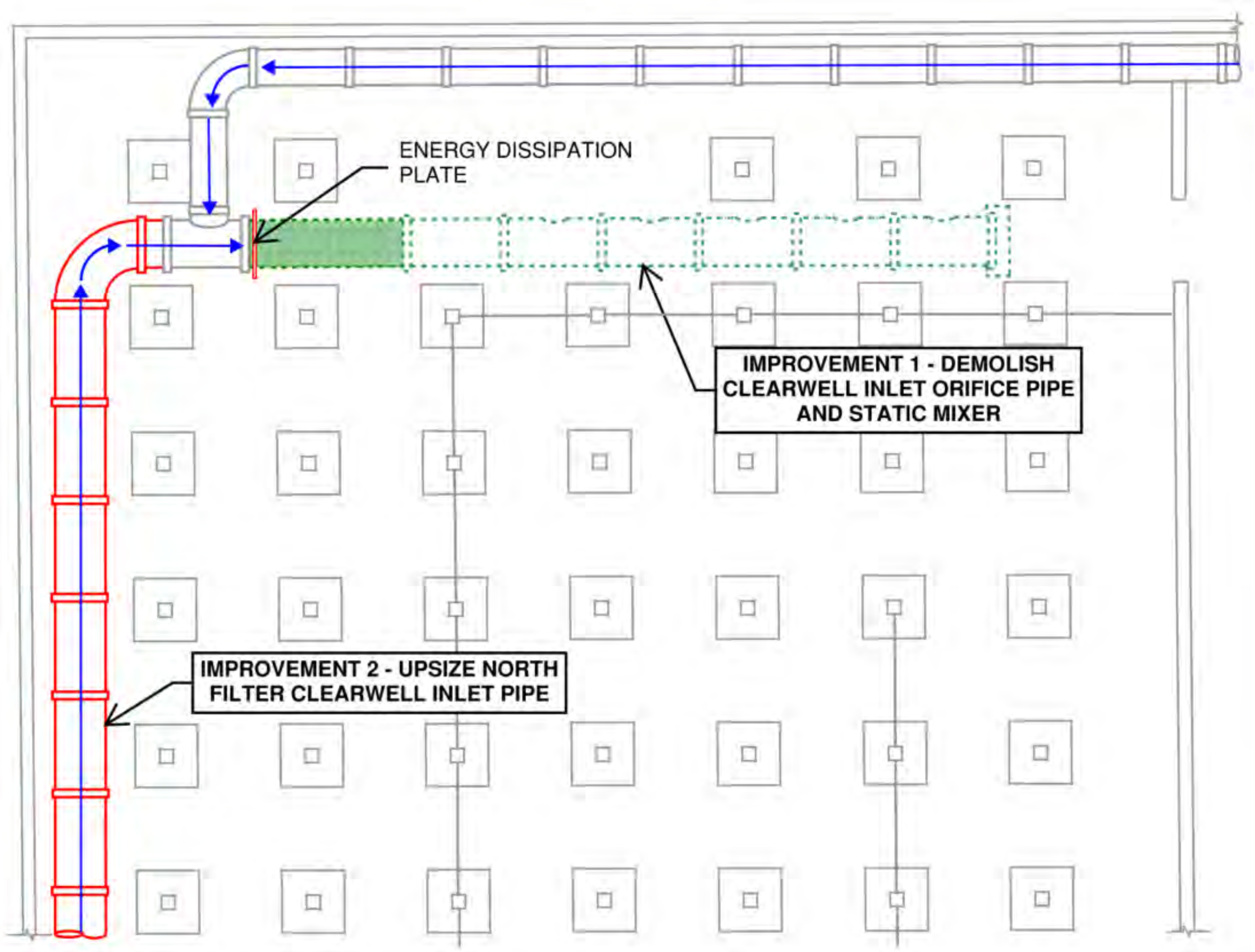


FIGURE 10: FILTER EFFLUENT IMPROVEMENT 2 - UPSIZE NORTH FILTER CLEARWELL INLET PIPE

Implementing Improvements 1 and 2 reduces the headloss in the filter effluent piping by 7.65 feet at 75 MGD, resulting in 4.17 feet of filter headloss accumulation available.

Improvement 3 – Modify Yard Piping from North Filters

Filter Effluent Improvement 3 involves modifying the undersized yard piping from the north filters to the clearwell. Four potential yard piping alternatives are presented below. Each alternative accommodates the potential for a future ultraviolet (UV) disinfection facility.

- Improvement 3A: Construction of a parallel 48-inch pipe
- Improvement 3B: Addition of a 64-inch pipe routed to minimize shutdown time
- Improvement 3C: Removal and replacement of the existing 48-inch pipe with a 64-inch pipe
- Improvement 3D: Construction of a new 64-inch pipe directly from the filter effluent to the clearwell

Figure Nos. 11 through 14 illustrate Improvement 3A through 3D, respectively.

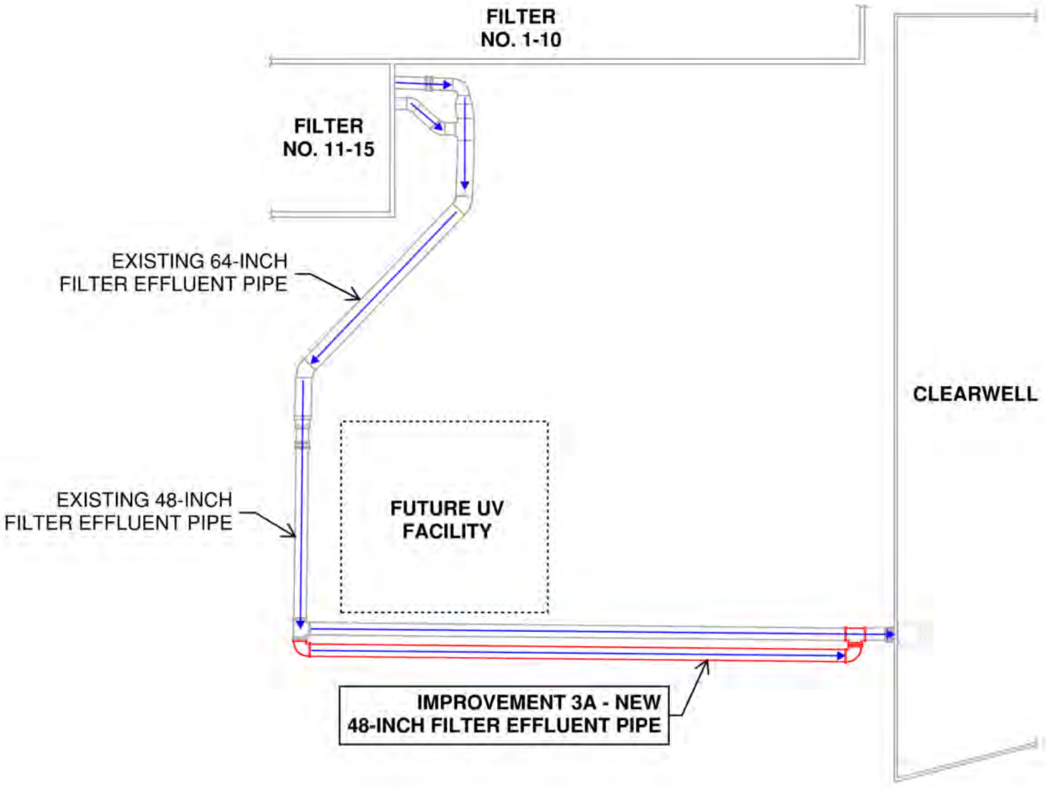


FIGURE 11: FILTER EFFLUENT IMPROVEMENT 3A - PARALLEL 48-INCH FILTER EFFLUENT YARD PIPE

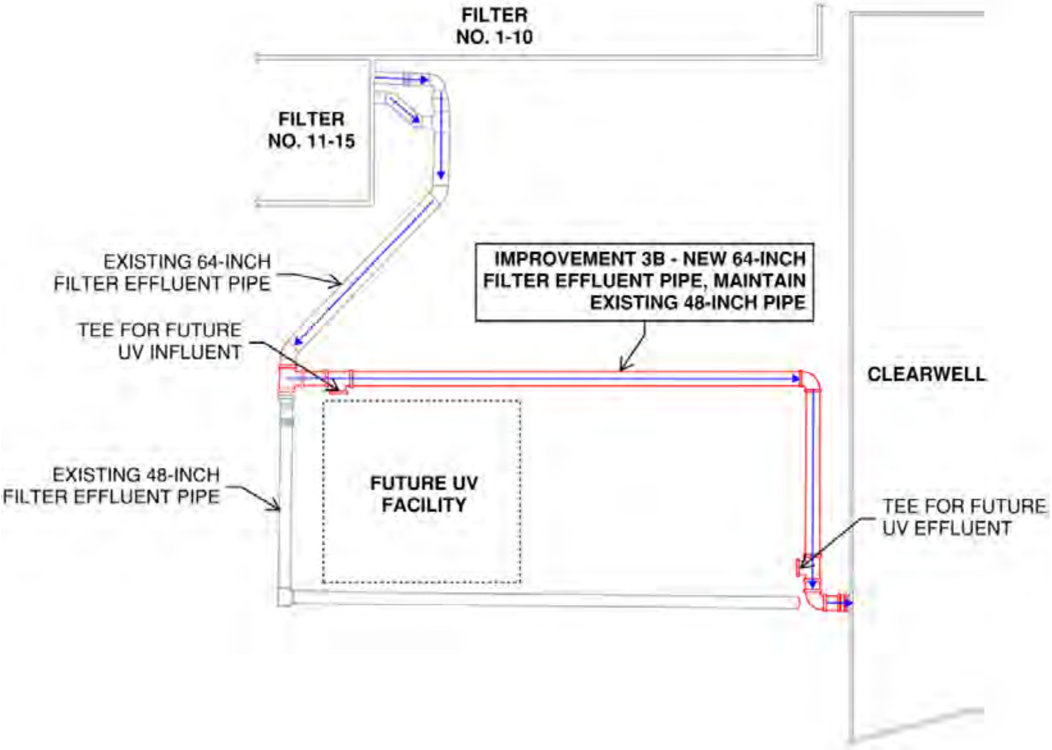


FIGURE 12: FILTER EFFLUENT IMPROVEMENT 3B - 64-INCH FILTER EFFLUENT YARD PIPE, MAINTAIN EXISTING 48-INCH PIPE

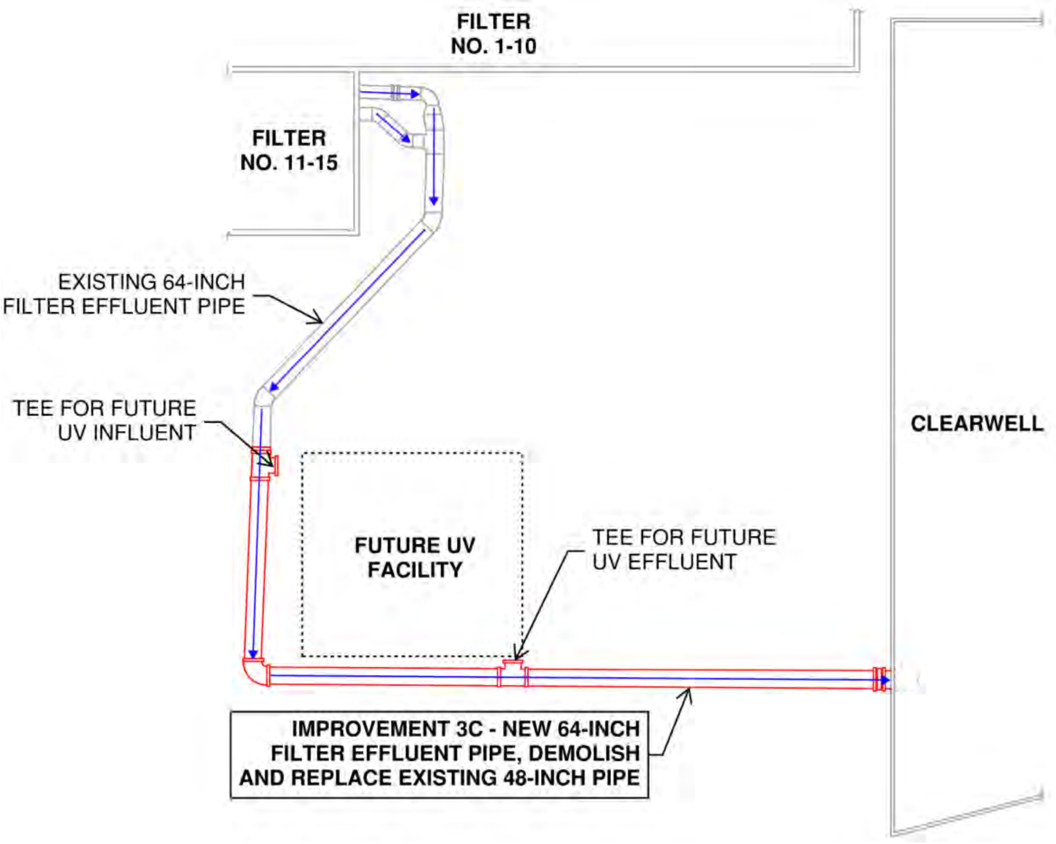


FIGURE 13: FILTER EFFLUENT IMPROVEMENT 3C - 64-INCH FILTER EFFLUENT YARD PIPE, DEMOLISH AND REPLACE EXISTING 48-INCH PIPE

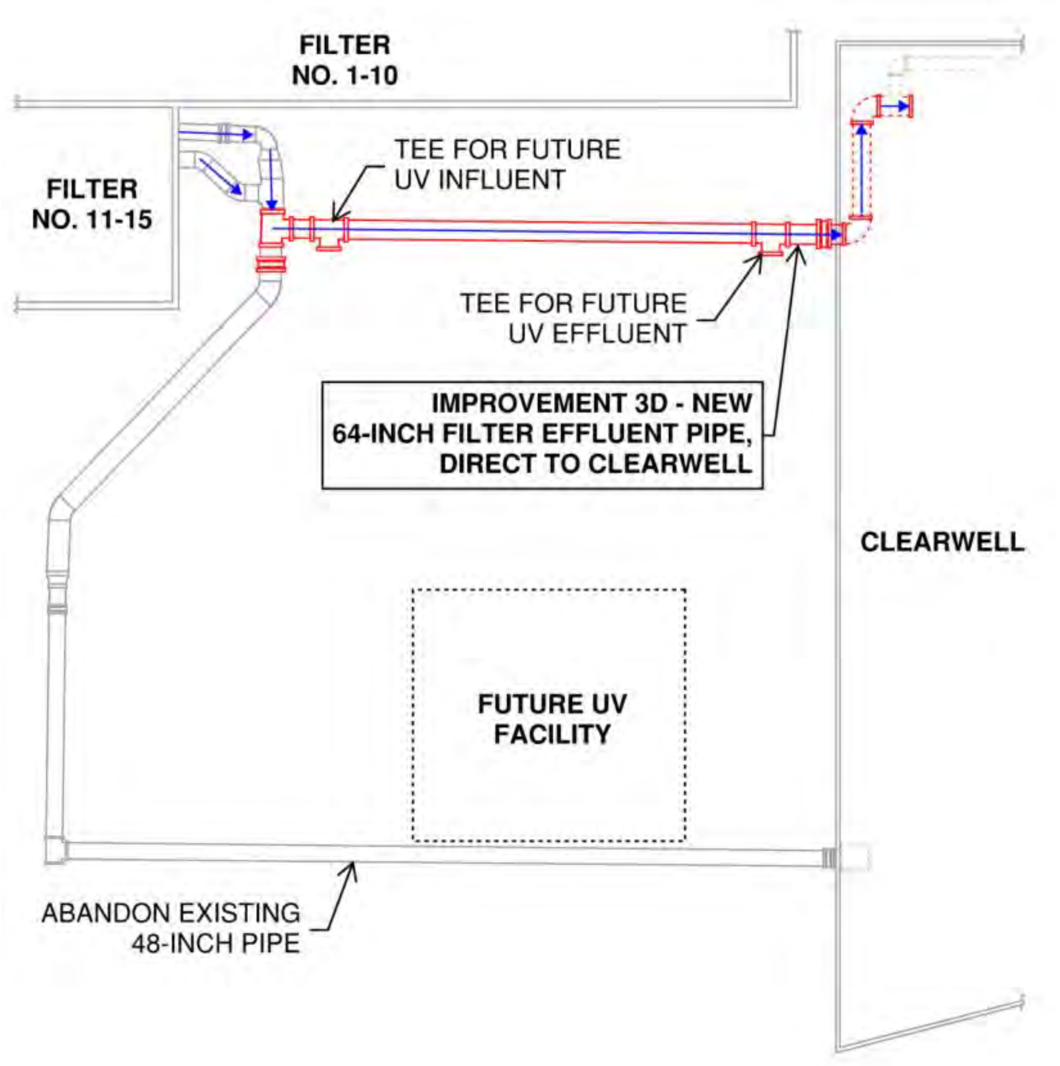


FIGURE 14: FILTER EFFLUENT IMPROVEMENT 3D - 64-INCH FILTER EFFLUENT YARD PIPE ROUTED DIRECTLY TO CLEARWELL, ABANDON EXISTING 48-INCH PIPE

Table 14 summarizes the proposed filter effluent improvements' impact on filter effluent headloss at 75 MGD. Modifications must be made to the filter effluent yard piping (in addition to the Improvement 1 and 2 modifications inside the clearwell) to achieve at least 5 feet of headloss availability. Improvement 3D is the recommended alternative because it is the only option which can achieve 7.5 feet of headloss availability. The City would like to have the ability to bypass the Clearwell and send filter effluent directly to the North Reservoir; currently flo can only be bypassed from Filter No.1 - 5. If the filter effluent piping modifications from Filter No. 6-15 are made, a bypass line could be provided to achieve this. Note that all disinfection contact time (CT) must be achieved in the North Reservoir if the Clearwell is bypassed. Further discussion about this can be found in Section 3-3-4.

TABLE 14: FILTER EFFLUENT IMPROVEMENTS AT 75 MGD

	Improvement 1	Improvement 2	Improvement 3A	Improvement 3B	Improvement 3C	Improvement 3D
Description	Demolish Clearwell inlet orifice pipe and static mixer	Upsize north filter clearwell inlet pipe	Parallel 48-inch filter effluent yard pipe	64-inch filter effluent yard pipe, maintain existing pipe	64-inch filter effluent yard pipe, demolish and replace existing pipe	64-inch filter effluent yard pipe straight to Clearwell
Filter Headloss Available (ft) (1) (2)	1.20	4.17	5.05	6.22	6.45	9.34

Notes:

1) Assumed filter operating level is 1433.28 feet.
2) At 75 MGD, the solids contact and recarbonation basins upstream overflow unless additional improvements are implemented. Filter headloss available shown is hypothetical.

Filter Media Configuration and Biofiltration

The SFWPP filters have 20 inches of GAC and an L/d ratio (defined as the ratio of bed depth to grain size) of 635. The sand layer is 12 inches deep with an L/d ratio of 510. The overall L/d for the filter media is 1145. Typically filters in water treatment plants have L/d ratios of 1000 or higher. While it is not recommended to add additional filter media in the near-term, new media configurations (i.e. more GAC/less sand) and pilot testing (prior full-scale implementation) is a consideration for the future.

In addition to evaluating alternative GAC and sand depths, biofiltration pilot testing is recommended. By allowing the filters to operate biologically, the media replacement frequency could potentially be reduced from the current replacement frequency of every 5 years (based on iodine absorbance levels below 500 mg/g). Biological filtration also helps to reduce Total Organic Carbon (TOC), in particular assimilable organic carbon, which will reduce the DBP formation potential and increase biological stability throughout the distribution system. Although chlorine is not added upstream of the filters, the backwash supply is chlorinated finished water which inhibits biological activity in the filters. To allow the filters to operate biologically, addition of a chlorine quenching chemical such as sodium thiosulfate is required to eliminate the chlorine residual in the backwash supply water.

Air Scour Blower Redundancy

The facility currently has only one air scour blower. Filter washing can occur without air scouring if a blower is out-of-service for repairs; however, this results in less effective wash cycles and shorter filter run times. A second identical air scour blower is recommended to ensure air scouring can be performed every wash cycle without the risk of the blower being out of service.

Process Optimization – Filter Washing

There are opportunities to optimize filtration operations by reducing the filter wash times. Rather than waiting for air to escape after the air scour step, a simultaneous air/backwash step could be utilized. In this scenario, water in the filter box rises to a certain level, the blower is shut off, and the backwash pumps continue to operate. Ideally, this level is a certain distance below the top of the backwash troughs to prevent media loss. Another potential means to optimize filtration operations includes discontinuing the periodic surface wash process to reduce the wash cycle time and minimize water loss. Since the periodic surface wash may break up scaling that occur during periods of ineffective recarbonation, evaluation of this change should be conducted on a single filter. If the additional washing of the top several inches of media benefits from the surface wash step, elimination of the surface is not recommended. A review of the surface wash feature can be addressed during future modifications of the filters and/or installation of additional filters.

3-3-4 Disinfection

3-3-4-1 PROCESS SUMMARY

Filter effluent is sent via two lines (one from Filter No. 1-5 and one from Filter No. 6-15) to a 4-MG clearwell for disinfection. These two pipes combine within the basin where a chlorine solution and fluoride are injected. Flow is then sent to a static mixer and ultimately discharged to the clearwell. In 2001, baffle curtains were added to the interior of the clearwell to increase the baffle factor of the basin to 0.41.

Downstream of the clearwell, ammonia is added to form a chloramine residual for secondary disinfection in the distribution system.

Table 15 outlines the disinfection treatment process criteria. The chlorine concentration x time (CT) value required is based on achieving 0.5-log *Giardia* inactivation under worst-case operating conditions with a pH of 8.2 (the recarbonation basin effluent pH target), temperature of 5 degrees Celsius, and a free chlorine residual of 2.0 mg/L.

TABLE 15: DISINFECTION TREATMENT PROCESS CRITERIA

Parameter	Unit	Value	Notes
Clearwell Operating Depth	ft-in	13'-4"	Maximum operating level
	ft-in	10'-8"	Typical operating level
Clearwell Operating Volume	gallons	4,211,000	At maximum operating level
	gallons	3,360,000	At typical operating level
Clearwell Theoretical Retention Time	mins	80.8	At 75 MGD and maximum operating level
	mins	64.5	At 75 MGD and typical operating level
Clearwell Baffle Factor	-	0.41	
CT Required	mg-min/L	44.5	For 0.5-log *Giardia* inactivation, based on worst-case operating conditions: pH = 8.2; Temperature = 5.0 degrees Celsius; Cl_2 residual = 2.0 mg/L

3-3-4-2 Process Limiting Factors and Improvement Recommendations

Clearwell Baffle Factor

The SFWPP must provide 0.5-log *Giardia* inactivation and 2-log virus inactivation through disinfection downstream of filtration (2.5-log *Giardia* and 2-log virus removal credit is provided by the conventional filtration process). *Giardia* requires much higher CT values compared to virus inactivation with the current system configuration. As previously noted, at a finished water pH of 8.2, chlorine residual of 2.0 mg/L, and temperature of 5 degrees Celsius (as a worst-case scenario), the CT required for 0.5-log *Giardia* disinfection is 44.5 mg-min/L. Figure 15 shows the CT achieved for these conditions at various process flowrates and with the current and improved baffling factors of 0.41 and 0.5, respectively.

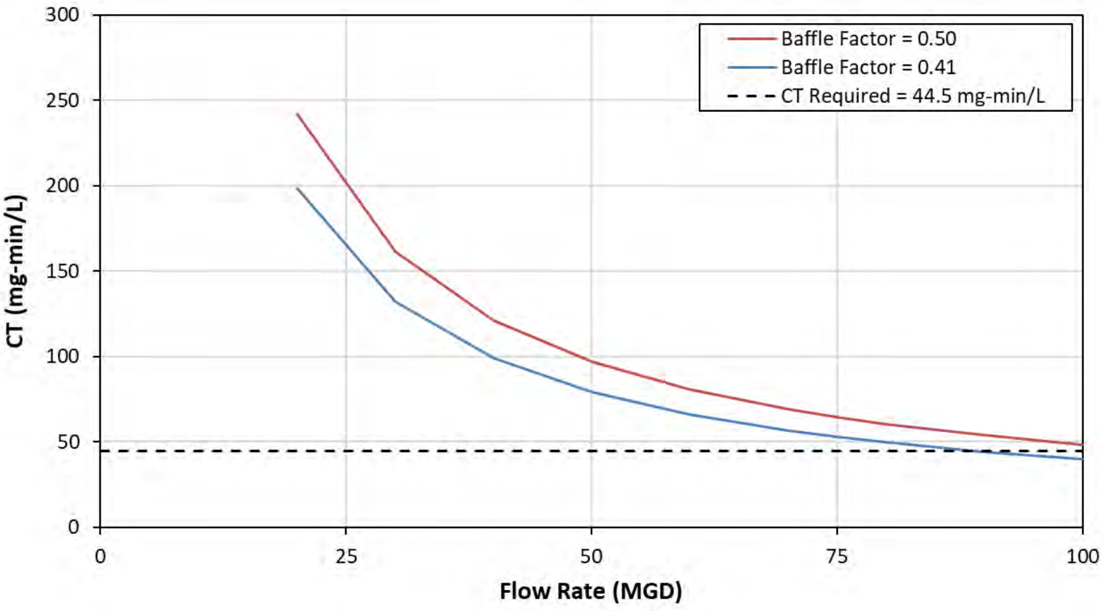


FIGURE 15: SFWPP DISINFECTION EVALUATION (PH = 8.2, CL2 = 2.0 MG/L, TEMPERATURE = 5 DEG C)

Under these conditions, the SFWPP can achieve the required CT with its current baffling factor of 0.41, but with a small margin of safety. Modifications to slightly increase the baffling factor to 0.5 provides a 45% safety factor and allows for more flexible disinfection process operations (lower clearwell operating level, higher pH, lower chlorine residual, etc.).

As part of the overall goal of increasing the maximum treatment capacity of the SFWPP to 75 MGD, baffling modifications are recommended to increase the baffling factor to 0.5 or greater to achieve CT. The exact configuration of the improvements required to achieve the improved baffling factor include the addition of an energy dissipation mechanism at the clearwell inlet and additional baffle partitions within the clearwell.

A computational fluid dynamics (CFD) study is recommended to analyze baffling strategies. CFD allows for baffle factors to be evaluated and optimized on numerous alternative configurations without the need for a full-scale tracer study. The CFD study should also include an evaluation of the North Reservoir to evaluate the potential to bypass the Clearwell and achieve all required CT in this structure; this evaluation should assess the current baffle factor for the tank as well as alternatives for increasing the baffle factor to ensure adequate CT can be achieved under all water quality and treatment flowrate conditions.

UV Disinfection

An alternative disinfection approach to free chlorine involves UV disinfection upstream of the clearwell to achieve *Giardia* inactivation (free chlorine in the clearwell would still be used for virus inactivation). While UV is a very effective disinfection technology, there are several major drawbacks for implementation at the SFWPP. As noted above, the current clearwell disinfection scheme is capable of handling 75 MGD under worst-case water quality conditions. The recommendation to increase the baffle factor to 0.5 is a low-cost improvement providing an improved safety factor.

Constructing a new UV facility costs substantially more and only marginally enhances the facility's treatment resiliency. Furthermore, adding UV disinfection increases headloss. As previously discussed, the filter effluent headloss is a major hydraulic bottleneck for the SFWPP's hydraulic treatment capacity. Adding additional headloss to this system offsets the proposed filter effluent hydraulic improvements.

The major benefit to implementing UV at the SFWPP is the ability to achieve higher levels of *Cryptosporidium* inactivation should the City's bin classification change in the future. At this time, UV disinfection is not recommended for the SFWPP; however, proposed near-term improvements should continue to ensure future implementation of UV if required (providing piping tie in locations, keeping area on the site available, etc.).

Nitrosamine Formation Potential

As previously discussed, future regulation of NDMA and other nitrosamine species by the USEPA is possible. The use of chloramines for distribution system residual has been associated with higher levels of NDMA detected in drinking water distribution systems. In the interim, assessment of formation potential is recommended, if the City has not previously collected data on nitrosamine formation. Additionally, biological filtration can support the reduction in DBP precursors, including nitrosamines.

3-3-5 Solids Handling

3-3-5-1 PROCESS SUMMARY

Residuals are generated by several of the treatment processes at the SFWPP including coagulant sludge from the Actiflo® process, lime sludge from the solids contact basins, filter backwash water, and filter-to-waste water. A portion of the water from each of these streams is reclaimed and recycled back into the process. Ultimately, all residuals are sent through an 8-inch pipe to a series of five off-site sludge lagoons that are located one mile east of the treatment plant as shown in Figure 16.

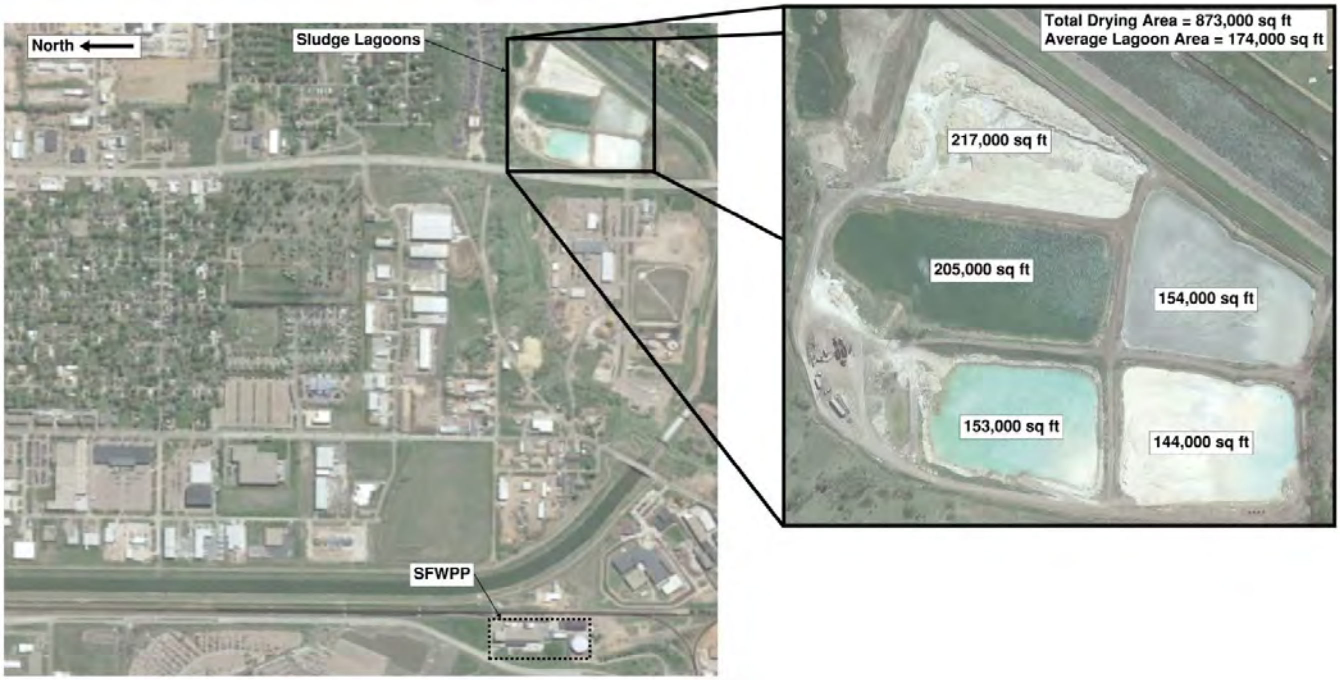


FIGURE 16: SOLIDS DRYING LAGOONS

The lagoons are filled one at a time until the residuals reach the discharge pipe; it typically takes one year to fill a lagoon. Decant is pumped to the wastewater treatment plant; however, decant flows are limited to a maximum flowrate of 250 GPM and are only pumped when heavy rains are not in the forecast. During winter months, water is not decanted due to freezing, so a spare lagoon is required until decanting operations can resume. Once full, a lagoon will sit for approximately two years for drying. Dry solids are removed from the lagoon by a contractor and land applied for agricultural purposes.

Carollo's Blue-Plan-it® software was used to model SFWPP solids production and lagoon cycling to determine when this process may limit overall treatment capacity. Table 16 summarizes monthly operating data parameters contributing to solids production as well as the estimated monthly unit solid production rates (USPR) for the SFWPP based on operating data from 2016-2021. A majority of the solids production originates from the softening process. Based on current operations, the sludge lagoon loading rate is approximately 145 lb/sq ft/year.

TABLE 16: SFWPP SOLIDS PRODUCTION SUMMARY

Month	BSR Hardness (mg/L as $CaCO_3$)	GW Hardness (mg/L as $CaCO_3$)	Effluent Water Hardness (mg/L as $CaCO_3$)	Polymer Dose (mg/L)	Ferric Chloride Dose (mg/L)	PAC Dose (mg/L)	Softening USPR (lb/MG)	Total USPR (lb/MG)
January	653	518	187	0.21	8.3	1.9	7,800	8,000
February	662	520	179	0.16	5.0	1.1	7,900	8,400
March	638	507	181	0.19	2.7	0.8	7,700	7,800

April	534	491	174	0.12	2.6	1.0	7,500	7,800
May	539	482	174	0.18	2.3	0.0	6,900	7,400
June	548	491	203	0.25	2.6	4.0	6,400	6,500
July	472	488	205	0.27	5.6	4.1	5,700	5,800
August	456	476	187	0.24	4.4	1.8	5,500	5,600
September	453	474	187	0.66	4.2	6.8	5,800	6,000
October	527	480	177	0.16	3.0	0.0	7,000	7,100
November	618	494	177	0.17	5.5	2.9	7,400	7,700
December	635	498	178	0.22	4.4	3.7	7,300	7,500

Actiflo® Sludge

Sludge from the Actiflo® process settles in the sedimentation basins of each treatment train, is collected by scrapers, and then pumped to a series of hydrocyclones which separate microsand from residual sludge. The reclaimed microsand is recycled back into the Actiflo® process and the sludge is sent to a series of two sludge thickening tanks. Thickened sludge from the bottom of these tanks is pumped to the off-site lagoons while decant water goes to a collection trough where it is directed back to the Actiflo® influent wet well.

Solids Contact Basin Sludge

Each contact basin has a scraper which collects settled lime sludge in the center hopper of each clarifier. Collected sludge is pumped directly from the basins to the off-site sludge lagoons. Because this process generates the largest amount of solids, it is given priority for utilizing the 8-inch pipeline to the lagoons.

Filter Backwash Water

Filter backwash water is collected and sent to the backwash water reclamation basin. This structure is partitioned into two independent passes such that influent flow goes through the west half first where solids settle out of solution. The west half of the structure has two chain and flight sludge collectors and a cross collector at the north end to move settled solids into a collection sump where two sludge pumps are used to send the residual solids to the off-site lagoons. At the south end of the basin, decant flow turns around the partition wall to the east half of the structure where it is pumped back into the treatment process. Figure 17 shows the equipment within the backwash water reclamation basin.

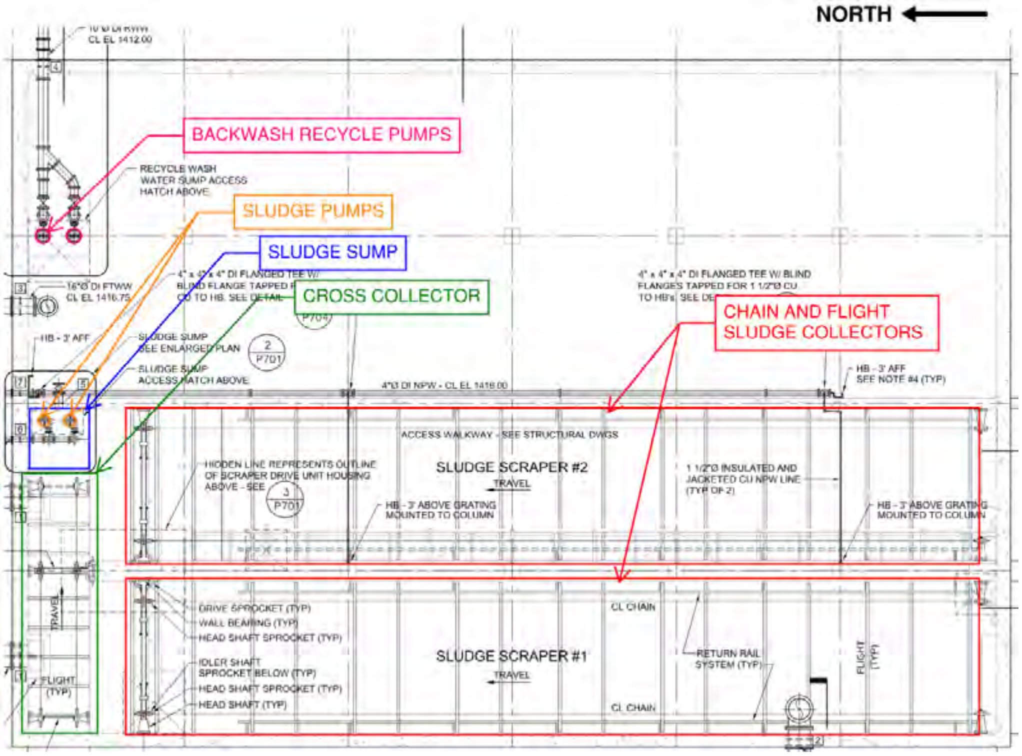


FIGURE 17: BACKWASH WATER RECLAMATION BASIN

If surface water from the BSR is being treated, flow is returned to the Actiflo® influent wet well. However, if the BSR is not being used, water is sent to the Actiflo® Train No. 1 coagulation tank to prevent solids build up in the wet well. Reclaimed backwash water can also be pumped directly to the lagoons and not recycled through Actiflo®.

Filter-to-Waste

The SFWPP has two basins for collecting and recycling filter-to-waste flows. Filter-to-waste flow from Filter Nos. 1-10 goes to Filter-to-Waste Basin No. 1, which is under the facility's auditorium in the administration area. From here water is pumped to the south recarbonation basin influent channel. Filter-to-waste flow from Filter Nos. 11-15 goes to Filter-to-Waste Basin No. 2 on the northern end of the site. Water from this tank is recycled to the north filter influent channel (this stream bypasses the recarbonation process). Although not currently practiced, filter-to-waste from Filter Nos. 11-15 can also be sent to the eastern half of the Backwash Water Reclamation Basin and recycled to the Actiflo® process.

Table 17 outlines the residuals handling process design criteria for the SFWPP. Figure 18 shows one of the solids contact basin sludge pumps.

TABLE 17: RESIDUALS HANDLING PROCESS CRITERIA

Parameter	Unit	Value	Notes
Actiflo®			
Number of Sand-Sludge Pumps, per Train	-	3	

Sand-Sludge Pump Capacity, Each	gpm	156	
Number of Hydrocyclone Units, per Train	-	3	
Sand Discharge Rate, each Hydrocyclone	gpm	22	
Sludge Discharge Rate, each Hydrocyclone	gpm	88	
Number of Sludge Thickening Tanks	-	2	
Sludge Thickening Tank Volume, each Tank	gallons	199,000	
Number of Thickened Sludge Pumps	-	2	
Thickened Sludge Pump Capacity	gpm	TBD	
Thickened Sludge Pump Power	hp	40	
Solids Contact Basins			
Number of Sludge Pumps, per Train	-	1	
Sludge Pump Capacity, Each	gpm	TBD	
Sludge Pump Power, Each	hp	30	
Filter Backwash Water			
Typical Backwash Volume	gallons	244,000	
Backwash Water Reclamation Basin Volume	gallons	450,000	
Number of Reclaim Washwater Pumps	-	2	
Reclaim Washwater Pump Capacity (one Pump)	gpm	700	
Reclaim Washwater Pump Capacity (two Pumps)	gpm	1100	
Reclaim Washwater Pump Power, each Pump	hp	25	
Number of Reclamation Basin Sludge Scrapers	-	2	Chain and flight style
Reclamation Basin Sludge Scraper Power, Each	hp	0.5	
Reclamation Basin Cross Collector Power	hp	0.5	
Number of Reclaim Washwater Sludge Pumps	-	2	
Reclaim Washwater Sludge Pump Capacity, each Pump	gpm	TBD	
Reclaim Washwater Sludge Pump Power, each Pump	hp	40	
Filter-to-Waste			
Filter-to-Waste Basin No. 1 Volume	gallons	107,000	
Filter-to-Waste Basin No 1 Number of Pumps	-	2	
Filter-to-Waste No. 1 Pump Capacity, each Pump	gpm	TBD	
Filter-to-Waste No. 1 Pump Power, each Pump	hp	7.5	
Filter-to-Waste Basin No. 2 Volume	gallons	240,000	
Filter-to-Waste Basin No 1 Number of Pumps	-	3	
Filter-to-Waste No. 2 Pump Capacity, each Pump	gpm	600	
Filter-to-Waste No. 2 Pump Power, each Pump	hp	15	

FIGURE 18: BACKWASH WATER RECLAMATION BASIN 3-3-5-2 PROCESS LIMITING FACTORS AND IMPROVEMENT RECOMMENDATIONS

Sludge Pipeline Capacity

The pipeline to the lagoons has a limited capacity, thus only solids from one process can be pumped at a time. The order of priority for sending solids through the pipeline to the lagoons is: 1) lime sludge from the solids contact basins, 2) coagulant sludge from Actiflo®, and 3) settled backwash water solids (filter-to-waste does not generate a large amount of residual solids). Decant water from the lagoons is sent to the wastewater treatment plant.

Capacity of the pipeline is not currently a limiting factor for the SFWPP. However, at future higher flowrates the need for sending residuals to the lagoons from multiple processes simultaneously will be necessary. Installation of a larger parallel line from the SFWPP to the lagoons is recommended to provide redundancy and additional capacity.

Sludge Drying

As previously noted, it is estimated that the lagoons are currently loaded at approximately 145 lb/sq ft. It is typically recommended to layer lime softening sludge at a maximum of 12 lb/sq ft to ensure effective drying. By overloading the sludge basin far beyond this threshold, it is likely that drying is inhibited which likely explains the 2-year period currently required for drying.

Carollo's Blue-Plan-it® lagoon cycling model was used to evaluate solids drying capacity for current and future conditions using current plant operations. The model was first calibrated to match current operations (one year fill/two year drying cycle) with the USPR values previously shown in Table 16. The calibrated model was then used to simulate future conditions in which monthly average flow rates were scaled based on the ratio of the current maximum monthly average treatment rate of 20.2 MGD (which occurs in July) and the assumed future maximum monthly average flowrate of 55.9 MGD. This future average flowrate for July was derived by assuming the future maximum daily flow is 75 MGD and a peaking factor of 1.34 to obtain the monthly average. The peaking factor is based on current operations and system demand data. For future planning scenarios, it was assumed that the current monthly average USPR values would not change (i.e., changes in solids production would be the result of increased treatment flow rates).

Figure 19 below shows the Blue Plan-it® lagoon cycling model results for current operations. This demonstrates that under current operations four lagoons are sufficient for solids handling (three lagoons used plus a fourth to use during the winter when decanting an online lagoon is not possible). Because of the varying lagoon size, having five lagoons is appropriate.

FIGURE 19: BLUE PLAN-IT LAGOON CYCLING MODEL - CURRENT CONDITIONS

For future conditions, the solids production rate will increase as the result of the SFWPP treating higher flowrates requiring more frequent cycling of the lagoons. Unless operational changes are made, it is anticipated that solids drying will continue to require two years of drying before they are cleaned and ready for in-service use. As shown in Figure 20, this results in a required total of seven lagoons for future conditions.

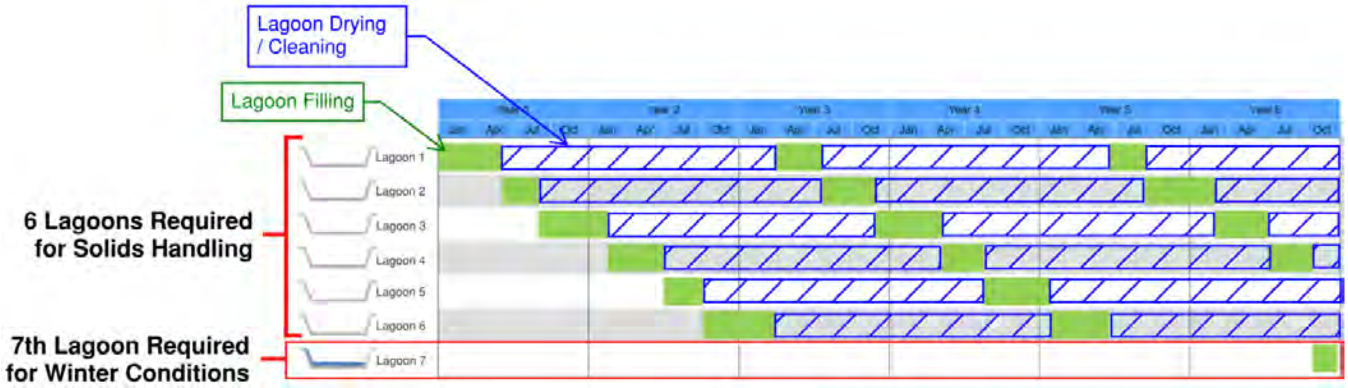


FIGURE 20: BLUE PLAN-IT LAGOON DRYING MODEL - FUTURE CONDITIONS

Construction of an additional two or three lagoons of similar size to the existing ones is required to accommodate future solids production if land is available. However, if lagoon expansion is not feasible, the alternative means for solids handling such as sludge thickening and/or mechanical dewatering (belt filter presses, centrifuges, etc.) will be required.

3-3-6 Chemical Feed and Storage

3-3-6-1 PROCESS SUMMARY

The SFWPP uses a variety of chemicals in the treatment process. A majority of these chemicals are delivered in bulk quantities and stored on site in large tanks. Some of the chemicals with lower usage rates are stored in either drums or totes. The following sections provide an overview of the chemical storage and feed systems at the SFWPP.

Potassium Permanganate

Potassium permanganate is added to BSR raw water as a pre-oxidant for taste and odor control. This chemical is added off-site, at the surface water intake. Dry potassium permanganate is stored in a 68-ton silo that has a pneumatic fill line, a baghouse for dust control, and a compressed air system to prevent clumping. The permanganate dose is determined by taking a grab sample and evaluating oxidant demand in the lab. The approximate feed rate is then set through SCADA and operators check the feed rate manually and adjust the feeder speed as necessary.

With an average potassium permanganate dose of 5.0 mg/L, the silo provides approximately 108 days of storage at the Actiflo® treatment capacity of 30 MGD (maximum BSR flowrate). Table 18 shows the design criteria for the potassium permanganate system.

TABLE 18: POTASSIUM PERMANGANATE STORAGE AND FEED CRITERIA

Parameter	Unit	Value	Notes
Average Potassium Permanganate Dose	mg/L	5.0	Based on BSR flowrate
Potassium Permanganate Silo Capacity	tons	68	
Potassium Permanganate Silo Days of Storage, Maximum Flow	days	108	At 30 MGD of BSR and average dose

Ferric Chloride

Ferric chloride is used in both the Actiflo® and lime softening processes as a coagulant. This chemical is delivered in bulk and stored in two 18,000-gallon tanks in the SFWPP chemical building. With an average cumulative ferric chloride dose of 4.2 mg/L (based on the total SFWPP treatment flowrate) these tanks would each provide 32 days of storage (64 days total) at the treatment plant capacity of 75 MGD. Table 19 presents the design criteria for the ferric chloride system.

TABLE 19: FERRIC CHLORIDE STORAGE AND FEED CRITERIA

Parameter	Unit	Value	Notes
Bulk Ferric Chloride Density	lb/gal	11.7	

Bulk Ferric Chloride Solution Concentration	%	40	
Bulk Ferric Chloride Active Concentration	%	100	
Average Ferric Chloride Dose	mg/L	4.2	Based on total plant flowrate
Number of Ferric Chloride Tanks	-	2	
Ferric Chloride Tank Volume, each Tank	gallons	18,000	
Ferric Chloride Days of Storage, each Tank	days	32	At 75 MGD and average dose
Ferric Chloride Days of Storage, Total	days	64	At 75 MGD and average dose
Number of Ferric Chloride Transfer Pumps	-	2	
Number of Ferric Chloride Feed Pumps	-	7	

PolyDADMAC

PolyDADMAC polymer (Clarifloc® C-318) is used as a coagulant aid in the Actiflo® process. While the facility has a 9,500-gallon storage tank for polyDADMAC, the usage rate is not high enough to justify bulk deliveries of this chemical. Instead, 55-gallon drums are located on the Actiflo® operating deck and 2-3 gpm of carrier water is used to dilute the bulk product. With an average polyDADMAC dose of 4.9 mg/L, each drum provides 10 hours of storage at the Actiflo® process capacity of 30 MGD. The existing tank provides up to 70 days of storage if utilized instead of drums. Table 20 presents the design criteria for the polyDADMAC system.

TABLE 20: POLYDADMAC STORAGE AND FEED CRITERIA

Parameter	Unit	Value	Notes
Bulk polyDADMAC Density	lb/gal	9.01	
Bulk polyDADMAC Solution Concentration	%	100	
Bulk polyDADMAC Active Concentration	%	100	
Average polyDADMAC Dose	mg/L	4.9	Based on Actiflo process flowrate
Number of PolyDADMAC Tanks	-	1	
PolyDADMAC Tank Volume	gallons	9,500	Not currently used – 55-gallon drums used instead
PolyDADMAC Days of Storage, Tank	days	27	At 30 MGD and average dose
PolyDAMAC Drum Hours of Storage, 55-gallon Drum	hours	10	At 30 MGD and average dose
Number of PolyDADMAC Feed Pumps	-	3	

Cationic Polymer

Cationic polymer is used in the lime softening process to aid with solids settling. While the facility has a 4,000-gallon polymer tank, the current use rates do not justify using bulk deliveries. Instead, 55-gallon drums of a commercial polymer product (Clarifloc® C-6220) are used for this purpose. The average polymer dose is 0.2 mg/L (based on the total SFWPP treatment flowrate). At 75 MGD, each drum provides one day of storage. The existing tank provides up to 89 days of storage if utilized in lieu of drums. Table 21 presents the design criteria for the cationic polymer system.

TABLE 21: CATIONIC POLYMER STORAGE AND FEED CRITERIA

Parameter	Unit	Value	Notes
Bulk Polymer Density	lb/gal	8.17	
Bulk Polymer Solution Concentration	%	40	
Bulk Polymer Active Concentration	%	100	
Average Polymer Dose	mg/L	0.2	
Number of Polymer Tanks	-	1	
Polymer Tank Volume	gallons	4,000	
Polymer Days of Storage, Tank	days	89	
Polymer Days of Storage, 55-gallon Drum	days	1	At 75 MGD and average dose
Number of Polymer Feed Pumps	-	3	

Lime

Lime is used to raise the pH of the water as the primary treatment mechanism in the contact basins. Unlike other bulk chemicals at the facility, lime is delivered by railcar on the east side of site. The railcars unload pebble lime (calcium oxide) to a series of five, 80-ton below-grade bunkers. Vacuum pumps transfer lime from the bunkers to a series of four-day bins which feed the slakers. With an average lime dose of 275 mg/L, each bunker provides roughly 22 hours of storage at 75 MGD.

Backup rail cars of lime can be housed on the on-site rail line to provide an additional 300 tons of lime storage. Between the bunkers and the spare railcars, there is approximately eight days of on-site lime storage at 75 MGD. Table 22 shows the design criteria for the lime system.

TABLE 22: LIME STORAGE AND FEED CRITERIA

Parameter	Unit	Value	Notes
Average Lime Dose (mg/L)	mg/L	275	
Number of Lime Bunkers	-	5	
Lime Bunker Storage Capacity, each Bunker	tons	80	
Lime Hours of Storage, each Bunker	hours	22	At 75 MGD and average dose
Lime Days of Storage, Total	days	4.5	At 75 MGD and average dose, 8 days using spare railcars
Number of Lime Slakers	-	4	

PAC

PAC is added upstream of the solids contact basins (along with lime, ferric chloride, and cationic polymer) to remove taste and odor compounds when the BSR source is being utilized. PAC is delivered in bulk as a dry powder and sent to three, 42,000-gallon concrete slurry tanks. Each tank has a 30-hp mixer. Make-up water is added to the slurry tanks and mixed with the PAC to create a 1 lb/gallon slurry. A carbon dust scrubber system is used to mitigate PAC dust during dry PAC deliveries.

Slurry from the slurry tanks is pumped to a 1,500-gallon day tank and is diluted to a 0.25 lb/gallon feed stock. The average PAC dose is 2.8 mg/L. At 75 MGD each of the slurry tanks provide 24 days of storage (based on a 1 lb/gallon slurry; 72 days of total storage), and the day tank provides 20 hours of storage (based on a 0.25 lb/gallon slurry). Table 23 shows the design criteria for the PAC system.

TABLE 23: PAC STORAGE AND FEED CRITERIA

Parameter	Unit	Value	Notes
Average PAC Dose	mg/L	2.8	
Number of PAC Slurry Tanks	-	3	
PAC Slurry Tank Volume, each Tank	gallons	42,000	
Number of PAC Day Tanks	-	1	
PAC Day Tank Volume	gallons	1,500	
PAC Days of Storage, each Slurry Tank	days	24	At 75 MGD and average dose
PAC Days of Storage, Total in Slurry Tanks	days	72	At 75 MGD and average dose
PAC Hours of Storage, Day Tank	hours	20	At 75 MGD and average dose
Number of PAC Transfer Pumps	-	3	
Number of PAC Feed Pumps	-	7	

Carbon Dioxide

Carbon dioxide is added at the recarbonation basins to lower pH after lime softening and redissolve any precipitated solids that carry over from the contact basins. Carbon dioxide is delivered in bulk to two cryogenic storage tanks in the northeast corner of the SFWPP site. Pressurized carbon dioxide gas is sent to a control panel in the chemical building and then is fed via gas diffusers to each of the recarbonation basins. With an average carbon dioxide dose of 21.9 mg/L, at 75 MGD the 120,000 lb and 60,000 lb storage tanks provide eight days of storage and four days of storage, respectively (12 days of storage total). Table 24 shows the design criteria for the carbon dioxide system. Figure 21 shows the SFWPP carbon dioxide tanks.

TABLE 24: CARBON DIOXIDE STORAGE AND FEED CRITERIA

Parameter	Unit	Value	Notes
Average Carbon Dioxide Dose	mg/L	21.9	
Number of Carbon Dioxide Tanks	-	2	
Carbon Dioxide Tank No. 1 Capacity	lb	120,000	
Carbon Dioxide Tank No. 2 Capacity	lb	60,000	
Carbon Dioxide Days of Storage, Tank No. 1	days	8	At 75 MGD and average dose
Carbon Dioxide Days of Storage, Tank No. 2	days	4	At 75 MGD and average dose
Carbon Dioxide Days of Storage, Total	days	12	At 75 MGD and average dose

FIGURE 21: CARBON DIOXIDE STORAGE TANKS

Polyphosphate

Polyphosphate is fed upstream of the filters to prevent scaling. While the facility has a 6,000-gallon polyphosphate storage tank, the current use rates do not justify bulk deliveries. Instead, 275-gallon totes of a commercial polyphosphate product (Carus® 1100) are used. With an average dose of 0.1 mg/L, at 75 MGD each tote would provide ten hours of storage. The 6,000-gallon tank provides nine days of storage if used instead of the totes. Table 25 shows the design criteria for the polyphosphate system.

TABLE 25: POLYPHOSPHATE STORAGE AND FEED CRITERIA

Parameter	Unit	Value	Notes
Bulk Polyphosphate Density	lb/gal	11.59	
Bulk Polyphosphate Solution Concentration	%	1	
Bulk Polyphosphate Active Concentration	%	100	
Average Polyphosphate Dose	mg/L	72	
Number of Polyphosphate Tanks	-	1	
Polyphosphate Tank Volume	gallons	6,000	
Polyphosphate Days of Storage, Tank	days	9	At 75 MGD and average dose
Polyphosphate Hours of Storage, 275-gallon Tote	hours	10	At 75 MGD and average dose
Number of Polyphosphate Feed Pumps	-	2	

Chlorine

Chlorine gas is used as a primary disinfectant and injected in the inlet pipe to the clearwell. It is also used to prevent biofilm growth upstream of the filters and is added after the clearwell to supplement chloramine formation. Chlorine gas is delivered in banks consisting of four, one-ton cylinders which are housed in the chlorine building on the south end of the SFWPP site. The average applied chlorine dose is 4.0 mg/L (across the entire treatment process). At 75 MGD, each chlorine gas cylinder bank provides three days. The chlorine system also includes a media-based scrubber is connected to the chlorine storage room ventilation system and is sized to neutralize one ton of chlorine. Table 26 presents the design criteria for the chlorine system. Figure 22 shows the chlorine storage room and Figure 23 shows the chlorine scrubber.

TABLE 26: CHLORINE STORAGE AND FEED CRITERIA

Parameter	Unit	Value	Notes
Average Chlorine Dose	mg/L	4.1	
Chlorine Cylinder Capacity	lb	2000	
Chlorine Days of Storage, each Cylinder Bank, 4 Cylinders/Bank	days	3	At 75 MGD and average dose
Number of Chlorine Feeders	-	6	

FIGURE 22: CHLORINE STORAGE ROOM

FIGURE 23: CHLORINE SCRUBBER

Aqua Ammonia

Ammonium hydroxide (aqua ammonia) is added to the clearwell effluent to form chloramines prior to sending finished water to the distribution system. In the fall of 2021, a new ammonia storage facility on the south end of the SFWPP site was commissioned. The purpose of the new storage facility is to enhance facility safety by decreasing the distance to the clearwell effluent (previously aqua ammonia was stored in the chemical building). Aqua ammonia is delivered in bulk and stored in two 3,500-gallon tanks. The average ammonia dose is 0.7 mg/L. At 75 MGD, each tank provides 11 days of storage (total storage of 22 days). Table 27 presents the design criteria for the aqua ammonia system.

TABLE 27: AQUA AMMONIA STORAGE AND FEED CRITERIA

Parameter	Unit	Value	Notes
Bulk Aqua Ammonia Density	lb/gal	7.76	
Bulk Aqua Ammonia Solution Concentration	%	19	
Bulk Aqua Ammonia Active Concentration	%	100	
Average Aqua Ammonia Dose	mg/L	0.7	
Number of Aqua Ammonia Tanks	-	2	
Aqua Ammonia Tank Volume	gallons	3,500	
Aqua Ammonia Days of Storage, each Tank	days	11	
Aqua Ammonia Days of Storage, Total	days	22	At 75 MGD and average dose
Number of Aqua Ammonia Feed Pumps	-	3	

Hydrofluorosilicic Acid

Hydrofluorosilicic acid is added downstream of the clearwell to increase finished water fluoride (F) levels. This chemical is delivered in bulk and stored in a 6,000-gallon tank in the chemical building. The average hydrofluorosilicic acid dose is 0.4 mg/L as F. At 75 MGD, the bulk tank provides 34 days of storage. Table 28 presents the design criteria for the hydrofluorosilicic acid system.

TABLE 28: HYDROFLUOROSILICIC ACID STORAGE AND FEED CRITERIA

Parameter	Unit	Value	Notes
Bulk Hydrofluorosilicic Acid Density	lb/gal	10.09	
Bulk Hydrofluorosilicic Acid Solution Concentration	%	18	
Bulk Hydrofluorosilicic Acid Active Concentration	%	79	
Average Hydrofluorosilicic Acid Dose	mg/L	0.4	
Number of Hydrofluorosilicic Acid Tanks	-	1	
Hydrofluorosilicic Acid Tank Volume	gallons	6,000	
Hydrofluorosilicic Acid Days of Storage	days	34	At 75 MGD and average dose
Number of Hydrofluorosilicic Acid Feed Pumps	-	2	

3-3-6-2 Process Limiting Factors and Improvement Recommendations

Pre-oxidant Optimization

A pre-oxidation study is recommended to determine if potassium permanganate is the most effective chemical for taste and odor control, or if another chemical could be more effectively used for this purpose. Other oxidants which could be evaluated include: ozone, hydrogen peroxide, chlorine, and chlorine dioxide.

Potassium Permanganate Load Cells

Equipping the silo with load cells is recommended for more effective and efficient monitoring of potassium permanganate usage at the raw water intake. The existing storage silo would not require replacement.

Storage Volumes

Several chemicals are currently fed from totes or drums (e.g., polyDADMAC, polymer, polyphosphate) requiring frequent replacement and resulting in a high degree of chemical handling. As the plant flowrate increases the drum or tote systems will not be sufficient due to the inadequate storage volume and resulting replacement frequency. For PolyDADMAC and cationic polymer, the existing bulk storage tanks would provide sufficient storage at higher flowrates. For polyphosphate, carbon dioxide, and lime the SFWPP's existing bulk storage may be limited when treating sustained higher flowrates; it is recommended that each chemical have a minimum of 15 days of storage at average dose and maximum flow conditions.

Chemical Feed Pump Age

The existing Pulsafeeder® diaphragm metering pumps are at the end of their useful life and are recommended for replacement. These could be replaced in-kind with identical units; however, operations staff have noted that these require significant, costly regular maintenance, particularly the PAC feed pumps. Peristaltic metering pumps are recommended for most chemicals because they are typically easier to operate and maintain. Peristaltic metering pumps are less energy efficient than diaphragm pumps; however, the added energy usage for this application would be marginal.

Pump Redundancy

Currently there are only seven ferric chloride feed pumps. Typically, only four of these would ever be needed under current high flowrate operating conditions (one Actiflo® train online, three contact basins online). However, to operate at higher flowrates, all six contact basins and both Actiflo® trains will be in service. Nine units are required to have a dedicated chemical feed pump for each injection location and a swing spare.

Similarly, there are currently two polyphosphate feed pumps. To ensure redundancy and the ability to always operate both the north and south treatment trains, a third pump is required.

Hydrofluorosilicic Acid Tank

The interior of the existing hydrofluorosilicic acid fiberglass reinforced plastic (FRP) storage tank is delaminating. The tank has been relined once, but the issue persists and replacement is recommended. Despite the delamination issues with the existing tank, FRP provides a high degree of chemical resistance to hydrofluorosilicic acid and is recommended for the new replacement tank. Additionally, a crosslinked high density polyethylene tank could be evaluated as an alternative tank material.

Modifications to the current room configuration are required for tank removal and replacement. It is likely the east wall of the chemical storage room will need to be partially demolished. Installation of an overhead door or removable wall panel is recommended to ease future tank replacement efforts.

Carbon Dioxide Inefficiency

Carbon dioxide bubble diffuser systems have a relatively low chemical transfer efficiency. This results in higher carbon dioxide use rates than alternative feed systems.

Replacement of the existing carbon dioxide bubble diffuser systems with a side-stream carbon dioxide injection system is recommended. This consists of three feed skids and associated carrier water pumps (two duty, one standby). The skids produce a liquid carbonic acid solution which is fed directly to the process flow. It is recommended that the solution feed directly to the recarbonation basin inlet channels where the bulk flow for the North and South treatment trains is consolidated. Another option is to incorporate chemical injection taps on each of the solids contact basin effluent pipes. This approach requires installation of seven feed skid/carrier water pumps (six duty, one standby). In both alternatives, the carbon dioxide feed skids and injection pumps are located in the existing chemical building.

As previously noted, replacement of the bubble diffuser system with side-stream carbonic dioxide injection allows removal of the over/under baffles in the recarbonation basins; thereby, removing a major hydraulic bottleneck.

Chemical Optimization

A wide variety of chemicals are used in the Actiflo® and softening processes. There may be opportunities to reduce chemical usage through optimization. Jar testing is recommended to evaluate the impacts of coagulant and polymer usage on the Actiflo® performance.

Because PAC is primarily used to remove taste and odor compounds from BSR water, it would be more efficient to feed it upstream of surface water and ground water blending (upstream of Actiflo® or in the Actiflo® process itself) rather than in the contact basins where a number of other competing chemical reactions occur. BSR PAC addition could also be evaluated with jar testing.

Chlorine Gas Safety

While chlorine gas has traditionally been widely used for disinfection at large treatment facilities in the United States, many utilities have transitioned or are planning to transition to an alternate chlorination chemical. There are various concerns over the continued use of gaseous chlorine including:

- Safety concerns associated with the transportation, storage, and use of chlorine gas and the risk of an accidental release.
- The use of gaseous chlorine requires a Risk Management Plan (RMP), which involves significant effort to maintain the necessary documentation associated with the plan.
- The Occupational Safety and Health Administration (OSHA) requires a Process Safety Management program in concurrence with the RMP.

To improve overall chemical safety at the SFWPP (both for the operations staff and the public), conversion from chlorine gas to sodium hypochlorite as a chlorine-based disinfectant is recommended for consideration in the future. Sodium hypochlorite is available in a high concentration bulk solution (nominally 12.5 percent by weight) or generated on site at a lower concentration (0.8 percent by weight) using a concentrated brine (sodium chloride) solution and electrolytic cells.

The water quality considerations between the use of chlorine gas and sodium hypochlorite are shown below:

- Chlorine Gas:
    - $Cl_2 + H_2O \Leftrightarrow HOCl^- + H^+ + Cl^-$
    - Consumes 1.41 milligrams per liter (mg/L) alkalinity (as calcium carbonate) per mg/L of chlorine added.
- Sodium Hypochlorite:
    - $NaOCl + H_2O \Leftrightarrow HOCl^- + Na^+ + OH^-$:
    - Bulk (12.5 percent solution):
        - Adds 0.33 mg/L of alkalinity per mg/L of chlorine added (depending on the pH of the delivered sodium hypochlorite).
        - Can cause an increase in total trihalomethanes (TTHM) if the localized pH is high (TTHM are base catalyzed). Properly designed chemical injection/dispersion can also mitigate the occurrence of high localized pH (chemical dilution).
    - On-site Sodium Hypochlorite Generation (OSHG):
        - A less concentrated solution with a pH of 9 and does not add a significant amount of alkalinity to the water.

Bulk sodium hypochlorite systems have a significantly lower capital cost than OSHG systems since they require only bulk storage tanks and metering pumps as opposed to brine tanks, sodium hypochlorite generators, bulk storage tanks, and metering pumps. The tanks and pumps for OSHG systems are larger than a bulk sodium hypochlorite system because the solution strength is two orders of magnitude lower. However, the lower solution strength also presents advantages from a safety and off-gassing perspective. The cost of bulk sodium hypochlorite is also much higher than the salt and electricity inputs required for OSHG.

If the City choses to convert to a sodium hypochlorite system in the future, projected future flowrates should be considered when evaluating bulk and OSHG systems. Figure 24 shows the 20-year NPV costs for OSHG, bulk sodium hypochlorite, and chlorine gas at various average annual flowrates. At the current annual average flowrate of 10 MGD, bulk sodium hypochlorite is more cost effective. However, when the annual average flowrate is above 27 MGD, OSHG is more cost effective.

Note that chlorine gas is significantly cheaper than both sodium hypochlorite alternatives. The drive to discontinue chlorine gas use is typically motivated by enhancing safety rather than economic considerations.

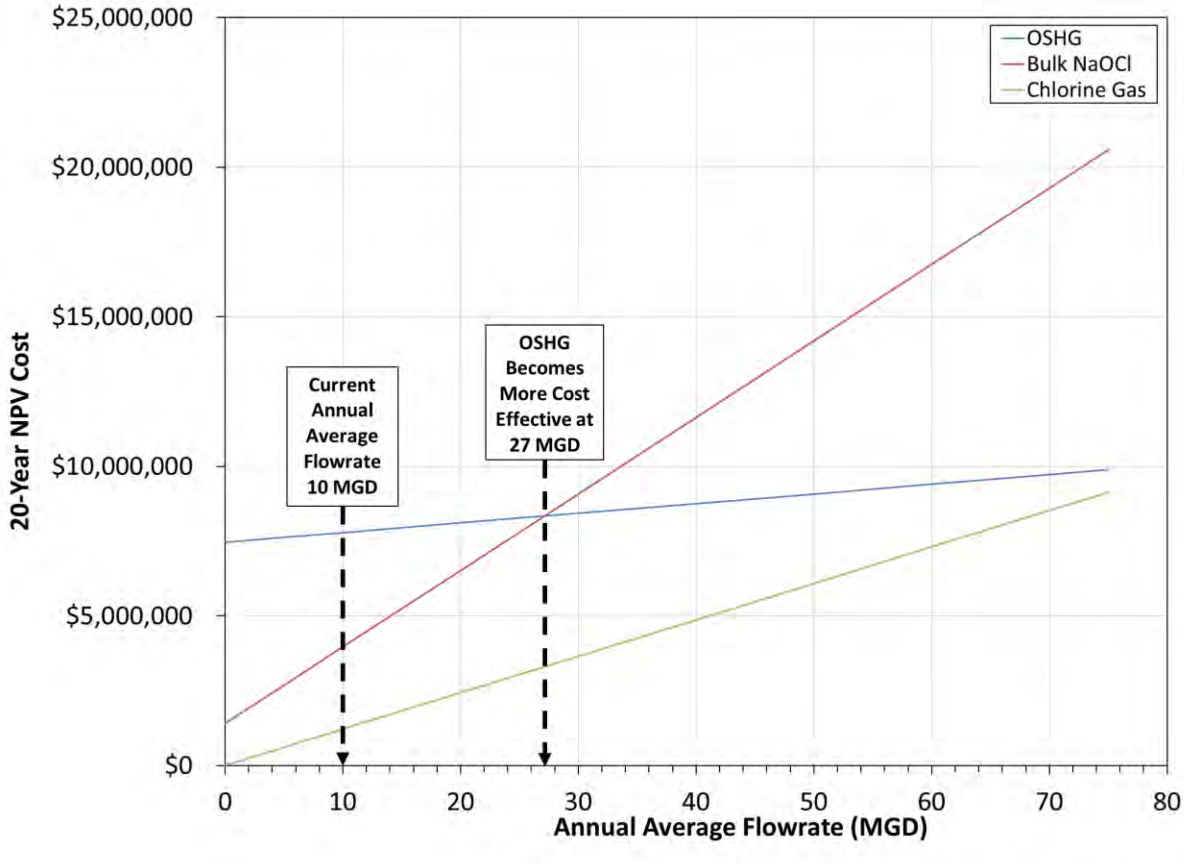


FIGURE 24: 20-YEAR NPV ANALYSIS FOR BULK SODIUM HYPOCHLORITE VS. OSHG

Section 4 Treatment Expansion Alternatives

4-1 Surface Water Treatment Expansion

The existing Actiflo® treatment trains are not recommended for operation above 15 MGD each to prevent flooding of the effluent launders and to avoid impacting treatment performance. If the City purchases additional surface water rights, expansion of the surface water treatment process is required. Construction of an additional Actiflo® train in the area directly west of the existing Actiflo® building is recommended. In this location one additional treatment train could be installed without impacting Filter-to-Waste Basin No. 2. Installation of a second new train is possible if the basin were demolished and relocated.

An additional train of Actiflo® results in a total surface water treatment capacity of 45 MGD (or 60 MGD if two trains are implemented). Relocation of the small diameter piping (potable water, utility water, etc.) is required to implement the expansion. Additionally, reconfiguration of the access road to the west of the parking lot is required. It is anticipated that expansion of the sludge thickening process is necessary if the surface water treatment capacity is increased. However, the availability for expansion to the east is limited by the existing groundwater headers. A smaller parallel thickening tank arrangement could be constructed east of the existing facility.

Figure 25 illustrates the proposed site layout for Actiflo® expansion.

FIGURE 25: PROPOSED ACTIFLO AND SLUDGE THICKENING EXPANSION

4-2 Softening Expansion

The existing softening process has an estimated capacity of approximately 55 MGD. In order to maintain continued operation of this critical process in the future, the City plans on refurbishing, repairing, or replacing aging concrete, miscellaneous metals, and mechanical components as necessary.

Construction of additional solids contact basins is required to increase the overall capacity of the softening process. Three additional units (at 56-foot diameter each) or two additional units (at 69-foot diameter each) are required to achieve 75 MGD under the same surface loading rates.

Removal of the obsolete power plant is recommended for construction of the new softening infrastructure due to the limited available space. Currently the facility is used for storage. The new contact basins do not require the entire footprint, thus allowing partial demolishing of the power plant or construction a new storage facility in conjunction with the new treatment basins.

Figure 26 illustrates the proposed softening expansion.

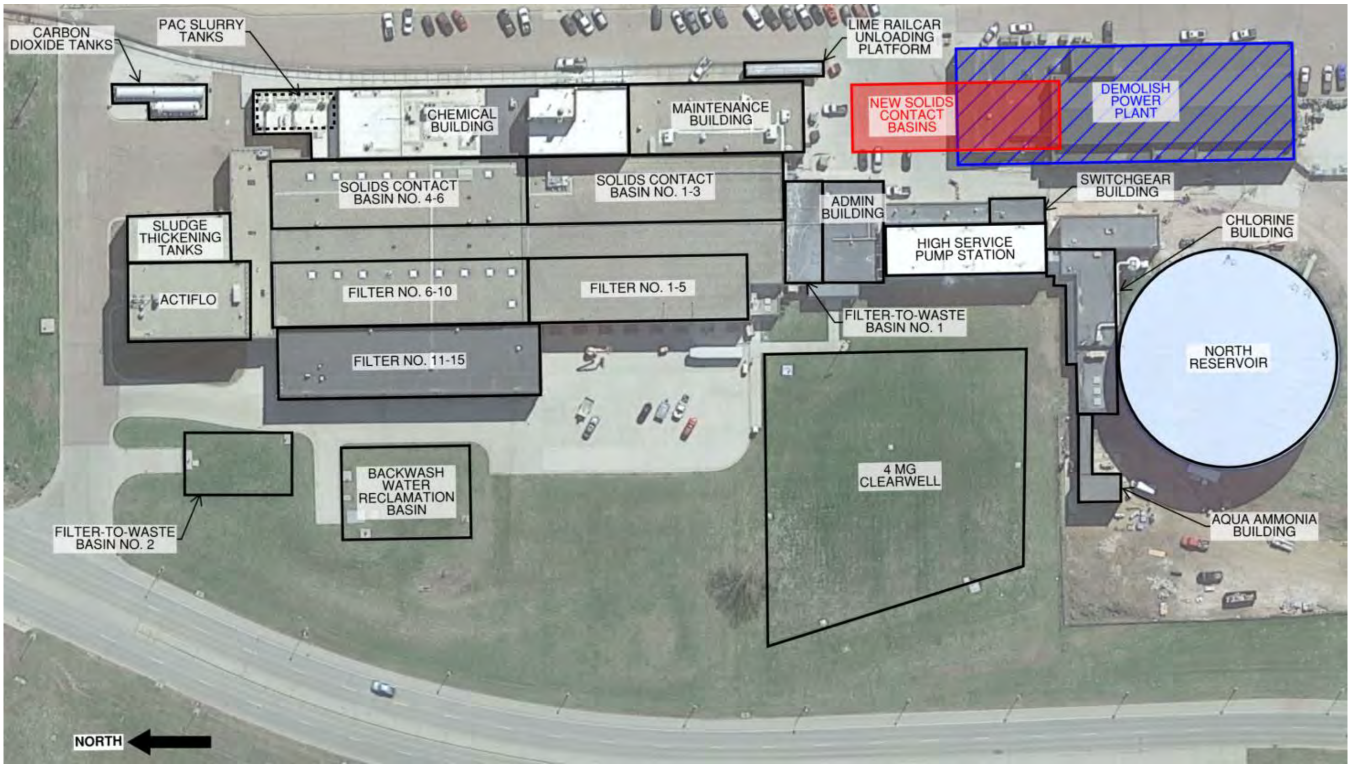


FIGURE 26: PROPOSED SOFTENING EXPANSION

An alternative site layout for the proposed Actiflo® and softening expansions is show in Figure 27. In this scenario, all process expansions are located north of the existing plant access road.

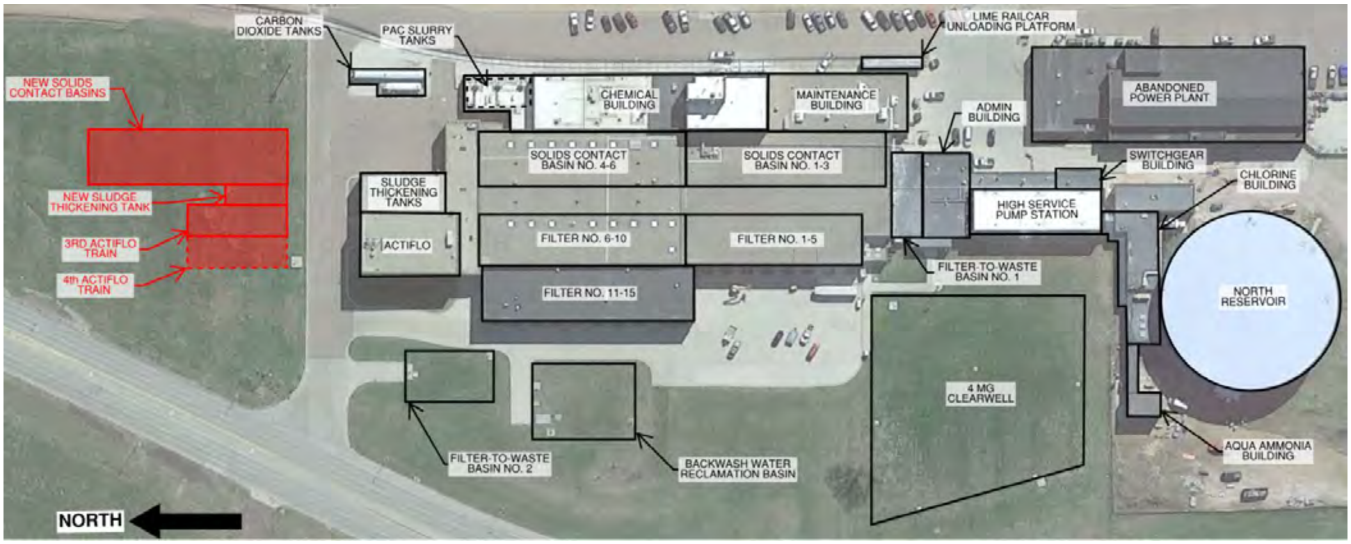


FIGURE 27: ALTERNATIVE ACTIFLO AND SOFTENING EXPANSION LAYOUT

4-3 Filter Expansion Alternatives

If the recommended hydraulic improvements and softening process expansion are implemented, the existing SFWPP filters could achieve 75 MGD if all of them were operating at their capacity of 5 MGD. However, because filters must periodically be taken offline for backwashing, the firm capacity of the WTP is only 70 MGD. To achieve a firm capacity of 75 MGD an additional 3-4 filters are required to allow for several filters to be in standby. The additional filters could fit in several potential locations on the west side of the site. Construction of the new filters as close to the existing filters as possible to minimize headloss and simplify operations.

Figure 28 shows one proposed location for two new filters. Construction of this alternative may require Filter Nos. 6-15 to be offline during construction. However, the new filter building design could incorporate the filter effluent piping from these units in order to minimize this disruption.

FIGURE 28: PROPOSED FILTER EXPANSION

4-4 Future Considerations

This master plan reviewed alternatives on how to reach a supply and treatment capacity of approximately 75 MGD. This capacity was selected based on what can reasonably be achieved utilizing existing infrastructure plus proposed improvements within the site constraints of the existing facility. These constraints include Minnesota Avenue to the west and north and the Diversion Canal to the east. In addition, portions of the SFWPP are within the proposed development area of the Sioux Falls Regional Airport where future expansion plans will require additional coordination with airport agencies during the planning phases.

An alternate treatment location is recommended for flows above 75 MGD. The following is a summary of the benefits of a satellite treatment facility:

1. Provides a fully redundant treatment plant in case the existing plant is taken offline due to a natural disaster or unforeseen repair.
2. Provides a second location where treated water is pumped into the distribution system and reduces the friction losses and pumping costs by reducing the distance the finished water travels to reach the outer portions of the distribution system.
3. Allows for construction of cost effectively developed alternative well fields adjacent to the proposed WPP.

Consideration of a future WPP is recommended when planning future, large diameter transmission mains within the distribution system. For example, if a new finished water transmission main is planned in the near term to help deliver finished water from the existing WPP to the west, consideration should be given to converting this main to a raw water main in the future. After a new WPP is constructed on the west side and supplying treated water and pressure from this location, the finished water main from the existing WPP is less critical to the operation of the distribution system. This main could then be converted to a raw water main and provide a very cost-effective means to provide raw water from the existing well field to the new plant. This also provides a means to eventually transition away from full reliance on the existing plant where portions will have reached the end of its design life.

Section 5 Recommendation Summary

5-1 Recommended Non-Construction Projects

Below are several recommended studies that will serve as the basis for preliminary design in support of the recommended improvements presented through the technical memorandum. The recommended studies include:

- CFD Modeling of the Clearwell
- Corrosion Control Study
- Filter Pilot Study
- Pre-oxidation Study
- Coagulant and Polymer Jar Testing Evaluation on Actiflo® Performance
- Future Water Purification Plant Siting Study

Each of these recommended projects is briefly discussed in the following sections.

5-1-1 CFD MODELING OF THE CLEARWELL

Additional baffling in the clearwell is recommended to maximize the baffle factor to achieve a 0.5 baffling factor and to provide a factor of safety and operational flexibility for the disinfection process under worse case conditions (75 MGD, pH 8.2, chlorine residual of 2.0 mg/L, varying water level, and temperature of 5 degrees Celsius). CFD analysis of the existing clearwell and multiple baffling permutations can assist in determining which baffling modifications can achieve this target. CFD allows for tracer studies to be simulated without the need for full-scale implementation and testing. Sample results from a CFD study conducted to evaluated disinfection in a 2 MG tank are shown in Figure 29 below.

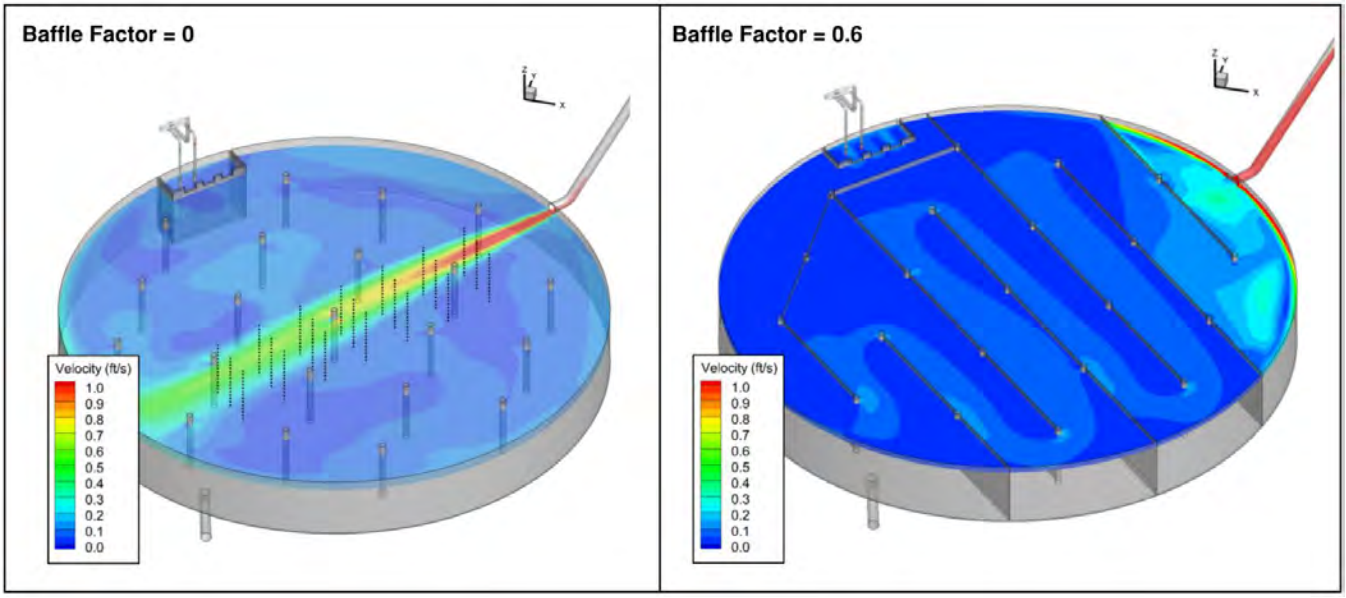


FIGURE 29: SAMPLE CFD TRACER STUDY RESULTS

5-1-2 CORROSION CONTROL STUDY

As discussed in previous sections, the forthcoming LCRR will alter requirements for corrosion control as well as lead and copper monitoring. Due to the SFWPP's high finished water alkalinity and pH, it is not anticipated the lead and copper corrosion will be a major issue for the City moving forward. However, the LCRR requirements will make any trigger level or action level exceedance more burdensome than the current LCR requirements. In order to be proactive and ensure adequate CCT is in place prior to 2024 when the LCRR takes effect, a desktop corrosion control study is recommended.

A desktop corrosion control study can evaluate the City's current CCT practices and determine if modifications are warranted. While not required under the LCRR (since the City has not had an action level exceedance), a pipe loop or coupon study could also be conducted to evaluate alternative CCT approaches. These tests require harvesting sections of premises plumbing from Tier I or Tier II lead and copper sampling sites.

5-1-3 FILTER PILOT STUDY

A pilot study could be conducted to evaluate alternative filter media configurations and potential biofiltration operation. Various media configurations are set up in test columns and fed full scale contact basin effluent.

5-1-4 PRE-OXIDATION STUDY

A pre-oxidation study is recommended to determine if potassium permanganate is the most effective chemical for taste and odor control, or if another chemical could be more effectively used for this purpose. Other oxidants which could be evaluated include: ozone, hydrogen peroxide, chlorine, and chlorine dioxide.

5-1-5 JAR TESTING EVALUATION

To ensure the Actiflo® process is operating in an optimal manner, a jar testing evaluation is recommended. The study evaluates coagulant chemistry (ferric chloride, polyDADMAC, and cationic polymer dosing) and oxidant demand (potassium permanganate dosing). PAC addition either upstream of the Actiflo® process or within the process itself can also be evaluated to determine if this can reduce chemical usage and provide more effective taste and odor compound removal.

5-1-6 FUTURE WPP SITING STUDY

A siting study for a future WPP is recommended to assist the City plan for future infrastructure needed to provide raw water supply and treated water capacity above 75 MGD. The location of this future treatment plant site will be influential in determining where future new water supply sources are developed outside of the existing wellfield.

5-2 Recommended Treatment Improvements

The following is a summary of the recommended improvements to be implemented at the SFWPP in order to be able to treat 75 MGD:

- Actiflo®
    - Construct parallel Actiflo® Treatment train(s) and sludge thickening basins.
- Softening / Recarbonation
    - Replace the existing bubble diffuser carbon dioxide system with a side stream injection.
    - Demolish/modify over/under baffles in the recarbonation basins to alleviate hydraulic bottlenecks.
    - Refurbish solids contact basins.
    - Construct 2-3 new solids contact basins (demolish the power plant to make room for these).
- Filtration
    - Modify filter effluent piping to reduce headloss (recommend adding a single 64-inch line that goes directly from north filters to the clearwell, demolishing the static mixer and orifice pipe within the clearwell).
    - Increase media depth (pending the results of the pilot study)
    - Convert to biofiltration (pending the results of the pilot study)
    - Add a redundant air scour blower.
    - Filter backwash process optimization (add simultaneous air/water wash step, eliminate surface wash).
- Disinfection
    - Add baffling to clearwell to increase baffle factor to at least 0.5 (pending results of CFD study).
    - Implement UV disinfection only if the City's *Cryptosporidium* bin classification changes or if the clearwell is to be used for future treatment processes (beyond 75 MGD).
- Solids Handling
    - Install a parallel sludge line to the lagoons to increase solids handling capacity.
    - Construct 2-3 additional sludge lagoons or implement mechanical dewatering to handle future solids production rates.
- Chemical Storage and Feed
    - Implement an alternative pre-oxidant (pending the results of the pre-oxidation study)
    - Install load cells below the potassium permanganate silo.
    - Replace existing diaphragm metering pumps with peristaltic pumps.

  - Utilize existing bulk chemical storage tanks to reduce operator handling of chemicals.
  - Modify the hydrofluorosilicic acid room so that the bulk tank can be removed and replaced.
  - Convert from chlorine gas to a bulk sodium hypochlorite system.

The hydraulic modeling analysis for this project demonstrates that the current maximum hydraulic capacity of the SFWPP is 55 MGD. Although the facility's filters can treat 60 to 75 MGD, these higher flows are not sustainable due to filter headloss accumulation and backwash frequency. In addition to the backwash considerations, high flows greater than 55 MGD will result in an overflow condition upstream of the filters. In order for the plant to be capable of hydraulically passing 75 MGD, modifications to the recarbonation basin and filter effluent piping are required. Demolition or modification of the recarbonation basin under baffle is recommended to remove a major hydraulic bottleneck. This improvement will also require replacement of the existing carbon dioxide gas bubble diffuser with a side stream carbon dioxide injection system.

Based on the filter headloss accumulation rate, 5 – 7.5 feet of filter headloss accumulations should be provided so the facility can operate at 75 MGD without hydraulic restriction. As discussed in this TM, modifications to the filter effluent piping can provide up to 9 feet of headloss accumulation for the filters.

Based on AE2S's 2020 Future Water Supply Needs TM update, peak day customer demands could reach 83 MGD by 2055 and 88 MGD by 2060 (under average dry conditions). Assuming the entire Lewis and Clark allocation of 28 MGD is utilized, the amount of treated water from the WPP is 55 and 60 MGD, respectively. In order to ensure the facility can reliably meet these demands, expansion of the SFWPP's treatment capacity to 75 MGD prior to 2055 through the process expansion and hydraulic improvements projects proposed in this TM is recommended. While the planning horizon for this is more than 30 years in the future, implementation of these projects in the next ten years is recommended to ensure capital improvement costs are spread out over several decades.

In the near term, implementation of projects focusing on equipment replacement and process optimization are recommended. Figure 30 shows the overall proposed site plan for the SFWPP if all recommended improvements and expansions are implemented.

FIGURE 30: SFWPP SITE PLAN WITH ALL RECOMMENDED IMPROVEMENTS IMPLEMENTED

Table 29 outlines the proposed phasing of the improvements projects.

TABLE 29: PROJECT PHASING

Project	Planning Period	Comment
Desktop Corrosion Control Study	1-2 Years	Non-construction project (LCR takes effect in 2024)
Actiflo Chemical Optimization Study	1-5 Years	Non-construction project
Filter Wash Optimization	1-5 Years	Non-construction project
Clearwell/North Reservoir Baffling CFD Study	1-5 Years	Non-construction project
Pre-Oxidant Study	1-5 Years	Non-construction project
Nitrosamine Formation Potential Study	1-10 Years	Non-construction project
Future Filter Pilot Study	1-10 Years	Non-construction project
Existing Filter Media Configuration/Biofiltration Study	1-10 Years	Non-construction project
Future WPP Siting Study	1-10 Years	Non-construction project
Recarbonation Basin/Carbon Dioxide System Modifications	1-10 Years	
Clearwell/North Reservoir Baffling Modifications	15 Years	
Filter Effluent Piping Modifications	15 Years	
Filter Media Reconfiguration/Biofiltration Conversion	15 Years	
Add Redundant Air Scour Blower	15 Years	
Add Chemical Storage (polyphosphate, carbon dioxide, lime)	20 Years	
Softening Process Expansion	20 Years	Could be deferred if new WPP is constructed
Actiflo Expansion	20 Years	Could be deferred if new WPP is constructed
Filter Expansion	20 Years	Could be deferred if new WPP is constructed
Install Parallel Sludge Line to Lagoons	25 Years	
Sludge Drying Capacity Expansion	25 Years	
Construct a Second WPP	20-30 Years	Depends on if the SFWPP is expanded
Hydrofluorosilicic Acid Tank Replacement/Room Modification	As Needed	Recommended long-term fix
Implement Potassium Permanganate Load Cells	As Needed	Pending Pre-Oxidant Study

Note that most of the recommended projects for the next 10 years are non-construction projects (i.e. studies and process optimization). The only recommended capital improvements within the next ten years are the recarbonation basin and carbon dioxide system modifications. As shown in Table 30, this is anticipated to cost roughly $863,000. Note that this is a Level 5 cost estimate based on the American Association of Cost Engineers International Cost Estimate Classification System. Based on these guidelines, the expected range of accuracy for this type of estimate is +100 percent to -50 percent of the actual project cost.

TABLE 30: RECARBONATION BASIN/CARBON DIOXIDE SYSTEM MODIFICATIONS COST ESTIMATE

Project	Cost
DEMOLITION	
Demolition of Baffle Walls, Mixers, Feed Panel	$50,000

DEMOLITION TOTAL	***$50,000***
CARBON DIOXIDE FEED	
Chemical Feed Piping Modifications	$18,000
Carrier Water Pumps	$38,000
Feed Panels	$355,000
CARBON DIOXIDE FEED TOTAL	**$411,000**
Contingency (30%)	$138,000
Estimated Construction Cost	**$599,000**
General Conditions (5%)	$30,000
Contractor Overhead/Profit/Mobilization (15%)	$90,000
Engineering Design (14%)	$84,000
Construction Administration (6%)	$36,000
Funding – Legal Admin (4%)	$24,000
ESTIMATED PROJECT COST	**$863,000**

Technical Memorandum

Water Supply and Treatment Master Plan

Chapter 8:

Future Growth and Peak Demand Solutions

November 2022

(Revised: September 2023)

HR Green Project No: 210506

Prepared For:

CITY OF SIOUX FALLS

Table of Contents

List of Tables

Appendices

Section 1: Introduction

This Future Growth and Peak Demand Solutions technical memorandum is prepared for the City of Sioux Falls Water Purification Plant (WPP) as part of the Water Purification Master Plan. This memo is intended to be a cursory review of future water sources that could be explored to address additional capacity needed to meet the long-term 50- and 100-year planning periods.

1-1 Background

As part of the overall Water Distribution System Master Plan, evaluations were conducted to determine the overall water system's peak day demand and the corresponding projected water supply capacity for the 10-, 20-, 50- and 100-year planning periods of 2035, 2045, 2066, and 2116, respectfully. Tables 1 and 2 illustrate how the various water sources available to the City could be engaged to attempt to meet the peak day demands for the different planning periods. Additionally, the estimated capacity available is adjusted downward as the assumed climatic conditions move from normal precipitation to extended drought conditions.

The estimated capacity for the Lewis & Clark Rural Water System (LCRWS) is based on the City's water supply agreement with LCRWS and the anticipated increased water supply from the LCRWS Phase II improvements. The following is an estimated timeline of the buildout of the LCRWS to achieve the full allocation of 34 MGD:

- Current Allocation – 17 MGD
- 2026 Allocation – 28 MGD
- 2030 Allocation – 34 MGD

The deficit in water supply capacity for each planning period is indicated in the Required Future Water Source rows. The deficit indicates the City will not have a sufficient source water supply to meet the projected City peak day water demand. Table 1 shows the peak day water demand with no water restrictions implemented and should be considered as a worse-case scenario. In actuality, the City would likely implement water restrictions which would significantly decrease the peak day water demand. Table 2 displays the peak day water demand where the City's most stringent water restrictions are implemented. Table 2 illustrates the best-case scenario, which shows that nearly all of the planning periods would be capable of providing enough water during all four climatic conditions with the exception of the 100-year planning period at the extended drought condition. In reality, the City's peak day water demand will most likely fall in between the values provided in Tables 1 and 2.

The additional required future water source could come from a few different areas as summarized below:

- Missouri River Surface Water Rights
- Expansion of LCRWS
- Aquifers south of Sioux Falls
- Regional Water System

1-2 Missouri River Surface Water Rights

The City currently has a future use permit which would allow approximately 25.2 MGD continuous withdrawal from the Missouri River. This permit could serve as a starting point in developing an extension of the City's water system to bring this high quality water source to the City of Sioux Falls. Multiple options exist on how this could be done:

1) raw water could be pumped to Sioux Falls for treatment; 2) could be treated at a new plant adjacent to the Missouri River and treated water could be pumped to the City. Additionally, other regional partners could

TABLE 1: PROJECTED WATER SOURCES FOR PLANNING PERIODS WITH NO WATER RESTRICTIONS

		Peak Day Capacity Req'd, MGD$^{1, 2}$	Estimated Capacity Available			
			Normal Conditions, MGD	Average Dry Conditions, MGD	Drought Conditions, MGD	Extended Drought Conditions, MGD
10-Year Planning Period	Wellfield	71.6	22.0	19.0	17.0	11.0
	BS River Pump Station		23.0	23.0	0.0	0.0
	Lewis & Clark RWS		34.0	34.0	34.0	34.0
	Req Future Water Source		N/A	N/A	20.6	26.6
	Total		79.0	76.0	71.6	71.6
20-Year Planning Period	Wellfield	83.8	29.0	24.0	22.0	11.0
	BS River Pump Station		23.0	23.0	0.0	0.0
	Lewis & Clark RWS		34.0	34.0	34.0	34.0
	Req Future Water Source		N/A	2.8	27.8	38.8
	Total		86.0	83.8	83.8	83.8
50-Year Planning Period	Wellfield	90.7	31.0	26.0	23.0	12.0
	BS River Pump Station		23.0	23.0	0.0	0.0
	Lewis & Clark RWS		34.0	34.0	34.0	34.0
	Req Future Water Source		2.7	7.7	33.7	44.7
	Total		95.0	90.7	90.7	90.7
100-Year Planning Period	Wellfield	128.1	34.0	28.0	24.0	12.0
	BS River Pump Station		23.0	23.0	0.0	0.0
	Lewis & Clark RWS		34.0	34.0	34.0	34.0
	Req Future Water Source		37.1	43.1	70.1	82.1
	Total		128.1	128.1	128.1	128.1

Notes: 1. Peak day capacity required assumes no watering restrictions are implemented and the per capita demand is approximately 270 gpcd.

2. The value of peak day capacity required is provided from the AE2S's future water supply evaluation that was derived in Section 2 of the Master Plan..

TABLE 2: PROJECTED WATER SOURCES FOR PLANNING PERIODS WITH WATER RESTRICTIONS

		Peak Day Capacity Req'd, MGD[1]	Estimated Capacity Available			
			Normal Conditions, MGD	Average Dry Conditions, MGD	Drought Conditions, MGD	Extended Drought Conditions, MGD
10-Year Planning Period	Wellfield	30.3	22.0	19.0	17.0	11.0
	BS River Pump Station		23.0	23.0	0.0	0.0
	Lewis & Clark RWS		34.0	34.0	34.0	34.0
	Req Future Water Source		N/A	N/A	N/A	N/A
	Total		79.0	76.0	51.0	45.0
20-Year Planning Period	Wellfield	35.5	29.0	24.0	22.0	11.0
	BS River Pump Station		23.0	23.0	0.0	0.0
	Lewis & Clark RWS		34.0	34.0	34.0	34.0.
	Req Future Water Source		N/A	N/A	N/A	N/A
	Total		86.0	81.0	56.0	45.0
50-Year Planning Period	Wellfield	39.1	31.0	26.0	23.0	12.0
	BS River Pump Station		23.0	23.0	0.0	0.0
	Lewis & Clark RWS		34.0	34.0	34.0	34.0
	Req Future Water Source		N/A	N/A	N/A	N/A
	Total		88.0	83.0	57.0	46.0
100-Year Planning Period	Wellfield	58.2	34.0	28.0	24.0	12.0
	BS River Pump Station		23.0	23.0	0.0	0.0
	Lewis & Clark RWS		34.0	34.0	34.0	34.0
	Req Future Water Source		N/A	N/A	N/A	12.2
	Total		91.0	85.0	58.0	58.2

Notes:
1. Peak day capacity required assumes watering restrictions are implemented and the per capita demand is approximately 115 gpcd.
2. The reduction in peak day capacity required from the water restrictions is taken from the City of Sioux Falls technical memorandum, Future Water Supply Needs, dated June 2020.

be added to share in the cost of the new infrastructure and ongoing operation and maintenance needed for a new source water system. It is recommended the City conduct a Feasibility Study to evaluate the pros, cons, and estimated planning level costs for this new system. The following is a list of suggested topics to evaluate in the Feasibility Study:

- Identify potential sites for new intake and pumping and/or treatment facilities
- Feasibility of obtaining additional surface water rights above the current 25 MGD
- Identify potential piping routes and associated pros and cons of each route
- Identify potential regional partners
- Identify potential funding options

1-3 Expansion of LCRWS

Currently the City has agreements in place with LCRWS to deliver approximately 17 MGD of treated water to the City's system. There are also plans to increase this amount to 28 MGD in approximately 2026 and to 34 MGD by approximately 2030. As shown in Tables 1 and 2, these planned LCRWS allocations are already included and are a critical component of Sioux Falls' ability to meet future demands. Even with these planned allocations, additional water source quantities are needed to meet long-range growth. The LCRWS has begun conceptual planning to expand their system beyond what is currently allocated. This planning effort has been referred to as LCRWS II. The City of Sioux Falls should explore the feasibility of being involved in LCRWS II so it can effectively compare this option with other source water options being considered.

1-4 Aquifers South of Sioux Falls

As part of the Master Plan, a requested task was to provide a brief summary of other possible aquifers available as a water source in the area south of the City. Data regarding twelve of the major aquifers located in Minnehaha and Lincoln County are summarized in Table 3. Three of the twelve aquifers are bedrock aquifers (Sioux Quartzite, Dakota, and Split Rock Creek aquifers), and the remaining nine are glacial or glacial/fluvial aquifers. A summary of additional information regarding aquifers south of Sioux Falls can be found in Appendix A.

It is beyond the scope of the Master Plan to provide detailed conclusions or recommendations regarding which aquifer or aquifers to consider developing as a raw water source. None of the twelve can provide the volume of water needed to make up the shortfall in raw water source supply that is projected with the continued rapid population growth of the City. The aquifers that appear most suitable for augmenting the City's source supply are the Parker-Centerville aquifer and the Big Sioux:South Aquifer.

TABLE 3: SUMMARY OF MAJOR AQUIFERS SOUTH OF SIOUX FALLS

Aquifer	Distance* (miles)	Recoverable Water In Storage - Lincoln County (Hedges, et. al., 1982) (acre-feet)	Recoverable Water In Storage - Minnehaha County (Hedges, et. al., 1982) (acre-feet)	Identified Recharge Sources	Average Aquifer Thickness (feet)	Average Depth to Top of Aquifer (feet)	Iron (mg/L)	Manganese (mg/L)	Sulfate (mg/L)	Total Dissolved Solids (mg/L)	Hardness as CaCO3 (mg/L)	Water Quality Information Source	Estimated Amount Available for Appropriation (ac-ft/yr)	Estimated Amount Available for Appropriation (MGD)	Comment
Big Sioux:South	1	70,200	20,640	Precipitation, Big Sioux River, other aquifers	22	10	1.1	2.3	303 (d)	991	620	Niehus, 1994	5,490	4.9	Un-used water rights of nearly 1.9 MGD
Brule Creek	25	99,600	NP	Precipitation	33	46	0.675	0.075	430 (d)	1,285	690	Niehus, 1994	5,431	4.8	
Dakota	9	4,297,900	NP	Underlying Formations	216	281	1.76	0.19	360 (d)	1,800	480	Niehus, 1994	29,570	26.4	Regional aquifer, highly variable quality
Harrisburg	5	105,170	NA	Glacial Till	26	59	6	3.23	2,100 (d)	4,075	2,700	Niehus, 1994	Not Quantified	Not Quantified	
Lennox	10	43,830	NP	Possibly UVM aquifer, Glacial Till	NA	~300	3.4	1.5	1,164	2,296	1,357	Beffort, 1961	Not Quantified	Not Quantified	
Newton Hills	24	25,200	NP	Precipitation, possibly Brule Creek aquifer	36	72	0.18 (dM)	0.050 (dM)	570 (d)	1,230	1,050	Niehus, 1994	Not Quantified	Not Quantified	Limited data available
Parker-Centerville	27	6,600	NP	Precipitation, UVM aquifer, Vermillion River	35	17	1.49	1.2	360 (d)	777	600	Niehus, 1994	4,850	4.3	Aquifer extends further west into
Schindler	9	124,590	1,360	Harrisburg aquifer, Glacial Till	31	103	4.2	1.49	1,200 (d)	2,220	1,255	Niehus, 1994	Not Quantified	Not Quantified	Very poor water quality, limited data
Sioux Quartzite	0	NA	NA	Precipitation, Big Sioux River	NA	120	0.025 (d)	0.007 (d)	127	696	586	Lindgren & Niehus, 1992 (Table 8)	Not Quantified	Not Quantified	Wells dependant on intercepting
Split Rock Creek	3	NP	99,400	Sioux Quartzite	48	160	0.31 (d)	0.19 (d)	271	853	637	Lindgren & Niehus, 1992 (Table 8)	None	None	In 2019 City withdrew a Future Use
Upper Vermillion Missouri	21	149,180	NP	Parker-Centerville aquifer, Glacial Till	41	162	3.6	2.2	1,400 (d)	2,400	1,300	Niehus, 1994	Not Quantified	Not Quantified	Recharge exceeds withdrawals
Wall Lake	0	70,400	75,690	Sioux Quartzite	33	106	0.37	2.69	757.1	1,086	977	Filipovic & Pence, 2001	Not Quantified	Not Quantified	Likely water available for appropriation

* Approximate, as measured from City's former filter plant along Skunk Creek following township boundaries (see text).
Water quality data are mean or average values of total recoverable concentrations unless otherwise indicated.

~	Approximated from data in Beffort (1961)	mg/L	milligrams per liter	UVM	Upper Vermillion Missouri aquifer	$CaCO_3$	calcium carbonate
NA	Not available	ac-ft/yr	acre-feet per year	(d)	dissolved		
NP	Not present	MGD	million gallons per day	(dM)	maximum dissolved concentration from limited sample number		

1-5 Regional Water System

The final future water source option that was considered at a cursory level was the concept of a new regional water system. Under this scenario the City would pool resources and facilities with other regional partners to develop a single administrative structure that would deliver additional treated water to the members of the newly formed regional water system. The advantage of a regional system is the costs for planning, design, construction, and operation and maintenance are split between the members. Regional systems can also improve efficiency of management by having a larger pool of resources to draw from. Additional funding may also be available to a larger group of users since a larger population will receive benefit. The challenge of regionalization and the primary reason they sometimes fail to gain traction is all parties need to be motivated to make a change at relatively the same time and be willing and able to invest into the new system from the onset.

The regionalization concept could be structured in several different ways. One alternative could focus on utilizing a groundwater source located as close to the City as feasible and offer a contrasting option to the Missouri River Feasibility Study.

Another option is to again target the Missouri River as the source and build additional infrastructure to convey the water to the City of Sioux Falls. This concept can take shape in a variety of different ways. It can be noted that a steering committee designated as Water 2040 has recently been formed to brainstorm a vision for future. A primary goal of the group is to conduct regional needs assessments and feasibility studies to assess the region's current and future needs and evaluate the capacity of the state's water resources to meet such needs. The City of Sioux Falls currently has representation on this Steering Committee. A fact sheet and additional information is included in Appendix B.

Regardless of how regionalization takes form, the following is a list of suggested topics to evaluate in the Regional Water Feasibility Study:

- Review options for pooling of water rights and where additional water rights are available.
- Review how water from the regional water system would be delivered to the City and how it would enter the distribution system.
- Identify potential regional partners likely within a 30 to 60 mile radius of Sioux Falls.
- Identify new infrastructure needs.
- Establish water quality goals.
- Outline cost sharing concepts among the users of the system.
- Outline how the new system would be governed, managed, and maintained.

Appendix

MEMORANDUM

To:	Nicholas Borns, Gavin Graverson, Ted Lewis, and Chris Myers
From:	LRE Water, HR Green, and Carollo
Subject:	Water Purification Master Plan – Aquifers South of Sioux Falls
Project Number:	210506
Date:	September 23, 2022

The purpose of this Memorandum (Memo) is to provide a one-page summary of the aquifers located south of Sioux Falls. Data regarding twelve of the major aquifers located in Minnehaha County and in Lincoln County are summarized in the attached Table 1. Three of the twelve aquifers are bedrock aquifers (Sioux Quartzite, Dakota, and Split Rock Creek aquifers), and the remaining nine are glacial or glacial/fluvial aquifers.

The distance shown in Table 1 is the approximate distance from the City's former filter plant, located south of Skunk Creek on W. Reservoir Street in Sioux Falls, to the nearest mapped boundary of the aquifer as measured orthogonally along section or township boundaries. The distance is provided as a relative measure. In nearly all cases, if the City were to construct additional wellfields in one or more of the twelve aquifers, the actual distance would be greater, as the wellfield would be sited some distance from the aquifer boundary to avoid negative boundary conditions (increased drawdown) associated with proximity to the edge of the aquifer.

The data shown in Table 1 provide a snapshot for relative comparisons among the aquifers. The amount of recoverable water in storage shown for the aquifers in Minnehaha and Lincoln counties is based on a 1982 publication, and some of the aquifer boundaries (notably the Upper Vermillion-Missouri aquifer, and the Wall Lake aquifer) have been revised with information from later studies. The aquifer thickness, depth, and water quality data shown in Table 1 are primarily from Lindgren and Niehus (1992) and Niehus (1994). All the references cited in Table 1 are listed at the end of this Memo.

For those aquifers with estimated recharge rates, the amount of groundwater available for appropriation is provided. This information was obtained from the water rights database maintained by the Water Rights Program of the South Dakota Department of Agriculture & Natural Resources. If the volume data provided are in ranges or approximated, the lesser amount is shown. The information is current as of September 22, 2023.

It should be noted that the amount shown as available for appropriation from the Dakota aquifer is misleading, as that volume represents what may be available from the entire aquifer and is not representative of what might be possible from a potential wellfield located south of Sioux Falls. The Dakota aquifer is a regional bedrock aquifer, comprised of a complex, interbedded sequence of fine-grained claystones, mudstones, and sandstone that is present throughout much of west-central, central, east-central, and southeastern South Dakota. The northern edge of the aquifer is in northern Lincoln county, and water quality along the northern edge of the aquifer is of poorer quality than that contained in other parts of the aquifer (Iles, 1984). The City of Canton and South Lincoln Rural Water System have wells completed in the Dakota aquifer

It is beyond the scope of this Memo to provide detailed conclusions or recommendations regarding which aquifer or aquifers to consider developing as a raw water source. None of the twelve can provide the volume of water needed to make up the shortfall in raw water production that is projected with the continued rapid population growth of the City. The following statement "Construction of a regional water supply system from the Missouri River would be a solution to most of the water quality and quantity problems discussed in this report." is from a South Dakota Geological Survey report published in 1989 (Barari, et. al., 1989), and remains true today (even with the current Lewis & Clark Regional Water System). Those aquifers that appear most suitable for augmenting the City's raw water supply are the Parker-Centerville aquifer and the Big Sioux:South aquifer.

References Cited

Barari, A., Iles, D. L., and Cowman, T. C., 1989. Assessment of Water Resources and Conceptual Evaluation of a Regional Water Supply for Southeastern South Dakota, Open-File Report 60-UR, South Dakota Geological Survey, Science Center, University of South Dakota, Vermilion, South Dakota, 21 p.

Beffort, J.D., 1969. Ground-Water Investigation for the City of Lennox, South Dakota, Special Report 46, South Dakota Geological Survey, Science Center, University of South Dakota, Vermilion, South Dakota, 47 p.

Buhler, K. A., 2015. Report to the Chief Engineer on the North Management Unit of the Upper Vermillion Missouri Aquifer. SD DANR – Water Rights Program, Joe Foss Building, Pierre, SD., 25 p.

Filipovic, Dragan, and Pence, Stan F., 2001. The Wall Lake Aquifer Study, Open-File Report 88-UR, South Dakota Geological Survey, Science Center, University of South Dakota, Vermilion, South Dakota, 74 p.

Hedges, Lynn S., Burch, Stephen L., Iles, Derric L., Barari, Rachel A., and Schoon, Robert A., 1982. Evaluation of Ground-Water Resources, Eastern South Dakota and Upper Big Sioux River, South Dakota and Iowa, Task 1 through Task 4, Final Report, March 1982, prepared for U.S. Army Corps of Engineers, Omaha, NE, 122 p.

Iles, D. L., 1984. Pleistocene Recharge to Dakota Formation in Lincoln County, South Dakota; In Geohydrology of the Dakota Aquifer, Proceedings of the First C.V. Theis Conferences on Geohydrology, National Water Well Association, and the U.S. Geological Survey, 13 p.

Lindgren, Richard J., and Niehus, Colin A., 1992. Water Resources of Minnehaha County, South Dakota. U.S. Geological Survey Water-Resources Investigations Report 91-4101, Huron, South Dakota, 87 p.

Niehus, Colin A., 1994. Water Resources of Lincoln and Union Counties, South Dakota. U.S. Geological Survey Water-Resources Investigations Report 93-4195, Rapid City, South Dakota, 62 p.

Attachments

Table 1. Summary of Major Aquifers South of Sioux Falls

Table 1. Summary of Major Aquifers South of Sioux Falls

Aquifer	Distance* (miles)	Recoverable Water In Storage - Lincoln County (Hedges, et. al., 1982) (acre-feet)	Recoverable Water In Storage - Minnehaha County (Hedges, et. al., 1982) (acre-feet)	Identified Recharge Sources	Average Aquifer Thickness (feet)	Average Depth to Top of Aquifer (feet)	Iron (mg/L)	Manganese (mg/L)	Sulfate (mg/L)	Total Dissolved Solids (mg/L)	Hardness as CaCO3 (mg/L)	Water Quality Information Source	Estimated Amount Available for Appropriation (ac-ft/yr)	Estimated Amount Available for Appropriation (MGD)	Comment
Big Sioux:South	1	70,200	20,640	Precipitation, Big Sioux River, other aquifers	22	10	1.1	2.3	303 (d)	991	620	Niehus, 1994	5,490	4.9	Un-used water rights of nearly 1.9 MGD
Brule Creek	25	99,600	NP	Precipitation	33	46	0.675	0.075	430 (d)	1,285	690	Niehus, 1994	5,431	4.8	
Dakota	9	4,297,900	NP	Underlying Formations	216	281	1.76	0.19	360 (d)	1,800	480	Niehus, 1994	29,570	26.4	Regional aquifer, highly variable quality
Harrisburg	5	105,170	NA	Glacial Till	26	59	6	3.23	2,100 (d)	4,075	2,700	Niehus, 1994	Not Quantified	Not Quantified	
Lennox	10	43,830	NP	Possibly UVM aquifer, Glacial Till	NA	~300	3.4	1.5	1,164	2,296	1,357	Beffort, 1961	Not Quantified	Not Quantified	
Newton Hills	24	25,200	NP	Precipitation, possibly Brule Creek aquifer	36	72	0.18 (dM)	0.050 (dM)	570 (d)	1,230	1,050	Niehus, 1994	Not Quantified	Not Quantified	Limited data available
Parker-Centerville	27	6,600	NP	Precipitation, UVM aquifer, Vermillion River	35	17	1.49	1.2	360 (d)	777	600	Niehus, 1994	4,850	4.3	Aquifer extends further west into
Schindler	9	124,590	1,360	Harrisburg aquifer, Glacial Till	31	103	4.2	1.49	1,200 (d)	2,220	1,255	Niehus, 1994	Not Quantified	Not Quantified	Very poor water quality, limited data
Sioux Quartzite	0	NA	NA	Precipitation, Big Sioux River	NA	120	0.025 (d)	0.007 (d)	127	696	586	Lindgren & Niehus, 1992 (Table 8)	Not Quantified	Not Quantified	Wells dependant on intercepting
Split Rock Creek	3	NP	99,400	Sioux Quartzite	48	160	0.31 (d)	0.19 (d)	271	853	637	Lindgren & Niehus, 1992 (Table 8)	None	None	In 2019 City withdrew a Future Use
Upper Vermillion Missouri	21	149,180	NP	Parker-Centerville aquifer, Glacial Till	41	162	3.6	2.2	1,400 (d)	2,400	1,300	Niehus, 1994	Not Quantified	Not Quantified	Recharge exceeds withdrawals
Wall Lake	0	70,400	75,690	Sioux Quartzite	33	106	0.37	2.69	757.1	1,086	977	Filipovic & Pence, 2001	Not Quantified	Not Quantified	Likely water available for appropriation

* Approximate, as measured from City's former filter plant along Skunk Creek following township boundaries (see text).

Water quality data are mean or average values of total recoverable concentrations unless otherwise indicated.

~	Approximated from data in Beffort (1961)	mg/L	milligrams per liter	UVM	Upper Vermillion Missouri aquifer	$CaCO_3$	calcium carbonate
NA	Not available	ac-ft/yr	acre-feet per year	(d)	dissolved		
NP	Not present	MGD	million gallons per day	(dM)	maximum dissolved concentration from limited sample number		

WATER 2040

A VISION FOR THE FUTURE OF WATER RESOURCES IN EASTERN SOUTH DAKOTA

WATER 2040 STEERING COMMITTEE

KURT PFEIFLE
Executive Director
SDARWS
605-556-7219
kpfeifle@sdarws.com

JAY GILBERTSON
Manager
East Dakota WDD.
605-688-6741
edwdd@brookings.net

TROY LARSON
Executive Director
Lewis & Clark RWS
605-368-2400
tlarson@lcrws.org

SCOTT PICK
Manager
Randall CWS
605-487-7823
Scott.pick@rcwd.org

CHERYL CHAPMAN
Executive Director.
Western Dakota RWS
605-519-7333
Cheryl.chapman@wdrws.org

MARK COTTER
Public Works Director
City of Sioux Falls, SD
605-367-8663
mcotter@siouxfalls.org

KENT ROE
Board of Directors
Sioux RWS
605-520-4710
oxfordthomas@gmail.com

PROBLEM STATEMENT

The increasing trend of potable water demands in eastern South Dakota, coupled with a public desire for better water quality and mounting regulatory burdens placed on water purveyors, portray and foretell a desperate and thirsty future for residents of eastern South Dakota. Action is needed to strengthen our water utilities and establish their resiliency to these growing challenges.

Recent additions to the State Water Resource Management System (SWRMS) start to address these water issues in western and northeastern South Dakota, the Western Dakota Regional Water System (WDRWS) and, the Water Investment in Northern South Dakota (WINS) respectively. To address the needs of all areas of the state, planning needs to begin now for water security in the central and southern portions of eastern South Dakota.

Regional supplies that exist in this area of South Dakota are all looking to the future and trying to identify from where their next sources of water will come. Lewis & Clark has already embarked on a strategic plan to expand its system from 45 million gallons per day (MDG) to 60 MGD. Mid-Dakota expanded its capacity from 9 MGD to 13.5 MGD and is now looking again to expand further. Nothing suggests these trends will reverse and get better… rather they point to an indefinite future of increasing water needs.

South Dakota must take steps now to protect our most precious resource, water, from many stresses and risks that can prevent or impair our ability to put the water to beneficial use in our state.

GOAL

Conduct regional needs assessments and feasibility studies to more accurately assess the region's current and future water needs and evaluate the capacity of local water resources to meet such needs.

- Conceptually, this would involve an effort analogous to that which led to the 1989 "Assessment of Water Resources and Conceptual Evaluation of a Regional Water Supply for Southeastern South Dakota," SDGS Open-File Report 60-UR.

STEPS TO ACHIEVE THIS GOAL:

1. Form an organization to coordinate and lead discussions, assessments, and studies for eastern South Dakota. This organization would be similar in purpose and scope to those recently formed and added to the SWRMS list i.e., WDRWS and WINS.

2. Identify and secure the fiscal and technical resources needed to pursue regional needs assessments and feasibility studies. Identify and pursue regionalization concepts and solutions to water issues.

3. Assist in securing future governmental (state and federal) authorization and funding for the implementation and construction of the projects identified.

SOUTH DAKOTA DANR AND THE GOVERNOR'S SUPPORT ARE CRUCIAL IF THE AFOREMENTIONED GOALS ARE TO BE ACCOMPLISHED.