STERLING
A Colorado Treasure

Sterling Water Treatment System Preliminary Engineering Report

June 2009

Submitted by

Arber
Water, Wastewater & Reuse Engineers

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Drinking Water Preliminary Engineering Report Guidance & Review Checklist Form

Name of Project:
Applicant Name, Address & Phone Number:
Consultant Name, Address & Phone Number:
WQCD Project Manager:
District Engineer:

Section (Suggested Outline)	Necessary Elements (Guidance)	Addressed on Page # (Applicant)	Complete (Reviewer)
(1) Executive Summary	**Summarize the system needs, selected alternative, and the public health benefits of the proposed project**.		
(2) Planning Conditions	**This section should contain an overview of the significant regional features defining the context of the report and proposed project. Displaying much of the information in map and tabular formats is highly recommended for ease of review and discussion.**		
(2.1) Planning Area	Include map(s) of current and projected service area for the 20-year planning period; identify environmental features such as streams, lakes, wetlands, and floodplains for the entire planning area. *This documentation does not require field surveys and may be obtained from existing data sources such as the National Wetlands Inventory, FEMA and USGS. All or parts of this discussion may be referenced if covered in the Environmental Assessment Report in accordance with the National Environmental Policy Act (NEPA).*	Figure 2-1 Appendix B	
(2.2) Local and Regional Government Coordination	If the proposed project is within or near an urban growth boundary, address conformance with the boundary and any other planning limitations such as tap or water quantity/supply limitations.	No Urban Growth Boundary	
(2.3) Growth Areas and Population Trends	Summarize population projections for the project planning area for a 20-year period; compute and compare recent growth rates with projected growth rates; estimate increases in equivalent residential units (EQRs); identify specific areas of concentrated growth; and reference sources of this information.	Page 7-9	
(2.4) Drinking Water Supply	Briefly summarize projected drinking water demands (average day, peak day and peak hour) for the project planning area for the 20-year planning period. Summarize flow reduction measures such as water conservation plan measures. Address the supply source(s) and primary water quality parameters of concern.	Page 7-9 Appendix C	
(3) **Description of ExistingFacilities**	**This section should provide a description of the existing treatment and distribution facilities**.		
(3.1) Service Area Features	On the planning area map, identify the locations of existing drinking water treatment plants, water sources, major distribution lines, and storage facilities.	Figure 2-1 Page 10-11	
(3.2) Facilities	Provide a process flow schematic layout and narrative		

Section (Suggested Outline)	Necessary Elements (Guidance)	Addressed on Page # (Applicant)	Complete (Reviewer)
Layout and Description	description of existing treatment facilities including design capabilities and remaining useful life as compared to state design criteria. Describe present adequacy of water supply, storage, and distribution capabilities of any existing central facilities. Include current population and per capita flows (gpcd). Note the quantity of unaccounted for water (e.g., distribution system losses).	Figure 2-1 Page 10-11	
(3.3) Financial Status and Users	Discuss the financial status of the drinking water system including O & M costs, existing debt, required reserve accounts, rate structure and other capital improvement programs. Also include a tabulation of volumes used by types of users (e.g., residential, commercial, industrial) for the most recent typical fiscal year.	Page 12-13	
(3.4) Technical, Managerial and Financial (TMF) Capacity	Highlight TMF Capacity issues of concern as indicated by the TMF guidance for the State Revolving Fund program.	Page 14 Appendix E	
(4) Project Purpose and Need	**This section should document the applicable reasons for considering modifications to the existing facilities.**		
(4.1) Health and Compliance	Include a discussion of the system's current compliance status with the "Colorado Primary Drinking Water Regulations" and its potential for acute or chronic health risks. Evaluate any other current or future drinking water quality and quantity issues including secondary MCLs.	Page 15-17	
(4.2) Security	Summarize results of most recent vulnerability assessment.	Page 17 Appendix F	
(4.3) Operation and Maintenance (O&M)	Identify applicable O&M issues such as operational constraints, water loss, and adequate controls.	Page 17-18	
(4.4) Growth	Summarize quality and quantity concerns; considerations for consolidation and phased capacity; reasons for projected future growth during planning period; support by additional revenues and local and regional planning efforts. Note: projects designed solely to serve future development and population growth are not eligible for State Revolving Fund financing.	Page 18	
(5) Assessment of Alternatives	**This section should contain a description of the reasonable alternatives (no action, blending, optimizing the current facilities, and interconnecting with other existing facilities) that were considered in planning a solution to meet the identified needs. If alternatives for upgrades or new treatment facilities alternatives are considered, include the EPA Best Available Technology (BAT) for contaminant(s) removed. <u>Complete assessments should be grouped by alternative and should include information requested in (5.1) through (5.8) below</u>:**		
(5.1) Description	Describe and compare all feasible water treatment technologies, including new technologies that have been thoroughly tested and installed or piloted with successful operating and compliance track records, water supply	Page 19-31	

Section (Suggested Outline)	Necessary Elements (Guidance)	Addressed on Page # (Applicant)	Complete (Reviewer)
	sources, and the facilities, including distribution facilities (storage, transmission and pumping), associated with each alternative.		
(5.2) Design Criteria	State the design parameters, including the need to meet primary drinking water standards, used for evaluation purposes of each alternative. The parameters must comply with state regulatory requirements (Ref. WQCD Policy State of Colorado Design Criteria for Potable Water Systems.) Address treatment residuals management and ultimate disposal methods and costs in detail.	Page 19-31	
(5.3) Environmental Impacts	Describe direct and indirect impacts unique to each alternative on floodplains, wetlands, wildlife habitat, historical and archaeological properties, etc., including any projected permits and certifications.	Appendix B	
(5.4) Land Requirements	Identify all necessary sites and easements, as well as permits and certifications, required for each alternative, and specify if the properties are currently owned, to be acquired, or leased by the applicant.	Appendix B AppendixB-TM4 Appendix L Page 57-58 Page 63-64	
(5.5) Construction Problems	Discuss concerns such as subsurface rock, high water table, limited access, or other conditions that may affect cost of construction or operation of a facility for each alternative.	Appendix M	
(5.6) Operational Aspects	Discuss, in general terms, the staffing requirements, certification level requirements (including distribution), and the expected basic operating configuration and process control complexities for each alternative.	Page 27-31	
(5.7) Cost Estimates	Provide cost estimates for each alternative, including breakdowns for construction, non-construction, and annual operations and maintenance, as well as a present worth analysis for each alternative. A reasonable discount rate should be used for determining the present worth of the uniform series of O&M values (in today's dollars) and the salvage value.	Page 31-33	
(5.8) Advantages/ Disadvantages	Describe, in a narrative format, how each alternative affects the applicant's current and future needs with respect to technical, managerial, and financial concerns; how each alternative complies with regulatory requirements; and how each alternative satisfies public and environmental concerns. Summarize, in a matrix rating system, the advantages and disadvantages of each alternative for clarity.	Page 31-34	

(6) Selected Alternative	**This section should contain the detailed description of the chosen alternative.**		
(6.1) Justification of Selected Alternative	Demonstrate the recommended alternative is the most favorable based on monetary and non-monetary considerations covered in section 5 above. Address whether or not the technology is addressed in the CDPHE design criteria. If the EPA-BAT technology is not selected please include rationale.	Page 31-34	
(6.2) Technical Description	Describe the major features – water source(s); schematic flow diagram of unit treatment processes; unit process sizes (including clearwell); treated water storage capacity; residual handling; treatment and distribution system operator requirements; design criteria – design flow, reserve capacity, process loading rates, treatment log removals, disinfection log removals; any other information pertinent or unique to treatment. Include a bulleted list of all project components and identify which are eligible or ineligible for State Revolving Fund assistance. For more information on determining eligibility please see the "State Revolving Fund Eligibility Assessment Guidance Document." Also be sure to highlight components of the project designed specifically for any of the following purposes: water conservation, source water protection, or beneficial use of sludge.	Chapter 6 Page 69-70	
(6.3) Costs	Provide detailed project-related capital costs, operation and maintenance budget – staffing, training, materials, electricity, lab expenses, residual disposal, compliance monitoring etc.; replacement costs; projected increase in and total average monthly user charges; 20-year cash flow projection spreadsheet. If some components are ineligible for funding (see Section 6.2), identify specific costs associated with the eligible and ineligible components.	Page 68-74 Figure 10-1	
(6.4) Project Implementation	Hold a public meeting with 30-day notice period and summarize outcome; financing recommendations; legal arrangements, intergovernmental agreements; project schedule and/or time required for completion of design and construction – substantial and final completion. Note that a separate Technical, Managerial, and Financial (TMF) Capacity Review process will be required as part of the State Revolving Fund Program. Design approval, a monitoring plan, and vulnerability assessment are additional steps in the implementation process.	Page 75-76	

Prepared By: Richard P. Arber Associates

Reviewed By: _____ Date:_____

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STATE OF COLORADO

Bill Ritter, Jr., Governor
James B. Martin, Executive Director

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Colorado Department
of Public Health
and Environment

August 10, 2009

City of Sterling
Joseph D. Kiolbasa, City Manager
421 North 4th St.
Sterling, CO 80751

Re: The City of Sterling Draft Preliminary Engineering Report (960156D)

Dear Mr. Kiolbasa :

The Water Quality Control Division has reviewed the Draft Preliminary Engineering Report for the *Water System Improvements*, prepared by Richard P. Arber Associates, Inc., June 2009. To comply with the requirements of the Drinking Water Revolving Fund (DWRF) loan program, the following items require further clarification and/or attention:

1. The proposed disposal strategy for the nanofiltration concentrate is to discharge into two deep underground injection wells (which is also pending issuance of a permit from EPA Region VIII). These wells are to be sized such that the combined capacity can only handle the 2022 peak day concentrate production rates. If one of these wells were to fail during peak demand season, then the system may not be able to properly manage the concentrate waste. Therefore, either additional well capacity or an appropriate contingency plan must be developed to ensure that there is a reliable means of disposal in the event of failure of one of the injection wells. Additionally, based upon the process control details provided, if the injection wells were to fail, it appears that the concentrate storage tank could overflow if the concentrate pumps shut down from high pressure and the nanofiltration process continues in production mode; this overflow situation will also need to be addressed with appropriate contingencies to minimize occurrence and/or mitigate environmental impacts.

2. The chlorine contact time requirements will be determined based upon the microfiltration units that are selected. If the units have a demonstrated removal of giardia and crypto of 4-log or greater, then the chlorine contact chamber can be sized for 4-log viral inactiviation; if the units achieve less than 4-log removal of giardia and crypto, then the chlorine contact chamber will need to be sized for 0.5-log giardia inactivation. The current proposed process is sized for 30 minutes of contact time, which may not be sufficient for 0.5-log giardia inactivation depending on the pH, temp, and chlorine residual.

3. The Scalva wells are of greatest concern to the Division for susceptibility to direct surface water influence. The Division understands that the City may be interested in designing a treatment process

which could allow for a filtration bypass for any wells that are true groundwater. If the process can be designed to allow for isolation of groundwater and GWUDI wells, then this approach may be acceptable. This can be evaluated further during the detailed design phase of the project. If the process is reconfigured such that all filtration requirements are met with the nanofiltration skids, then the disinfection process will only need to be sized for 4-log viral inactivation.

4. It is not clear how the concentrate from the future first stage nanofiltration skid will be managed. The second stage skid does not appear to be sized to handle this flow, however, no other management strategies were identified either. This will need to be addressed in detail in the final design submittal.

5. The ROSA model scenarios provided in the report do not directly correspond with the proposed configuration of the water treatment plant (e.g. there is no recycle stream in the model scenario), and furthermore do not directly correspond with the pilot study set-up. Additional model scenarios should be included in the final design submittal to demonstrate predicted full-scale operations as well as scenarios to compare with pilot study results.

6. An integrity testing protocol will need to be developed for the nanofiltration membranes to ensure that the surface water treatment barrier is intact. This can generally be accomplished through conductivity monitoring. Based upon information on page 47 of the report, it appears that only the combined permeate will be continuously monitored for conductivity. This will not be sufficient for purposes of surface water treatment verification and either additional monitors should be added, or a field kit can be used to run periodic grab samples from multiple units. The Division expects the final design submittal to include a proposed membrane integrity monitoring plan.

7. The concentrate storage tank may fall within the jurisdiction of the Solid Waste Program of the Hazardous Materials and Waste Management Division. If this is the case, there may be additional design and operations requirements. It is recommended that the City and its consultants work with the Solid Waste Program during final design to confirm any such requirements.

8. It is not clear if the cost of adding the future first stage skid or concentrate disposal capacity in the year 2022 is included in the cash flow projections. If these have been included, additional clarification should be provided; if not, then these costs must be included and the projections revised accordingly.

9. Based upon the user demands, estimated growth, and well production data, it does not appear that the City has sufficient water supply to meet future peak demands. Although this may not necessarily impact the design of the WTP, the City will need to evaluate options to either reduce future demands or augment existing supplies. The following example illustrates this issue: on page 35 of the report, Table 6-1 shows that the raw water supply needs in twenty years will be approximately 11.48 MGD, however, on page 39, Table 6-4 shows that the total production capability of the well field is 10.8 MGD (this value is a conversion from the 7500 gpm listed in the report).

10. The City should be aware that the spent cartridge filters will also be a waste stream that needs appropriate management. It is possible that uranium could be present in the particulate matter that will be entrapped in the cartridges. Therefore, it is likely that sampling for uranium will be required to determine appropriate disposal facilities.

11. The Division would like to note the following issue. The target 80/20 blend ratio appears to be based upon a finished water hardness goal of approximately 130 mg/L. The input data for these calculations was from a well field of better quality than the Scalva wells; the concentration of hardness and total dissolved solids in the Scalva wells is nearly double that of the input data and could result in exceedances of the City's aesthetic water quality goals. There are not regulatory

requirements for removal of hardness or total dissolved solids, and this comment does not necessarily require a response.

In addition to the above PER comments, please hold a public meeting to inform the citizens in the affected area of the proposed drinking water project to comply with the Federal public participation requirement. The meeting must be noticed at least 30 days prior to the scheduled meeting date, and should include a discussion of project alternatives, the preferred alternative, any projected rate increases, and construction related and/or environmental impacts of the project. A responsive summary, minutes from the meeting and list of attendees should be submitted to the WQCD.

Prior to construction of the proposed project, a plans and specifications review will be required by the WQCD *regardless of the funding source*.

If you have any questions, or wish to discuss the project in more detail, please contact me via telephone at 303-692-3374, or via e-mail at michael.s.beck@state.co.us.

Sincerely,

Michael Beck
Project Manager
Financial Solutions Unit
Water Quality Control Division

ec: Rob Demis, Arber Associates
Ryan Walsh, Arber Associates
Jon Erickson, WQCD
Jackie Whelan, WQCD
Louanna Cruz, WQCD

EXECUTIVE SUMMARY

CITY OF STERLING EXISTING WATER SYSTEM

The City of Sterling is located within Logan County approximately 120 miles northeast of Denver along Interstate 76 adjacent to the South Platte River. Sterling's City limits encompass 5.38 square miles. Primary water uses in the City of Sterling include residential, commercial, industrial, and government water use, as well as irrigation. The City water system serves a residential population of approximately 13,900 people and 4,965 service taps. The City of Sterling operates under a Council/Manager form of government.

The City of Sterling obtains its drinking water from 15 alluvial wells. Drinking water is pumped from the alluvial wells, chlorinated, and conveyed to the distribution system. The City of Sterling water system has four water storage tanks all within the same pressure zone. Two ground level tanks are located in the West Well Field and have water storage volumes of 7.5 million gallons (MG) and 2.0 MG. Two elevated tanks are located within the City (North and South Tanks), and both have a water storage volume of 250,000 gallons each. The City has a total of 10 MG of storage within the distribution system. There is one booster pump station in the distribution system. The booster pump station serves the prison and hotels located near Interstate 70. There is no dedicated storage for the pressure zone served by the booster pump station. The distribution system includes a network of 85 miles of transmission and distribution lines. Pipe diameters in the system range from 6-inch to 24-inch.

Irrigation for parks, cemeteries, sports fields, and golf courses is supplied by a combination of irrigation-only wells and dedicated irrigation connections to the potable water distribution system. The ethanol plant, located in the north east side of town has two dedicated wells. Water for the ethanol plant is treated with a reverse osmosis (RO) process.

ENFORCEMENT ORDER AND EXISTING WATER QUALITY

The City of Sterling was issued an Enforcement Order (DC-080902-1) by the Colorado Department of Public Health and Environment (CDPHE) on September 2, 2008 related to violations of two National Primary Drinking Water Standards, which are legally enforceable. A copy of the Enforcement Order is found in Appendix A.

1. The City's well water supply has elevated concentrations of uranium that exceed the Maximum Contaminant Limit (MCL) of 30 µg/L.
2. The City has experienced levels of TTHM which have occasionally approached and exceeded the MCL of 80 µg/L.

In addition to these violations of the National Primary Drinking Water Standards, the City has several other water quality concerns:

1. CDPHE is concerned that the wells should be considered Ground Water Under Direct Influence (GUDI) of surface water.

2. Several of the wells, in particular those located on west side of the City, have elevated concentration of nitrate that sometimes approach but do not exceed the Primary Standard of 10 mg/L.
3. The City's water supply has elevated concentrations of total dissolved solids (TDS), sulfate and hardness that exceed Secondary Standards (i.e., non-enforceable standards based on aesthetics in lieu of health).

SELECTED TREATMENT PROCESS

The following three treatment processes were evaluated.

(1) Nanofiltration (NF) with a blend stream filtered with a microfiltration process. Concentrate would be managed using one of the four following concentrate management scenarios.
    a. Concentrate discharge to surface water.
    b. Concentrate discharge to groundwater.
    c. Concentrate discharge to evaporation ponds.
    d. Concentrate discharge to deep well injection.

(2) Lime softening followed by media filtration. Residuals from the softening process would be disposed of via landfill.

(3) Modified coagulation filtration with granular activated carbon (GAC). Residuals from the coagulation filtration process would be disposed of via landfill.

The alternative selected for implementation is NF with a blend stream filtered via microfiltration. The NF process provides the necessary removal for Primary Drinking Water contaminants while also treating for Secondary Standards, thereby improving the public acceptability of the finished water, which is a high priority for the City of Sterling. In addition to meeting contaminant limits and increasing the aesthetic quality of the finished water, the consumer cost impact of the NF process has been estimated as the most favorable.

Opinions of probable capital and operation and maintenance (O&M) costs were developed for the project. All costs are presented in 2009 dollars and no attempt has been made to escalate these costs to a future date. The opinion of probable capital cost for the project is $26,630,000. The opinion of probable O&M cost at the time that the plant goes into operation in 2012 is approximately $1,510,000 per year or $1.13 per 1,000 gallons. The O&M costs generally include labor associated with operation and maintenance of the plant, electricity, chemical treatment, membrane cleaning costs, equipment maintenance, cartridge filter replacement and long-term membrane replacement costs.

The Sterling Water Treatment Plant Project will be funded through the State Drinking Water Revolving Fund (DWRF). The DWRF provides low interest loans to government agencies for drinking water public health and compliance purposes. The loans are offered below market interest rates and with extended loan terms.

IMPLEMENTATION SCHEDULE

The City of Sterling has specific deadlines that must be met as a condition of the Enforcement Order. The following Table ES-1 outlines the timeline of the WTP project as outlined in the Enforcement Order. A copy of the Enforcement Order is found in Appendix A.

Table ES-1: Project Timeline

Item	Date	Comment
Receipt of enforcement order	September 2, 2008	
Retain a professional engineer	September 30, 2008	Completed
Complete evaluation and submit to CDPHE a written report on well operation plan to reduce levels of uranium	November 1, 2008	Completed
Complete evaluation and submit a written report to CDPHE on measures to ensure best water quality with respect to TTHMs	December 16, 2008	Completed
Develop and submit to CDPHE an Outreach and Communication Strategy	March 1, 2009	Completed
Submit Preliminary Engineering Report (PER) to CDPHE	July 1, 2009	
Submit Final Design Report to CDPHE	November 1, 2009	
Submit Final Design Plans and Specifications to CDPHE	May 1, 2010	
Complete Construction/Implementation of Improvements	December 31, 2011	
Submit engineer's certification to CDPHE to show system improvement/constructed/installed to comply with uranium and TTHM	February 15, 2012	

CHAPTER 1
INTRODUCTION

1.1 PROJECT BACKGROUND

This Preliminary Engineering Report (PER) was prepared for the City of Sterling by Richard P. Arber Associates to present the preliminary engineering and design of the proposed Sterling Water Treatment Plant (WTP). Preparation of the PER includes the following general activities:

- Description of the service area and existing water supply system
- Potable water demand projections, and description of water supply configuration
- Evaluation of raw water quality characteristics
- Identification of water supply, quality and treatment requirements
- Evaluation of alternatives and selection of alternatives to be implemented
- Preliminary design of the water treatment facilities
- Preliminary design of raw and potable distribution system upgrades
- An evaluation of reliability and redundancy requirements for the system
- Discussion of discharge issues and permitting
- Opinions of probable construction and operation and maintenance costs
- Project implementation schedule

The PER is required by the Water Quality Control Division (WQCD) of the Colorado Department of Public Health and Environment (CDPHE) as part of their review process for financial assistance from the Drinking Water Revolving Fund (DWRF), and for approval of the water treatment facilities. The PER must demonstrate the economic, environmental, and engineering feasibility of the proposed project.

1.2 PROJECT DESCRIPTION AND NEED FOR PROJECT

The City's water system is currently supplied by 15 existing wells. Two of the wells (Scalva Well 1 and Scalva Well 2) have recently been constructed but are not yet approved by the CDPHE. Therefore, the Scalva Wells are not currently part of the City's distribution system. The City's existing wells have uranium concentrations that are near or above the drinking water standard of 30 µg/L. The running annual average for total trihalomethanes (TTHM), a disinfection byproduct (DBP), is near or above the drinking water standard of 80 µg/L.

There are two main well fields serving the City with potable water: the East Well Field located east of the City near highway I-76 with 11 wells plus the two Scalva Wells, and the West Well Field located west of the City with 3 wells. The City's wells are typically 60 to 100 feet deep.

The City was recently issued an Enforcement Order by CDPHE related to violations of two National Primary Drinking Water Standards, which are legally enforceable. A copy of the Enforcement Order is found in Appendix A.

1. The City's well water supply has elevated concentrations of uranium that exceed the standard of 30 µg/L.

2. The City has experienced levels of TTHM which have occasionally approached, and exceeded, the standard of 80 µg/L.

In addition to these violations of the National Primary Drinking Water Standards, there are several other water quality concerns:

1. CDPHE is concerned that the wells should be considered Groundwater Under Direct Influence (GUDI) of surface water, which could require full filtration.

2. Several of the wells, in particular those located on west side of the City, have elevated concentration of nitrate that sometimes approach, but have not exceeded, the Primary Standard of 10 mg/L.

3. The City's water supply has elevated concentrations of total dissolved solids (TDS), sulfate and hardness that exceed Secondary Standards (i.e., non-enforceable standards based on aesthetics in lieu of health).

The City of Sterling must construct a new WTP that addresses, at a minimum, Primary Standards. The City also desires to address the Secondary Standards of TDS, sulfate and hardness to increase the public acceptability of the finished drinking water.

1.3 REPORT ORGANIZATION

The planning documents for this project consist of several documents:

- This Report titled *City of Sterling Water Treatment Plant Project, Preliminary Engineering Report*, dated June 2009
- A draft environmental report under separate cover titled *Draft Environmental Assessment – Sterling Water Treatment Plant – Sterling, Colorado*, dated May 20, 2009
- A Colorado Drinking Water Revolving Fund Application for Financial Assistance, and associated documentation, required for the Drinking Water Revolving Fund (under separate cover)
- Technical, Managerial and Financial (TMF) Capacity worksheets, and associated documentation, required by the Drinking Water Revolving Fund
- Technical Memorandum Number 1 - *Uranium Concentration Evaluation and Well Operations Plan*, dated October 31, 2008
- Technical Memorandum Number 2 - *Total Trihalomethanes Evaluation and Interim Improvements Plan*, dated December 22, 2008
- Technical Memorandum Number 3 - *Consumer Cost Impact for Centralized Advanced Water Treatment for Secondary Standards*, dated December 16, 2008
- Technical Memorandum Number 4 - *Site Selection Alternatives Evaluation*, dated December 19, 2008
- Technical Memorandum Number 5 - *Water Treatment Plant Capacity Evaluation*, dated April 3, 2009

- A draft of the report titled *City of Sterling Water Conservation Plan*, dated March 2009

All of these documents, except for the DWRF Loan Application, are included as appendices to this report. The TMF Capacity Evaluation Worksheets are included in the appendices; however, the supporting documentation is included under a separate cover.

CHAPTER 2
PLANNING CONDITIONS

2.1 PLANNING AREA

The City of Sterling is located within Logan County approximately 120 miles northeast of Denver along Interstate 76 adjacent to the South Platte River. Sterling's City limits encompass 5.38 square miles. Primary water uses in the City of Sterling include residential, commercial, industrial, and government water use, as well as irrigation. The City water system serves a residential population of approximately 13,900 people and 4,965 service taps. The City of Sterling operates under a Council/Manager form of government.

The City of Sterling service area is shown in Figure 2-1. Also shown in Figure 2-1 are major environmental features such as streams, lakes and ditches. Additional mapping of environmental features is found Appendix B - *Draft Environmental Assessment - Sterling Water Treatment Plant*.

2.2 POPULATION TRENDS

The City of Sterling has experienced little growth over the recent years. Historic growth has been obtained from the Department of Local Affairs (DOLA) and presented in Table 2-1.

Table 2-1: Historic Population Growth

Year	Population	Percent Growth
2003	13,866	
2004	13,665	-1.4%
2005	13,529	-1.0%
2006	13,556	0.1%
2007	13,695	1.0%

Population projections were obtained from DOLA. DOLA projects population for Colorado by county; therefore, the population projections for Sterling are based on projections for Logan County. Population projections for the City of Sterling were developed using the same growth rate projected by DOLA for Logan County. Figure 2-2 illustrates population projections for Logan County and the City of Sterling:

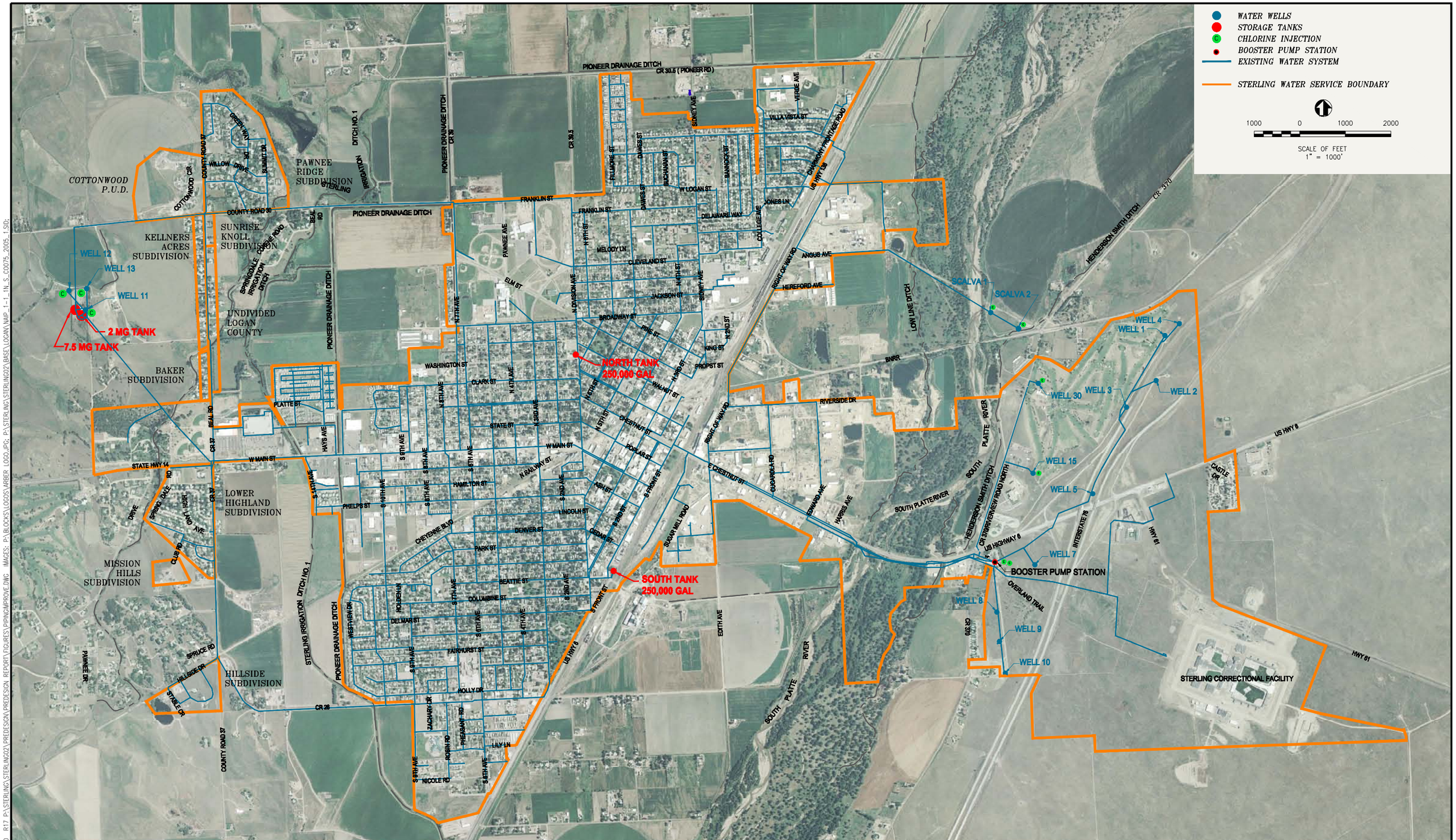

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FIGURE 2-1

CITY OF STERLING-WATER TREATMENT PLANT SERVICE AREA/EXISTING WATER SYSTEM

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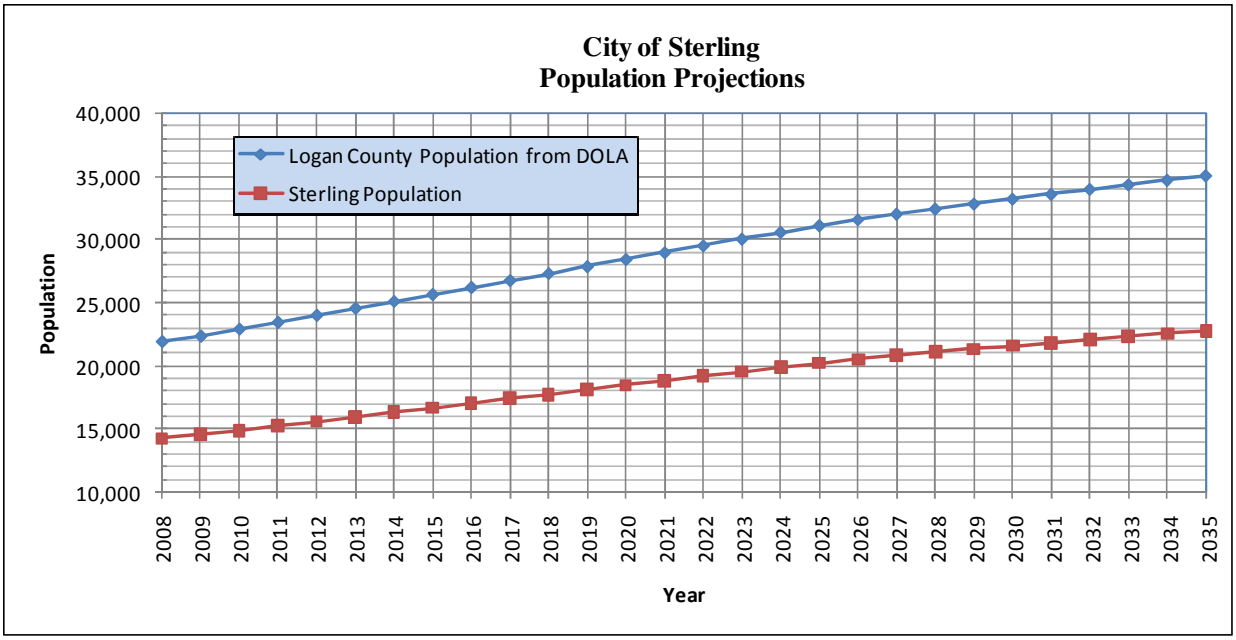

Figure 2-2: Logan County and City of Sterling Population Projections

2.3 DRINKING WATER SUPPLY

The new WTP will be designed to meet the peak day demand for the potable water system. Billing and pumping data from the City of Sterling Finance Department and Public Works Department was collected and compiled to break down the existing water demands by user class. The user classes for the City of Sterling are as follow.

- Single family residential
- Multi-family residential
- Commercial
- Industrial
- Government
- Parks

Three demand scenarios were developed to project future demands on the potable water system.

1. Scenario No. 1: No Additional Water Conservation
2. Scenario No. 2: Additional Water Conservation as Identified in the Water Conservation Plan (WCP)
3. Scenario No. 3: Additional Water Conservation as Identified in the WCP Plus Installation of Additional Irrigation Only Wells

The three demand scenarios are explained in greater detail in Appendix C - *City of Sterling Water Conservation Plan* and Appendix D – Technical Memorandum No. 5 - *Water Treatment Plant Capacity Evaluation*.

The City will implement additional water conservation and install irrigation only wells to reduce the potable water demand. As such, Scenario No. 3 was selected by the City as a reasonable forecast of future water demands. This PER and design of the WTP will be based upon Scenario No. 3, which projects water demands for the City to year 2032. Figure 2-3 illustrates the average day and peak day demands for the City.

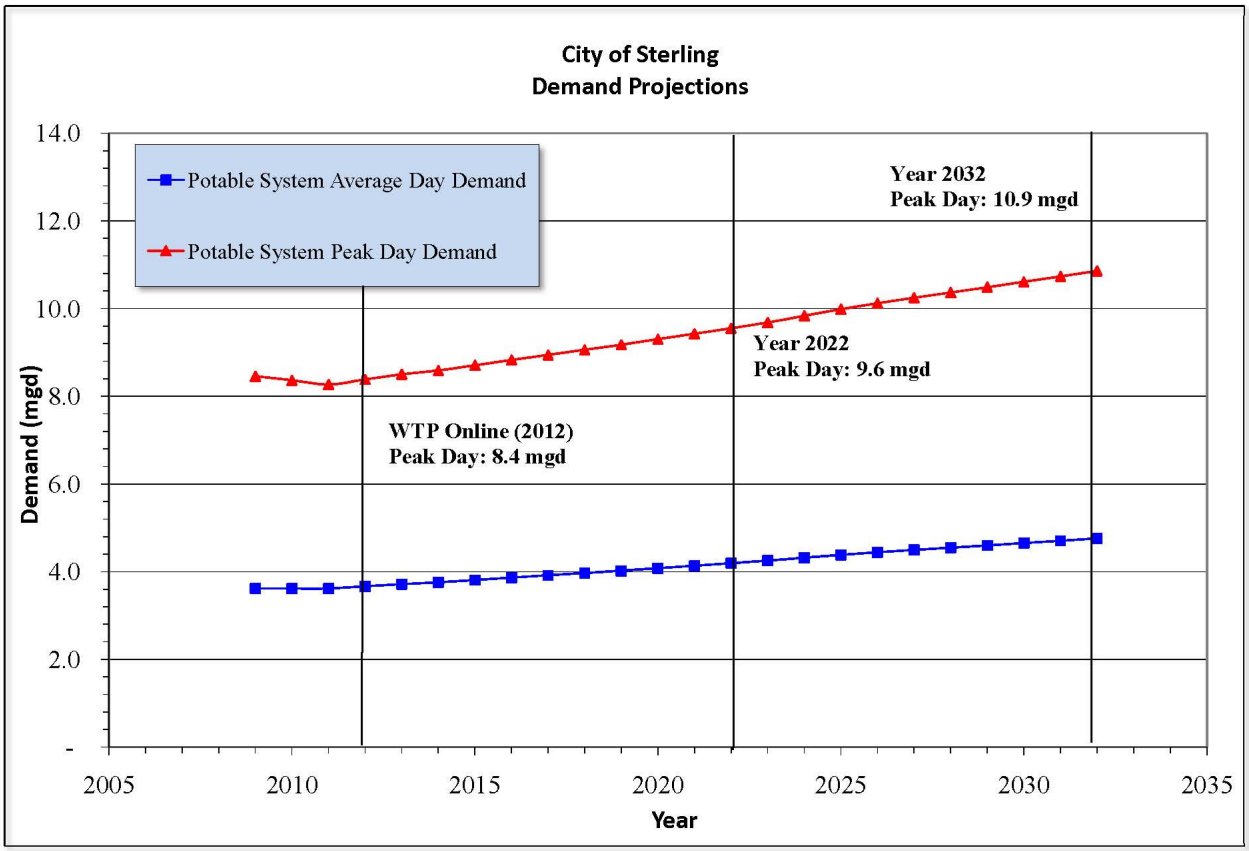

Figure 2-3: Demand Projections

CHAPTER 3
DESCRIPTION OF EXISTING FACILITIES

3.1 SERVICE AREA FEATURES AND EXISTING FACILITIES

The City of Sterling does not have a centralized water treatment plant. Drinking water is pumped from alluvial wells, chlorinated, and conveyed to the distribution system. The City of Sterling water system has four water storage tanks all within the same pressure zone. Two ground level tanks are located in the West Well Field and have water storage volumes of 7.5 million gallons (MG) and 2.0 MG. Two elevated tanks are located within the City (North and South Tanks), and both have a water storage volume of 250,000 gallons each. The City has a total of 10 MG of storage within the distribution system. There is one booster pump station in the distribution system located at the common entry point to the distribution system for two groups of wells. One set of booster pumps are dedicated to Wells 1, 2, 3, 4, 5 and 7, also referred to as Site 1; and the other set of booster pumps is dedicated to Wells 8, 9 and 10, also referred to as Site 2. The booster pump station serves the prison and hotels located near Interstate 70. There is no dedicated storage for the pressure zone served by the booster pump station. The distribution system includes a network of 85 miles of transmission and distribution lines. Pipe diameters in the system range from 6-inch to 24-inch.

Irrigation for parks, cemeteries, sports fields, and golf courses is supplied by a combination of irrigation-only wells and dedicated irrigation connections to the potable water distribution system. The ethanol plant, located in the north east side of town has two dedicated wells. Water for the ethanol plant is treated with a reverse osmosis (RO) process. The irrigation-only wells and the wells that serve the ethanol plant are not included in the potable drinking water system for the City of Sterling and will not be discussed further in this report.

Figure 2-1 illustrates the major components of the distribution system including drinking water wells, pumps, water storage tanks, and the booster pump station.

The existing distribution system is in average condition. Pipe materials include ductile and cast iron, PVC and steel. The City has recently purchased leak detection equipment and implemented a leak detection program to efficiently identify leaks in the distribution system to be repaired or replaced.

The City's drinking water system is supplied by 15 wells. The capacity of each of the wells is summarized in Table 3-1 below.

Table 3-1: Summary of Potable Wells and Water Production

Well Number	Well Field	Typical Water Production (GPM) [1]
1	EAST	300
2	EAST	400
3	EAST	210
4	EAST	650
5	EAST	350
7	EAST	380
8	EAST	470
9	EAST	290
10	EAST	360
15	EAST	750
30	EAST	840
Scalva Well 1 [2]	EAST	1,250
Scalva Well 2 [2]	EAST	1,250
SUBTOTAL	**EAST**	**7,500**
11	WEST	500
12	WEST	1,035
13	WEST	740
SUBTOTAL	**WEST**	**2,275** [3]
	Total Water Production	**9,775**

[1] Typical water production values presented are equal to well capacity or decreed capacity, whichever is lower.
[2] Scalva Wells are currently not permitted.
[3] Well 11, 12 are seasonal wells. Well 13 is an emergency well.

3.2 EXISTING WATER USAGE AND UNACCOUNTED FOR WATER

The City classifies five main types of potable demands; residential, commercial, industrial, government, and parks. Residential water sales can be further broken down into two types: single-family and multi-family. The existing per capita residential usage for the City is 124 gallons per capita per day.

One measure of efficiency for water distribution systems is lost and unaccounted for water. Unaccounted for water is the difference between the water that is produced and the sum of water sold and accounted for losses in the system. Unaccounted water typically consists of system leakage, meter inaccuracies, illegal connections, and uses that are unmetered such as main flushing and fire fighting. A value of under 10% is typically considered acceptable for most water systems according to the American Water Works Association Leak Detection and Water Accountability Committee.

Recent records for total water pumped for the calendar year were compared to the total amount of water billed. According to billing and production data for the years 2006 – 2008, the average unaccounted for water is approximately 17%. It is estimated that system losses are approximately 11%. Most of the City's municipal buildings are unmetered, which accounts for approximately 6%.

The City is currently implementing a program to install meters on all government buildings. This will enable the system losses to be clearly defined, thereby making the water accounting system more transparent. Additionally, the City has purchased leak detection equipment and implemented a leak detection program. Increased metering and the leak detection program are explained in greater detail in the draft *City of Sterling Water Conservation Plan* - Appendix C.

3.3 FINANCIAL STATUS AND USERS

A Technical, Managerial and Financial (TMF) Capacity Evaluation has been completed for the City of Sterling. The TMF worksheets are found in Appendix E. Detailed financial information for the City of Sterling can be found in the TMF supporting documents, which are available under a separate cover.

3.3.1 Existing Rate Structure

One of the City's revenue sources for the water system comes from the sales of water based on actual water consumption for each customer. There are two different rate structures, one for customers within City boundaries and one for customers outside of City boundaries. The minimum monthly rate varies based upon tap size. The City has a tiered rate structure to encourage water conservation. Table 3-2 summarizes the current monthly minimum and Table 3-3 summarizes the current rate structure based on consumption.

Table 3-2: Existing Rate Structure – Minimum Monthly Charge

Meter Size	Monthly Minimum (Inside City Limits)	Monthly Minimum (Outside City Limits)
5/8-inch – 3/4-inch	$8.25	$10.68
1-inch	$9.10	$11.80
1 1/2-inch	$11.18	$14.52
2-inch	$13.66	$17.77
3-inch	$19.46	$25.37
4-inch	$27.75	$36.22
6-inch	$48.48	$63.38
8-inch	$64.83	$84.80
10-inch	$77.92	$110.95

Table 3-3: Existing Rate Structure – Charge per Consumption

Consumption (Thousands of Gallons Per Month)	Charge per Thousand Gallons (Inside City Limits)	Charge Per Thousand Gallons (Outside City Limits)
2-10	$1.44	$1.78
11-20	$1.46	$1.81
21-50	$1.49	$1.85
51-100	$1.53	$1.89
Greater Than 100	$1.63	$1.98

Another source of revenue for the water utility is derived from tap fees and plant investment fees. A tap fee is a one-time capital charge for a new (or enlarged/increased) connection to the system and is based upon the tap sizes. The current charge for a tap of 1-inch or smaller is a flat rate of $470. Tap fees for taps larger than 1-inch are assessed on a case by case basis. Plant investment fees are based on tap size. Table 3-4 summarizes the existing plant investment fees based on tap size.

Table 3-4: Existing Plant Investment Fee Structure

Tap Size	Plant Investment Fee (Inside City Limits)	Plant Investment Fee (Outside City Limits)
5/8-inch – 3/4-inch	$1,255	$1,644
1-inch	$2,095	$2,744
1 1/2-inch	$4,190	$5,489
2-inch	$6,700	$8,777
3-inch	$13,400	$17,544
4-inch	$20,940	$27,431
6-inch	$41,880	$54,758
8-inch	$67,000	$87,770
10-inch	$96,325	$126,186

The tap fee and plant investment fee revenues are utilized for repayment of debt service and funding capital projects associated with the expansion of the water system.

3.3.2 Volumetric Use By User Category

The City's current potable water demands, broken down by category, are summarized in Table 3-5. The water demands presented in Table 3-5 are based on billing records.

Table 3-5: Potable Water Demands By Customer Class (Year 2008)

Customer Class	Annual Usage (MG) [1]	Percent of Total Annual Usage (%)
Single Family Residential	608	49%
Multi-Family Residential	117	9.4%
Commercial	199	16%
Industrial	2	0.2%
Government [2]	248	20%
Parks [3]	67	5.4%
Total	*1,241*	*100%*

[1] MG = million gallons.
[2] 79% of government use is the Sterling Correctional Facility.
[3] Parks includes potable water used to irrigate parks throughout the City.

3.4 TECHNICAL, MANAGERIAL, AND FINANCIAL (TMF) CAPACITY

A TMF Capacity Evaluation has been completed. As noted, and Enforcement Order has been issued for this drinking water system. Therefore, the system is not in compliance with Federal and State water quality regulations. The TMF Capacity Evaluation Worksheets are included in Appendix E. A copy of the Enforcement Order is found in Appendix A.

CHAPTER 4
PROJECT PURPOSE AND NEED

4.1 NATIONAL PRIMARY AND SECONDARY DRINKING WATER STANDARDS

Federal drinking water regulations are based on the requirements of the Safe Drinking Water Act (SDWA) and other regulations passed in conjunction with the SDWA. The SDWA was first passed in 1974 and has undergone four major revisions since then, most recently in 1996. The SDWA establishes the requirements of the National Primary Drinking Water Regulations (NPDWRs). The NPDWRs are legally enforceable standards meant to protect drinking water supplies and public health by setting maximum concentration limits on contaminants that can adversely affect public health. The NPDWRs include Maximum Contaminant Levels (MCL), which establishes the maximum permissible level of a contaminant in potable water.

In addition to the NPDWRs, the SDWA includes standards established through the National Secondary Drinking Water Regulations (NSDWRs). The NSDWRs are non-enforceable standards that regulate contaminants that may result in cosmetic deficiencies (such as skin or tooth discoloration) or aesthetic deficiencies (such as taste, odor, or color), but are not a threat to public health. The NSDWRs include standards for a series of inorganic chemicals, and other water quality parameters such as pH, color, odor, corrosivity, sulfates and total dissolved solids (TDS). Although non-enforceable, it is recommended that the requirements of the Secondary Standards be met in most circumstances.

4.1.1 Uranium, Disinfection By-Products and Nitrate Regulations

Uranium is regulated under the Radionuclide Rule for drinking water. In 2000, this rule was updated to include uranium with an MCL of 30 µg/L. Uranium is a naturally occurring contaminant in drinking water, often resulting from the erosion of natural deposits and manmade activities such as mining. Uranium in drinking water may lead to an increased risk of cancer and is toxic to the kidneys. Sterling's current average uranium level, according to Enforcement Order DC-080902-1 is 43 - 45 µg/L. Uranium will be removed with the selected treatment process identified in this PER.

The Stage 1 Disinfectants/Disinfection By-products (D/DBP) Rule was passed as part of the 1996 SDWA Amendments in order to protect people from the residual disinfectant and disinfection by-products that are a result of chemical disinfection. The Stage 1 of the D/DBP Rule went into effect for all ground water systems, regardless of size, on January 1, 2004. The D/DBP Rule includes an MCL of 80 µg/L for total trihalomethanes (TTHM) and 60 µg/L for the sum of five haloacetic acids (HAA_5). The Stage 1 Rule will soon to be superseded by the Stage 2 D/DBP Rule. Under this rule the MCL values will remain the same but will require water utilities to meet the MCL at each monitoring site rather than as a system wide average of the monitoring locations. Thus, utilities that are having difficulties in meeting the Stage 1 regulation will have additional difficulties in meeting the Stage 2 requirement, unless alternative treatment or other mitigation measures are implemented. The City's high TTHM levels in the past are believed to be a combination of high total organic carbon (TOC) concentrations (materials that

serve as DBP precursors), high bromide concentrations that significantly increase the formation of TTHMs, and high water age in the distribution system. Sterling's current average TTHM level from 2006 - 2007, according to Enforcement Order DC-080902-1 is 83 - 91 µg/L The focus of a treatment system will be to remove the TOC that serves a DBP precursor.

Nitrate is often prevalent in water sources located adjacent to agricultural lands where fertilizers are being applied. Nitrates may also be a result of leaching from septic tanks, sewage, or erosion of natural deposits. High nitrate concentrations may cause "blue baby syndrome" in infants under six months of age, a potentially life threatening condition. The MCL for nitrate is 10 mg/L as nitrogen. Sterling is not in violation of the nitrate MCL. The wells on the west side of the City with higher nitrate levels will be used as emergency only wells and will not be connected to the WTP.

4.1.2 Ground Water Under Direct Influence

Ground water systems that are located adjacent to surface waters are under the threat of microbial/pathogen contamination from that surface water if the sources are hydraulically connected. This situation is referred to as "ground water under direct influence" (GUDI). Historically, evaluations indicating the amount of microbial and particulate materials present in the ground water that are expected to originate from a surface water were used by CDPHE to determine GUDI status. However, CDPHE has recently begun to scrutinize sources more heavily, in particular alluvial well systems such as the City of Sterling's East Well Field. If a water system is considered to be GUDI, the requirements of the Interim Enhanced Surface Water Rule (IESWTR) apply.

The IESWTR was finalized in December 1998. Compliance with this rule was required by January 2002. This rule expands upon the requirement of Surface Water Treatment Rule (SWTR). This rule applies to systems using GUDI and that serve a population 10,000 or greater, and hence Sterling will fall under this rule if its sources are to be designated as GUDI. CDPHE has recently shown concern with Sterling's wells and have stated Sterling's wells will likely be considered as GUDI. The impact of this determination is that while Sterling currently only provides disinfection of the well water, the City will be required to provide a treatment technology, such as filtration with disinfection for all wells. Sterling will now be required to meet finished water turbidity as well as microbial (*Cryptosporidium*, Giardia *lamblia* and virus) reduction requirement, and may be required to meet certain minimal percent removals of DBP precursors to meet requirements of the Enhanced Coagulation Rule. Requirements of the SWTR include the following.

- Giardia *lamblia*: 99.9% (3-log) reduction or inactivation
- Viruses: 99.99% (4-log) reduction or inactivation
- *Cryptosporidium*: 99.0% (2-log) reduction or inactivation
- HPC: No more than 500 colonies per mL.
- Turbidity: At no time to exceed 1.0 nephelometric turbidity units (NTU). Turbidity not to exceed 0.3 NTU (for conventional or direct filtration) in 95% of the monitored samples taken every month.

- Residual Chlorine: Maintain a 0.2 mg/L residual at all locations within the distribution system.

4.2 ENFORCEMENT ORDER

The City of Sterling was issued an Enforcement Order (DC-080902-1) by the Colorado Department of Public Health and Environment (CDPHE) on September 2, 2008 related to violations of two National Primary Drinking Water Standards, which are legally enforceable. A copy of the Enforcement Order is found in Appendix A.

1. The City's well water supply has elevated concentrations of uranium that exceed the Maximum Contaminant Limit (MCL) of 30 µg/L.
2. The City has experienced levels of TTHM which have occasionally approached and exceeded the MCL of 80 µg/L.

In addition to these violations of the National Primary Drinking Water Standards, the City has several other water quality concerns:

1. CDPHE is concerned that the wells should be considered GUDI of surface water.
2. Several of the wells, in particular those located on west side of the City, have elevated concentrations of nitrate that sometimes approach but do not exceed the Primary Standard of 10 mg/L.
3. The City's water supply has elevated concentrations of total dissolved solids (TDS), sulfate and hardness that exceed Secondary Standards (i.e., non-enforceable standards based on aesthetics in lieu of health).

4.3 SECURITY

A Vulnerability Study has been completed for the City of Sterling. A Vulnerability Study Certification has been included in Appendix F of this report. Additionally, the Vulnerability Study Certification has been included as part of the TMF Capacity Evaluation (TMF Worksheets found in Appendix E).

4.4 OPERATION AND MAINTENANCE (O&M)

Operation and control of the existing water system is based upon water level in the South Tank. As the water level in the tanks varies, certain wells are called to run via a radio telemetry system. These wells feed water directly into the potable water distribution system. All of the tanks "float" on the potable water distribution system meaning that they are all within the same pressure zone. Once the South Tank has reached full operating level, the wells are called to shut down. Should the South Tank control system fail, the North Tank will become the controlling tank.

As indicated in Chapter 3, the City is currently implementing a program to equip all City Buildings with meters. Additionally, the City has purchased leak detection equipment and implemented a leak detection program. Increasing the metering coverage within the City coupled

with a leak detection program will allow the City to develop a more transparent water accounting system and reduce the overall unaccounted for water within the system. Increased metering and the leak detection program are explained in greater detail in the draft *City of Sterling Water Conservation Plan* - Appendix C.

There are no major O&M issues with the existing water system. The purpose of the Sterling Water Treatment Project is to address violations of Primary Drinking Water Standards and not O&M issues.

4.5 GROWTH

Future potable water demands were projected in Chapter 2. The WTP building, raw water piping, finished water piping, and major process piping, and some tanks will be sized for the capacity projected in year 2032. Major equipment will be sized for the capacity projected in year 2022. This first phase of construction will provide capacity for ten years with the plant coming online in year 2012. The purpose of this project is to address violation of Primary Drinking Water Standards, not to serve future growth in the City.

CHAPTER 5
ASSESSMENT OF ALTERNATIVES

The following sections summarize the existing water quality and treatment goals, alternatives evaluated, cost comparisons between the evaluated alternatives, and the selected treatment process.

5.1 WATER QUALITY

The City of Sterling's raw water quality contains contaminants that exceed both Primary and Secondary Drinking Water Standards. At a minimum, Primary Standards must be addressed; however, Secondary Standards improve the aesthetic value of the finished water and reduce adverse cosmetic effects. Table 5-1 summarizes the water quality and treatment goals for the City of Sterling. Additional water quality data is found in Appendix G.

Table 5-1: Water Quality

Contaminant	Standard	Sterling's Typical Range
Primary Drinking Water Standards		
Uranium	30 µg/L	2 - 54 µg/L
TTHM TOC [(1) (2)] Bromide [(2)]	80 µg/L - -	30 - 139 µg/L 1.5 - 4.0 mg/L 90 -700 µg/L
HAA_5	60 µg/L	3 - 34 µg/L
Nitrate	10 mg/L	1 – 9 mg/L
Secondary Drinking Water Standards		
Hardness (as $CaCO_3$) [(3)]	100 – 200 mg/L	208 – 970 mg/L
TDS	500 mg/L	359 – 2,220 mg/L
Sulfate	250 mg/L	1 – 1,170 mg/L

[(1)] TOC = total organic carbon
[(2)] TOC and bromide are TTHM precursors
[(3)] Not a regulated Secondary Standard, but a typical desired range.

Disinfection Byproducts (DBPs), such as TTHMs are the product of raw water precursors being exposed to disinfection. In the case of TTHMs, the precursors of concern are total organic carbon (TOC) and bromide. Sterling's raw water has a typical range of TOC of 1.5 - 4.0 mg/L. Research has indicated that a TOC concentration of between 1.8 - 2.0 mg/L should be a treatment goal to prevent the formation of DBPs.

5.2 TREATMENT TECHNOLOGIES CONSIDERED

A list of alternatives to be evaluated was developed based on the Environmental Protection Agency (EPA) Best Available Technology (BAT), the Colorado Radionuclide Abatement and Disposal Strategy (CO-RADS) Report, proprietary treatment processes, and engineering judgment. The City of Sterling has a challenging water quality. Due to the nature of the City's water, and the number of contaminants of concern, multiple technologies will be necessary to achieve the desired water quality.

The CDPHE is concerned that Sterling's wells are GUDI. Therefore, any combination of technologies must provide the following removal and/or inactivation of microbial contaminants via a treatment technology.

- 99.9% (3-log) removal and/or inactivation of Giardia *lamblia* cysts, and
- 99.99% (4-log) removal and/or inactivation of viruses, and
- 99% (2-log) removal and/or inactivation of *Cryptosporidium* oocysts.

The following technologies were considered.

- Ion exchange
- Reverse osmosis (RO)/nanofiltration (NF)
- Lime softening with filtration
- Coagulation filtration
- Microfiltration (MF)
- Granular activated carbon (GAC)
- MIEX® from Orica Watercare
- Z-92™ Uranium Removal Process from Water Remediation Technology (WRT®)

Ion exchange, RO, lime softening, and coagulation filtration are BATs for removal of uranium. Coagulation filtration, lime softening, and GAC are BATs for removal of DBP precursors.

The CO-RADS report identified RO/NF followed by evaporation ponds or coagulation filtration as the two best technologies available for the City of Sterling. Ultimately, due to capital cost considerations, CO-RADS recommended coagulation filtration for compliance with Primary Drinking Water Standards.

RO and NF are similar processes. RO membranes have smaller pore sizes and therefore are capable of higher rejection of contaminants. RO membranes are ideal for brackish and seawater applications. NF membranes are ideal for systems requiring lower rejection (especially of monovalent ions). NF systems require lower feed pressures and therefore lower energy demand. Additionally, NF systems typically require less chemical addition because the mineral content in the permeate water is higher due to lower rejection.

MF could be used in concert with other technologies that do not provide filtration to comply with the Surface Water Treatment Rule (SWTR) in the event that Sterling's wells are classified as Groundwater Under Direct Influence (GUDI) of surface water.

The MIEX® process is a proprietary product from Orica Watercare. The MIEX® process is an ion exchange process using a continuously recirculated magnetized media operating as a fluidized bed. MIEX® can be used to remove uranium and the DBP precursors of TOC and bromide.

The Z-92™ Uranium Removal Process is a proprietary product by WRT®. The Z-92™ process is a highly selective ion exchange process for removal of uranium. The spent media is then removed, transported, and disposed of off site by WRT®.

Table 5-2 summarizes the barriers provided for Primary and Drinking Water contaminants by the technologies chosen for consideration.

Table 5-2: Barriers Provided by Various Water Treatment Processes

Treatment Process	Uranium	DBP Precursors	Nitrate	Hardness	TDS	Sulfate	Filtration
Ion Exchange	X	X	X	X		X	
RO/NF	X	X	X	X	X	X	X
Lime Softening with Filtration	X	X [(1)]		X			
Coagulation/Filtration	X	X					X
MF							X
GAC		X					
MIEX®	X	X	X			X	
Z-92™ Uranium Removal Process	X						

[(1)] Requires high lime dose to increase pH to ≥ 11.

As previously indicated, the City of Sterling water quality is challenging. It is likely that no single treatment process will provide the finished water necessary for compliance with the Primary Drinking Water Standards. Additionally, the City of Sterling has indicated a strong desire to treat for Secondary Drinking Water Standards to improve the public acceptability of the finished drinking water.

5.2.1 Residuals Management

Management of solid or liquid residuals was a major consideration during the treatment process selection. Residuals management in selection and design of drinking water systems is often the most challenging part of a project.

Table 5-3 summarizes the technologies for initial consideration as well as the residuals stream produced by each process.

Table 5-3: Technologies for Initial Consideration

Technology	Residuals
Ion Exchange	• Intermittent regeneration liquid stream discharged to sewer [(1)], drying beds with disposal of solids via landfill [(2)], or surface water. [(3)] • Intermittent disposal of spent media to landfill. [(2)]
RO/NF	• Concentrate stream discharge to surface water [(3)], groundwater [(3)], evaporation ponds with disposal of solids via landfill [(2)], or deep well injection. [(4)] • One-pass system (17% residuals), two-pass system (5% residuals).
Lime Softening	• Large quantity of solid residuals dried and disposed of to landfill. [(2)]
Coagulation Filtration	• Residuals (3%) dried and disposed of to landfill [(2)] or discharged to sewer. [(1)]
MF	• Reverse filtration backwash water discharged to sewer.
GAC	• Intermittent disposal or regeneration of carbon.
MIEX®	• Regeneration liquid stream discharged to sewer [(1)], drying beds with disposal of solids via landfill [(2)], or surface water. [(3)]
Z-92™ Uranium Removal Process	• Disposal of spent media by Water Remediation Technology (WRT®). [(5)]

[(1)] Discharge to sewer would require evaluation of collection system and wastewater system as well as evaluation of permit limits.
[(2)] Disposal at landfill would require evaluation of State and local regulations including Technologically Enhanced Naturally Occurring Radioactive Material (TENORM) regulations.
[(3)] Discharge to surface water or groundwater would require evaluation of permit limits.
[(4)] Deep well injection would require a Class I underground injection well permit through EPA Region 8 Underground Injection Control (UIC) Program.
[(5)] WRT® maintains control of disposal of spent media. No special permitting required.

5.3 BENCH SCALE AND PILOT SCALE TESTING

Bench scale and pilot scale testing was performed on Sterling's water. The purpose of the testing was to determine the effectiveness of several of the treatment technologies. More testing will be performed during the design phase of the project to further confirm the results from initial testing. The following sections summarize the testing that was performed and the most pertinent results.

5.3.1 Coagulation/Filtration Jar Tests

The specific treatment objectives for the jar testing were to evaluate the performance of the coagulation filtration process. In addition, the bench-scale data was gathered to establish the following:

1. Effective coagulant dose and coagulant type.
2. Optimal coagulation condition (in terms of coagulating pH) for raw water.
3. Characterization of raw water and finished water in terms of Primary and Secondary contaminants.

4. Percent removal of various contaminants, including turbidity (if present), uranium and dissolved organic carbon (DOC) (i.e., DBP precursors) from the raw water.

The three coagulants used were aluminum sulfate (alum), ferric chloride (ferric), and polyaluminum chloride (PACl). Two source waters were used, Site 1 and Scalva 1. Site 1 water was collected from the booster pump station and is a combination of Wells 1, 2, 3, 4, 5 and 7. Scalva 1 water was collected from Scalva Well 1.

Table 5-4 summarizes the results of the jar tests. Additional data from the jar testing can be found in Appendix H.

Table 5-4: Coagulation/Filtration Jar Testing Results

Parameters	Alkalinity (mg/L as $CaCO_3$)	pH (SU)	DOC (mg/L)	DOC (removal)	Uranium (µg/L)	Uranium (removal)
Site1-Raw	195	7.8	2.9	-	34	-
Site1-Alum (50 mg/L)	-	7.5	2.7	7%	29	15%
Site1-Ferric (50 mg/L)	-	7.4	2.5	14%	29	15%
Site1-PACl (50 mg/L)	-	7.6	2.6	10%	6	82%
Scalva1-Raw	260	7.7	4.6	-	36	-
Scalva1-Alum (50 mg/L)	-	7.1	4.2	9%	31	14%
Scalva1-Ferric (50 mg/L)	-	7.3	4.0	13%	28	22%
Scalva1-PACl (50 mg/L)	-	7.5	4.1	11%	14	61%

The water quality parameter of DOC is presented in Table 5-4. For a filtered water, it can be assumed that all of the organic carbon is dissolved; therefore DOC is equal to TOC.

Sterling's raw water has a low specific ultraviolet light absorbance (SUVA) value. SUVA is calculated as the ratio of normalized ultraviolet light at a wavelength of 254 nm (UV254) absorbed to DOC. Low SUVA values (<2.0 L/mg-m) are indicative of low aromaticity and low molecular weight. Low aromaticity, low molecular weight carbon is difficult to coagulate. Sterling's raw water has a range of SUVA values from 1.2 – 1.7 L/mg-m. As previously indicated, a finished water goal of 1.8 mg/L for TOC is being targeted. None of the coagulants used in the jar testing were effective for removal of DOC.

Alum and ferric were not effective for removal of uranium. PACl was effective for removal of uranium at a dose of 50 mg/L.

The results of the jar testing indicate that coagulation filtration alone is not an effective treatment process for compliance with Primary Drinking Water Standards due to the inadequate removal efficiency for DBP precursors. A copy of the bench scale protocol is included in Appendix H.

5.3.2 MIEX® Bench-Scale Testing

A sample of Sterling's water was sent to Orica Watercare for bench scale testing with the proprietary MIEX® process. The MIEX® process is an ion exchange process that uses a magnetic resin. The contact chamber is a fluidized bed with a continuous flow of regenerated resin. The resin is continuously regenerated and recycled back into the process.

The purpose of the MIEX® bench scale testing was to determine the process's ability to remove uranium, TOC, and bromide. Two configurations of the MIEX® process were tested; 1) MIEX® alone, and 2) MIEX® followed by coagulation filtration. The raw water used was from Scalva Well 1 because Scalva Well 1 has the most challenging water chemistry. The results from the bench scale testing are summarized in Table 5-5 below. Additional data from the MIEX® bench scale testing can be found in Appendix H.

Table 5-5: MIEX® Bench Testing Results

Parameters	DOC (mg/L)	DOC (removal)	Uranium (µg/L)	Uranium (removal)	Bromide (µg/L)	Bromide (removal)
Scalva1-Raw	4.1		36		790	
Scalva1-MIEX® (200 BV)	2.9	29%	8	78%	640	19%
Scalva1-MIEX® (200 BV) + (100 mg/L of Ferric)	2.6	36%	5	86%	-	-

As indicated in the results above, MIEX® alone is effective for removal of uranium; however, it is only moderately effective for the removal of DOC and bromide. As indicated previously a goal of 1.8 mg/L of TOC should be targeted to prevent the formation of DBPs. Removal of bromide would provide additional prevention of brominated DBPs. It is believed that the resulting concentrations of DOC and bromide are not adequate to sufficiently prevent the formation of DBPs.

The treatment rate required was 200 bed volumes (BV). BV is the volumetric ratio of treated water to resin and is inversely proportional to the regeneration rate. The BV for the bench-scale MIEX® test (200 BV) was low. A typical MIEX® system would have a BV of approximately 1,000 BV. The high regeneration rate was due to the high sulfate levels in the raw water. The MIEX® resin has a high selectivity for sulfate. The high sulfate levels in the raw water are suspected to be responsible for the low removal efficiency for bromide.

MIEX® followed by ferric only slightly increased the removal efficiency of uranium and DOC. The optimum ferric dose was very high at 100 mg/L.

The results of the MIEX® treatment bench scale testing indicate that MIEX® is not effective as a stand-alone process for compliance with Primary Drinking Water Standards due to the inadequate removal of DBP precursors.

5.3.3 Nanofiltration Pilot Testing

Pilot testing of Sterling's raw water using a NF process has been performed for two source waters (Site 1 and Scalva Well 1). The type of membrane used was the Filmtec® NF90 4040 from the DOW Chemical Company. The pretreatment chemical used was Vitec™ 4000 Silica Scale Inhibitor and Dispersant from Avista® Technologies. Cut sheets for the membrane and pretreatment chemical are found in Appendix I.

The specific treatment objective for the pilot-scale study was to evaluate the performance of the membrane system. In addition, it was used to gather pilot data, which was analyzed to establish the following:

1. Evaluate/confirm key design criteria for the system such as flux rate, recovery and transmembrane pressure (TMP).
2. Perform an initial evaluation of pretreatment requirements for the system in order to control membrane fouling rates.
3. Perform preliminary assessment of membrane cleaning frequencies, fouling characteristics, etc.
4. Gather additional raw water quality that is pertinent to NF system design that wouldn't typically be measured (i.e., barium concentration).
5. Provide supporting information for the CDPHE review and approval.
6. More accurately characterize NF brine stream water quality for supporting discharge permit efforts and potential treatment.
7. Allow the operators to become more familiar with NF concept in a relatively simple pilot format.

Initial testing was performed on Site 1 water (Wells 1, 2, 3, 4, 5 and 7) from February 23 to March 24, 2009. Testing was performed on Scalva Well 1 water from March 25 to April 26, 2009.

The contaminant removal performance of the pilot testing produced favorable results for Primary and Secondary contaminants. The following typical removal efficiencies were reported.

- Uranium removal: 90 – 100%
- TOC removal: 100%
- Bromide removal: 65 – 76%
- Hardness removal: 95 – 100%
- TDS removal: 89 – 97%
- Sulfate removal: 95 – 100%

The pilot unit performed favorably at Site 1. The pretreatment chemical performed well, preventing fouling of the membrane and keeping TMP within an acceptable range.

The pilot unit did not perform favorably at Scalva Well 1, and the membrane appeared to foul prematurely. The TMP required to maintain the desired recovery was higher than desired. The

membrane elements were sent to a laboratory to undergo autopsies in order to determine what caused the membranes to foul. An evaluation of the autopsy results is underway.

A full scale plant would only be treating a portion of Scalva Well 1 water, and it is anticipated that fouling would not be as severe. However, additional pilot testing is recommended. Pretreatment for Scalva Well 1 could be necessary depending on its overall contribution to the raw water blend.

Based on the results from the pilot testing and the concentrate water quality, there are multiple contaminants of concern with respect to a surface water or groundwater discharge. This concentrate water quality and management strategies are discussed later in this report in greater detail in Section 5.5.1.

A more detailed summary of the raw water, permeate, and concentrate water quality and the pilot testing protocol is found in Appendix H.

5.4 TECHNOLOGIES CONSIDERED FOR FURTHER EVALUATION

The bench scale and pilot scale testing results were useful in determining which of the available technologies could be eliminated from consideration or considered for further evaluation. Table 5-6 summarizes the technologies eliminated from consideration and the reasoning behind each decision.

Table 5-6: Technologies Considered for Further Evaluation

Technology	Further Evaluation	Comments
Ion Exchange (1)	Yes	Provides treatment for Primary Standards and some Secondary Standards. Process would most likely be an ancillary process to meet discharge permit limits for residuals.
RO/NF	Yes	Provides treatment for Primary and Secondary Standards. Provides filtration. Blend stream would reduce capital and chemical costs and must be filtered.
Lime Softening	Yes	Provides treatment for Primary Standards and some Secondary Standards. Additional unit process would be required for filtration. Bench-scale testing required.
Coagulation Filtration	Yes	Bench scale testing indicated inadequate removal of TTHM precursors. Must add additional treatment process(s) to remove TOC and/or bromide.
MF	Yes	Filtration process most appropriately applied in concert with another process to provide filtration credit for SWTR.
GAC	Yes	Process could be added to coagulation filtration process to provide removal of TOC. Bench-scale testing required.
MIEX®	No	Bench scale testing indicated inadequate removal of TTHM precursors. Additional unit process would be required for filtration.
Z-92™ Uranium Removal Process (1)	Yes	Only removes uranium. Process would most likely be an ancillary process to meet discharge permit limits for residuals.

(1) The ion exchange and the Z-92™ processes would only be used as ancillary processes to remove contaminants from residuals to meet discharge permit limits.

5.5 DEVELOPMENT OF PRELIMINARY TREATMENT PROCESSES

As mentioned previously, due to the challenging water quality and regulatory situation for the City of Sterling, no single technology will be adequate to address all water quality issues. Therefore, the technologies considered for further evaluation in Table 5-6 were arranged into a multi-technology conceptual treatment process to address all water quality issues. The following three treatment processes were evaluated.

(1) NF with a blend stream filtered with an MF process. Concentrate would be managed using one of the four following concentrate management scenarios.
    a. Concentrate discharge to surface water.
    b. Concentrate discharge to groundwater.
    c. Concentrate discharge to evaporation ponds.
    d. Concentrate discharge to deep well injection.
(2) Lime softening followed by media filtration. Residuals from the softening process would be disposed of via landfill.
(3) Modified coagulation filtration with GAC. Residuals from the coagulation filtration process would be disposed of via landfill.

The following sections summarize the general design concepts for each alternative.

5.5.1 Nanofiltration

Nanofiltration membrane treatment is effective in removing a wide range of contaminants that are often found in water sources. The primary mechanism for contaminant removal is diffusion whereby water diffuses through the membrane at a significantly higher rate than the contaminants. Electrostatic repulsion and physical straining are also important mechanisms of removal. In NF systems, the raw water is fed under high pressure to the membranes, which separates the water into a treated stream (permeate), and into a waste stream (concentrate). The concentrate is a liquid waste stream that must be disposed of, and often presents a significant water loss.

The main treatment process would include NF membrane skids. A blend stream of 20 – 30% would be filtered via MF and blended together with permeate from the NF process. The blend stream reduces capital cost of additional NF skids and chemical costs by reducing the amount of re-mineralization required.

As mentioned previously, the concentrate stream from the NF process would require a management plan. There are four alternatives that were considered for concentrate management; 1) discharge to groundwater, 2) discharge to surface water, 3) discharge to evaporation basins, or 4) discharge to deep wells.

The NF process would be designed differently based upon the concentrate management strategy implemented. If groundwater or surface water discharge were to be implemented, the NF process would be a single-pass system. The single-pass configuration is common in drinking water applications and consists of two stages. Concentrate from the first stage membranes would be fed to the second stage membranes for further recovery, and permeate from both stages is combined. The total recovery (permeate to feed ratio) of a typical single-pass two-stage NF process is 80 - 85%.

If evaporation basins or deep well injection were to be implemented, the NF process would be a two-pass system. The first pass of the two-pass system is identical to the single-pass configuration described above. The second pass of the two-pass system would include an NF process configured in two stages to further treat the concentrate from the first pass. The feed to the second pass would need to be boosted by a second set of pumps. The total recovery of a two-pass system is 90 - 95%

If evaporation basins or deep well injection were implemented, the concentrate stream would be a loss from a water balance perspective because the water would never be returned to the South Platte River. Therefore, implementing a two-pass system would minimize water rights impacts. Additionally, the construction costs for evaporation basins and deep wells are high; therefore, minimizing the concentrate stream reduces capital costs.

Preliminary Effluent Limits (PELs) were requested from CDPHE on January 29, 2009. Two sets of PELs were requested; 1) discharge to the South Platte (surface water), and 2) discharge to recharge basins located on the Scalva Property (groundwater). PELs were received from CDPHE on February 27, 2008. The PELs from CDPHE can be found in Appendix J.

Four concentrate management alternatives were identified for the City of Sterling. Based on the concentrate water quality from the pilot testing and the PELs there are multiple contaminants of concern with respect to a surface water or groundwater discharge. Table 5-7 summarizes the four concentrate management alternatives.

Table 5-7: NF Concentrate Management Alternatives

Contaminant	Concentrate Level [1]	Discharge Limit	Treatment Method
Surface Water Discharge to South Platte River			
Selenium	24.8 µg/L	4.6 µg/L	Adsorption Media
Sodium	561 mg/L	160 mg/L	Regulatory Relief [2]
Sulfate	2,710 mg/L	250 mg/L	Ion Exchange
Groundwater Discharge to the Scalva Property			
Arsenic	24 µg/L	10 µg/L	Dilution With WWTP Effluent
Fluoride	2.7 mg/L	2.0 mg/L	Dilution Using WWTP Effluent
Manganese	50 µg/L	50 µg/L	Dilution with Groundwater
Selenium	24.8 µg/L	20 µg/L	Dilution with Groundwater
Evaporation Ponds in Scalva Property			
Zero Liquid Discharge – Requires a large surface area (100 + acres)			
Deep Well Injection ~ 7,000 feet +			
Zero Liquid Discharge – Class I Underground Injection Well Permitted By EPA Region 8			

[1] Concentrate levels are results from pilot testing for Site 1.
[2] The sodium limit cannot be met with a treatment method. Flexibility of the discharge limit is necessary.

The conceptual process flow diagram for an NF system is shown in Figure 5-1. The process stream includes a pretreatment chemical feed system and cartridge filter for pretreatment. Following pretreatment, a high-pressure pump is used to boost pressure prior to the membranes. The blend stream is filtered through an MF system to meet filtration requirements and combined in the clearwell. The blend stream also supplies the finished water with mineral content, decreasing the amount of chemical addition necessary. Post treatment of the blended water includes a sodium hydroxide (caustic) feed to stabilize the finished water and adjust pH and a sodium hypochlorite feed and chlorine contact in a clearwell.

5.5.2 Lime Softening

Lime softening provides an effective means of lowering hardness from raw water. However, it is not effective in removing dissolved secondary contaminants such as sulfate and/or chloride from raw water. Lime softening is primarily used for removing polyvalent metallic ions, such as calcium and magnesium hardness from water. The addition of lime (calcium hydroxide) or quick lime (calcium oxide), can quickly convert the calcium and magnesium into calcium carbonate and magnesium hydroxide precipitates, which can be settled out and removed in sedimentation basins.

Generally, lime softening is not effective for removing dissolved organic matter (DBP precursors), nitrate or other primary contaminants from water. The formation of positively charged magnesium hydroxide precipitate by increasing the lime dose and elevating the pH (pH $\geq$ 11) thereby enhancing the softening process (referred to as enhanced softening) can provide

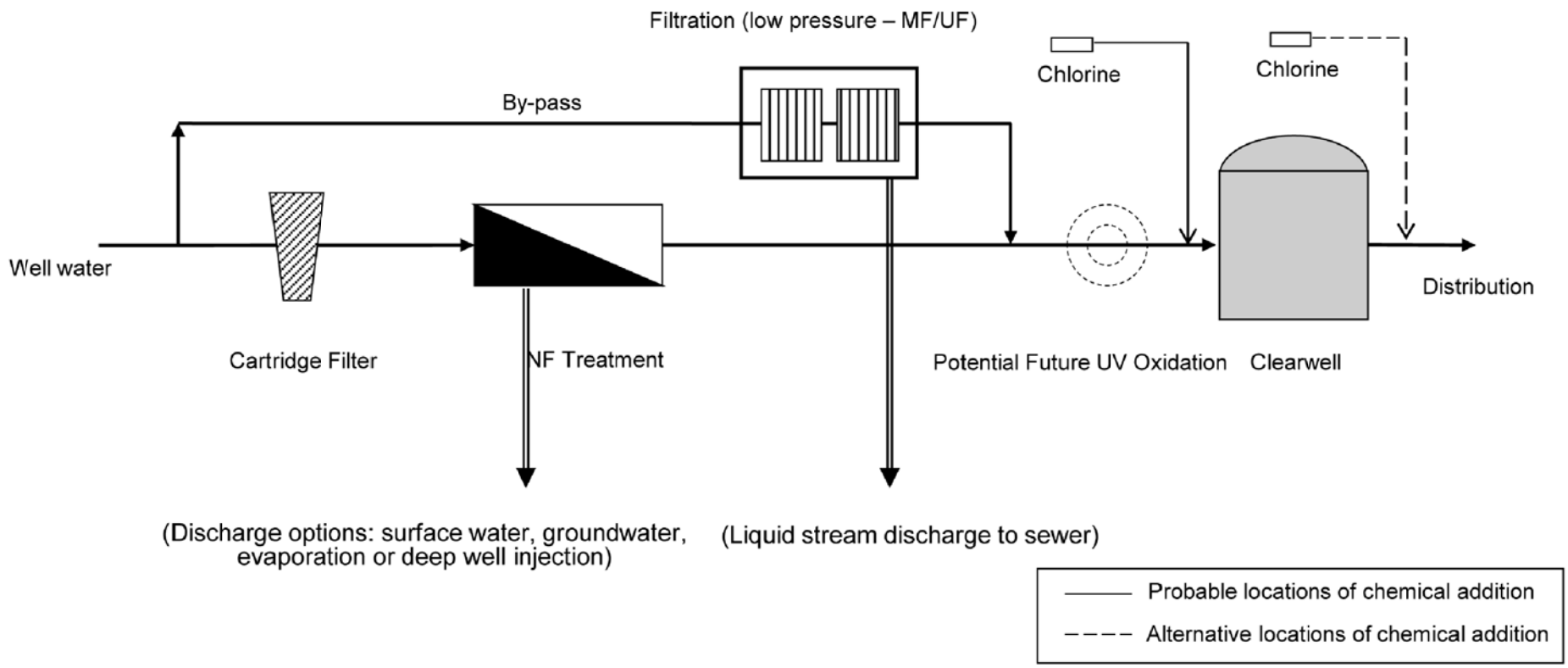

FIGURE 5-1

CITY OF STERLING – WATER TREATMENT PLANT
NF SYSTEM – CONCEPTUAL FLOW DIAGRAM

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higher positively charged surface area that can aid in improving organic matter reduction. Although magnesium hydroxide precipitation can provide dissolved organic matter reduction, it is not an attractive choice to many softening plants. Increase in lime dosages (to raise pH above 11), can lead to significant increase in costs, increases the amount of solids production and requires further dewatering, which sometimes is difficult to achieve and can result in higher handling and disposal costs. After lime softening, the water is filtered. There are a number of filtration systems that are available for use in the coagulation filtration process, including conventional gravity filtration through sand media, pressure vessel filtration using sand media, and the use of membrane technology. For the purposes of this evaluation it is assumed that gravity sand media filtration would be used. The finished water requires significant pH adjustment and disinfection prior to distribution.

Figure 5-2 illustrates a conceptual process flow diagram for a lime softening system. The process stream includes a rapid mix chamber, addition of softening chemicals, reaction/sedimentation chambers, a filtration process to meet filtration requirements, carbon dioxide feed for pH adjustment, and a sodium hypochlorite feed and chlorine contact in a clearwell.

5.5.3 Coagulation Filtration With Granular Activated Carbon

Coagulation filtration is a two step process. In coagulation, a positively charged metal coagulant, such as alum or iron salt is added to the water to neutralize and destabilize negatively charged particulates, dissolved ions and/or colloidal matter from water. The destabilized particles aggregate and enmesh into larger particles, which can then be removed by a filtration process.

There are a number of filtration systems that are available for use in the coagulation filtration process, including conventional gravity filtration through sand media, pressure vessel filtration using sand media, and the use of membrane technology. For the purposes of this evaluation it is assumed that gravity sand media filtration would be used.

Solids that accumulate in the filter are occasionally backwashed. These solids can either be discharged to the sewer, or can be treated in sludge drying beds that separate the solids from the water and produce a solid waste to be disposed of via landfill.

According to data from the jar testing conducted on Sterling's water, the optimum coagulant for uranium removal is PACl at 50 mg/L. None of the coagulants tested were effective for removal of TOC. Therefore a GAC process will be necessary in order to remove TOC. GAC is a highly porous media with a large surface area typically manufactured from materials high in carbon such as coal, wood, coconut shells, or walnut shells. The large surface area provides a high density of active sites for sorption of organic compounds. GAC reaction columns can be manufactured to remove different types of TOC from water. Bench scale or pilot testing would be required.

The conceptual process flow diagram for a coagulation filtration system with GAC is shown in Figure 5-3. The process stream includes a coagulant feed and rapid mix as part of the coagulations step, followed by filtration and GAC. Post treatment of the finished water includes

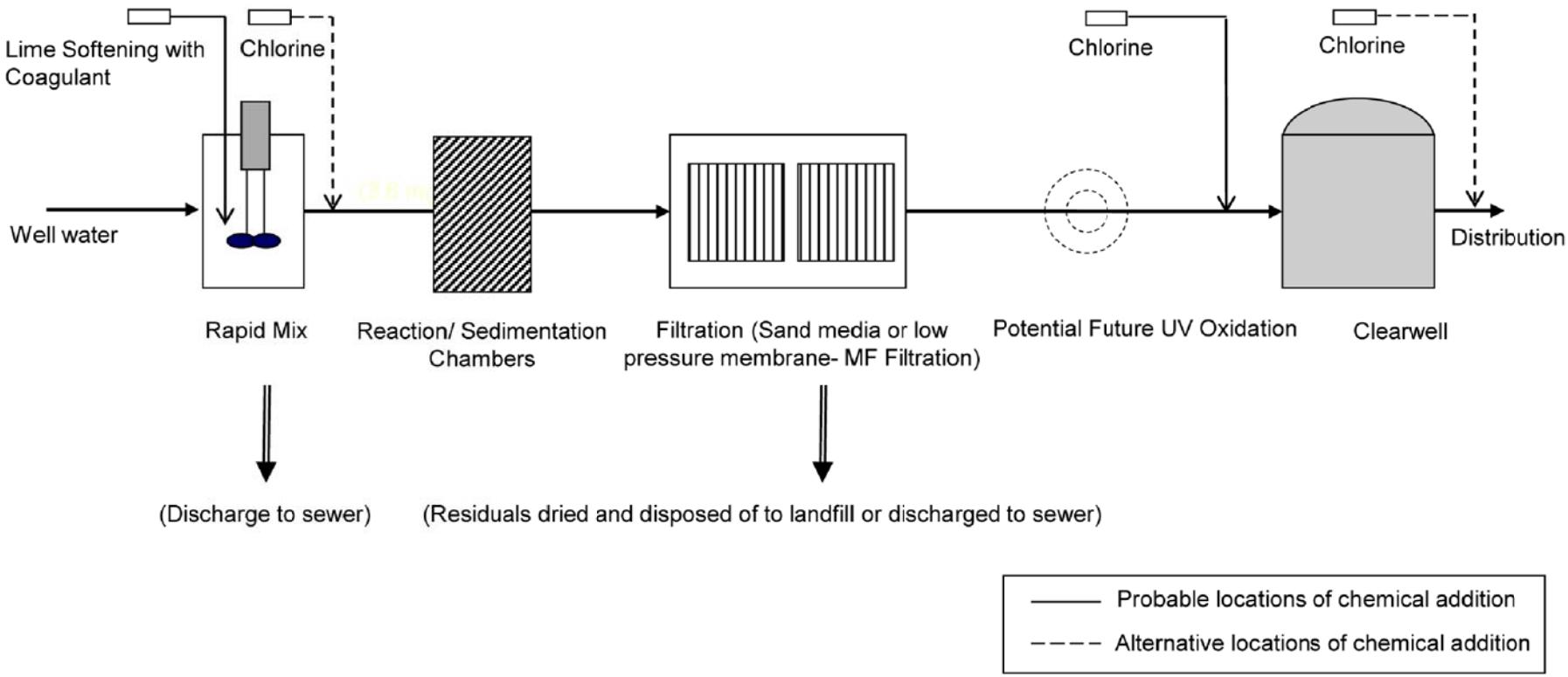

FIGURE 5-2

CITY OF STERLING - WATER TREATMENT PLANT
LIME SOFTENING SYSTEM - CONCEPTUAL FLOW DIAGRAM

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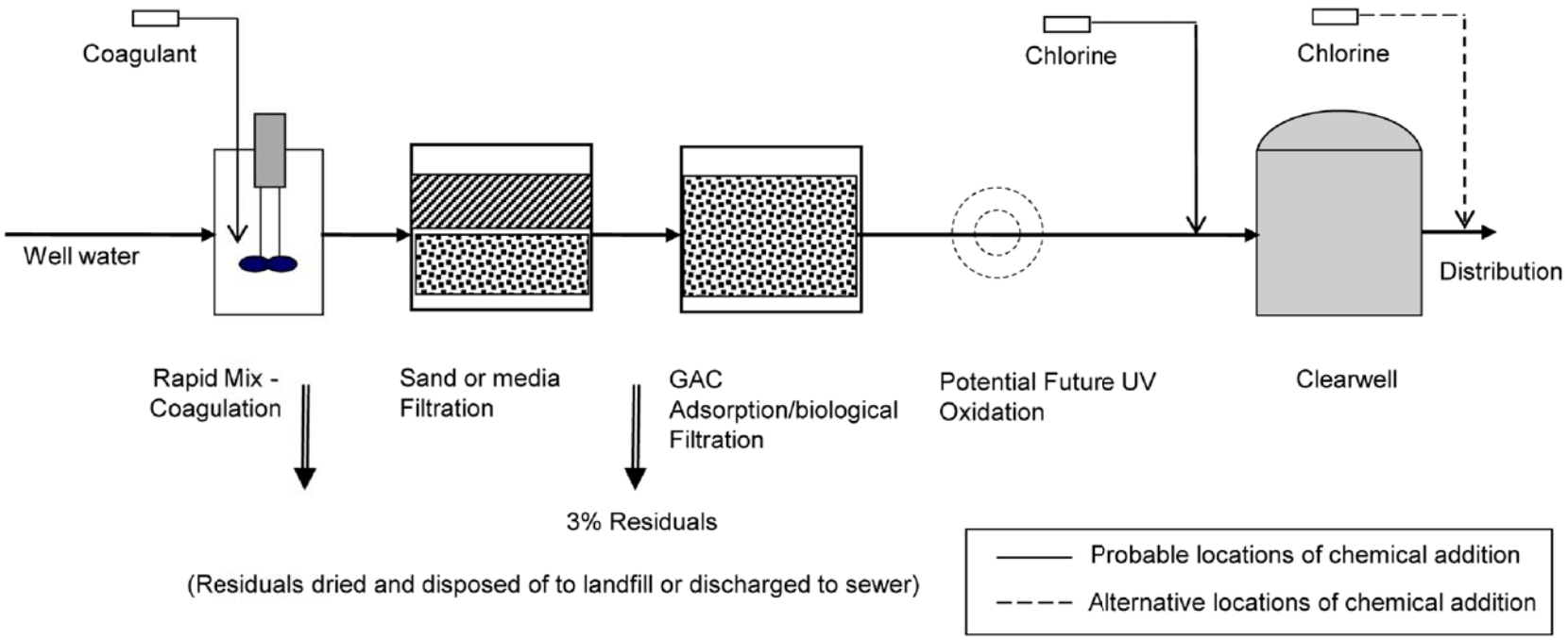

FIGURE 5-3

CITY OF STERLING - WATER TREATMENT PLANT
COAGULATION FILTRATION WITH GAC - CONCEPTUAL FLOW DIAGRAM

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a sodium hypochlorite feed and chlorine contact in a clearwell. As indicated, 100% of the water is treated through the modified coagulation filtration process to meet filtration requirements.

5.6 BARRIERS PROVIDED BY THE THREE ALTERNATIVE TREATMENT PROCESSES

Table 5-8 summarizes the process alternatives and the contaminant barriers provided by each.

Table 5-8: Barriers Provided by the Three Alternative Treatment Processes

Treatment Process	Uranium	DBP Precursors	Nitrate	Hardness	TDS	Sulfate	Filtration
NF with MF Blend Stream	X	X	X	X	X	X	X
Lime Softening with Filtration	X	X [(1)]		X			X
Coagulation Filtration with GAC	X	X					X

[(1)] Requires high lime dose to increase pH to ≥ 11.

5.7 ESTIMATED PROJECT AND OPERATION AND MAINTENANCE COSTS

The American Association of Cost Engineers (AACE) has defined three basic categories of estimates in an effort to establish expected accuracy range for various types of cost estimates. The AACE definitions are as follows:

Order of Magnitude Estimate- This is an approximate estimate made without detailed engineering data. Some examples would be: an estimate from cost-estimating curves, an estimate using scale-up or scale-down factors, and an approximate ratio estimate. It is normally expected that an estimate of this type would be accurate within +50% to –30%.

Budget Estimate- Budget in this case applies to the Owner's budget, and not to the budget as a project-control document. A budget estimate is prepared with the use of spreadsheets, layouts, and equipment details. It is normally expected that an estimate of this type would be accurate within +30% to –15%.

Definitive Estimate- As the name applies, this is an estimate prepared from very defined engineering data. As a minimum, the data must include: fairly complete plot plans and elevations, piping and instrumentation diagrams, one-line electrical diagrams, soil data and sketches of major foundations, building sketches and a complete set of specifications. It is expected that a definitive estimate would be accurate to within +15% to –5%.

The estimated project and O&M costs presented in this section are close to an Order of Magnitude Estimate, with an expected accuracy of +50% to –30%. These costs were developed to provide a cost comparison among the three alternative treatment processes.

The costs for the NF process are unique in that there are four potential concentrate management alternatives. The following section summarizes the NF process costs used to compare with the other alternatives.

5.7.1 NF Process Cost Estimate

The NF process alternative consists of four sub-alternatives due to the concentrate management alternatives. Table 5-9 outlines the project and O&M costs for the NF alternative.

Table 5-9: NF Process Order of Magnitude Cost Estimates

Treatment Plant Cost	Concentrate Management Cost	Water Rights Cost	Total
Surface Water Discharge to South Platte River			
Capital: $18,500,000	Capital: $4,700,000	O&M: $70,000 (1)	Capital: $23,200,000
O&M: $2,800,000 (1)	O&M: $1,400,000 (1)		O&M: $4,200,000
Groundwater Discharge to the Scalva Property			
Capital: $18,500,000	Capital: $10,200,000	O&M: $70,000 (1)	Capital: $28,700,000
O&M: $2,800,000 (1)	O&M: $1,200,000 (1)		O&M: $4,000,000
Evaporation Ponds in the Scalva Property (2)			
Capital: $18,500,000	Capital: $15,300,000	O&M: $60,000 (1)	Capital: $33,800,000
O&M: $2,800,000 (1)	O&M: Not evaluated due to high capital cost		
Deep Well Injection ~7,000 feet (2)			
Capital: $18,500,000	Capital: $7,800,000	O&M: $60,000 (1)	Capital: $26,300,000
O&M: $2,800,000 (1)	O&M: $800,000 (1)		O&M: $3,600,000

(1) O&M Costs are presented as annual costs and include debt service.
(2) The capital and O&M costs for evaporation ponds and deep well injection include additional membrane treatment costs for a two-pass system.

5.7.2 Cost Comparison of Alternatives

Table 5-10 summarizes the Order of Magnitude Project Costs and O&M costs for the three treatment processes.

Table 5-10: Planning Level Cost Comparisons

Treatment Process	Estimated Project Cost Range (1)	Estimated Annual O&M Cost (2)
Nanofiltration	$23,000,000 - $29,000,000	$3,900,000 (3)
Lime Softening	$18,000,000 - $24,000,000	$3,700,000
Coagulation Filtration with GAC	$17,000,000 - $23,000,000	$3,200,000

(1) Project costs include construction, legal and administrative costs, and engineering.
(2) O&M costs presented as annual costs (3.7 mgd) and include debt service on 20-year loan at 4.5%.
(3) O&M costs for nanofiltration are the average between the concentrate management alternatives.

5.8 CONSUMER COST IMPACT

A study titled Technical Memorandum No. 3 - *Consumer Cost Impact for Centralized Advanced Water Treatment for Secondary Standards* (Appendix D) was prepared to evaluate the financial impact of a new WTP to the City of Sterling ratepayers. The study incorporated the cost of in-home treatment systems commonly used in the City of Sterling due to the poor aesthetic quality of the water. Additionally, the study takes into account the adverse impact of hard water on plumbing fixtures. Table 5-11 summarizes the in-home treatment costs used for the study.

Table 5-11: In-Home Treatment Costs

Treatment Type	Estimated Annual O&M Cost [1]
In-Home Treatment and Plumbing Fixture Replacement ($69/month; 4,965 taps; 50% of homes currently use this system)	$2,000,000 [2]
Bottled Water for Drinking, No In-Home Treatment, Fixture Replacement ($85/month; 4,965 taps; 25% of homes currently use this system)	$1,300,000
Fixture Replacement, No In-Home Treatment or Bottled Water ($14/month; 4,965 taps; 100% of homes currently incur this cost)	$800,000

[1] Debt service was not included for in-home treatment.

The costs presented in Tables 5-10 and 5-11 were used to evaluate the economic impact on the citizens of Sterling. If an NF system were to be placed on-line, in-home treatment systems would be significantly reduced due to the reduction of aesthetic secondary contaminants such as TDS, hardness, and sulfate. If a lime softening system were to be placed on-line, it is estimated that some in-home treatment systems would remain, as TDS and sulfate are not removed with lime softening. If a coagulation filtration system were placed on-line, no reduction of in-home treatment costs are anticipated. Table 5-12 summarizes the overall consumer cost impact comparison between the three treatment alternatives.

Table 5-12: Annual Consumer Cost Impact Comparison

Treatment Process	Plant O&M Cost [1]	In-Home O&M Cost [2]	Total O&M Cost
NF	$3,900,000	$0	$3,900,000
Lime Softening	$3,700,000	$800,000 - $1,300,000	$4,500,000 - $5,000,000
Coagulation Filtration with GAC	$3,200,000	$2,000,000	$5,200,000

[1] Debt service is included in O&M costs for plant.
[2] Debt service is not included in the in-home O&M costs.

5.9 SELECTED ALTERNATIVE

The alternative selected for implementation is NF with a blend stream filtered via MF. The NF process provides the necessary removal for Primary Drinking Water contaminants while also treating for Secondary Standards, thereby improving the public acceptability of the finished water which is a high priority for the City of Sterling.

As indicated in Table 5-8, the NF process provides barriers for Primary and Secondary Drinking Water contaminants and filtration. The City of Sterling has indicated a strong desire to treat for Secondary Standards to increase the overall public acceptability of the finished drinking water.

In addition to meeting contaminant limits and increasing the aesthetic quality of the finished water, the consumer cost impact of the NF process has been estimated as the most favorable.

5.9.1 Concentrate Management

The selected alternative for concentrate management is deep well injection. Deep well injection has many advantages over the other potential concentrate management scenarios.

Surface water discharge is a potential viable alternative. Treatment processes for sulfate and selenium removal would be required to meet discharge limits. Additionally, regulatory relief would be required for the sodium limit. Meetings with the Colorado Department of Public Health and Environment (CDPHE) have indicated that regulatory relief is possible. The sodium limit is based on a policy titled *Implementing Narrative Standards in Discharge Permits for the Protection of Irrigated Crops*. As the standard is based on a policy and not a regulation, there is potential for flexibility. A study to determine the overall sodium loading to the South Platte River as a result of a surface water discharge is underway. Preliminary results have indicated that the sodium load to the South Platte would be reduced as a result of the new WTP due to the decreased usage of water softeners within the City. Flexibility will be designed into the plant to allow for a surface water discharge if necessary; however, surface water discharge will not be pursued at this time.

Groundwater discharge would require multiple treatment processes, dilution with wastewater effluent, and dilution with additional augmentation wells. The capital and O&M costs to meet the discharge limits make groundwater discharge unpractical.

Evaporation would require a significant land area of lined basins (100+ acres). The capital cost makes evaporation basins unpractical. Additionally, the solids remaining after evaporation would need to be disposed. An analysis would need to be conducted to determine if the solids could be disposed of in a municipal landfill.

CHAPTER 6
TREATMENT FACILITIES PRELIMINARY DESIGN

The purpose of this chapter is to describe the treatment processes and facilities, and establish design criteria for the treatment system.

6.1 WATER TREATMENT PLANT CAPACITY AND PROCESSES

As discussed in Chapter 2, the projected potable water peak day demand for the year 2022 is 9.6 mgd, and the projected peak day demand for the year 2032 is 10.9 mgd. The capacity of major equipment will be for the year 2022 demands (Phase I). The building, pipelines and some tanks will be sized for the year 2032 (Buildout) demands. Table 6-1 summarizes the Phase I and Buildout demands used for design criteria for the Sterling WTP.

Table 6-1: Design Demands

Design Phase		Finished Water Demand	Raw Water Demand [1]	Concentrate Flow [1]
Phase I (Year 2022)	Average Annual	4.19 mgd	4.43 mgd	0.24 mgd
	Peak Month [2]	7.96 mgd	8.42 mgd	0.46 mgd
	Peak Day	9.55 mgd	10.10 mgd	0.55 mgd
Buildout (Year 2032)	Average Annual	4.76 mgd	5.03 mgd	0.27 mgd
	Peak Month [2]	9.04 mgd	9.56 mgd	0.52 mgd
	Peak Day	10.86 mgd	11.48 mgd	0.62 mgd

[1] Raw water demands and concentrate flow are based on an NF system with a 20% blend stream and recovery of 93%.
[2] Peak month demands are based on a peaking factor of 1.9 (peak month to average annual).

The project will include two process trains. One of the treatment trains primarily satisfies the need for filtration via MF membranes, and the other treatment train provides advanced treatment for both Primary and Secondary Drinking Water Standards with an NF process. Treated water from the two treatment trains will be blended, and the finished water will be stabilized and disinfected with chemical feed systems. Raw water will be supplied to the new WTP with the City's existing potable drinking water wells on the east side of the City. The wells on the west side of the City (wells 11, 12 and 13) will not be connected to the new WTP and will be used for emergency purposes only.

The MF treatment train will include two membrane skids fed by vertical turbine pumps located above a raw water storage tank. The NF treatment train will include three cartridge filters, a two pass NF process with three membrane skids in the first pass and one membrane skid in the second pass. A concentrate equalization (EQ) tank may be used with two cartridge filters for the second pass. An alternative method is to directly couple the first pass and the second pass units, eliminating the need for a concentrate EQ tank. This will be evaluated further during design. The two treatment trains will be blended together prior to the clearwell. Stabilization and disinfection chemicals will be added prior to the clearwell, and finished water will be delivered to the distribution system via four vertical turbine pumps after disinfection.

The concentrate from the second pass will be collected in a concentrate storage tank. Three submersible pumps will deliver the concentrate to two deep wells drilled approximately 7,000 feet into formations below any potential drinking water aquifer.

A Process Flow Diagram for the potable water treatment processes and the concentrate treatment processes is shown in Figure 6-1. An equipment list for the potable water treatment processes and concentrate treatment processes is presented in Table 6-2. The preliminary process floor plans and tank plan are presented in Figures 6-2, 6-3 and 6-4. Treatment facilities and processes are described in further detail in the following sections of this chapter. Cut sheets for individual unit processes can be found in Appendix I.

Table 6-2: City of Sterling Water Treatment Plant Potable Water Treatment Processes Equipment List (9.6 mgd)

Pretreatment	
Number of Cartridge Filter Vessels	3 (2 duty, 1 standby)
Nominal Flow per Cartridge Filter Vessel	5.0 mgd (3,470 gpm)
Filtration Rate per 10-inch equivalent	4.5 gpm
Cartridge Filter Length	40 inches
Number of Filters per Vessel	190
Cartridge Filter Vessel Diameter	44 inches
Vessel Orientation	Horizontal
Nominal Cartridge Pore Size Rating	5 microns
Nanofiltration Equipment (First Pass)	
Number of Trains	3 (3 duty, 0 standby)
Recovery	70%
Feed Pressure	90-110 psig
Feed Flow per Train	2.86 mgd (1,988 gpm)
Permeate Flow per Train	2.00 mgd (1,390 gpm)
Concentrate Flow per Train	0.86 mgd (598 gpm)
Number of Stages per Train	2
Number of First Stage Pressure Vessels	36
Number of Second Stage Pressure Vessels	18
Number of Elements per Vessel	7
Feed Pump Type	Vertical Turbine (VFD driven, variable speed)
Feed Pump Horsepower	140 - 175 hp
Nanofiltration Equipment (Second Pass)	
Number of Trains	1 (1 duty, 0 standby)
Recovery	78%
Feed Pressure	110-130 psig
Feed Flow per Train	2.56 mgd (1,782 gpm)
Permeate Flow per Train	2.00 mgd (1,390 gpm)
Concentrate Flow per Train	0.56 mgd (392 gpm)
Number of Stages per Train	2
Number of First Stage Pressure Vessels	36
Number of Second Stage Pressure Vessels	18
Number of Elements per Vessel	7
Feed Pump Type	Vertical Turbine (VFD driven, variable speed)
Feed Pump Horsepower (boost pressure from first pass)	50 - 90 hp
Microfiltration Equipment	
Number of Trains	2 (2 duty, 0 standby)
Feed Flow per Train	1.45 mgd (1,008 gpm)
Feed Pressure	30 - 40 psig
Feed Pump Type	Vertical Turbine (VFD driven, variable speed)
Feed Pump Horsepower	75 hp

Finished Water Pumps	
Number of Pumps	4 (3 duty, 1 standby)
Pump Type	Vertical Turbine (VFD driven, variable speed)
Three Larger Pumps Capacity at Design Point (ea)	4.17 mgd (2,900 gpm)
Total Dynamic Head at Design Point (TDH)	210 feet
Horsepower	200 - 250 hp
One Smaller Pump Capacity at Design Point (ea)	2.73 mgd (1,900 gpm)
Total Dynamic Head at Design Point (TDH)	210 feet
Horsepower	150 hp
Concentrate Pumps	
Number of Pumps	3 (2 duty, 1 standby)
Pump Type	Submersible
Capacity (ea)	0.25 – 0.29 mgd (175 - 200 gpm)
Total Dynamic Head at Design Point (TDH)	200 - 300 feet
Horsepower	10 - 20 hp
Deep Wells	
Number of Wells	2 (2 duty, 0 standby at peak day demand) 2 (1 duty, 1 standby at average day demand)
Depth (ea)	7,000 feet
Capacity (ea)	0.25 - 0.29 mgd (175 - 200 gpm)

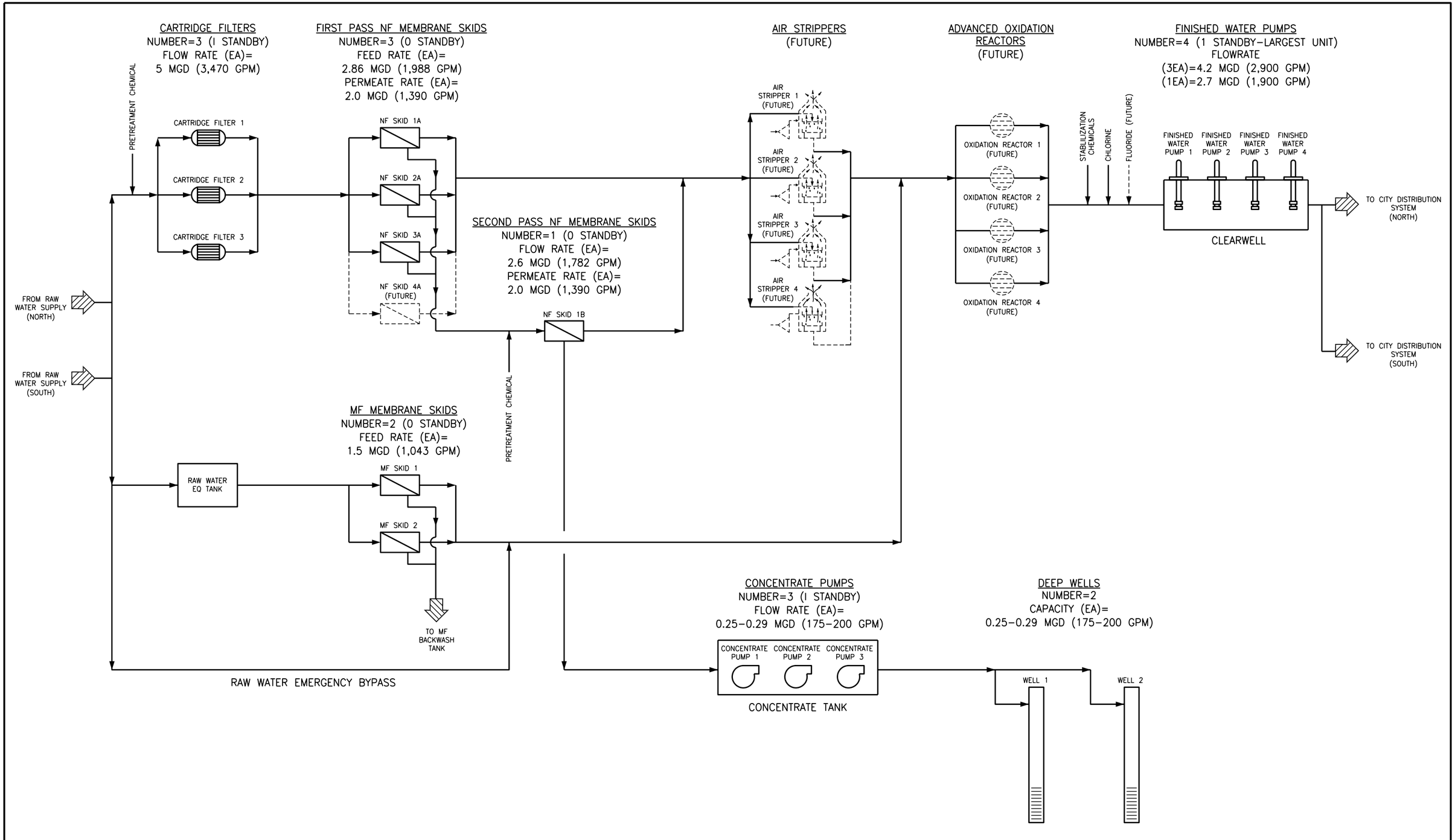

FIGURE 6-1
CITY OF STERLING - WATER TREATMENT PLANT
PROCESS FLOW DIAGRAM

Arber
Water, Wastewater & Reuse Engineers
Richard P. Arber Associates
Consulting Engineering & Project Management

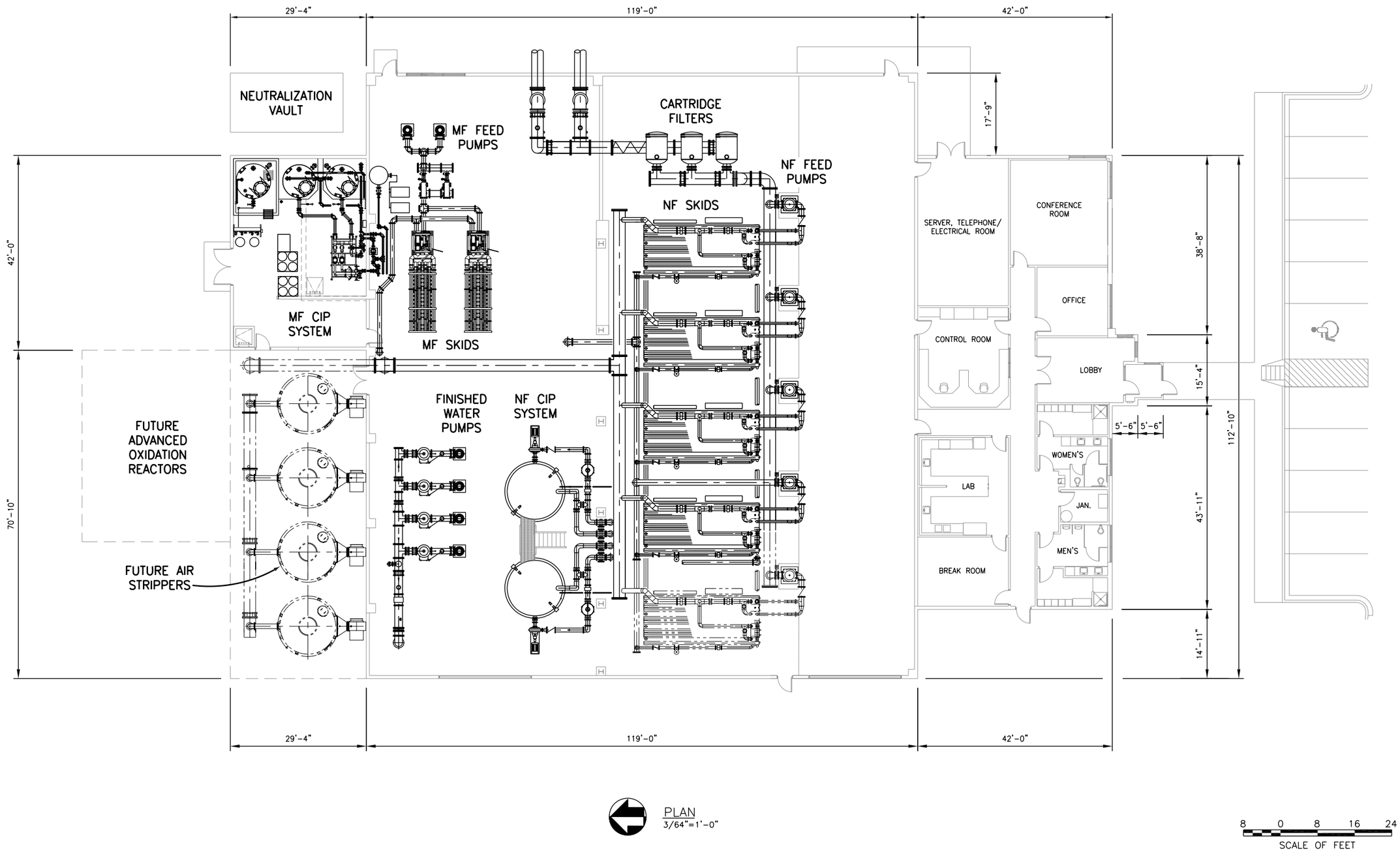

FIGURE 6-2

CITY OF STERLING - WATER TREATMENT PLANT
PROCESS BUILDING - FLOOR PLAN

Arber
Water, Wastewater & Reuse Engineers
Richard P. Arber Associates
Consulting Engineering & Project Management

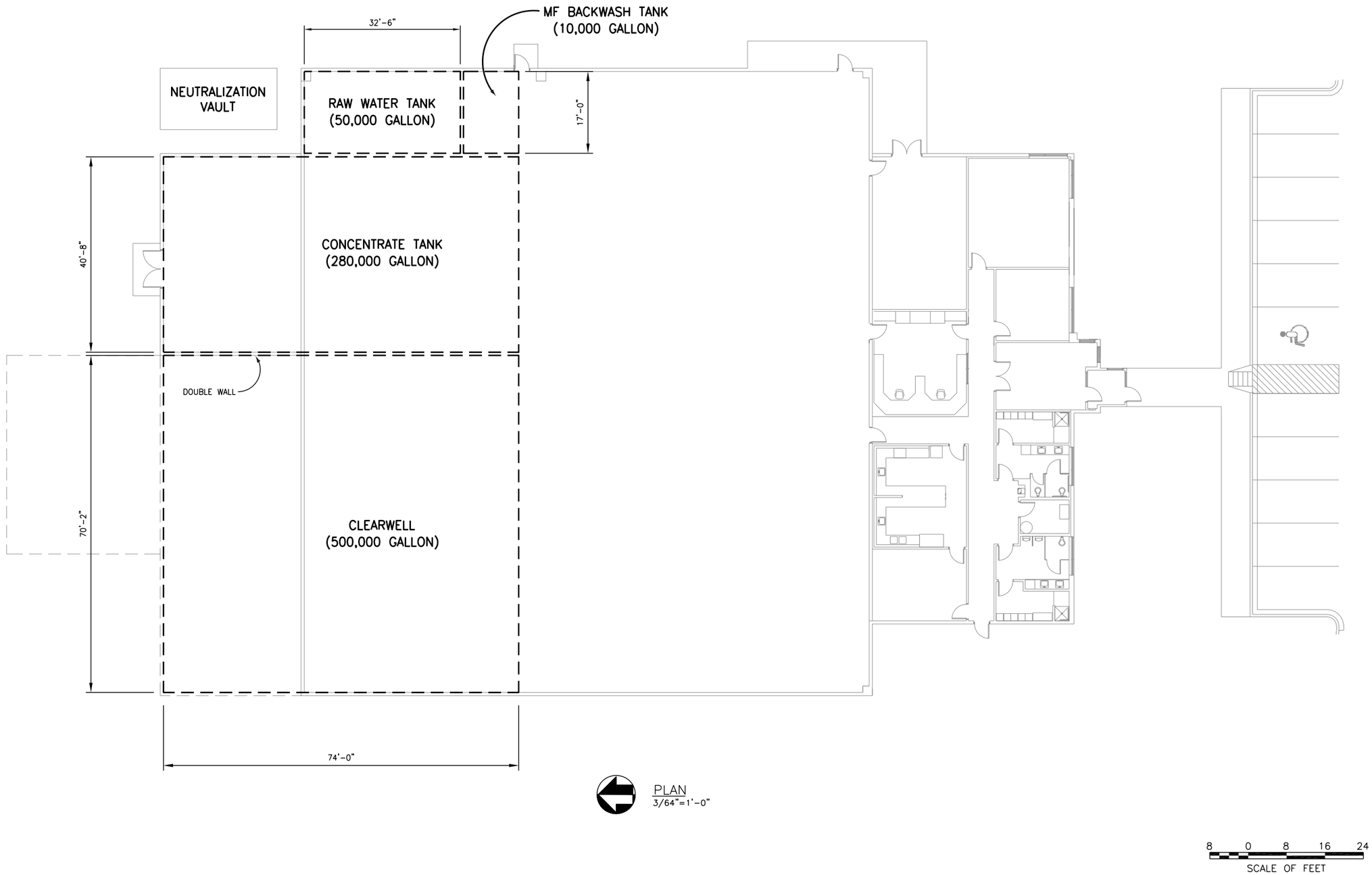

FIGURE 6-3
CITY OF STERLING - WATER TREATMENT PLANT
PROCESS BUILDING - TANK PLAN

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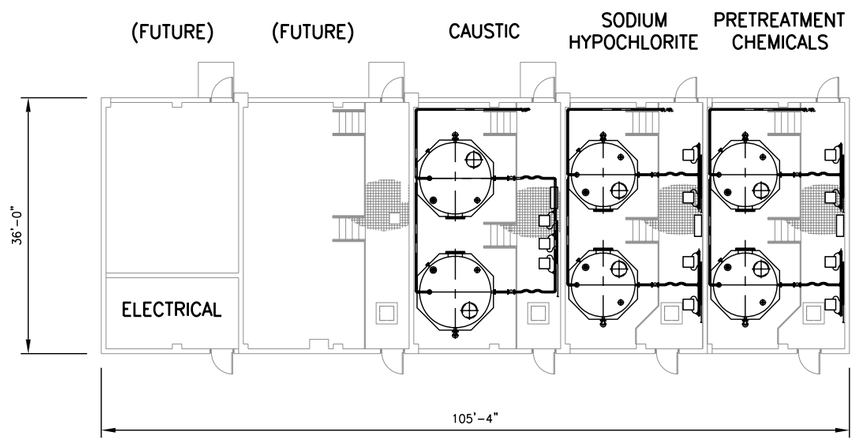
Consulting Engineering & Project Management



PLAN
3/64"=1'-0"

8 0 8 16 24
SCALE OF FEET

FIGURE 6-4
CITY OF STERLING - WATER TREATMENT PLANT
CHEMICAL BUILDING - FLOOR PLAN

Arber
Water, Wastewater & Reuse Engineers
Richard P. Arber Associates
Consulting Engineering & Project Management

6.2 BLENDING CALCULATIONS

The amount of blend water was calculated to provide a finished water quality that meets Primary and Secondary Drinking Water Standards. The water quality parameter that drives the blend stream calculation for the City of Sterling is hardness. A target hardness of 130 mg/L as $CaCO_3$ was used, which falls within the range of 100 - 150 mg/L as $CaCO_3$, or slightly hard water. A blend stream of 20% achieves target hardness of 130 mg/L as $CaCO_3$. The WTP will be designed with the flexibility to blend between 20% and 30%. Table 6-3 summarizes the blending calculations used to determine the blending ratio.

Table 6-3: Blend Ratio Calculations

Parameter	Goal (1)	Raw Water Concentration	Permeate Concentration (2)	Blended Concentration (80/20) (3)
Uranium	20 µg/L	40 µg/L	3 µg/L	10 µg/L
TOC	1.8 mg/L	3.0 mg/L	< 0.5 mg/L	< 1.0 mg/L
TDS	500 mg/L	1,217 mg/L	99 mg/L	323 mg/L
Hardness (as $CaCO^3$)	130 mg/L	576 mg/L	15 mg/L	127 mg/L
Sulfate	250 mg/L	512 mg/L	12 mg/L	112 mg/L
Chloride	250 mg/L	75 mg/L	12 mg/L	24 mg/L

(1) Goals are below Primary and Secondary Drinking Water Standards.
(2) Permeate concentration based on pilot studies and/or model output (blending 75% permeate from first pass and 25% from second pass).
(3) 80/20 blend represents 80% through NF process and 20% through MF process.

6.3 RAW WATER DELIVERY SYSTEM

6.3.1 Process and Facilities Description

A total of 13 existing alluvial wells will serve as raw water extraction wells. The raw water extraction wells that will supply raw water to the WTP, and the water production rates, are summarized in Table 6-4.

Table 6-4: Summary of Potable Wells and Water Production

Well Number	Well Field	Typical Water Production (GPM) (1)
1	EAST	300
2	EAST	400
3	EAST	210
4	EAST	650
5	EAST	350
7	EAST	380
8	EAST	470
9	EAST	290
10	EAST	360
15	EAST	750
30	EAST	840

Well Number	Well Field	Typical Water Production (GPM) [1]
Scalva Well 1 [2]	EAST	1,250
Scalva Well 2 [2]	EAST	1,250
Total Water Production		**7,500**

[1] Typical water production values are equal to well capacity or total decreed capacity, whichever is less.
[2] Scalva Wells are currently not permitted.

6.3.2 Design Criteria

The existing well capacity is adequate to serve the Phase I peak day demand of 9.6 mgd/6,672 gpm (raw water demand of 10.3 mgd/7,159 gpm). Additional wells may need to be developed depending on growth within the City.

A new raw water pipeline (approximately 3,500 feet of 16-inch pipe) will be constructed to deliver raw water from the Site 1 and Site 2 wells (1, 2, 3, 4, 5, 7, 8, 9 and 10) and Wells 15 and 30. A new raw water pipeline (approximately 2,300 feet of 16-inch pipe) will be constructed to deliver raw water from the Scalva Wells. A plan of the future raw water delivery system, including raw water extraction well locations and pipeline routing, is shown in Figure 6-5.

Due to the operation of the NF skids, raw water will need to be delivered to the plant at specific flow rates depending upon the number of skids in operation, and preferably within a relatively narrow pressure range. The number of raw water extraction wells in operation, and flow control devices, will allow the specific flow rates to be delivered to the plant at a pressure range of 50 – 60 psi.

Raw water delivered to the MF skids will be from a 50,000 gallon raw water storage tank. The raw water storage tank will serve to store raw water to be delivered to the microfiltration skids and also provides a blow off for the raw water delivered to the NF skids adding additional flexibility for pressure control upstream of the NF feed pumps.

All new wells may be provided with a pump-to-waste system that will discharge several hundred to a couple of thousand of gallons of water upon startup. The initial purging of the water in the casing at startup is preferable to avoid low quality water that may include bacteria, iron from the casing, partially oxidized metals and oxygen that may further oxidize metals. This low quality water is removed from the raw water supply system to reduce fouling of the membranes.

6.3.3 Instrumentation and Control Features

The instrumentation and control associated with the raw water delivery system will be as follows:

- Upon START signal for the first, or an additional NF treatment train, wells will receive START command.
- Well run status for each well associated with the NF treatment train will be verified prior to START of an NF skid.

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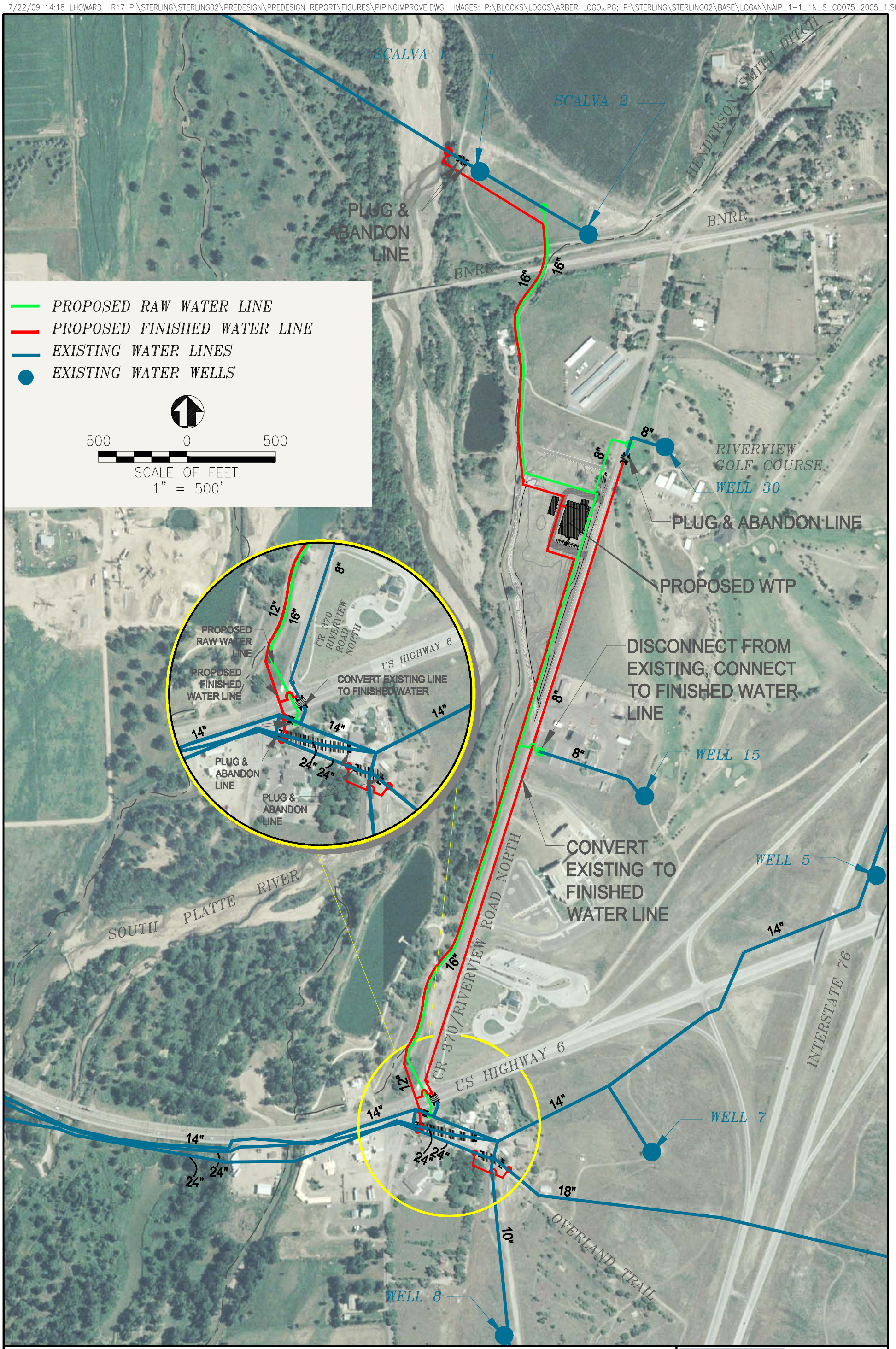

FIGURE 6-5
CITY OF STERLING - WATER TREATMENT PLANT
FINISHED WATER & RAW WATER PIPING IMPROVEMENTS SCHEMATIC

Arber
Water, Wastewater & Reuse Engineers
Richard P. Arber Associates
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Lakewood, Colorado 80228
Website: www.arber.com
Phone: 303.831.4700
Fax: 303.831.0290

- Upon successful completion of STOP sequence for an NF treatment train and the treatment trains associated NF skid, raw water extraction wells associated with the treatment train will receive STOP signal.
- Blend water will be delivered to the raw water storage tank with a modulating valve. The modulating valve will increase or decrease flow based on the number of NF skids in operation and desired blending.
- Pressure relieve valve on raw water line will blow off into raw water storage tank, providing additional pressure control.

6.4 PRETREATMENT

The NF treatment process requires pretreatment of raw water upstream of the membranes to prevent damage and fouling of the membranes.

Selection of pretreatment processes is dependent upon feed water quality and operation of the membrane process, and therefore the pretreatment process varies from plant to plant. Appropriate pretreatment is required to maintain membrane performance and prevent premature replacement of the membranes.

There are generally three classes of substances that can adversely affect membrane performance including membrane damaging substances, membrane fouling substances, and membrane scaling substances. These classes of substances that adversely affect membrane performance are summarized in Table 6-5.

Table 6-5: Classes of Substances that Adversely Affect Membrane Performance

Membrane Damaging	Membrane Fouling	Membrane Scaling
▪ Acid or base solutions ▪ Free chlorine and other oxidants ▪ Bacteria	▪ Particulate matter ▪ Colloids ▪ Biological substances ▪ Organic substances ▪ Sulfur precipitates	▪ Silica ▪ Precipitates of sparingly soluble salts ▪ Iron and manganese

Pretreatment for the Sterling WTP will consist of cartridge filter filtration, two chemical feeds for a scale inhibitor/anti-dispersant, and raw water instrumentation and water quality monitoring. Cartridge filters will prevent fouling of the membranes due to particulate matter. The scale inhibitor/anti-dispersant will prevent scaling of sparingly soluble salts and/or silica and fouling due to iron or organic material and biological substances. Instrumentation will be utilized to provide information on water quality prior to the NF membranes, and will verify that raw water quality is acceptable for the membranes.

6.4.1 Cartridge Filters

6.4.1.1 Process and Facilities Description

A cartridge filter system will be used to reduce suspended particles in the feed water. Common indicators of suspended particulate matter for NF systems are turbidity and Silt Density Index (SDI). Membrane manufacturers have developed both maximum and long-

term average goals for both turbidity and SDI. For turbidity, the maximum limit is 1.0 NTU and the long-term average goal is 0.5 NTU. For SDI, the maximum limit is 4.0 and the long-term average goal is 1.0. Pilot testing has indicated typical raw water SDI from cartridge filter effluent from 0 to 1.5 with an average of below 1.0 using a 5 micron cartridge filter. Pilot testing has indicated that particulate material in the raw water can be reduced to acceptable levels through the cartridge filters.

6.4.1.2 Design Criteria

Design criteria for the cartridge filters are summarized in Table 6-6.

Table 6-6: Cartridge Filter Design Criteria

Description	Unit	Value
Number		
Total number of units (Phase I and Buildout)	ea	3
Number of units typically in operation (Phase I and Buildout)	ea	3
Number of units required for maximum plant flow (Phase I and Buildout)	ea	2
Design Flow Rates		
Flow rate per unit	gpm	3,470
Cartridge filter filtration rate (maximum)	gpm/10-inch length	4.5
Cartridge Filters		
Number per filter housing	ea	190
Dimensions	inch	2.5 x 40
Particle filtration rating	micron	5
Filter Housing Orientation	-	Horizontal

Cartridge filters are disposable and are typically replaced 3 to 6 times per year.

6.4.1.3 Instrumentation and Control Features

The instrumentation and control associated with the cartridge filter system will be as follows:

- Manually operated valves will be located on the feed and discharge pipes to each cartridge filter housing so that it may be removed from service for maintenance without shutting down the plant.
- A differential pressure transmitter will be used to measure pressure loss across the cartridge filters.

6.4.2 Chemical Pretreatment

6.4.2.1 Process and Facilities Description

A pretreatment chemical will be used to reduce fouling of the membranes. Anti-scalants are threshold inhibitors that prevent the growth of crystals/scales from sparingly soluble salts. Numerous companies manufacture scale inhibitors and anti-foulants. Scale inhibitors can control scaling from a wide range of substances, or may be formulated to prevent scales of a specific element such as silica or calcium salts. Anti-foulant is a general description of biocides, anticoagulants, dispersants and/or antideposition agents for controlling membrane fouling. Anti-foulants can be used to control fouling from colloids, biological substances, sulfur precipitates and organic substances.

Whereas an anti-scalant is typically used for all membrane systems, anti-foulants are typically only used when unique characteristics of the raw water quality indicate that fouling can be minimized with their use. Some pretreatment chemicals have both anti-scalant and anti-foulant properties. The Sterling WTP is a two pass system with two feed water qualities. Due to the two feed water qualities, at least two different pretreatment chemicals will be required. Anti-scalant and anti-foulant feeds are summarized in Table 6-7.

Table 6-7: Summary of Anti-Scalant and Anti-Foulant Chemical Feeds

Pretreatment Feed	Chemical	Treatment Description	Process Description
Pretreatment 1	Scale Inhibitor/ Anti-dispersant	Broad range scale inhibitor specially formulated for high silica concentrations with an anti-dispersant for colloidal particles	Equipment will be installed as part of the original construction to provide pretreatment for NF membranes in the first-pass
Pretreatment 2	Scale Inhibitor/Anti-dispersant	Broad range scale inhibitor specially formulated for high silica concentrations with an anti-dispersant for colloidal particles	Equipment will be installed as part of the original construction to provide pretreatment for NF membranes in the second-pass
Pretreatment 3	Anti-scalant or Anti-foulant	Broad range scale inhibitor or anti-foulant for biological or organic fouling	Space will be left in the Chemical Building for any additionally potential pretreatment chemicals

6.4.2.2 Design Criteria

Design criteria features for the pretreatment chemicals feeds will be discussed in the Chemical Feed Section.

6.4.2.3 Instrumentation and Control Features

Instrumentation and control features for the pretreatment chemicals feeds will be discussed in the Chemical Feed Section.

6.4.3 Raw Water Instrumentation and Water Quality Monitoring

6.4.3.1 Process and Facilities Description

Instrumentation will be used to monitor raw water quality, and verify that raw water is acceptable to be fed to the membrane treatment system for treatment. In addition, raw water pressure, both prior to and following the cartridge filters, will be monitored.

6.4.3.2 Instrumentation and Control Features

The instrumentation and control associated with the raw water instrumentation and raw water quality monitoring process will be as follows:

- Instrumentation will be used to measure raw water flow rate, inlet pressure to the NF skids, pH, temperature, conductivity and turbidity.
- High turbidity downstream of the cartridge filters will cause the NF system to stop, and raw water will stop being diverted to the NF system.

6.5 NANOFILTRATION TREATMENT SYSTEM

The NF system includes the membrane skids, feed pumps, concentrate tank, and membrane clean-in-place system.

6.5.1 Membrane Skids

6.5.1.1 Process and Facilities Description

Nanofiltration membrane treatment is very effective in removing a wide range of contaminants that are often found in water sources. The primary mechanism for contaminant removal is diffusion whereby water diffuses through the membrane at a significantly higher rate than the contaminants. Electrostatic repulsion and physical straining are also important mechanisms of removal. In NF, the raw water is fed under high pressure to the membranes, which separates the water into a treated stream (permeate), and into a waste stream (concentrate). The concentrate is a liquid waste stream that must be disposed of, and often presents a significant water loss.

A typical NF membrane train consists of the feed pump, which is used to boost the pressure of the incoming water, and a membrane skid that holds the pressure vessels, piping and valving, and instrumentation. NF membranes are packaged in spiral wound elements. These elements are typically 40 inches long and 8 inches in diameter. For large systems, 6 or 7 elements are connected in series within the pressure vessel, and the pressure vessels are then staged in an array configuration consisting of one to three stages. There is significant instrumentation and valving associated with an NF train, including actuated valves, flow meters, pressure gauges and switches, and conductivity meters. This instrumentation is discussed in further detail in section 6.4.1.3, which addresses instrumentation and control features for the membrane system.

A recovery rate of 93% was established for the Sterling WTP, in order to reduce system water loss and reduce the amount of concentrate that needs to be deep well injected. In order to maintain the relatively high recovery of 93% established for this project, the membranes trains will contain two passes, each with two stages. The first and second pass will include NF membranes. The second pass of a two-pass system treats the concentrate from the first pass; thereby increasing the recovery and decreasing the concentrate production.

The NF skids will be sized and valved such that operation in single-pass or two-pass is possible. The pressure vessel array configuration for the first pass and second pass skids will be identical. Therefore, if the operators desired to change the system configuration to single-pass, a series of manual valves could be manipulated.

Composite polyamide membranes will be used, which offer high water production rates and high rejection, and the ability to operate at a wide pH range. One limit of the composite polyamide membranes is that they have practically no tolerance to oxidants in the raw water.

Additional treatment process(s) may be required to remove contaminants if deep well injection is not used for management of the concentrate stream. Additional space will be left on the plant site for ancillary equipment for concentrate treatment.

Nanofiltration membranes provide a positive barrier for removing pathogens, and are generally accepted to have at a minimum 3-log removal of Giardia *Lamblia*, a minimum 3-log removal of *Cryptosporidium*, and a minimum 3-log removal of viruses. The NF membranes are very effective at removing inorganic contaminants and metals, and will remove a majority of the TDS in the raw water. The class of NF membranes selected for this project is rated for 85% to 97% rejection of salts in the feed water.

The NF membranes are also very effective for removing most radionuclides. According to pilot testing, the NF membranes are capable of removing 95% of uranium.

In addition to proving a barrier for pathogens and removing inorganics, the NF membranes selected for the project will remove most organics. According to pilot test results, the NF membranes are capable of removing TOC to below detection limits. Volatile and semi-volatile organics are typically rejected at a rate of 50-75%, depending on the particular substance.

A model of the proposed NF system was developed using software developed by a membrane manufacturer, and was used to simulate the membrane performance. Data from the model runs is found in Appendix K.

Pilot testing of the NF membranes has been performed at two separate sites; Site 1 and Scalva Well 1. Site 1 consists of Wells 1, 2, 3, 4, 5, and 7. It is anticipated that additional pilot testing will be performed to collect data on the performance of the membranes when

used for the second pass. The goals of the pilot testing were to evaluate the performance of membrane treatment on the water, further develop design criteria, and evaluate long term fouling potential and the required level of pretreatment. The pilot protocol and results are found in Appendix H.

6.5.1.2 Design Criteria

Design criteria for the NF membrane process are discussed in Table 6-8.

Table 6-8: NF Membrane System Design Criteria

Description	Unit	Value
Number		
Number of first pass skids (Phase I)	ea	3 (3 duty, 0 standby)
Number of first pass skids (Buildout)	ea	4 (4 duty, 0 standby)
Number of second pass skids (Phase I)	ea	1 (1 duty, 0 standby)
Number of second pass skids (Buildout)	ea	1 (1 duty, 0 standby)
Design Flow Rates		
Recovery (First Pass)	%	70
Recovery (Second Pass)	%	78
Feed flow per skid (First Pass)	gpm	1,988
Feed flow per skid (Second Pass)	gpm	1,782
Permeate flow per skid (First/Second Pass)	gpm	1,390
Concentrate per skid (First Pass)	gpm	598
Concentrate per skid (Second Pass)	gpm	392
Maximum Average Flux Rate	gfd	15
Membrane Process Configuration		
Number of stages	-	2
Number of first stage pressure vessels (1)	ea	36
Number of second stage pressure vessels (2)	ea	18
Number of elements per vessel	ea	7
Membrane Feed Pumps (First Pass)		
Feed pressure	psi	90-110 psi
Type	-	Vertical Turbine (VFD)
Horsepower	hp	140 – 175 Hp
Membrane Feed Pumps (Second Pass)		
Feed pressure	psi	110-130 psi
Type	-	Vertical Turbine (VFD)
Horsepower	hp	50 – 90 Hp
Concentrate Equalization Tank (if used)		
Number	ea	1
Volume	gallons	750,000

(1) Number of first stage vessels in second pass skid would be increased to 49 at Buildout.
(2) Number of second stage vessels in second pass skid would be increased to 24 at Buildout.

6.5.1.3 Instrumentation and Control Features

The instrumentation and control features for the skids in the first and second pass will be similar. The instrumentation and control associated with the membrane skid process will be as follows:

- Upon START signal, an actuated valve on the suction side of the NF Feed Pump will open. A VFD associated with the NF Feed Pump will be enabled after the first 3-5 minutes of operation, and will be disabled during the last 3-5 minutes of operation. Upon STOP signal, the actuated valve will close and the VFD disabled.
- Pretreatment chemical metering pumps ready status and flow signal will be verified prior to opening the actuated valve on the suction side of the NF Feed Pump.
- Pressure switches on the suction side and discharge side of the NF Feed Pump will stop the pump and the train from being in operation in the event of LOW suction pressure or HIGH discharge pressure. LOW suction pressure alarm and HIGH discharge pressure alarms when pressure is below/above programmed values.
- Magnetic flow meters will be located on the first stage permeate line, total permeate line, and concentrate line.
- A constant total permeate flow rate for each NF train will be maintained by adjusting the NF Feed Pump speed through the associated VFD. Following the initial 3-5 minute period, the NF Feed Pump speed will adjust to 40% for a programmed period of time, after which time the VFD will adjust speed to maintain the constant total permeate flow rate. HIGH and LOW permeate flow alarms when the flow is above or below programmed values. HIGH-HIGH permeate flow will cause the train to shut down and be disabled.
- A constant concentrate flow rate for each NF train will be maintained by adjusting valve settings on second stage boosters. HIGH and LOW concentrate flow alarms will indicate when the flow is above or below programmed values. LOW-LOW concentrate flow will cause the train to shut down and be disabled.
- A manual valve located on the first stage permeate line will allow control of relative permeate flow production from the first stage and second stage membranes.
- Train feed pressure, first stage permeate pressure, second stage feed pressure, total permeate pressure and concentrate pressure will be monitored by pressure transmitters.
- Total permeate conductivity and concentrate conductivity will be monitored by conductivity analyzers. HIGH conductivity alarm will be initiated when permeate conductivity is above a programmed value.
- The system configuration will be able to be changed from two-pass to single-pass by manipulating a series of manual valves.

6.5.2 Membrane Clean-In-Place System

6.5.2.1 Process and Facilities Description

In order to maintain the performance of the NF membranes, periodic cleaning of the membranes will need to be performed to remove precipitates, scales or biological growth on the surface of the membranes. The cleaning process requires circulating a series of chemicals through the pressure vessels for a specified period of time, normally 1 to 12 hours. Citric acid is commonly used for a mild acidic wash at a pH of 3-4 to remove precipitates and scales, and sodium hydroxide is commonly used for a mild basic wash at a pH of 10 to remove any biological growth. If significant biofouling or other types of fouling occur, it may be necessary to use specialty cleaning solutions which are available through many different suppliers. Following a chemical cleaning, it is necessary to perform a permeate flush of the membranes.

The cleaning system consists of a cleaning solution tank, a circulation pump, cartridge filter to remove particulates from the cleaning solution, and manual valves and controls. Cleaning chemicals are placed in the tank (either dry or liquid), and are mixed to the proper concentration using permeate water from a piped connection to the permeate line. The mixing of the cleaning solution is accomplished by circulating the solution through the system before the cleaning process begins. A bayonet-style electric heater system will be provided for the cleaning solution tanks, since chemical cleanings are generally more effective at a temperature of 100 – 105 ° F.

6.6 BLEND STREAM FILTRATION SYSTEM

The blend stream will be filtered via an MF process consisting of a raw water EQ tank, membrane feed pumps, microfiltration skids, and a clean-in-place system. The blend stream will be sized to treat 20 – 30% of the peak day demand.

6.6.1 Process and Facilities Description

The MF system will consist of two MF trains, including a raw water tank, feed pumps, strainers, MF skids, reverse flow tanks and reverse flow pumps. The microfiltration trains will allow continuous operation of the blend stream filtration process during backwashing, and during daily and monthly membrane cleaning cycles. An air compressor, chemical feed tank and clean-in-place chemical feed system will be provided for use with backwashing and the daily and monthly cleaning cycles. The CIP system will include pumps and a chemical feed tank for use of caustic, citric acid and/or sodium hypochlorite as required.

6.6.2 Design Criteria

Selected design criteria for the blend stream filtration system are shown in Table 6-9.

Table 6-9: Blend Stream Filtration System Design Criteria

Description	Unit	Value
Flow Rate		
Design flow rate (Initial)	mgd	2.9
Design flow rate (Buildout)	mgd	3.3
Treatment Performance (1) (2)		
Giardia Lamblia removal	log	4.0
Virus removal	log	0.5
Cryptosporidium removal	log	4.0
Membrane Treatment System		
Total number of skids (Initial)	ea	2
Total number of skids (Buildout)	ea	2
Total number of modules per skid (Initial)	ea	49
Total number of modules per skid (Buildout)	ea	56
Feed pump type	-	Vertical Turbine (VFD)
Feed pump horsepower	hp	75
Surface area per module	ft^2	440
Design flux rate	gfd	67
Recovery	%	97
Clean-In-Place System	ea	1

(1) Log removal credits based on California Surface Water Treatment Alternative Filtration Technology Demonstration Report, June, 2001.

(2) The CDPHE does not award specific removal credits. The approach of the CDPHE is to evaluate the entire plant as a whole to determine compliance with the SWTR.

6.6.3 Instrumentation and Control Features

The instrumentation and control associated with the blend stream filtration system will be as follows:

- MF membrane units will be placed in operation as required to match the required blend.
- Forward filtration flow valves will open upon START signal and close upon STOP signal.
- Pressure sensors in each MF unit will control the VFD associated with each feed pump. As the MF modules foul, the pump speed will increase to maintain the programmed flow rate.

6.7 CHEMICAL POST TREATMENT, FINSIHED WATER AND CLEARWELL

6.7.1 Process and Facilities Description

The blended NF permeate and MF filtrate will discharge into a 500,000 gallon clearwell. The first compartment of the clearwell will be separated by a perforated baffle wall. This first compartment will provide an opportunity for the blend streams to combine and the chemicals to mix into the water. The baffled clearwell provides contact time for disinfection using sodium hypochlorite before the water is pumped into the distribution system. The clearwell also provides operational volume for the finished water pump system. The clearwell has been sized for buildout peak day demand (year 2032).

The permeate will be blended with the MF filtrate and sodium hydroxide will be added to the blended water to produce a water with an acceptable mineral content, pH and alkalinity, and to reduce the corrosivity of finished water. Sodium hypochlorite will be added to the treated water to provide inactivation of pathogens and to maintain chlorine residual throughout the distribution system. Space will be left in the chemical building and a chemical injection location will be provided for sodium silicofluoride to provide fluoride in the future. On-line instrumentation will be used to monitor the water quality into the City's distribution system.

The primary characteristics of the expected finished water quality is presented in Table 6-10. The expected finished water quality assumes the following chemicals and doses:

- Sodium hydroxide = 6.7 mg/L
- Sodium hypochlorite = 1.0 mg/L

Table 6-10: Expected Finished Water Quality

Water Quality Parameter	Value
pH (s.u.)	8.05
TDS (mg/L)	323
Alkalinity (mg/L as $CaCO_3$)	68
Hardness (mg/L as $CaCO_3$)	127
Calcium (mg/L)	36
Magnesium (mg/L)	9
Sodium (mg/L)	43
Sulfate (mg/L)	112
Chloride (mg/L)	24
Fluoride (mg/L)	0.2
Uranium (µg/L)	10
TOC (mg/L)	< 1.0
Bromide (µg/L)	290
Langelier Saturation Index (LSI)	0.02

Corrosive water can result in premature failing of piping in the distribution and piping and fixtures in households. Additionally, corrosive water can lead to violations of the Lead and

Copper Rule. The blend stream and addition of sodium hydroxide decrease the overall corrosively of the finished water. A positive Langelier Saturation Index (LSI) indicates water that is saturated with respect to carbonate thereby indicating the water is less likely to be corrosive. In addition to using a blend stream and sodium hydroxide, room will be left in the Chemical Building for a future corrosion inhibitor chemical feed.

6.7.2 Design Criteria

Selected design criteria for the clearwell is discussed in Table 6-11.

Table 6-11: Clearwell Design Criteria

Description	Unit	Value
Required contact time	min	30
Baffling factor	-	0.7
Volume required for contact time (peak day)	gal	325,000
Operating volume	gal	175,000
Total clearwell volume	gal	500,000
Clearwell high water level	ft	12
Minimum water level for contact time (buildout peak day – year 2032) (buildout peak month – year 2032) (buildout average day – year 2032)	 ft ft ft	 7.8 6.5 4.2
Overflow capacity	mgd	10

Selected design criteria for the finished water instrumentation and water quality monitoring system are shown in Table 6-12.

Table 6-12: Finished Water Instrumentation and Water Quality Monitoring Design Criteria

Instrumentation	Location	Control	Typical Measurement Range
pH	Finished water line	Automatic/ On-line	4 – 10 s.u.
Chlorine Residual	Finished water line	Automatic/ On-line	0.01 – 5.0 mg/L
Turbidity	Finished water line	Automatic/ On-line	0.05 – 10 NTU
Conductivity	Finished water line	Automatic/ On-line	100 – 1,000 µS

Design criteria features for the post treatment and stabilization chemicals feeds will be discussed in the Chemical Feed Section.

6.7.3 Instrumentation and Control Features

The instrumentation and control associated with the Chemical Post Treatment and Clearwell will be as follows:

- Two ultrasonic level elements will be used to monitor the water level in the clearwell. Operator will select one element as the primary element, and the other as backup. HIGH and LOW clearwell level alarms will be provided. HIGH-HIGH water level will cause the plant to shut down. LOW-LOW water level will cause the finished water pumps to shut down.
- Instrumentation will be used to measure pH, chlorine residual, turbidity and conductivity will be transmitted to the PLC.
- HIGH or LOW finished water pH alarm will be provided.
- HIGH or LOW finished water chlorine residual alarm will result in plant shut down.
- HIGH finished water turbidity alarm will result in plant shut down.
- HIGH or LOW finished water conductivity alarm will be provided.
- Instrumentation and control features for the post treatment chemicals feeds will be discussed in the Chemical Feed Section

6.8 FINISHED WATER PUMPING AND TRANSMISSION

6.8.1 Process and Facilities Description

The finished water pumping system will consist of four pumps. Three of the pumps will be identical, with the same design point, horsepower, and speed. One smaller pump will allow for finer flow delivery control. The finished water pumps will be of vertical turbine type. Each of the finished water pumps will be equipped with a variable frequency drive.

An isolation valve, check valve and air and vacuum valve will be provided on the discharge side of each pump. A flow meter on the common discharge header will measure the total finished water flow.

Finished water pipes will be constructed to deliver finished water to the existing distribution system. A 16-inch pipe (approximately 3,000 feet) will connect to the existing 24-inch transmission line under the South Platte to the north of the WTP site near the Scalva Wells. A 12-inch pipe (approximately 3,700 feet) will connect to the existing three transmission lines (one 14-inch and two 24-inch) south of the WTP near the intersection of County Road 370 and Highway 6. Figure 6-5 illustrates the approximate finished water piping alignments.

6.8.2 Design Criteria

Computer modeling was performed on the water distribution system to develop system head curves for a variety of operating conditions. In general, the most severe pumping conditions occur during the summer night when the pumps deliver all of the design flow to the distribution system with full water storage tanks. During high water demand period, the pumps and the outflow from the water storage tanks will meet the demand. This will require a lower total

dynamic head for the finished water pumps to deliver the same design flow. The system curves developed from the hydraulic modeling were used to develop key design criteria based on the most severe pumping conditions. Table 6-13 summarizes the basic design criteria for the finished water pumping system.

Table 6-13: Finished Water Pumps Design Criteria

Description	Unit	Value
Number (larger units)		
Total number of units	each	3 (2 duty, 1 standby)
Type	-	Vertical turbine (VFD)
Flow	gpm	2,900
Total Dynamic Head	ft	210
Horsepower	hp	200
Number (smaller unit)		
Total number of units	each	1 (1 duty, 0 standby)
Type	-	Vertical turbine (VFD)
Flow	gpm	1,900
Total Dynamic Head	ft	210
Horsepower	hp	150

6.8.3 Instrumentation and Control Features

The instrumentation and control associated with the Finished Water Pumping will be as follows:

- The operation of the finished water pumps will be controlled by the water level in the water storage tanks. Storage tank water level signals will be used to START and STOP the pumps, and to establish the flow requirements for each set of the pumps. The pumping from the clearwell will be set to match the inflow rate into the clearwell. When the water level in the clearwell is out of the preset operating range, the pump speed will be adjusted up and down to keep the water level within the range.
- Pressure switches on the discharge side of the Finished Water Pumps will stop the pump from being in operation in the event of LOW or HIGH discharge pressure.

6.9 CONCENTRATE MANAGEMENT SYSTEM

Concentrate from the second pass of the NF system will be collected in a 280,000 gallon concentrate tank. Three submersible pumps, two duty and one standby, will deliver the concentrate to a set of two deep wells. The deep wells will be drilled to a depth of approximately 7,000 feet.

6.9.2 Process and Facilities Description

Concentrate from the second pass of the NF system will be collected and equalized in a concentrate storage tank. The concentrate tank will have the capacity to store concentrate for 12 hours at the buildout peak day (year 2032) and 1.13 days at the buildout average day. Each deep

well will be sized to accept the Phase I (year 2022) average annual concentrate flow. Both deep wells will be used to dispose of concentrate during the peak day.

6.9.3 Concentrate Water Quality

A model of the proposed NF system was developed using software developed by a membrane manufacturer, and was used to simulate the membrane performance. The anticipated concentrate water quality is found in Appendix K.

6.9.4 Design Criteria

Selected design criteria for the concentrate treatment system are shown in Table 6-14.

Table 6-14: Concentrate Management System Design Criteria

Description	Unit	Value
Concentrate Pumps		
Total number of units	Each	3 (2 duty, 1 standby)
Type	-	Submersible
Flow	gpm	175 - 200
Total dynamic head	ft	200 - 300
Horsepower	hp	10 – 20
Deep Wells		
Total number of units	Each	2 (1 duty, 1 standby at average day demand) 2 (2 duty, 0 standby at peak day demand)
Depth	ft	7,000
Capacity (each)	gpm	175 - 200

A detailed evaluation of the geologic formation into which concentrate will be discharged will be conducted as part of the permitting process. The geologic evaluation will provide more detail on the ability of the formation to accept concentrate. As such, the capacity listed in Table 6-14 is an estimate based on other deep wells in the area used as oil and gas disposal wells.

6.9.5 Instrumentation and Control Features

The instrumentation and control associated with the concentrate management system will be as follows:

Concentrate Pumping Process

- The concentrate pumps will be controlled by the water level in the concentrate storage tank and plant water production. The pumps will maintain a low water level.
- Pressure switches on the discharge side of the Concentrate Pumps will stop the pump from being in operation in the event of LOW or HIGH discharge pressure.
- A HIGH level alarm on the concentrate tank will start the lag pump.
- A LOW level alarm on the concentrate tank will stop all of the concentrate pumps.

6.10 CHEMICAL FEED SYSTEMS

6.10.1 Process and Facilities Description

The chemical feed systems will provide storage and pumping for chemicals throughout the plant. The chemical feed systems include:

- Scaling inhibitor/anti-dispersant NF pretreatment chemical for the first pass membrane process
- Scaling inhibitor/anti-dispersant NF pretreatment chemical for the second pass membrane process
- Sodium hydroxide for pH adjustment and stabilization of the treated water
- Sodium hypochlorite for disinfection
- Sulfuric acid for NF pretreatment pH control (if required)
- Sodium silicofluoride for fluoride (future)
- Corrosion inhibitor (if required)

The chemical storage rooms will be grouped together in a separate building to the west of the process building. All of the chemical feed systems will have a separate chemical feed rooms except for the two membrane pretreatment chemicals which are stored in the same room. An additional two rooms will be included in the building for future chemicals if necessary. Each chemical feed room will be provided with an eyewash station.

All of the chemical feed systems consist of liquids. Each system will consist of storage tanks, chemical metering pumps, and appurtenances. Each chemical feed system will be provided with one standby chemical metering pump for redundancy.

6.10.2 Design Criteria

Design criteria for the chemical feed systems are based on the design dosage of the chemical, storage facilities that are needed and backup requirements. Design criteria for the chemical feed systems are presented in Table 6-15.

Table 6-15: Chemical Feed Systems Design Criteria

Description	Unit	Value
NF Pretreatment Chemical (First Pass)		
Type	form	Liquid
Active Strength	%	100
Solution Strength	lb/gal	9.26
Storage Tanks		
Total Working Volume	gal	4,000
Number of Tanks	ea	1 (4,000 gallon each)
Storage Time @ Buildout Average Day	days	145
Chemical Metering Pumps		
Application Point	-	Raw Water
Dosage (typical)	mg/L	7.5
Number of Pumps	ea	2 (1 duty, 1 standby)
Pumping Capacity	gph	0.30 – 6.03
Required Turndown Ratio	-	20:1
NF Pretreatment Chemical (Second Pass)		
Type	form	Liquid
Active Strength	%	100
Solution Strength	lb/gal	9.26
Storage Tanks		
Total Working Volume	gal	1,000
Number of Tanks	ea	1 (1,000 gallon each)
Storage Time @ Buildout Average Day	days	121
Chemical Metering Pumps		
Application Point	-	Feed to Second Pass
Dosage (typical)	mg/L	7.5
Number of Pumps	ea	2 (1 duty, 1 standby)
Pumping Capacity	gph	0.07 - 1.80
Required Turndown Ratio	-	27:1
Sodium Hydroxide		
Type	form	Liquid
Active Strength	%	50
Solution Strength	lb/gal	6.38
Storage Tanks		
Total Working Volume	gal	6,000
Number of Tanks	ea	2 (3,000 gallon each)
Storage Time @ Buildout Average Day	days	168
Chemical Metering Pumps		
Application Point	-	Clearwell
Dosage (typical)	mg/L	6.7

Description	Unit	Value
Number of Pumps	ea	2 (1 duty, 1 standby)
Pumping Capacity	gph	0.48 – 8.76
Required Turndown Ratio	-	19:1
Sodium Hypochlorite		
Type	form	Liquid
Active Strength	%	10
Solution Strength	lb/gal	0.96
Storage Tanks		
Total Working Volume	gal	3,000
Number of Tanks	ea	2 (1,500 gallon each)
Storage Time @ Buildout Average Day	days	85 [(1)]
Chemical Metering Pumps		
Application Point	-	Clearwell
Dosage (typical)	mg/L	0.5 - 5.0
Number of Pumps	ea	2 (1 duty, 1 standby)
Pumping Capacity (each)	gph	0.48 – 21.74
Required Turndown Ratio	-	46:1

[(1)] Long storage and the resulting reduction in strength of sodium hypochlorite may require Sterling to order "short loads" more frequently to maintain adequate solution strength.

6.10.3 Instrumentation and Control Features

The instrumentation and control associated with the chemical feed systems will be as follows:

Liquid Storage and Feed Systems

- An ultrasonic level element will be used to monitor the liquid level in each chemical storage tank. HIGH and LOW level alarms will be provided.
- Each chemical metering pump will be provided with both automatic stroke length control as well as a variable speed drive to adjust the pump speed.
- A flow switch will be provided for each chemical feed system to verify chemical flow when the metering pumps are in operation. LOW flow alarm will be initiated under low chemical flow.
- A magnetic flow meter will be provided for the membrane pretreatment feed systems to measure chemical flow rate. Plant will shut down on HIGH or LOW chemical flow rates.

6.11 EASEMENTS AND RIGHTS-OF-WAY

A raw water pipeline will be required to deliver water from the north (Scalva Wells) to the WTP, and a raw water pipeline will be required to deliver water from the south (Wells 1, 2, 3, 4, 5, 7, 8, 9, 10, 15 and 30) to the WTP. Both of the new raw water pipelines will be located in the Henderson Smith Ditch property. The City of Sterling owns this property. A copy of the property deeds for the Henderson Smith Ditch and the Scalva property (ownership by the City) are found in Appendix L.

A finished water pipeline will be required to deliver water from the new WTP to the existing 24-inch main transmission line across the South Platte River to the north. A finished water pipeline will be required to deliver water from the new WTP to the three transmission lines (one 14-inch and two 24-inch) across the South Platte River to the south. Both of the new finished water pipelines will be located in the Henderson Smith Ditch property. A copy of the property deeds for the Henderson Smith Ditch are found in Appendix L.

The raw water and finished water pipelines will be located the Henderson Smith Ditch property. If the Henderson Smith Ditch property cannot be used, the County Road 370 right-of-way will be utilized. It is anticipated that Logan County will allow the City to place the pipelines in the right of way.

The routing of the new pipelines is shown in Figure 6-5.

The preliminary design and permitting process for the deep wells is currently underway. The exact location of the deep wells is not known at this time; however, they will be constructed on City property. Once the routing for the concentrate discharge lines is determined, the final design will reflect the location of the wells and the routing of the discharge lines.

6.12 WASTE STREAMS

The City of Sterling WTP will produce several waste streams. Table 6-16 describes the volumes, characteristics, and disposal method for the various waste streams produced by the WTP.

Table 6-16: Waste Stream Descriptions

Stream	Volume	Characteristics	Disposal Method
Sanitary	Typical <1,000 gpd	Domestic Sewage	To sanitary sewer located on the site
Spent Cleaning Fluid	Approximately 150,000 gallons per year at buildout	Acidic, caustic and misc. cleaning agent	Neutralized solution to sanitary sewer
On-line Instrumentation	Approximately 150-250 gpd	Similar to raw water and finished potable water	To sanitary sewer
MF Reverse Filtration	Year 2022: Avg. = 25,000 gpd Peak Month = 49,000 gpd	Similar to raw water with high particulate loading	Equalized and discharged to sanitary sewer
Concentrate Stream	Year 2022: Avg. = 0.24 mgd Peak Month = 0.46 mgd	Concentrated contaminants removed from raw water, resulting TDS of approx. 15,000 – 20,000 mg/L.	Deep well injection

As indicated in Table 6-16, there are several discharges to the sanitary sewer. The sanitary and on-line instrumentation have relatively minor flows and will not impact the WWTP. The spent cleaning fluid is also a relatively minor flow when averaged across the course of the year, and

should not impact WWTP as long as the chemical solution is properly neutralized and discharged to the sewer at a gradual rate.

CHAPTER 7
RELIABILITY AND REDUNDANCY

This chapter addresses reliability and redundancy considerations for the City of Sterling WTP. Specific unit processes are addressed, as well as system wide considerations such as the overall water system configuration. This chapter also discusses protection from flooding and system security.

7.1 GENERAL CONSIDERATIONS

The Water Quality Control Commission of CDPHE outlines criteria for reliability and redundancy for water treatment facilities. These criteria are documented in CDPHE "Design Criteria for Potable Water Systems", dated March 31, 1997. These criteria (CDPHE criteria) outline general requirements for water treatment facilities, as well as specific criteria for certain treatment processes. While CDPHE criteria address many aspects of the design of a water treatment facility, they do not cover all areas. General engineering practices and conditions specific to each system must be considered when factoring reliability and redundancy into the design of a water treatment facility.

7.2 OVERALL SYSTEM RELIABILITY AND REDUNDANCY

7.2.1 Potable Water System Configuration

The City of Sterling distribution system has 10 million gallons of water storage. The existing raw water wells do not have emergency generators. In the event of a City-wide power outage, water is supplied by the existing water storage tanks.

7.2.2 Treatment Processes Reliability and Redundancy

Redundancy is generally provided for equipment and treatment processes where it is cost effective, or where typical maintenance of equipment would significantly impact operation of the plant if standby units were not provided.

Reliability and redundancy considerations for each major unit process are discussed in Table 7-1.

Table 7-1: Reliability and Redundancy for Major Treatment Processes

Treatment Process/Facility	Redundancy
Raw Water Extraction Wells	Thirteen wells will be provided for supplying raw water to the WTP at Phase I (year 2022). Maximum required raw water flow rate will be provided at peak day demand with any one well out of service except for either one of the Scalva Wells.
Cartridge Filters	Three parallel units provided. Maximum plant flow will be provided with one unit out of service.
Nanofiltration (First Pass)	Three parallel units provided. If one unit is out of service, the blend ratio will be changed to 70/30. 80% of the Phase I (year 2022) peak day demand will be provided with one unit out of service.
Nanofiltration (Second Pass)	One unit provided. If the unit is out of service, the plant will have the ability to operate as a one pass system, taking the skid offline. The blend ratio will be changed to 70/30. 90% of the Phase I (year 2022) peak day demand will be provided with the second pass skid out of service.
Finished Water Pumps	A standby for the largest unit will be provided. The Phase I (year 2022) peak day demand will be provided with one unit out of service.
Chemical Feed Systems	Multiple chemical storage tanks will be provided for most chemicals. Metering pumps for each chemical will have one standby unit.

The design blend ratio of 80/20 is based on meeting a target hardness of 130 mg/L as $CaCO_3$. The plant will be designed with the flexibility of operating at a higher blend ratio (70/30). A blend ratio of 70/30 will result in a finished water hardness above the goal of 130 mg/L as $CaCO_3$; however, all Primary and Secondary Drinking Water Standards will be met.

A raw water emergency bypass will be provided. In the event of a catastrophic failure of multiple NF units, raw water will bypass the MF process and be delivered to the chlorine contact chamber for disinfection. At a blend ratio of 50/50, all Primary Drinking Water Standards will be achieved.

7.3 PROTECTION FROM FLOODING

Both CDPHE and Drinking Water Revolving Fund criteria require that structures and mechanical equipment be protected from physical damage from a 100-year flood.

The 100-year flood level at the City of Sterling WTP is estimated to vary across the site, with an average elevation of 3928.5 feet. The finished floor elevation of the WTP will be above the 100-year flood level at an elevation of 3932.0 feet, and therefore the building and mechanical equipment will be protected from the 100-year flood. The clearwell overflow pipe will discharge to the Henderson Smith Ditch at an elevation above the 100-year flood level, and the overflow weir within the clearwell will also be at an elevation above the 100-year flood level. Therefore, the WTP will remain fully operational during the 100-year flood event.

7.4 SYSTEM SECURITY

As discussed in Chapter 4 of this report, the City of Sterling has completed a Vulnerability Study. The Vulnerability Study Certification is found in Appendix F.

A security fence will be located around the perimeter of the water treatment plant, and exterior lighting will be provided for the site. The control room, which is often manned during working hours, will be located so that operators can monitor both the front door and main process area. Coded key access and intrusion alarms will be located on each exterior door. Motion detectors will be provided at key locations within the plant. Other security for the water treatment facility will be evaluated during final design.

CHAPTER 8
SITE LAYOUT AND SITE CIVIL DESIGN CRITERIA

The purpose of this chapter is to establish site civil design criteria for the project, and present a preliminary plan for the plant site showing major features.

8.1 TREATMENT PLANT SITE SELECTION

Two potential sites for the Sterling WTP were identified for consideration. The potential sites were evaluated considering the following criteria.

- Location within the 100-year floodplain
- Room to expand
- Ownership, zoning, platting
- Raw water and finished water pipeline upgrades necessary
- Availability of utilities
- Delivery access
- Impact to adjacent properties
- Subsurface conditions

The selected site is located north of Highway 6 on the east side of the City. The site is bounded on the east by County Road 370 and bounded on the west by the Henderson Smith Ditch. The City of Sterling owns the property. A copy of the deed is included in Appendix L.

A document titled Technical Memorandum Number 4 - *Site Selection Alternatives Evaluation* is found in Appendix D summarizing the two sites evaluated and the evaluation criteria.

8.2 LOCATION WITHIN 100-YEAR FLOODPLAIN

The Federal Emergency Management Agency (FEMA) Flood Insurance Rate Map (FIRM) for Logan County, Colorado, Panel No. 0801100335B defines the effective floodplain for the South Platte River adjacent to the proposed project site. Portions of the west side of the property lie within the boundary of the 100-year floodplain. However, the Base Flood Elevations from the published flood profiles, when delineated on the topographic mapping prepared for the City of Sterling, depict a much reduced impact to the property. Only a small portion of the property would be within the 100-year floodplain when the effective flood elevations are plotted on the new, more detailed mapping. None of the property where structures will be located would be within the 100-year floodplain.

The City will most likely apply to FEMA for a Letter of Map Revision (LOMR) based on the better topographic information. It is anticipated that the City will be able to utilize most of the property for the proposed project. The LOMR application would be through the FEMA Region 8 Office in the Denver Federal Center. In the review process FEMA may also solicit comments from the Colorado Water Conservation Board who is a Cooperating Technical Partner on floodplain matters in this jurisdiction.

Additional permits or processes may be required for construction of pipelines located in the 100-year floodplain to and from the plant. Approvals for the pipelines in the floodplain, typically do not involve a significant amount of data acquisition or technical analysis, provided that the ground surface following construction is restored to the preconstruction grades and properly stabilized.

8.3 SITE LAYOUT AND IMPROVEMENTS

Figure 8-1 shows the preliminary site layout and improvements. Two buildings will be located on the site, the main process building and the chemical building. Delivery vehicle access is provided between the two buildings to allow for chemical delivery. A parking lot is located on the south side of the process building where the main entrance to the plant will be located. Figure 8-1 shows the preliminary site layout for the Sterling WTP.

A geotechnical evaluation was completed for the proposed WTP site. A copy of the geotechnical report is found in Appendix M.

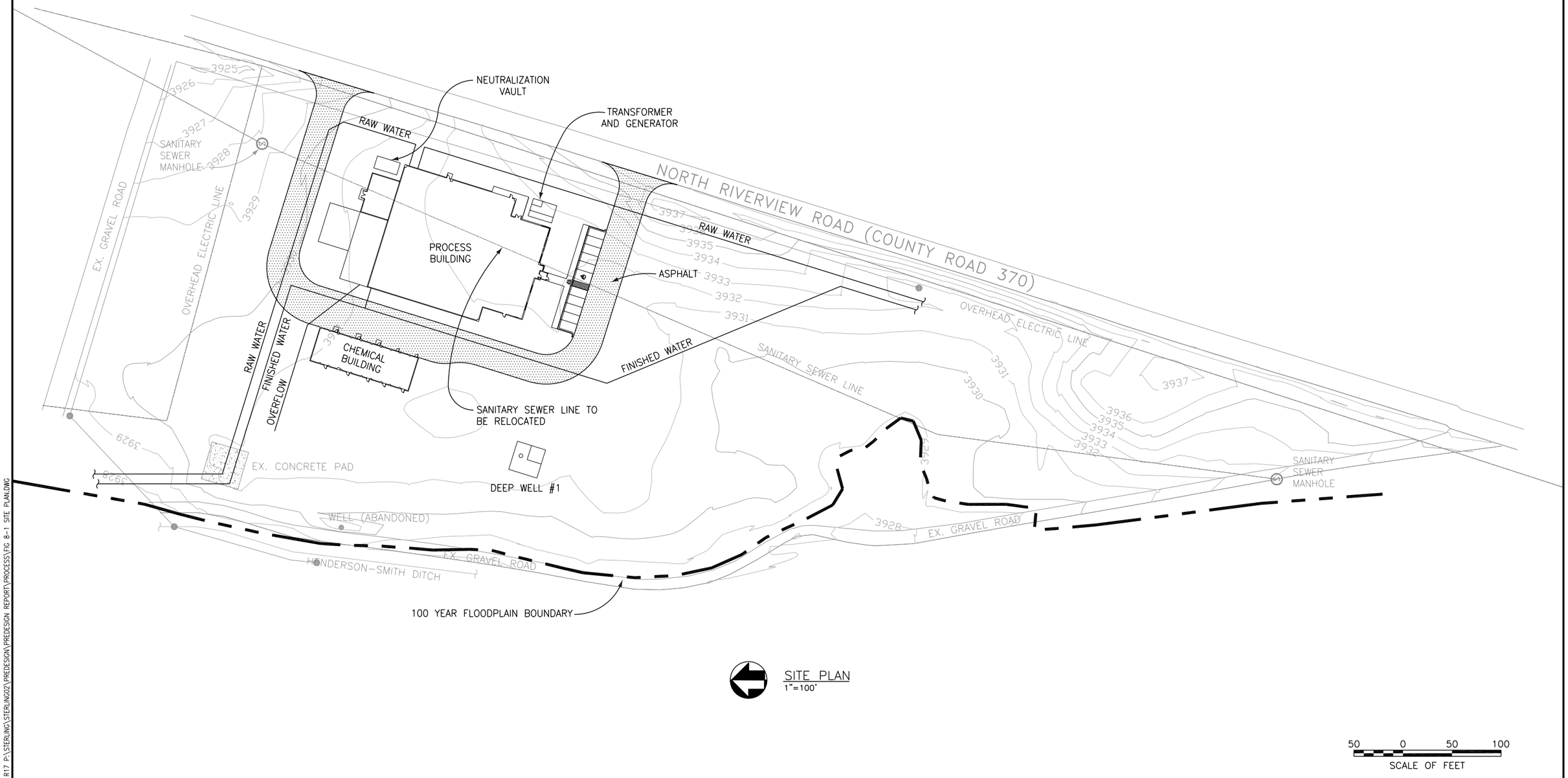

FIGURE 8-1
CITY OF STERLING - WATER TREATMENT PLANT
SITE PLAN

Richard P. Arber Associates
Consulting Engineering & Project Management

7/29/09 14:30 LHOWARD R17 P:\STERLING\STERLING02\PREDESIGN\PREDESIGN REPORT\PROCESS\FIG 8-1 SITE PLAN.DWG

CHAPTER 9
CONCENTRATE STREAM PERMITTING

9.1 INTRODUCTION

The City of Sterling WTP will include treatment using NF membranes. Treatment of the water using NF will result in a waste stream (concentrate) that contains the rejected material in the raw water, and that must be discharged. The volume of the water discharged will be 6% - 7% of the NF process feed water flow. Phase I (year 2022) will have an annual average flow of approximately 0.24 mgd, a peak month flow of approximately 0.46 mgd, and a peak day flow rate of approximately 0.55 mgd. Since a large portion of the dissolved material in the raw water will be removed through the NF process, it will be concentrated in the waste stream.

9.2 CONCENTRATE DISCHARGE PERMITTING

The Sterling WTP will be designed to discharge the concentrate stream to deep wells (described in the next section). However, flexibility will be designed into the WTP to discharge to surface water if necessary. The flexibility of the NF process is described in Chapter 6. Permits will be required for either a deep well injection system or a surface water discharge. These permits are described in the following section.

9.2.1 Deep Well Injection

A Class I, Non-Hazardous Industrial Waste Disposal Well permit will be required through the Underground Injection Control (UIC) program. The Environmental Protection Agency (EPA) has primacy over the UIC program in the State of Colorado; therefore the permitting process would be through EPA Region 8. However, CDPHE would be involved in the review process.

Class I Wells are required to be drilled into a formation that is below the lowermost formation containing an underground source of drinking water (USDW). Within the Sterling area, it is estimated that this depth would be approximately 7,000 feet below ground surface. A geologic study will be required to ensure that the receiving formations are sufficiently permeable to accept the concentrate and that no vertical migration will occur. There are a number of monitoring requirements including, but not limited to, monitoring of pressure to ensure no new fractures are initiated and monitoring of the chemistry of the concentrate. Additionally, an internal and external mechanical integrity test (MIT) would be required every five (5) years.

Initial contact has been made with EPA Region 8 and CDPHE to begin the permitting process. It is anticipated that the geologic investigation and well design would have an approximate timeline of six (6) months. Once the geologic report, design, and permit application have been submitted to the EPA, the review process is anticipated to take approximately six (6) months to one (1) year. A public review and comment period of 60-days is expected.

9.2.2 Surface Water Discharge

A National Pollution Discharge Elimination System (NPDES) permit will be required for a surface water discharge of the concentrate stream. The State of Colorado has been given authority by the EPA to issue and enforce NPDES permits, administered by the CDPHE Permits and Enforcement Section of the Water Quality Control Division. The NPDES permit will describe the effluent quality requirements for the concentrate stream, as well as describe other conditions, such as monitoring schedules, that must be met by the discharger. Water treatment facilities are typically issued Industrial Discharge Permits by CDPHE. Industrial Discharge Permits often are much narrower in scope than those issued to wastewater treatment facilities, focusing in on specific contaminants expected to be found in the discharge. However, many Industrial Discharge Permits are as thorough as discharge permits issued to wastewater treatment facilities.

Preliminary Effluent Limits (PELs) were requested and received from CDPHE to anticipate the discharge limits. Comparing pilot testing results to the PELs, several contaminants of concern would need to be addressed in order to meet discharge permit limits. Table 9-1 summarizes the contaminants of concern for a surface water discharge as compared to the projected water quality of the concentrate stream and the proposed treatment method to address the contaminants. Note that the concentrations presented in Table 9-1 represent anticipated concentrations from a single-pass NF process.

Table 9-1: Concentrate Contaminants of Concern

Contaminant	Concentrate Level [(1)]	Discharge Limit	Treatment Method
Selenium	24.8 µg/L	4.6 µg/L	Adsorption Media
Sodium	561 mg/L	160 mg/L	Regulatory Relief [(2)]
Sulfate	2,710 mg/L	250 mg/L	Ion Exchange

[(1)] Concentrate Levels are results from pilot testing for Site 1.
[(2)] The sodium limit cannot be met with a treatment method. Flexibility of the discharge limit is necessary.

Selenium would be removed using an adsorptive media. The media would need to be periodically removed and disposed of via landfill. A more thorough analysis of the contaminant concentrations on the media would need to be conducted to determine if any special permitting would be required, and if municipal landfills would accept the media.

Sulfate would be removed using an ion exchange process. The media would be regenerated with a concentrated brine stream discharged to the sanitary sewer, drying beds, or a combination of both. A more thorough analysis would need to be conducted on chemistry of the regenerant stream to determine an appropriate residuals management strategy.

The additional treatment processes required for a surface water discharge will not be constructed; however, space will be left on the plant site to house additional processes should they be required.

The sodium limit can only be met if the limit is relaxed. Meetings with CDPHE have indicated that regulatory relief is possible. The sodium limit is based on a policy titled *Implementing Narrative Standards in Discharge Permits for the Protection of Irrigated Crops*. As the standard is based on a policy and not a regulation, there is potential for flexibility. A study to determine the overall sodium loading to the South Platte River as a result of a surface water discharge is underway. Preliminary results have indicated that the sodium load to the South Platte would be reduced as a result of the new WTP due to the decreased usage of water softeners within the City.

In addition, the permit will require that Whole Effluent Toxicity (WET) testing be performed to demonstrate that the concentrate stream is not toxic to aquatic life. It is anticipated that by blending the concentrate stream with the City's wastewater treatment plant (WWTP) effluent, the blended water would pass a WET test.

CHAPTER 10
OPINIONS OF PROBABLE COST AND RATE EVALUATION

10.1 OPINION OF PROBABLE PROJECT COST

The opinion of probable capital cost for the project is $26,630,000. The opinion of probable cost is presented in more detail in Table 10-1 at the end of this chapter. Additional cost information is found in Appendix N.

The opinion of probable cost assumes that subsequent pilot testing will indicate that cartridge filters and pretreatment chemical feeds will provide adequate pretreatment for the NF membranes. The opinion of probable cost will increase if more thorough pretreatment is required for the membranes.

The opinions of probable project cost that are presented in this section are based on cost data developed from previous projects, vendor quotes and recently bid construction projects. The costs presented are in terms of year 2009 dollars and no attempt has been made to escalate these costs to a future date. The Engineering News Record (ENR) Construction Cost Index (CCI) at the time of this report was 8574.

The American Association of Cost Engineers (AACE) has defined three basic categories of estimates in an effort to establish expected accuracy range for various types of cost estimates. The AACE definitions are as follows:

Order of Magnitude Estimate- This is an approximate estimate made without detailed engineering data. Some examples would be: an estimate from cost-estimating curves, an estimate using scale-up or scale-down factors, and an approximate ratio estimate. It is normally expected that an estimate of this type would be accurate within +50% to –30%.

Budget Estimate- Budget in this case applies to the Owner's budget, and not to the budget as a project-control document. A budget estimate is prepared with the use of spreadsheets, layouts, and equipment details. It is normally expected that an estimate of this type would be accurate within +30% to –15%.

Definitive Estimate- As the name applies, this is an estimate prepared from very defined engineering data. As a minimum, the data must include: fairly complete plot plans and elevations, piping and instrumentation diagrams, one-line electrical diagrams, soil data and sketches of major foundations, building sketches and a complete set of specifications. It is expected that a definitive estimate would be accurate to within +15% to –5%.

The opinion of probable cost presented in this report is close to a Budget Estimate, with an expected accuracy of +30% to –15%.

10.2 OPINION OF PROBABLE OPERATION AND MAINTENANCE COST

Opinions of probable O&M cost were developed for the project, both at the time that the plant goes into operation in 2012 and at buildout. The costs presented are in terms of year 2009 dollars and no attempt has been made to escalate these costs to a future date. The O&M costs generally include labor associated with operation and maintenance of the plant, electricity, chemical treatment, membrane cleaning costs, equipment maintenance, cartridge filter replacement and long-term membrane replacement costs.

Based on experience with other water treatment facilities it is assumed that three operators will be required to operate and maintain the water treatment facilities. The performance of the NF membranes will deteriorate over time as a result of fouling and chemical cleaning, and the membranes will therefore need to be replaced. A membrane life of five years for the first pass NF membranes and three years for the second pass membranes has been assumed in the O&M costs. It is anticipated that the life of the second pass membranes will be shorter due to the water quality of the feed to the second pass. Funds required to replace the membranes are often collected on a continual basis through monthly water bills.

Table 10-2 presents the O&M costs at the time the plant goes into operation in 2012. The opinion of probable O&M costs at the time the plant goes into operation is approximately $1,510,000 per year, or $1.13 per 1,000 gallons. Table 10-3 presents O&M costs at Phase I (year 2022). The opinion of probable O&M costs at Phase I is approximately $1,630,000 per year, or $1.07 per 1,000 gallons. The O&M costs do not include existing distribution costs, debt service, capital outlay costs, or O&M reserve costs. More specific information concerning assumptions used in developing the O&M costs can be found in Tables 10-2 and 10-3 at the end of this chapter.

10.3 STATE REVOLVING LOAN PROGRAM

The Sterling Water Treatment Plant Project will be funded through the State Drinking Water Revolving Fund (DWRF). The DWRF provides low interest loans to government agencies for drinking water public health and compliance purposes. The loans are offered below market interest rates and with extended loan terms. The following types of projects or components of projects are eligible for funding through the DWRF.

- Projects/expenditures to address Safe Drinking Water Act (SDWA) compliance. Projects to prevent current and/or future violations.
- Projects to replace aging infrastructure if they are needed to maintain compliance with the SDWA.
- Projects for entities that deliver water through constructed conveyances not considered public water systems for purposes other than residential use. The installation of point-of-use devices for treatment of water at entities not considered to be public water systems.
- Land acquisition if it is an integral part of a project to meet or maintain compliance with the SDWA.
- Expenditures for planning and design of drinking water projects. Costs for preparing environmental assessments may be in included.

- Consolidation costs with another public water system to maintain SDWA compliance. These costs include legal fees and water buy-in fees.
- Restructuring of systems lacking the technical, managerial and financial (TMF) capacity to maintain the water system. These costs are eligible only if compliance is ensured and the owner or operator of the system agrees to make the necessary changes to ensure adequate TMF capacity.

The following types of systems, projects or components of projects are not eligible for funding through the DWRF.

- Systems that lack TMF capacity.
- Systems that are in significant noncompliance, unless the State conducts a review and determines that the project will enable the system to return to compliance and the system will maintain adequate TMF capacity.
- Projects with the primary purpose of supplying or attracting growth.
- Dams or rehabilitation of dams.
- Water rights, except if the water rights are owned by a system that is being purchased through consolidation as part of a capacity development strategy.
- Reservoirs, except for reservoirs that are part of the treatment process or on the treatment facility property.
- Expenses for monitoring laboratory fees.
- O&M expenses.
- Projects with the primary purpose of fire protection.

The primary purpose of the Sterling WTP is to address existing Primary Drinking Water Standard Violations of uranium and TTHMs. All components of the project as identified in the Opinion of Probable Project Cost are eligible for funding by the DWRF.

10.4 20-YEAR CASH FLOW AND RATE PROJECTIONS

An evaluation of Sterling's 20-year cash flow projection was prepared based on current operating expenditures and projected increased expenditures as a result of the new WTP. The following revenue sources were included in the cash flow evaluation.

- User fees
- Tap fees
- Other miscellaneous fees.

The following expenditures were included in the cash flow evaluation.

- O&M costs for the WTP
- O&M costs for the distribution system
- Debt service
- Capital outlay costs
- O&M reserve costs

- Other miscellaneous expenses

The cash flow evaluation is not a rate study for the City. The rates included are only projected rates. A rate study is currently being prepared by the City of Sterling.

Figure 10-1 presents the 20-year cash flow for the City of Sterling. The background used to prepare the 20-year cash flow is found in Appendix N.

Figure 10-1: Cash Flow Projection Worksheet

	Actual			Estimated																				
	2007	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**
Available Resources: January 1	$ (261,897)	$ (442,132)	$ (517,373)	$ (704,396)	$ (545,276)	$ (231,580)	$ 283,775	$ 774,729	$ 1,280,482	$ 1,801,897	$ 2,337,979	$ 2,891,487	$ 3,462,596	$ 4,051,599	$ 4,659,572	$ 5,290,679	$ 5,942,375	$ 6,610,818	$ 7,303,950	$ 8,024,198	$ 8,778,277	$ 9,565,360	$ 10,386,495
Revenue:																							
User Fees	$ 1,534,695	$ 1,814,614	$ 1,820,500	$ 1,804,182	$ 3,508,012	$ 5,729,935	$ 5,465,443	$ 5,632,345	$ 5,808,950	$ 5,974,877	$ 6,171,401	$ 6,370,100	$ 6,572,301	$ 6,786,648	$ 7,047,020	$ 7,279,743	$ 7,470,524	$ 7,748,981	$ 8,054,449	$ 8,433,953	$ 8,804,584	$ 9,186,955	$ 9,493,425
Tap Fees	$ 48,632	$ 19,756	$ 20,000	$ 511,845	$ 527,462	$ 554,622	$ 585,212	$ 599,879	$ 621,602	$ 660,648	$ 679,699	$ 705,609	$ 737,821	$ 772,865	$ 773,584	$ 810,509	$ 842,929	$ 866,941	$ 878,069	$ 830,970	$ 802,349	$ 773,894	$ 830,162
Other Revenue	$ 83,417	$ 89,135	$ 76,000																				
Total Revenue	$ 1,666,744	$ 1,923,505	$ 1,916,500	$ 2,316,027	$ 4,035,474	$ 6,284,558	$ 6,050,655	$ 6,232,225	$ 6,430,551	$ 6,635,525	$ 6,851,100	$ 7,075,709	$ 7,310,123	$ 7,559,512	$ 7,820,604	$ 8,090,251	$ 8,313,453	$ 8,615,922	$ 8,932,518	$ 9,264,923	$ 9,606,934	$ 9,960,850	$ 10,323,588
Expenditures:																							
Operations and Maintenance - WTP	$ -	$ -	$ -	$ -	$ -	$ 1,577,854	$ 1,663,333	$ 1,748,854	$ 1,844,501	$ 1,945,583	$ 2,051,214	$ 2,161,917	$ 2,278,203	$ 2,403,563	$ 2,533,479	$ 2,672,333	$ 2,818,070	$ 2,976,536	$ 3,141,928	$ 3,311,450	$ 3,486,243	$ 3,666,527	$ 3,856,990
Operations and Maintenance - Distribution System	$ 1,679,534	$ 1,706,828	$ 1,798,823	$ 1,461,875	$ 1,520,350	$ 1,581,164	$ 1,644,411	$ 1,710,187	$ 1,778,595	$ 1,849,739	$ 1,923,728	$ 2,000,677	$ 2,080,705	$ 2,163,933	$ 2,250,490	$ 2,340,510	$ 2,434,130	$ 2,531,495	$ 2,632,755	$ 2,738,065	$ 2,847,588	$ 2,961,491	$ 3,079,951
Debt Service	$ -	$ -	$ -	$ -	$ 1,844,062	$ 1,844,062	$ 1,844,062	$ 1,844,062	$ 1,844,062	$ 1,844,062	$ 1,844,062	$ 1,844,062	$ 1,844,062	$ 1,844,062	$ 1,844,062	$ 1,844,062	$ 1,844,062	$ 1,844,062	$ 1,844,062	$ 1,844,062	$ 1,844,062	$ 1,844,062	$ 1,844,062
Capital Outlay	$ 167,445	$ 291,918	$ 304,700	$ 329,564	$ 342,746	$ 356,456	$ 370,714	$ 385,543	$ 400,964	$ 417,003	$ 433,683	$ 451,030	$ 469,072	$ 487,835	$ 507,348	$ 527,642	$ 548,747	$ 570,697	$ 593,525	$ 617,266	$ 641,957	$ 667,635	$ 694,341
O&M Reserve	$ -	$ -	$ -	$ 365,469	$ 14,619	$ 409,667	$ 37,181	$ 37,824	$ 41,014	$ 43,056	$ 44,905	$ 46,913	$ 49,078	$ 52,147	$ 54,118	$ 54,008	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Other Expenses	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Total Expenditures	$ 1,846,979	$ 1,998,746	$ 2,103,523	$ 2,156,908	$ 3,721,777	$ 5,769,203	$ 5,559,701	$ 5,726,471	$ 5,909,136	$ 6,099,443	$ 6,297,592	$ 6,504,600	$ 6,721,120	$ 6,951,539	$ 7,189,497	$ 7,438,555	$ 7,645,010	$ 7,922,791	$ 8,212,270	$ 8,510,844	$ 8,819,850	$ 9,139,715	$ 9,475,344
Excess (Deficiency) Revenue Over Expenditures	$ (180,235)	$ (75,241)	$ (187,023)	$ 159,120	$ 313,697	$ 515,354	$ 490,954	$ 505,753	$ 521,415	$ 536,081	$ 553,508	$ 571,109	$ 589,003	$ 607,973	$ 631,106	$ 651,696	$ 668,443	$ 693,132	$ 720,248	$ 754,079	$ 787,084	$ 821,134	$ 848,244
Available Resources: December 31	$ (442,132)	$ (517,373)	$ (704,396)	$ (545,276)	$ (231,580)	$ 283,775	$ 774,729	$ 1,280,482	$ 1,801,897	$ 2,337,979	$ 2,891,487	$ 3,462,596	$ 4,051,599	$ 4,659,572	$ 5,290,679	$ 5,942,375	$ 6,610,818	$ 7,303,950	$ 8,024,198	$ 8,778,277	$ 9,565,360	$ 10,386,495	$ 11,234,738

Table 10-1: Opinion of Probable Project Capital Cost

Richard P. Arber Associates, Inc.
Consulting Engineering and Project Management

OPINION OF PROBABLE CONSTRUCTION COST

Client: **City of Sterling**	
Project: **City of Sterling Water Treatment Plant**	
Item: **Preliminary Design - Preliminary Engineering Report Summary**	

Project No: STERLNG02	
By: DRW	Chk By: RJD
Date: 5-21-09	Date: 5-29-09

*All costs are year 2009, unless noted otherwise

DESCRIPTION	COST
Site Civil	**$400,000**
Process Building	**$11,430,000**
Chemical Building	**$1,050,000**
Offsite Pipelines	**$1,680,000**
Deep Wells	**$2,400,000**
General Conditions, Bonds, Insurance (9%)	**$1,530,000**
Subtotal (2009)	**$18,490,000**
Unidentified Items (20%)	**$3,700,000**
Construction Total (2009)	**$22,190,000**
Engineering, Legal, and Administrative (20%)	**$4,440,000**
PROJECT TOTAL (2009)	**$26,630,000**
INCREASED TO YEAR 2010 (3%)	**$27,430,000**

Based upon the American Association of Cost Engineers (AACE), Estimate Level = Budget Estimate
It is normally expected that an estimate of this type would be accurate within +30% to –15%.

Table 10-2: Opinion of Probable O&M Costs 2012 Annual Average Demand (Constant Flow At 3.7 mgd)

Description	Annual O&M Cost
Plant Operator Costs[1,2]	$249,600
Plant Equipment and Maintenance Cost	
Plant Equipment and Maintenance[3]	$110,950
Membrane Replacement Cost[4]	$194,040
Pretreatment Cartridge Filter Replacement Cost[5]	$29,700
CIP Cartridge Filter Replacement Cost[6]	$2,472
Well Maintenance[7]	$20,000
Plant Chemical Feeds	
Scale inhibitor & dispersant cost (liquid)	$430,871
Sodium Hypochlorite (liquid)	$85,971
Caustic	$60,448
Membrane Cleaning Costs	
Citric Acid	$2,800
Caustic	$2,200
Power Costs	
NF & Feed Pumping[8]	$180,291
Second Pass NF Pumping[9]	$18,590
Finished Water Pumping[10]	$101,286
MF Blend Stream Treatment System[11]	$9,282
Misc. Electrical[12]	$15,472
Total=	**$1,510,000**
Cost per 1,000 gals=	**$1.13**

Notes:

1 Assumes three full time operators at 2,080 hrs per year, $40/HR
2 Some operation/maintenance time may be by current employees
3 Estimated to be 0.5% of Plant Construction Cost
4 Estimated 5 yr membrane life for first pass, 3 yr membrane life for second pass
378 membranes per skid. 4 skids. $550 per membrane
5 Estimated that cartridges replaced three times per year. 275 per filter. $12 ea
6 Estimated that cartridges replaced once a year. 103 per filter. $12 ea
7 Estimated at $100,000 every 5 years
8 Estimated 250 ft through skid and 100 ft from well, 75% efficiency,
Head through skid based on NF model results + 20%
9 Estimated 90 ft through second pass (pressure boost from first pass). 75% efficiency
10 Estimated 180 ft pumping head, 75% efficiency, Based on hydraulic modeling results +20%
11 Estimated 60 ft TDH, 75% efficiency
12 Estimated to be 5.0% of total of other electrical costs
13 All costs in 2009 dollars. Cost of electricity $0.10/kW-hr

Table 10-3: Opinion of Probable O&M Costs 2022 Annual Average Demand (Constant Flow at 4.2 mgd)

Description	Annual O&M Cost
Plant Operator Costs[1,2]	$249,600
Plant Equipment and Maintenance Cost	
Plant Equipment and Maintenance[3]	$110,950
Membrane Replacement Cost[4]	$194,040
Pretreatment Cartridge Filter Replacement Cost[5]	$29,700
CIP Cartridge Filter Replacement Cost[6]	$2,472
Well Maintenance[7]	$20,000
Plant Chemical Feeds	
Scale inhibitor & dispersant cost (liquid)	$478,873
Sodium Hypochlorite (liquid)	$98,421
Caustic	$69,201
Membrane Cleaning Costs	
Citric Acid	$2,800
Caustic	$2,200
Power Costs	
NF & Feed Pumping[8]	$206,398
Second Pass NF Pumping[9]	$21,282
Finished Water Pumping[10]	$115,953
MF Blend Stream Treatment System[11]	$10,626
Misc. Electrical[12]	$17,713
Total=	**$1,630,000**
Cost per 1,000 gals=	**$1.07**

Notes:

1 Assumes three full time operators at 2,080 hrs per year, $40/HR
2 Some operation/maintenance time may be by current employees
3 Estimated to be 0.5% of Plant Construction Cost
4 Estimated 5 yr membrane life for first pass, 3 yr membrane life for second pass
378 membranes per skid. 4 skids. $550 per membrane
5 Estimated that cartridges replaced three times per year. 275 per filter. $12 ea
6 Estimated that cartridges replaced once a year. 103 per filter. $12 ea
7 Estimated at $100,000 every 5 years
8 Estimated 250 ft through skid and 100 ft from well, 75% efficiency,
Head through skid based on NF model results + 20%
9 Estimated 90 ft through second pass (pressure boost from first pass). 75% efficiency
10 Estimated 180 ft pumping head, 75% efficiency, Based on hydraulic modeling results +20%
11 Estimated 60 ft TDH, 75% efficiency
12 Estimated to be 5.0% of total of other electrical costs
13 All costs in 2009 dollars. Cost of electricity $0.10/kW-hr

CHAPTER 11
PROJECT IMPLEMENTATION

11.1 PROJECT SCHEDULE

The City of Sterling has specific deadlines that must be met as a condition of the Enforcement Order (DC-080902-1). Table 11-1 outlines the timeline of the WTP project as outlined in the Enforcement Order. A copy of the Enforcement Order is found in Appendix A.

Table 11-1: Project Deadlines

Item	Date	Comment
Receipt of enforcement order	September 2, 2008	
Retain a professional engineer	September 30, 2008	Completed
Complete evaluation and submit to CDPHE a written report on well operation plan to reduce levels of uranium	November 1, 2008	Completed
Complete evaluation and submit a written report to CDPHE on measures to ensure best water quality with respect to TTHMs	December 16, 2008	Completed
Develop and submit to CDPHE an Outreach and Communication Strategy	March 1, 2009	Completed
Submit Preliminary Engineering Report (PER) to CDPHE	July 1, 2009	
Submit Final Design Report to CDPHE	November 1, 2009	
Submit Final Design Plans and Specifications to CDPHE	May 1, 2010	
Complete Construction/Implementation of Improvements	December 31, 2011	
Submit engineer's certification to CDPHE to show system improvement/constructed/installed to comply with uranium and TTHM	February 15, 2012	

As one of the requirements for approval of this PER, a Technical, Managerial, and Financial (TMF) Capacity Evaluation has been completed. As noted, and Enforcement Order has been issued for this drinking water system. Therefore, the system is not in compliance with Federal and State water quality regulations. The TMF Capacity Evaluation Worksheets are included in Appendix E.

11.2 PUBLIC INVOLVEMENT

The citizens of Sterling will have an opportunity to participate in a public comment period for this report. The report will be made available to the public and multiple legal notices will be

placed in the Journal Advocate Newspaper advertising the 30-day public review period. Comments will be documented. The comments and responses will be included in Appendix O in the final PER.

In addition to the 30-day public comment period, a vote will be required to approve the bond issue for the DWRF loan money. It is anticipated that the vote will occur in November of 2009.