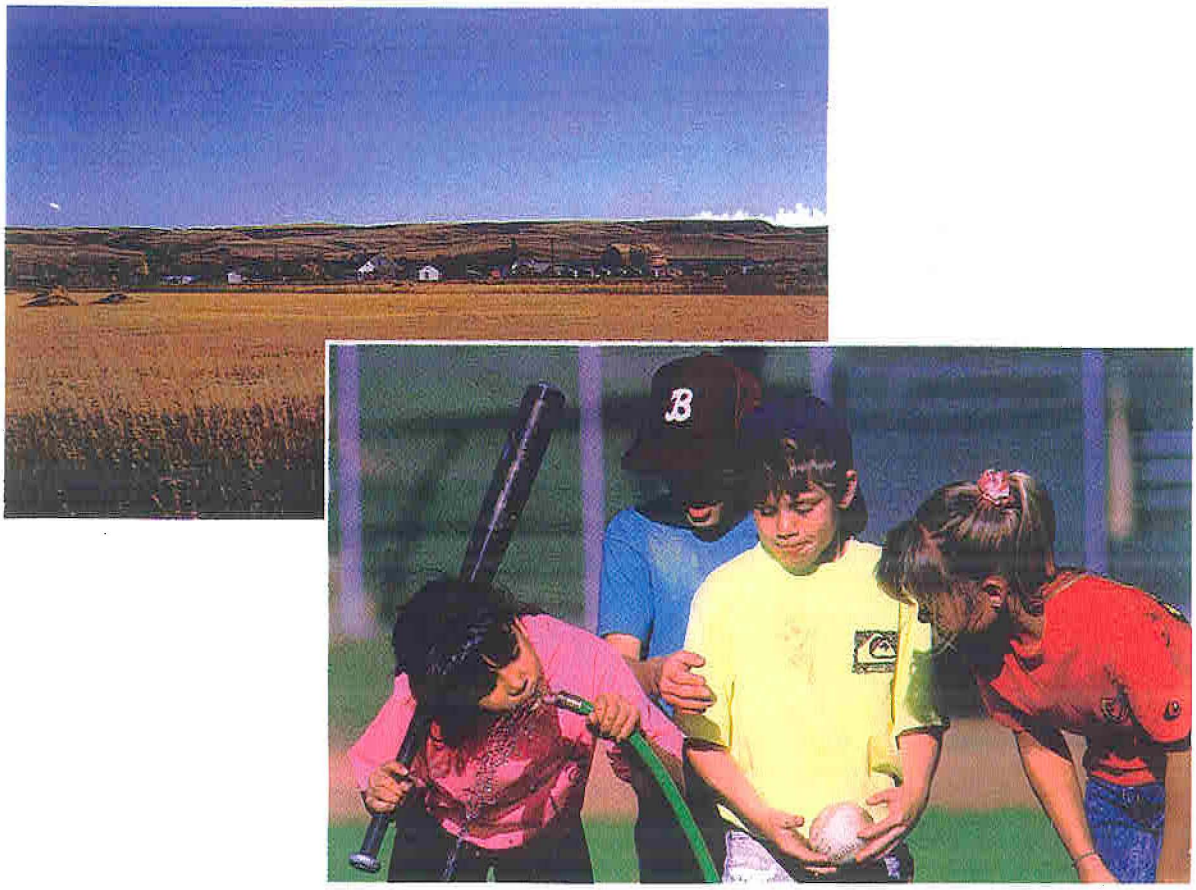

North Dakota State Water Commission and the Garrison Diversion Conservancy District

Northwest Area Water Supply Project Biota Transfer Control Measures

September 1998

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September 16, 1998

Mr. David Sprynczynatyk, State Engineer
North Dakota State Water Commission
State Office Building
900 East Boulevard
Bismarck, North Dakota 58505

Subject: Biota Transfer Control Measures
Northwest Area Water Supply Project
Specific Authorization No. 21

Dear Mr. Sprynczynatyk:

Subsequent to the development of the Northwest Area Water Supply Project Pre-Final Design Final Report (June 1995), the Engineering-Biology Task Group report (May 1994), and the conclusions of the US - Canada Consultative Group, a number of refinements and project design elements have been completed to better define the project. These refinements and design elements have been developed as special studies and continued work associated with the project tasks. Several studies were undertaken to specifically address biota transfer issues and initiate programs to satisfy the conclusions of the US - Canada Consultative Group.

This report consolidates and summarizes all of the reports, results of special studies, the current configuration and criteria of the project, and preliminary design for the pipeline project from the raw water intake to the Minot water treatment plant, that relate to biota transfer control issues. Key elements include pretreatment required to satisfy biota transfer criteria, monitoring programs, pipeline and facility integrity, sludge disposal at the Minot water treatment plant, control, fail-safe systems, and emergency response planning. Several elements of the project have yet to be defined pending the results of monitoring programs currently being undertaken on both Lake Audubon and Lake Sakakawea. However, data and information collected to date will be used to describe options and facility requirements that remain viable for the project.

Design criteria listed for each of the project elements is based on the current project configuration as presented in the Northwest Area Water Supply Project Draft Environmental Assessment (June, 1997), except as refined or modified by design efforts. These conditions are specifically noted in the text that follows.

We appreciate the opportunity to prepare this document to further advance the NAWS project with US - Canada Consultative Group and the Garrison Joint Technical Committee.

Respectfully submitted,

Montgomery Watson

William G. Lynard

William G. Lynard

Houston Engineering, Inc.

Roger C. Hagen

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/ps

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Section 1

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SECTION 1

INTRODUCTION

BACKGROUND

The Northwest Area Water Supply Project (NAWS) Pre-Final Design Report (June 1995), identified three separate systems to supply municipal drinking water to communities in northwestern North Dakota. Only one of the systems, the East System, would transport raw water from the Missouri River Basin into the Hudson Bay Basin. This raised issues and concerns regarding biota transfer.

Following the development of the Pre-Final Design Report, a number of studies, evaluations and consultations were initiated to identify and quantify the specific biota transfer issues, define methods to mitigate the potential impacts, and to develop a consensus regarding project design criteria and facility requirements. Work has continued with the US - Canada Consultative Group (CG), the Garrison Joint Technical Committee (JTC), and the Engineering - Biology Task Group to define an acceptable project configuration. The following sections describe the process and conclusions that refined the project to its current level of design and facilities requirements.

This report consolidates the results of the studies, findings, process recommendations and management plans for biota transfer control into a single document that reflects the current direction of the project prior to final design. A number of modifications to the pre-final design layout and facilities have been made since the initial evaluations made by the Engineering - Biology Task Group Report in May 1994. These changes were made to the project to demonstrate positive biota transfer control, increase reliability and dependability, and meet the needs of the NAWS Project.

ENGINEERING - BIOLOGY TASK GROUP REPORT

The Engineering - Biology Task Group was formed in December 1993 by JTC to carry out the task given it by the CG. The Task Group evaluated the risks posed to Canada by the proposal to transfer untreated water via pipeline from the Missouri River Basin to the Minot Water Treatment Plant (Minot WTP) for final treatment prior to distribution. The basis for the evaluation was the work underway on the NAWS Pre-Final Design Report.

The Engineering - Biology Task Group evaluated several options and associated relative risks of biota transfer that ranged from the transport of untreated water to the Minot WTP to complete treatment at the raw water source in the Missouri River Basin. Each progressive option included additional project components and physical safeguards to reduce the risk of biota transfer.

The options included:

- Option 0: Raw water supply to the Minot WTP,

- Option 1: Chloramination of the raw water supply to control slime growth, with transport to Minot WTP for treatment,

- Option 2: Chloramination of the raw water supply to control slime growth, treatment at the Minot WTP, blow-off containment structures, extra signage, motor operated mainline valves, welded pipe, WTP containment structures, and WTP flood control,

- Option 3: Option 2 plus a rupture containment system,

- Option 4: Phased development, including a 20.5 MGD treatment plant at the source, with 8 MGD at the Minot WTP using existing sources. The treated water would be mixed at the Minot WTP,

- Option 5: Complete treatment at the source in the Missouri River drainage.

The key findings from the Task Group Report which were incorporated into the configuration and layout of the NAWS Project were:

- The Task Group found that all pipeline options had a relatively low risk of transferring biota to the Hudson Bay drainage if they included chloramination disinfection at the source of the pipeline to control slime growth. Implementation of additional safeguards would decrease the relative risk of biota transfer.

- Because of the consequences of pipeline failure, operation, maintenance, and replacement must ensure the integrity of the pipeline for its entire operational life.

  The likelihood of failure of the East System could be reduced through the adoption of the following measures:

  - Identify one agency responsible for operating and maintaining the entire system;

  - All raw water captured in containment structures, which could not meet the 50-day seepage travel time criteria, would be transferred to the Minot WTP for treatment, or would be decontaminated, or would be disposed of in the Missouri River drainage;

  - Minot WTP sludge would be handled in such a manner that incidental or accidental discharge to the Souris River is not possible;

  - All structural components are monitored, maintained and repaired as called for in the original designs;

  - Disinfectant residual is monitored and maintained to the original design standard, and other water quality standards will be monitored.

- If chloramination within the Missouri River drainage proves to be effective in addressing biota transfer concerns, standard engineering practices for construction, maintenance, and replacement could be followed.

The effectiveness of chloramination or other disinfection practices and their relationship to the requirements on the NAWS design project were further described in the Task Group Report as follows:

> "If the raw water were disinfected to drinking water standards in the Missouri River drainage, there would be no concerns regarding leakage, pipeline rupture, or other drainage from the pipeline during routine dewatering. Engineering designs would, therefore, be in accordance with "standard practice" and generally accepted safety factors."

The disinfection requirements were identified as 3-log *Giardia* and 4-log virus inactivation.

US - CANADA CONSULTATIVE GROUP CONCLUSIONS

The US – Canada Consultative Group considered and accepted the findings of the Engineering-Biology Task Group during a joint meeting of the CG and JTC in September 1994. The GC did however, conclude that a study of the effectiveness of the proposed chloramination process be undertaken.

Based on the Engineering-Biology Task Group findings, the NAWS facilities, as presented in the NAWS Pre-Final Design Report, were configured with the assumption that chloramination would be practiced for control of slime in the pipeline and that additional basic features and safeguard options would be employed to provide reduced risk for biota transfer. Studies were also initiated to address the effectiveness of disinfection practices pursuant to the GC conclusions, to determine, if 3-log *Giardia* and 4-log inactivation could be met through disinfection alone and thereby allow the project to follow standard engineering and design practices.

CHLORAMINE CHALLENGE STUDY

A challenge study was conducted to document, through standard experimental protocol, the effectiveness of disinfection technologies to achieve disinfection requirements identified under Conclusion 6i of the CG. The study results indicated that both chlorine followed by ammonia addition to form chloramines and ozonation would achieve the disinfection requirements of 3-log *Giardia* and 4-log virus inactivation.

Based on the results of the Chloramine Challenge Study - Final Report (December 1995), the Canadian section of the JTC expressed a preference for ozone pretreatment due to its greater effectiveness in inactivating water-born fish pathogens and encouraged the State of North Dakota to consider ozonation as the pretreatment disinfection process. Partly because of this preference, ozone was used to develop the project configuration. However, chlorine/chloramine disinfection also meets biota transfer inactivation requirements and may be used pending additional water quality evaluations. Ozone is a considerably more powerful disinfectant than

chlorine/chloramines and it has been demonstrated that the disinfection requirements for the project can be readily exceeded through the use of ozone. Thus, an additional safety factor for biota reduction is achieved. Design criteria and details of the ozone pretreatment disinfection system are contained within this report.

Based on the demonstrated effectiveness of the proposed pretreatment system, it was concluded that standard engineering practices for design and construction, maintenance and replacement of the NAWS system could be followed. This is the approach developed as part of the project facilities refinement procedures and a description of the design approach is presented in this report.

SCOPE OF BIOTA TRANSFER FACILITIES REPORT

The purpose of this report is to consolidate the project technical reports and their findings, the proposed approach for the monitoring program, and the design, construction, and operation of the NAWS Project, to date, relative to requirements for control of biota transfer. The NAWS Project facilities and alternatives have undergone additional study and refinement since the NAWS Pre-Final Design Report. This included system reconfiguration based on contract user signees. Additional alternatives have been investigated through the Environmental Assessment process and through special studies which were conducted to address specific water quality issues. In addition, the NAWS Project team has conducted site evaluations and design criteria meetings on the Minot WTP, the pretreatment system, and the pipeline system facilities to establish final design criteria, address design issues, assess project constructability, and identify areas for further investigation.

Based on studies, engineering investigations, and the analysis discussed above, the descriptions of the proposed NAWS Project facilities and management plans are presented in the following sections. This report is subdivided into sections that address the specific requirements of the CG and the JTC. These include:

- Major NAWS Facilities and Criteria,
- Monitoring Programs,
- System Operation and Control,
- Operations, Maintenance, and Replacement Plans.

NAWS CRITERIA AND FLOWS

The NAWS East System has been reconfigured to provide service to users who have signed contracts to receive NAWS water. The reconfigured system is shown in Figure 1-1. The future system capacity, however, includes both contract users capacity and non-contract users who are adjacent to the pipeline routes. The pipeline facilities are sized to handle the future system capacity.

Until future capacity demands are realized, the system will operate at lower levels. Mechanical equipment such as pumps and capacity upgrade requirements of the Minot WTP will be initially sized to satisfy the interim Phase I design flow rates. As various phases of the project are

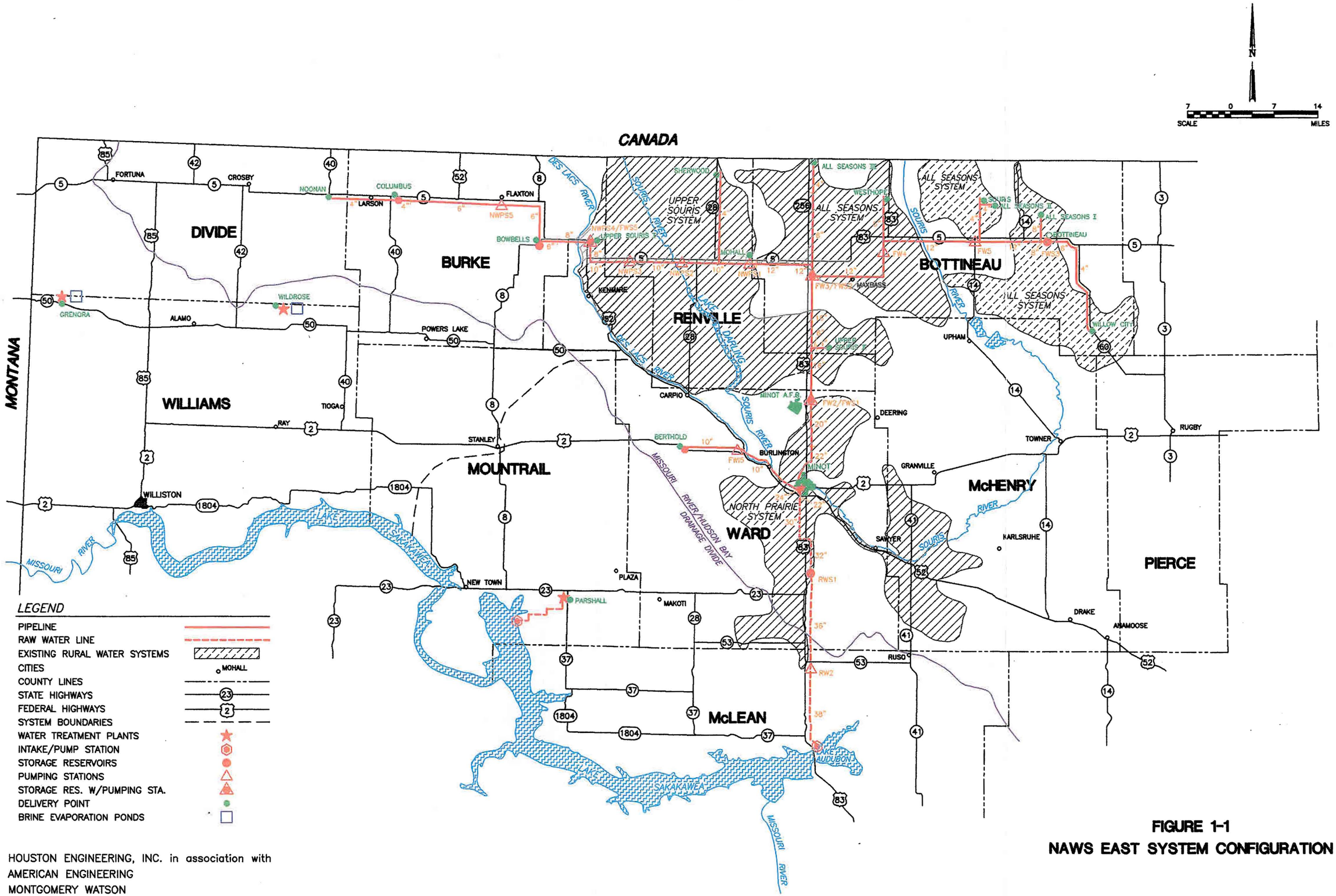

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FIGURE 1-1
NAWS EAST SYSTEM CONFIGURATION

required and funded, incremental capacity will be added at the pump stations and at the Minot WTP. A description of the phased design flow rates is presented in Table 1-1.

TABLE 1-1

NAWS DESIGN FLOW RATES

Flow Criteria	Total System Capacity (mgd)*	Phase I Capacity (mgd)	Current Minot Demand (mgd)
Maximum Day	26.0	18.0	14.2
Average Day	10.4	7.4	5.8
Minimum Day	5.2	3.8	3.0

* Includes both contract and non-contract demands. Maximum day demand for contract only users is 22.9 mgd.

ABBREVIATIONS

In order to conserve space and improve readability, the following abbreviations have been used throughout this report:

ASME	American Society of Mechanical Engineers
CG	US - Canada Consultative Group
DBP	disinfection by-product
DIP	ductile iron pipe
EPA	United States Environmental Protection Agency
ESWTR	Enhanced Surface Water Treatment Rule
fps	feet per second
GOX	gaseous oxygen
HPC	heterotrophic plate count
JTC	Garrison Joint Technical Committee
LOX	liquid oxygen
MCL	maximum containment level
mgd	million gallons per day
Minot WTP	Minot Water Treatment Plant
NAWS	Northwest Area Water Supply
NDDH	North Dakota Department of Health
NDSWC	North Dakota State Water Commission
NTU	Nephelometric Turbidity Unit
PIT	pressure indicating transmitter
PLC	programmable logic controller
PRV	pressure reducing valve
RTU	remote telemetry unit
SCADA	Supervisory Control and Data Acquisition
scfh	standard cubic feet per hour
SDWA	Safe Drinking Water Act
SWTR	Surface Water Treatment Rule
TDS	total dissolved solids
TOC	total organic carbon
UPS	un-interruptible power supply
USGS	United States Geological Survey
VFD	variable frequency drives

Section 2

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SECTION 2

MAJOR NAWS FACILITIES AND CRITERIA

INTRODUCTION

This section describes the current design status and design criteria developed for the following major facilities of the NAWS System from the intake to the Minot WTP:

- Raw water intake and pump station
- Ozone disinfection pretreatment facility
- Booster pump station
- Pretreated water storage facility
- Pressure reducing valve station
- Minot WTP
- Pipeline facilities

The relative locations and elevations of the above facilities are shown in Figure 2-1. A major emphasis has been placed on developing the conceptual design of the ozone disinfection pretreatment facility, as this is one of the major mechanisms for limiting biota transfer from the Missouri River drainage basin to the Hudson Bay drainage basin.

RAW WATER INTAKE AND PUMP STATION

The raw water intake and pump station will consist of three basic components: the intake structure, screening facilities, and pumping facilities. The design and arrangement of these components depend on site specific soil, topographical, climatic, limnological, and water quality conditions. Lake Audubon and Lake Sakakawea intake locations are being considered for the NAWS supply source as indicated of Figure 2-2.

The intake must be located in an easily accessible location and designed to supply a specified quantity of the best available quality of water. The intake system design will consider reliability, operation, and maintenance costs. Site selection for the raw water intake system will be based on the following considerations:

- The stratification characteristics of the water source due to seasonal changes in water temperature

- The quality of the raw water source including algal growth characteristics, turbidity, etc.

- Shore conditions, wind direction, and velocity

- The conditions of the catchment area, including potential sources of pollution

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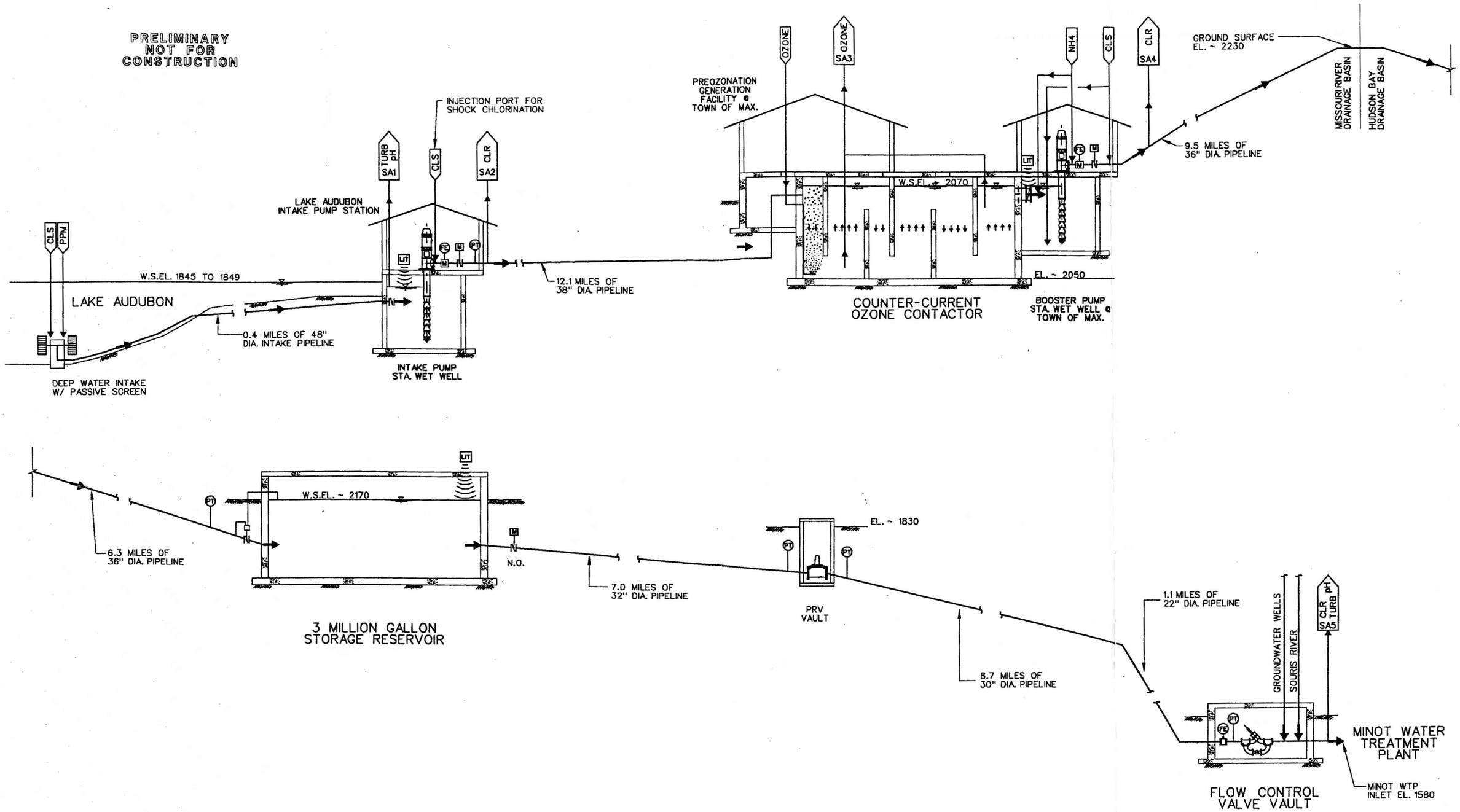

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Boise, Idaho

APPROVED — DATE
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NORTH DAKOTA STATE WATER COMMISSION
NORTHWEST AREA WATER SUPPLY PROJECT
WATER SUPPLY AND PRETREATMENT
PROCESS FLOW SCHEMATIC (9/97)

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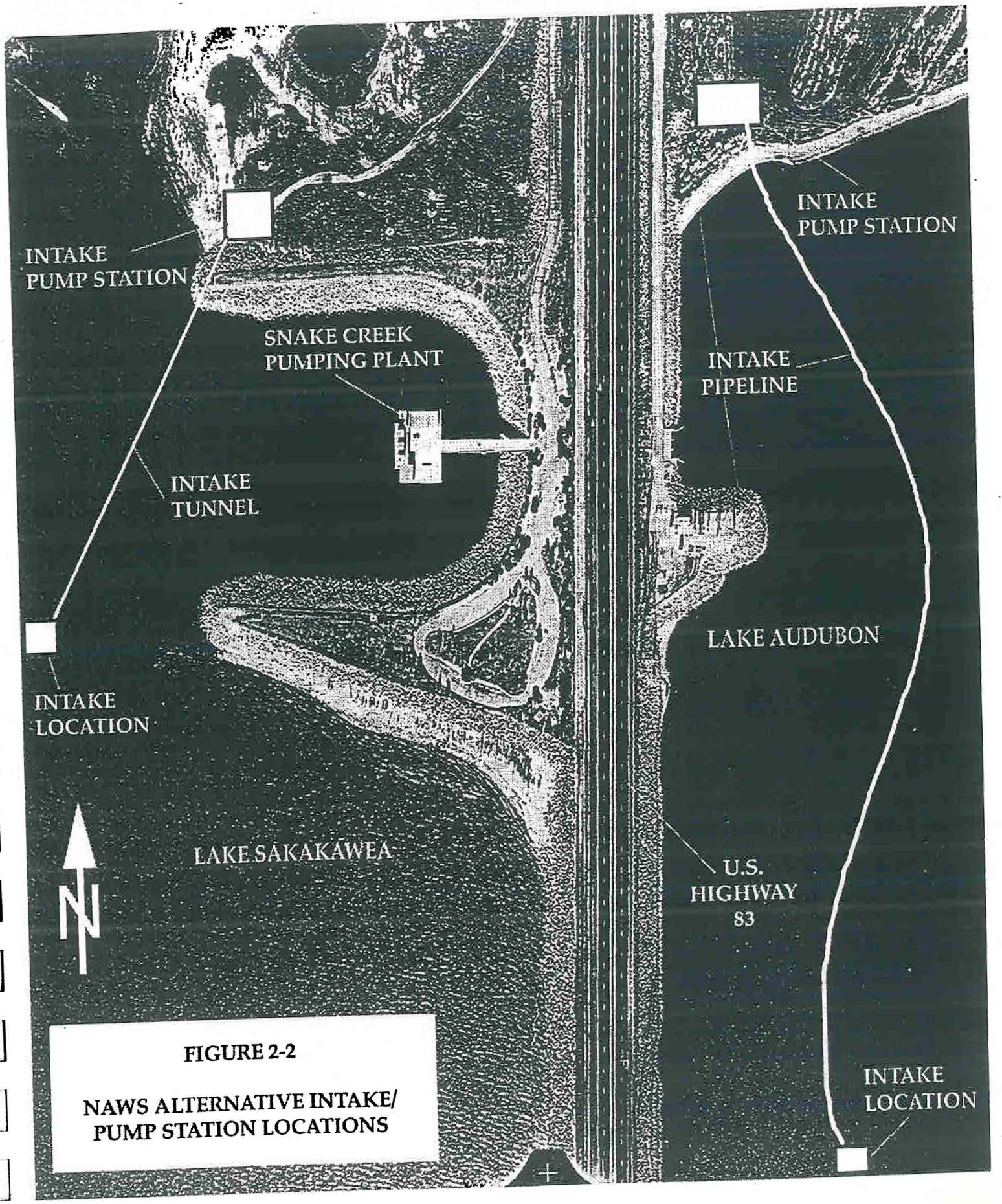


FIGURE 2-2

NAWS ALTERNATIVE INTAKE/ PUMP STATION LOCATIONS

- The siltation conditions in the reservoir
- The ultimate purpose of the lake and the impact of joint users
- The potential impacts upon or interferences with the Snake Creek Pumping Plant
- The historical and expected future water level fluctuations

Background Information

The NAWS intake/pump station will ultimately supply the maximum daily demand of 26 mgd to the Minot WTP for treatment and distribution. The raw water intake and pump station alternatives investigated in the 1995 Pre-Final Design Report focused on a shallow water intake alternative for Lake Audubon. Since the Pre-Final Design, deep water intake alternatives in both Lake Audubon and Lake Sakakawea have been investigated because of suspected warm water temperatures during the summer, higher algal concentrations in the surface zone, and the greater potential for fish fry in shallow water.

The re-evaluation of alternative intakes for the source of supply was conducted as a part of the NAWS Environmental Assessment. The investigations have resulted in the identification of intake locations and configurations in both lakes that may be feasible. However, because of the potential for large lake level fluctuations in Lake Sakakawea the configuration of an intake in this source will be more expensive than a source in Lake Audubon. Pump operation, sizing, and control for a Lake Sakakawea intake will be more difficult.

Both the Lake Audubon deep water intake and the Lake Sakakawea intake options are being considered for implementation. The long-term monitoring program will provide data to evaluate each option. The sampling effort will quantify the water quality issues concerning both sources.

Water Quality Issues

Both Lake Audubon and Lake Sakakawea are considered treatable sources for the Minot WTP, but it is recognized that Lake Audubon has a lower quality water. Either source will provide water which can be treated at the Minot WTP to meet the drinking water standards of the EPA. Lake Audubon is operated as an off-stream reservoir with Lake Sakakawea as its source. Lake Audubon water levels are maintained within an approximate four-foot storage elevation by the Snake Creek Pumping Plant. These stable water elevations have favored selection of Lake Audubon as an intake location. Lake Audubon has a limited flushing capacity and is also shallower and has higher algal concentrations than Lake Sakakawea. The long-term water quality of Lake Audubon has been raised as a concern by the North Dakota Department of Health.

Therefore, the factors for considering Lake Sakakawea as a water source are:

- Potentially lower turbidity
- Potentially lower algal concentrations
- Deeper water source for temperature stability

- Slightly lower TDS, sodium, sulfates, and hardness

Water quality information recently gathered from the Dickinson and the Garrison Water Treatment Plants indicates that Lake Sakakawea has low susceptibility to algae, turbidity, and potential taste and odor problems. The monitoring program underway at the NAWS intake sites will characterize the water quality conditions in both lakes.

Alternative Intake Configurations

The deep water Lake Audubon intake will have an intake pipeline along the lake bottom, approximately 2,500 feet long, accessing water between 40 to 50 feet deep. The Lake Sakakawea intake will access the deep-water forebay channel of the Snake Creek Pumping Plant through a 100-foot deep caisson and tunnel beneath the lake bottom. A description of the location and configuration of each is presented below.

NAWS Intake Structure on Lake Audubon. Siting of the NAWS intake on Lake Audubon involved an analysis of a number of issues including:

- Relative location of the intake to deep water in Lake Audubon
- Topography of the bank and lake bottom
- Access
- Location relative to power supply
- Raw water pipeline route and constructability

The current recommended siting of the intake pump station structure is on the north shoreline of Lake Audubon, about 150 feet east of the access road which parallels Highway 83. The intake pipeline would be constructed from the shore-based facility to the intake location.

The intake pump station facility would include:

- A concrete intake structure situated near the deepest point in the lake
- Horizontal passive screens located approximately five feet above the lake bottom with 1/4-inch openings
- Approximately 2,500 feet of 48-inch diameter intake pipeline routed along the lake bottom to the north shore pump station
- A 20-foot deep concrete wetwell structure situated on northwest shoreline of the lake
- Vertical turbine pumps installed for a Phase I maximum day capacity of 18 mgd (with space for an additional future 8 mgd capacity)

Mechanical screens may be used at the pump station facility. If mechanical screens are used, a trash rack grating would replace the horizontal passive screen at the intake structure.

Lake Sakakawea Intake and Pump Station Alternative. The Lake Sakakawea intake would draw water from elevation 1780 or lower. The proposed intake site is located to the north of the northern embankment surrounding the Snake Creek Pumping Plant. The proposed intake includes construction of a 25-foot diameter caisson wet well approximately 100 feet deep to reach an invert elevation of 1760/msl. From the bottom of the caisson, a 48-inch diameter intake pipeline/tunnel, approximately 700 feet in length, would be constructed to reach the Snake Creek Pump Station dredged inlet channel. A passive screen structure with ¼ inch openings would be constructed at the deep-water intake site to screen out debris.

Alternative Evaluation. The selection of either the Lake Audubon or the Lake Sakakawea intake alternative will be based on the raw water quality data, further development of construction cost, and implications on pretreatment and water treatment plant operation costs.

Pump Control Strategy

Intake pump operation will be controlled by the wet well level at the booster pump station near the town of Max. Establishing pump sizes will involve balancing equipment at both pump stations. The wet well at the booster pump station and the pretreatment storage reservoir volumes will be used as operational storage to buffer pumping rates and demand at the Minot WTP.

The intake pump control strategy will utilize a programmable logic controller (PLC) at the pump station. The PLC will communicate with the central control facility and PLCs at other NAWS facilities, through the Supervisory Control and Data Acquisition (SCADA) system. Under normal operation, the PLC will control pump operation to maintain wet well levels at the booster pump station within an operational band. The SCADA system will monitor and report system status, lake levels, flow rate, pressure, alarms, and water quality characteristics. Intake pump control on the Lake Sakakawea alternative will include operational settings to account for potential variations in suction head due to lake level fluctuations.

The PLC will be programmed to shut down pumping operations in emergency situations, as described in Section 4, and will alarm the operators through the SCADA system.

Screening and Surge Control

Screening. Screening operations will be controlled through a PLC that will monitor either lake level and wet well level in the case of a passive screen or water level upstream and downstream of mechanical screens. This instrumentation will be used to monitor screen conditions and signal the need for cleaning or maintenance operation. Annual underwater inspection of the intake/screens will be performed. If cleaning is required, it will be performed during the inspection, under normal operating conditions. If the PLC senses a problem with the screening system, underwater inspection and cleaning would be performed as needed.

The screen mesh or slot size will be 1/4-inch to prevent fish fry from entering the pipeline. The screen area will be based on maximum approach velocity of 0.5 fps at maximum day flow plus a safety factor to account for screen fouling.

Surge Control. A surge control tank will be connected to the pump discharge header at the intake pump station. Size and configuration will be based on final pipeline hydraulic characteristics under power failure conditions. Combination air/vacuum valves will be placed at critical locations on the pipeline between the intake pump station and the pretreatment facility near the town of Max to control negative pressure.

Chemical Feed Systems

Provisions will be incorporated at the intake facility for periodic (once or twice per year) shock chlorination injection into the pipeline. Shock chlorination will be used to disinfect and clean the raw water pipeline. No permanent residual disinfection system will be incorporated at the intake pump station. Residual disinfection chemicals could react with ozone. During shock chlorination, the ozone facilities would not be operated. Ozone will be applied at the booster pump station near the town of Max. Additional chemical feed capability will be incorporated into the intake facility for potential chemical addition to the intake structure in the lake to control aquatic biota such as snails and mussels.

Pipeline Cleaning Facilities

Provisions will be incorporated into the pump discharge header for a pipeline cleaning system (pipeline pigging). The pig launching structure will be located downstream of any valve or control equipment at the intake pump station.

Operations Criteria

The physical conditions that will affect the operation of the intake/pump station alternatives include reservoir operating levels and cold weather operation.

Lake Audubon Water Levels and Intake Design Criteria. Since 1975 when Lake Audubon's water surface was raised from an average elevation of 1834 msl to elevation 1847 msl, the lake level has fluctuated seasonally over a small range. Recent annual water surface fluctuations are about four feet. The following seasonal and normal operational water surface ranges were reported:

Season	Water Surface Elevation Ranges, msl
Summer	1846.0 to 1847.0
Winter	1843.0 to 1844.0
Normal	1845.0 to 1847.2

The Lake Audubon pool elevations are controlled by the U.S. Bureau of Reclamation using the Snake Creek Pumping Plant. During the spring, Lake Audubon is filled to the spring target water surface elevations. The maximum pool level for Lake Audubon is 1850 msl.

The May 22, 1996 "Letter of Understanding" between the U.S. Bureau of Reclamation, the U.S. Fish and Wildlife Service, the North Dakota Game and Fish Department, and the U.S. Corps of Engineers identified operating procedures for water level management in Lake Audubon. Annual water levels would range from a winter low water surface elevation of 1844.50 msl to a normal summer high water surface elevation of 1847 msl. Under emergency maintenance conditions it is possible to draw water down to elevation 1835 msl or below.

Given the above operating conditions, the design lake level for the Lake Audubon intake facility was established over the range from elevation 1843 msl to elevation 1848.5 msl.

Lake Sakakawea Water Levels and Intake Design Criteria. The Lake Sakakawea intake alternative would have to accommodate a wider range of lake level fluctuations. The normal lake level fluctuation is about 25 feet ranging from elevation 1825 msl to 1850 msl. However, during drought conditions, the lake elevation could drop substantially below the average operating pool to a minimum pool elevation of 1775 msl. In order to provide reliability of this primary raw water supply, the intake pump station on Lake Sakakawea would have to be able to draw water from a pool elevation of approximately 1775 msl.

Cold Weather Operations. Cold weather conditions will be incorporated into the design of the intake pump station and the intake piping for protection of equipment. The potential for frazil ice formation will be evaluated at the screening facilities. Under both intake alternatives, the deep-water withdrawal is expected to limit concerns for exposed equipment to frazil ice and interference from sheet ice. All mechanical equipment will be housed in buildings with no direct exposure to the elements.

Frazil ice formation may be an issue if water temperatures at the intake structure approach 0°C. Winter monitoring at the intake site will provide data to determine if special measures are needed at the intake pump station to control frazil ice formation.

The intake pipeline and the intake structure will be designed to limit exposure from sheet ice damage. The intake pipe will be buried beneath the lake bottom in the near shore area and the intake structure will be located on high ground near the north shore area.

PRETREATMENT FACILITIES

Based upon the results of the Chloramine Challenge Study - Final Report (December 1995) and the preference of the Canadian section of the JTC for ozone as the NAWS pretreatment disinfectant, the North Dakota State Water Commission (NDSWC) selected ozone as the pretreatment disinfection method to be carried forward in the design process. However, chlorine/chloramine disinfection also meets biota transfer inactivation and may be used pending additional water quality evaluations. Ozone is a more powerful disinfectant than chlorine and chloramines. The Challenge Study results demonstrated that the disinfection requirements for the raw water supply can be exceeded through the use of ozone. Design criteria and details of the ozone pretreatment disinfection system as well as the pipeline residual disinfection system are described below.

Chloramine Challenge Study Results

The 1995 Chloramine Challenge Study evaluated the use of chloramines and ozone to meet disinfection requirements in both Lake Audubon and Lake Sakakawea water. The study demonstrated that either free chlorine followed by chloramine or ozone could achieve the 3-log (99.9 percent) *Giardia* inactivation and 4-log (99.99 percent) virus inactivation requirements. The results of the Challenge Study relative to the use of ozone to meet the disinfection requirements were:

- For Lake Audubon, seasonal changes in raw water turbidity (up to 6.4 NTUs) did not appear to impact the inactivation of either the virus or the protozoa.

- Ozone could be employed for disinfection of Lake Audubon water. Greater than 3-logs of *Giardia* inactivation were achieved, in all study conditions, in approximately four minutes at ozone residuals of 0.3 mg/l ozone at 4°C.

- Ozone demand and decay evaluations were conducted on raw waters from both Lake Audubon and Lake Sakakawea. Ozone demands at 20°C ranged from about 2.5 to 3.1 mg/l for Lake Audubon and were slightly lower at about 2.3 to 2.7 mg/l for Lake Sakakawea. Dissolved ozone decay (the half life of ozone) in cold water (4°C) ranged from about 3.5 to 4.5 minutes for both lakes, while the half life of ozone in warm water (20°C) ranged from about 1.7 to 2.0 minutes for both lakes.

Figure 2-3 shows the inactivation of *Giardia* in Lake Audubon water at various ozone residual concentrations.

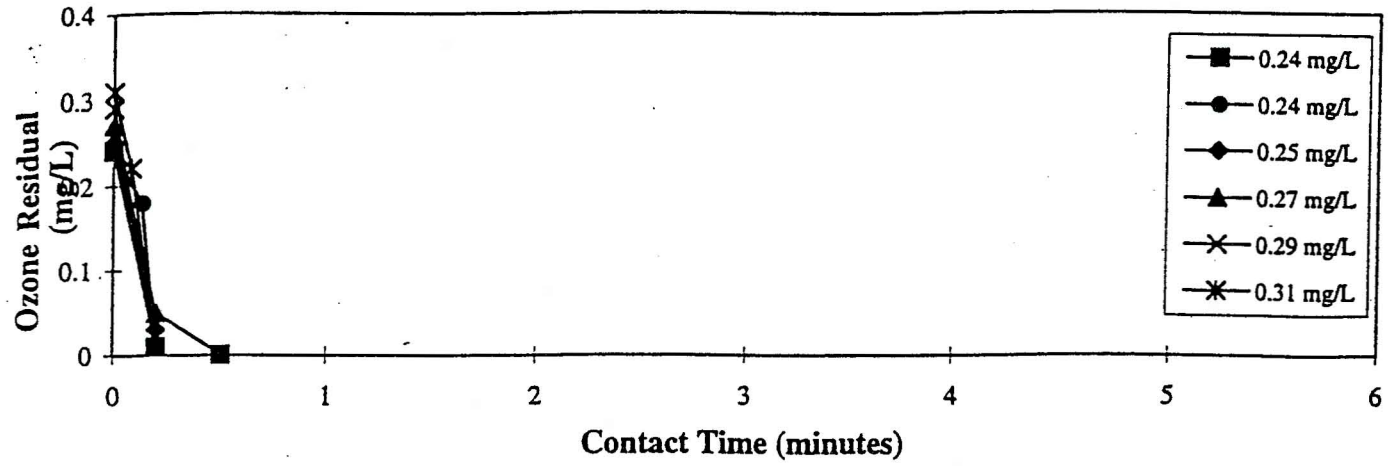
Full-Scale Ozone System Design Criteria

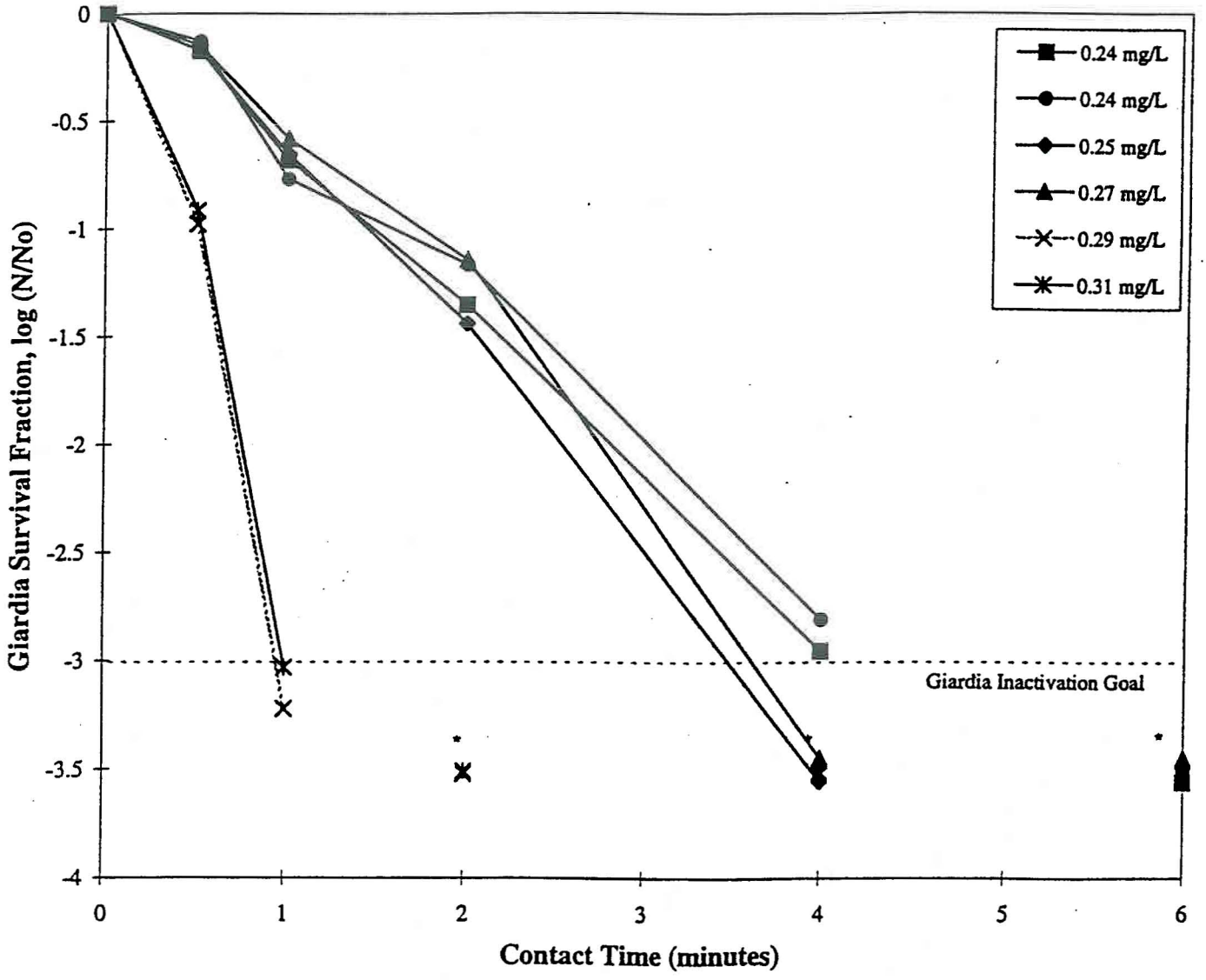
The design criteria for the full-scale facilities used a 33-percent safety factor applied to the ozone residual results in the Challenge Study. The design criteria for the full-scale ozone pretreatment facility are as follows:

- Design is based on the maximum ozone demand numbers determined for Lake Audubon (2.5 to 3.1 mg/l). These values are slightly larger than the maximum ozone demand for Lake Sakakawea.

- The challenge study utilized a batch reactor while a conventional flow-through reactor will be designed for the full-scale system. An "achieved residual" greater than or equal to 0.3 mg/l, as stated in the challenge study, is defined to mean that, at full scale, sufficient ozone must be added to achieve a target <u>dissolved ozone residual</u> in the water of 0.3 mg/l at the outlet of the first stage gas mix chamber. The 0.3 mg/l target ozone residual was subsequently increased by 33-percent to 0.4 mg/l for final design criteria.

- An ozone demand and decay analysis was used to determine the applied ozone dosage through a conventional counter-current contactor to achieve the 0.4 mg/l





* Indicates values less than sensitivity of the experimental assay.

Figure 2-3- Inactivation of *Giardia* in Lake Audubon Water by various ozone concentrations at pH 8.2 and 4°C
August 21, 1995

ozone residual after the first stage mix chamber. A dosage of 3.3 mg/l is required to achieve a 0.4 mg/l residual under worst case summer time conditions when ozone demand is at its highest.

- The mix chambers of the ozone contactors will be designed with a hydraulic detention time of approximately one minute.

- The total hydraulic detention time (T) of the ozone contactor was increased from four minutes to six minutes at maximum flow rates. This provides more contact time for disinfection to occur as well as additional capacity for any increased disinfection regulations in the future. The hydraulic contactor will be designed to achieve a minimum T_{10}/T ratio of 0.60. (T_{10} is defined as the amount of time required for 10-percent of an initial plug flow of water to travel through an ozone contactor.)

Table 2-1 summarizes the design criteria for the full-scale pretreatment ozone disinfection system.

LOX Tank. A 9,000-gallon liquid oxygen (LOX) tank will provide approximately 55 days of continuous, 99.9 percent purity, oxygen gas service to the ozone generation system assuming an average flow of 7.4 mgd. The LOX tank will be a medium pressure (ASME code 250 psig) horizontal vessel designed for outdoor installation, with concrete or masonry walls to protect the tank.

Vaporizers. Two, 5,000 standard cubic feet per hour (scfh) all-aluminum ambient gas vaporizers will be installed with the LOX system. One vaporizer will be operational at any given time with the other vaporizer serving as a stand-by unit. The ambient vaporizers have no moving parts and provide a large surface area for heat transfer to occur from the ambient air temperature to the liquid oxygen. Because LOX must be stored at temperatures below -275°F to keep the oxygen in a liquid form, even exposure to snow and ice, and outdoor ambient temperatures of -40°F provide sufficient heat to vaporize the LOX into gaseous oxygen (GOX).

Control and Monitoring Systems. LOX tank systems are extremely reliable because of the lack of any mechanical or moving parts. Refilling of the tank would normally occur when the volume of LOX in the tank falls to the 3,000-gallon level. This level represents a sufficient volume to provide continual service for 20 days of operation at the average day conditions.

Because of the importance of the ozone disinfection system in the prevention of biota transfer in the NAWS Project, an automated liquid level transmitter system would be included in the NAWS SCADA system. This would provide remote, continuous monitoring of the LOX tank level.

TABLE 2-1

PRETREATMENT OZONE DISINFECTION FACILITY DESIGN CRITERIA

Description	Units	Criteria
Pretreatment Ozone Disinfection System Capacities		
Installed capacity of ozone generators:	mgd	18
Additional capacity of ozone generators for future installation:	mgd	8
Installed capacity of ozone contactors:	mgd	26
Installed capacity of Liquid Oxygen (LOX) feed system:	mgd	18
LOX Storage Facility		
Type: (vertical tank, medium pressure with economizer recovery system)	-	-
Tank volume:	gal.	9,000
Average Gaseous Oxygen (GOX) usage at 7.4 mgd, :	scf/day	18,500
	gal. LOX/day	162
Time required to consume 9,000 gal. LOX (at average conditions):	days	55
Max. allowable venting rate (when not in use):	% vol./day	0.5
No. of ambient vaporizers (one duty & one standby):	no.	2
Flow capacity of each vaporizer:	scfh	5,000
Ozone Generation Facility		
Type: (horizontal tube, oxygen feed gas)	-	-
Frequency: (up to 1,000 hertz)	-	medium
Maximum required ozone dosage	ppm	3.3
Ozone generator gas concentration.:	% by weight	10
No. of installed ozone generators (1-duty & 1-standby):	no.	2
No. of future ozone generators:	no.	1
Ozone generator capacity:	lbs/d	540
Ozone Contactors		
Type (Conventional Counter-current, Concrete)	-	-
Number of ozone contactors	no	3
Chambers per ozone contactor	no	6
Maximum flow per contactor	mgd	9
Minimum flow per contactor	mgd	3.5
T_{10}/T	ratio	0.60
T_{10} detention time @ maximum flow	min.	6.0
Ozone residual design target after first mix chamber	mg/l	0.4
Water depth (D)	ft	20
Length of non-mixing chambers (L)	ft	8
Length of gas-mixing chambers	ft	3.5 to 4.0
Width of all chambers (W)	ft	10
Ozone Gas Diffusers		
Type (ceramic, cylindrical, w/ 316L ss conn.)	-	-
Floor area of first gas mixing chamber	sq. ft.	35 to 40
No. of diffusers per gas mixing chamber	no.	6
Minimum gas loading rate at minimum flow	scfm/sq. ft.	0.12

Ozone Generation System

High concentration ozone generators are recommended for the NAWS Project. The benefits of high concentration ozone generators are:

- High concentration ozone gas (i.e., 8 to 12 percent by weight) results in higher mass transfer efficiency of ozone to the water supply than does medium concentration (i.e., 4 to 6 percent by weight) ozone gas.

- High concentration ozone generators require approximately half as much oxygen gas as do medium concentration ozone generators, thus resulting in significant savings in both capital and operational costs of oxygen feed gas systems.

The ozone generator selected for the NAWS pretreatment facility is a horizontal tube, water cooled, medium frequency ozone generator capable of producing 540 lbs. per day of ozone gas at 10 percent (by weight) gas at 100 percent power input levels. Each ozone generator would be capable of providing an ozone dose of 3.3 mg/l at a peak flow of 18 mgd. Two ozone generators will be installed in Phase I of the project with one unit serving as a stand-by generator. Additional space will be provided inside the ozone generator room for the addition of a third ozone generator in the future.

Ozone Mixing and Contacting System

A number of alternatives for ozone gas mixing and contactor design were evaluated. The contactor alternatives involved in-line pipe contactors, horizontal concrete ozone contactors, and conventional vertical, counter-current ozone contactors. Various methods of ozone gas injection are possible for each contactor concept. Difficulties were identified in the siting of the contactors at either Lake Audubon or Lake Sakakawea because of lake level fluctuations. The lake level fluctuations would have resulted in the application of non-standard contactor designs to meet the disinfection process requirements.

The recommended facility provides a conventional, vertical contactor design. The most feasible location to place the contactor is prior to the booster pump station near the town of Max. This location eliminates the need to provide double pumping to permit the use of the conventional, counter-current contactor.

A total of three (3), nine mgd capacity, counter-current, over-under ozone contactors would be installed. Six (6) ceramic diffusers would be provided in the first downflow stage of each contactor to completely mix the ozone gas into the flow. Ozone gas would be injected into the diffusers at approximately 10 psig. The ozonated water would then travel through five additional chambers before entering the booster pump station wet well. The key benefits of the ozone contactor design include:

- Counter-current ozone contactors have a long history of proven performance with specific design criteria which aid in assuring that disinfection design criteria are met.

- The diffuser gas mix system has few mechanical parts which require maintenance; yet, still can handle the low gas flows from the high concentration ozone generators.

- The conventional ozone contactor and diffuser system was the most cost-effective alternative in terms of its 20-year present worth for capital and operations and maintenance costs.

A preliminary layout for the ozone gas mixing and counter-current ozone contactor is shown in Figure 2-4.

Operation and Control Strategy for Ozone Disinfection System

The ozone disinfection system will be designed for automatic and manual control. Automatic control mode will provide full control, monitoring, and emergency shutdown through the SCADA system and locally at the pretreatment facility. Manual control constitutes complete manual setting of all ozone system components directly at the equipment.

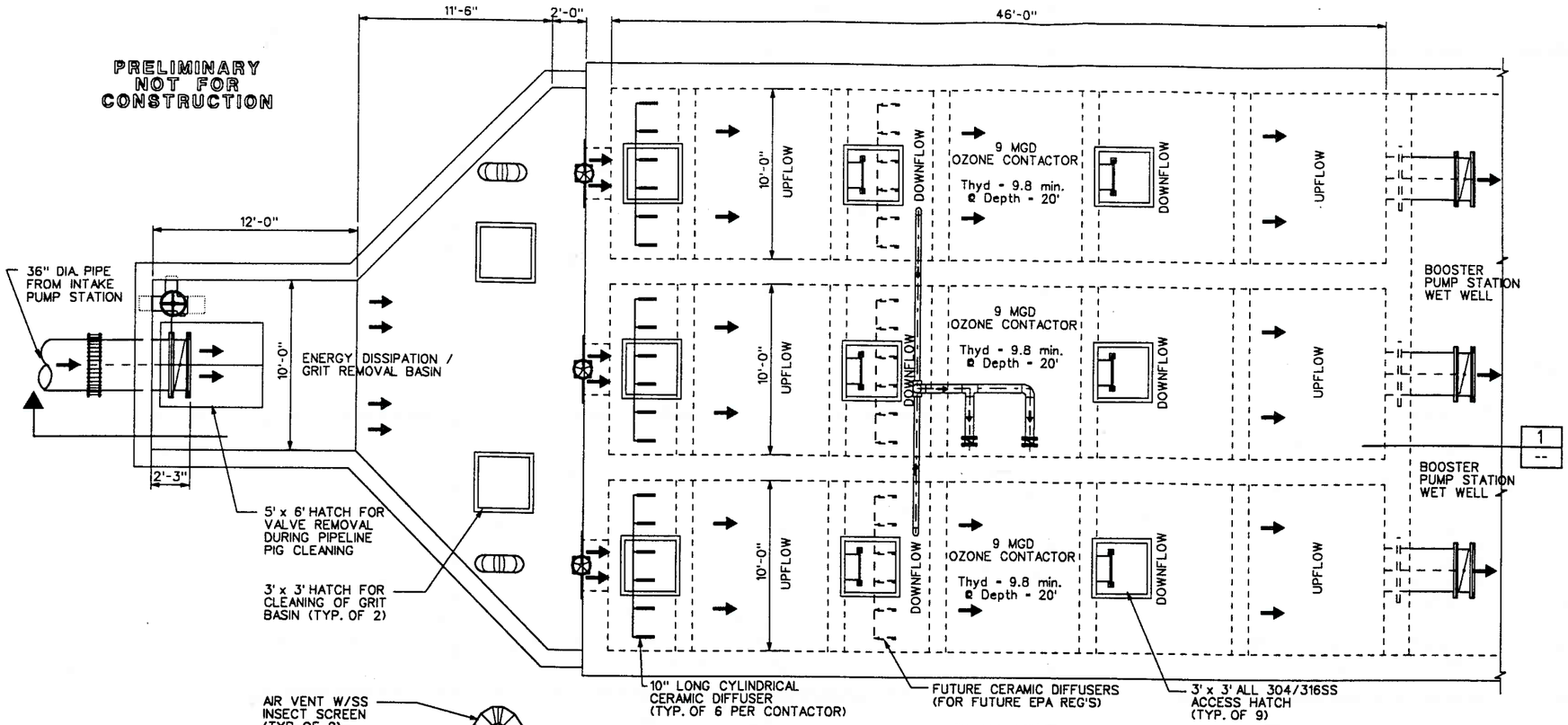
The major components for automatic control of the ozone generators includes the following:

- PLCs
- Man/Machine Interface (MMI) and Software
- Influent Flow Meter
- Ozone Residual Analyzer

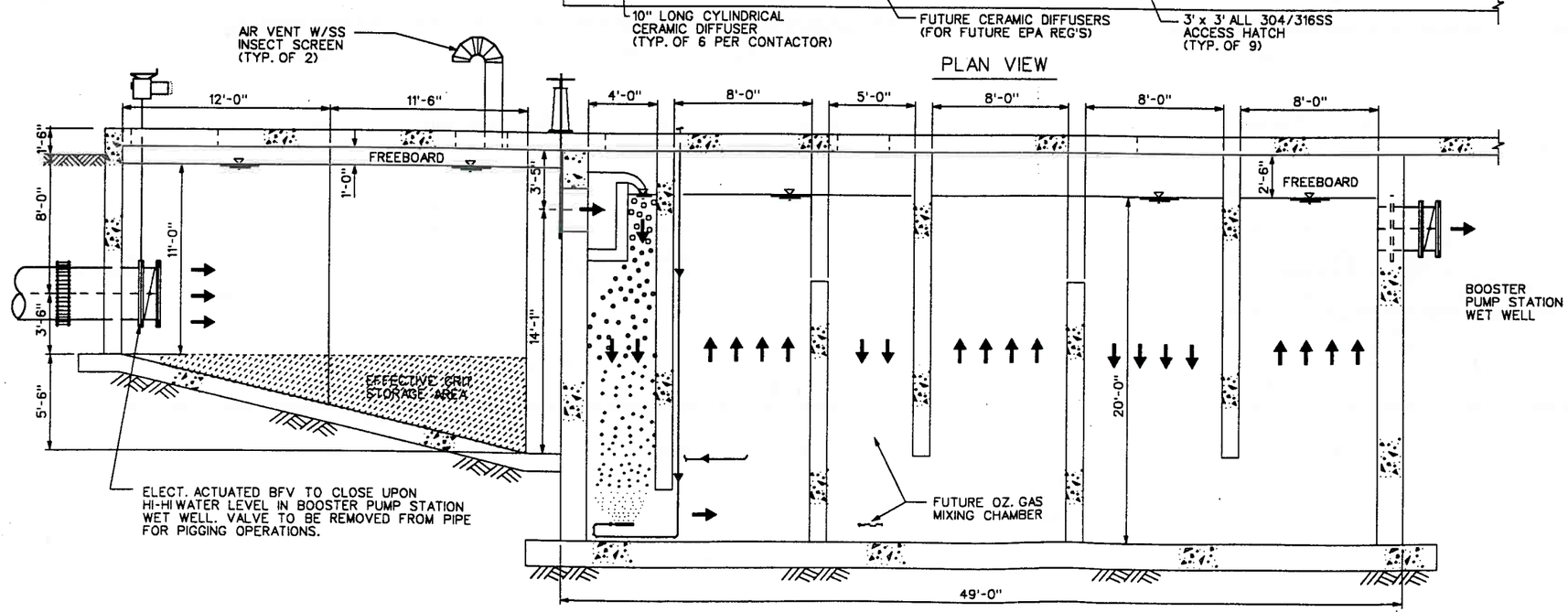
PLCs will provide the automatic control link between the equipment and the MMI. The MMI software will provide the window for operator input of the desired applied ozone dosage (mg/l) and ozone residual (mg/l). The input desired ozone dosage and the ozone contactor influent flow meter will provide the primary (coarse) values for control of ozone generation feed rate (lb/day) applied to the 1st stage of the ozone contactor. The allowable range for operator input of applied ozone dosage will be 1.5 mg/l to 4.5 mg/l. The ozone residual analyzer will measure the ozone residual (mg/l) after the 1st stage gas mix chamber of the ozone contactor. The measured ozone residual, compared to the operator input ozone residual will provide the secondary (trim) control for ozone generator feed rate. The allowable range for operator input of ozone residual will be 0.3 mg/l to 0.6 mg/l. This primary and secondary control loop will provide stable ozonation of the raw water under varying influent flow rates and ozone demand.

Oxygen gas flow changes to the ozone generators will be a manual operation, which will probably require adjustment once or twice per month to maximize efficiency of oxygen consumption. A weekly calibration of the dissolved ozone monitor will be performed to insure accurate and reliable performance.

In any mode of operation, the dissolved ozone monitor will be programmed through the PLC to provide both a low-level alarm and a low/low level setpoint shutdown function should the dissolved ozone residual in the contactor drop to unacceptable levels. It is presently anticipated that a dissolved ozone residual low-level alarm setpoint will be in the range of 0.30 to 0.35 mg/l. The low/low level shutdown setpoint will be in the range of 0.25 to 0.30 mg/l. This system



PLAN VIEW



SECTION 1

PRETREATMENT FACILITY DESIGN CRITERIA

DESCRIPTION	UNITS	CRITERIA
PRESETTLING & OZONE CONTACTOR DESIGN CAPACITIES		
INSTALLED CAPACITY OF GRIT REMOVAL BASIN	MGD	26
INSTALLED CAPACITY OF OZ. CONTACTORS	MGD	26
INSTALLED CAPACITY OF LOX FEED SYSTEM	MGD	18
GRIT SETTLING BASIN		
TYPE: CONVENTIONAL, GRAVITY SETTLING BASIN.		
NUMBER OF BASINS	NO.	1
MIN. PARTICLE SIZE TO BE SETTLED	MM	0.6
REQUIRED SETTLING RATE	FPM	~12
REQUIRED SURFACE LOADING RATE	GPM/SQ.FT.	~90
ACTUAL SLR (BASED UPON RECT. BASIN ONLY)	GPM/SQ.FT.	~79
EFFECTIVE LENGTH:WIDTH RATIO (" " " ")	NO.	~3:1
EFFECTIVE WATER DEPTH	FT.	11
HYD. DETENTION TIME	MIN.	1.5
MEAN FLOW VELOCITY.	FPM	22
OZONE GAS MIXING		
TYPE: CYLINDRICAL, FINE BUBBLE, CERAMIC DIFFUSERS		
NUMBER PER MIX CHAMBER	NO.	6
LENGTH	INCHES	10
PORE SIZE	MICRONS	30
MIN. GAS FLOW ALLOWABLE PER DIFFUSER	SCFM/FT	1.0
MAX. GAS FLOW PER DIFFUSER	SCFM/FT	2.5
MAX. ALLOWABLE HEADLOSS	IN. W.C.	10
OZONE CONTACTORS		
TYPE: COUNTER CURRENT, MULTISTAGE, CONTACTOR DESIGNED FOR 3-LOG REMOVAL OF GIARDIA PER THE DEC. 95, NAWS CHLORAMINE CHALLENGE STUDY REPORT		
NUMBER OF CONTACTORS	NO.	3
DESIGN FLOW (EACH)	MGD	9.0
HYD. DET. TIME AT DESIGN FLOW	MIN.	9.8
T10 / HYD. DET. TIME RATIO	NO.	0.6
WATER DEPTH	FT.	20
MIN. TRANSFER EFFICIENCY	%	0.97
REQ. DISSOLVED OZONE RESID. CONC. (AFTER 1ST MIX CHAMBER)	PPM	0.40
DISSOLVED OZONE RESID. CONC. AT CONTACTOR EFFLUENT	PPM	<0.02

PRELIMINARY
NOT FOR
CONSTRUCTION

REV	DATE	BY	DESCRIPTION

SCALE: 1/4" = 1'-0"

WARNING: 0 1/2 1 — IF THIS BAR DOES NOT MEASURE 1" THEN DRAWING IS NOT TO SCALE.

DESIGNED M. S. Moughamian
DRAWN M. S. Moughamian
CHECKED W.B. Lynard

SUBMITTED
PROJECT ENGINEER — DATE
MONTGOMERY WATSON — P. E. NO. — DATE

MONTGOMERY WATSON
Boise, Idaho

APPROVED — DATE
APPROVED — DATE

NORTH DAKOTA STATE WATER COMMISSION
NORTHWEST AREA WATER SUPPLY PROJECT
SELECETED ALTERNATIVE FOR
GRIT SETTLING BASIN & OZONE CONTACTOR @ BOOSTER PUMP STA.
PLAN AND SECTION

SHEET FIG. 2-4 OF SHTS

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shutdown feature will automatically shut down the lake intake pump station and the booster pump station. Based on the Chloramine Challenge study results, 3-log *Giardia* inactivation will be achieved at the shutdown set point.

Chloramine Pipeline Disinfection System Design Criteria

Design Criteria. Table 2-2 presents the design criteria for the pretreated water pipeline residual disinfection system using chloramines. A minimum 0.2 mg/l total chlorine residual will be maintained at the inlet to the Minot WTP. The maximum chloramine dose is 1.0 mg/l.

Chemical Descriptions. Ammonia is typically supplied in either a gaseous form (anhydrous ammonia) or in a liquid form (aqueous ammonia). Use of aqueous ammonia, which can be supplied in 750-lb drums, is proposed for the design.

Chlorine could be supplied in 1 ton chlorine cylinders, or as 12 percent strength liquid sodium hypochlorite. The advantage of using liquid sodium hypochlorite is that no hazardous gas handling is required as is the case with a chlorine gas system. A chlorine gas system will require the installation of a chlorine gas scrubber and emergency leak detection system. The advantage of using chlorine gas systems is low maintenance. The design criteria shown in Table 2-2 assume that chlorine gas will be used.

System Control. Due to the long flow time (eight hours at 26 mgd) between the booster pump station and the Minot WTP, it is not feasible to control the chloramine chemical feed system with any type of automated feed-back control loop strategy. The chloramine chemical feed system will be equipped with an automatic flow paced control system through the local PLC which will be connected to the SCADA telemetry system. The SCADA system will be used to adjust and control the chemical feed system. The desired chemical feed dosage for both the chlorine and the ammonia system will be entered into the PLC, and an analog signal from a flow meter located on the booster pump station discharge would provide the flow rate signal to the PLC. The PLC

would control the chemical feed pumps. Residual total chlorine levels will be monitored at the booster pump station discharge (after chlorine is added) and at the Minot WTP inlet structure.

BOOSTER PUMP STATION

Location

The booster pump station will be located near the town of Max, approximately 9.5 miles before the pipeline reaches the basin divide between the Missouri River drainage and the Hudson Bay drainage. The final siting will be performed once the pipeline profiles and hydraulic evaluations are completed.

TABLE 2-2

PRETREATED WATER PIPELINE DISINFECTION SYSTEM CHLORAMINE FEED SYSTEM DESIGN CRITERIA

Description	Units	Criteria
Pretreatment Pipeline Disinfection. System Capacities		
Installed capacity of chlorine feeders:	mgd	18
Installed capacity of ammonia feeders:	mgd	18
Phase I maximum day flow rate:	mgd	18
Phase I minimum day flow rate:	mgd	3.8
Chlorine (Gaseous, 1-ton cylinders)		
Dosage, minimum	mg/l	0.4
Dosage, maximum	mg/l	1.0
Gas feed rate (at maximum flow and maximum dosage)	lbs/day	150
Gas feed rate (at minimum flow and minimum dosage)	lbs/day	13
Chlorinators (one on-line & one stand-by)	no.	2
Chlorinator capacities, each	lbs/day	150
One ton cylinders (one on-line & two stand-by)	no.	3
Days storage (at Phase I average daily flow of 7.4 mgd and maximum dosage)	days/cylinder	32
Ammonia (Aqueous ammonia, liquid, 29.4% concentrate solution; 2.2 lbs of NH2/gallons)		
Ratio of chlorine to ammonia feed	no.	3.5
Ammonia dosage, minimum	mg/l	0.12
Ammonia dosage, maximum	mg/l	0.30
Liquid feed rate (neat solution at 18 mgd and maximum dosage)	gallons/hour	0.85
Liquid feed rate (neat solution at 3.8 mgd and minimum dosage)	gallons/hour	0.07
Metering pumps (one duty , one stand-by)	no.	2
Storage container (drum) weight	lbs/drum	750
Storage drum volume	gallons NH2/drum	100
Drums on site	no.	6
Days storage (at Phase I average daily flow of 7.4 mgd and maximum dosage)	days/drum	12

Facility Layout and Configuration

Siting of the booster pump station will depend upon hydraulic grade line and pipeline routing requirements. Presently, the pretreatment system and booster pump station are tentatively located 12 miles north of Lake Audubon. Other issues which may influence final site selection include:

- Accessibility to the potential site
- Location relative to power supply
- Land availability

The booster pump station will consist of a concrete wet well structure equipped with vertical turbine pumps. The wet well structure in conjunction with the ozone contactor provides an atmospheric break in the hydraulic grade line. The final design size of the concrete wet well will depend upon final pump selection and the balance of flow at the intake pump station and the demand flow rates at the Minot WTP. The booster pump station will pump to the pretreated water storage tank.

Equipment

The booster pump station will utilize vertical turbine pumps because of their pump characteristics, accessibility for pump service, and their high-energy efficiency. The selection of constant speed pumps or a combination of both constant speed and variable frequency drive (VFD) pumps will depend upon final flow requirements of the system.

Each pump will be equipped with a check valve, a pump control valve, a combination air/vacuum relief valve, and a high-pressure cut-off switch.

Operation and Control Strategy

The operation strategy logic for both the intake pump station as well as the booster pump station will be designed to provide continuous pump station operation (minimize pump starts and stops). The pretreatment ozone facility should be operated to maintain a continuous, relatively constant flow operation. The booster pump station will be controlled by the operating level of the pretreated water storage reservoir. The booster pump station PLC will respond to water level signals from the reservoir as well as its own wet well. The SCADA system will serve as the communications and control link to the main computer system and the PLC at the storage reservoir.

In emergency situations, the PLC will shut down the station pump and alarm the operators through the SCADA system. On loss of SCADA telemetry, the booster pump station will shut down.

Surge Control

The booster pump station will incorporate a surge control tank connected to the pump discharge header. Size and configuration will be based on final pipeline characteristics under power failure conditions. Combination air/vacuum valves will be placed at critical locations on the pipeline between the booster pump station and the pretreated storage reservoir to control surge.

Chemical Feed Systems

The pipeline residual disinfection system will be located at the booster pump station. The facilities for chlorine and ammonia addition at the booster pump station have been previously described in the "Pretreatment Facilities" portion of this Section.

PRETREATED WATER STORAGE RESERVOIR

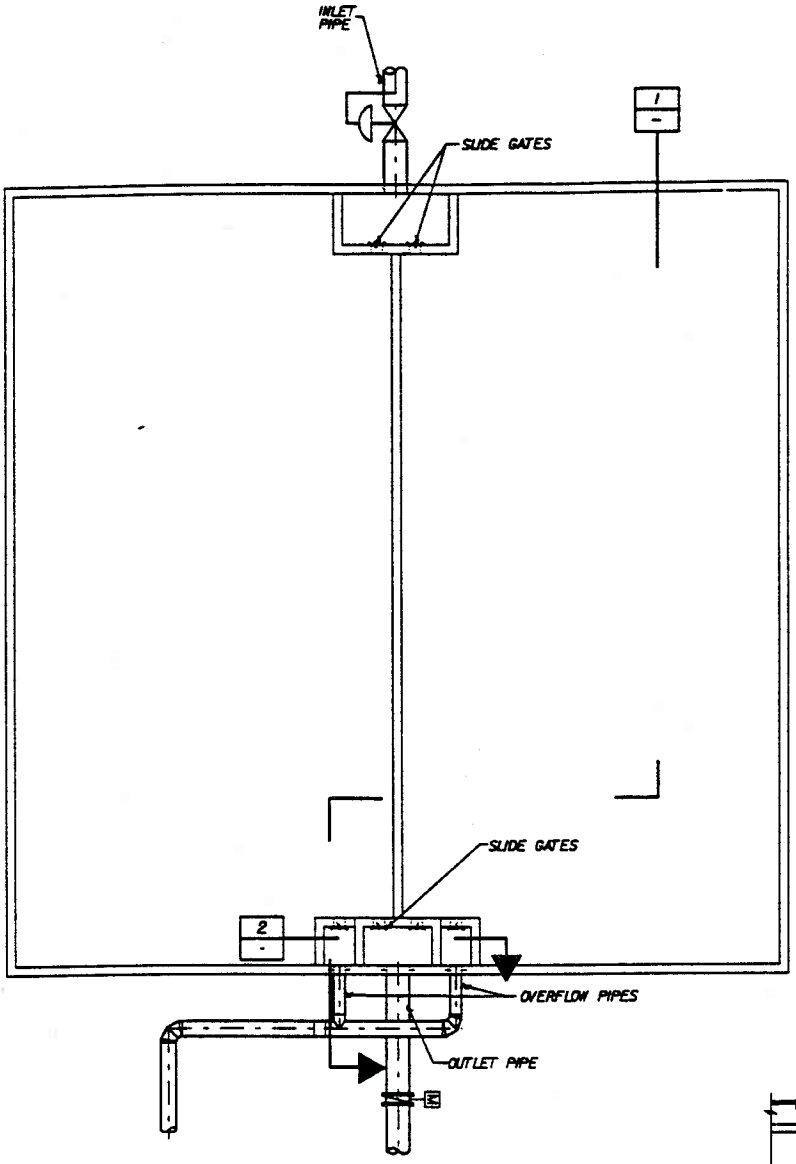
A storage reservoir will be located on the pretreated water pipeline within the Hudson Bay drainage. The siting of the reservoir will achieve three benefits; first, the reservoir will be used as a break to atmosphere to reduce the static hydraulic gradeline and permit the use of lower pressure class pipe below the reservoir. Second, the reservoir will provide operational storage to balance water demand at the Minot WTP and pumping at the booster pump station. Third, the reservoir will serve as an isolation point on the pipeline.

Location

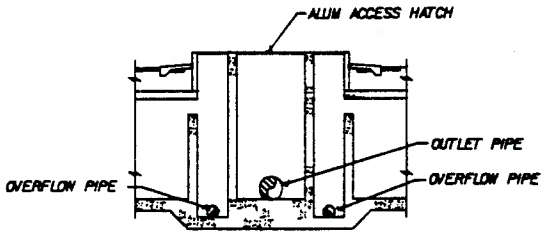
The reservoir will be located at a point approximately 4.7 miles downstream of the top of the divide between the Missouri River drainage and the Hudson Bay drainage. The final site will be selected once the pipeline profiles and hydraulic evaluations are completed. The site should be at a location where the ground surface is close to, but below the hydraulic grade line at 26 mgd. Two locations have been identified based on preliminary hydraulics and the preliminary pipeline route. They are both in the vicinity of the former military radar base approximately 18 miles south of Minot.

Facility Layout/Configuration

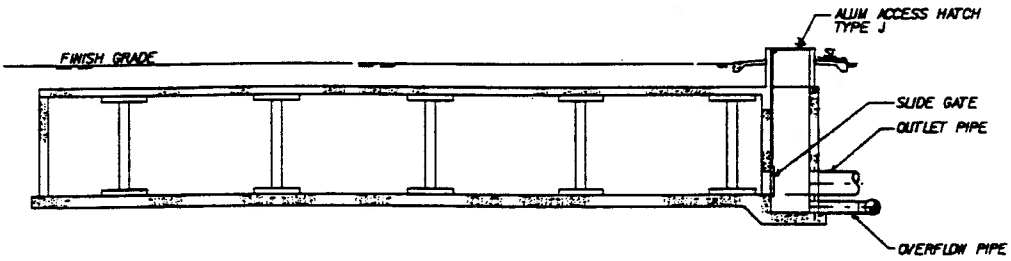
The pretreated water storage reservoir is anticipated to be a buried rectangular concrete storage reservoir. The reservoir will be constructed with a center dividing wall creating two independent chambers that will permit cleaning of either half while maintaining the system in service. A preliminary layout of the facility is shown in Figure 2-5. Each chamber will be baffled to reduce short-circuiting in the structure. Under normal operation, the entire reservoir will be utilized through control of the entrance and discharge structures. These structures will contain control gates to permit use of either or both halves of the reservoir. These structures will also house the control systems and equipment.



FLOOR PLAN



OVERFLOW SECTION 2



TYPICAL SECTION 1

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TYPICAL CONCRETE RESERVOIR
PLAN AND SECTIONS
FIGURE 2-5

1" = 10'-0"

Operational Storage

The reservoir will contain approximately two million gallons of operational storage. The final volume of storage will be determined once the final pump selection for the booster pump station and the intake pump station are made relative to the characteristics of the demand at the Minot WTP. The operational storage will be used to balance flow rate and volume to pump cycle times.

Equipment and Control

The pretreated water storage reservoir will be monitored and controlled through the SCADA telemetry system. In addition, this facility will have a local PLC which will be programmed for emergency operation of the facility in the event of loss of signal from the telemetry system. Control valves will be required to provide control under normal and emergency operations.

The reservoir inlet facility will be equipped with a pressure-sustaining valve to insure upstream full pipe flow conditions under all flow rates. Under normal operation, this valve will be used to prevent air pockets and transient hydraulic conditions from occurring in the pipeline from the divide to the storage reservoir by maintaining a backpressure on the pipeline. Under emergency conditions, such as loss of power, a telemetry failure or a full reservoir condition, the valve will serve as a fail-safe feature that will close and prevent water from entering the reservoir.

The outlet structure will be equipped with a motor control valve to isolate the storage reservoir from the downstream system. This valve will be activated by a low reservoir level, the SCADA system, or a low pressure reading in the pipeline at the Pressure Reducing Valve (PRV) facility.

Overflow/Spill Control

The pretreated water storage reservoir would be equipped with an overflow structure to prevent over pressurization of the reservoir in the event that all fail-safe systems failed. The overflow would be discharged to a small containment berm constructed around the storage reservoir or to a containment basin.

PRESSURE REDUCING VALVE STATION

A PRV will be located on the pretreated water pipeline to reduce higher upstream pressure to a lower downstream pressure to allow the use of lower pressure class pipe. The PRV station is required for flow rates which are less than the design flow rate of 26 mgd.

Location

The PRV station will be located approximately six miles downstream from the storage reservoir at approximate elevation 1830. The actual location will be determined by the final siting of the storage reservoir and the water surface elevation in the reservoir. The location of the PRV will be at a point where the static upstream pressure approaches 150 psi.

Criteria

The PRV design will include the requirements of system operational pressures, surge analysis, and required system flow rate range. Valving will be designed to control flows ranging from low (near static) conditions to peak demand.

Configuration

The facility will be constructed with three parallel PRVs. The pipe configuration will include isolation valves for each PRV. Upstream and downstream pressure gauges will be installed for use in valve calibration, adjustments, and sensing failures.

The PRV station structure will be an underground concrete vault. The vault will be equipped with lighting, ventilation, heating, telemetry, PLC, and intrusion/entry alarms. Vault drainage will use a daylighted drain or sump pump system, depending on siting of the structure. Site and vault drainage will be directed in a manner to allow infiltration into the soil. Site and vault drainage will not be allowed to enter the Souris River via surface runoff. The valves will be equipped to close on an emergency signal, loss of power, or loss of SCADA signal. This facility will provide a pipeline isolation location.

Control/Instrumentation

Pressure indicating transmitters will be installed upstream and downstream of the PRVs. The pressure sensor output will be incorporated into the SCADA system for monitoring.

The facility will be equipped with a battery-powered emergency power supply to maintain the monitoring signals during a power outage and emergency shutdown of the facility.

MINOT WATER TREATMENT PLANT FACILITIES

The upgrades and expansion of the Minot WTP described in this section focus on the criteria necessary for meeting the Biota Transfer issues, Surface Water Treatment Rule (SWTR), and expected requirements of the Enhanced Surface Water Treatment Rule (ESWTR). The Phase I and future phase design requirements are developed around the use of a water supply from Lake Audubon or Lake Sakakawea. The approach used for the Minot WTP facilities is based on the use of standard engineering practices for construction, maintenance, and replacement. The upgrades and expansion modifications described in this section reflect standard engineering practices to meet the above stated requirements and the "specific design elements" stated in the "Draft Environmental Assessment."

Biota Transfer Issues

"Specific design elements" addressing the biota transfer issues at the Minot WTP Facilities were listed in the Draft Environment Assessment, June 1997, as follows:

- "The pretreated water will be softened and filtered at the upgraded Minot WTP. Chloramine will be used for a distribution system disinfectant residual."

- "A water-containment levee will be constructed north of the Minot WTP adjacent to the Souris River as an additional safety measure. This levee will also prevent flooding of the treatment plant during periods of flooding on the Souris River. The Minot treatment plant is situated above the 500-year flood level."

- "A 2.4 million gallon overflow basin will be constructed at the Minot treatment plant to contain incoming pipeline flows in case of an emergency shutdown of the WTP."

- "The sludge handling system at the Minot WTP will be upgraded to further reduce the potential for biota transfer. The sludge is currently disposed of in a Class A landfill which includes containment berms, lined landfill cells, and a leachate collection system."

- Standby power at Minot WTP to ensure continuous monitoring in case of temporary or total power outage.

- Minot WTP control equipment to monitor and alarm specific critical conditions relative to biota transfer issues and plant operation.

These "specific design elements" are discussed as appropriate in the following sections which describe the Minot WTP facilities, upgrades, operation, and management.

Facility Upgrade and Expansion Criteria

A detailed evaluation (audit) of the Minot WTP is being conducted to evaluate the capacity and capability to meet the NAWS Phase I and Ultimate Facility requirements for treating the new water supply from Lake Audubon or Lake Sakakawea.

The existing Minot WTP has the hydraulic and process capacity for treating up to 18 mgd which is the Phase I goal, but the plant has a hydraulic limitation at the high service pump station of about 14 mgd. Hydraulic and process capacity will have to be added to meet the Ultimate phase requirement of 26 mgd. The existing unit processes, using lime softening, clarification, filtration, chlorination, and chloramination, will continue to be the treatment process for the pretreated Missouri River water supply. The upgrades and expansion requirements to meet the Phase I and Ultimate Facility requirements are described as follows:

Phase I. Upgrades to the Minot WTP are necessary to accept the Missouri River pretreated water supply and to address biota transfer requirements. New and upgraded equipment will be sized to meet the Ultimate Facility capacity as appropriate. The upgrades include the following:

- Demolition of the existing aerators
- Influent flow control facility
- Influent chemical feed systems

- Replace existing lime slakers
- New sludge dewatering equipment
- Upgrade specific Minot WTP control and monitoring systems.

The existing raw water aeration equipment have severely deteriorated and the initial audit evaluations indicate that they are not a required treatment process for the groundwater, Souris River or Missouri River water supplies. Therefore, these aerators will be demolished and removed from the Minot WTP. It is currently anticipated that the new intake flow control facility will be located in the space.

A new influent flow control facility will connect the Missouri River pretreated water supply to the existing Souris River and groundwater supply piping system located in the existing aerator space. New chemical feed systems will be added to inject primary coagulant and coagulant aid into the pretreated water at the influent flow control facility. The new chemical feed system will be designed to feed ferric or alum coagulants and cationic polymers. New lime slakers will replace the existing slakers which are beyond service life. The new lime slakers will be sized for 26 mgd feed rate capacity. New sludge dewatering equipment will be installed to replace the existing equipment which are at the end of their useful life.

The existing Minot SCADA/telemetry system and Minot WTP control systems were installed in the 1980's. Replacement of this system will require significant capital expenditure. No upgrades or changes to the Minot SCADA/telemetry system are incorporated into the NAWS Phase I project. Upgrades and modifications of the Minot WTP control system will be limited to controls and alarms associated with new equipment, fail-safe systems, and biota transfer safeguards. These new controls and alarms will be incorporated into the Central Control Facility computer system discussed in Section 4. New controls that will be added include the following:

- Influent flow rate control, monitoring, and alarms
- Flow pacing of the new chemical feed equipment
- Clarifier and clearwell level monitoring and alarms

The remainder of the Minot WTP control system however, should be upgraded as soon as funds are available. It is anticipated that this will occur prior to construction of the future phases of the NAWS treated water distribution system. The existing standby power generator is sufficiently sized to provide emergency power to critical process elements. Un-interruptible power supplies (UPS) and fail-safe systems will provide monitoring and control during transfers to and from the standby power generator.

Ultimate Facility. The Ultimate Facility capacity of 26 mgd will require expanding the process and hydraulic capacity of the Minot WTP. This will require an additional 8-mgd softener/clarifier. Results of the filter evaluation conducted during the audit confirmed the recommendations in the NAWS Project Final Report Pre-Final Design, June 1995, that only modifications to the existing filters are required for the Ultimate Facility process flow rate. These modifications include new dual media (changing effective size and depth), new filter underdrains, new filter effluent piping and valves, and new filter control systems. These modifications will permit increased filtration rates. Additional filter waste washwater equalization basin storage capacity is recommended for the Ultimate Facility. This additional

equalization volume is necessary because filter backwash frequency will be increased at the higher filtration rates.

A new clearwell and high service pump station will be required to provide an additional 12-mgd of additional future demand. The required clearwell volume is currently estimated at 800,000 gallons. The final size will be determined based on regional system storage capacity.

Influent Flow Control/Facility

The new influent flow control facility will include the following:

- Two parallel rate-of-flow control valves with manual isolation valves
- One flow meter
- System by-pass plug valve
- Chemical flash mix system
- Chemical injection diffusers
- Sample locations for monitoring water quality parameters
- Flow rate control system

The two parallel rate-of-flow valves will provide control over the entire 26-mgd flow range, and provide redundancy for maintenance purposes. The rate-of-flow control valves will be hydraulic alloy pilot activated valves with solenoids or electrically actuated for valve position control and emergency shutdown capability. Isolation valves on these valves will provide maintenance capability with the plant on-line and emergency manual closure back-up. The flow meter will measure the flow rate and total volumes, and combine with the rate-of-flow control valves for open/close and flow rate control. The by-pass plug valve provides total manual operation.
Chemical injection diffusers for feeding coagulants, coagulant aids, and spare diffusers will be installed down-stream of the rate-of-flow control valves. The chemical flash mix system will provide the mixing energy for these chemicals using the pretreated water stream. The flash mix pipe system will by-pass approximately two percent of the influent flow around the rate-of-flow control valve system and re-inject this flow immediately downstream of the coagulant diffuser. A flow meter, two pressure reducing valves with pressure gauges, and two solenoid valves on the flash mix pipe system will provide manual flow rate control with automatic emergency shut-down.

Two sample tap systems will provide influent water quality monitoring and analysis. One sample tap will be located immediately upstream of the rate-of-flow control valves to monitor turbidity, pH, and temperature. The second sample tap will be located downstream of the connection of the three raw water supply pipes. This sample tap will also monitor turbidity, pH, and temperature. These water quality measured values will be recorded on the central control facility computer for monitoring, alarming, and trending.

The flow rate control system will provide automatic, manual, and emergency control of the pretreated Missouri River supply. In the automatic mode, the operation staff will enter the desired influent flow rate through the central control facility computer system. A flow control logic program will monitor the influent flow meter flow rate value and modulate the rate-of-flow control valve position to maintain the flow rate. The manually operated by-pass plug valve

provides manual control of influent flow rate. This valve is provided for emergency operation only. The emergency control system logic will automatically close the rate-of-flow control valve(s) and flash mix by-pass system.

Operation

The Phase I facility upgrade will incorporate the equipment and control systems for normal, emergency, and fail-safe operation for the new Missouri River supply facilities at the Minot WTP.

Normal Operations. The primary water supply to the Minot WTP will be the pretreated Missouri River water supply. The groundwater and Souris River supplies will be utilized only if the Missouri supply is shut down for any reason. The Minot WTP will continue to soften, filter, and use chloramine for maintaining disinfection residuals for the new water supply. The Phase I facility upgrade provides control of the new influent rate-of-flow control facility, new chemical feed system, and emergency conditions. No modifications to the normal operations and control of the clarifiers, filters, backwash systems, and existing chemical feed systems will be incorporated into the Phase I facility upgrade. Operations staff will continue to control plant flow rate, filter backwashing sequences, clarification, sludge thickening process, and existing chemical feed systems. The new central control facility will provide control of new facilities needed to meet biota transfer issues. This includes monitoring, trending, and alarming of water quality through the process; influent flow rate; clarifier, filter, clearwell, and sludge thickener basin water levels; and finished water pumps.

Emergency Operations. Emergency operations include any failure which activates closing the influent rate-of-flow control valve system. Failures which could activate this closure condition include the following:

- Loss of telemetry signal between Minot WTP and any Missouri River water supply facilities
- Activation of any of the fail-safe systems at any of the Missouri River water supply facilities
- Loss of primary power at Minot WTP
- Loss of the Minot WTP high service pump station
- High or low influent pressure
- High water alarm in the clarifiers, filters and clearwell

Placing the rate-of-flow control valve system back into service will require the emergency condition be acknowledged by operations staff, the emergency condition cleared, and reactivation by operations staff. If a prolonged failure associated with the Missouri supply

system is anticipated, operation staff may switch to the groundwater and Souris River raw water supplies.

Fail-Safe Systems. Fail-safe systems are integral in forcing closure of the rate-of-flow control system and flash mix system during an emergency conditions. Normally closed solenoid valves will be interrupted on flash-mix system and hydraulic pilot actuator piping on the rate-of-flow control valves. Normally closed solenoid position is defined as the valve automatically closes with loss of power to the solenoid valve contacts. Any of the emergency operation conditions will force loss of power to the solenoids, which will hydraulically force the rate-of-flow control valves closed.

Overflow Requirements (Pipeline Storage)

A critical element of the fail-safe system is plant overflow prevention. High-level float switches will be located in each clarifier and the clearwell. (Note: The clarifiers have a direct hydraulic connection to the filters which eliminates the need for filter high level float switches.) These high-level float switches will be hard-wired directly to the solenoids which will force closure of the rate-of-flow control valve(s) and flash mix system. Emergency closure time of the rate-of-flow control valves will be approximately 60 seconds. The volume of water passing through the closing valve at the maximum design flow rate (26-mgd) for 60 seconds equals approximately 2,400 cubic feet. The total surface area of the Ultimate Facility clarifiers, channels and filters will be in excess of 24,000 square feet. Therefore, during an emergency closure of the rate-of-flow control valves and flash mix system less than a 0.1 foot rise in water level will be experienced in the WTP process units.

The minimum available freeboard above normal operating level prior to overflow is two feet. This provides twenty minutes of overflow safeguard contingency, in which plant operations staff can also close the influent facility manual isolation valves, if necessary. This fail-safe system eliminates the need of the 2.4 million gallon overflow basin for containing incoming pipeline flows in case of emergency Minot WTP shutdown.

A failure in the raw water supply, pretreatment facilities, and Minot WTP will initiate the fail-safe condition and close the influent rate-of-flow control valves. The pretreated water will be contained in the pipeline and pretreated water storage reservoir, thereby preventing any overflow at the Minot WTP. If for any reason the pipeline system must be drained, the pretreated water will be processed through the Minot WTP.

Flood Protection

Construction of a levee along the north side of the Minot WTP exceeds the requirement of standard engineering practices required by the "NAWS Engineering-Biology Task Group 1994" report. The water containment levee "Specific design element" requires a levee to be constructed north of the Minot WTP with a top elevation two feet above the 100-year flood level. The levee function is to contain untreated Missouri supply water from direct discharge into the Souris River and protect the Minot WTP from flooding from the Souris River. The pretreatment process and fail-safe measures on the Missouri River water supply facilities and Minot WTP prevent

pretreated Missouri River water supply from discharging directly into the waters of the Hudson Bay drainage.

The Canada - United States Souris River Flood Control Project, which was recently completed, provides 100-year flood protection to the City of Minot and the Minot WTP. A flood warning system has been constructed which will allow the Minot WTP to switch from pretreated Missouri water to groundwater supply under emergency situations, if necessary. The existing Minot WTP facilities, with the exception of the Souris River intake pump station, are above the 500-year flood level. All planned facilities and structures for the Minot WTP will also be above the 500-year flood level. The proposed levee height is below the 500-year flood level, thus minimizing the flood protection value. Therefore, the levee has been removed from planned construction at the Minot WTP.

Sludge Management

The sludge facility upgrades and an operation and maintenance plan will be implemented with the Phase I upgrade to the Minot WTP. Sludge characteristics, operations, handling and disposal facilities, maintenance plan, and emergency operation are discussed in the following paragraphs.

Sludge Characteristics. Lime sludge will be produced from the softening clarification process for treating the Missouri River pretreated water supply. Currently about ten tons of dewatered sludge is produced per one million gallons of treated groundwater. The calculated dewatered sludge production of Lake Audubon or Lake Sakakawea is approximately five tons per one million gallons of treated water. The sludge thickening process slurry and dewatered sludge will have a pH exceeding twelve. At this elevated pH biological activity essentially ceases to exist. In fact, lime is used as a pasteurization process for municipal wastewater sludges.

Sludge Handling Facilities. The existing sludge thickeners, associated pumps, and appurtenances are of sufficient size to handle the sludge produced from the 26-mgd Ultimate Facility. New sludge dewatering equipment will be installed to replace the existing sludge vacuum filters. Spill containment and wash down facilities, within the confines of the existing sludge dewatering/loading area, will be incorporated with the installation of the new dewatering equipment. Washdown water and spills will be confined within this area and piped directly to the sludge-thickening pump wet well for recycling.

Sludge dewatering is a batch process which is activated by plant operations staff. The dewatered sludge will be loaded directly into dedicated dewatered sludge truck(s) for disposal at the Sludge Disposal Facility. Minot WTP operation staff will monitor the dewatering and truck loading operation during the batching operation. All spills during the truck loading operation will be contained within the loading area. Each sludge transport truck and the loading area will be washed down, prior to a truck leaving the dewatered sludge loading facility.

Sludge Disposal Facility. The City of Minot has a Class A landfill which includes containment berms, lined landfill cells, and a leachate collection system. All sludge will be deposited in this landfill.

Maintenance/Housekeeping. The pH of lime sludge necessitates excellent maintenance and housekeeping. As part of the Phase I project, maintenance/housekeeping procedures will be initiated. The procedures include daily washdown, cleaning, and lubrication of the sludge handling equipment and spaces. All washdown water will be contained in this facility and piped to the sludge-thickening pump wet well.

Emergency Operations. Sludge spills may occur during the truck loading operation within the confined loading space or a truck accident on route to the landfill. Emergency Operations will include procedures for cleanup and disposal of any sludge spillage which may occur between the sludge loading facility and the landfill. Lime sludge spill will be cordoned off to prevent traffic from tracking the sludge along roadways. The sludge will be physically removed from the roadway and not washed down storm drains. Final cleaning shall be performed with vacuum sweepers or absorbent material.

PIPELINE FACILITIES

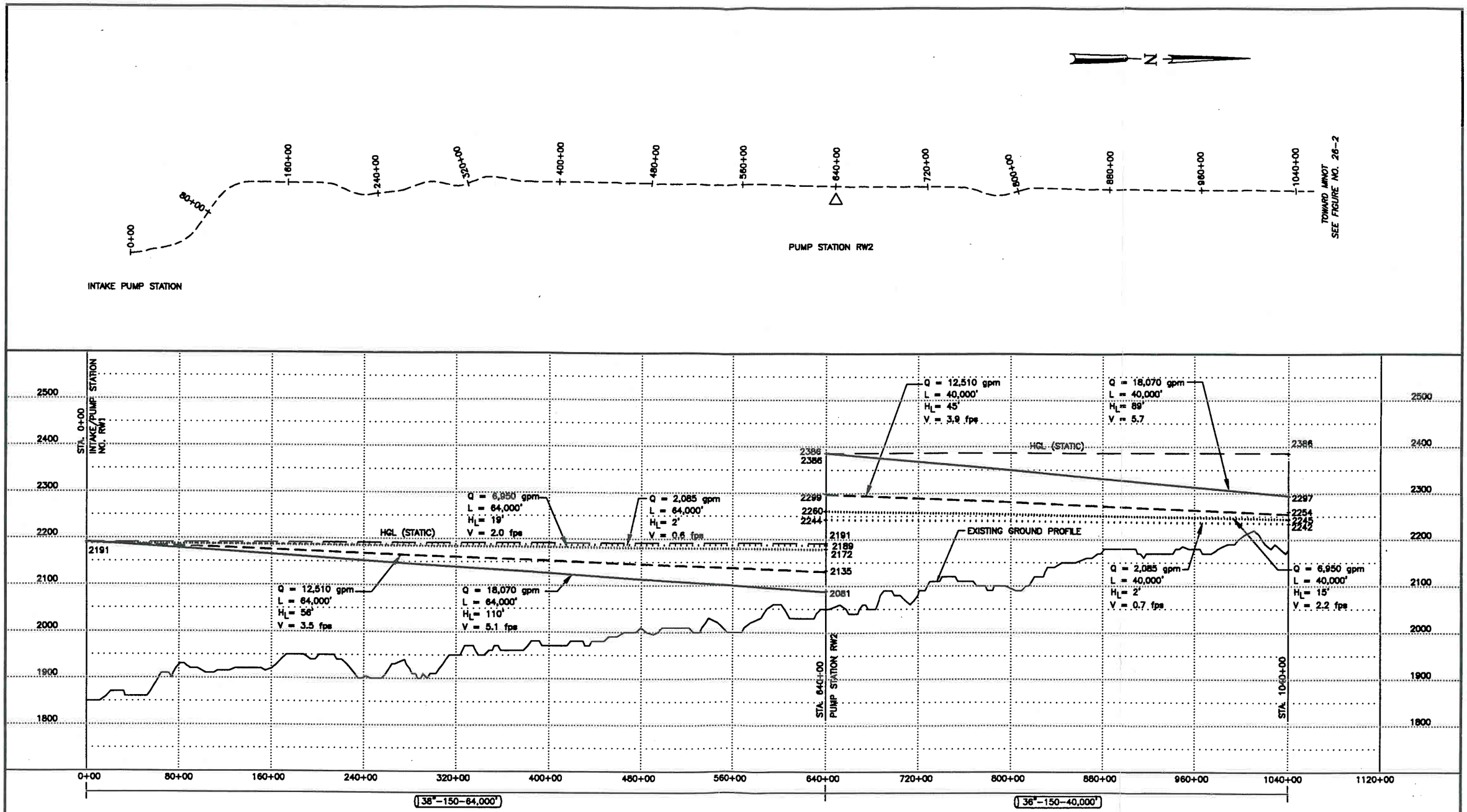
Pipeline Materials and Construction

Alignment. Optimum pipeline alignment would connect the Missouri River water source to the Minot WTP along the most direct route possible. In general, the current design for the alignment of the pipeline follows Highway 83. This alignment would require private easements for a majority of the pipeline length. Generally, the pipeline will not be located in the highway right-of-way, however, in some areas it may have to be in the right-of-way for short stretches. Where the pipeline is located in the right-of-way, it must be located more than 42 feet from the centerline of the highway to conform to the Highway Department's request. When possible, the pipeline will be routed around ponds and lakes, however, if the pipeline must be constructed through water, special design and construction practices will be required. Specific route selection will consider the following siting constraints:

- Hydraulic constraints of the system,
- Property values,
- Paralleling existing roadways or rights-of-way,
- Year-round accessibility,
- Route geology and topography,
- Site reclamation requirements.

Hydraulic Gradeline. A preliminary hydraulic gradeline was developed for maximum day flows (26 mgd), and for flows of 18, 10, and 3 mgd. The hydraulic gradeline of the current conceptual design layout is shown in Figure 2-6. The hydraulic gradeline analysis includes the consideration of the special control valves at the reservoir and at the PRV station.

Pipeline Criteria. Generally, operating pressures in the NAWS pretreated water pipeline will be designed at or below 150 psi, since valves and other appurtenances with this pressure rating are readily available. Lower pressures allow the use of less expensive pipe. A maximum pressure of 150 psi will be the target in design, but may be increased along certain segments of pipe to eliminate some hydraulic facilities.



LEGEND

PIPE DIA.-CLASS-LENGTH

△ PUMP STATION

● STORAGE RESERVOIR

TREATED WATER LINE:
IN PLAN & PROFILE ———
IN PLAN VIEW ONLY ———

RAW WATER LINE:
IN PLAN & PROFILE — — —
IN PLAN VIEW ONLY — — —

Q = FLOW (IN GPM)
H_L = HEAD LOSS
L = LENGTH
V = VELOCITY
HGL = HYDRAULIC GRADE LINE – DESIGN FLOW

SCALE 100 0 100 200 FEET
VERTICAL SCALE

SCALE 4000 0 4000 8000 FEET
HORIZONTAL SCALE

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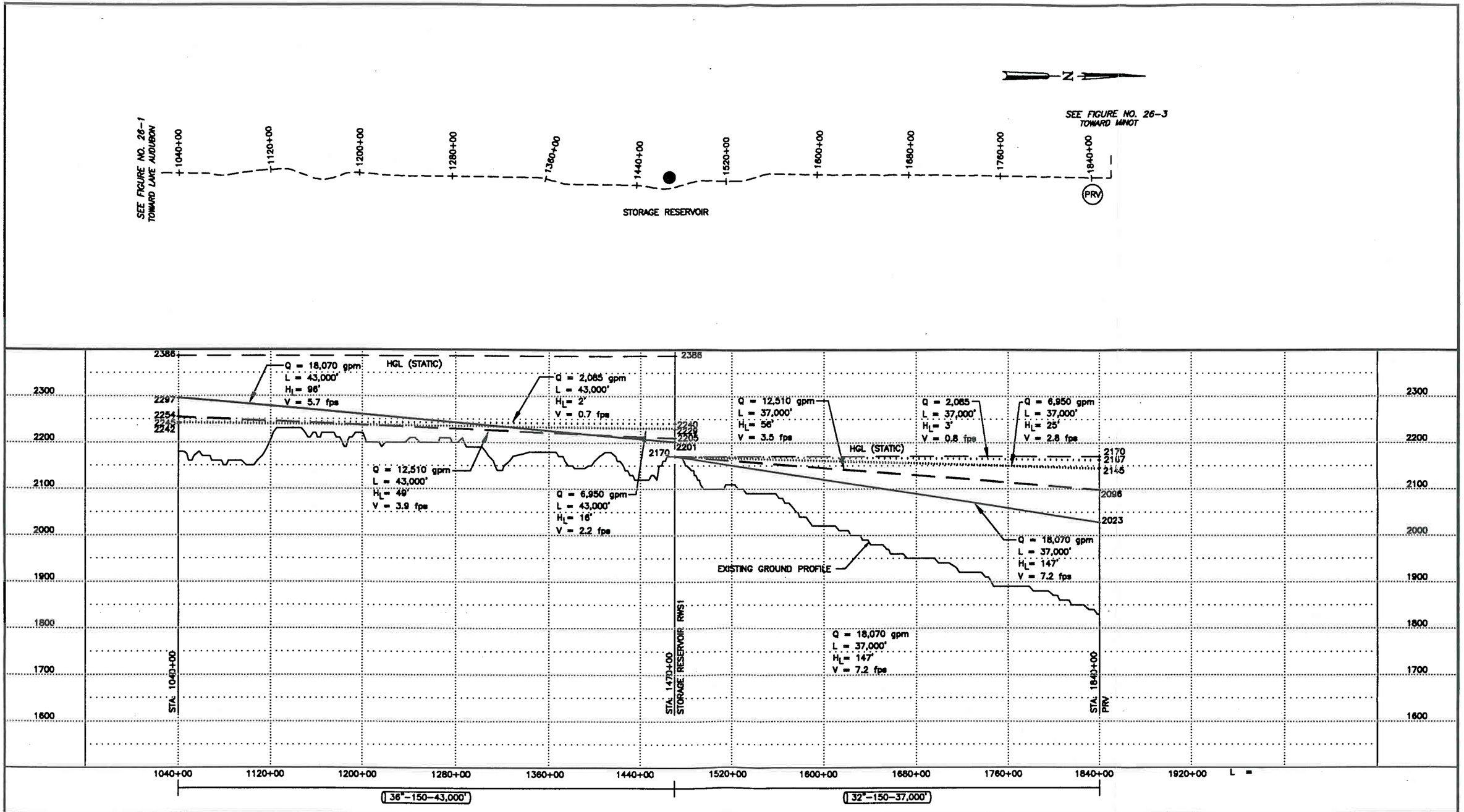
MONTGOMERY WATSON

PIPELINE PLAN AND PROFILE
-EAST SYSTEM-

3, 10, 18, and 26 MGD

FIGURE 2-6 SHEET 1

NORTH DAKOTA STATE WATER COMMISSION
AND
GARRISON DIVERSION CONSERVANCY DISTRICT



LEGEND

PIPE DIA.-CLASS-LENGTH

△ PUMP STATION

● STORAGE RESERVOIR

TREATED WATER LINE:
IN PLAN & PROFILE ———
IN PLAN VIEW ONLY ———

RAW WATER LINE:
IN PLAN & PROFILE — — —
IN PLAN VIEW ONLY — — —

Q = FLOW (IN GPM)
H_L = HEAD LOSS
L = LENGTH
V = VELOCITY
HGL = HYDRAULIC GRADE LINE – DESIGN FLOW
PRV = PRESSURE REDUCING VALVE

SCALE 100 0 100 200 FEET
VERTICAL SCALE

SCALE 4000 0 4000 8000 FEET
HORIZONTAL SCALE

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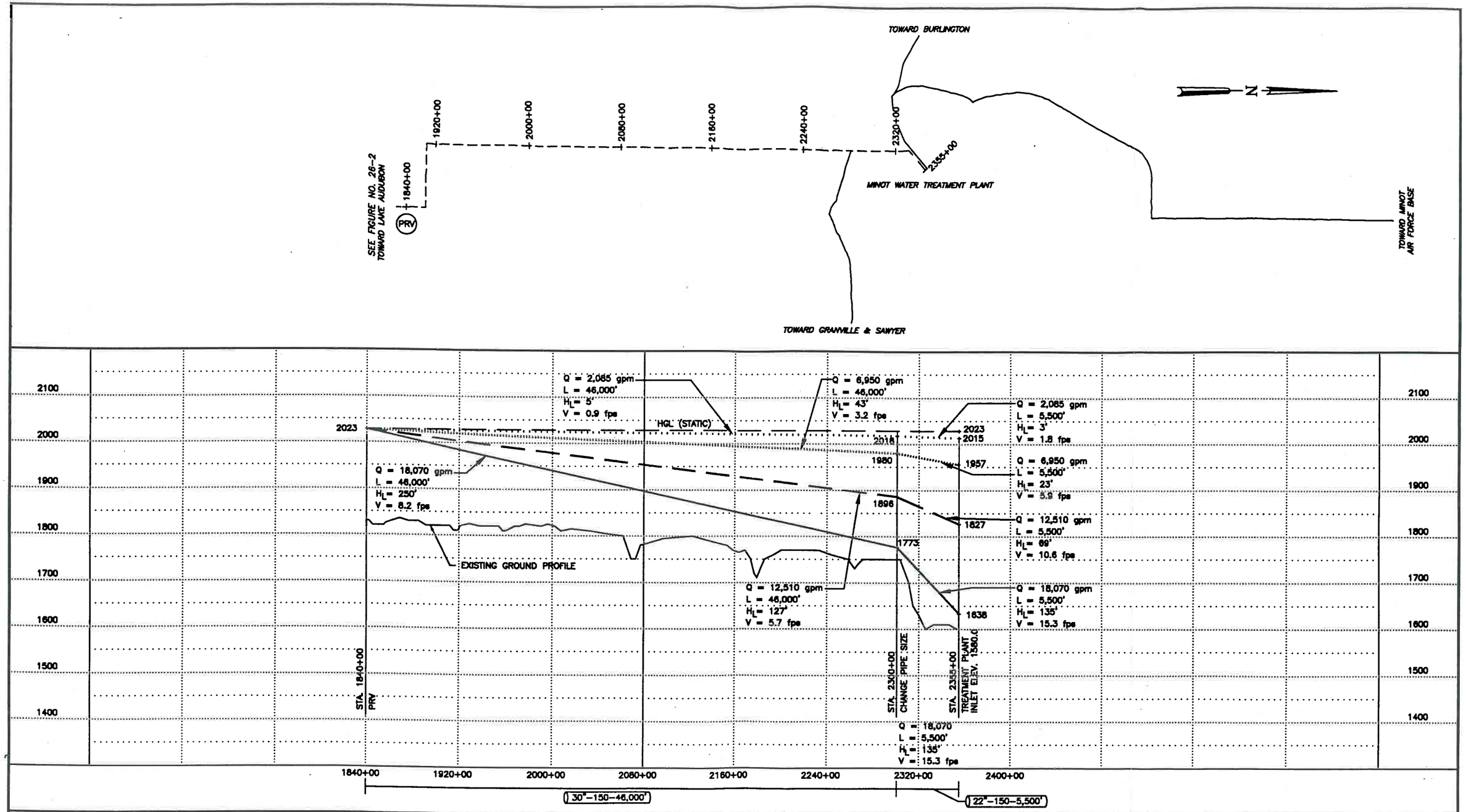
PIPELINE PLAN AND PROFILE
-EAST SYSTEM-

3, 10, 18, and 26 MGD

FIGURE 2-6 SHEET 2

NORTH DAKOTA STATE WATER COMMISSION
AND
GARRISON DIVERSION CONSERVANCY DISTRICT



LEGEND

PIPE DIA.-CLASS-LENGTH

△ PUMP STATION

● STORAGE RESERVOIR

TREATED WATER LINE:
IN PLAN & PROFILE ———
IN PLAN VIEW ONLY ———

RAW WATER LINE:
IN PLAN & PROFILE — — —
IN PLAN VIEW ONLY — — —

Q = FLOW (IN GPM)
H_L = HEAD LOSS
L = LENGTH
V = VELOCITY
HGL = HYDRAULIC GRADE LINE – DESIGN FLOW
PRV = PRESSURE REDUCING VALVE

SCALE 100 0 100 200 FEET
VERTICAL SCALE

SCALE 4000 0 4000 8000 FEET
HORIZONTAL SCALE

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PIPELINE PLAN AND PROFILE
–EAST SYSTEM–

3, 10, 18, and 26 MGD

FIGURE 2-6 SHEET 3

NORTH DAKOTA STATE WATER COMMISSION
AND
GARRISON DIVERSION CONSERVANCY DISTRICT

The pipeline will be structurally designed to withstand the lateral earth loads, pipe loads, working pressure, and transient pressure on the pipe.

Pipeline Materials. Pipe materials considered for this portion of the NAWS pipeline include steel and ductile iron. Steel pipe will be manufactured in accordance with AWWA C200 to accommodate the various diameter and pressure class requirements to be used on the pretreated water pipeline from the intake to the Minot WTP. Minimum wall thickness will be 0.135 inches. Ductile iron pipe (DIP) will be manufactured in accordance with AWWA C151.

Coatings. Exterior coating for steel pipe will be an 80-ml cold-applied plastic tape. The type of exterior coating for DIP will be developed once the corrosion study is completed. Dielectric bonding will be used if cathodic protection is required. Design of the piping systems will be developed to provide equivalent service and corrosion protection for each type of pipe.

Lining. An interior cement mortar lining will be required for both steel and DIP. Lining thickness will be determined by AWWA C205 for steel and AWWA C104 for DIP.

Joints. Non-restrained joints for steel and DIP will be push-on gasketed bell and spigot joints. Restrained joints will be utilized where required for thrust restraint or where structural integrity is needed such as at stream crossings. Steel pipe restrained joints will be welded lap joints. Buttstrap closures may be required at cased roadway and railroad crossings. DIP can be furnished with a proprietary restrained system.

Corrosion Control Measures. Corrosion evaluation and mitigation measures will be developed in the corrosion study. The corrosion mitigating methods to be developed include: bonded dielectric pipe coatings, joint bonds, insulated joints, and cathodic protection systems. At this point in the design process it is expected that an impressed current cathodic protection system will be used.

Construction Methods. Pipeline installation will generally be by conventional cut and cover methods. Push-on or welded pipe joint construction will require pipe to be laid one length at a time. The joint sections will be left uncovered for taping, placement of joint bonds, or welding where required. Maximum open trench will generally be limited to 2,000 linear feet, unless local authority or physical conditions require otherwise.

Roadway and railroad crossings that cannot be crossed by open-cut methods will require casing pipe installation by boring, jacking, or tunneling methods.

Depth

The project will be required to meet State of North Dakota Health Department guidelines for domestic water system depth of bury requirements. The requirement is a depth of bury of 7.0 feet to 7.5 feet.

The Project Team has identified several issues which distinguish differences between distribution systems and pretreated water transmission systems. A review of arctic

engineering practices regarding raw (pretreated) transmission systems and the Project Team's construction experience may show the feasibility of reducing the minimum bury depth without impacting frost depth concerns.
Documentation will be developed to support the consideration of utilizing a minimum bury of 5 feet depth. Latent heat energy calculations and frost bubble development data will be included in the documentation.
The potential benefit of being able to utilize a wider construction depth window would be the possible reduction in the number of air vacuum/air release valves and blow-offs required by being able to build longer transitions relative to surface topography features.

Backfill

Pipe zone bedding and backfill will use imported sand or small aggegate material. Pipe zone dimensions extend from 6 inches below the pipe to a minimum of 6 inches above the pipe. Excavated materials may be used for backfill above the pipe zone providing they consist of suitable material.

Testing

The purpose of pipeline hydrostatic field tests is to determine the adequacy of the field joints.

Gasketed pipe joints are subjected to a test pressure (based on the lowest elevation in the test section) of 133 percent of the pipe pressure class. The test pressure is held for a four-hour period. The allowable leakage test for rubber gasketed joint pipe in 40-foot or greater lengths between joints is 10 gallons per inch of diameter per mile per 24 hours.

Hydrostatic tests on DIP joints will be performed in accordance with AWWA C600.

Signage. Pipeline appurtenance facilities will be identified by steel marker posts. Marker post location will either be centerline of pipeline or at offsets indicated on the posts, where required, depending on land use at the particular location. Pipeline centerline will be monumented with marker posts at 1/2-mile intervals and at alignment changes. Where there may be potential for construction activities near the pipeline, the signage spacing will be reduced.

Locator Tape. Pipelines located in urban areas will have locatable plastic tape placed in the backfill over the pipe centerline.

Pipeline Appurtenant Facilities

This section describes pipeline appurtenances, configuration, and selected design criteria that will be utilized during design of the NAWS facilities.

Air-Vacuum/Air Release Valves. Air vacuum and air release valves are required on a pipeline to prevent collapse of the pipe when the line is drained and to release air that accumulates in the line during filling. Air vacuum valves are also located at points along the pipeline where the

surge evaluations indicate maximum negative pressure will occur. All air vacuum /air release valves will be contained within vault structures.

Location

Combination air-vacuum/air-release valves will be installed at all defined high points along the pipeline profile, on the downhill side of all mainline valves, on the uphill side of mainline valves located at high points, at 1/2 to one mile intervals on long horizontal runs lacking a clearly defined high point, and at locations required for surge control.

Equipment

Combination valves have a large orifice which will vent air from the pipeline during pipeline filling and admit air during draining operations to avoid negative internal pressures which could damage the pipeline. Air-vacuum/air-release valves will be equipped with isolation valves and screened standpipe(s). All valve bodies should be ductile iron.

For vacuum relief during pipe draining, the valve will be sized on the full pipeline design flow and a 5-psi allowable differential pressure. For air venting during pipeline filling, a flow corresponding to a filling rate of 1 foot/second and an allowable differential pressure of 2 psi will be used.

Smaller air release valves will be provided at high points and at sudden changes in slopes to release air accumulated during normal system operation. The size of small diameter air release valves will be based on 2.0 percent of the design flow and the system pressure.

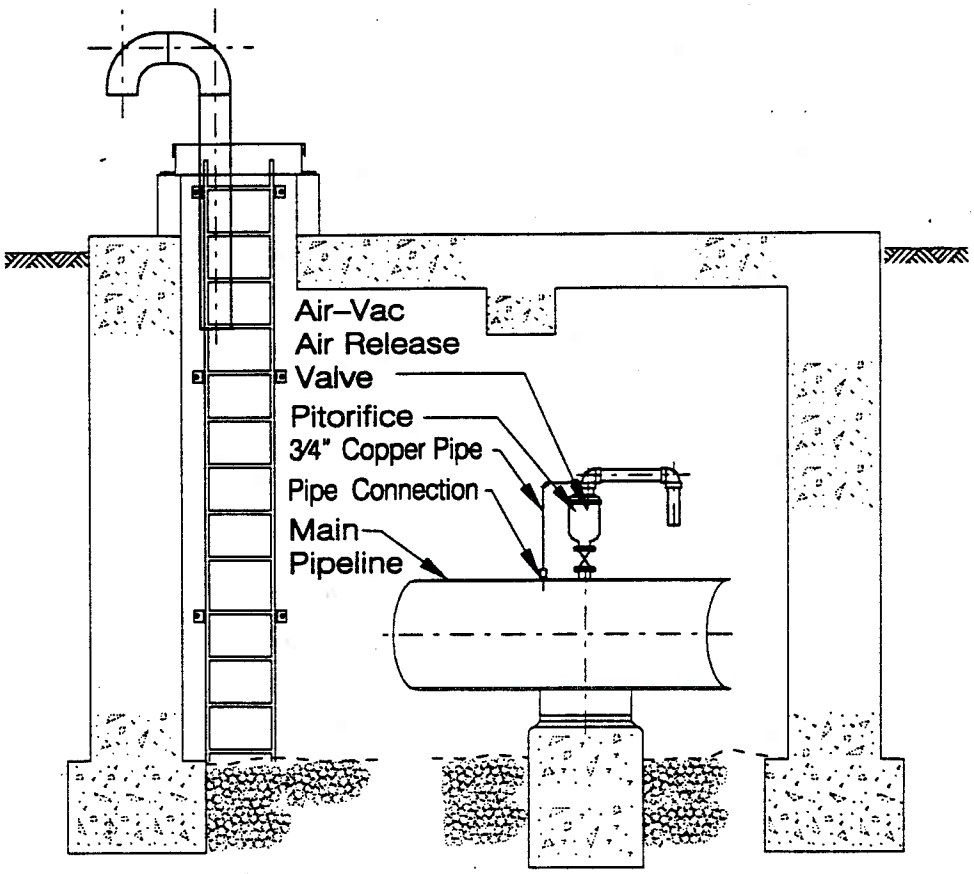
Vault Configuration

The vaults will be accessible from the top with the floor constructed of gravel. Figure 2-7 shows a typical buried air vacuum/air release valve configuration. Cold weather protection will be provided in the vaults.

Cold Weather Design

Several alternatives are being investigated to determine the best method to prevent freezing of these valves and associated piping. One alternative is to run a bleeder line from the pipeline to the main body of the valve to keep a continuous flow of water through the valve. This alternative is shown in Figure 2-7. Other alternatives include methods to generate heat in the vaults. Alternatives being considered include heat generation by solar power, wind, and geothermal. Where power is readily available along the pipeline route, the vault may be wired for heaters or heat tracing.

Blowoffs. Blowoff piping will be provided to facilitate intentional or scheduled dewatering of pipeline segments for maintenance and repairs. All blowoff water will have been pretreated (3-log *Giardia* and 4-log virus inactivation).



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Air–Vac Air Release Valve in Vault

Figure 2–7

Location

Blowoffs will generally be installed at low points in the pipeline profile and on the uphill sides of mainline valves.

Configuration

The blowoff valves will be buried with a connection to the lowest point on the pipeline to permit complete pipeline water evacuation. A standpipe to the surface will be provided for installation of a submersible pump. The pump will be used to assist the evacuation of water through the blowoff. Figure 2-8 shows a typical buried blowoff valve assembly.

Volumes

The largest volume of water that will need to be drained from a blowoff in the Hudson Bay basin is approximately 300,000 gallons. A significant portion of the pipeline volume can be drained through the Minot WTP if the pipeline needs to be taken out of service.

Disposal

Where possible, water from blowoffs will be drained to natural ground. An energy dissipater will be provided where pipeline drainage may cause erosion. Water will be directed from the blowoff to appropriate drainage facilities. The water that is drained through the blowoff will be land applied in such a manner so that it is allowed to infiltrate in to the soil. If it is not possible to dispose of the water from the blowoff valves in this manner, containment structures could be constructed on an as needed basis, or tanker trucks could be used to haul the water to an appropriate location. Water from the blowoff valves will not be allowed to enter the Souris River via surface runoff.

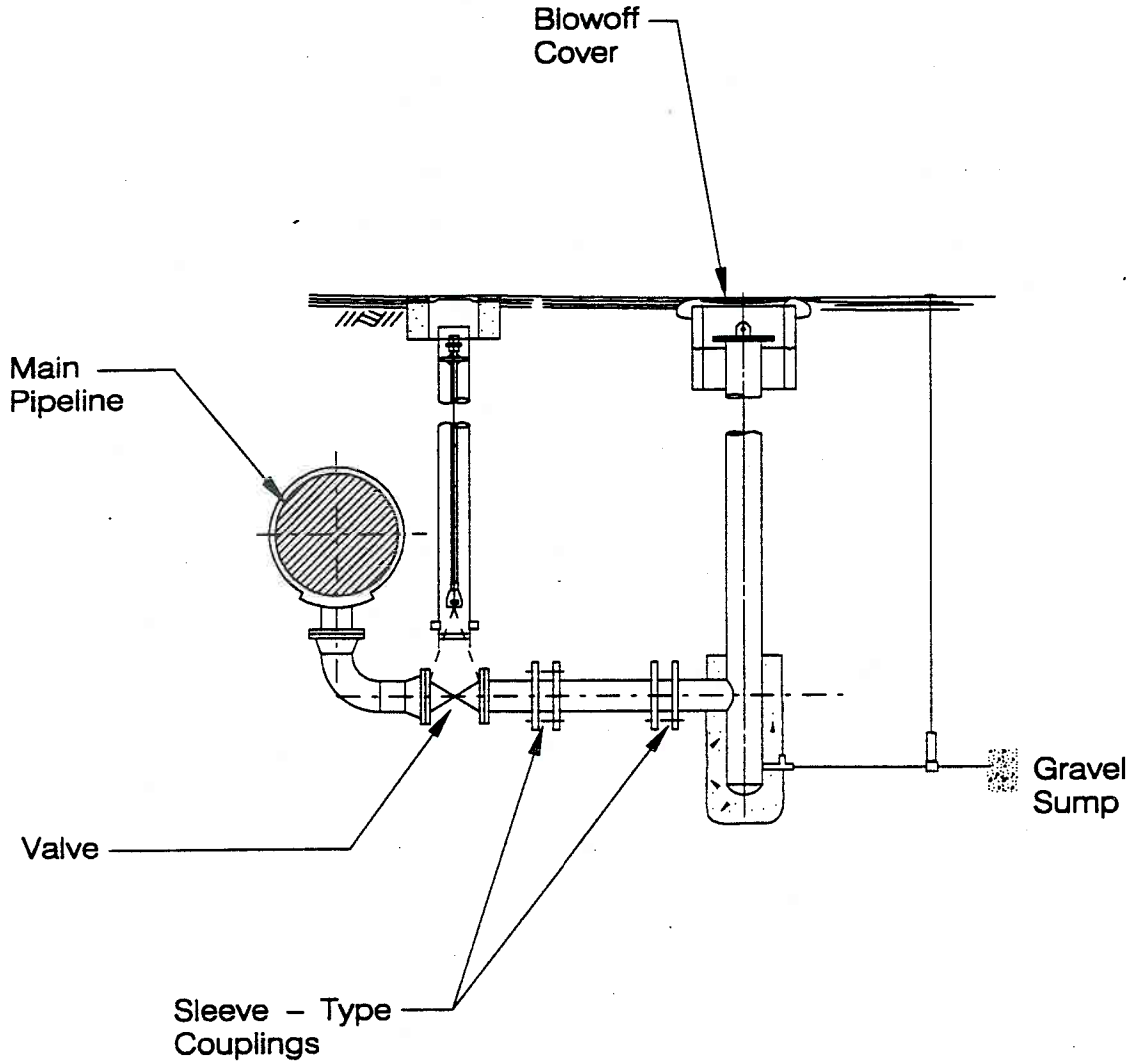
Mainline Isolation Valves. Mainline isolation valves will be located and used to provide a means to isolate the major facilities along the pipeline and thus provide isolated pipeline segments.

Location

Mainline isolation valves will be used at the major facilities. Isolation valves will be added to other areas along the pipeline if it is determined during the design phase that they are required. With isolation valves at the pretreated water storage reservoir and at the PRV station, the pipeline in the Hudson Bay drainage would have three isolated segments.

Valve Criteria/Equipment

Butterfly valves or other slow closing valves such as gate valves are suitable for use as isolation valves. The mainline isolation valves will be placed in vaults with cold weather



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Typical Blowoff Assembly

Figure 2–8

protection to prevent freezing. The valves will be designed to minimize hydraulic transients, and will include a bypass valve leg, if necessary. Valve selection will consider the need for pipeline cleaning equipment and access for valve maintenance. Isolation valves at the major structures on the pipeline will be motor operated valves. Other mainline isolation valves may be manual valves or motor operated valves depending on the location and need. This will be addressed during the final hydraulic analysis and design efforts.

Vault Configuration

The mainline isolation valves will be located in insulated vaults with gravel bases and top access. Figure 2-9 shows a typical mainline isolation valve and vault. Where valves are integrated into other structures, the valve will be located in that structure or provided in a vault outside the structure.

Control

Motor operated valves will be monitored and controlled through the SCADA system. Where valves are part of the emergency/fail safe system, the valves will be equipped with hard wire contacts to automatically close on alarm signal set-points.

Pipeline Access Ports. Buried access ports will be provided along the pipeline to accommodate initial construction, interior inspection, and maintenance.

Location/Spacing

Buried access ports should be located at a maximum spacing of one half mile. Where welded joints are necessary, access ports with pass holes should be located at a spacing of 400 to 500 feet.

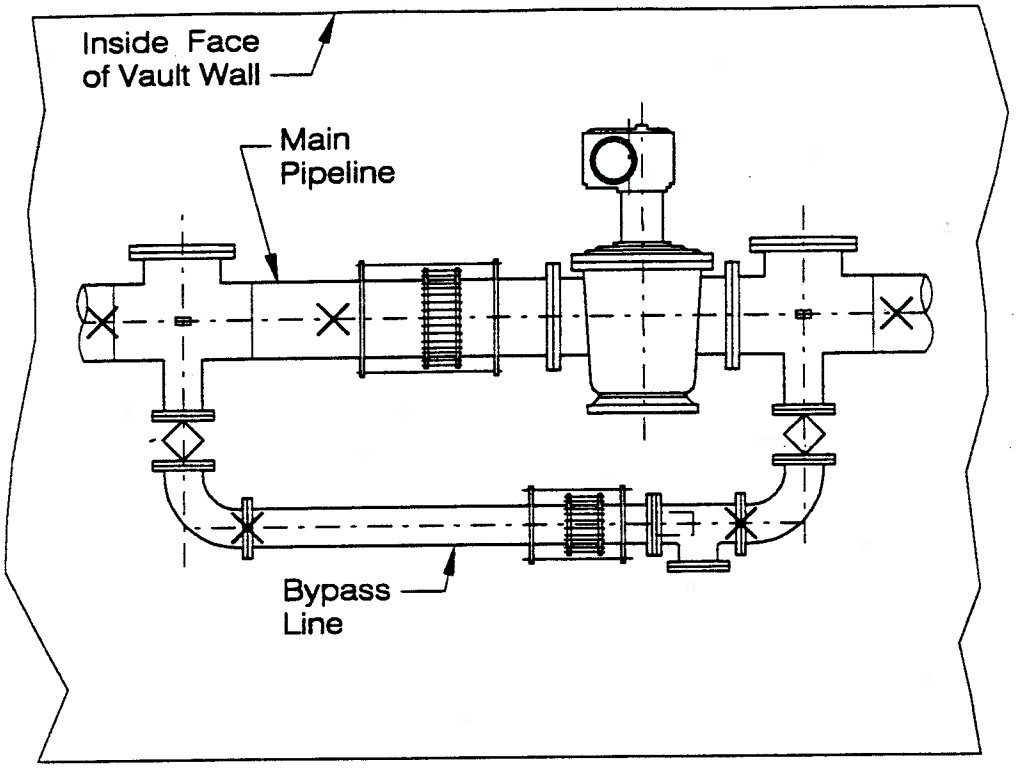
Configuration

Buried access ports will typically consist of a 24-inch diameter side outlet and blind flange and will be marked with a steel post. However, top entry access ports are required when placed at large air vacuum/air release valve vaults.

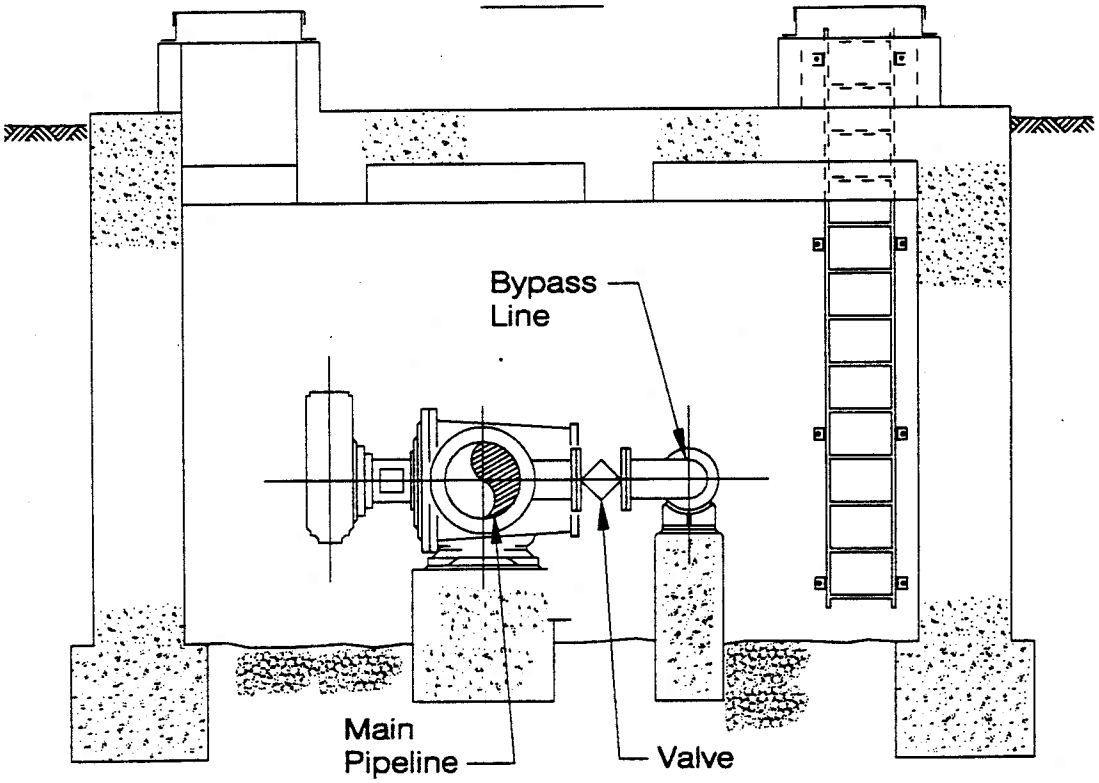
Pipeline Monitoring and Control. The pipeline will be designed to include instrumentation and equipment that will monitor operating conditions and have the ability to shut down sections of the system in both routine and emergency situations.

Flow Control

The pipeline will use flow meters, level indicator transmitters, and pressure transmitters to monitor the status of pipeline operation. This equipment will be used to monitor conditions and compare them to design conditions and readings at other locations along the pipeline. Any discrepancies between expected and measured readings will signal an



Plan



Section

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Typical Isolation Valve in Vault

Figure 2–9

alarm and a program that can initiate a sequence of events to shut down sections of the system.

Operational Monitoring

The pipeline will be inspected regularly to insure structural integrity. The operator inspecting the pipeline will check for corrosion, signs of leakage, and any visual indicators of structural problems. Monitoring of the corrosion system will also be performed on a routine basis to insure that the system is operating within design specifications.

Section 3

HOUSTON ENGINEERING
MONTGOMERY WATSON
AMERICAN ENGINEERING

SECTION 3

MONITORING PROGRAMS

GENERAL

The objective of the NAWS Project is to provide a safe, reliable, and aesthetically acceptable water supply to consumers of the NAWS water service area while minimizing both delivered cost to the consumers and the risk of biota transfer from the Missouri River drainage basin to the Hudson Bay drainage basin. The required water quality is measured against the standards set by state and federal governments which regulate drinking water quality, specifically the EPA and the North Dakota Department of Health (NDDH).

WATER QUALITY MONITORING PROGRAM

Introduction

The development of a Long Term Water Quality Monitoring Program and Special Water Quality Monitoring Program has been completed by the NDSWC. The monitoring program plan consists of the following elements:

- Program Objectives
- Sample Site Selection
- Sample Depths
- Sample Frequency and Collection
- Analytical Laboratory Selection
- Data Compilation and Reporting

The water quality programs will be carried out at the potential water intake sites on Lake Audubon and Lake Sakakawea to meet the following objectives:

- To better understand the implications of the raw water source selection on the operation and control of the pretreatment disinfection facilities. Key constituents include turbidity, temperature, and pH, for which a long-term database is desired

- To document water quality differences between Lake Sakakawea and Lake Audubon to assess if the differences warrant selection of one source over the other for the intake site

- To document seasonal water quality constituents and concentrations which may influence water treatment process selection, operation, and control at the Minot WTP to meet the requirements of the SDWA

The first water quality-sampling event for the long-term monitoring program occurred on August 5, 1997 while the first sampling event for the special monitoring program occurred on September 2, 1997.

Sample collection and analytical procedures for both the long term and the special water quality monitoring programs have been established through the joint efforts and a cooperative agreement between the NDSWC and the United States Geological Survey (USGS) office in Bismarck, North Dakota.

Existing Raw Water Quality Data, Lake Audubon and Lake Sakakawea

The Minot WTP will be supplied with pretreated water from either Lake Audubon or Lake Sakakawea. Both lakes are derived from the Missouri River and have superior water quality compared to either the Souris River or available groundwater sources in the Minot area. Sources for the existing raw water quality data utilized in the NAWS Pre-Final Design Report include the Northwest Area Water Supply Study (1988), the Bureau of Reclamation's quarterly sampling reports, and sampling efforts by the U.S. Army Corps of Engineers.

Generally, the waters of the Missouri River in the area of Lake Sakakawea have been characterized as good quality; hard with a high, but acceptable dissolved mineral concentration; and relatively high in sodium and sulfates. Lake Sakakawea has been classified as oligotrophic, while Lake Audubon may be classified somewhere between oligotrophic and mesotrophic. Both lakes develop algae blooms throughout the warmer months, but algae levels are low. The productivity of Lake Audubon is higher than Lake Sakakawea. Total dissolved solids (TDS) levels in Lake Sakakawea water typically range from 330 to 540 mg/l. In comparison, Lake Audubon water TDS levels have a higher range, yet still are at levels below concern. Sodium levels for Lake Audubon range from 97 to 107 mg/l and hardness is relatively high ranging from about 240 to 320 mg/l. Iron and manganese levels for both Lake Audubon and Lake Sakakawea have been very low in the past.

Testing for total organic carbon (TOC) from the 1995 Challenge Study showed concentrations ranging from 5.3 to 6.4 mg/l on Lake Audubon and from 3.6 to 4.2 mg/l for Lake Sakakawea, based on five different samples during 1994-1995. However, some historical samples of Lake Sakakawea taken at the Garrison Dam have shown much higher TOC concentrations (up to 9 mg/l). It is likely that similar high concentrations have been reached in Lake Audubon as well because its water supply is taken from Lake Sakakawea.

Table 3-1 summarizes some general raw water quality parameters from both Lake Sakakawea and Lake Audubon and contrasts this data with the SDWA standards.

Lake Audubon Water Quality Evaluation

The initial phase of the Water Quality Monitoring Program provided a characterization of Lake Audubon water quality. The analyses of enteric viruses, *Giardia/Cryptosporidium*, and coliform were not included in this characterization.

TABLE 3-1

GENERAL WATER QUALITY PARAMETERS FOR LAKE AUDUBON AND LAKE SAKAKAWEA[a]

Water Quality Parameter	Units	Lake Audubon	Lake Sakakawea @ Garrison Dam	Federal MCL[b]
TDS	mg/l	535 - 873	330 - 540	500[c]
Sodium	mg/l	97 - 107	48 - 82	ne[d]
Calcium	mg/l	42 - 47	47 - 65	ne
Magnesium	mg/l	24 - 36	12 - 28	ne
Chloride	mg/l	16 - 17	3.8 - 14	250
Sulfate	mg/l	200 - 374	120 - 250	250[c]
Nitrate (as N)	mg/l	0.025 - 0.04		10
TOC[g]	mg/l	5.3 - 6.4	3.6 - 4.2	ne[e]
UV-254nm Absorb.[g]	(unfiltered)	.085 - 0.10	0.086 - 0.097	ne[d]
pH	---	8.1 - 8.8	6.5 - 8.5	6.5 - 8.5[c]
Alkalinity, as $CaCO_3$	mg/l	184 - 212	140 - 276	ne
Hardness, as $CaCO_3$	mg/l	257 - 321	170 - 260	ne
Turbidity	NTU	2 - 7	.2 - 10	0.5[f]
Temperature	°C	1.6 - 25.3		ne
Field Conductivity	mhos/cm	869 - 1001	500 - 810	ne

Notes:
a) Water quality data collected by U.S. Bureau of Reclamation, U.S. Army Corp. of Engineers, and Montgomery Watson.
b) Maximum Contaminant Level.
c) Non-enforceable, secondary standard.
d) Non-existent.
e) Conventional treatment plants will be required to achieve certain percent reductions under the proposed D/DBP Rule.
f) Treatment technique based on a filtered water turbidity in 95 percent of the measurements taken each month.
g) Water quality data taken from the December, 1995 Chloramine Challenge Study

The Lake Audubon water quality characterization study was conducted to identify potential contaminants and constituents which are of concern for pretreatment and water treatment process operations or which would warrant further evaluation in the long-term monitoring program.

Sample Location and Parameters. Lake Audubon was selected for this analysis because this body of water is generally regarded as being of slightly lower water quality than Lake Sakakawea. If water quality issues are identified in Lake Audubon, it is assumed that these will represent worst-case conditions, and would serve to establish water treatment operational criteria.

Sampling of the water from Lake Audubon occurred on October 29, 1996. Samples were taken near the proposed NAWS intake/pump station on the Snake Creek Embankment at the Snake Creek Pumping Plant discharge channel. The water samples were taken at elevation 1830 msl or at a water depth of about 15 feet.

Samples were placed in pre-prepared sample bottles, cooled and shipped overnight to Montgomery Watson Laboratories in Pasadena, California.

The sample analysis included the following general categories:

- Inorganic Analysis
  - Asbestos
  - Metals
  - General Minerals
  - NH_3, TKN, T-P
  - Bromide

- Organic Analysis
  - VOCs
  - SOCs
  - Pesticides
  - N/P Pesticides
  - Herbicides
  - Carbonates
  - Diquat
  - Glyphosate
  - Endothall
  - EDB/DBCP

- Disinfection By-Products
  - THM Formation Potential
  - HAA Formation Potential

- Radiological Analysis
  - Gross Alpha/Beta

- Other Analysis
  - Color
  - Odor
  - Turbidity
  - Oil & Grease
  - Phenol
  - TOC
  - Cyanide

Monitoring Results

The monitoring results for those constituents above the minimum detection level (MDL) of the test methods are summarized in Table 3-2. The results did not indicate any major issues or vary appreciably from previous limited sample results (Northwest Area Water Supply Project - Chloramine Challenge Study Final Report, December 1995 and the Northwest Area Water Supply Project Final Report - Pre-Final Design, June 1995).

Water Quality Issues. A discussion of the significance of several of the constituents analyzed in the monitoring program is presented in the following paragraphs. This discussion focuses primarily on those parameters in the raw water that may influence water treatment operations or influence the final users' aesthetic perception of the finished water.

The raw water exceeds proposed Federal drinking water standards or secondary standards for only five constituents, as shown in Table 3-3. The primary concern is total potential trihalomethanes at 216 µg/l. This disinfection by-product (DBP) of chlorination will require control of the disinfection process to hold the formation below the anticipated Stage I maximum contaminant level (MCL) of 80 µg/l. Future regulations under Stage II will possibly establish the MCL at 40µg/l. This is achievable as was demonstrated in the Chloramine Challenge Study.

Total potential haloacetic acids are just slightly above the Stage I MCL of 60 µg/l. The potential Stage II MCL is 30µg/l. Sulfates and total dissolved solids are just slightly above the secondary standard of 250 mg/l and 500 mg/l, respectively.

The turbidity of the Lake Audubon water at the time of sampling was 2.0 NTU. All other parameters were either near or below drinking water standards.

Treatment Issues

Several parameters may influence treatment operations and chemical use at the Minot WTP. The principal parameter is TOC with measurements of 5.3 to 6.4 mg/l for Lake Audubon. At levels above 2.0 mg/l, the treatment operations will be required to practice enhanced coagulation.

Bromide at 0.095 mg/l is near the threshold limit (depending upon pH) at which possible concerns could arise if ozone is used as a primary disinfectant. However, the Chloramine Challenge Study reported bromide levels at 0.10 mg/l and ozonation by-products below Federal MCLs. Under Stage I of the proposed DBP Rule, bromate will be regulated at 10 µg/l.

General Conclusions

The general water quality of Lake Audubon is good and represents a treatable source of water supply for the NAWS Project. With hardness at 264 mg/l, sodium at 110 mg/l, total dissolved solids at 530 mg/l and sulfate at 255 mg/l, the untreated raw water supply exceeds the quality of the existing groundwater supplies in the project area.

TABLE 3-2

LAKE AUDUBON
RAW WATER SAMPLE RESULTS

Contaminants	Units	Raw Lake Audubon
Alkalinity	mg/l	205
Anion Sum	meq/l	9.78
Bromide	mg/l	0.095
Calcium	mg/l	45
Cation Sum	meq/l	10.2
Chloride	mg/l	12
Free CO_2	mg/l	1.25
Carbonate	mg/l	6.42
Apparent Color	ACU	3
Specific Conductance	µmho/cm	865
Flouride	mg/l	0.64
Hardness	mg/l	264
Bicarbonate	mg/l	248
Potassium	mg/l	6.1
Langelier Index	None	1.2
Surfactants	mg/l	0.15
Magnesium	mg/l	37
Sodium	mg/l	110
Odor	TON	2
Hydroxide	mg/l	0.068
Lab pH	units	8.6
pH of $CaCO_3$ Saturation (25°C)	units	7.4
pH of $CaCO_3$ Saturation (60°C)	units	7.0
Sulfate	mg/l	255
Total Dissolved Solids	mg/l	530
Total Organic Carbon	mg/l	5.9
Turbidity	NTU	2.0
Semivolatiles		
Di-n-Butylphthalate	µg/l	0.6
Gross Alpha and Beta Radiation		
Alpha, Gross	pCi/l	2.5
Alpha, Two Sigma Error	pCi/l	2.3
Alpha, Min Detectable Activity	pCi/l	2.5
Beta, Gross	pCi/l	2.8
Beta, Two Sigma Error	pCi/l	1.8
Beta, Min Detectable Activity	pCi/l	2.1

TABLE 3-2 (Continued)

LAKE AUDUBON
RAW WATER SAMPLE RESULTS

Contaminants	Units	Raw Lake Audubon
Herbicides		
2,4-D	µg/l	0.10
Inorganics		
Arsenic	µg/l	3.0
Barium	µg/l	80
Cadmium	µg/l	0.64
Copper	µg/l	6.8
Iron	µg/l	67
Manganese	µg/l	5.6
Lead	µg/l	6.9
Zinc	µg/l	15
Trihalomethanes		
Bromoform	µg/l	2.2
Chloroform	µg/l	142
Dibromochloromethane	µg/l	23.0
Bromodichloromethane	µg/l	48.6
Total Trihalomethanes	µg/l	216
Haloacetic		
Bromochloroacetic acid	µg/l	19
Bromodichloroacetic acid	µg/l	10
Chlorodibromomacetic acid	µg/l	3
Dibromoacetic acid	µg/l	5
Dichloroacetic acid	µg/l	42
Monobromoacetic acid	µg/l	2
Tribromoacetic acid	µg/l	2
Trichloroacetic acid	µg/l	20
D/DBP Haloacetic Acids	µg/l	69
Volatile Organic Compounds		
m+p-Xylenes	µg/l	0.5

TABLE 3-3

LAKE AUDUBON
CONTAMINANTS ABOVE REGULATORY LEVELS

Contaminant	Units	Federal Drinking Water MCL[1]	Secondary Standard	Raw Lake Audubon
Total Trihalomethanes	µg/l	80[2]	-	216[4]
Total Haloacetic Acids	µg/l	60[2]	-	69[4]
Sulfate	mg/l	500	250	255
Total Dissolved Solids	mg/l	-	500	530
Turbidity	NTU	PS[3]	-	2.0

Notes:
1. MCL = maximum contaminant level
2. Stage 1 MCL.
3. PS = performance standard. For turbidity means less than 0.5 NTU 95% of the time and never greater than 5.0 NTU.
4. Concentrations are total "potential" values.

The Lake Audubon water quality characterization results did not reveal parameters which should be included in the long-term monitoring program beyond the following minimum list of constituents:

- Turbidity
- pH
- Temperature
- TOC
- Alkalinity
- Hardness
- TDS
- Sodium
- Sulfate

Under the proposed Special Sampling Program to characterize particular water quality issues, it is proposed to remove taste, odor and color from the sampling program based on the results of this program, especially in light of the selection of ozone as the pretreatment disinfectant. Therefore, the list of parameters to be included in the Special Sampling Program will include:

- Algae

- Heterotrophic Plate Counts (HPC)
- UV-254 Absorbance
- Particle Counts

Long Term Water Quality Monitoring Program

Program Objectives. The development of a Long Term Water Quality Monitoring Program is recommended to achieve two primary objectives. First, the JTC has requested the development of a long-term record of water quality constituents which may affect disinfection effectiveness. Second, it is desirable to begin to develop a long-term record of water quality parameters which may influence water treatment process selection required to meet the requirements of the SDWA.

The present list of water quality parameters to be measured in both Lake Audubon and Lake Sakakawea in the Long Term Water Quality Monitoring Program include:

- Turbidity (NTU)
- pH
- Temperature (°C)
- TOC (mg/l)
- TDS (mg/l)
- Total Alkalinity (mg/l as CaCO3)
- Hardness (mg/l)
- Calcium (mg/l as CaCO3)
- Magnesium (mg/l as CaCO3)
- Chloride (mg/l)
- Sodium (mg/l)
- Sulfate (mg/l)

USGS Vertical Column Profile. Independent of the long term monitoring parameters, the USGS will perform field measurements of the following parameters at approximate one meter vertical intervals (from the water surface to the lake bottom) at each sampling site:

- Temperature (°F or °C)
- Specific Conductance (µmhos/cm)
- pH
- Dissolved Oxygen (mg/l)

These parameters will be field measured by the USGS at each sampling site for each sampling event.

Sample Site Selection. The possibility of obtaining more seasonally stable, higher quality water from deep water on both Lake Audubon and Lake Sakakawea prompted the identification of potential deep water intake sites on both lakes. Lake bottom topographic surveys were carried out on each lake in 1996 and 1997 to help identify potential deep-water intake sites. The main

deep water area in Lake Audubon lies approximately 1,600 feet to the south of the Snake Creek Pumping Plant discharge channel.

In this vicinity, the deepest location on Lake Audubon was found by the USGS during their Sept. 2, 1997 sampling date by use of a sonic depth sounder. The Lake Audubon sampling site is approximately 53.5 feet deep (bottom elevation 1793.0 msl), with a water surface elevation of 1846.41, at latitude 47° 36' 29" and longitude 101° 15' 41". A sampling site almost due west was selected on Lake Sakakawea with a lake depth of approximately 72.5 feet deep (bottom elevation 1776.9) at water surface elevation of 1849.4 msl The site has a latitude of 47° 36' 33" and a longitude of 101° 16' 14".

Sample Depths. For the Long Term Monitoring Program, all ion and nutrient parameters are being discretely sampled, at the following depths:

1) A surface sample within 0.5 meters of the surface,

2) A bottom sample within 0.5 meters of the lake bottom,

3) If a thermocline exists, then an additional sample is taken at the top of the thermocline.

4) If a thermocline bottom is found before reaching the bottom of the lake, then an additional sample is taken at the bottom of the thermocline.

Sample Frequency and Collection. During the facilities design stage, monthly discrete sampling and analysis of the listed long-term water quality parameters will be taken. Once permanent pretreatment facilities are constructed and put into operation, continuous monitoring of some parameters such as turbidity, temperature, and pH will be performed at the intake. Other parameters affecting the Minot WTP process operation will be monitored at the plant.

Discrete monthly sampling for both lakes is being carried out on the same day, weather permitting. The USGS will collect monthly samples on both Lake Audubon and Lake Sakakawea for the indicated water quality parameters, at the sample site locations described above. All samples are currently being collected with a three liter volume, Kemmer bottle sampler. Future samples will be collected with a new three-liter, alpha bottle sampler device.

Analytical Laboratory Selection. The USGS is utilizing their own national analytical laboratory located in Denver, Colorado for analyses of all of the indicated parameters in the long term monitoring program.

Data Compilation and Reporting. Data compilation will be mostly performed by the USGS with all results forwarded to the NAWS Project team. A letter report will be prepared on a six-month schedule summarizing all water quality results analyzed during the preceding period. All of the long-term water quality parameters from each lake will be summarized and compared in terms of their maximum concentration, average concentration, and minimum concentration.

Results to Date. To date, no results have been received from the USGS with respect to the eleven water quality parameters listed for long term monitoring on each lake. However, water quality results have been obtained from the field measurements of the vertical column profiles and are shown in Tables 3-4 and 3-5. Figures 3-1 and 3-2 illustrate the results.

For Lake Audubon, the specific conductance was virtually constant with depth at a value of 870-880 µmhos/cm on 8/05/97, a value of 910 µmhos/cm on 9/02/97, and a value of 925-935 µmhos/cm on 9/24/97. pH also was relatively constant on all dates with depth varying from about 8.1 to 8.3.

No Lake Sakakawea samples were collected on the 8/05/97 sample date. Specific conductance was virtually constant with depth at a value of 615 µmhos/cm on both sample dates and pH was also virtually constant with depth at values ranging from 7.9 to 8.1 on both dates, with the exception of lower pH ranging from 7.4 to 7.9 over the top 3 meters of water on 9/24/97.

Special Water Quality Monitoring Program

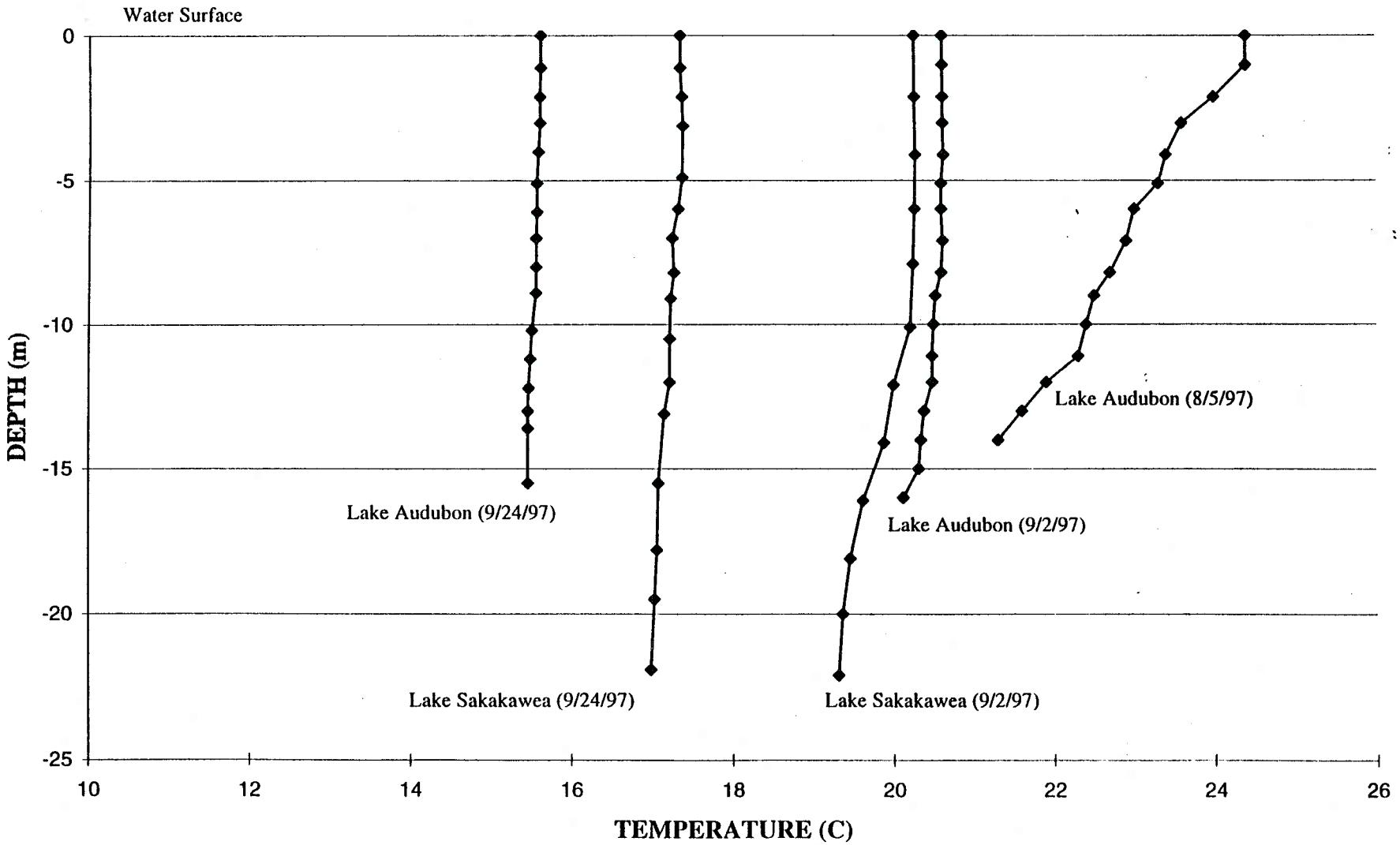
Program Objectives. The Special Water Quality Monitoring Program is to be a series of specific tests aimed at characterizing particular algae and turbidity related water quality issues. These tests will provide information which will assist in establishing specific design criteria and also help to characterize specific water quality conditions that may occur on either seasonal or weather related frequencies.

The program has two main components. First, an algae identification survey is being performed on both lakes to determine both the types and density of algae at the varying sample depths indicated below. Algae identification is being carried out down to the family or genus level of detail, as appropriate. The type and density of algae may be important from the standpoint of both disinfection effectiveness as well as taste and odor production. Characterization of algae is important to determine if algae masses or single cells are present, which could influence masking effects during disinfection.

The second component of this program is a turbidity characterization study to determine the nature of turbidity events. A series of six samples will be collected to analyze turbidity, UV-254 nm absorbence, particle counts (over six discrete channels from 1 micron to 120 microns), and HPCs to characterize the nature of the turbidity.

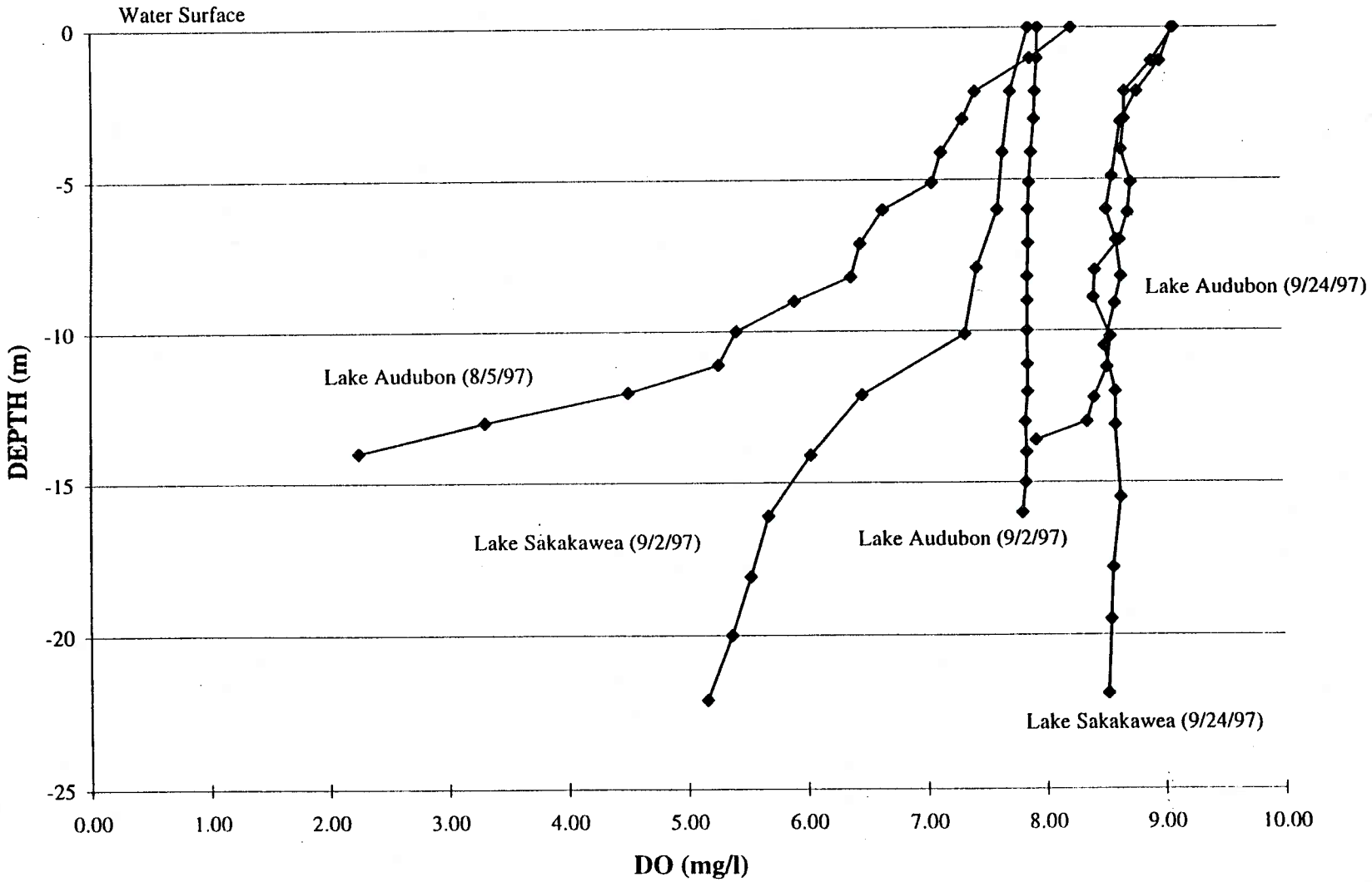
Sample Site Selection. The same sample sites were utilized for the special water quality-monitoring program as those selected for the long-term water quality-monitoring program described above.

Sample Depths. For both lakes, three different sample depths were identified in order to investigate possible significant differences in water quality, as related to depth, at the two intake sites.



LAKE AUDUBON AND LAKE SAKAKAWEA
TEMPERATURE PROFILE
AUTUMN 1997

FIGURE 3-1



LAKE AUDUBON AND LAKE SAKAKAWEA
DISSOLVED OXYGEN PROFILE
AUTUMN 1997

FIGURE 3-2

TABLE 3-4

LAKE AUDUBON
VERTICAL PROFILE WATER QUALITY DATA

Sample Depth (Meters)	Water Temperature (°C)			Dissolved Oxygen (mg/l)		
	8/05/97	9/02/97	9/24/97	8/05/97	9/02/97	9/24/97
0.0	24.4	20.6	15.6	8.25	7.97	9.12
1.0	24.4	20.6	15.6	7.90	7.96	8.93
2.1	24.0	20.6	15.6	7.43	7.94	8.70
3.0	23.6	20.6	15.6	7.32	7.93	8.69
4.1	23.4	20.6	15.6	7.14	7.90	8.66
5.1	23.3	20.6	15.6	7.06	7.88	8.74
6.0	23.0	20.6	15.6	6.65	7.87	8.71
7.1	22.9	20.6	15.6	6.46	7.87	8.64
8.2	22.7	20.6	15.6	6.38	7.86	8.43
9.0	22.5	20.5	15.6	5.91	7.86	8.42
10.0	22.4	20.5	15.5	5.42	7.86	8.56
11.1	22.3	20.5	15.5	5.27	7.86	8.53
12.0	21.9	20.5	15.5	4.51	7.86	5.52
13.0	21.6	20.4	15.5	3.31	7.84	8.36
14.0	21.3	20.3	15.5	2.25	7.85	7.93
15.0	-	20.3	15.5	-	7.84	-
16.0	-	20.1	-	-	7.81	-

For Lake Audubon and Lake Sakakawea, the following three sample depths were selected:

- A top shallow sample depth was selected in which a composite water sample is collected over the phototrophic (light penetrating) zone depth of each lake. The phototrophic zone depth was estimated to be approximately two times the Secchi Disk reading for sampling purposes (From past sampling experience on the lakes by the USGS, it is anticipated that Secchi Disk readings will vary from about 1 to 3 meters, depending upon the weather and time of year). The composite sample will be collected by taking three or four, vertically, evenly spaced, grab samples over the phototrophic zone and combined into one composite sample:

  - An intermediate depth grab sample taken at approximately 20 feet above the bottom of the lake

  - A deep grab sample taken at approximately 5 feet above the bottom of the lake

TABLE 3-5

LAKE SAKAKAWEA
VERTICAL PROFILE WATER QUALITY DATA

Sample Depth (Meters)	Water Temperature (°C)			Dissolved Oxygen (mg/l)		
	8/05/97	9/02/97	9/24/97	8/05/97	9/02/97	9/24/97
0.0	-	20.3	17.4	-	7.89	9.11
2.1	-	20.3	17.4	-	7.73	8.80
4.1	-	20.3	17.4	-	7.66	8.60
6.0	-	20.3	17.3	-	7.61	8.53
7.9	-	20.2	17.3	-	7.43	8.65
10.1	-	20.2	17.2	-	7.33	8.51
12.1	-	20.0	17.2	-	6.47	8.60
14.1	-	19.9	17.1	-	6.04	8.60
16.1	-	19.7	17.1	-	5.68	8.60
18.1	-	19.5	17.1	-	5.53	8.57
20.0	-	19.4	17.0	-	5.57	8.55
22.1	-	19.3	17.0	-	5.16	8.52

Sample Frequency and Collection. Discrete sampling for both lakes is being carried out on the same day, weather permitting. It is anticipated that all of the following sampling events would be carried out by the USGS. The following sampling frequency was felt to be sufficient for both the algae and turbidity characterization portions of the study, on both Lake Audubon and Lake Sakakawea:

- Sample Date No. 1: September 2, 1997
- Sample Date No. 2: September 24, 1997
- Sample Date No. 3: Last week of October, 1997
- Sample Date No. 4: Mid-winter sample during first week of January or first week of February, 1998 (assuming safe ice)
- Sample Date No. 5: Spring sample during first week of April or May, 1998 (assuming safe conditions after ice break-up)
- Sample Date No. 6: Mid summer sample during first week of July, 1998

After the six samples have been collected and analyzed, it is recommended that the data be reviewed to determine if additional sampling through the fall and winter of 1998 would provide any pertinent water quality information relative to the planned design of the intake and pretreatment facilities.

All samples are currently being collected with a 3-liter volume, Kemmer bottle type sampler. Future samples will be collected with a new alpha bottle sampler situated horizontally instead of vertically like the Kemmer sampler.

Analytical Analysis Laboratory Selection. Montgomery Watson Laboratories are being used for the analytical analysis for the special water quality-monitoring program. For algae characterization and enumeration, the Montgomery Watson Limnological Laboratory in Minneapolis, MN is being utilized. For the special turbidity characterization portion of the study (including turbidity, UV-254 nm absorbence, particle counts, and HPC analyses), the Montgomery Watson Applied Research Department in Pasadena, CA is being utilized.

Results. Table 3-6 presents a summary of the initial results from the algae characterization portion of the monitoring program.

From this first sampling event, the following preliminary results are indicated for the algae identification and count tests:

- Algae concentrations at the intermediate and deep levels were approximately 50 to 60 percent of the algae concentrations determined for the surface composite samples on both lakes.

- Algae concentrations for Lake Sakakawea were about 40 percent of the algae concentrations at the same depth sites for Lake Audubon.

- Algae in the green algae groups made up approximately 86 to 87 percent of the total algae counts for Lake Audubon (at all depths) and approximately 92 to 96 percent of the total algae counts for Lake Sakakawea (at all depths).

Data Compilation and Reporting. All data compilation and reporting will be performed by the NAWS Project Team and forwarded to the NDSWC within one week of receiving all laboratory analytical results from the sample event. A summary report will be prepared at the end of the last sample date.

PRETREATMENT COMPLIANCE MONITORING PLAN

Background Information

The JTC has requested a monitoring program to verify the effectiveness of the pretreatment system once the NAWS raw water system is placed in operation. Specifically, the monitoring parameters identified were "*Giardia* or an approved surrogate."

TABLE 3-6

ALGAE CHARACTERIZATION OF LAKE SUPPLIES

Sample from Lake:	Sample Depth	Sample Date	Total Count (cells/ml)	Breakdown by Group			
				% Green Algae	% Euglenophyta	% Diatoms	% Blue-Green Algae
Audubon	Phototrophic Zone	9/2/97	4758	85.9	0.3	13.7	0.0
		9/24/97	1583	80.2	3.8	5.7	10.2
Audubon	Intermediate	9/2/97	2974	86.0	0.1	13.7	0.0
		9/24/97	2530	87.0	1.7	6.1	5.2
Audubon	Deep	9/2/97	2689	86.8	.02	12.6	0.0
		9/24/97	3687	87.4	1.6	6.5	4.5
Sakakawea	Phototrophic Zone	9/2/97	2051	86.0	3.2	0.8	0.0
		9/24/97	2748	98.5	1.5	0.0	0.0
Sakakawea	Intermediate	9/2/97	938	91.9	8.1	0.0	0.0
		9/24/97	1737	82.4	3.8	13.8	0.0
Sakakawea	Deep	9/2/97	1019	95.1	4.9	0.0	0.0
		9/24/97	2264	93.1	2.9	4.0	0.0

The NAWS Project Chloramine Challenge Study, December 1995, determined that either chlorine followed by ammonia (chloramines) or ozone could achieve the specified design criteria disinfection requirements of 3-log *Giardia* and 4-log virus inactivation. This criteria was established as the level of pretreatment disinfection necessary to control fish pathogens from being transported across the divide to the Hudson Bay Basin from the Missouri River Basin.

The proposed pretreatment system will provide primary disinfection using ozone to meet the requirements for 3-log *Giardia* and 4-log virus inactivation, as determined by the Challenge Study. Following pretreatment, a chloramine residual will be maintained in the pipeline to reduce biological regrowth. Chlorine residual will be monitored on the pipeline system to maintain a minimum delivery residual at the WTP of at least 0.2 mg/l.

The pretreatment compliance-monitoring plan can be approached from either a process performance basis in which the pretreatment disinfectant residual is monitored or from actual biological monitoring along the pretreated water pipeline. These two approaches are discussed in the following sections.

Surrogate Parameters

It is not practical to monitor the disinfection effectiveness for all pathogens. Disinfection effectiveness is usually measured against a surrogate and the results extrapolated to the unmeasured population. The issue is to define a meaningful surrogate parameter and conduct monitoring of that parameter to provide documentation of effectiveness of the disinfection process. However, use of microbiological parameters as a method for process control can not be used because of laboratory turnaround time. Turnaround time to analyze microbiological monitoring does not permit immediate response to changes in conditions in the disinfection process. Four potential surrogate parameters are discussed below. These include monitoring of the disinfectant residuals (Process performance), *Giardia*, coliform organisms, and HPCs.

Process Performance. Monitoring of the disinfectant residual is the most commonly used practice in the water treatment industry to measure the effectiveness of disinfection processes for inactivation of viruses, protozoa, parasites, or other microbial organisms from the water supply. Results of residual monitoring are obtained and controlled on a real-time basis by the SCADA and control systems which provides quick adjustment of ozone feed rates. EPA established Ct requirements as a means of determining disinfection effectiveness for filtered water, because of the difficulty (and time delay) with monitoring biological parameters. The main purpose of the Chloramine Challenge Study was to define the levels of disinfectant residuals and contact times necessary to achieve the process design criteria (i.e., 3-log *Giardia* and 4-log virus inactivation). Thus, for the ozone disinfection process, monitoring of the dissolved ozone residual concentration as the treated water leaves the first contact chamber of the ozone contactor is the most reliable means for determining compliance with the design criteria.

Giardia-lamblia. *Giardia* cysts occur in natural waters that have been contaminated with human or animal intestinal organisms. The ability to measure or quantify *Giardia* in natural waters is statistically more difficult compared to other organisms such as *Escherichia coli*, where large

numbers of *E. coli* may be present compared to relatively few *Giardia* cysts. Identifications of *Giardia* requires a filtered sample and microscopic identification. The chances of obtaining a positive identification from a given sample, even if *Giardia* may be present in the water, is much more difficult than for other organisms such as bacteria or virus where background populations may be in the millions.

In challenge studies or spiking experiments, precise quantities of *Giardia* are cultured (usually millions), counted, treated with a disinfectant, and re-counted to determine inactivation effectiveness. Large numbers of cultured *Giardia* are required to document 99.9 percent inactivation. In nature, these large quantities do not exist, therefore it will be virtually impossible to statistically predict an inactivation rate. Also, the time constraints of laboratory analysis turnaround and the procedural difficulty to determine cyst viability place into question the value using *Giardia* as a "real-time" measure of performance. Utilization of *Giardia* as an indicator organism in the disinfected water would not represent an accurate measure of disinfection effectiveness.

HPCs and Coliforms. If biological monitoring were to be an absolute requirement, HPC and coliform organisms could be used to measure the effectiveness of water treatment and disinfection processes to remove pathogens from the water supply. Dr. Susumu Kawamura in "Integrated Design of Water Treatment Facilities", 1991, discusses these surrogate organisms:

> "Coliform organisms, particularly *Escherichia coli* (*E. coli*), are continuously present in the human intestine in large numbers. Billions of these organisms are excreted by an average human or animal per day. Thus, their presence in the process water is indicative of fecal pollution. The coliform group of bacteria is defined as all anaerobic and facultative anaerobic, gram-negative, non-spore-forming bacilli that produce acid and gas through the fermentation of lactose.
>
> The most common method of assessing the safety of the drinking water supply is the coliform test. However, microbiologists generally agree that coliforms may be more rapidly inactivated as much lower disinfectant dosages than some enteric viruses and protozoan cysts. Consequently, the EPA has proposed that the standard plate count be instituted as a routine test to screen for bacteria regrowth. The presence of a large population of organisms, as indicated by the plate count (heterotrophic bacteria), would certainly be indicative of an ineffective disinfection process. The heterotrophic plate count (HPC) for the water in the distribution system should be less than 10 colonies per ml."

HPCs are most often used to evaluate the effectiveness of disinfection in distribution systems. If biological monitoring is required in addition to measuring disinfectant residual, it is recommended that HPCs be considered as an appropriate indicator for monitoring the potential for regrowth and general effectiveness of the disinfection process on the pretreated water line.

Sampling Locations for HPC Monitoring. Pipeline sampling locations that may be used to take HPC samples of the pretreated water would be on the Hudson Bay drainage side of the

watershed divide. A possible location would be the pretreated water storage reservoir located about six miles north of the divide. Another possible location would be at the Minot WTP, before the water enters the plant facilities. The WTP location would represent a more convenient location for sampling because the samples could be taken by plant operating staff.

Monitoring Plan Summary

A process performance based monitoring plan is the principal means by which compliance with the pretreatment disinfection criteria could be met. One of the reasons for conducting the Challenge Study was to determine the required disinfectant dosages, disinfectant residual concentrations (C), and resulting contact times (t) required to achieve actual 3-log *Giardia* inactivation and 4-log virus inactivation. Measurement of disinfectant residual at key locations in the full-scale pretreatment system is an effective method to insure that the process is operating at the prescribed dosages to achieve 3-log *Giardia* inactivation and 4-log virus inactivation.

Monitoring pretreatment compliance on the full-scale system through the use of biological testing (i.e., HPC and coliform testing) may be questionable for the following reasons:

- The relationship between HPC counts and *Giardia* and virus inactivation efficiency at the pretreatment system is probably difficult, if not impossible, to develop.
- The time necessary to obtain lab results is measured in days.
- Positive HPC and/or coliform tests is more a reflection of how the pipeline residual chloramine disinfection system is working. Positive tests may result from other factors not related to the pretreatment process.

Given the issues stated above, the pretreatment disinfection facility may be more effectively monitored for compliance with design criteria through the use of a process performance based plan. For the case of the proposed ozone disinfection system process, performance will be gauged by means of providing continual, on-line, measurement of dissolved ozone residual at the outlet to the first ozone gas-mixing chamber.

Record Keeping

All ozone residual information will be monitored and recorded with a daily average values (computed over 24 hourly readings), as well as a daily maximum value and a daily minimum values. One daily, visual verification check of the dissolved ozone residual reading will be performed by an operator. Pipeline chloramine residuals will also be recorded on a daily basis.

Incorporated into the alarm system will be automatic switchover to standby equipment as appropriate. Automatic switchover to standby equipment will be incorporated with all pump systems and pretreatment chemical feed systems.

Un-Interruptible Power Supply

Un-interruptible power supplies (UPS) will be incorporated at each facility PLC. The UPS system will provide local PLC power during a power failure for alarm functions and activation of the emergency control logic.

OPERATIONS STRATEGY

The operations strategy of the NAWS system will provide a complete "window" into and control of all NAWS facilities and processes, exclusive of the Minot WTP unit processes. The operations strategy is based on 24-hour per day staffing and monitoring of the central control facility, to control normal and emergency operations. The strategy of the control system will provide operational flexibility for control during normal operations plus acknowledgment and implementation of the emergency control strategy based on alarm conditions. Fail-safe contingencies will be incorporated to activate facility shutdown independently of operations staff actions.

Normal Operation

The flow rate into the Minot WTP will be set by the operations staff by inputting the treatment plant flow rate into the SCADA system. The influent rate will be maintained and controlled at the influent flow control facility at the Minot WTP. This flow can be set anywhere from zero to the maximum plant flow rate.

The PRV vault is located upstream from the WTP. The PRV vault consists of a parallel system of PRVs used to maintain downstream pressure. Pressure transducers/transmitters will be located on the upstream and downstream sides of the valve system.

Upstream of the PRV vault, a pretreated water storage reservoir will provide operational storage of the water. Flow into the reservoir will be provided by the booster pump station at the pretreatment facility. An influent valve, located at the storage reservoir, will maintain backpressure on the pipeline and at the pump station. This influent valve will also be used for emergency level control of the storage reservoir and system shutdown.

The booster pumps at the pretreatment facility will be controlled by the level in the storage reservoir. The booster pumps will operate to maintain the level in the reservoir between storage level setpoints. A flowmeter on the discharge of the booster pumps will be used for flow pacing of the ozone and the chloramine chemical feeders.

Section 4

HOUSTON ENGINEERING
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AMERICAN ENGINEERING

SECTION 4

SYSTEM OPERATION AND CONTROL

INTRODUCTION

All NAWS facilities will be designed for primary systems operations control, monitoring, and data acquisition from a centralized dedicated control/monitoring station. A radio based telemetry system will provide the SCADA communication link between each individual facility and the centralized control station. This SCADA/telemetry system will provide the NAWS system operations staff with complete monitoring, control, and data acquisition capability for operation of the system. This section will describe the control and operations strategy, including emergency safeguards, and an emergency response plan for the NAWS system.

CONTROL STRATEGY

The Ultimate NAWS system consists of three major elements; the Missouri River water delivery facilities (including pretreatment), the Minot WTP, and the treated water distribution system. The control strategy to meet the requirements for operating, monitoring, and controlling all facilities associated with these three elements is based on the following:

A central control station will be located in Minot, North Dakota,

- The control station will be dedicated to operate, control, and monitor the NAWS facilities, independent of existing Minot WTP operations, control, and monitoring
- The control station will be staffed 24 hours per day (initially, using WTP operations)
- Each NAWS facility will be provided with total system control capability through PLCs to function independent of the central control station during emergency conditions and to control local functions

This overall control strategy will provide complete flexibility for operating, monitoring, and controlling all NAWS facilities, including emergency safeguards.

SCADA/Telemetry Systems

The NAWS Project will be implemented in various phases; Phase I includes the Missouri River water delivery system. The SCADA/telemetry system will be designed to meet the requirements of the Phase I project, with expansion capability for the Ultimate Project. The central control station for the SCADA/telemetry systems will be located at the Minot WTP. The Minot WTP is staffed 24 hours per day.

A radio based communication system will be used as the primary link for the NAWS facilities to the central control station. Existing fiber optic and dedicated telephone line communications are being investigated as a redundant back-up communication link. Final selection of the mode of communications will be made after completion of a radio interference study. The radio interference study will be based on UHV and VHF frequency bands.

Each major facility will be equipped with a remote telemetry unit (RTU) to communicate directly with the central control station. The polling frequency between the central control station and each RTU will be established based on a critical facility hierarchy. At this time, the most critical facilities are associated with the pretreated water supply from the Missouri River. These facilities include the intake pump station, pretreatment facility, booster pump station, pretreated water storage reservoir, and the pressure reducing station. The new Minot WTP influent flow control facility is also a critical facility and it will be hard wired directly to the central control station.

Main Control Functions

Main control functions will be transmitted from the central control station computer system to each facility. The main control functions will include the following:

- On/Off control of each pump located in the intake pump station,
- On/off and feed rate (dosage) setpoint control of the pretreatment facility chemical feed systems including ozone, chlorine, and ammonia systems,
- On/off control of each pump located in the pretreated booster pump station,
- Open/close control of the pretreated water reservoir influent and effluent valves,
- On/off control at all treated water booster pumps.

Operations level control of the pretreated water booster pump station wet well and storage reservoir will be incorporated into the intake and booster pump station pump control logic.

Local Control Systems

Local PLCs will be used at each facility requiring remote and local control. The local PLC system will provide the logic for control of pumps, valves, and chemical feed systems. The local PLC systems will provide the primary control for each system, communicate with the RTU, and provide control to the emergency control features at each facility.

Status Monitoring

The central control station computer system will continuously monitor status and conditions at all NAWS facilities via the SCADA/telemetry system. Status monitoring will include locally

controlled operations through each facility's PLC. The central control station will provide the following status of the operation of each facility:

- On/off, local /remote, and fail status of each raw water intake and booster pump
- Open/close, local/remote, and fail status of all pump control valves and emergency control valves
- Wet well and reservoir levels
- Pretreatment chemical feeders and associated appurtenances: on/off, local/remote, flows, rates, pressures, chemical volumes, and fail status as appropriate
- Upstream and downstream pressures within the PRV vault
- Water quality parameters including:
  - Raw water turbidity, pH, temperature
  - Pretreated water ozone residuals within the ozone contactors
  - Chlorine residual in pretreated raw water booster pump station discharge
  - Chlorine residual entering Minot WTP influent rate-of-flow facility
- Intake pump station and pretreated raw water booster pump station discharge flow rates
- Miscellaneous alarms (intrusion, etc.,)

All status monitoring data will be recorded on the data acquisition system.

Alarm Functions

Alarm systems will be incorporated into the central control facility computer and at each remote facility. Alarms will be programmed for all conditions and statuses that are monitored. The alarms will be set to activate if any failure or out-of-range condition occurs. The alarms will be programmed to require one of the following actions:

- Operations staff acknowledgment and clearing only
- Equipment shut-down/closure with staff remotely resetting after acknowledgment through the SCADA system
- Equipment shut-down /closure and requiring on site repair and acknowledgment and local restart

Incorporated into the alarm system will be automatic switchover to standby equipment as appropriate. Automatic switchover to standby equipment will be incorporated with all pump systems and pretreatment chemical feed systems.

Un-Interruptible Power Supply

Un-interruptible power supplies (UPS) will be incorporated at each facility PLC. The UPS system will provide local PLC power during a power failure for alarm functions and activation of the emergency control logic.

OPERATIONS STRATEGY

The operations strategy of the NAWS system will provide a complete "window" into and control of all NAWS facilities and processes, exclusive of the Minot WTP unit processes. The operations strategy is based on 24-hour per day staffing and monitoring of the central control facility, to control normal and emergency operations. The strategy of the control system will provide operational flexibility for control during normal operations plus acknowledgment and implementation of the emergency control strategy based on alarm conditions. Fail-safe contingencies will be incorporated to activate facility shutdown independently of operations staff actions.

Normal Operation

The flow rate into the Minot WTP will be set by the operations staff by inputting the treatment plant flow rate into the SCADA system. The influent rate will be maintained and controlled at the influent flow control facility at the Minot WTP. This flow can be set anywhere from zero to the maximum plant flow rate.

The PRV vault is located upstream from the WTP. The PRV vault consists of a parallel system of PRVs used to maintain downstream pressure. Pressure transducers/transmitters will be located on the upstream and downstream sides of the valve system.

Upstream of the PRV vault, a pretreated water storage reservoir will provide operational storage of the water. Flow into the reservoir will be provided by the booster pump station at the pretreatment facility. An influent valve, located at the storage reservoir, will maintain backpressure on the pipeline and at the pump station. This influent valve will also be used for emergency level control of the storage reservoir and system shutdown.

The booster pumps at the pretreatment facility will be controlled by the level in the storage reservoir. The booster pumps will operate to maintain the level in the reservoir between storage level setpoints. A flowmeter on the discharge of the booster pumps will be used for flow pacing of the ozone and the chloramine chemical feeders.

The raw water intake pumps will be controlled by the level in the booster pump station wet well. When this level starts to drop, the raw water pumps will come on to supply more water to the pretreatment facility.

Emergency Operations

Each facility is tied to the central control SCADA System in an overall control strategy to deal with emergency operations. Malfunction of any element of the pretreated water pipeline system will result in an immediate shut down of that facility, other critical facilities, and the posting of alarm status. The main control computer will assess the priority assigned to each facility to determine action or response to emergency conditions.

Major failure scenarios together with the contingency plan actions are presented in Table 4-1.

PLCs at each facility will have preprogrammed logic to deal with emergency operations with the process or equipment at the appropriate location. A pump failure at a pump station need not result in system shutdown where redundant facilities are available to take over duty.

The system control logic includes fail-safe features that will automatically shut down should a system component failure and telemetry failure occur at the same time.

The fail-safe system will include a direct, hard-wired control system independent of the SCADA system. The control valves at the inlets to each facility on the pipeline system will be hardwired to contacts to automatically close on loss of power or level conditions. The system will be designed to cascade shutdown through the entire raw water system. The cascade operation is a hydraulic sensing or electrical control system that forces shutdown of each facility.

Start-up Operation

Start-up of any NAWS facility and the entire system will be a joint team effort performed by the Contractor(s), engineers, Minot WTP staff, North Dakota State Water Commission representative(s), and equipment manufacturer representatives. Prior to any facility start-up, all equipment systems and controls will be tested to verify they are fully operational. Testing will include certified hydraulic testing and disinfection of all pipeline segments and hydraulic structures.

Testing and start-up procedures, sequences, and schedules will be produced for each facility and the system. These documents will provide the necessary tools for start-up team members. Checks and balances will be incorporated into the start-up procedures to mitigate against major failure of a system.

TABLE 4-1

FAILURE SCENARIOS AND CONTINGENCY PLAN ACTIONS

FAILURE SCENARIO	ACTION
Power failure at any facility	Automatic shutdown of each facility through the SCADA system and local PLCs with UPS backup.
SCADA/Telemetry failure	Automatic shutdown through local PLCs and hydraulic cascade shutdown
Ozone failure: low residual, generator failure, etc. [a]	Automatic system shutdown through SCADA
Pipeline Rupture (Catastrophic)	Low pipeline pressure alarm followed by automatic system shutdown through SCADA
Pipeline Rupture (Catastrophic) & telemetry failure	Hydraulic cascade shutdown
High water level above setpoints at any facility	Action Sequence: 1) Alarm 2) Reduction of upstream pumping 3) Shutdown by SCADA & hydraulic cascade shutdown
High pressure above setpoints	Action Sequence: 1) automatic sequential shutdown of pumps through SCADA 2) Hydraulic cascade shutdown
Malfunction of influent flow control valves at Minot WTP	Action Sequence: 1) Automatic shutdown of all facilities through SCADA 2) Hydraulic cascading 3) WTP staff manual closing isolation valves which activates hydraulic cascading

a) Standby unit/PLC/if fails to solve problem, then automatic shutdown.

Operator Error

The potential exists in any system for operator error. For the NAWS pretreated water delivery system, operator error is a possibility, however, the design of the operation, control, and fail-safe systems will limit this possibility. The following elements describe the potential actions which will be implemented or are included in the proposed system to reduce the consequences of operator actions.

Operators training and checklists will be required on the function and operation of the system. This activity will be initiated during system start-up.

During normal operations under the control of the SCADA system, any operator action will be detected by the system instrumentation and automatic response will be initiated if preset operating limits are exceeded. The potential for operator error affecting the system would therefore exist if the operator overrides the emergency safeguards in either the SCADA system or at a local PLC. To limit possible problems, operators will be required to notify the central control station before switching any system from automatic to manual control. Communications will always be maintained by either telephone or radio, during manual operation of any facility or equipment system.

There will also be several system safeguards that cannot be overridden under manual operation. Those include the hard wired emergency systems to the influent control valves at the major structures which comprise the hydraulic cascading shutdown system and interlocks of critical facilities such as the ozone generation system and the booster pump station.

Emergency Control Logic

The emergency control logic will be based on the alarm conditions and logic control systems. The emergency control logic will be implemented to control the system for a fail-safe operation during a critical failure condition. The emergency control logic will function independently of the SCADA/telemetry system. Failure of any facility and/or piece of critical equipment shall cause shutdown of all related facilities, as necessary.

EMERGENCY RESPONSE PLAN

Introduction

An emergency response plan was outlined for the project. The purpose of the plan will be to identify the steps to be taken in the event of a catastrophic pipe failure resulting in a discharge of pretreated project water within the Hudson Bay basin. In developing the plan the maximum volume of water discharged was calculated and the travel time to the Souris River was estimated to develop a basis of identifying critical failure points and the magnitude of response required.

The effort was concentrated in the natural drainage systems to the south of Minot as well as the portion of the pipeline immediately upstream (along the pipeline) from the Minot Water

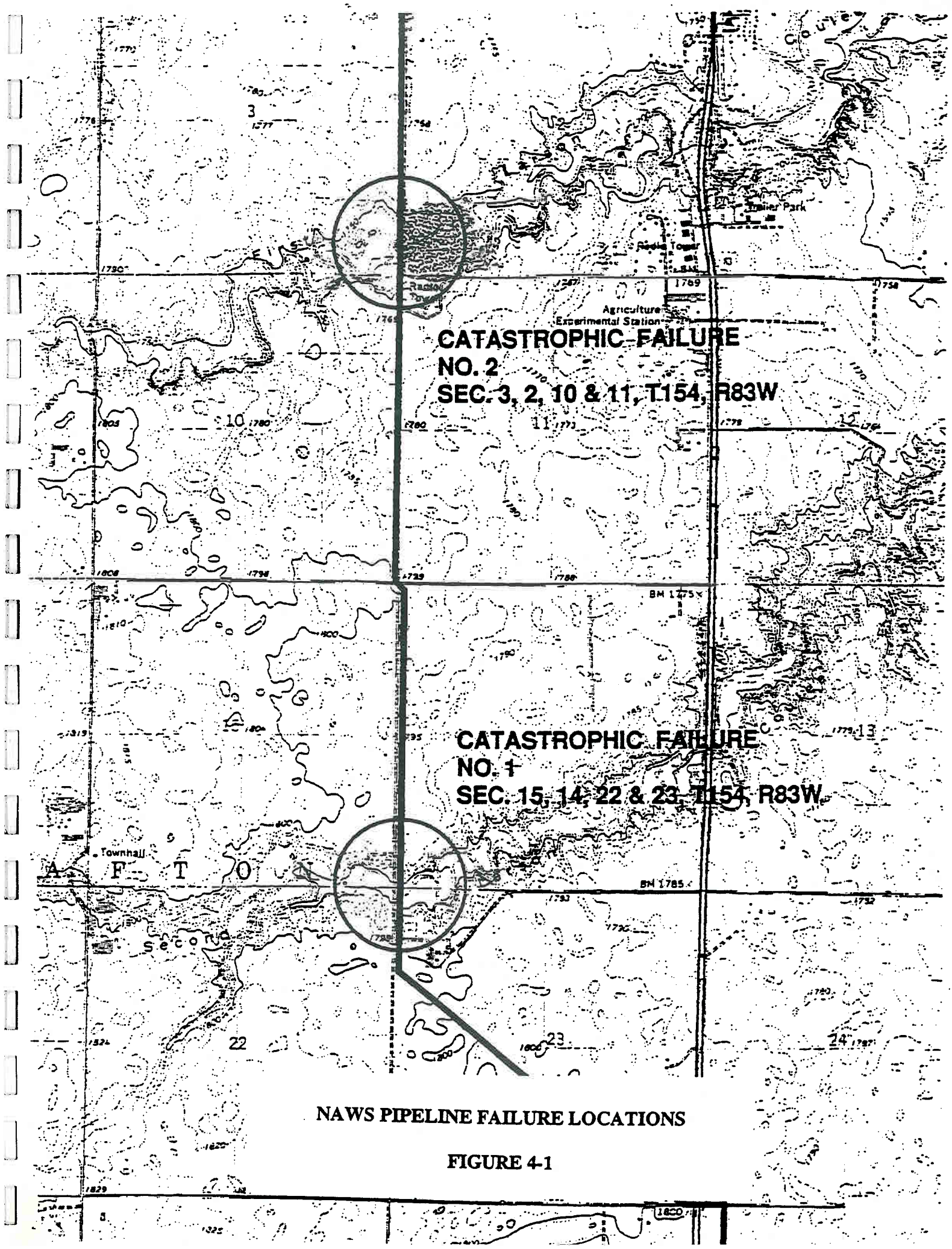
Treatment Plant (WTP). The elevation change from the continental divide into Minot is on the order of 400 feet. Of this amount about 150 feet is within the last mile. Four locations were selected for analysis. These locations are shown on Figures 4-1 and 4-2. Two of the locations selected correspond to ephemeral streams south of Minot. Another is at a location at the top of the river valley about 5,000 feet from the WTP. The last is immediately adjacent to the WTP.

To identify the maximum failure conditions for all of the locations considered, a sudden catastrophic failure of the pipeline was assumed, such as could conceivably develop if the pipeline burst as a result of structural failure. Catastrophic structural failure could be caused by faulty manufacturing, hydraulic surge in excess of design pressure, or by a seismic event. The maximum volume which could be released by a catastrophic failure is equal to the volume of water which would flow out of the pipe during the period before the failure is detected and the upstream valve closes plus the volume of water which would drain out of the pipe in a no flow condition if it were exposed to the atmosphere at a given point. The upstream valve will minimize the discharge volume depending on the location of the failure. For the two ephemeral streams to the south of Minot as well as the pipeline adjacent to the Minot WTP, the upstream controlling valve will be the pressure reducing valve (PRV) located approximately at Station 2200 + 00. For failures occurring to the south (upstream) of the PRV, the controlling valve will be the control valve on the discharge side of the pretreated water reservoir located approximately at Station 1910 + 00.

Pipelines may be subject to minor damage from excavating equipment. However, this is only expected to result in leakage, not a catastrophic rupture. North Dakota has a "one call" system for locating underground utilities. State law requires anyone conducting excavation to contact the state notification center to allow operators of underground utilities to locate their facilities, if any, in the area to be excavated. This law minimizes the chances of an accidental damage of the pipe due to excavation.

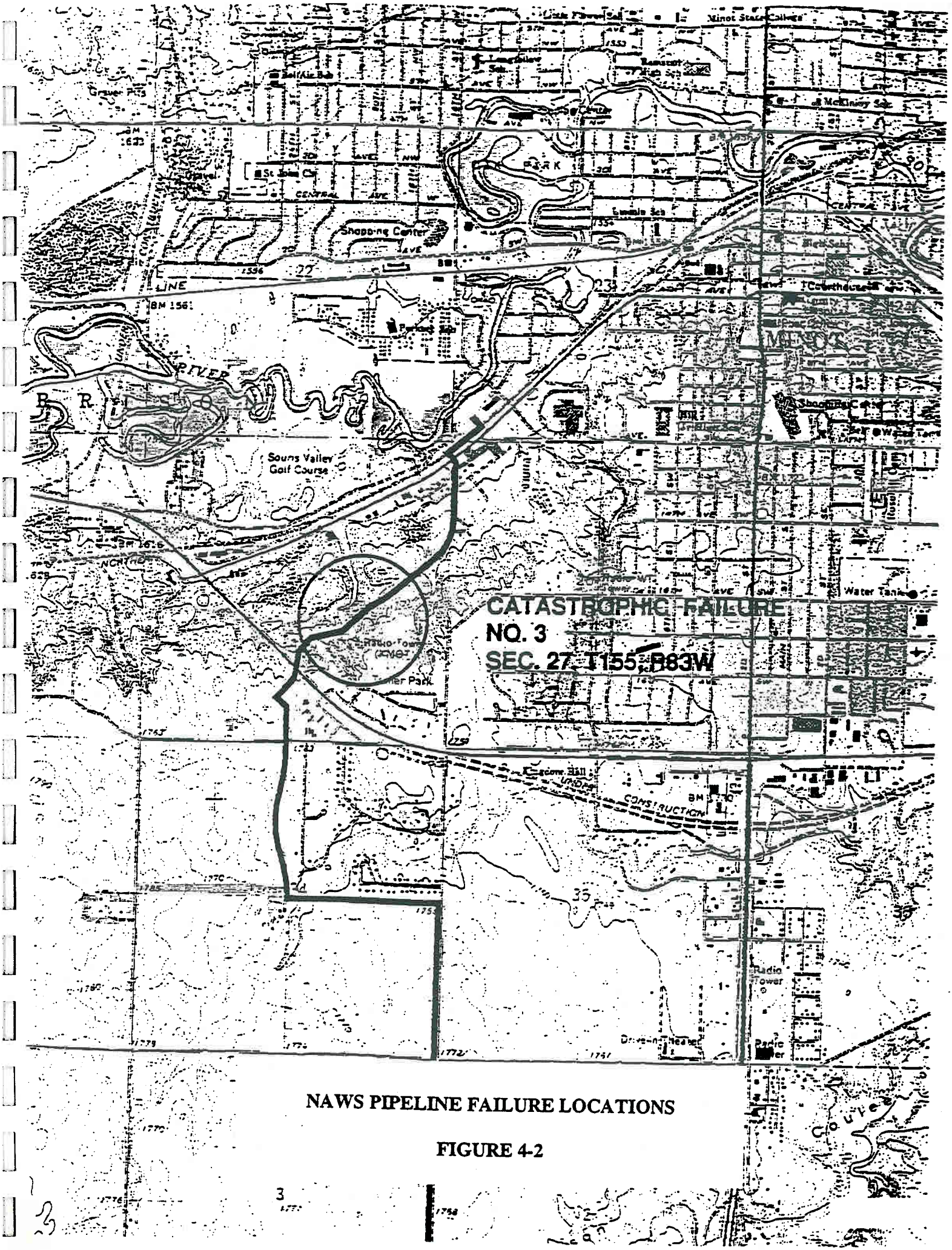
System Response

Upon a catastrophic failure of the pipeline a sudden pressure drop will occur at the location of the failure, and the hydraulic grade line at the failure will drop to a level equal to the atmospheric pressure. This pressure drop will travel as a negative surge in both the upstream and downstream directions. The pressure reducing valve equipment will initially sense a low-pressure condition and open slightly. The pressure condition, given the valve position and pressure difference across the valve will be outside the range of operation and the valve will close down. The low-pressure condition at the PRV and at the WTP inlet valve will also be sensed by the Supervisory Control and Data Acquisition (SCADA) system. This condition will trigger an alarm which will immediately cause the system to shut down. The maximum time for this detection and shut down sequence to take place is estimated to be three minutes. Of this period, two minutes is estimated for the SCADA system to detect a failure and send an alarm signal. One minute is the minimum time for the PRV valve to shut without causing further damage to the system



NAWS PIPELINE FAILURE LOCATIONS

FIGURE 4-1



NAWS PIPELINE FAILURE LOCATIONS

FIGURE 4-2

Release Volumes and Travel Times

Release Volumes. The volume of water released by a catastrophic failure is dependent on the location, the nature of the failure, the system response, and the existing flow condition at the time of the failure. For the purposes of this analysis the assumption is made that the flow in the pipeline is the maximum design flowrate of 40.23 cfs (26 MGD). A further assumption is made that the failure is catastrophic in nature, allowing the entire contents of the pipe to exit. The volumes of water released at each location with the preceding assumptions are given in the table below.

Location	Station	Volume, ft^3
1	2279+00	30,174
2	2389+00	57,864
3	2542+00	94,533
4 (WTP)	2591+00	111,781 (30,000)

If a motor-controlled pipe isolation valve is added at the top of the steep grade into Minot, the volume of water lost if a breach occurred at the Minot WTP (location #4) would be reduced to approximately 30,000 ft^3. The actual volume of water released will be less than that shown because the pipeline will still convey water to the treatment plant. Control logic in the system will be designed such that the inlet control valve at the Minot WTP will remain open in the event a pipeline rupture is sensed upstream.

Travel Times. The amount of time for water to reach the Souris River was calculated for each release point. Topographic maps were used to determine reach lengths and slopes. At the specified flowrate (40.23 cfs) normal depth was calculated assuming a that the flow conditions could be approximated by a trapezoidal channel with a four foot (4') bottom and 2:1 side slopes. Once normal depth was determined, the velocity was calculated, and then travel time was derived for a specified reach. Many of these assumptions are conservative and it is likely that actual travel times would exceed those calculated.

Location	Station	Travel Time
1	2279+00	10.6 hrs
2	2389+00	11.0 hrs
3	2542+00	36 min
4 (WTP)	2591+00	instantaneous

Emergency Action Plan

The emergency response plan will be implemented before the project becomes operational, and it will be updated each year. The project operator will do whatever is possible to contain and prevent water released from a failure of the pipeline from entering the Souris River. The plan will include a list of available earth moving equipment at local contracting businesses and government agencies, which can be deployed, on an emergency basis to contain a water spill. The emergency response will include building emergency containment structures and blocking

roadway culverts. Water released will be contained and allowed to evaporate, infiltrate into the soil, or be hauled to sites where the water can be spread over the land.

Upon sensing a failure of the pipeline the SCADA system will notify the operator on duty of the alarm. The control system will shut down the upstream valve in the minimum allowable time span. The operator will confirm the alarm and immediately dispatch personnel to patrol the pipeline between the upstream valve which sensed the failure and the next downstream valve or the WTP as appropriate to locate the failure. The inlet control valves at the WTP will remain open and water will continue to flow into the WTP as the pipe drains. Once the location and nature of the failure have been determined the operator will, if appropriate, immediately consult the list of local contractors and government agencies with earthmoving equipment in Appendix A. Earthmoving equipment will be dispatched to the site to contain any spills which may have occurred. The operator will then notify the people listed in Appendix B that a failure has occurred.

Section 5

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SECTION 5

OPERATIONS, MAINTENANCE, AND CAPITAL REPLACEMENT PLAN

INTRODUCTION

This section describes the operations, maintenance and capital equipment replacement plans for the NAWS facilities to be constructed from the source, either Lake Audubon or Lake Sakakawea, to the Minot WTP. The operations plan includes projected staffing, discussion of the operation of the facilities, and initial schedule of operations. The operation of each integrated element of the NAWS system and the interrelationship of each element and the overall facilities is explained in previous sections. The maintenance plan includes the procedures required for the preventive maintenance of the equipment to insure the cost-effective reliable operational and mechanical durability of the project components. The maintenance plan is divided into the mechanical systems; which include valves, pumps, intake facility, pretreatment facility, and the WTP; and the supporting mechanical and structural systems which include the pipelines, valves, controls, and the storage reservoir. The capital replacement plan presents a method to determine when an item should be completely replaced instead of continued maintenance and repair. The capital replacement plan provides direction for the replacement of treatment equipment, piping and appurtenances, and the control systems components.

OPERATIONS PLAN

The operations plan sets forth the procedures required to sustain the proper operations of the facility or maintain them in a ready state of operation. The plan includes a list of specific responsibilities for the operations personnel, description of required resources and staff, the operations function of each element, and a schedule for operations and maintenance activities.

Responsibility

The overall responsibility for the operations, maintenance and administration of the NAWS Project will be under the singular responsibility of one agency or authority. The Southwest Pipeline Project in southwest North Dakota is a recently developed regional water distribution system similar to NAWS. The Southwest Authority was created by the 1991 North Dakota Legislative Assembly to provide treated water to southwest North Dakota. A similar authority is presumed for the NAWS project, but there are a number of different models for this authority.

The State of North Dakota, through the State Water Commission, will retain ownership of all project features with the possible exception of the Minot WTP facilities. As currently anticipated, the authority established to administer the NAWS Project would contract with the City of Minot to operate and maintain the intake pretreatment facility, transmission line and appurtenances and provide final treatment of the Missouri River water at the existing Minot WTP. Operational responsibility for the system may change in future years in order to better utilize available resources or reduce overall cost of service.

Staffing/Resources

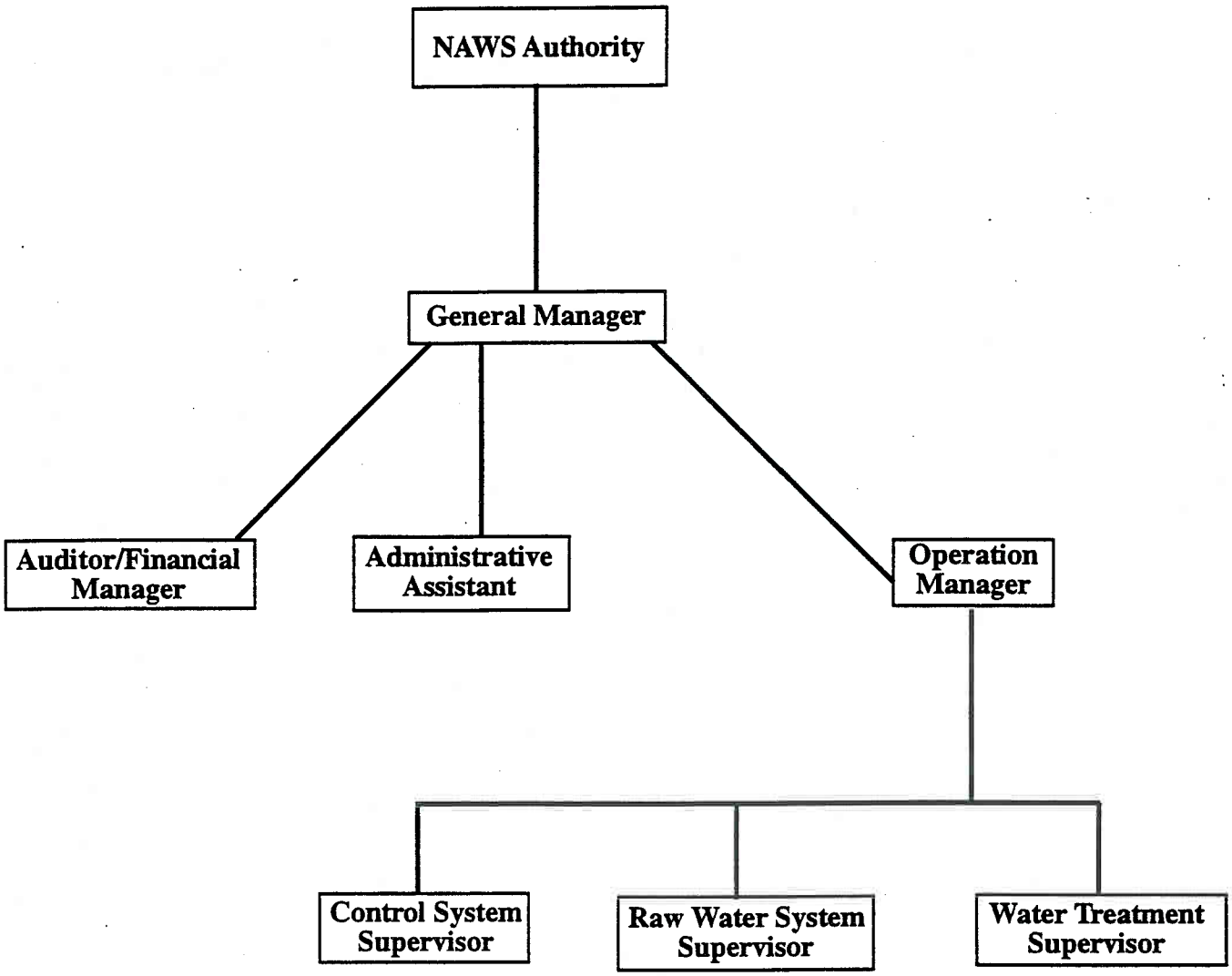
A full time operations manager or project supervisor would head the staff of operations personnel. Initially we have anticipated that the operation manager would be an employee of the City of Minot under contract to the NAWS authority. The operations manager would be responsible for the operation of all project components and would report to a general manager or the NAWS authority. The operations manager would prepare assignments for the operations and maintenance staff, be responsible for scheduling each worker's responsibilities and time, schedule non-emergency repairs and preventive maintenance, and report the status of the system to the general manager or authority on a monthly basis.

In addition to the operations manager there would be two full time operation and delivery system maintenance staff. One of the workers would be a licensed electrician. The licensed electrician would be primarily responsible for the SCADA/telemetry system, corrosion control system, and all electrical elements at the facilities. The other full time staff would be a system operator. The operator and licensed electrician would have daily assignments. The two full time staff personnel are for the operation of the pipeline from the intake to the Minot WTP. As the NAWS Project develops to serve the cities and rural water systems north of Minot, the number of full time staff would increase. During the summer months, the operations manager would employ one to two full time seasonal workers. These seasonal workers would assist in scheduled annual maintenance activities.

The operations manager and full time maintenance staff will work 8-hour shifts for 40 hours per week. All workers will work the daytime shift. During the off hours, one full time maintenance staff or the operations manager will be on-call. If a problem occurs during off hours, either the SCADA system or a WTP operator will notify the operations manager of the problem and location. The Minot WTP is staffed 24 hours per day and the WTP operator will have access to the SCADA system.

The operations of the Minot WTP is currently the responsibility of employees of the City of Minot. With the development of the NAWS Project, it is anticipated that final water treatment will continue to remain under the auspices and direction of the City of Minot's water treatment staff. The operations manager would be responsible for treatment and treated water distribution as well as the pretreated water transmission system.

In addition to operations personnel, the NAWS authority would retain a general manager, an auditor/financial manager, and an administrative assistant. The general manager would oversee all administrative aspects of the water system and report directly to the authority. The general manager would handle major customer concerns and contracts. The auditor/financial manager would be responsible for all financial matters including system billing, accounts receivable, and purchasing. The auditor/financial manager would report to the general manager. The administrative assistant would receive and direct customers questions on a regional basis and assist the general manager, auditor/financial manager, and operations manager. The administrative assistant would report directly to the general manager. Figure 5-1 provides a summary of the proposed NAWS operations organization.



Proposed
NAWS Resource Organization Chart
Figure 5-1

The operations manager and each full time maintenance supervisor will be supplied with 3/4-ton pick-up truck with an equipment box and radio. This will allow each staff member to perform their daily work assignments and to have immediate communication with the manager and other maintenance workers. Lap top computers will be supplied for the operations staff. The computers can be connected into the SCADA system through the telephone system. This will allow the on-call operator to be in constant communication with the pipeline system. From their computer, the staff can access the operating status of each facility and be able to control each facility remotely.

Scheduling

The inspection of each facility along the raw and pretreated water pipelines should occur daily. Each day, one maintenance worker should travel both the raw and pretreated water pipeline routes. The maintenance staff should inspect the pipeline for apparent waterline leaks. Along the route, the maintenance staff should perform the prescribed inspection activities at each facility. The operations manager should alternate this task between maintenance staff, as staffing allows.

In addition, the SCADA system will constantly provide system operating information on flow, pressure and other operation parameters to the computer and alarm system. This information will be monitored on a regular basis. Alarm functions for system shutdown (emergency) or maintenance requirements (normal problem) will be automated to contact the appropriate individual for response.

Facilities Operation Functions and System Control

For each of the major system components, a detailed and operational maintenance control checklist will be developed. Each item on the checklist will require input from the operations personnel. The data from the checklist will be input into the computer. The data will be reviewed by the operations manager to determine needed maintenance. At each individual facility (i.e. intake, pump station, etc.) there will be a log book to record visit data, system data, and readings (i.e. flow, temperature, etc.) of various instruments and equipment.

Intake/Pump Station. The operations plan for the intake/pump station includes checking the pumps, screening facilities (if on shore), system pressures and operating conditions and wet well characteristics. When monitoring operations of the pumps, the operator will verify that each pump has cycled on at least once in the prescribed period and that no failures have occurred.

Pretreatment Facility. The operations plan for the pretreatment facility includes checking the intake area, chemical feed system, and ozone contact chamber. The intake area inspection will include the flow meter and the intake piping. The chemical feed system will be checked to ensure adequate ozone production. The ozone contact chamber will be inspected for any blockage or solids buildup. All instrumentation will be calibrated according to the manufacturer's specifications.

Booster Pump Station. The booster pump station will be inspected in conjunction with the adjacent pretreatment facility. When observing the booster pump station, the operator will check the pumps, chemical feed systems, and wet well. The operator will check the pumps to assure that each pump has cycled on at least once. The chemical feed system will also be inspected. The chlorine and ammonia tanks will be replaced as needed. The water level in the wet well will be checked. All instrumentation will be checked and calibrated according to the manufacturer's specifications. Flow measurements from the pump station will be verified with system readings.

On a weekly basis during winter months when water use is low, the maintenance staff will run (exercise) all of the large pumps. When these booster pumps are turned on, the large pumps at the intake/pump station will operate. The operator should perform this exercise prior to visiting the intake/pump station so he can verify that the large pumps at the intake/pump station are operating in their automatic mode as programmed.

Pretreated Water Storage. The operations plan for the pretreated water storage reservoir consists of visually inspecting the reservoir. The maintenance staff will check for evidence that the tank has overflowed. The maintenance staff will also check the water level in the tank and compare the level in the tank to the water level recorded by the pressure sensors. The integrity of the tank will be ascertained by the visual inspection.

Pressure Reducing Valve Station. The operations plan for the pressure reducing valve station consists of verifying the operation of the station. The maintenance staff will compare the upstream and downstream pressure to determine that the appropriate pressure drop is occurring. The equipment, valves, and piping will be checked for leaks.

Water Treatment Plant Operations. The operation of the WTP will be conducted by the plant staff of the City of Minot. The NAWS Project operations plan will include checking the flow control valve vault to verify the inflow into the WTP. The NAWS Project maintenance staff will check with the WTP staff to determine that the inflow and quality into the WTP is adequate.

MAINTENANCE PLAN

The maintenance plan will describe a routine set of activities that will be performed on equipment to better assure that each facility will be productive through its design life.

Description

In the design of the NAWS Project each element has an individual defined design life. The approximate design life of various elements are as follows:

Elements	Approximate Design Life (yrs.)
Pipelines	60
Pumps	20
Valves	20
Mechanical Equipment	20
Concrete Structures	60
Buildings	40
Control and Electrical Systems	20

To better assure that each element meets or exceeds its design life, certain maintenance procedures will be performed. The elements that require maintenance are divided into two groups; mechanical systems and structural systems.

Mechanical Systems

Mechanical systems include all project elements that have movable parts subject to wear and requiring maintenance. The design life of these elements are shorter and more tentative than fixed structural components. The maintenance plan for mechanical systems requires a more frequent and preventive maintenance routine than for the structural systems. Mechanical system elements include pumps, motors, valves, instrumentation, control items, testing items, and controls with mechanical elements. As a minimum, the maintenance schedule for each item should follow the equipment supplier's recommendation for maintenance.

Equipment. The mechanical equipment includes pumps, motors, chemical feed systems, and meters. The operations manager will monitor the pumping times for each pump. Over time, the pump impellers or bowls will begin to show wear which will reduce the pump output and cause longer run times on the pumps. The motors will require periodic maintenance which includes checking and replacing the bearings, oil and grease. The pulsating or diaphragm pumps in the chemical feed systems feed chemicals into the pipeline. The diaphragms and chemical feed lines will periodically become worn and require replacement. The ozone system requires regular maintenance to maintain the oxygen feed gas equipment and replace dielectrics, fuses, controls, etc. Meters and monitors will be calibrated on a schedule prescribed by the manufacturer.

Valves. The valves that require regular maintenance include blowoff valves, air-vacuum/air release valves, pressure reducing valves, and flow control and isolation valves. The maintenance plan will include operating every valve at least once a year unless specified more frequently by the manufacturer. Valve seats will be replaced periodically according to the manufacturer's specifications.

Control. The control facilities include flow meters, pressure surge tanks, SCADA system components, and the controls associated with the pretreatment system. Surge tanks are installed to control large increases and decreases in pressure along the pipeline to avoid loss of integrity

and leakage. These large increases and decreases in pressure are caused by sudden changes of the energy input into the pipeline system. The direct causes of the large changes in pressure include pump failure, power failure, multiple rapid pump startup, and sudden valve closure. In addition to surge tanks, controlled valve operations assist in minimizing the changes in pressure. The daily surge tank inspection will include valve settings and air-to-water ratio in the surge tanks. The interior of the surge tank will be inspected on an annual basis.

The maintenance of the SCADA system components will be continuous. The observation of the pipeline system performance through the SCADA system and the daily inspections will notify the operations manager of any failure of the SCADA system components.

The operation of the raw water pretreatment facilities is automatic and controlled by both flow and water quality (oxidant demand). This is a relatively complex interrelated system that must maintain a balance between ozone application rates (dose), effluent ozone concentration (residual) and subsequent application of chloramines. While the system can be reliably automated, daily observation of operating function and some occasional system calibration of meters and sensors is required.

Testing. On an annual basis, check valves, pump control valves, and flow control valves will be tested according to manufacturer's specifications. Testing of the pumps will be performed by comparing the run times of the pumps with the flows measured by flow meters and the change in storage volume in the storage reservoir, pump performance will be observed and calibrated.

Calibration. The flow meters, pressure reducing valve, and flow control valve will be calibrated annually. The calibration will include testing the instrument to determine if the instrument is within the manufacturer's specifications. Units not meeting these specifications will be repaired, calibrated or replaced.

Repair. As part of the maintenance plan, the operations manager will schedule non-emergency repairs. Non-emergency repairs are repairs that do not effect the ability of the system to deliver water, will not result in a release of pretreated water in the Hudson Bay basin, and will not cause significant damage to property or equipment. The operations manager will schedule non-emergency repairs at the earliest practical time after a problem is identified. All emergency repairs will be performed immediately.

Structural Systems

Structural systems include elements that have non-movable parts. For the NAWS Project, the structural systems include the pipeline, the pretreated water storage reservoir, and other structural elements (i.e., pump bases, concrete slabs, buildings, etc.).

Pipeline. The maintenance plan for the pipeline includes inspecting the pipeline, cleaning the pipeline, monitoring the corrosion system protecting the pipeline, and testing the pipeline.

Inspection Schedule

Pipelines will be inspected daily. As maintenance workers perform their daily operations activities, they will be observing the ground above the pipeline. The inspection of the inside of the pipeline will occur if conditions indicate that it is necessary to further investigate problems or confirm that a problem is occurring. If, based upon the flow and system pressure data that is being continuously collected by the SCADA system, it appears that the pipeline hydraulics are varying from the design conditions, then the operations manager will schedule an inspection of the interior of the pipeline to determine the problem and correct it.

Cleaning

Pipelines can be cleaned in various ways. Two of the most common are chemical cleaning and mechanical cleaning. Chemical cleaning of the NAWS system will involve both continuous, ongoing addition of chloramines to control biological growth in the system and shock applications of chlorine. It is anticipated that routine addition of chlorine plus ammonia (chloramine residual formation) will, for the most part, prevent appreciable buildup of biological growth. In the event that an unusual problem would develop, the delivery system could be taken out of service for a short period of time, to allow high dosages of chlorine to be added to the system. The chlorine would be allowed to oxidize the growth (algae and bacteria) and then the treated water would be discharged to Minot WTP for treatment after the chlorine residuals reach an acceptable level.

The mechanical method used for cleaning the pipeline is called "pigging". A pig consists of spongy material that cleans the pipe wall as it travels. Pigs can be designed with a series of metal bristles that can scour the pipe wall as the pig travels downstream. For this project, the pipeline would be taken out of service and a pig inserted. The pump on the upstream side of the pig would pump water into the line. The increased pressure would push the pig to the end of the section of pipeline to be cleaned. At the end of the section of the pipeline to be cleaned, a section of pipe would be removed and the pig would exit the pipeline. This cleaning would be scheduled by the operations manager.

Corrosion System

To protect the longevity of the metallic pipeline system, a corrosion protection system must be maintained. There are two basic types of corrosion systems; galvanic systems and impressed current systems. The final design will select the best apparent system for the NAWS project based on the selected pipeline material and the corrosivity of the soil along the proposed route. On a monthly basis, a maintenance staff will inspect either each anode field (galvanic system) or each rectifier (impressed current system). Based on the results of the inspection, the operations manager will schedule the necessary repairs.

Testing

The pipeline will be pressure tested during construction. Upon completion of a repair, the pipeline will be visually inspected for any leaks prior to backfilling the trench.

Pretreated Water Storage Reservoir. The maintenance plan for the concrete pretreated water storage reservoir will include periodic visual inspection of the concrete walls and other appurtenances. During daily inspections of the reservoir, if it is noticed that excess sediment has been deposited in the bottom of the tank, one half of the reservoir tank will be sequentially taken out of service and cleaned while the other half remains operational. The cleaning of the tank can also be regularly scheduled.

CAPITAL EQUIPMENT REPLACEMENT PLAN

The replacement plan is developed to provide a method for replacing worn and depleted equipment. This plan is not intended to replace all the facilities or provide financing for supplies that would be considered routine operations and maintenance.

Description

A capital replacement reserve account is a part of the proposed NAWS rate structure. This replacement reserve account will be used to finance the capital equipment replacement plan. The replacement plan describes a method of accumulating funds for replacing worn and depleted equipment over a defined period of time. The replacement plan will replace major capital equipment that has a design life shorter than the long term debt financing (20 to 40 years). The elements to be included in the replacement plan are mechanical and electrical equipment and control systems.

In determining a method for scheduling replacement of various elements, the cost to own and operate the element will be considered. The costs to be considered include depreciation, replacement, investment, maintenance and repair.

Equipment Replacement

Equipment will be replaced when the increases in the maintenance and repair costs, along with downtime costs, exceed depreciation, replacement, and investment costs. The operations manager will monitor each element and keep records of maintenance and repair costs and downtime costs to determine an appropriate replacement schedule.

Pipe Repair/Replacement Plan

Depending on the pipeline material and extent of damage, the operations manager will plan a repair or replacement procedure. For ductile iron pipe, the operation manager will have in storage at least two joints of every size of ductile iron pipe, appropriate sizes of sleeve couplings, and joint restraint harnesses used in construction. These spare parts will allow the operations

manager to replace a section of ductile iron pipeline, as required. For steel pipe, the operations manager will have steel plates that can be welded on the steel pipeline for an immediate repair. The operations manager will maintain an inventory of all fittings that may require emergency replacement.

Control System Replacement and Repair Plan

The operations manager will have on hand a supply of common spare parts for the replacement of various control system elements, meters, and monitors. These spare parts will include anodes for the corrosion system, repair parts for the SCADA system, sensors for monitoring, control boards, and other electrical components used in the SCADA system.

Appendix A

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APPENDIX A

BIOTA TRANSFER CONTROL MEASURES

NAWS CONTRACTOR AND EQUIPMENT CONTACTS

List to be compiled prior to system start-up and will be reviewed and updated annually.

Appendix B

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APPENDIX B

BIOTA TRANSFER CONTROL MEASURES

NAWS CONTACT INDIVIDUALS

Northwest Area Water Supply Project Manager	Jim Lennington (701) 223-3899 home (701) 328-4959 work
Minot Public Works Director	Alan Walter (701) 857-4140 work
Minot WTP Superintendent	Byron Thronson (701) 857-4760