

RECLAMATION

Managing Water in the West

DRAFT **Potential Water Distribution** **System Pressure Zone Layout** **And Preliminary Review of Fireflow** **Requirements**

Feasibility Study for Water Supply System
Santee Sioux Nation
Santee, Nebraska
Village of Niobrara, Nebraska



Mission Statements

The mission of the Department of the Interior is to protect and provide access to our Nation's natural and cultural heritage and honor our trust responsibilities to Indian Tribes and our commitments to island communities.

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

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Background

The Santee Sioux Water Supply Feasibility Study will examine alternatives that will provide potable water service to the reservation and the adjacent community of Niobrara. First steps in planning a water system include:

- Finding an adequate water source
- Designing appropriate water treatment based on the raw water quality and the treated water objectives
- Designing the distribution/storage system

Distribution system design requires understanding the magnitude and locations of all service area water demands, the topography of the service area, and agreement on basic design assumptions addressing the water delivery. This report documents initial efforts in these areas and especially the *design assumptions addressing the water delivery* which will allow for the eventual feasibility level design of the Santee Sioux Nation's water distribution system. The ideas presented are intended to promote further design and analysis leading to discussion and eventually consensus among the stakeholders.

Current and future (2050) population estimates are shown in figures 1 and 2, respectively, along with names given to the population tracts. The existing Village distribution system supplies water to four main areas:

- Highway 12 Community
- Casino, gas station, and residence within 500 feet of the treatment building
- Residences and tribal facilities along Highway S54D
- Residences and tribal facilities in the Village

The service area in the feasibility study includes the Reservation and the Town of Niobrara.

Design Features

Reclamation follows design standards for water treatment and distribution systems on a case by case basis. Since our work is located across the Nation, we have not found a need to develop a Reclamation standard. Locally based regulations are followed when found or consultation with local regulators typically leads to established industry standards from such agencies as USDA, AWWA, EPA, or the *Recommended (Ten State) Standards for Water Works*. Design of municipal water distribution systems strive for efficiency and reliability. This is accomplished by using gravity rather than pumping where possible and avoiding pressure surges and non-standard pipe classes. To accomplish these goals, systems are typically designed with:

Potential Water Distribution System Pressure Zone Layout

- More than one raw water source for redundancy and to avoid long distance pumping. This includes back-up wells or a completely different source if available.
- Low head pumping systems to avoid pressure surges and using pipe with higher pressure ratings.
- Dividing large service areas with significant elevation differences into areas of similar elevations and therefore pressures. These areas are called “pressure zones” and are explained in detail below.
- More than one storage tank per pressure zone where long distances are involved. This adds system reliability (avoiding placing all water storage in one location) and shortens time of distribution.
- Looped lines from storage tanks through the service area so water can be delivered from the tank to the service connection from more than one direction.

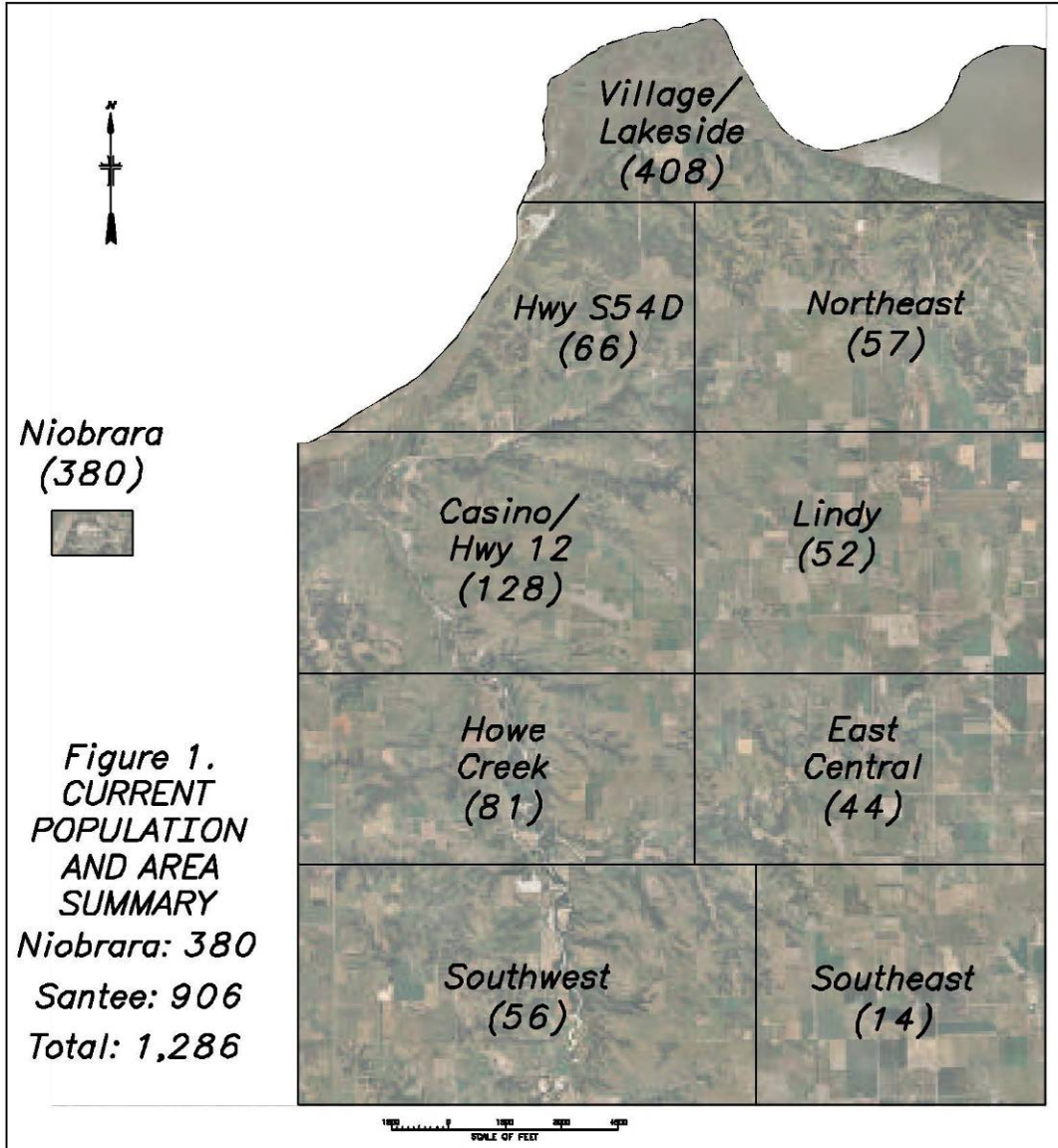


Figure 1. Current population and area summary.

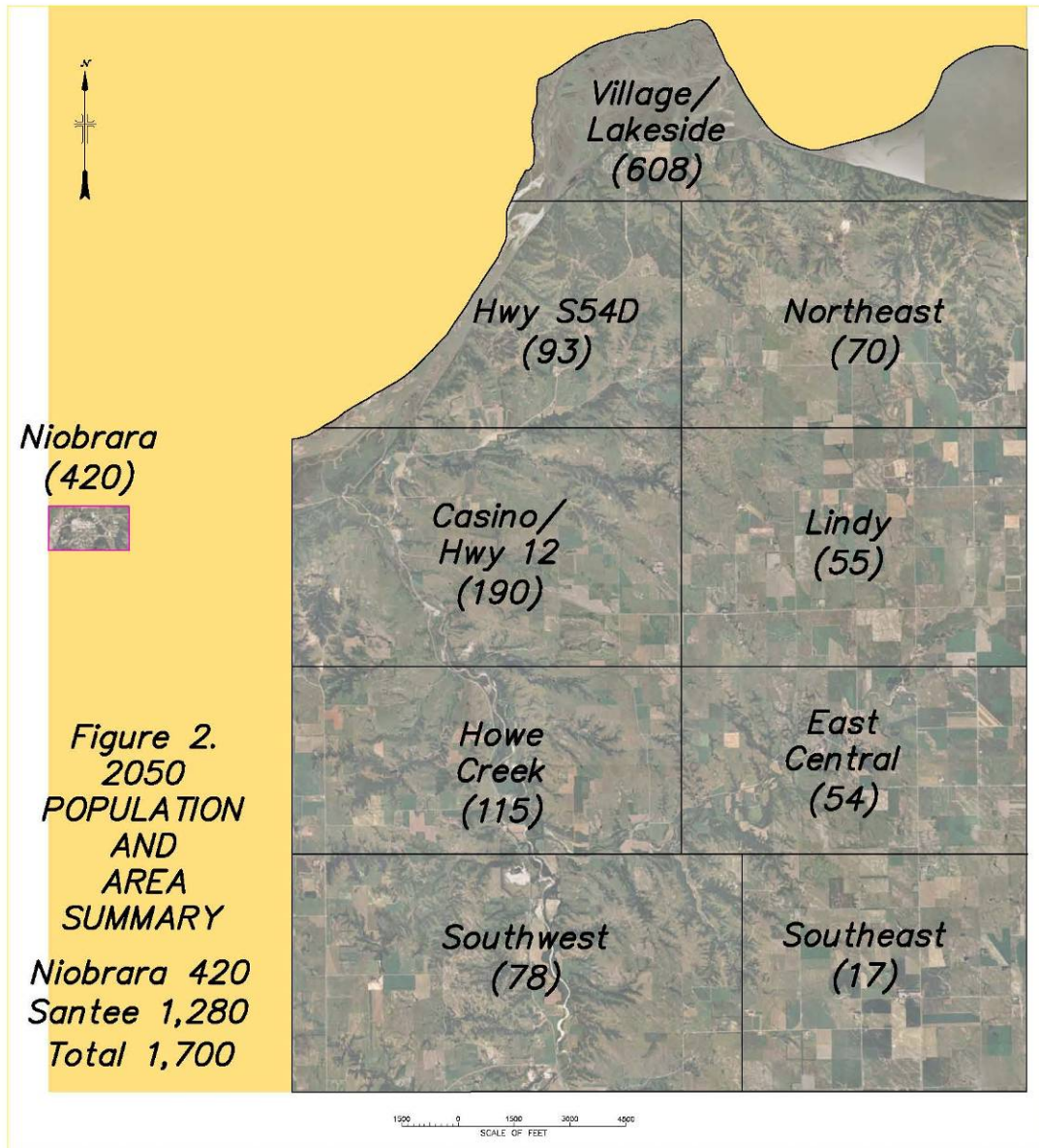


Figure 2. 2050 population and area summary.

Looped lines minimize headloss in the pipe since the flow of delivered water from two directions requires less flow in each pipeline than if all of the flow was from one direction in one pipeline. Looped lines also offer the advantage of maintaining service in the event of a line break. Unfortunately in remote areas, looped lines may not be economically justified.

Definition and Benefits of Pressure Zones

A pressure zone is defined as the area bounded by both a lower and upper elevation, all of which receives water from a given hydraulic grade line (HGL) or pressure from a set water surface. The HGL is usually provided by one or more storage tanks located at the same elevations so they share high and low water surfaces. Ideally, pressure zones contain the same pressures and, therefore, the infrastructure within each pressure zone can be designed with a uniform set of design criteria which stresses efficiency, reliability and durability.

The goal of the owner of a large water distribution system is to provide a safe and abundant water supply to its customers in the most cost efficient manner possible. Dividing a large service area up into several pressure zones provides for low O&M cost by:

- Utilizing standard, low pressure class of either PVC or DI pipe for normal water distribution or for fire flow.
- Utilizing standard, low pressure class valves.
- Minimal pumping of treated water since areas of demand are served by storage tanks located to serve their respective pressure zone.
- Low head pumping since the limits of pressure are as defined by each zone.
- Homes do not need individual pressure reducing valves. PRV's on a main at a pressure zone boundary can allow flow from an upper zone into a lower zone during an emergency.
- Fighting a fire from storage tank located close to the impact area.

Water delivery pressure is actually the difference between the HGL (e.g., storage tank's water surface elevation or pump station discharge pressure) and the ground at the tap, less line losses or headloss from the flow of demands to the area. Since lines are sized based on providing acceptable velocities during peak flow conditions, (e.g., fireflow or peak hour flow), headloss from the tank to the tap is usually minimal. Detailed delivery pressures from the storage tanks can be determined accurately during a final design phase through the use of a computer-aided hydraulic model simulation of the system with model runs for varying conditions of flow (average day, peak hour, peak hour with a fire, etc.).

Water distribution system pressure zone pressures typically range from approximately 40 pounds per square inch (lb/in²) to 100 lb/in² (92 to 231 ft of head) at all service taps located within the pressure zone.¹ This range of pressure

¹ For water at standard conditions, pressure is determined based on head (i.e., feet of water) with 1 lb/in² = 2.31 ft of elevation or 1 ft of head = 0.433 lb/in²

is a guideline but can be used initially to analyze service area pressures uniformly. Distribution system pressure can be supplied by a pump, a water storage tank, or combination of both. The range of pressures within the zone, say 40 lb/in² (92 ft) to 100 lb/in² (231 ft), sets the zone boundaries such that the difference, 139 ft, creates the width of each pressure zone. Also, the upper limit (the 100 lb/in² elevation) of one zone is shared with the lower limit (40 lb/in²) of the next higher zone.

With the use of pressure zones, gravity service is provided and low pressure pumping from either a treatment plant clearwell or lower pressure zone storage tank only occurs to fill an upper zone storage tank. Pump control can be automated based on water levels in the storage tank. When the tank's level drops from water demands in the system, pumps in the lower zone activate and start to fill the tank and/or satisfy the demands. Since the pump's design discharge pressure is set to overcome headloss enroute to the tank's high water level, service taps essentially receive the same pressure as they would if the water was flowing by gravity to them from the storage tank.

Santee Pressure Zone Scenarios

Reclamation performed a screening of several water sources in FY2006, the result of which favored using the Missouri River with treatment located near the source. A clearwell (treated water storage) by the treatment plant is assumed to contain a set of high service pumps which can pump treated water to storage tanks serving the lowest pressure zone. The location and size of the storage tanks have yet to be designed but will depend on the magnitude and locations of the water demands. The existing Santee Village water storage tank maximum water surface elevations were used to initially consider and identify most of the pressure zones. The analysis indicates that for the upper pressure zones, since the required elevation for a storage tank is not available, a hydro-pneumatic tank may be considered if the water source is the Missouri River, or perhaps another water source should be considered.

An aerial photograph file, a U.S. Geological Survey existing contour file, and the population tract information were combined and used as the basis for mapping and identifying pressure zones. These base maps can be used to create other feasibility study exhibits if needed. As previously stated, pressure zone boundaries are ideally determined around pressures (the HGL minus ground elevation minus pipe losses) however, pressure zone boundaries may also be defined considering elevations of existing tanks or other unique circumstances.

For the Santee Indian Reservation, two pressure zone scenarios were developed and are shown in Figure 3, Existing Pressure Zone Layout, and Figure 4, Ideal Pressure Zone Layout. (Ideal in this context, refers to the establishment of pressure zones without considering existing infrastructure of water storage and distribution piping. It does not necessarily imply a superior scenario to that termed "existing".) The existing pressure zone layout was developed considering

the elevation of the Santee Village’s existing 115,000-gallon storage tank. Using this tank’s high water surface elevation of 1396 feet, and a design standard 40 lb/in² pressure zone minimum pressure, the highest area to be served by this tank is at elevation 1304 feet. The highest pressure from this existing tank would be found at the reservation’s low point of 1240. The pressure at this point is 67.5 lb/in² (the elevation difference of 1396 to 1240 feet, times 0.433 lb/in²/ft).

Table 1 lists the low and high grade elevations for the existing and ideal scenarios as well as the maximum water surface elevations for the water storage tanks for each zone.

Table 1. Existing and Ideal Pressure Zone Scenario Elevations

Pressure Zone	Low point (Elevation), ft	High Point (Elevation), ft	Storage Tank Maximum Water Surface Elevation, ft
Existing Scenario			
1	1240	1304	1396 ¹
2	1304	1443	1535
3	1443	1582	1674
4	1582	1721	1813
5	> 1721		1952
Ideal Scenario			
1	1240	1379	1471
2	1379	1518	1610
3	1518	1657	1749
4	1657	1796	1888
5	> 1796		2027

¹ Existing 115,000-gal tank’s high water elevation.

As described in the previous section, delivery pressures to service connections will be the difference between the tank’s water level, less headlosses in the pipe, and less the ground elevation at the service connection. Also as stated, line losses are usually minimal since the pipelines are sized for peak flow (fireflow or peak hour) conditions. Delivery pressures can be expected to be between 40 and 100 lb/in² during normal demand situations. According to Reclamation’s Plan of Study, fire protection is to be provided only in those areas where there is existing fire protection, .i.e., village, casino etc. Generally, fire protection delivery pressures are at least 25 lb/in² (the Insurance Services Office standard for fire protection, this value needs to be confirmed with the local fire protection District) of residual pressure in an adjacent fire hydrant when the fireflow rate is delivered. Using computer simulations in a final design phase, the pipelines will be sized large enough to provide this residual pressure.

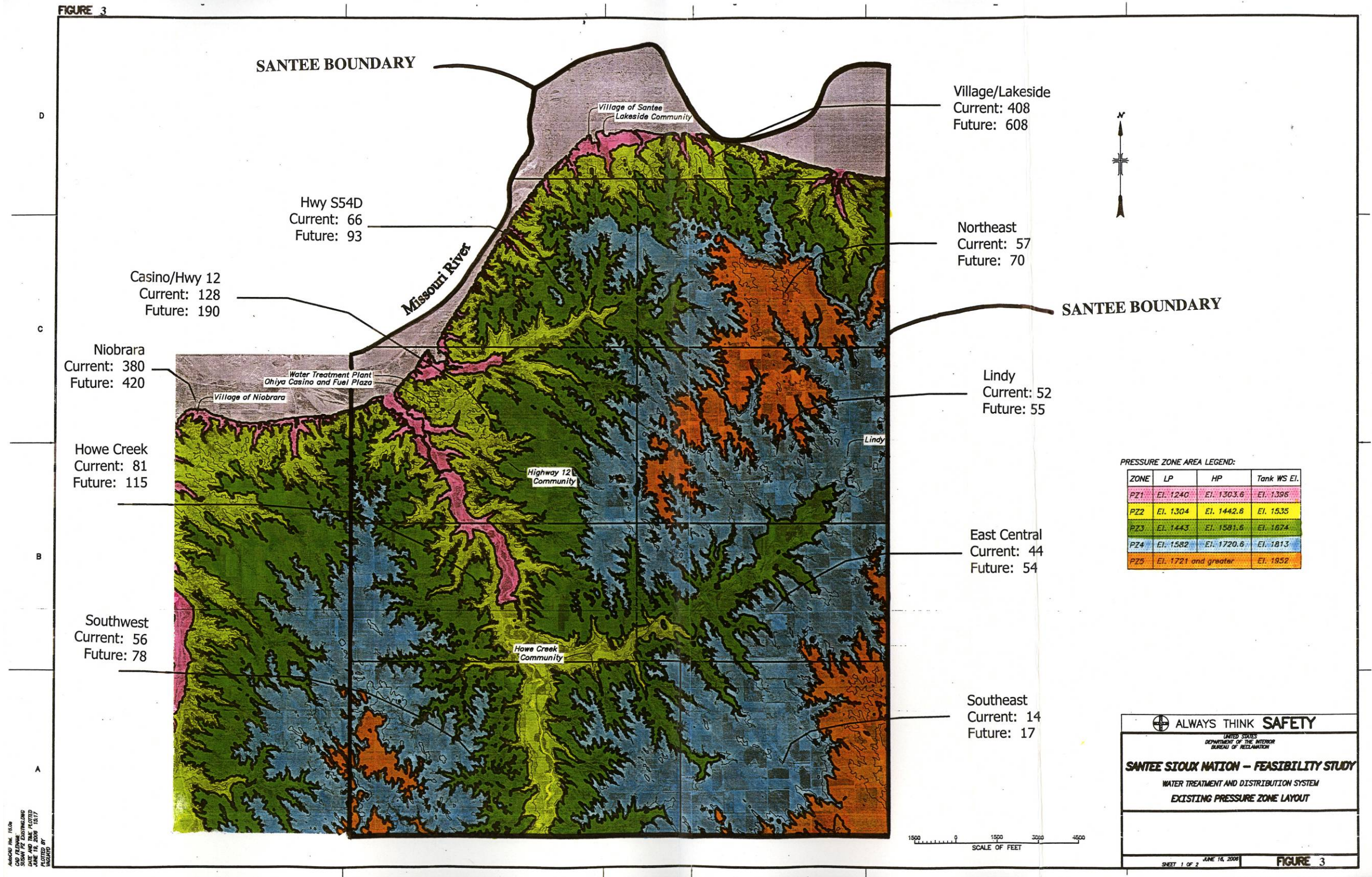


Figure 3. Existing pressure zone layout.

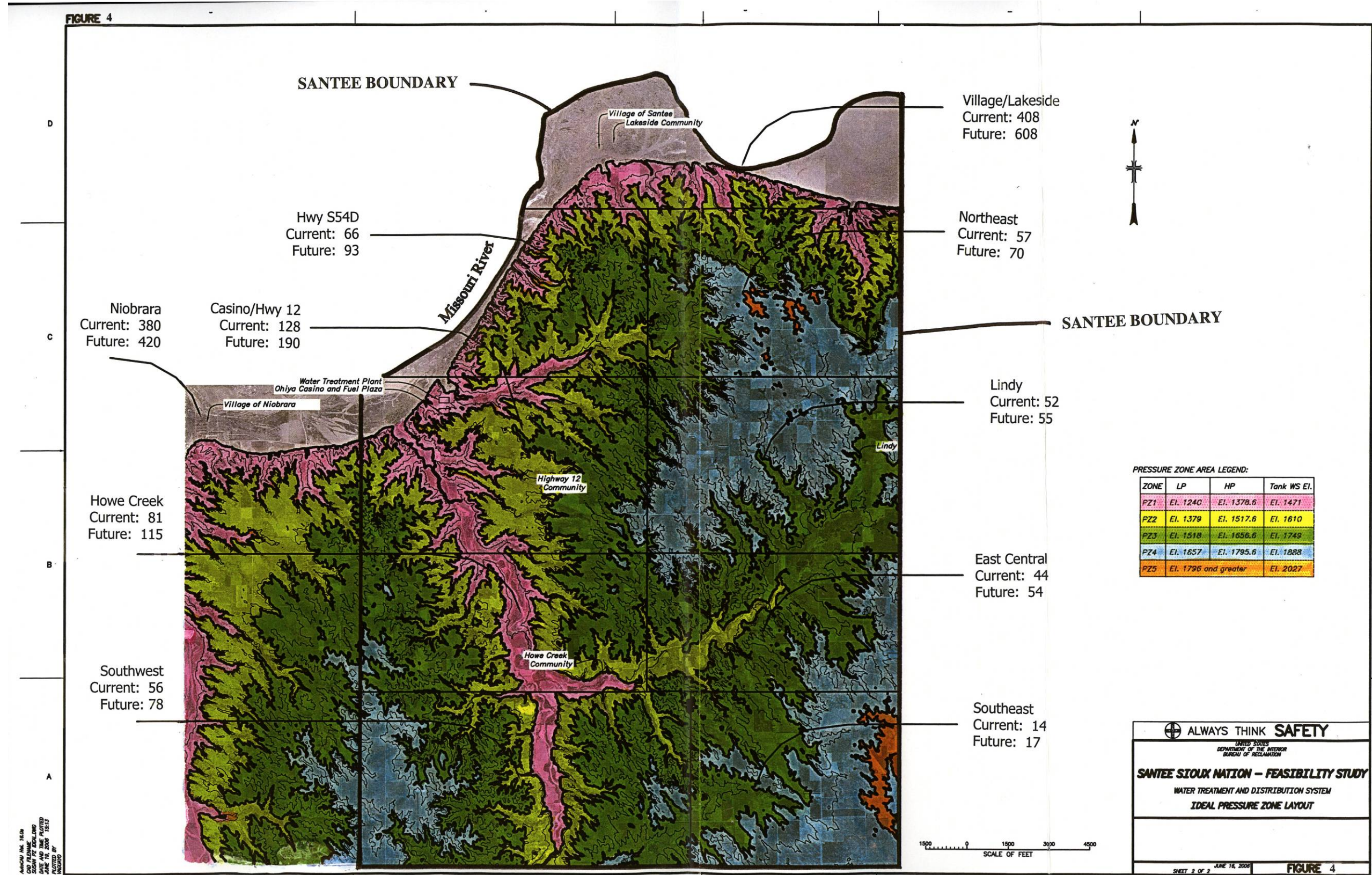


Figure 4. Ideal pressure zone layout.

Review of Pressure Zone Scenarios

As described in the Design Features section, utilizing water storage in more than one location affords some added reliability should one of the tanks need to be taken out of service. In either the existing or ideal scenarios, due to the large distance between the water demands from the Village of Santee and the commercial/casino area, it is likely that two pressure zone 1 storage tanks would be needed. This is a preliminary determination and would have to be confirmed with further engineering analysis. Such analysis is further described in the next section.

The ideal scenario serves the Santee Service area with four pressure zones to a greater aerial extent than the existing scenario. That is, the ideal scenario serves all land between elevations 1240 feet to 1796 feet, whereas the existing scenario serves only land between elevations 1240 feet to 1721 feet. While the existing scenario utilizes the site of the existing tank, it limits the extent of zone 1. Both scenarios include a low point within the service area and for zone 1 of elevation 1240 feet. In the existing pressure zone scenario, zone 1's upper limit was set by placing 40 lb/in² from the existing tank's high water surface. This zone is smaller than the ideal pressure zone scenario (64 ft vs. 139 ft) but would match the Santee Village's current delivery pressure.

Setting the 40 lb/in² upper pressure of zone 1 equal to the highest pressure found in zone 2 (100 lb/in²) determines the existing pressure zone 2 boundary elevations at 1304 feet to 1443 feet, with a corresponding high water tank elevation of 1535. Coincidentally, the adjacent community of Niobrara has an elevated standpipe with a high water elevation of 1528 feet. Since this nearly matches the existing scenario zone 2 tank elevation, there would be many advantages or benefits using the existing zone scenario.

Benefits of existing scenario include:

- Should there ever become a need to do so, filling either Niobrara's tank from the tribe or the tribal tank from Niobrara would be easier to accomplish if these tanks are in the same pressure zone. (The feasibility study envisions two independent systems making this provision to replenish the others' tank for emergency purposes only.)
- Providing Village residents with pressures equal to what is currently provided.
- More land area served by a given number of pressure zones.

Another point of discussion is that the highest two zones in either scenario lie in the eastern or in the southern and eastern parts of the reservation, which have very low populations and corresponding water demands. Instead of constructing an elevated storage tank to serve these high zones, they could be served instead by a hydro-pneumatic tank which receives water at a low pressure from the zone it is located in and boosts the pressure from a pneumatically filled, pressurized ASME (American Society of Mechanical Engineers) certified tank. The desired HGL (shown in table 1 as Storage Tank Maximum Water Surface Elevation) is provided by the outlet pressure of the tank. This concept of service from a pressurized tank could also apply to zone 4 in either scenario. Other more economic options for service for these remote areas may include groundwater development (wells with chlorination) or water delivered from an adjacent district.

Next Steps

To complete the Feasibility level design of the water system layout the following major steps will be required:

1. Decide if service to sparsely populated areas (i.e., in the southwest and southeast portions of the reservation) is justified using extensions of the conventional water distribution system or if there are other alternatives to serve these remote areas. Other alternatives may include drilling to find groundwater and installing wells, service from an adjacent water district, or use of imported or bottled water. An economic analysis may be needed for these areas to determine an efficient solution.
2. For the service area using conventional water distribution, identify the location and magnitude of all demands. This would include fire flows and fire protection storage volumes.
3. Agree on the maximum and minimum pressures that service taps in the service area will receive. These pressures will set the boundaries for pressure zones as explained in this report.
4. Using a pressure zone map such as figure 3 or figure 4, apportion all water demands into the pressure zone.
5. Size and locate storage facilities for each pressure zone. Storage volume design criteria need to be established and agreed to. Typical storage tanks are sized for at least three components: equalization for maximum day water usage; fireflow volume, and emergency service (i.e., 3 to 5 days of loss of source water or power).

6. Size larger water mains from the storage tanks to deliver the water in a looped fashion such that smaller waterlines can be used to deliver water from a main to all service areas. Velocity and headloss design criteria need to be established and followed to properly size the mains for the maximum expected flow.
7. Install some mainline pressure reducing valves which provide emergency service from upper pressure zones to lower pressure zones.

Fireflows and Fireflow Storage Volume

The Feasibility Study will provide a plan for fire protection in areas which currently have fire protection. This would include the Village of Santee, the casino/gas station complex (to be confirmed), and the town of Niobrara. Fireflows represent the flow inside a pipe necessary for fire protection. Fireflows usually are significantly greater than the peak instantaneous flows found from domestic (residential) or C/O/I (commercial/office/industrial) use. Therefore, when sizing water lines, it is the expected fireflow which must be considered. Failure to recognize this flow in pipe segments could result in a water distribution system that is unable to deliver the needed fireflow (e.g., waterlines that are too small for fireflows create negative pressures within the water system which could result in collapsed pipelines).

In FY 2006, Reclamation started to look into appropriate fireflow for the Santee and Niobrara facilities. Currently, the Santee casino has a fire protection system installed which uses water from the well house. Throughout the Village of Santee, fire hydrants were observed which are assumed to provide fire protection to the community. Niobrara, according to the Insurance Services Office's Derrick Thomas (312-930-0070 ext. 3) requires fireflow; however, a design fireflow rate and duration have yet to be agreed upon.

The following is text taken from Reclamation's September 2006 "Preliminary Engineering Report, Santee Sioux Tribe of Nebraska, Water Treatment Plant Assessment," prepared for the U.S. Environmental Protection Agency. It is provided for information. In summary, fireflow rate and its duration are critical components of the water demands and storage for a distribution system and neither have been finalized for this Feasibility Study

Determination of an actual required fire flow rate or water storage volume is the responsibility of the Tribe, local fire district, Insurance Services Organization (ISO), and an engineer performing a final design. Fire flow rates and water storage volumes are based on several factors, which are not known at this time, including construction materials, finished square footage, approximate location of nearest buildings, spacing of fire hydrants, exact length and sizes of all pipelines, sizes and volumes of fire pumper trucks to be used, etc. This discussion is for planning, is based on several assumptions and is not a recommendation for final design or construction. Fire flow rates and water storage volumes must be calculated for each structure or set of structures within close proximity.

Needed Fire Flow Rate According to ISO, several factors are required to determine the needed fire flow rate, gpm, for a single structure or set of structures. These include the area of the structure, construction class, occupancy class, structure exposure, and separation or protection between structures.

Based on separation between dwellings, ISO's *Guide for Determination of Needed Fire Flow*, 2005, lists the following needed fire flow rates for 1 to 2 family dwellings which are less than 2 stories in height:

- More than 100 feet = 500 gpm
- Between 31-100 feet = 750 gpm
- Between 11-30 feet = 1,000 gpm
- Less than or equal to 10 feet = 1,500 gpm

For estimating purposes only, it is assumed the **500 gpm** flow rate will meet the requirements of the following residential areas and tribal facilities:

- Residences at Lakeside and Howe Creek
- Highway 12
- Single residence within 500 feet of the treatment building
- Residences and tribal facilities along Highway S54D
- Residences and tribal facilities in the Village proper

Appendix A of ISO's *Guide for Determination of Needed Fire Flow* lists the fire flow rate based on the type of construction and effective area of a structure. For estimating purposes only, Appendix A was consulted for selecting a needed fire flow rate for the casino and gas station using the following assumptions. Actual conditions must be used to determine the actual needed fire flow.

- The effective area for any one structure is between 17,410 – 21,267 square feet
- The construction class is 2 (joisted masonry construction)

Using these assumptions, ISO requires a maximum a **2,500 gpm** flow rate for the casino and gas station.