RECLAMATION

Managing Water in the West

Water Needs Assessment Technical Report

Northwest Area Water Supply (NAWS) Project, North Dakota
Dakotas Area Office, Great Plains Region

U.S. Department of the Interior
Bureau of Reclamation

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Contents

Page

1.0 Introduction

The purpose of this water needs assessment is to project the future water needs for a 50-year planning period (2010 through 2060) for the ten-county area of North Dakota which would be served by the Northwest Area Water Supply (NAWS) project. The ten-county area includes Bottineau, Burke, Divide, McHenry, McLean, Mountrail, Pierce, Renville, Ward, and Williams Counties (Figure 1). Projections were developed for both the entire ten-county area (Project Area) and the geographic extent of the Project Area that would receive water service from the NAWS Project (Water Service Area). Ancillary data created in support of projecting the water needs of the Project Area and Water Service Area, including population projections and average per capita water use, are also provided.

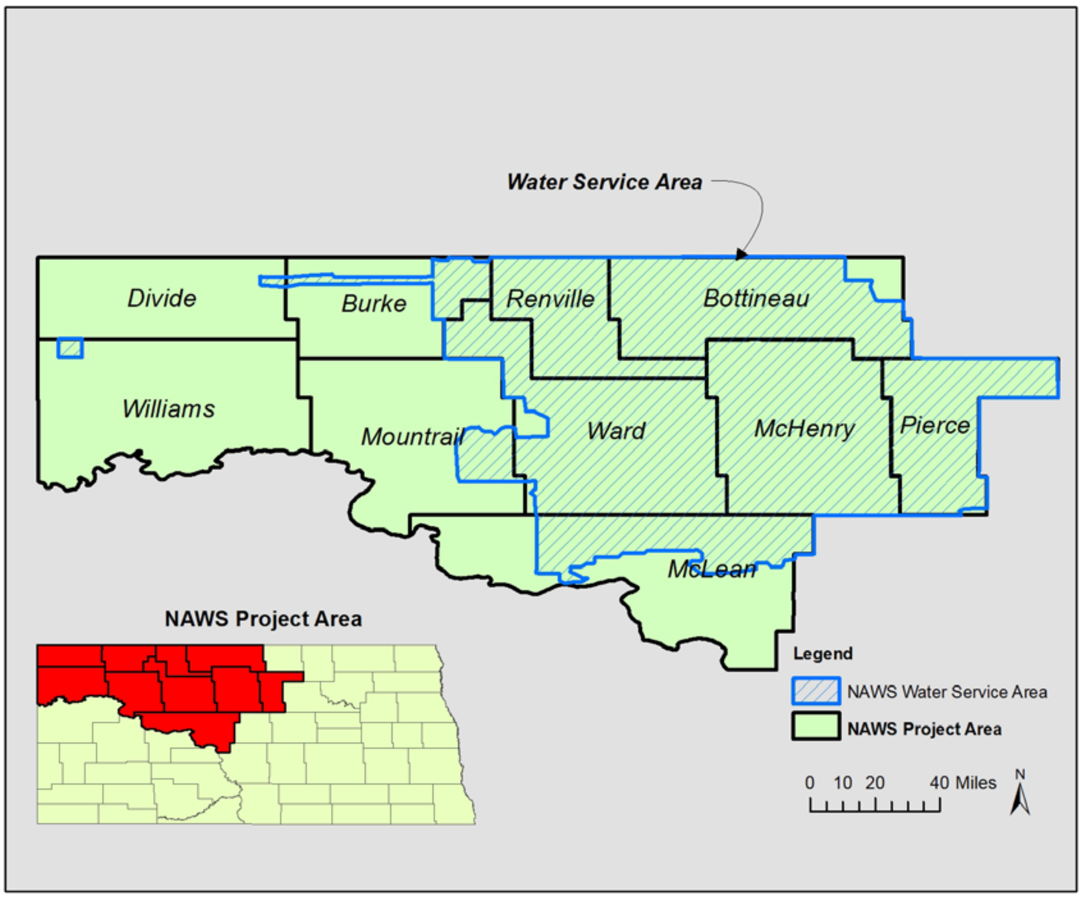

Figure 1. Map of the NAWS Project Area and the NAWS Water Service Area.

The following chapters address: 1) the purpose of the Water Needs Assessment Technical Report; 2) a discussion of the water supply service areas; 3) an overview of the current water suppliers participating in the NAWS project; 4) a detailed overview of the water needs and population projections for the Project Area and Water Service Area, and a description of the methods used in their development; 5) a summary of the population and water needs projections; 6) an overview of the effects that climate change might have on the future water needs of the Project Area; and 7) a summary of the findings of this study. Additionally, two appendices of supporting data and calculations are included as attachments.

2.0 Purpose

This Water Needs Assessment Technical Report was authorized by the U.S. Bureau of Reclamation (Reclamation) in support of the Supplemental Environmental Impact Statement (SEIS) for the NAWS project (Project). Since the mid-1980's, an Environmental Assessment (EA), an Environmental Impact Statement (EIS) and other engineering studies that have been prepared for the Project, have presented population and water needs projections for various planning periods. In response to a U.S. District Court order issued in March 2010 (U.S. District Court, 2010), Reclamation chose to prepare a Supplemental Environmental Impact Statement that addresses the issues identified by the Court, as well as updating information from the previous environmental analyses completed for the Project.

An updated assessment of the projected water needs for the Project was conducted to determine how recent growth trends in northwestern North Dakota may be affecting population growth rates and water use habits in the Project Area. Water supply options and alternatives, which are presented in the SEIS, were designed to meet the projected future water needs of the Project based on the findings of this assessment.

3.0 Water Supply Service Areas

3.1 Municipalities & Rural Water Districts

Multiple municipalities and other entities in the Project Area would be served by the Project. The NAWS member entities include cities, unincorporated suburban areas, and rural water districts, which do not directly correspond to county boundaries (Table 1; Figure 2). In addition to the municipalities noted in Table 1, the rural water districts collectively serve numerous individual small towns, unincorporated rural areas, and rural users.

Table 1**.** Municipalities and Rural Water Districts Included in the Project (Houston Engineering, 2001 and 2005 and email correspondence with Reclamation staff, 2011).

Rural Water Associations & Districts					
All Seasons Water Users District					
North Central Rural Water Consortium					
North Prairie Rural Water District[1]					
Upper Souris Water Users					
West River Water & Sewer District					
Cities & Municipal Areas					
Berthold	Columbus	Flaxton	Lansford	Mohall	Tolley
Bottineau	Deering	Gardena	Larson	Noonan	Upham
Bowbells	Des Lacs	Glenburn	Maxbass	Rugby	Voltaire
Burlington	Donnybrook	Grenora	Minot	Sherwood	Westhope
Carpio	Douglas	Kenmare	Minot A.F.B.	Souris	Willow City
1) Currently served by Minot					

3.2 Development of Service Area Boundary Maps

Utility service areas, for the purposes of this report, are defined as all areas that currently have or will have water service during the planning period. Determining individual utility service areas was an important component of the method used to project future population and water needs for the Project Area. A project geographic information system (GIS) was developed to facilitate the mapping and data management of each individual municipal or water district service area for the entities listed in Table 1.

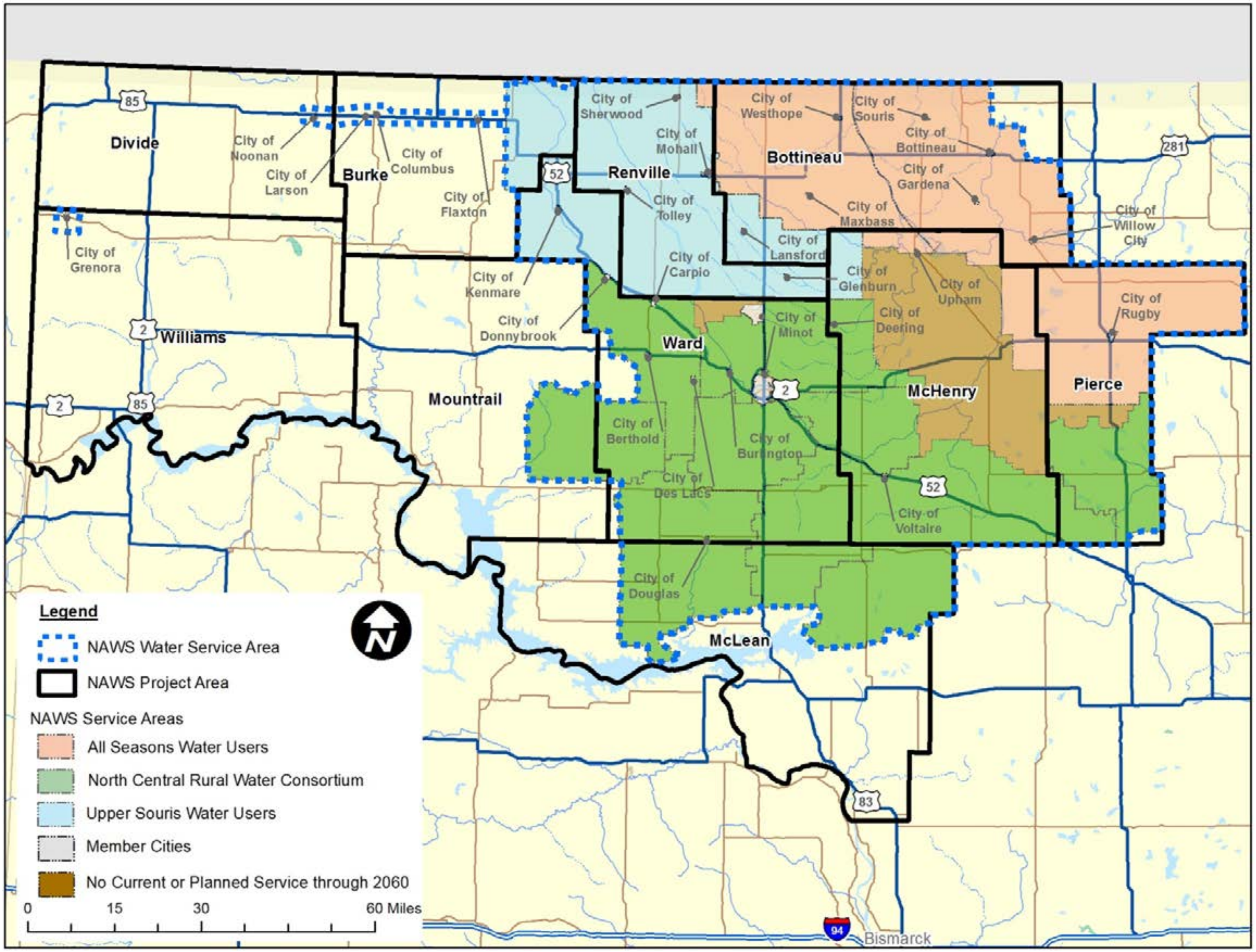

Figure 2. Map of the Project Area and the Current Water Service Area.

Service area boundaries were developed using the following data sources:

Water User Surveys - A water user survey was developed and circulated to each of the NAWS member utilities to solicit data regarding the utilities' water systems (Appendix 1). Many of the completed utility surveys were useful in determining which areas are currently served or will be served in the future by the existing public water supply systems. In some cases descriptions of the service area extents were provided or the utilities confirmed that their service areas were concordant with the city or town corporate boundary. Other utilities included maps of their service areas along with the completed water user surveys. Additional details of each member water system are included in Section 4.

North Dakota State Water Commission (SWC) GIS Data – The SWC maintains a spatial dataset of service areas for the rural water districts of the state of North Dakota. The data shows accurate external geographic boundaries for the districts (SWC, 2011), however, the internal extent of several of the mapped districts required editing and updating to accurately depict the district service areas. The rural water district service areas, which cover large portions of several counties, were also drawn to include municipalities which produce and supply their own water (self-supplied). The self-supplied utilities, some of which are also NAWS members, were extracted from the rural water districts to enable the calculation of their water needs separately from those of the water districts.

Publicly-Available Reports – In several instances, publicly-available reports were used to supplement the data provided by NAWS members in the water user surveys. Reports accessed from the web were useful in the digitization of utility service areas for the City of Minot, the All Seasons Water Users District, and the North Central Rural Water Consortium.

Generally, the service area maps acquired for each water district lacked good resolution, and these areas were digitized into the project GIS using "heads-up" digitizing techniques. The "heads up" technique involves electronically connecting the water district service areas to the edge of the nearest 2010 census block boundaries for the purpose of projecting population (Figure 3). Census blocks are the smallest geographic division used in decennial U.S. Censuses (U.S. Census Bureau, 2011) and are the basis of the Water Service Area population projections presented in this report.

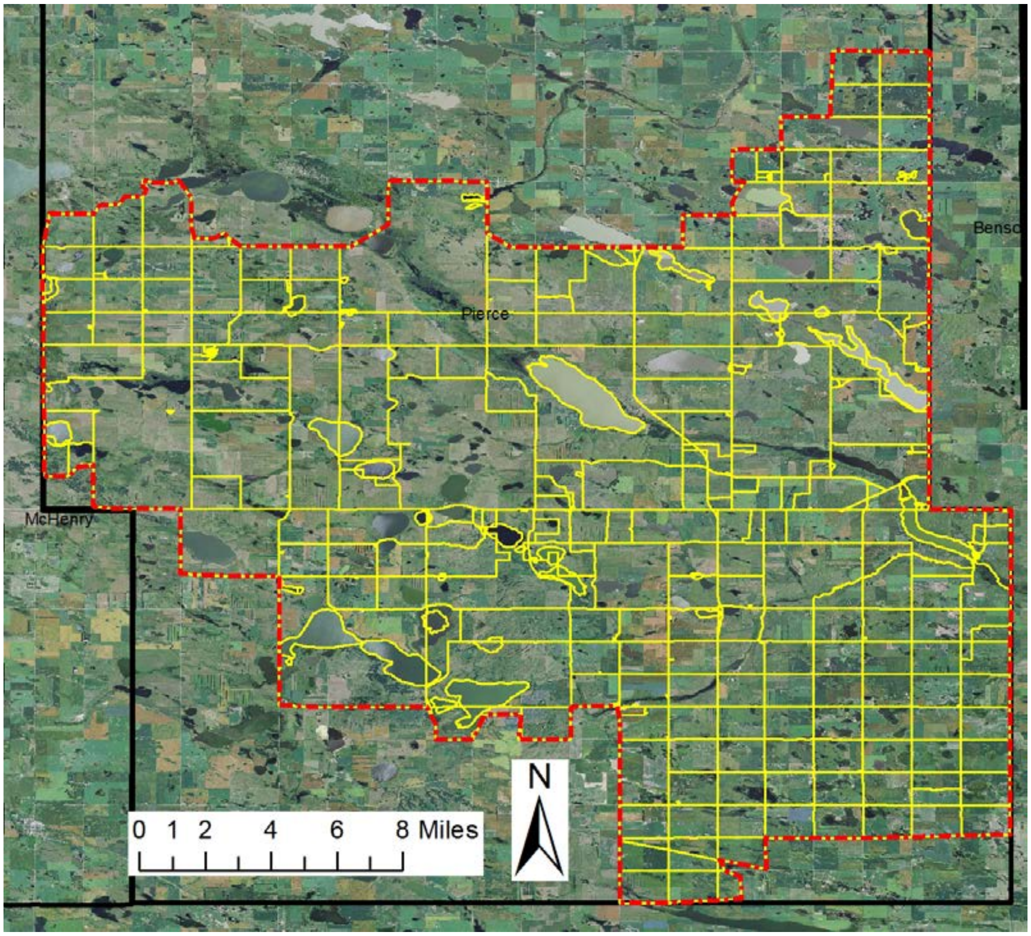

Figure 3. 2010 Census Blocks in the North Central Rural Water Consortium Pierce County Service Area.

According to the water user surveys, the majority of NAWS municipal members provide water service only to users within their corporate limits. The corporate limits generally correspond to census-designated places, which are municipal areas comprised of multiple census blocks, for which U.S. Census population data is reported as a unit. The individual service areas for each municipality were drawn along the census-designated place boundaries (Figure 4 provides an example of this technique) unless otherwise specified by the NAWS municipalities in the water user surveys. Table 1 is a list and description of each individual service area. Figure 2 is a map of the Water Service Area and individual service areas.

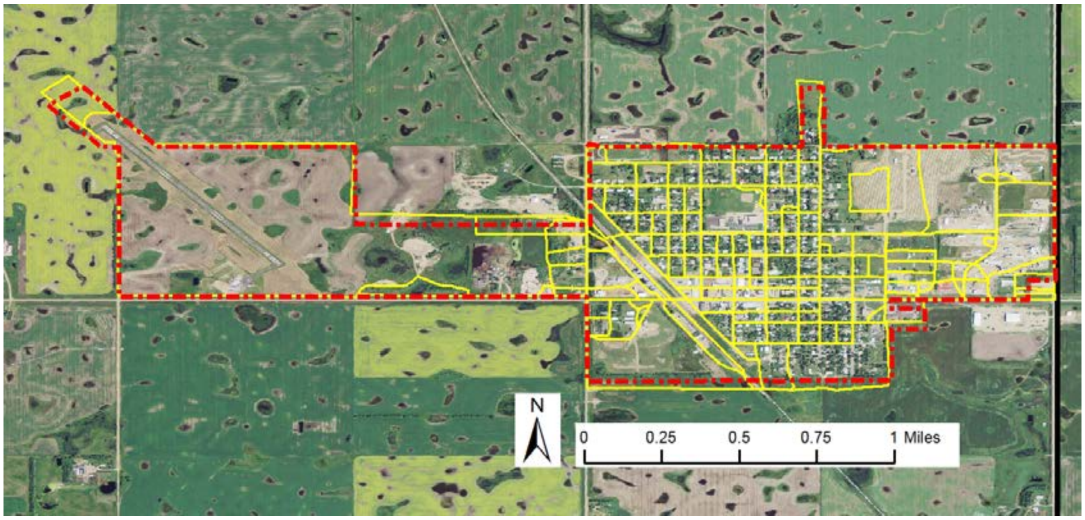

Figure 4. Example 2010 Census Blocks within the City of Mohall Corporate Boundary.

4.0 Participating Water Suppliers

4.1 Water System Profiles

As previously discussed, water user surveys were obtained from many of the current water suppliers who would be connected to the Project. Data from each of these surveys and permit data obtained from the SWC online water permit database were used to develop a water use profile for each participating NAWS member. To the extent available, data on historic populations, historic peak water use, and future service area annexations or growth was compiled or calculated by the participating water supplier (Table 2). Survey data are only provided for the nine NAWS members that responded to the survey. The profile of each participating water supplier was used in the calculation of the population and water needs projections as described in Section 5.0 of this report.

4.2 Project Peaking Factor

SWC staff, in cooperation with the water users within in the Project Area, have determined that a peaking factor of 2.6 is appropriate for the Project. The peaking factor of 2.6 is comparable to the peaking factors used in other regional water supply projects in North Dakota, such as the Western Area Water Supply Project (design peaking factor of 3.0) and the Southwest Pipeline Project (design peaking factor of 2.75-3.0). These regional water systems are similar in size to the Project, with similar populations and water use profiles. In regional systems, higher design peaking factors are necessary to accommodate uncertainties in population growth and also to provide redundancy and operational flexibility in treatment facilities. In other regional water systems in North Dakota, it has also been observed that when high-quality water is made available, per capita water use increases. A peaking factor of 2.6 would account for any increases in per capita related to the availability of high-quality NAWS water (SWC, 2012).

Table 2. Water System Data Provided by NAWS Members.

City or Rural Water District	Population & Industries Served	Service Area & Distribution System	Planned Future Service Areas	Historical Demand (mgd)	Historical Peak Demand (mgd)	Description of Service Area
All Seasons Water Users	624 residential connections & 1720 people	ASWU has 4 service areas. Service areas 1 & 3 would receive NAWS water. Service areas 2 and 4 are outside of the Project Water Service Area.	750-connection annex to be served by 2014 (0.54 mgd)	NP[3]	0.25	Parts of Bottineau, Pierce, & McHenry Counties
City of Berthold	199 residential connections (460 people); 25 commercial connections	10 blocks wide by 11 blocks long; corporate boundary	Growth expected within city limits	NP[3]	NP[2]	Corporate Boundary
City of Burlington	360 residential connections (1,060 people)	Burlington corporate boundary	25 planned residential lots to be developed	NP[3]	0.18	Corporate Boundary
City of Kenmare	440 residential connections (1,160 people); 60 commercial / industrial connections	Kenmare corporate boundary	Growth expected adjacent to city limits	NP[3]	0.4	Corporate Boundary
City of Minot	12,500 residential connections (50,000 people); 952 industrial / commercial connections	Minot corporate boundary, outlying areas, & Minot AFB; North Prairie Rural Water System is also a water customer of the City	Northern Lights Planned Unit Development (PUD) to connect by 2012 (0.5 mgd); growth expected SW of city	NP[3]	10	Corporate Boundary & other areas in Ward County
City of Mohall	340 residential connections (783 people); minor commercial and industrial use	same as Mohall corporate boundary	Nordkill PUD will connect by 2012 (0.05 mgd)	0.08	0.12	Corporate Boundary
City of Sherwood	152 residential connections (242 people); 18 commercial and industrial connections	Sherwood corporate boundary; 40 city blocks	Growth expected adjacent to city limits	NP[3]	0.025	Corporate Boundary
North Central Rural Water Consortium	14,633 people served	10 service areas covering large portions of the Water Service Area	Berthold-Carpio, Deering-Granville, & Mountrail II service areas to connect by 2012	1.05	2.1	Parts of Mountrail, Ward, McLean, McHenry, & Pierce Counties
Upper Souris Water Users	570 residential connections (2,400 people)	Service area covers NW portions of the Water Service Area	N/A	0.16	0.4	Parts of Burke, Bottineau, Renville, Ward, & McHenry Counties

1) Calculated using data provided in the water use surveys, and/or data gathered from the SWC website (average of past five years of water use)
2) Peak demands are met via storage facilities. Capacity of source water is limited.
3) Not Provided

5.0 Water Needs Assessment

Water needs and population projections for the Project Area and Water Service Area were developed using methods based on the American Water Works Association (AWWA) guidelines as explained in *Forecasting Urban Water Demand (*Billings and Jones, 2008). Elements of both the AWWA "standard" and "pragmatic" approaches were employed in the projections. The "standard" methods involve gathering and analyzing historic population and water use data using a series of simple statistical methods to discover trends which are used to project future populations and/or water demands. The AWWA pragmatic approach is an adaptive approach which involves deviating from the "standard" approach where necessary to develop defensible projections. For the purposes of this Project, it involved coupling the statistical approaches of the "standard" method with GIS population modeling methods, which were needed to accurately forecast and represent the future population and water use of the Project Area.

5.1 Population Projections for Public Water Supply Areas

5.1.1 Projection Methodology

Population projections were developed for the Project Area and the Water Service Area to support the development of water needs projections. The best available data from the past three decennial U.S. Censuses was used as input data for the projections. Rates of population growth or decline for each member municipality of the NAWS system were developed using the year 2010 as a baseline population estimate for the study. Complete Census data (accessed via http://factfinder.census.gov/home/saff/aff_transition.html) exists for the year 2010, and the associated GIS files, which were used to assign populations to the municipal service areas, were also downloaded from the U.S. Census Bureau.

Depending on the projection area, city-level or county-level population data for 1990, 2000, and 2010 were used to extrapolate population growth rate trends for each municipal service area within the Water Service Area (Figure 2). The population data were used to calculate a cumulative growth or decline trend based on the rate of change between 1990 and 2010.

The historic decennial U.S. Census data was analyzed graphically and statistically to extrapolate growth or decline trends, which were then expressed in the form of an equation. Linear and logarithmic trend lines were fitted to each population data set. Examples of each type are shown in Figure 5 and Figure 6.

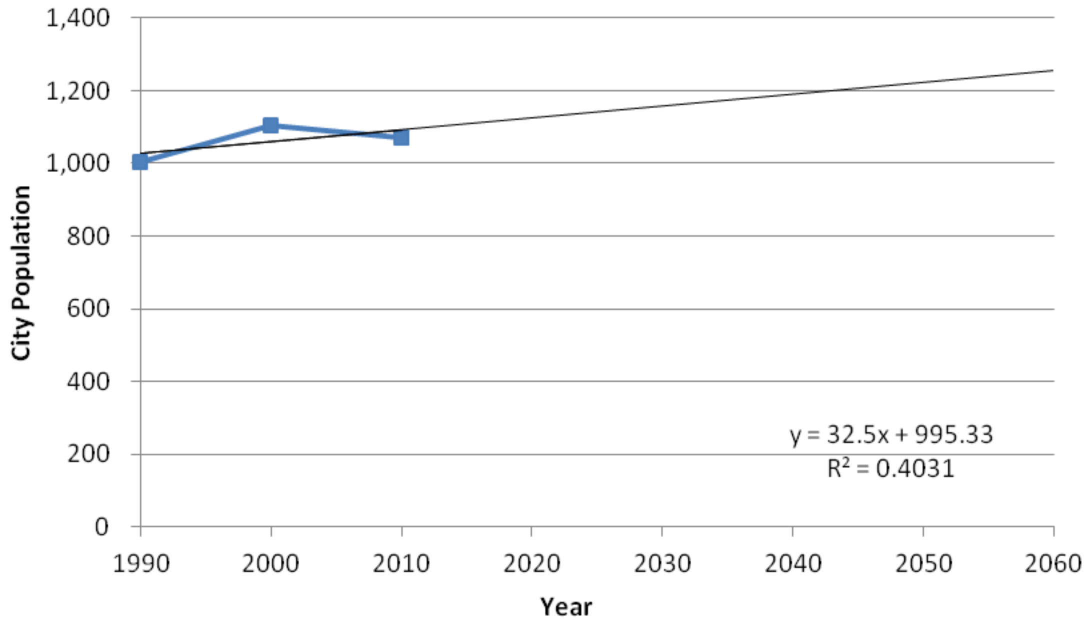

Figure 5. Example Linear Population Trend for the City of Burlington.

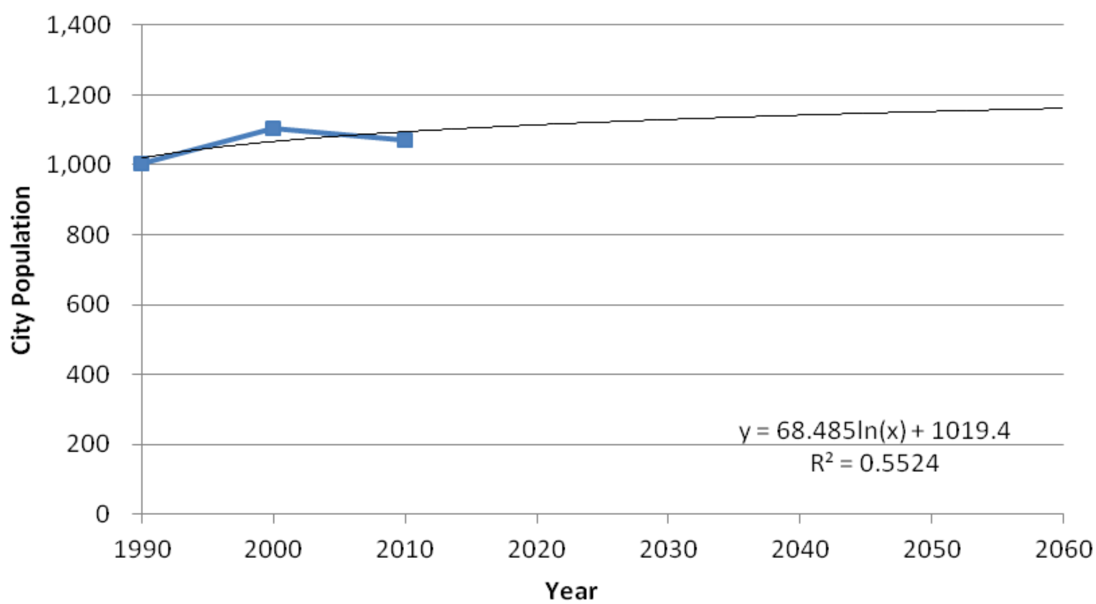

Figure 6. Example Logarithmic Population Trend for the City of Burlington.

After a trendline was fitted to each population data set, an equation was derived that expresses the (growth or decline) logarithmic or linear trend represented by the curve. The equation was then used to calculate growth for each of the 10-year increments of the planning period.

The "x" variable of the equation (Figures 5 and 6) represents the period of time (in 10 year increments) elapsed since the start of the projections. For projections beginning in 2010, "x" was expressed as (2020 population-2010 population), (2030 population-2010 population), (2040 population-2010 population), etc. The result of the equation, “y”, is the population based upon the logarithmic or linear growth trend used. Both logarithmic and linear trends were developed and analyzed for goodness of fit, or the best statistical fit to the actual population dataset (Appendix 2). The method that provided the best “goodness of fit”, as evidenced by the R^2 value for each trendline, was used to develop the projections.

County-level and Project Area population projections were developed first, (Figure 7, Table 3, and Figure 8) followed by projections for municipal areas and utility service areas (Table 4, Figure 9). Projections for the utility service areas were calculated by applying the appropriate county- or city-level growth rates to the 2010 census blocks which comprise each individual service area within the Water Service Area. GIS methods allowed for the calculation of different growth rates and trends within a single service area, which was especially important for the municipal service areas that cross city and/or county boundaries. Growth trends for each municipality or rural water district were calculated individually because it was necessary to capture their differing growth rates to accurately project municipal water needs in the Project Area. The projections for each municipal service area were then added together to derive the total projected population of the Water Service Area for each of the 10-year increments of the planning period (Table 4). It is important to note that for municipalities with a population of less than 200 at the 2010 Census, populations were held constant at the 2010 level for the entire duration of the planning period.

5.1.2 Planning Period Population Trends

The population projections are a function of the historical input population data and the duration of the baseline population data set. The input Census data set (1990 – 2010) provides a representative cross-section of growth patterns that have occurred during the past 20 years in the Project Area, including population growth and decline associated with oil and gas exploration, and an overriding continual decline in rural populations. Based on trends determined from the past 20 years of U.S. Census population data, county-level populations are projected to decline in seven of the ten Project Area counties during the planning period. The populations of Mountrail, Ward, and Williams Counties respectively, are projected to increase by approximately 1,391, 9,051, and 2,505 people during the planning period, while the overall Project Area population is projected to increase by approximately 492 people during the planning period. Currently, widespread, rapid population growth is occurring across northwestern North Dakota, including the Project Area. Since much of the recent growth has occurred from approximately 2010 to the present, it may not be reflected in the growth rates developed for this assessment. At this time, data are not available to determine whether the current rapid growth will continue during the entire planning period.

The population of the Water Service Area is projected to increase by 4,037 people during the planning period (Table 4, Figure 9). The City of Minot service area is projected to experience the greatest growth, followed by the North Central Rural

Water Consortium, and the City of Burlington. The majority of individual utility service areas are projected to experience declines in population during the planning period. Growth trends within the service areas of the larger NAWS members, including the City of Minot, are of major significance to the overall projected population and water needs for the Project.

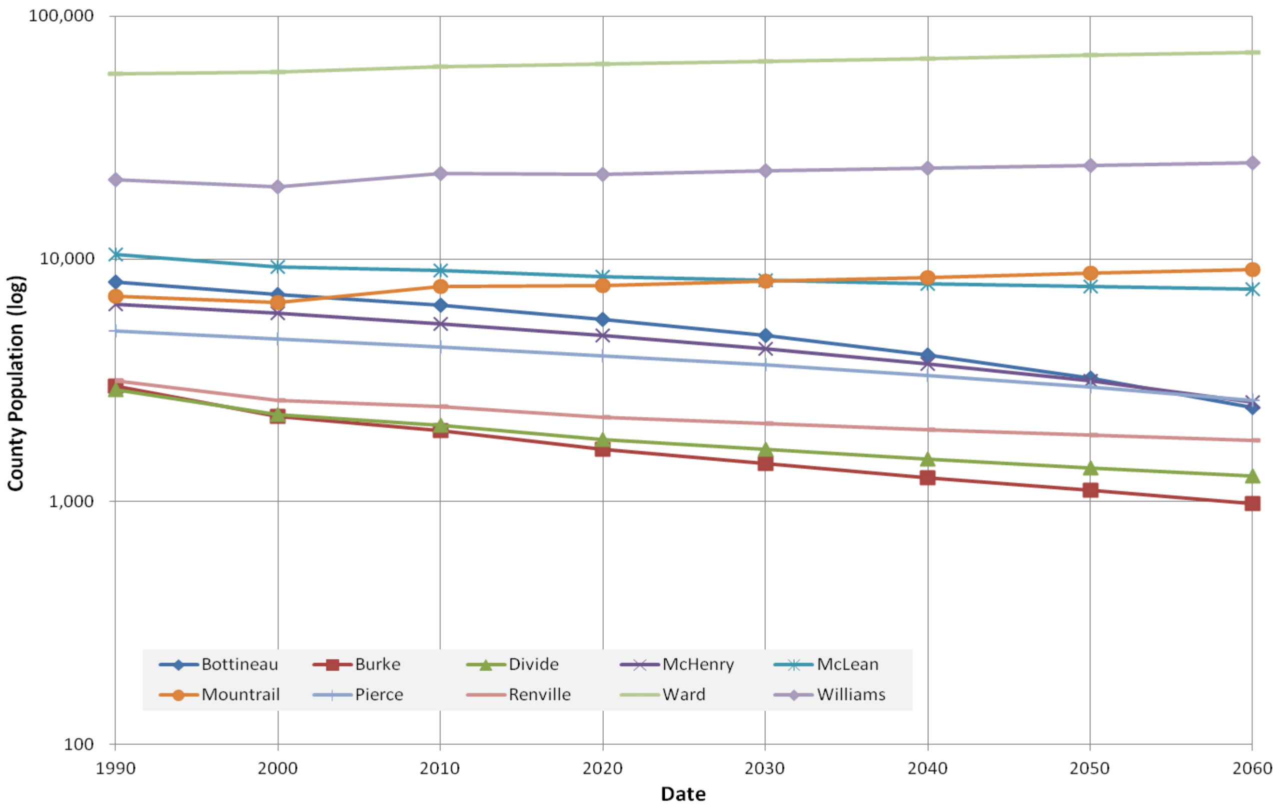

Figure 7. County Populations from 1990 – 2010 (US Census, 2010) and 2020 – 2060 (Projected).

Table 3. County-Level Population Projections for the Project Area.

County	2010 Census Population	Projected 10-County Population					Change in Population (2010 - 2060)
		2020	2030	2040	2050	2060	
Bottineau	6,429	5,614	4,823	4,032	3,241	2,450	-3,979
Burke	1,968	1,648	1,434	1,260	1,112	984	-984
Divide	2,071	1,812	1,640	1,500	1,382	1,279	-792
McHenry	5,395	4,837	4,271	3,704	3,138	2,571	-2,824
McLean	8,962	8,478	8,168	7,914	7,699	7,513	-1,449
Mountrail	7,673	7,760	8,086	8,412	8,738	9,064	1,391
Pierce	4,357	4,000	3,652	3,305	2,957	2,610	-1,747
Renville	2,470	2,237	2,093	1,975	1,876	1,789	-681
Ward	61,675	63,218	65,095	66,972	68,849	70,726	9,051
Williams	22,398	22,365	23,000	23,634	24,269	24,903	2,505
Totals	**123,398**	**121,969**	**122,262**	**122,708**	**123,260**	**123,890**	**492**

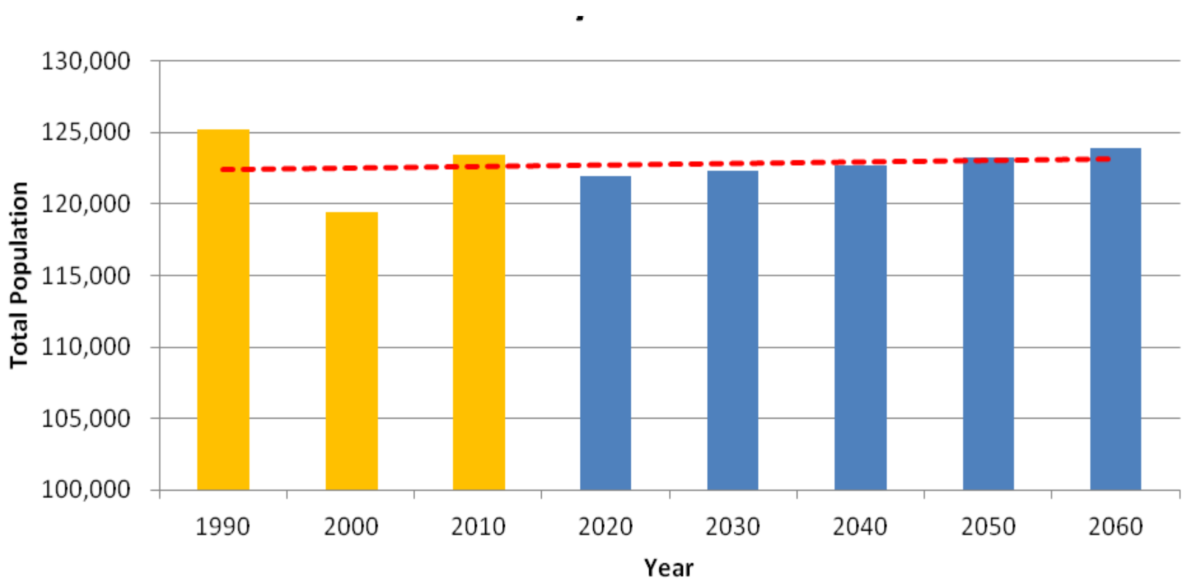

Figure 8. Project Area Population from 1990 – 2010 (US Census, 2010) and 2020 – 2060 (Projected).

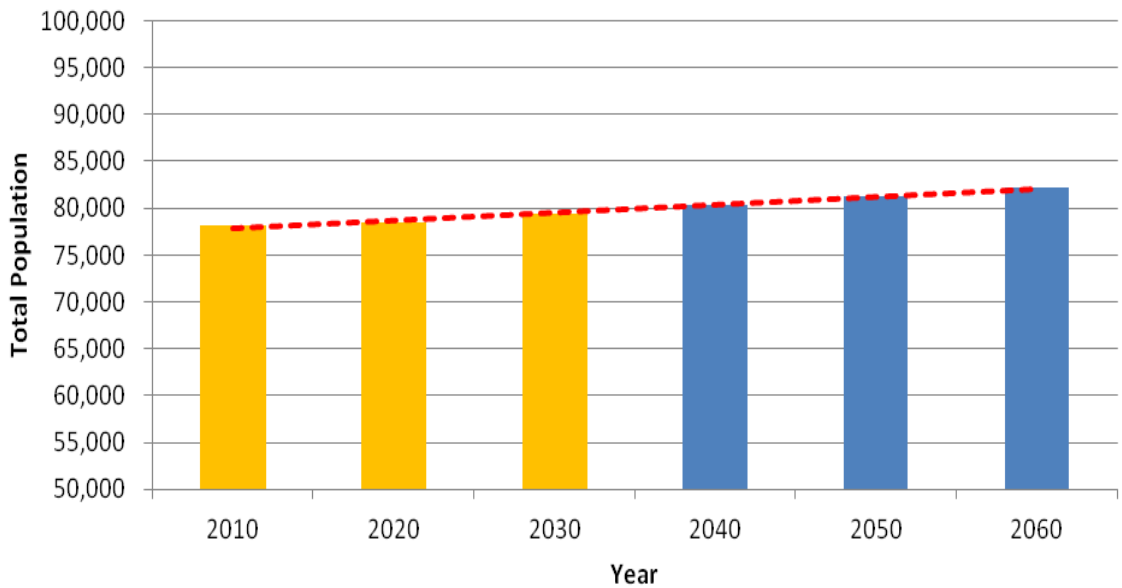

Figure 9**.** Water Service Area Population from 2010 – 2060 (US Census, 2010).

Table 4**.** Projected Service Area-Level Population for the Water Service Area.

Service Area[1]	County	2010 Census Population	Projected Service Area Population					Change in Population (2010 - 2060)
			2020	2030	2040	2050	2060	
All Seasons Water Users	Multiple Counties	3,465	3,074	2,693	2,313	1,932	1,552	-1,913
City of Berthold	Ward	454	479	489	497	504	510	56
City of Bottineau	Bottineau	2,211	2,102	2,022	1,958	1,903	1,855	-356
City of Burlington	Ward	1,070	1,114	1,130	1,142	1,153	1,162	92
City of Columbus[2]	Burke	133	133	133	133	133	133	0
City of Deering	McHenry	98	107	107	108	108	108	10
City of Des Lacs	Ward	204	201	199	197	195	194	-10
City of Flaxton[2]	Burke	66	66	66	66	66	66	0
City of Grenora	Williams	244	218	212	208	205	202	-42
City of Kenmare	Ward	1,096	1,038	1,012	991	973	958	-138
City of Maxbass[2]	Bottineau	84	84	84	84	84	84	0
City of Minot	Ward	47,099	48,313	49,871	51,428	52,986	54,543	7,444
City of Mohall	Renville	783	733	702	676	655	636	-147
City of Noonan[2]	Divide	121	121	121	121	121	121	0
North Central Rural Water Consortium[3]	Multiple Counties	14,633	14,708	14,780	14,860	14,945	15,034	401
City of Rugby	Pierce	2,876	2,875	2,859	2,842	2,826	2,809	-67
City of Sherwood	Renville	242	229	220	213	206	201	-41
City of Souris[2]	Bottineau	58	58	58	58	58	58	0
City of Upham[2]	McHenry	130	130	130	130	130	130	0
Upper Souris Water Users	Multiple Counties	2,722	2,453	2,270	2,109	1,965	1,833	-889
City of Westhope	Bottineau	429	364	290	215	141	66	-363
City of Willow City[2]	Bottineau	163	163	163	163	163	163	0
Totals		**78,381**	**78,763**	**79,611**	**80,512**	**81,452**	**82,418**	**4,037**

1) Each service area may be composed of several smaller service areas. Populations are shown only for the portion(s) of the service area which are in the Project Area.

2) For entities with fewer than 200 people (per the 2010 U.S. Census) and a declining population trend, populations were held constant at 2010 Census levels.

3) For the purposes of population and water demand projections and based on information provided by the utilities, the North Central Rural Water Consortium includes the North Prairie Rural Water District and the West River Water and Sewer District service areas.

5.1.2.1 Oil and Gas Development Influences on Population

Over the past five years there has been a large influx of oilfield, construction, and support industry workers in northwestern North Dakota in response to oil and gas development in the Bakken formation. As a result, population in the Project Area has been increasing more rapidly than projected in this assessment, especially between 2010 and the present. Census estimates from 2011 indicate that approximately 5,000 new residents moved into the Project Area since the 2010 Census. This is larger than this assessment's projected population increase in the Water Service Area of 4,037 persons by 2060 (Table 4). It is currently unknown how many of the new residents reside in the Water Service Area, which occupies approximately 50 percent of the Project Area. It is important to note that in Ward County, where the majority of future Water Service Area customers are located, the estimated 2011 population of 64,072 is below the projected 2060 county population of 70,726 residents.

The Water Service Area population is the most important factor in determining how much of the future water needs of NAWS members could be met by the Project. Despite the rapid growth in the Project Area, data that clearly supported an assumption that this level of growth would continue throughout the 50-year planning period were not available. In addition, definitive evidence suggesting that the 2060 Water Service Area population projections provided in this assessment will be exceeded due to the rapid expansion of oil and gas development activities during the planning period was lacking.

There is a high degree of uncertainty when developing population projections for a 50-year period and this uncertainty is compounded when population is strongly influenced by an event such as a rapid expansion of oil and gas development. Prior to concluding that the current population increases in the Project Area will be sustained over the entire planning period, the factors that contribute to the uncertainty should be identified and carefully analyzed.

The following list introduces some of the factors that contribute to the uncertainty of long-range planning efforts, but it is not intended to be a complete list or a comprehensive analysis of them. These factors include: 1) location of oil and gas reserves relative to the Project Area, 2) the duration of past oil and gas booms in the region, 3) estimates of recoverable reserves, 4) rates of depletion of recoverable reserves, 5) phases of oil and gas expansions, and 6) regulations and new technologies.

- Location of oil and gas reserves: The majority of oil and gas exploration activities appear to be occurring to the west of the Water Service Area (Figure 10). While it is acknowledged that population in the Water Service Area is increasing in response to extraction activities, the largest increases in population (US Census, 2011) are occurring further to the west in the Williston area.

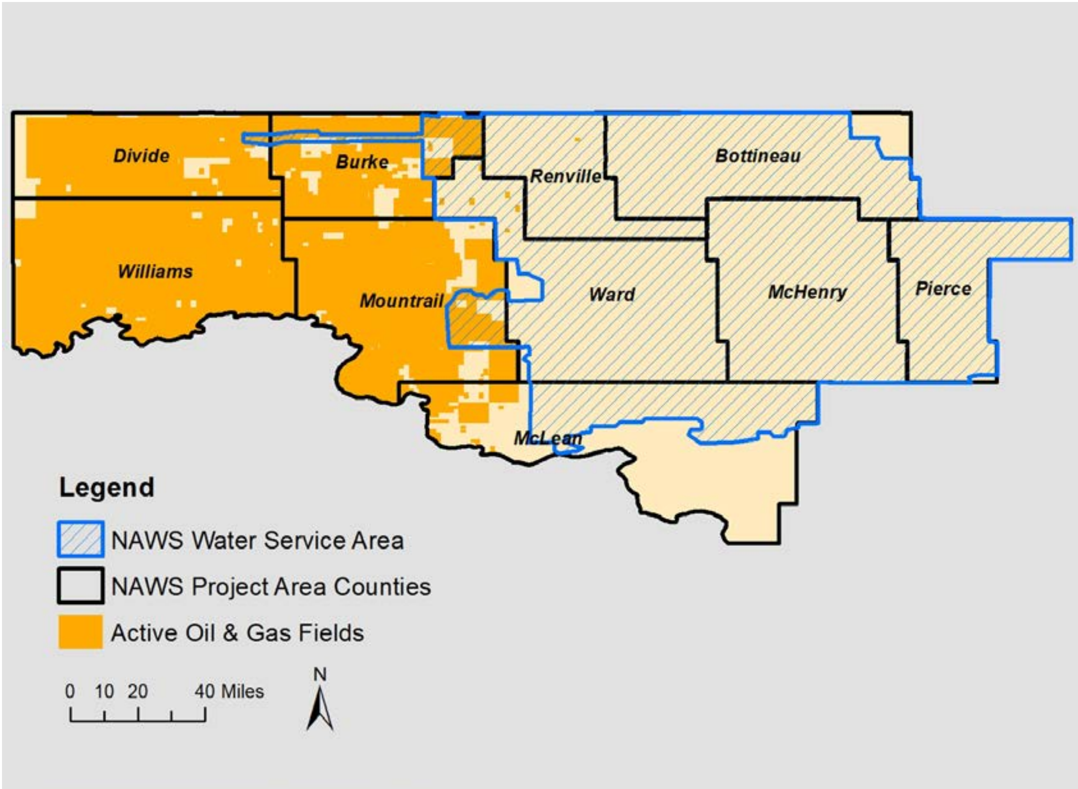

Figure 10**.** Active Oil and Gas Fields within the Project Area (O&GD, 2011).

- Duration of past oil and gas expansions: The state's previous two significant oil and gas expansions, as defined by peaks in well construction activity above the period of record average of 284 wells constructed per year (Figure 11), were approximately eight and ten years in duration, respectively. Population of the region increased as extraction activities increased, then returned to pre-expansion levels once extraction activities waned.

- Estimates of recoverable reserves: The United States Geological Survey (USGS) performed an assessment of the recoverable crude oil reserves in the Bakken formation of the Williston Basin. The assessment estimated that 3.0 to 4.3 billion recoverable barrels (a mean of 3.65 billion barrels) might exist within the formation. Other estimates of reserves developed by the State of North Dakota and the private sector have indicated higher quantities of recoverable reserves (USGS, 2008).

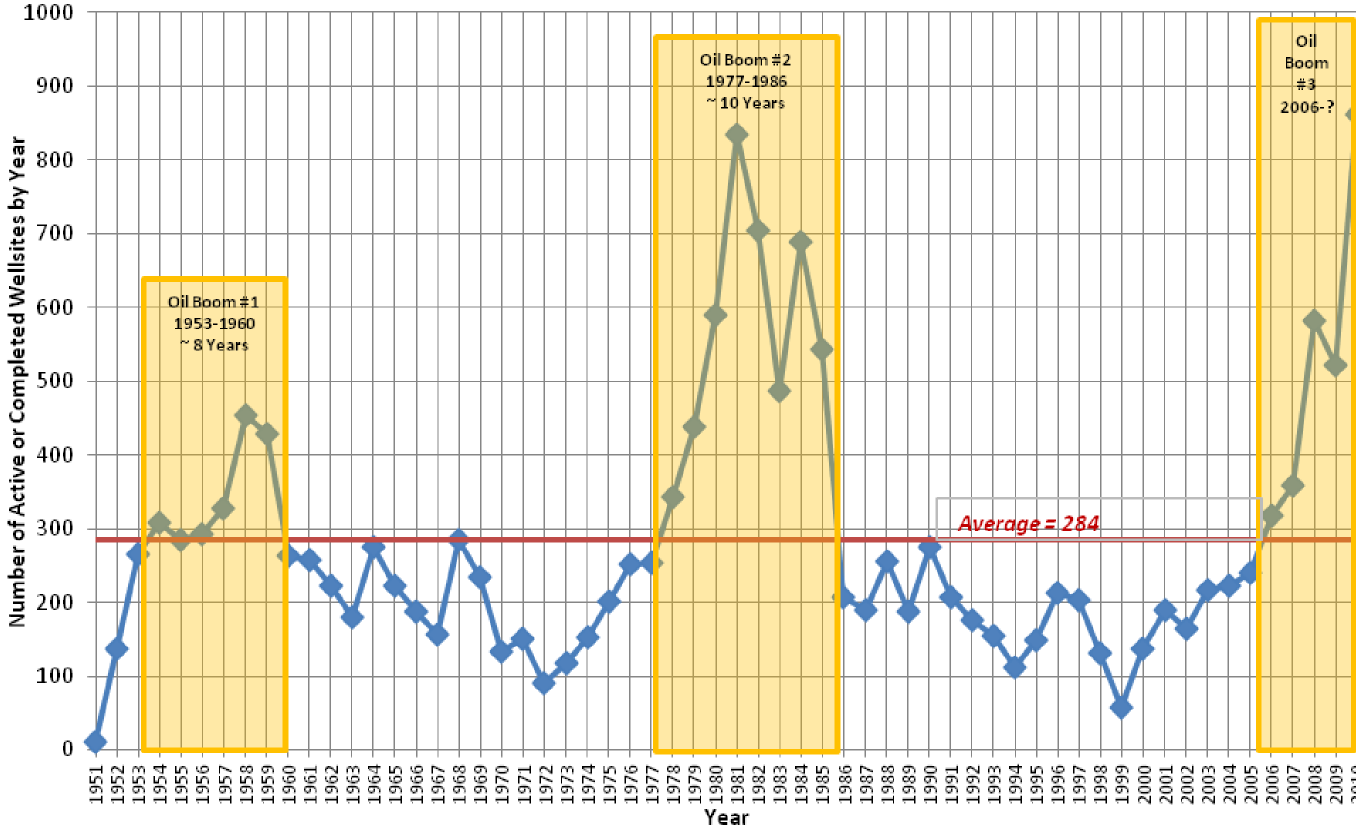

Figure 11**.** Historical Rates of Well Construction Activity by Year (O&GD, 2011).

- Rate of depletion of reserves: The rate of depletion of recoverable reserves will depend on a variety of market and regulatory factors. None of the available estimates of recoverable reserves included a projected rate of reserve depletion.

- Phases of oil and gas booms: Typically, the greatest population growth in a rapid oil and gas expansion occurs during the exploration and well construction phases, as opposed to long-term oil and gas field production activities, which do not require the number of workers that oilfield start-up activities do (Jacquet, 2009). This is why estimates of recoverable reserves and depletion rate are so important in projecting long-term population trends.

- Regulations and new technologies: Changes in the regulatory environment and new technological developments could increase or decrease the depletion rate of recoverable reserves.

The uncertainty discussed above that is inherent in estimating water needs based on long-term population projections, may be mitigated to some degree through the use of a peaking factor for the Project. As explained in Section 4.0, the peaking factor used in this assessment is 2.6, which equates to a Project peak day and annual average water need of 26.3 mgd and 10.4 mgd, respectively. In regional systems, higher design peaking factors are necessary to accommodate uncertainties in population growth and also to provide redundancy and operational flexibility in treatment facilities.

5.2 Water Needs Projections for Public Water Supply Areas

Future municipal supply needs for the Water Service Area were developed using the population projections described in section 5.1 with water use records from each of the NAWS member municipalities. Water use records were collected for each municipal supply system from the SWC's online Water Permit database. In some cases, data for multiple permits held by a single municipality were tabulated to calculate total yearly use by each municipality. For each municipality, per capita demands were established by distributing the average yearly water use (in gallons) for the years 2000 and 2010 over 365 days to derive a daily average usage (in gallons per day (gpd)). The years 2000 and 2010 were chosen because they are decennial U.S. Census years and reflect current water use and conservation trends.

After the daily average water use (gpd) was calculated for each municipality (Table 5), this value was divided by the current (2010) population of the municipal service area to derive an average per capita water use (in gallons per capita per day (gpcd)). Although this gpcd generally reflects the average water use per person per day within each service area, it is important to note that water usage for municipally-serviced commercial, industrial, and institutional users, in addition to water losses in the treatment and transmission system are also reflected in this value. Furthermore, peak demands are reflected in the gpcd because real usage data (during which peak demands historically occurred) was used in their development.

Once the average gpcd was calculated, it was multiplied by the incremental population projections described in the previous section for the years 2020, 2030, 2040, 2050, and 2060 to derive water demand projections for each municipality for the planning period. Municipal system demands were totaled to determine the total municipal water demand for the Water Service Area (Table 6). Between 2010 and 2060, municipal and rural water needs within the Water Service Area are projected to increase by 2.49 mgd. It is also important to note that the peak planning period water needs for several of the NAWS members is projected to occur in 2020, rather than 2060.

The water needs projections for the Water Service Area assume a full connection rate of all domestic users within each individual service area by 2020. The completion of the Project may hasten the connection rate of current self-supplied users to public water systems.

Table 5. Average Per Capita Water Use within the Water Service Area.

City or District	Pumpage (mgd)[1]		Population (Census)		Per Capita (gpcd)		Average Per Capita (gpcd)
	2000	2010	2000	2010	2000	2010	
All Seasons WUD[2]	0.19	0.25	1,595	1,595	116.14	153.73	**134.94**
Berthold	0.03	0.03	466	454	62.84	75.55	**69.19**
Bottineau	0.35	0.22	2,336	2,211	148.24	98.37	**123.30**
Burlington	0.12	0.03	1,096	1,060	113.14	32.68	**72.91**
Columbus	0.02	0.02	151	133	105.96	142.86	**124.41**
Deering	0.01	0.01	118	98	58.26	101.12	**79.69**
Des Lacs[3]	0.004	0.002	209	204	17.09	10.07	**13.58**
Flaxton	0.01	0.01	73	66	88.05	79.16	**83.61**
Grenora	0.004	0.02	202	244	20.74	99.14	**59.94**
Kenmare	0.12	0.03	1,081	1,096	114.71	31.60	**73.16**
Maxbass	0.01	0.01	91	84	94.18	117.46	**105.82**
Minot (includes Minot AFB & other areas)	5.55	5.28	44,166	46,754	125.65	113.02	**119.33**
Mohall	0.12	0.08	812	783	143.59	96.46	**120.02**
Noonan	0.01	0.01	154	121	53.33	64.46	**58.90**
North Central Rural Water Consortium	-	1.09	-	10,302	-	105.57	**105.57**
Rugby	0.34	0.21	2,939	2,876	117.22	71.89	**94.56**
Sherwood	0.02	0.01	255	242	65.12	56.44	**60.78**
Souris	0.01	0.01	83	58	84.97	98.51	**91.74**
Upham	0.01	0.01	155	130	82.36	63.52	**72.94**
Upper Souris Water Users[2]	0.19	0.13	2,400	2,400	77.74	52.26	**65.00**
Westhope	0.08	0.06	533	429	149.24	145.04	**147.14**
Willow City	0.02	0.03	221	163	100.99	172.04	**136.51**
						Average Per Capita	**91.5**

1) *Data source is SWC, 2011*
2) *Population data was not available for some of the rural water districts. 2010 population data was used in place of the missing data. This may result in a slightly higher average per capita for each of these utilities.*
3) *The City of Deering obtains most of its water from other water suppliers.*

Table 6**.** Projected Water Needs for the Water Service Area.

Service Area[1]	***County***	***2010 Water Use***	***Projected Water Needs (mgd)***					***Change in Demand (2010 - 2060)***
			2020	***2030***	***2040***	***2050***	***2060***	
All Seasons Water Users	Multiple Counties	0.250	0.955	0.903	0.852	0.801	0.749	0.50
City of Berthold	Ward	0.030	0.033	0.034	0.034	0.035	0.035	0.01
City of Bottineau	Bottineau	0.220	0.259	0.249	0.241	0.235	0.229	0.01
City of Burlington	Ward	0.030	0.081	0.082	0.083	0.084	0.085	0.05
City of Columbus	Burke	0.019	0.017	0.017	0.017	0.017	0.017	-0.002
City of Deering	McHenry	0.010	0.009	0.009	0.009	0.009	0.009	-0.001
City of Des Lacs	Ward	0.002	0.003	0.003	0.003	0.003	0.003	0.001
City of Flaxton	Burke	0.005	0.006	0.006	0.006	0.006	0.006	0.001
City of Grenora	Williams	0.02	0.013	0.013	0.012	0.012	0.012	-0.008
City of Kenmare	Ward	0.030	0.076	0.074	0.073	0.071	0.070	0.04
City of Maxbass	Bottineau	0.010	0.009	0.009	0.009	0.009	0.009	-0.001
City of Minot	Ward	5.280	6.265	6.451	6.637	6.823	7.009	1.73
City of Mohall	Renville	0.080	0.138	0.134	0.131	0.129	0.126	0.05
City of Noonan	Divide	0.010	0.007	0.007	0.007	0.007	0.007	-0.003
North Central Rural Water Consortium[2]	Multiple Counties	1.450	1.553	1.560	1.569	1.578	1.587	0.14
City of Rugby	Pierce	0.210	0.272	0.270	0.269	0.267	0.266	0.06
City of Sherwood	Renville	0.010	0.014	0.013	0.013	0.013	0.012	0.002
City of Souris	Bottineau	0.010	0.005	0.005	0.005	0.005	0.005	-0.005
City of Upham	McHenry	0.010	0.009	0.009	0.009	0.009	0.009	-0.001
Upper Souris Water Users	Multiple Counties	0.130	0.159	0.148	0.137	0.128	0.119	-0.01
City of Westhope	Bottineau	0.060	0.054	0.043	0.032	0.021	0.010	-0.05
City of Willow City	Bottineau	0.030	0.022	0.022	0.022	0.022	0.022	-0.01
Totals		**7.91**	**9.96**	**10.06**	**10.17**	**10.28**	**10.40**	**2.49**

1) Each Service Area may be composed of several smaller service areas. Water needs are shown only for the portion(s) of the service area which are in the Project Area.
2) For the purposes of population and water demand projections, the North Central Rural Water Consortium includes the North Prairie Rural Water District and the West River Water and Sewer District service areas.

It is important to note that through previous planning studies for the Project is was determined that it was not feasible to serve the water needs of the cities of Grenora and Rugby via the distribution pipeline system. The proposed solution for these communities is for them to remain on their existing water sources and upgrade their existing water treatment plants as needed to meet their future needs. The information presented in Table 6 includes projections for Grenora and Rugby to account for their potential water needs estimated to be 0.3 mgd (average). The 2060 water needs, which would be served by the Project through the main distribution pipeline system, are estimated to be 10.1 mgd (average) and 26.3 mgd (peak).

5.3 Water Needs Projections for Domestic Self-Supply Uses

Water needs for all self-supplied entities were projected for the planning period based upon USGS water use estimates for North Dakota, using the 1985, 1990, 1995, 2000, and 2005 county-level data sets (available for download, with a description of the methodology from http://water.usgs.gov/watuse/) as a base for the projections. A literature search conducted to find historic water use data for self-supplied entities indicated that the USGS water use data represents the most complete historic data set available for the Project Area. The historical water use estimates were used to calculate growth rates for each water use sector. The equations and trendline methods described in Section 5.1 were also used in the development of the USGS-based projections.

Water needs projections were developed from the USGS historical estimates of water use for domestic self-supplied users within the Project Area (Table 7). Domestic self-supplied uses include potable, household, and outdoor uses for individual residences which are not connected to a public water system. Throughout the planning period, domestic water needs are projected to decrease in each of the Project Area counties, with the exception of Williams County.

Table 7**.** Projected Domestic (Self-Supplied) Water Needs for the Project Area

County	Projected Self-Supplied Domestic Water Needs by Year (mgd)[1]						Change in Demand (2010 - 2060)
	2010	2020	2030	2040	2050	2060	
Bottineau	0.17	0.16	0.15	0.14	0.13	0.13	-0.05
Burke	0.06	0.05	0.04	0.03	0.02	0.02	-0.04
Divide	0.05	0.05	0.04	0.03	0.03	0.02	-0.03
McHenry	0.19	0.17	0.15	0.14	0.13	0.12	-0.07
McLean	0.22	0.21	0.19	0.18	0.17	0.16	-0.07
Mountrail	0.17	0.16	0.15	0.14	0.14	0.13	-0.04
Pierce	0.10	0.09	0.08	0.07	0.06	0.05	-0.05
Renville	0.07	0.07	0.06	0.05	0.05	0.05	-0.03
Ward	0.83	0.71	0.62	0.54	0.47	0.42	-0.42
Williams	0.37	0.40	0.42	0.44	0.46	0.47	0.10
Totals	**2.25**	**2.05**	**1.89**	**1.77**	**1.66**	**1.56**	**-0.69**

1) Source of historical water use estimate data used to develop the projections: USGS, 2011

The decline in domestic water needs parallels the long-term declining rural population trends occurring in the Project Area. To a lesser extent, the declining domestic water need is a function of the expansion of several rural water district utility service areas to extend water service to rural users who are currently self-supplied. It is anticipated that current self-supplied domestic users in the rural water district service areas would continue to connect to these systems as water service and distribution systems are extended across the Project Area. It is important to consider that domestic self-supplied water needs may decrease more rapidly than projected in this report when the Project is completed.

5.4 Water Needs Projections for Agricultural Uses

Agricultural water needs projections for self-supplied users and users supplied by irrigation diversion projects were developed from the USGS historical estimates of water use for the Project Area (Table 8), using the methods described in Section 5.3. The agricultural projections include water needs for crop irrigation and livestock watering. Some livestock watering needs would be served by the Project, via the rural water districts. Therefore, a portion of the livestock water needs for the Project Area are included in the public supply water needs projections, provided in Section 5.2. No irrigation water would be provided as part of the Project.

Agricultural operations constitute the largest cumulative user of water (approximately 58 percent of all water use by 2060) within the Project Area. Trends based on estimated historical agricultural water use indicate that the need for water to support agricultural operations within the Project Area would grow by 1.63 mgd, an increase of 3.5 percent during the planning period.

Table 8**.** Projected Agricultural (Self-Supplied) Water Needs for the Project Area.

County	Projected Agricultural Water Needs by Year (mgd)[1]						Change in Demand (2010 – 2060)
	2010	2020	2030	2040	2050	2060	
Bottineau	0.38	0.35	0.33	0.30	0.27	0.24	-0.14
Burke	0.47	0.53	0.57	0.61	0.64	0.67	0.20
Divide	1.81	1.57	1.39	1.25	1.12	1.01	-0.80
McHenry	20.58	21.86	22.85	23.66	24.35	24.94	4.36
McLean	6.97	8.65	10.33	12.01	13.69	15.37	8.40
Mountrail	0.78	0.78	0.77	0.77	0.77	0.77	-0.01
Pierce	0.42	0.40	0.39	0.37	0.37	0.36	-0.06
Renville	0.09	0.09	0.10	0.10	0.10	0.10	0.01
Ward	0.88	0.75	0.66	0.58	0.52	0.46	-0.42
Williams	14.85	11.94	9.68	7.84	6.28	4.93	-9.92
Totals	**47.22**	**46.93**	**47.07**	**47.49**	**48.10**	**48.85**	**1.63**
1) Source of historical water use estimate data used to develop the projections: USGS, 2011							

5.5 Water Needs Projections for Industrial Uses

5.5.1 Non Oil and Gas Industrial Uses

Non-oil and gas industrial water needs projections (Table 9) were developed using historical water use estimate data from the USGS (USGS, 2010). Water needs for self-supplied industrial, non-oil and gas mining (i.e. gravel, lignite, potash), commercial, institutional, aquaculture, consumptive thermoelectric power generation, and processing facilities are all included in this sector. The projection methods used are described in Section 5.3. The projected water needs presented in this section are not currently proposed to be served by the Project.

5.5.2 Oil and Gas Industrial Uses

Water needs for the oil and gas production process were developed using background data from *Water Appropriation Requirements, Current Water Use, & Water Availability for Energy Industries in North Dakota: A 2010 Summary – North Dakota State Water Commission Water Resources Investigation No.49* (Schuh, 2010). Additionally, water use records from the SWC water permit database were used to develop the projections (SWC, 2011). The study provides estimates of oil and gas well completion rates in the Bakken-Three Forks-Sanish (B-TF-S) formations in northwestern North Dakota. The report indicates that up to 1,800 new wells per year may be developed across the B-TF-S oil and gas fields through the year 2026. Each well may require up to 4 million gallons for hydraulic fracturing operations during the operation of the well and 2,500 gallons or more during drilling and well development. The report also indicates that approximately 18.4 mgd is currently permitted for use by the petroleum industry (via private water depots) in the Project Area. Although 18.4 mgd is permitted for oil and gas use, only approximately 2.66 mgd was used during 2010 (Figure 12). It is also important to note that some of the water developed for use in oil and gas operations may be used at wellsites outside the Project Area.

Oil and gas production data for 2010 from the North Dakota Oil and Gas Division indicates that approximately 57 percent of the petroleum production from the B-TF-S fields occurred in the Project Area (ND O&GD, 2011). The projections presented in this assessment assume that this trend would continue, with 57 percent of the 1,800 new wells that could potentially be constructed annually being located in the Project Area. The 2010 oil and gas water use (2.66 mgd) was used as the baseline for the projections.

Projections were developed for 2010-2030, as the production capacity of the B-TF-S fields are unknown beyond that period (Table 10). By 2030, the oil and gas industry would require approximately 2.95 mgd in additional water supplies.

Table 9. Projected Industrial/Commercial/Institutional (self-supplied) Water Needs for the Project Area.

County	Projected Industrial/Commercial/Institutional Water Needs by Year[1] (mgd)						Change in Demand (2010 – 2060)
	2010	**2020**	**2030**	**2040**	**2050**	**2060**	
Bottineau	0.61	0.83	1.06	1.28	1.51	1.73	1.12
Burke	0.02	0.02	0.02	0.02	0.02	0.02	0.00
Divide	0.00	0.00	0.00	0.00	0.00	0.00	0.00
McHenry	0.26	0.38	0.50	0.62	0.73	0.85	0.59
McLean	12.38	12.73	13.00	13.22	13.41	13.57	1.20
Mountrail	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Pierce	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Renville	0.13	0.13	0.13	0.13	0.13	0.13	0.00
Ward	0.05	0.04	0.03	0.02	0.02	0.01	-0.04
Williams	0.63	0.71	0.77	0.82	0.86	0.90	0.27
Totals	**14.07**	**14.83**	**15.50**	**16.11**	**16.68**	**17.21**	**3.14**

1) Source of historical water use estimate data used to develop the projections: USGS, 2011

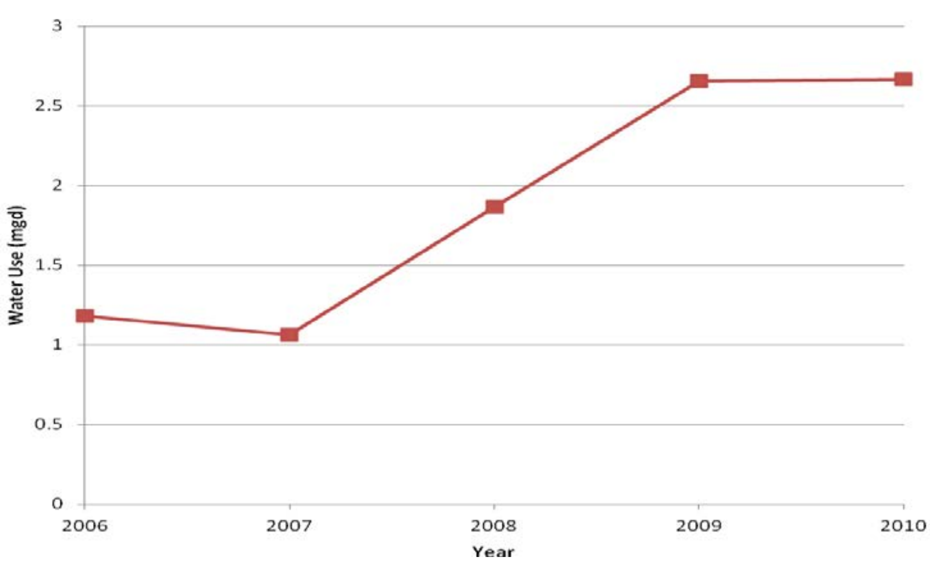

Figure 12. Project Area Water Usage from 2006 - 2010 by the Oil and Gas Industry (SWC, 2011).

Table 10. Projected Oil and Gas (Self-Supplied) Water Needs for the Project Area.

County	Water Needs for Oil & Gas Development (mgd)			Change in Demand (2010 - 2060)
	2010	2020	2030	
Bottineau	0.09	0.13	0.18	0.09
Burke	0.08	0.12	0.16	0.09
Divide	0.13	0.21	0.28	0.15
McHenry	0.001	0.002	0.002	0.00
McLean	0.01	0.02	0.03	0.02
Mountrail	1.91	2.97	4.02	2.12
Pierce	-	-	-	-
Renville	0.03	0.05	0.07	0.04
Ward	0.002	0.003	0.005	0.00
Williams	0.41	0.63	0.86	0.45
Totals	**2.66**	**4.14**	**5.62**	**2.95**

6.0 Climate Change Considerations

Climate simulations developed by Reclamation (Reclamation, 2011) and others (U.S. GCBR, 2011) suggest that mean yearly precipitation and average temperatures will increase by up to 20 percent over 1990 levels by 2070 in the Missouri River Basin. Additionally, the models indicate that by 2070, the spring melt period will occur earlier than it does currently, with greater spring-melt runoff volumes, which will translate to higher short term river flows. Summers will be increasingly warmer and longer (U.S. GCBR, 2011) with a notable decrease in precipitation, with increasing precipitation occurring in the fall, winter, and spring seasons.

For the purposes of this assessment, the potential ramifications of climate change are only evaluated qualitatively with respect to their bearing on water needs during the planning period. As previously stated, climate models indicate that the western portion of North Dakota will experience increasingly intense and dry summers. This is significant with respect to water needs, because the yearly peak water demand for many of the water users in the Project Area typically occurs between June and August.

Increasing summer temperatures will likely result in increased evapo-transpiration rates in the Project Area. This will translate to increased water needs for agricultural water users during the planning period to alleviate crop heat stress and to replenish and maintain soil moisture within crop root zones. Additionally, water stored in canals, impoundments, and other storage or conveyance features for irrigation purposes will evaporate faster than in previous years, necessitating additional quantities to replenish water stored for irrigation purposes. Additional analysis, including modeling using an appropriate irrigation demand model, could be conducted to determine the increased water needs by crop type based upon predicted future climatic conditions. Furthermore, because of changing climate and increased evaporative losses, additional quantities of water will likely be needed during the planning period to support livestock operations (during the summer months) in the Project Area.

Because much of the irrigation and livestock water used in the Project Area is self-supplied, the increased water needs associated with climate change are not anticipated to have an impact on the future municipal water needs of NAWS Members. However, some residential and ranch lawn and garden irrigation needs, in addition to limited livestock watering needs, would be supplied by the Project. Outdoor water use appears to be greatest in the rural water districts in the Project Area, but yearly water use in each of the NAWS member service areas also peaks during the summer months, partly due to increased outdoor water use.

In summary, due to the changing climate, additional quantities of water to support agricultural operations in the Project Area will likely be necessary during the planning period. The greatest increase in water demand will be associated with the irrigation needs of large-scale agricultural operations, which would not be served by the Project. Minor increases in summer water demands, which will be served by the Project, may occur in the Water Service Area. It is important to note that the potential increases in water demand for the Project Area and Water Service Area are not included in the water needs projections presented in this report. Additional modeling and analysis would be required to estimate potential future increases in water needs.

7.0 Summary of Findings

7.1 Population Trends

Based on the methods outlined in this report, the population of the Project Area is projected to increase by approximately 492 people during the planning period. Ward County and the City of Minot are expected to continue to gain population during the planning period. Within the Water Service Area, population is projected to increase by 4,037 people during the planning period. Continued population growth, which would occur in the City of Minot and Ward County, is projected to outweigh decreasing population trends present in the rural water districts and smaller towns within the Water Service Area.

Over the past five years there has been a large influx of oilfield, construction, and support industry workers in western North Dakota in response to the Bakken formation oil and gas expansion. As a result, population in the Project Area has been increasing more rapidly than projected in this assessment, especially between 2010 and the present. Census estimates from 2011 indicate that approximately 5,000 new residents moved into the Project Area since the 2010 Census. This is larger than this assessment's projected population increase in the Water Service Area of 4,037 persons by 2060 (Table 4). It is currently unknown how many of the new Project Area residents reside in the Water Service Area, which occupies approximately 50 percent of the Project Area. It is also important to note that in Ward County, where the majority of future Water Service Area customers are located, the estimated 2011 population of 64,072 is below the projected 2060 county population of 70,726 residents. The Water Service Area population is the most important factor in determining how much of the future water needs of NAWS members can be met by the Project. Despite the current rapid growth in the Project Area, definitive evidence to suggest that the 2060 Water Service Area population projections provided in this assessment would be exceeded due to the oil and gas expansion during the planning period was not available.

There is a high degree of uncertainty when developing population projections for a 50-year period and this uncertainty is compounded when population is strongly influenced by events such as an oil and gas expansion. Prior to concluding that the current population increases in the Project Area would be sustained over the entire planning period, the factors that contribute to the uncertainty should be identified and carefully analyzed. These factors include: 1) location of oil and gas reserves relative to the Project Area, 2) the duration of past oil and gas expansions, 3) estimates of recoverable reserves, 4) rates of depletion of recoverable reserves, 5) phases of oil and gas expansions and population, and 6) regulations and new technologies.

The uncertainty that is inherent in estimating water needs based on long–term population projections, may be mitigated to some degree through the use of a peaking factor for the Project. As explained in Section 4.0, the peaking factor used in this assessment is 2.6. In regional systems, higher design peaking factors are necessary to accommodate uncertainties in population growth and also to provide redundancy and operational flexibility in treatment facilities.

7.2 Water Needs for the Water Service Area

Municipal and rural water needs for the Water Service Area are projected to increase by approximately 2.49 mgd during the planning period. Much of the projected increase in demand can be attributed to the following factors:

- It is anticipated that self-supplied users in current utility service areas would connect to the Project. Service area descriptions provided by the utilities indicate that they plan to serve substantial rural populations, which are currently not connected to a public water system. The projection methods used in this assessment assume that these connections would occur by the year 2020.

- Several entities are planning to extend water service to additional service areas or planned unit developments. Some of the annexed areas would be comprised of mixed use developments, which would require substantial additional quantities of water by 2020. The entities with planned system expansions or annexations between 2010 and 2020 include the All Seasons Water Users District (0.73 mgd), the City of Minot (0.5 mgd), the City of Mohall (0.05 mgd), and the North Central Rural Water Consortium (0.07 mgd), for a total of 1.35 mgd. These demands are in addition to the demands associated with growth in the existing service areas.

- Significant growth is expected during the planning period in the All Seasons Water Users District service area, the City of Minot, several service areas of the North Central Rural Water Consortium, the City of Kenmare, the City of Rugby, and Ward County.

The maximum projected annual average demand for the Water Service Area during the planning period is 10.4 mgd in the year 2060 with the design peak day demand (See Table 11). For some of the NAWS members, peak planning period demands would occur in 2020. Water needs for the cities of Grenora and Rugby, will not be met with bulk water supply via the distribution pipeline system. Both cities are currently served by their own water systems and these communities could use Project funding to upgrade their existing water treatment plants to meet their future water needs. This assessment includes projections for Grenora and Rugby to account for their potential water needs. The 2060 water needs, which will be served by the Project through the main distribution pipeline system are estimated to be 10.1 mgd (average) and 26.3 mgd (peak).

Table 11**.** NAWS Project Projected Population and System Design Capacities.

NAWS Service Area Projected Population Growth (2010 -2060)	2060 Design Average Day (mgd)	2060 Design Peak Day (mgd)
4,037	10.40	27.04

7.3 Water Needs for the Project Area

Within the Project Area, the need for additional water supplies is projected to increase during the planning period (Table 12).

Table 12**.** Projected Water Needs for all Use Sectors (Except Oil and Gas) in the Project Area.

Water Use Sector	2010	Projected Project Area Water Needs by Year (mgd)[1]					Change in Demand (2010 - 2060)
		2020	2030	2040	2050	2060	
Agricultural[2]	47.22	46.93	47.07	47.49	48.1	48.85	1.63
Domestic[2]	2.25	2.05	1.89	1.77	1.66	1.56	-0.69
Industrial / Commercial / Institutional[2]	14.07	14.83	15.5	16.11	16.68	17.21	3.14
Public Supply (NAWS)	8.01	9.80	9.84	9.90	9.97	10.04	2.03
Public Supply (Other)	4.09	3.87	3.66	3.46	3.27	3.10	-0.99
Totals	**75.54**	**77.64**	**78.18**	**79.00**	**79.99**	**81.12**	**5.58**

1) Does not include water needs for Oil and Gas development
2) Self-supplied industry

Water needs for the agricultural, industrial/commercial/institutional, and public supply sectors in the Project Area are projected to increase by 5.1 mgd collectively during the planning period. Water needs for domestic self-supplied users and public supply needs for municipalities in the Project Area which are not part of the Project are projected to decline by 1.7 mgd collectively during the planning period.

Water needs for the oil and gas sector are not included in the demands presented above because projections for this sector were only developed for the period between 2010 and 2030. Demand for the oil and gas sector is projected to increase by approximately 2.95 mgd during this period.

7.4 Climate Change Considerations

Climatic models indicate that changes in the climatic conditions of the Project Area will likely occur during the planning period. The models indicate that increased precipitation will occur in the spring, fall, and winter months, while the summer months will be considerably drier. Additionally, average temperatures and the occurrence of prolonged heat waves are projected to increase during the planning period. Peak water needs in the Project Area typically occur during the summer months, and it is possible that peak water needs would increase with the hotter, drier summers. Outdoor water uses, such as crop and turf irrigation, will likely increase along with the projected climatic changes because plants will require more water to offset the increased rates of evapo-transpiration. Climate change will likely have a minor effect on summer water use in the Water Service Area, as the Project would serve public supply needs (mostly indoor uses). Self-supplied agricultural operations within the Project Area will likely experience moderate increases in water needs during the planning period to support crop irrigation and livestock needs. Additional modeling and assessment will be required to estimate the quantity of water that may be needed to meet the increased outdoor water needs associated with climate change in the Project Area.

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