Platte River Basin Plan 2016 Update
Volume 4
Water Demand Projections




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Harvey Economics
HDR Engineering

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December 2016

Explanation of Cover Photos

Lake Marie in the Snowy Range Mountains. Lake Marie lies south in the shadow of the quartzite massif of 12,847-foot Medicine Bow Peak at an elevation of 11,000-feet. Winter and Spring precipitation in the Snowing Range constitutes an important portion of the water supply in the Platte River Basin.

The bald eagle (*Haliaeetus leucocephalus*, from Greek hali "sea", aiētos "eagle", leuco "white", cephalos "head"). It is a common, frequently observed breeding and winter resident in the North Platte Basin of Wyoming. The bird is strongly associated with large rivers, lakes and reservoirs with an abundant food supply and riparian environments with large trees used for roosting and nesting. The bald eagle is an opportunistic predator which subsists primarily on fish. During the winter, they also feed on dead or injured waterfowl and road or winter killed deer and antelope. The bald eagle is both the national bird and national animal of the United States of America. It is the most familiar success story of the Federal Endangered Species Act. During the latter half of the 20th century it was on the brink of extirpation in the contiguous United States and was one of the first species to receive protections under the precursor to the Endangered Species Act in 1967. Populations have since recovered and the species was removed from the U.S. government's list of endangered species on July 12, 1995 and transferred to the list of threatened species. It was removed from the List of Endangered and Threatened Wildlife in the Lower 48 States on June 28, 2007 but remains protected under the provisions of the Bald and Golden Eagle Protection Act.

Historical photo of flood irrigation. Flood irrigation is an ancient method of irrigating crops and was the first form of irrigation used by humans as they began cultivating crops. In the Platte River Basin, it is still commonly used to irrigate grass hay. In areas of the Platte River Basin where higher value crops are raised such as corn, sugar beets and alfalfa hay, conversion to sprinkler irrigation has the dual benefits of improved crop yields while conserving water.

The Dave Johnston Power Plant is named for W.D. “Dave” Johnston a former PacifiCorp Vice-President. The plant generates power by burning coal that produces steam under high pressure. The steam drives turbines and the turbine blades to engage generator that produce electricity. The plant was commissioned in 1958. There have been four phases of plant expansion to-date and numerous upgrades to comply with changing environmental requirements. The present power generation capacity is 817 megawatts.

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The Platte River Basin Plan 2016 Update is a planning tool developed for the Wyoming Water Development Office. It presents estimated current and estimated future uses of water in Wyoming's Platte River Basin. The Plan is not intended to be used to determine compliance with the administration of state law, federal law, court decrees, interstate compacts, or interstate agreements.

Contents

Figures

Tables

Appendices

4.0 Water Demand Projections

4.1 SUMMARY

"Hindsight is always 20/20"
- Billy Wilder

4.1.1 Platte Basin Population and Demographics

As of 2014, there were about 257,000 people living in the Platte River Basin (Basin), approximately 44 percent of Wyoming's total population. Between 2000 and 2014, the Basin's population increased by over 36,000 people, or about 16.3%. In comparison, the State of Wyoming as a whole grew slightly faster than the Basin, with total population growth of about 18.3% over that period. The Pathfinder to Guernsey and the South Platte subbasins grew the fastest and added the most people during that time. Eighty percent of the Basin's growth occurred in the South Platte and Pathfinder to Guernsey subbasins. The Lower Laramie experienced the smallest amount of growth.

Over the course of the last decade, natural population growth and in-migration have each accounted for about half of that growth. When compared to more historical periods, in-migration has been a much more important component of population growth over the last decade. Other demographic changes include an aging population and decreasing household size. Overall, the population of the Basin is aging, as indicated by an increasing median age for all Basin counties. The slight decrease in labor force participation rates is also likely the result of the aging population.

Subbasin / City	Population		Total Growth	Percent Growth
	2000	2014	2000 - 2014	2000 - 2014
Above Pathfinder Dam	16,381	16,909	527	3.2%
Guernsey to State Line	9,967	10,839	873	8.8%
Horse Creek	2,389	2,676	287	12.0%
Lower Laramie	7,844	8,002	158	2.0%
Pathfinder to Guernsey	73,662	87,915	14,253	19.3%
South Platte	80,349	94,909	14,560	18.1%
Upper Laramie	30,299	35,745	5,446	18.0%
Total	**220,891**	**256,996**	**36,105**	**16.3%**
State of Wyoming	**493,782**	**584,153**	**90,371**	**18.30%**

4.1.2 Employment and Key Economic Sectors

There were about 172,800 jobs within the Basin as of 2014, about 43% of all jobs statewide. As of late 2015, only one subbasin had an unemployment rate higher than the state average. The largest employment sector in the Basin is government, followed by retail trade and healthcare. As the largest employment sector by far, the government sector (federal, military, state and local government jobs); included about 37,400 jobs, or about 22% of total Basin jobs, in 2014. Mining accounts for about 5.5% of Basin jobs; the majority of those are located in the Above Pathfinder Dam and the Pathfinder to Guernsey subbasins. Agriculture contributes 3.0% of total Platte Basin employment. However, while employment in agriculture is relatively small, the sector accounts for the overwhelming majority of water use. Between 2002 and 2014, the total number of jobs in the Basin increased by about 27,200, from 145,600 full and part-time positions in 2002 to 172,800 total positions in 2014. Over this period, Basin jobs accounted for about 43% of total jobs in

Wyoming. Employment growth in individual Basin counties ranged from 0.6% per year up to 2.6% per year over this period; both Basin employment and statewide employment grew at an average rate of about 1.6% annually. Annual earnings within each economic sector vary widely, but averaged about $51,800 in 2014, slightly lower than the statewide average.

From a water use standpoint, important sectors in the Basin include agriculture, energy, minerals, utilities and recreation. Among the economic sectors, changes in the agricultural sector drive overall water demands for the Basin since that sector comprises a relatively large portion of total diversions and consumptive use. The agricultural sector also drives monthly water use patterns for the Basin. Under the High and Low Scenarios, water demands for that sector change substantially, largely dwarfing changes in other sectors. However, it is important to note that municipal demands increase by 18% under the Low Scenario and 70% under the High Scenario, given the projected population growth in the Basin. Industrial demands have the potential to grow by as much as 34% under the High Scenario. Although water demands in those sectors make up small portions of total demands, it was necessary to address those future needs.

Agriculture. Agriculture is comprised primarily of cattle ranching and hay production. Irrigated acreage has decreased in recent years (a 14% reduction over the last decade), likely due to increases in technology and changes in commodity prices, among other factors. Currently, there were about 524,000 irrigated acres in the Basin and about 656,000 head of livestock, compared to about 613,000 irrigated acres and 686,000 head of livestock at the time of the previous Basin Plan. As a result, Basin wide agricultural water use has decreased somewhat in recent years, although fluctuations in water use do occur from year to year.

Oil and Gas. A large portion of the State's oil production comes from within the Basin (about 21% produced in Basin counties in 2002 and about 38% by 2014). Oil production from Basin counties has increased annually through 2015, with crude oil production reaching over 34.5 million barrels in that year. There are three oil refineries in the Basin, which use large amounts of water for cooling towers and steam generation. In 2015, about 16% of the State's natural gas was produced in Basin counties. Annual production in those counties has generally declined in recent years, mainly in response to changes in commodity prices; however, both 2014 and 2015 saw small increases in natural gas production in the Basin, even as total statewide production continued to decline. Basin wide, permitted water use in this industrial sector increased by more than 50% over the last 10 years.

Minerals. Although the amount of uranium produced in the Basin has remained relatively constant over the last decade, increasing prices have increased recent interest and investment in potential new uranium mining activity across the state, including within the Basin. Permitted water use for uranium recovery and processing operations has increased substantially in the Basin in recent years. All coal mines in the Basin have now closed and no coal is currently produced within the Basin.

Power Generation. In terms of major power generation facilities, the U.S. Bureau of Reclamation (USBR) operates six hydropower facilities within the Basin and the Laramie River Station and Dave Johnston Power Plant are also located in the Basin. In 2014, the 132 MW natural-gas fired Cheyenne Prairie Generating Station began operation. Water demands for power generation have increased slightly in the interim since the previous Basin Plan.

Other Economic Activity. In addition to the activities described above, the Basin is home to the University of Wyoming in Albany, the Wyoming State Penitentiary in Rawlins and several large retailers and distribution facilities located in larger cities. However, the

Wyoming Ethanol facility in Torrington closed in 2015 and the Western Sugar Cooperative plans on closing its Torrington location by 2017.

4.1.3 Consumptive Water Demands

Between 2005 and 2015, total estimated consumptive use in the Basin (under normal year conditions) decreased by about 6.5%. That net decrease was made up of changes in individual sectors: a 16% decrease in total agricultural water demand (due to a reduction of about 88,000 irrigated acres and 30,000 fewer head of livestock); about a 4.5% increase in municipal/rural domestic demand (population growth and changes in per capita water usage); and an almost 51% increase in industrial demands (increased water demands for oil and gas production, mining activity, power generation, aggregate production and other miscellaneous industrial demands).

Economic Sector	Estimated Consumptive Use (AF)	
	2005	2015
Irrigated Agriculture	662,000	556,000
Livestock	6,300	5,800
Municipal/ Rural Domestic	28,910	30,200
Industrial	104,200	157,300
Total Water Usage	**801,410**	**749,300**

Current consumptive water demands in the Basin are estimated to be about 749,300 AF per year, with about 75% of that demand coming from the agricultural sector.

Three future scenarios for economic and demographic growth in the Platte River Basin were projected through the year 2045. All three scenarios employed an economic base modeling approach, in which prospects for key economic sectors that either bring money into the region and/or are the source of substantial water use were analyzed in detail along with prospects for regional growth. Based upon these analyses, High, Low, and Mid Scenarios were developed for the Basin, leading to total employment and population projections. The High and Low Scenarios presented in the document are intended to bracket optimistic and pessimistic assumptions about the future, but they represent useful bounds for water planners. It is Harvey Economics' (HE) judgment that the Mid Scenario is the most realistic and is the most likely scenario to occur.

The three scenarios presented in this volume portray markedly different potential futures for the region. They reflect varying assumptions for agricultural activity, mineral prices, recreational demands and other economic activities. Projected Platte River Basin population in 2045 under the High Scenario would reach 440,000 residents, compared with 307,000 residents under the Low Scenario and about 347,000 residents under the Mid Scenario.

As shown in the two tables below, projected water demands (consumptive demands in a normal year) under the High, Low and Mid Scenarios have been revised since the previous Basin Plan. Current projections for 2045 reflect higher consumptive use under the High Scenario and lower consumptive demands under the Low and Mid Scenarios. Year 2045 water demands, in terms of consumptive use, range from 633,200 AF up to 939,100 AF. Those estimates reflect a change in consumptive use demands ranging from -15.5% to +25.3%, as compared to 2015 water demands; Mid Scenario changes represent about a 4% decrease in consumptive use. The reduction in total consumptive use demands under the Low and Mid Scenarios is largely due to an assumed reduction in irrigated acres over time.

Economic Sector	Estimated Consumptive Use (AF)			
	2006 Basin Plan			
	2005	Year 2035		
		High Scenario	Low Scenario	Mid Scenario
Irrigated Agriculture	662,000	700,000	650,000	661,000
Livestock	6,300	7,600	5,200	6,600
Municipal/Rural Domestic	28,910	50,910	39,810	42,810
Industrial	104,200	115,760	75,290	92,450
Total Water Usage	**801,410**	**874,270**	**770,300**	**802,860**

Economic Sector	Estimated Consumptive Use (AF)			
	2016 Basin Plan			
	2015	Year 2045		
		High Scenario	Low Scenario	Mid Scenario
Irrigated Agriculture	556,000	671,000	436,000	497,000
Livestock	5,800	6,900	5,000	5,800
Municipal/Rural Domestic	30,200	51,200	35,500	41,100
Industrial	157,300	210,000	156,700	174,700
Total Water Usage	**749,300**	**939,100**	**633,200**	**718,600**

4.1.4 Environmental and Recreational Water Demands

Non-consumptive environmental and recreational water uses in the Basin are very important to anglers, rafters, those who participate in a wide variety of outdoor activities and those who value the natural environment. Those uses are correlated to traditional diversions, while demand is driven by population levels. Numerous rivers, streams, reservoirs, mountains and forest lands in the Basin provide ample opportunities for these endeavors. Water in the Basin provides for a number of environmental and recreational (E and R) uses, including the existence of wetlands; support of other aquatic habitat; and fishing, boating and other recreational activities. E and R water uses exist throughout the Basin, although some subbasins include a greater concentration of E and R amenities than others. The Basin contains a number of major recreational reservoirs, as well as blue, red and yellow ribbon trout streams. E and R water uses are highly dependent on traditional water uses. Specific locations and water uses are categorized as protected, complementary or competing with existing traditional uses in each subbasin. As a result, the analysis of future demands for this sector is a reflection of the interactions of traditional water uses and these non-consumptive uses. Under the Low Scenario, recreational water use will be stable or will decline modestly; environmental water use is likely to expand. The High Scenario will have mostly positive effects on recreational water use, but the outlook for environmental water uses is mixed. E and R uses under the Mid Scenario would largely remain similar to current conditions.

Water demand projections were developed for the Platte River Basin under three alternative scenarios. Quantitative relationships (water use factors) for each water use sector together with projected demographic and economic information were applied to develop annual water use projections by sector under three alternative scenarios. Estimated monthly distributions of annual totals for each sector enabled derivation of monthly aggregate water use projections for each scenario.

Succinct summaries of recent economic conditions in the Platte River Basin are presented below.

Above Pathfinder Dam Subbasin	
Population (2014)	16,909
Households (2014)	6,706
Total Jobs	10,900
Unemployment Rate (Dec 2015)	3.9%
Agricultural Activity	
Irrigated Acres	124,000
Head of Livestock	108,000
Non-Agricultural Activity	
Oil and Gas Production	Uranium Mining
Wyoming State Penitentiary	Recreational Activity
Transportation Industry	Government Services
Retail/Commercial Mix	Construction

Pathfinder to Guernsey Subbasin	
Population (2014)	87,915
Households (2014)	36,220
Total Jobs	62,700
Unemployment Rate (Dec 2015)	5.4%
Agricultural Activity	
Irrigated Acres	65,000
Head of Livestock	199,000
Non-Agricultural Activity	
Oil and Gas Production	Uranium Mining
Power Generation (Dave Johnston Power Plant)	
Aggregate Production	Recreational Activity
Government Services	Health Care

Guernsey to State Line Subbasin	
Population (2014)	10,839
Households (2014)	4,265
Total Jobs	5,900
Unemployment Rate (Dec 2015)	3.2%
Agricultural Activity	
Irrigated Acres	81,000
Head of Livestock	68,000
Non-Agricultural Activity	
Government Services	Health Care
Specialty manufacturing	Retail/Commercial Mix
Western Sugar Cooperative (will close by 2017)	

Upper Laramie Subbasin	
Population (2014)	35,745
Households (2014)	15,527
Total Jobs	20,600
Unemployment Rate (Dec 2015)	3.0%
Agricultural Activity	
Irrigated Acres	104,000
Head of Livestock	60,000
Non-Agricultural Activity	
University of Wyoming	Government Services
Retail/Commercial Mix	Health Care
Recreational Activity	

Lower Laramie Subbasin	
Population (2014)	8,002
Households (2014)	3,534
Total Jobs	5,300
Unemployment Rate (Dec 2015)	3.9%
Agricultural Activity	
Irrigated Acres	66,000
Head of Livestock	85,000
Non-Agricultural Activity	
Power Generation (Laramie River Station)	
Government Services	Transportation
Health Care	Retail/Commercial Mix

Horse Creek Subbasin	
Population (2014)	2,676
Households (2014)	1,112
Total Jobs	1,600
Unemployment Rate (Dec 2015)	3.9%
Agricultural Activity	
Irrigated Acres	41,000
Head of Livestock	57,000
Non-Agricultural Activity	
Hawk Springs Reservoir and State Park	

South Platte Subbasin	
Population (2014)	94,909
Households (2014)	40,941
Total Jobs	65,600
Unemployment Rate (Dec 2015)	4.2%
Agricultural Activity	
Irrigated Acres	43,000
Head of Livestock	77,000
Non-Agricultural Activity	
Oil and Gas Production	Government Services
Power Generation (Cheyenne Generating Station)	
Aggregate Production	Retail/Commercial Mix
Recreational Activity	Health Care

Platte Basin Summary	
Population (2014)	256,996
Households (2014)	108,306
Total Jobs	172,600
Unemployment Rate (Dec 2015)	
Agricultural Activity	
Irrigated Acres	524,000
Head of Livestock	656,000
Non-Agricultural Activity	

4.2 FUTURE ECONOMIC AND DEMOGRAPHIC SCENARIOS TO SUPPORT UPDATED WATER DEMAND PROJECTIONS

"***The only function of economic forecasting is to make astrology look respectable.***"
- John Kenneth Galbraith

Between 2000 and 2014, the Basin's population increased by over 36,000 people, or about 16.3%. In comparison, the State of Wyoming as a whole grew slightly faster than the Basin, with total population growth of about 18.3% over that period. Eighty percent of the Basin's growth occurred in the South Platte and Pathfinder to Guernsey subbasins; other subbasins grew by much smaller amounts. As shown in **Table 4.1**, the Basin makes up about 44% of the State's population (also see **Figure 4.2** for a graphical depiction of current population distribution). In-migration has been a much more important component of population growth over the last decade, as compared to more historical periods. Between 2000 and 2013, in-migration comprised about half the Basin's population growth. Other demographic changes include an aging population and decreasing household size. The slight decrease in labor force participation rates is also likely the result of the aging population.

Table 4.1: Population Distribution and Growth in the Platte Basin from 2000 to 2014

Subbasin / City	Population		Total Growth	Percent Growth
	2000	2014	2000 – 2014	2000 - 2014
Above Pathfinder Dam	16,381	16,999	527	3.2%
Guernsey to State Line	9,967	10,839	873	8.8%
Horse Creek	2,389	2,676	287	12.0%
Lower Laramie	7,844	8,002	158	2.0%
Pathfinder to Guernsey	73,662	87,915	14,253	19.3%
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Upper Laramie	30,299	35,745	5,446	18.0%
Total	**220,891**	**256,996**	**36,105**	**16.3%**
State of Wyoming	**493,782**	**584,153**	**90,371**	**18.30%**

4.2.1 Employment and Key Economic Sectors

Between 2002 and 2014, the total number of jobs in the Basin increased by about 27,200, from 145,600 full and part-time positions in 2002 to 172,800 total positions in 2014. Over this period, Basin jobs accounted for about 43% of total jobs in Wyoming. Employment growth in individual Basin counties ranged from 0.6% per year up to 2.6% per year over this period; both Basin employment and statewide employment grew at an average rate of about 1.6% annually.

The Basin's largest employment sectors include the government sector, followed by retail trade; healthcare; accommodation and food service; construction and mining. As the largest employment sector by far, the government sector (federal, military, state and local government jobs); included about 37,400 jobs, or about 22% of total Basin jobs, in 2014. Mining accounts for about 5.5% of Basin jobs; the majority of those are located in the Above Pathfinder Dam and the Pathfinder to Guernsey subbasins. Agriculture is a key sector in the Basin in terms of water use; however, employment in that sector is relatively small. Annual earnings within each economic sector vary widely, but averaged about $51,800 in 2014.

From a water use standpoint, important sectors in the Basin include agriculture, energy, minerals, utilities and recreation.

Agriculture. Agriculture is comprised primarily of cattle ranching and hay production. Irrigated acreage has decreased in recent years (a 14% reduction over about the last decade), likely due to increases in technology and changes in commodity prices, among other factors. Currently, there were about 524,000 irrigated acres in the Basin and about 656,000 head of livestock, compared to about 613,000 irrigated acres and 686,000 head of livestock at the time of the previous Basin Plan. As a result, Basin-wide agricultural water use has decreased somewhat in recent years, although fluctuations in water use do occur from year to year.

Oil and Gas. A large portion of the State's oil production comes from within the Basin (about 21% produced in Basin counties in 2002 and about 38% by 2014). Oil production from Basin counties has increased annually through 2015, with crude oil production reaching over 34.5 million barrels in that year. There are three oil refineries in the Basin, which use large amounts of water for cooling towers and steam generation. In 2015, about 16% of the State's natural gas was produced in Basin counties. Annual production in those counties has generally declined in recent years, mainly in response to changes in commodity prices; however, both 2014 and 2015 saw small increases in natural gas production in the Basin, even as total statewide production continued to decline. Basin-wide, permitted water use in the industrial sector increased by more than 50% during the last 10 years.

Minerals. Although the amount of uranium produced in the Basin has remained relatively constant over the last decade, increasing prices have increased recent interest and investment in potential new uranium mining activity across the state, including within the Basin. Permitted water use for uranium recovery and processing operations has increased substantially in the Basin in recent years. All coal mines in the Basin have now closed and no coal is currently produced within the Basin.

Power Generation. In terms of major power generation facilities, the USBR operates six hydropower facilities within the Basin and the Laramie River Station and Dave Johnston Power Plant are also located in the Basin. In 2014, the 132 MW natural-gas fired Cheyenne Prairie Generating Station began operation. Water demands for power generation have increased slightly in the interim since the previous Basin Plan.

Other Economic Activity. In addition to the activities described above, the Basin is home to the University of Wyoming in Albany, the Wyoming State Penitentiary in Rawlins and several large retailers and distribution facilities located in larger cities. However, the Wyoming Ethanol facility in Torrington closed in 2015 and the Western Sugar Cooperative plans on closing its Torrington location by 2017.

4.2.2 Consumptive Water Demands

Between 2005 and 2015, total estimated consumptive use in the Basin (under normal year conditions) decreased by about 6.5%. That net decrease was made up of changes in individual sectors: a 16% decrease in total agricultural water demand (due to a reduction of about 88,000 irrigated acres and 30,000 fewer head of livestock); about a 4.5% increase in municipal/rural domestic demand (population growth and changes in per capita water usage); and an almost 51% increase in industrial demands (increased water demands for oil and gas production, mining activity, power generation, aggregate production and other miscellaneous industrial demands). The change in total consumptive use is skewed by the fact that irrigated agriculture accounts for between 74% and 83% of total water use in the basin as shown in **Table 4.2**.

Table 4.2: Change in Consumptive Use Between 2005 and 2015 in the Platte River Basin by Economic Sector

Economic Sector	Estimated Consumptive Use (AF)	
	2005	2015
Irrigated Agriculture	662,000	556,000
Livestock	6,300	5,800
Municipal/Rural Domestic	28,910	30,200
Industrial	104,200	157,300
Total Water Usage	**801,410**	**749,300**

Current consumptive water demands in the Basin are estimated to be about 749,300 AF per year, with about 75 percent of that demand coming from the agricultural sector. Projected water demands (consumptive demands in a normal year) under the High, Low and Mid Scenarios have also been revised since the previous Basin Plan. Current projections for 2045 reflect higher consumptive use under the High Scenario and lower consumptive demands under the Low and Mid Scenarios. Year 2045 water demands, in terms of consumptive use, range from 633,200 AF up to 939,100 AF. Those estimates reflect a change in consumptive use demands ranging from -15.5 percent to +25.3 percent, as compared to 2015 water demands; Mid Scenario changes represent about a 4 percent decrease in consumptive use. As shown in tables 4.3 and 4.4, the reduction in total consumptive use demands under the Low and Mid Scenarios is largely due to an assumed reduction in irrigated acres over time.

Table 4.3: Projected Changes in Consumptive Use in 2035 in the Platte River Basin by Economic Sector for the High, Low, and Mid Growth Scenarios Based on the 2005 Consumptive Use Data

Economic Sector	Estimated Consumptive Use (AF)			
	2006 Basin Plan			
	2005	Year 2035		
		High Scenario	Low Scenario	Mid Scenario
Irrigated Agriculture	662,000	700,000	650,000	661,000
Livestock	6,300	7,600	5,200	6,600
Municipal/Rural Domestic	28,910	50,910	39,810	42,810
Industrial	104,200	115,760	75,290	92,450
Total Water Usage	**801,410**	**874,270**	**770,300**	**802,860**

Table 4.4: Projected Changes in Consumptive Use in 2045 in the Platte River Basin by Economic Sector for the High, Low and Mid Growth Scenarios Based on the 2016 Consumptive Use Data

Economic Sector	Estimated Consumptive Use (AF)			
	2016 Basin Plan			
	2015	Year 2045		
		High Scenario	Low Scenario	Mid Scenario
Irrigated Agriculture	556,000	671,000	436,000	497,000
Livestock	5,800	6,900	5,000	5,800
Municipal/Rural Domestic	30,200	51,200	35,500	41,100
Industrial	157,300	210,000	156,700	174,700
Total Water Usage	**749,300**	**939,100**	**633,200**	**718,600**

4.2.3 Environmental and Recreational Water Demands

Water in the Basin provides for a number of E and R uses, including the existence of wetlands; support of other aquatic habitat; and fishing, boating and other recreational activities. E and R water uses exist throughout the Basin, although some subbasins include a greater concentration of E and R amenities than others. The Basin contains a number of major recreational reservoirs, as well as blue, red and yellow ribbon trout streams. E and R water uses are highly dependent on traditional water uses. Specific locations and water uses are categorized as protected, complementary or competing with existing traditional uses in each subbasin. As a result, the analysis of future demands for this sector is a reflection of the interactions of traditional water uses and these non-consumptive uses. Under the High Scenario, recreational water use will be stable or will decline modestly; environmental water use is likely to expand. The Low Scenario will have mostly positive effects on recreational water use, but the outlook for environmental water uses is mixed. E and R uses under the Mid Scenario would largely remain similar to current conditions.

4.2.4 Current Economic and Demographic Conditions

Introduction

This portion of Section 4.2 describes the current economic and demographic conditions and physical characteristics of Wyoming's Platte River Basin (Basin) and the seven subbasins located within that Basin. The data and information herein provides an update to the work conducted as part of the 2006 Basin Plan. At that time, HE developed a memo in support of the Basin Plan which described the longer term historical economic and demographic trends. This section focuses on the changes that have taken place since that previous work and on current conditions. The information included here is used to establish a baseline for projecting long-term economic and demographic activity, evaluating future water use opportunities and projecting future water demand.

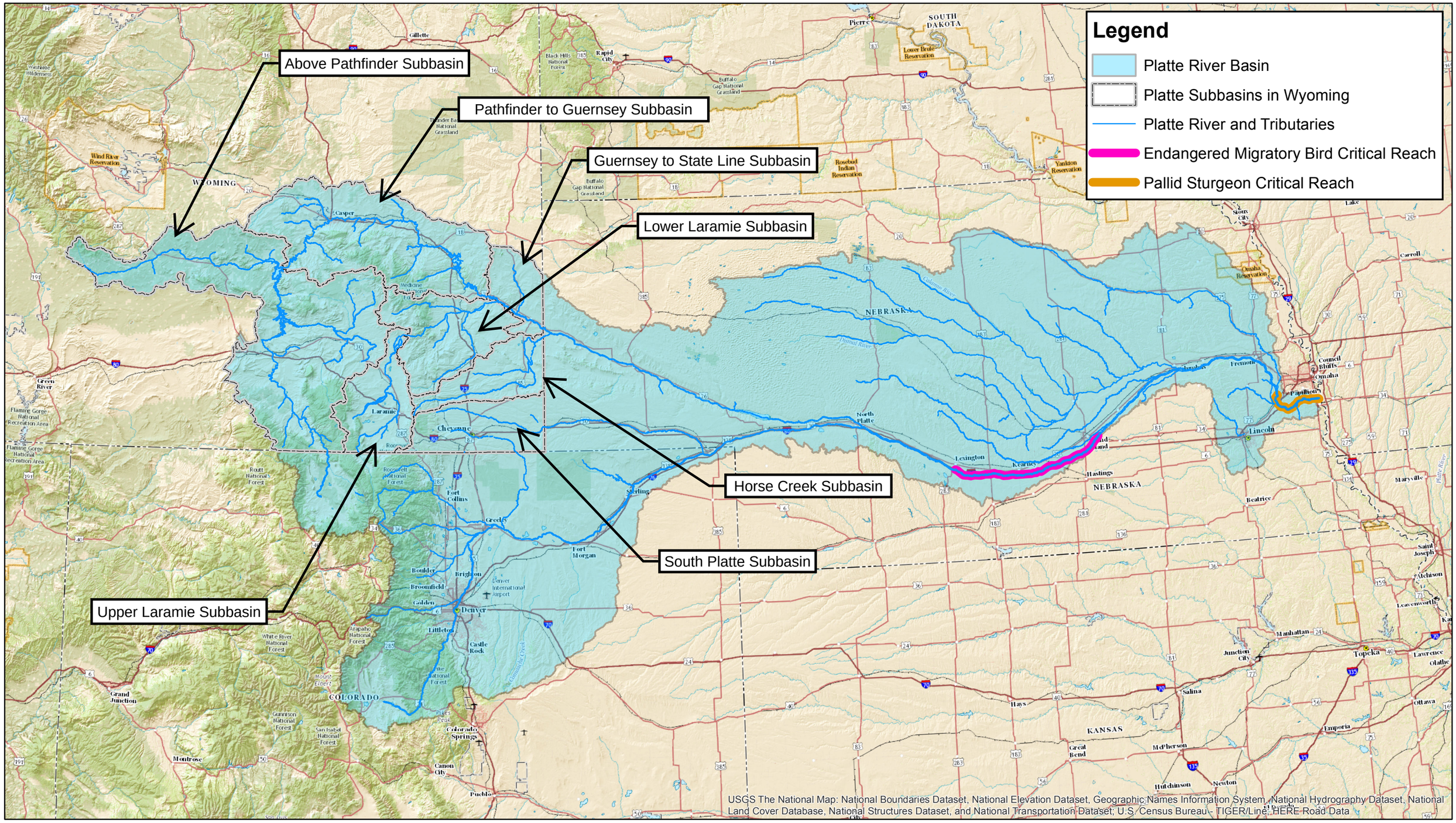
A Brief Overview of Basin Geography

The Platte River Basin encompasses all or part of 10 Wyoming counties, including Albany, Carbon, Converse, Fremont, Goshen, Laramie, Natrona, Niobrara, Platte and Sublette. However, only about 1% of the total land mass of Sublette County is within the Basin, and there are no towns within that area. Therefore, the demographic and economic analysis of the Basin excludes Sublette County. Sublette County was excluded from the descriptions of current conditions in HE's previous work; that approach was retained for this update.

The remaining nine counties represent divergent geographic areas with distinct conditions, rendering basin-wide generalizations less useful. HE has considered the data at the basin, subbasin and county level where possible to provide the most appropriate picture of the geographic area under examination. As described below, we have derived subbasin demographics to further develop our insights into the forces that influence growth and development in these areas. A map of the Platte River Basin in Wyoming, Colorado, and Nebraska, and the subbasins in Wyoming is illustrated in **Figure 4.1**.

Basin and Subbasin Allocations of Demographic and Economic Activity

Almost all demographic data are compiled by political units, such as cities and counties, and most of the economic data are reported at the county, state or national level. However, several counties include land area, population centers and jobs both inside and outside the Basin. For this update, HE approached the allocation of population, households and jobs within the Basin in the same manner as in the work previously completed for the 2006 Basin Plan. That is, HE determined population at the county and city levels and then based the rural population on the percentage of land in each county that was included in the Basin.



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Wyoming Water Development Commission

Figure 4.1 Platte River Basin - Source to Missouri River Confluence

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Other demographic and economic characteristics were estimated for the Basin by applying the portion of the population in Basin to those resources.

A similar process was followed to derive subbasin figures. Each subbasin includes portions of a number of counties, with the Pathfinder to Guernsey subbasin including portions of seven different counties. For the Basin as a whole, HE assigned the populations of incorporated cities and towns with each county to specific subbasins and then determined the remaining population based on the portion of land within that subbasin. Other demographic and economic characteristics were assigned in a similar manner. Specific adjustments were then made to account for the effects of topography and urban area concentrations. For example, a large land area may not support the commensurate population due to certain topography. Likewise, a concentration of unincorporated areas located in a small area may be undercounted by a land allocation approach. The adjustments made are a best effort to most accurately reflect individual subbasin conditions.

Demographic Overview

As of 2014, the Platte River Basin was home to almost 257,000 people, living in over 108,300 households. At that time, the Basin included about 44% Wyoming's 584,000 residents. Almost 74% of Basin residents resided in the Basin's ten largest communities, and roughly 60% of the Basin's residents lived in Cheyenne, Casper and Laramie, the three largest cities. Populations and households for each of the seven subbasins and the ten largest cities in the Basin are shown in **Table 4.5**.

Table 4.5: Subbasin Population and Households, 2000 and 2014

Subbasin / City	Population		Households	
	2000	2014	2000	2014
Above Pathfinder Dam	**16,381**	**16,909**	**6,369**	**6,706**
Rawlins	8,538	9,227	3,320	3,431
Saratoga	1,726	1,692	757	803
Guernsey to State Line	**9,967**	**10,839**	**4,107**	**4,265**
Torrington	5,776	6,736	2,436	2,618
Horse Creek	**2,389**	**2,676**	**827**	**1,112**
Lower Laramie	**7,844**	**8,002**	**3,140**	**3,534**
Wheatland	3,548	3,659	1,539	1,672
Pathfinder to Guernsey	**73,662**	**87,915**	**29,796**	**36,220**
Casper	49,644	60,086	20,343	24,760
Douglas	5,288	6,423	2,118	2,672
Evansville	2,255	2,831	848	1,076
Mills	2,591	3,690	1,161	1,613
South Platte	**80,349**	**94,909**	**31,528**	**40,941**
Cheyenne	53,011	62,845	22,324	27,009
Upper Laramie	**30,299**	**35,745**	**12,580**	**15,527**
Laramie	27,204	32,081	11,336	13,944
Total	**220,891**	**256,996**	**88,346**	**108,306**
Basin-wide increase		**36,105**		**19,960**
% Change		**16.3%**		**22.6%**

Source: US Census Bureau, Wyoming Economic Analysis Division and Harvey Economics, 2016.

Historic Population Growth

Between 2000 and 2014, the Basin's population increased by over 36,000 people, or about 16.3%. At that same time, the number of households increased by almost 20,000, or about 22.6%. The faster rate of growth for households as compared to population indicates that individual household size is decreasing in the Basin, suggesting an aging of the population

base. In comparison, the State of Wyoming as a whole grew slightly faster than the Basin, with total population growth of about 18.3% over that period.

The counties that comprise the Basin grew at varying rates, ranging from about 23%, or an increase of over 15,000 people in Natrona County to a loss of about 8 people, or less than one tenth of one percent, in Platte County. Each of the seven subbasins also experienced varying rates of growth between 2000 and 2014. The Upper Laramie, South Platte and Pathfinder to Guernsey subbasins each grew by a total of between 17% and 18% over that period. Although the Horse Creek subbasin grew by 12%, it only added about 300 people. The Guernsey to State Line subbasin grew by about 9%, adding less than 1,000 people and the Lower Laramie and Above Pathfinder Dam subbasins each grew by between 2% and 3%.

The distribution of the population throughout the Basin remained relatively constant over the past 15 years. As illustrated in **Figure 4.2**, the South Platte and Pathfinder to Guernsey subbasins comprise the majority of the Basin's total population; over 70% of the Basin's population resides in one of those two Basins. Other subbasins include much smaller portions of Basin population, ranging from about 14% in the Upper Laramie subbasin to about 1% in the Horse Creek subbasin.

The population increases seen in the Basin since 2000 incorporate both natural population changes (births minus deaths) and net migration (in-migration minus out-migration). Between 2000 and 2013, natural population change accounted for an increase of over 20,800 people in Basin counties, while net migration added about another 22,600 people. Therefore, each of those components generally made up about half of the population increases experienced in the Basin.

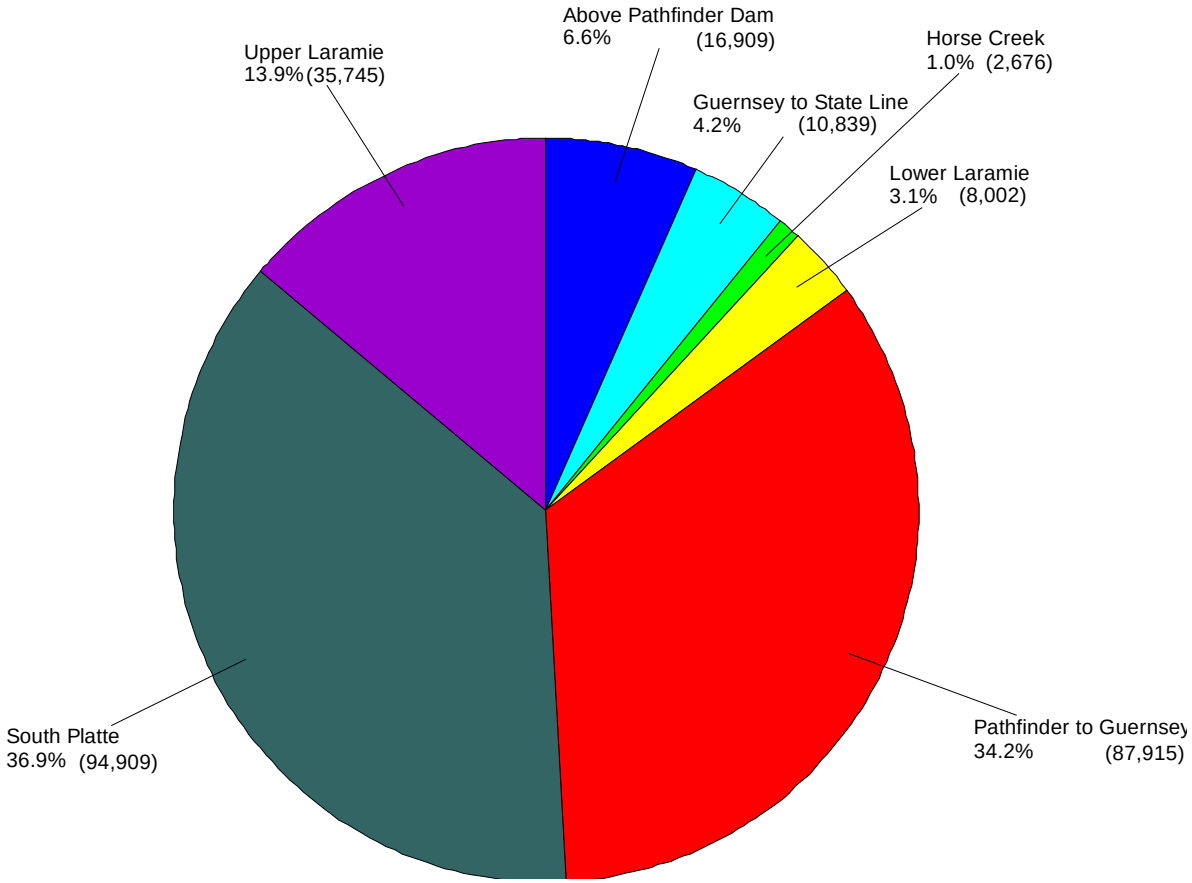
Although natural population change varied among individual Basin counties, the change for all Basin counties combined remained relatively constant over time, averaging an increase of about 1,500 people per year. In contrast, net migration, both for individual counties and for all Basin counties combined experienced large changes from year to year. For example, in 2000, net migration data for the counties showed an overall loss of about 400 people, while in 2012, those same counties experienced an influx of about 4,200 people. Net migration was positive in all years since 2001, indicating that more people moved into the area than left the area in each year since 2001. Net annual net migration data for Basin counties is depicted in **Figure 4.3**.

The Aging Population

In general, Basin residents are older than the average Wyoming resident, as indicated by the age comparisons provided in **Table 4.6**. The median ages of residents living in the majority of Basin counties (six of the nine) are greater than the median age of all Wyoming residents. Many of those counties are smaller in terms of population, and are more rural, with larger agricultural bases. The age distribution of Laramie County residents is about the same as for the state, while residents of Albany and Natrona Counties are generally younger than the average Wyoming resident.

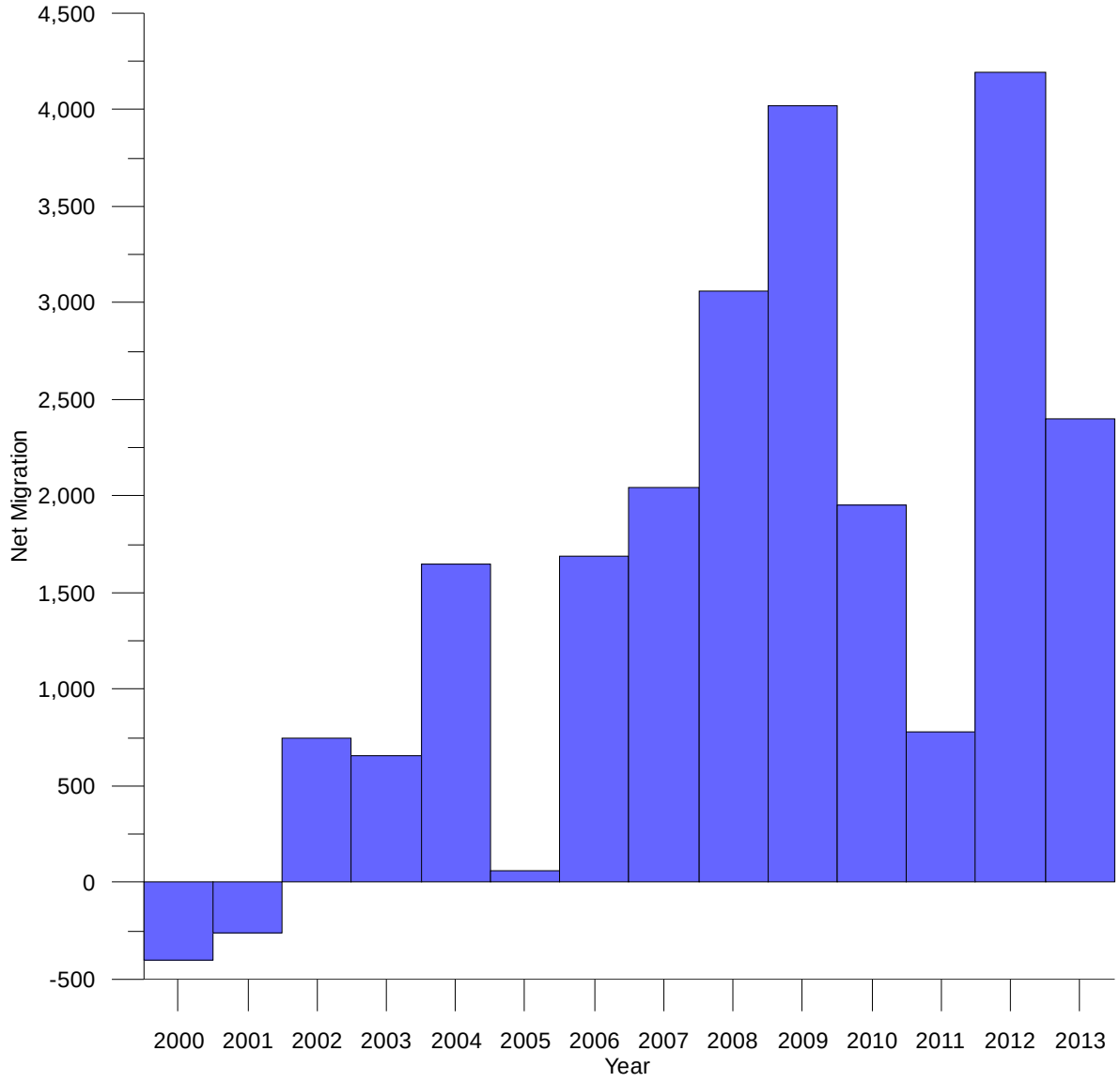
Not only are Basin residents older than the statewide average, but the median age of Basin residents has increased over time as well. Only in Carbon and Natrona Counties did the median ages of residents decrease, as compared to 2000; that may be due, in part, to the younger workers required in the oil and gas industry. Median ages of residents increased in all other counties.

Figure 4-2: Distribution of Population, by Subbasin, 2014



Source: US Census Bureau, Wyoming Economic Analysis Division and Harvey Economics, 2016.

Figure 4-3: Net Migration in Platte River Basin Counties, 2000 to 2013



Source: Wyoming Department of Administration and Information, Economic Analysis Division.

Table 4.6: Age Cohorts by Percentage for the U.S., Wyoming and Basin Counties, 2014

Age Group	US	WY	Albany	Carbon	Converse	Fremont	Goshen	Laramie	Natrona	Niobrara	Platte
0 - 19	26	26	23	26	27	28	23	26	26	18	22
20 - 34	21	22	39	21	19	19	19	22	23	20	15
35 - 54	26	25	19	25	26	23	23	25	25	25	24
55 - 64	13	14	11	15	14	14	15	13	13	17	16
65 & Older	15	14	10	14	14	16	21	14	13	21	23
Median Age, 2014	37.7	36.8	27.5	37.6	38.7	38.1	42.9	36.8	35.8	45	47.4
Median Age, 2000	35.3	36.2	26.7	38.9	37.5	37.7	40	35.3	36.4	42.8	41.2
Source: US Census Bureau											

The age distribution of Wyoming and Wyoming counties is explained by a number of factors, including the aging of the large baby boom generation as seen across the U.S., the in-migration of retirees seeking Wyoming's low cost of living; and the out-migration of young people looking for employment opportunities. An older population can have a number of effects on a region, particularly in a rural environment. For example, increased demand for healthcare may induce a concentration of older residents in areas convenient to doctors and hospitals.

Unemployment and Labor Force Participation

As of December 2015, unemployment rates across the Basin ranged from a high of 6% in Fremont County to a low of 2.9% percent in both Albany and Niobrara Counties. Only Fremont and Natrona Counties experienced higher unemployment rates than the 2015 statewide average of 4.5% percent; the remaining counties experienced relatively low unemployment rates at that time. Unemployment rates by subbasin are provided in **Table 4.7**.

Table 4.7: Unemployment Rates in the Platte River Basin, by Subbasin, 2015

Subbasin	Unemployment Rate
Above Pathfinder	3.9%
Guernsey to State Line	3.2%
Horse Creek	3.9%
Lower Laramie	3.9%
Pathfinder to Guernsey	5.4%
South Platte	4.2%
Upper Laramie	3.0%
Sources: Bureau of Labor Statistics and Harvey Economics, 2016	

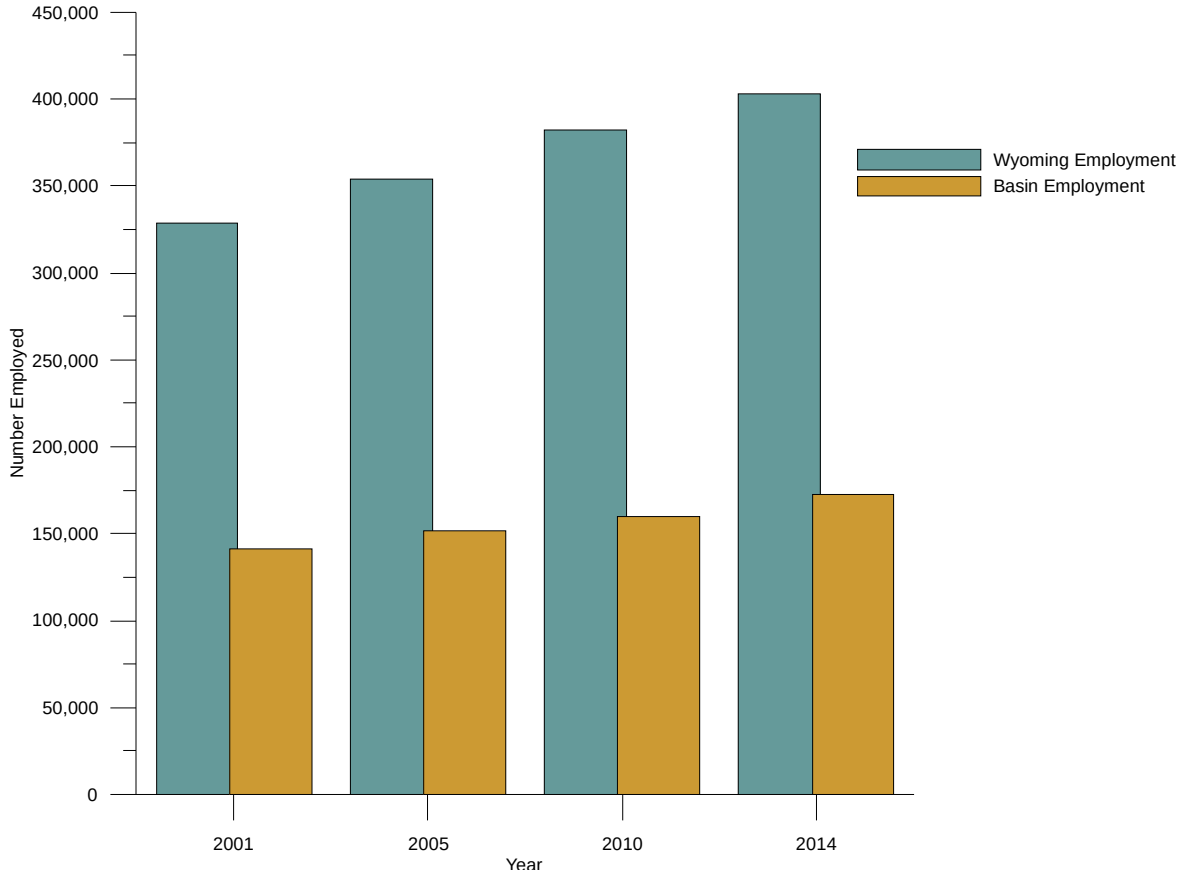
The labor force participation rate is the percentage of residents in a given region over the age of 16 who are employed or actively seeking work. As of 2014, the labor participation rate for Wyoming was 68.4 percent, down slightly from 70 percent in 2000; that decrease is likely due to the aging of the population in Wyoming. Within the Basin, only Natrona County (70.6 percent) and Converse County (71.9 percent) had participation rates higher than the state average; those higher rates may be due to oil and gas industry activity in those areas and the demand for services to support those workers. Carbon (65.9 percent), Fremont (66.4 percent), Goshen (61.3 percent), Laramie (65.1 percent) and Platte (61.5 percent)

Counties lagged behind the statewide average. Many Basin counties experienced decreasing labor force participation rates between 2000 and 2014.

Platte Basin Employment Overview

As of 2014, there were a total of about 206,400 full and part-time jobs in the nine Basin counties. The study team estimates that 172,800 of those positions were within the Basin area. At that time, Basin jobs accounted for about 43% of total jobs in Wyoming; that rate has remained generally constant since 2001. Between 2001 and 2014, both statewide employment and Basin employment grew at an average rate of 1.6% annually, although employment growth in individual Basin counties ranged from 0.6% to 2.6% per year. **Figure 4.4** depicts total employment in Wyoming and the Platte River Basin between 2001 and 2014.

Figure 4-4: Total Employment in Wyoming and the Platte River Basin, 2001 to 2014



Sources: U.S. Bureau of Economic Analysis, Regional Economic Information System, http://www.bea.doc.gov/bea/regional/reis/ and Harvey Economics, 2016.

Employment and Earnings by Sector

The proportion of employment by economic sector within the Basin, as compared to the state and the nation, provides insight into which sectors are most important to the regional economic base. The Basin's largest employment sector is the government sector, including federal, military, state and local government jobs; about 22% of Basin employment occurs in that sector, compared with 19% of statewide employment and 13% of national employment. Although the federal government, through various agencies such as the BLM

and USFS, controls a large amount of land in the state and Basin, the majority of government sector jobs are in local government. The government sector currently employs about 37,400 people in the Basin.

Mining currently accounts for about 9% of all jobs in Wyoming and about 5.5% of jobs within the Basin, compared with less than 1% of jobs nationwide. About 66% of Basin mining employment takes place in Natrona County, with Converse, Laramie and Carbon Counties making up roughly 30%, indicating that mining is most important in Above Pathfinder Dam and Pathfinder to Guernsey Subbasins. The other counties have little or no mining employment. Total mining employment in the Basin amounts to over 9,300 people.

Agriculture also plays a larger role in Wyoming than in the nation as a whole, contributing about 3.5% of statewide employment and 2.7% in the Basin, as compared to 1.4% nationally. About 4,700 people are employed in agriculture Basin wide. On the other hand, the manufacturing sector in both Wyoming and the Basin is smaller than the national average, accounting for only about 3% of total employment in the Basin and the state, versus 7% nationally. Manufacturing employs about 5,300 people throughout the Basin.

For other economic sectors, Basin employment is generally similar in proportion to that of the state and the U.S. as a whole, with the notable exceptions of health care and professional/scientific and technical services. The percentage of Basin and state employment in those sectors is smaller than at the national level.

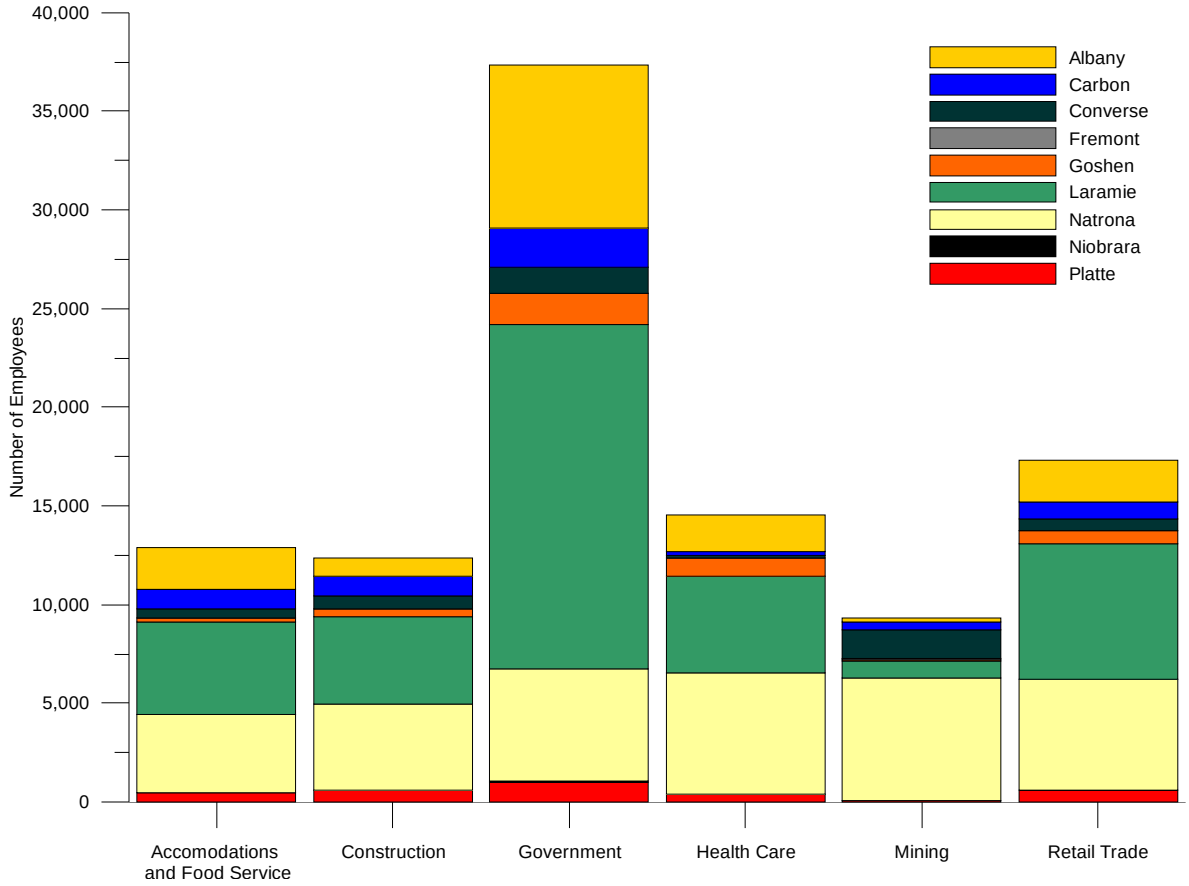
Figure 4.5 illustrates current employment in the Platte River Basin for the six largest economic sectors, including government; retail trade; health care; accommodations and food service; construction; and mining. Together, those sectors employ about 104,000 people Basin wide, about 60% of total Basin employment. Employment in the government sector is more than double the next largest sector, retail trade. As discussed previously, although agriculture is important to the area in terms of culture, identity and water use, agricultural employment within the Basin is relatively small. **Figure 4.5** also illustrates employment by sector for each Basin county; therefore, the relative importance of each of those key sectors can be identified by county.

The economic sectors with the largest employment numbers are not necessarily the ones that generate that largest amount of earnings. The top six sectors, in terms of earnings, exclude accommodations and food service, which are typically lower paid jobs, and instead include transportation and warehousing. **Figure 4.6** depicts the earnings in each Basin county for the six highest earning employment sectors. Total earnings in the government sector were by far greater than for any other sector due both to the large amount of employment in that sector, as well as higher than average earnings in that sector.

Overall, the average earnings per employee in the Basin amounted to about $51,800 in 2014. However, average earnings per employee within each economic sector varied widely. For example, the average annual earnings for farm employment in Basin counties was about $32,900, while government employees averaged wages of about $68,200.[1] Mining provided the highest wage with average annual earnings of $90,600. Accommodations and food service workers earned some of the lowest wages, at about $22,200 per worker.

[1] Earnings estimates include that of proprietors.

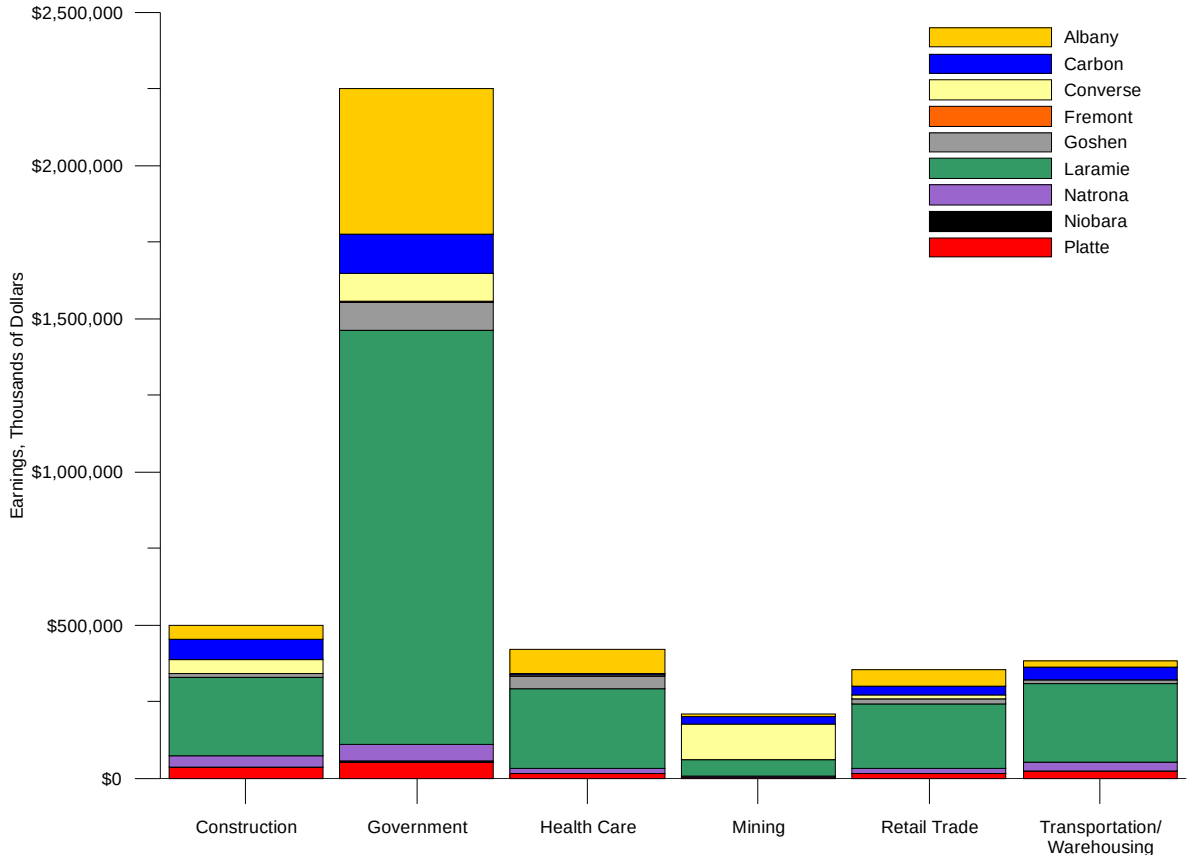
Figure 4-5: Platte River Basin Employment by Key Economic Sector, 2014



Note: Only small portions of Niobrara and Fremont Counties are included in the Basin; therefore, Basin employment in those counties is extremely limited.

Sources: U.S. Bureau of Economic Analysis, Regional Economic Information System, http://www.bea.doc.gov/bea/regional/reis/and Harvey Economics, 2016.

Figure 4-6: Platte River Basin Earnings for Key Economic Sectors, 2014



Note: Only small portions of Niobrara and Fremont Counties are included in the Basin; therefore, Basin earnings from those counties are extremely limited.

Sources: US Bureau of Economic Analysis, Regional Economic Information System, Local Area Annual Estimates, http://www.bea.doc.gov/bea/regional/data.htm and Harvey Economics, 2016.

Key Economic and Water Use Sectors

Agriculture's impact on the Basin's land and water use is significant. The energy and mineral sectors have historically added volatility to the Basin economy but also provide high paying jobs and often require a comparatively large amount of water. While municipal water consumption is a small percentage of the overall water used in the Basin, cities and towns have unique requirements that demand quality and reliability. Travel, tourism and recreation contribute to the Basin economy and water plays an important, but somewhat different, role in this sector. Environmental water use is notable and indirectly affects the economy. Finally, there is an ongoing effort to attract new business and manufacturing interests into the area, which in the long run may increase the Basin's economic base and may create new demand for water supplies. A discussion follows of each of these sectors.

The future of each of these sectors is integral to economic, demographic and water demand projections for the Platte River Basin. In Sections 2 and 3 of this volume (Volume 4), low, medium and high growth scenarios have been developed to forecast water demands.

Agriculture

Overview. Over a third of Wyoming's irrigated acres lie within the Platte River Basin, and over 40% of the State's livestock are raised in the Basin.[2] To gain an understanding of the current status and future trends in this sector, HE gathered agricultural data for the Basin, primarily from the Wyoming Department of Agriculture and other federal and State sources. In addition, Lidstone and Associates, Inc. provided data on current irrigated agricultural acreage for the Basin and for each subbasin.

As agricultural owner/operators age and farms/ranches change hands in the region, two seemingly contradictory trends have emerged. One is the consolidation of ranches, often to corporations, resulting in larger ranches. The other is the subdivision of ranches, resulting in smaller operations. The latter trend is particularly evident in more populous areas where land values and incomes are higher and where the market for "hobby" farms is growing. For example, between 2002 and 2012, the number of agricultural operations climbed by 25% while the number of farm acres declined by 10% in Basin counties (USDA 2012).

Crop Production. Cropping patterns and livestock production are closely related. Alfalfa hay, other hay, and irrigated pasture account for over 80% of the irrigated crops in the Basin; that hay is used directly to feed Basin livestock. Other irrigated crops include corn, dry beans, sugar beets, barley, winter wheat, oats and spring wheat. Most irrigation is by flood, but pivots are increasing in some areas. Surface water is the most common water source, though groundwater is increasingly prevalent.

Energy and input prices, like fertilizer and equipment, influence crop patterns and rising prices can drive production levels. About 4% of the Basin's total landmass is used for dryland and irrigated cropland; about 2% is irrigated. **Figure 4.7** provides the irrigated agricultural acreage for each subbasin in 2012. The Above Pathfinder Dam and Upper Laramie subbasins include the largest numbers of irrigated acreage, while the Horse Creek subbasin has the least.

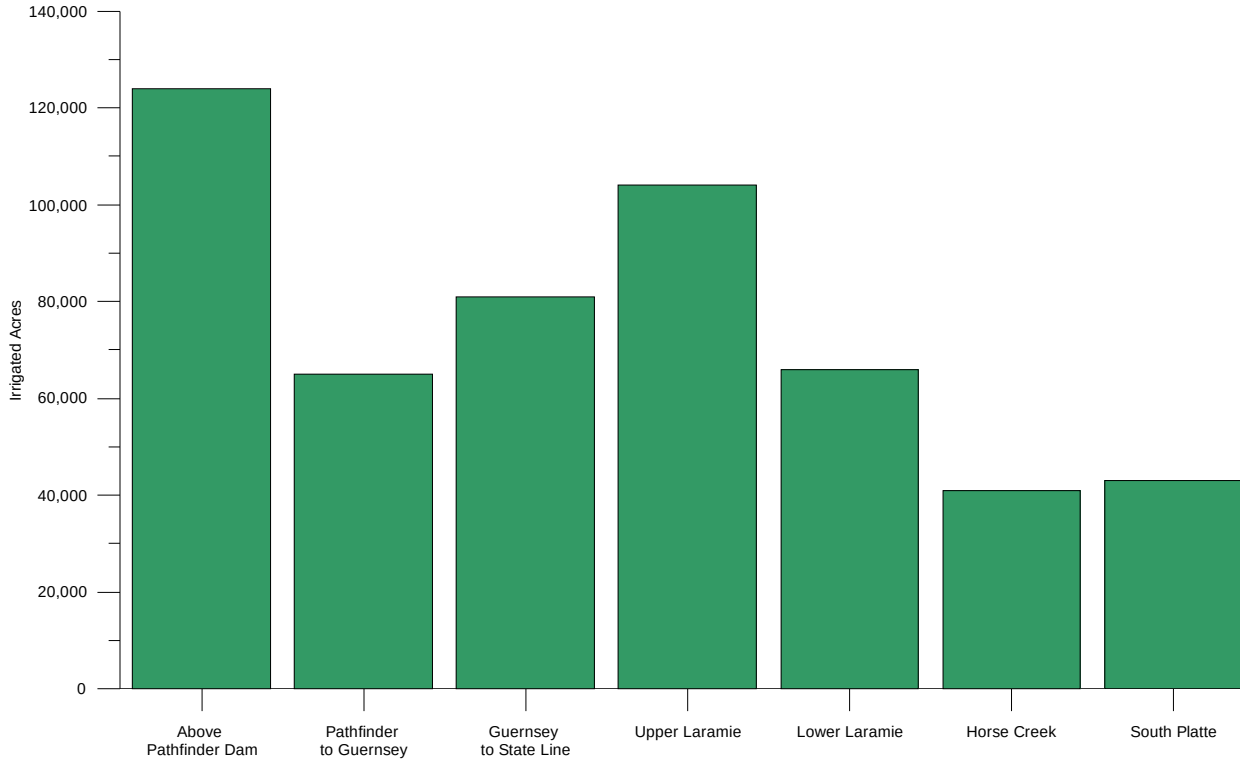
Cropping patterns by subbasin are illustrated in **Figure 4.8**. All seven subbasins include irrigated pasture, alfalfa and other hay. Irrigated acreage in the Upper Laramie subbasin only includes those three crops; the remaining six subbasins also contain other crops.

The Above Pathfinder Dam and Upper Laramie subbasins are almost entirely dependent on livestock production that consumes the hay cultivated there; those subbasins include very little in the way of cash crops. Crop production increases downstream toward Nebraska, where more favorable climate conditions justify the investment in cash crop production. Three counties, Goshen, Laramie and Platte, accounted for almost 80% of the value of crops sold in the Basin in 2012.

Cattle. As of 2015, there were about 539,000 head of cattle in the Platte River Basin. This is a 0.4% decline from 2005, when there were about 541,000 head. With the exception of a larger herd in 2005 and 2006, the number of cattle in the basin has been relatively flat for the past decade. In addition to these cattle, which are counted as of January 1 each year, in some counties, yearlings from other states are brought in for grazing in April and then shipped back to those states in October. These yearlings are not included in the total cattle head counts.

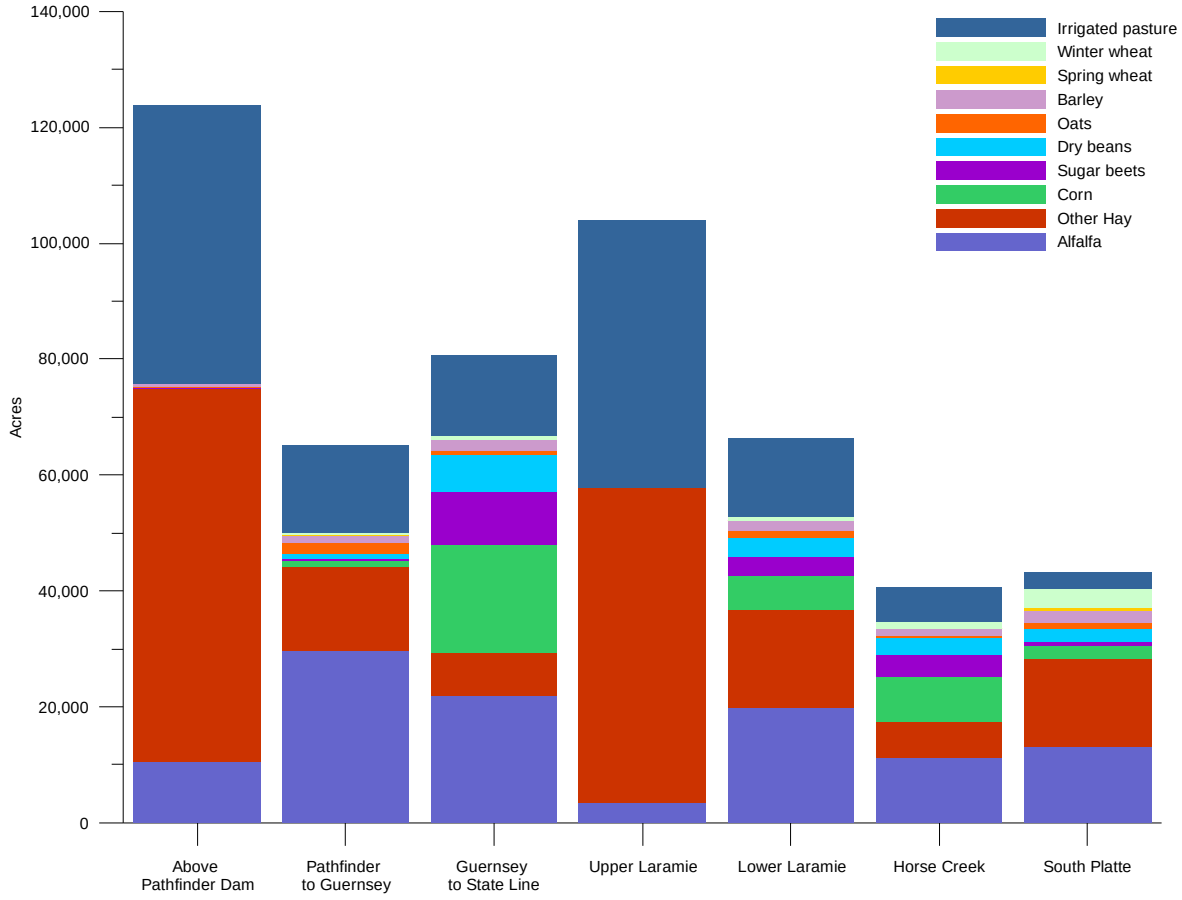
[2] Wyoming had roughly 1.4 million irrigated acres in 2012, according to the Wyoming Agricultural Statistics Service; the Platte River Basin included about 523,000 irrigated acres, or 36% of the state total. Wyoming had about 1.3 million head of cattle in 2015, and the Platte River Basin had roughly 539,000 head of cattle in 2015, or 41% of the state total.

Figure 4-7: Irrigated Agricultural Acreage, by Subbasin, 2012



Source: Lidstone and Associates, Inc., 2015.

Figure 4-8: Cropping Patterns, by Subbasin, 2012.



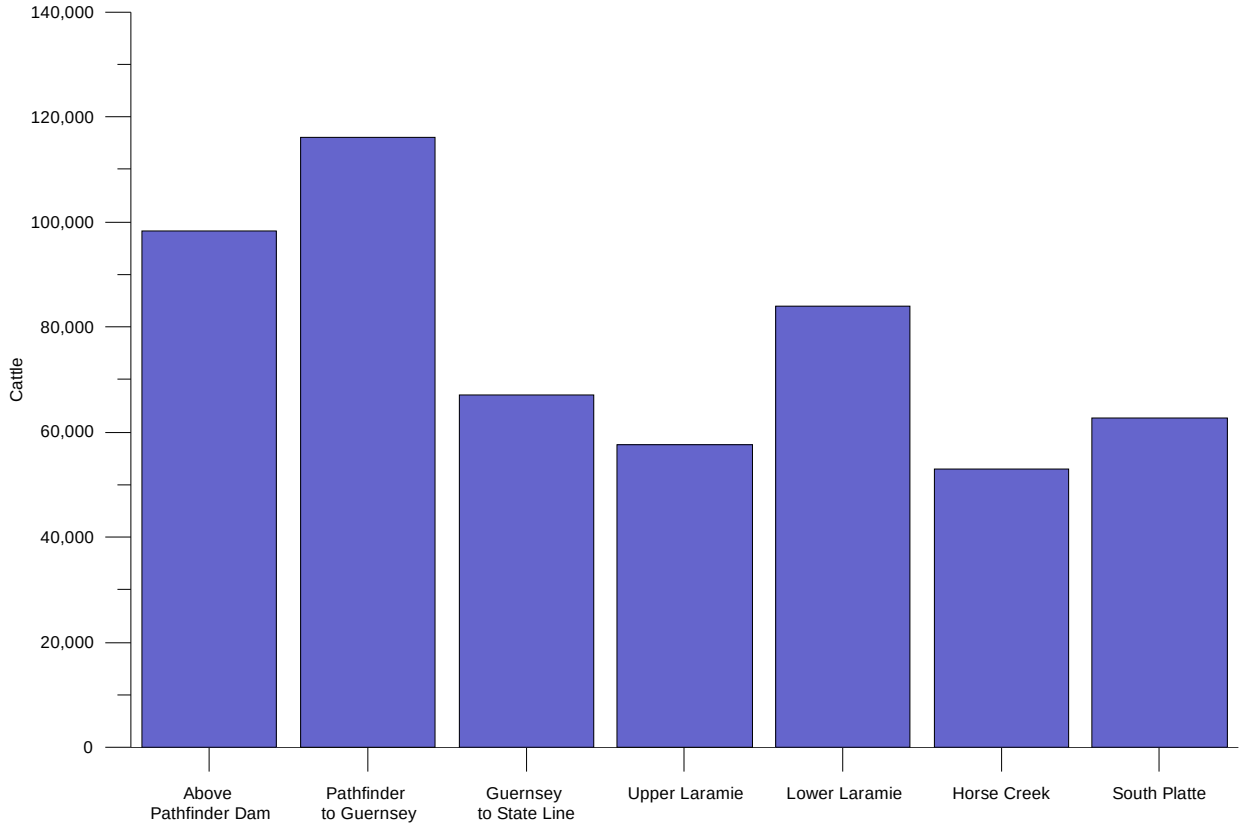
Sources: Lidstone and Associates, Inc., 2015 and Harvey Economics, 2016.

It should be noted that the average calf, presumably the same age, weighs as much as 200 pounds more per animal than it would have two decades ago, attributable to breeding and feed choice, primarily (Olson, 2011). Therefore, although cattle numbers are down slightly from 1995 (4% reduction), production, in terms of weight, has stayed about the same. This is significant because calf prices per cwt (hundred weight) are the most important driver of agricultural economics in the Basin (Mount 2005). Since 1999, cattle prices have risen sporadically, with a large spike in 2014.

Ranchers in the Basin depend on forage to supplement the hay they feed their animals. Therefore, during drought they cannot afford to raise as many cattle. Although hay and alfalfa are grown across the Basin, most areas are net importers of hay, much of it from the Wheatland area. As of 2014, hay cost $130 to $150 per ton, with a 1,000 pound cow requiring two tons to get through the winter (Wyoming Agricultural Bulletin). Most of the grazing land in the eastern portion of the Platte Basin is privately held, minimizing reliance on BLM land for grazing. However, in Natrona, Carbon and Converse Counties, public land for grazing is very important. BLM and USFS grazing policy has been fairly constant and no changes are anticipated.

Figure 4.9 portrays the number of cattle in each subbasin. The Pathfinder to Guernsey and the Above Pathfinder Dam subbasins are home to the largest numbers of cattle, while the Horse Creek subbasin has the fewest.

Figure 4-9: Estimated Head of Cattle in the Platte River Basin, by Subbasin, 2015



Note: Basin abbreviations - Above Pathfinder Dam (APF), Pathfinder to Guernsey (PG), Guernsey to State Line (GSL), Upper Laramie (UL), Lower Laramie (LL), Horse Creek (HC) and South Platte (SP).

Sources: USDA National Agricultural Statistics Service Wyoming Field Office www.nass.usda.gov/wy/ and Harvey Economics, 2016.

Sheep. In 2004, there were about 107,000 sheep in the Basin. Since that time, the number of sheep produced in the Basin rose to over 140,000 and then declined to about 117,000 by 2015. As of 2015, over 70% of the Basin's sheep were grown in the Pathfinder to Guernsey subbasin. Each of the remaining subbasins included smaller numbers of sheep.

Dairies. The climate, limited growing season, distance to market and scarcity of water resources has discouraged development of a notable dairy industry in the Basin. There are a few dairies near the Nebraska border, but they are not a significant agricultural presence.

Energy, Minerals and Utilities

Across the Basin, the importance of the energy sector varies greatly. For example, mining employment ranged from less than 20 people in Fremont County to about 6,200 people in Natrona County. On a countywide level, the 2014 production of crude oil ranged from 514 barrels in Platte County to more than 5.6 million barrels in Natrona County. Likewise, the production of natural gas ranged from zero for several Basin counties to over 97.1 million mcf in Carbon County. **Table 4.8** provides mineral production for Basin counties in 2010 and 2014.

Table 4.8: Mineral Production by Type for the Platte River Basin, 2010 and 2014

Commodity	2010		2014	
	Basin Total	% of State Total	Basin Total	% of State Total
Crude Oil, barrels	7,450,333	20%	28,331,013	38%
Stripper Oil, barrels	6,741,934	46%	NA	NA
Natural Gas, mcf	265,132,030	11%	241,299,286	13%
Coal, tons	26,944,748	6%	23,798,965	6%
Bentonite, tons	93,746	2%	117,212	3%
Sand and Gravel, tons	4,596,060	38%	6,462,926	45%
Uranium, tons	1,711,712	100%	1,601,873	47%
Decorative Stone, tons	22	0.4%	0	0%
Granite Ballast, tons	2,656,715	100%	2,593,952	100%
Limestone, tons	786,391	62%	906,367	100%
Shale, tons	165,775	100%	163,470	100%
Gold, tons	1	100%	0	NA
Leonardite, tons	42,071	100%	47,652	100%
Moss Rock, tons	568	100%	614	100%

Notes:
1. Stripper oil production for 2014 was not included in the Department of Revenue's 2015 Annual Report.
2. No gold was produced in Wyoming in 2014.

Source: State of Wyoming Department of Revenue, annual reports, selected years.

All Basin counties produced some amount of crude oil and sand and gravel in 2014. Other minerals were produced in combinations unique to each county, with most counties producing at least three different types of minerals. In several instances, such as granite ballast, limestone and shale, production in the Basin counties constituted total statewide production of that mineral in 2014.

Oil Production and Refining. As of 2014, Wyoming ranked 8th in the U.S. for oil production and about 38% percent of Wyoming's production came from the Basin counties (Wyoming State Geological Survey and Wyoming Oil and Gas Conservation Commission). In those Basin counties, annual oil production has increased steadily in recent years, reaching over 28 million barrels in 2014 and over 34.5 million barrels in 2015. Oil drilling and production do not use substantial amounts of water except for injection production, drilling lubrication and well sealing. Most water for those activities is provided by nearby groundwater wells.

There are three oil refineries in the study area. Refineries require a large amount of water in cooling towers and for steam generation.

HollyFrontier's Cheyenne Refinery uses about 1,200 gallons per minute (GPM) from the city's municipal supply. The refinery's water use is constrained by the amount of effluent it is allowed to create, and the operator is thus incentivized to decrease water use. Production is expected to remain constant or decline over the long run. Even with an increase in production, the firm's expectations are that with improved technology, such as air cooling, water use will decline (Wohgnant 2004).

The Sinclair Refineries in Carbon County utilize about 1,500 GPM (4 cfs). They have a water right for about 1.5 cfs and a 50 year lease with the City of Sinclair for an additional 4.21 cfs. This lease is renewable for another 50 years. Current use is less than available supply, and unused water simply flows past the inlet. If production increases, plans are to employ air cooling as needed (Fritz 2004).

The operators of these facilities have not applied for any additional groundwater or surface water permits in recent years and therefore, it is assumed that water production at these refineries has, and will, remain relatively constant.

Natural Gas. Wyoming is currently the fifth largest producer of natural gas in the U.S. (Wyoming State Geological Survey). In 2015, about 16% of the state's natural gas was produced in the Basin counties (Wyoming Oil and Gas Conservation Commission, 2016). Annual production in those counties has generally declined in recent years, mainly in response to changes in commodity prices; however, both 2014 and 2015 saw small increases in natural gas production in the Basin, even as total statewide production continued to decline.

Statewide, coalbed methane (CBM) has seen annual decreases in production in recent years and by 2015 production was down by about 65%, as compared to its recent high production point in 2009. The majority of CBM is produced in the Powder River Basin. Historically, less than 1% of total CBM production has occurred outside that Basin; however, that percentage has increased slightly in recent years. Natural gas production uses minimal water supplies in drilling and may produce non-hydrologically linked groundwater in some instances with coalbed methane extraction. Water production is expected to be minimal as related to any future coalbed methane development in the Basin.

Coal Mining. Although coal is produced in Converse County, the Antelope coal mine in that county is not located within the boundaries of the Platte River Basin. There are currently no operating coal mines within the Basin. As of 2014, the majority of coal mining in Wyoming occurred in Campbell County (91% of statewide coal production). Only about 6% of coal was produced from within Converse County, and as stated previously, that activity occurred outside of Basin boundaries. There is currently no active coal mining or coal production taking place in Carbon County (Wyoming Mining Association). The Seminoe I, Seminoe II and Rosebud mines in that county are all now reclaimed mining sites; there is no production at the Elk Mountain Mine.

Other Minerals. As of 2014, Converse County produced almost half of Wyoming's uranium, down from 100% of statewide uranium production in previous years. About half of the state's sand and gravel comes from Basin counties, an increase from recent years. Laramie County produces all of the state's granite ballast and statewide production of limestone, shale, leonardite and moss rock comes from Albany County. The production of these other minerals requires relatively small amounts of water.

Utilities

As of 2015, there were a number of electric generating facilities operating within the Basin, as well as several proposed for future development. Of these, the USBR operates six hydropower facilities, including Alcova (36 MW), Fremont Canyon (fed by Pathfinder at the upstream side of Alcova Reservoir, 67 MW), Glendo (38 MW), Guernsey (6 MW), Kortes (36 MW) and Seminoe (45 MW). The first priority for the USBR reservoirs with hydropower facilities is irrigation, followed by minimum flow agreements, and then power generation. There is almost no consumptive water use from hydrogeneration.

The Laramie River Station in Platte County is operated by Basin Electric Power Cooperative. That facility employs about 325 people and has a generating capacity of 1,710 MW from three coal-based units. This coal-fired plant uses about 23,250 acre-feet of water each year. There are no known plans for expansion.

The Dave Johnston Plant in Converse County is owned and operated by PacifiCorp and provides jobs to 191 full time employees. The plant burns coal for steam generated power

and has a capacity of 817 MW. The facility consumes approximately 8,600 acre-feet of water annually. The plant owns three sets of water rights for a total of 11,266 acre-feet per year. There are no known plans for expansion.

The Cheyenne Prairie Generating Station in Laramie County is a 132 MW natural gas-fired generating power plant owned by Black Hills Corporation. The power plant includes a natural gas-fired combustion turbine generator (simple cycle) and a combined cycle unit. The simple cycle unit is wholly owned by Cheyenne Light and the combined cycle unit is a joint ownership between Cheyenne Light and Black Hills. The power generated by this facility will be used as replacement generation for Black Hills and Cheyenne Light, including 82 MW of older, coal-fired generation that cannot be economically retrofitted to meet new EPA air emissions for Black Hills and 40 MW for a terminating power supply agreement for Cheyenne Light. This project started construction in 2013 and the facility went into operation in October 2014. In the short term, the plant will require about 500 acre-feet of water per year; however, increasing future demands may result in requirements of up to 1,000 acre-feet per year (Cheyenne BOPU, 2013). The generating station requires about 10 full time employees for operations.

The Power Company of Wyoming's proposed Chokecherry and Sierra Madre Wind Energy Project is an up to 1,000-turbine wind farm to be located south of Sinclair and Rawlins in Carbon County, Wyoming. The project will generate up to 3,000 MW. This project is nearing the final stages of the federal NEPA permitting process (BLM, 2015). In general, wind energy projects require little to no water for operations.

The Pathfinder Wind Energy Project is a proposed 2,100 MW wind project to be located in Platte County, Wyoming (Pathfinder, 2016). The project is currently in the initial stages and is based on a partnership between General Electric, Duke American Transmission Company, Magnum Energy LLC and several financial companies. This project would also include an energy storage component.

Recreation, Travel and Tourism

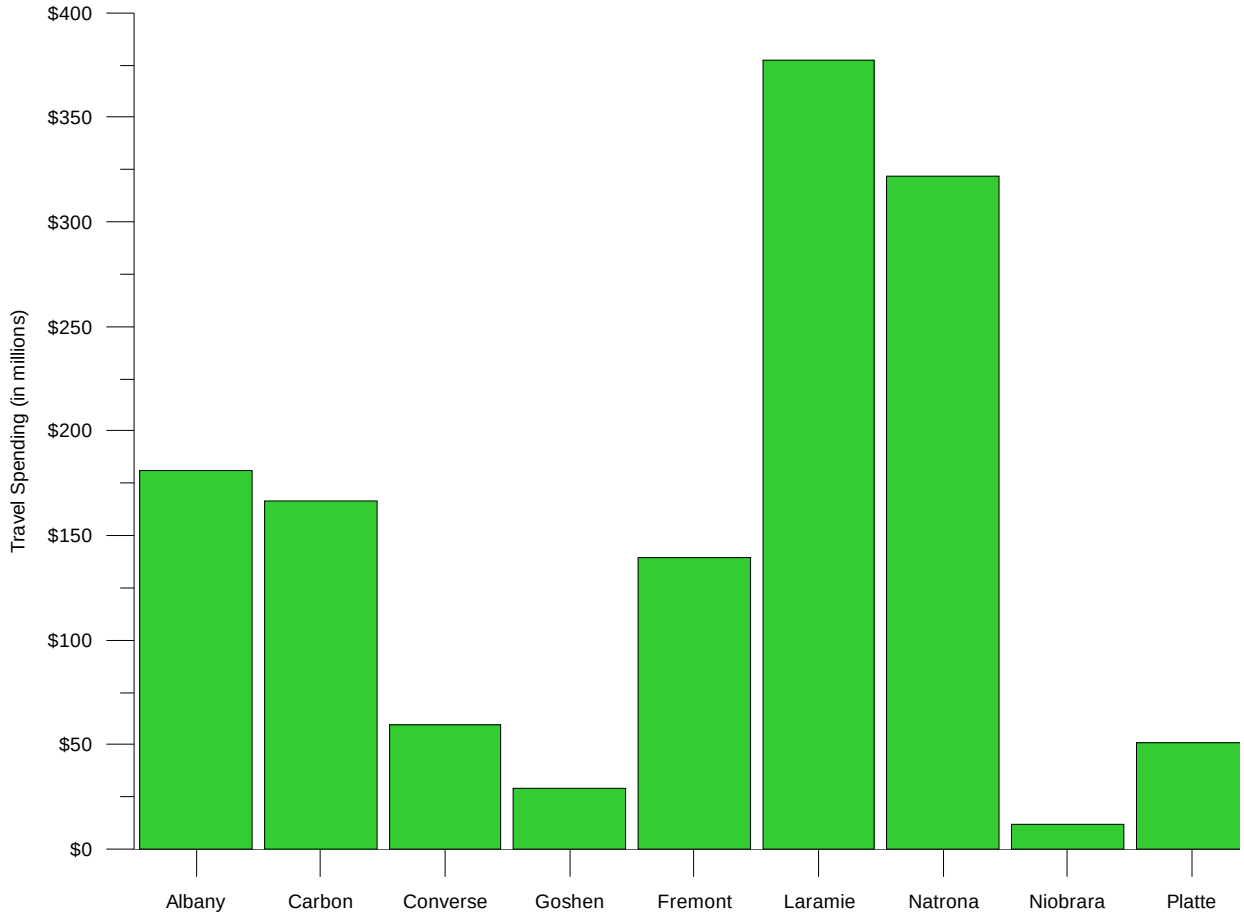
Travel and tourism are important to the economy of the Basin, although the Basin lacks a large destination tourist attraction. These activities increase overall water use in the Basin due to the influx of visitors. Activities and opportunities in this sector have remained generally the same since the original Basin Plan. However, due to changes to the organization of the Current Basin Surface Water Use Profiles, non-consumptive recreational water use is discussed only briefly in this document.[3] Consumptive water use for recreation includes golf course maintenance and snow-making.

Local use and day trips from Colorado and other nearby areas account for much of the recreational activity and related travel within the Basin. Larger cities, such as Cheyenne, Casper and Laramie, also attract conventions and other business related travel. For Basin areas that lack tourist attractions or recreational facilities, there is a benefit from drive-through traffic to other tourist or recreational locations. Overall, travel spending in the Basin represented about 35% of all travel spending in the State in 2014 (Dean Runyan, 2015). These activities contribute greatly to the retail trade and accommodation and food services sectors, which are among the largest employers in the Basin. In 2014, more than 12,000 jobs were generated by travel and tourism in Basin counties. Since 2000, travel spending in the Basin has increased about 5% each year, on average.

[3] The Recreation and Environmental Water Use discussion in Volume 2, Section 4 of this Platte Plan Update provides a detailed discussion of water use in those sectors.

As was true at the time of the original Basin Plan, travel related spending varies significantly within the Basin counties as shown in **Figure 4.10**. Laramie County, which includes the City of Cheyenne, and Natrona County, which includes Casper, were the recipients of the largest amounts of travel related spending in 2014.

Figure 4-10: Travel Spending by within the Platte Basin Counties, 2014



Note: Most of the tourist attractions in Fremont County are located outside of the Basin.
Source: Dean Runyon Associates. *Wyoming Travel Impacts, 2000 – 2014.* April 2015.

Environmental and recreational water uses in the Basin are very important to anglers, rafters those who participate in a wide variety of outdoor activities and those who value the natural environment. The numerous rivers, streams, reservoirs, mountains and forest lands in the Basin provide ample opportunities for these endeavors. Key recreational water uses in the Basin include fishing, boating and whitewater rafting. Much of this activity takes place on or near the North Platte River, its tributaries and associated reservoirs. There are numerous blue, red and yellow ribbon trout streams in the Basin, which provide excellent opportunities for anglers. In addition, USFS lands and mountainous areas provide extensive recreational options for outdoor enthusiasts. Boating occurs primarily on the reservoirs, which are assumed to be protected uses. Camping is also a popular activity in the Basin, and although it is not directly related to water use, many of the camping locations are located near streams and reservoirs and their use may be directly tied to water levels.

Reservoirs. There are a number of reservoirs in the Basin that provide recreational opportunities. However, the reservoirs were developed for flood control, irrigation and power, and as such, do not have a recreation reserve pool. As a result, recreational use at

the reservoirs generally peaks in July and then declines as water levels are drawn down for irrigation. Drought also impacts use, not only because of reduced water levels but also because of the prohibition of campfires. Even so, three of the largest reservoirs, Pathfinder, Glendo and Guernsey, each attract thousands of visitors each year. Glendo and Guernsey also have state parks at the reservoir location. In 2014, Glendo State Park had more than 300,000 visitors and Guernsey State Park had about 78,000 (Wyoming Division of State Parks, 2014).

The potential for additional vacation homes around Basin reservoirs is limited due to federal ownership of surrounding lands. However, interest appears to exist in developing available lands around Basin Reservoirs, as feasible. For example, in 2011 Natrona County commissioned a study regarding development of properties at Alcova Reservoir and of an existing marina site, without tenant improvements, at Pathfinder Reservoir (Holthouse, 2012).

Golfing. There are 19 golf courses with nearly 300 holes covering more than 2,000 irrigated acres in the Basin. Unlike other recreational activities, golf courses do require consumptive use of water. Only a few new courses are anticipated in the near future across the Basin.

Skiing. There are two alpine ski areas that consumptively use water to make snow in the Platte River Basin. Both the Hogadon Basin near Casper and the Snowy Range ski area near Laramie have surface water rights for snowmaking.

Manufacturing and Other Industry

As noted earlier in this analysis, Wyoming has proportionately less employment in the manufacturing sector as compared with the rest of the nation, due in part to the relatively small population base and limited workforce. However, there is a concerted effort in Basin counties to encourage location and development of manufacturing and light industry within the region and to reduce dependence on the more volatile energy sector.

Albany County. Manufacturing makes up less than 2% of total employment in Albany County. The University of Wyoming is located in Laramie and is both the largest employer and the largest water user in the county. Other large employers are generally related to government, education and healthcare; some larger retailers also operate in the county, mainly in or near Laramie. Mountain Cement Company in Laramie is the county's only other single large water user. Agriculture is the county's largest water consuming sector.

Carbon County. Historically, manufacturing has made up about 4% to 5% of County employment. Other than local government and school districts, the County's largest employers include the Sinclair Oil refinery (580 employees), Memorial Hospital (178), Union Pacific Railroad (172) and Walmart (169). The largest water users in Carbon County are parks and a golf course. The state prison in Rawlins houses 700 inmates and employs 300 and is the second largest user of water in the county. Major industries include transportation and energy, natural gas and agriculture.

Converse County. Manufacturing is a very small component of the Converse County economy; mining, ranching and transportation are the principal economic activities. As of 2015, there were no large manufacturing or industrial employers in the County. A food supplements manufacturer, Nutri-West, is located in Douglas, the firm has its own well and is not a large water user. A coal gasification plant has been proposed and would generate significant construction employment over several years, with ongoing employment of several hundred people. This facility may require a large amount of water, but its prospect for development is still very uncertain.

Fremont County. A small portion of Fremont County is located inside the Basin; that portion does not include the larger cities of Lander or Riverton, where any measurable amount of manufacturing activity might occur. Even so, only a small amount of manufacturing occurs throughout the County as a whole. The County's largest economic sectors, in terms of employment, are the government and retail trade sectors.

Goshen County. As of 2014, the manufacturing sector employed about 4.5% of people working in Goshen County. However, the future of manufacturing in the County is uncertain. The Wyoming Ethanol Facility in Torrington, which had been in business since 1995, closed in fall 2015. In addition, the Western Sugar Cooperative plans to close its Torrington facility within the next year or two (2017 at the latest); that facility has been a major employer and one of the County's larger water users. Other, smaller, manufacturing companies in the County include synthetic wood production and the manufacturing of specialty farm equipment. The economy is dominated by agriculture and associated businesses. Additionally, the State is currently building a correctional facility in Goshen County that will generate local employment.

Laramie County. Most industry in this Basin is located in and around Cheyenne. However, manufacturing accounts for only about 2.5% of employment in the area; the County's largest sources of employment are government services, including the military; health care; and education. Individual large employers include Sierra Trading Post (877 employees), Union Pacific Railroad (660), Echostar Communications (380), HollyFrontier Oil (301) and Dyno Nobel (221), an industrial fertilizer manufacturer. Additionally, both Walmart and Lowe's operate regional distribution centers in Cheyenne and the Cheyenne Prairie Generating Station is located in the area. In recent years, Microsoft has also expanded its data center operations in the Cheyenne area; the company is currently considering an additional expansion.

Natrona County. The health care, retail trade and mining industries employ the greatest number of people in Natrona County; only about 3.5% of the County's employment is included in the manufacturing sector. Other than school districts and local government, large employers include several health care facilities, a glass repair company (384 employees), several oil and gas service providers and Keyhole Technologies, a construction services company (270 employees). Oil and gas production drive the economy and create many jobs in the County.

Niobrara County. Almost no manufacturing at all occurs in Niobrara County. The County's economy is largely based on ranching and dry land agriculture, along with some oil production and retail trade activity. The school district and local governments are major employers. The Union Pacific Railroad and Wyoming Women's Center, a correctional facility, also employ larger numbers of people. Only a small portion of Niobrara County is included in the Basin.

Platte County. Manufacturing comprises less than 2% of total employment in Platte County. The largest employers in the County are the Basin Electric Power Cooperative that operates the Laramie River Station, the Platte County School Districts, Burlington Northern Railroad and Platte County Memorial Hospital. The Platte County Economic Development Corporation is optimistic about the potential for increased economic activity from tourism and the recent location of several oil service companies in the area. Amenities continue to be developed at Glendo State Park, which attracts an increasing number of recreational visitors each year. Agriculture is the most significant economic sector in the county, although it does not provide a great deal of direct employment.

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4.3 METHODOLOGY FOR UPDATING DEMAND PROJECTIONS

"The only way to predict the future is to have power to shape the future."
- Eric Hoffer

Section 4.2 describes the approach used to evaluate projected economic and demographic conditions in the Basin under three alternative scenarios: high, low and medium water use levels. These sections include the following:

- An evaluation of the forecasting approach used in the existing Basin Plan, including explanations of any suggested changes in approach or other revisions employed in this study;
- Alternative scenario projections for each of the key economic sectors within the Basin, including agriculture, mining and oil and gas development;
- Population and employment projections, by subbasin, under each scenario; and,
- Aggregate economic and demographic projections under each scenario incorporating the individual sector projections.

The data and information used to develop and define the alternative water use scenarios summarized in this section were largely gathered from publicly available secondary sources, along with specific interviews. Those sources are listed in the reference section at the end of this section.

4.3.1 Evaluation of Existing Approach and Methodology

The projections of economic and demographic conditions and the water demand projections presented in the 2006 Basin Plan were developed using an approach known as "economic base analysis". The economic base approach focuses directly on specific activities that are likely to drive economic and demographic changes in the future. HE's 2005 technical memo regarding projected economic and demographic conditions for the Basin at that time describes the application of economic base analysis as follows:

1) *Identify the existing and potential basic economic activities in the region through analysis of economic statistics and local interviews.* Basic activities are defined as businesses or governmental organizations that bring money into the region from sales of goods or services to outside areas or through transfers of public funds.

2) *Identify the current statistical relationships: a) between total employment in economic base activities and other employment in the economy (termed "local service employment"); and b) between total employment and population*. The latter relationship reflects the proportion of the population that is of working age, the labor force participation rate amongst the working age population and the unemployment rate plus in-commuting or out-commuting from the area.

3) *Conduct industry studies for each of the basic economic sectors to identify trends in employment and production and factors affecting potential future growth of those sectors.* These studies entail research and analysis of available industry data and local interviews.

4) *Develop specific projections of future basic economic activity levels*. These are based upon the results of Step 3 and clearly defined scenario assumptions.

5) *Develop overall employment and population projections built upon the basic activity projections developed in step 4 and the statistical relationships developed in Step 2.*

HE re-visited the economic base analysis approach to determine its appropriateness for use in the updated Basin Plan. HE determined that the use of an economic base analysis approach is relevant and applicable to the task of determining future Basin water demands for several reasons: (1) it can be applied to a geographic area that does not follow political or other legal boundaries, such as county lines; (2) it provides the ability to focus on specific industries or water users that are important to the Basin; and (3) it allows for the incorporation of Basin specific demographic characteristics, such as labor force participation rates and unemployment rates. Each of Wyoming's river basins comprises a unique and diverse set of economic and demographic characteristics; the characteristics of the Platte Basin are best reflected in the Basin's future water demand projections through the use of economic base analysis.

4.3.2 Overview of Alternative Planning Scenarios

The water demand projections included in the 2006 Basin Plan were based on HE's development of three alternative planning scenarios for growth and water use: high, low and mid scenarios. We believe that this multiple scenario approach continues to be a useful way to study, evaluate and plan for the Basin's future water needs. Therefore, the general definitions of the high, low and mid scenarios for the Basin remain unchanged:

High Scenario

In the simplest terms, the High Scenario incorporates HE's views of the most growth in each of the key sectors and in the region that could potentially occur over the forecast horizon. It is possible that one or more of the key sectors could grow even more than we have assumed under this case, or an unforeseen, new basic economic activity could establish itself and flourish in the region. However, it is also possible that other sectors will not develop to the maximum and so the growth in aggregate employment and population that drives future water demand will be somewhat moderated if one sector expands beyond the bounds we foresee. Therefore, the study team felt that the underlying aggressive assumption that each of the key sectors will achieve its highest reasonably likely growth at the same time makes this scenario a useful upper bound for subsequent water planning purposes.

Low Scenario

The Low Scenario embodies the study team's views of the lowest simultaneous growth (or largest contraction) reasonably likely to occur in each of the key sectors and in the region over the planning horizon. While even lower economic activity levels in one or more sectors are not impossible, again, the study team felt that the assumption of simultaneous low activity levels in each of the key sectors, though somewhat artificial, made this scenario a supportable lower bound for planning purposes. While the Low Scenario obviously will not impose pressure on regional water resources, this scenario is sometimes used for purposes of determining the financial risk involved with potential water resource enhancements.

Mid Scenario

The Mid Scenario represents the study team's views of the most realistic level of growth likely to occur in each of the key sectors and in the region over the planning horizon. As in the other two scenarios, the potential interaction between the economic sectors and the wider economy is acknowledged. Although the actual economic growth experienced in the Basin may vary somewhat from this projection, the assumed activity levels represent, in the

study team's best judgment, the rate of growth most likely to be experienced in the Basin. As such, this scenario is perhaps the most useful for water planning purposes.

4.3.3 Economic Base Scenario Assumptions for Key Sectors

The economic base scenario assumptions for the 1) agriculture, 2) tourism and recreation,3) electric power generation, 4) mining and mine reclamation, 5) oil and gas (refining, exploration, production and reclamation; 6) aggregates, cement and concrete; and, 7) miscellaneous industry, including road construction are presented in Sections 4.2.4 through 4.2.10.

Agriculture - Economic Base Scenario Assumptions

The general factors that have the potential to influence the future of agriculture in the Platte River Basin have not changed since the 2006 Basin Plan was prepared. Those include (1) the demand for and price of beef; (2) changes in public land grazing policies; (3) second home and subdivision development; (4) the aging of the ranching population; (5) management and application of livestock and irrigation techniques. Although agriculture's share of the Basin's economy continues to be small in terms of employment, sales and income, it remains an important industry in the Basin and supports the character and identity of the area. Agriculture is also, by far, the largest water using sector.

Historical Trends and Current Conditions. Between 2002 and 2012, the number of farms in the Platte River Basin increased by about a quarter, but the number of acres of farmland declined by around 10% (USDA Census of Agriculture 2012). From 2005 to 2015, the number of cattle in the basin remained relatively flat (a decrease of 0.4%), while the number of sheep decreased by 12%.

The number of irrigated acres in the Basin decreased by about 88,000, or about 14% between the 1995-2001 time period and 2012 (Agricultural Use, Volume 2, 2016). All but one of the subbasins (Upper Laramie) experienced a drop in the number of irrigated acres during that time. Losses ranged from about 2,200 irrigated acres in the South Platte subbasin (5% of total irrigated acres in that subbasin) to almost 26,600 irrigated acres in the Above Pathfinder Dam subbasin (18% of total irrigated acres in that subbasin). The largest percentage loss occurred in the Horse Creek subbasin, which lost about 19,000 acres, or about 32% of total irrigated acres. The Upper Laramie was the only subbasin to gain irrigated acreage, experiencing a 13% increase, or about 12,000 acres.

The slight drop in overall cattle numbers in the Basin masks several large changes in cattle inventory in the subbasins. Four of the seven subbasins enlarged their cattle inventory, with increases ranging from 1% to over 38%. The two subbasins that decreased their cattle inventory (Pathfinder to Guernsey and Lower Laramie) dropped by 10% and 24% respectively. And the Guernsey to State Line subbasin remained unchanged over the 2005-2015 period.

The overall decrease in the number of sheep in the basin is fairly widespread, with all but one subbasin experiencing a drop in inventory. The South Platte subbasin increased its sheep inventory by 0.5% from 2005 to 2015. The decreases in the remaining subbasins ranged from 8% to 43%.

Scenario Approach. Similar to the approach used in the 2006 Basin Plan, HE projected High, Low and Mid Scenarios for livestock, irrigated acreage and crop mix in the Basin based on historic trends and assumptions about public lands grazing policies, beef productivity and prices and demand, wool and lamb prices. To standardize the analysis in terms of livestock forage levels, county level livestock inventories were converted to "animal units" by dividing estimated cattle inventories by two and sheep inventories by five for water use purposes.

For all scenarios, HE assumed that the mix of crops would not change substantively over the projection period. In reality, the crop mix is determined by a multitude of factors including relative prices of the various crops, irrigation water forecasts and individual farm circumstances such as crop rotation and equipment availability. These factors are problematic to estimates of crop mix from year-to-year, let alone 30 years into the future. Alfalfa, other hay and irrigated pasture account for over 80% of total crop acreage and, given that hay and cattle have remained as Wyoming's top crop and livestock products for over a decade, it is reasonable to assume that this will continue.

HE also assumed that the consumptive use of water for each crop has remained the same as the last plan and will persist for the future. The consumptive use of a crop depends more on environmental factors, climate conditions, irrigation schedules and water availability than the particular crop cultivar.

High Scenario. The High Scenario for livestock production reflects what the study team believes are the most optimistic stocking assumptions given production of feed from irrigated lands and arid rangelands and strong demand and prices for beef, wool and lamb. Under the High Scenario, HE assumed that future cattle and sheep inventories would reach the historical maximum number over the previous 10 years. To attain those numbers under the High Scenario, HE assumed that the current strong beef, sheep and wool prices would be maintained, or increase and the herds would build up in response to a long-term price signal. HE also assumed that, because these numbers have been achieved in the last decade, the infrastructure necessary to maintain herds this size is available. By the end of the planning horizon in 2045, HE projects roughly 625,000 head of cattle and 166,000 head of sheep within the Basin, up from 539,000 and 117,000 head of cattle and sheep, respectively, in 2015. These assumptions represent increases of 16% and 42%, respectively, for cattle and sheep.

Under the High Scenario, irrigated acreage in the Basin will increase by 19%, as compared to current levels, from 524,000 acres to 624,000 acres. As with the livestock, this represents the maximum number of acres irrigated in the previous decade. In fact, the strong animal numbers will drive most of the increase in hay and irrigated pasture acres, which make up the largest share of irrigated acres in the Basin. HE also assumed that the cash crop prices would be strong, allowing some of the less productive acres to be brought back into production profitably. As described above, the crop mix is projected to remain similar to current conditions, with roughly 80% of irrigated acreage planted in alfalfa, other hays and pasture. Under this scenario, ranchers bring into irrigated production some marginal lands that under normal economic conditions may not be economically viable to cultivate, given low returns on investment. HE assumed that the investment in irrigation techniques already in place indicates that the use of flood versus pivot irrigation and surface versus groundwater will remain consistent under all scenarios.

Low Scenario. The Low Scenario for livestock production reflects what the study team thinks are the most pessimistic stocking assumptions for the Basin, given production of feed from irrigated lands and arid rangelands and weak demand and prices for beef, wool and lamb. HE generally assumed that the declining historic trend in both cattle and sheep inventories would continue to 2045. By the end of this planning horizon, HE projects roughly 483,000 head of cattle and 62,000 head of sheep within the Platte River Basin, down from 539,000 and 117,000 head of cattle and sheep, respectively, in 2015. Those assumptions represent decreases of about 10% and 47%, respectively, for cattle and sheep.

Under the Low Scenario, irrigated acreage will decrease by 18% from current levels, from 524,000 acres to 428,000 acres. HE assumed that the declining historical trend in irrigated acres would continue, but at a declining rate, e.g. the irrigated acres in Above Pathfinder

Dam subbasin would decrease at 2% per year (the recent 10-year average decline) from 2015 to 2025, then by 1% per year from 2025 to 2035 and, finally by 0.5% per year to 2045. The basis for this reduction in acres is twofold; fewer head of livestock will require fewer acres of irrigated pasture and less hay, and as irrigation efficiencies and crop production methods improve, farmers will be able to realize the same or greater yields from fewer acres. This will result in the less-productive acres being taken out of production, while the most productive acres will be maintained throughout the forecast period.

Mid Scenario. The Mid Scenario for livestock production reflects what the study team feels are the most realistic stocking assumptions for lands in the Basin, given production of feed from irrigated lands and arid rangelands and steady demand and prices for beef, wool and lamb. HE assumed that the current inventory of cattle and sheep will be maintained through 2045. This is roughly the recent historical average cattle and sheep inventory in each county. Over the last decade, there have been large (positive and negative) swings in both the number of cattle and sheep, from a 9% increase to a 9% decrease in cattle and from 24% to -10% in sheep. HE assumed that these swings would continue based on fluctuations in livestock prices, but the overall trend would be flat. By the end of the planning horizon, HE projects roughly 539,000 head of cattle and 117,000 head of sheep within the Platte River Basin.

Under the Mid Scenario, irrigated acreage will decrease by 9%. While the number of livestock will remain the same, maintaining the hay and pasture acres, the efficiency trend in cash crop production will continue, allowing farmers to produce more crops on fewer acres. The marginal acres will be taken out of production in favor of the most productive acres. Additionally, acreage may be lost to ranch sales to large corporations or to developers in the more urban areas around Cheyenne, Torrington, Laramie and Casper. **Table 4.9** presents HE's projections for cattle and sheep numbers and irrigated acreage by crop type in the Basin for 2045 under the High, Low and Mid Scenarios. These same data in a more summary form by subbasin are presented in **Tables 4.10 and 4.11**.

Table 4.9: Projected Cattle, Sheep and Irrigated Acres by Crop Type, Platte River Basin, by Scenario

	Current (2015)	Projected (2045)		
		Low	Mid	High
Crop - Acres				
Alfalfa	109,000	78,000	94,000	137,000
Other hay	179,000	156,000	167,000	209,000
Irrigate pasture	145,000	126,000	135,000	170,000
Corn	36,000	27,000	32,000	43,000
Sugar beets	17,000	13,000	15,000	21,000
Dry beans	16,000	12,000	14,000	19,000
Oats	6,000	4,000	5,000	7,000
Barley	8,000	6,000	7,000	10,000
Winter wheat	6,000	5,000	6,000	8,000
Spring wheat	1,000	1,000	1,000	1,000
Total Crops - Acres	**524,000**	**428,000**	**475,000**	**624,000**
Livestock - Head				
Cattle	539,000	483,000	539,000	625,000
Sheep	117,000	62,000	117,000	166,000
Total Livestock - Head	**656,000**	**545,000**	**656,000**	**791,000**

Note: Totals may not add due to rounding.
Source: Census of Agriculture for Wyoming (USDA, 2014).
Projections made by Harvey Economics 2015.

Table 4.10: Projected Irrigated Acres by Subbasin, by Scenario

	Current (2015)	Projected (2045)		
		Low	Mid	High
Subbasin				
Above Pathfinder Dam	124,000	88,011	106,960	150,238
Pathfinder to Guernsey	65,000	37,064	51,244	89,966
Guernsey to State Line	81,000	74,063	77,726	84,569
Upper Laramie	104,000	104,038	114,095	128,947
Lower Laramie	66,000	37,904	52,335	91,674
Horse Creek	41,000	22,031	31,312	57,652
South Platte	43,000	39,507	41,591	45,503
Total Basin Irrigated Acreage	**524,000**	**428,000**	**475,000**	**624,000**

Note: Totals may not add due to rounding.
Source: Census of Agriculture for Wyoming (USDA, 2014).
Projections made by Harvey Economics 2015.

Table 4.11: Projected Livestock by Subbasin, by Scenario

	Current (2015)	Projected (2045)		
		Low	Mid	High
Subbasin				
Above Pathfinder Dam	108,000	80,000	108,000	129,000
Pathfinder to Guernsey	199,000	135,000	199,000	247,000
Guernsey to State Line	68,000	66,000	68,000	81,000
Upper Laramie	60,000	55,000	60,000	61,000
Lower Laramie	85,000	74,000	85,000	121,000
Horse Creek	57,000	57,000	57,000	66,000
South Platte	77,000	78,000	77,000	84,000
Total Basin Head of Livestock	**656,000**	**545,000**	**656,000**	**791,000**

Note: Totals may not add due to rounding.
Source: Census of Agriculture for Wyoming (USDA, 2014).
Projections made by Harvey Economics 2015.

Tourism and Recreation - Economic Base Scenario Assumptions

The tourism and recreation sector does not play a large role within the economy of the Platte River Basin, but it is important to note the extent to which it contributes to sales, income and employment in several of the Basin's important economic sectors, including retail trade and accommodations and food services. As tourism and recreation contribute to providing jobs and income for the region, the effects on economic and population projections are captured in the municipal and rural domestic projections discussed later in this section. More importantly, tourism and recreation create notable consumptive and non-consumptive demands on water in the basin for golfing, alpine skiing, angling, boating, swimming, waterskiing and enjoyment of water amenities such as creeks, rivers, reservoirs and the scenery and habitats that accompany them.[4]

HE specifically examined two recreational sectors, alpine skiing and golfing. These two sectors consumptively use water across the subbasins, and growth assumptions are important for water demand projections.[5]

Golf. Three new golf courses have been developed in the Basin since the 2006 Basin Plan. These include a private course in the Saratoga area, a municipal course in Pine Bluffs and one additional private course in the Casper area; the Casper course is located on the site of

[4] Volume 2, Section 4 also provides a detailed discussion of water use in these sectors.
[5] In a change from the 2006 Basin Plan, the water demands associated with these two recreational activities are now included with the municipal and rural domestic projections and are not presented separately for individual analysis and evaluation in Section 4.3.

the former Amoco Refinery. The water demands associated with these new courses are included in the Basin's 2015 water demand calculations. Additional golf-related water demands under the High, Low and Mid Scenarios are described below.

The demand for golfing and additional golf courses will be largely driven by the employment and population growth projected for the Basin over the next 30 years. The High Scenario includes an increase of about 180,000 people and over 100,000 jobs in the Basin by 2045, while the Low and Mid Scenarios assume more modest growth rates.[6] The projected development of new golf courses and golf course expansions is partially based on estimates of the number of holes available in the Basin on a per capita basis, as well as the location of projected population growth.

Under the High Scenario, HE assumes that any planned or proposed courses or expansions in each subbasin will be built and irrigated at similar acreage and irrigation rates as other courses in that subbasin. In the Above Pathfinder Dam subbasin, a new 18-hole course will begin operation in Rawlins with 95 irrigated acres using surface water from a raw water pipeline (Florquist, 2005).[7] In the Pathfinder to Guernsey subbasin, where a large portion of the additional projected population will reside, HE projects the development of two new 18 hole golf courses (190 new irrigated acres) and the expansion of both the Trail Ruts golf course in Guernsey and the Glenrock Golf Course. Each of those courses will expand from 9 to 18 holes over the next 30 years, adding about 80 new irrigated acres on groundwater. No new courses or expansions are anticipated in the Guernsey to State Line subbasin. The Laramie County Club course in the Upper Laramie subbasin will expand from 9 to 18 holes, adding about 30 new irrigated acres. In the Lower Laramie subbasin, HE projects that the Wheatland Golf Club will expand from 9 to 18 holes, adding 95 irrigated acres on surface water. There are no courses in the Horse Creek subbasin. In the South Platte subbasin, HE projects that the Prairie View Golf Course will expand from 9 to 18 holes, adding 70 new irrigated acres on surface water. The Leaning Rock Golf Course in Pine Bluffs would also expand from 9 to 18 holes, adding an additional 30 irrigated acres. HE also projects that the Cheyenne area will add two new golf course communities with 18 holes each and a total of 300 new irrigated acres on surface water (Ashby, Matsen and Mason, 2005).[8] Altogether, the High Scenario includes five new courses and six expansions throughout the Basin. The demand for those facilities will be supported by population growth and strong economic activity in several sectors, including mining, oil and gas production and power generation. The jobs in those sectors are typically relatively high paying and will generate additional employment in services and other sectors, as well as provide employees with a certain amount of disposable income. Under this scenario, HE assumes that regional tourism activity is strong and that the demand for recreational amenities is high.

In the Low Scenario, HE assumed that no new courses or expansions would be built in any of the subbasins and that all current operations would continue as they do currently. Population and employment growth would be slower and additional Basin residents would use existing golf amenities to the extent desired. Under this scenario, demographic characteristics may result in less interest in golf, as compared to other leisure activities, and economic conditions may leave less money available for golfing activity. Under the Low Scenario, activity in the mining, oil and gas and power generation sectors is expected to remain relatively constant and employment in those sectors is assumed to remain relatively

[6] Population and employment projections for the Basin are presented in a subsequent section of this volume.
[7] This golf course has yet to be developed and was included in the future water demand projections at the time of the 2006 Basin Plan.
[8] At the time of the 2006 Basin Plan, interviews suggested that two new courses would be developed in the Cheyenne area in the future. Since then, one course was developed in Pine Bluffs, relieving some of the demand closer to Cheyenne.

steady. Overall, employment and population growth would be less than half of that projected for the High Scenario. That level of growth, in combination with relatively stagnant economic conditions would not generate the demand for new courses or expansions.

The Mid Scenario includes the development of three new golf courses and the expansion of four existing courses. One new 18 hole course would be built in Rawlins, adding about 95 irrigated acres in the Above Pathfinder Dam subbasin. In the Pathfinder to Guernsey subbasin, one new 18 hole course would be developed, adding about 95 irrigated acres, and the Trail Ruts golf course in Guernsey would expand from 9 to 18 holes, for an additional 30 irrigated acres. The Wheatland Golf Club in the Lower Laramie subbasin would undergo expansion from 9 to 18 holes, adding 95 new acres. In the South Platte subbasin, the Prairie View and Leaning Rock golf courses would each be expanded from 9 to 18 holes, for a total of about 100 new irrigated acres. Additionally, one new 18 hole course would be developed in the Cheyenne area, for an additional 150 irrigated acres. Both the Above Pathfinder Dam subbasin and the Pathfinder to Guernsey subbasin will experience growth in the mining and oil and gas sectors under the Mid Scenario, which will add employment, attract new people to the area and generate demands for additional recreational facilities. Considerable growth will also occur in the South Platte subbasin.

Skiing. There are two alpine ski areas that consumptively use water to make snow in the Platte River Basin. Both the Hogadon Basin near Casper (Pathfinder to Guernsey subbasin) and the Snowy Range ski area near Laramie (Upper Laramie subbasin) have surface water rights for snowmaking. Both of these ski areas cater to a local customer base and while the population of the Basin is expected to increase under all scenarios, there are no known plans or proposals for expansion of either facility. The Snowy Range ski area is located on U.S. Forest Service land and any expansion would likely require a lengthy environmental analysis. Therefore, HE assumes that these two ski areas will maintain their current demands for water under all future scenarios. Additionally, no new ski areas are expected to be developed in the Basin.

Non-consumptive Recreation and Environmental Demands. In large part, the Basin's environmental and recreational water demands are non-consumptive; the consumptive uses of golf courses and ski areas comprise a very small portion of total recreational use in the Basin. Non-consumptive environmental and recreational uses are detailed in Volume 2, Section 4 that was developed as part of this Basin Plan update. That section focuses specifically on the environmental and recreational needs within the Platte River Basin and each of the subbasins. A brief overview of the types of non-consumptive recreational and environmental water uses available in the Basin is provided below.

Key recreational water uses in the Basin include fishing, boating and whitewater rafting. Much of this activity takes place on or near the North Platte River, its tributaries and associated reservoirs. There are numerous blue, red and yellow ribbon trout streams in the Basin, which provide excellent opportunities for anglers. In addition, Forest Service lands and mountainous areas provide extensive recreational options for outdoor enthusiasts. Boating occurs primarily on reservoirs. Camping is also a popular activity in the Basin, and although it is not directly related to water use, many of the camping locations are located near streams and reservoirs and their use may be directly tied to water levels.

Many of the environmental water uses in the Basin are associated with maintaining or enhancing crucial stream corridors and other areas designated as aquatic enhancement areas. This designation is determined by Wyoming Game and Fish and for each area critical issues and potential remediation activities are established. Although these designations do not establish specific protection for these areas, they are recognized and efforts are made to

improve the health of these important habitats, as possible. There are 13 instream flow rights in the Basin. These critical stream segments are protected but are governed by their priority date, many of which are relatively recent. There are also two important wetlands areas in the Basin, Laramie Plains Wetlands Complex and the Goshen Hole Wetlands Complex. Waterfowl hunting and viewing also benefits from these important environmental areas.

Although there are no specific factors that drive future non-consumptive recreational or environmental demands, the overall economic conditions in the Basin under the High, Low and Mid Scenarios will affect those uses. An examination of the future trends for this sector of water use is included in Section 4.3 detailing future water demand projections for the Basin.

Power Generation - Economic Base Scenario Assumptions

Since the 2006 Basin Plan, groundwater use for power generation has increased in the Lower Laramie and South Platte subbasins. In the Lower Laramie subbasin, the Basin Electric Power Cooperative added one new well with a permitted water right of 950 gpm (~1,530 acre-feet) for use at the Laramie River Station, which is a steam power electric generation plant. The water is used for cooling water, process water and fire protection (Industrial Use, Volume 2, 2016). In the South Platte subbasin, the Generation Development Company, LLC was issued a permit for 400 gpm (~650 acre-feet) for use at the Cheyenne Prairie Generating Station, a natural gas fired plant completed in 2014. That water is used as an alternate supply for make-up water for the cooling tower (Industrial Use, Volume 2, 2016). The remaining subbasins either do not have power generation facilities (Above Pathfinder Dam, Guernsey to State Line, Upper Laramie and Horse Creek) or their water demands for power generation have remained constant (Pathfinder to Guernsey).

The Platte Basin is also home to a number of existing or proposed wind energy projects. Wind projects require little to no water; therefore, no water use associated with those projects is included in the Basin's water demand projections.

The High, Low and Mid Scenarios each assume that water use at the Cheyenne Prairie Generating Station will increase by about 50% by 2045, based on estimates provided by Generating Station staff to the City of Cheyenne Board of Public Utilities (Cheyenne BOPU, 2013).

HE's High Scenario also assumes the construction of one new natural gas plant which was in the planning stages at the time of the 2006 Basin Plan, but which is not yet in operation. That natural gas fired plant will be located between Glenrock and Douglas in the Pathfinder to Guernsey subbasin and will be sized for a capacity of 1,000 MW of power (Schroeder, 2005). That plant will use about 10,000 acre-feet of water consumptively each year. The Basin's projected population increases, along with potential regional population growth given the assumed strong economic conditions under the High Scenario, will support the development of a new power plant. Additionally, activity in the industrial sector, the largest consumer of electricity in Wyoming (EIA, 2016), is expected to increase under the High Scenario, further generating demand for power. Expansion of various industrial sector activities, including uranium mining, oil and gas exploration and production and road construction and maintenance, will require additional source of power.

The Low and Mid Scenarios assume that the plant described above is not built and that power demands are met with existing facilities. Population and employment growth under these scenarios is more modest and industrial activity in the Basin either remains relatively steady (Low Scenario) or increases moderately (Mid Scenario). Slower economic growth will

also slow the demand for additional power or power generation sources, as evidenced by the combination of slower economic growth and reduced electric demands at the national level in recent years (Godby 2015).

All three scenarios assume that water use at the Dave Johnston power plant in the Pathfinder to Guernsey subbasin and at the Laramie River Station remains constant in the future. Across the U.S. and in Wyoming, many coal fired plants are being converted to natural gas or are being decommissioned (Dixon, 2014). As an example, one of the purposes of the construction of the Cheyenne Prairie Generating Station was to replace the power generated by four coal fired units, which have since been decommissioned (Black Hills, 2016). The use of coal to generate power is facing increasing challenges, including EPA regulations for air quality, the low price of natural gas and rising costs for coal production (Godby, 2015; Wyoming Mining Association, 2016). Therefore, future expansion of the Basin's existing coal fired plants, or the development of new coal fired plants within the Basin, seems unlikely.

Mining and Mine Reclamation - Economic Base Scenario Assumptions

Water use for mining and mine reclamation occurs only in the Above Pathfinder Dam subbasin and the Pathfinder to Guernsey subbasin; none of the other subbasins include water use for mining purposes. Since the development of the 2006 Basin Plan, water use for uranium recovery and processing operations has greatly increased in the Pathfinder to Guernsey subbasin. The largest uranium mining company in that area (Cameco Resources) has four operating plants and mines uranium via the in-situ recovery process. Each of those plants can use up to 4,200 gpm (~6,800 acre-feet) of water, or a total of as much as 16,800 gpm (~27,100 acre-feet per year), although the company has recently acquired rights to more than double that amount (34,900 gpm or about 56,300 acre-feet). Four other, smaller companies have obtained permits for a combined 670 gpm (~1,100 acre-feet) related to uranium operations in that subbasin. In the Above Pathfinder Dam subbasin, the Kennecott Uranium Company has new rights to 150 gpm (~240 acre-feet) for uranium operations. There are currently no coal mines in the Basin and all other mining activity is related to reclamation.

Four additional uranium projects are in the permitting, proposed or exploratory phase in the Basin (Wyoming State Geological Survey, 2015). Three are located in the Above Pathfinder Dam subbasin (Sheep Mountain, Shirley Basin and Bootheel/Buck Point projects) and one is located in the Pathfinder to Guernsey subbasin (Ludeman project). Energy Fuels Wyoming, Inc. is the owner of the Sheep Mountain project. That project has been in the permitting phase since 2010 and the company anticipates that the project will start up in late 2016/ early 2017 (Industrial Use, Volume 2, 2016). Energy Fuels has permits totaling 2,000 gpm (~3,300 acre-feet) for that project.

In terms of future coal production, Arch of Wyoming (Arch Coal) has acquired water rights for 2,300 gpm (~3,700 acre-feet) for mine dewatering and dust suppression for coal mining at the Saddleback Hills Mine near Elk Mountain in the Above Pathfinder Dam subbasin (Industrial Use, Volume 2, 2016). That mine has yet to be developed due to lack of market demand. The future demand for coal from this mine may be more or less dependent on the development of the coal conversion facility described for the oil and gas sector later in this section. The future of coal is unclear due, in part, to proposed environmental regulations, future natural gas prices, national demand for coal and electricity and other factors. Several sources indicate zero to negative growth in the coal industry in the future (Godby, 2015).

High Scenario. According to the Wyoming State Geological Survey, "U.S. uranium reserves are strongly dependent on price" and their reports state that "many experts agree that a gap between worldwide demand and supply of yellowcake may apply upward pressure to

prices in the future". Based on recent uranium activity in the Basin, along with the positive outlook for uranium from the Geological Survey, under the High Scenario, HE assumes high uranium prices and projects that all four proposed uranium projects will be permitted and will begin operations within the 30 year time frame of these projections. Each of those projects is assumed to require the same amount of water as the Sheep Mountain project (2,000 gpm). Additionally, we assume that Cameco Resources will expand their operations and perhaps build an additional plant in the Pathfinder to Guernsey subbasin, requiring an additional 4,200 gpm. Under this scenario, HE also assumes that the Saddleback Hills Mine will begin coal mining operations; those operations would mainly serve the production needs of the new coal gasification plant, which is projected to be developed under the High Scenario.

Low Scenario. Existing uranium operations would continue to operate with no additional activity in the Basin. The Saddleback Hills Mine would not be developed and no new coal production would take place in the Basin. Reclamation water use would be minimal.

Mid Scenario. The Sheep Mountain uranium project would be developed in the Above Pathfinder Dam subbasin and an expansion of activities at the Cameco Resources facilities would occur in the Pathfinder to Guernsey subbasin in response to small to moderate increases in uranium prices. Similar to the Low Scenario, the Saddleback Hills Mine would not be developed and no new coal production would take place in the Basin in the Mid Scenario.

Oil Refining, Oil and Gas Exploration and Production, Reclamation - Economic Base Scenario Assumptions

Since 2005, oil and gas prices have experienced highs and lows, affecting annual production levels for those resources, as well as associated water demands. Since the previous Basin Plan, water demands related to oil refining; oil and gas exploration and production; and reclamation have increased in all subbasins, with the exception of the Upper Laramie, in which this type of water use has remained constant at less than 100 acre-feet. Basin wide, water use in this industrial sector increased by almost 18,000 acre-feet, or over 50%, in the last 10 years.[9]

The Pathfinder to Guernsey subbasin remains the largest consumer of this type of water at about 25,000 acre-feet per year, an increase of about 39% since 2005. New water use in this subbasin is related to oil and gas exploration and reclamation. The South Platte subbasin experienced the largest increase in oil and gas related water demands, with over 8,400 acre-feet of additional water permits. In 2005, the Guernsey to State Line and Lower Laramie subbasins had no permits related to oil and gas activities; each of these subbasins now includes about 800 acre-feet of permitted water use in this sector. Other subbasins experienced small increases in permitted water demands, with the exception of Upper Laramie, as noted above.

Individual Basin counties have experienced unique trends in oil and gas production, but for all Basin counties combined, 2015 saw record high oil production as well as an up-tick in gas production (WOGCC, 2016). Oil production in the Basin increased by an average of about 20% per year over the last four years, reaching over 34.5 million barrels in 2015, about 40% of total statewide oil production. Although 2015 gas production was about 15%

[9] This increase accounts for all new permitted water use and may not reflect actual water use by individual users. Within Laramie County individual water users reports of water used for oil and gas fracing is significantly less than permitted quantities.

lower than in 2005, both 2014 and 2015 saw small increases in overall gas production in the Basin.

The oil and gas industry experiences cyclical boom and bust periods, which are determined by a myriad of factors, including weather patterns, national and international demands, governmental regulations and other types of energy production. The High, Low and Mid Scenarios account for differences in each of these factors. Crude oil prices and natural gas prices have varied over time, but have seen dramatic declines since 2014. Current low prices for those commodities have put pressure on oil and gas production across Wyoming.

Under the High Scenario, HE projects that oil and gas prices will increase, encouraging additional production and exploration. Under that scenario, HE projects that oil and gas prices will increase at a slightly faster rate than the modest amounts currently projected by the EIA (EIA, 2015). Several potential large oil or oil and gas projects or other developments proposed on BLM and other properties are currently in the midst of various NEPA analyses (BLM, 2016). Portions of some of those projects may be located within the Basin (Converse County Oil and Gas Project), but even projects in close proximity to Basin boundaries (i.e. Moneta Divide Natural Gas and Oil Development Project in Natrona and Fremont Counties; Continental Divide-Creston Natural Gas Project in Carbon and Sweetwater Counties; Greater Crossbow Oil and Gas Exploration and Development Project in Campbell and Converse Counties) have the potential to drive industry activity and support businesses within the Basin. In fact, the scale of many of those proposed projects is quite large, including the development of several thousand wells. Under the High Scenario, HE projects that these projects will be approved and will come online within the next 10 to 20 years, given steadily increasing oil and gas prices and increasing demands.

In addition to the oil and gas projects discussed above, a new coal conversion facility would be constructed in the Above Pathfinder Dam subbasin under the High Scenario.[10] This plant will produce about 100 MW of electricity for internal use and about 9,000 barrels of gasoline per day. The plant will consumptively use roughly 500 acre-feet of water each year (Industrial Use, Volume 2, 2016 and Gathmann, 2016). **Given the recent trends in oil and gas production in the Basin, the potential for increased commodity prices and the potential for the approval and development of many additional oil and gas projects in the region, HE projects that water demands for this sector will increase by 20% by 2045.**

The Low Scenario reflects continued low commodity prices and continued pressure on profit margins for companies and production in the Basin. This scenario assumes that even if proposed oil and gas projects are approved by the BLM, prices will remain low enough that development and production activities are postponed by the proponent companies indefinitely. The oversupply of oil and natural gas, as compared to demand will continue nationally and internationally under the Low Scenario. This will discourage additional exploration activity. However, HE also assumes that prices under the Low Scenario are near current lows and that they will not continue to decline in such a way as to significantly reduce current production levels in the Basin. **Therefore, under the Low Scenario, water demands for this sector will remain stable over the projection**

[10] In the 2006 Basin Plan, this proposed facility was described as producing 300 to 500 MW of electricity and more than 9 million barrels of diesel fuel per day; water use estimates at that time were on the range of 15,000 to 20,000 acre-feet per year. Since then, DKRW Energy has greatly scaled back the size of the facility and decided to use a different process for converting methane to gasoline. This new process uses much less water than the original proposed process; in fact, the new process actually creates water, which is then recirculated and used within the facility.

period, at current levels. In essence, new wells will replace existing wells as those play out.

The Mid Scenario assumes that gas prices rise modestly over time, as projected by the EIA at the national level, and that national and global demand for oil and gas also increases steadily over time (EIA, 2015). Additional oil and gas exploration and production will occur within and outside the Basin, encouraging the development of additional oil and gas support services as well. Some of the oil and gas projects under review by the BLM will become profitable due to the increasing prices, but others will be put on hold throughout the 30-year projection period. **Under the Mid Scenario, water demands for this sector will increase by 10%.**

Aggregates, Cement and Concrete - Economic Base Scenario Assumptions

Water use aggregate, cement and concrete production increased by about 23% between 2005 and 2015. Water use for those purposes increased by varying amounts in all subbasins, with the exception of the Guernsey to State Line subbasin, in which no water is used for this sector, and the Horse Creek subbasin, in which this type of water use remained constant. The Pathfinder to Guernsey subbasin experienced the largest increase in water use for aggregate, cement and gravel production, with an additional 1,500 gpm (~2,400 acre-feet) of water use permitted to two separate companies.

According to the USGS, "natural aggregates are a major basic raw material used by construction, agriculture and industries employing complex chemical and metallurgical processes" (USGS, 1999). Products made with aggregates include asphalt, concrete, bricks, plastics, glass, paint, fertilizers and other items. Historically, national production of these materials has increased at a relatively slow, but steady annual rate. However, more recently, production has grown at slightly higher rates for all aggregate products. In 2015, sand and gravel production increased by 2%, cement production by 3.2% and crushed stone by 7% (Krehbiel, 2015). According to aggregate industry reports, "pricing data shows cement, ready-mix concrete, sand and gravel and crushed stone prices increasing, while asphalt prices plateaued and have begun to decline as a result of lower oil prices" (Krehbiel, 2015). However, national demand for asphalt is expected to increase as a result of a recently approved $305 billion highway and transit bill (Fixing America's Surface Transportation (FAST) act). The near-term outlook for aggregates and cement is for continued increases in annual growth (Kuhar and Smith, 2016).

Future demands for these products will be driven by activity in the transportation, infrastructure and construction (residential and non-residential) sectors (Kuhar, 2014; Kuhar and Smith, 2015). The demand for materials and supplies to develop those facilities will ultimately drive the demand for aggregates and other materials and therefore, the demand for related water supplies. The demand for aggregates, cement and gravel produced within the Basin is likely to come from both within and outside the Basin.

As described previously for other industrial sectors, the **High Scenario includes the expansion of the agricultural sector, development of new uranium projects, a large power plant, a coal conversion facility, and oil and gas development.** Additionally, as described later in this section, the High Scenario projects strong population growth within the Basin. Overall, under the High Scenario, there is a great amount of activity that will occur in the Basin, all of which supports increased demand for aggregates and aggregate products. The amount of industrial and residential construction that would occur under the High Scenario will drive up the demand in this sector. **HE forecasts a 20% increase in aggregate production related water demands over the 30 year projection period under the High Scenario.**

The Low Scenario assumes no changes in current water demands for the aggregate sector. Under this scenario, economic activity within the Basin remains relatively unchanged from current conditions. None of the agricultural activity, uranium projects or other facility developments would occur and the oil and gas industry would remain relatively stable. **Basin population is expected to grow relatively slowly under the Low Scenario and construction demands related to that growth is anticipated to be met at current production levels.**

Under the Mid Scenario, the demand for aggregates is also driven by increased agricultural and industrial activity, as well as by Basin wide population growth; however, growth in those sectors is somewhat tempered, as compared to the High Scenario. The Mid Scenario includes modest population growth and increased demand for residential construction, as well as some new uranium and oil and gas development, which will fuel industrial sector demands for aggregates. Activity under the Mid Scenario will not reach the levels anticipated for the High Scenario. **HE projects a 10% increase in aggregate production related water demands for this Scenario.**

Miscellaneous Industry, including Road Construction - Economic Base Scenario Assumptions

New miscellaneous water use in the Basin since the preparation of the 2006 Basin Plan generally includes water for certain agricultural purposes, such as mixing of liquid fertilizers and pesticides; some irrigation; dust suppression; equipment washing; stock watering and other, unique uses. The largest use of new miscellaneous water in the Basin is for stock watering. Basin wide, water use for miscellaneous purposes, other than for road construction, increased by about 13% between 2005 and 2015, based on the additional permits issued within that time frame.

Road construction is also included in the miscellaneous category. Water use for road and bridge construction and maintenance only occurs when those activities are in progress. These types of construction projects are generally short-term and local in nature, lasting only several years or less over a small area. Therefore, water use in this sector may vary widely from year to year and from subbasin to subbasin. Between 2013 and 2014, WYDOT was issued three permits totaling 350 gpm (~600 acre-feet) related to the reconstruction of several miles of I-25 and Wyoming 319 in the Pathfinder to Guernsey subbasin. Only two other permits were issued for road construction projects between 2005 and 2015, each for 100 gpm (less than 200 acre-feet) and each in different subbasins.

Major changes in miscellaneous industrial water use occurred, or will occur, in the Guernsey to State Line subbasin. The Wyoming Ethanol facility in Torrington, which had been in operation since 1995, closed in the fall of 2015. That facility's water use is included in the 2015 water use data for the subbasin, but does not play a part in any future projections. In addition, the Western Sugar Cooperative plans to close its Torrington facility within the next year or two (by 2017 at the latest), eliminating their water use from future projections as well. HE assumes that the Wyoming Ethanol facility and the Western Sugar facility in Torrington will re-open at present capacities under the High Scenario but will remain closed under the Mid and Low scenarios.

The High Scenario includes the development of additional uranium projects, a new power plant, one coal mine and oil and gas development. Together, these activities will stimulate the economy, resulting in healthy growth of all industries. That growth is likely to create additional, miscellaneous water demands from various sources. For example, HE projects that the Dyno Nobel ammonium nitrate plant in the South Platte subbasin will add a new production unit and increase water use by 10%, as compared to current levels, under

the High Scenario. Other miscellaneous water use by individuals or smaller entities (non-road construction use) will also increase by a total of 10% overall for the Basin. The development activity and population growth expected to occur under the High Scenario is more than likely to result in the need for road construction and maintenance, as traffic volumes would likely increase as well. Additionally, the strong economy will allow the Wyoming Department of Transportation (WYDOT) to move forward with a number of projects that may have been delayed due to lack of funding (WYDOT 2013 and 2015); the same situation may be true at the county or municipal levels. Therefore, HE projected use of 2,000 acre-feet of water per year for road construction and maintenance activities under the High Scenario.

Under the Low and Mid Scenarios, miscellaneous water use (non-road construction) is expected to hold steady at current levels, other than the loss of Wyoming Ethanol and Western Sugar. The Low Scenario includes water use of 500 acre-feet per year for road and bridge construction maintenance, essentially holding that type of use constant, as compared to 2015. That level of use reflects the relatively slow economic conditions and growth expected under the Low Scenario.

The Mid Scenario assumes 1,000 acre-feet of water per year will be required for road and bridge construction and maintenance activities. That level of use reflects the more moderate economic conditions and growth expected under the Mid Scenario, including some new uranium and oil and gas projects.

4.3.4 Summary of Economic and Demographic Projections

The preceding evaluations and assumptions were incorporated into a model of Platte River Basin employment and population to develop aggregate estimates of total residents and total jobs in 2045 under each of the three planning scenarios. The estimates of future population drive the projections of future water demands for the municipal and rural domestic sector.

Overview of Projection Technique

The approach used to project future employment and population as part of the Basin Plan update remains generally the same as for the 2006 Basin Plan. HE estimated current jobs and population in the Basin (2015) using data from the State of Wyoming's Economic Analysis Division, the Bureau of Labor Statistics and the Bureau of Economic Analysis and then made projections for a period of 30 years, through the year 2045. Employment projections begin with forecasts of the Basin's basic economic sectors, which are those sectors that drive the economy, including:

- Natural resources and mining;
- Manufacturing;
- Tourism portion of retail trade;
- Agriculture; and
- Portions of other sectors that generate economic resources from outside the Basin.

HE applied an employment multiplier of 1.4 to the forecasts of basic jobs to obtain the total number of jobs available to people working in the region (Minnesota IMPLAN Group, Inc., 2004).[11] HE then proceeded to apply the following Basin specific factors to the projections of total jobs to develop estimates of Basin population under each scenario.

- Net in-commuters: This step is necessary because, on net, a sizable number of workers commute into the Basin from other locations. These in-commuters' jobs do not actually contribute to population levels inside the Basin itself and must be removed from the total to forecast population. HE assumed that the number of net in-commuters would remain constant over the projection period.
- Multiple job holding rate: This factor accounts for the fact that the total number of jobs is greater than the number of employed persons.
- Unemployment rate: The unemployment rate incorporates the idea that there are more people included in the Basin's labor force than is reflected in the employment data. There is an additional group of people looking for work that is not included in the jobs data.
- Labor force participation rate: This factor accounts for the portion of the population over the age of 16 that is not included in the labor force, i.e. stay at home parents, retirees. HE assumed average participation rates would decrease by about 5% over the projection period, reflecting the aging of basin population.
- Percentage of the population aged 16 and older: This final factor was utilized to project the total future population in the Basin.

Economic and Demographic Projections

The final product of this analysis is projection of population in the Basin in 2045 under the High, Low and Mid Scenarios.

High Scenario. HE projected High Scenario employment in the Basin through 2045 based on the information described for each sector as summarized in **Table 4.12**.

Table 4.12: Projected Economic Sector Changes, Platte River Basin, High Scenario

Economic Sector	Sector Prospects	Quantitative Changes
Agriculture	Growth in irrigated acres, livestock with high demand	Irrigated acres up 100,000 Livestock up 135,000
Recreation	Five new golf courses and six expansions	890 new irrigated acres
Power generation	One new natural gas plant; increased water demands at the Cheyenne Prairie Generating Station	1,000 MW, 300 jobs
Mining	Five new uranium projects, one new coal conversion facility, one new coal mine	Additional employment and production
Oil and gas production and exploration	Commodity prices recover, production and exploration increases	Employment increasing
Other industries	Production generally increasing	Employment increasing
Source: Harvey Economics, 2016.		

[11] The employment multiplier indicates the total number of jobs created by one job in a basic sector. For example, an employment multiplier of 1.4 means that each basic job creates roughly an additional 0.4 local service jobs, such as additional retail and other services, for a total of 1.4 jobs.

With these inputs and assumptions, HE began with 2015 employment numbers and projected basic employment and population through 2045 according to the steps outlined above. The results of this analysis for the High Scenario are presented in **Table 4.13**.

Table 4.13: Projected Basic Employment, Total Employment and Population by Subbasin, 2015 and 2045, High Scenario

	Basic Employment		Total Employment		Population	
	2015	2045	2015	2045	2015	2045
Subbasin						
Above Pathfinder Dam	7,800	9,700	10,900	13,600	17,000	22,000
Pathfinder to Guernsey	44,800	82,100	62,700	115,000	88,000	171,000
Guernsey to State Line	4,200	5,100	5,900	7,100	11,000	14,000
Upper Laramie	14,700	17,500	20,600	24,500	36,000	45,000
Lower Laramie	3,800	4,700	5,300	6,600	8,000	11,000
Horse Creek	1,200	1,700	1,600	2,300	3,000	5,000
South Platte	46,900	79,900	65,600	111,900	95,000	172,000
Total Basin	**123,400**	**200,700**	**172,600**	**281,000**	**258,000**	**440,000**

Source: Harvey Economics, 2016.

HE projects that Basin employment under the High Scenario will increase by roughly 63%, from 172,600 jobs at present to about 281,000 by 2045. This increase would be primarily driven by growth in the minerals and energy sector, which would create support service and related employment, and by growth in services to accommodate an aging population, including healthcare and social services. Under the High Scenario, the Basin's population is projected to increase by over 70%, to about 440,000 residents by 2045.

Low Scenario. The slower employment growth projected for the Low Scenario is supported by the Low Scenario assumptions outlined in the earlier discussions of this volume for each economic sector, as summarized in **Table 4.14**. Thus, these projections represent a reliable lower bound for planning purposes in this study.

Table 4.14: Projected Economic Sector Changes, Platte River Basin, Low Scenario

Economic Sector	Sector Prospects	Quantitative Changes
Agriculture	Decline in irrigated acres and livestock with weak demand, urban development, aging ranchers	Irrigated acres down 96,000, livestock down 111,000
Recreation	No new golf courses or expansions	Steady irrigated acres
Power generation	No new plants or expansions; increased water demands at the existing Cheyenne Prairie Generating Station	Steady employment
Mining	Current uranium mining operations continue	Steady water demands and employment
Oil and gas production and exploration	Oil and gas prices remain at low levels; production levels relatively steady	Water demands and employment relatively steady
Other industries	Production generally steady to decreasing	Employment flat to decreasing

Source: Harvey Economics, 2016.

HE proceeded through the same forecasting approach, using the assumptions outlined in 4.12. The results of this analysis are presented in **Table 4.15**.

Table 4.15: Projected Basic Employment, Total Employment and Population by Subbasin, 2015 and 2045, Low Scenario

	Basic Employment		Total Employment		Population	
	2015	2045	2015	2045	2015	2045
Subbasin						
Above Pathfinder Dam	7,800	8,200	10,900	11,500	17,000	19,00
Pathfinder to Guernsey	44,800	52,200	62,700	73,100	88,000	109,000
Guernsey to State Line	4,200	4,400	5,900	6,200	11,000	12,000
Upper Laramie	14,700	15,400	20,600	21,500	36,000	40,000
Lower Laramie	3,800	4,000	5,300	5,600	8,000	9,000
Horse Creek	1,200	1,300	1,600	1,800	3,000	3,000
South Platte	46,900	53,600	65,600	75,100	95,000	115,000
Total Basin	**123,400**	**139,100**	**172,600**	**194,800**	**258,000**	**307,000**

Source: Harvey Economics, 2016.

Under the **Low Scenario**, Basin wide jobs are projected to increase by less than a half of one percent per year, rising by about 22,200 jobs over the 30-year projection period. Under the Low Scenario, population within the Basin is projected to experience growth of about 0.6% annually and total growth of about 19% over the next 30 years; the Basin's population is projected to reach about 307,000 residents by 2045 under the Low Scenario. Both employment and population under the Low Scenario would be a fraction of that experienced under the High Scenario.

Mid Scenario. Under the Mid Scenario, employment and population projections are based on the Mid Scenario assumptions discussed previously in this section for each economic sector, summarized in **Table 4.16**.

Table 4.16: Projected Economic Sector Changes, Platte River Basin, Mid Scenario

Economic Sector	Sector Prospects	Quantitative Changes
Agriculture	No change in irrigated acreage, stable livestock inventory and demand	Irrigated acres down by 49,000, livestock remains at current levels
Recreation	Three new golf courses, four expansions	565 new irrigated acres
Power generation	One new natural gas plant	1,000 new MW, 300 jobs
Mining	Two new uranium projects	Employment increases slightly
Oil and gas production and exploration	Oil and gas prices rise modestly over time, strong global demand	Employment relatively steady, small increases
Other industries	Production generally steady, small expansions	Employment flat to increasing

Source: Harvey Economics, 2016.

HE proceeded through the same steps of forecasting from basic employment through total employment to population for the Basin under the Mid Scenario. The results of this analysis are presented in **Table 4.17**.

Table 4.17: Projected Basic Employment, Total Employment and Population by Subbasin, 2015 and 2045, Mid Scenario

	Basic Employment		Total Employment		Population	
	2015	2045	2015	2045	2015	2045
Subbasin						
Above Pathfinder Dam	7,800	8,700	10,900	12,200	17,000	20,000
Pathfinder to Guernsey	44,800	60,700	62,700	85,000	88,000	126,000
Guernsey to State Line	4,200	4,600	5,900	6,500	11,000	13,000
Upper Laramie	14,700	16,100	20,600	22,500	36,000	42,000
Lower Laramie	3,800	4,200	5,300	5,900	8,000	10,000
Horse Creek	1,200	1,400	1,600	2,000	3,000	4,000
South Platte	46,900	61,300	65,600	85,800	95,000	132,000
Total Basin	**123,400**	**157,000**	**172,600**	**219,900**	**258,000**	**347,000**
Source: Harvey Economics, 2016.						

Under the Mid Scenario, aggregate jobs are projected to increase by roughly 47,300 over the course of the projection period. Population within the Basin would experience steady growth of about 1% per year over the next 30 years, gaining about 89,000 additional people to reach a total of about 347,000 residents.

4.3.5 References

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4.4 UPDATED DEMAND PROJECTIONS

"No one can forecast the economy with certainty."
- Jamie Dimon

4.4.1 Introduction

The information presented in Section 4.4 is the third in a series related to water demands authored by HE for the purpose of updating the 2006 Platte Basin Plan. An overview of the current conditions in key economic and water use sectors was provided in the previous sections (Section 4.1 through Section 4.13) of Volume 4 that present economic and demographic projections upon which the updated Basin water demand projections are based. The water demand projections included here are largely based on HE's estimates and projections, which also incorporate information gathered from publicly available secondary sources.

Section 4.4 provides future water demand projections for the Platte River Basin under three alternative scenarios. Water use factors for four key water use sectors (agriculture, municipal/domestic, industrial and recreation) are addressed and water use projections for those sectors are described. This section includes the following:

- Estimation of existing water use relationships (or water use factors) for each of the major economic and demographic water consuming sectors provided in the second section;
- A discussion of changes in baseline, or current, water demands as compared to the year 2005 water demands included in the 2006 Platte River Basin Water Plan (Basin Plan);
- Basin wide water use projections (both future diversions and consumptive use) for each of the key water using economic sectors — agricultural, municipal and rural domestic, industrial and recreational[12] — under three scenarios;
- Water use projections for the Basin presented on a monthly basis; and
- Water use projections (diversions and consumptive use) for each of the seven subbasins of the Platte River Basin, by sector, under each of the three scenarios (**Appendix 4-A**).

4.4.2 Projected Water Use Factors for Economic Sectors

This section of the Platte Basin Plan Update describes the development of the estimated water use relationships for each of the key water using sectors — agricultural, municipal and rural domestic, industrial and recreational — within the Basin. Separate estimates of total diversions and consumptive use were calculated for each sector. A summary of all water use factors for all sectors is presented in **Table 4.18**.

[12] Although current and future ski area and golf course demands are estimated and projected independently from municipal/rural domestic demands, they are grouped together for purposes of presentation in this Platte Basin Plan Update.

Table 4.18: Water Demand Factors by Economic Sector, Annual Consumptive Use and Annual Diversions

Average Demand by Economic Sector	Units	Diversions		Consumptive Use	
		Normal	Max	Normal	Max
Agriculture					
Irrigation					
Alfalfa	AF/acre	2.6	3.8	1.1	1.6
Other hay	AF/acre	2.5	3.9	1.1	1.6
Irrigated pasture	AF/acre	1.7	3.0	0.7	1.3
Corn	AF/acre	3.3	4.2	1.4	1.8
Sugar beets	AF/acre	3.6	4.6	1.6	1.9
Dry beans	AF/acre	2.4	3.3	1.1	1.4
Oats	AF/acre	2.6	3.3	1.1	1.4
Barley	AF/acre	2.8	3.6	1.2	1.5
Winter wheat	AF/acre	2.2	3.1	0.9	1.3
Spring wheat	AF/acre	2.0	2.8	0.9	1.2
Livestock					
Cattle	AF/head	0.010	0.010	0.010	0.010
Sheep	AF/head	0.004	0.004	0.004	0.004
Municipal/Rural Domestic					
Basin average	Gal/cap/day	202	303	101	152
Industrial					
Individual to sectors and entities					
Recreational Facilities					
Alpine skiing (snowmaking)	AF/facility	22	37	5	9
Golf courses (irrigation)	AF/AC	4.7	5.2	2.4	2.7

Source: Harvey Economics, 2016.

Agricultural Sector

The agricultural sector consists of two primary areas of water use: irrigated crop production and livestock sustenance. As discussed earlier, the majority of the irrigated acreage within the Basin is alfalfa, other hay, and irrigated pasture, although producers grow a variety of other crops in the Basin, including corn, wheat, barley, sugar beets and dry beans.

For the 2006 Basin Plan, the study team developed crop-specific information on annual consumptive irrigation requirements (CIR) for each subbasin for the period 1972 through 2001 (TriHydro Corporation, 2005). HE determined that these CIRs are still applicable in 2015 and applied the CIR data from the years of maximum and average consumptive use to represent the maximum and normal consumptive use demands that irrigated agricultural acreage would place on the Platte River Basin under the High, Low and Mid Scenarios of economic development. CIR data for different crops in different subbasins ranged from 10 to 25 acre-inches per acre in the maximum water use year and from 6 to 21 acre-inches per acre in a normal water use year.[13] These ranges are comparable to those found in other Wyoming Basin planning studies. Estimated application efficiency depends on the relative proportion of acreage using gravity or sprinkler irrigation systems and using groundwater versus surface water. The study team assumed on farm application efficiencies of 50% for flooded acreage and 70% for sprinkler-irrigated acreage (Venn, 2005), and proportions of usage of each system were based on an assumption of flood irrigation used for alfalfa, hay

[13] Because "wet," "dry," and "normal" years were defined using annual stream flows while calculated consumptive irrigation requirements are a function of precipitation and temperature, some data anomalies occurred within the consumptive irrigation requirement averages. The study team felt that this was the best approach to establish a representative range of consumptive irrigation requirement estimates for each county within the Basin.

and pasture and pivots used for all other crops. Proportions of groundwater versus surface water were based upon the study team's records of water rights and irrigation mapping (Trihydro, 2005). The study team assumed that groundwater incurs no conveyance losses, while conveyance losses for surface water supplies varied by subbasin and the irrigation districts involved (WWDC 2015).

Combining on-farm irrigation efficiencies with conveyance losses, the net weighted average irrigation efficiency estimates ranged from roughly 25% for acreage in the Horse Creek subbasin to 55% in the South Platte subbasin. Diversions in a normal demand year average about 3.9 acre-feet per acre of hay and 2.3 acre-feet per acre of grain across the Basin as a whole. Corresponding diversions during a high demand year are 4.4 and 2.5 acre-feet per acre, respectively. Note that these diversion estimates are unconstrained, assuming no supply limitations within the subbasins. These diversion rates are roughly comparable with other Wyoming basin planning studies.

Livestock water use factors in the Basin, both diversion and consumptive use, are estimated at .01 acre-feet per cattle head per year and.004 acre-feet per sheep head per year (Broyles, 2005).

Municipal and Rural Domestic Sector

Based on data from the WWDC's 2013 *State of Wyoming Public Water System Survey Report*, as summarized in Lidstone, 2015, HE calculated a municipal and rural domestic diversion water use factor for each subbasin in the Basin. Those factors ranged from 168 gallons per capita per day (gpcd) in the Horse Creek subbasin up to 264 gpcd in the Guernsey to State Line subbasin; the Basin wide average was 202 gpcd in a normal water demand year. The difference between municipal diversions and effluent discharge is assumed to be 50%, based on interviews and previous basin studies. Therefore, the municipal and rural domestic consumptive use within each subbasin is calculated as 50% of the diversion factor. The maximum demand factors were calculated in the same way, assuming Basin municipal users' unconstrained peak year would be 50% higher than a normal year. This factor is similar to other basin plan assumptions in Wyoming.

Based on the inventory of municipal and rural domestic water use, HE assumed that roughly 75% of water use in this sector employs surface water, and 25% of use employs groundwater.

Industrial Sector

Although only a fraction of agricultural water use, industrial water use in the Basin is substantial. Major sectors include power generation; uranium mining; oil and natural gas production; aggregates and gravel; and miscellaneous industries such as road and bridge maintenance and stock watering. Industrial water use in the Basin is specific to individual users, projects and facility operations; therefore no one industrial water use factor could be developed for use in projecting future industrial water demands. Future water demands for various industrial sectors were based on sector specific assumptions under the High, Low and Mid Scenarios. Those assumptions are summarized below:

Power Generation. Under the High Scenario, HE projects that power generation water use will increase due to increased demand from the existing Cheyenne Prairie Generating Station and the addition of one new natural gas power plant in the Pathfinder to Guernsey subbasin that will consumptively use 10,000 acre-feet of water each year. Water demands from other existing power generation facilities will remain constant.

Under the Low and Mid Scenarios, HE projects that total power generation water use will remain relatively constant, as no new plants would be constructed. Increased water

demands at the existing Cheyenne Prairie Generating Station would be small and other existing power generation water use would remain constant.

Mining and Mine Reclamation. Under the High Scenario, HE projects that four currently proposed uranium projects will be permitted and will begin operations within the 30 year time frame of these projections (three in the Above Pathfinder Dam subbasin and one in the Pathfinder to Guernsey subbasin). Each of those projects is assumed to require about 3,200 acre-feet of water per year. Additionally, we forecast the expansion of an existing uranium mining operation in the Pathfinder to Guernsey subbasin, requiring about 6,700 acre-feet of water per year. The High Scenario also includes the development of one coal gasification plant in the Above Pathfinder Dam subbasin that will consumptively use about 500 acre-feet of water each year and the commencement of coal mining operations at the Saddleback Hills Mine in that same subbasin to support the plant. Coal mining operations will require up to 3,700 acre-feet per year.

Under the Low Scenario, existing uranium mining operations would continue, but there would be no additional mining activity in the Basin. The Saddleback Hills Mine would not be developed and no coal production would take place in the Basin.

Under the Mid Scenario, one new uranium project would be developed in the Above Pathfinder Dam subbasin (3,200 acre-feet per year), as would the expansion of existing uranium mining operations in the Pathfinder to Guernsey subbasin (6,700 acre-feet per year). Similar to the Low Scenario, the Saddleback Hills Mine would not be developed and no new coal production would take place in the Basin in the Mid Scenario.

Oil Refining, Oil and Gas Exploration, Production and Reclamation. Under the High Scenario, HE projects that oil and gas prices will increase and will encourage additional production and exploration. Under this scenario, water demands for this sector will increase by 20% by 2045.

The Low Scenario reflects continued low commodity prices and continued pressure on profit margins for companies and production in the Basin. Under the Low Scenario, water demands for this sector will remain constant at 2015 levels.

The Mid Scenario assumes that gas prices rise modestly and that global demand for oil and gas continues steadily. Under the Mid Scenario, water demands for this sector will increase by 10%.

Aggregates, Cement and Gravel. Under the High Scenario, which includes uranium, coal and oil and gas development, HE forecasts a 20% increase in aggregate production related water demands over the 30-year projection period. The Low Scenario assumes no changes in current water demands and the Mid Scenario reflects a 10% increase in water demands.

Miscellaneous Industry (including road construction). Under the High Scenario, HE projects that both the Wyoming Ethanol facility and the Western Sugar facility in Torrington would re-open at some point within the 30-year projection period. Additionally, the Dyno Nobel ammonium nitrate plant in the South Platte subbasin will add a new production unit and increase water use by 10%, as compared to current levels. As described previously, the High Scenario includes the development of additional mining and power generation projects, as well as oil and gas development. Together, these activities are likely to result in the need for road construction and maintenance; HE projected 2,000 acre-feet per year of use for those activities under the High Scenario. Other miscellaneous water use by individuals or smaller entities will also increase by a total of 10% overall throughout the Basin.

The Low Scenario includes water use of 500 acre-feet per year for road and bridge construction and the Mid Scenario assumes 1,000 acre-feet per year for that activity. HE assumes that the Wyoming Ethanol facility and the Western Sugar facility in Torrington will remain closed under both the Low and Mid Scenarios. Other miscellaneous water use is expected to hold steady at current levels under both the Low and Mid Scenarios.

Consumptive Recreational Use

The majority of recreational water use (boating, fishing, etc.) in the Basin is non-consumptive. Two consumptive recreational water uses include snowmaking at alpine ski areas and golf course irrigation. The assumptions used to project water demands for those recreational uses are described below. The demands themselves are included with municipal/rural domestic demands later in this volume.

Skiing. HE projects that the two ski areas in the Basin (one each in the Pathfinder to Guernsey and Upper Laramie subbasins) will maintain their current demands for water under all future scenarios. No new ski areas are expected to be developed in the Basin under any of the scenarios.

Golf. Under the High Scenario, HE projected the development of five new 18 hole golf courses and the expansion of six existing courses, from 9 holes to 18 holes each. One new course would be built in the Above Pathfinder Dam subbasin and two new courses would be developed in each of the Pathfinder to Guernsey and the South Platte subbasins. Golf course expansions would occur in the Pathfinder to Guernsey (two courses), Upper Laramie (one course), Lower Laramie (one course) and South Platte (two courses) subbasins. The demand for additional golfing amenities is supported by the projected population growth as well as increased economic activity. About 900 new irrigated acres would be added under the High Scenario.

In the Low Scenario, HE assumed that no new courses or expansions would be built in any of the subbasins and that all current operations would continue. The Mid Scenario incorporates the development of three new 18 hole courses: one each in the Above Pathfinder Dam, Pathfinder to Guernsey and South Platte subbasins. Additionally, four existing courses would be expanded under the Mid Scenario: one each in the Pathfinder to Guernsey and Lower Laramie subbasins and two in the South Platte subbasin. About 570 new irrigated acres would be added under the Mid Scenario.

The consumptive use irrigation estimates derived for the 2006 Basin Plan were assumed to have remained constant over time and were also applied to all new or expanded courses in the High and Mid Scenarios.

4.4.3 Current Annual Water Demands, as Compared to the 2006 Basin Plan

The 2006 Basin Plan included water demands current to that time; those demands reflected water use in the year 2005. Since that time, there have been some major changes in water use in all sectors. Current water demands in 2015 look very different from those of 2005. Therefore, a brief discussion of the changes that have taken place in the Basin in the interim, with regards to water demands, provides some context for examining the projections included in this Basin Plan update. These changes can be summarized as follows:

- Total water diversions in the Basin decreased from about 1,721,040 acre-feet in 2005 to about 1,513,200 acre-feet in 2015, a drop of about 208,000 acre-feet, or about 12%. That net decrease is made up of changes in individual sectors.

- Agricultural operations and activities use the largest amount of water in the Basin. Between 2005 and 2015, the number of irrigated acres in the Basin decreased by about 14%. Number of cattle declined slightly, but generally remained relatively constant; sheep declined by a considerable amount. As a result, water diversions for agricultural use in the Basin decreased from about 1,559,300 acre-feet to about 1,295,800, given normal year conditions. That change amounts to a drop of about 263,500 acre-feet, or about 17%.

- Industrial water use throughout the Basin increased by about 53,000 acre-feet, or about 50%. That increase is mainly due to increased water demands for oil and gas production (17,700 acre-feet) and uranium mining (28,300 acre-feet). Other industrial sectors changed by smaller amounts.

- Municipal and rural domestic demands, including consumptive recreation, increased by about 5,800 acre-feet, or about 12%. Municipal demands increased in five of the seven basins due to population and employment increases, but decreased slightly in the Guernsey to State Line subbasin and the Upper Laramie subbasin due to reductions in per capita water use in those subbasins.

4.4.4 Projected Annual Water Demands by Scenario

This section presents current and projected annual water demands, both diversions and consumptive use, for the Basin under each of three separate scenarios: High, Low and Mid economic growth. The assumptions underlying the agricultural, municipal, industrial and recreational sectors for each scenario have been previously described in Section 4.2.

Water demands are derived by multiplying current or projected demographic or economic activity described in Section 4.2 by the water use factors presented in **Table 4.18** or by outright forecasts of individual water demands for various entities. Total water diversions and consumptive use are presented and discussed for each sector, relying on three pairs of tables, one pair for each scenario. Patterns of change from current to projected future use by sector do not vary from diversions to consumptive use within each scenario. At the bottom of each exhibit, these totals are aggregated into surface water and groundwater totals for the Basin.

High Scenario

Assuming normal water demand conditions, total Basin water diversion requirements are projected to increase by about 25% between 2015 and 2045 under the High Scenario; that amounts to an increase of about 377,000 acre-feet. In a high demand year, the increase is also projected to be around 25%, or about 510,600 acre-feet.

Under the High Scenario, total agricultural water demand grows by an estimated 22% over the projection period. Agriculture continues to comprise the vast majority of total water demand under the High Scenario; agriculture accounts for 84% of total water diverted and roughly 72% of total consumptive use in normal demand year 2045. Consumptive use is only 43% of total diversions for irrigated agricultural production within the Basin, reflecting low efficiencies and reuse of return flows. The vast majority of agricultural water demand remains in irrigated crop production, with less than 1% of total projected agricultural diversions and consumptive use going to direct livestock sustenance.

Under the High Scenario, while municipal water demand in the Basin increases by 70% over the 30-year projection period, it remains a relatively small sector, accounting for only 4% of total water diversions and 4% of total consumptive use in a normal demand year 2045.

Water demand within the industrial sector increases by about 34% over the projection period under the High Scenario for both consumptive use and diversions. Water demands in the industrial sector will account for a slightly greater percentage of total water use in 2045, as compared to 2015, but will remain only a small portion of the Basin's water demands, as compared to agriculture. Industrial demands will account for 22% of total consumptive use and 11% of total diversions under the High Scenario in a normal year 2045.

The share of aggregate water demand met by groundwater resources versus surface water within the Basin is projected to decrease slightly under the High Scenario.

About 82% percent of water diversions will continue to come from surface water by 2045, a decrease of about 2% over the projection period.

Tables 4.19 and 4.20 provide estimates of current and projected annual diversions and consumptive use under the High Scenario.

Table 4.19: Current and Projected Annual Platte River Basin Water Demand Annual Diversions in Acre-Feet per Year, High Scenario

Economic Sector	Current (2015)		Project (2045)	
	Normal	Max	Normal	Max
Agricultural				
Irrigation				
Alfalfa	316,000	435,000	403,000	550,000
Other hay	434,000	635,000	518,000	758,000
Irrigated pasture	258,000	412,000	307,000	493,000
Corn	125,000	159,000	152,000	192,000
Sugar beets	63,000	82,000	77,000	100,000
Dry beans	39,000	54,000	47,000	64,000
Oats	16,000	19,000	21,000	24,000
Barley	23,000	28,000	28,000	36,000
Winter wheat	14,000	19,000	16,000	21,000
Spring wheat	2,000	2,000	2,000	2,000
Subtotal	*1,290,000*	*1,845,000*	*1,571,000*	*2,240,000*
Livestock	5,800	5,800	6,900	6,900
Municipal/Rural Domestic	60,100	87,800	102,100	149,600
Industrial				
Oil refining and production	51,300	51,300	61,600	61,600
Coal and uranium mining	28,600	28,600	52,000	52,000
Power generation	27,200	27,200	37,500	37,500
Miscellaneous and other	50,200	50,200	58,900	58,900
Total Water Usage	1,513,200	2,095,900	1,890,000	2,606,500
Surface Water	1,271,200	1,789,400	1,567,000	2,202,100
Ground Water	242,000	306,500	323,000	404,400
Share Water Usage				
Surface Water	84%	85%	83%	84%
Ground Water	16%	15%	17%	16%

Notes:
1. Municipal/Rural Domestic demands include water demands for ski areas and golf courses.
2. All irrigation water demands are rounded to the nearest thousand acre-feet.

Source: Harvey Economics, 2016.

Table 4.20: Current and Projected Annual Platte River Water Demand Consumptive Use in Acre-Feet per Year, High Scenario

Economic Sector	Current (2015)		Project (2045)	
	Normal	Max	Normal	Max
Agricultural				
Irrigation				
Alfalfa	136,000	186,000	172,000	232,000
Other hay	187,000	271,000	221,000	320,000
Irrigated pasture	111,000	176,000	131,000	208,000
Corn	54,000	68,000	65,000	81,000
Sugar beets	27,000	35,000	33,000	42,000
Dry beans	17,000	23,000	20,000	27,000
Oats	7,000	8,000	9,000	10,000
Barley	10,000	12,000	12,000	15,000
Winter wheat	6,000	8,000	7,000	9,000
Spring wheat	1,000	1,000	1,000	1,000
Subtotal	*556,000*	*788,000*	*671,000*	*945,000*
Livestock	5,800	5,800	6,900	6,900
Municipal/Rural Domestic	30,200	44,300	51,200	74,900
Industrial				
Oil refining and production	51,300	51,300	61,600	61,600
Coal and uranium mining	28,600	28,600	52,000	52,000
Power generation	27,200	27,200	37,500	37,500
Miscellaneous and other	50,200	50,200	58,900	58,900
Total Water Usage	749,300	995,400	939,100	1,236,800
Surface Water	571,300	789,700	698,100	961,200
Ground Water	178,000	205,700	241,000	275,600
Share Water Usage				
Surface Water	76%	79%	74%	78%
Ground Water	24%	21%	26%	22%

Notes:
1. Municipal/Rural Domestic demands include water demands for ski areas and golf courses.
2. All irrigation water demands are rounded to the nearest thousand acre-feet.

Source: Harvey Economics, 2016.

Low Scenario

Total water diversion requirements under the Low Scenario in a normal demand year are projected to decline by about 19% from 2015 to 2045, or about 284,000 acre-feet. Maximum or drought year demand year diversion requirements are also projected to drop by about 18% over the same period. Consumptive use is expected to drop slightly less under the Low Scenario, by 16% in a normal demand year and by 15% in a high demand year.

Under the Low Scenario, total agricultural water demand declines considerably over the projection period – about 23%, in terms of diversions and about 22% in terms of consumptive use. Agriculture continues to comprise the vast majority of total water demand under the Low Scenario; agriculture is responsible for 81% of total water diverted and roughly 70% of total consumptive use in a normal demand year 2045. Consumptive use amounts to 44% of total diversions for irrigated agricultural production within the Basin, reflecting low efficiencies and reuse of return flows. The vast majority of agricultural water demand remains in irrigated crop production, with about one percent of total projected agricultural diversions and consumptive use going to direct livestock sustenance.

In the municipal sector, the 18% increase in both diversions and consumptive use is the direct result of the projected increases in Basin population levels, but it remains a small portion of overall Basin water demands.

Under the Low Scenario, industrial water demand remains relatively constant through 2045 as oil and gas production increases at a slow, but steady pace and uranium mining continues. This sector will represent a greater portion of overall water demands under the Low Scenario, as agricultural water use decreases.

Under the Low Scenario, the share of total groundwater diversions and consumptive use is expected to decrease slightly, by roughly 2%.

Tables 4.21 and 4.22 present estimates of the current and projected annual water diversions and consumptive use estimates under the Low Scenario.

Table 4.21: Current and Projected Annual Platte River Water Demand Annual Diversions in Acre-Feet per Year, Low Scenario

Economic Sector	Current (2015)		Project (2045)	
	Normal	Max	Normal	Max
Agricultural				
Irrigation				
Alfalfa	316,000	435,000	217,000	306,000
Other hay	434,000	635,000	359,000	529,000
Irrigated pasture	258,000	412,000	215,000	343,000
Corn	125,000	159,000	94,000	122,000
Sugar beets	63,000	82,000	48,000	62,000
Dry beans	39,000	54,000	30,000	39,000
Oats	16,000	19,000	9,000	12,000
Barley	23,000	28,000	16,000	21,000
Winter wheat	14,000	19,000	9,000	14,000
Spring wheat	2,000	2,000	0	2,000
Subtotal	*1,290,000*	*1,845,000*	*997,000*	*1,450,000*
Livestock	5,800	5,800	5,000	5,000
Municipal/Rural Domestic	60,100	87,800	71,000	103,900
Industrial				
Oil refining and production	51,300	51,300	51,300	51,300
Coal and uranium mining	28,600	28,600	28,600	28,600
Power generation	27,200	27,200	27,500	27,500
Miscellaneous and other	50,200	50,200	49,300	49,300
Total Water Usage	1,513,200	2,095,900	1,229,700	1,715,600
Surface Water	1,271,200	1,789,400	1,008,600	1,439,800
Ground Water	242,000	306,500	221,100	275,800
Share Water Usage				
Surface Water	84%	85%	82%	84%
Ground Water	16%	15%	18%	16%

Notes:
1. Municipal/Rural Domestic demands include water demands for ski areas and golf courses.
2. All irrigation water demands are rounded to the nearest thousand acre-feet.

Source: Harvey Economics, 2016.

Table 4.22: Current and Projected Annual Platte River Water Demand Consumptive Use in Acre-Feet per Year, Low Scenario

Economic Sector	Current (2015)		Project (2045)	
	Normal	Max	Normal	Max
Agricultural				
Irrigation				
Alfalfa	136,000	186,000	95,000	133,000
Other hay	187,000	271,000	157,000	230,000
Irrigated pasture	111,000	176,000	94,000	149,000
Corn	54,000	68,000	41,000	53,000
Sugar beets	27,000	35,000	21,000	27,000
Dry beans	17,000	23,000	13,000	17,000
Oats	7,000	8,000	4,000	5,000
Barley	10,000	12,000	7,000	9,000
Winter wheat	6,000	8,000	4,000	6,000
Spring wheat	1,000	1,000	0	1,000
Subtotal	*556,000*	*788,000*	*436,000*	*630,000*
Livestock	5,800	5,800	5,000	5,000
Municipal/Rural Domestic	30,200	44,300	35,500	52,200
Industrial				
Oil refining and production	51,300	51,300	51,300	51,300
Coal and uranium mining	28,600	28,600	28,600	28,600
Power generation	27,200	27,200	27,500	27,500
Miscellaneous and other	50,200	50,200	49,300	49,300
Total Water Usage	749,300	995,400	633,200	843,900
Surface Water	571,300	789,700	464,200	650,700
Ground Water	178,000	205,700	169,000	193,200
Share Water Usage				
Surface Water	76%	79%	73%	77%
Ground Water	24%	21%	27%	23%

Notes:
1. Municipal/Rural Domestic demands include water demands for ski areas and golf courses.
2. All irrigation water demands are rounded to the nearest thousand acre-feet.

Source: Harvey Economics, 2016.

Mid Scenario

In both normal and high demand years, total Basin water diversions are projected to decrease by about 7% between year 2015 to year 2045 under the Mid Scenario. Consumptive use is projected to decrease by about 4% in both normal and high demand years. The projected difference in aggregate diversions and aggregate consumptive use under normal water demand conditions amounts to roughly 104,300 acre-feet and 30,700 acre-feet, respectively.

Under the Mid Scenario, total agricultural water demand declines by about 11% over the projection period, measured in terms of diversions or consumptive use. Agriculture continues to comprise the vast majority of total water demand under the Mid Scenario; agriculture is responsible for 82% of total water diverted and roughly 70% of total consumptive use in a normal demand year 2045. Consumptive use is only 44% of total diversions for irrigated agricultural production within the Basin, reflecting low efficiencies and reuse of return flows. The vast majority of agricultural water demand remains in irrigated crop production, with less than 1% of total projected agricultural diversions and consumptive use going to direct livestock sustenance.

Under the Mid Scenario, while municipal water demand increases by 37% over the 30-year projection period, it remains a relatively small sector, accounting for only 4% of total water diversions and total consumptive use within the Basin in a normal demand year 2045.

Under the Mid Scenario, industrial water diversions and consumptive use in the Basin industrial sector are projected to increase by 11% from current levels. Industrial water use will become a larger portion of the overall Basin water demand, increasing to 12% of diversions and 24% of consumptive use in a normal demand year 2045.

Under the Mid Scenario, the share of total diversions and consumptive use from groundwater sources is projected to decrease slightly, by about 2% to 3%.

Tables 4.23 and 4.24 present estimates of the current and projected annual diversions and consumptive use estimates under the Low Scenario.

Table 4.23: Current and Projected Annual Platte River Water Demand Annual Diversions in Acre-Feet per Year, Mid Scenario

Economic Sector	Current (2015)		Project (2045)	
	Normal	Max	Normal	Max
Agricultural				
Irrigation				
Alfalfa	316,000	435,000	267,000	371,000
Other hay	434,000	635,000	396,000	580,000
Irrigated pasture	258,000	412,000	237,000	376,000
Corn	125,000	159,000	111,000	142,000
Sugar beets	63,000	82,000	55,000	72,000
Dry beans	39,000	54,000	35,000	46,000
Oats	16,000	19,000	12,000	16,000
Barley	23,000	28,000	21,000	26,000
Winter wheat	14,000	19,000	12,000	16,000
Spring wheat	2,000	2,000	0	2,000
Subtotal	*1,290,000*	*1,845,000*	*1,146,000*	*1,647,000*
Livestock	5,800	5,800	5,800	5,800
Municipal/Rural Domestic	60,100	87,800	82,400	119,800
Industrial				
Oil refining and production	51,300	51,300	56,400	56,400
Coal and uranium mining	28,600	28,600	38,600	38,600
Power generation	27,200	27,200	27,500	27,500
Miscellaneous and other	50,200	50,200	52,200	52,200
Total Water Usage	1,513,200	2,095,900	1,408,900	1,947,300
Surface Water	1,271,200	1,789,400	1,156,600	1,633,900
Ground Water	242,000	306,500	252,300	313,400
Share Water Usage				
Surface Water	84%	85%	82%	84%
Ground Water	16%	15%	18%	16%

Notes:
1. Municipal/Rural Domestic demands include water demands for ski areas and golf courses.
2. All irrigation water demands are rounded to the nearest thousand acre-feet.

Source: Harvey Economics, 2016.

Table 4.24: Current and Projected Annual Platte River Water Demand Consumptive Use in Acre-Feet per Year, Mid Scenario

Economic Sector	Current (2015)		Project (2045)	
	Normal	Max	Normal	Max
Agricultural				
Irrigation				
Alfalfa	136,000	186,000	116,000	160,000
Other hay	187,000	271,000	172,000	250,000
Irrigated pasture	111,000	176,000	103,000	162,000
Corn	54,000	68,000	48,000	61,000
Sugar beets	27,000	35,000	24,000	31,000
Dry beans	17,000	23,000	15,000	20,000
Oats	7,000	8,000	5,000	7,000
Barley	10,000	12,000	9,000	11,000
Winter wheat	6,000	8,000	5,000	7,000
Spring wheat	1,000	1,000	0	1,000
Subtotal	*556,000*	*788,000*	*497,000*	*710,000*
Livestock	5,800	5,800	5,800	5,800
Municipal/Rural Domestic	30,200	44,300	41,100	60,100
Industrial				
Oil refining and production	51,300	51,300	56,400	56,400
Coal and uranium mining	28,600	28,600	38,600	38,600
Power generation	27,200	27,200	27,500	27,500
Miscellaneous and other	50,200	50,200	52,200	52,200
Total Water Usage	749,300	995,400	718,600	950,600
Surface Water	571,300	789,700	526,600	731,800
Ground Water	178,000	205,700	192,000	218,800
Share Water Usage				
Surface Water	76%	79%	73%	77%
Ground Water	24%	21%	27%	23%

Notes:
1. Municipal/Rural Domestic demands include water demands for ski areas and golf courses.
2. All irrigation water demands are rounded to the nearest thousand acre-feet.

Source: Harvey Economics, 2016.

4.4.5 Projected Monthly Demands by Scenario

Current and projected monthly water demands (both diversions and consumptive use) have been prepared for the Basin under the High, Low and Mid scenarios. Monthly water demands are derived by multiplying current and projected annual water demands for each sector by monthly shares of annual water use based upon the assumptions used in the 2006 Basin Plan. Total water diversions and consumptive use are presented and discussed for each consuming sector under each scenario.

An analysis of the temporal distribution of water demands throughout the year illustrates the seasonal nature of water demand within the Basin. Almost all sectors exhibit a significant difference in demand between the peak summer months and the off-peak winter months. Such distinct seasonal patterns in water demand are characteristic of regions with colder climates. The percentage of diversions and consumptive use occurring in each month over the course of a year are assumed to be the same under each scenario.

The distribution of irrigation water demand used in the 2006 Basin Plan was also used for this update. That distribution is based on aggregate CIR information developed at that time. Livestock water demand is assumed to be twice as high during the months of April through

September to reflect both the presence of the spring calf crop and the increased temperatures during those months.

Municipal and rural domestic use is distributed throughout the year with heavy use in the summer months of June through September and relatively lighter use in October through May. HE estimates that roughly 50% of total municipal and rural domestic use occurs throughout the summer months, with the remainder of water use spread equally throughout the rest of the year.

Industrial water demand in the Basin was assumed to be constant throughout the year, as most processes and production in the industries in the Basin are fairly stable across seasons. Recreational water demands were assumed to occur in different seasons. HE assumed that snowmaking would occur evenly throughout the months of December through March, while golf irrigation would occur from April through September, similar to agricultural irrigation.

High Scenario

The aggregate temporal distribution of water demand within the Basin under the High Scenario is presented in **Table 4.25**. It is possible to divide the months into three categories of water use: the baseline or off-peak months of October through March; the peak months of June and July; and the shoulder months of April, May, August and September.

Table 4.25: Current and Projected Monthly Platte River Basin Water Demand, Estimated Diversions and Consumptive Use in Acre-Feet per Month, High Scenario

	Current 2015 Demands				2045 High Scenario Demands			
	Normal		Max		Normal		Max	
	Diversions	CU	Diversions	CU	Diversions	CU	Diversions	CU
January	17,200	15,300	18,900	16,200	24,300	21,100	27,200	22,600
February	17,200	15,300	18,900	16,200	24,300	21,100	27,200	22,600
March	17,200	15,300	18,900	16,200	24,300	21,100	27,200	22,600
April	89,100	46,500	121,600	60,200	111,800	58,700	151,900	75,400
May	212,400	99,600	298,000	135,600	262,000	122,800	366,000	165,700
June	364,100	165,300	515,100	228,700	448,600	203,000	632,300	278,800
July	371,000	168,300	524,900	232,900	457,000	206,600	644,300	283,800
August	233,000	108,800	327,500	148,600	288,800	134,800	404,600	182,700
September	140,500	68,900	195,300	92,100	176,300	86,700	244,100	115,000
October	17,200	15,300	18,900	16,200	24,300	21,100	27,200	22,600
November	17,200	15,300	18,900	16,200	24,300	21,100	27,200	22,600
December	17,200	15,300	18,900	16,200	24,300	21,100	27,200	22,600
Total Annual Demand	**1,513,300**	**749,200**	**2,095,800**	**995,300**	**1,890,300**	**939,200**	**2,606,400**	**1,237,000**

Note: All water demands are rounded to the nearest hundred acre-feet.
Source: Harvey Economics, 2016.

Water demand growth occurs in both the peak and off-peak months of demand under the High Scenario. Percentage increases are greater in the non-irrigation months given a smaller starting point of use and given relatively higher growth in the municipal and rural domestic sector that makes up the vast majority of water use during the non-irrigation months.

Low Scenario

The aggregate temporal distribution of water demand in the Basin under the Low Scenario is presented in **Table 4.26**.

Table 4.26: Current and Projected Monthly Platte River Basin Water Demand, Estimated Diversions and Consumptive Use in Acre-Feet per Month, Low Scenario

	Current 2015 Demands				2045 Low Scenario Demands			
	Normal		Max		Normal		Max	
	Diversions	CU	Diversions	CU	Diversions	CU	Diversions	CU
January	17,200	15,300	18,900	16,200	17,800	15,600	19,800	16,600
February	17,200	15,300	18,900	16,200	17,800	15,600	19,800	16,600
March	17,200	15,300	18,900	16,200	17,800	15,600	19,800	16,600
April	89,100	46,500	121,600	60,200	73,400	40,000	100,600	51,800
May	212,400	99,600	298,000	135,600	168,700	81,700	239,200	112,100
June	364,100	165,300	515,100	228,700	287,500	133,900	412,000	187,600
July	371,000	168,300	524,900	232,900	292,800	136,300	419,700	190,900
August	233,000	108,800	327,500	148,600	186,100	89,600	264,600	123,500
September	140,500	68,900	195,300	92,100	114,700	58,400	160,700	78,400
October	17,200	15,300	18,900	16,200	17,800	15,600	19,800	16,600
November	17,200	15,300	18,900	16,200	17,800	15,600	19,800	16,600
December	17,200	15,300	18,900	16,200	17,800	15,600	19,800	16,600
Total Annual Demand	**1,513,300**	**749,200**	**2,095,800**	**995,300**	**1,230,000**	**633,500**	**1,715,600**	**843,900**

Note: All water demands are rounded to the nearest hundred acre-feet.
Source: Harvey Economics, 2016.

Under the Low Scenario, overall water demand for the Basin decreases considerably. Because those decreases are due to changes in the agricultural sector, the greatest reductions occur during the irrigation season. Industrial use, which is evenly distributed year-round, remains relatively constant, while municipal water demands increase over time.

Mid Scenario

The aggregate temporal distribution of water demand in the Basin under the Mid Scenario is presented in **Table 4.27**. The temporal distribution of water demand under the Mid Scenario essentially splits the difference between the patterns exhibited under the other two scenarios.

Table 4.27: Current and Projected Monthly Platte River Basin Water Demand, Estimated Diversions and Consumptive Use in Acre-Feet per Month, Mid Scenario

	Current 2015 Demands				2045 Mid Scenario Demands			
	Normal		Max		Normal		Max	
	Diversions	CU	Diversions	CU	Diversions	CU	Diversions	CU
January	17,200	15,300	18,900	16,200	20,000	17,400	22,400	18,600
February	17,200	15,300	18,900	16,200	20,000	17,400	22,400	18,600
March	17,200	15,300	18,900	16,200	20,000	17,400	22,400	18,600
April	89,100	46,500	121,600	60,200	83,900	45,300	114,100	58,400
May	212,400	99,600	298,000	135,600	193,500	92,900	271,500	126,200
June	364,100	165,300	515,100	228,700	330,100	152,400	467,900	211,400
July	371,000	168,300	524,900	232,900	336,200	155,100	476,700	215,200
August	233,000	108,800	327,500	148,600	213,600	101,900	300,500	139,200
September	140,500	68,900	195,300	92,100	131,500	66,300	182,400	88,400
October	17,200	15,300	18,900	16,200	20,000	17,400	22,400	18,600
November	17,200	15,300	18,900	16,200	20,000	17,400	22,400	18,600
December	17,200	15,300	18,900	16,200	20,000	17,400	22,400	18,600
Total Annual Demand	**1,513,300**	**749,200**	**2,095,800**	**995,300**	**1,408,800**	**718,300**	**1,947,500**	**950,400**

Note: All water demands are rounded to the nearest hundred acre-feet.
Source: Harvey Economics, 2016.

4.4.6 Projected Water Use in the Non-consumptive Environmental and Recreational Sectors

As described in Volume 2, Section 4 of this Basin Plan Update, activities in the environmental and non-consumptive recreational use sectors are highly dependent on traditional water uses.[14] Therefore, this analysis of future demands is a reflection of the interactions of traditional water uses and these non-consumptive uses. Ideally, the mapping of E&R water use in the Surface Water Profile would be translated into a number, expressed in acre feet, which would demonstrate how much of the Basin's water resources contribute to these important sectors; that information would then serve as a basis for the E&R demand projections. Unfortunately, flow data for the Basin is incomplete and thus such a calculation has not been possible. A qualitative discussion of HE's expectations for E&R water use under each of the scenarios is provided below.

High Scenario

Under these conditions, it is likely that recreational water use will be stable or will decline modestly. As agricultural activity increases, diversions will also increase, which will have a dual impact. Uses that have been classified as complementary or protected should continue to be available or even increase because these recreational uses rely upon senior downstream diverters, who would operate at maximum or near maximum levels. However, competing uses might be threatened as increasing diversions on over-appropriated stream segments would constrain or even eliminate those recreational uses, especially in dry years. The growing population under this scenario would create greater recreational demands, placing additional pressure on the remaining resources.

On the environmental side, a strong economy would tend to expand those water uses on the whole. Agricultural irrigation tends to improve and expand wetlands, a beneficial complementary relationship. As competition for water increases, in-stream flow applications might become more difficult, although increase in environmental protection interests might offset this. Development activity and increased governmental revenues are both likely to have the effect of increasing interest in environmental protection and remediation. Remedial activities for critical habitat areas have been established and include actions such as improved grazing management, river bank restoration, control of invasive species, obtaining conservation easements, and restoration of native populations, to name just a few. These activities require government expenditures that will be much more likely under the high scenario.

Low Scenario

As with the High Scenario, the Low Scenario will produce contradictory impacts but mostly positive effects on recreational water use. Less water will be diverted for agriculture, so competing uses will not threaten recreational uses, unless other non-agricultural uses step in (unlikely under the low scenario). However, the complementary uses might be threatened if senior water right diverters reduced dramatically or eliminated their use. As described previously, it is the existence of downstream diversions that support stream-based recreation. This is unlikely, given the value of such water diversions. Draw-down of reservoirs would also be reduced, increasing the attractiveness of recreation at those locations later in the season. Environmental water uses under the low scenario face a mixed outlook to negative outlook. Reductions in agricultural activities will naturally improve environmental conditions, such as adverse impacts from grazing. However, reductions in irrigation will also mean fewer wetlands. The extended period of relatively low energy

[14] HE's Recreation and Environmental Water Use discussion in Volume 2 of the Platte River Basin Update provides a detailed discussion of water use in these sectors.

production envisioned in this scenario will have a negative impact on State mineral revenues, so remediation will be less.

On the whole, there will be less pressure to divert water, which leaves it for in-stream recreational uses. Over-appropriated streams will feel less pressure and thus competing stream segments will likely be available in non-drought conditions. Population increases under this scenario, albeit modest, will take advantage of these improved conditions and activity levels should increase.

Mid Scenario

This scenario reflects conditions that assume modestly declining agriculture and modestly increasing industrial and domestic water use. It is likely that recreational opportunities will remain about the same. Protected and complementary locations will still be available. Those competing uses that are already subject to drought and over-appropriation will continue to be available only in wetter years. A growing population will bring increase activity levels. Environmental conditions are also expected to improve at the margin. Wyoming Game and Fish will continue to identify remedial actions to improve habitat, but without large increases in funding, these improvements will be modest.

4.4.7 References

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Appendix 4-A

Appendix 4-A provides the summary water demand projection exhibits for 2015 and 2045 for each subbasin of the Platte River Basin in Wyoming. Each subbasin has six tables in three pairs. Each pair matches consumptive use of water and water diversions for each of three economic growth scenarios described in the High, Low and Mid Scenarios. Water demands within each table are specified for normal/average demand years and for high/maximum demand years. HE developed all information for the economic and demographic scenarios and for water use throughout Volume 4 at the Basin and subbasin level to be able to generate exhibits 4-A-1 through 4-A-44. All of the irrigation diversions and consumptive use data included in these tables have been rounded to the nearest thousand acre-feet.

Exhibit 4-A-1: Above Pathfinder Dam Subbasin Current and Projected Annual Water Demand Annual Diversions in Acre-Feet per Year, High Scenario

	Current (2015)		Projected (2045)	
Economic Sector	**Normal**	**Max**	**Normal**	**Max**
Agricultural				
Irrigation				
Alfalfa	20,000	27,000	25,000	34,000
Other hay	164,000	216,000	201,000	266,000
Irrigated pasture	94,000	132,000	116,000	162,000
Corn	0	0	0	0
Sugar beets	0	0	0	1,000
Dry beans	0	0	0	0
Oats	0	1,000	0	1,000
Barley	1,000	1,000	1,000	2,000
Winter wheat	0	0	0	0
Spring wheat	0	0	0	0
Subtotal	279,000	377,000	343,000	466,000
Livestock	1,000	1,000	1,200	1,200
Municipal/Rural Domestic	6,300	8,700	8,100	11,200
Industrial				
Oil refining and production	15,500	15,500	18,600	18,600
Coal and uranium mining	300	300	13,700	13,700
Power generation	0	0	0	0
Miscellaneous and other	3,100	3,100	3,700	3,700
Total Water Usage	305,200	405,600	388,300	514,400
Surface Water	267,000	359,300	328,400	444,300
Ground Water	38,200	46,300	59,900	70,100
Share Water Usage				
Surface Water	87%	89%	85%	86%
Ground Water	13%	11%	15%	14%

Source: Harvey Economics, 2016.

Exhibit 4-A-2: Above Pathfinder Dam Subbasin Current and Projected Annual Water Demand Annual Consumptive Use in Acre-Feet per Year, High Scenario

	Current (2015)		Projected (2045)	
Economic Sector	**Normal**	**Max**	**Normal**	**Max**
Agricultural				
Irrigation				
Alfalfa	9,000	12,000	10,000	14,000
Other hay	71,000	92,000	86,000	112,000
Irrigated pasture	41,000	56,000	49,000	68,000
Corn	0	0	0	0
Sugar beets	0	0	0	0
Dry beans	0	0	0	0
Oats	0	0	0	0
Barley	0	1,000	1,000	1,000
Winter wheat	0	0	0	0
Spring wheat	0	0	0	0
Subtotal	121,000	161,000	146,000	195,000
Livestock	1,000	1,000	1,200	1,200
Municipal/Rural Domestic	3,100	4,400	4,000	5,500
Industrial				
Oil refining and production	15,500	15,500	18,600	18,600
Coal and uranium mining	300	300	13,700	13,700
Power generation	0	0	0	0
Miscellaneous and other	3,100	3,100	3,700	3,700
Total Water Usage	144,000	185,300	187,200	237,700
Surface Water	118,800	155,400	143,500	188,300
Ground Water	25,200	29,900	43,700	49,400
Share Water Usage				
Surface Water	83%	84%	77%	79%
Ground Water	18%	16%	23%	21%

Source: Harvey Economics, 2016.

Exhibit 4-A-3: Above Pathfinder Dam Subbasin Current and Projected Annual Water Demand Annual Diversions in Acre-Feet per Year, Low Scenario

	Current (2015)		Projected (2045)	
Economic Sector	**Normal**	**Max**	**Normal**	**Max**
Agricultural				
Irrigation				
Alfalfa	20,000	27,000	14,000	19,000
Other hay	164,000	216,000	115,000	151,000
Irrigated pasture	94,000	132,000	66,000	92,000
Corn	0	0	0	0
Sugar beets	0	0	0	0
Dry beans	0	0	0	0
Oats	0	1,000	0	0
Barley	1,000	1,000	1,000	1,000
Winter wheat	0	0	0	0
Spring wheat	0	0	0	0
Subtotal	279,000	377,000	196,000	263,000
Livestock	1,000	1,000	800	800
Municipal/Rural Domestic	6,300	8,700	6,800	9,500
Industrial				
Oil refining and production	15,500	15,500	15,500	15,500
Coal and uranium mining	300	300	300	300
Power generation	0	0	0	0
Miscellaneous and other	3,100	3,100	3,100	3,100
Total Water Usage	305,200	405,600	222,500	292,200
Surface Water	267,000	356,200	190,600	252,400
Ground Water	38,200	49,400	31,900	39,800
Share Water Usage				
Surface Water	87%	88%	86%	86%
Ground Water	13%	12%	14%	14%

Source: Harvey Economics, 2016.

Exhibit 4-A-4: Above Pathfinder Dam Subbasin Current and Projected Annual Water Demand Annual Consumptive Use in Acre-Feet per Year, Low Scenario

	Current (2015)		Projected (2045)	
Economic Sector	**Normal**	**Max**	**Normal**	**Max**
Agricultural				
Irrigation				
Alfalfa	9,000	12,000	6,000	8,000
Other hay	71,000	92,000	50,000	66,000
Irrigated pasture	41,000	56,000	29,000	40,000
Corn	0	0	0	0
Sugar beets	0	0	0	0
Dry beans	0	0	0	0
Oats	0	0	0	0
Barley	0	1,000	0	0
Winter wheat	0	0	0	0
Spring wheat	0	0	0	0
Subtotal	121,000	161,000	85,000	114,000
Livestock	1,000	1,000	800	800
Municipal/Rural Domestic	3,100	4,400	3,400	4,700
Industrial				
Oil refining and production	15,500	15,500	15,500	15,500
Coal and uranium mining	300	300	300	300
Power generation	0	0	0	0
Miscellaneous and other	3,100	3,100	3,100	3,100
Total Water Usage	144,000	185,300	108,100	138,400
Surface Water	118,800	155,400	85,600	112,500
Ground Water	25,200	29,900	22,500	25,900
Share Water Usage				
Surface Water	83%	84%	79%	81%
Ground Water	18%	16%	21%	19%

Source: Harvey Economics, 2016.

Exhibit 4-A-5: Above Pathfinder Dam Subbasin Current and Projected Annual Water Demand Annual Diversions in Acre-Feet per Year, Mid Scenario

	Current (2015)		Projected (2045)	
Economic Sector	**Normal**	**Max**	**Normal**	**Max**
Agricultural				
Irrigation				
Alfalfa	20,000	27,000	17,000	23,000
Other hay	164,000	216,000	141,000	185,000
Irrigated pasture	94,000	132,000	81,000	113,000
Corn	0	0	0	0
Sugar beets	0	0	0	0
Dry beans	0	0	0	0
Oats	0	1,000	0	0
Barley	1,000	1,000	1,000	1,000
Winter wheat	0	0	0	0
Spring wheat	0	0	0	0
Subtotal	279,000	377,000	240,000	322,000
Livestock	1,000	1,000	1,000	1,000
Municipal/Rural Domestic	6,300	8,700	7,600	10,500
Industrial				
Oil refining and production	15,500	15,500	17,100	17,100
Coal and uranium mining	300	300	3,500	3,500
Power generation	0	0	0	0
Miscellaneous and other	3,100	3,100	3,200	3,200
Total Water Usage	305,200	405,600	272,400	357,300
Surface Water	267,000	356,200	232,300	307,500
Ground Water	38,200	49,400	40,100	49,800
Share Water Usage				
Surface Water	87%	88%	85%	86%
Ground Water	13%	12%	15%	14%

Source: Harvey Economics, 2016.

Exhibit 4-A-6: Above Pathfinder Dam Subbasin Current and Projected Annual Water Demand Annual Consumptive Use in Acre-Feet per Year, Mid Scenario

	Current (2015)		Projected (2045)	
Economic Sector	**Normal**	**Max**	**Normal**	**Max**
Agricultural				
Irrigation				
Alfalfa	9,000	12,000	7,000	10,000
Other hay	71,000	92,000	61,000	80,000
Irrigated pasture	41,000	56,000	35,000	49,000
Corn	0	0	0	0
Sugar beets	0	0	0	0
Dry beans	0	0	0	0
Oats	0	0	0	0
Barley	0	1,000	0	0
Winter wheat	0	0	0	0
Spring wheat	0	0	0	0
Subtotal	121,000	161,000	103,000	139,000
Livestock	1,000	1,000	1,000	1,000
Municipal/Rural Domestic	3,100	4,400	3,800	5,100
Industrial				
Oil refining and production	15,500	15,500	17,100	17,100
Coal and uranium mining	300	300	3,500	3,500
Power generation	0	0	0	0
Miscellaneous and other	3,100	3,100	3,200	3,200
Total Water Usage	144,000	185,300	131,600	168,900
Surface Water	118,800	155,400	103,000	136,000
Ground Water	25,200	29,900	28,600	32,900
Share Water Usage				
Surface Water	83%	84%	78%	81%
Ground Water	18%	16%	22%	19%

Source: Harvey Economics, 2016.

Exhibit 4-A-7: Pathfinder to Guernsey Subbasin Current and Projected Annual Water Demand Annual Diversions in Acre-Feet per Year, High Scenario

	Current (2015)		Projected (2045)	
Economic Sector	**Normal**	**Max**	**Normal**	**Max**
Agricultural				
Irrigation				
Alfalfa	98,000	119,000	137,000	167,000
Other hay	36,000	57,000	50,000	79,000
Irrigated pasture	24,000	43,000	33,000	60,000
Corn	4,000	4,000	5,000	6,000
Sugar beets	2,000	2,000	2,000	2,000
Dry beans	2,000	2,000	2,000	3,000
Oats	7,000	6,000	9,000	9,000
Barley	4,000	4,000	5,000	6,000
Winter wheat	0	1,000	1,000	1,000
Spring wheat	0	1,000	1,000	1,000
Subtotal	177,000	239,000	245,000	334,000
Livestock	1,500	1,500	1,800	1,800
Municipal/Rural Domestic	21,000	30,500	40,000	58,500
Industrial				
Oil refining and production	25,000	25,000	30,000	30,000
Coal and uranium mining	28,300	28,300	38,300	38,300
Power generation	8,000	8,000	18,000	18,000
Miscellaneous and other	23,900	23,900	27,500	27,500
Total Water Usage	284,700	356,200	400,600	508,100
Surface Water	188,400	250,800	267,100	360,400
Ground Water	96,300	105,400	133,500	147,700
Share Water Usage				
Surface Water	66%	70%	67%	71%
Ground Water	34%	30%	33%	29%

Source: Harvey Economics, 2016.

Exhibit 4-A-8: Pathfinder to Guernsey Subbasin Current and Projected Annual Water Demand Annual Consumptive Use in Acre-Feet per Year, High Scenario

	Current (2015)		Projected (2045)	
Economic Sector	**Normal**	**Max**	**Normal**	**Max**
Agricultural				
Irrigation				
Alfalfa	42,000	51,000	58,000	71,000
Other hay	15,000	24,000	21,000	34,000
Irrigated pasture	10,000	18,000	14,000	25,000
Corn	2,000	2,000	2,000	3,000
Sugar beets	1,000	1,000	1,000	1,000
Dry beans	1,000	1,000	1,000	1,000
Oats	3,000	3,000	4,000	4,000
Barley	2,000	2,000	2,000	2,000
Winter wheat	0	0	0	1,000
Spring wheat	0	0	0	0
Subtotal	76,000	102,000	103,000	142,000
Livestock	1,500	1,500	1,800	1,800
Municipal/Rural Domestic	10,700	15,500	20,000	29,300
Industrial				
Oil refining and production	25,000	25,000	30,000	30,000
Coal and uranium mining	28,300	28,300	38,300	38,300
Power generation	8,000	8,000	18,000	18,000
Miscellaneous and other	23,900	23,900	27,500	27,500
Total Water Usage	173,400	204,200	238,600	286,900
Surface Water	87,400	114,200	121,000	162,800
Ground Water	86,000	90,000	117,600	124,100
Share Water Usage				
Surface Water	50%	56%	51%	57%
Ground Water	50%	44%	49%	43%

Source: Harvey Economics, 2016.

Exhibit 4-A-9: Pathfinder to Guernsey Subbasin Current and Projected Annual Water Demand Annual Diversions in Acre-Feet per Year, Low Scenario

	Current (2015)		Projected (2045)	
Economic Sector	**Normal**	**Max**	**Normal**	**Max**
Agricultural				
Irrigation				
Alfalfa	98,000	119,000	55,000	67,000
Other hay	36,000	57,000	20,000	32,000
Irrigated pasture	24,000	43,000	13,000	24,000
Corn	4,000	4,000	2,000	2,000
Sugar beets	2,000	2,000	1,000	1,000
Dry beans	2,000	2,000	1,000	1,000
Oats	7,000	6,000	4,000	4,000
Barley	4,000	4,000	2,000	2,000
Winter wheat	0	1,000	0	1,000
Spring wheat	0	1,000	0	0
Subtotal	177,000	239,000	98,000	134,000
Livestock	1,500	1,500	1,100	1,100
Municipal/Rural Domestic	21,000	30,500	25,100	36,860
Industrial				
Oil refining and production	25,000	25,000	25,000	25,000
Coal and uranium mining	28,300	28,300	28,300	28,300
Power generation	8,000	8,000	8,000	8,000
Miscellaneous and other	23,900	23,900	23,400	23,400
Total Water Usage	284,700	356,200	208,900	256,660
Surface Water	188,400	250,800	118,200	159,200
Ground Water	96,300	105,400	90,700	97,460
Share Water Usage				
Surface Water	66%	70%	57%	62%
Ground Water	34%	30%	43%	38%

Source: Harvey Economics, 2016.

Exhibit 4-A-10: Pathfinder to Guernsey Subbasin Current and Projected Annual Water Demand Annual Consumptive Use in Acre-Feet per Year, Low Scenario

	Current (2015)		Projected (2045)	
Economic Sector	**Normal**	**Max**	**Normal**	**Max**
Agricultural				
Irrigation				
Alfalfa	42,000	51,000	24,000	29,000
Other hay	15,000	24,000	9,000	14,000
Irrigated pasture	10,000	18,000	6,000	10,000
Corn	2,000	2,000	1,000	1,000
Sugar beets	1,000	1,000	0	0
Dry beans	1,000	1,000	0	1,000
Oats	3,000	3,000	2,000	2,000
Barley	2,000	2,000	1,000	1,000
Winter wheat	0	0	0	0
Spring wheat	0	0	0	0
Subtotal	76,000	102,000	43,000	58,000
Livestock	1,500	1,500	1,100	1,100
Municipal/Rural Domestic	10,700	15,500	12,630	18,490
Industrial				
Oil refining and production	25,000	25,000	25,000	25,000
Coal and uranium mining	28,300	28,300	28,300	28,300
Power generation	8,000	8,000	8,000	8,000
Miscellaneous and other	23,900	23,900	23,400	23,400
Total Water Usage	173,400	204,200	141,430	162,290
Surface Water	87,400	114,200	58,100	75,900
Ground Water	86,000	90,000	83,330	86,390
Share Water Usage				
Surface Water	50%	56%	41%	47%
Ground Water	50%	44%	59%	53%

Source: Harvey Economics, 2016.

Exhibit 4-A-11: Pathfinder to Guernsey Subbasin Current and Projected Annual Water Demand Annual Diversions in Acre-Feet per Year, Mid Scenario

	Current (2015)		Projected (2045)	
Economic Sector	**Normal**	**Max**	**Normal**	**Max**
Agricultural				
Irrigation				
Alfalfa	98,000	119,000	77,000	93,000
Other hay	36,000	57,000	28,000	44,000
Irrigated pasture	24,000	43,000	19,000	33,000
Corn	4,000	4,000	3,000	3,000
Sugar beets	2,000	2,000	1,000	1,000
Dry beans	2,000	2,000	1,000	2,000
Oats	7,000	6,000	5,000	5,000
Barley	4,000	4,000	3,000	3,000
Winter wheat	0	1,000	0	1,000
Spring wheat	0	1,000	0	1,000
Subtotal	177,000	239,000	137,000	186,000
Livestock	1,500	1,500	1,500	1,500
Municipal/Rural Domestic	21,000	30,500	30,000	43,600
Industrial				
Oil refining and production	25,000	25,000	27,500	27,500
Coal and uranium mining	28,300	28,300	35,100	35,100
Power generation	8,000	8,000	8,000	8,000
Miscellaneous and other	23,900	23,900	25,000	25,000
Total Water Usage	284,700	356,200	264,100	326,700
Surface Water	188,400	250,800	158,700	212,600
Ground Water	96,300	105,400	105,400	114,100
Share Water Usage				
Surface Water	66%	70%	60%	65%
Ground Water	34%	30%	40%	35%

Source: Harvey Economics, 2016.

Exhibit 4-A-12: Pathfinder to Guernsey Subbasin Current and Projected Annual Water Demand Annual Consumptive Use in Acre-Feet per Year, Mid Scenario

	Current (2015)		Projected (2045)	
Economic Sector	**Normal**	**Max**	**Normal**	**Max**
Agricultural				
Irrigation				
Alfalfa	42,000	51,000	33,000	40,000
Other hay	15,000	24,000	12,000	19,000
Irrigated pasture	10,000	18,000	8,000	14,000
Corn	2,000	2,000	1,000	1,000
Sugar beets	1,000	1,000	0	1,000
Dry beans	1,000	1,000	1,000	1,000
Oats	3,000	3,000	2,000	2,000
Barley	2,000	2,000	1,000	1,000
Winter wheat	0	0	0	0
Spring wheat	0	0	0	0
Subtotal	76,000	102,000	58,000	79,000
Livestock	1,500	1,500	1,500	1,500
Municipal/Rural Domestic	10,700	15,500	15,000	21,800
Industrial				
Oil refining and production	25,000	25,000	27,500	27,500
Coal and uranium mining	28,300	28,300	35,100	35,100
Power generation	8,000	8,000	8,000	8,000
Miscellaneous and other	23,900	23,900	25,000	25,000
Total Water Usage	173,400	204,200	170,100	197,900
Surface Water	87,400	114,200	74,500	98,400
Ground Water	86,000	90,000	95,600	99,500
Share Water Usage				
Surface Water	50%	56%	44%	50%
Ground Water	50%	44%	56%	50%

Source: Harvey Economics, 2016.

Exhibit 4-A-13: Guernsey to State Line Subbasin Current and Projected Annual Water Demand Annual Diversions in Acre-Feet per Year, High Scenario

	Current (2015)		Projected (2045)	
Economic Sector	**Normal**	**Max**	**Normal**	**Max**
Agricultural				
Irrigation				
Alfalfa	68,000	109,000	72,000	115,000
Other hay	25,000	28,000	26,000	30,000
Irrigated pasture	31,000	37,000	33,000	40,000
Corn	66,000	89,000	70,000	94,000
Sugar beets	33,000	44,000	35,000	47,000
Dry beans	17,000	25,000	18,000	26,000
Oats	2,000	3,000	2,000	3,000
Barley	5,000	7,000	5,000	8,000
Winter wheat	2,000	3,000	2,000	3,000
Spring wheat	0	0	0	0
Subtotal	249,000	345,000	263,000	366,000
Livestock	700	700	800	800
Municipal/Rural Domestic	3,600	5,300	4,700	6,900
Industrial				
Oil refining and production	800	800	1,000	1,000
Coal and uranium mining	0	0	0	0
Power generation	0	0	0	0
Miscellaneous and other	3,400	3,400	4,000	4,000
Total Water Usage	257,500	355,200	273,500	378,700
Surface Water	233,200	320,400	247,400	341,200
Ground Water	24,300	34,800	26,100	37,500
Share Water Usage				
Surface Water	91%	90%	90%	90%
Ground Water	9%	10%	10%	10%

Source: Harvey Economics, 2016.

Exhibit 4-A-14: Guernsey to State Line Subbasin Current and Projected Annual Water Demand Annual Consumptive Use in Acre-Feet per Year, High Scenario

	Current (2015)		Projected (2045)	
Economic Sector	**Normal**	**Max**	**Normal**	**Max**
Agricultural				
Irrigation				
Alfalfa	29,000	46,000	31,000	49,000
Other hay	11,000	12,000	11,000	13,000
Irrigated pasture	13,000	16,000	14,000	17,000
Corn	29,000	38,000	30,000	40,000
Sugar beets	14,000	19,000	15,000	20,000
Dry beans	7,000	11,000	8,000	11,000
Oats	1,000	1,000	1,000	1,000
Barley	2,000	3,000	2,000	3,000
Winter wheat	1,000	1,000	1,000	1,000
Spring wheat	0	0	0	0
Subtotal	107,000	147,000	113,000	155,000
Livestock	700	700	800	800
Municipal/Rural Domestic	1,800	2,700	2,500	3,600
Industrial				
Oil refining and production	800	800	1,000	1,000
Coal and uranium mining	0	0	0	0
Power generation	0	0	0	0
Miscellaneous and other	3,400	3,400	4,000	4,000
Total Water Usage	113,700	154,600	121,300	164,400
Surface Water	100,800	137,200	107,300	145,600
Ground Water	12,900	17,400	14,000	18,800
Share Water Usage				
Surface Water	89%	89%	88%	89%
Ground Water	11%	11%	12%	11%

Source: Harvey Economics, 2016.

Exhibit 4-A-15: Guernsey to State Line Subbasin Current and Projected Annual Water Demand Annual Diversions in Acre-Feet per Year, Low Scenario

	Current (2015)		Projected (2045)	
Economic Sector	**Normal**	**Max**	**Normal**	**Max**
Agricultural				
Irrigation				
Alfalfa	68,000	109,000	62,000	98,000
Other hay	25,000	28,000	22,000	25,000
Irrigated pasture	31,000	37,000	28,000	34,000
Corn	66,000	89,000	60,000	80,000
Sugar beets	33,000	44,000	30,000	40,000
Dry beans	17,000	25,000	15,000	22,000
Oats	2,000	3,000	2,000	2,000
Barley	5,000	7,000	5,000	7,000
Winter wheat	2,000	3,000	2,000	3,000
Spring wheat	0	0	0	0
Subtotal	249,000	345,000	226,000	311,000
Livestock	700	700	700	700
Municipal/Rural Domestic	3,600	5,300	3,900	5,700
Industrial				
Oil refining and production	800	800	800	800
Coal and uranium mining	0	0	0	0
Power generation	0	0	0	0
Miscellaneous and other	3,400	3,400	2,600	2,600
Total Water Usage	257,500	355,200	234,000	320,800
Surface Water	233,200	320,400	212,300	289,600
Ground Water	24,300	34,800	21,700	31,200
Share Water Usage				
Surface Water	91%	90%	91%	90%
Ground Water	9%	10%	9%	10%

Source: Harvey Economics, 2016.

Exhibit 4-A-16: Guernsey to State Line Subbasin Current and Projected Annual Water Demand Annual Consumptive Use in Acre-Feet per Year, Low Scenario

	Current (2015)		Projected (2045)	
Economic Sector	**Normal**	**Max**	**Normal**	**Max**
Agricultural				
Irrigation				
Alfalfa	29,000	46,000	27,000	43,000
Other hay	11,000	12,000	10,000	11,000
Irrigated pasture	13,000	16,000	12,000	15,000
Corn	29,000	38,000	26,000	35,000
Sugar beets	14,000	19,000	13,000	17,000
Dry beans	7,000	11,000	7,000	10,000
Oats	1,000	1,000	1,000	1,000
Barley	2,000	3,000	2,000	3,000
Winter wheat	1,000	1,000	1,000	1,000
Spring wheat	0	0	0	0
Subtotal	107,000	147,000	99,000	136,000
Livestock	700	700	700	700
Municipal/Rural Domestic	1,800	2,700	2,000	3,000
Industrial				
Oil refining and production	800	800	800	800
Coal and uranium mining	0	0	0	0
Power generation	0	0	0	0
Miscellaneous and other	3,400	3,400	2,600	2,600
Total Water Usage	113,700	154,600	105,100	143,100
Surface Water	100,800	137,200	93,700	127,500
Ground Water	12,900	17,400	11,400	15,600
Share Water Usage				
Surface Water	89%	89%	89%	89%
Ground Water	11%	11%	11%	11%

Source: Harvey Economics, 2016.

Exhibit 4-A-17: Guernsey to State Line Subbasin Current and Projected Annual Water Demand Annual Diversions in Acre-Feet per Year, Mid Scenario

	Current (2015)		Projected (2045)	
Economic Sector	**Normal**	**Max**	**Normal**	**Max**
Agricultural				
Irrigation				
Alfalfa	68,000	109,000	66,000	104,000
Other hay	25,000	28,000	24,000	27,000
Irrigated pasture	31,000	37,000	30,000	36,000
Corn	66,000	89,000	63,000	85,000
Sugar beets	33,000	44,000	32,000	42,000
Dry beans	17,000	25,000	16,000	24,000
Oats	2,000	3,000	2,000	3,000
Barley	5,000	7,000	5,000	7,000
Winter wheat	2,000	3,000	2,000	3,000
Spring wheat	0	0	0	0
Subtotal	249,000	345,000	240,000	331,000
Livestock	700	700	700	700
Municipal/Rural Domestic	3,600	5,300	4,100	6,200
Industrial				
Oil refining and production	800	800	900	900
Coal and uranium mining	0	0	0	0
Power generation	0	0	0	0
Miscellaneous and other	3,400	3,400	2,700	2,700
Total Water Usage	257,500	355,200	248,400	341,500
Surface Water	233,200	320,400	225,500	308,400
Ground Water	24,300	34,800	22,900	33,100
Share Water Usage				
Surface Water	91%	90%	91%	90%
Ground Water	9%	10%	9%	10%

Source: Harvey Economics, 2016.

Exhibit 4-A-18: Guernsey to State Line Subbasin Current and Projected Annual Water Demand Annual Consumptive Use in Acre-Feet per Year, Mid Scenario

	Current (2015)		Projected (2045)	
Economic Sector	**Normal**	**Max**	**Normal**	**Max**
Agricultural				
Irrigation				
Alfalfa	29,000	46,000	28,000	45,000
Other hay	11,000	12,000	10,000	11,000
Irrigated pasture	13,000	16,000	13,000	15,000
Corn	29,000	38,000	28,000	37,000
Sugar beets	14,000	19,000	14,000	18,000
Dry beans	7,000	11,000	7,000	10,000
Oats	1,000	1,000	1,000	1,000
Barley	2,000	3,000	2,000	3,000
Winter wheat	1,000	1,000	1,000	1,000
Spring wheat	0	0	0	0
Subtotal	107,000	147,000	104,000	141,000
Livestock	700	700	700	700
Municipal/Rural Domestic	1,800	2,700	2,100	3,200
Industrial				
Oil refining and production	800	800	900	900
Coal and uranium mining	0	0	0	0
Power generation	0	0	0	0
Miscellaneous and other	3,400	3,400	2,700	2,700
Total Water Usage	113,700	154,600	110,400	148,500
Surface Water	100,800	137,200	98,400	132,300
Ground Water	12,900	17,400	12,000	16,200
Share Water Usage				
Surface Water	89%	89%	89%	89%
Ground Water	11%	11%	11%	11%

Source: Harvey Economics, 2016.

Exhibit 4-A-19: Upper Laramie Subbasin Current and Projected Annual Water Demand
Annual Diversions in Acre-Feet per Year, Low Scenario

	Current (2015)		Projected (2045)	
Economic Sector	**Normal**	**Max**	**Normal**	**Max**
Agricultural				
Irrigation				
Alfalfa	7,000	10,000	7,000	10,000
Other hay	112,000	177,000	113,000	179,000
Irrigated pasture	69,000	121,000	70,000	123,000
Corn	0	0	0	0
Sugar beets	0	0	0	0
Dry beans	0	0	0	0
Oats	0	0	0	0
Barley	0	0	0	0
Winter wheat	0	0	0	0
Spring wheat	0	0	0	0
Subtotal	188,000	308,000	190,000	312,000
Livestock	600	600	600	600
Municipal/Rural Domestic	7,100	10,600	9,100	13,500
Industrial				
Oil refining and production	100	100	100	100
Coal and uranium mining	0	0	0	0
Power generation	0	0	0	0
Miscellaneous and other	2,700	2,700	3,600	3,600
Total Water Usage	198,500	322,000	203,400	329,800
Surface Water	180,400	291,300	184,200	297,600
Ground Water	18,100	30,700	19,200	32,200
Share Water Usage				
Surface Water	91%	90%	91%	90%
Ground Water	9%	10%	9%	10%

Source: Harvey Economics, 2016.

Exhibit 4-A-20: Upper Laramie Subbasin Current and Projected Annual Water Demand
Annual Consumptive Use in Acre-Feet per Year, Low Scenario

	Current (2015)		Projected (2045)	
Economic Sector	**Normal**	**Max**	**Normal**	**Max**
Agricultural				
Irrigation				
Alfalfa	3,000	4,000	3,000	4,000
Other hay	48,000	75,000	48,000	75,000
Irrigated pasture	30,000	52,000	30,000	52,000
Corn	0	0	0	0
Sugar beets	0	0	0	0
Dry beans	0	0	0	0
Oats	0	0	0	0
Barley	0	0	0	0
Winter wheat	0	0	0	0
Spring wheat	0	0	0	0
Subtotal	81,000	131,000	81,000	131,000
Livestock	600	600	600	600
Municipal/Rural Domestic	3,600	5,300	4,500	6,700
Industrial				
Oil refining and production	100	100	100	100
Coal and uranium mining	0	0	0	0
Power generation	0	0	0	0
Miscellaneous and other	2,700	2,700	3,600	3,600
Total Water Usage	88,000	139,700	89,800	142,000
Surface Water	79,000	125,400	80,200	126,900
Ground Water	9,000	14,300	9,600	15,100
Share Water Usage				
Surface Water	90%	90%	89%	89%
Ground Water	10%	10%	11%	11%

Source: Harvey Economics, 2016.

Exhibit 4-A-21: Upper Laramie Subbasin Current and Projected Annual Water Demand
Annual Diversions in Acre-Feet per Year, High Scenario

	Current (2015)		Projected (2045)	
Economic Sector	**Normal**	**Max**	**Normal**	**Max**
Agricultural				
Irrigation				
Alfalfa	7,000	10,000	8,000	12,000
Other hay	112,000	177,000	137,000	215,000
Irrigated pasture	69,000	121,000	85,000	148,000
Corn	0	0	0	0
Sugar beets	0	0	0	0
Dry beans	0	0	0	0
Oats	0	0	0	0
Barley	0	0	0	0
Winter wheat	0	0	0	0
Spring wheat	0	0	0	0
Subtotal	188,000	308,000	230,000	375,000
Livestock	600	600	500	500
Municipal/Rural Domestic	7,080	10,620	7,880	11,720
Industrial				
Oil refining and production	100	100	100	100
Coal and uranium mining	0	0	0	0
Power generation	0	0	0	0
Miscellaneous and other	2,700	2,700	2,800	2,800
Total Water Usage	198,480	322,020	241,280	390,120
Surface Water	180,400	291,300	219,700	353,400
Ground Water	18,080	30,720	21,580	36,720
Share Water Usage				
Surface Water	91%	90%	91%	91%
Ground Water	9%	10%	9%	9%

Source: Harvey Economics, 2016.

Exhibit 4-A-22: Upper Laramie Subbasin Current and Projected Annual Water Demand
Annual Consumptive Use in Acre-Feet per Year, High Scenario

	Current (2015)		Projected (2045)	
Economic Sector	**Normal**	**Max**	**Normal**	**Max**
Agricultural				
Irrigation				
Alfalfa	3,000	4,000	4,000	5,000
Other hay	48,000	75,000	60,000	93,000
Irrigated pasture	30,000	52,000	37,000	64,000
Corn	0	0	0	0
Sugar beets	0	0	0	0
Dry beans	0	0	0	0
Oats	0	0	0	0
Barley	0	0	0	0
Winter wheat	0	0	0	0
Spring wheat	0	0	0	0
Subtotal	81,000	131,000	101,000	162,000
Livestock	600	600	500	500
Municipal/Rural Domestic	3,590	5,290	3,890	5,890
Industrial				
Oil refining and production	100	100	100	100
Coal and uranium mining	0	0	0	0
Power generation	0	0	0	0
Miscellaneous and other	2,700	2,700	2,800	2,800
Total Water Usage	87,990	139,690	108,290	171,290
Surface Water	79,000	125,400	97,700	154,200
Ground Water	8,990	14,290	10,590	17,090
Share Water Usage				
Surface Water	90%	90%	90%	90%
Ground Water	10%	10%	10%	10%

Source: Harvey Economics, 2016.

Exhibit 4-A-23: Upper Laramie Subbasin Current and Projected Annual Water Demand
Annual Diversions in Acre-Feet per Year, Mid Scenario

	Current (2015)		Projected (2045)	
Economic Sector	**Normal**	**Max**	**Normal**	**Max**
Agricultural				
Irrigation				
Alfalfa	7,000	10,000	7,000	11,000
Other hay	112,000	177,000	122,000	192,000
Irrigated pasture	69,000	121,000	76,000	132,000
Corn	0	0	0	0
Sugar beets	0	0	0	0
Dry beans	0	0	0	0
Oats	0	0	0	0
Barley	0	0	0	0
Winter wheat	0	0	0	0
Spring wheat	0	0	0	0
Subtotal	188,000	308,000	205,000	335,000
Livestock	600	600	600	600
Municipal/Rural Domestic	7,080	10,620	8,280	12,320
Industrial				
Oil refining and production	100	100	100	100
Coal and uranium mining	0	0	0	0
Power generation	0	0	0	0
Miscellaneous and other	2,700	2,700	3,200	3,200
Total Water Usage	198,480	322,020	217,180	351,220
Surface Water	180,400	291,300	197,200	317,600
Ground Water	18,080	30,720	19,980	33,620
Share Water Usage				
Surface Water	91%	90%	91%	90%
Ground Water	9%	10%	9%	10%

Source: Harvey Economics, 2016.

Exhibit 4-A-24: Upper Laramie Subbasin Current and Projected Annual Water Demand
Annual Consumptive Use in Acre-Feet per Year, Mid Scenario

	Current (2015)		Projected (2045)	
Economic Sector	**Normal**	**Max**	**Normal**	**Max**
Agricultural				
Irrigation				
Alfalfa	3,000	4,000	3,000	5,000
Other hay	48,000	75,000	53,000	83,000
Irrigated pasture	30,000	52,000	33,000	57,000
Corn	0	0	0	0
Sugar beets	0	0	0	0
Dry beans	0	0	0	0
Oats	0	0	0	0
Barley	0	0	0	0
Winter wheat	0	0	0	0
Spring wheat	0	0	0	0
Subtotal	81,000	131,000	89,000	145,000
Livestock	600	600	600	600
Municipal/Rural Domestic	3,590	5,290	4,090	6,190
Industrial				
Oil refining and production	100	100	100	100
Coal and uranium mining	0	0	0	0
Power generation	0	0	0	0
Miscellaneous and other	2,700	2,700	3,200	3,200
Total Water Usage	87,990	139,690	96,990	155,090
Surface Water	79,000	125,400	87,000	139,100
Ground Water	8,990	14,290	9,990	15,990
Share Water Usage				
Surface Water	90%	90%	90%	90%
Ground Water	10%	10%	10%	10%

Source: Harvey Economics, 2016.

Exhibit 4-A-25: Lower Laramie Subbasin Current and Projected Annual Water Demand
Annual Diversions in Acre-Feet per Year, High Scenario

	Current (2015)		Projected (2045)	
Economic Sector	**Normal**	**Max**	**Normal**	**Max**
Agricultural				
Irrigation				
Alfalfa	64,000	84,000	89,000	117,000
Other hay	58,000	80,000	81,000	113,000
Irrigated pasture	30,000	47,000	41,000	65,000
Corn	20,000	27,000	27,000	37,000
Sugar beets	11,000	16,000	15,000	23,000
Dry beans	8,000	12,000	12,000	16,000
Oats	3,000	5,000	4,000	7,000
Barley	5,000	6,000	7,000	9,000
Winter wheat	2,000	2,000	3,000	3,000
Spring wheat	0	0	0	0
Subtotal	201,000	279,000	279,000	390,000
Livestock	800	800	1,200	1,200
Municipal/Rural Domestic	2,500	3,500	3,700	5,200
Industrial				
Oil refining and production	800	800	900	900
Coal and uranium mining	0	0	0	0
Power generation	18,500	18,500	18,500	18,500
Miscellaneous and other	800	800	1,200	1,200
Total Water Usage	224,400	303,400	304,500	417,000
Surface Water	205,200	275,700	278,800	379,200
Ground Water	19,200	27,700	25,700	37,800
Share Water Usage				
Surface Water	91%	91%	92%	91%
Ground Water	9%	9%	8%	9%

Source: Harvey Economics, 2016.

Exhibit 4-A-26: Lower Laramie Subbasin Current and Projected Annual Water Demand
Annual Consumptive Use in Acre-Feet per Year, High Scenario

	Current (2015)		Projected (2045)	
Economic Sector	**Normal**	**Max**	**Normal**	**Max**
Agricultural				
Irrigation				
Alfalfa	28,000	36,000	38,000	49,000
Other hay	25,000	34,000	34,000	48,000
Irrigated pasture	13,000	20,000	17,000	27,000
Corn	9,000	11,000	12,000	16,000
Sugar beets	5,000	7,000	7,000	10,000
Dry beans	4,000	5,000	5,000	7,000
Oats	1,000	2,000	2,000	3,000
Barley	2,000	3,000	3,000	4,000
Winter wheat	1,000	1,000	1,000	1,000
Spring wheat	0	0	0	0
Subtotal	88,000	119,000	119,000	165,000
Livestock	800	800	1,200	1,200
Municipal/Rural Domestic	1,200	1,800	1,900	2,600
Industrial				
Oil refining and production	800	800	900	900
Coal and uranium mining	0	0	0	0
Power generation	18,500	18,500	18,500	18,500
Miscellaneous and other	800	800	1,200	1,200
Total Water Usage	110,100	141,700	142,700	189,400
Surface Water	99,900	128,000	129,800	171,400
Ground Water	10,200	13,700	12,900	18,000
Share Water Usage				
Surface Water	91%	90%	91%	90%
Ground Water	9%	10%	9%	10%

Source: Harvey Economics, 2016.

Exhibit 4-A-27: Lower Laramie Subbasin Current and Projected Annual Water Demand
Annual Diversions in Acre-Feet per Year, Low Scenario

	Current (2015)		Projected (2045)	
Economic Sector	**Normal**	**Max**	**Normal**	**Max**
Agricultural				
Irrigation				
Alfalfa	64,000	84,000	36,000	47,000
Other hay	58,000	80,000	33,000	45,000
Irrigated pasture	30,000	47,000	17,000	26,000
Corn	20,000	27,000	11,000	15,000
Sugar beets	11,000	16,000	6,000	9,000
Dry beans	8,000	12,000	5,000	7,000
Oats	3,000	5,000	2,000	3,000
Barley	5,000	6,000	3,000	4,000
Winter wheat	2,000	2,000	1,000	1,000
Spring wheat	0	0	0	0
Subtotal	201,000	279,000	114,000	157,000
Livestock	800	800	700	700
Municipal/Rural Domestic	2,500	3,500	2,700	3,900
Industrial				
Oil refining and production	800	800	800	800
Coal and uranium mining	0	0	0	0
Power generation	18,500	18,500	18,500	18,500
Miscellaneous and other	800	800	800	800
Total Water Usage	224,400	303,400	137,500	181,700
Surface Water	205,200	275,700	125,000	164,400
Ground Water	19,200	27,700	12,500	17,300
Share Water Usage				
Surface Water	91%	91%	91%	90%
Ground Water	9%	9%	9%	10%

Source: Harvey Economics, 2016.

Exhibit 4-A-28: Lower Laramie Subbasin Current and Projected Annual Water Demand
Annual Consumptive Use in Acre-Feet per Year, Low Scenario

	Current (2015)		Projected (2045)	
Economic Sector	**Normal**	**Max**	**Normal**	**Max**
Agricultural				
Irrigation				
Alfalfa	28,000	36,000	16,000	20,000
Other hay	25,000	34,000	14,000	20,000
Irrigated pasture	13,000	20,000	7,000	11,000
Corn	9,000	11,000	5,000	6,000
Sugar beets	5,000	7,000	3,000	4,000
Dry beans	4,000	5,000	2,000	3,000
Oats	1,000	2,000	1,000	1,000
Barley	2,000	3,000	1,000	2,000
Winter wheat	1,000	1,000	0	1,000
Spring wheat	0	0	0	0
Subtotal	88,000	119,000	49,000	68,000
Livestock	800	800	700	700
Municipal/Rural Domestic	1,200	1,800	1,300	2,000
Industrial				
Oil refining and production	800	800	800	800
Coal and uranium mining	0	0	0	0
Power generation	18,500	18,500	18,500	18,500
Miscellaneous and other	800	800	800	800
Total Water Usage	110,100	141,700	71,100	90,800
Surface Water	99,900	128,000	64,000	81,500
Ground Water	10,200	13,700	7,100	9,300
Share Water Usage				
Surface Water	91%	90%	90%	90%
Ground Water	9%	10%	10%	10%

Source: Harvey Economics, 2016.

Exhibit 4-A-29: Lower Laramie Subbasin Current and Projected Annual Water Demand
Annual Diversions in Acre-Feet per Year, Mid Scenario

	Current (2015)		Projected (2045)	
Economic Sector	**Normal**	**Max**	**Normal**	**Max**
Agricultural				
Irrigation				
Alfalfa	64,000	84,000	50,000	66,000
Other hay	58,000	80,000	45,000	63,000
Irrigated pasture	30,000	47,000	23,000	36,000
Corn	20,000	27,000	15,000	21,000
Sugar beets	11,000	16,000	9,000	13,000
Dry beans	8,000	12,000	6,000	9,000
Oats	3,000	5,000	2,000	4,000
Barley	5,000	6,000	4,000	5,000
Winter wheat	2,000	2,000	1,000	2,000
Spring wheat	0	0	0	0
Subtotal	201,000	279,000	155,000	219,000
Livestock	800	800	800	800
Municipal/Rural Domestic	2,500	3,500	3,000	4,200
Industrial				
Oil refining and production	800	800	900	900
Coal and uranium mining	0	0	0	0
Power generation	18,500	18,500	18,500	18,500
Miscellaneous and other	800	800	1,000	1,000
Total Water Usage	224,400	303,400	179,200	244,400
Surface Water	205,200	275,700	163,300	221,500
Ground Water	19,200	27,700	15,900	22,900
Share Water Usage				
Surface Water	91%	91%	91%	91%
Ground Water	9%	9%	9%	9%

Source: Harvey Economics, 2016.

Exhibit 4-A-30: Lower Laramie Subbasin Current and Projected Annual Water Demand
Annual Consumptive Use in Acre-Feet per Year, Mid Scenario

	Current (2015)		Projected (2045)	
Economic Sector	**Normal**	**Max**	**Normal**	**Max**
Agricultural				
Irrigation				
Alfalfa	28,000	36,000	22,000	28,000
Other hay	25,000	34,000	20,000	27,000
Irrigated pasture	13,000	20,000	10,000	16,000
Corn	9,000	11,000	7,000	9,000
Sugar beets	5,000	7,000	4,000	5,000
Dry beans	4,000	5,000	3,000	4,000
Oats	1,000	2,000	1,000	2,000
Barley	2,000	3,000	2,000	2,000
Winter wheat	1,000	1,000	1,000	1,000
Spring wheat	0	0	0	0
Subtotal	88,000	119,000	70,000	94,000
Livestock	800	800	800	800
Municipal/Rural Domestic	1,200	1,800	1,400	2,200
Industrial				
Oil refining and production	800	800	900	900
Coal and uranium mining	0	0	0	0
Power generation	18,500	18,500	18,500	18,500
Miscellaneous and other	800	800	1,000	1,000
Total Water Usage	110,100	141,700	92,600	117,400
Surface Water	99,900	128,000	83,600	105,600
Ground Water	10,200	13,700	9,000	11,800
Share Water Usage				
Surface Water	91%	90%	90%	90%
Ground Water	9%	10%	10%	10%

Source: Harvey Economics, 2016.

Exhibit 4-A-31: Horse Creek Subbasin Current and Projected Annual Water Demand
Annual Diversions in Acre-Feet per Year, High Scenario

	Current (2015)		Projected (2045)	
Economic Sector	**Normal**	**Max**	**Normal**	**Max**
Agricultural				
Irrigation				
Alfalfa	31,000	41,000	44,000	59,000
Other hay	12,000	25,000	18,000	37,000
Irrigated pasture	7,000	25,000	10,000	37,000
Corn	30,000	32,000	44,000	46,000
Sugar beets	15,000	17,000	21,000	24,000
Dry beans	8,000	9,000	11,000	13,000
Oats	2,000	1,000	2,000	2,000
Barley	3,000	4,000	4,000	6,000
Winter wheat	3,000	3,000	4,000	4,000
Spring wheat	0	0	0	0
Subtotal	111,000	157,000	158,000	228,000
Livestock	500	500	600	600
Municipal/Rural Domestic	600	800	900	1,400
Industrial				
Oil refining and production	500	500	600	600
Coal and uranium mining	0	0	0	0
Power generation	0	0	0	0
Miscellaneous and other	7,400	7,400	8,500	8,500
Total Water Usage	120,000	166,200	168,600	239,100
Surface Water	103,600	144,900	147,600	210,700
Ground Water	16,400	21,300	21,000	28,400
Share Water Usage				
Surface Water	86%	87%	88%	88%
Ground Water	14%	13%	12%	12%

Source: Harvey Economics, 2016.

Exhibit 4-A-32: Horse Creek Subbasin Current and Projected Annual Water Demand
Annual Consumptive Use in Acre-Feet per Year, High Scenario

	Current (2015)		Projected (2045)	
Economic Sector	**Normal**	**Max**	**Normal**	**Max**
Agricultural				
Irrigation				
Alfalfa	13,000	18,000	19,000	25,000
Other hay	5,000	11,000	8,000	15,000
Irrigated pasture	3,000	11,000	4,000	15,000
Corn	13,000	14,000	19,000	19,000
Sugar beets	6,000	7,000	9,000	10,000
Dry beans	3,000	4,000	5,000	5,000
Oats	1,000	1,000	1,000	1,000
Barley	1,000	2,000	2,000	2,000
Winter wheat	1,000	1,000	2,000	2,000
Spring wheat	0	0	0	0
Subtotal	46,000	69,000	69,000	94,000
Livestock	500	500	600	600
Municipal/Rural Domestic	300	400	500	700
Industrial				
Oil refining and production	500	500	600	600
Coal and uranium mining	0	0	0	0
Power generation	0	0	0	0
Miscellaneous and other	7,400	7,400	8,500	8,500
Total Water Usage	54,700	77,800	79,200	104,400
Surface Water	43,300	64,100	65,100	87,600
Ground Water	11,400	13,700	14,100	16,800
Share Water Usage				
Surface Water	79%	82%	82%	84%
Ground Water	21%	18%	18%	16%

Source: Harvey Economics, 2016.

Exhibit 4-A-33: Horse Creek Subbasin Current and Projected Annual Water Demand
Annual Diversions in Acre-Feet per Year, Low Scenario

	Current (2015)		Projected (2045)	
Economic Sector	**Normal**	**Max**	**Normal**	**Max**
Agricultural				
Irrigation				
Alfalfa	31,000	41,000	16,000	22,000
Other hay	12,000	25,000	7,000	14,000
Irrigated pasture	7,000	25,000	4,000	14,000
Corn	30,000	32,000	16,000	17,000
Sugar beets	15,000	17,000	8,000	9,000
Dry beans	8,000	9,000	4,000	5,000
Oats	2,000	1,000	1,000	1,000
Barley	3,000	4,000	1,000	2,000
Winter wheat	3,000	3,000	1,000	2,000
Spring wheat	0	0	0	0
Subtotal	111,000	157,000	58,000	86,000
Livestock	500	500	500	500
Municipal/Rural Domestic	600	800	600	800
Industrial				
Oil refining and production	500	500	500	500
Coal and uranium mining	0	0	0	0
Power generation	0	0	0	0
Miscellaneous and other	7,400	7,400	7,500	7,500
Total Water Usage	120,000	166,200	67,100	95,300
Surface Water	103,600	144,900	54,700	80,000
Ground Water	16,400	21,300	12,400	15,300
Share Water Usage				
Surface Water	86%	87%	82%	84%
Ground Water	14%	13%	18%	16%

Source: Harvey Economics, 2016.

Exhibit 4-A-34: Horse Creek Subbasin Current and Projected Annual Water Demand
Annual Consumptive Use in Acre-Feet per Year, Low Scenario

	Current (2015)		Projected (2045)	
Economic Sector	**Normal**	**Max**	**Normal**	**Max**
Agricultural				
Irrigation				
Alfalfa	13,000	18,000	7,000	10,000
Other hay	5,000	11,000	3,000	6,000
Irrigated pasture	3,000	11,000	2,000	6,000
Corn	13,000	14,000	7,000	7,000
Sugar beets	6,000	7,000	3,000	4,000
Dry beans	3,000	4,000	2,000	2,000
Oats	1,000	1,000	0	0
Barley	1,000	2,000	1,000	1,000
Winter wheat	1,000	1,000	1,000	1,000
Spring wheat	0	0	0	0
Subtotal	46,000	69,000	26,000	37,000
Livestock	500	500	500	500
Municipal/Rural Domestic	300	400	300	400
Industrial				
Oil refining and production	500	500	500	500
Coal and uranium mining	0	0	0	0
Power generation	0	0	0	0
Miscellaneous and other	7,400	7,400	7,500	7,500
Total Water Usage	54,700	77,800	34,800	45,900
Surface Water	43,300	64,100	25,000	34,900
Ground Water	11,400	13,700	9,800	11,000
Share Water Usage				
Surface Water	79%	82%	72%	76%
Ground Water	21%	18%	28%	24%

Source: Harvey Economics, 2016.

Exhibit 4-A-35: Horse Creek Subbasin Current and Projected Annual Water Demand
Annual Diversions in Acre-Feet per Year, Mid Scenario

	Current (2015)		Projected (2045)	
Economic Sector	**Normal**	**Max**	**Normal**	**Max**
Agricultural				
Irrigation				
Alfalfa	31,000	41,000	24,000	32,000
Other hay	12,000	25,000	10,000	19,000
Irrigated pasture	7,000	25,000	6,000	19,000
Corn	30,000	32,000	23,000	24,000
Sugar beets	15,000	17,000	11,000	13,000
Dry beans	8,000	9,000	6,000	7,000
Oats	2,000	1,000	1,000	1,000
Barley	3,000	4,000	2,000	3,000
Winter wheat	3,000	3,000	2,000	2,000
Spring wheat	0	0	0	0
Subtotal	111,000	157,000	85,000	120,000
Livestock	500	500	500	500
Municipal/Rural Domestic	600	800	800	1,100
Industrial				
Oil refining and production	500	500	500	500
Coal and uranium mining	0	0	0	0
Power generation	0	0	0	0
Miscellaneous and other	7,400	7,400	7,600	7,600
Total Water Usage	120,000	166,200	94,400	129,700
Surface Water	103,600	144,900	79,900	111,400
Ground Water	16,400	21,300	14,500	18,300
Share Water Usage				
Surface Water	86%	87%	85%	86%
Ground Water	14%	13%	15%	14%

Source: Harvey Economics, 2016.

Exhibit 4-A-36: Horse Creek Subbasin Current and Projected Annual Water Demand
Annual Consumptive Use in Acre-Feet per Year, Mid Scenario

	Current (2015)		Projected (2045)	
Economic Sector	**Normal**	**Max**	**Normal**	**Max**
Agricultural				
Irrigation				
Alfalfa	13,000	18,000	10,000	14,000
Other hay	5,000	11,000	4,000	8,000
Irrigated pasture	3,000	11,000	2,000	8,000
Corn	13,000	14,000	10,000	10,000
Sugar beets	6,000	7,000	5,000	6,000
Dry beans	3,000	4,000	3,000	3,000
Oats	1,000	1,000	1,000	0
Barley	1,000	2,000	1,000	1,000
Winter wheat	1,000	1,000	1,000	1,000
Spring wheat	0	0	0	0
Subtotal	46,000	69,000	37,000	51,000
Livestock	500	500	500	500
Municipal/Rural Domestic	300	400	400	600
Industrial				
Oil refining and production	500	500	500	500
Coal and uranium mining	0	0	0	0
Power generation	0	0	0	0
Miscellaneous and other	7,400	7,400	7,600	7,600
Total Water Usage	54,700	77,800	46,000	60,200
Surface Water	43,300	64,100	35,300	47,900
Ground Water	11,400	13,700	10,700	12,300
Share Water Usage				
Surface Water	79%	82%	77%	80%
Ground Water	21%	18%	23%	20%

Source: Harvey Economics, 2016.

Exhibit 4-A-37: South Platte Subbasin Current and Projected Annual Water Demand
Annual Diversions in Acre-Feet per Year, High Scenario

	Current (2015)		Projected (2045)	
Economic Sector	**Normal**	**Max**	**Normal**	**Max**
Agricultural				
Irrigation				
Alfalfa	28,000	44,000	30,000	47,000
Other hay	28,000	51,000	30,000	55,000
Irrigated pasture	3,000	7,000	3,000	7,000
Corn	5,000	8,000	6,000	8,000
Sugar beets	3,000	3,000	3,000	3,000
Dry beans	5,000	6,000	5,000	6,000
Oats	2,000	3,000	2,000	3,000
Barley	5,000	6,000	6,000	6,000
Winter wheat	6,000	9,000	7,000	9,000
Spring wheat	1,000	1,000	1,000	1,000
Subtotal	86,000	138,000	93,000	145,000
Livestock	700	700	700	700
Municipal/Rural Domestic	19,000	28,400	35,600	52,900
Industrial				
Oil refining and production	8,700	8,700	10,400	10,400
Coal and uranium mining	0	0	0	0
Power generation	600	600	1,000	1,000
Miscellaneous and other	8,900	8,900	10,500	10,500
Total Water Usage	123,900	185,300	151,200	220,500
Surface Water	94,300	148,300	113,500	173,300
Ground Water	29,600	37,000	37,700	47,200
Share Water Usage				
Surface Water	76%	80%	75%	79%
Ground Water	24%	20%	25%	21%

Source: Harvey Economics, 2016.

Exhibit 4-A-38: South Platte Subbasin Current and Projected Annual Water Demand
Annual Consumptive Use in Acre-Feet per Year, High Scenario

	Current (2015)		Projected (2045)	
Economic Sector	**Normal**	**Max**	**Normal**	**Max**
Agricultural				
Irrigation				
Alfalfa	12,000	19,000	13,000	20,000
Other hay	12,000	22,000	13,000	23,000
Irrigated pasture	1,000	3,000	1,000	3,000
Corn	2,000	3,000	2,000	4,000
Sugar beets	1,000	1,000	1,000	1,000
Dry beans	2,000	2,000	2,000	3,000
Oats	1,000	1,000	1,000	1,000
Barley	2,000	3,000	2,000	3,000
Winter wheat	3,000	4,000	3,000	4,000
Spring wheat	0	0	0	0
Subtotal	36,000	58,000	38,000	62,000
Livestock	700	700	700	700
Municipal/Rural Domestic	9,500	14,200	17,800	26,500
Industrial				
Oil refining and production	8,700	8,700	10,400	10,400
Coal and uranium mining	0	0	0	0
Power generation	600	600	1,000	1,000
Miscellaneous and other	8,900	8,900	10,500	10,500
Total Water Usage	65,700	92,500	80,500	113,400
Surface Water	42,200	65,600	51,200	79,600
Ground Water	23,500	26,900	29,300	33,800
Share Water Usage				
Surface Water	64%	71%	64%	70%
Ground Water	36%	29%	36%	30%

Source: Harvey Economics, 2016.

Exhibit 4-A-39: South Platte Subbasin Current and Projected Annual Water Demand
Annual Diversions in Acre-Feet per Year, Low Scenario

	Current (2015)		Projected (2045)	
Economic Sector	**Normal**	**Max**	**Normal**	**Max**
Agricultural				
Irrigation				
Alfalfa	28,000	44,000	25,000	39,000
Other hay	28,000	51,000	25,000	46,000
Irrigated pasture	3,000	7,000	3,000	6,000
Corn	5,000	8,000	5,000	7,000
Sugar beets	3,000	3,000	2,000	3,000
Dry beans	5,000	6,000	4,000	5,000
Oats	2,000	3,000	2,000	2,000
Barley	5,000	6,000	5,000	5,000
Winter wheat	6,000	9,000	6,000	8,000
Spring wheat	1,000	1,000	1,000	1,000
Subtotal	86,000	138,000	78,000	122,000
Livestock	700	700	700	700
Municipal/Rural Domestic	19,000	28,400	24,000	35,400
Industrial				
Oil refining and production	8,700	8,700	8,700	8,700
Coal and uranium mining	0	0	0	0
Power generation	600	600	1,000	1,000
Miscellaneous and other	8,900	8,900	8,900	8,900
Total Water Usage	123,900	185,300	121,300	176,700
Surface Water	94,300	148,300	90,800	139,000
Ground Water	29,600	37,000	30,500	37,700
Share Water Usage				
Surface Water	76%	80%	75%	79%
Ground Water	24%	20%	25%	21%

Source: Harvey Economics, 2016.

Exhibit 4-A-40: South Platte Subbasin Current and Projected Annual Water Demand
Annual Consumptive Use in Acre-Feet per Year, Low Scenario

	Current (2015)		Projected (2045)	
Economic Sector	**Normal**	**Max**	**Normal**	**Max**
Agricultural				
Irrigation				
Alfalfa	12,000	19,000	11,000	17,000
Other hay	12,000	22,000	11,000	20,000
Irrigated pasture	1,000	3,000	1,000	3,000
Corn	2,000	3,000	2,000	3,000
Sugar beets	1,000	1,000	1,000	1,000
Dry beans	2,000	2,000	2,000	2,000
Oats	1,000	1,000	1,000	1,000
Barley	2,000	3,000	2,000	2,000
Winter wheat	3,000	4,000	2,000	3,000
Spring wheat	0	0	0	0
Subtotal	36,000	58,000	33,000	52,000
Livestock	700	700	700	700
Municipal/Rural Domestic	9,500	14,200	12,000	17,700
Industrial				
Oil refining and production	8,700	8,700	8,700	8,700
Coal and uranium mining	0	0	0	0
Power generation	600	600	1,000	1,000
Miscellaneous and other	8,900	8,900	8,900	8,900
Total Water Usage	64,400	91,100	64,300	89,000
Surface Water	41,100	64,400	40,200	61,600
Ground Water	23,300	26,700	24,100	27,400
Share Water Usage				
Surface Water	64%	71%	63%	69%
Ground Water	36%	29%	37%	31%

Source: Harvey Economics, 2016.

Exhibit 4-A-41: South Platte Subbasin Current and Projected Annual Water Demand
Annual Diversions in Acre-Feet per Year, Mid Scenario

	Current (2015)		Projected (2045)	
Economic Sector	**Normal**	**Max**	**Normal**	**Max**
Agricultural				
Irrigation				
Alfalfa	28,000	44,000	27,000	42,000
Other hay	28,000	51,000	27,000	49,000
Irrigated pasture	3,000	7,000	3,000	6,000
Corn	5,000	8,000	5,000	8,000
Sugar beets	3,000	3,000	3,000	3,000
Dry beans	5,000	6,000	4,000	5,000
Oats	2,000	3,000	2,000	3,000
Barley	5,000	6,000	5,000	6,000
Winter wheat	6,000	9,000	6,000	8,000
Spring wheat	1,000	1,000	1,000	1,000
Subtotal	86,000	138,000	83,000	131,000
Livestock	700	700	700	700
Municipal/Rural Domestic	19,000	28,400	28,600	41,900
Industrial				
Oil refining and production	8,700	8,700	9,600	9,600
Coal and uranium mining	0	0	0	0
Power generation	600	600	1,000	1,000
Miscellaneous and other	8,900	8,900	9,500	9,500
Total Water Usage	123,900	185,300	132,400	193,700
Surface Water	94,300	148,300	98,900	152,100
Ground Water	29,600	37,000	33,500	41,600
Share Water Usage				
Surface Water	76%	80%	75%	79%
Ground Water	24%	20%	25%	21%

Source: Harvey Economics, 2016.

Exhibit 4-A-42: South Platte Subbasin Current and Projected Annual Water Demand
Annual Consumptive Use in Acre-Feet per Year, Mid Scenario

	Current (2015)		Projected (2045)	
Economic Sector	**Normal**	**Max**	**Normal**	**Max**
Agricultural				
Irrigation				
Alfalfa	12,000	19,000	12,000	18,000
Other hay	12,000	22,000	12,000	21,000
Irrigated pasture	1,000	3,000	1,000	3,000
Corn	2,000	3,000	2,000	3,000
Sugar beets	1,000	1,000	1,000	1,000
Dry beans	2,000	2,000	2,000	2,000
Oats	1,000	1,000	1,000	1,000
Barley	2,000	3,000	2,000	2,000
Winter wheat	3,000	4,000	3,000	4,000
Spring wheat	0	0	0	0
Subtotal	36,000	58,000	36,000	55,000
Livestock	700	700	700	700
Municipal/Rural Domestic	9,500	14,200	14,300	21,000
Industrial				
Oil refining and production	8,700	8,700	9,600	9,600
Coal and uranium mining	0	0	0	0
Power generation	600	600	1,000	1,000
Miscellaneous and other	8,900	8,900	9,500	9,500
Total Water Usage	64,400	91,100	71,100	96,800
Surface Water	41,100	64,400	44,800	66,900
Ground Water	23,300	26,700	26,300	29,900
Share Water Usage				
Surface Water	64%	71%	63%	69%
Ground Water	36%	29%	37%	31%

Source: Harvey Economics, 2016.