TECHNICAL MEMORANDUM

SUBJECT: **Green River Basin Plan II**
Irrigation Water Needs and Demand Projections

DATE: October 15, 2009 (Revised March 17, 2011)

PREPARED BY: WWC Engineering

Introduction

This memorandum presents projections of irrigation water requirements in the Green River Basin for the period from 2005 through 2055. The projections provide a basis for estimating agricultural water needs in the Basin over the next 10, 30 and 50 years.

Following guidelines established by the Wyoming Water Development Commission, projections were developed for three planning scenarios:

1. Low Growth
2. Moderate Growth
3. High Growth

The projections for each scenario were developed based upon a review of previous water planning documents and other technical memoranda data. Econometric models were not considered for projecting future irrigation water needs, as the factors that influence irrigation water needs and the ability of irrigators to satisfy those needs are not amenable to quantification in multivariate economic models (Watts, 2000).[1]

The agriculture projections and methods discussion draw heavily on the work done by Watts and Associates for the 2001 Green River Basin Water Planning Process Report and associated technical memoranda. Much of the content of this technical memorandum is updated from and compared to the work done by Watts and Associates in 2000.

Background

Irrigated agricultural production is the largest user of water in the Green River Basin. Currently, Basin irrigators consumptively use an average of about 396,000 acre-feet of water in an average year. Irrigation water consumption varies considerably from year to year, however, depending upon water availability, rainfall, and other climatic conditions.

[1] Econometric models are statistical models that relate the variable to be forecast, in this case irrigation water requirements, to other variables for which future values are more easily forecast, such as beef consumption.

In a typical dry year, Basin-wide irrigation water consumption drops to about 371,000 acre-feet. In a typical wet year, consumption rises to about 422,000 acre-feet (WYRAG Memorandum, 2009).

The State Engineers Office, Wyoming Water Planning Program (WWPP) estimated that there were about 330,000 acres irrigated in the Green River Basin in 1970 (WWPP, 1970). The estimate of irrigated acreage developed for the Green River Basin Plan, 2001 study put the current irrigated acreage total at 321,500 acres. This is a slight decrease in irrigation from the 1970 estimate (Green River Basin Plan, 2001). However, in the Wyoming Water Rights Attribution GeoDataBase study effort, the average total irrigated acreage is reported as 334,500 acres (WYRAG Memorandum, 2009). The average irrigated acreage numbers from 1970, 2001 and 2009 are very comparable. From the higher acreage reported in 2009 to the lower acreage reported in 2001 is a variation of only about 4 percent.

The state agriculture sector generated about $965,800,000 of total cash receipts in 2005 (Equality State Almanac, 2007). Livestock and products made up $814,800,000 of these receipts or 84 percent. The Green River Basin agriculture sector is even more dependent on livestock and its associated products. The primary use of irrigation is to generate a forage base for the livestock enterprises in the basin. The bulk of the irrigated land is devoted to the production of forage crops (alfalfa, grass hay, and irrigated pasture). Small amounts of grain are grown on irrigated acreage along the Black's Fork and Smith's Fork Rivers, the lower Little Snake River Basin, and in the Eden Valley area. The irrigated acreage devoted to grain production in these areas is less than three percent. In other parts of the Basin, forage crops constitute effectively 100 percent of irrigated agricultural production (Green River Basin Plan, 2001).

The irrigated land in the Basin is mechanically harvested, devoted to irrigated pasture, or is only irrigated on an intermittent basis. Table 1 shows estimates of harvested forage acreage in the Basin for the years 2002 and 2007 as developed by the USDA National Agricultural Statistics Service (NASS, 2007 Census of Agriculture).[2] That table shows that the number of acres of forage crops harvested varied from about 238,500 acres in 2002 to about 272,700 acres in 2007. The distribution of harvested forage acreage by county is shown in Figure 1. Sublette County is the largest forage producer in the Basin, harvesting over 50 percent of all forage harvested in 2002 and in 2007. Uinta County is the second largest forage producer with over 20 percent of the total, followed by Carbon, Lincoln, and Sweetwater Counties.

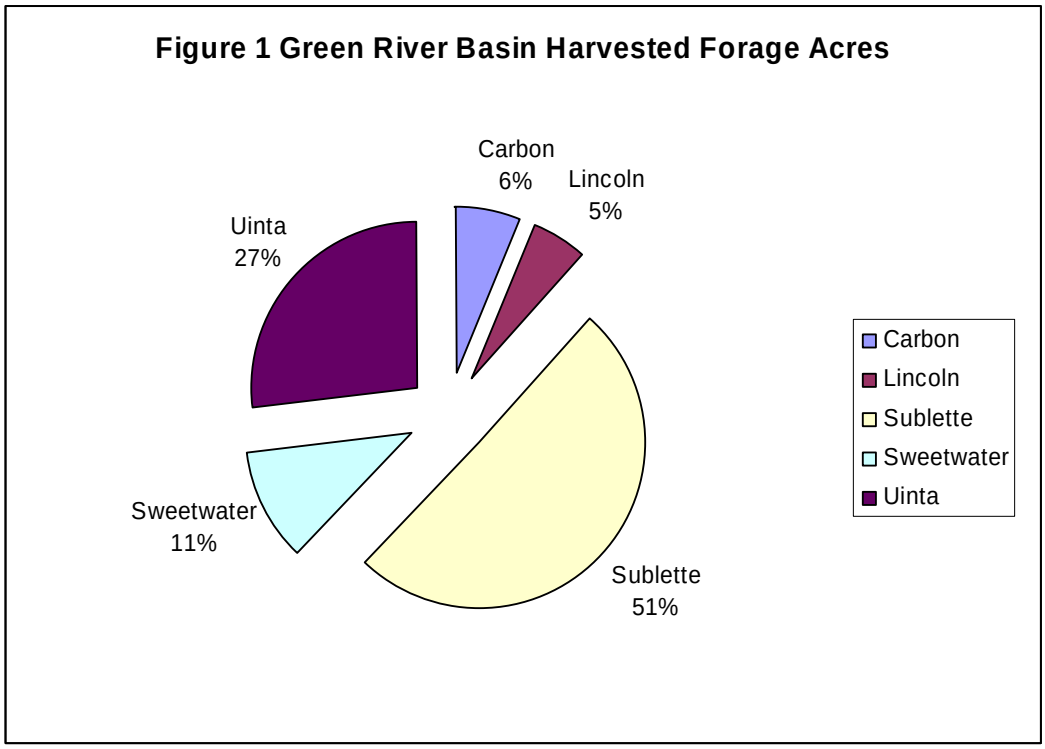
[2] NASS county-level harvested acreage data were adjusted to Basin-wide estimates based upon the mapped irrigated lands by County from the Wyoming Water Planning Report No. 7 Irrigated Lands Inventory for Wyoming, January 1971.

Table 1 Harvested Acres of Irrigated Forage Crops Green River Basin 2002 and 2007

2002 Census of Agriculture							
Five County Area				Portion in Green River Basin			
County	Harvested Cropland	Pastureland and Other land	County Total	% of Irrigated Acres in GRB[1]	Harvested Cropland	Pastureland and Other land	GRB County Total
Carbon	66,361	58,158	124,519	0.117	7,744	6,787	14,531
Lincoln	58,648	16,931	75,579	0.224	13,131	3,791	16,922
Sublette	88,984	42,773	131,757	0.972	86,501	41,580	128,081
Sweetwater	14,542	6,448	20,990	1.000	14,542	6,448	20,990
Uinta	49,534	33,388	82,922	0.699	34,634	23,345	57,979
TOTAL	**278,069**	**157,698**	**435,767**		**156,553**	**81,950**	**238,504**
2007 Census of Agriculture							
Five County Area				**Portion in Green River Basin**			
Carbon	69,029	77,518	146,547	0.117	8,056	9,046	17,102
Lincoln	52,884	12,414	65,298	0.224	11,841	2,779	14,620
Sublette	82,147	59,226	141,373	0.972	79,855	57,574	137,429
Sweetwater	23,269	7,015	30,284	1.000	23,269	7,015	30,284
Uinta	52,736	52,077	104,813	0.699	36,873	36,412	73,285
TOTAL	**280,065**	**208,250**	**488,315**		**159,894**	**112,827**	**272,720**

Source: USDA, National Agricultural Statistics Service, 2007 Census of Agriculture - County Data

[1] Wyoming Water Planning Report No. 7 Irrigated Lands Inventory for Wyoming, January 1971

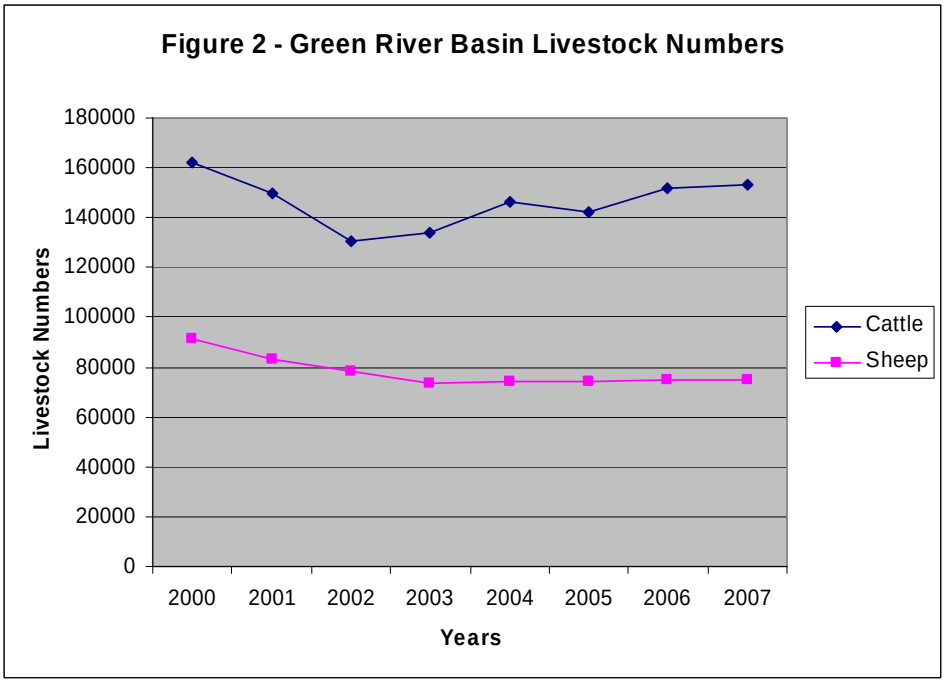


Surface water is the primary irrigation water supply source in the Green River Basin. However, there are a few active irrigation wells scattered across the basin. The availability of storage water varies widely across the Basin, and agricultural production in some parts of the Basin is limited by inadequate or non-existent storage facilities. The Eden-Farson area and the New Fork River valley have the largest ratio of storage to irrigated acreage in the Basin. There are about 2.5 acre-feet of storage per irrigated acre in the Eden-Farson area and about 1.8 acre-feet of storage per irrigated acre in the New Fork River Valley. With the construction of High Savery Reservoir the Little Snake Drainage has about 1.1 acre-feet of storage per irrigated acre. Other areas of the Basin have less than one acre-foot of storage per irrigated acre. In the Bridger Valley, reservoirs on the Black's Fork and Smith's Fork Rivers provide an average of 0.7 acre-feet of storage per irrigated acre. Along the Henry's Fork, the storage to irrigated acreage ratio is 0.4, and along the Ham's Fork it is 0.1. The lack of storage is most notable on tributaries entering the Green River from the west above Fontenelle Reservoir (hereafter referred to as the northwest tributaries). Only three small private reservoirs are located in this part of the Basin, and over 80,000 acres of irrigated lands suffer from late season and dry year irrigation water shortages. The storage to irrigated acreage ratio in this area is less than 0.1 acre-feet per acre (Green River Basin Plan, 2001).

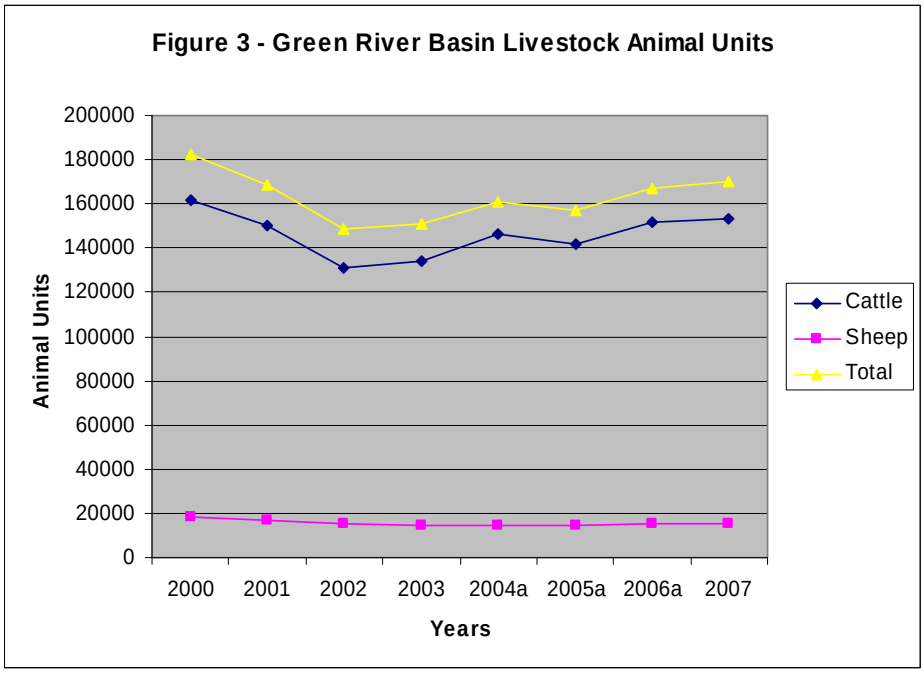
Trends in Livestock Production

Over the past three decades livestock production in the Green River Basin Counties has been relatively stable. However, there has been a shift from sheep production to cattle production. Cattle numbers increased from about 250,000 in 1979 to about 300,000 in

1999, an increase of 20 percent (Green River Basin Plan, 2001). However, these numbers are based on the five county area that encompasses the Green River Basin Planning Area. The five county area encompassing the Green River Basin had cattle inventories of about 275,000 in 2000 and inventories in the five county area declined to about 260,000 in 2007 (NASS, 2007 Census of Agriculture). Inventory numbers are likely impacted by the recent drought. The WYWRAG analysis identified the year 2002 as the dry year in the period of record used, 1971 through 2007 (WYRAG Memorandum, 2009) and it coincides with the lower inventories experienced in the period 2000 to 2007. Sheep numbers peaked at about 230,000 head in the early 1980s and declined to about 135,000 head in 1999, a decrease of about 40 percent (Green River Basin Plan, 2001). Sheep numbers continued their decline through 2003 when there were about 112,000 sheep in the five county area but have increased slightly to about 116,000 in the five county area in 2007 (NASS, 2007 Census of Agriculture). Sheep numbers appear to have stabilized in the Green River Basin. Figure 2 shows the cattle and sheep inventories for the Green River Basin. These numbers are adjusted to reflect inventories for the land area that is actually within the Green River Basin Planning Area.



The total number of animal units in the basin has remained fairly constant over the past 30 years. It was reported in the Green River Basin Plan of 2001 that total animal units were increasing. However, recent inventory numbers indicate that the livestock industry is fairly stable (NASS, 2002 and 2007 Census of Agriculture, Green river Basin Plan, 2001). Figure 3 shows estimated numbers of animal units in the Basin over the past 8 years. Sheep numbers have been converted into animal units by dividing the inventories of sheep by five. It has been estimated that five sheep equal one animal unit (Watts, 2000).



The distributions of cattle and sheep by county are depicted in Figures 4 and 5. These figures reflect the most recent livestock inventory numbers available, Cattle 2007 and Sheep 2007 (NASS, 2007 Census). Figure 4 shows that Sublette County has been the largest cattle producer with about 38 percent of the Basin-wide cattle inventories. Uinta County has 21 percent followed by Carbon County with 18 percent, Lincoln County with 13 percent and Sweetwater County with 10 percent.

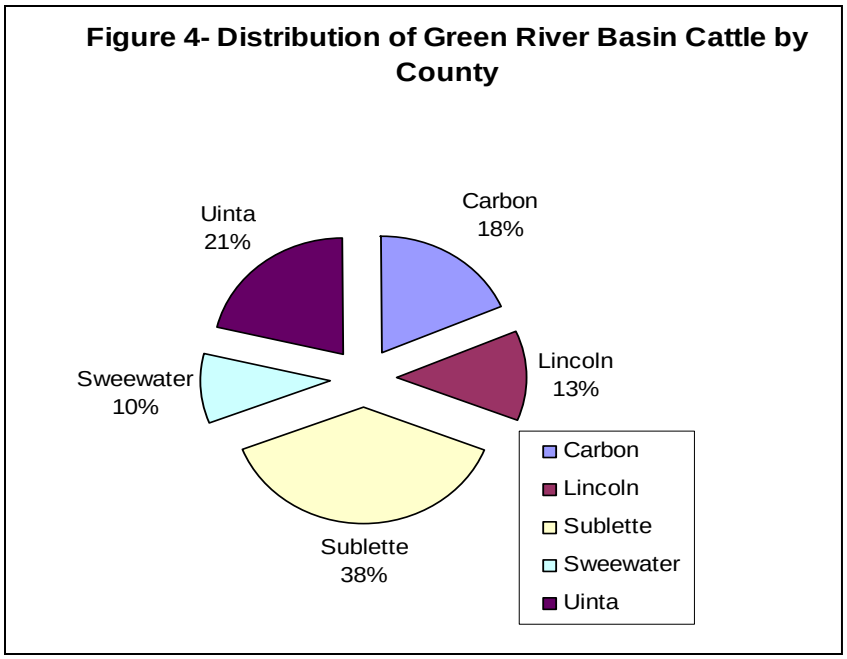
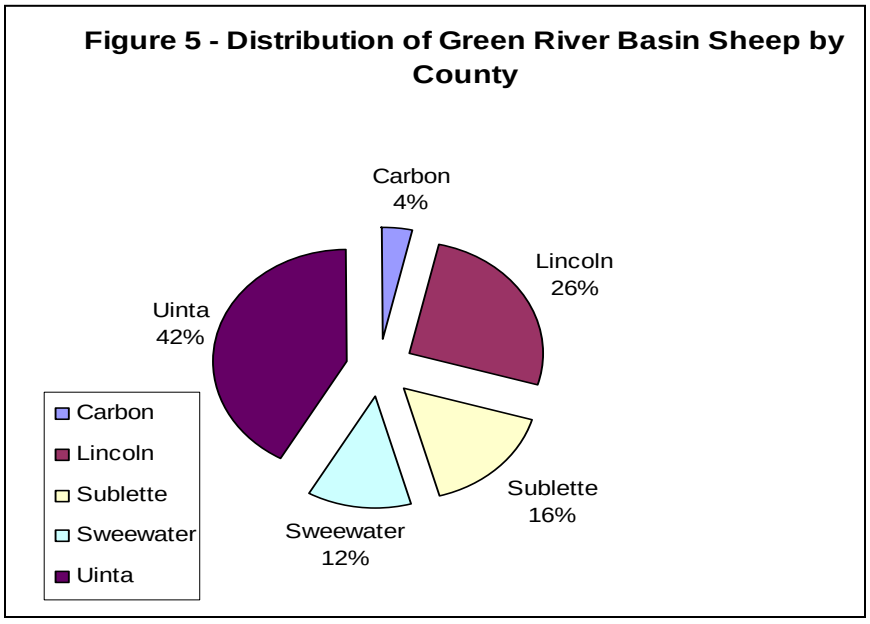


Figure 5 shows that Uinta and Lincoln Counties are presently the largest sheep producers in the Basin. These two counties accounted for 68 percent of all sheep production in the Basin in 2007. Carbon, Sublette and Sweetwater Counties accounted for the remaining 33 percent of production. It is interesting to note that Sweetwater County dropped from second place as reported in the 2001 Green River Basin Plan to fifth in the five county area as of 2007.



There appear to be several interrelated reasons why livestock production in the Basin has remained fairly stable rather than expand as was projected in the 2001 Green River Basin Plan. One limiting factor with respect to herd size is the availability of summer range on federal lands, which constitute a large proportion of the rangeland in the Basin. There has been little opportunity for producers with federal grazing allotments to increase production on federal land, and in some cases federal grazing rights have been restricted (Watts, 2000).

The only alternative available for increased livestock production in the Basin has been more intensive use and management of private lands, which can involve either increasing forage production on existing irrigated acreage or bringing new acreage into production. Bringing new irrigated acreage into production is a capital-intensive option that has not been financially feasible for most producers. There has been some increase in forage production on existing irrigated lands through more use of fertilizer and better water management practices (Watts, 2000).

Future Water Needs and Demands

The current and the future irrigation conditions in any basin are typically expressed in terms of needs and/or demands for irrigation water. To address irrigation in the Green River Basin, it is necessary to distinguish between needs and demands for irrigation water. A need for additional irrigation water is an identifiable current or future amount that would supply the total crop irrigation requirement (CIR) of a crop. Providing the total CIR would

satisfy the crop's biological water requirement and thus would enhance the economic well being of the irrigator and/or the economy of the Basin as a whole. Demands are distinguished from needs by the fact that they are measured in relationship to price. For example, an irrigator may need additional irrigation water to provide for the CIR in a dry year to grow enough hay to provide winter feed for his cattle. If additional water costs $500 per acre-foot, however, the irrigator's demand for additional water would probably be zero because it would be more cost-effective to either buy additional forage from other producers or reduce the size of his herd (Watts, 2000).

Municipal and industrial water needs and demands are often viewed as being the same. Municipal needs are usually assumed to be essential and thus will be translated into demands over a reasonable price range (Watts, 2000).

Electric power production and soda ash production are the two largest water consuming industries in the Green River Basin. Water cost makes up a relatively minor part of the total production costs involved in electric power and soda ash production. Therefore, it is reasonable to assume that industrial users will demand the water that they need to maintain or expand production over a reasonable range of prices (Watts, 2000).

The agriculture sector is the largest water consuming sector in the Basin and in the State. Agriculture is an industry where individual operators have very little if any control over prices received or the cost of inputs to their production process. Due to this lack of control or limited influence and the large volume of water used, irrigators are reluctant to invest in expensive water development projects. The result is an industry in which producers are very sensitive to the price of water, and their demands for water can change dramatically as a function of price (Watts, 2000).

There are current needs for storage water to meet late season and dry year crop requirements in areas of the Basin where storage is not available or is inadequate to fully meet irrigation requirements. The 2001 Green River Basin Plan estimated that in the average year there is a need for about 75,500 acre-feet of consumptive irrigation use to provide a full water supply to existing crops (Green River Basin Plan, 2001). The current estimate of the shortage is 64,900 acre-feet in an average year (Rice, 2009). The two sub-basin areas that make up the bulk of this shortage are the Blacks Fork sub-basin and the Upper and Mainstem Green River sub-basin. The Blacks Fork is estimated to be about 35,500 acre-feet short and the Upper Green is about 19,800 acre-feet short. Theses two sub-basins make up about 85 percent of the total basin shortages in an average year. The portion of the Upper Green that makes up the majority of the shortage is the northwest tributaries area. Additional storage in the Blacks Fork sub-basin and in the northwest tributaries would greatly stabilize forage production and allow ranchers to operate more profitably. However, development of water supplies to provide a full water supply to all water short acres in the basin may not be economically justified.

Supplemental irrigation water supply storage would allow some operators to adjust to potential changes in federal grazing allotment management. If access to forage on federal lands is further restricted in the future, the only alternative available to ranchers for keeping

their operations at current production levels will be to increase forage production on private lands (Watts, 2000). More intensive management and more irrigation water would be required on private land resources to increase production. On some tributaries, additional irrigation water might allow producers to expand their cattle herds on private holdings or grow additional hay for sale. As was noted in the 2001 Basin Plan, the Basin has more irrigable land than it has available water. Availability of irrigation water can be impacted by timing of runoff, location, and transmission loss.

The primary crops grown in the Green River Basin are forage crops. Forage production returns in recent decades have not been sufficient to offset the costs of new water storage projects or major canal rehabilitation projects. A sizeable percentage of the total acreage used for forage production is irrigated pasture. The percentage in pasture in 2002 was 35 percent and in 2007, 41 percent was in pasture. Pasture is assumed to be the crop first shorted if irrigation supplies are limited resulting in lower returns. Studies of returns to irrigation water in the Little Snake Drainage and in other parts of Wyoming indicate that one acre-foot of irrigation water used for forage production in relatively high altitude areas of the state can be expected to generate a $15 to $25 increase in net farm income (Western Research Corporation, 1989). The cost of developing new storage can be significantly higher than that figure even under very favorable funding circumstances. For example, the recently completed Greybull Dam and Reservoir in the Big Horn River Basin of Wyoming is considered a very cost-effective project from a cost per acre-foot of yield perspective. The project's total cost was approximately $32 million for 30,000 acre-feet of storage, or almost $1,100 per acre-foot of storage (WWDC Legislative Report, 2007). On an annual basis, the project's cost is equivalent to $58.53 for each acre-foot of reservoir storage, excluding O & M charges.[3] Current WWDC guidelines for new water project developments in Wyoming allow for up to a 75 percent state grant for project construction. If new irrigation water projects were developed in the Green River Basin with WWDC assistance, the total cost of storage would probably be at least $58.53 per acre-foot annually. Under current WWDC guidelines, irrigators would be responsible for 25 percent of the cost or annual payment of at least $14.63 per acre-foot of storage plus O&M charges. Irrigators in the Big Horn Basin can repay costs of this magnitude because they predominantly grow higher valued cash crops such as dry beans and sugar beets. However, these costs may exceed the returns that most producers in the Green River Basin would realize from additional forage production under current market conditions. This discussion is based on cost of storage not on yield from storage. Cost per unit of yield would be substantially higher.

The most recent reservoir constructed through the WWDC programs is High Savery Reservoir on Savery Creek a tributary of the Little Snake River located in the Southeastern part of the Green River Basin Study area. High Savery had a total cost of about $30,000,000 and has a capacity of 22,433 acre feet with about 16,733 dedicated to irrigation and the remaining capacity, 5,700 acre feet, going to an environmental pool for Colorado River Cutthroat Trout. This results in a cost of about $1,600 per acre foot of storage. High

[3] Annual costs were computed by amortizing the $32,057,458 construction cost over 50 years at four percent interest and dividing by 30,000 acre-feet.

Savery Reservoir is owned and operated by the State of Wyoming through the WWDC. The WWDC has contracted with Little Snake River Conservancy District for the yield of the reservoir. The annual cost to the conservancy district is $36,000 per year for the yield of the conservation pool. Yield was estimated at 12,000 acre feet 8 years out of 10. This reservoir is unique as it is the only reservoir owned and operated by the State (Besson, WWDC, 2009).

Demand for additional irrigation water in the Green River Basin is dependent upon factors that either increase the returns that Basin irrigators receive from irrigation or reduce the cost to them of developing new storage. Increased economic returns to irrigated agriculture in the Basin might include diversifying cropping patterns into higher valued crops. Another possibility is that hay prices may rise to the point that it would be profitable to export hay from the Basin to other domestic markets, and the possibility that cattle prices may rise significantly in the future (Watts, 2000).

Due to climatic conditions in the Basin, diversifying cropping patterns away from forage production is not likely to occur on a wide enough scale to warrant significant new water development projects. Most of the Basin above Fontenelle Reservoir is characterized by high elevations, cool nights, and a short growing season, making forage crops the only practical alternative. Grains can be grown in some parts of the Basin. Malting barley is the only grain crop that has been grown in the Basin that has shown significantly higher returns than alfalfa. Increased malt barley production alone would probably not increase net returns to irrigation enough to warrant the construction of additional storage projects, especially since it requires less irrigation water than hay crops (Watts, 2000).

Specialty crops, such as alfalfa seed or seed potatoes, could possibly be grown in some of the lower elevation areas of the Basin (Watts, 2000). Seed alfalfa production is moving into Wyoming, where acreage has grown from 3,750 acres in 2002 to 10,315 acres in 2007 (NASS, 2002 and 2007 Census of Agriculture). Due to the climatic conditions in the Green River Basin, the basin is at a disadvantage compared to lower elevation areas in the State. It has been stated that population trends in the Western US may be pushing agriculture production to other areas (Watts, 2000). However, forage production in Imperial County California, the largest irrigated area that depends on the Colorado River system, has shown growth in forage production over the past 20 years. In 1987 there were 199,440 acres of irrigated forage crops and in 2007 there were 228,839 acres of irrigated forage crops (NASS, 1992, 2007 Census of Agriculture). If population pressures in Arizona, California, and parts of Idaho, Oregon, and Washington displace agricultural production, especially forage production, forage production may become more valuable as a cash crop for the Basin. As more agricultural land is taken from production in the future, there will be less hay production because it is among the lower valued crops that can be grown in lower elevation areas. It has been reported that dairy producers have been relocating from California to other areas. However, the inventory of milk cows in California has shown steady growth over the past 20 years. In 1987 there were 1,070,366 milk cows in California and in 2007 there were 1,840,730 (NASS, 1992, 2007 Census of Agriculture). The relocation of dairy producers from California to states such as Idaho, Nebraska, and western Kansas is more likely expansion of their production areas. Dairy producers in the Boise,

Idaho area and along the Colorado Front Range are having difficulty securing enough alfalfa locally and are relying upon imports from other states or are relocating to hay producing areas (Watts, 2000). However, the inventory of milk cows in Wyoming has declined over the past 20 years, 9,287 milk cows in 1987 and 6,644 milk cows in 2007 (NASS, 1992, 2007 Census of Agriculture). The end result of this discussion is that the potential for increased forage production in the Green River Basin as a cash crop is real but is likely farther into the future than was anticipated in the 2001 Green River Basin Plan.

Wyoming's top quality alfalfa hay is exported to other states for use in the dairy and equine industries (Wyoming Business Council, 2009). Through the Business Council, grower organizations and the University of Wyoming the "Forage Promotion Program" has been developed to promote Wyoming hay. This is accomplished through promotion at trade events, web published directories, and the Wyoming Hay hotline. However, statistics are not available on the volume of hay exported from Wyoming. It has been estimated that about 25 percent is exported. This percentage is likely to increase in the future. Colorado is the largest market for Wyoming hay, however, some producers in the Big Horn Basin are shipping hay as far away as Florida and other east coast states (Watts, 2000). The Green River Basin is in an ideal location for hay production as a cash crop as producers have ready access to rail and truck shipping facilities and the Basin is capable of producing high quality, low fiber content hay.

Hay has been an important cash crop in Wyoming for sometime. In the period 2000 to 2005 cash receipts from hay sales made up over 60 percent of total crop cash receipts (NASS, Wyoming Agricultural Statistics 2006). The types of hay expected to be in high demand in the future are alfalfa for dairies and Timothy hay for horses. Alfalfa hay can be grown in lower elevation areas of the Basin, and Timothy hay can be grown in higher elevation areas (Watts, 2000). If future market prices for hay crops are sufficiently high, it may become practical for Green River Basin producers to develop additional supplemental supply storage and expand production of these crops for export markets.

Other factors that could translate into increased demand for irrigation water in the Basin would be a significant and sustained increase in cattle prices and/or an increase in the amount of financial assistance available to producers for reservoir construction and system improvement and rehabilitation.

Since the 2001 Green River Basin Plan was published, cattle prices have increased somewhat. From 2000 to 2007 prices have varied from about $90.00 per hundred weight for 500 to 600 pound steers to about $129.00 per hundred. During the same time frame price for heifers has ranged from $85.00 per hundred to about $117.00 per hundred (Iowa State Extension, 2009). There has been a noticeable upward trend in prices for that period. U.S. beef consumption has stabilized at around 67 pounds per-capita (USDA, ERS, 2005). The USDA, however, is forecasting a significant increase in exports of U.S. beef (High Plains/Midwest, 2009). The North American Free Trade Agreement (NAFTA) has impacted beef exports. The top four markets for beef exports are, in order of export volume; Mexico, Canada, Japan and South Korea. Mexico and Canada have moved ahead of Japan and NAFTA is credited with the shift. Demand for high quality beef is expected to

increase significantly in the future as the economies of these countries recover from the world wide recession (High Plains/Midwest, 2009). The U. S. has been and will continue to be the primary source of high quality beef for export, including exports for the hotel-restaurant market, primarily because of the availability of grain and feedlots for fattening. Although Argentina, Australia, and Brazil are also expected to increase their beef exports in the future, these exports will be composed primarily of lower quality grass fed beef, some of which will be imported by the U.S. for use in processed foods and hamburger (Watts, 2000).

Although the U.S. is now a net importer of beef, the USDA projects that the U.S. will become a net exporter of beef (High Plains/Midwest, 2009). The net effect of expanded export markets for quality beef is expected to be an increase in cattle prices that could well extend further into the future (Watts, 2000). In the 2001 Green River Basin Plan it was reported that USDA projections of cash returns above expenses to cow-calf enterprises were expected to increase from an annual average of $32.02 per cow in 1999 and 2000 to $47.14 per cow during 2008 and 2009. However, the Livestock Marketing Information Center (LMIC) estimated returns over expenses at a negative $20.00 per cow for 2008. However, in 2004 returns were estimated at $150.00 per cow (Cattle Network, 2008). Cow-calf enterprise returns are quite volatile and extension of returns over a significant time frame questionable. If returns were to stabilize at some level above the $47.14 per cow estimated in 2000, it could make additional storage affordable to some Green River Basin cattle producers.

The prospects of federal assistance for reservoir construction are less likely to occur than projected increases in cattle prices. Federal assistance for new reservoir construction has been declining in recent years. The Greybull Valley Irrigation District (GVID) in the Big Horn Basin of Wyoming attempted to secure federal assistance to construct an irrigation reservoir. Due to the difficulty experienced acquiring federal construction funding the GVID decided to secure State funding instead. There are no indications that this situation will change over the planning horizon. The 2005 session of the Wyoming State Legislature authorized a new dam and reservoir section to be administered by the WWDC. The legislation also established a Water Account Number 3 and provided funding of $10,000,000 from the Budget Reserve Account and $54,070,000 from Water Account Number 1. In addition the legislation established a revenue stream of ½ of 1 percent from the Severance Tax Distribution Account to fund the construction of, or expansion of existing dam and reservoir facilities. One of the initial projects contemplated was enlargement of Viva Naughton Reservoir on the Hams Fork River. The Legislature also authorized four positions in the Wyoming Water Development Office to conduct analyses of dams and reservoirs and to operate High Savery Reservoir (WWDC, 2006).

The counties in the Green River Basin established a Water Development Joint Powers Board in 2003 to pursue water development in the Green River Basin. The Joint Powers Board was filed with the Wyoming Secretary of State on July 21, 2003. This board has sponsored studies of new water development facilities. The formation of the Dam and Reservoir section in the WWDO, the authorization of a funding stream, and the formation

of a joint powers board have not resulted in the Basin irrigators moving forward on any of the reservoir projects that have been identified

For the reasons discussed above, the low, moderate, and high growth scenarios for future irrigation water demand in the Basin are based upon varying assumptions concerning the financial returns to beef and forage production and the availability of WWDC assistance for new project construction. Those scenarios are described in the following sections of this memorandum.

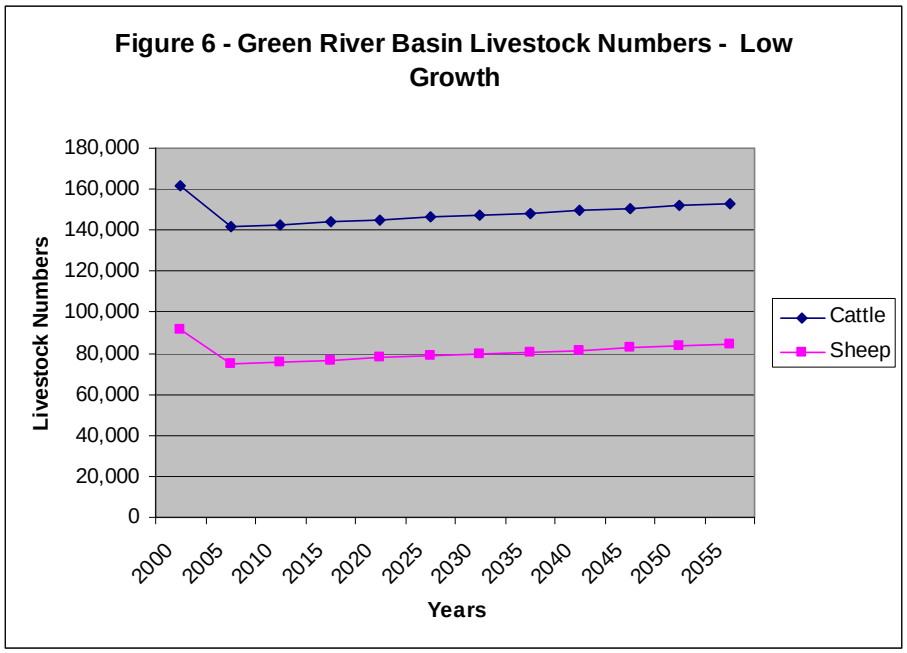
Low Growth Scenario

The low growth scenario is based upon the assumptions that irrigation in the Basin will continue to be dominated by forage production for winter livestock feed and that cattle and forage prices will not make sustained increases over the planning horizon.

Under the Low Growth scenario, there may be a small reduction in total irrigated acreage in the Basin as some lands are taken out of production due to alkalinity and salinity problems, and other lands are converted to home sites in the more scenic parts of the Basin. Forage production will probably increase somewhat as irrigators adopt better water management techniques and production practices. This increase in forage production may allow cattle numbers to increase modestly over the planning horizon. As indicated above cattle numbers and total livestock units have been relatively stable over the past eight years. Sheep numbers appear to have stabilized as was predicted in the 2001 Green River Basin Plan. Figure 6 shows the projected increases in cattle and sheep numbers as producers adopt new marketing and production practices. Irrigation consumptive water use in the Basin is estimated at 396,246 acre feet per year in the average year situation (WYRAG, 2009). Irrigation consumptive water use is expected to remain relatively constant declining from about 396,000 acre-feet in 2005 to about 386,500 in 2055, assuming average year runoff. Table 2 shows the projected consumptive use over the planning period.

Table 2 - Green River Basin Projected Consumptive Use - Low Growth

	Consumptive Use in Acre Feet					
Year	**2005**	**2015**	**2025**	**2035**	**2045**	**2055**
Low Growth	396,246	394,275	392,313	390,361	388,419	386,487



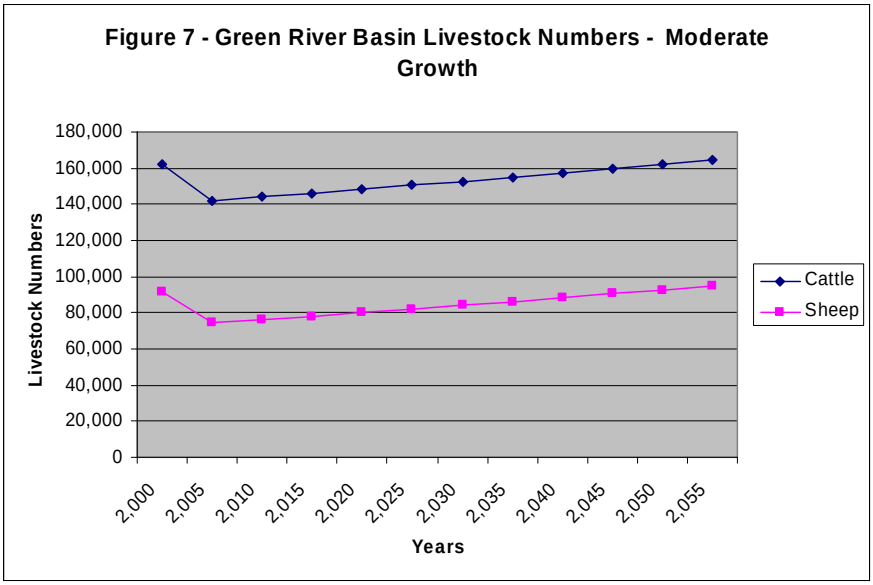
An additional consumptive water use by the agriculture sector is the direct consumption of water by livestock. It has been estimated that a cow will drink about 10 gallons per day. If sheep and cattle numbers are converted to animal units where one cow is equal to one animal unit and five sheep equal one animal unit the total number of animal units in 2005 would be 156,767 animal units. The number of animal units is projected to increase to 169,798 in 2055. Direct consumptive use is projected to increase from 1,755 acre feet in 2005 to 1,901 acre feet in 2055 for the low growth scenario.

Moderate Growth Scenario

The moderate growth scenario is based upon the reasonably foreseeable possibility that cattle prices will increase significantly in response to increased demand for high quality beef in Mexico, Canada, due in part to NAFTA, and the Pacific Rim markets (USDA, ERS, 2009). Cattle prices are projected to stabilize at these higher prices over the planning horizon and thus provide a financial incentive for ranchers in water-short areas of the Basin to develop storage facilities for dry year and late season water supplies. The WWDC has increased its financial commitment to new storage projects through the authorization of the new Dam and Reservoir section and the providing of a funding stream (WWDC, 2006). Cattle and sheep numbers have been projected to increase over the planning horizon. Figure 7 shows the projected numbers of cattle and sheep for the basin. Irrigation consumptive water use is projected to increase over the planning horizon from about 396,000 acre feet in 2005 to about 401,000 acre feet in 2055. Table 3 shows the projected consumptive use over the planning period.

Table 3 - Green River Basin Projected Consumptive Use - Moderate

	Consumptive Use in Acre Feet					
Year	2005	2015	2025	2035	2045	2055
Moderate Growth	396,246	398,227	400,218	402,219	404,231	406,252



The combination of projected higher cattle prices and increased WWDC assistance through their new Dam and Reservoir section will allow irrigators to develop and fund some new storage projects in those parts of the Basin that are in the greatest need. A logical place for such developments to take place is in the Blacks Fork sub-basin and along the northwest tributaries of the Upper Green River. These areas have less storage per irrigated acre than other sub-basins and irrigators market almost all of their hay through cattle (Watts, 2000). The producers in these two areas suffer water shortages during dry years and are chronically short of late season irrigation water. The irrigators in the Blacks Fork sub-basin have developed storage through the US Bureau of Reclamation (USBR) in the past. They have formed a water conservancy district to operate and manage the two reservoirs built by the USBR. However, this area experiences more shortages in the average year than any of the other sub-basins (WYRAG, 2009).

The next sub-basin in shortages is the Upper and Mainstem Green River sub-basin. The majority of the shortage occurs on the northwest tributaries. The northwest tributaries area has had more storage studies than the Blacks Fork drainage area. However, the irrigators in the northwest tributaries area have not been able to organize and form a legal entity to deal with the funding agencies and ultimately sponsor a storage project. They would have a large incentive to develop new storage if cattle prices increase as projected.

Over the past 20 to 30 years there have been numerous studies that looked at providing additional storage in the Green River Basin planning area. A pre-feasibility study of potential reservoir sites in this area was prepared for the WWDC in 1983 by the ARIX Corporation (ARIX, 1983). That study identified eight potential reservoir sites that could be developed. These sites are located along Cottonwood Creek, Piney Creek, and La Barge

Creek (ARIX, 1983). Reservoir construction costs and permitting requirements have changed considerably since 1983. In 2007 Kleinfelder submitted to WWDC a final report, "Upper Green River Storage Level II Study". This report identified four sites up stream from Fontenelle Reservoir that had potential to help satisfy identified shortages in the Upper Green River sub-basin. Three of the sites are located in the northwest tributaries area and the remaining one is located in the New Fork drainage. The three northwest tributaries sites are Mickelson Creek, Horse Pasture Draw, and Cow Gulch. These sites are all off channel sites. The site in the New Fork drainage is the Lower Willow Creek site, an on-channel site. These four sites could provide about 49,500 acre feet of new storage. Additional sites identified by the WWDC in the northwest tributaries area are Sand Hill and McNinch Wash. These are off channel sites also.

It seems likely that some of the more cost effective sites identified in the WWDC studies could be developed if financial returns to cow-calf operations and WWDC assistance increase as projected over the planning horizon.

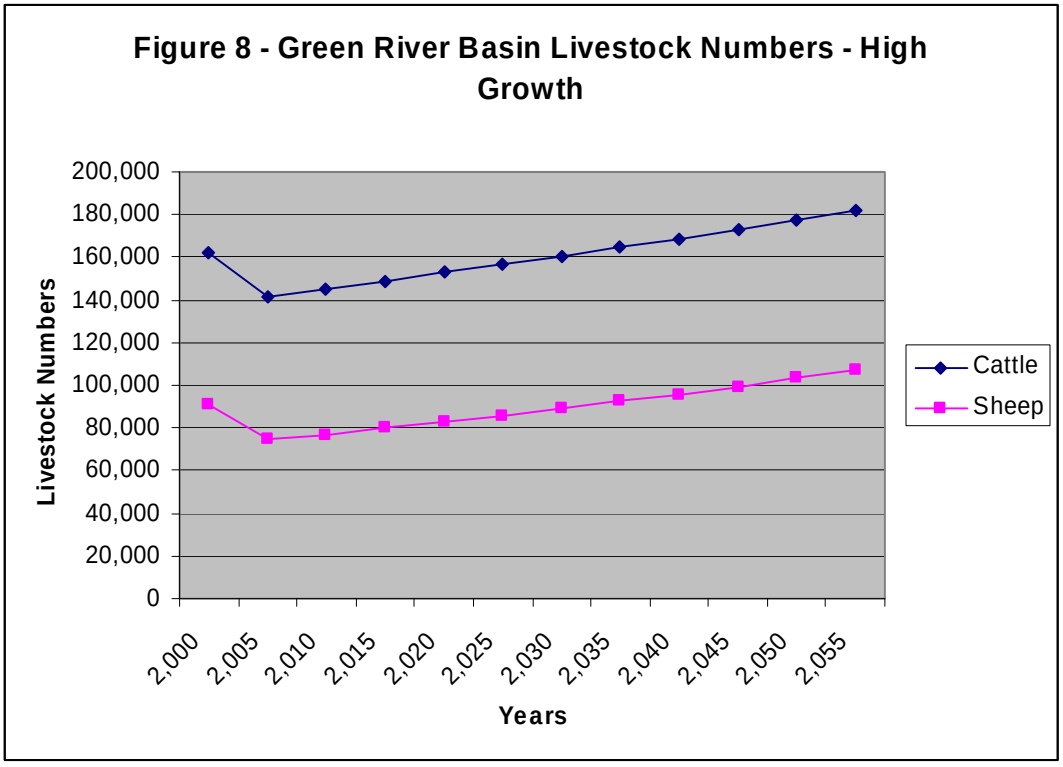
The three sites identified by Kleinfelder would provide approximately 26,340 acre-feet of storage at an average construction cost of about $2,740 per acre-foot (Kleinfelder, 2007). The moderate growth scenario is based upon the assumption that an additional 25,000 acre-feet of storage is developed along tributaries of the Upper Green at sites identified by WWDC or at alternative sites identified in the future. Reservoirs with 25,000 acre-feet of storage would increase irrigation depletions in the Basin. As a result, annual irrigation depletions in the Basin are estimated to increase from about 396,000 acre-feet annually (moderate growth scenario) to just over 406,000 acre-feet.

The Little Snake River Conservancy District and the Little Snake River Conservation District have requested analysis of additional irrigation storage reservoirs in the drainage. Among those studied are Big Gulch in the Savery Creek drainage and Battle Creek and South Fork of the Little Snake River above the confluence of Savery Creek and the Little Snake River. Agricultural operators in the Little Snake Drainage have expressed interest in irrigating some additional acreage in the future. These plans include a number of small reservoirs on tributaries to the Little Snake River. If fully developed, these projects would result in a total irrigation depletion increase of about 10,000 acre-feet annually. For purposes of projecting future water use under the moderate growth scenario, it was assumed that 50 percent of the Little Snake projects would be developed over the 50-year planning horizon, with annual depletions of 5,000 acre-feet. Adding these depletion increases to those along the northwest tributaries yields a Basin-wide average annual irrigation depletion estimate of about 406,000 acre-feet for the moderate growth scenario.

An additional consumptive water use by the agriculture sector is the direct consumption of water by livestock. It has been estimated that a cow will drink about 10 gallons per day. The number of animal units is projected to increase from 156,767 in 2005 to 183,581 in 2055. Direct consumptive use is projected to increase from 1,755 acre feet in 2005 to 2,055 acre feet in 2055 for the moderate growth scenario.

High Growth Scenario

The high growth scenario is based on increased cattle prices and higher prices for export forage over the planning horizon. In the High Growth scenario, cattle and sheep numbers have been projected to increase over the planning horizon. Figure 8 shows the projected numbers of cattle and sheep for the basin. High forage prices will encourage Basin irrigators to produce alfalfa and Timothy hay as cash crops. Alfalfa is typically grown in lower elevation areas of the Basin and production could be expanded in those areas. The hay would be exported from the Basin to dairies in other states. Some new lands may be brought under irrigation as a result. In higher elevation areas of the Basin, irrigators could diversify into Timothy hay as a cash crop in addition to producing mixed grass hay for winter feed. Some of the Timothy hay would be exported out of the Basin to surrounding states (Watts, 2000).



If agricultural prices stabilize at higher levels and reservoir construction funding is increased in the future, additional storage could be developed in the Basin to support increased forage production as a feed base and as a cash crop. Projecting additional storage and increased consumptive irrigation water use across the basin are very difficult. The sub-basins that exhibit the greatest need for additional irrigation water have not been as aggressive in pursuing water development as other sub-basins. The Little Snake River sub-basin has been quite aggressive in developing new storage. High Savery Reservoir is an example. Irrigators, in general, tend to demand relatively large amounts of water at relatively low prices and relatively small amounts of water at relatively high prices (Watts, 2000). Irrigators in the Green River Basin are likely as sensitive to irrigation water costs.

The level of irrigation water costs that the basin irrigators are willing to accept will be a controlling factor in the level of future development under the high growth scenario.

As a result, it is possible to make only very general approximations of how much additional water would be developed and used for irrigation under the High Growth Scenario.

The preliminary water use projections for this scenario are that about an additional 26,000 acre-feet of irrigation water will be consumptively used annually. Average annual consumptive use by Basin irrigators will increase to about 423,000 acre-feet annually and is shown in Table 4. In the 2001 Green River Plan it was projected that an increase of 8,000 to 12,000 acre-feet annually would be associated with new storage projects along the northwest tributaries. Another 10,000 acre-feet of increased consumptive use was projected to be associated with future projects identified by the Little Snake River Water Conservation District (Green River Plan, 2001). These assumptions of future development are still relevant. Based on the volume of studies requested in the northwest tributaries area and the Little Snake River sub-basin, it is logical to assume that those areas are the most likely to develop new storage. The remaining 4,000 to 8,000 acre-feet of new consumptive use is projected to occur in other parts of the Basin as cost-effective reservoir sites are identified.

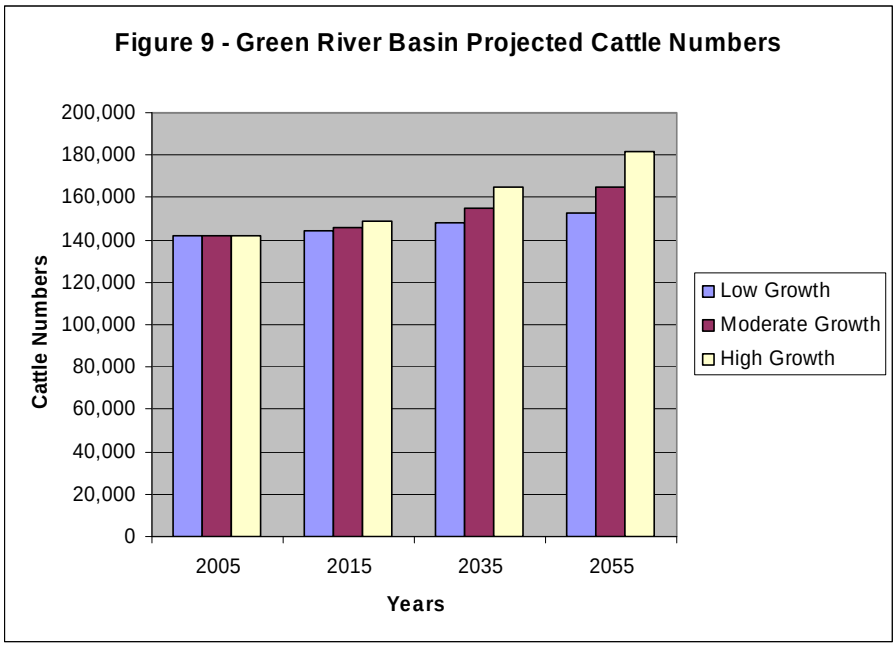
Table 4 - Green River Basin Projected Consumptive Use - High Growth

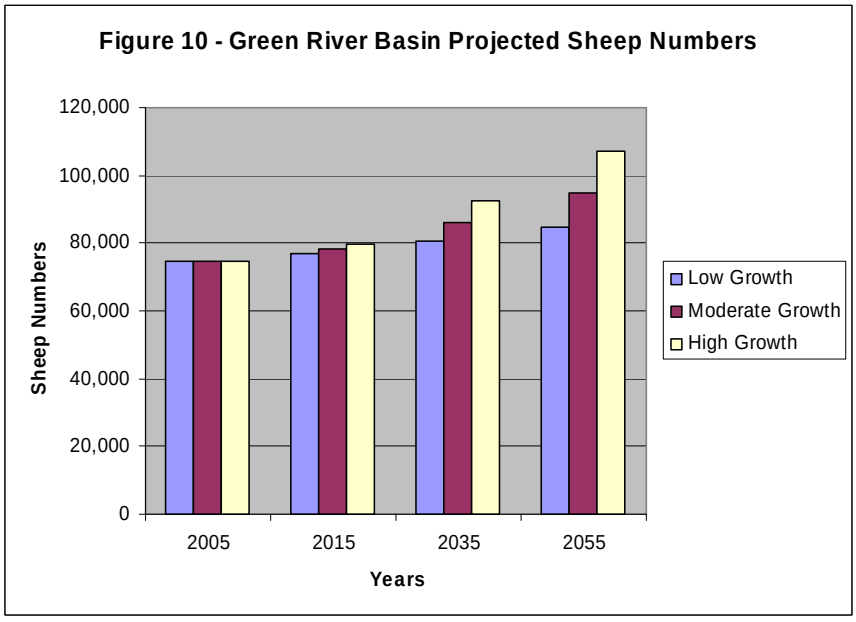
	Consumptive Use in Acre Feet					
Year	**2005**	**2015**	**2025**	**2035**	**2045**	**2055**
High Growth	396,246	400,208	404,211	410,274	416,428	422,674

An additional consumptive water use by the agriculture sector is the direct consumption of water by livestock. It has been estimated that a cow will drink about 10 gallons per day. The number of animal units is projected to increase from 156,767 in 2005 to 203,035 in 2055. Direct consumptive use is projected to increase from 1,755 acre feet in 2005 to 2,273 acre feet in 2055 for the high growth scenario.

Summary of Findings

Almost all agricultural water use in the Green River Basin is tied to livestock production. Estimated numbers of livestock were prepared for the three planning scenarios, low, moderate and high growth. The projections of cattle numbers are shown on Figure 9. The Low Growth projections show continued growth but do not attain the levels seen in earlier years. The Moderate Growth projections show growth to slightly higher than the 2000 level. The High Growth projections show more aggressive growth. The projections of sheep numbers are shown in Figure 10. The Low Growth scenario projections do not return to the levels seen in 2000, but do show an upward trend over the planning period. The Moderate Growth projections show increases over the planning period and numbers return to a level slightly higher than the level seen in 2000. The High Growth projections show fairly aggressive growth over the planning period.





Estimates of current and projected consumptive irrigation water use in the Basin were done in ten year increments over the planning horizon. The specific target years for planning are 10, 20 and 50 years into the future or 2015, 2035, and 2055. The first set of bars in Figure 11 represent the current situation for the three development scenarios, low growth, moderate growth and high growth. Current consumptive use averages about 396,000 acre-feet annually. Estimated consumption can be higher in a wet year, about 422,000 acre feet and lower in a dry year, about 371,000 acre feet (WYRAG, 2009). The remaining sets of bars compare the annual consumptive use over the planning horizon for the three

development scenarios. Table 5 presents the projected volume of consumptive irrigation water use.

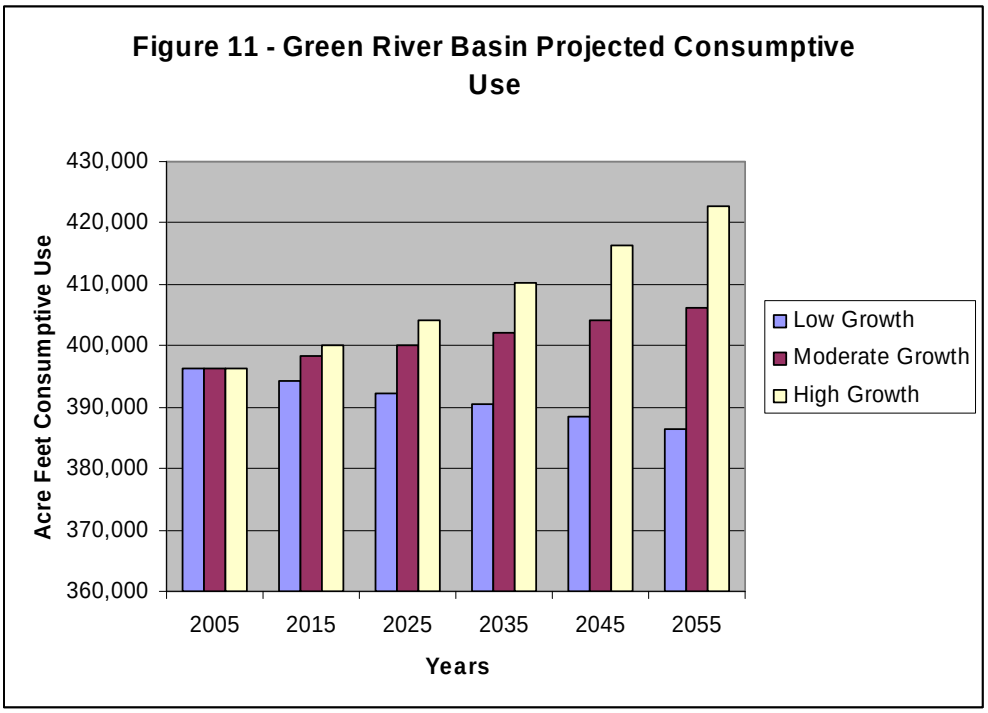


Table 5 - Green River Basin Projected Consumptive Use

	Consumptive Use in Acre Feet					
Year	**2005**	**2015**	**2025**	**2035**	**2045**	**2055**
Low Growth	396,246	394,275	392,313	390,361	388,419	386,487
Moderate Growth	396,246	398,227	400,218	402,219	404,231	406,252
High Growth	396,246	400,208	404,211	410,274	416,428	422,674

From Figure 11 and Table 5 it can be seen that in the case of the Low Growth scenario, consumptive use will decline over the planning period to about 386,500 acre feet annually in 2055. This is a decline of about two percent. The Moderate Growth scenario shows some growth over time to about 406,000 acre feet annually in 2055. This is an increase of about three percent. The High Growth scenario has water consumption increasing to about 423,000 acre feet annually in 2055. This represents an increase of about seven percent. These projections for all three growth scenarios are quite conservative but are realistic when compared to the historical changes in agriculture in the Basin.

The potential for increased forage production in the Green River Basin as a cash crop is real but is likely farther into the future than was anticipated in the 2001 Green River Basin Plan.

In additional to irrigation consumptive water use by the agriculture sector, there is direct consumption of water by livestock. It has been estimated that a cow will drink about 10 gallons per day. If sheep and cattle numbers are converted to animal units where one cow is equal to one animal unit and five sheep equal one animal unit the total number of animal units in 2005 would be 156,767 animal units with a consumptive use of 1,755 acre feet per

year. Table 6 shows the projected consumptive use by livestock for the three growth scenarios for the Green River Basin for the planning period.

Table 6 - Projections of Animal Unit Consumptive Use

Year	2005	2015	2035	2055
	Acre Feet per Year			
Low Growth	1,755	1,784	1,842	1,901
Moderate Growth	1,755	1,812	1,930	2,055
High Growth	1,755	1,848	2,049	2,273

*One animal unit is equal to one cow or five sheep.

**Consumptive Use is equal to 10 gallons per animal unit per day

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