# *Potential For Specialty Crop Production in Southwestern Wyoming*

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## INTRODUCTION

Agriculture is the second or third (depending upon the method used to determine economic impact) most economically important industry in the state of Wyoming. In addition to the direct economic benefit provided by the industry, agriculture provides both tangible as well as intangible benefits that can be as significant in their impact to Wyoming as are the economic contributions. Benefits such as winter wildlife habitat, maintenance of open spaces, preservation of custom and culture, long term stability for rural economies faced with the up's and down's of energy dependence, late season return flows to rivers and streams which provide improved and extended fish habitat, benefits and "safe harbors" to threatened or endangered species, increased wetlands due to water development and distribution and a myriad of other benefits all accrue due to the presence of a stable and vibrant agriculture presence.

Wyoming is characterized as being a generally semi-arid and continental climate state and is drier and windier in comparison to most of the United States with greater temperature extremes. The climate of any area in Wyoming is largely determined by its latitude, altitude and its local topography. Annual precipitation is 15.45". Temperature can vary from below 20° F in the winter to above 90°F in the summer; however the average temperature is 45.6°F for Wyoming. The growing season ranges from 140 days in the eastern side (lower elevation) of the state to 60 days in the higher elevation (central and western) part of the state. Due to all of these factors, water development and irrigation are tremendously important to Wyoming agriculture.

Recently two Wyoming citizens, Bill Taliaferro of Rock Springs, WY along with the author of this report, approached both the Governor of Wyoming as well as both the Wyoming Water Development Commission and the Wyoming Legislature (through the Legislature's Select Water Committee) with a concept which, if developed as conceived, could be the largest irrigation development project in the history of the state of Wyoming. Taliaferro and Reece's vision is to utilize unallocated water stored in Fontenelle Reservoir in southwestern Wyoming and transport it to private land south of the reservoir. The water would be transported via pipeline and would be delivered to land which was once proposed for development of irrigated land as part of the Seedskadee Project. In order to be successful, the land proposed for development needs to be used in its highest and best agricultural use. The land has limitations however in terms of climate and soil morphology.

The purpose of this project is to first provide a historical review of the proposed Seedskadee Project from the 1960's and exam the reasons for its abandonment. The report will also review the development of Fontenelle Reservoir and assess its available water resources which could be utilized for agricultural production. The current agricultural crop production base in the proposed area of development (the Green River Basin) will be reviewed. Finally, based upon the characteristics of soil morphology, climate and environment, the potential for specialty crop production in the proposed development will be examined and reviewed and some of the most likely specialty crops will be analyzed .

**FONTENELLE DAM AND THE SEEDSKADEE PROJECT**

**BEGINNINGS** The initial project began as the Green River Project in the early 1920's. The Bureau of Reclamation (BOR) began acquiring lands either through withdrawal of public lands or through purchase of private lands. The withdrawals and acquisitions continued until 1956 when the Colorado River Storage Project Act authorized the Seedskadee Project as a participating project and replaced the Green River Project.

BOR subsequently carried out investigations of the Seedskadee as an independent project. In November 1950, the Bureau prepared a feasibility report, issued as a supplement to the December 1950 report on the Colorado River Storage Project (CRSP)--a project located within the five adjacent states of Arizona, Colorado, New Mexico, Utah, and Wyoming. In October 1953, a third supplement brought construction costs and project benefit estimates up to date. The latter supplement, after being submitted to Congress, provided the basis for project authorization. Congress authorized the Colorado River Storage Project with the Act of April 11, 1956--initial units included Glen Canyon, Flaming Gorge, Curecanti, Navajo, and eleven other projects. This act included authorization for the Seedskadee Project, one of the initial group of participating projects in CRSP

Nearly 60,000 acres of desert range land was planned for irrigation from the Green River in an area situated about 38 miles northwest of the town of Green River. Seedskadee Project purposes included: municipal and industrial (M&I), irrigation, flood control and power. The Act of August 28, 1958 (public Law 85-797) augmented the authorizing legislation of the Seedskadee Project by authorizing BOR to sell to private individuals and business entities the withdrawn and acquired lands to be irrigated by the Seedskadee Project. The ultimate objective of the project was to create (through providing irrigation facilities and irrigation water) privately-held, economically-viable agricultural operations.

It was for this purpose that BOR either withdrew or acquired large tracts of lands in addition to the lands needed for the dam and reservoir. Following project authorization and preparatory to construction, advance planning studies of the Seedskadee Project were undertaken by Bureau of Reclamation. Those studies culminated in the definite plan report of April 1959.The plan proposed in the April 1959 definite plan report included construction of Fontenelle Reservoir on the Green River in lieu of the diversion dam and a portion of the distribution system in the authorizing plan. The reservoir was to regulate runoff of the Green River for 58,775 acres of land in farm units and community pasture and provide water for the Seedskadee National Wildlife Refuge to be established along the Green River. The reservoir was to be constructed to a capacity of 285,000 acre-feet, and the dam was to be 116 feet high.

Under the 1959 definite plan regulated releases from Fontenelle Reservoir were to be distributed for irrigation through three major canals--the West Side Canal extending from the right abutment of Fontenelle Dam, the Big Sandy Canal extending from the dams left abutment, and the East Side Canal branching from the Big Sandy Canal. The canal outlets are about 86 feet above streambed. Two hydraulically driven pumps at drops in the West Side Canal were to lift irrigation water to project lands above the canal. Thirty-five laterals with sublaterals were to branch from the three major canals to distribute water to the project lands. Land drains were to be provided as needed and some sections of the canals and laterals were to be lined to prevent seepage.

In addition, initial development work on community pasture was to be undertaken and technical assistance provided for the settlers. The 58 1775 acres to be furnished irrigation water under the 1959 plan included 54,520 acres in farm units and 4,255 acres in community pasture. The lands in farm units were divided in five blocks with Blocks 1 through 3 including land under the West Side Canal, Block 4 including land under the East Side Canal, and Block 5 including land under the Big Sandy Canal. The acreage was based on a land classification survey made as part of the feasibility study in 1946-48 with revisions made as part of the definite plan studies in 1955-57.

**THE DISCOVERY OF TRONA[1]:** Technically known as sodium sesquicarbonate and the most common of the sodium carbonate minerals found in nature, Trona (Na 2 CO 3 NaHCO 3 2H 2 O) is used to produced soda ash or sodium carbonate. Glass manufacturing requires nearly one-half of the sodium carbonate produced; chemicals consume one-quarter; and the remainder goes to pulp, paper, soap, detergent and aluminum production, water treatment, and other miscellaneous uses.

In 1959, drilling by the Stauffer Chemical Company indicated a minable deposit of trona located in the southern or lower end of the project. They discovered that the southern part of the Green River Basin in southwestern Wyoming overlays the largest known deposit of trona in the world, about 1,400 square miles. The Wilkins Peak Member of the Eocene Green River Formation contains about sixty-seven billion tons of trona in twenty-four beds more than three-feet thick. In a 1,400-square mile area in the Green River Basin these beds lie at depths of 400 to 3,500 feet. In the southern part of the area fourteen beds, more than three-feet thick, contain another thirty-six billion tons of mixed trona and halite.

On January 14, 1960, after Stauffer's discovery, the Wyoming Natural Resource Board arranged a meeting with the officials of the Union Pacific Railroad Company, Stauffer Chemical Company, and representatives of the Bureau of Reclamation; representatives from the Bureau of Mines, Bureau of Land Management (BLM), and the U.S. Geological Survey (USGS) also attended. The Wyoming Natural Resource Board unanimously passed a resolution, at the conclusion of the meeting, recommending Reclamation continue to seek Congressional appropriations for the Seedskadee Project with the confidence that the interested parties would work out the issue surrounding the mining of trona on potential project lands. The project plan was modified, after much discussion, deferring the development of the area underlain by trona until a suitable solution to the conflict between mining and irrigation could be reached. To facilitate a decision, the Stauffer Chemical Company began mining a deposit east of the Green River outside the project area. Planning to determine the pattern and extent of surface subsidence as mining operations proceeded; officials thought that a suitable solution of mining and irrigation could be worked out with the findings of these studies. The lack of irrigation on the Project later made the concerns regarding the coexistence of mining and irrigation irrelevant.

**CONSTRUCTION AND DEVELOPMENT OF FONTENELLE DAM AND OF IRRIGATION AND POWER FACILITIES:** The Fontenelle Dam is located on the Green River 24 miles southeast of La Barge, Wyoming. A zoned earthfill structure, the dam is 139 feet high with a crest length of 5,421 feet, and a volume of 5,265,000 cubic yards of material. The spillway consists of an uncontrolled crest, open chute, and stilling basin with a design capacity of 20,200 cubic feet per second. Fontenelle Powerplant is located adjacent to the toe of the dam, with the power

[1] "Seedskadee Project", Toni Rae Linenberger, Bureau of Reclamation, 1997

penstock branching from the river outlet works. The powerplant consists of one 10,000-kilowatt generator and one 16,000-horsepower hydraulic turbine.

The reservoir has an active capacity of 150,500 acre-feet and a total capacity of 345,360 acre-feet, with a surface area of 8,058 acres. The lake is 20 miles in length when full, and has a shoreline of approximately 56 miles.

Construction of Fontenelle Dam was started in June 1961 and completed in April, 1964. The reservoir has a total capacity of. 3451000 acre-feet including a dead storage of 600 acre-feet below the intake sill to the river outlet, an inactive capacity of 154,400 acre-feet below the intake sill to the West Side canal, and an active capacity of 190,000 acre feet.

In September 1965 after the reservoir had filled to capacity, water passing through relief cracks in the right abutment carried away part of the downstream embankment over the abutment and failure of the dam was threatened. The reservoir was evacuated and a repair program was undertaken that extended late into 1967. The reservoir was refilled in the spring of 1968. As a part of the reservoir construction, State Highway 189 was relocated for a 7-mile long section along the west side of Fontenelle Reservoir. The emergency reservoir drawdown that occurred in 1965 caused subsidence and bank sloughing along the upper west reservoir margin and resulted in settlement of sections of the highway. A maintenance and improvement program was undertaken to restore the highway to original condition.

Construction of Fontenelle Powerplant and appurtenant facilities was started in February 1963 and completed in January 1966. Transmission lines between the Fontenelle and Flaming Gorge power plants were constructed by the Bridger Electric Association. Commercial power generation was delayed until May 1968 because of the repair work on the dam and related facilities. Construction of the Fontenelle government camp to serve the Seedskadee Project was started in April 1961 and completed in 1963. This camp was built as the headquarters for construction activity on the Seedskadee Project and was later to become the headquarters for project operation and maintenance activities. It included facilities for housing and administration

**DEFERMENT OF IRRIGATION:** On May 21, 1962, the Commissioner of Reclamation issued a stop order suspending construction of irrigation features of the Seedskadee Project until a review of Wyoming reclamation projects could be accomplished. The stop order was as a result of Congressional hearings on the Riverton and Eden Projects in Wyoming that brought to light the serious financial and economic problems encountered by farmers on these high-altitude irrigation projects. The stop order came just prior to the opening of bids for the first 9.4 miles of the project's West Side Canal and associated features.

**SEEDSKADEE DEVELOPMENT FARM:** Following construction of Fontenelle Dam and Reservoir, the first portion of the Seedskadee project was completed in 1962. Settlement on units averaging about 190 acres was scheduled to begin in late 1963. However, early in 1962 Congressional Committees became concerned as to the economic adequacy of this size unit, and held up funds until some studies could be made relating to unit size; specific concern related to the question of how a family type operation with limited labor could safely manage water on larger units. Other related studies on soil and water management were requested to provide guidelines before completing the last phase of this project.

BOR employees, personnel of the University of Wyoming and other interested parties met with the Wyoming Reclamation Projects Survey Team, to discuss the development of the Seedskadee Project, during the first months of 1963. Subsequently, the Survey Team held several public meetings in April and May throughout southwestern Wyoming to obtain public views of the Project.

Joe Budd, an alternative member of the Colorado River Commission called a public meeting in Kemmerer on May 6, 1963, to review the report of the meeting held by the Survey Team. In addition, Bud vigorously pointed out the dangers of losing Wyoming's share of the Colorado River water to the lower states. The Wyoming Resource Board as well as industry and stock interests in the area also expressed the desire to maintain Wyoming's share of the Colorado River waters. Overall the general public's sentiments appeared to support the reports of the survey team.

In their report dated, June 30, 1963, the Wyoming Reclamation Projects Survey Team recommended that a pilot farm program be established immediately for the purpose of determining the necessary components of a successful irrigation operation; the Farm would be operated by the Bureau of Reclamation in cooperation with the Agricultural Research Service of the Department of Agriculture and the University of Wyoming. After making these examinations a request could be sent to Congress requesting legislation authorizing the Secretary of the Interior Stewart Udall to act in accordance with the evidence as it relates to unit size. Awaiting information from the operation of the Development Farm, construction of the project irrigation distribution system was deferred indefinitely, beginning the last of March.

Preparation of design data for the Seedskadee Development Farm began August 26, 1963, under the recommendation of the Wyoming Reclamation Projects Survey Team. Located approximately eleven miles downstream from the Dam, the site selected for the Farm represents the project's soils and topography. In October, topography maps were completed and a collection of design data for the various features initiated.

The Bureau initiated construction, in accordance with general recommendations of the Advisory Committee, during the spring of 1964 and completed the Farm in the summer of 1965. Summer of 1964 saw establishment of crops, while fall brought the addition of livestock. The Agricultural College of the University of Wyoming supervised the Farm Operations directly, under the general supervision of the Advisory Committee. Reclamation financed operations directly with appropriated funds. The Agricultural College scheduled the submission of a report of findings late in 1966.

Reclamation awarded the contract, for the construction of a farm access road, fencing, pumping plant, and buildings, to Landon Construction Company of Casper, Wyoming, beginning Farm construction. The contractor moved his equipment in on March 27, 1964, and began work March 30. Also on March 30, an additional contract, for the construction of earthwork and structures for laterals, drains, and land leveling, was let to Benson Construction Company of Grace, Idaho. Work began April 16. Until completion in early August, work continued steadily. After leveling and completing the laterals, individual fields were turned over to the University of Wyoming for seeding and initial irrigation. All nine fields of the upper bench had been seeded by mid-August. Landon Construction Company moved a 2-bedroom relocatable house to the farm from Fontenelle Community, to serve as quarters for farm help and experimental workers.

In April of 1964 the Bureau of Reclamation contracted and started land clearing and leveling. Domestic water was provided from a 900 foot artesian well; water was brought in 21 miles; housing, fencing and other necessary improvements were provided during the summer of 1964. That year a 305 acre block of land on the upper bench was cleared, leveled and provided with a border irrigation system capable of handling heads of water up to 18 cfs.  As the individual units of this field were cleared the University assumed responsibility and established crops and continued the development program. Approximately 179 acres were seeded for irrigated pasture and 126 acres to alfalfa for hay as individual fields were leveled and borders installed.

On September 1, 1964, the College of Agriculture of the University of Wyoming assumed operation of the Development Farm, with funds advanced by the Bureau of Reclamation. Former Manager of the University of Wyoming Pilot Farm at Farson, Wyoming, Mr. E. E. Buckendorf was selected as Resident Manager of the Development Farm. The Farm manager erected minor improvements such as fencing and a large pole shed for livestock in the fall. The fields of the upper bench were seeded with alfalfa, oats, and various grasses. The oats started remarkably well without fertilizer, according to observations in early summer. The earth distribution system and the river pumping plant functioned well.

The overall objective of the Development Farm was to find the best adapted modern irrigation methods for those particular soil's and cropping conditions; and to provide such information to planners and finally to settlers coming onto the project to insure the success of project settlement. The major specific objectives initiated by the University in talking on the responsibility of directing the Development Farm was to check out in the shortest possible time the performance of several systems of irrigation on the soils of this project. The goal was to develop practical guidelines for a system of soil and water management to provide: 1). Minimum labor inputs; 2, High efficiency in water us; 3). Minimum risks in raising a water table and seeping out land; 4). High yields of adapted crops. Other necessary objectives included methods of land clearing and development, fertilizer requirements, crop varieties and year around 1lvestock management techniques.

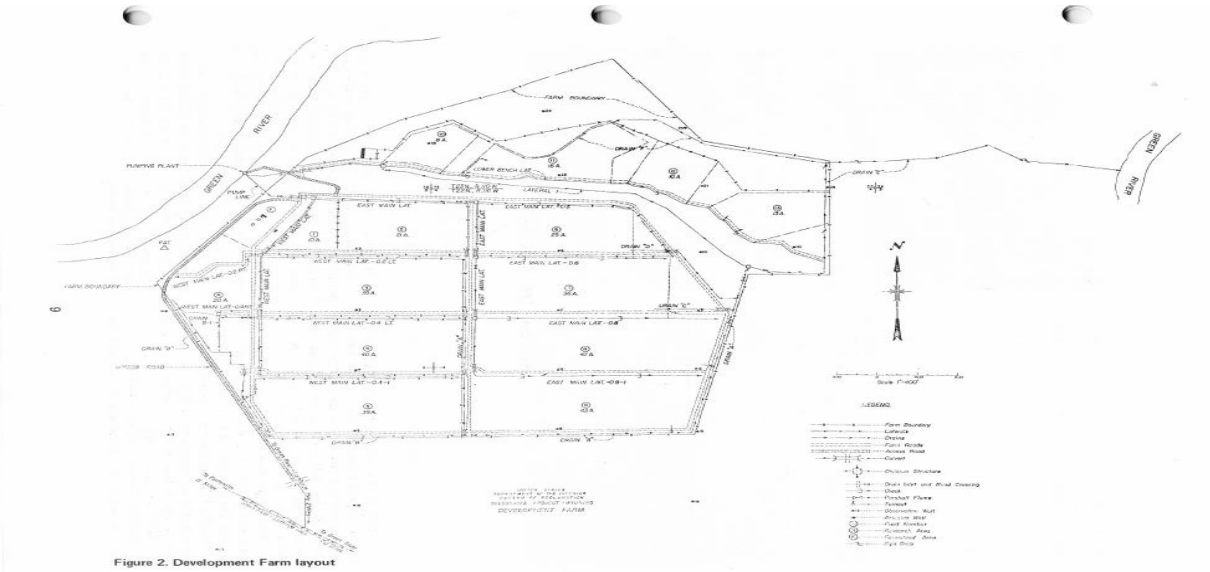


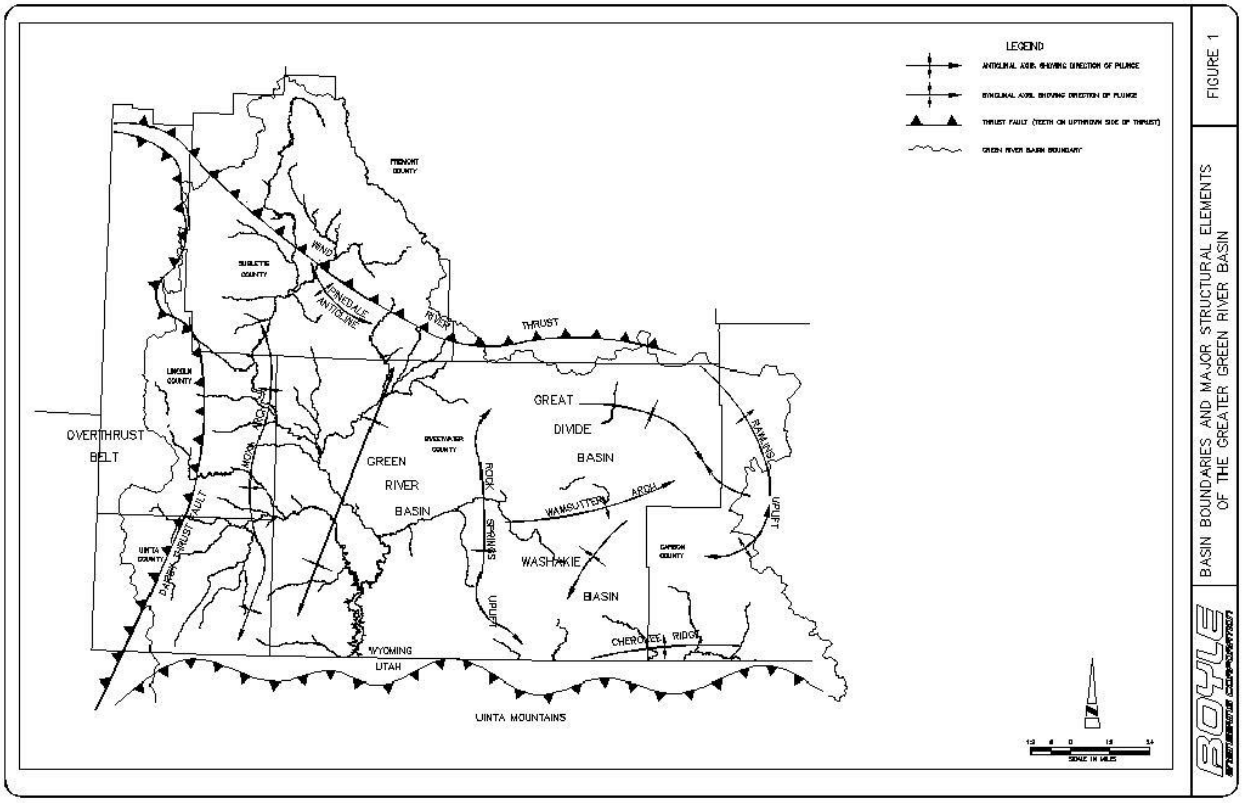
Figure 2. Development Farm layout

In 1965, the Farm completed its first year of operation. The State of Wyoming through the University of Wyoming, successfully operated the Farm for the next four years, 1966-69. In 1965 an additional 75 acres were cleared and prepared for comparison of different systems of irrigation. Approximately 50 acres were on the lower bench, classed as 3 and 4 lands, and 25 acres on the upper bench consisting primarily of class 2 lands. The Agricultural- Research Service cooperated on this work until they closed out in 1967, In 1967 an additional 142 acres were cleared and seeded to alfalfa and grass on the upper bench class 2 lands under an automated circular sprinkler system. With the above additions, the farm then consisted of 522 acres under various systems of irrigation. In addition there was approximately 140 acres in roads, farmstead, waste land and corrals and feed ground for livestock. In 1970, the five year contract made between Reclamation and the State of Wyoming expired and the Farm reverted to Reclamation control. Beginning January 1, 1972, Reclamation advertised for lease, the Seedskadee Development Farm, including approximately 740 acres near Green River Wyoming. 33 These lands lie fallow, as no one ever purchased the Farm.

Currently, Fontenelle Reservoir provides no water for irrigation despite the fact that approximately 100,000 acres could potentially be developed. Other than the years when the State of Wyoming controlled the lands used by the Seedskadee Development Farm, project lands have never left BOR control. In 1998, BOR began the process of revoking the lands it had withdrawn for the Seedskadee Project (~150,000 acres) and transferring them over to the Bureau of Land management. BLM has managed these lands since BOR abandoned the Project. In 2014, BOR issued a Finding of No Significant Impact (FONSI) under NEPA and is moving to finally complete the transfer to BLM.

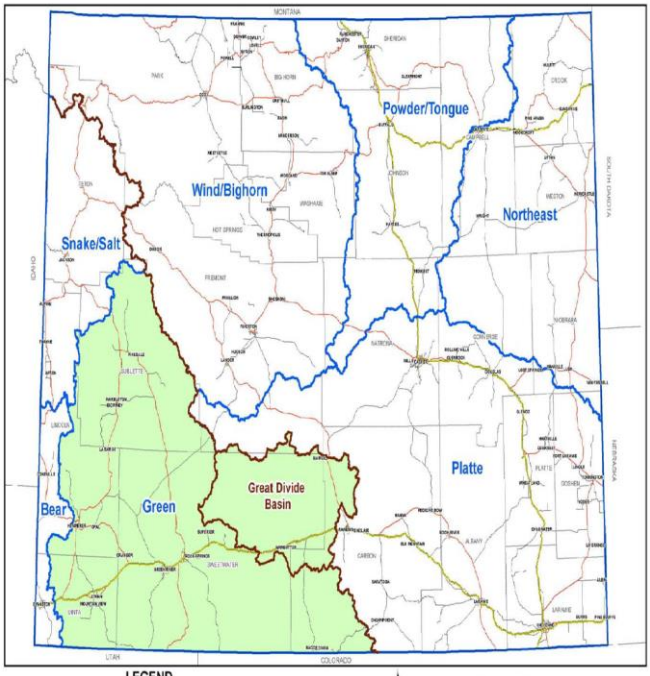
**IRRIGATION WATER NEEDS AND DEMAND PROJECTIONS FOR THE GREEN RIVER BASIN**[2] NOTE: The following was largely lifted from the document: TECHNICAL MEMORANDUM: Green River Basin Plan II: Irrigation Water Needs and Demand Projections; October 15, 2009 (Revised March 17, 2011); PREPARED BY: WWC Engineering

In order to fully understand the potential for future irrigation development and crop production in the Green River Basin (GRB), a complete review and understanding of current agriculture production, land use and type in the Basin and current water uses, demands and potential development needs must be examined. For purposes of this report, the boundaries of the Greater Green River Basin are as shown in the figure below[3] and include the Green River drainage, the Little Snake River drainage, and adjacent areas of internal drainage, such as the Great Divide Basin.




[2] TECHNICAL MEMORANDUM: Green River Basin Plan II: Irrigation Water Needs and Demand Projections; October 15, 2009 (Revised March 17, 2011); PREPARED BY: WWC Engineering

[3] TECHNICAL MEMORANDA: Green River Basin Water Plan, Available Ground Water Determination, William F. Hahn, P.G., Boyle Engineering Corporation and Chris A. Jensen, G.I.T., States West Water Resources Corporation

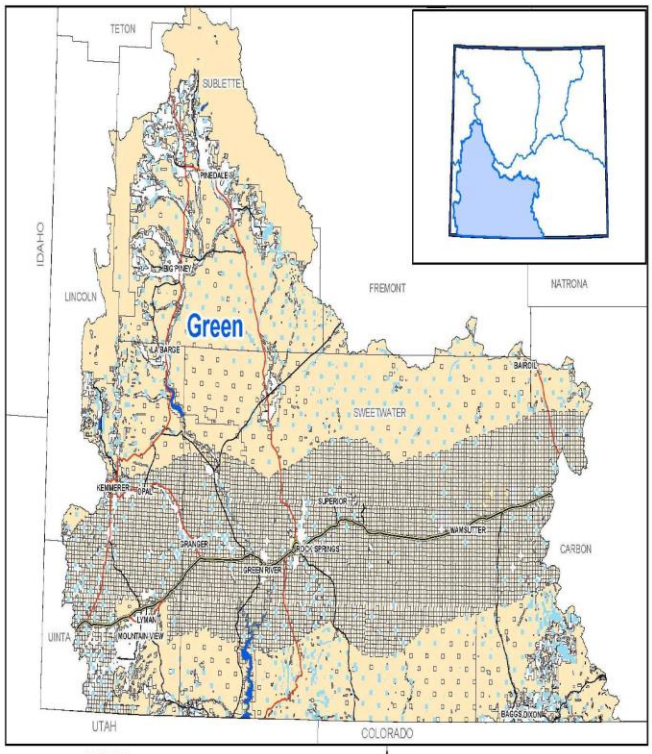



**LEGEND**

River Basin Planning Area — Continental Divide

Note: The Great Divide Basin is a closed basin included within the Green River Basin Planning Area.

**Figure 3-1**
**River Basin Planning Area Map**

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Private — State — Federal

**Figure 3-2**
**Green River Basin Land Ownership**

**AGRICULTURAL USES:** 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. 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. 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).

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. These 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 expa nd 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.

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

**TRENDS IN LIVESTOCK PRODUCTION:** Currently, the primary purpose and use of irrigated agriculture in the Green River Basin is for the production of feed for livestock, either in the form of hay production, or through irrigated pasture. Consequently, in order to examine and determine the potential and feasibility of increased agricultural production through irrigation in the GRB, it is helpful to analyze current trends in livestock production in the Basin.

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.

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. 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).

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. These 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.

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 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).

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.

Some trends in the agricultural industry in the western U.S. suggest that certain types of forage production will become more valuable in the future as cash crops. Population pressures in Arizona, California, and parts of Idaho, Oregon, and Washington are increasingly displacing agricultural production in those states; especially forage production. 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. This trend has already resulted in a large exodus of dairy producers from California to states such as Idaho, Nebraska, and western Kansas because of the lack of alfalfa in California. Dairy producers in the Boise, Idaho area and along the Colorado Front Range are now having difficulty securing enough alfalfa locally and are relying upon

imports from other states or are relocating to hay producing areas. One dairy recently moved into the Riverton area in Wyoming and another is considering relocation to Torrington (Gray, 2000).

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 of½ 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

**POTENTIAL FOR SPECIALTY CROP PRODUCTION IN THE GREEN RIVER BASIN GIVEN THE POSSIBILITY OF A NEW IRRIGATION PROJECT**

SPECIALTY CROPS DEFINED Specialty crops are defined in law as “fruits and vegetables, tree nuts, dried fruits and horticulture and nursery crops, including floriculture.” This definition, although more exact than previous legal definitions, leaves a certain amount of latitude in interpretation. Fruits, vegetables, tree nuts, nursery crops and floricultural crops are all considered to be horticultural crops. Regardless, the specific mention of these crop groups means that plants so classified automatically qualify as specialty crops. Where interpretation is needed is in which plants, not specifically mentioned in legislation, can be classified as horticulture (sic) crops

**ALTERNATIVE CROP PRODUCTION IN WYOMING[4]:**

One alternative for increasing profit margins of the Wyoming agricultural industry is through the introduction of new crops. Wallis et al. (1989) defines new or alternative crops as either crops new to a particular county, region or state, or as a crop that has been, or is being developed, from a plant that has never been cultivated for commercial production. Alternative crops such as cabbage, mint, pumpkins, squash, and turf grass seed have been cultivated in Wyoming, but are most often marketed for local consumption rather than being commercially produced. Specialty crops, such as seed potatoes, could possibly be grown in some of the lower elevation areas of the Green River Basin. Seed alfalfa production is moving into Wyoming's Big Horn Basin, where acreage has grown from 2,000 to 15,000 acres in recent years (Gray, 2000). Nevertheless, the Green River Basin will always have a competitive disadvantage with respect to specialty crops compared to lower elevation areas such as Wyoming's Big Horn Basin or lower North Platte River Basin.

One of the myths about Wyoming is the climate is too harsh to grow many horticultural crops. Producers may not be able to grow much sweet corn, watermelon, okra, or other warm-season crops, but they can certainly raise cool-season plants. High levels of light and cool nights are conducive to growing all sorts of vegetables in many areas of the state. Radishes, lettuce, spinach, peas, beets, broccoli, cabbage, and even green onions can flourish in the state's generally short growing season. The vegetables can be cultivated in plastic-mulched rows using drip irrigation, but other methods are also used commercially. Grapes are grown in several counties including Sheridan and Goshen, and they can probably be produced in other warmer areas of Wyoming. Raspberries can thrive and maybe even strawberries at lower elevations. Other berries to consider include serviceberries, elderberries, currants, and gooseberries. These are perennial crops that will be in production for many years and so require some up- front planning and thought. They can be placed in rows or plots and all require manual harvesting.

Many culinary herbs can be grown with little fuss in Wyoming's climate. The easiest are those cultivated for their leaves – basil, chives, and mint for example. The toughest are those nurtured for their seeds (caraway, dill, anise, etc.). Usually, herbs are planted from seeds although transplants can be used. Planting in rows and using drip irrigation and mulch is common. Most herbs can be sold fresh at nearby farmers' markets. Many can be dried and preserved and then sold farther from the field. Annual herbs or non-winter perennials that can be raised include anise, basil, coriander (cilantro), dill, marjoram, oregano, rosemary, sage, and summer savory. Biennials, which need two growing seasons, include caraway and parsley. Perennials that will produce for several years include chives, mint, winter savory, tarragon, and thyme.

As a specialty within Wyoming, there are literally dozens of annual and perennial flowering crops that can be developed for fresh market sales or for drying and preserving. Usually reared in rows with drip irrigation and plastic mulch, specific varieties have been developed for this type of production. Most are grown from seeds. The producer can buy seeds and start them on their own or purchase seedlings and then transplant them outdoors. The list of possible plant materials is enormous. A few of the many annuals that can be grown in the field for cut flowers include ageratum (flossflower – fresh or dry), snapdragons (fresh), calendula (fresh), celosia (cockscomb – fresh or dry), gomphrena (globe amaranth – fresh or dry), lavatera (mallow – fresh),

[4] "*Wyoming Offers Opportunities for Alternative Crops*"; UW Barnyards to Backyards, Winter 2008; Dr. Karen Painter, University of Wyoming Cooperative Extension Service, Horticulture Specialist

statice (fresh or dry), and poppies (fresh). Some perennials to try include yarrow (several species – fresh or dry), butterfly weed (fresh), delphinium (several species – fresh), goldenrod (several hybrids – fresh), speedwell (several species – fresh), and culver's root (fresh). All these perennials and dozens of others are hardy in Wyoming.

Woody plants can be grown in the field for a year or two and then sold to local consumers or at farmers' markets. This is a highly competitive area of but could provide niche types of plant materials resilient in Wyoming that may be hard to find otherwise. Most woody plants are brought in from huge nurseries in other states, and the plant material may or may not be acclimated to the state. There are many different methods of producing woody plants: in rows, in the ground, in containers, and in plots, as examples. There are also different ways to water them, including using overhead sprinklers or drip irrigation. Special planting methods used include grow bags or pots in other pots. Starter materials should be purchased with bare roots and then planted outdoors for continued growth. This type of specialty crop offers more long-term possibilities than others and requires planning far in advance.[5]

**CLIMATE WITHIN THE GREEN RIVER BASIN:**

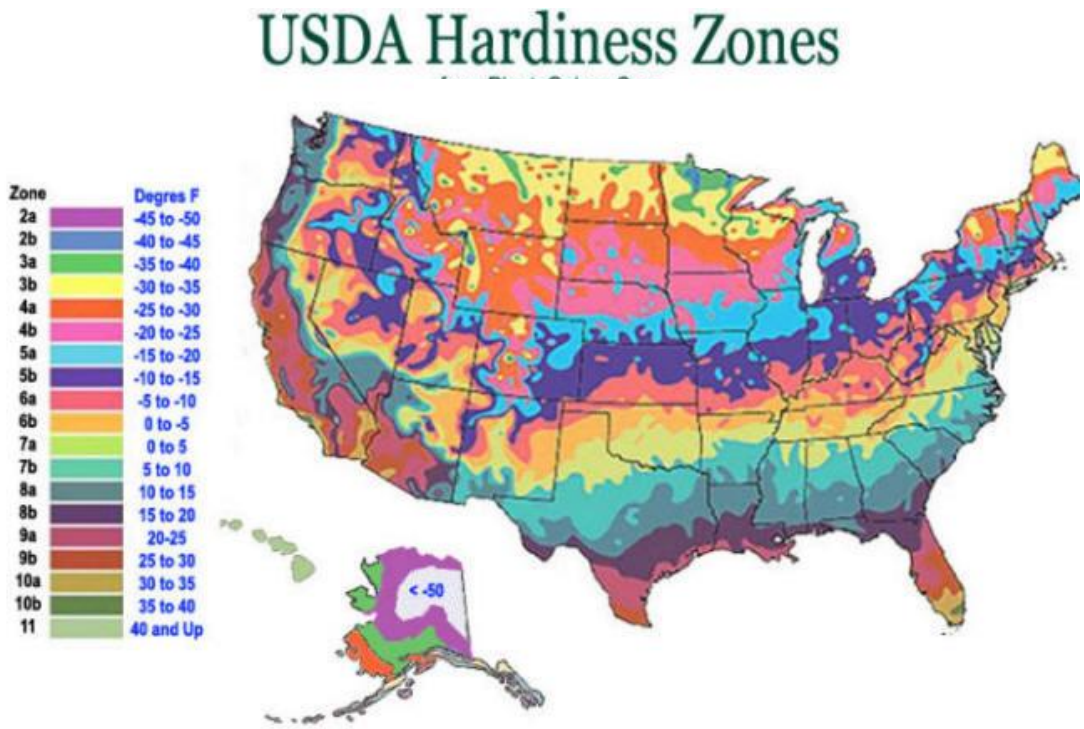
Climate within the area of interest is semiarid and is characterized by wide daily and annual temperature variations and well defined seasons. During summer months days are warm and nights are cool. Winter months are cold with moderate snowfall. Humidity is usually low.

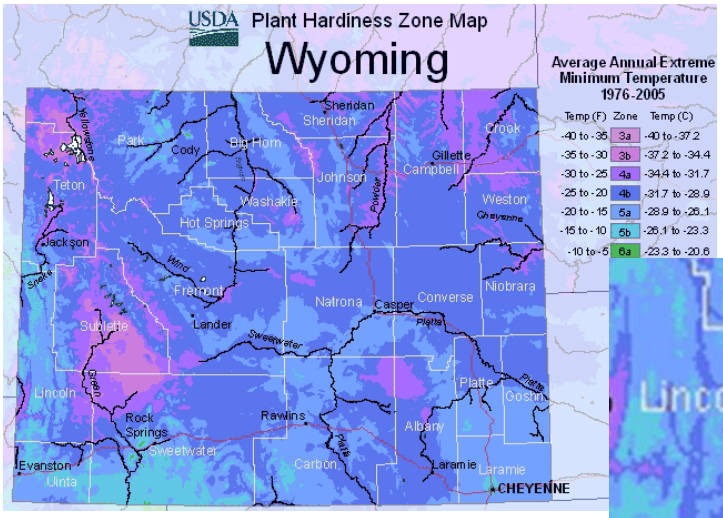
The Green River Basin is characterized by a relatively short growing season due to high elevations, a short frost-free period in the spring, summer, and fall, and sporadic distribution of precipitation throughout the year. The frost-free period or consecutive period with temperatures above 32°F extends from about June 15 to September 1, an average of about 78 days. The growing season averages 125 days, extending from about May 15 thru September 17. Annual precipitation averages approximately 6.9 inches, of which about 3 inches falls during the growing season.

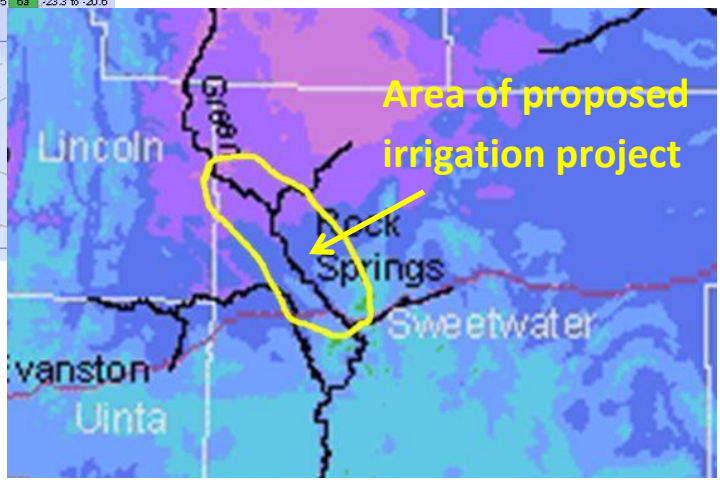
Climate throughout the Basin varies as a function of elevation, latitude and orographic effects, but most of the Basin follows the pattern of a high desert region. Higher precipitation and lower temperatures generally accompany higher elevations. On average, the Basin receives between 10 to 15 inches of precipitation annually with less than 13% of the Basin receiving more than 20 inches. On average, the Basin receives the most precipitation in April and May and the least in December and February. The higher elevations receive the majority of their precipitation in winter months (October–March when the lower elevations in the middle of the Basin are at their driest. While long, mild-intensity rainfall events do occur in the Basin, the majority of the rainfall occurs in short, intense storms. In the proposed area of irrigation development, precipitation averages about 8.9 inches annually, of which. 4.2 inches occur from May to September. The precipitation varies widely from year to year, ranging from 50 percent to 160 percent of normal.

[5] [5] "*Wyoming Offers Opportunities for Alternative Crops*"; UW Barnyards to Backyards, Winter 2008; Dr. Karen Painter, University of Wyoming Cooperative Extension Service, Horticulture Specialist

Temperature and frost conditions typically restrict the variety of crops that can be successfully produced to forage grasses, alfalfa hay, tame hay mixture's, small grains, and hardy vegetables, Winds are often strong and difficult to operate in, particularly during protracted dry spells when dust storms are common.





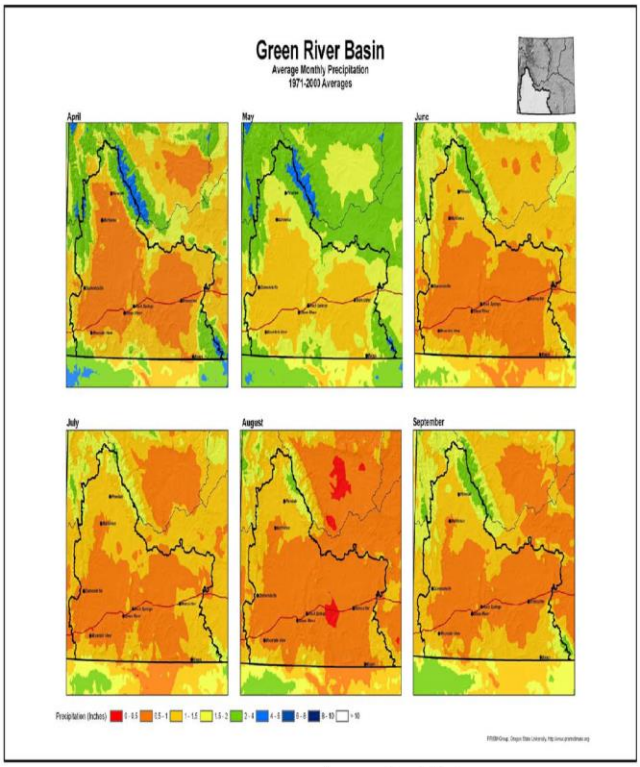
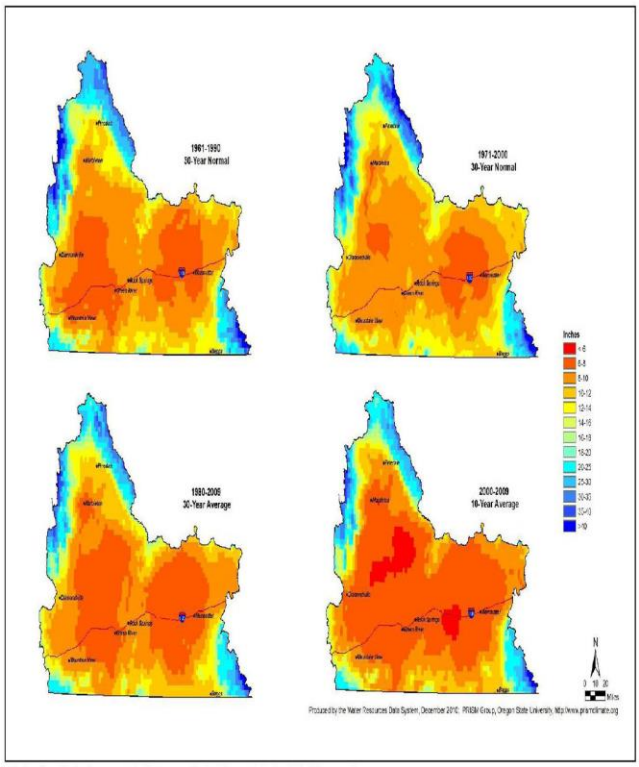




Figure 3-4 Cont
Average Monthly Precipitation, 1971-2000 Averages




The term "normal" refers to averages calculated across a standard 30-year period, either 1981-1990 or 1971-2000. Such 30-year normals are used in climatic and hydrological analyses, and the normal values presented here were calculated by the NOAA National Climatic Data Center. The term "averages" refers to values calculated by WRDS across a non-standard time period (1980-2009 or 2000-2009).

Figure 3-3
Annual Precipitation Comparisons

## SOILS AND TOPOGRAPHY

The area of major interest for the possible irrigation project lies south of Fontenelle Reservoir along both sides of the Green River towards the towns of Rock Springs and Green River, WY. The major area of interest is on the east side of the river on lands lying below the 6400' elevation mark.

As indicated in the image below, the availability of USDA soil survey data for this area is extremely limited to almost non-existent. The best analysis of soils in this area is found from the records of various documents which have been prepared over the years for a variety of reasons and purposes. From these various publications, a somewhat comprehensive picture of the soil resources in the area can be compiled.

The greatest source of soils data is likely derived from a review of the records of the UW/BOR Joint Research Farm which was part of the Seedskadee Project. The following information was taken from those records[6]:

> *The elevation of the upper terrace lands-ranges between 6385 and 6400 feet. The original-slope before leveling varied from one to four feet per thousand for the Class 2 lands of the study area to as high as 3 and 4 feet per hundred for the Classes 3 and 4 lands of the lower terrace. Natural drainage of the farm fields of the upper terrace is to the southwest.*
>
> *Soils of the Seedskadee Project are mainly alluvial materials deposited in branches and terraces above the flood plain of the Green River.*
>
> *First, or lower terrace soils are predominantly interspersed Class 3 and 4 Lands characterized by shallow depths (6 to 24 inches) and low water holding capacity (generally less than 1.25 inches of available moisture in the soil profile.) Soil textures range from light clay to loamy sand and exhibit good permeability. The soil mantle is calcareous and underlain with about 13 feet of sand and gravel over shale.*
>
> *Second terrace soils of the 305-acre border-irrigated field and 142-acre sprinkler area are comprised largely of calcareous Class 2 land. Soil depths are generally 34 to 50 inches thick over sand and gravel. Permeability is good, and water holding capacity is about twice that on first terrace soils.*

Other reviews of the soils found within the proposed project area include:
*Contemporary USDA soil maps for Seedskadee NWR (and most of southwest Wyoming) are not available. Gross-scale maps prepared for the refuge in 1957 (Soil Conservation Service 1957) indicate a heterogeneous distribution of soil types with moderately deep sandy and loam soils that are strongly alkaline near the Green River in floodplains and on natural levees; deep clayey, alkali soils on alluvial fans; intermingled gravel and shallow loam soils on recent terraces; moderately deep clay saline-alkali and shallow gravelly soils on upland terraces; and moderately deep sandy soils on remnant terraces and upland benches (Fig. 4)[7].*

And from the September, 2002 "Seedskadee National Wildlife Refuge Comprehensive Conservation Plan":

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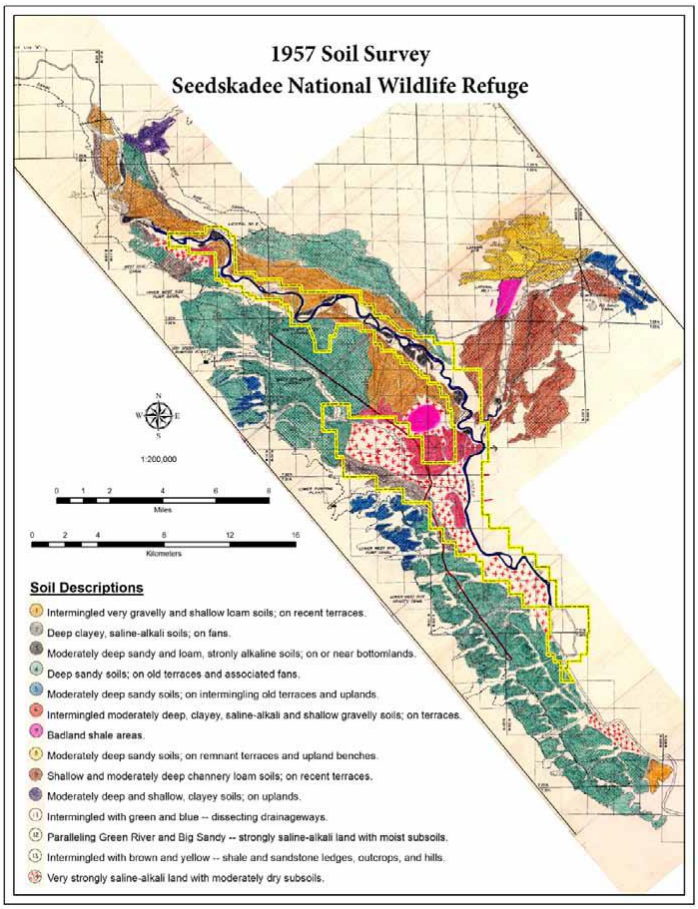
SEEDSKADEE DEVELOPMENT FARM; Progress Report 1964 1969: Bulletin 506, Agricultural Extension Service, January 1970, University of Wyoming
Heitmeyer, M. E., A. R. Henry, and M. J. Artmann. 2012. *Hydrogeomorphic evaluation of ecosystem restoration and management options for Seedskadee National Wildlife Refuge, Wyoming*. Prepared for U. S. Fish and Wildife Service, Region 6, Denver, Colorado. Greenbrier Wetland Services Report 12-02, Blue Heron Conservation Design and Printing LLC, Bloomfield, MO;

*The soils located within the Seedskadee NWR are described in the BLM Green River Resource Area Resource Management Plan (1992) to include the following four soil units:*

*II Cambarge, Pepal, Huguston, Leckman soils (northern and western portion of the Refuge) Deep, well drained, gravely sandy loam and fine sandy loam soils formed on nearly level or sloping stream terraces and alluvial fans. Elevations are from 6,200 to 6,500 feet. Precipitation ranges from 7 to 9 inches per year.*

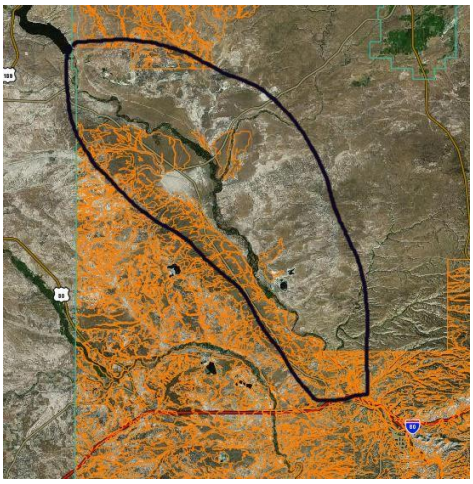
*II Teagulf, Huguston, Haterton, Wint, Tasselman, Seedskadee, Leckman, Kandaly soils (eastern portion of the Refuge) These soils are moderately deep to very shallow, well drained soils formed on rolling upland plains dissected by rock ravines, short escarpments, and draws. Elevations are from 6,100 to 6,700 feet. Precipitation ranges from 7 to 9 inches per year.*




*II Kandaly, Westvaco, Haterton, Teagulf, Huguston soils (eastern portion of the Refuge) Deep sand dunes intermingled with moderately deep to very shallow, well drained, strongly alkaline soils formed on rolling upland plains and fans. Included in this unit are some areas of badlands. Elevations are from 6,300 to 7,000 feet. Precipitation ranges from 7 to 9 inches per year.*

*II Dines, Quealman, Chrisman soils (mid- to southern-portion of the Refuge, bottomlands) Deep, poorly to well-drained soils formed on nearly level or sloping floodplains, bottomlands, and alluvial fans. Some soils in this unit are strongly saline and/or alkaline. Elevations are from 6,000 to 6,600 feet. Precipitation ranges from 7 to 9 inches per year.*

*Seedskadee NWR's sandy soils (Kandaly, Westvaco, Huguston) are very susceptible to wind erosion when the protective vegetative cover has been removed. Soluble salt levels in some soils affect management potentials due to toxicity, reduced infiltration rates, limits on nutrient availability, and reduction of water available to plants. Major causes of increased salinity contribution from public lands are irrigation, overgrazing, off-road vehicles, and energy exploration and extraction. These activities cause some compaction of the soil surface, with a reduction of plant cover, which in turn leads to increased runoff carrying salt laden sediments into drainages. Within the region, moderately saline soils can be found along major drainages such as the Green River, Big Sandy River, Bitter Creek, and Blacks Fork River. Soils especially susceptible to surface disturbing activities include unstable soils, sandy soils and erosive soils.*



**USDA Web Soil Survey with approximate area of primary interest indicated- note availability of soil survey data in most of area**

**RESULTS: POTENTIAL SPECIALTY CROP PRODUCTION IN THE GREEN RIVER BASIN**

The determination of specific specialty crops that could be grown in the GRB in the area being considered for new irrigation development is difficult. With the wide range of variables that are involved in selecting alternative crops, coupled with the degree of uncertainty in some of these parameters within the potential development area, selection of specific crops is difficult. Following a review of crop growth parameters of several dozen alternative crops, the following eight crops were selected for further review: Lavender, Potatoes, Onions, Woody Ornamentals, Landscaping/Christmas Trees, and Strawberries. These crops were analyzed using the following parameters; Optimum Temperature, Soil Attributes, Precipitation, Frost-free Season, Minimum Temperature and Maximum Temperature. The results of that analysis are found on the accompanying spreadsheet.

An assumption as regards perception was made given the fact that the purpose of the proposed water development in southwestern Wyoming is to deliver stored water from Fontenelle Reservoir to new lands to be placed under irrigation. Given the fact that if construction does proceed forward on the new development, water for irrigation purposes, at least initially, should not be a limiting factor. The precipitation parameter was used primarily to screen out crops that require exorbitant levels of precipitation or which require high levels of humidity in order to flourish. Since neither of these environmental variables are present in southwestern Wyoming, crops which might require such were automatically screened out. Under certain conditions, all of these eight crops have potential for production within the study area.

The two most limiting environmental factors in this area of southwestern Wyoming are limitations in soil types and the short growing season. Direct experience on the ground in this area to date, however, demonstrates that with supplemental sources of water, a wide variety of crops can be, and have been, produced.

Based upon the soil morphology, climate and environmental parameters found in this area, these six crops should be further explored as potential alternative crops that could be utilized in this area of southwestern Wyoming.

| Common Name | Lavender | Potatoes | Onions |
|---|---|---|---|
| **Scientific name** | *Lavendula augustifolia* | Varies by variety or subspecies | Varies by variety or subspecies |
| **NOTES:** | | | |
| **Optimal Tempurature** | Varies by variety or subspecies | Varies by variety or subspecies | Varies by variety or subspecies |
| **Soil Attributes** | ideal soil is considered to consist of 45% mineral (sand, silt, and clay), 5% organic matter, and 50% pore space, prefers a light, well-drained, deep and not overly rich soil, will grow in a relatively wide pH range between 6.1 (mildly acidic) and 8.5 (alkaline) with a preferred range between 6.5 and 7.5, | Potatoes grow well with a wide variety of soils, and soil pH can be as low as 5.0, with best production between 5.5 and 6.8. Potatoes are less susceptible to scab when soil pH is between 5.0 and 5.5. Good water penetration and aeration are musts for proper growth and tuber formation. Excessive tillage and land preparation cause compaction and should be avoided, soil should be plowed below any compacted layer within the normal root zone, then disk harrowed before planting. Spike-tooth harrowing to break up clods and level the soil may be needed just prior to planting. | Soil pH is normally in the range of 6-7, but on organic soils, onions can be grown down to pH's of 4. When pH drops below 5.5, magnesium and molybdenum availability drops and above 6.5, zinc, manganese and iron become deficient. Soils need to be well structured and fertile to maximize growth and produce high yields. Soil should be firm, not loose, and well drained. Seedbed condition is critical, particularly if crops are being grown from seed. A fine, consolidated seed zone is required for maximum germination and good establishment. When grown on particularly light soils, inter-row guard crops of barley or wheat, or the use of straw helps minimize erosion. Clods and stones will hinder growth, herbicide |

| | | | |
|---|---|---|---|
| | | | efficiency and mechanical harvesting, so heavy or stony soils are usually avoided. |
| **Precipitation** | In Wyoming, will require irrigation. | In Wyoming, will require irrigation. | In Wyoming, will require irrigation. |
| **Frost-free Season** | | | 90-110 days |
| **Minimum temp.** | | | 20F |
| **Maximum Temp.** | unavailable or varies by subspecies or variety | unavailable or varies by subspecies or variety | unavailable or varies by subspecies or variety |

| Common Name | Woody ornamentals | Landscaping/Christmas trees and shrubs | Strawberries |
|---|---|---|---|
| **Scientific name** | Varies by variety or subspecies | Varies by variety or subspecies | *Fragaria* |
| **NOTES:** | These are trees and shrubs whose branches are sold to florists and individuals for arrangements and craft products such as wreaths. Most types have colorful stems, odd stems or stems with attractive berries, buds or flowers. Species varies but can include willow, dogwood, aspen, sagebrush, some species of pine, etc | Varies but can include: Balsam Fir, Douglas Fir, Blue Spruce, Crabapple, Hawthorn, Service Berry, Honey Locust, Poplar, Pine and Sprice | |
| **Opt. Temp.** | Varies by species, subspecies or variety | Varies by species, subspecies or variety | Varies by variety or subspecies |
| **Soil Attributes** | Varies by variety or subspecies | Varies by variety or subspecies | well-drained soil at least 8 inches deep, slope of 2 to 4 percent, high organic matter concentrations highly desirable, optimum soil pH between 5.0 and 7.0 (production possible on slightly alkaline soils). Light or sandy soils are suitable for commercial production when irrigation is available and close attention is paid to nutritional (fertilizer) needs of the plant. Light soils are advantageous because they (1) warm up earlier in the spring than heavier soil types; (2) drain well, and (3) have fewer root disease problems than heavy soils. |
| **Precipitation** | Some will require some form of irrigation | Most require some form of irrigation | Requires irrigation in most areas |

| | | | |
|---|---|---|---|
| **Frost-free Season** | | Varies by species or subspecies | Varies by species or subspecies but in general, ideal tempertures are 60°F to 80°F,,,,sustained temperatures above 85°F can damage weak plants |
| **Min. Temp.** | | Varies by species or subspecies | 25°F--50°F |
| **Max. Temp.** | unavailable or varies by subspecies or variety | unavailable or varies by subspecies or variety | unavailable or varies by subspecies or variety |

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**USDA Soil Capability Class Definitions**

From: http://soils.usda.gov/technical/handbook/contents/part622.html

Land Capability Classification (622.02)

a. Definition. Land capability classification is a system of grouping soils primarily on the basis of their capability to produce common cultivated crops and pasture plants without deteriorating over a long period of time.

b. Classes. Land capability classification is subdivided into capability class and capability subclass nationally. Some states also use a capability unit.

c. Significance. Land capability classification has value as a grouping of soils. National Resource Inventory information, Farmland Protection Policy Act, and many field office technical guides have been assembled according to these classes. The system has been adopted in many textbooks and has wide public acceptance. Some state legislation has used the system for various applications. Users should reference Agriculture Handbook No. 210 ( Exhibit 622-2 ) for a listing of assumptions and broad wording used to define the capability class and capability subclass.

d. Application. All map unit components, including miscellaneous areas, are assigned a capability class and subclass. Agriculture Handbook No. 210 ( Exhibit 622-2 ) provides general guidance, and individual state guides provide assignments of the class and subclass applicable to the state. Land capability units can be used to differentiate subclasses at the discretion of the state. Capability class and subclass are assigned to map unit components in the national soil information system.

e. Categories.

1. Capability Class.

i. Definition. Capability class is the broadest category in the land capability classification system. Class codes I (1), II (2), III (3), IV (4), V (5), VI (6), VII (7), and VIII (8) are used to represent both irrigated and nonirrigated land capability classes.

ii. Classes and definitions.

Class I (1) soils have slight limitations that restrict their use.

Class II (2) soils have moderate limitations that reduce the choice of plants or require moderate conservation practices.

Class III (3) soils have severe limitations that reduce the choice of plants or require special conservation practices, or both.

Class IV (4) soils have very severe limitations that restrict the choice of plants or require very careful management, or both.

Class V (5) soils have little or no hazard of erosion but have other limitations, impractical to remove, that limit their use mainly to pasture, range, forestland, or wildlife food and cover.

Class VI (6) soils have severe limitations that make them generally unsuited to cultivation and that limit their use mainly to pasture, range, forestland, or wildlife food and cover.

Class VII (7) soils have very severe limitations that make them unsuited to cultivation and that restrict their use mainly to grazing, forestland, or wildlife.

Class VIII (8) soils and miscellaneous areas have limitations that preclude their use for commercial plant production and limit their use to recreation, wildlife, or water supply or for esthetic purposes.

2. Capability Subclass.

i. Definition. Capability subclass is the second category in the land capability classification system. Class codes e, w, s, and c are used for land capability subclasses.

ii. Subclasses and definitions.

Subclass e is made up of soils for which the susceptibility to erosion is the dominant problem or hazard affecting their use. Erosion susceptibility and past erosion damage are the major soil factors that affect soils in this subclass.

Subclass w is made up of soils for which excess water is the dominant hazard or limitation affecting their use. Poor soil drainage, wetness, a high water table, and overflow are the factors that affect soils in this subclass .

Subclass s is made up of soils that have soil limitations within the rooting zone, such as shallowness of the rooting zone, stones, low moisture- holding capacity, low fertility that is difficult to correct, and salinity or sodium content.

Subclass c is made up of soils for which the climate (the temperature or lack of moisture) is the major hazard or limitation affecting their use.

iii. Application. The subclass represents the dominant limitation that determines the capability class. Within a capability class, where the kinds of limitations are essentially equal, the subclasses have the following priority: e, w, s, and c. Subclasses are not assigned to soils in capability class I (1) and subclass “e” is not used in class V (5).

3. Capability unit.

i. Definition. Capability unit is the first category listed in the land capability classification system. It is a grouping of one or more individual soil mapping units having similar potentials and continuing limitations or hazards.

ii. Application. Use of this category and definition of codes are state options. Valid entries in NASIS are integers ranging from 1 to 99.