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**TECHNICAL MEMORANDUM**

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SUBJECT:           **Green River Basin Plan**  
***Irrigated Lands and Permit GIS DATA***

PREPARED BY:   Mike O'Grady, States West Water Resources Corporation  
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### **Irrigated Lands Mapping Process – Green River Water Plan**

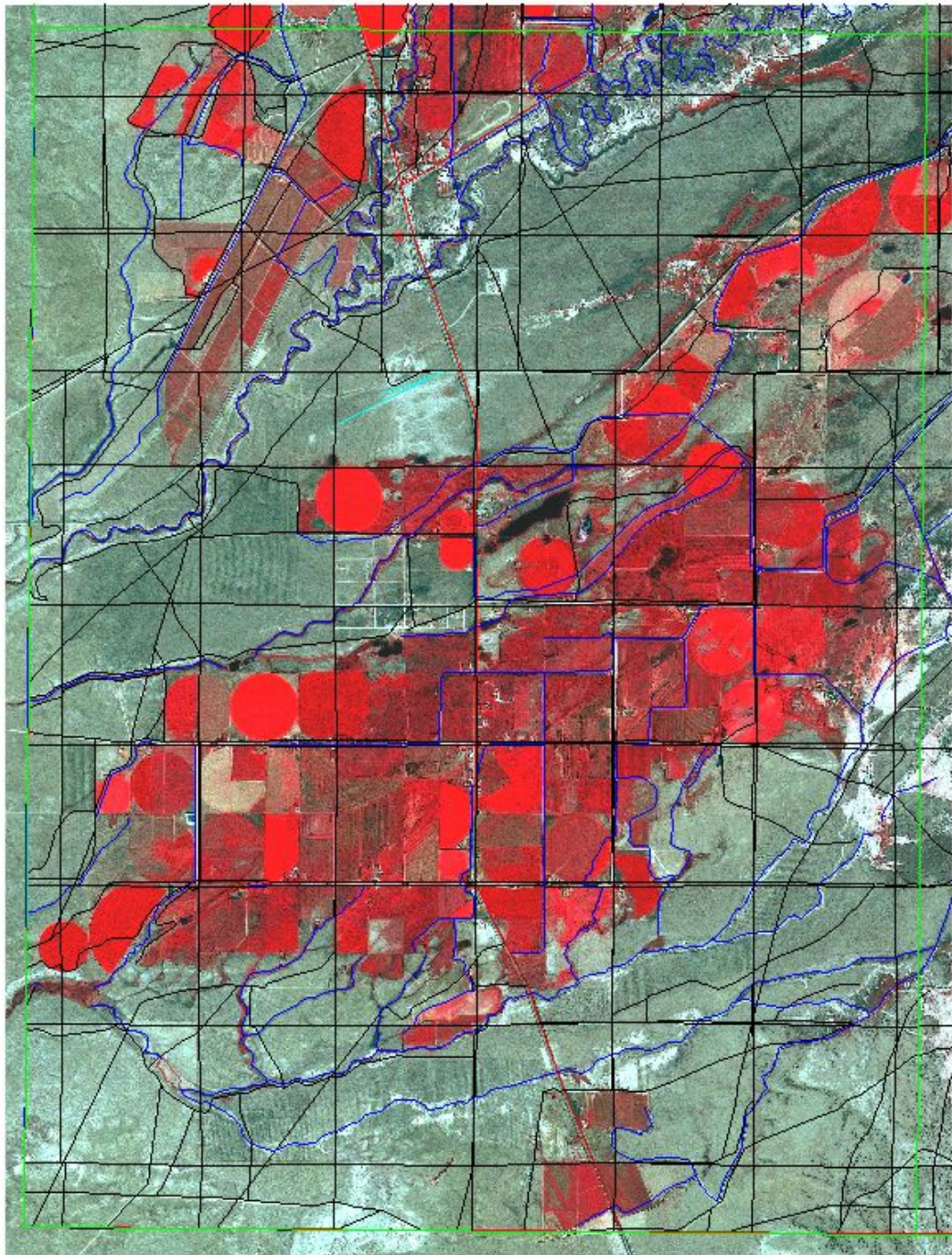
States West Water Resources Corporation was contracted by the Wyoming Water Development Commission Office in June, 1999. One of our tasks was to develop GIS mapping of all recently irrigated lands within Wyoming's Green River Basin. While our procedures varied slightly for each sub-basin, the process was based upon four general phases, all of which are described below. In general, States West developed mapping of all currently irrigated agriculture (1999) in the Green River, Little Snake, and Great Divide Basins in Wyoming and attached all associated water rights to those lands.

#### **Aerial and Satellite Photography Interpretation and Mapping**

Aerial photos were obtained from the Wyoming Water Development Commission (WWDC) offices in Cheyenne, Wyoming. This photography is quadrangle-centered, quadrangle-scale (1:24,000) color infra-red film positives. This photography was obtained for Wyoming by Mark Hurd Aerial Surveys in the summers of 1983/84 and was conducted under the direct supervision of Mr. Michael O'Grady. Mr. O'Grady served as the project manager for Water Division IV (Green, Snake, and Bear River Basins) for the Wyoming Water Development Commission at that time.

The aerial photography was supplemented by infra-red satellite imagery (figure 1). The files were obtained from Space Imaging and range in date from late 1997 to 1999. They are ortho-rectified images that were delivered in TIFF format on CD. TFW files were also included to provide location and scale of the image in the correct state plane coordinate system (Wyoming West, Wyoming West Central, and Wyoming East Central). These files were plotted on bond for comparison to the clear overlays described later. Of the over 300 quadrangles in the three basins, only the 128 satellite images showing irrigated lands were purchased. Figure 2 illustrates those quadrangles.

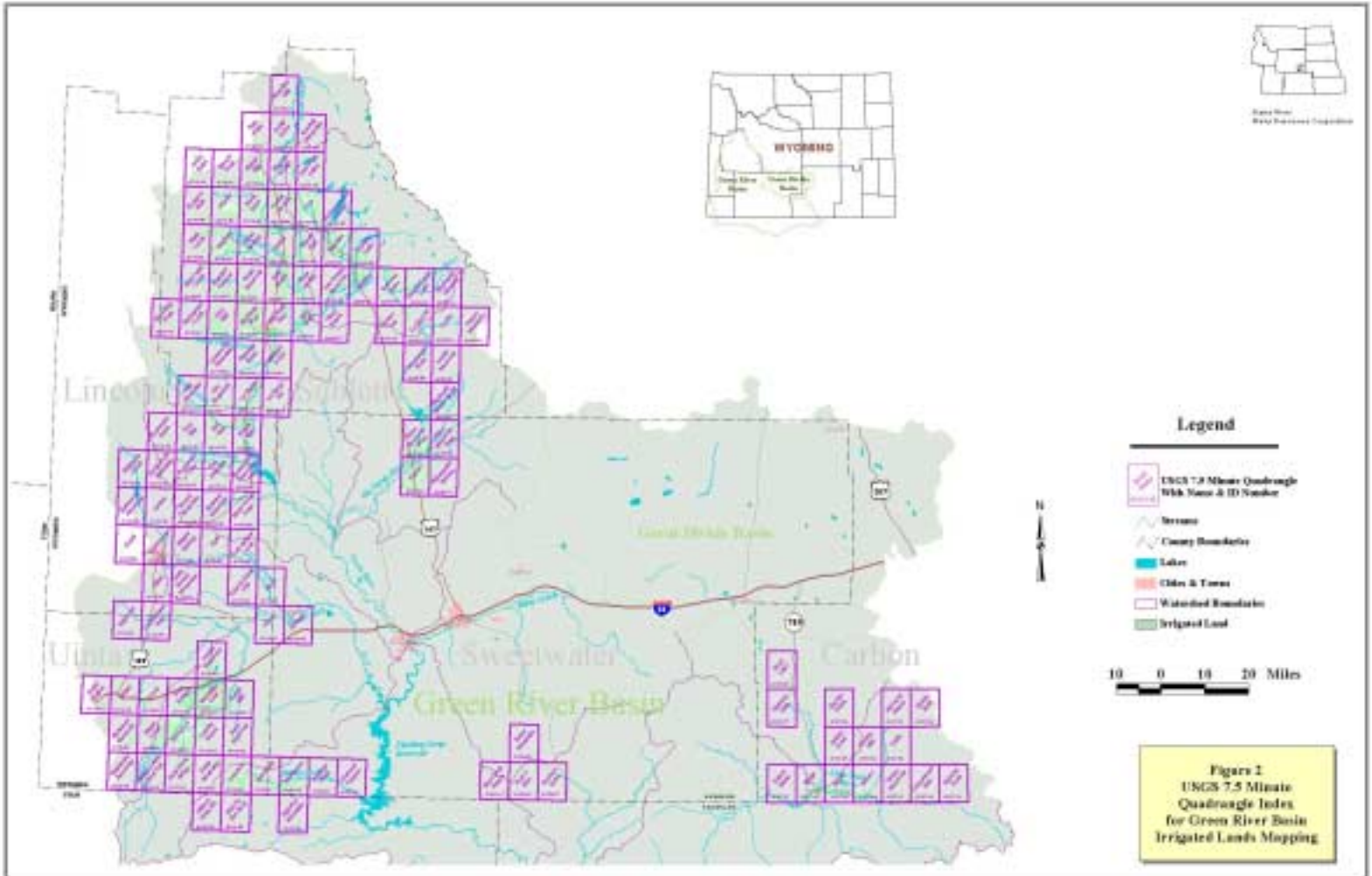
The current mapping project was performed much as it was for the first comprehensive irrigated lands mapping of the basin, conducted for the Green River basin Water Plan by the Wyoming Water Planning Program (WWPP) in 1970. (WWPP Report #9, 1971)



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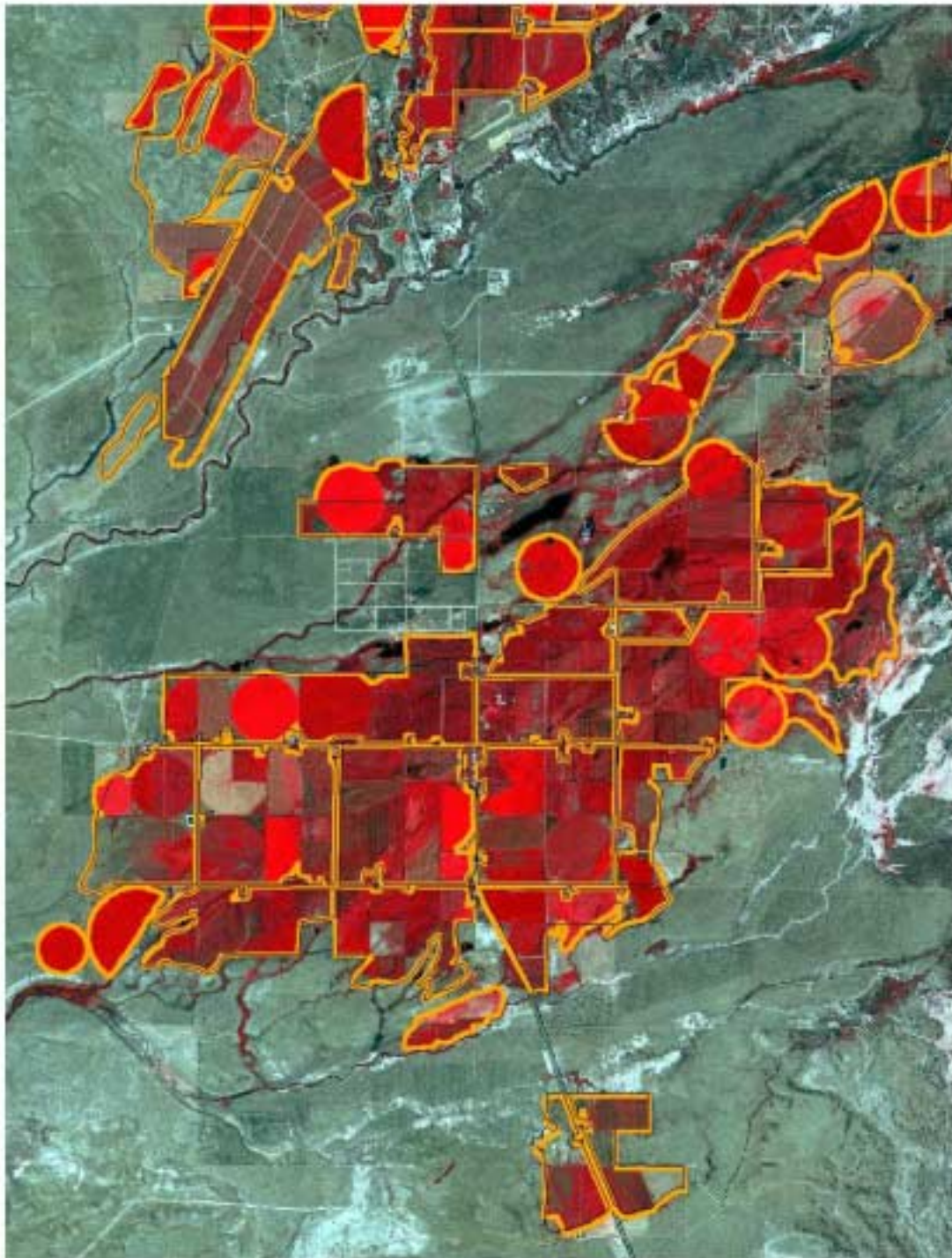
**Figure 1**  
**Farson Satellite Image**  
**with CAD**  
**Vector Data**



For the present mapping project, States West obtained 7.5 minute digital vectorized USGS quadrangle coverage for the irrigated portions of the Green River, Little Snake and Great Divide Basins. On Figure 1, the overlaid lines represent the vectors. These Autocad files contain all roads, hydrography, section lines, pipelines, trails, and other quadrangle features excluding topography. The digital quadrangles were then plotted onto clear mylar and used to directly overlay the WWDC photography and the satellite imagery. The procedure followed was to determine base irrigated polygons using the WWDC photography with recent changes (additions to or deletions from the base) determined from the 1997-1999 imagery. It is important to note that not all roads, canals, ditches, power lines, etc. were excluded from the irrigated polygon. This is because at 1:24,000 scale imagery the width of an interpreted boundary line is approximately 100 feet. To attempt to exclude these small linear features or very small polygons from an irrigated polygon would only increase the error in assessing the total irrigated acreage. Upon completion of the irrigated land interpretation, the final mylar plots consisted of the original background information, irrigation according to the earlier WWDC photography and the changes illustrated by the recent satellite imagery. This product forms the basis of all the digital coverages produced for irrigated lands in the study basins. Figure 3 shows the final resulting polygons on the Farson Quadrangle.

It is also important to note that the use of two mapping products to determine irrigated acreage introduces certain characteristics to the final product that cannot be avoided. First, the WWDC photography is at higher resolution than the recent satellite imagery, but it is non-rectified. This causes minor "stretch" when digitized polygons from these photos are initially overlaid on the satellite imagery background, which is rectified. However, the increased resolution of the photography is more desirable for determining the base irrigated polygon boundaries because the "edges" are much sharper. In instances in which the new field boundaries or locations greatly differed, they were modified according to the new imagery. This results in land mapping that matches the new imagery, but appears to have errors when comparisons are made to the old WWDC photography. The use of the imagery to determine only the incremental changes since the date of the WWDC photography (a time span of 16 years) provides a defensible measure of the current irrigated acreage. The procedure as described (determination of irrigated acreage from WWDC photos subsequently modified from satellite imagery) has been accepted in the Nebraska vs. Wyoming lawsuit on the North Platte River, which meets the litigation standard required in the scope of work.

A large format Summagraphics LCL digitizer provided the conversion from the manual interpretation into a digital format. This device permits resolutions up to 1000 lines per inch. The necessity to digitize every polygon in the states plane coordinate system requires the equipment to be recalibrated for each map or anytime work is suspended. For verification of the actual digitizing, comparisons were made between the photography, satellite imagery, manual interpretation sheets, screen images, and subsequent plots. A minimum of three checks was completed to ensure the comprehensiveness of the final product.



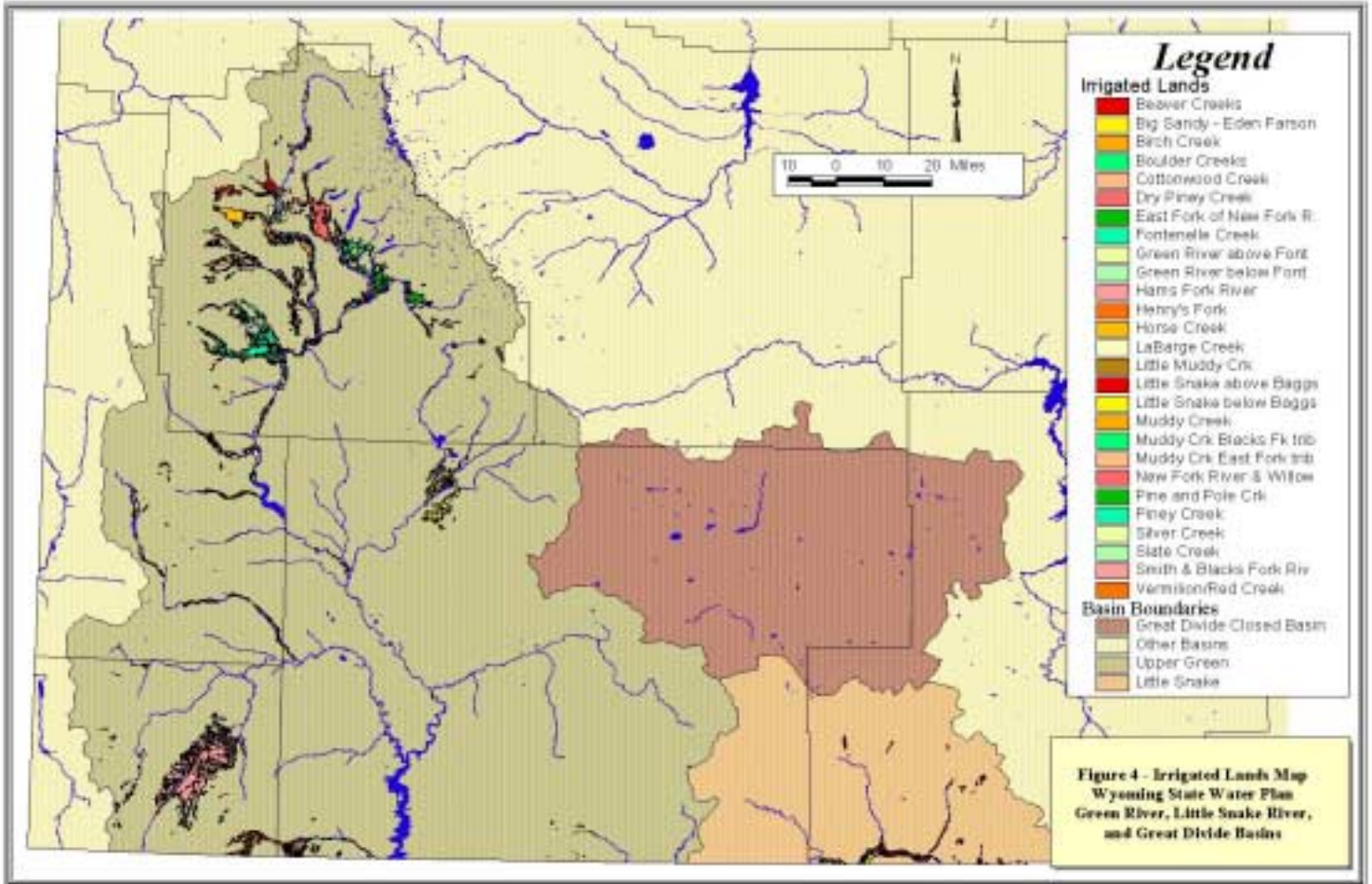
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Reference Date: 1983

Reference Date: 1999

**Figure 3**  
Farson Satellite Image  
with Mapped  
Irrigated Lands



The fundamental criterion used in the identification of irrigated lands is as follows: "Irrigated land is all land that can be identified as receiving water induced by the works of man." This interpretation criteria is consistent with that used in the Upper Colorado River Compact and other recent mapping projects performed by Mr. O'Grady. A similar definition which could also be used is found on page 58 of the North Platte River United States Supreme Court Decree (Doherty, 1943): "The term 'acreage irrigated' needs to be clarified. Much of testimony relates to what may be referred to as the 'right' acreage, that is acreage having an existing water right. As used in this report, 'acreage irrigated' refers only to such 'right' acreage as currently demanding and using water. The maximum limit would be the greatest acreage irrigated in any one year, assuming a water supply sufficient to permit full irrigation."

It is commonly recognized that all lands that are capable of being irrigated are not always irrigated in a given year. A number of factors may influence the actual farming and irrigation practices in a given year resulting in greater or fewer acres actually being irrigated. These factors include the available water supply (e.g., many junior water rights have no water available in some years or may be out-of-priority after the spring runoff concludes in late May), local, regional and even national economic conditions (including farm product prices, labor, real estate values, etc.), climatic conditions such as severe weather, and the individual decisions that each landowner makes with respect to the use of his/her land in a given year.

### **Field Verification**

Upon completion of draft irrigated lands mapping, irrigated polygons were digitized in Auto-Cad and transferred to Arc-Info via Arc-Cad software. Draft final mapping was then plotted onto bond paper and distributed to the appropriate Wyoming State Engineer's Office field personnel for field verification. For the Green River Basin, the plots were sent to Jade Henderson, Division IV Superintendent. For the Little Snake Basin, Randy Tullis, Division I Superintendent, acted as the contact point. Field personnel delineated any changes on those maps that may have occurred since the date of the satellite imagery. Most changes related to water transfers and/or abandonments since the date of satellite acquisition.

### **Irrigated Lands Coverage**

Figure 4 depicts all irrigated lands mapped (as described above), by quadrangle, within the Green River, Little Snake, and Great Divide drainage basins during 1999. This mapping includes a total of 128 – 7.5 minute quadrangles.

### **Water Rights Attribution**

Upon completion of mapping, Mr. Frank Carr performed water rights attribution for each identified irrigated polygon. To assist the reader, Mr. Carr has provided a brief description of water rights terminology specific to Wyoming's water law policy and procedure in Appendix A of this memo.

The water rights attached to each individual irrigated polygon were abstracted from the original records on file in the office to the Wyoming State Engineer and State Board of

Control located in Cheyenne, Wyoming. Once the water right information was abstracted and identified, the polygon was assigned an attribute number which correlates with the respective water right information. Then, a water right database for each quadrangle was prepared. The water right database fields include the permit number, source, ditch or well name, priority date, amount of appropriations (cfs-gpm), number of acres, type of supply (original, additional, supplemental, secondary), and status (adjudicated, unadjudicated, expired, and canceled). This information was formatted in a spreadsheet which was then converted into the Arc-Info Dbase files.

Water rights attribution allows for the attachment of those water rights which are associated with actual irrigation. Where multiple water rights were associated with a single irrigated polygon, the rights were assigned according to their corresponding priority date. At the same time or concurrent with the records abstraction, the points of diversion for the irrigation ditches were plotted and attributed. This was the same for all wells over 50 gpm.

## **Final GIS Products –Database**

### **Irrigated Lands Database**

The creation of the GIS coverages was performed by Mr. Jack Meena, P.E.. Mr. Meena is a project engineer and a GIS manager for States West.

Along with acreage, four other items were added to the irrigated lands GIS coverages. The first, the quadrangle name, was used to help locate the lands. The next item, island identifier, is a simple flag field used to help sort out non-irrigated polygons inside irrigated polygons. This item helps to efficiently eliminate lands that are not irrigated. The third item is an ID field that allows for future linking to the permit database. The last item, drainage, was added to assist in the determination of drainage basins when all the final basin coverages are joined. The major basins are as follows:

- Big Sandy Creek
- Black's Fork River
- Green River above Fontenelle Reservoir
- Green River mainstem below Fontenelle Reservoir
- Ham's Fork River
- Henry's Fork River
- Little Snake River
- New Fork River
- Vermilion Creek, Red Creek, Salt Wells Creek

### **Water Rights Permit Coverage**

Arc-Info point coverages were developed to associate permits with the mapped irrigated lands. However, since the actual permit maps were not digitized most of the irrigated polygons are associated with multiple permits. Although this process does not provide a



one-to-one relationship between irrigated lands and permits, a database has been created of permits for those described lands demonstrating actual irrigation. The purpose for developing this procedure was to allow the creation of an active permits database.

### **Database Fields**

In addition to the values available on the actual permits, the database also contains a flag field for programmer use. The permit information includes the following fields:

Facility Name  
Source  
Permit Number  
Permit Date  
Type  
Status  
Permitted Acres  
Additional Supply Type  
Additional Supply Status  
Additional Supply Permitted Acres  
Permitted Amount  
Use

### **Flag Fields:**

Flag - Used to remove redundant permits.  
0 - Permit is included in totals  
-999 - Permit is redundant.

Along with these database fields, several additional fields are included automatically in the GIS software. These include the coordinates of each point. Again, those coordinates are in the Wyoming West, Wyoming West Central, Wyoming East Central State Plane Coordinate Systems in feet. The original coverages will maintain these fields; however, the published coverages will eliminate them and will be placed in the geographic (latitude and longitude) coordinate system.

### **Points of Diversion Coverage**

In order to determine actual locations where permits divert from their source, the points of diversion for most of the active permits were mapped and used to create this GIS coverage. A few points of diversion for permits that irrigate less than 10 acres were not mapped. The final coverage contains all the fields described in the permit section excluding the flag fields.

### **Water Well Permit Coverage**

Arc-Info point coverages were developed to map all ground water wells that have a capacity over 50 gpm. This includes irrigation, industrial, and municipal wells that meet the minimum output criteria. The database fields include the permit information as stated

above in the water rights permit coverage. When well location maps were unavailable, the location of the wells was estimated from the quarter-quarter description on the permit.

### **Summary**

From the GIS coverages, some statistics were extracted to show the overall characteristics of the basin. Charts 1 through 5 show the relationship between the number of points of diversion, active irrigation permits and actual irrigation among the sub-basins in the entire basin. For actual acreages in each sub-basin, Table 1 further dissects the basins into smaller drainages and provides totals for each basin. The irrigation is broken into irrigated lands and sub-irrigated lands to allow for future analysis. In addition, a check between groundwater and surface water irrigation was performed. Throughout the entire study area, only one original supply groundwater permit supplied actively irrigated lands. The permit called for 122.0 acres to be supplied. There were numerous additional supply permits totaling 567.8 acres that served lands supplied by surface water rights. Table 2 illustrates the totals and the number of wells within each basin.

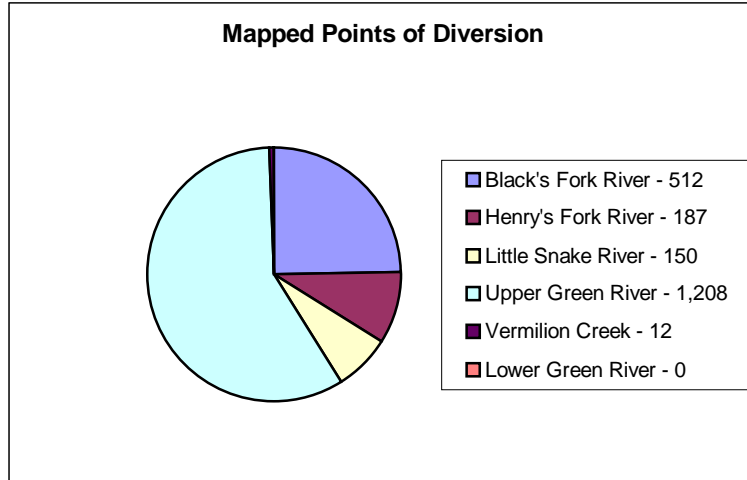


Chart 1- Points of Diversion

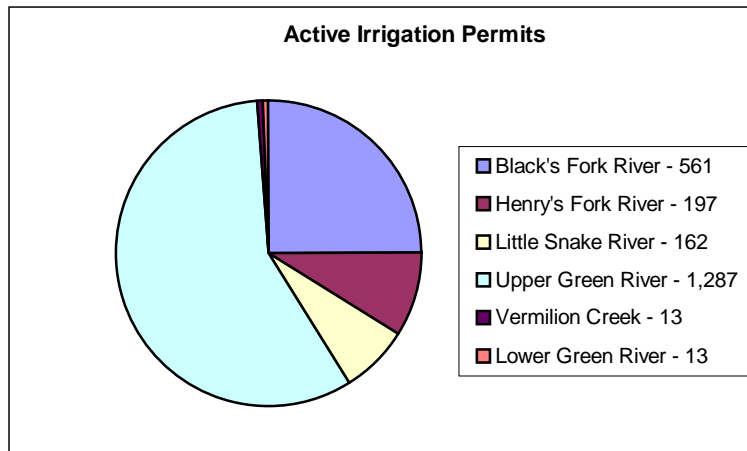


Chart 2 – Water Rights on Active Irrigation

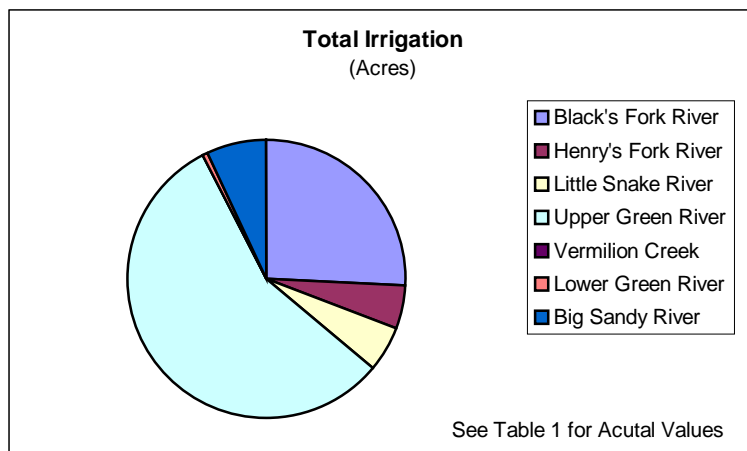


Chart 3 – Total Irrigation by Sub-Basin

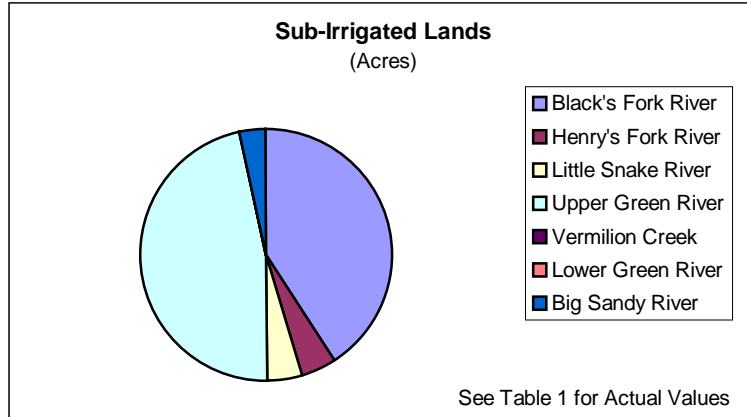
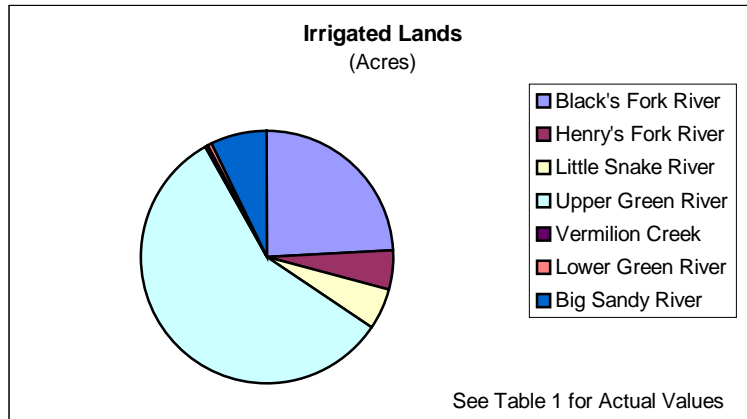


Chart 4 – Sub-Irrigated Lands



Sub-Irrigated LandsChart 5 – Active Irrigation

**Table 1 – Irrigated Land Totals by Sub-Basin.**

<b>BASIN</b>	<b>1999 Irrigated Acres (acres)</b>	<b>1999 Sub-Irrigated Lands (acres)</b>	<b>1999 TOTAL (acres)</b>
<b><i>Green River above Fontenelle</i></b>			
Green River Above Fontenelle without New Fork River			
Beaver Creeks	9,367	293	9,660
Cottonwood Creek	21,123	2,687	23,810
Dry Piney Creek	706	-	706
Fontenelle Creek	3,043	-	3,043
Green River above Fontenelle Res.	28,742	2,958	31,700
Horse Creek	14,549	2,823	17,372
LaBarge Creek	6,297	615	6,913
Muddy Creek	1,232	48	1,280
Piney Creek	34,046	4,645	38,691
Slate Creek	197	-	197
Subtotals	119,302	14,068	133,370
New Fork River			
Boulder Creeks	10,375	535	10,910
East Fork of New Fork R.	5,304	192	5,497
Muddy Creek - East Fork Trib.	2,867	-	2,867
New Fork River & Willow Creek	24,267	1,329	25,595
Pine and Pole Creek	6,888	203	7,091
Silver Creek	747	-	747
Subtotals	50,447	2,259	52,707
<b>TOTALS</b>	<b>169,750</b>	<b>16,327</b>	<b>186,077</b>
<b><i>Big Sandy - Eden Farson</i></b>			
Big Sandy - Eden Farson	21,318	1,188	22,506
<b><i>Henry's Fork</i></b>			
Birch Creek	1,717	170	1,887
Henry's Fork	13,369	1,434	14,802
<b>TOTALS</b>	<b>15,086</b>	<b>1,604</b>	<b>16,690</b>



## Appendix A – Wyoming Water Rights Terminology

**Surplus Water:** Whenever the supply of water in a stream reaches the point where there is water available over and above the needed to fill all appropriations with a priority senior to March 1, 1945, then this stream is in surplus flow condition. When surplus flows are available, the water is to be divided proportionally among the senior rights up to an additional 1.0 cfs to every 70 acres or 1.0 cfs to every 35 acres total supply. (W.S. 41-3-319-324)

**Excess Water:** Each water right with a priority date of post March 1, 1945 but pre March 1, 1985 is entitled to 2.0 cfs for every 70 acres before any water is made available to post March 1, 1985 water rights. If there is insufficient water to furnish 2.0 cfs to each post March 1, 1945 and pre March 1, 1985 water right, but more than enough to furnish 1.0 cfs to each of these rights, the excess water is divided among those rights on a pro-rata basis. (W.S. 41-4-330)

**Territorial Appropriation:** This is an appropriation of water with a priority date prior to statehood. These rights were filed under a system of statement of claims to water under territorial law rather than a permit system. They were adjudicated after statehood by the then-established State Board of control. No permits numbers were assigned to those water rights, and they can be identified only by the proof number.

**Direct Flow Appropriation:** This is an appropriation of water that diverts from a surface water source and is measured in cubic feet per second (cfs). The appropriation is granted by the State Engineer and gives the appropriator the right to divert water as set out in the permit. The statutes set the amount of diversion for irrigation at a rate of 1.0 cfs for every seventy (70) acres to be irrigated. (W.S. 41-3-317)

**Unadjudicated Permit:** This is a permit that has not been fully perfected. It can be in the construction stage through the application of water to beneficial use. When the permit is issued by the State Engineer, the applicant is given time limits to commence construction, complete construction, and apply the water to beneficial use. While all this is taking place the permit is considered as “unadjudicated”.

**Adjudicated Permit:** This is a permit where the notice of completion of beneficial use has been filed, proof of appropriation prepared, a field inspection made with the finding that the facility is built within the terms of the permit, the proof advertised with no protests, and the proof considered and allowed by the State board of Control. After these items are completed, an order of the Board and the Certificate of Appropriation are prepared, issued, and recorded in the court house of the respective county and made a matter of record in the Tabulation of Adjudicated Water Rights.

**Storage Right (Reservoirs):** This is a permit that allows an appropriator to store or impound for beneficial purposes unappropriated water. Water can be stored for irrigation, stock, municipal, fish, recreational, and other purposes, provided that a permit

is secured from the State Engineer. Upon completion of reservoir construction, the storage right is considered as being put to beneficial use. (W.S. 41-3-301)

**Secondary Application:** A Secondary permit may be secured by filing with the State Engineer a secondary application solely for the purposes of attaching water stored for irrigation purposes to specific lands. The application requests that a certain number of acre-feet of stored water be allocated to specific lands. Once the application is granted, the allocated water cannot be used on any other lands or for any other purpose.

**Supplemental Supply:** direct flow water from a different source and different point of diversion to augment or supplement the available water for an existing appropriation (water right) for which the original source does not provide a full supply constitute a supplemental supply. The amount of supplemental water which may be diverted is the amount available, in priority, to bring the total water diverted from all sources up to the appropriated amount of 1.0 cubic foot per second (cfs) for every 70 acres to be irrigated. (W.S. 41-3-113)

**Court Decrees:** A small number of water rights were confirmed (adjudicated) by court decrees prior to the creation of the State Board of Control.

**Original Supply Groundwater:** Groundwater is appropriated in gallons per minute (gpm). Original supply is a water right attached to land or uses where there is no other water right of record. It is the first priority water right attached to and to be used on the identified land.

**Additional Supply Groundwater:** Additional supply is additional water to lands or uses which already have a valid existing water right. It can be additional water to surface water irrigation and/or groundwater irrigation. Additional groundwater is measured in gallons per minute (gpm).

**Unadjudicated Groundwater:** A valid groundwater permit (well permit) which is in the process between the issuance of the permit and completion of beneficial use, I.e., construction, pump testing, application of water to beneficial use, mapping, and filing the necessary paper work to begin the adjudication process is considered unadjudicated.

**Adjudicated Groundwater:** A groundwater permit (well permit) where notice of completion of beneficial use has been filed, the adjudication map prepared and filed, proof of appropriation prepared, inspected and advertised with no protests received, proof considered by the State Board of Control and allowed, Certificate of Appropriation prepared, issued, and recorded in the respective county court house is considered adjudicated. The appropriation is made a matter of record in the Tabulation of Adjudicated Water Rights.



## **References**

The following is a list of documents relied upon in the preparation of this technical memo and associated data:

Carr, Frank, 1999-2000, "Water Rights Attribution Mapping", Maps and spreadsheets.

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