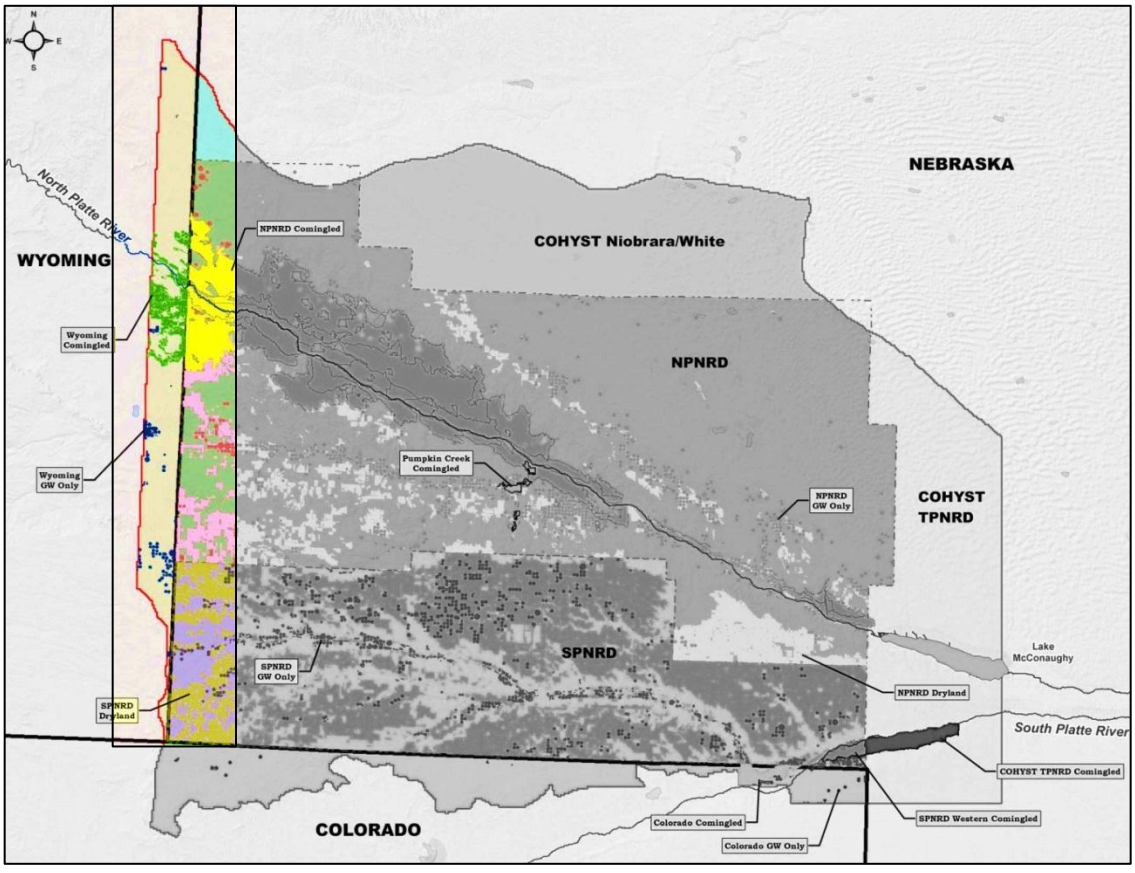
WWUM Technical Memorandum
Wyoming Ground Water Only Pumping and Recharge Estimates
January 4, 2013

Overview: The Western Water Use Management Model (WWUM) ground water model extent encompasses the North Platte and South Platte NRD areas, and extends beyond the NRD boundaries to include relatively small areas of land in Wyoming, Colorado, and neighboring NRDs in Nebraska. The pumping and irrigation recharge associated with irrigated lands in these surrounding areas must be included in the overall ground water model; this technical memorandum discusses the estimation of ground water only pumping and recharge for irrigated lands in Wyoming that are North and South of the North Platte River Valley as shown in **Figure 1**. Note this analysis is only for the ground water only lands not captured in the original *Western Water Use Management Model Historical Crop Consumptive Use Analysis*.

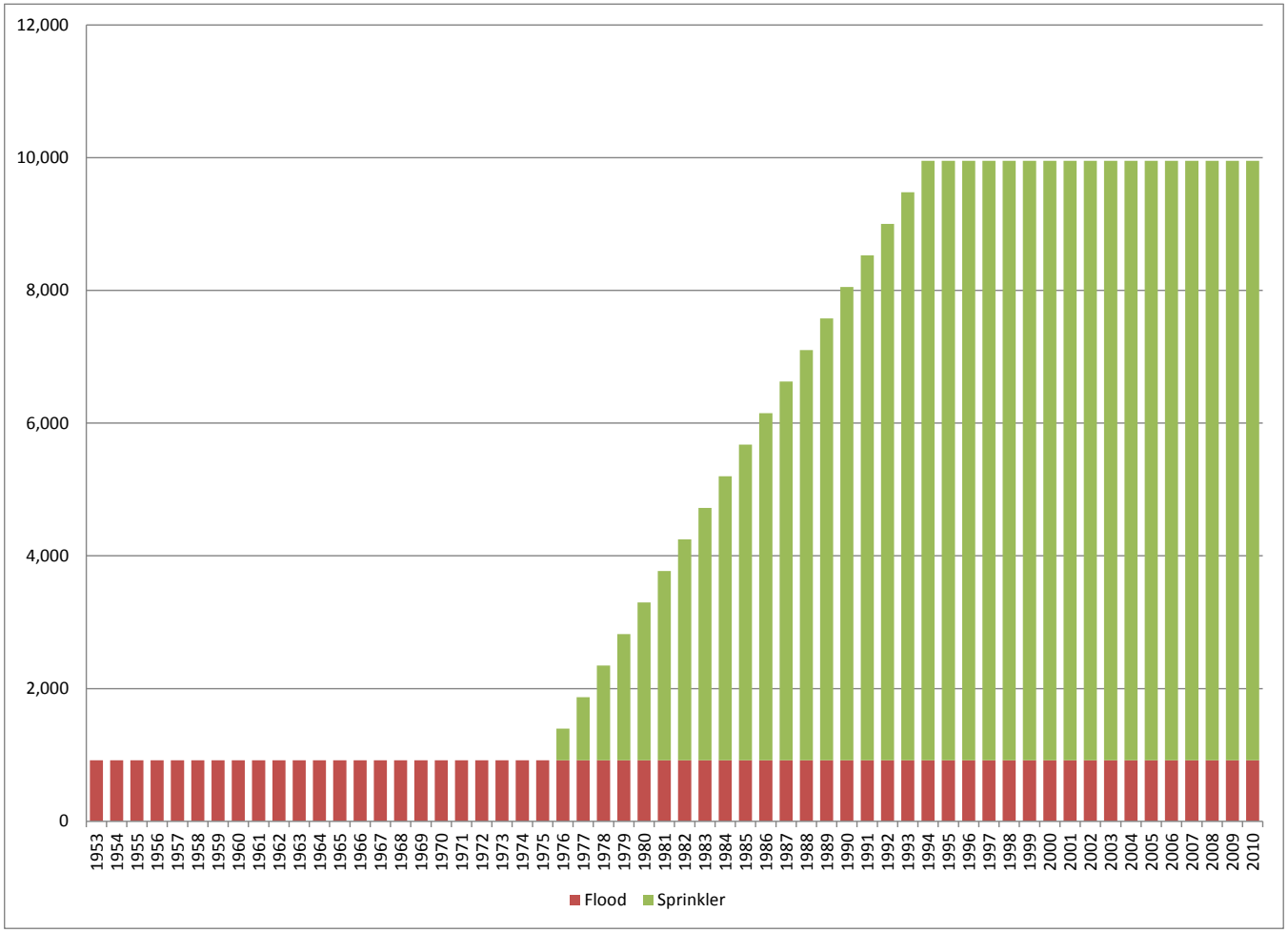
Figure 1: Wyoming Ground Water Only Irrigated Lands



Acreage: The Wyoming irrigated assessment was originally developed for the Wyoming State Engineers Office and Wyoming Water Development Commission in support of the Nebraska vs. Wyoming litigation and Platte River Basin Plan. The irrigated acreage assessment was based on 1992 through 1994 aerial imagery and included both delineation of irrigated lands and assignment of water supply sources. The resulting 1994 Wyoming irrigated acreage shapefile was used as the basis for this analysis.

Because multiple Wyoming irrigated acreage coverages were not available to indicate the change in ground water only acreage over time with the increase in sprinkler acreage, the trend seen in the WWUM model irrigated acreage assessment in Nebraska was used to represent acreage changes from 1953 to 1994. In general, ground water only lands prior to 1975 were assumed to be flood and remained constant for the period of record. Sprinkler development was represented by a linear interpolation from 1975 to 1994. By 1994 additional sprinkler development was assumed to be minimal and the 1994 acreage associated with each irrigation method was carried forward to 2010. **Figure 2** shows the change of modeled ground water only Wyoming lands over time.

Figure 2: Wyoming Aggregated Ground Water Acreage by Irrigation Method (1953 – 2010)



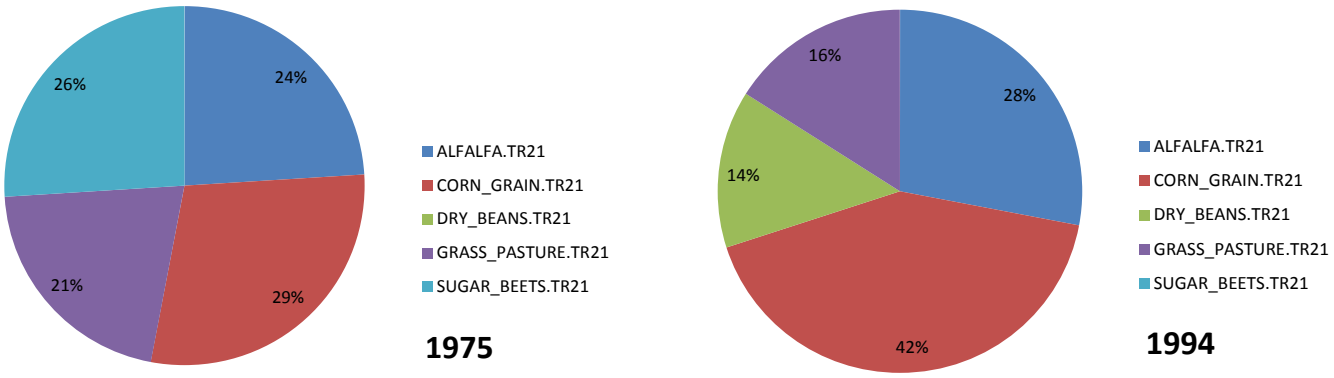
Structures: A spatial analysis using the WWUM ground water model boundary and the 1994 Wyoming irrigated acreage coverage was performed to determine the ground water only structures with irrigated lands within the WWUM ground water model boundary. Ground water only aggregates were formed representing irrigated acreage North and South of the North Platte River. **Table 1** is a summary of the average annual irrigated acreage of the Wyoming ground water only aggregates in the WWUM ground water model boundary. Note co-mingled and ground water only lands within close proximity to the North Platte River were modeled separately under the original *Western Water Use Management Model Historical Crop Consumptive Use Analysis*.

Table 1: Wyoming Ground Water Only Aggregates in the WWUM GW Model Area

Structure	Description	Average Annual Acreage
WY_North	GW Only Lands North of the North Platte River Valley in Wyoming	184
WY_South	GW Only Lands South of the North Platte River Valley in Wyoming	4,785
Total		**4,969**

Crops: Historical cropping information (1953-1994) for Wyoming was based on information from the Dr. Martin report; crop information from 1994 was carried forward through to 2010. A full discussion of the assignment of crop information in both Wyoming and Nebraska can be found in Appendix C of the *WWUM Irrigated and Dryland Acreage Assessment* report. Figure 3 shows the assigned cropping patterns assigned in 1975 and 1994.

Figure 3: Wyoming Crop Pattern Assignments, 1975 and 1994



NIR: Monthly NIR information was provided by CropSim based on climate data, crop type, and acreage totals. NIR for each irrigated parcel was then aggregated by structure and by month resulting in NIR for each structure in this analysis. Note that the change in acreage over time, as discussed above, was used to correctly tabulate the total NIR for each structure in each year.

Efficiencies: Maximum flood application efficiency of 65 percent and maximum sprinkler application efficiency ranging from 70 to 85 percent was used in the model.

AWC: Available water content (AWC) is important in defining the available soil moisture reservoir for each crop type. The irrigated acreage assigned to each structure was used to determine the AWC information, used by StateCU to determine the volume of the soil moisture zone available to store excess irrigation for each structure. The average AWC of the irrigated land assigned to the structure was used in StateCU analysis. The soil coverage from The Flat Water Group did not cover the entire Wyoming portion of the model area, therefore the portion that did extend into Wyoming was used to estimate a representative AWC for the lands to the north and south of the river. An AWC value of 0.1458 inches per inch was used for the structures with land to the south of

the river, and an AWC value of 0.1250 inches per inch was used for lands to the north of the river in Wyoming. The representative AWC values in Wyoming were confirmed by the USGS Soils Survey data.

Approach: A StateCU water balance analysis was performed to estimate irrigation recharge, and ground water only pumping for the Wyoming ground water only acreage in the WWUM GW Model for the 1953 to 2010 period. The analysis also resulted in an estimate of historical potential CU, water supply limited CU, irrigation shortages, pumping, and irrigation recharge for each Wyoming ground water aggregate. Additional summaries and structure-specific information can be accessed by obtaining the StateCU input files and StateCU model.

The results of the StateCU analysis are reported in several summary output files and are stored in a binary output file (*.BD1 file). TSTool, a data management interface, uses commands to access specific results from the binary file, perform user-specified data calculations, and output the results to a format that can be integrated with the WWUM GW model. The following steps summarize the actions performed by TSTool to extract the results from the analysis:

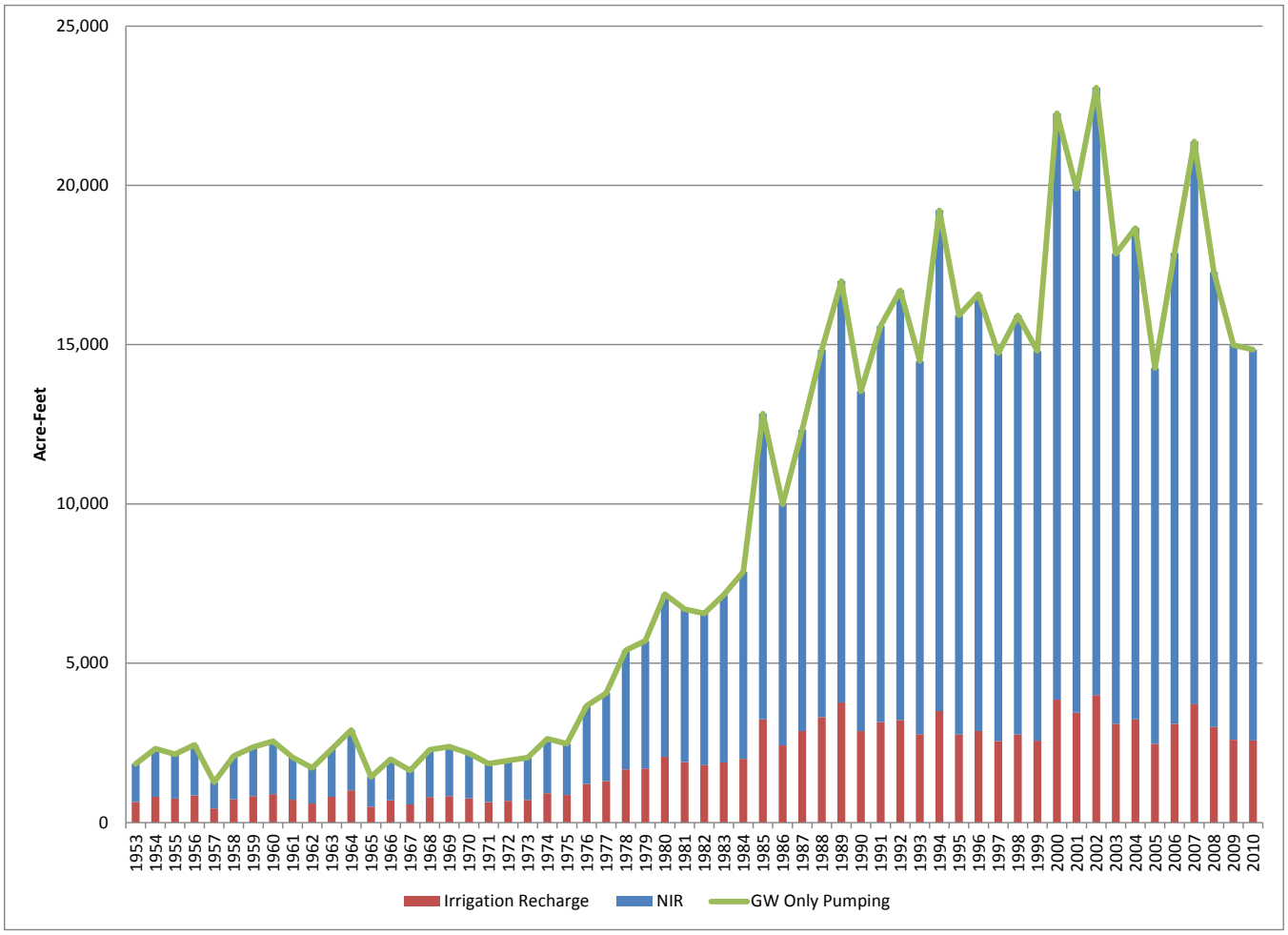
1. Read the SPDSS StateCU Binary File (Wy2012.BD1) into TSTool.
2. Query for the "SW & GW Non-Consumed" monthly results for each of the structures, which represents the amount of non-consumed water from ground water supplies at the field (i.e. irrigation recharge).
3. Query for the "GW Diversion" monthly results from each of the structures, which represents the amount of historical pumping on these lands. Note that StateCU calculates pumping based on the amount of irrigation water requirement and the irrigation application efficiency assigned to the structures.
4. Output the pumping and recharge to a text file (WY_GW_Only_Pumping_Recharge.stm) for integration into the WWUM ground water model.

Results: The resulting text file (**WY_GW_Only_Pumping_Recharge.stm**) contains monthly values of pumping and recharge for the structures listed in **Table 1** for the 1953 through 2010 period. **Table 2** below summarizes the average annual pumping and recharge for the Wyoming ground water only aggregate structures, and **Figure 4** provides pumping and irrigation recharge over the study period.

Table 2: Average Annual Pumping and Recharge (1953 – 2010)

Structure	Acreage	NIR (AF)	Recharge (AF)	Pumping (AF)
WY_North	184	271	92	362
WY_South	4,785	6,929	1,847	8,775
Total	**4,969**	**7,199**	**1,939**	**9,138**

Figure 4: Annual Pumping, Recharge, and NIR (1953 – 2010)



The annual variability seen in pumping and recharge for ground water structures can be attributed to the variable climatic conditions and its impact on irrigation water requirement. The general increase in pumping and recharge in the early years of the study period can be attributed to the increase in ground water acreage.

Integration: In order to integrate the historical Wyoming ground water only pumping and recharge into the WWUM ground water model, it was necessary to spatially project the tabular information. In general, the total pumping and recharge calculated for each aggregate was evenly distributed over the active WWUM ground water model cells that coincide with irrigated acreage for the ground water aggregate structures. The *WWUM Integration and Calibration Plan* report provides more detail on the integration of this information into the ground water model.