WIND/BIG HORN BASIN PLAN
TECHNICAL MEMORANDUM

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Subject: ***WIND RIVER RANGE GLACIERS***
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INTRODUCTION

The Wind River Range of Wyoming is the headwaters of the three major drainage systems in the United States, the Wind-Missouri-Mississippi, Snake-Columbia, and Green-Colorado drainages. The range is also home to a total of 63 glaciers, covering 17 square miles, greater than the total of all other glaciers in the American Rockies at 12 square miles. Seven of the ten largest glaciers in the continental United States are located in the Wind River Range. Of the total area of glaciers in the Wind River Range, 77% by area are located in the Wind River drainages, with the remainder draining to the Green and Snake rivers. (Marston, et. al., 1991). Based upon a literature search of available documents relating to the glaciers in the Wind River Range, the glaciers have been retreating during recent times. Glaciers have been compared to natural reservoirs, which store water in the form of ice during cool periods both on an annual and long term climatological scale, and release water during warmer periods. The melt water from the glaciers contributes to the flow in the Wind River, and is thought to be important during late summer and early fall to supplement flows in the Wind River needed for irrigation and fisheries, and for the fulfillment of interstate water compacts. This report summarizes the results of the literature review, and addresses three potential scenarios for future impacts to the Wind River due to glacial changes.

GLACIAL RECESSION AND PALEOCLIMATIC RESEARCH

The earliest references to the Wind River glaciers are found dating back to 1851, with formal studies as early as 1878. Most of the studies indicate that the glaciers have been steadily retreating since the 1850's, with the exception of Wentworth and Delo, (1931), who reported that Dinwoody Glacier had readvanced by 1930 to it's furthest terminus of the late Neoglacial period. Renewed retreat occurred during the 30's, slowing in the 40's with little or no retreat during the late 40's, then continuing to retreat from the 50's to the present.

Very little research was performed on the glaciers from 1960 until 1988. From 1988 to the present there has been renewed interest in the glaciers as sources of paleoclimatic and environmental data. Researchers estimate that the glaciers may disappear within 20 years if retreat continues to occur at the rates observed during this century. This belief has contributed to a sense of urgency among the scientists who wish to obtain ice cores for research purposes before the glaciers melt completely. (Schuster, Naftz, et. al., 2000).

Ice cores from Upper Fremont Glacier were analyzed by the USGS using data from electrical conductivity measurements (ECM), oxygen isotope ratios, concentrations of elements including chlorine, sulfur, mercury, and radioactive tritium, and Carbon 14 dating of grasshopper leg belonging to an extinct species found near the base of the glacier. The data was then compared with known events such as volcanic eruptions, periods of nuclear testing, and other natural and anthropogenic events which could have left a chemical signature in the ice. A combination of these time indicators was used to refine the chronological time line of the ice core. The data for Upper Fremont Glacier indicates that the glacier was formed during a cooling period known as the Little Ice Age, which occurred from approximately 1740 to 1845 A.D. The end of the Little Ice Age appears to have been quite abrupt, occurring within a span of less than 10 years. Prior to the Little Ice Age, tree ring records show evidence of a warming period which extended from approximately 1650 to 1740. (Naftz, et. al., 1996, 2000, 2002).

POTENTIAL WATERSHED IMPACTS OF GLACIERS

The total annual runoff from glaciers in the Wind River Range is estimated to be approximately 56,756 ac-ft (70 x 10^6 m^3) for the annual melting period of July through October. Assuming equitable distribution of flows based upon aerial location, 77% of glacial runoff would enter Wind River drainages, or 43,783 ac-ft (54 x 10^6 m^3) on an annual basis. This flow represents approximately 8% of the total flow in the Wind River during the same period. (Pochop, Marston, et. al., 1989). The two primary creeks by which glacial meltwater is conveyed to the Wind River are Bull Lake Creek and Dinwoody Creek. Dinwoody Creek, which is fed by both Gannett and Dinwoody Glaciers, drains more glacial area than any other single headwater creek in the continental United States. (Wentworth and Delo, 1931). The following table summarizes the results of limited streamflow gauging efforts on Dinwoody Creek in July, 1988 by Pochop, Marston, et. al., and extrapolation of that data by comparison with flow measurements made in the Cascade Mountains. Dinwoody Creek is estimated to convey 25% of the total ice melt contribution to the Wind River.

ESTIMATED CONTRIBUTION OF DINWOODY AND GANNETT GLACIERS TO DINWOODY CREEK FLOWS

MONTH	ESTIMATED ICE MELT (ACRE-FT)	DINWOODY CREEK FLOW (ACRE-FT)	% OF FLOW FROM ICE MELT
JUNE	691	27790	3
JULY	4080	30642	13
AUGUST	3268	19990	16
SEPTEMBER	2117	7929	27
OCTOBER	812	2527	32

The above estimates (Pochop, Marston, et. al.) show the importance of glacial meltwater to total flows during the late season flows (27% and 32% of Dinwoody Creek during September and October, respectively). Similar estimates have not been made on other glacial fed creeks in the Wind River Range. Three scenarios are discussed below regarding the potential impacts glacial change may have on flows in the Wind River.

SCENARIO 1: NO SIGNIFICANT CLIMATE CHANGE

Under scenario 1, the assumption would be that the climate will remain fairly stable within observed average ranges, with brief periods of glacial accumulation followed by periods of drought and glacial melting on a decadal scale. One example of this type of behavior would be the brief glacial advance from 1920 to 1935 at Dinwoody Glacier, replenishing water reserves, followed by a melting period. Alternatively, snow fall contributing to glacial accumulation could roughly equal glacial ablation, resulting in continued release of melt without an overall net loss in glacial volume. The effects of glacial recession or advance would remain relatively constant, and the overall stream flows would not vary significantly. The overall impact would be minimal to irrigators and other stream uses.

SCENARIO 2: DROUGHT CONDITIONS PERSIST

The assumption made by Marston, et. al., and Naftz, et. al. regarding the life span of the glaciers was that the current warm / dry climate trends will continue without ceasing, and cause the disappearance of the glaciers within 20 years. If this occurs, flow to the Wind River could be reduced by approximately 8%, creating or exacerbating shortages for irrigators and in-stream flow demands. Under this scenario, the effects are predicted to be most noticeable during late summer and early fall, when runoff from snowmelt and rains is minimal and water use is high. If these climate predictions are correct, the loss of glacial input to Wind River flows will not be the only reduction in flow, as snow pack and annual precipitation will be expected to fall below observed averages, further reducing flows.

SCENARIO 3: RETURN OF COOL / WET PERIOD

Review of the dates of cooling periods and warming trends presented as a result of ice core and tree ring data from the Wind River Range indicates that warming and cooling cycles are natural phenomenon. Geologists estimate that there have been seven major continental glacial episodes in Earth's history, punctuated by many smaller events such as the Little Ice Age. Five different periods of glacial advance and retreat have been documented in the Wind River Range. Glacial ice core and tree ring data indicates a warming trend of approximately 90 years from 1650 to 1740, a 105 year cooling period known as the Little Ice Age from 1740 to 1845, another warming trend for 75 years extending from 1845 to 1920 followed by a brief cooling trend from 1920 to 1935, with 67 years of warming from 1935 to the present. If an average of these cycle lengths is taken as 70 years, it would not be unreasonable to predict that a new cooling episode may occur in the near future. Paleoclimatological data suggests that the shift between warm and cool periods may be quite abrupt, and the scale of such an event may be relatively large, such as the Little Ice Age, or small such as the brief advance of Dinwoody Glacier in the 20's and 30's.

For an extended planning period of 50 years, the question would be the timing of such an event. If the cooling period were to occur within the next 15 to 20 years, before the glaciers melt completely, the glaciers would be replenished for future melt contributions to flows in the Wind River. If the current warming cycle continues for a longer period of time, the available flows would be diminished, much like Scenario 2 above, until conditions change. Jan Curtis, the Wyoming State Climatologist, indicates that if the current pattern of drought-wet years continues, increasing annual precipitation and resulting increases in glacial mass should occur over the next twenty years.

> *"Glaciers have decreased probably more because of lack of precipitation than due to global (regional) warming. Since 1931, decadal average annual temperature trend shows no appreciable change over the Wind River, thus the argument for glacier melting (decrease in mass) is questionable. Unless (If) we continue to have less annual precipitation (especially winter snows), the glaciers will decrease in size. Projecting when they would disappear is highly speculative. If the pattern of drought-wet years resumes, then we should see increasing annual precipitation and therefore increasing glacier mass over the next twenty years. Since 1200 A.D., regional droughts have been relatively short and mild compared with the pre-Columbian era. I don't see that we are returning to this scenario. However, the increased population and land / water use will certainly impact the total water availability in the future irregardless of climate."*
> (Personal correspondence, Jan Curtis, WRDS Coordinator, Wyoming State Climatologist, July 12, 2002).

SUMMARY

The meltwater from glaciers in the Wind River Range contributes to flow in the Wind River. The glaciers have been observed to be receding in recent decades, and are estimated by some to be completely gone in 20 years if current weather trends continue. If this were to occur, flows in the Wind River could be diminished by as much as 8%, impacting irrigators, instream flow demands, and interstate compacts. A review of ice core records, tree ring data, and historical temperature and precipitation data indicates that the climate has a cyclic nature, with alternating cool/wet and warm/dry periods. The impact of climate on the glaciers and subsequently the Wind River water users will depend on the timing of the next cool/wet period. In the event that the current dry period continues for an extended period of time, decreased quantities of base flow in the Wind River will exacerbate shortages caused by low precipitation and snowpack. However, if cool/wet weather patterns return, increasing annual precipitation would result in renewed advance of the glaciers, providing storage for future dry periods.

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