Supplemental Data in support of the Walker River Paiute Tribe & National Fish and Wildlife Foundation MOU Exhibit 1 - Program Water Conveyance Accounting Protocol for Pending Application 80700

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Information herein is offered in support of the NFWF-WRPT MOU Exhibit 1 Program Water Conveyance Accounting Protocols. Furthermore, Exhibit 1 of the referenced MOU has been jointly drafted by the above signatories in working with technical representatives of NWFW and BIA.

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Lower Walker River Flow Data

The Program Water Conveyance Accounting Protocol ("Accounting Protocol") uses average daily, monthly, and annual stream flow data derived from the US Geological Survey (USGS) National Water Information System (NWIS) website at http://waterdata.usgs.gov/nwis. Table 1 summarizes the primary Lower Walker River gages.

The Accounting Protocol also was based on information obtained from USGS published reports on the Lower Walker River, copies of which may be down-loaded from the USGS publications warehouse at http://pubs.er.usgs.gov/.

Allander, K. K., Smith, J. L., and Johnson, M. J., 2009, Evaporation from the Lower Walker River Basin, West-Central Nevada, Water Years 2005-07; USGS Scientific Investigations Report 2009-5079.

Lopes, T. J., and Allander, K. K., 2009, Hydrologic Setting and Conceptual Hydrologic Model of the Walker River Basin, West-Central Nevada; USGS Scientific Investigations Report 2009-5155.

Lopes, T. J., and Allander, K. K., 2009, Water Budgets of the Walker River Basin and Walker Lake, California and Nevada; USGS Scientific Investigations Report 2009-5157.

Table 1 – Summary of Primary Lower Walker River Flow Gages and Periods of Record

Gage Name	Common Name	USGS Gage Site Number	Elevation	Latitude	Longitude	Period of Record	Notes
WALKER RV AT MILLER LN NR YERINGTON, NV	Miller Lane	10301120	4353	39°02'53.8"	119°07'59.0"	2010 - present	Approximately 2.5 miles down-stream of Yerington Weir
WALKER RV NR WABUSKA, NV	Wabuska	10301500	4300	39°09'8.86"	119°05'56"	1902-present	Missing or incomplete data from 1905-1920,1936-1939,1942, and 1944
WALKER RV ABV WEBER RES NR SCHURZ, NV	Cow Camp	10301600	4215	39°06'12"	118°55'42"	1977-present	Missing or incomplete data from 1983-1994
WEBER RES NR SCHURZ, NV	Weber Reservoir	10301700	4218	39°02'41"	118°51'33"	1995-present	Missing or incomplete data from 1996, 2000, 2008 and 2009
CANAL NO 2 ABV LITTLE DAM NR SCHURZ, NV	Canal 2	10301742	4160	39°00'51"	118°51'36"	1995-present	Missing or incomplete data from 1995-1997
WALKER RV ABV LITTLE DAM NR SCHURZ, NV	Little Dam	10301745	4160	39°00'49"	118°51'36"	1995-present	Missing or incomplete data from 1995, and 2001-2004
CANAL NO 1 BLW LITTLE DAM NR SCHURZ, NV	Canal 1	10301755	4160	39°00'45"	118°51'37"	1995-present	Missing or incomplete data from 1995-1997
WALKER RV AT LATERAL 2-A SIPHON NR SCHURZ, NV	Lateral 2-A Siphon	10302002	4105	38°56'25"	118°48'10"	1994-present	Missing or incomplete data from 1994
WALKER RV NR MOUTH AT WALKER LAKE, NV	Walker River near Mouth	10302025	3940	38°47'28"	118°43'34"	2004-present	Missing or incomplete data from 2004, 2006-2011

Walker River Flows at the Wabuska Gage (USGS 10301500)

One of the longest periods of record for flow on the Walker River is at the Wabuska Gage site directly up-stream of the Reservation. Intermittent records are available starting in 1903, and nearly continuous records are available from about the mid-1940s to present. For the period of available record through 2011, the average annual flow at Wabuska is 118,170 acre-feet, and the median is 70,591 acre-feet (Figure 1).

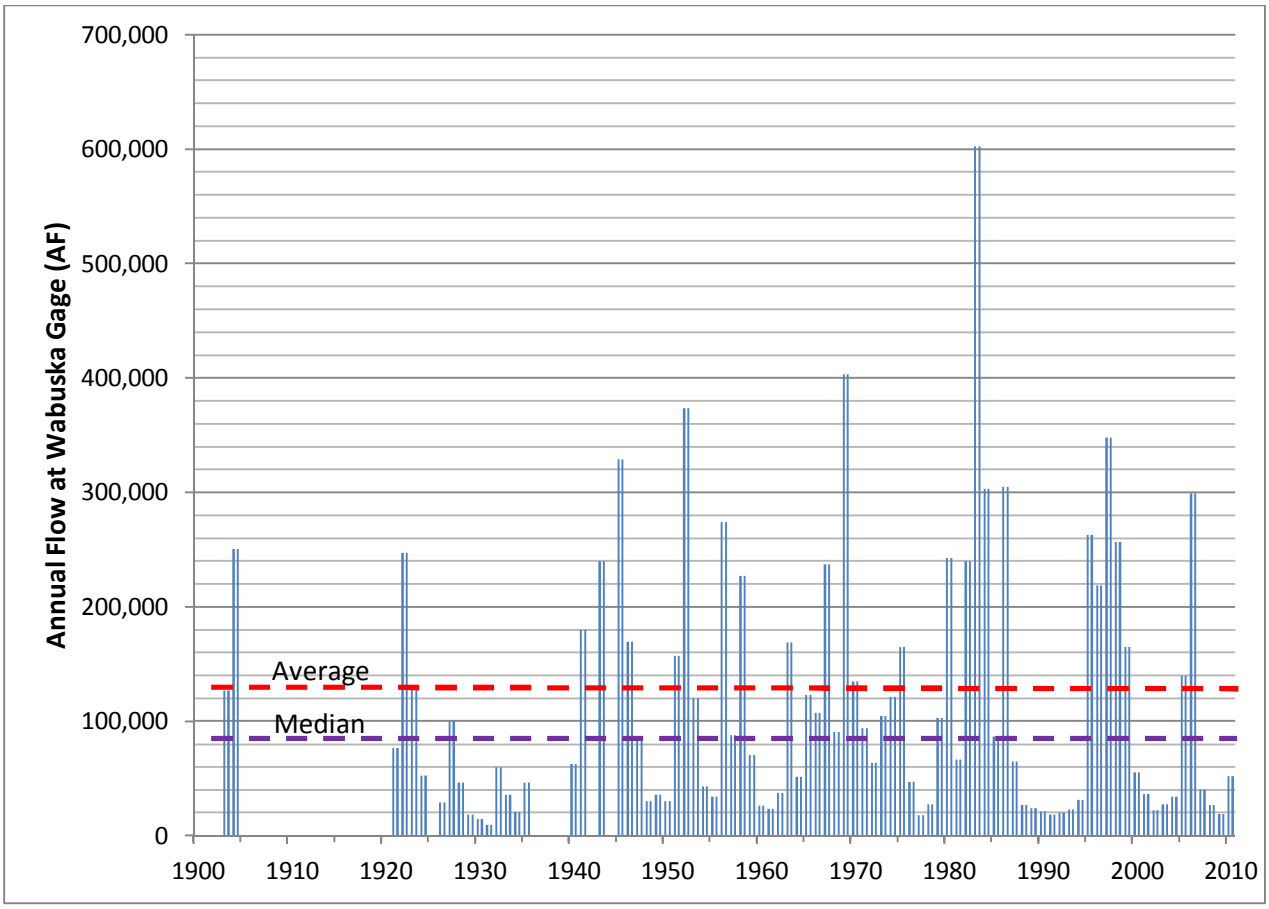

Figure 1 – Annual Flow in the Walker River at the Wabuska Gage, 1903 to 2011

Monthly flow statistics at Wabuska are summarized in Table 2 for the irrigation season months. The drought year 2002 is noted to contain several low period of record flow months, and is one of the most severe drought years in recent decades.

Table 2 - Summary of Flow Volumes at Wabuska for the Period of Gage Record, for the March through October Irrigation Months

Month	Ave. AF	Median AF	Low AF	2002 (Drought)
March	9840.87	4333.18	822.80	822.80
April	8771.24	4041.59	1569.62	1569.62
May	24226.50	13096.73	2449.75	2911.93
June	27600.29	10933.61	1928.06	1928.06
July	17636.23	4284.58	1418.27	2747.29
August	4822.56	2719.52	1597.79	1939.96
September	3777.31	2574.71	1131.29	2485.45
October	3045.67	2501.32	261.20	2287.09

Walker River Flows at the Cow Camp Gage (USGS 10301600)

Concerns are present regarding inaccuracies of the Cow Camp gage. Preliminary examination of the historic data and field conditions indicate that the gage is probably accurate for low flow regimes, below approximately 1,000 cfs. However, at higher flows, by-pass flow conditions occur and not all flow has been historically measured by the gage. The 1978-82 gage data do not appear to have this issue. Information from the USGS indicates that during high flow conditions, a rating (or correction) based on measurements up-stream (approximately 2 miles) were used and reported during 1978-82. Pre-1983 data shows good linear correlation with between flows reported at Wabuska and Cow Camp (Figure 2). Post-1983 data, which begins in October 1994, exhibits a reasonably linear relationship for flows at Wabuska below about 1,300 cfs. As an initial step to correct the Cow Camp gage data for bypass flow, an adjustment back to a linear relationship can be applied to the post-1983 Cow Camp data to estimate flows when they exceed 1,300 cfs at Wabuska. Based on June 2011 field observations, by-pass conditions may begin occurring at a lower flow threshold, but the data suggest that the Cow Camp gage is still reasonably accurate until flow conditions are equal to and exceed approximately 1,300 cfs at Wabuska (equal to approximately 1,000 to 1,100 cfs at Cow Camp).

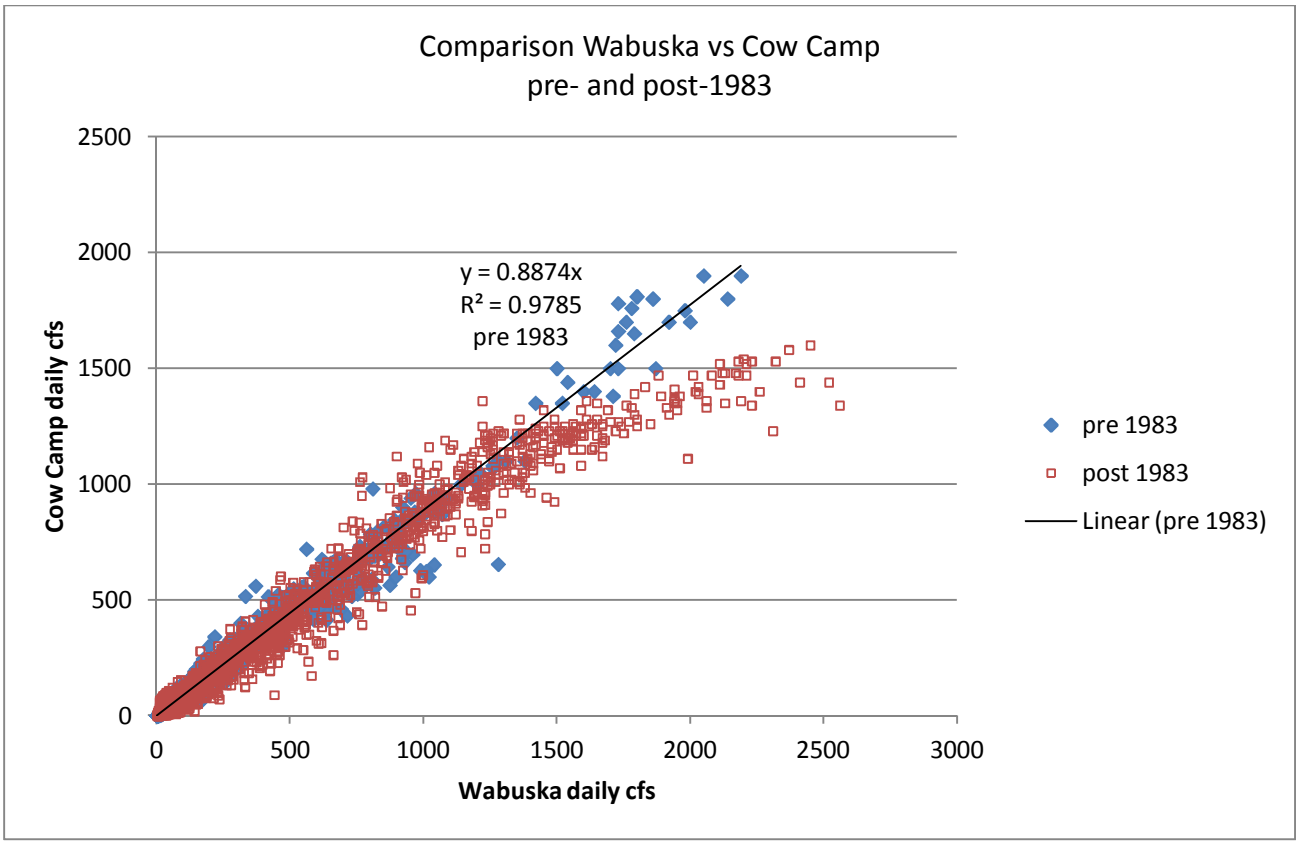

Figure 2 – Daily flows reported at Cow Camp versus Wabuska gages

A reconstructed flow dataset at Cow Camp has been prepared for use in reviewing monthly and annual flow totals at Cow Camp, using a linear adjustment applied to flows at Cow Camp when Wabuska flows are equal to or greater than 1,300 cfs, and applied only to post-1983 data. The reconstruction only affects a very small percentage of the daily data (166 days of 8,172 total records, or approximately 2 percent), as shown in Figure 3.

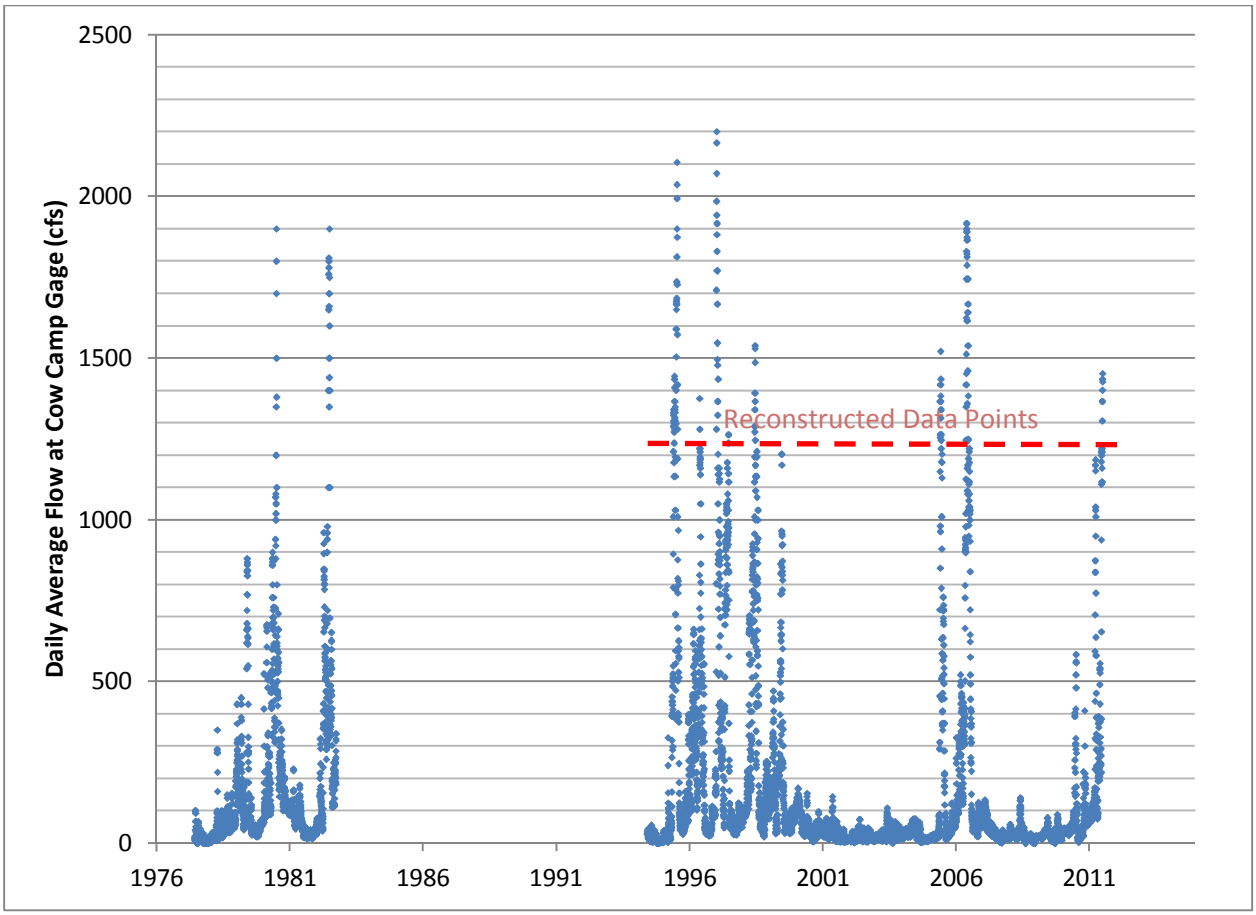

Figure 3 – Reconstructed daily average flows in the Walker River at the Cow Camp gage.

Estimated Natural River Flow Losses from Wabuska to Cow Camp

The river reach from Wabuska to Cow Camp is approximately 13.1 miles in length (river miles), with a sinuosity factor of approximately 1.26 (river length divided by linear path length). This reach does not have any irrigation diversions and supports a thriving community of riparian and phyreatophyte vegetation, including cottonwood groves. The flood plain corridor is typically about ¼ mile in width.

This reach of the river almost always experiences a natural loss in river flow due to channel seepage and evapotranspiration water use by plants. Occasionally, flows at Cow Camp are recorded higher than Wabuska (Figure 4), which is attributed to isolated precipitation events, standard gage error - which for a "fair" rating is equal to plus minus 8 percent, and bank storage releases of shallow groundwater.

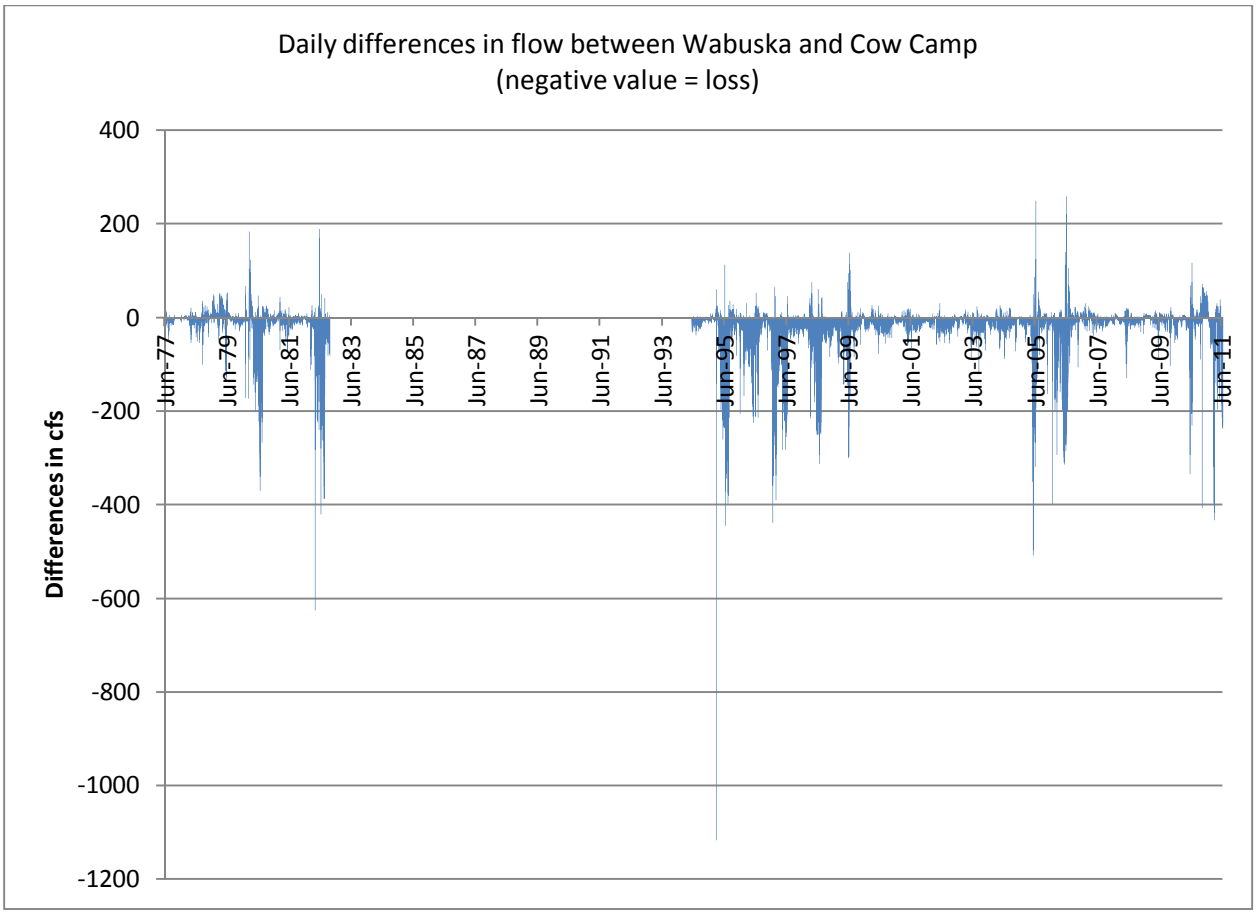

Figure 4 – Differences in Daily Average Flows at Wabuska and Cow Camp Gages

When data are processed to average monthly flows over the period of available record data common to both gages, the river flow loss between the gages is approximately 13 percent annually. Regression of the data indicates that approximately 80 percent of the difference in flows between the gages can be defined by a linear relationship (Figure 5). It is important to note that the volume of water lost in this segment of the river varies considerably from year to year (Figure 6).

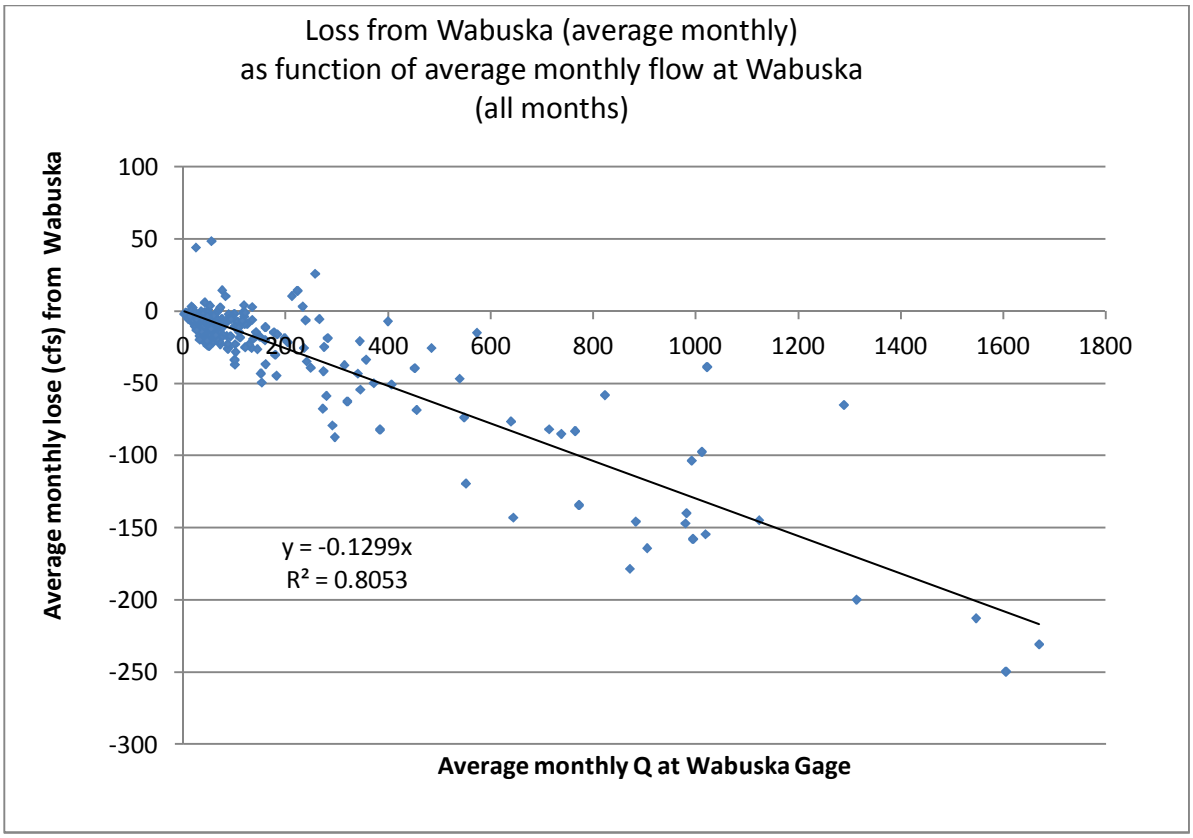

Figure 5 – Segment 1 Monthly Loss Relationship from the Wabuska to Cow Camp Gages

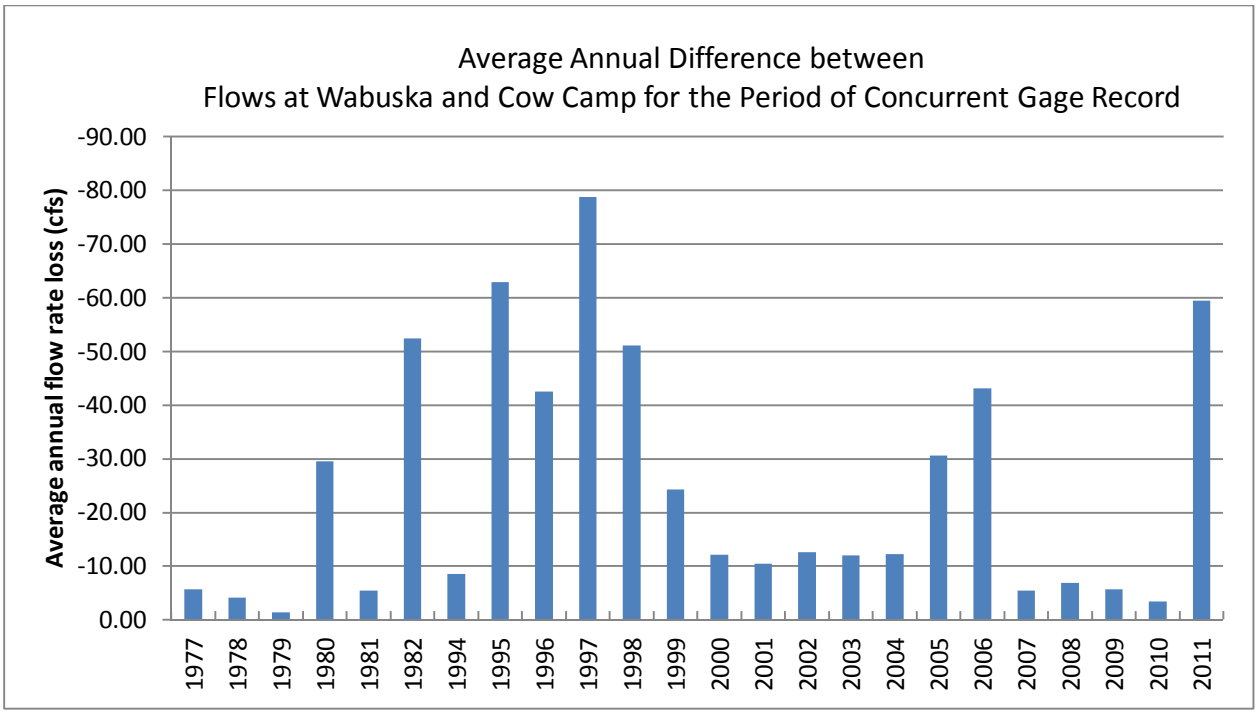

Figure 6 – Average Annual Difference in Flows between Wabuska and Cow Camp Gages

Beyond the annual variability noted, an even more complex picture emerges when losses are considered on a monthly basis for the spring through fall irrigation season. The percent loss between the gages tends to increase through the irrigation season, and on average peaks in the August, although late summer losses remain high (Figure 7). The summer peaking of losses can be attributed to several variables: increased evapotranspiration and an inverse relationship and dependency on volume of flow, i.e., summer months have the lowest flows and if seepage loss volume remains relatively constant, the percent loss increases as the total flow decreases.

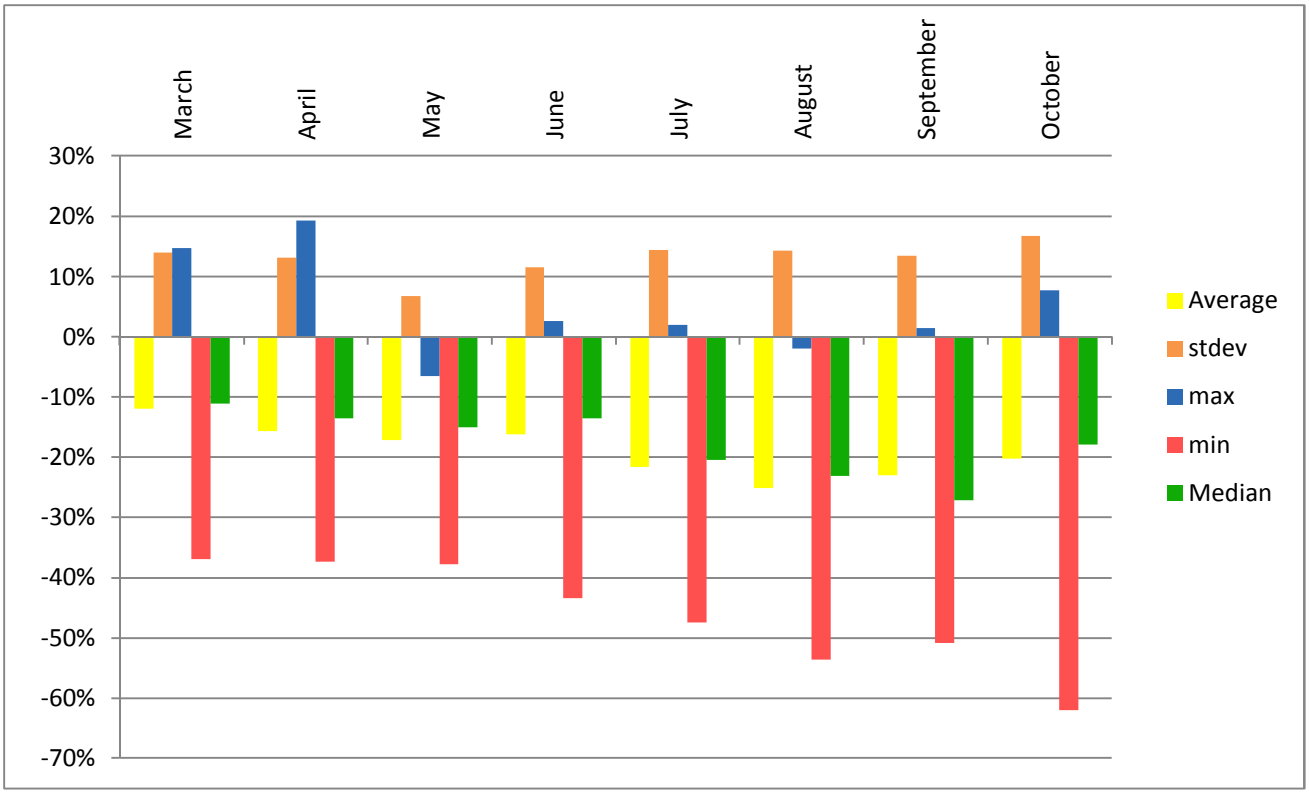

Figure 7 – Average Monthly Flow Loss between Wabuska and Cow Camp Gages

During the irrigation season months, the average and median flow losses (Table 3) are also notably higher than the long-term annual loss of approximately 13 percent. The irrigation season average loss is 18.9 percent and the median flow loss is 17.8 percent.

Further review of monthly average flow data and losses between the gages does not show a defined inverse relationship with volume of flow and percent loss (Figures 8 and 9). Undoubtedly, there are other variables involved, such as antecedent moisture in soils adjacent to the river channel, the physical condition and state of vegetation within and adjacent to the channel, potential pooling and damming by beavers, and aquifer storage depletion from and replenishment to a shallow and connected fluvial aquifer along the river corridor. Also of note, as illustrated in Figure 9, is a potential bimodal loss and flow relationship for low flow (<100 cfs) and moderate to high flow (>100 cfs) regimes. The low flow-loss relationship is non-specific (random) but at generally greater values under low flow regimes, and appears to be possibly linear but at lower values under high flow regimes.

Table 3 – Summary of Percent Loss of Flow by Month during the Typical Irrigation Season Period in the Walker River Reach from Wabuska to Cow Camp

Statistic	March	April	May	June	July	August	September	October
Average	-12%	-16%	-17%	-16%	-22%	-25%	-23%	-20%
Std. Dev.	14%	13%	7%	12%	14%	14%	13%	17%
Maximum	15%	19%	-7%	3%	2%	-2%	1%	8%
Minimum	-37%	-37%	-38%	-43%	-47%	-54%	-51%	-62%
Median	-11%	-14%	-15%	-14%	-20%	-23%	-27%	-18%

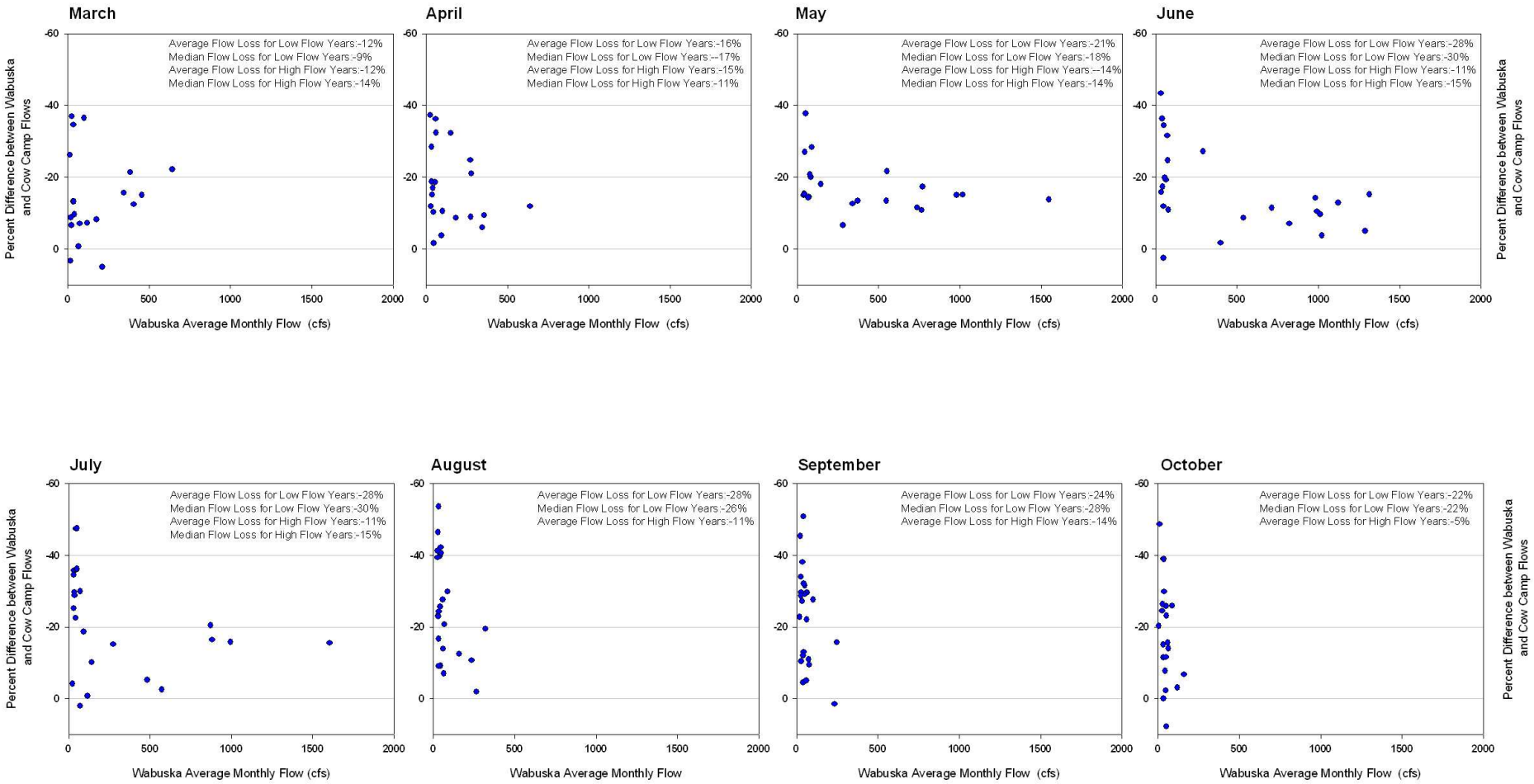

Figure 8 – Monthly Variability Plots for Stream Flow Loss on the Walker River between Wabuska to Cow Camp Gages

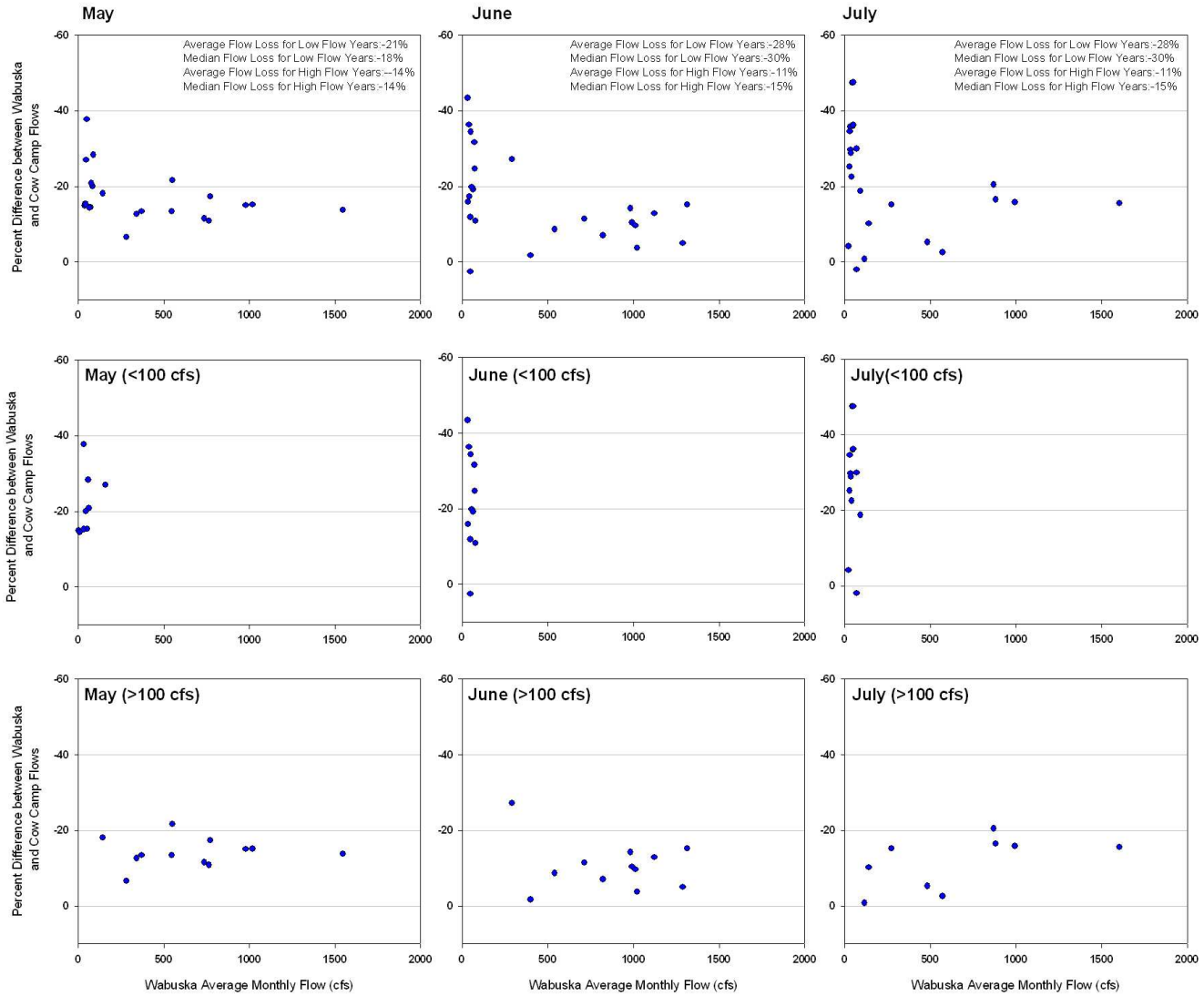

Figure 9 – Flow versus Percent Loss for May, June and July Months

Losses between Cow Camp and Little Dam

This reach of the Lower Walker River extending from the Cow Camp gage to the Little Dam and the WRPT Canal 1 and 2, incorporates Weber Reservoir, which is operated to regulate and deliver irrigation water to the decreed irrigation lands (2,100 acres) on the Reservation. The length of this reach is 8.7 river miles, 2.7 miles of which are situated down-stream of the Weber Reservoir dam. The portion of the reach above Weber Reservoir has a flood plain occupied by abandoned oxbow depressions and primarily willow and grass vegetation. The portion below the dam supports cottonwood groves.

The flow in Walker River at the Little Dam site is where the Tribal irrigation diversions in Canal 1 and 2 take place. USGS naming of the gages on the river and canals leads to some confusion regarding the locations of gages up or down stream of Little Dam. Total flow at the Little Dam site is the sum of flow observed in the Walker River at Little Dam (actually measured just down-stream of the dam), plus the flow measured in Canal 1 and 2, which divert flow at Little Dam, and up-stream of the Little Dam gage.

Over the period of record, this segment shows a loss in flow, except during the first two years of record in portions of 1995 and 1996 (Figure 10). Weber Reservoir operation affects the daily losses or gain observed from between the gages, and likely accounts for gains in 1995 and 1996, which were high runoff years.

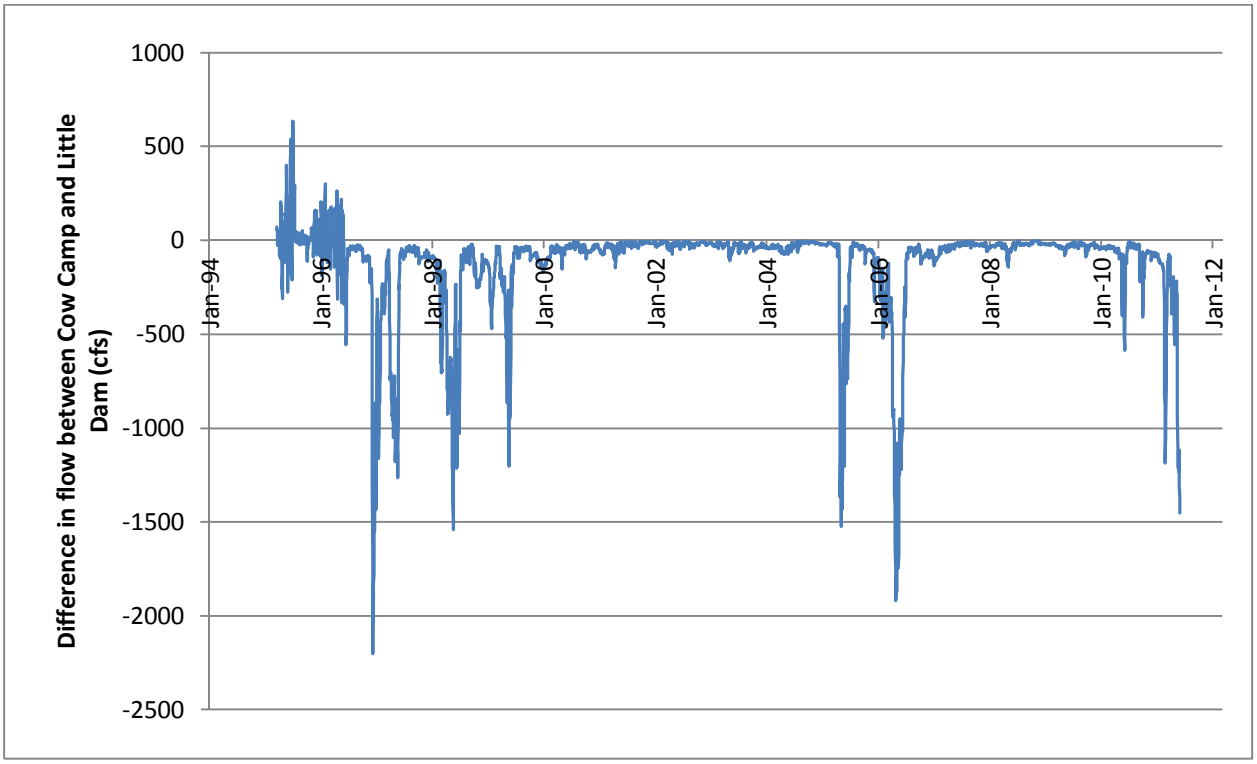

Figure 10 – Difference in Daily Flows between Cow Camp and Little Dam 1995 to 2011 Period of Record (including diversions from Canals 1 and 2)

Weber Reservoir normally operates at a maximum stage of 4,208 feet above mean sea level (ft amsl). Starting in 2000, Weber Reservoir was operated at a reduced impoundment stage of 4,196.5 ft amsl due to dam seismic safety concerns, which was increased to 4,200 ft amsl from 2004 to 2007. The dam was rebuilt in the time frame of 2006 to 2009, after which the reservoir has regained a maximum stage level of 4,208 ft amsl. Published bathymetry (Katzer and Harmsen, 1973) determined a maximum storage capacity of 10,700 acre-feet at a stage of 4,208 ft amsl. Weber Reservoir was originally designed and built in the 1930s for a capacity of 13,000 acre-feet. Both the surface area and storage capacity have generally linear relationships with reservoir stage until the capacity of the reservoir falls below approximately 2,500 acre-feet (stage 4,196.5 ft amsl), after which the stage – storage relationships drops off steeply.

Generally coinciding with the time period of dam reconstruction (2000 to 2009), for the WRPT irrigation seasons in 2007 to 2010, a fallowing program occurred on the Reservation and there were no irrigation diversions.

Prior to the interim reservoir operation, between 1987 to 1999, Weber Reservoir operated at seasonal maximum storage ranging from 3,900 acre-feet in 1992 (severe drought year) to 10,300 acre-feet in 1999, a wet year preceded by several high runoff years (Figure 11). The average maximum storage impoundment during the 1987 to 1999 timeframe was approximately 7,100 acre-feet, and occurred at the end of March to end of May. Maximum storage impoundment tended to occur later in early summer during high runoff years. The average impounded water at the end of October was 2,700 acre-feet, for an average differential in storage volume of 4,400 acre-feet.

Evaporation loss of water from the reservoir is estimated at 5 ft per year based on work by Lopes and Allander (2009) and occurs seasonally as shown in Figure 12, with approximately 3.9 ft occurring in the April through October timeframe. The estimated average evaporative loss from the reservoir surface during the 1987 to 1999 period is 1,780 acre-feet per year, with 1,410 acre-feet occurring during April through October. If the evaporative loss is subtracted from the average storage differential, the storage released for irrigation season water / conveyance is approximately 3,000 acre-feet.

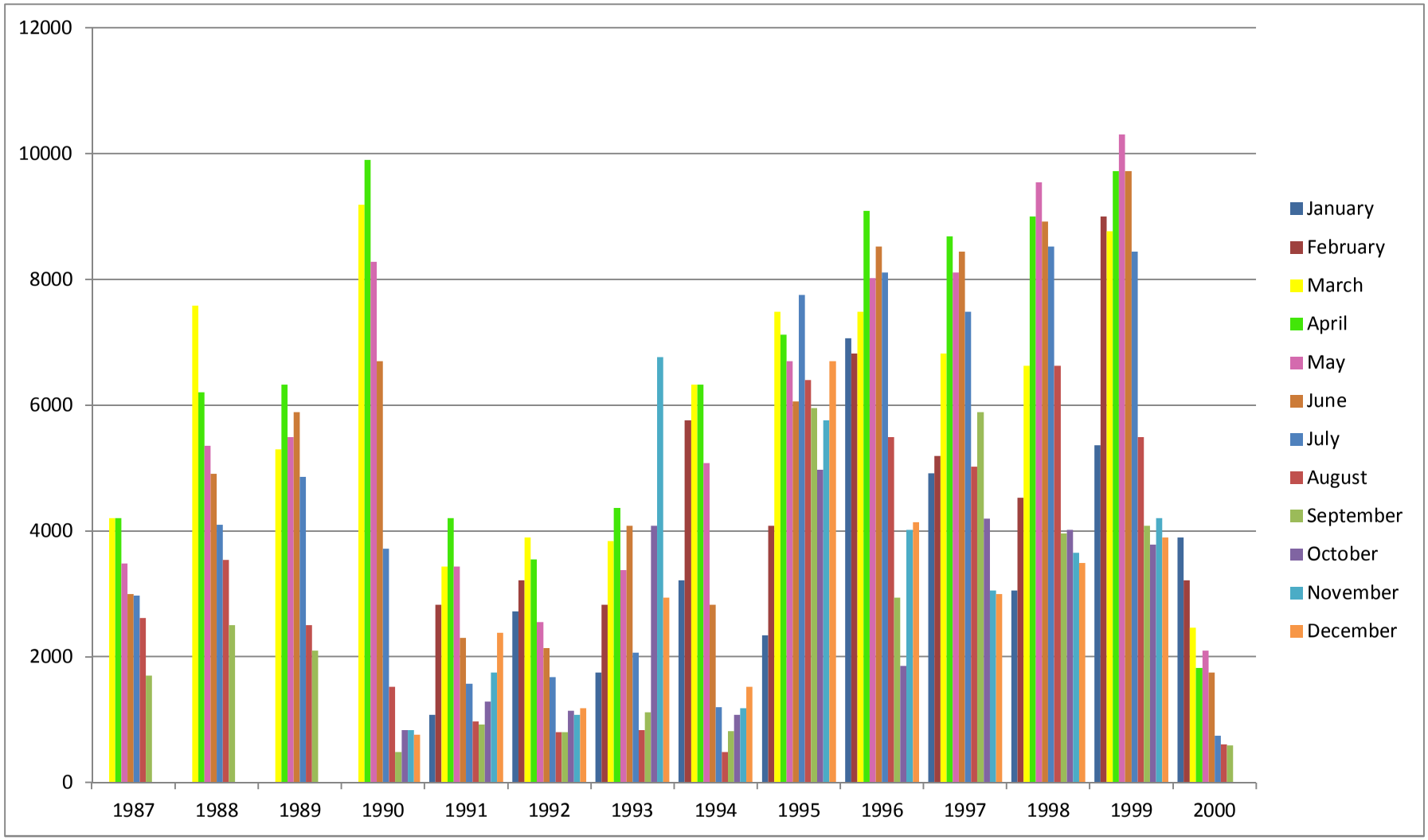

Figure 11 - Weber Reservoir Storage Volumes (end of month). Note: 1987 to 1994 volumes derived from stage data provided by BIA

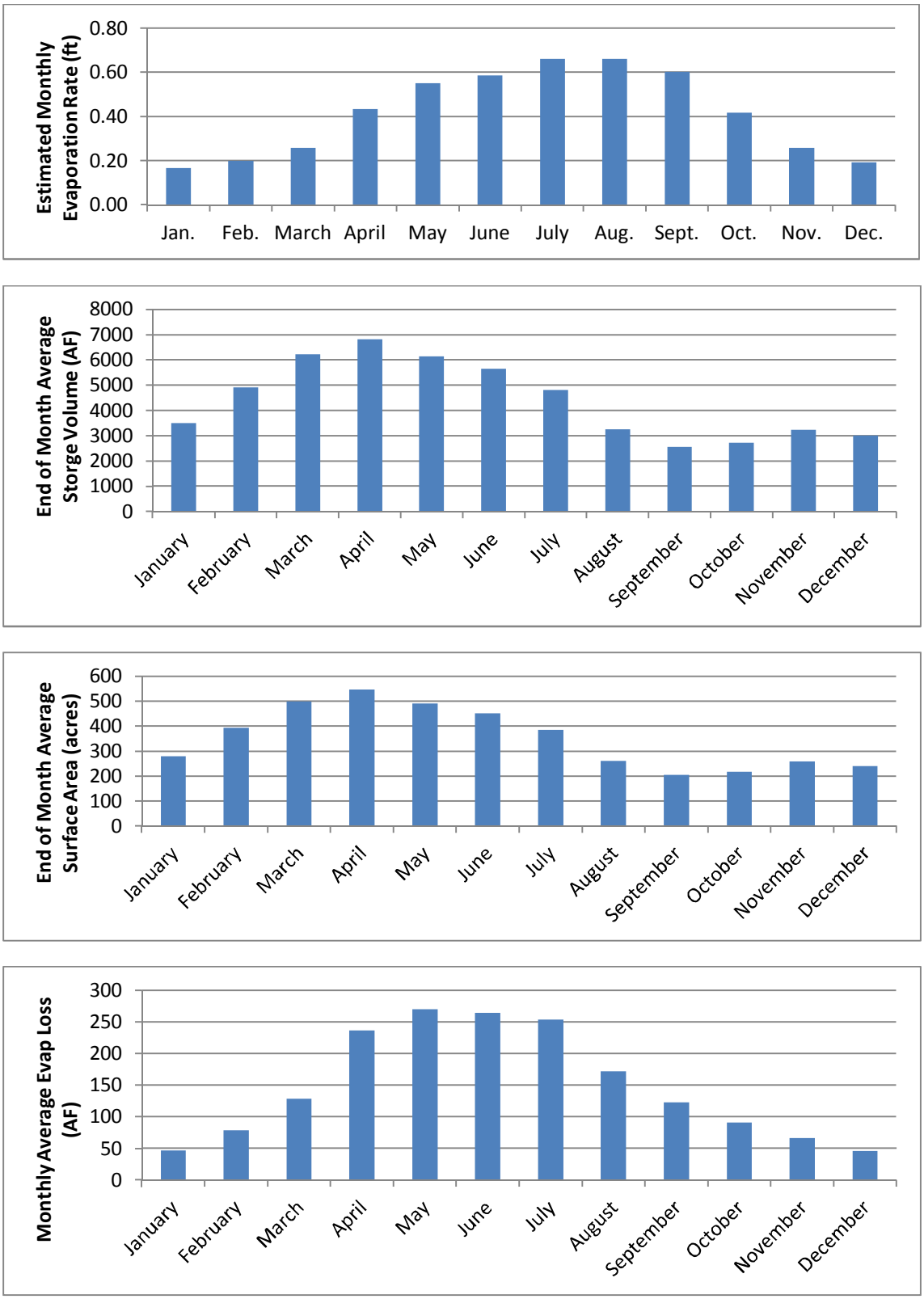

Figure 12 - Estimated Monthly Evaporation from Weber Reservoir

Cumulative Present Day Conveyance Losses to Flow from Wabuska to Little Dam

Over the 17 year period from 1995 to 2011 during which there have been gages in concurrent operation at Wabuska and Little Dam, the loss in river flow between Wabuska and Little Dam averages 30.7%, with a standard deviation of 13.0% (Table 4). During low flow years, the loss in flow between Wabuska and Little Dam increases to 38.2%, with a standard deviation of 12.6%.

Table 4 - Irrigation Season Difference in the Walker River Flow at Little Dam and Wabuska, 1995 - 2011

Year	Wabuska Total Annual Flow (AF)	Wabuska Flow between April 15th to October 15th (AF)	Little Dam Flow between April 15th to Oct 15th (AF)	Difference between Little Dam and Wabuska Irrigation Season Flow (AF)	Little Dam Flow Percent of Wabuska Flow during the Irrigation Season Flow (%)
1995	287,252	280,909	230,910	49,999	82.2
1996	220,730	157,575	102,769	54,806	65.2
1997	352,655	180,272	138,361	41,911	76.7
1998	275,722	226,252	193,791	32,461	85.6
1999	151,515	107,859	95,184	12,675	88.2
2000	53,024	25,473	**14,812**	10,661	**58.1**
2001	30,967	20,661	**10,070**	10,591	**48.7**
2002	23,422	16,861	**8,756**	8,105	**51.9**
2003	30,826	22,125	**11,479**	10,646	**51.8**
2004	31,158	21,061	**14,339**	6,722	**68.0**
2005	150,581	150,313	111,212	39,101	73.9
2006	305,964	278,828	218,034	60,794	78.1
2007	32,357	14,324	**9,273**	5,051	**64.7**
2008	25,181	18,721	**16,486**	2,235	**88.0**
2009	24,523	15,551	**9,821**	5,730	**63.1**
2010	62,291	41,950	24,215	17,735	57.7
2011	247,873	186,836	141,000	45,836	75.4
Average					**69.3**
Std. Dev.					**13.0**
Ave. Low Flow					**61.8**
Std. Dev.					**12.6**

Present Weber Reservoir outlet and Canal 1 and 2 diversion facilities are manually operated. Regulating these facilities on a day-to-day basis to pass both NFWF Program Water and provide WRPT irrigation water will not be an exact process. The magnitude of daily regulating error is uncertain but could range from 5% to 25% difference between target release flow from Weber Reservoir and pass through at Little Dam, and actual delivered total at Little Dam. On an annual basis, the operational imprecision of these facilities could result in a cumulative error range as summarized in Table 5. Program Water conveyance protocols will need to equitably account for daily operational imprecision of the existing facilities.

Table 5 - Estimate of Operational Error for Weber Reservoir Release and Little Dam Flow Diversion Regulation during an Irrigation Season

NFWF Program Water Average Daily Flow Rate (CFS)	Equivalent NFWF Program Water in Acre-feet per Season	Annual Volume Above or Below Target Delivery (Values in AF) at Varying Operation Error				
		5%	10%	15%	20%	25%
5	1,984	50	99	149	198	248
10	3,967	99	198	298	397	496
20	7,934	198	397	595	793	992
50	19,836	496	992	1,488	1,984	2,480
100	39,672	992	1,984	2,975	3,967	4,959

Assumptions:
50% of Error Above and 50% Below Target Rates
Average Program Water Delivery Season = 200 Days
Assumes Operating Under Pass-Through for the Entire Season

MAP

The map on the following page provides information on the location of USGS on the Walker River Paiute Reservation.

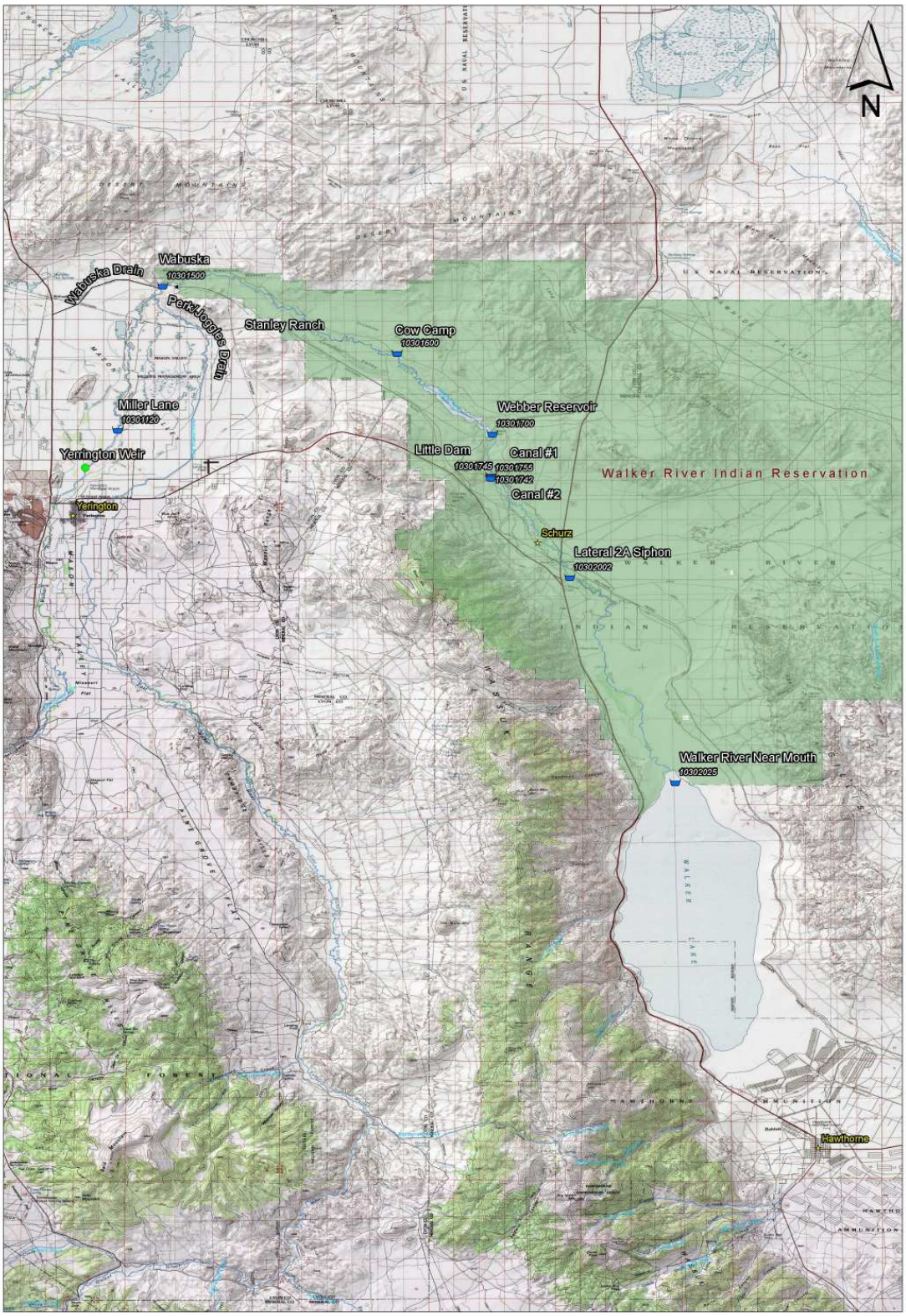

Plate 1: Lower Walker River Gage Locations