6

Project Impacts on the San Joaquin River

October 1, 2001 – December 31, 2002

Michael C. S. Eacock[1]
Nigel W.T. Quinn[2]

Grassland Bypass Project

1 Natural Resource Specialist, US Bureau of Reclamation, South-Central California Area Office, 1243 N Street, Fresno, California 93721 (559) 487-5133 ceacock@mp.usbr.gov
2 Staff Geological Scientist/Water Resources Engineer, Lawrence Berkeley National Laboratory, 1 Cyclotron Road, Building 70A-3317H, Berkeley, California 94720 (510) 486-7056 nquinn@lbl.gov

Introduction

The purpose of this chapter is to compare the loads of salt discharged by the Grassland Bypass Project (GBP) with loads that might exist in the absence of the project. This comparison uses flow and salinity data for Stations B, D, F, and N from October 1985 to December 2002. Two methods are used:

- Simple comparison of flow and salt loads as percentages, and
- A theoretical dilution analysis.

The theoretical dilution analysis was agreed upon in meetings involving the US Bureau of Reclamation (Reclamation), the South Delta Water Agency and its legal counsel, and the California Regional Water Quality Control Board, as a means of demonstrating that the Project was not causing adverse downstream impacts. This analysis was not specified in the Compliance Monitoring Program (Reclamation et. al., June 2002) or the Quality Assurance Project Plan (Reclamation et. al., August 2002). Work continues to standardize the methodologies used to calculate loads and the theoretical dilution.

The 2001 Agreement for Use of the San Luis Drain includes the following statement:

"*It is the objective and intention of RECLAMATION and the AUTHORITY, among other things, to ensure that continued use of the Drain as provided in this Agreement results in improvement in water quality and environmental conditions in the San Joaquin River, delta, and estuary relative to the quality that existed prior to the term of this Agreement, insofar as such quality or conditions may be affected by drainage discharges from the Drainage Area (as hereinafter defined), and to ensure that such continued use of the Drain does not reduce the ability to meet the salinity standard at Vernalis compared to the ability to meet the salinity standard that existed prior to the term of this Agreement.*" (Reclamation and San Luis & Delta-Mendota Water Authority, 2001)

Comparison of Flow and Salt Loads as Percentages

Tables 1a, 1b, and 1c compare the monthly flows and loads of salt discharged by the GBP with those in the San Joaquin River at Crows Landing through the six years of the Project. During the fifteen month study period (October 1, 2001 – December 31, 2002), the GBP contributed between two and fourteen percent of the flow, and 10 to 41 percent of the salt load, in the river each month (Table 1a). During WY 2002, overall discharge from the GBP was five percent of the flow and about 32 percent of the salt load in the river as measured at Crows Landing (Table 1b).

Tables 2a, 2b, and 2c compare the volumes of water discharged from the 97,000 acre Grassland Drainage Area (GDA) with flows in the Mud and Salt Slough watershed. The monthly discharge from the Grassland Drainage Area ranged from 12 to 32 percent of the regional flow during the fifteen month study period, (Table 2a). During the WY 2002, 28,400 acre-feet of water were discharged from the GDA, which was approximately 15 percent of the 185,140 acre-feet that flowed from the region (Table 2a). The WY 2002 volume was about 43 percent less than the average annual volume of drainage water discharged prior to the GBP (Table 2b).

Tables 3a, 3b, and 3c compare the loads of salts discharged from the GDA with the salts in water in Mud and Salt Sloughs. During the WY 2002, about 116,260 tons of salt were discharged from the GDA, which was almost 36 percent of the 319,660 tons that left the region through Mud and Salt Sloughs (Table 3a). The WY 2002 salt load was about 39 percent less than the average annual salt load discharged prior to the GBP (Table 3b). The WY 2002 regional salt load was about 18 percent less than the average annual salt load discharged prior to the GBP (Table 3b).

Theoretical Dilution of GBP Discharges to Meet Vernalis Standards

In order to assess the effect of GBP on salinity in the San Joaquin River, an analysis was developed to theoretically isolate the effects of GBP from other activities potentially affecting salinity concentrations in the river. Drainage from GBP was assumed as the only drainage relevant to project-related changes in salt load on the San Joaquin River. The analysis was cast in terms of theoretical dilution water needed to bring the GBP discharges to the Vernalis seasonal EC objectives.

The salinity objectives for Vernalis are 1,000 µS/cm (640 mg/L Total Dissolved Solids) in the winter months (September-March) and 700 µS/cm (448 mg/L TDS) in the summer months (April-August). Figure 1 shows the theoretical volume of water that would be needed to dilute the combined salt loads from the GDA, measured at Station B, and the regional watershed, drained by Mud Slough and Salt Slough (Stations D & F), to meet the Vernalis standards. This analysis does not take into account any of the other operational criteria, nor does it consider salinity contributions to the River other than those derived from the GDA. The value of the analysis is that it permits a "with" and "without" project comparison with prior year hydrology, in terms (water quality releases from a reservoir) meaningful to water users and managers.

The assimilative capacity analysis considers the total volume of dilution water (assumed to have a salinity of 100 ppm) that would be needed to reduce the drainage water alone to the salinity objective. Note that the monthly volume of dilution water is highly dependent on the 100-ppm assumption. Note also that the relation between dilution water quality and required volume is non-linear.

Figure 1 shows the monthly theoretical dilution requirements for WY 1986 through 2002. Figure 2 shows the total theoretical dilution requirement for each water year. The unshaded areas in Figures 1 and 2 represent the theoretical dilution requirements for salt loads generated by the Mud and Salt Slough watershed which includes the GDA and other agricultural areas, wetlands, and uncontrolled runoff from the Coast Range watersheds. The shaded area in the Figures shows the theoretical dilution requirements for salt loads discharged from only the GDA.

The data for Figure 2 are summarized in Tables 4a and 4b. During the 2002 WY, about 166,400 acre-feet of water would have been required to dilute the 28,400 acre-feet of drainage water discharged from the GDA. In comparison, approximately 415,900 acre-feet of water would have been needed to dilute the 185,140 acre-feet of regional discharges to meet the Vernalis standards. The 2002 WY theoretical dilution requirement for the GDA is about 43 percent less than that required during the years prior to the implementation of the GBP Table 4b). The WY 2002 theoretical dilution requirement for the region was eight percent less than that required during the years prior to implementation of the GBP.

These percentages should be put into context of the 1990 – 1994 drought and the initiation of CVPIA water deliveries to wetlands (private, State and Federal) in the Grasslands Basin that preceded the authorization of the Grassland Bypass Project. The latter has profoundly affected the hydrology of the Grasslands Basin and has affected the timing of salt loading to the San Joaquin River.

The allocation to federal contractors in WY 2002 was 65 percent. Data for the GDA for WY 1986 to 2002 show that between WY 1999 and 2002, the salt loads (Tables 3a and 3b) and theoretical dilution requirements (Tables 4a and 4b, and Figures 1 and 2) were smaller than in all other years with the exception of the drought years of WY 1991 and 1992.

The theoretical dilution required for the entire region in WY 2002 was 21 percent less than the average of all prior years and about 30 percent less than the average of water years with above normal water years (Table 4b).

WY 1999 through 2002 had no unusual or unexpected hydrologic events as occurred in WY 1997 and WY 1998. As listed in Table 2a, CVP irrigation deliveries during WY 1999 – 2002 were lower than the WY 1997 and 1998, and the volume of water discharged from the GDA continued to be comparable to that discharged during the drought years of 1991 and 1992.

Data for several more years will be necessary before the impact of the GBP on the San Joaquin River can be quantified with confidence.

Calculations

The formula for theoretical dilution is:

Q2= Q1(C3-C1)/(C2-C3)

Q1 = Drainwater discharge in acre-feet per month

Q2 = Volume of water needed to dilute Q1 to meet Vernalis standards in acre-feet per month

C1 = Measured concentration of GBP drainage water in parts per million (mg/L)

C2 = Assumed concentration of dilution water = 100 mg/L

C3 = Vernalis standard concentration = 448 mg/L April – August, 640 mg/L September - March

References

U.S. Bureau of Reclamation and the San Luis & Delta-Mendota Water Authority. September 28, 2001. Agreement for Use of the San Luis Drain. Agreement No. 01-WC-20-2075.

U.S. Bureau of Reclamation, et. al. June 2002. Monitoring Program for the Operation of the Grassland Bypass Project, Phase II October 1, 2001 – December 31, 2009.

U.S. Bureau of Reclamation, et. al. August 22, 2002. Quality Assurance Project Plan for the Compliance Monitoring Program for the Use and Operation of the Grassland Bypass Project.

Table 1a. Comparison of Flows and Salt Loads Discharged by the Grassland Bypass Project to the San Joaquin River, October 2001 - December 2002

	Discharged from GDA Station B acre-feet	Total Monthly Flow San Joaquin River at Crows Landing Station N acre-feet	B as % of N	Discharged from GDA Station B tons	Total Monthly Salt Load San Joaquin River at Crows Landing Station N tons	B as % of N
Oct-2001	1,100	45,632	2%	4,294	29,550	15%
Nov-2001	1,320	58,918	2%	5,024	39,992	13%
Dec-2001	1,250	58,325	2%	5,308	49,967	11%
Jan-2002	1,660	73,507	2%	7,162	58,572	12%
Feb-2002	2,730	44,321	6%	11,853	58,225	20%
Mar-2002	3,370	53,186	6%	14,892	77,629	19%
Apr-2002	2,430	41,598	6%	11,372	47,247	24%
May-2002	2,640	57,543	5%	11,082	39,690	28%
Jun-2002	3,320	30,054	11%	13,134	35,656	37%
Jul-2002	3,260	25,482	13%	12,749	30,855	41%
Aug-2002	3,410	25,141	14%	11,922	29,466	40%
Sep-2002	1,910	20,256	9%	7,387	20,581	36%
Oct-2002	1,240	38,744	3%	5,213	26,560	20%
Nov-2002	1,150	48,671	2%	4,840	43,994	11%
Dec-2002	1,360	64,739	2%	6,236	59,992	10%
Fifteen month total	32,150	686,117		132,468	647,975	20%

Data Sources: Station B - US Geological Survey Site 11262895
Station N - US Geological Survey Site 11274550
Note: January - March 2002 EC and salt loads at Station N estimated from CVRWQCB autosampler data.

Table 1b. Comparison of Flows and Salt Loads Discharged by the Grassland Bypass Project to the San Joaquin River, Water Years 1997 - 2002

	Discharged from GDA Station B acre-feet	Total Flow San Joaquin River at Crows Landing Station N acre-feet	B as % of N	Discharged from GDA Station B tons	Total Salt Load San Joaquin River at Crows Landing Station N tons	B as % of N
WY 1997	37,549	3,844,270	1%	167,739	1,080,703	16%
WY 1998	45,940	4,904,910	1%	205,104	1,511,470	14%
WY 1999	32,310	1,015,350	3%	149,133	680,098	22%
WY 2000	31,260	1,027,480	3%	134,994	703,876	19%
WY 2001	28,254	653,425	4%	120,008	623,555	19%
WY 2002	28,400	556,214	5%	116,180	542,457	21%

Table 1c. Comparison of Flows and Salt Loads Discharged by the Grassland Bypass Project to the San Joaquin River, Calendar Years 1997 - 2002

	Discharged from GDA Station B acre-feet	Total Flow San Joaquin River at Crows Landing Station N acre-feet	B as % of N	Discharged from GDA Station B tons	Total Salt Load San Joaquin River at Crows Landing Station N tons	B as % of N
CY 1997	37,478	3,590,370	1%	169,236	1,072,468	16%
CY 1998	46,240	5,064,280	1%	208,884	1,516,097	14%
CY 1999	32,250	864,520	4%	146,530	664,465	22%
CY 2000	30,210	1,059,222	3%	128,576	689,512	19%
CY 2001	28,014	638,208	4%	119,266	623,841	19%
CY 2002	28,480	523,242	5%	117,842	528,466	22%

Table 2a. Annual Volume of Water Discharged from the Grassland Drainage Area and Mud/Salt Slough Watershed

Water Year (1)	% CVP Contract Delivery (2)	Discharge from GDA (3)	Discharge from Region (4)	GDA discharge as percent of Regional discharge
	acre-feet	acre-feet	acre-feet	
WY 1986	100%	67,006	284,316	24%
WY 1987	100%	74,902	233,843	32%
WY 1988	100%	65,327	230,454	28%
WY 1989	100%	54,186	211,393	26%
WY 1990	50%	41,662	194,656	21%
WY 1991	25%	29,290	102,162	29%
WY 1992	25%	24,533	85,428	29%
WY 1993	50%	41,197	167,955	25%
WY 1994	35%	38,670	183,546	21%
WY 1995	100%	57,574	263,769	22%
WY 1996	95%	52,978	267,948	20%
WY 1997 GBP	90%	37,549	287,021	13%
WY 1998 GBP	100%	45,940	378,670	12%
WY 1999 GBP	70%	32,310	253,127	13%
WY 2000 GBP	65%	31,260	235,501	13%
WY 2001 GBP	49%	28,254	226,763	12%
WY 2002 GBP	65%	28,400	180,150	16%

Table 2b. Comparison of 2002 WY Discharge Volume to Previous Years

	Water Year	Discharge from GDA (3) acre-feet	WY 2002 difference	WY 2002 difference
Average, all years	1986 - 2002	44,179	-36%	-19%
Prior years average	1986 - 2001	45,165	-37%	-20%
Before GBP average	1986 - 1996	49,757	-43%	-11%
GBP average	1997 - 2002	33,952	-16%	-31%
Below Normal Water Years	(5)	38,668	-27%	-5%
Above Normal Water Years	(6)	49,767	-43%	-30%

Table 2c. Total Volumes of Water

	Water Years	Discharge from GDA (3) acre-feet	Discharge from Region (4) acre-feet	GDA discharge as percent of Regional discharge
All years	1986 - 2002	751,038	3,786,702	20%
Before GBP	1986 - 1996	547,325	2,225,470	25%
GBP total	1997 - 2002	203,713	1,561,232	13%

Notes: Pre-project data compiled by Nigel Quinn (LBNL) from CVRWQCB and USGS reports.

(1) Water Year - October 1 - September 30

(2) Percent of Contract Delivery of CVP water to Delta Division and San Luis Unit

(3) Grassland Drainage Area Station B - US Geological Survey Site 11262895 San Luis Drain

(4) Mud and Salt Sloughs Station D - US Geological Survey Site 11262900 Mud Slough near Gustine
Station F - US Geological Survey Site 11361100 Salt Slough at Hwy 165

(5) Below Normal Water Years with 50% or less CVP delivery: WY 1990 - 1994, 2001

(6) Above Normal Water Years with more than 50 percent CVP delivery: WY 1986 - 1989, 1995 - 2000, 2002

Table 3a. Annual Loads of Salt Discharged from the Grassland Drainage Area and Mud/Salt Slough Watershed

Water Year (1)		% CVP Contract Delivery (2)	Discharge from GDA (3) tons	Discharge from Region (4) tons	GDA load as percent of Regional load
WY 1986		100%	214,250	494,544	43%
WY 1987		100%	241,526	438,904	55%
WY 1988		100%	236,301	455,956	52%
WY 1989		100%	202,420	389,325	52%
WY 1990		50%	171,265	380,564	45%
WY 1991		25%	129,899	221,542	59%
WY 1992		25%	110,327	197,352	56%
WY 1993		50%	183,021	336,522	54%
WY 1994		35%	171,495	379,408	45%
WY 1995		100%	237,530	499,339	48%
WY 1996		95%	197,526	477,725	41%
WY 1997	GBP	90%	167,739	446,693	38%
WY 1998	GBP	100%	205,104	627,687	33%
WY 1999	GBP	70%	149,133	401,614	37%
WY 2000	GBP	65%	134,994	372,452	36%
WY 2001	GBP	49%	120,008	383,155	31%
WY 2002	GBP	65%	116,180	331,596	35%

Data Sources: Station B - US Geological Survey Site 11262895 San Luis Drain
Station D - US Geological Survey Site 11262900 Mud Slough near Gustine
Station F - US Geological Survey Site 11361100 Salt Slough at Hwy 165

Table 3b. Comparison of 2002 WY Salt Loads to Previous Years

		Discharge from GDA (3) acre-feet	**WY 2002 difference**	**Discharge from Region (4)** acre-feet	**WY 2002 difference**
Average, all years	1986 - 2002	175,807	-34%	402,022	-18%
Prior years average	1986 - 2001	179,534	-35%	406,424	-18%
Before GBP average	1986 - 1996	190,505	-39%	388,289	-15%
GBP average	1997 - 2002	148,859	-22%	427,200	-22%
Below Normal Water Years	(5)	167,032	-30%	371,690	-11%
Above Normal Water Years	(6)	191,155	-39%	448,712	-26%

Notes: Pre-project data compiled by Nigel Quinn (LBNL) from CVRWQCB and USGS reports.
(1) Water Year - October 1 - September 30
(2) Percent of Contract Delivery of CVP water to Delta Division and San Luis Unit
(3) Grassland Drainage Area Station B - US Geological Survey Site 11262895 San Luis Drain
(4) Mud and Salt Sloughs Station D - US Geological Survey Site 11262900 Mud Slough near Gustine
Station F - US Geological Survey Site 11361100 Salt Slough at Hwy 165
(5) Below Normal Water Years with 50% or less CVP delivery: WY 1990 - 1994, 2001
(6) Above Normal Water Years with more than 50 percent CVP delivery: WY 1986 - 1989, 1995 - 2000, 2002

Table 4a. Theoretical Annual Volumes of Dilution Water Needed to Meet Vernalis Standards

Water Year (1)		Theoretical Annual Volume of Water Needed to Dilute GDA Discharge to Meet Vernalis Standard (3) acre-feet	Theoretical Annual Volume Water Needed to Dilute Regional Discharge to Meet Vernalis Standard (4) acre-feet
WY 1986		303,361	426,147
WY 1987		332,189	406,134
WY 1988		335,151	424,453
WY 1989		294,834	350,406
WY 1990		245,167	341,299
WY 1991		186,454	235,849
WY 1992		160,419	191,068
WY 1993		272,851	325,964
WY 1994		249,057	363,094
WY 1995		344,983	451,505
WY 1996		283,339	418,393
WY 1997	GBP	246,094	301,219
WY 1998	GBP	302,996	456,678
WY 1999	GBP	216,577	290,092
WY 2000	GBP	195,422	400,730
WY 2001	GBP	174,543	458,769
WY 2002	GBP	124,538	320,031

Table 4b. Comparison of Theoretical Dilution Requirement

		Theoretical Annual Volume of Water Needed to Dilute GDA Discharge to Meet Vernalis Standard (3) acre-feet	WY 2002 difference	Theoretical Annual Volume Water Needed to Dilute Regional Discharge to Meet Vernalis Standard (4) acre-feet
Average, all years	1986 - 2002	251,057	-50%	362,461
Prior years average	1986 - 2001	258,965	-52%	365,112
Before GBP average	1986 - 1996	273,437	-54%	357,665
GBP average	1997 - 2002	210,028	-41%	371,253
Below Normal Water Years	(5)	235,505	-47%	372,679
Above Normal Water Years	(6)	270,862	-54%	385,981

Notes:

Pre-project data compiled by Nigel Quinn (LBNL) from CVRWQCB and USGS reports.

(1) Water Year - October 1 - September 30

(2) Percent of Contract Delivery of CVP water to Delta Division and San Luis Unit

(3) Grassland Drainage Area

(4) Mud and Salt Sloughs

(5) Below Normal Water Years with 50% or less CVP delivery: WY 1990 - 1994, 2001

(6) Above Normal Water Years with more than 50 percent CVP delivery: WY 1986 - 1989, 1995 - 2000, 2002

Figure 1. Theoretical Monthly Volumes of Water Needed to Dilute Drainage Water from the Grassland Drainage Area and Regional Watershed to Meet Vernalis Standards October 1986 – December 2002

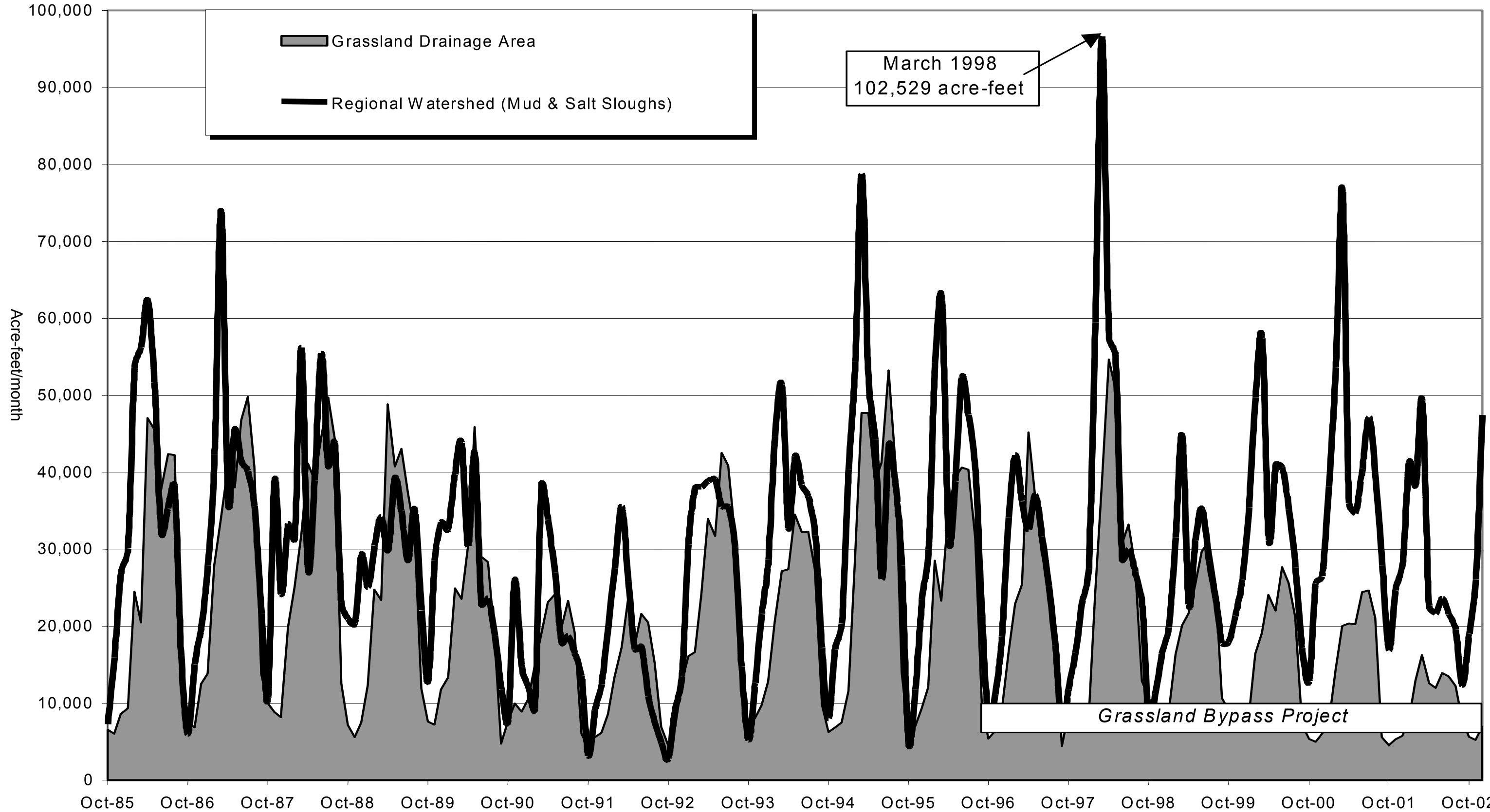
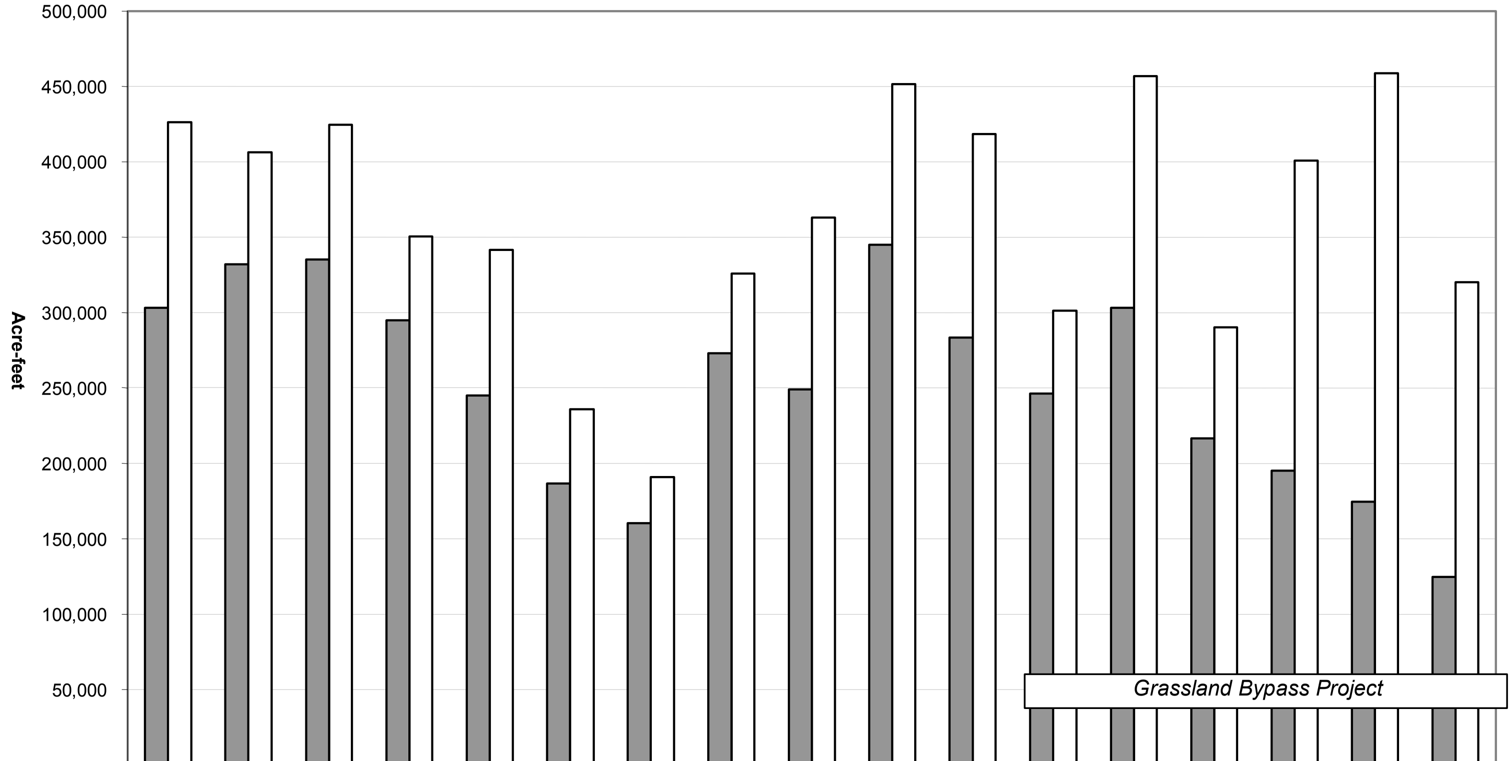


Figure 2 - Theoretical Annual Volumes of Water Needed to Dilute Drainage from the Grassland Drainage Area and the Regional Watershed to Meet Vernalis Standards (1986 - 2002 Water Years)



	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
GDA	303,361	332,189	335,151	294,834	245,167	186,454	160,419	272,851	249,057	344,983	283,339	246,094	302,996	216,577	195,422	174,543	124,538
Regional	426,147	406,134	424,453	350,406	341,299	235,849	191,068	325,964	363,094	451,505	418,393	301,219	456,678	290,092	400,730	458,769	320,031