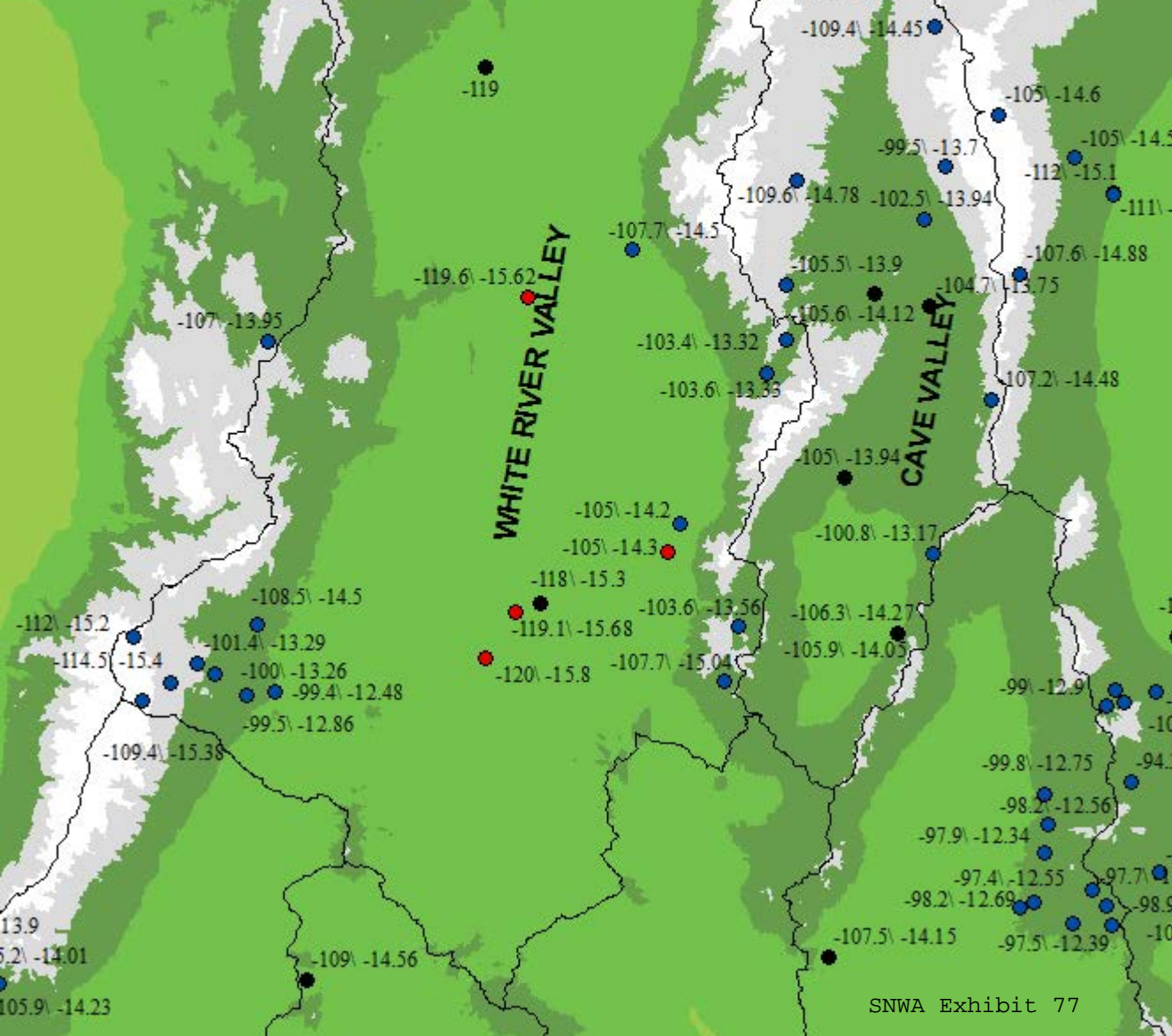


Spring, Cave, Dry Lake and Delamar Valleys



SOUTHERN NEVADA
WATER AUTHORITY

Presentation For:
Dr. Thomas Testimony



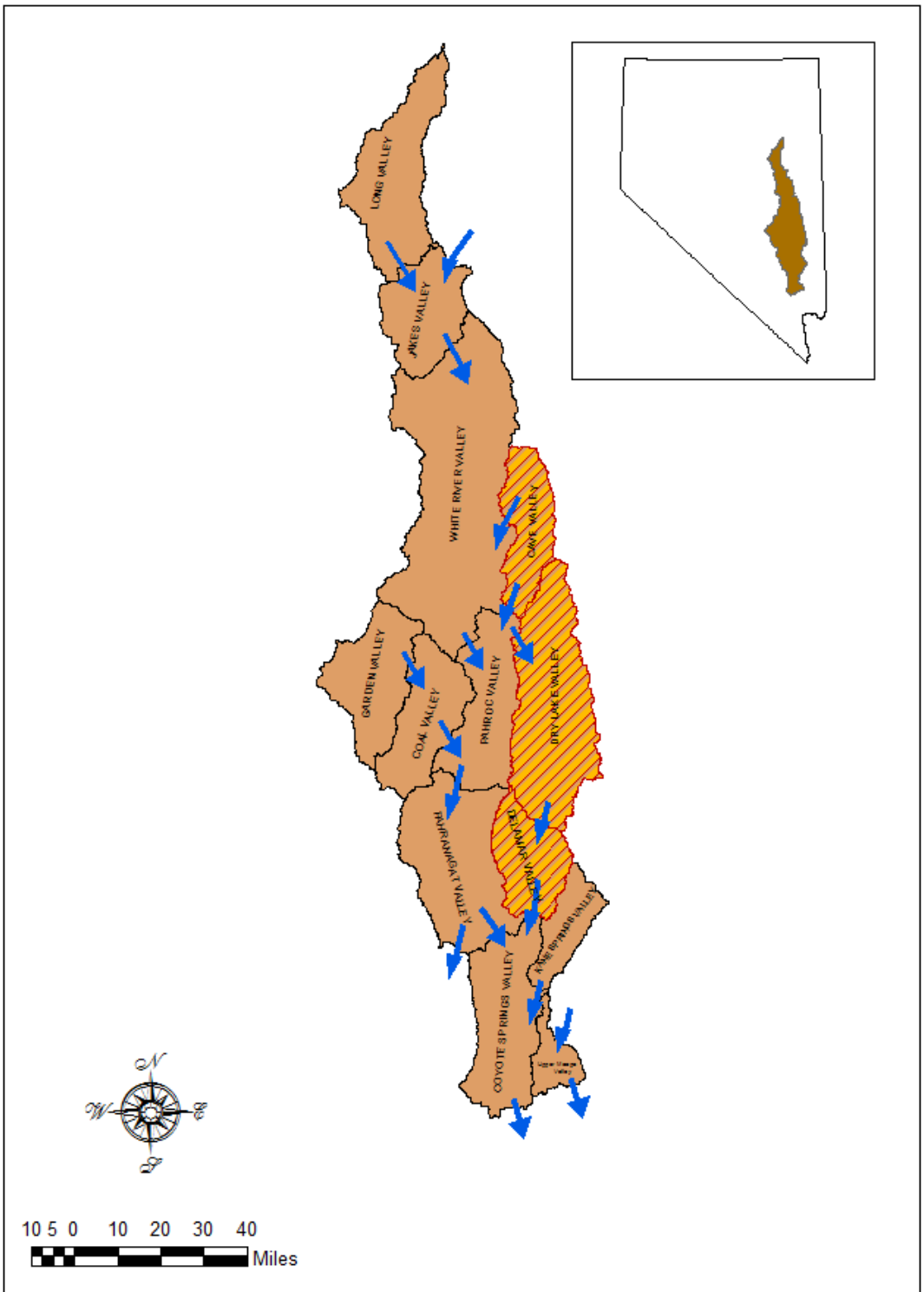


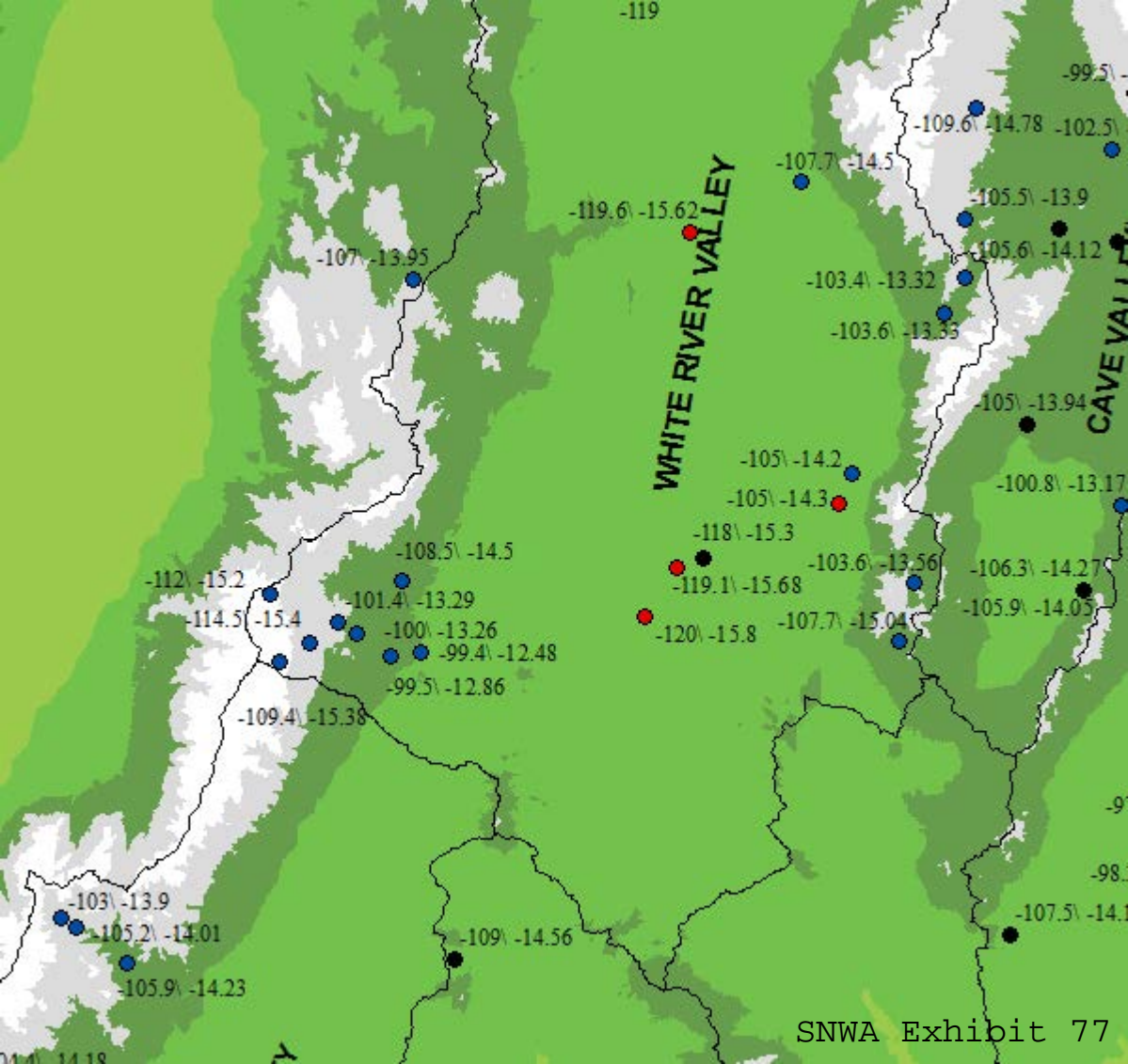
Figure 1. Study area location showing the White River Flow System (WRFS), which includes Delamar, Dry Lake, and Cave valleys (DDC area is shaded). General groundwater flow directions are from Burns and Drici (2011) and are shown by arrows.

APPENDIX 1. ISOTOPIC, FIELD PARAMETER, AND WATER CHEMISTRY DATA FOR ALL SITES USED IN THIS STUDY AND SOME ADDITIONAL SITES IN EASTERN AND SOUTHERN NEVADA.

Name	Latitude Degrees	Longitude Degrees	Water Temp. (°C)	DO (mg/L)	pH	δ ¹⁸ O (‰)	δD (‰)	Ca (mg/L)	Mg (mg/L)	Na (mg/L)	K (mg/L)	Cl (mg/L)	HCO ₃ (mg/L)	SO ₄ (mg/L)	SiO ₂ (mg/L)	F (mg/L)	Sample #	REF_ID	Site Type	Site #	Date
Abandoned Spring	37.49914	-114.72889	10.2	7.7	7.80	-12.32	-94.5	81.00	20.00	50.00	2.26	35.20	357.00	41.80	27.80	--	59699	--	Spring	266	03/26/04
Acoma Well	37.54861	-114.17306	17.0	--	7.70	-12.60	-95.0	38.00	5.30	21.00	7.00	17.00	149.00	10.00	54.00	0.3	244	GS91	Well	118	06/03/85
Adaven Spring	38.13861	-115.60139	12.5	6.9	7.54	-13.95	-103.0	63.00	25.00	14.00	2.20	4.80	324.00	18.00	28.00	0.2	341	GS131	Spring	177	07/31/85
Adaven Spring	38.13861	-115.60139	9.9	--	7.10	-14.07	-107.6	--	--	--	--	--	358.00	--	--	--	340	IT115	Spring	177	02/03/97
Alamo City Well #7	37.36222	-115.16833	18.5	--	7.57	-13.46	-101.1	61.42	56.00	96.30	13.73	54.60	454.00	188.00	59.13	1.3	205	IT116	Well	104	08/08/95
Albert Spring	38.56833	-115.36167	14.5	--	--	-13.95	-107.0	--	--	--	--	--	--	--	--	--	403	GS182	Spring	204	07/24/85
APCAR	36.71099	-114.71682	--	--	--	-12.94	-98.2	62.90	27.20	95.00	11.20	62.10	257.00	176.00	31.60	--	61616	--	Spring	292	10/19/04
Arrow Canyon	36.73421	-114.74778	--	--	--	-12.91	-99.4	--	--	--	--	--	--	--	--	--	SNWA	--	Well	619	02/01/06
Ash Springs	37.46361	-115.19250	--	--	--	--	-107.0	--	--	--	--	--	--	--	--	--	222	IT27	Spring	110	08/01/68
Ash Springs	37.46361	-115.19250	--	--	--	--	-109.0	--	--	--	--	--	--	--	--	--	223	IT28	Spring	110	01/01/69
Ash Springs	37.46361	-115.19250	--	--	--	--	-112.0	--	--	--	--	--	--	--	--	--	224	IT29	Spring	110	03/01/70
Ash Springs	37.46361	-115.19250	36.0	2.3	7.04	-14.10	-108.0	43.00	14.00	27.00	7.40	8.50	259.00	34.00	30.00	0.8	225	GS81	Spring	110	07/20/81
Ash Springs	37.46356	-115.19252	--	--	--	-14.03	-110.0	--	--	--	--	--	--	--	--	--	SNWA	--	Spring	--	05/24/04
Ash Springs	37.46361	-115.19250	34.0	1.6	7.42	-14.20	-108.4	46.40	16.80	28.40	7.26	8.60	248.00	32.80	32.70	--	61099	--	Spring	110	07/30/04
Aspen Springs South	39.21629	-115.39800	6.9	9.4	7.00	-16.02	-120.9	--	--	--	--	--	--	--	--	--	62721	DRI-WP-16	Spring	324	06/07/05
Aspen Springs North	39.22100	-115.39905	6.9	7.7	6.50	-15.84	-119.3	--	--	--	--	--	--	--	--	--	62716	DRI-WP-11	Spring	349	06/07/05
Bailey Spring (Fairview)	38.17593	-114.72829	18.9	7.0	7.77	-12.68	-98.5	86.40	21.40	29.80	2.10	48.30	331.00	26.60	32.40	--	60849	--	Spring	277	06/29/04
Bailey Spring (Fairview)	38.17593	-114.72829	10.7	6.0	6.99	-12.70	-97.9	96.20	25.80	42.40	1.66	70.30	327.00	49.70	33.10	--	62407	DRI-FR-5	Spring	277	05/01/05
Bailey Spring (Wilson Ck)	38.35295	-114.36718	17.9	6.4	7.84	-12.93	-102.0	45.00	9.43	18.50	2.06	40.60	135.00	16.10	36.70	--	60310	--	Spring	310	05/18/04
Baldwin Spring	36.72035	-114.72415	31.9	2.6	7.30	-12.95	-96.3	63.80	28.10	96.30	11.60	63.80	260.00	180.00	32.00	--	58496	DRI-MV-3	Spring	291	01/12/04
Baldwin Spring	36.72035	-114.72415	32.0	3.0	7.48	-12.93	-96.8	63.70	27.60	94.70	11.10	64.10	263.00	180.00	29.20	--	60309	DRI-MV-3	Spring	291	05/18/04
Baldwin Spring	36.72035	-114.72415	--	--	--	-12.96	-98.6	62.80	27.40	95.00	11.20	61.40	258.00	174.00	32.10	--	61620	DRI-MV-3	Spring	291	10/19/04
Baldwin Spring	36.72035	-114.72415	31.8	2.7	7.30	-12.94	-98.1	63.10	27.40	95.70	11.20	61.70	252.00	178.00	29.60	--	62034	DRI-MV-3	Spring	291	02/10/05
Baldwin Spring	36.72035	-114.72415	32.0	2.8	6.80	-12.94	-97.2	--	--	--	--	--	--	--	--	--	62035	DRI-MV-3	Spring	291	06/08/05
Baldwin Spring	36.72035	-114.72415	31.8	2.6	7.32	-13.05	-98.0	63.50	27.20	96.80	10.90	61.10	253.00	176.00	29.60	2.2	64174	DRI-MV-3	Spring	291	02/16/06
Baldwin Spring	36.72035	-114.72415	30.2	5.3	7.35	-13.03	-98.2	71.10	22.10	93.40	11.20	63.40	254.00	180.00	30.40	2.2	64903	DRI-MV-3	Spring	291	06/21/06
Baldwin Spring	36.72035	-114.72415	32.3	4.8	7.29	-13.03	-97.1	64.50	28.00	83.90	9.35	61.70	259.00	178.00	29.10	2.2	65284	DRI-MV-3	Spring	291	08/23/06
Baldwin Spring	36.72035	-114.72415	31.7	4.3	7.33	-12.91	-97.9	61.80	27.40	93.50	11.20	60.00	251.00	175.00	29.50	2.2	65662	DRI-MV-3	Spring	291	10/30/06
Barrel Spring	38.13105	-114.05505	9.8	6.2	7.72	-13.36	-100.5	55.70	6.12	16.50	0.52	18.80	193.00	10.70	22.90	--	60316	--	Spring	317	05/21/04
Bennett Spring	37.78417	-114.52806	24.0	--	7.50	-13.70	-103.0	56.00	26.00	6.50	1.50	7.90	318.00	6.90	14.00	<1	288	GS103	Spring	141	04/10/85
Big Muddy Spring	36.72196	-114.71682	--	--	--	--	-98.0	--	--	--	--	--	--	--	--	--	121.2	--	Spring	69	3/00/70
Big Muddy Spring	36.72196	-114.71682	32.5	3.0	7.24	-12.90	-96.5	66.00	26.00	96.00	10.00	61.00	270.00	190.00	29.00	2.1	122	GS42	Spring	69	07/22/81
Big Muddy Spring	36.72196	-114.71682	--	--	--	-12.75	-98.0	--	--	--	--	--	--	--	--	--	125	--	Spring	69	10/30/85
Big Muddy Spring	36.72196	-114.71682	--	--	--	-13.05	-99.0	--	--	--	--	--	--	--	--	--	124	GS44	Spring	69	01/07/88
Big Muddy Spring	36.72196	-114.71682	31.0	--	--	-12.84	-98.4	64.40	27.60	99.90	10.90	64.20	270.00	198.00	29.90	--	60308	--	Spring	69	05/18/04
Big Muddy Spring	36.72196	-114.71682	--	--	--	-12.89	-97.6	63.40	27.00	99.10	10.90	64.50	255.00	178.00	32.60	--	61615	--	Spring	69	10/19/04

Table 2. Spatial variability of δD and $\delta^{18}O$ in mountain block recharge areas of the DDC area. Values are reported in permil. NA: not applicable.

Site Name		Number of Samples	Minimum	Maximum	Median	Mean	Standard Deviation
Cave Valley							
South Schell Creek Range	δD	6	-109.5	-99.5	-106.2	-105.0	4.0
South Schell Creek Range	$\delta^{18}O$	6	-14.88	-13.17	-14.47	-14.21	0.64
South Egan Range	δD	8	-111.4	-103.4	-106.6	-106.9	3.3
South Egan Range	$\delta^{18}O$	8	-15.04	-13.32	-14.21	-14.15	0.70
Dry Lake Valley							
South Schell Creek Range	δD	1	-100.9	-100.9	-100.9	-100.9	NA
South Schell Creek Range	$\delta^{18}O$	1	-13.17	-13.17	-13.17	-13.17	NA
North Pahroc Range	δD	8	-97.3	-90.5	-94.1	-94.3	2.4
North Pahroc Range	$\delta^{18}O$	8	-13.06	-11.76	-12.43	-12.39	0.42
Fairview Range	δD	13	-103.5	-97.4	-98.9	-99.5	2.0
Fairview Range	$\delta^{18}O$	13	-13.60	-12.34	-12.73	-12.88	0.44
Bristol and Highland Ranges	δD	6	-101.2	-95.0	-99.1	-98.9	2.2
Bristol and Highland Ranges	$\delta^{18}O$	6	-13.87	-12.07	-13.36	-13.28	0.66
Chief Range	δD	9	-98.9	-88.2	-95.0	-94.6	3.9
Chief Range	$\delta^{18}O$	9	-12.98	-11.69	-12.32	-12.36	0.52
Delamar Valley							
Delamar Range	δD	17	-98.9	-87.0	-91.8	-92.4	4.2
Delamar Range	$\delta^{18}O$	17	-12.98	-11.46	-12.47	-12.32	0.49
South Pahroc Range	δD	8	-97.4	-92.6	-94.2	-94.6	1.8
South Pahroc Range	$\delta^{18}O$	8	-13.24	-12.30	-12.84	-12.81	0.35



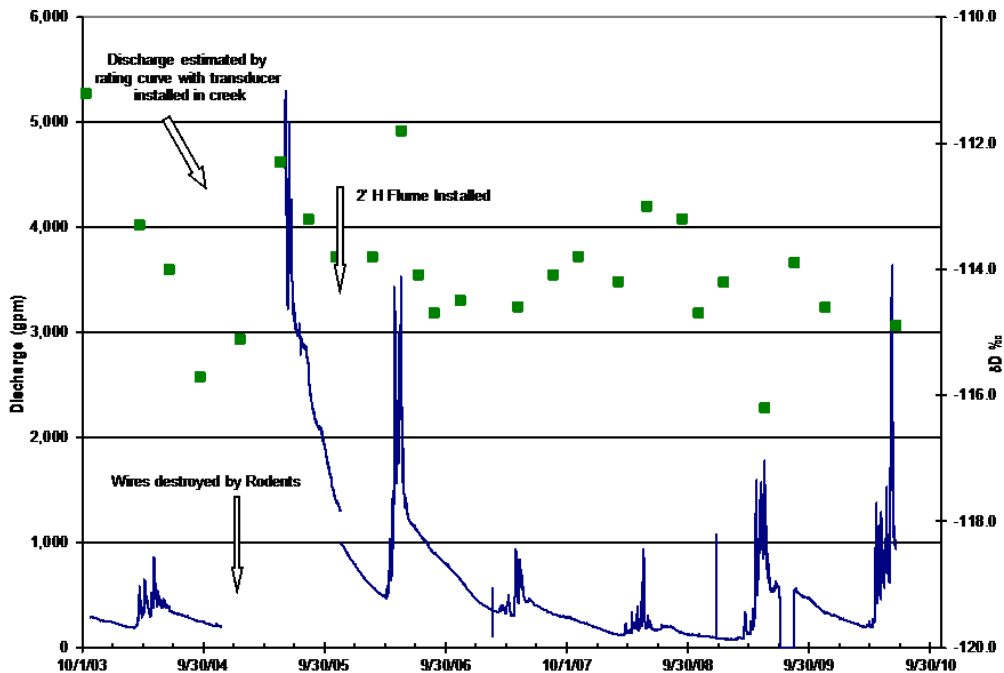


Figure 2. Deuterium and flow data for Monitoring Spring WR1 in the White Pine Range in northwestern White River Valley. Green squares are the deuterium data, which have an analytical uncertainty of $\pm 1.0\%$. Blue line is spring flow. The high spring flows in the spring of 2005 are estimated from a rating curve developed from continuous stream-height data and flow measurements (flow exceeded the flume capacity).

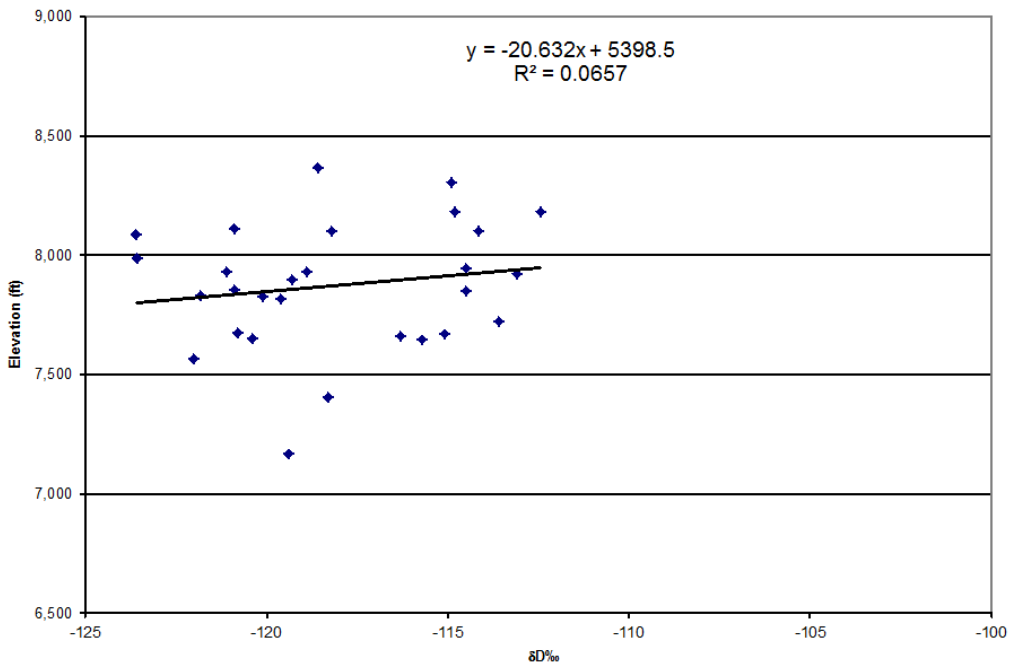


Figure 5. Deuterium as a function of altitude in the White Pine Range. δD data have an analytical uncertainty of ± 1.0 ‰.

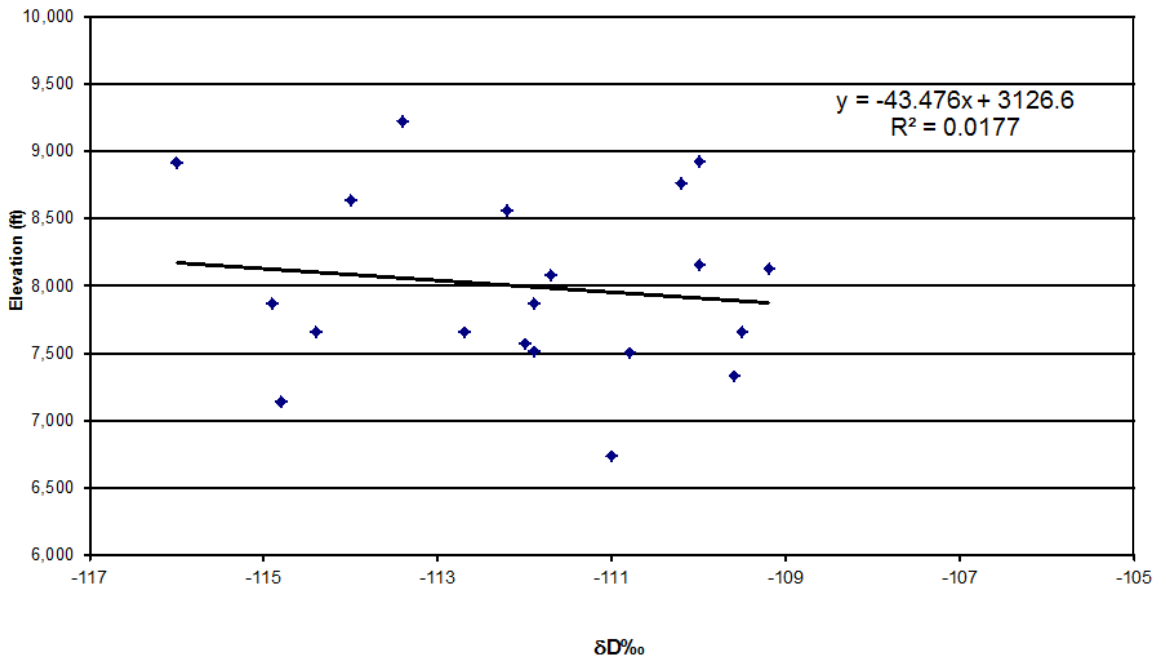


Figure 6. Deuterium as a function of altitude in the Central Egan Range. δD data have an analytical uncertainty of ± 1.0 ‰.

Table 2. Spatial variability of δD and $\delta^{18}O$ in mountain block recharge areas of the DDC area. Values are reported in permil. NA: not applicable.

Site Name		Number of Samples	Minimum	Maximum	Median	Mean	Standard Deviation
Cave Valley							
South Schell Creek Range	δD	6	-109.5	-99.5	-106.2	-105.0	4.0
South Schell Creek Range	$\delta^{18}O$	6	-14.88	-13.17	-14.47	-14.21	0.64
South Egan Range	δD	8	-111.4	-103.4	-106.6	-106.9	3.3
South Egan Range	$\delta^{18}O$	8	-15.04	-13.32	-14.21	-14.15	0.70
Dry Lake Valley							
South Schell Creek Range	δD	1	-100.9	-100.9	-100.9	-100.9	NA
South Schell Creek Range	$\delta^{18}O$	1	-13.17	-13.17	-13.17	-13.17	NA
North Pahroc Range	δD	8	-97.3	-90.5	-94.1	-94.3	2.4
North Pahroc Range	$\delta^{18}O$	8	-13.06	-11.76	-12.43	-12.39	0.42
Fairview Range	δD	13	-103.5	-97.4	-98.9	-99.5	2.0
Fairview Range	$\delta^{18}O$	13	-13.60	-12.34	-12.73	-12.88	0.44
Bristol and Highland Ranges	δD	6	-101.2	-95.0	-99.1	-98.9	2.2
Bristol and Highland Ranges	$\delta^{18}O$	6	-13.87	-12.07	-13.36	-13.28	0.66
Chief Range	δD	9	-98.9	-88.2	-95.0	-94.6	3.9
Chief Range	$\delta^{18}O$	9	-12.98	-11.69	-12.32	-12.36	0.52
Delamar Valley							
Delamar Range	δD	17	-98.9	-87.0	-91.8	-92.4	4.2
Delamar Range	$\delta^{18}O$	17	-12.98	-11.46	-12.47	-12.32	0.49
South Pahroc Range	δD	8	-97.4	-92.6	-94.2	-94.6	1.8
South Pahroc Range	$\delta^{18}O$	8	-13.24	-12.30	-12.84	-12.81	0.35

Plot of deuterium versus oxygen-18 for recharge areas in Delamar, Dry Lake, and Cave Valleys

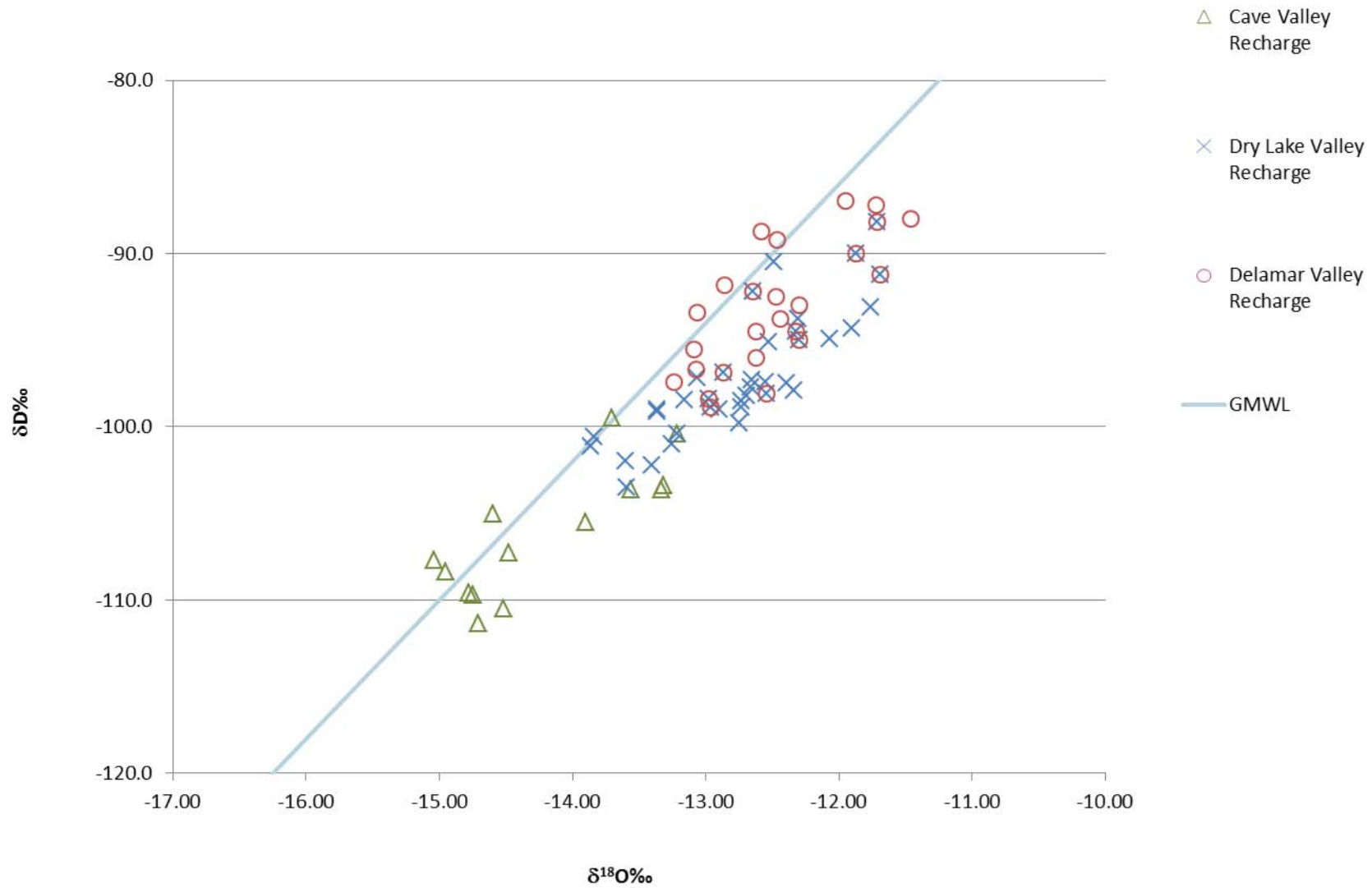


Table 4. DDC area average isotopic values for mountain block recharge areas, valley groundwaters, and inflows and outflows to the valleys; and estimated recharge and evapotranspiration (ET) average annual rates, and outflow and inflow rates to valleys. δD and $\delta^{18}O$ values are in permil and recharge and ET values are in acre-feet per year. Recharge and ET values are from Burns and Drici (2011).

Site Name	δD	$\delta^{18}O$	Recharge/ET
Cave Valley			
South Schell Creek Range	-105.0	-14.21	6,800
South Egan Range	-106.9	-14.15	6,900
Recharge to Cave Valley	-105.9	-14.18	13,700
ET from Cave Valley	-105.9	-14.18	1,300
Flow out of Cave Valley to southeastern White River Valley and northeastern Pahroc Valley	-105.9	-14.18	12,400
Dry Lake Valley			
South Schell Creek Range	-100.9	-13.17	2,200
North Pahroc Range	-94.3	-12.39	1,000
Fairview Range	-99.5	-12.88	3,700
Bristol and Highland Ranges	-98.9	-13.28	7,600
Chief and Burnt Spgs Ranges	-94.6	-12.36	1,800
Recharge to Dry Lake Valley	-98.6	-13.02	16,300
Inflow to Dry Lake Valley from NE Pahroc Valley	-105.9	-14.18	2,000
ET from Dry Lake Valley			0
Flow out of Dry Lake Valley to Delamar Valley	-99.4	-13.15	18,300
Delamar Valley			
Delamar Range	-92.4	-12.32	5,600
South Pahroc Range	-94.6	-12.81	1,000
Recharge to Delamar Valley	-92.8	-12.39	6,600
Inflow to Delamar Valley	-99.4	-13.15	18,300
ET from Delamar Valley			0
Flow out of Delamar Valley to Coyote Springs Valley	-97.6	-12.95	24,900

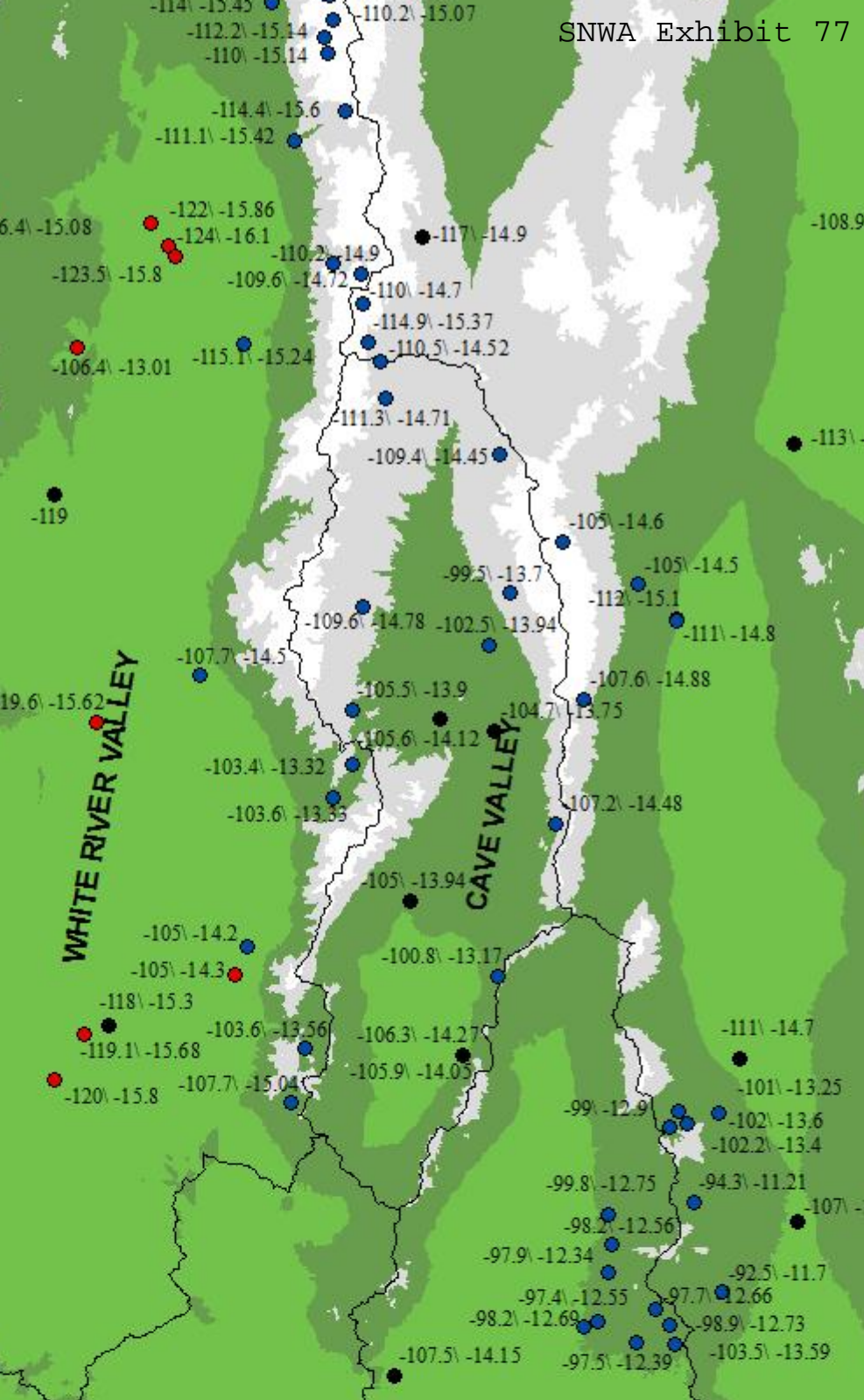


Table 4. DDC area average isotopic values for mountain block recharge areas, valley groundwaters, and inflows and outflows to the valleys; and estimated recharge and evapotranspiration (ET) average annual rates, and outflow and inflow rates to valleys. δD and $\delta^{18}O$ values are in permil and recharge and ET values are in acre-feet per year. Recharge and ET values are from Burns and Drici (2011).

Site Name	δD	$\delta^{18}O$	Recharge/ET
Cave Valley			
South Schell Creek Range	-105.0	-14.21	6,800
South Egan Range	-106.9	-14.15	6,900
Recharge to Cave Valley	-105.9	-14.18	13,700
ET from Cave Valley	-105.9	-14.18	1,300
Flow out of Cave Valley to southeastern White River Valley and northeastern Pahroc Valley	-105.9	-14.18	12,400
Dry Lake Valley			
South Schell Creek Range	-100.9	-13.17	2,200
North Pahroc Range	-94.3	-12.39	1,000
Fairview Range	-99.5	-12.88	3,700
Bristol and Highland Ranges	-98.9	-13.28	7,600
Chief and Burnt Spgs Ranges	-94.6	-12.36	1,800
Recharge to Dry Lake Valley	-98.6	-13.02	16,300
Inflow to Dry Lake Valley from NE Pahroc Valley	-105.9	-14.18	2,000
ET from Dry Lake Valley			0
Flow out of Dry Lake Valley to Delamar Valley	-99.4	-13.15	18,300
Delamar Valley			
Delamar Range	-92.4	-12.32	5,600
South Pahroc Range	-94.6	-12.81	1,000
Recharge to Delamar Valley	-92.8	-12.39	6,600
Inflow to Delamar Valley	-99.4	-13.15	18,300
ET from Delamar Valley			0
Flow out of Delamar Valley to Coyote Springs Valley	-97.6	-12.95	24,900

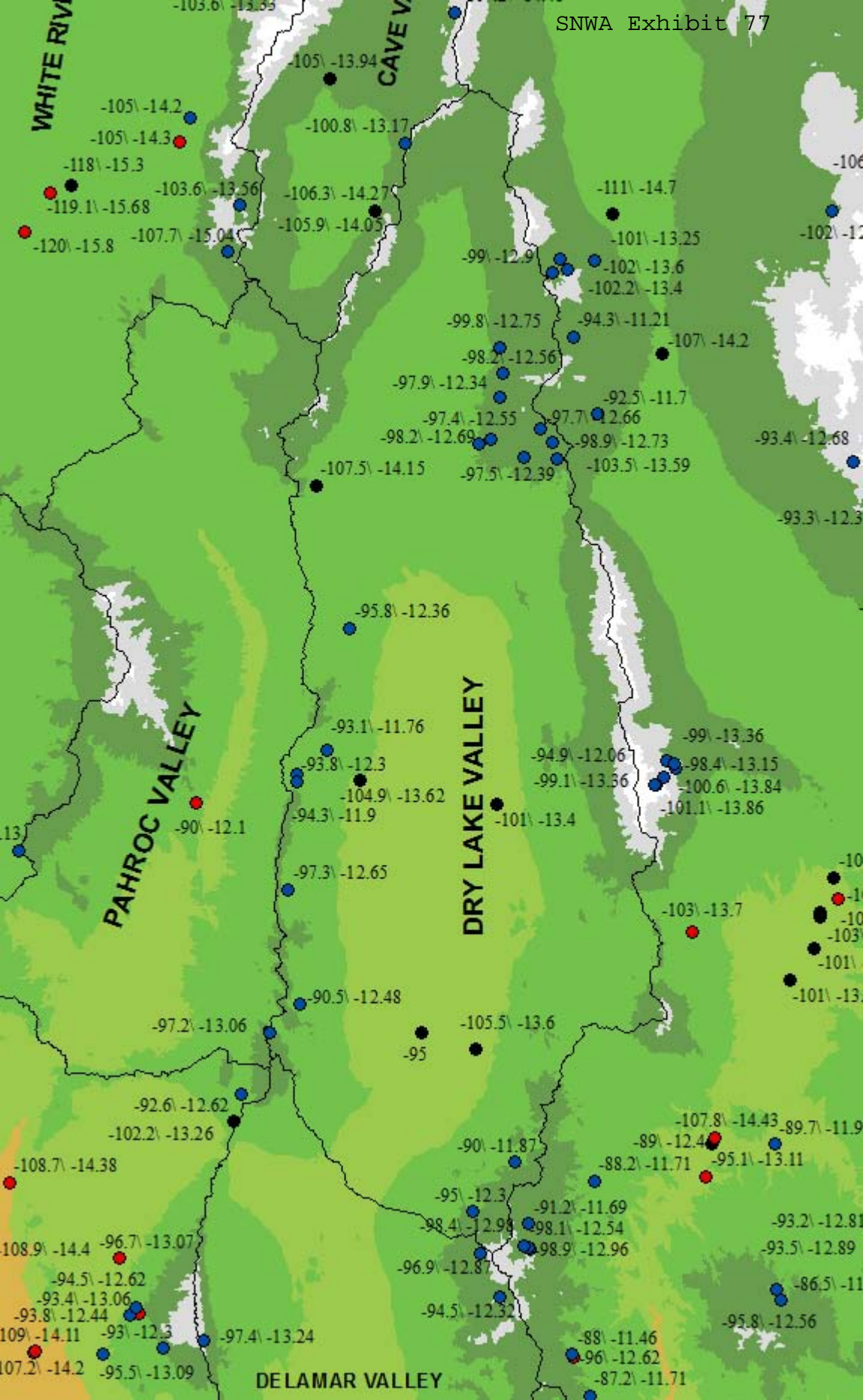
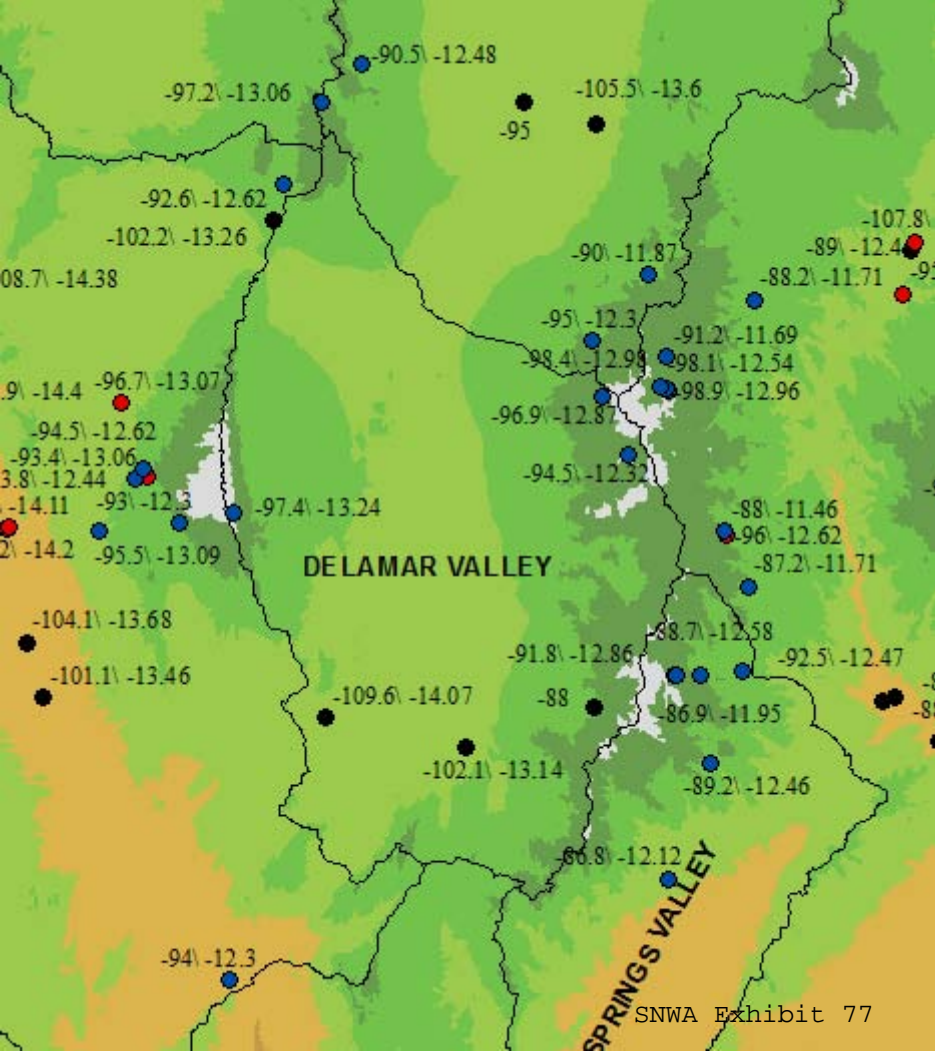
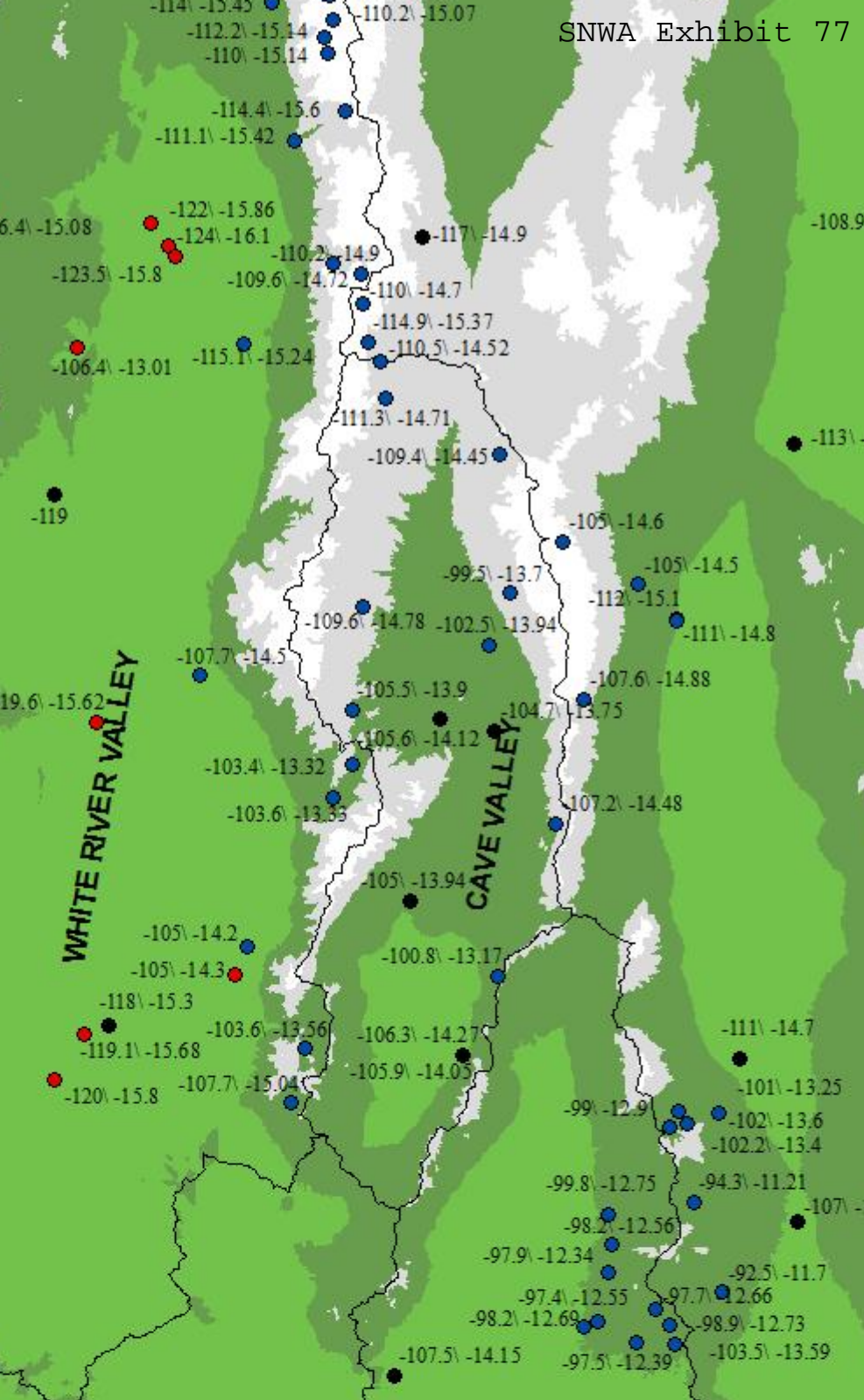
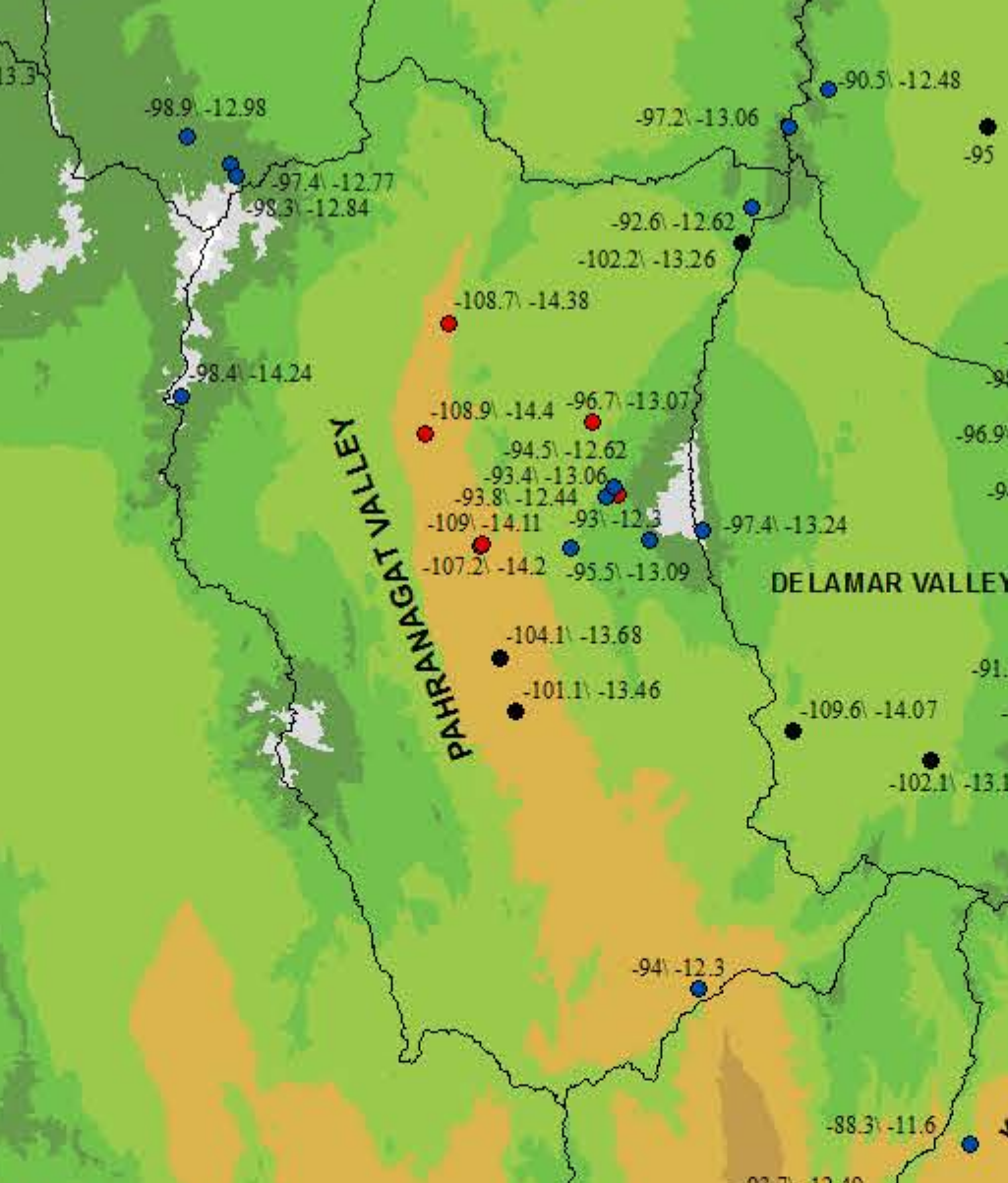


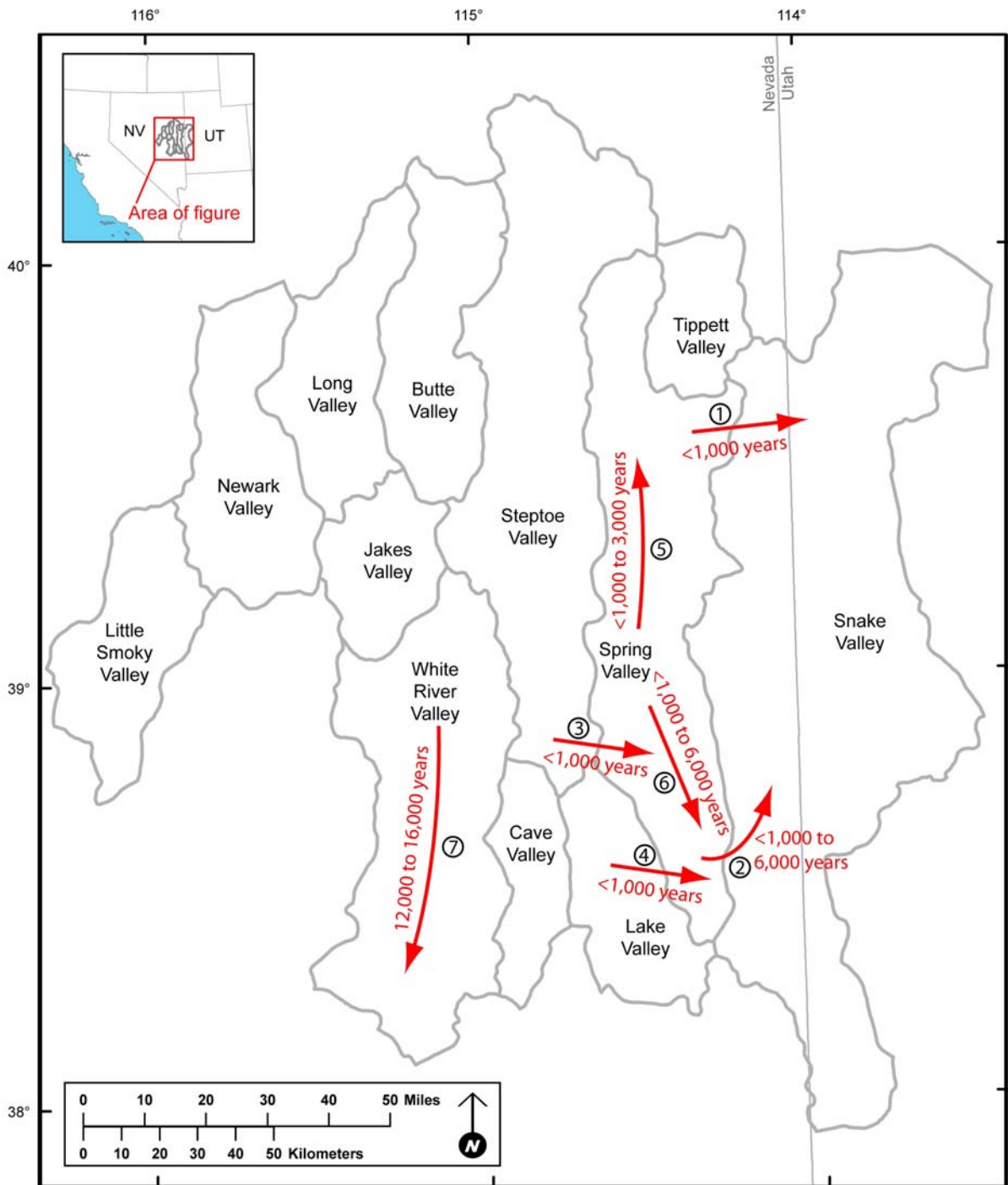
Table 4. DDC area average isotopic values for mountain block recharge areas, valley groundwaters, and inflows and outflows to the valleys; and estimated recharge and evapotranspiration (ET) average annual rates, and outflow and inflow rates to valleys. δD and $\delta^{18}O$ values are in permil and recharge and ET values are in acre-feet per year. Recharge and ET values are from Burns and Drici (2011).

Site Name	δD	$\delta^{18}O$	Recharge/ET
Cave Valley			
South Schell Creek Range	-105.0	-14.21	6,800
South Egan Range	-106.9	-14.15	6,900
Recharge to Cave Valley	-105.9	-14.18	13,700
ET from Cave Valley	-105.9	-14.18	1,300
Flow out of Cave Valley to southeastern White River Valley and northeastern Pahroc Valley	-105.9	-14.18	12,400
Dry Lake Valley			
South Schell Creek Range	-100.9	-13.17	2,200
North Pahroc Range	-94.3	-12.39	1,000
Fairview Range	-99.5	-12.88	3,700
Bristol and Highland Ranges	-98.9	-13.28	7,600
Chief and Burnt Spgs Ranges	-94.6	-12.36	1,800
Recharge to Dry Lake Valley	-98.6	-13.02	16,300
Inflow to Dry Lake Valley from NE Pahroc Valley	-105.9	-14.18	2,000
ET from Dry Lake Valley			0
Flow out of Dry Lake Valley to Delamar Valley	-99.4	-13.15	18,300
Delamar Valley			
Delamar Range	-92.4	-12.32	5,600
South Pahroc Range	-94.6	-12.81	1,000
Recharge to Delamar Valley	-92.8	-12.39	6,600
Inflow to Delamar Valley	-99.4	-13.15	18,300
ET from Delamar Valley			0
Flow out of Delamar Valley to Coyote Springs Valley	-97.6	-12.95	24,900









Legend

- ① Flowpath number
- <1,000 years** Flowpath and dissolved inorganic carbon ¹⁴C ground-water travel time

Figure 34. Dissolved inorganic carbon ¹⁴C ground-water travel times for the BARCAS study area.

