RGDSS Memorandum

Phase 6 - Stream Inflow, Rim Inflow, and Rim Recharge Estimates

Final

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1. Introduction

This memorandum documents the implementation of estimates for stream inflow, rim inflow, and rim recharge as part of Phase 6 of the Rio Grande Decision Support System (RGDSS) Groundwater Model (Model) as defined by Model Version 6P98.

The Model explicitly represents 30 streams and simulates their flows and interactions with the groundwater system. The stream inflow into the Model domain from the major streams is well understood because of numerous streamflow gages around the San Luis Valley (Valley). In addition, inflows from 35 minor stream drainage basins around the perimeter, or "rim" of the Valley, are incorporated into the Model as "rim inflow." The amount and timing of water entering the Valley as rim inflow is not gaged and therefore must be estimated. The rim inflow that enters the Model domain may be diverted for use and the remaining flow then recharges the groundwater aquifer system as "rim recharge." Rim recharge is defined herein as infiltration to the groundwater system from those streams not explicitly simulated in the Model.

The objective of this memo is to document the methodologies used in Phase 6 to compile and estimate information for stream inflow, rim inflow and rim recharge. The tasks completed are as follows:

1. *Estimate stream inflows for streams explicitly represented in the Model.*
2. *Estimate Rim Inflows at the Model's boundary.*
3. *Estimate Rim Recharge to the Model.*

2. Previous Efforts

Rim inflows to the Valley were previously estimated during two separate efforts. In the early 1970s, flows emanating from approximately 24 ungaged drainage areas around the perimeter of the Valley were estimated by the U.S. Geological Survey (USGS) for the period 1924 to 1969 (Emery, 1973). The second effort was conducted in the early 1990s, where the State took and expanded upon the USGS effort to estimate rim inflows over the period 1970 to 1982, and included a more detailed delineation of contributing drainage basins (HRS, 1999). Both of these efforts used standard hydrologic techniques that estimate flows in ungaged basins based on flows in gaged basins and proportioning flows by considering contributing drainage area and basin elevation differences.

Further investigations as part of the RGDSS led to the installation of eleven new stream gages in order to provide additional stream inflow data, see **Table 1** below. Note that two of these gages (identified with an * after their ID) have historical data but had been abandoned for a number of years before being re-equipped through the RGDSS efforts.

Table 1
RGDSS Stream Flow Gaging Stations

1. CHECRECO	Wild Cherry Creek near Crestone, CO
2. 08229500 *	Cottonwood Creek near Crestone, CO
3. 08226700 *	Cotton Creek near Mineral Hot Springs, CO
4. DEDCRECO	Deadman Creek near Crestone, CO
5. GARVILCO	Garner Creek near Villa Grove, CO
6. MAJVILCO	Major Creek near Villa Grove, CO
7. RITCRECO	Rito Alto Creek near Crestone, CO
8. SANCRECO	San Isabel Creek near Crestone, CO
9. SOUCRECO	South Crestone Creek near Crestone, CO
10. SPACRECO	Spanish Creek near Crestone, CO
11. WILCRECO	Willow Creek near Crestone, CO

* Indicates historical data exists

The additional gage data and the extension of the study period through 2002 in Phase 4 warranted a re-evaluation of rim inflows, which lead to the development of new estimates of rim inflow and rim recharge (RGDSS Task 8.9, 2004). <u>The methods developed and implemented in Phase 4 have continued to be used in subsequent Model updates and are currently in use within the Phase 6 Model. Descriptions of these methods and implementation within the Phase 6 Model are described below.</u>

Further refinements were completed in Phase 5. Twenty-one streams that had not been simulated or were incorporated into the rim inflow estimates were explicitly included in the stream inflows to allow the Model to simulate stream depletions on these streams. Further, one stream (08240500 – Trinchera Creek Abv Turners Ranch) was removed from the stream inflow list because it represented a flow that is outside the Model domain and is fully regulated by Mountain Home Reservoir, also outside of the Model domain. The deliveries from Mountain Home Reservoir are to canals for irrigation purposes that were already correctly incorporated within the Model.

3. Approach

Throughout this discussion please refer to the attached figures:

- **Figure 1** presents the rim inflow areas and their associated rim recharge areas. The rim inflow areas represent the drainage areas that are within Division 3 and fall outside of the drainage areas of explicitly modeled streams. The rim recharge areas extend from the Model boundary up to two miles inside the Model domain and are the regions where the estimated rim inflows recharge the groundwater system.
- **Figure 2** presents the entire watershed of Division 3 showing the drainage areas of stream inflow (Model Basins) and rim inflow (Rim Inflow Areas), and the rim recharge regions (Rim Recharge Areas). It can be seen from **Figure 2** that the entirety of the Division 3 drainage area outside of the Model domain boundary has been considered in estimating flows into the Model domain.

3.1. <u>Stream Inflow Estimates for Streams Explicitly Represented in the Model</u>

The Model explicitly represents 30 streams as shown in **Table 2**. Each of these streams is represented in the Model as beginning at a defined point at the Model boundary or within the Model domain. Interactions between these streams and the underlying groundwater aquifer are simulated using the stream package available in the MODFLOW groundwater modeling software.

Stream inflows are simulated as the flows in the explicitly modeled streams that enter the Model domain at the highest point of the simulated stream (usually at the Model boundary). Data necessary for representing these streams in the Model accurately include: streamflow, location of streamflow relative to the Model domain boundary, additional ungaged streamflow that enters the stream system below a gaged location, and diversions that occur between the streamflow location and the starting point of the simulated stream. Depending on the relative location of a stream gage to the Model domain boundary, four general conditions exist and are discussed below. Details about the process to estimate the flow conditions at the stream's starting point in the Model are described below:

Type 1. Stream gage located **<u>at</u>** the Model boundary. Gaged data are directly used for the stream inflow estimates. Data processing is only required for filling missing data.

Type 2. Stream gage located **<u>inside</u>** the Model boundary. Gage data are used for the stream inflow estimates and adjusted by adding diversions that occur above the gage up to the Model boundary. The additional drainage area between the gage and the boundary is accounted for in the gage data and adjustment is not made to add or subtract flow based on this area. Without a gain/loss study it is unknown if the stream is a gaining or losing stream between the Model boundary and the gage, which in most cases have not been completed, therefore no gain/loss adjustment is made.

Type 3. Stream gage located **<u>outside</u>** the Model boundary. The drainage area between the gage and the boundary must be accounted for as contributing to the modeled stream flow. The estimation of flow from the ungaged area is conducted by calculating the ratio of drainage area that is below the gage and the average precipitation for that region, to the drainage area above the gage and the average precipitation for this second region; see Equation 1 below in Section 3.2. The modeled stream flow at the boundary is equal to the gaged flow plus additional flow from the ungaged area. Any diversions between the gage and the Model boundary are subtracted from the modeled stream flow to estimate the stream inflow at the boundary.

Type 4. **<u>No flow</u>** gage. These streams start either inside the Model domain or at the boundary. No gage is needed for estimating flows for this type of stream as the flow is estimated to be zero. There is one stream that starts within the Model domain which is a segment of Trinchera Creek that is above Smith Reservoir, which can be represented as having no flow at its starting point and allowed to be simulated to pick up returnflows from irrigation and.

Further refinements were completed in Phase 6, which removed Major Creek and Garner Creek from the explicitly modeled stream list. These streams were removed because of the close proximity of the stream gages to the Model boundary and that these streams are completely diverted at a location just below the gage creating an insignificant active stream segment within the Model domain. Major and Garner Creek have been reincorporated to the rim inflow and rim recharge packages. Werner Arroyo has been modified to be simulated as part of the Saguache Creek system. Records for Werner Arroyo were set to be historical records kept by the Water District 26 Water Commissioner. Furthermore, Werner Arroyo is represented as a diversion from Saguache Creek and water is routed to the stream segment.

Table 2
Streams Explicitly Represented in the Model

No.	Name of Stream	Gage ID	Relative Location to Model Boundary	Diversion Adjustment	Drainage Area Adjustment
1.	Rio Grande*^	08220000	Outside	Yes, subtract	Yes
2.	Rock Creek	08223500	Outside	Yes, subtract	Yes
3.	San Luis Creek	08224110	Inside	No	No
4.	Kerber Creek*	08224500	Outside	Yes, subtract	Yes
5.	Cotton Creek	08226700	Outside	No	Yes
6.	Saguache Creek	08227000	Outside	Yes, subtract	Yes
7.	North Crestone Creek	08227500	Outside	No	Yes
8.	Cottonwood Creek	08229500	At boundary	No	No
9.	Carnero Creek	08230500	Outside	Yes, subtract	Yes
10.	La Garita Creek	08231000	Outside	Yes, subtract	Yes
11.	Alamosa River	08236500	Outside	Yes, subtract	Yes
12.	La Jara Creek	08238000	Outside	Yes, subtract	Yes
13.	Sangre de Cristo Creek	08241500	Inside	Yes, add	No
14.	Ute Creek	08242500	Inside	Yes, add	No
15.	Conejos River	08246500	At boundary	No	No
16.	San Antonio River	08247500	Outside	No	Yes
17.	Los Pinos River	08248000	Outside	Yes, subtract	Yes
18.	Culebra Creek*^	08250000	Inside	Yes, subtract and add	Yes
19.	Costilla Creek	08261000	Outside	No	Yes
20.	Wild Cherry Creek	CHECRECO	Outside	No	Yes
21.	Deadman Creek*	DEDCRECO	Inside	No	No
22.	Medano Creek^	MEDSANCO	Inside	No	Yes
23.	Rito Alto Creek	RITCRECO	Outside	No	Yes
24.	San Isabel Creek*	SANCRECO	Inside	No	Yes
25.	Sand Creek	SANDUNCO	Inside	No	No
26.	South Crestone Creek	SOUCRECO	Inside	Yes, add	No
27.	Spanish Creek	SPACRECO	At boundary	No	No
28.	Trinchera Creek**	No flow	Inside	No	No
29.	Willow Creek	WILCRECO	Inside	No	No
30.	Zapata Creek^	Estimate	Estimated at boundary	---	---

* Add to gage flow from other streams or tributaries or drainage area or subtract diversions from tributaries
** Internal stream with starting flow = 0
^ Complex modeling estimates

There are stream inflow locations that require additional consideration in calculating the flow at the Model boundary. For these stream inflow locations, please refer to the command files that calculate the stream inflow for the details on how the basins and diversions were considered.

3.2. Rim Inflow Estimates at the Model's Boundary

Rim inflows were estimated using a common hydrologic technique that utilizes known gaged flow data from one basin (reference gage) to estimate unknown ungaged flow data for another basin (ungaged) using area and precipitation data. The relationship used to estimate flows in ungaged basins is as follows:

$$Q_{(ungaged)} = Q_{(ref)} * [(A_{(ungaged)} * P_{(ungaged)}) / (A_{(ref)} * P_{(ref)})] \qquad \text{Equation 1}$$

Where:

Q = Stream flow in units of acre-feet per month
A = Drainage area in units of square miles
P = Precipitation in units of inches per year

To evaluate an ungaged basin, a representative reference gage is chosen based on location, length of gage record, and similar drainage basin size; and then the drainage basin area and average annual precipitation for both the ungaged and gaged basins are determined. The assumptions within the estimates are that the flows, depletions, and timing of flows at the ungaged location are proportional to the observations at the gaged location. Rim inflow basins are assumed to contribute flow to the Valley floor and represent drainages around the perimeter of the Valley in the Model, see **Figure 1**.

In Phase 6, the active Model domain was refined and there were changes to which streams are explicitely represented. These refinements required that the rim inflow basins along with corresponding recharge areas were re-delineated and are shown on **Figure 1** and discussed below. The analysis described herein utilized the geographic boundary of the Model and GIS data developed as part of RGDSS. As shown on **Figure 1**, delineation of the rim inflow basins were based on geographic elevation contours that contribute to corresponding recharge areas. The drainage area of each rim inflow basins were calculated using GIS. Weighted average precipitation for each rim inflow basin was determined using isohyetal precipitation maps for Colorado Water Division 3 and for northern New Mexico.

The final step in estimating rim inflows is to select a reference gage. Ideally, the ungaged basin of interest should have physical characteristics (elevation, size, slope, aspect) similar to the selected reference gage. Further, in selecting the reference gage it is preferred that the gage have a long historical record so as to not introduce additional error by filling missing gaged data for the reference gage. Utilizing the previously mentioned criteria, reference gages were selected for each of the ungaged rim inflow basins as shown in **Table 3**, which also provides drainage area and precipitation of ungaged basins as well as the corresponding reference gages used in the estimates. Rim inflow in Phase 6 was processed using TSTool. One of the advantages of using the TSTool is that TSTool command files list all data processing procedures which provide additional documentation regarding data sources and methodologies. The estimates of rim inflows over the period 1950 – 2010 are presented in the result section below.

Table 3
Summary of Characteristics Used to Estimate Ungaged Rim Inflows

Recharge Zone	Basin Name	Precipitation	Basin Area	Reference Gage				Factor[&]
				Gage	Gage ID	Precip.	Area	to
		inches	acres	Creek Name		inches	acres	Gage
Biedell	Biedell	13.60	18914.9	Carnero	08230500	22.10	67979.6	0.1712
Cottonwood_A	Cottonwood_A	22.80	436.3	North Crestone	08227500	28.70	8233.5	0.0421
Cottonwood_B	Cottonwood_B	20.20	940.5	North Crestone	08227500	28.70	8233.5	0.0804
Cottonwood_C	Cottonwood_C	21.50	738.3	North Crestone	08227500	28.70	8233.5	0.0672
Cottonwood_D	Cottonwood_D	20.10	2086.7	North Crestone	08227500	28.70	8233.5	0.1775
Cove_Lake***	Cove_Lake	14.00	32428.9	San Antonio	08247500	30.30	102159	0.1467
CulebraCr***	CulebraCr	24.50	121211.6	Culebra nr Chama	08249400	28.10	43156.2	2.4488
GatoCr	GatoCr	20.00	27689.8	Pinos	08220500	28.30	44277.5	0.4420
LaGarita_A	LaGarita_A	11.40	5844.8	La Garita	08231000	23.90	39828.3	0.0700
LaGarita_B	LaGarita_B	13.70	3869.4	La Garita	08231000	23.90	39828.3	0.0557
LaGarita_C	LaGarita_C	11.40	20894.1	La Garita	08231000	23.90	39828.3	0.2502
LaJaraCr	LaJaraCr	11.60	59806.5	La Jara	08238000	22.20	65754.7	0.4753
LSanLuis_A	LSanLuis_A	17.20	1760.1	North Crestone	08227500	28.70	8233.5	0.1281
LSanLuis_B	LSanLuis_B	16.40	296.6	North Crestone	08227500	28.70	8233.5	0.0206
LSanLuis_C	LSanLuis_C	20.60	3181.1	North Crestone	08227500	28.70	8233.5	0.2773
MSanLuis_A	MSanLuis_A	15.30	12673	Saguache	08227000	20.40	346717.6	0.0274
MSanLuis_B	MSanLuis_B	22.40	22564.5	Kerber	08224500	25.00	29108	0.6946
PoleCr	PoleCr	21.30	5527.2	North Crestone	08227500	28.70	8233.5	0.4982
Raton_Cat	Raton_Cat	14.80	52539.5	Pinos	08220500	28.30	44277.5	0.6206
Rito_Hondo	Rito_Hondo	17.50	29659.6	San Antonio	08247500	30.30	102159	0.1677
RockCr	RockCr	14.00	15803.8	Pinos	08220500	28.30	44277.5	0.1766
Saguache_A	Saguache_A	13.20	13665.3	Saguache	08227000	20.40	346717.6	0.0255
Saguache_B	Saguache_B	17.40	22869.6	Saguache	08227000	20.40	346717.6	0.0563
Saguache_C	Saguache_C	16.50	12001.1	Saguache	08227000	20.40	346717.6	0.0280
SanFranCr	SanFranCr	19.30	19986	Pinos	08220500	28.30	44277.5	0.3078
SanIsabel_A	SanIsabel_A	22.90	1459.4	North Crestone	08227500	28.70	8233.5	0.1414
SanIsabel_B	SanIsabel_B	20.30	1163.8	North Crestone	08227500	28.70	8233.5	0.1000
SanJuan	SanJuan	14.40	18574.2	Carnero	08230500	22.10	67979.6	0.1780
TracyCanyon	TracyCanyon	14.50	18419.7	Carnero	08230500	22.10	67979.6	0.1778
Trinchera_A	Trinchera_A	14.80	4246.2	North Crestone	08227500	28.70	8233.5	0.2659
Trinchera_B	Trinchera_B	13.50	21667.9	North Crestone	08227500	28.70	8233.5	1.2379
USanLuis_A	USanLuis_A	17.30	22304.3	Kerber	08224500	25.00	29108	0.5303
USanLuis_B	USanLuis_B	22.00	17497.9	Kerber	08224500	25.00	29108	0.5290
Zapata_A	Zapata_A	19.50	4546	North Crestone	08227500	28.70	8233.5	0.3751
Zapata_B	Zapata_B	22.40	18630.6	North Crestone	08227500	28.70	8233.5	1.7661

[&] Factor = $(Area_{ungaged} \times Precip_{ungaged}) / (Area_{gaged} \times Precip_{gaged})$

*** Based on geology, hydrology, and water use in the drainage CulebraCr and Cove_Lake are set to 0 af/yr for Rim Inflows.

3.3. Rim Recharge Estimates to the Model

Rim recharge into the Model is generally calculated as **rim inflows** less **diversions** of water from within the rim inflow and rim recharge areas. The size and shape of rim recharge areas were refined in Phase 6, as mentioned above:

- Rim recharge areas are the area inside the Model domain between the Model boundary and up to two miles inside the Model domain.
- Rim recharge areas were further refined to not cross impervious structures such as highways or canals that drainages do not cross.
- Further, rim recharge areas were limited to not encroach on explicitly modeled streams by buffering these streams by ¼ mile on either side of the stream.

Rim recharge for a given rim recharge area was determined based on the corresponding rim inflows and historical diversions that divert water from the rim inflow and rim recharge areas. The estimates of rim recharge for the period 1950 – 2010 are presented in results section below.

4. Results

The results of stream inflow estimates are presented in **Table 4,** rim inflow in **Table 5**, rim diversions in **Tables 6**, and rim recharge in **Table 7**.

Table 4
Summary of Estimated Flows in Streams Explicitly Represented in the Model (1950-2010)

No.	Stream Name	Annual Flow (af/yr) Min.	Max.	Average
1	Rio Grande	136,983.17	872,514.83	437,466.49
2	Rock Creek	849.28	7,613.29	3,533.61
3	San Luis Creek	541.95	1,080.28	748.87
4	Kerber Creek	2,555.87	28,885.61	12,385.42
5	Cotton Creek	2,908.80	13,657.21	8,085.06
6	Saguache Creek	16,582.81	87,292.24	43,074.78
7	North Crestone Creek	1,515.56	14,492.26	8,477.19
8	Cottonwood Creek	1,258.29	8,112.85	4,407.85
9	Carnero Creek	227.23	17,907.58	3,691.39
10	La Garita Creek	2,330.16	18,962.47	8,212.49
11	Alamosa River	20,157.80	165,016.93	83,474.04
12	La Jara Creek	4,227.31	46,118.79	15,785.18
13	Sangre de Cristo Creek	4,724.10	43,957.67	19,785.07
14	Ute Creek	2,452.21	34,913.44	14,747.14
15	Conejos River	55,321.80	376,234.24	216,924.70
16	San Antonio River	1,816.46	45,915.27	17,902.15
17	Los Pinos River	7,394.26	164,390.34	72,534.48
18	Culebra Creek	13,339.63	49,458.57	30,158.51
19	Costilla Creek	471.97	28,480.08	6,785.96
20	Wild Cherry Creek	350.59	3,852.54	2,253.95
21	Deadman Creek	235.84	6,682.58	3,899.94
22	Medano Creek	1,206.45	17,510.28	8,553.46
23	Rito Alto Creek	2,135.57	15,673.52	8,722.83
24	San Isabel Creek	1,455.63	9,603.89	5,769.97
25	Sand Creek	1,005.48	20,113.06	11,222.38
26	South Crestone Creek	462.42	4,055.64	1,972.05
27	Spanish Creek	533.40	3,423.21	1,903.38
28	Trinchera Creek	0.00	0.00	0.00
29	Willow Creek	1,154.43	7,493.91	4,051.70
30	Zapata Creek	626.78	12,784.78	6,103.18
	Average Total			1,062,633.22

Table 5
Summary of Estimated Rim Inflows (1950-2010)

No.	Basin Name	Annual Flow (af/yr) Min.	Max.	Average
1	Biedell	301.85	3,957.88	1,257.49
2	Cottonwood_A	63.55	607.69	355.47
3	Cottonwood_B	121.37	1,160.54	678.85
4	Cottonwood_C	101.44	970.00	567.40
5	Cottonwood_D	267.94	2,562.13	1,498.71
6	Cove_Lake	0.00	0.00	0.00
7	CulebraCr	0.00	0.00	0.00
8	GatoCr	2,048.78	17,002.94	7,994.94
9	LaGarita_A	162.28	1,408.97	608.96
10	LaGarita_B	129.13	1,121.14	484.56
11	LaGarita_C	580.05	5,036.07	2,176.59
12	LaJaraCr	1,719.18	14,317.19	5,505.45
13	LSanLuis_A	193.37	1,849.06	1,081.60
14	LSanLuis_B	31.10	297.35	173.93
15	LSanLuis_C	418.59	4,002.69	2,341.36
16	MSanLuis_A	447.92	2,367.12	1,169.03
17	MSanLuis_B	1,126.74	13,091.97	5,736.01
18	PoleCr	752.04	7,191.28	4,206.51
19	Raton_Cat	2,876.63	23,873.36	11,225.48
20	Rito_Hondo	297.86	7,529.08	2,935.55
21	RockCr	818.58	6,793.48	3,194.36
22	Saguache_A	416.86	2,202.98	1,087.96
23	Saguache_B	920.36	4,863.83	2,402.05
24	Saguache_C	457.73	2,418.96	1,194.63
25	SanFranCr	1,426.73	11,840.51	5,567.52
26	SanIsabel_A	213.45	2,041.04	1,193.90
27	SanIsabel_B	150.95	1,443.45	844.34
28	SanJuan	313.84	4,115.09	1,307.44
29	TracyCanyon	313.49	4,110.47	1,305.97
30	Trinchera_A	401.38	3,838.14	2,245.10
31	Trinchera_B	1,868.64	17,868.50	10,452.10
32	USanLuis_A	860.22	9,995.21	4,379.22
33	USanLuis_B	858.12	9,970.70	4,368.48
34	Zapata_A	566.22	5,414.39	3,167.12
35	Zapata_B	2,665.97	25,492.81	14,911.91
	Average Total			107,619.99

Table 6
Summary of Estimated Rim Diversions (1950-2010)

No.	Basin Name	Annual Flow (af/yr) Min.	Max.	Average
1	Biedell	480.79	7,073.74	1,822.71
2	Cottonwood_A	0.00	0.00	0.00
3	Cottonwood_B	0.00	0.00	0.00
4	Cottonwood_C	0.00	0.00	0.00
5	Cottonwood_D	0.00	0.00	0.00
6	Cove_Lake	0.00	0.00	0.00
7	CulebraCr	0.00	0.00	0.00
8	GatoCr	0.00	0.00	0.00
9	LaGarita_A	53.56	4,901.41	1,787.16
10	LaGarita_B	0.00	0.00	0.00
11	LaGarita_C	0.00	0.00	0.00
12	LaJaraCr	5.50	7,260.26	1,504.46
13	LSanLuis_A	0.00	0.00	0.00
14	LSanLuis_B	0.00	0.00	0.00
15	LSanLuis_C	0.00	240.57	56.40
16	MSanLuis_A	0.00	0.00	0.00
17	MSanLuis_B	808.17	3,234.39	1,979.53
18	PoleCr	0.00	0.00	0.00
19	Raton_Cat	595.64	3,384.01	1,495.17
20	Rito_Hondo	0.00	1,315.06	212.21
21	RockCr	0.00	2,374.48	519.39
22	Saguache_A	0.00	0.00	0.00
23	Saguache_B	0.00	688.00	139.59
24	Saguache_C	0.00	1,865.34	411.18
25	SanFranCr	124.96	3,458.63	1,472.68
26	SanIsabel_A	0.00	0.00	0.00
27	SanIsabel_B	0.00	0.00	0.00
28	SanJuan	0.00	436.36	109.53
29	TracyCanyon	0.00	1,283.33	594.03
30	Trinchera_A	0.00	0.00	0.00
31	Trinchera_B	0.00	656.55	174.31
32	USanLuis_A	33.10	3,935.31	1,671.14
33	USanLuis_B	1,051.81	4,503.92	2,747.16
34	Zapata_A	0.00	0.00	0.00
35	Zapata_B	363.29	8,047.77	2,212.17
	Average Total			18,908.82

Table 7
Summary of Estimated Rim Recharge in the Model (1950-2010)

No.	Basin Name	Annual Flow (af/yr)		
		Min.	Max.	Average
1	Biedell	0.00	1,061.30	215.12
2	Cottonwood_A	63.50	607.60	355.47
3	Cottonwood_B	121.10	1,160.60	678.84
4	Cottonwood_C	101.50	970.10	567.40
5	Cottonwood_D	268.10	2,562.30	1,498.71
6	Cove_Lake	0.00	0.00	0.00
7	CulebraCr	0.00	0.00	0.00
8	GatoCr	2,048.70	17,002.90	7,994.94
9	LaGarita_A	27.90	229.60	80.92
10	LaGarita_B	129.10	1,121.00	484.57
11	LaGarita_C	580.10	5,036.00	2,176.59
12	LaJaraCr	684.10	14,259.20	4,394.37
13	LSanLuis_A	193.30	1,849.20	1,081.59
14	LSanLuis_B	31.10	297.40	173.91
15	LSanLuis_C	418.50	3,956.80	2,284.94
16	MSanLuis_A	448.10	2,367.10	1,169.06
17	MSanLuis_B	353.30	11,417.60	3,883.64
18	PoleCr	751.80	7,191.20	4,206.50
19	Raton_Cat	2,037.60	21,852.80	9,743.05
20	Rito_Hondo	297.90	6,506.70	2,739.02
21	RockCr	818.60	5,602.20	2,688.19
22	Saguache_A	416.80	2,203.00	1,087.95
23	Saguache_B	534.90	4,798.80	2,265.75
24	Saguache_C	148.00	2,391.50	838.54
25	SanFranCr	1,115.20	9,459.70	4,100.24
26	SanIsabel_A	213.50	2,041.10	1,193.89
27	SanIsabel_B	151.00	1,443.50	844.36
28	SanJuan	313.90	3,935.10	1,197.88
29	TracyCanyon	130.90	3,246.70	786.87
30	Trinchera_A	401.40	3,838.00	2,245.12
31	Trinchera_B	1,868.60	17,399.20	10,277.77
32	USanLuis_A	732.30	7,456.50	2,720.93
33	USanLuis_B	27.50	6,590.70	2,122.64
34	Zapata_A	566.20	5,414.40	3,167.11
35	Zapata_B	2,302.70	22,616.90	12,707.42
	Average Total			91,973.30

5. References

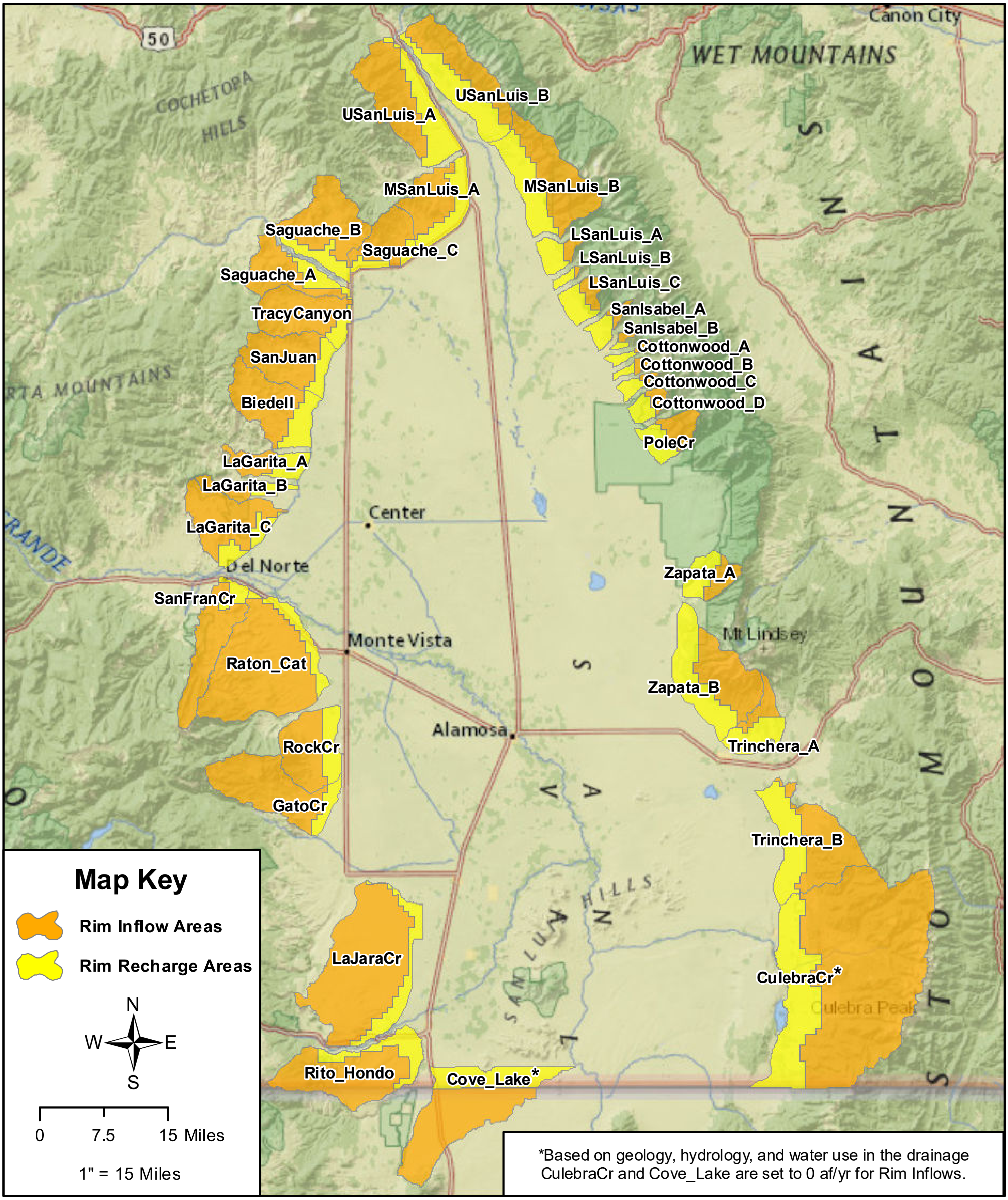
Emery, Philip A., Snipes, Robert J., Dumeyer, John M., and Klein, John M., 1973, Water in the San Luis Valley, South-Central Colorado: Colorado Water Resources Circular 18.

HRS Water Consultants, Inc., Judith Schenk, Jeff Foster, and Eric Harmon, P.E., 1999, RGDSS Ground Water Component Final Report – Task 2: Documentation of the San Luis Valley ground water model, Colorado Division of Water Resources.

RGDSS Memorandum "RGDSS Surface Water, Task 8.9 – Estimate Stream Inflows, Rim Inflows, and Rim Recharge for use in the RGDSS Ground Water Model (4th Update)" by Ed Armbruster, Leonard Rice Engineers, Inc. May 18, 2004.

RGDSS Memorandum "RGDSS Groundwater Model – Phase 6 DWR GIS Data Refinements" by Chris Brown, Colorado Division of Water Resources, 7/17/2012 (see RGDSS Phase 6 Memoradum under the file name of *RGDSS_P6_GIS_Parcels.pdf*, Attachment 1).

Figures



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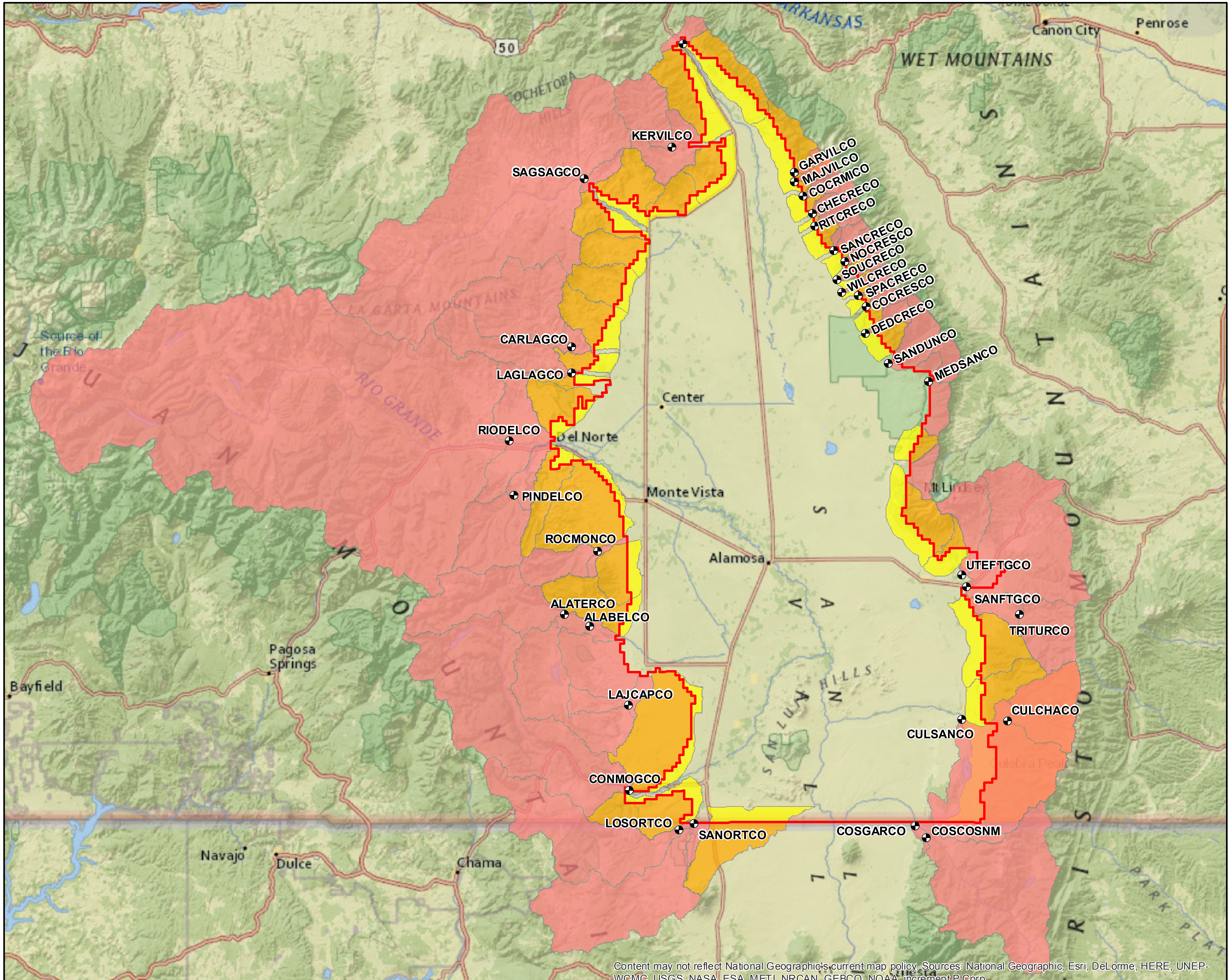
RGDSS Phase 6
Rim Inflow and Rim Recharge Areas

Figure 1

Figure 2
RGDSS Phase 6 Model Gages and Basins



Map Key

- Model Gages
- Model Basins
- Rim Inflow Areas
- Rim Recharge Areas
- Model Boundary

N
W E
S

0 7.5 15 Miles

1" = 15 Miles

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