District Court, Water Division 3, State of Colorado Court Address: 8955 Independence Way, Alamosa, CO 81101 Phone Number: (719) 589-4996	DATE FILED: March 15, 2019 10:14 AM CASE NUMBER: 2015CW3024
IN THE MATTER OF THE RULES GOVERNING THE WITHDRAWAL OF GROUNDWATER IN WATER DIVISION 3 (THE RIO GRANDE BASIN) AND ESTABLISHING CRITERIA FOR THE BEGINNING AND END OF THE IRRIGATION SEASON IN WATER DIVISION NO. 3 FOR ALL IRRIGATION WATER RIGHTS. **IN ALAMOSA, MINERAL, RIO GRANDE, SAGUACHE, HINSDALE, CONEJOS, COSTILLA, SAN JUAN AND ARCHULETA COUNTIES, COLORADO.**	**COURT USE ONLY** Case Number: 2015CW3024 Div.: CJ-1 Ctrm:
FINDINGS OF FACT, CONCLUSIONS OF LAW, JUDGMENT AND DECREE	

Table of Contents

This matter came before the Court on protests to the *Rules Governing the Withdrawal of Groundwater in Water Division No. 3 (The Rio Grande Basin) and Establishing Criteria for the Beginning and End of the Irrigation Season in Water Division No. 3 for all Irrigation Water Rights* ("Rules"). Beginning January 29, 2018, the Court held a 13-day trial on the protests to the Rules. Based on the pleadings and other filings, the evidence presented at trial, and the written legal argument of counsel and self-represented parties, the Court makes the following Findings of Fact and Conclusions of Law and enters the following Judgment and Decree.

I. PROCEDURAL HISTORY, PARTIES, AND STIPULATIONS

1. On September 23, 2015, the State Engineer, acting under sections 37-80-104 and 37-92-501, C.R.S., adopted the Rules and filed them with the Water Clerk, Water Division No. 3. The Court accepted the Rules for filing and assigned this proceeding Case No. 2015CW3024. The Rules are attached as **Appendix A**.

2. Pursuant to section 37-92-501(2)(g), C.R.S., the proposed Rules were published in Alamosa, Archuleta, Conejos, Costilla, Hinsdale, Mineral, Rio Grande, Saguache, and San Juan counties. *Order for Publication* (October 18, 2015). Notice of the Rules was also published in the September 2015 resume for Water Division No. 3. Full and proper notice was provided as required by law. *See Proof of Publication* – Alamosa (October 24, 2015); *Proof of Publication* – Archuleta (October 22, 2015); *Proof of Publication* – Conejos (October 21, 2015); *Proof of Publication* – Costilla (October 22, 2015); *Proof of Publication* – Hinsdale (October 30, 2015); *Proof of Publication* – Mineral (October 22, 2015); *Proof of Publication* – Rio Grande (October 21, 2015); *Proof of Publication* – Saguache (November 5, 2015); and *Proof of Publication* – San Juan (October 22, 2015).

3. Section 37-92-501(3)(a), C.R.S., provides that any person desiring to protest a proposed rule and regulation may do so in the same manner as provided in section 37-92-304, C.R.S., for the protest of a ruling of a referee. Sitting as the Water Judge for Water Division No. 3, this Court has jurisdiction and is designated to hear and dispose of all protests as promptly as possible. Section 37-92-501(3)(a), C.R.S., *see also* 37-92-203(1).

4. The following entities filed statements of opposition in support of the Rules: Rio Grande Water Users Association; Rio Grande Water Conservation District; San Luis Valley Irrigation District; Battle Mountain Resources, Inc.; San Luis Valley Water Conservancy District; and Conejos Water Conservancy District.

5. The following individuals or entities filed statements of opposition protesting the Rules: Northeast Water Users Association; San Luis Valley Confined Aquifer Sustainability Group, Inc.; Groundwater Management Subdistrict of the Trinchera Water Conservancy District; Colin J. and Karen H. Henderson, *pro se;* Richard A. Blumenhein; San Luis Valley Irrigation Well Owners, Inc.; Town of Crestone; Town of Del Norte; Senior Water of the Rio Grande; City of Alamosa; Town of Saguache; City of Monte Vista; Norman Slade; Kelly Sowards, *pro se*; El Codo Ditch Company; Llano Ditch Company; Las Sauces Ditch Company; Chavez Ditch Company; Ryan Fox; Rito Alto and San Luis Ranches, Inc., *pro se*; Thomas and Lillian McCracken, *pro se*; Perry and Renee Hazard, *pro se*; Edwin C. Nielsen, *pro se*; Tim Lovato, *pro se*; Alpha Hay Farms, LLC; Natural Prairie Colorado Farmlands Holdings, LLC; James Warner, *pro se*, and the 2J Ranches Group composed of: 2J Ranches, Inc., Charles E. and Valerie K. Finnegan, Colin J. and Karen H. Henderson, Donald Larsen, Joseph A. Martinez, LeRoy O. and Rosalie M. Martinez, Querina B. Martinez, Edon Ruybal, Dick M. and Georgann M. Smith, and Armando R. and Jessica Q. Valdez (collectively, "Protestors" or the "2J Group").

6. The Court conducted a case management and trial setting conference on February 22, 2016. At the beginning of that conference, Judge Swift disclosed that she and her husband were the owners of surface and groundwater rights in southern Costilla County in the area known as the Costilla Plain. Judge Swift described the specific water rights that she and her husband owned and the sources of those water rights. Judge Swift also stated that because Proposed Rules 6-12 do not apply to the Costilla Plain, she did not think she had a conflict of interest in presiding over this case. Judge Swift asked counsel for the parties and the *pro se* parties present whether anyone thought differently, and no party expressed disagreement with Judge Swift's conclusion that she did not have a conflict of interest and that she could preside over this case.

7. The State Engineer reached stipulations with a majority of the Protestors, as follows:

a. San Luis Valley Confined Aquifer Sustainability Group, Amended Stipulation approved by order dated January 21, 2017.

b. San Luis Valley Irrigation Well Owners, Inc., Amended Stipulation approved by order dated July 18, 2017.

c. Alpha Hay Farms, LLC, approved by order dated July 30, 2017.

d. Thomas and Lillian McCracken, approved by order dated July 30, 2017.

e. Ryan Fox, approved by order dated July 30, 2017.

f. Natural Prairie Colorado Farmlands Holdings, LLC, approved by order dated July 30, 2017.

g. Conejos Water Conservancy District, approved by order dated October 4, 2017.

h. Richard A. Blumenhein, approved by order dated October 22, 2017.

i. Groundwater Management Subdistrict of the Trinchera Water Conservancy District, approved by order dated November 6, 2017.

j. Rito Alto and San Luis Ranches, Inc., approved by order dated November 18, 2017.

k. City of Monte Vista, approved by order dated December 5, 2017.

l. Town of Crestone, approved by order dated December 5, 2017.

m. Town of Del Norte, approved by order dated December 5, 2017.

n. Town of Saguache, approved by order dated December 5, 2017.

o. Northeast Water Users Association, approved by order dated January 9, 2018.

p. Rio Grande Water Conservation District, approved by order dated January 9, 2018.

q. Senior Water of the Rio Grande, approved by order dated January 16, 2018.

r. San Luis Valley Water Conservancy District, approved by order dated January 28, 2018.

s. Battle Mountain Resources, Inc., approved by order dated January 28, 2018.

t. Perry L. Hazard and Renee Hazard, approved by order dated January 28, 2018.

u. El Codo Ditch Company; Llano Ditch Company; Las Sauces Ditch Company; and Chavez Ditch Company ("El Codo Group"), approved by order dated January 28, 2018.

v. City of Alamosa, approved by order dated February 26, 2018.

w. Norman Slade, approved by order dated February 26, 2018.

x. Edwin C. Neilson, approved by order dated February 26, 2018.

8. As set forth below, several stipulations with Protestors acknowledge that refinement of the Rio Grande Decision Support System ("RGDSS") Groundwater Model ("RGDSS Model" or "Model") is an ongoing process in which the State Engineer incorporates reliable new information as it becomes available. Thus, these stipulations set forth agreements for the Protestor and State Engineer to work together going forward to continue gathering information to refine the RGDSS Model and to apply specific rules based on existing information. For instance:

a. In its stipulation with the El Codo Group, the State Engineer agrees to work with the El Codo Group and the RGDSS Peer Review Team to develop the scope and location of additional geologic and hydrologic investigations, including one or more monitoring wells, in the southern portion of the Conejos Response Area, and to determine the best location for a stream gage in the vicinity of the confluence of the

San Antonio and Conejos Rivers, and to incorporate data gathered from these investigations into the Model if appropriate.

b. In its stipulation with Senior Water of the Rio Grande ("Senior Water"), the State Engineer agrees to work with Senior Water and the RGDSS Peer Review Team to address Senior Water's concerns about potential refinements and changes to the RGDSS Model and the stipulation identifies the process through which the State Engineer and Senior Water will do so. The stipulation also sets forth agreements regarding the manner of calculating a well user's Stream Depletions and replacement obligations for purposes of a groundwater management plan, augmentation plan, or substitute water supply plan, as well as the manner in which the State Engineer will interpret and implement Rule 14, entitled "Irrigation Season."

c. In its stipulation with the Conejos Water Conservancy District, the State Engineer agrees to coordinate with the Conejos Water Conservancy District and the RGDSS Peer Review Team to carry out model sensitivity analyses, additional field investigation, and a well-sampling program aimed at verifying the representation of different aquifer layers within the RGDSS Model and assignment of wells to specific aquifer layers within the Model in all Response Areas, each as part of developing future updates to the Model.

d. In its stipulation with the San Luis Valley Confined Aquifer Sustainability Group ("CAS"), the State Engineer acknowledges new information provided by CAS regarding groundwater withdrawals occurring between 1978 and 2000 for the Conejos and Alamosa-La Jara Response Areas that was not available when the State Engineer calculated groundwater withdrawals for the Rules. In recognition of CAS's resulting concern with the Rules' calculations, the State Engineer agrees to work with CAS and the RGDSS Peer Review Team to incorporate the information as appropriate and modify the requirements of the Rules if warranted. Further, based on a mathematical analysis CAS performed and the State Engineer reviewed, the parties agree to a procedure for application of Rules 8.1.6 and 8.1.7 governing the manner for calculating average annual groundwater withdrawals for the Conejos and Alamosa-La Jara Response Areas.

e. In its stipulation with the Rio Grande Water Conservation District, the State Engineer agrees to the same procedure for application of Rules 8.1.6 and 8.1.7 set forth in its stipulation with CAS for the Saguache and San Luis Creek Response Areas.

9. On April 13, 2016, the Court entered a Modified Case Management Order ("MCMO") to govern the parties' preparation for trial.

10. Prior to trial, the Groundwater Management Subdistrict of the Trinchera Water Conservancy District ("Trinchera Subdistrict") and the State Engineer filed motions for

determination of questions of law pursuant to Rule 56(h), the State Engineer also filed a motion to strike one of the 2J Group's witnesses and the 2J Group filed a motion *in limine*.

a. The Trinchera Subdistrict's Rule 56(h) motion sought a determination that a water conservancy district or subdistrict formed under section 37-45-120, C.R.S., possesses authority to develop, submit for approval, and if approved, to implement, a groundwater management plan as defined in section 37-92-501(4), C.R.S. The Court granted the motion, finding that the governing statutes, including section 37-92-501(4)(c), C.R.S., authorize a subdistrict of a Water Conservancy District formed pursuant to section 37-45-120, C.R.S., in Water Division No. 3, to develop and implement a groundwater management plan in Water Division No. 3 and that the Rules shall be interpreted accordingly.

b. The State Engineer's Rule 56(h) motion sought a determination regarding the burden of proof that applied to any protest asserting that the Rules were not "consistent with preventing material injury to senior surface water rights" as required by section 37-92-501(4)(a), C.R.S. The State Engineer argued that any such protestor must prove (1) that implementation of the Rules will lead to some non-speculative current or future material injury and (2) that the Rules preclude an adequate remedy for those injured water rights. The Court denied the motion.

c. The State Engineer's motion to strike sought to strike the 2J Group's disclosure of Eric Harmon as an expert witness and to prevent the 2J Group from calling Mr. Harmon to testify regarding his 2014 report related to Arroya/Diamond Springs. The Court denied the motion.

d. The 2J Group's motion *in limine* sought an order precluding Proponents from presenting evidence related to the RGDSS Model in defense of the 2J Group's protest. The 2J Group argued that, because the RGDSS Model is not calibrated to Arroya/Diamond Springs[1] – the claimed source of the 2J Group's water rights – and cannot reliably predict depletions to Arroya/Diamond Springs, evidence related to the RGDSS Model was irrelevant to their protest. The Court denied the motion at the outset of trial.

11. In accordance with section 37-92-501(3)(a), C.R.S., the Court held a 13 day trial on the remaining protests to the Rules beginning on January 13, 2018, and ending on February 14, 2018.

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[1] The Proponents always call these springs "Diamond Springs" and the 2J Group always calls these springs "Arroya Springs." There is no rational basis upon which the Court can decide to use one name or the other. The Court thinks it would be confusing to alternate the use of the names throughout this opinion. Accordingly, the Court has chosen to use both names, together, throughout: "Arroya/Diamond Springs."

12. The following parties appeared in support of the Rules: the State of Colorado, represented by Chad Wallace and Daniel Steuer; the Rio Grande Water Users Association, represented by William Paddock and Mason Brown; and the Rio Grande Water Conservation District, represented by Peter Ampe and David Robbins[2] (collectively, "Proponents"). The 2J Group appeared in protest of the Rules, represented by Kendall Burgemeister and Marcus Lock. James Warner appeared *pro se* for some, but not all, of the trial. After trial, Mr. Richard Arnett entered his appearance as counsel for Mr. Warner. Kelly Sowards appeared *pro se* for some, but not all, of the trial. Karen and Colin Henderson appeared *pro se* regarding their separate protest to Rule 8, with Karen Henderson appearing by telephone. Dr. and Ms. Henderson appeared for some, but not all, of the trial.

13. Battle Mountain Resources, Inc., appeared through counsel on the first four days of trial but did not otherwise participate. The Conejos Water Conservancy District appeared through counsel on the first day of trial but did not otherwise participate.

14. Protestor Tim Lovato, *pro se*, did not enter into a stipulation with the State Engineer and did not appear at trial.

15. To facilitate the orderly presentation of evidence at trial, pursuant to the Trial Management Order, the Proponents proceeded first, presenting a joint case in support of the Rules. *Pro se* Protestor Kelly Sowards was permitted to testify during the Proponents' presentation of their joint case to accommodate Mr. Sowards' special needs. Otherwise, the Protestors each presented their evidence at the close of the Proponents' joint case. The Proponents followed the Protestors' presentation of evidence with a combined rebuttal case. The order of presentation of evidence did not affect the burden of proof on the protests to the Rules.

[2] Mr. Robbins was present at the beginning of the trial but did not participate in most of it.

16. During their case-in-chief, Proponents presented testimony from six expert witnesses and six lay witnesses. The Proponents' expert witnesses were: Division Engineer Craig Cotten, P.E.; Eric Harmon, P.E.; James Slattery, P.E.; Assistant Division Engineer James Heath, P.E.; Willem Schreüder, Ph.D.; and Deputy State Engineer Mike Sullivan, P.E. The Proponents' lay witnesses were: Nathan Coombs; Steve Vandiver, P.E.; Lawrence Crowder; Cleave Simpson; State Engineer Kevin Rein, P.E.; and Greg Higel. The 2J Group presented testimony from one expert witness and six lay witnesses. The 2J Group's expert witness was Gregory Sullivan, P.E. The 2J Group's lay witnesses were Joseph A. "Tony" Martinez, James Vannoy, Charles Finnegan, Dick Smith, Thomas Ruybal, and Armando Valdez. In rebuttal the Proponents presented expert testimony from Mr. Heath, Dr. Schreüder, Mr. Slattery, and Mr. Mike Sullivan. The 2J Group was permitted limited sur-rebuttal testimony by its expert Mr. Gregory Sullivan.

17. The Court heard testimony from Protestors Kelly Sowards, Colin Henderson, M.D., Karen Henderson, and James Warner, each appearing *pro se.* Protestor Karen Henderson testified by telephone and was questioned by Dr. Henderson.

18. The Court admitted 165 exhibits offered by Proponents, six of which were received for demonstrative purposes only. The Court admitted 30 exhibits offered by the 2J Group, five of which were received for demonstrative purposes only. Between Proponents' and the 2J Group's admitted exhibits, ten were duplicates. The Court admitted six exhibits offered by Colin and Karen Henderson, *pro se*.

19. At the conclusion of the trial, the Court directed the parties to submit simultaneous written closing arguments and proposed findings of fact, conclusions of law, judgment and decree. The Court further directed the parties to submit simultaneous responses to the other parties' written closing arguments and proposed decrees.

20. The Proponents put on a *prima facie* case supporting all of the Rules. Craig Cotten and Mike Sullivan described the functions of the Rules in detail. Messrs. Cotten and Sullivan also explained how the Rules carry out statutory directives for rulemaking in Water Division No. 3. Proponents also submitted documentary evidence regarding the Rules. Starting with the premise that the Rules are presumed valid, the evidence presented by the Proponents supports a finding that uncontested Rules 1 through 5.8, 5.10 through 5.15, 6, 7.2, 7.6, and 9 through 23 are appropriate and valid ("uncontested Rules")[3].

II. GENERAL SUMMARY OF THE RULES

21. The Court received testimony summarizing the general intent and purpose of each Rule and how the Rules implement existing statutory requirements. Testimony of M. Sullivan, Feb. 7, 2018 (p.m.); Testimony of C. Cotten, Jan. 29, 2018 (p.m.). Although the Court must make the ultimate decisions on whether the Rules meet the relevant legal requirements, the Court finds this testimony to be relevant and helpful in making that determination.

22. Conceptually, the Rules can be divided into six broad categories. Rules 1 through 5 contain statements of the purpose and authority for the Rules, the definitions used in the Rules, and principles and findings underlying the Rules. The core Rules for the regulation of groundwater usage are contained in Rules 6 through 8, 16, and 24. The standards for groundwater management plans and associated annual replacement plans, augmentation plans, and the time for completion of the same are found in Rules 9 through 12 and 21. The geographic scope of the Rules is contained in Rule 13, and the presumptive irrigation season is addressed in Rule 14. Variances from the Rules, appeals, and various other procedural matters are contained in Rules 15, 17 through 20, and 22 through 23.

[3] The 2J Group initially protested some of these rules but did not pursue these protests at trial. *See* discussion at ¶ 37 below.

23. The following is a general summary of the Rules. Rules 1 and 2 state the title and statutory authority for the Rules. Rule 3 indicates that the Rules apply to all withdrawals of groundwater within Water Division No. 3 unless Rule 3.2 specifically exempts such withdrawals. Rule 3 also restates the statutory mandates from section 37-92-501(4), C.R.S., to explain the purposes of the Rules and make clear that nothing in the Rules is designed or should be construed to allow an expanded or unauthorized use of water. Rule 4 provides definitions for terms used in the Rules.

24. Rule 5 sets forth the governing principles the General Assembly established in section 37-92-501(4), C.R.S., and the State Engineer's findings underlying the Rules.

25. Rule 6 provides three ways in which a Well User may continue to make lawful withdrawals of groundwater that are subject to the Rules: pursuant to a groundwater management plan for an approved subdistrict, pursuant to a plan for augmentation decreed by the water court, or pursuant to a substitute water supply plan, all of which must meet the requirements of the Rules.

26. Rule 7 establishes the RGDSS Model as the presumptive tool to calculate Stream Depletions from groundwater withdrawals within the RGDSS Model Domain provided that the RGDSS Model is used in the manner for which it was developed. Rule 7 also requires the State Engineer to develop Response Functions derived from the RGDSS Model that can be used to determine the proportional Stream Depletions caused by well diversions in a Response Area. In addition, Rule 7 requires the State Engineer to establish a lower limit of reliability of the RGDSS Model, which reflects the level below which the State Engineer does not have confidence that Stream Depletions the Model predicts actually occur. Thus, the State Engineer will not develop Response Functions for streams on which the RGDSS Model predicts annual Stream Depletions

that are below the lower limit of reliability. The current lower limit of reliability for RGDSS Model predictions is 50 acre-feet per year. This Rule also requires a Well User whose well lies outside the RGDSS Model Domain to use the best practical and reliable methodology to predict Stream Depletions.

27. Rule 8 sets forth standards to achieve and maintain a Sustainable Water Supply. The Rule divides Water Division No. 3 into three main areas: (1) those areas within the RGDSS Model Domain[4] in which groundwater withdrawals are predominantly from the Confined Aquifer System; (2) those areas within the RGDSS Model Domain in which groundwater withdrawals are predominantly from unconfined aquifers; and (3) areas outside the RGDSS Model Domain. This Rule recognizes that all wells withdrawing groundwater from a common aquifer must share the burden of achieving and maintaining a Sustainable Water Supply in the aquifer. Rule 8 also establishes sustainability requirements for these three areas. The provisions of Rule 8.1, and particularly Rule 8.1.7, addressing sustainability standards for the Confined Aquifer, have been further clarified in the previously described separate stipulations the State Engineer entered into with the Confined Aquifer Sustainability Group and with the Rio Grande Water Conservation District.

28. Rule 9 sets out the requirements for a subdistrict's groundwater management plan and lists the information that a proposed Plan must contain. Rule 10 recognizes that Well Users may apply for and have decreed a plan for augmentation in order to satisfy their obligations under the Rules and sets forth the minimum requirements for such plans. Rule 11 addresses the requirements for a subdistrict's Annual Replacement Plan ("ARP") and describes the process for

[4] The RGDSS Model grid extends beyond the floor of the San Luis Valley but only the Model cells shown in Exhibit A to the Rules (Exhibit SE-1) are active and considered to be in the RGDSS Model Domain.

the State Engineer's review of an ARP. Rule 12 contains the requirements for subdistricts' annual reports on the actual operation of any ARP in effect during the previous year.

29. Rule 13 provides that Rules 6 through 12 currently apply to all of Water Division No. 3, except the region known as the Costilla Plain in southern Costilla and Conejos Counties as set forth in Rule 13.2 and depicted in Exhibit G to the Rules. It is appropriate to exclude the Costilla Plain from Rules 6 through 12 because, based on current hydrogeologic knowledge, the Rio Grande south of the San Luis Hills is not in hydraulic connection with the groundwater system in the Costilla Plain so well pumping in the Costilla Plain does not affect the Rio Grande or the remainder of Water Division No. 3. Testimony of E. Harmon, Jan. 31, 2018 (a.m.). *See* Exhibit SE-8, Opinion 20, p. DWR0000713. Rule 13.2 provides that the State Engineer may amend the Rules (or adopt new rules) to apply to the Costilla Plain if the State Engineer subsequently acquires sufficient information to determine that wells in the Costilla Plain are causing injurious Stream Depletions.

30. Rule 14 establishes the criteria the Division Engineer will use to set the beginning and ending of the Irrigation Season in Water Division No. 3 each year. The presumptive Irrigation Season begins on April 1 and ends on November 1. The Rules grant the Division Engineer discretion to modify these dates in the manner stated in the Rule. This Rule also provides for an expedited appeals process for challenging the Division Engineer's decisions setting dates for the beginning and end of the Irrigation Season. Rule 14 does not affect existing permits or decrees that contain a specific irrigation season, which are controlled by their own terms.

31. Rule 15 contains the process by which the State Engineer may grant a variance to the requirements of these Rules. Rule 16 provides that, if a well permit or decree does not

specify a period of time on which to base an annual limit for the total quantity of groundwater withdrawals under such permit or decree, the length of time is a five-year running average.

32. Rule 17 provides that the Rules do not exempt groundwater use from the applicable requirements of any other laws or rules governing the use of groundwater. Rule 18 provides that anyone who withdraws groundwater in violation of the Rules will be subject to an Order pursuant to section 37-92-502, C.R.S., and may be subject to court proceedings, costs, fees, fines, or other applicable remedies. Rule 19 provides that if the Court finds any Rule, or part of a Rule, to be invalid, the remaining Rules will remain in full force and effect. Rule 20 establishes the process to appeal a decision under the Rules.

33. Rule 21 sets out a timeline for subdistricts to form, develop, and implement groundwater management plans, and allows time for certain entities to contract with subdistricts to comply with the Rules. This Rule also allows Well Users who will operate their wells pursuant to plans for augmentation to continue to operate if they have filed an application in water court within two years of the effective date of the Rules, are operating under approved substitute water supply plans, and are diligently prosecuting a plan for augmentation. The Rule allows the State Engineer to extend the compliance period on a showing of good cause.

34. Rule 22 sets out the standard notice requirements for certain actions taken by the State Engineer pursuant to the Rules. Rule 23 sets the effective date of the Rules as 60 days after publication under section 37-92-501(10)(g), C.R.S., unless protests are filed in the water court, in which case the Rules will not be effective until all protests are resolved.

35. Rule 24 establishes a rebuttable presumption that the RGDSS Model reliably determines the amount, time, and locations of Stream Depletions from groundwater withdrawals and that the Model is suitable only for the purposes for which it has been designed. Rule 24 also

explains the role of the RGDSS Model in the application of the Rules, including the requirement that the State Engineer incorporate new or updated data and components under certain circumstances, as well as a mandatory review of all Response Functions and the lower limit of reliability every five years. More specifically, Rule 24.3.1 requires the State Engineer to timely incorporate new or updated information into the Model if doing so will better represent the hydrologic system that the Model simulates. The State Engineer must update Response Functions if updates would predict Stream Depletions that are significantly different from those predicted by the Response Functions then in use. The State Engineer must also update the Model's lower limit of reliability and all Response Functions when the Model is revised pursuant to Rule 24.3. This Rule acknowledges, as this Court has previously held, the RGDSS Model is not a static tool, but must be continually maintained and updated as new reliable data becomes available, if such data will improve the Model's predictive ability.

III. SUMMARY OF DISPUTED ISSUES

36. Paragraph 5(B)(I)(c) of the MCMO required any party desiring to present evidence contesting any of the proposed Rules to file a statement identifying each Rule to which the party objected, and stating whether the objection was to the RGDSS Model; Response Functions derived from the Model; data used in the Model and/or application of the Model; and, if relevant, any task memoranda disclosed by the State Engineer to which the party objected. Paragraph 5(B)(I)(e) of the MCMO provided that a Protestor would not be permitted to present evidence challenging any Rule or aspect of the RGDSS Model unless each challenge was identified in a statement under paragraph 5(B)(1)(c) of the MCMO. None of the Protestors participating at trial identified a challenge to the uncontested Rules.

37. On September 15, 2016, the 2J Group filed its statement of objections listing objections to Rules 5.2; 5.9; 7.1-7.5; and 24. In its *Closing Statement* and proposed findings and conclusions, the 2J Group limited its objections to Rules 5.9, 7.1, 7.3 through 7.5, and 24.1. The 2J Group objects to these rules because these rules create a rebuttable presumption that the RGDSS Model is reliable, yet, according to the 2J Group, the RGDSS Model and the Response Functions developed from it do not reliably measure the depletions they have suffered to their senior surface water rights as the result of junior well pumping. The 2J Group owns water rights (more specifically described below at ¶ 176) sourced from Arroya/Diamond Springs. The 2J Group claims that beginning in the 1940s, junior wells withdrew increasing amounts of groundwater from the Confined Aquifer causing the flow of Arroya/Diamond Springs to decrease, and that continued groundwater withdrawals caused groundwater levels to decrease to such an extent that the flow of Arroya/Diamond Springs ceased almost entirely by the early 1970s. The 2J Group objects to the Model for the following reasons: (1) the RGDSS Model is not calibrated to Arroya/Diamond Springs or La Jara Arroya Creek; (2) the Model does not calculate Stream Depletions to Arroya/Diamond Springs or La Jara Arroya Creek caused by groundwater pumping; (3) the Model cannot reliably predict Stream Depletions to Arroya/Diamond Springs or La Jara Arroya Creek; and (4) no Response Functions were generated for Arroya/Diamond Springs or La Jara Arroya Creek. Because the RGDSS Model is not calibrated to Arroya/Diamond Springs, the 2J Group argues that the rebuttable presumptions contained in Rules 5.9, 7.1, 7.3, 7.4, 7.5 and 24.1, are arbitrary and capricious and violate subsections 37-92-501(1), (2)(e), and (4)(a), C.R.S.

38. The State Engineer agrees that the RGDSS Model is not calibrated to Arroya/Diamond Springs or La Jara Arroya Creek and argues that this is appropriate because

there is insufficient reliable data to do so at this time. The 2J Group responds that if there is insufficient reliable data to calibrate the Model to Arroya/Diamond Springs, then there is insufficient reliable data to promulgate the Rules because they fail to establish replacement requirements for groundwater depletions to Arroya/Diamond Springs. The 2J Group also argues that the presumptions in the contested Rules are contrary to law because they require senior surface water users to prove injury, rather than requiring junior groundwater users to prove their continued pumping does not cause injury. Finally, the 2J Group asserts that even if the successful implementation of the Rules results in the restoration of artesian pressure in the Confined Aquifer to the levels present between 1978 and 2000, as required by statute, this result does not meet the State Engineer's separate statutory requirement to regulate junior groundwater diverters to require them to replace injurious depletions to Arroya/Diamond Springs based on hydrological conditions that would exist in Arroya/Diamond Springs absent historic well pumping.

39. Karen and Colin Henderson challenged the Rules as part of the 2J Group and they also filed a *pro se* statement protesting Rule 8. They proceeded *pro se* at trial on their challenges to Rule 8. The Hendersons argue that Rule 8 improperly gives Well Users an additional ten years to reduce their depletions to the Confined Aquifer because the Rule creates a program of data gathering which will result in a report in ten years from which the State Engineer will "determine the preferred methodologies to maintain a Sustainable Water Supply in the Confined Aquifer System." *See* Rule 8.1.3. The Hendersons believe the State Engineer has sufficient data now, particularly in the measurements from Well CON1, that would allow the State Engineer to require Well Users to replace depletions and/or reduce diversions to bring the Confined Aquifer potentiometric head, as measured by the level in Well CON1, to the level that it had during 1978 through 2000.

40. Neither of the other parties who appeared *pro se* at trial, James Warner nor Kelly Sowards, filed a statement under paragraph 5(B)(I)(c) of the MCMO. While James Warner and Kelly Sowards testified at trial, neither addressed specific rules. Mr. Sowards generally supported some action to replace injurious Stream Depletions caused by groundwater withdrawals. Mr. Warner's testimony concerned the fate of his water rights in a plan for augmentation. He also questioned the reliability of the groundwater modeling process, although he presented no expert testimony to support his questions. Therefore, neither James Warner nor Kelly Sowards articulated challenges to any particular Rule.

41. Most of the Rules were not challenged by any party at trial. Rules promulgated by the State Engineer are presumed valid and the burden to show otherwise rests with anyone challenging the Rules. Rule 23 establishes the effective date for the Rules. If anyone files a protest, the effective date is the date on which all the protests have been resolved. Rule 19 allows severance of each of the Rules from one another. Therefore, the uncontested Rules will be in full force and effect upon the Court's resolution of the protests of the contested Rules, regardless of how the Court resolves the protests to those Rules.

IV. HISTORY OF GROUNDWATER REGULATION IN DIVISION 3

A. Background to the Current Rules

42. The water resources of the Rio Grande Basin in Colorado's Water Division No. 3, including all tributary sources of surface water and all tributary groundwater aquifers, are over-appropriated and have been for many years. The Water Right Determination and Administration Act of 1969 requires the State Engineer to integrate administration of these ground and surface water rights to protect the rights of senior appropriators but with the minimum impact on existing vested groundwater rights. Sections 37-92-101 *et seq.*, C.R.S. ("1969 Act"). The statute allows the State Engineer to adopt rules, such as the Rules at issue in this case, to assist in that

administration so long as the rules provide for "optimum use of water consistent with preservation of the priority system of water rights." Section 37-92-501(2)(e), C.R.S. But, as this Court has previously noted:

> The boldness of the 1969 Act's promise to integrate groundwater with surface streams is not discussed often, but the real world difficulties of accomplishing the integration, both with the science and with the practical and financial realities has played out across the state for the past forty years.

2006CV64 & 2007CW52 *Concerning the State Engineer's Approval of the Plan of Water Management for Special Improvement District No. 1 of the Rio Grande Water Conservation District*, Findings of Fact, Conclusions of Law, Judgment and Decree dated May 27, 2010 ("Subdistrict No. 1 Decree") at ¶ 210.

43. The State Engineer first attempted to promulgate groundwater rules in Water Division No. 3 in 1975, as described in *Alamosa-La Jara Water Users Protection Association v. Gould*, 674 P.2d 914 (Colo. 1983). The Colorado Supreme Court affirmed the water court's disapproval of the proposed groundwater rules and remanded to the State Engineer for reconsideration in light of the decision in that case. The State Engineer did not seek to promulgate new groundwater rules mainly because of the creation of the Closed Basin Project and the (unrealized) projection that it would provide up to 60,000 acre feet of water annually to meet Rio Grande Compact delivery requirements, thus freeing surface water rights in the Valley to be used by the farmers and others who owned them. *See* 2004CW24 *In the Matter of the Rules Governing New Withdrawals of Groundwater in Water Division No. 3 Affecting the Rate or Direction of Movement of Water in the Confined Aquifer System*, Findings of Fact, Conclusions of Law, Judgment and Decree dated November 9, 2006, ("Confined Aquifer New Use Rules Decree") at ¶¶ 97-113.

44. The next significant step toward groundwater regulation in Water Division No. 3 occurred in 1998 when the General Assembly enacted House Bill 98-1011 ("HB 98-1011") to address concerns regarding new withdrawals of groundwater affecting the Confined Aquifer System in Water Division No. 3. The 1998 legislation recognized that there was, at that time, insufficient comprehensive data and knowledge of the relationship between the surface streams and the Confined Aquifer System to permit a full understanding of the effect of groundwater withdrawals upon the natural streams and aquifer systems in Water Division No. 3. Ch. 231, Sec. 1, 1998 Colo. Sess. Laws 852. The 1998 legislation directed the State Engineer to promulgate rules for new withdrawals of groundwater affecting the Confined Aquifer System based on specific study of the Confined Aquifer System. *Id*. Sec. 2.

45. To comply with the General Assembly's directive in HB 98-1011 the State Engineer created the Rio Grande Decision Support System ("RGDSS") and promulgated the *Rules Governing New Withdrawals of Groundwater in Water Division No. 3 Affecting the Rate or Direction of Movement of Water in the Confined Aquifer System* ("Confined Aquifer New Use Rules"). The Confined Aquifer New Use Rules recognize that there is no unappropriated water in the Confined Aquifer, so any new withdrawal essentially requires one-for-one replacement or the retirement of existing wells to account for the new withdrawal. Several Protestors challenged the Confined Aquifer New Use Rules and, after a trial, this Court upheld the Confined Aquifer New Use Rules and the use of the then-current version of the RGDSS Model in those rules. *See* Confined Aquifer New Use Rules Decree. The Colorado Supreme Court upheld this Court's ruling in *Simpson v. Cotton Creek Circles, L.L.C.*, 181 P.3d 252 (Colo. 2008).

46. The next significant step in groundwater regulation in Water Division No. 3 occurred in 2004, when the General Assembly enacted Senate Bill 04-222 ("SB 04-222"), which

added a new subsection (4) to section 37-92-501 of the 1969 Act applicable to rules and regulations governing the use of "underground water" in Water Division No. 3. This statute established the guiding principles for the Rules now before the Court.

47. Then, in 2005 as part of the State Engineer's ongoing efforts to collect additional reliable data on groundwater use, the State Engineer promulgated the *Rules Governing the Measurement of Ground Water Diversions Located in Water Division No. 3, the Rio Grande Basin* ("Measurement Rules"). In approving the Measurement Rules, this Court found that:

> The Rules will assist the State Engineer in the administration, distribution and regulation of the waters of the state in accordance with the constitution of the state of Colorado and other applicable laws and to enable the [S]tate of Colorado to meet its obligations under the Rio Grande Compact, codified at section 37-66-101, C.R.S. (2005). Further, the information obtained by the measurements required by these [Measurement] Rules will be useful to the State Engineering [sic] for, among other things, regulating [the] use of the confined and unconfined aquifer systems to maintain a sustainable water supply in each aquifer system, with due regard for the daily, seasonal and long-term demands for underground water, and the prevention of injury to senior surface water rights.

Case No. 05CW12, Order Approving Rules Governing the Measurement of Ground Water Diversions Located in Water Division No. 3, the Rio Grande Basin at 2 (August 1, 2006).

48. After the General Assembly enacted SB 04-222 and this Court approved both the Confined Aquifer New Use Rules and the Measurement Rules, groundwater users within the Closed Basin established a groundwater management subdistrict under the Rio Grande Water Conservation District known as "Subdistrict No. 1." The purpose of Subdistrict No. 1 is to remedy injurious Stream Depletions caused by net consumptive use of groundwater by wells included in its Plan of Water Management and to re-establish and maintain a sustainable groundwater supply in Subdistrict No. 1. There was extensive litigation regarding the creation of Subdistrict No. 1, the creation and approval of its Plan of Water Management, and the review and approval of its first Annual Replacement Plan. *See generally,* Cases No. 06CV64 and

07CW52, Findings of Fact, Conclusions of Law and Order (February 18, 2009), Subdistrict No. 1 Decree (May 27, 2010), Findings of Fact, Conclusions of Law, Judgment and Decree (April 10, 2013); *In re Office of State Engineer's Approval of Plan of Water Mgmt. v. Special Improvement Dist. No. 1*, 351 P.3d 1112 (Colo. 2015); *San Antonio, Los Pinos and Conejos River Acequia Preservation Ass'n v. Special Improvement Dist. No. 1*, 270 P.3d 927 (Colo. 2011).

49. Since the final approval of Subdistrict No. 1's Plan of Water Management, the Subdistrict has remedied injurious depletions caused by groundwater withdrawals from Subdistrict wells. Subdistrict No. 1 continues to work toward achieving and maintaining a sustainable groundwater supply in the Unconfined Aquifer beneath the Subdistrict. Testimony of C. Simpson, Feb. 7, 2018 (a.m.). Significantly, since the final approval of Subdistrict No. 1's first Annual Replacement Plan, no party has objected to or challenged the Response Functions that Subdistrict No. 1 uses to determine injurious depletions from groundwater withdrawals in any of its subsequent Annual Replacement Plans or Annual Reports. *Id.* The Water Management Plan and the Annual Replacement Plan for Subdistrict No. 1 provided many of the guiding principles for Rules 9 through 12 now before the Court.

B. <u>Public Process to Formulate the Rules</u>

50. The Rules now before the Court are another step in the effort to integrate the administration of groundwater and surface water in Water Division No. 3. The State Engineer developed the Rules through an open, public process. In December 2008, then State Engineer Dick Wolfe formed the Special Advisory Committee, which was composed of approximately 56 individuals representing governmental entities such as the Rio Grande Water Conservation District, water conservancy districts, cities, counties, and irrigation districts. It also included water user organizations, groundwater users, and surface water users. The purpose of the Special

Advisory Committee was to assist the State Engineer in gathering information, and reviewing and providing comment on drafts of the proposed Rules. Testimony of M. Sullivan, Feb. 7, 2018 (p.m.).

51. Beginning in March 2009, the Special Advisory Committee held approximately 25 separate public meetings and various subcommittees held additional meetings. The Special Advisory Committee meetings were advertised throughout the Valley and more than 300 individual invitations were sent for each meeting. Any interested person could attend the meetings and ask questions or provide comments. Interested persons could also provide written comments to the State Engineer on each version of the draft Rules. The State Engineer actively encouraged both the Special Advisory Committee members and the general public to participate. *Id*.

52. The Special Advisory Committee met frequently, except for a period of time from 2011 to 2013. *See* http//:state.co.us/SurfaceWater/RulesmakingAndAdvising/SLVAC/ Pages/SLV Meetings.aspx. In 2011, the Committee requested that its work be paused until the RGDSS Model was sufficiently calibrated to provide water users a reasonable idea of the magnitude and location of depletions groundwater withdrawals had caused and were causing. Testimony of M. Sullivan, Feb. 7, 2018 (p.m.). Once the State Engineer provided that information, the public meetings and work of the Special Advisory Committee resumed, continuing through May 2015. *Id*. The State Engineer filed the Groundwater Rules with this Court on September 23, 2015. *Id*.

V. THE RIO GRANDE DECISION SUPPORT SYSTEM (RGDSS) AND THE RGDSS MODEL

53. The Rio Grande Decision Support System is one of several decision support systems the Colorado Division of Water Resources has created and maintains. Development of

the RGDSS began in 1998. Testimony of M. Sullivan, Feb. 7, 2018 (a.m.). The RGDSS is applied within Water Division No. 3 and is, effectively, the ongoing specific study of the aquifer systems contemplated by HB 98-1011. Confined Aquifer New Use Rules Decree at ¶ 122. This ongoing study consists of the collection and evaluation of existing data, the supplementation of the existing data with new data and studies, the development of models, and the organization of the data and models into an accessible format. *Id*. This Court has previously held, and it remains true, that "the RGDSS Study is one of the most comprehensive studies of the Valley's geology and hydrology that has ever been undertaken." *Id*.

54. The RGDSS can generally be described as "an interactive computer-based system that utilizes data and computer models to help decision makers solve unstructured problems." Confined Aquifer New Use Rules Decree at ¶ 149. The State Engineer has collected the data used in the RGDSS through various means including installing additional stream gages; drilling test wells; collecting specific data on irrigation practices; reviewing existing hydrogeologic data; interviewing water users; studying the consumptive use of water by non-irrigated native vegetation; surveying and mapping streams, canals and drains; and combining this data into useable databases. Data collection and updating of the RGDSS continues today. Testimony of M. Sullivan, Feb. 7, 2018 (p.m.).

55. The RGDSS is both vast and complex, involving many different databases and tools to manage, update, and make data available to the RGDSS Model. For example, there are databases of geohydrological data including streamflow, diversions, geology, etc.; GIS data sets including mapping of irrigated acres, as well as information about types of crops grown, and irrigation practices; and a water balance model, to name a few. A schematic diagram which

indicates these databases and shows the processes and steps involved in running the RGDSS is shown in Exhibit SE-710.

56. One of the most significant tools within the RGDSS is the RGDSS Model which is a groundwater model. In general, a groundwater model is an attempt to simulate mathematically the operation of the physical world, Testimony of J. Slattery, Feb. 1, 2018, (a.m.), or stated another way, it is an idealized version of a physical thing. Testimony of W. Schreüder, Feb. 6, 2018 (a.m.). Specifically, the RGDSS Model is a mathematical computer model, *i.e.* a series of mathematical equations, that simulates the operation of the groundwater hydrologic system and tries to approximate the rate and direction of flow of water in the groundwater system of the San Luis Valley within the RGDSS Model Domain.

A. Need for the RGDSS and a Digital Mathematical Groundwater Model

57. The purpose of the Rules is to allow the "optimum use of water consistent with preservation of the priority system of water rights" while also regulating the use of the Confined and Unconfined Aquifers to maintain a Sustainable Water Supply in each aquifer. *See* Rules 3.3 and 3.4. To accomplish this task, the Rules require that those who divert groundwater in Water Division No. 3 must replace or remedy injurious Stream Depletions "that deprive senior surface water rights in Water Division No. 3 of water that would have been physically and legally available for diversion in the absence of the Stream Depletions." Rule 4.13. Given the highly complex and variable geologic and hydrologic conditions in the Valley as well as the non-linear relationship between groundwater withdrawals and their effects on the flow of surface streams, the only way to determine the injurious Stream Depletions caused by a well or group of wells in Water Division No. 3 is to create a mathematical groundwater model and to use computers to perform all of the complex calculations. This is because the Stream Depletions caused by one or

more groundwater withdrawals cannot be directly measured; rather one must determine what amount of water would have been available in the system in the absence of the groundwater diversions that have occurred and are occurring. Decision Support Systems like the RGDSS are an appropriate tool for analyzing complex aquifer systems and their associated Stream Depletions. Testimony of James Slattery, Feb. 1, 2018 (a.m.).

58. In prior opinions, this Court has discussed the initial development, application, and use of previous versions of the RGDSS Model. Confined Aquifer New Use Rules Decree at ¶¶ 272-305. In the Confined Aquifer New Use Rules Decree, this Court found:

> 274. A groundwater model is necessary for the complete evaluation of any new application for withdrawal of water from the Confined Aquifer due to the complex geologic and hydrologic conditions in the Valley and the large number and complexity of factors that must be considered when making such an evaluation. A mathematical computer model is currently the only practical way for the State Engineer to perform this duty. *Transcript (Slattery) Vol. IX* at p. 1677, ln. 18- p. 1679, ln. 5; *Transcript (Simpson) Vol. XVII* at p. 3202, ln. 12-20. The leap forward in ambition and potential usefulness of a mathematical computer groundwater model in comparison to the electrical analogue model of the Rio Grande Basin presented in the 1970's by Phillip Emery is immediately evident as one reviews the exhibits and testimony. This effort seeks to apply state-of-the-art modeling techniques to the complexities of the Rio Grande Basin. As part of the RGDSS, the groundwater model is an essential element of an approach to water resource management based upon scientific investigation as the foundation for decision making.

Id. at ¶ 274 (footnote omitted). Subsequently, this Court expressly approved the use of the Phase 5 RGDSS Model as the basis for determining Stream Depletions caused by the net consumptive use of groundwater in Special Improvement District No. 1 of the Rio Grande Water Conservation District. *See* Subdistrict No. 1 Decree at 27–30.

59. The evidence presented in this case confirms that a scientifically sound digital groundwater model is an essential element for the State Engineer to fulfill his water management

responsibilities, including the regulation of groundwater, in Water Division No. 3 in the manner section 37-92-501(4), C.R.S. contemplates.

60. The geologic and hydrologic conditions in the San Luis Valley are highly variable and very complex. Exhibit SE-700B shows the complex geologic stratigraphy of the water-bearing formations in the San Luis Valley. There is considerable variability in depth and location of each of these water-bearing strata and considerable variability in rock types and structure in the various physiographic regions of the San Luis Valley. Testimony of E. Harmon, Jan. 31, 2018 (a.m.). There are groundwater withdrawals from each of these various water-bearing formations in the Valley. Exhibits SE-331, 332, 333. The amount and location of the groundwater withdrawals is different in each area. *Id.* A groundwater model is needed to represent the different geologic and hydrologic characteristics within each water-bearing strata and to simulate the flow of groundwater within and between each of the strata.

61. A groundwater model is also necessary to simulate the complicated ways in which water enters the Model Domain from the Model boundaries at the edges of the San Luis Valley floor. In some locations, streams recharge the Unconfined and Confined Aquifers in the rim recharge zones. In other locations, groundwater underflow enters the Model Domain from the Model boundaries. Exhibit SE-700B; Testimony of E. Harmon, Jan. 31, 2018 (a.m.).

62. Beyond the great complexity of the geology and hydrology in the San Luis Valley, the shallow groundwater levels in many areas of the Valley create further complexities that can only be accounted for by use of a computerized groundwater model.

63. A basic principle underlying a groundwater model is the law of conservation of mass, *i.e.* that matter (including water) can neither be created nor destroyed. Exhibit SE-504 (DWR0020367). In a groundwater model this means that inflow into the groundwater system, or

a portion of it, minus outflow from the same area, is equal to the change in storage in that area. *Id.*; Testimony of W. Schreüder, Feb. 6, 2018 (a.m.). The Model therefore has a water balance or water budget that compares inflows to the groundwater system against outflows from the groundwater system. *E.g.*, Exhibit SE-499 (listing inflow and outflow types); Exhibit SE-727 (Transient Water Budget); Exhibit SE-652 at 16 (1998 Average Annual Ground Water Budget). As these exhibits illustrate, the major outflows from the groundwater system in Water Division No. 3 are agricultural groundwater pumping and evapotranspiration of groundwater (ETg) by native vegetation and from subirrigated meadows and alfalfa.

64. The analysis of the effect of groundwater pumping on the hydrologic system is greatly complicated by the way ETg changes depending on depth to groundwater. When you stop pumping a well, the groundwater levels will rise but some of the water will then be consumed by native plants, subirrigated meadows and alfalfa. So, the Injurious Depletions the well causes to a surface stream will be less than the total amount of water pumped from the well. Furthermore, the relationship between ETg and the various vegetative types is not linear, but rather, ETg decreases with depth to water at different rates depending upon vegetation type. Exhibit SE-715. Moreover, the location of ETg by vegetation type and the corresponding rates of ETg vary widely across the San Luis Valley. Exhibit SE-716. Finally, the analysis is further complicated because there can be more than one well pumping groundwater that vegetation would have removed through evapotranspiration if the groundwater level were higher, yet there is only a finite amount of ETg across a given area. In such a non-linear system, the sum of the individual parts does not equal the sum of the whole. Exhibit SE-652 at 18. This means, in the context of ETg, two wells cannot both cause the same reduction in ETg, or cannot “salvage” the same ETg and, to correctly model the situation, the Model must be able to take this complication

into account. The non-linear relationship between ETg and groundwater levels greatly complicates the engineering analysis needed to determine the effect of groundwater use on surface streams. Testimony of J. Slattery, Feb. 1, 2018 (p.m.).

65. Further complicating the analysis is the fact that return flows from the withdrawal of groundwater from the Confined Aquifer can add inflow to the Unconfined Aquifer, effectively off-setting Stream Depletions that might otherwise affect the surface streams. Examples of this are found on the Rio San Antonio and La Jara Creek. Testimony of J. Slattery, Feb. 1, 2018 (p.m.). In addition, the rate of leakage between the Confined Aquifer and Unconfined Aquifer changes depending on the amount of groundwater in the Unconfined Aquifer and the potentiometric pressure in the Confined Aquifer. Testimony of J. Slattery, Feb. 14, 2018 (p.m.).

66. These complexities confirm this Court's prior decisions that the use of a groundwater model in the San Luis Valley is necessary to address the unique hydrologic and geologic conditions of the Valley, to estimate the effects on the rate and direction of groundwater movement resulting from groundwater withdrawals, and to reliably estimate the depletions to stream flow resulting from groundwater withdrawals. The Protestors do not dispute the need for a groundwater model to accomplish this purpose.

B. The Technical & Scientific Underpinnings of the RGDSS Model

67. The RGDSS Model is based on the United States Geological Survey ("U.S.G.S.") MODFLOW program as modified and implemented by the State Engineer. Testimony of J. Slattery, Feb. 1, 2018 (a.m.). The U.S.G.S. MODFLOW program is now well-accepted as a reasonable and appropriate computer program to create a groundwater model. *Id.*

68. The Model represents the hydrogeologic system of the San Luis Valley by dividing the groundwater system throughout the Valley into ½ mile by ½ mile square cells through five different layers. Exhibit SE-333 shows the five layers of the RGDSS Model which

represent the complex stratigraphy of the water-bearing geologic formations in the San Luis Valley. To properly represent these formations, the cells within each layer are of varying depths and the layers themselves are of varying depths and aerial extent. For example, Layer 1, the topmost layer, has both the largest aerial extent and the least depth. Testimony of W. Schreüder, Feb. 6, 2018 (a.m.); Exhibits SE-494, SE-508. There are 51,015 active grid cells within the RGDSS Model Domain. Testimony of W. Schreüder, Feb. 6, 2018 (p.m.).

69. The Model uses a differential equation that combines the law of the conservation of mass with Darcy's Law to calculate the hydraulic head and groundwater flow rate at discrete points in space and at discrete time intervals throughout the Model Domain. The conservation of mass equation or the mass balance equation is expressed as:

Inflow – Outflow = Change in Storage

Because of the law of conservation of mass, any water that flows into a cell must then either flow out of the cell or remain in storage in the cell as a change in the hydraulic head in the cell. This same balance of inflows less outflows equals storage applies to the system as a whole and is represented by the water budget.

70. In accordance with the law of conservation of mass, the Model keeps track of all inflows to the groundwater system, such as precipitation inflow, return flows from irrigation, leakage from streams, canals and ditches, and underground inflow from the edges of the Valley (*i.e.* exterior boundary of the RGDSS Model Domain). The Model also keeps track of all outflows from the groundwater system including groundwater withdrawals, evapotranspiration by native plants, subirrigation, flow into streams from the groundwater system, and spring flows. The combination of all of these inflows and outflows is known as the Model's water budget or

mass balance. Exhibit SE-499. The Model's water budget is approximately 1,500,000 acre-feet per year. Testimony of W. Schreüder, Feb. 6, 2018 (p.m.).

71. Darcy's Law is the fundamental equation that is used to determine how fast water can move through the ground. Testimony of Wm. Schreüder, Feb. 6, 2018 (a.m.). Or, stated in mathematical terms:

$$Q = k\ I\ A$$

Q is flux or the amount of water passing through a certain surface area expressed as volume per time. *K* is the hydraulic conductivity, or resistance to flow, of the material through which the water is passing. *I* is the hydraulic gradient which is the difference in hydraulic head between two points. *A* is the area. Another way to represent this equation is:

$$Q = K \times A \times \frac{(H_1 \text{ (groundwater level at 1)} - H_2 \text{ (groundwater level at 2)}}{\text{(L (length of flow path)}}$$

Exhibit SE 652 at 13. What Darcy's Law basically says is that Q, the groundwater flow through an aquifer equals K, the hydraulic conductivity of the material of the aquifer multiplied by A, the cross-sectional area, multiplied by the gradient, which is the difference in head H1, upstream, and H2 downstream-- so the difference between the two is the amount of head that is pushing the water through the aquifer material—divided by the length of the flow path. Testimony of James Slattery, Feb. 1, 2018 (p.m.). Hydraulic conductivity or K is very important in this equation because for the same head difference, $H_1 - H_2$, there will be more flow if there is greater hydraulic conductivity, *e.g.* if the aquifer is composed of more sand and gravels, versus less flow if the hydraulic conductivity, K, is lower because the material is tighter and does not allow water to be conducted through it so easily.

72. Darcy's Law and the mass balance equation are combined into the groundwater flow equation which is the differential equation that represents groundwater flow in three dimensions. Exhibit SE 504, DWR0020369. The Model solves this groundwater flow equation for each one of the 51,015 active grid cells within the RGDSS. To accurately depict the change in storage and flow of groundwater, the model must calculate the flow through each of the six faces (North, South, East, West, top and bottom) of each of the 51,015 active grid cells.

73. The Model also keeps track of changes that occur inside an individual cell, such as groundwater withdrawals, recharge, or evapotranspiration. The Model then applies the groundwater differential equation to determine the change in head (water level or artesian pressure) in each cell. The change in head in each cell is also affected by the change in head in all bordering cells. Thus, running the model requires the ability to solve the groundwater equation in all model cells simultaneously. To do this, the equations must be solved through an iterative process. Testimony of W. Schreüder, Feb. 6, 2018 (a.m.); Exhibit SE-524.

74. The time period over which the Model calculates hydraulic heads is known as a time-step. The Model uses a time-step of approximately one week. A stress period is the interval at which inputs such as recharge or groundwater withdrawals remain constant. The Model uses a stress period of one month, thus, there are four time-steps per stress period. Testimony of W. Schreüder, Feb. 6, 2018 (a.m.).

75. The Model can run three types of simulations: steady state, periodic, and transient. A steady state model run is an over-simplification of the physical system being modeled in which there are no changes over time. The modeler uses this type of run to look at average inflows and outflows. A steady state model is a preliminary step to development of a transient model. In general, a steady state model is not used for predictive purposes, but only to

provide a general sense of the Model's ability to represent the physical system. That is how the steady state runs of the RGDSS Model were designed and used. The periodic simulation, also called the average monthly simulation, is another intermediate step to development of the transient model. In this step the modeler is attempting to accurately represent the short-term behavior of the physical system, but not the long-term behavior. In a periodic simulation, the physical system returns to the same conditions from where the Model began, over some period of time. Once the modeler has refined the Model using the steady state and periodic simulations, the final step is the transient Model run which attempts to reasonably replicate the actual operation of the physical system over some defined length of time. Testimony of W. Schreüder, Feb. 6, 2018 (a.m.).

76. The time period for the Model's steady state and periodic simulations was limited to 1990 through1998. Testimony of W. Schreüder, Feb. 6, 2018 (p.m.); Exhibit SE-504 at 10. The time period for the Model's monthly transient simulation is from 1970 through 2010. *Id*. The modelers also ran an initial-period steady state simulation from 1965 through 1969, the output from which they used to supply the beginning groundwater levels (known as the initial conditions) for the transient simulation. *Id*. The modelers chose the time period of 1970 through 2010 for the Model's transient simulation because there is insufficient reliable observation data from before 1970, especially groundwater levels or head data, to calibrate the model. *Id.*

C. The History and Development of the Current Version of the Model

77. The Model now before the Court is known as version 6P98. The "6" represents that the Model is part of phase 6 of the RGDSS. Phase 1 of the RGDSS, which began in approximately 1999 and continued through 2001, consisted of the data review, collection, and analysis of the groundwater model developed by the State of Colorado as part of the AWDI litigation. *See Am. Water Dev., Inc., v. City of Alamosa*, 847 P.2d 352 (Colo. 1994); Testimony

of W. Schreüder, Feb. 6, 2018 (a.m.); Testimony of E. Harmon, Jan. 30, 2018 (p.m.). Phase 2 extended from approximately 2001 to 2002 and involved constructing the first steady state RGDSS Groundwater Model. The phase 2 tasks included assembling data sets and creating the cell and grid system and the general hydrogeologic layers for the Model. Testimony of W. Schreüder, Feb. 6, 2018 (a.m.). Phase 3, from 2002 to 2003, involved the expansion of the Model's data sets and the creation of a working transient Model. *Id*. Phase 4 covered the period from 2003 through 2006 and involved the continued refinement and improvement of the transient Model and the use of the Model for the Confined Aquifer New Use Rules. This Court approved the phase 4 Groundwater Model for that purpose. *See* Confined Aquifer New Use Rules Decree. Phase 5 followed immediately after the conclusion of the Confined Aquifer New Use Rules litigation and continued until 2009. During phase 5, the simulation period was extended to 2005 and the modelers made additional refinements to the Model. Testimony of W. Schreüder, Feb. 6, 2018 (a.m.). Using the Phase 5 Model, the modelers created Response Functions, which are a simplified form of the output from the RGDSS Model and which can estimate Stream Depletions caused by the net groundwater consumptive use by wells in Subdistrict No. 1. This Court approved the use of the Model and Response Functions for that purpose. Subdistrict No. 1 Decree at ¶¶ 96-104.

78. At the end of the work on phase 3 of the Model and in an effort to improve the RGDSS, the State Engineer established an informal peer review group to critique and improve the Model. Confined Aquifer New Use Rules Decree at ¶ 302. That group, variously called the technical review committee, peer review team, or PRT, is made up of interested groundwater modelers, scientists, hydrogeologists, water resource engineers, water users, and water administrators. The PRT meetings are informal, open, public meetings that have helped develop

and improve the Model. Proponents of the Rules provided several examples of how the peer review process worked and the valuable input received from local water users that resulted in significant improvements to the Model, including, but not limited to, the representation of San Luis Creek and the Rio San Antonio. Testimony of E. Harmon, Jan. 30, 2018 (p.m.).

79. The process of updating the Phase 5 Model for the Phase 6 Model began in 2010. As with previous phases of the RGDSS Model, enhancements to the Phase 6 Model have been driven by a data-centered approach, where the Model is updated or enhanced only where reliable data exists to support a change. Testimony of J. Slattery, Feb. 1, 2018 (a.m.).

80. As part of its work, the PRT evaluates the results of Model runs and compares the results to existing observations. The PRT then identifies locations or topics that would benefit from further investigation to improve the reliability of the Model, including its ability to match observations of aquifer heads and stream gains and losses, and prioritizes these investigations. The State Engineer is, however, the final authority on whether to implement any actions the PRT recommends.

81. The PRT thoroughly evaluates and critiques additional data that has been collected to determine its reliability and utility, and determines whether and how to represent any recommended changes in the Model. After incorporating such data into the Model, results based on the new data are compared to earlier Model results to determine if the new data improved the Model in terms of matching observed water levels, artesian head pressure, and stream gains and losses. Based on this comparison, the PRT either recommends that the new data be accepted for incorporation into the Model or recommends further investigation or Model refinement. Testimony of J. Heath, Feb. 5, 2018 (p.m.).

82. This process of (1) identifying and prioritizing areas that would benefit from further enhancement or investigation, (2) rigorous evaluation of any new data collected and how and whether that data improves the reliability of the Model, and (3) either incorporating such data and/or enhancements into the Model, or recommending further investigations or refinement, is an iterative and ongoing process of the PRT that has resulted in significant improvements to the RGDSS Model during phase 6. The Phase 6 Model matches observed conditions more closely than all prior phases of the Model. Testimony of J. Heath, Feb. 5, 2018 (p.m.); Exhibit SE-495.

83. Examples of the types of new data included in the Phase 6 Model include new geologic mapping and geophysical information for discrete areas of the San Luis Valley, new or more complete records of groundwater levels, new or more complete records of groundwater withdrawals, improved analysis of stream gain and loss data, new spatial data such as new crop type data and new satellite imagery, new or more complete climate data, and new evaluations of existing data. Testimony of J. Heath, Feb. 5, 2018 (p.m.); Feb. 6, 2018 (a.m.).

84. During phase 6, numerous location-specific hydrogeologic reviews and investigations were done in the following areas of the San Luis Valley:

a. Conejos River valley and the San Antonio River valley, in Conejos County, approximately from Highway 285 downstream to the confluence of the Conejos River and the Rio Grande. Testimony of E. Harmon, Jan. 31, 2018 (p.m.); Exhibit SE-323.

b. San Antonio and Los Pinos River valleys, in Conejos County, approximately from the Colorado – New Mexico State line on the south to Highway 285 at Antonito, Colorado, on the north. Testimony of E. Harmon, Jan. 31, 2018 (a.m.); Exhibit SE-326.

c. Rio Grande valley approximately from Del Norte downstream to the Rio Grande – Alamosa County line. Testimony of E. Harmon, Jan. 31, 2018 (p.m.); Exhibits SE-325, 287, 285.

d. Saguache Creek valley approximately from the Saguache Creek stream gage downstream to the town of Saguache, in Saguache County. Testimony of E. Harmon, Jan. 31, 2018 (a.m.); Exhibit SE-322.

e. The area generally encompassed by Saguache Creek, Werner Arroyo, and the Gunbarrel (U.S. Highway 285), encompassing the Russell Springs / Russell Lakes area. Testimony of E. Harmon, Jan. 31, 2018 (a.m.); Exhibit SE-321.

f. Upper San Luis Creek area in Saguache County, approximately from Kerber Creek on the north to County Road AA on the south. Testimony of E. Harmon, Jan. 31, 2018 (a.m.); Exhibit SE-327.

g. Manassa Fault and McIntire Spring area in Conejos County, approximately from the San Luis Hills on the east to the Mogote topographic escarpment on the west. Testimony of E. Harmon, Jan. 31, 2018 (a.m.); Exhibit SE-323.

h. The Mesita Fault area approximately from the Colorado-New Mexico state line north to the San Luis Hills, in Costilla County. Testimony of E. Harmon, Jan. 31, 2018 (a.m.); Exhibit SE-324.

i. The RGDSS Model southeast boundary region, approximately from Fort Garland on the north to the Colorado – New Mexico State line on the south. Testimony of E. Harmon, Jan. 31, 2018 (a.m.); Exhibit SE-318.

See generally Exhibit SE-328.

85. In addition to these location-specific hydrogeologic reviews and investigations, the following hydrogeologic reviews, not specific to one location of the San Luis Valley, were performed during phase 6:

a. Documentation of development of the geographic extent of the RGDSS Model grid. Exhibit SE-319.

b. Review of the protocols for assignment of water levels where Confined Aquifer wells used for monitoring are screened across more than one layer in the Confined Aquifer. Exhibit SE-316.

c. Review of wells and areas of high model residuals, including review and evaluation of hydrogeology and individual well records in 15 different geographic areas located in the San Luis Valley. Exhibit SE-317.

86. Each of these hydrogeologic studies were relevant to and improved the hydrogeologic conceptualization of the San Luis Valley, ultimately improving the Model.

87. Two phase 6 hydrogeologic studies addressed McIntire Springs. In general terms, springs are points of discharge at which the level of the groundwater has reached the surface and the groundwater present at that location discharges and becomes surface water. There are many different types of springs in the San Luis Valley, and springs can be and often are geologically complex. There are springs that are formed where there are geologic faults, in other words, an offset or a truncation of one rock type that is set against another in the subsurface. There are springs that emanate because erosion created a topographic low point at which water is drained. There can be contact springs where one formation which is more permeable abuts a less permeable formation. Under those conditions groundwater will follow a path of least resistance upward and discharge as a spring at the ground surface. Testimony of E. Harmon, Jan. 31, 2018 (a.m.).

88. Not every spring in the Valley is included in the Model. Springs that do not flow very much or do not emanate or discharge from the San Luis Valley aquifers are excluded from the Model. For example, Joyful Journey Hot Spring, a mineral hot spring in the north end of the Valley, and Valley View Hot Spring, along the Sangre de Cristo mountain front, are not included in the Model because they discharge from a deep bedrock or a pathway that is deeper or is different from the groundwater pathways that define the San Luis Valley's Unconfined and Confined Aquifers. *Id.* On the other hand, McIntire Springs is included in the Model because it is one of the most productive springs in the San Luis Valley.

89. From a geologic perspective, McIntire Springs exists for a number of reasons. Because of the overall hydrogeology of the San Luis Valley, groundwater in the Confined Aquifer generally flows downward toward the center of the Valley at which point it begins to move upward. At McIntire Springs, the Confined Aquifer water is moving basically from the

southwest to the northeast toward the springs and the San Luis Hills. When the water encounters the low hydraulic conductivity rock of the San Luis Hills it flows in the path of least resistance, which at that location is upward. The Manassa Fault zone located in the southwestern portion of the Valley also contains different branches which elevate the hydraulic conductivity in a vertical direction in the vicinity of the spring. Exhibit SE-323. Furthermore, the talus and rubble of the San Luis Hills likely exists beneath the ground surface to some extent, which also provides a pathway for groundwater movement in a vertical direction. Testimony of E. Harmon, Jan. 31, 2018 (p.m.).

90. Because the hydrogeology of McIntire Springs was not fully understood, the PRT requested the two investigations identified above at paragraphs 84(g) and (h). The first phase 6 study of McIntire Springs, finalized in 2012, analyzed water quality testing data and compared measured flows at McIntire Springs to head pressures at the CON2 monitoring well located less than a mile and a half north of the springs. This study concluded that the water produced at McIntire Springs was sourced, at least predominantly, from the Confined Aquifer in layers 3 and 4 of the Model. *See* Exhibit SE-323; Testimony of E. Harmon, Jan. 31, 2018 (p.m.).

91. After the PRT analyzed the results of multiple rounds of review and calibration Model runs it once again determined that the RGDSS Model was not replicating the flows at McIntire Springs as well as the PRT desired. The PRT believed that the RGDSS Model could be improved through further refinement of the Model's understanding of the hydrogeology of McIntire Springs, and so initiated additional investigation.

92. In 2014, after further analysis of flow data from McIntire Springs, head pressures at the CON2 monitoring well, head pressures from RGDSS piezometer No. 3 located approximately 1.7 miles from the springs, and water chemistry data, Mr. Harmon concluded that

the amount of water discharged at McIntire Springs closely corresponded with the head in Layer 3 of the Confined Aquifer. *See* Exhibit SE-320; Testimony of E. Harmon, Jan. 31, 2018 (p.m.). As a result, Mr. Harmon recommended that the Model represent McIntire Springs as being sourced from the Confined Aquifer Layer number 3 and this was incorporated into phase 6 of the RGDSS Model, improving the calibration of the Model to McIntire Springs.

93. In addition to the hydrogeologic studies, other investigations and analyses were conducted resulting in additional enhancements to the Phase 6 RGDSS Model.

94. Additional study was conducted on the evapotranspiration of groundwater for native phreatophytes and subirrigated meadows, alfalfa, and other crops. Further analysis was also conducted regarding the evapotranspiration curves that were implemented in prior phases of the Model, and refinements to those curves were recommended. The results of these studies were incorporated into and improved the RGDSS Model. Exhibits SE-389, 390; Testimony of J. Heath, Feb. 5, 2018 (p.m.).

95. Additional study was conducted to evaluate non-irrigation groundwater uses in the San Luis Valley, including municipal and industrial wells and other non-agricultural uses. Further investigations were performed to refine the consumptive use associated with these operations. The results of these studies were incorporated into and improved the RGDSS Model. Exhibit SE-368; Testimony of J. Heath, Feb. 5, 2018 (p.m.).

96. Additional study was conducted to evaluate the groundwater uses of various state and federal wildlife areas located in the San Luis Valley, to ensure that their groundwater withdrawals were represented correctly in the Model. The results of this study were incorporated into and improved the RGDSS Model. Exhibit SE-365; Testimony of J. Heath, Feb. 5, 2018 (p.m.).

97. Additional analysis was performed to evaluate how stream inflows, rim inflows, and rim recharge are incorporated into phase 6 of the Model. This analysis was conducted because, as hydrogeologic investigations and enhancements change the geometry of the Model grid, those changes affect other aspects of the Model which then need to be evaluated and modified so the Model is congruent and represents all aspects appropriately. The results of this analysis were incorporated into and improved the RGDSS Model. Exhibit SE-367; Testimony of J. Heath, Feb. 5, 2018 (p.m.).

98. As additional and higher resolution satellite imagery data became available, the PRT evaluated the irrigated parcel data sets used in the Model. The results of this study were incorporated into and improved the RGDSS Model. Exhibit SE-373; Testimony of J. Heath, Feb. 5, 2018 (p.m.).

99. Similarly, as additional data became available, the PRT evaluated the sprinkler acreage timeline used in the Model. This evaluation resulted in a better understanding of when irrigated parcels went under sprinkler irrigation, and a better understanding of the historical consumptive use of water supplies to meet the irrigated agriculture needs throughout the San Luis Valley. The results of this study were incorporated into and improved the RGDSS Model. Exhibit SE-372; Testimony of J. Heath, Feb. 5, 2018 (p.m.).

100. Additional study was conducted to evaluate additional crop types now being grown in the San Luis Valley, but not represented in prior phases of the Model. The evaluation indicated how these crops should be represented in the StateCU (the state's crop consumptive use analysis tool) modeling, with crop coefficients and crop characteristics. The results of this study were incorporated into and improved the RGDSS Model. Exhibit SE-374; Testimony of J. Heath, Feb. 5, 2018 (p.m.).

101. Additional study was conducted to evaluate the weighting of climate station data. The PRT reviewed how the climate station weighting had historically been assigned for each ditch structure and concluded that the weighting could be revised to be more accurate. After this investigation was conducted, a more accurate method of climate station weighting was developed. The results of this study were incorporated into and improved the RGDSS Model. Exhibit SE-375; Testimony of J. Heath, Feb. 5, 2018 (p.m.).

102. Additional study was conducted to evaluate the existing StateCU process for incorporating precipitation into the overall water budget. The evaluation indicated that small precipitation events in the San Luis Valley do not go towards meeting the water demands of crops and should be discounted. The results of this study were incorporated into and improved the RGDSS Model. Exhibit SE-377; Testimony of J. Heath, Feb. 5, 2018 (p.m.).

103. Additional study was conducted to evaluate the reliability of the annual well meter data for 2009 and 2010 which was made available due to the Measurement Rules. The study found the data to be reliable and the well meter data was incorporated into and improved the RGDSS Model. Exhibit SE-492; Testimony of J. Heath, Feb. 5, 2018 (p.m.). Additional study was conducted to evaluate how to disaggregate the new annual well meter data into monthly time steps for use within the StateCU model. The results of this study were adapted for use in and improved the RGDSS Model. Exhibit SE-378; Testimony of J. Heath, Feb. 5, 2018 (p.m.). Finally, the StateCU code was enhanced to properly incorporate and process the newly available well meter data. Exhibit SE-366; Testimony of J. Heath, Feb. 5, 2018 (p.m.).

104. In addition, the modelers also enhanced the code with improvements to various pre-processors. Pre-processors are computer programs that take raw data and transform it into a format that the Model can use. Both StateFate and StatePP are pre-processors that were

enhanced in version 6 of the Model. Exhibits SE-491, 369; Testimony of J. Heath, Feb. 5, 2018 (p.m.); Feb. 6, 2018 (a.m.). StateFate is an improvement on ModFate which was developed during RGDSS phase 4. *Id.* ModFate, and the refined pre-processor StateFate "route drain flows calculated by the groundwater model and tail water calculated by StateCU to other ditches if it served as a source of surface water to another ditch." SE-369 at 2. Essentially, this program mimics the way farmers actually use their water by maximizing the use of surface water sources including drain and tail water sources before they turn on their pumps, because pumping groundwater is more expensive than irrigating with surface water. There were also enhancements to StatePP, which is the pre-processer that builds the input data sets for most of the MODFLOW packages, as well as to StateCU that improved the accuracy and efficiency of the Phase 6 Model.

105. The Division of Water Resources ("DWR") is constantly improving the reliability of the data sets used in the RGDSS Model by improving the reliability of data collection, data processing, and data estimation and DWR is constantly improving the software packages used in the Model. Ultimately, all of this work improves the overall reliability of the RGDSS Model.

106. These enhancements were based on work that began in 2009 at the end of the Subdistrict No. 1 litigation. Testimony of W. Schreüder, Feb. 6, 2018 (a.m.). Phase 6 fieldwork and data collection for enhancements to the Phase 6 Model were completed in late 2013. Testimony of M. Sullivan, Feb. 7, 2018 (p.m.). After field work concluded, the PRT evaluated the data and incorporated the new information into the Model where appropriate. *Id.* In September 2014, the PRT met to evaluate the Model results and the group accepted the then-current Model as reasonably calibrated and appropriate for use in these Rules. Testimony of M. Sullivan, Feb. 7, 2018 (p.m.); Testimony of W. Schreüder, Feb. 7, 2018 (a.m.). No PRT member

attending that meeting disagreed with that conclusion. *Id*. From that time until the Rules were finalized, the modelers made minor adjustments to the Model, but their primary task was to carefully apply the Model to evaluate the impacts of groundwater withdrawals from Response Areas and to develop the Response Functions for use in the Rules. Testimony of J. Slattery, Feb. 1, 2018 (p.m.); Testimony of W. Schreüder, Feb. 7, 2018 (a.m.).

107. As this Court and others have noted, no groundwater model is perfect and all can be refined and improved, but that does not mean the Model is not an appropriate tool or cannot be used appropriately. *See Kuiper v. Well Owners Conservation Ass'n*, 490 P.2d 268, 278–79 (Colo. 1971); New Use Rules Decree at ¶ 375; Subdistrict No. 1 Decree at ¶¶ 97–98 (May 27, 2010).

D. Planned Future Improvements to the Model

108. In the past, the State Engineer has represented to this Court that his office will continue to work to improve and enhance the RGDSS and the Model. The State has already identified several areas where additional data collection and refinement is necessary; some of this work has already begun and more will be completed as part of phase 7 of the RGDSS. Testimony of E. Harmon, Jan. 31, 2018 (p.m.); Testimony of W. Schreüder, Feb. 7, 2018 (a.m.); Testimony of M. Sullivan, Feb. 7, 2018 (p.m.). While the phase 7 studies are important, it was not possible to complete those studies, incorporate their results into the Model, refine and calibrate the Model with that data and still promulgate the Rules within a reasonable time period. Testimony of M. Sullivan, Feb. 7, 2018 (p.m.).

109. One area of on-going work to be completed in phase 7, is investigation of the hydrogeology in upper La Jara Creek. The State Engineer has contracted with Mr. Harmon to conduct geologic studies of that area to collect additional data and perform additional analyses, including assessing whether La Jara Creek is perched in its upper reaches and if there is a local,

shallow groundwater system separate from the regional Confined Aquifer System. Testimony of W. Schreüder, Feb. 7, 2018 (a.m.); Testimony of M. Sullivan, Feb. 7, 2018 (p.m.). Dr. Schreüder provided extensive testimony on how the Model responded to small changes in hydraulic conductivity in the upper La Jara Creek area during Model calibration and that, because of certain anomalous results, the Model is not currently capable of reliably predicting Stream Depletions to that area. Testimony of W. Schreüder, Feb. 6, 2018 (p.m.); Exhibit SE-721. And, as explained by Mr. Slattery, the remainder of La Jara Creek actually gains flow due to return flows from Confined Aquifer groundwater irrigation. Testimony of J. Slattery, Feb. 2, 2018 (a.m.).

110. The State has also identified a need to improve and refine how the Phase 7 Model represents Russell Springs and Arroya/Diamond Springs. Due to a lack of funds, the State Engineer requested and the Rio Grande Water Conservation District agreed to budget $50,000 for additional work in the Arroya/Diamond Springs area, including drilling a test well and potentially installing one or more monitoring wells. Testimony of M. Sullivan, Feb. 7, 2018 (p.m.); Testimony of C. Simpson, Feb. 7, 2018 (a.m.). The State Engineer plans to have further geologic investigations made in the area around Russell Springs and to review existing data, and, based on this work, to make a recommendation as to whether additional data collection is necessary in that area. Testimony of M. Sullivan, Feb. 7, 2018 (p.m.). The State also plans to continue additional geologic study of the Costilla Plain. *Id*. Pursuant to the terms of stipulations reached with various Protestors, the State has also agreed to pursue other work tasks to evaluate the Model. *See, e.g.* Stipulation Between State Engineer and El Codo Ditch Co., Llano Ditch Co., Las Sauces Ditch Co., and Chavez Ditch Co. (January 25, 2018). All of this is planned in

phase 7, in addition to general Model updates, such as additional years of metered pumping data and extending the transient simulation period to at least 2015. *Id*.

111. The State Engineer is also planning to develop a stand-alone groundwater model representing the area of the Rio Grande alluvium above the Del Norte gage. Testimony of M. Sullivan, Feb. 7, 2018 (p.m.). This area is outside the RGDSS Model Domain where there is no established method to determine Stream Depletions from groundwater withdrawals. The Rio Grande Water Conservation District is working with the Colorado Water Conservation Board to fund the development of a groundwater model to reliably calculate Stream Depletions from groundwater withdrawals in this area. Testimony of M. Sullivan, Feb. 7, 2018 (p.m.); Testimony of C. Simpson, Feb. 7, 2018 (a.m.). This model is planned to border the RGDSS Model Domain, but will not be part of the Model. Testimony of M. Sullivan, Feb. 7, 2018 (p.m.).

112. Rule 24 specifically contemplates these types of work and improvements. Because the Rules contemplate that the State will continue to improve and refine the Model, the current 6P98 version of the Model is not determinative of the Response Functions that will be used under the Rules in the future. Instead, the State Engineer will continue to update the Response Functions using enhanced versions of the Model. Thus, predicted future Stream Depletions may be different from those predicted by the current Response Functions. The Court expects the State Engineer to continue the open and public process of enhancing the RGDSS and the Model and generating updated Response Functions.

E. <u>Calibration of the Model</u>

113. The essential purpose of a groundwater model is to reliably estimate things that cannot be directly measured because if something can be directly measured, there would be no need to use a model to estimate its value. But, to have confidence in the values the Model predicts for the things that cannot be directly measured, the Model must correctly predict

historical conditions that have measured values. Calibration is the process of adjusting aquifer parameters that are not known with precision, within reasonable limits based on the best scientific evidence available, to obtain output from the Model that most closely replicates the actual, observed and measured historical hydrologic conditions. Testimony of W. Schreüder, Feb. 6, 2018 (a.m.).

114. The aquifer parameters that are adjusted are often difficult to directly measure or estimate with a high level of confidence--for example the hydrogeologic properties of the aquifer such as the porosity and permeability (or hydraulic conductivity) of the aquifer's material. Exhibit SE-280; Testimony of E. Harmon, Jan. 30, 2018 (p.m.). (This value is K in the equation representing Darcy's Law.) In the calibration process, the modelers adjust the aquifer parameters within estimated or expected ranges for each parameter. Then the Model is run for a specific period of time and the results are compared to actual historical field observations of readily measurable data—*e.g.* groundwater levels (which are H_1 and H_2 in the equation representing Darcy's Law), and to values that can be reliably estimated, such as baseflow and stream gains (which is Q in the equation representing Darcy's Law), to evaluate how well the Model replicated the way the hydrologic system actually worked.

115. An adequate number of scientifically reliable observations are necessary for calibration because they form the bases for evaluating the accuracy of the Model's predictions. Moreover, the calibration period must have a sufficient quantity of scientifically reliable data to produce a model that can make reliable predictions. Testimony of W. Schreüder, Feb. 6, 2018 (p.m.).

116. Therefore, one of the first steps of model calibration is a review of the scientific reliability of the observed data to which the Model is calibrated. Testimony of W. Schreüder,

Feb. 6, 2018 (a.m.). In this case, as part of the calibration process, the PRT extensively reviewed available observed data to determine whether that data was sufficiently reliable to be used in the Model. Testimony of E. Harmon, Jan. 30, 2018 (p.m.); Testimony of W. Schreüder, Feb. 6, 2018 (p.m.).

117. One of the most important kinds of observed, historical data that the modelers used to calibrate the Model are stream baseflow measurements. Stream baseflow is the gain or loss to a stream caused by the stream's interaction with groundwater or, as Dr. Schreüder described it: the flux from the aquifer to the river and from the river to the aquifer. Stream baseflow is calculated by subtracting the gaged streamflow at an upstream gaging station from the total of the gaged streamflow at a downstream gaging station plus the amount of water diverted out of the stream between the upstream and downstream gaging stations. Stream baseflow also does not include any surface runoff caused by precipitation or unusually large tail water runoff from an unusual irrigation practice. Such water is separated from the calculation of the stream's baseflow.

118. Numerous smaller streams in the San Luis Valley do not have upstream and downstream gaging stations. The modelers still made estimates of the historical flow of those streams by looking at other data the Division Engineer has collected including diversion records and records of when water arrived at the Rio Grande or Conejos from the side tributaries.

119. Stream baseflow is a target for calibration of the Model because it is the Q, or groundwater flow that the Darcy's Law equation calculates. The modelers run the Model simulating historical conditions and determine the amount of baseflow (gains or losses to the stream caused by groundwater) that the Model predicts will have affected different stream reaches during various historical periods and then compare the Model's estimate to the actual,

measured stream baseflow (or gains and losses) for those reaches for those historical periods. It is important that the Model accurately predict actual stream gains and losses because the Model is then used to predict Stream Depletions (losses) that were and will be caused by groundwater pumping.

120. Another type of historical data the modelers used to calibrate the Model was observed groundwater levels. It is impossible to calibrate a groundwater model without groundwater level measurements. Testimony of James Slattery, Feb. 1, 2018 (p.m.). The modelers obtained historical groundwater level measurements from data collected from observation wells drilled into the Confined and the Unconfined Aquifers throughout the San Luis Valley.

121. Under reasonable and standard engineering practice, if the Model accurately predicts historical stream baseflow measurements and if it accurately predicts historical groundwater levels, that means the Model is reliable and the modelers have properly incorporated the geological and hydrographical features from the real world into the Model. Such a result means that the Model is properly calibrated. Testimony of James Slattery, Feb. 1, 2018 (p.m.).

122. An appropriate time period to calibrate a model is one where there is good, reliable data on things like recharge, well-pumping, etc., to populate the model, and where there are good, reliable observations for groundwater levels and baseflow estimates to which the model can be calibrated. If there is insufficient scientifically reliable observation data in a given time period, a model should not be calibrated to that time period. Testimony of W. Schreüder, Feb. 6, 2018 (p.m.).

123. Although there were some Unconfined Aquifer observation wells prior to 1970, there were almost no Confined Aquifer observation wells prior to that time. Exhibit SE 720. And, there were not a significant number of Confined Aquifer observation wells until the late 1980s. Because of this, the modelers chose the calibration period for the 6P98 Model to run from 1970 through 2010, with a greater emphasis on the data from 1988 forward. Testimony of James Slattery, Feb. 1, 2018 (p.m.).

124. Although the modelers rely more heavily on the period beginning in 1988 for predicting Stream Depletions, both the calibration period and the transient simulation cover the period 1970 to 2010. Testimony of W. Schreüder, Feb. 6, 2018 (p.m.). During calibration, the Model is run for the period 1970 through 2010, and the Model's predicted values are compared to the actual observed data, such as groundwater levels or heads. Testimony of W. Schreüder, Feb. 6, 2018 (p.m.); Exhibit SE-717.

125. Calibrating the Model involves making adjustments to model parameters to reduce the difference between the Model's prediction for a certain measurement and the observed, historical value for that measurement. The difference between the Model's prediction and the observed value is called the "residual." The PRT reviewed and evaluated the residuals from Model runs. For those areas where the PRT determined that the Model's predictions did not sufficiently replicate the measured observations, the PRT changed aquifer parameters to attempt to improve the calibration and, if necessary, the PRT reviewed additional data or had additional studies conducted to try to understand why there was inadequate calibration at a particular location and what scientifically justified changes could be made to improve that calibration.

126. For example, the PRT asked Mr. Harmon and HRS Water Consultants, Inc., to study the hydrogeology of the Rio Grande as it runs from Del Norte to the Alamosa-Rio Grande County line. The PRT had determined that there were differences in what the RGDSS Model predicted and the actual data for water levels in the area. Essentially, the amount of loss in streamflow actually seen in this reach of the Rio Grande was much smaller than the modelers expected given the coarse, permeable deposits they expected to see in the alluvial fan of the Rio Grande at this location. Mr. Harmon investigated the situation, first by reviewing well logs to determine if there was some fine-grain or low permeability layer in that area that was inhibiting the downward leakage of water they expected to see. But, he found nothing like that in the well records. So then he went out to that area and visited many sites along the river and hand dug numerous test holes into the riverbed to see what the material was. In these test holes, Mr. Harmon found cobbles and boulders but also found a fine-grained material that appeared to fill in around the coarser materials and that was less permeable. He then did a couple of permeability tests and ultimately concluded that there was a layer of low permeability material that underlay the Rio Grande in this reach. As a result of these studies, Mr. Harmon recommended that the PRT revise the RGDSS Model in this area to show a lower streambed conductance. The PRT was skeptical of Mr. Harmon's results and asked him to return and do a more intensive study of the area with twenty test holes. Mr. Harmon used a small drilling rig to drill these test holes and collected a core of the sediments in each test hole. After reviewing and testing these samples, Mr. Harmon concluded that there was a lower permeability layer beneath the streambed of the Rio Grande throughout this location and he again recommended to the PRT that the river streambed conductance for this area of the Rio Grande be reduced. With this information, the PRT agreed to make the changes and the RGDSS now better replicates what was being observed

as to gains and losses in this stretch of the Rio Grande. Testimony of Eric Harmon, January 31, 2018 (a.m.).

127. Although it is appropriate to change aquifer parameters when there is physical evidence to support such a change, aquifer parameters cannot be changed merely to reach some desired result. To do that would not result in a scientifically valid model. Instead, the modelers only change aquifer parameters when there is a valid, data-driven reason to do so. The PRT applied a rigorous, data-based, and scientifically valid approach to calibration. Testimony of W. Schreüder, Feb. 6, 2018 (p.m.).

128. Previous versions of the RGDSS Model were calibrated by manually changing calibration parameters and then re-running the Model and comparing the predictions to the observations. The modelers, however, calibrated the 6P98 version using the parameter estimation program known as PEST, which is a contraction of **P**arameter **EST**imation. PEST is a widely used and scientifically reliable method for calibrating groundwater models as well as for estimating parameters in other types of environmental modeling. The actual version of PEST that the modelers used on version 6P98 of the RGDSS was BeoPEST which is a variant of PEST that Dr. Schreüder wrote to make it more suitable for parallel processing on tens of thousands of computers at once. Although the modelers also used BeoPEST (hereinafter "PEST") to help calibrate phase 5 of the Model, they could only run the program on the steady-state model of that version because at that time there was not sufficient computational power available to them to run it on the more complex transient model. Now, however, there is sufficient computational power available to the modelers so they were able to run PEST on the entire RGDSS transient Groundwater Model.

129. To calibrate the Model using PEST, the modelers begin by making a Model run and then calculating the residuals for each observation versus Model prediction. Then each residual is multiplied by a weight. The PRT weights the residuals for three reasons. First they assign weights to various residuals to allow PEST to use values that may be in different units, *e.g.* acre feet versus cubic feet per second (c.f.s.). They also assign weights to give greater weight to measurements the PRT believes are more reliable. Finally, they assign weights to give greater weight to measurements the PRT believes are more important, *e.g.* it is more important to match X observation with the predicted values than it is to match Y observation. The PRT assigns a weight to more than 100,000 observations that PEST deals with. Then PEST applies a mathematical formula to these weighted values and comes up with something called the "objective function."

130. The objective function is a measure of how well the Model's predictions match the observation data, which are called "targets" in PEST nomenclature. The goal of PEST is to achieve the smallest possible objective function. If the Model were perfectly calibrated, the objective function would be zero, which would mean there was no difference between the predictions and the observations or targets. Testimony of W. Schreüder, Feb. 6, 2018 (p.m.). PEST attempts to calibrate the Model against all of the various measurements and observations—or the targets—by altering aquifer parameters, such as hydraulic conductivity. PEST adjusts parameters but it does not change observations, it only tries to match them.

131. Since PEST is an automated calibration process, the modeler supplies the initial value limits on PEST's ability to alter parameters and weighting factors for observed data. The PRT determines what the possible range of values is for each parameter based on information obtained from hydrogeologic studies. Within these limitations, PEST then applies an algorithm

to adjust parameters and evaluate the results against the observations or targets. Essentially, PEST takes the 1,250 parameters in the Model and increases and decreases them to see how the objective function changes in an effort to get the lowest objective function, thus indicating the best match with the actual hydrologic system. Each time PEST adjusts a parameter, the Model must be run again. PEST adjusts each parameter both in the positive and the negative direction to get the best fit and obtain the lowest objective function. It requires about 2,500 computer hours to complete one run-through of the calibration with PEST. Although this would be more than 100 days of work if each of these Model runs was done consecutively, because the modelers have significant parallel computing power available to them, they can run this PEST calibration in approximately a day. This process must be repeated a number of times to complete the PEST calibration, ultimately running the Model about 10,000 times and taking approximately three to five days. The goal of all these PEST runs is to find the best set of parameters that explains the particular combination of observations and input data in the Model.

132. This process is complex but it is more efficient than manual calibration. When completed, PEST provides a set of parameters that the modelers can use to run the Model for its predictive purposes. In addition, PEST provides an output file with a large amount of information about what PEST did, including how well each of the predictions matched the observations, the sensitivities of the various parameters and other information which the PRT uses to evaluate whether the calibration PEST has supplied is reasonable. Testimony of W. Schreüder, Feb. 6, 2018 (p.m.).

133. The PRT and the State Engineer do not simply accept PEST's calibration and the resulting predictive results for the RGDSS Model. Instead, the PRT closely analyzes and questions the results. In one situation that Dr. Schreüder discussed at length, the PRT determined

that PEST's attempt at calibration and the resulting Model predictions about an area on La Jara Creek were not sufficiently reliable and the State Engineer is continuing work in this area to improve the Model's predictions. Testimony of W. Schreüder, Feb. 6, 2018 (p.m.). *See also* discussion above at ¶ 109.

134. Finally, calibration must address the issue of a non-unique solution to the groundwater equation. One of the problems that modelers face is that they have a finite set of observation data to use for calibration, which raises a concern that the final calibration – that is the final parameter values – are not unique and that there is an alternative set of parameters that would give the same prediction. Testimony of W. Schreüder, Feb. 6, 2018 (a.m.). Groundwater modelers address the non-uniqueness problem by using a sufficiently long period of time for calibration that encompasses varying hydrologic conditions, from wet to dry. Using such a time period results in a solution which the modelers can be confident is as unique as possible and for which the parameters are reasonable. *Id*. The time period used to calibrate the 6P98 RGDSS Model is of sufficient length and contains sufficient hydrologic variability to provide confidence in the uniqueness of the solution to the groundwater equations.

135. The evidence presented at trial shows that overall calibration of the Model to heads or groundwater levels around the Valley has steadily improved since the Phase 4 Groundwater Model, and the Model's predictions match the observations with reasonable accuracy. Testimony of W. Schreüder, Feb. 6, 2018 (p.m.); Exhibit SE-495. The RGDSS Model is also calibrated to stream gains and losses. The modelers derive gain and loss targets for streamflows from data developed through the peer review team process. Testimony of J. Slattery, Feb. 1, 2018 (a.m.; p.m.); Testimony of W. Schreüder, Feb. 6, 2018 (p.m.). Calibration of the Model to these gains and losses has also improved over time and the Model predicts these gains

and losses with reasonable accuracy. Testimony of W. Schreüder, Feb. 6, 2018 (p.m.); Exhibit SE-509. The 6P98 version of the RGDSS Model is reasonably calibrated and appropriate to use for the development of Response Functions for use under the Rules.

136. The Model makes separate calculations for each model cell within the Model Domain and those individual calculations affect the calculation of Stream Depletions. Not every cell in the Model has a specific target or calibration point, but a reasonably calibrated model can be applied to calculate water levels in locations throughout the model, not just individual calibration targets. Some features such as springs, however, are unique hydrogeologic features. This means that a reliable representation of properties of a spring, such as conductance, cannot be inferred without site-specific calibration, *i.e.* observation data. In the case of McIntire Springs, the PRT initiated two studies to verify the conceptual hydrogeologic model for, and the data used to calibrate the Model to the flow at, McIntire Springs. Testimony of W. Schreüder; Testimony of E. Harmon, Jan. 31, 2018 (p.m.). Such studies have not been conducted on Russell or Arroya/Diamond Springs.

137. In addition, Arroya/Diamond Springs is not correctly located in the Model. Its modeled location is one grid cell to the north and two grid cells to the east of the springs' actual location. Nevertheless, the evidence at trial demonstrated that the Model reasonably accurately replicates the anecdotally reported and observed behavior of these springs during the period 1970 to 2010. While Mr. Slattery and Dr. Schreüder testified that the Model predictions of the flows at Russell and Arroya/Diamond Springs were reasonable based on the information available, the evidence also established that currently there is not sufficient reliable site-specific data to calibrate the Model to the flow at these springs. This lack of data means the springs cannot be used as calibration points in the Model. Therefore, at the present time the State Engineer has no

reliable basis upon which to either calculate Stream Depletions due to groundwater withdrawals to these two springs or to require groundwater users to make replacements for the depletions, if any, to the springs.

F. Model Update Process

138. Updating the Model with new observation data is a complex and time-consuming series of tasks. It takes a minimum of 18 months and can take as long as three years to update the Model with a new year's worth of observation data. The process involves significant data collection and data processing, as well as quality assurance and quality control efforts at many different steps. Since the Model operates on a calendar year basis, the Model can only be updated when data is available for each month of the calendar year. Testimony of J. Heath, Feb. 5, 2018 (p.m.).

139. The first step in updating the Model is collecting the necessary data. Updated streamflow and diversion records are published approximately nine months after the end of the water year. Since the water year for both DWR and the United States Geological Survey ("USGS") stream gages runs from October 1st to September 30th, the final streamflow data through September is generally available in June of the following year. Data for the last three months of that calendar year, however, is not available until June of the next year, approximately 18 months after the end of the calendar year of the Model update.

140. Similarly, final diversion records which are kept for an administrative water year that runs from November 1st through October 31st are generally available in June of the following year. But, data for the last two months of that calendar year is not available until June of the next year, again, approximately 18 months after the end of the calendar year of the Model update. Since irrigation diversions are minimal in November and December, both because of minimal or no crop irrigation requirements and because of compact administration, historical diversion

records can be used to estimate diversions for those last two months, until final data is available for the last two months of a given calendar year.

141. The modelers obtain information about the crops grown in the San Luis Valley from the National Agricultural Statistics Service crop land data layer which is typically available at the end of January of the year following the calendar year of the Model update. The modelers also use satellite imagery to help determine what crops are grown in the Valley and that imagery is typically available at the same time. The modelers process this information to create an irrigated parcel dataset which generally takes until approximately June of the year after the end of the calendar year of the Model update.

142. The modelers obtain climate data from PRISM (Parameter-Elevation Regressions on Independent Slopes) which is the United States Department of Agriculture's climatological dataset. This data is finalized six months after the end of the calendar year, so the final data set is also available at the end of June of the following year.

143. Thus, much of the data to update the RGDSS Model for an additional year is available by the end of June of the year following the end of the Model update year, although the modelers may have to estimate some data for October, November, and December until the finalized data becomes available during the next calendar year.

144. The modelers then process certain kinds of data through the TSTool or Time Series Tool. They use that tool to pool information such as stream gage data, temperature data, precipitation data, and diversion records—all of which record occurrences that happen at a certain point in time: daily, monthly or annually. The modelers process other data that is non-time series data, such as information relating to the latitude and elevation of a climate station, more complex information about the way water is applied under a ditch, the number of crops,

and the number of lands that are irrigated by flood and sprinkler irrigation, through a software product called StateDMI. There are more than 150 command files that process this information, and each of these files must be updated to process the new data. This is an iterative process also involving quality assurance and quality control of the data and output to identify questionable or missing data and to correct that data or possibly acquire the data from a different source. This TSTool/StateDMI process takes approximately three months if everything goes smoothly; but it can be longer if new versions of the software products must be used, as is sometimes the case.

145. The modelers must also perform spatial data processing, which involves operating the CDSS Toolbox scripts and the StateDGI database program. CDSS Toolbox processes Geographic Information System (GIS) data and allows the modelers to intersect spatial data about the size and location of a water feature, *e.g.* a ditch, with other spatial information such as soil properties, and evaluate how these combined spatial data affect water movement, for example by determining ditch loss over the length of a ditch. StateDGI (Data-centered groundwater model interface) then takes the information generated from CDSS Toolbox and stamps that data into a cell or cells in the model grid so the Groundwater Model knows where ditches, streams and wells exist. As with the time series data processing, significant quality assurance and quality control occurs at many stages. The modelers process data through CDSS Toolbox scripts and the StateDGI database at the same time they are working with TSTool and StateDMI.

146. The modelers then take the information from TSTool, StateDMI, CDSS Toolbox and StateDGI and use it in the StateCU crop consumptive use analysis. To update the Model with a given calendar year of data, the StateCU analysis would be complete in roughly October of the following year.

147. The next step in the data update process is to build out the input files for StatePP, utilizing information processed by StateFate. Both StatePP and StateFate are pre-processors as described in paragraph 104 above. StatePP can usually be run within a month or two, so all of the data is generally processed and ready to be input into the Model a full year after the end of the calendar year for which the Model is to be updated.

148. The next step is to calibrate the Model to the additional year of data and run the historical run for the Model, which typically takes a couple of months, so this would be completed by the end of March of the second year after the end of the calendar year that is being modeled. The results of this Model run, as well as the results of the StateCU run, are then shared with the PRT, which evaluates and critiques the results. If the process goes smoothly, this meeting will take place in approximately April of the second year after the end of the calendar year that is being modeled.

149. If the PRT is satisfied with the results, the next step, as part of the StateFate program, is to pass the new drain flow file that the Model has calculated back to StateCU. This process is intended to properly account for the fact that the drains intercept groundwater when the groundwater tables are high and to account for the way farmers downgradient from an original irrigator will use the return flows that result when the original irrigator over-irrigates certain parcels. In the real world, farmers utilize these surface water sources, their cheapest water supplies, before turning on their wells, so, the Model must account for this by maximizing surface water sources, drain water sources and tail water sources before determining how much groundwater will be diverted. To properly calculate this, the modelers re-run StateFate and StateCU, repeatedly, to account for all the drain and tail water before estimating actual groundwater withdrawals. This iterative process is necessary to maximize the surface water

sources, drain water sources, and tail water sources to mimic how farmers actually operate their farms and ranches.

150. This process could take a month more, and then it would take another month to reprocess with StatePP, re-calibrate the Groundwater Model, and regenerate the historical run for the Model. So, the modelers will have completed these processes by approximately June of the second year following the end of the year being modeled.

151. The next step is to make impact runs (absence of historical pumping) for each Response Area to evaluate the groundwater operations' impacts on the streams. That process takes approximately another month, at which point the Excel Response Function spreadsheets are calibrated to the Model output. These steps take place over a couple more months and could be completed and ready for final review by the PRT in August or September, approximately 20 months after the end of the calendar year that is being updated in the Model.

152. This timeline is a best-case scenario for updating the Model with a new year of data. In circumstances where that new year of data also includes new data sources, such as the metered well pumping data that first became available in 2009, the PRT's review process could take significantly longer, up to an additional 12 to 24 months.

153. Because of the length of time that this data update process entails and the deadlines for including updates in phase 6, the Phase 6 RGDSS Model only includes data through 2010. DWR staff continue to work on the RGDSS Model, preparing data and updates for phase 7.

G. <u>Response Functions</u>

154. As this Court previously noted in the Subdistrict No. 1 Decree and as the evidence shows in this case, the RGDSS Model is a large and complex model that requires powerful computers to operate and requires highly experienced experts to properly set up and run it. In

addition, the Model makes its most accurate and reliable predictions when it is used to simulate extended time periods. As a result, it is impractical to run the Model to make the kind of monthly predictions of Stream Depletions that the Division Engineer needs to administer groundwater in Water Division No. 3 and that groundwater users need to be able to fashion appropriate augmentation plans and subdistrict annual replacement plans to operate subdistrict plans of water management.

155. Response Functions are a simplified form of the output from the RGDSS Model that can be used to calculate monthly Stream Depletions caused by groundwater diversions without the need to make frequent runs of the RGDSS Model. The procedure used to develop the Response Functions is summarized in Exhibit SE-339. In the Subdistrict No. 1 Decree, this Court approved the use of Response Functions to determine the amount, place and time of the injurious depletions that Subdistrict No. 1 was required to replace with each of its Annual Replacement Plans. Now, the Rules rely on the use of Response Functions to determine Stream Depletions from the net consumptive use of groundwater by wells in each Response Area.

156. The PRT divided Water Division No. 3 into seven Response Areas: Conejos, Alamosa-La Jara, Rio Grande Alluvium, Response Area No. 1, Saguache, San Luis Creek, and Trinchera. The goal in creating the Response Areas was to make them small enough to group together wells that would have similar characteristics as far as the streams they would affect but large enough that the Response Functions were reliable given the nonlinearity of the groundwater system in the San Luis Valley. All the Response Areas, except the Rio Grande Alluvium, include both unconfined and Confined Aquifer wells; the Rio Grande Alluvium Response Area only includes Unconfined Aquifer wells because these wells are drilled into the alluvium of the Rio Grande and they behave very differently from other wells in the basin.

Response Area No. 1 includes all of Subdistrict No. 1 plus some additional land where there were wells that had similar characteristics to the wells that were already a part of Subdistrict No. 1.

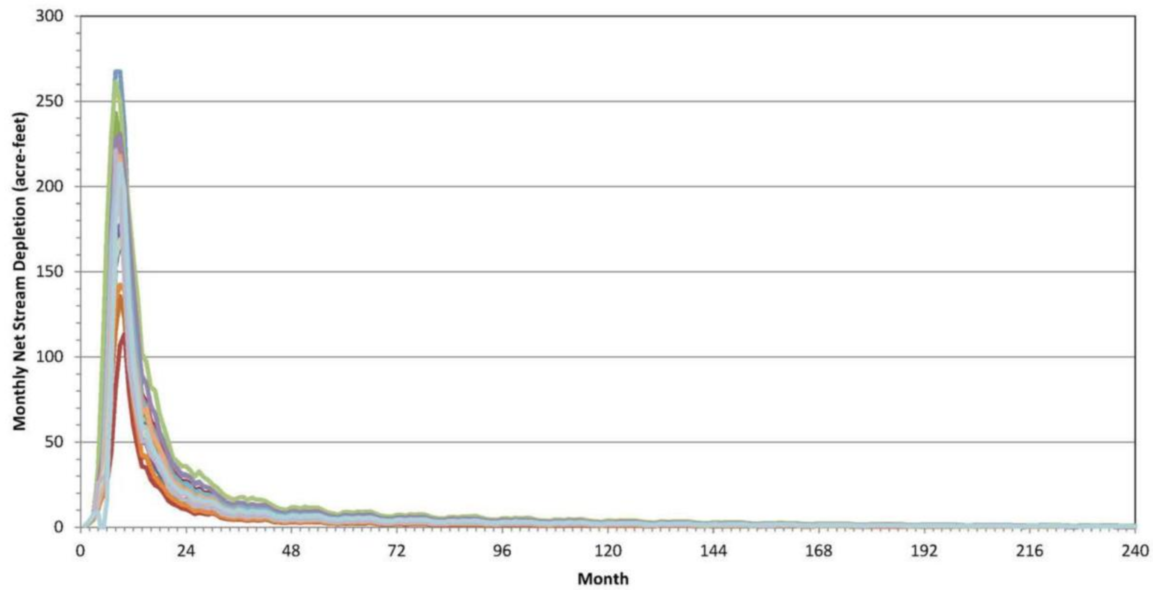
157. The Response Functions allow a prediction of the current and future effect of groundwater pumping occurring in a geographic Response Area on various streams in the San Luis Valley. The Response Functions are Excel spreadsheets which any water user or subdistrict can use to determine their wells' *pro-rata* share of the total Stream Depletions that all the wells in the Response Area are causing. Because groundwater travels very slowly through the aquifer system, the Response Functions calculate not only the effect of the current year groundwater diversion on a stream but also the lagged effects over a period of twenty years. Furthermore, because the San Luis Valley groundwater system is non-linear, the effects of groundwater diversions on streams will be different (and not proportionately so) depending on the level of precipitation during the year. So, the modelers created different Response Functions to be used when a year is predicted to be dry, average or wet.

158. The modelers use two different techniques to generate the Response Functions. For streams that typically flow year-round for their entire length within the RGDSS Model Domain, the modelers use the "2009 Method." This name refers to the technique this Court approved for use in the May 27, 2010, Subdistrict No. 1 Decree. Exhibit SE-339 at 10. The second technique is called the "Ratio Method" and it is used to generate Response Functions for streams that do not have continuous live flow throughout their entire length in the RGDSS Model Domain. Examples of such streams are Saguache Creek, Trinchera Creek, and the Alamosa River. *Id.* at 10-11.

159. The 2009 Method uses the period 1988 to 2010 to generate Response Functions. The modelers chose this time period because there were a wide variety of average, wet, and dry years during that time and because by 1988 there had been a series of wet years which had filled the aquifers. There are 23 years in this time period and the modelers created 23 impulse curves by making two different Model runs for each of these years. First, for each one of these years, the modelers ran the Model for each Response Area with historical pumping[5] followed by 19 years of average hydrologic conditions. Next, for each of these 23 years, the modelers made a Model run for each Response Area with no net consumptive use of groundwater—this is the "no pumping" run—followed by 19 years of average hydrologic conditions. The difference between these two different model runs is referred to as the impulse curve or the impulse run and it quantifies the Stream Depletions the Model estimated. The predicted Stream Depletions include the depletions that occur in the first year of pumping plus the lagged depletions over the next 19 years. The 23 impulse curves for the portion of the Conejos Response Area, called CON-2 (Conejos River below Seledonia/Garcia Ditches), are shown on the graph below which is taken from page 24 of Exhibit SE-0652. The modelers did the same thing for each of the Response Areas.

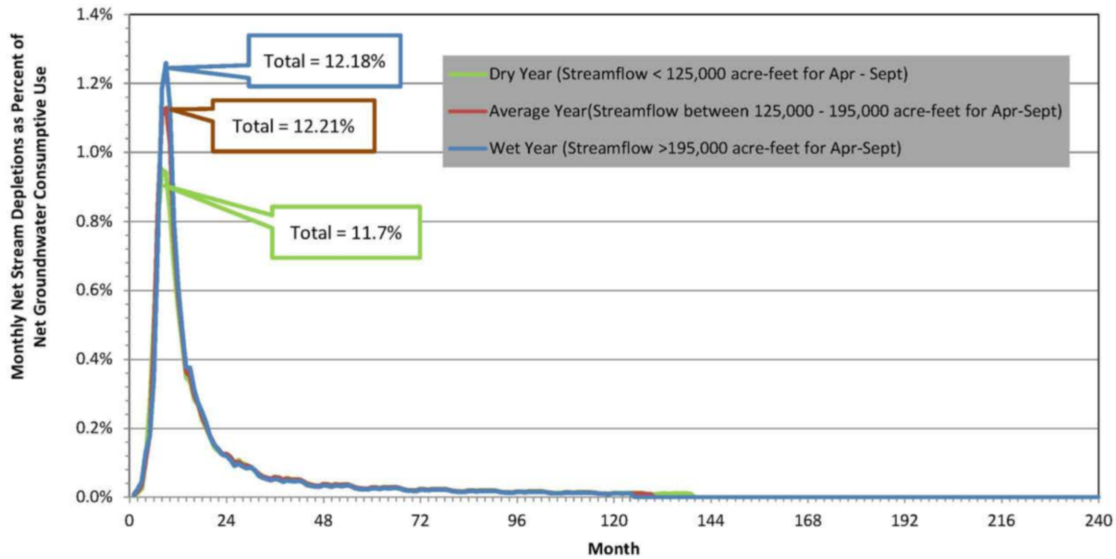
[5] The modelers actually input net groundwater consumption which is less than total pumping. The modelers estimate that 60 percent of groundwater that is pumped for flood irrigation is consumed and that 83 percent of groundwater that is pumped for sprinkler irrigation is consumed. The remaining 40 percent and 27 percent respectively is return flow.

Figure 1: RGDSS Groundwater Model Impulse Run Used to Generate Response Functions, One Curve Per Year for 1988-2010



160. The modelers then take the resulting 23 impulse runs and categorize whether they were for an average, wet, or dry year for the stream involved. The impulse runs for these different hydrologic conditions are then used to derive the "curve" for the Response Function for average, wet, and dry hydrologic conditions. The following graph shows the Response Functions as determined for the average, wet, and dry hydrologic conditions in the Conejos Response Area called CON-2 (Conejos River below Seledonia/Garcia Ditches) (taken from page 25 of Exhibit SE-0652). The percentages listed on the graph indicate the amount of Stream Depletions that will occur over 20 years as the result of net groundwater consumptive use in a wet year, an average year and a dry year. So, for example, if one pumps a well causing a net groundwater consumptive use of 100 acre feet in a wet year in the Conejos Response Area, that will cause a depletion to the stream of 12.18 acre feet over the course of the next twenty years—with the majority of the depletions occurring in the first two years.

Figure 2: Response Functions for Dry, Average, and Wet Years - Net Stream Depletions as a Percent of Average Net Groundwater Consumptive Use



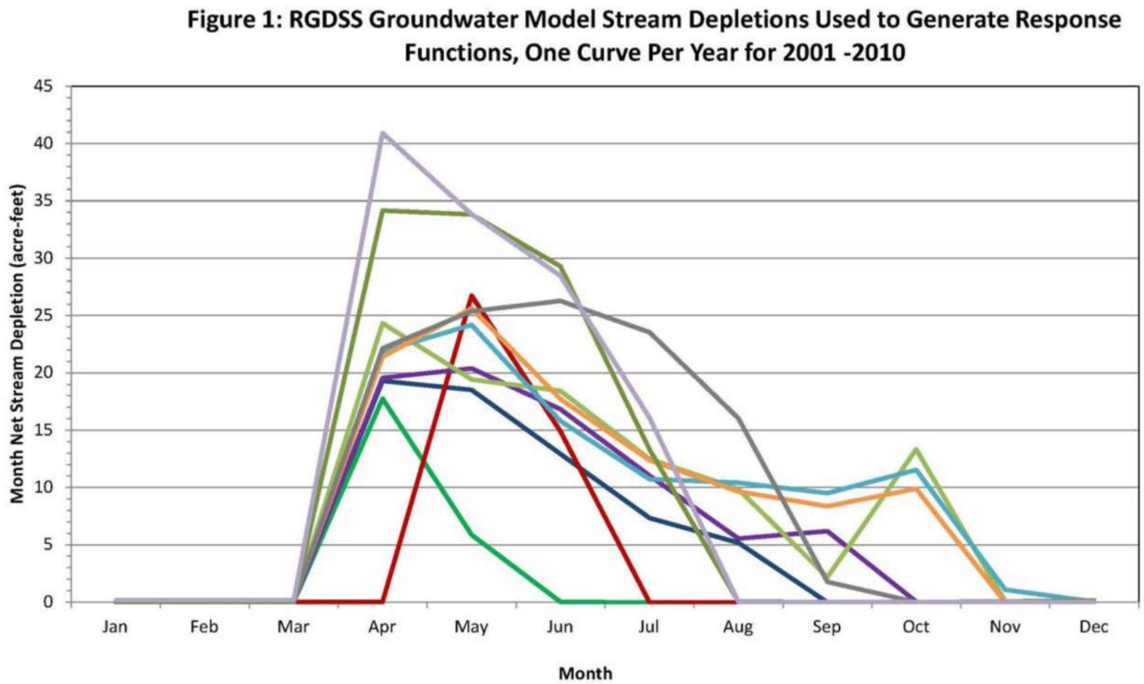
161. These total depletion percentages do not equal 100% because, in the San Luis Valley, the hydrologic system is not linear and all the net groundwater consumptive use does not affect a stream. One of the reasons for this is that if the wells were not pumping, native plants, alfalfa and other subirrigated crops would be removing some of the groundwater and keeping it from arriving at the stream. Also, although the total percentage of net Stream Depletions for wet, average and dry years in the Conejos Response Area are similar, there are dramatic differences in these percentages for some of the other Response Areas. Testimony of James Slattery, Feb. 1, 2018 (p.m.).

162. To ensure that the Response Functions reasonably replicate the Model's predictions, the modelers compare the Stream Depletions that the Response Functions predicted to the Stream Depletions the Model predicted and then the Response Functions are calibrated or "scaled" to more precisely mimic the Model's predicted Stream Depletions. The modelers had to "scale" the results mainly because of the nonlinear behavior of groundwater in the San Luis Valley—because there is only a finite amount of water in the system and if you aggregate the

lagged groundwater Stream Depletions predicted for all the response areas you would over-predict the depletions. A detailed example of this process is contained in Exhibit SE-584, the calibration package for the Conejos Response Area, Stream Reach: CON-2 (Conejos River below Seledonia/Garcia Ditches).

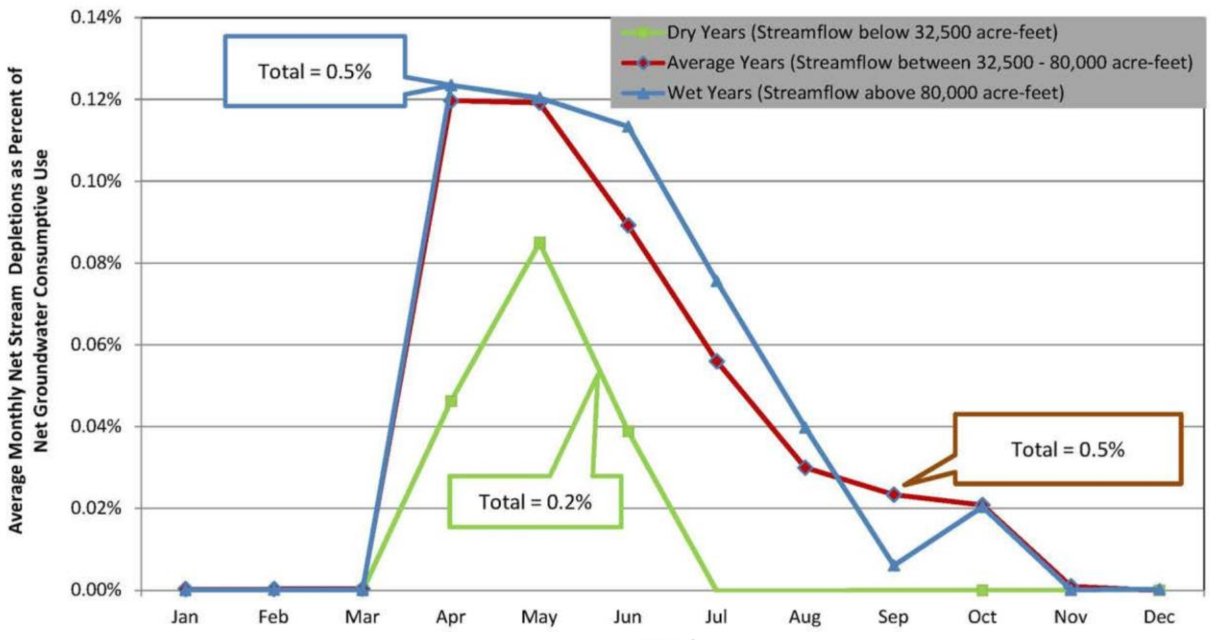
163. The second method for creating Response Functions, the Ratio Method, relies on the concepts and criteria of the 2009 Method, but was developed for streams or stream reaches where low or no streamflow creates a disconnection between the aquifer and the stream for periods of time. Exhibit SE-339 at 10. The second method is necessary because if one creates a Response Function for an intermittent stream using the 2009 Method, it will predict streamflow depletions during months when there was no streamflow.

164. The modelers used the time period from 2001 through 2010 to develop Response Functions using the Ratio Method. The Ratio Method uses the Model's predicted Stream Depletion for each month of each year for 2001 through 2010. The graph below shows the curves of predicted Stream Depletions on the Alamosa River from well-pumping in the Conejos Response Area for the ten years from 2001 through 2010: (Exhibit SE-0652 at page 31).



165. The modelers then classified the stream flows during each of these ten years as wet, average, or dry hydrologic conditions. The modelers determined the average annual net groundwater consumptive use for each month of each dry year and then divided it into the net Stream Depletion for the corresponding month. The modelers then repeated this process for years with wet and average hydrologic conditions. The modelers plotted the results for each year and then combined them into single "curves" or Response Functions for wet, average and dry hydrologic conditions on the stream. Testimony of J. Slattery, Feb. 1, 2018 (p.m.). The following graph shows the final curves as plotted for a wet, average and dry year for the net steam depletions to the Alamosa River caused by well pumping in the Conejos Response Area. (Exhibit SE-0652 at 32).

Figure 2: Response Functions for Dry, Average, and Wet Years - Net Stream Depletions as a Percent of Net Groundwater Consumptive Use



166. The modelers compared the Response Functions based on the Ratio Method to the Stream Depletions the Model predicted and then calibrated or "scaled" them to achieve a better match between the Model's predicted Stream Depletions and the Response Functions' predicted Stream Depletions. The resulting Response Functions are used to estimate Stream Depletions from the net consumptive use of groundwater on the intermittent streams. Just as these stream conditions make it more challenging to predict the effects of net groundwater consumption on the stream, thus requiring the use of the Ratio Method to develop Response Functions, they also make it more difficult to achieve a high degree of correlation, or R^2, for this type of Response Function. These Response Functions therefore tend to predict the same or slightly more groundwater depletion to streamflow than the Model predicts. Testimony of J. Slattery, Feb. 1, 2018 (p.m.). This correlation is within an acceptable range in the engineering field and, therefore, the Response Functions based on the Ratio Method are sufficiently reasonably accurate for their intended use.

167. The Response Functions and the Model do not determine the current Stream Depletions based on the current "depleted" status of the aquifer. Rather, the Model estimates what depletions would be to surface streams had there been no historical groundwater withdrawals. The Model runs made to develop the Response Functions therefore reflect Stream Depletions resulting from historical groundwater pumping. Testimony of W. Schreüder, Feb. 7, 2018 (a.m.).

168. The Model calculated average depletions (for the ten year period 2001-2010) from groundwater withdrawals for the following streams and stream reaches (24 streams with 37 stream reaches) (Exhibit SE-0339, Table 1, at 6 of 14).

Table 1: RGDSS Groundwater Model Reported Streams and Reaches

No.	Streams	*No.*	Stream Reaches
1	**Rio Grande**	*1*	Rio Grande Del Norte-Excelsior
		2	Rio Grande Excelsior-Chicago
		3	Rio Grande Chicago-State Line
2	**Conejos**	*4*	Conejos above Seledonia/Garcia
		5	Conejos below Seledonia/Garcia
		6	San Antonio River
3	**Alamosa**	*7*	Alamosa River
4	**La Jara**	*8*	La Jara Creek
5	**Saguache**	*9*	***Saguache Creek***[2]
		10	Saguache Creek Malone to Hearn
		11	Saguache Creek Braun Bros to Oklahoma
		12	Saguache Creek above Malone
		13	Saguache Creek Hearn to Braun Bros
		14	Werner Arroyo below Mountfield
		15	Werner Arroyo above Mountfield
		16	***Werner Arroyo***
6	**La Garita**	*17*	La Garita Creek
7	**Carnero**	*18*	Carnero Creek
8	**San Luis**	*19*	San Luis Creek above Arthur Young
		20	San Luis Creek below Arthur Young and Kerber Creek
9	**Rito Alto**	*21*	Rito Alto
10	**San Isabel**	*22*	San Isabel Creek
11	**Crestone**	*23*	Crestone Creek
12	**Spanish**	*24*	Spanish Creek
13	**Deadman**	*25*	Deadman Creek
14	**Willow**	*26*	Willow Creek
15	**Cottonwood**	*27*	Cottonwood Creek
16	**Cotton**	*28*	Cotton Creek
17	**Wild Cherry**	*29*	Wild Cherry Creek
18	**Sand**	*30*	Sand Creek
19	**Medano**	*31*	Medano Creek
20	**Big Spring**	*32*	Big Spring Creek
21	**Little Spring**	*33*	Little Spring Creek
22	**Zapata**	*34*	Zapata Creek
23	**Trinchera**	*35*	Trinchera Creek System above Smith Reservoir
		36	Trinchera Creek below Smith Reservoir
24	**Costilla**	*37*	Costilla Creek

169. The modelers did not develop Response Functions for all these streams because for many of the streams the predicted annual Stream Depletions from groundwater diversions were less than 50 acre-feet per year which is below the lower limit of reliability for the Model's predictions.

170. Mr. Slattery explained that the lower limit of reliability reflects the fact that the Model is most reliable over longer periods of time and over longer stream reaches. Because of the complexity of the Model and the non-linearity of the groundwater system in the San Luis Valley, the Model is less reliable as it is run over shorter time periods and shorter stream reaches. According to Mr. Slattery, it would be unrealistic to assume that the current Model can reliably predict Stream Depletions of less than 50 acre-feet annually. Testimony of J. Slattery, Feb. 1, 2018 (p.m.). Likewise, Dr. Schreüder explained that 50 acre-feet is a very small part of the Model's total annual water budget, which is in excess of one-million acre-feet, and that predictions of Stream Depletions of less than 50 acre-feet per year could be the result of numerical "noise" because of things like rounding off numbers. Dr. Schreüder explained that the PRT thoroughly vetted the lower limit of reliability and that group could not justify making any change at this time. Testimony of W. Schreüder, Feb. 6, 2018 (p.m.).

171. The lower limit of reliability was first developed in connection with the Plan of Water Management for Subdistrict No. 1, Cases No. 06CV64 and 07CW52. In that case, the Court originally suggested 50 acre-feet per month (or 600 acre-feet per year) as a proposed lower limit of reliability. Subdistrict No. 1 Decree at ¶¶ 177-179. (The *Modified Case Management Order* the Court issued instructed the modelers to determine monthly depletions to streams until the monthly depletions to the affected stream were less than 50 acre-feet per month.) Ultimately, the Court settled on the lower limit of 50 acre-feet per year. *Id.* at 133 (Condition 1 of the Terms and Conditions of approval of the Subdistrict Plan of Water Management: "Beginning in the year 2012, the Subdistrict shall replace all injurious depletions exceeding 50 acre-feet per year in time, location and amount, including ongoing injurious depletions resulting from past pumping.")

172. The evidence in the current case supports the absolute value of 50 acre-feet as the lower limit of reliability of the Model. The Court understands that, as the Model is refined, that value may be changed in the future in accordance with Rule 24.5. Testimony of W. Schreüder, Feb. 6, 2018 (a.m.). The Court expects that the lower limit of reliability will only be reduced in the future and not increased.

173. The State Engineer has generated Response Functions for those streams where the Model predicts an annual net Stream Depletion of 50 acre-feet or more and they are:

		Response Area						
		Response Area No. 1	**Rio Grande Alluvium**	**Conejos**	**Alamosa La Jara**	**San Luis**	**Saguache**	**Trinchera**
Stream Reaches	1	Rio Grande: Del Norte to Excelsior Ditch	Rio Grande: Del Norte to Excelsior Ditch	Alamosa River	Alamosa River	Crestone Creek	Rio Grande (RG123)*	Conejos River (CON21)*
	2	Rio Grande: Excelsior Ditch to Chicago Ditch	Rio Grande: Excelsior Ditch to Chicago Ditch	Conejos above Seledonia/Garcia Ditch	Conejos above Seledonia/ Garcia Ditch	San Luis Creek	Saguache Creek	Rio Grande (RG21)*
	3	Rio Grande: Chicago Ditch to State Line	Rio Grande: Chicago Ditch to State Line	Conejos below Seledonia/Garcia Ditch	Conejos below Seledonia/ Garcia Ditch		San Luis Creek	Rio Grande Excelsior to State Line
	4			Rio Grande: Del Norte to Excelsior Ditch	Rio Grande: Del Norte to Excelsior Ditch			Trinchera Creek (TRIN21) *
	5			Rio Grande: Excelsior Ditch to Chicago Ditch	Rio Grande: Excelsior Ditch to Chicago Ditch			
	6			Rio Grande: Chicago Ditch to State Line	Rio Grande: Chicago Ditch to State Line			

Note: * Indicates stream reaches where the net Stream Depletions are combined to the nearest stream reach.
** Response Function for La Jara Creek in the Alamosa/La Jara Response Area was not generated and is pending additional hydrogeologic review.

174. The uncontested evidence presented in this case shows that the RGDSS Model is the appropriate tool to generate annual Response Functions for the seven Response Areas. It is appropriate to use the annual Response Functions to generate calibrated Response Functions to determine Stream Depletions caused by net groundwater consumptive use under wet, dry and

average conditions. Furthermore, the procedures the modelers used to calibrate the Response Functions were scientifically valid and reasonable. Finally, the use of calibrated Response Functions to estimate Stream Depletions from net groundwater consumptive use provides reliable estimates of the time, place, and amount of depletions to the various affected streams. The procedures the modelers used to develop the Response Functions for the seven Response Areas are also consistent with the approach this Court approved in the Subdistrict No. 1 Decree.

175. The 2J Group did not contest the methodologies the State Engineer used to generate Response Functions. Rather, it contested the failure of the State Engineer to calibrate the Model to Arroya/Diamond Springs and the failure to generate a Response Function showing depletions to Arroya/Diamond Springs from the net consumptive use of groundwater. The 2J Group asserted that had the State Engineer done these things, then the Response Functions for the Conejos Response Area and the Alamosa-La Jara Response Area would likely be different from those generated by the State Engineer.

VI. 2J GROUP'S CHALLENGES TO THE RULES

176. Members of the 2 J Group own land in Conejos County, Colorado, that was historically irrigated by the following senior surface water rights:

a. Priority 97, decreed to the L D Eskridge Irrigating Ditch in the amount of 6.5 cubic feet per second ("cfs"), with an appropriation date of May 25, 1889, in Civil Action No. 304 (1903);

b. Priority 98, decreed to the South Side Arroya Ditch, in the amount of 7.5 cfs, with an appropriation date of May 25, 1889, in Civil Action No. 304 (1903);

c. Priority 108 decreed to the Arroya Springs Ditch in the amount of 7.0 cfs, with an appropriation date of February 11, 1902, by decree of the District Court, Conejos County, dated February 7, 1918;

d. Priority 109, decreed to the South Side Arroya Ditch, in the amount of 36 cfs, with an appropriation date of February 12, 1902, by decree of the District Court, Conejos County, dated February 7, 1918; and

e. Priority 115, decreed to the Arroya Springs Ditch in the amount of 12.5 cfs, with an appropriation date of October 2, 1911, by decree of the District Court, Conejos County, dated February 7, 1918.

All of these ditches are collectively designated as the "Arroya Springs Ditches."

177. The land that was historically irrigated by these water rights and the name of the current owner of each parcel is depicted on Figure 1-2 of Exhibit 2J-04, the May 25, 2017 Expert Report of Gregory K. Sullivan, P.E.

178. According to several witnesses, Arroya/Diamond Springs flowed reliably into the early 1960s and provided surface water for the Arroya Springs Ditches until that time. During the 1950s, the springs flowed year-round and there was a large pond of water and a large marshy area at the eye of Arroya/Diamond Springs. By the late 1960s, the springs were flowing at a much lower level. Arroya/Diamond Springs were dry in the late 1970s but flowed again, off and on, until the late 1990s.

179. Because Arroya/Diamond Springs quit flowing, the owners of the surface water sourced from the springs, including the members of the 2J Group, had to find other sources of water for their land. Some of them own other surface water rights but all of them also drilled irrigation wells as shown in Table 1-2 of Exhibit 2J-04. It is more expensive for the members of the 2J Group to irrigate their land with water from their wells than it was to irrigate with surface water.

180. For a long time, the members of the 2J Group have believed that the increasing number of wells and the increasing amount of water being withdrawn, especially from the Confined Aquifer, caused the artesian pressure in the Confined Aquifer to drop low enough in the vicinity of Arroya/Diamond Springs that it caused the springs to stop flowing. After this Court approved Subdistrict No. 1, around 2009 or 2010, several members of the 2J Group

repeatedly approached the Division Engineer's Office to discuss the loss of flow at Arroya/Diamond Springs and to seek assurances that the Rules for the Withdrawal of Groundwater would address their concerns. The Division Engineer's and State Engineer's staff did not give the 2J Group any such assurances and, in fact, repeatedly told the 2J Group that there were causes other than Confined Aquifer well-pumping for the loss of flow at Arroya/Diamond Springs.

181. The 2J Group then decided to hire a groundwater engineer or other water expert to review the situation at Arroya/Diamond Springs in order to have information that the State and Division Engineers would take more seriously. In 2014, the 2J Group hired hydrogeologist Eric Harmon of HRS Water Consultants, to review the situation at Arroya/Diamond Springs. Mr. Harmon has worked on the RGDSS since 1999 and has extensive experience with respect to the hydrogeology in the San Luis Valley. In fact, the State called Mr. Harmon as an expert witness in its case-in-chief in this case.

182. Mr. Harmon evaluated the hydrogeology of Arroya/Diamond Springs and wrote a report dated July 2, 2014. Exhibit 2J-34. In his report, Mr. Harmon concluded that "[t]he potentiometric head (i.e. artesian pressure) of the Confined Aquifer in the vicinity of Arroya Springs appears to have fluctuated over time, but overall reflects a decline in head." *Id.* at 22. He stated that "[t]he historic increase in Confined Aquifer well development between approximately the late 1930's and the early 1970's is a major cause of the decline in Confined Aquifer head in this area." *Id.* at 32. He further concluded that the decline in Confined Aquifer head "could, and in all likelihood has, caused Arroya Springs to change from one of the highest discharge springs in the San Luis Valley, to zero discharge at the time of this study." *Id.* at 33.

183. Mr. Harmon determined that there was no Unconfined Aquifer at Arroya/Diamond Springs and that "a basaltic rubble zone, interpreted to be the top of a Hinsdale Formation lava flow (part of RGDSS aquifer layer 3 . . .) is exposed at the ground surface." *Id.* at 18. He indicated that "[w]here fractured, which . . most certainly is the case in the Arroya Springs area, the basalt flows comprise a highly permeable aquifer." *Id.* at 19. Thus, he concluded that "[t]he water that discharged historically (and, in our view, most likely also prehistorically) from Arroya Springs did so from the Hinsdale lava rock layer, not from an overlying near-surface alluvial or soil layer." *Id.* at 19.

184. Mr. Harmon opined that "it is ground water movement from the various sources [of recharge] though [sic] the geologic layers that compose the Confined Aquifer to Arroya Springs that ultimately results in flow at the springs." *Id.* at 28. He stated it was his opinion that the amount of water discharged at Arroya/Diamond Springs had declined so severely because of the increase in Confined Aquifer well development between the 1930s and the early 1970's explaining that "[s]prings in general, and springs on the upgradient edge of an aquifer, such as Arroya Springs, in particular, are highly sensitive to the water level or Confined Aquifer head to which the springs are hydraulically connected." *Id.* at 33. He further opined that "Arroya Springs existed prior to ditch development and irrigation" because the boulders and cobbles exposed at Arroya/Diamond Springs "have been exposed to the atmosphere for a long time . . . most likely to times that pre-date settlement of this area of the San Luis Valley." *Id.* at 33.

185. Notably, he also opined that "[e]ven though the development of ditches and irrigation greatly increased the amount of water that historically discharged at Arroya Springs, the pathway for ground water at Arroya Springs is the same now as it was in pre-irrigation and most likely prehistoric time: into the Confined Aquifer." *Id.* at 34.

> Periods of high snowpack and runoff in pre-settlement times would have caused large amounts of Confined Aquifer recharge then, just as such periods do now (e.g. the 1920's and the mid-1980's). It is our opinion that during those times, even in pre-settlement and pre-irrigation times, there was spring discharge at Arroya Springs during times of high water supply due to "rejected recharge" and a high Confined Aquifer head.

Id.

186. The members of the 2J Group felt that Mr. Harmon's report supported their belief that Confined Aquifer well pumping was the main cause of the loss of flow at Arroya/Diamond Springs. The 2J Group presented the report to the Division of Water Resources but the State and Division Engineers and the PRT did not make any changes in the RGDSS or the Response Functions as a result. As already noted, the PRT did not develop a Response Function for Arroya/Diamond Springs and the RGDSS is not calibrated to Arroya/Diamond Springs. Thus, under the current Response Functions, those who pump Confined Aquifer wells in the San Luis Valley will have no obligation to replace depletions that the 2J Group believes such well-pumping has caused and is causing to Arroya/Diamond Springs. When the State took no action in response to the Harmon Report, the 2J Group members decided they would have to protest the Rules.

187. The 2J Group hired another expert water engineer, Gregory Sullivan, to evaluate the causes of the decline in the flow at Arroya/Diamond Springs and to evaluate the RGDSS and whether the injury to the Arroya/Diamond Springs water rights that the 2J Group felt was caused by Confined Aquifer well pumping would be remedied through implementation of the Rules that are at issue in this case. Mr. Sullivan concluded that the current version of the RGDSS, version 6P98, and the Response Functions derived from it, "do not accurately calculate the depletions to Arroya Springs and Arroya Creek caused by ground water withdrawals. As a result, the Rules

will not prevent or remedy the injury to the Protestants' Arroya Springs water rights caused by groundwater withdrawals." Exhibit 2J-04 at 3.

188. Before proceeding to make factual findings on these issues, the Court notes that it has some concern with the testimony of Eric Harmon. Although Mr. Harmon is clearly very competent and knowledgeable about the hydrogeology of the San Luis Valley, the Court is concerned with the divergence between what he wrote in his 2014 Report about Arroya/Diamond Springs and his testimony at trial. His report was relatively favorable to the 2J Group's position, even opining that groundwater withdrawals from the Confined Aquifer were a major cause of the decline in the flow at Arroya/Diamond Springs. But his testimony at trial was much more tentative and much less favorable to the 2J Group's position. If the Proponents' position relied solely on Mr. Harmon's testimony, the Court might make different findings. But the Proponents relied heavily on the testimony of Dr. Schreüder and Mr. Slattery and the Court finds both of them to be very credible. In addition, although the Court found the 2J Group's expert, Mr. Gregory Sullivan, to be well-qualified, logical and helpful, the Court finds that Dr. Schreüder and Mr. Slattery are more credible and persuasive concerning water matters in Water Division No. 3 because they are also very qualified and they have many, many years of experience in Division 3.

A. <u>Description of Arroya/Diamond Springs</u>

189. Arroya/Diamond Springs is located in the NW1/4 of section 31, T 35 N. R. 9 E., N.M.P.M., which is part of a topographic low, approximately 7,651 feet in elevation, between the Conejos River Drainage to the south and the La Jara Creek and Alamosa River Drainages to the north. It is located where the valley fill materials sourced from the alluvial fans of La Jara Creek, the Alamosa River, and the Conejos River abut the upper-most edge of the volcanic

Hinsdale Formation. The eroded edge of the Hinsdale Formation creates a topographic "step" or escarpment that is higher and steeper west of Arroya/Diamond Springs. Exhibit 2J-34 at 5.

190. Arroya/Diamond Springs, being a topographic low, acts as a sump to collect irrigation return flow, tail water, waste water, and high flows from the Alamosa River and La Jara Creek. The historical maps of the area show La Jara Arroya Creek as a branch of La Jara Creek that flows just to the north of Arroya/Diamond Springs. *See* Exhibits SE-310 and 310a; SE-705b, 2J-34 at 42. The 1938 Rio Grande Joint Investigation ("Joint Investigation") describes Arroya/Diamond Springs as emerging "on low ground south of a meandering distributary of La Jara Creek, in the N1/2 Sec. 31, T. 35 N., R. 9 E. The swampy tract from which the springs emerge covers 160 acres and is characterized by a dense growth of tules, with bodies of water that denote the locations of the different spring openings." Exhibit SE-257 at 262. From Arroya/Diamond Springs, the land surface slopes downward and easterly toward the towns of Romeo, Manassa, and La Jara.

191. Although, as indicated above, Mr. Harmon concluded that the blue clay or confining layer that separates the Confined and Unconfined Aquifers is not present under Arroya/Diamond Springs, the Proponents presented credible expert evidence disputing this conclusion. To truly know whether the blue clay layer is present under Arroya/Diamond Springs, it will be necessary to drill a test well there. Based on the evidence presented at trial, the Court concludes that more information is necessary to determine the western extent of the blue clay layer and whether it underlies Arroya/Diamond Springs.

192. Because we do not know whether the blue clay layer extends below Arroya/Diamond Springs or not, we do not know whether the water that has flowed from Arroya/Diamond Springs is rejected recharge from the Confined Aquifer, as opined by Mr.

Harmon and Mr. Gregory Sullivan, or is irrigation return flows and other recharge to a local unconfined aquifer as Mr. Slattery opined.

B. History of Arroya/Diamond Springs

193. Before settlers arrived and began irrigating in the vicinity of Arroya/Diamond Springs, there was only an intermittent flow from the spring. Once farmers began irrigating land in the area, the return flows from their irrigation water increased the amount of water available to the spring and caused it to begin to flow full-time, year-round. Numerous historical investigations, as well as the testimony at the 1903 general adjudication of water rights that included water rights from Arroya/Diamond Springs and more recent investigations, support this conclusion.

194. During the 1903 general adjudication, William H. Adams, L.D. Eskridge, and D.E. Newcomb testified before the referee that Arroya/Diamond Springs arose in 1889 after the construction of the Mogote Ditch. Exhibit SE-711 at 197, 210, 227. Mr. Newcomb testified that the spring "opened and commenced to run in the year 1889 soon after the Mogote Ditch was run on the lands west of the spring. It began to flow and covered from 40 to 80 acres of land, meadow land covering a part of the Northwest quarter of Section 31, Township 35, range [9]." Exhibit SE-0711 at 197. In the same hearings, W.H. Adams testified that the spring first appeared in the fall of 1889. Mr. Adams testified that he spent two or three days on the "particular piece of land" (where the spring later began to flow) in the summer of 1888 while moving cattle to New Mexico and no spring existed at that time. *Id.* at 210. He first noticed the spring in the fall of the following year when he returned with the cattle. *Id.*

195. In 1904, C. E. Siebenthal conducted extensive geologic and hydrologic investigations in the San Luis Valley, the results of which were published in U.S.G.S. Water

Supply Paper 250, Geology and Water Resources of the San Luis Valley, Colorado (1910). Exhibit SE-311. Siebenthal's report addressed numerous springs in the San Luis Valley, including McIntire Springs and Dexter Springs on the Conejos River, Spring Creek, Russell Springs, Medano Springs, Washington Springs, and others. His report, however, did not mention Arroya/Diamond Springs.

196. As part of his investigations, Siebenthal prepared a map showing the location of flowing (artesian) wells in the San Luis Valley and his projected boundary of the area of flowing wells. Exhibit SE-310. One such well is located one-quarter mile east of Arroya/Diamond Springs. Exhibit SE-310A. The fact that Siebenthal did not report on Arroya/Diamond Springs suggests that in 1904 the flow of the springs was very small because if the springs had "been of any consequence at that time [Siebenthal] undoubtedly would have reported them, especially in view of the fact that he located an artesian well only a quarter of a mile east of the spring area." Exhibit SE-257, Joint Investigation, at 262–63.

197. The Joint Investigation further stated that Division Engineer W.D. Carroll "reported that the flow of these springs was very small 30 years ago, probably not over a quarter of a second-foot, but that the flow began to increase materially about 1916 and has continued to increase since then." *Id.* at 262. The Joint Investigation was conducted in 1936-37, so the time period Mr. Carroll was referring to must have been in or around 1906-07, near the time of Mr. Siebenthal's field investigations.

198. In his March 1923 Report to the Department of the Interior titled "Modification of Embargo Drainage Data San Luis Valley, Colorado, Map," Engineer R. I. Meeker reported the first recorded measurement of Arroya/Diamond Springs which he made in the summer of 1916: 22 c.f.s. Exhibit SE-519 at DWR 20539. The measurement was apparently made in La Jara

Arroya Creek where current Conejos County Road 13 crosses La Jara Arroya Creek, downstream from the spring. *Id*. at DWR 20519. In his report Meeker observed that "[t]his return flow water is partly re-used during the irrigation season by the Arroyo Springs, South Side Arroyo and North Side Arroyo ditches. When not used for irrigation Diamond Springs water reaches the Rio Grande via La Jara Creek." *Id.* at DWR 20539. Meeker's report identified the source of Arroya/Diamond Springs to be "Return Flow From Irrigation." *Id.* at DWR 20540; *see also id.* at 20519, 20538–40.

199. Arroya/Diamond Springs is surrounded by irrigated lands to the north, northwest, south and east. To the west of Arroya/Diamond Springs is the outcrop of the Hinsdale Formation volcanic rock on which there is no irrigation. The location and extent of these irrigated lands supports Meeker's conclusion that Arroya/Diamond Springs is supplied by return flow from irrigation of the surrounding lands.

200. Mr. Meeker's report contained flow measurements for Arroya/Diamond Springs taken between 1916 and 1923. He reported one measurement in each 1916 and 1920, eight measurements in 1921, four measurements in 1922 and 11 measurements in 1923, a total of 24 measurements spanning seven years.

201. The next reported measurement of Arroya/Diamond Springs occurred in 1924 as part of a Seepage Investigation of La Jara Creek, Alamosa Creek, and the Conejos River conducted in August and September 1924 by D.S. Jones, Jr., hydrographer, Water Division No. 3. Exhibit SE-156. Mr. Jones reported the flow of Arroya/Diamond Springs at 36.1 c.f.s. on September 15, 1924, and stated "Diamond Springs has developed since irrigation has started in the San Luis Valley,…." *Id.* at DWR003116.

202. In his September 1924 Report on "Soil Conditions and Drainage in the San Luis Valley, Colorado," Engineer R. J. Tipton attributed the existence of several springs to the effect on groundwater flow caused by local impervious dykes running across natural underground drainage channels in the area southwest of the Rio Grande. Exhibit SE-533 at 15. He noted that in some places these dykes come to the surface and "spring flow is formed by the flowing of ground water out over the edge of the dyke." *Id.* Tipton identified Arroya/Diamond Springs and Spring Creek as examples of such springs and concluded "The above springs represent direct return of water from irrigation to the river, except that the water from some of them are diverted and reused." *Id.* at 19.

203. In 1938, the Joint Investigation likewise attributed the flow of Arroya/Diamond Springs to irrigation return flows. It characterized Arroya/Diamond Springs as located in a depression "in the margins of the confining beds of the artesian aquifer," which it hypothesized affords "opportunities for the artesian water to spill over the lip of the confining member, forming springs." Exhibit SE-257 at 262. It referred to this water as "artesian reject," representing overflow of the artesian aquifer. *Id.* It went on to observe that these "springs give convincing evidence in support of the theory that there has been a considerable increase in recharge of the artesian aquifers on account of the application of surface water for irrigation on the alluvial slopes." *Id*. at 263. Thus, according to the Joint Investigation, irrigation return flow caused an increase in groundwater levels which, in turn, resulted in the emergence of Arroya/Diamond Springs, among others.

204. The next investigator to report on Arroya/Diamond Springs was William J. Powell, who discussed Arroya/Diamond Springs in *Ground-Water Resources of the San Luis Valley, Colorado,* U.S.G.S. Water Supply Paper 1379 (1958). Exhibits SE-312, 313. While Mr.

Powell's study was primarily focused on the Closed Basin north of the Rio Grande, Exhibit SE-312 at 2, Mr. Powell extended the limits of the study area to include McIntire and Arroya/Diamond Springs because of their hydrologic importance at that time. *Id*. at 36. Powell described McIntire Springs as discharging at the base of the San Luis Hills near the contact of the Alamosa Formation and the San Luis Hills. *Id*. at 37. He attributed the flow of McIntire Springs to "artesian water arising to the surface along a fault plane. *Id*.

205. With respect to Arroya/Diamond Springs, Mr. Powell largely repeated the description of the spring found in the Joint Investigation. He took 14 measurements of the springs' flow and noted that "[t]here appears to have been little change in average discharge of Diamond Springs since 1936" and the "discharge fluctuates seasonally, however, is greatest during the summer when surface water is being applied for irrigation." *Id*. at 38.

206. Mr. Harmon, who investigated Arroya/Diamond Springs for the 2J Group, likewise testified that prior to the onset of irrigation, Arroya/Diamond Springs likely was ephemeral and only flowed at times when there was a lot of recharge. Testimony of E. Harmon, Jan. 31, 2018 (p.m.). Referring to Exhibit SE-707, Mr. Harmon further testified that Arroya/Diamond Springs are not artesian springs. Testimony of E. Harmon, Feb. 1, 2018 (a.m.). Mr. Harmon explained that water flows from Arroya/Diamond Springs when there is more recharge in the vicinity of Arroya/Diamond Springs than the aquifer can accept at a particular time and therefore the excess water discharges at the surface as spring-flow. *Id*. at Jan. 31, 2018 (p.m.); *see also* Exhibits 2J-34 at 30; SE-707. Mr. Harmon testified that there are three main sources of water for Arroya/Diamond Springs: irrigation return flows (including ditch seepage and tail water) from the lands to the north and south of the springs, precipitation, and seepage from surface streams. Of these three sources of water, irrigation return flows is by far the

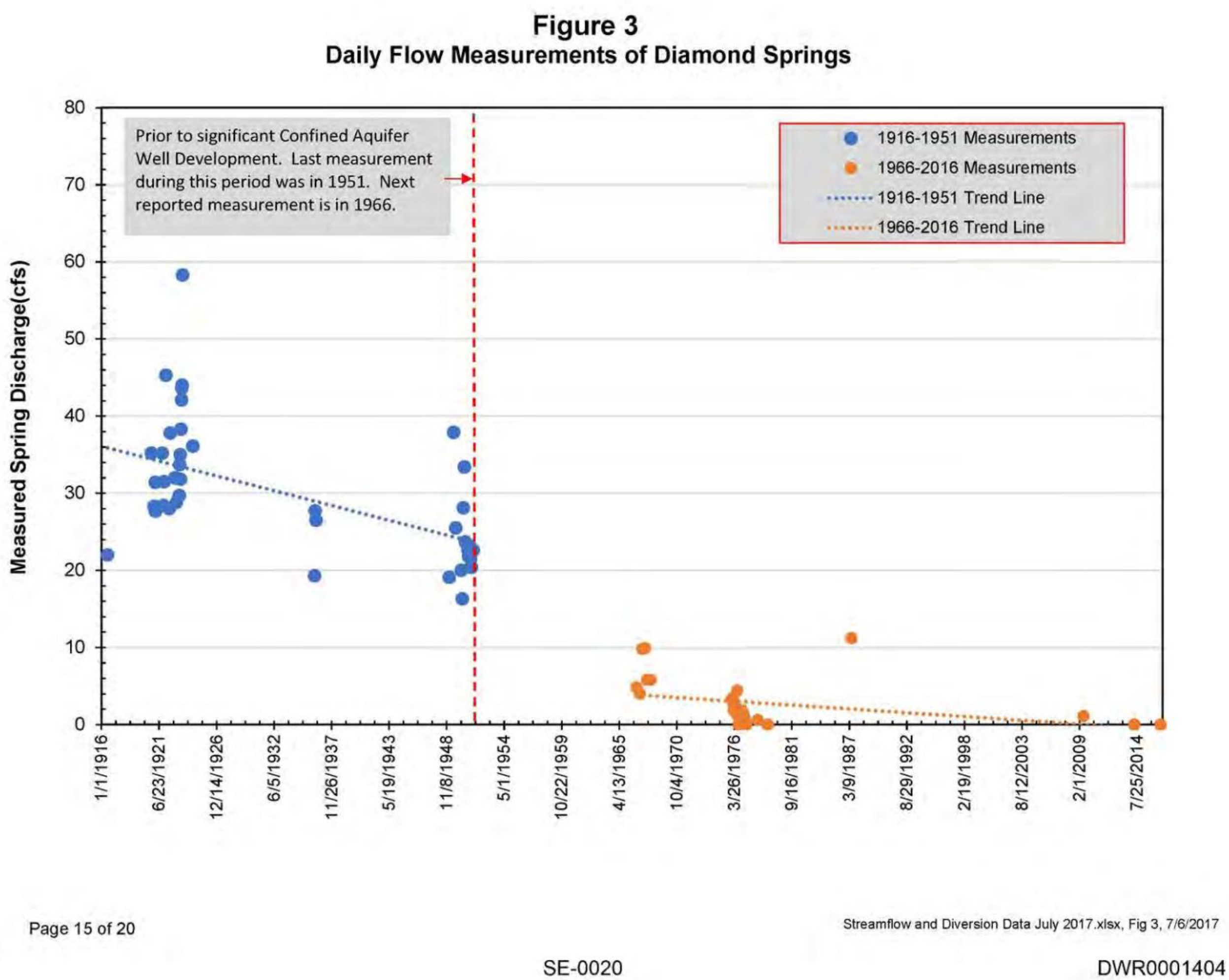
largest. Testimony of E. Harmon, Jan. 31, 2018 (p.m.); Exhibits 2J-34 at 30. In fact, in both his 2014 report and in his testimony, Mr. Harmon estimated that irrigation return flows made up 75% of the flow of water from Arroya/Diamond Springs. *Id.*

207. Based on the historical investigations as well as Mr. Harmon's more recent work, the Court finds that the main source of water for the flow at Arroya/Diamond Springs was irrigation return flows. Again, however, these return flows may have discharged from the spring as flows rejected from the Confined Aquifer because the Confined Aquifer piezometric head was higher than the elevation of the spring, or they may have discharged from the spring because they overflowed the local unconfined aquifer.

208. Exhibit 2J-26 summarizes all known measurements of Arroya/Diamond Springs and, in addition to the 24 measurements in Meeker's report, Exhibit SE-519, it shows one measurement in 1924, three measurements in 1936, three measurements in 1949, seven measurements in 1950, four measurements in 1951, one measurement in 1966, four measurements in 1967, one measurement in 1968, one measurement in 1975, 12 measurements in 1976, five measurements in 1977 (one of which was zero), one measurement each in 1978 (zero), 1979, 1987, and 2009, for a total of 70 measurements over 93 years. In addition, site visits in April 2014 and October 2016 confirmed that currently there is no flow at the spring. The parties agreed that the measurement in 1987 appeared to have been taken at a location that would not represent the flow of the springs. These measurements indicate that Arroya/Diamond Springs essentially had no flow by the late 1970s, with a modest resurgence during the wet periods in the 1980s and 1990s.

209. The sparse data that is available for the Arroya/Diamond Springs flow suggests that the spring flow was declining even before the period of increased Confined Aquifer well

construction which began in 1950. Exhibit SE-20 at 15, Rebuttal Engineering Report of James Slattery, Graph of Daily Flow Measurements:



The spring flow appears to have declined significantly between 1952 to 1966, a period in which there are no reported flow measurements, but during which there was a large increase in Confined Aquifer well development coupled with severe drought. Thereafter, the flows continued to decline except during wet periods.

C. <u>Reasons for the Decline in Flow at Arroya/Diamond Springs</u>

210. The 2J Group expert, Mr. Gregory Sullivan, opined that Confined Aquifer groundwater development was the main cause of the decline in flow at Arroya/Diamond Springs, particularly because of the increase in the number of Confined Aquifer wells between 1950 and 1970. Mr. Sullivan opined that the recharge to Arroya/Diamond Springs from irrigation return flows, precipitation, etc., remained relatively stable during the period from 1950 to 1970 but that the flow from the springs dropped precipitously. Furthermore, Mr. Sullivan hypothesized that those same return flows, precipitation, canal leakage etc., remain relatively the same today and yet the springs do not flow. It is his opinion that the one major change during the time period 1950 to 1970 was the increase in the amount of water being withdrawn from the Confined Aquifer and that it is this change that caused Arroya/Diamond Springs to stop flowing.

211. Mr. Sullivan based this opinion on a qualitative analysis of the correlation between groundwater development, particularly the increase in the cumulative adjudicated diversion rates of Confined Aquifer wells, over this period and the decline in flow at Arroya/Diamond Springs. He relied on a 1965 paper by Sir Austin Bradford Hill which created an analytic framework for physicians working in the field of occupational medicine to determine whether there was a strong enough relationship between sickness or injury and the conditions of work to recommend a change in those conditions. Exhibit 2J-166, "The Environment and Disease: Association or Causation?" Mr. Sullivan particularly relied on the strength and gradient as well as the specificity and temporality of the correlation between groundwater development in the San Luis Valley and the decline in flow of Arroya/Diamond Springs. Although this analysis is suggestive, the Court ultimately does not find this qualitative, as opposed to quantitative, analysis sufficiently persuasive to allow the Court to determine that, more probably than not,

groundwater withdrawals from the Confined Aquifer were the main cause of the reduction in flow at Arroya/Diamond Springs.

212. Although all the parties agree that the increase in the amount of water withdrawn from the Confined Aquifer because of the installation of numerous Confined Aquifer irrigation wells between 1950 and 1970 could have contributed to the reduction in flow at Arroya/Diamond Springs, the evidence does not support a finding that this was the primary cause of the reduction in flow.

213. Numerous Confined Aquifer irrigation wells were installed throughout the San Luis Valley between 1950 and 1970. Exhibit SE-314 at 6. Furthermore, if one adds together the total decreed diversion rates for all the Confined Aquifer wells drilled in Water District 21 and 22 (which includes the drainage basins of the Conejos, Alamosa and La Jara Rivers) over this period of time, it appears that total diversions from the Confined Aquifer in the vicinity of Arroya/Diamond Springs would have increased dramatically between 1950 and 1970. *See* Exhibit 2J-004, Figure 4-1.

214. But, the cumulative diversion rates of these Confined Aquifer wells do not represent the actual amount of water these wells have withdrawn from the Confined Aquifer. Just because a farmer owns an adjudicated groundwater right does not mean that the farmer pumps the well associated with that right. Both Nathan Coombs and Lawrence Crowder are farmers who grew up in the San Luis Valley and who have historically irrigated with both surface water provided by ditches and drains and groundwater from Confined Aquifer wells. They both testified that they fully use their available surface water supplies before using groundwater. This is an economic decision because it is costly to operate a well; they only pump their wells if the resulting increase in crop yield justifies the cost of pumping. The PRT also

confirmed this practice when, after receiving well pumping records, they discovered that in some areas of the Valley they had over-estimated groundwater withdrawals in the RGDSS. The over-estimation occurred primarily on meadow land and subirrigated land where groundwater is used as a supplemental supply only if it is economically justified.

215. In 1972, the State Engineer placed a moratorium on new appropriations from the Confined Aquifer, thus preventing additional appropriations from that aquifer. This explains why the line representing cumulative diversion rates by appropriation date for Confined Aquifer irrigation wells in Figure 4-1 of Exhibit 2J-04 becomes a flat line after 1972. Again, this shows that the cumulative adjudicated diversion rates as depicted in this graph are not a representation of the amount of water that was actually withdrawn from the Confined Aquifer. Although the flat line indicates the limit of adjudicated water rights, water owners would have diverted different amounts of water each year depending on other factors, such as the amount of precipitation.

216. Thus, the increase in the number of Confined Aquifer wells between 1950 and 1970 did not necessarily result in a corresponding increase in withdrawals from the Confined Aquifer. Exhibit SE-314 at 7. Instead, the magnitude of the withdrawals would have varied depending on surface water supplies. In drier years with less surface water available, Confined Aquifer withdrawals would increase and in wetter years with more surface water, Confined Aquifer withdrawals would have been lower. This pattern continues today.

217. In fact, there is very limited data on the actual volume of historical Confined Aquifer withdrawals, and how those withdrawals changed over time and in relation to flows at Arroya/Diamond Springs. This lack of data and the differing estimates of Confined Aquifer withdrawals by different investigators is illustrated in Exhibit SE-728 at 1–4. There is simply no

complete or fully reliable estimate of Confined Aquifer withdrawals until the commencement of mandatory well metering in 2009.

218. Furthermore, the evidence shows that numerous factors besides groundwater writhdrawals from the Confined Aquifer contributed to the decline in flow of Arroya/Diamond Springs and continue to contribute to the current lack of flow at the springs.

219. Much of the decline in the springs' flow between the earliest measurements in the 1910s and 20s and later in the 1930s is explained by a reduction in precipitation in the San Luis Valley. For example, Mr. Meeker took the earliest measurements of Arroya/Diamond Springs between 1916 and 1923, a hydrologic wet period. One can see that this was a wet period because, based upon a 34-year average, Meeker reported stream flows at the Rio Grande near Del Norte to be 724,000 acre-feet compared to the current long-term average of about 625,000 acre-feet. Exhibits SE-693 at 10; SE-97. Similarly, Meeker reported a 34-year average of 257,000 acre-feet of flow for the Conejos River near Mogote compared to a current long-term average of about 240,000 acre-feet. Exhibits SE-693 at 10; SE-670. Mr. Meeker also reported the 34-year average flow of the Alamosa River at Terrace Reservoir as 97,000 acre-feet and the 34-year average flow of La Jara Creek at Capulin to be 19,000 acre-feet per year. These average flows are substantially greater than the flows of the Alamosa River and La Jara Creek under hydrologic conditions since 1950 which are approximately 70,000 acre-feet and 11,000 acre-feet, respectively. Exhibit SE-20, figures 6 and 7. This same long-term drying trend is evident on Saguache Creek as well. Exhibit SE-99.

220. Because there was generally more water in the system during the 34-year period that ended in 1924, flows at Arroya/Diamond Springs in the period 1916 through 1924 would have been higher also. The greater water supply would have provided more irrigation water,

greater irrigation return flows and the potential for greater surface flows in the La Jara Arroyo all of which would have contributed to more water flowing from Arroya/Diamond Springs.

221. The second set of measurements of the flow at Arroya/Diamond Springs, in the mid-1930s, are lower than the measurements taken in the 1920s, not only because of a reduction in the amount of water available in the system, but also because of the construction of agricultural drains in the area. The increase in irrigation that gave rise to Arroya/Diamond Springs and other springs in the San Luis Valley also caused wide-spread water logging of soils, which resulted in the need for drainage to lower groundwater levels and allow continued agricultural use of the land. *See generally* Exhibit SE-533, Tipton, "Soil Conditions and Drainage in the San Luis Valley, Colorado"; Exhibit SE-693 R.I. Meeker, Water Supply, Irrigation and Drainage, Present and Future Conditions, San Luis Valley, Colorado (May 1924).

222. One such drainage system, the San Luis No. 1 Drain (a.k.a. La Jara Seepage Ditch), encompasses much of the land served by the Arroya Springs Ditch and the Southside Arroya Ditch. Tipton describes the San Luis No. 1 Drain as begun in 1919, completed in 1923, and discharging 11,880 acre-feet of water into La Jara Creek. Exhibit SE-533 at 39A. The San Luis No. 1 Drain is generally depicted on SE-246 as extending throughout an area east and south as well as southwest of La Jara with a lateral approximately one mile east of and downgradient from Arroya/Diamond Springs. The drain serves to lower groundwater levels so that the land over and near the drain can be productively farmed. The drain also acts to lower groundwater levels at Arroya/Diamond Springs.

223. The 2J Group's expert, Mr. Sullivan, explained that the San Luis No. 1 Drain, as well as the other drains in the Valley, would have had their main effect of lowering the water table within the first ten years after they were constructed. Testimony of Gregory Sullivan

February 9, 2018 (a.m.). According to Mr. Sullivan, the drains would have an on-going effect but, after the initial decline in water table, would not cause further decline in the water table or the flow of the springs. *Id.* Once the effect of the drain is fully realized it will cause no further declines in the water table or reduction in stream flow because the drain is at a fixed elevation and it cannot lower the water table below that elevation. *Id.*

224. Of course, the drains continue to affect the availability of groundwater in this area and accounting for the effects of the drain is an important part of the RGDSS Model. This is particularly clear when considered in relation to the RGDSS Model impact run, *i.e.* the RGDSS Model run to predict what would have occurred without groundwater withdrawals. Without groundwater withdrawals, the groundwater levels would rise but part of that increase in water level results in increased inflow into the drains, which perpetually limits the amount the water level can increase. Testimony of James Slattery, Feb. 14, 2018 (p.m.).

225. Another reason for the decline in flow at Arroya/Diamond Springs, and something that continues to affect the potential for spring flow at that location today, is Colorado's decision to strictly comply with the Rio Grande Compact. In 1952, the State of Colorado accrued a compact debit of 154,000 acre-feet because it failed to meet its scheduled deliveries. Exhibit SE-532 at 2. Colorado continued to accrue debits under the Rio Grande Compact and in 1966 Texas and New Mexico sued Colorado for its failure to comply with the Compact. *Alamosa-La Jara Water Users Protective Ass'n v. Gould*, 674 P.2d 914, 919 (Colo. 1983). In 1967, as part of its efforts to comply with the Compact, Colorado prohibited the practice of wintertime water diversions on the Rio Grande and Conejos River. In addition, in 1968 Colorado began "strict" compact administration, which entailed curtailing diversions of surface water rights to ensure

compliance with the separate Rio Grande and Conejos River delivery schedules in Article III of the Compact.

226. Exhibits SE-91, 92, 93 and 94 show how compact curtailment reduces the amount of water that is actually applied to the land. Even though a water right is in priority and there is water in the river, under strict compact administration the Division Engineer only allows the water owner to divert a percentage of the water to which the owner is entitled and requires the remaining water to stay in the river to flow to New Mexico to meet Colorado's water delivery requirements under the Rio Grande Compact. Furthermore, under strict compact administration the Division Engineer not only reduces the amount ditches may divert during the irrigation season but also prohibits diversions during the non-irrigation season. In 2017, compact curtailment resulted in 51% of the streamflow being taken past the ditches on the Conejos River for compact delivery. Testimony of N. Coombs, Jan. 30, 2018 (p.m.). Compact curtailment has a large impact on the over-all water balance because it reduces the amount of irrigation return flow that reaches the groundwater system. Testimony of J. Slattery, Feb. 14, 2018 (p.m.).

227. The 2J Group's expert, Mr. Gregory Sullivan, opined that, logically, the beginning of strict compact administration in 1968 could not be a cause of the reduction in the flow at Arroya/Diamond Springs that occurred between 1950 through 1968. But, of course, this would be a factor for the years between 1968 and 1970. In addition, the effects of strict compact compliance and the reduction in surface water diversions and, therefore, surface water return flows, is a continuing factor in the water balance in the Arroya/Diamond Springs area as well as throughout the entire San Luis Valley.

228. The evidence also establishes that changes in farming practices have reduced tailwater and return flows from irrigation in the vicinity of Arroya/Diamond Springs as well as

throughout the San Luis Valley. Beginning by at least the 1950s, many farmers leveled their fields. Leveling fields allows for more even application of irrigation water to the crops, increases crop yield and consumptive use, and decreases tailwater. Testimony of L. Crowder, Jan. 30, 2018 (p.m.). Mr. Coombs described the difficulties involved in the flood irrigation of unleveled fields and why tailwater resulted from that practice. Testimony of N. Coombs, Jan. 30, 2018 (p.m.).

229. The use of center-pivot sprinkler irrigation has become more common in the Alamosa-La Jara and Conejos River basins which also has contributed to the reduction in return flows and recharge. The practice began in the late 1960s or early 1970s and has expanded since then. Testimony of N. Coombs, L. Crowder, Jan. 30, 2018 (p.m.); Testimony of Lawrence Crowder, Jan. 30, 2018 (p.m.). Most of these sprinkler systems use surface water until it is no longer available, and then use groundwater. Center-pivot sprinkler irrigation is more efficient than is flood irrigation. Approximately 83% of the water applied by the sprinkler is consumed with about 17% return flow. Testimony of J. Slattery, Feb. 1, 2018 (p.m.). The maximum efficiency of flood irrigation is 60% consumed with 40% return flow. *Id*. Thus, where famers have installed center-pivot sprinklers where they formerly flood irrigated, they have reduced return flows on those fields by at least 23%,--a substantial decrease. As Mr. Gregory Sullivan pointed out, the fact that farmers began using more center-pivot sprinklers in the late 1960s and early 1970s would not explain the reduction in flow of Arroya/Diamond Springs that started in 1950. But, this change affects the current availability of irrigation recharge to supply Arroya/Diamond Springs.

230. The installation of center-pivot sprinklers and associated on-farm reservoirs has also increased the efficiency of ditch systems. The existence of on-farm reservoirs to supply sprinklers allows farmers to store water at times their sprinklers may not be operating, thereby

reducing excess ditch flows that might otherwise become tailwater. This is significant for Arroya/Diamond Springs and the Arroya Springs Ditches because, as shown on Exhibit 2J-005, a substantial portion of the formerly flood-irrigated lands that supplied return flows to Arroya/Diamond Springs from the south is now served by center-pivot sprinklers. In addition, as Mr. Coombs explained, the lands just to the west of this concentration of center-pivot sprinklers that were historically flood irrigated are no longer irrigated. Testimony of N. Coombs, Jan. 30, 2018 (p.m.). This reduced the amount of groundwater return flows and tailwater that flowed toward Arroya/Diamond Springs and the Arroya Springs Ditches. *See* Testimony of E. Harmon, Jan. 31, 2018 (p.m.). Mr. Harmon testified that the decline in precipitation and increase in irrigation efficiency has resulted in less recharge to the Confined Aquifer, which results in decreased flows at Arroya/Diamond Springs. *Id*. Additionally, the decline in water supply on La Jara Creek and the Alamosa River has further reduced the water available to provide return flows to Arroya/Diamond Springs and the La Jara Arroyo. Exhibit SE-20 at DWR0001393-97, 1407-08.

231. As the foregoing demonstrates, numerous factors have contributed to the decline in flows of Arroya/Diamond Springs. And, there are numerous factors that may not have caused the decline between 1950 and 1970 but that currently affect the availability of recharge to Arroya/Diamond Springs.

232. It is likewise undisputed that as a result of the wet years from 1984 through 1987, the aquifer systems in the San Luis Valley were essentially full by 1987 or 1988. Testimony of J. Slattery, Feb. 1, 2018 (p.m.). The 2J Group points to Exhibit SE-717 and argues that it shows the aquifers were not full in 1988. Page 2 of Exhibit SE-717 is a graph of the water level in observation well CON1 which was drilled into the Confined Aquifer within a few miles of

Arroya/Diamond Springs. The graph plots the observed water level, the water level predicted by the transient calibration run of the RGDSS and the predicted water level from the impact run, *i.e.* when groundwater withdrawals are taken out of the Model and the Model predicts water levels that would have occurred if there had been no groundwater withdrawals. The 2J Group argues that this shows the water level would have been at the level of the impact run, approximately 15 to 20 feet higher than the highest point of the actual water level readings, if the aquifers had, in fact been full in 1987 and 1988. As the Proponents point out, however, there is no testimony in the record to explain whether this is a correct interpretation of Exhibit SE-717.

233. Other evidence in the record supports Mr. Slattery's testimony. The filling of the aquifers resulted in flow at Arroya/Diamond Springs in 1987 although at a rate lower than the historical flow rate at the springs. Exhibits 2J-04 at 8. This occurred after there was no flow at the springs for some years. Since Arroya/Diamond Springs is not an artesian spring that discharges from the Confined Aquifer, Testimony of Eric Harmon, Feb. 1, 2018 (a.m.), it can only flow when groundwater levels are above the land surface at that location. Testimony of Eric Harmon, Jan. 31, 2018 (p.m.). The water level could be above the land surface at Arroya/Diamond Springs either because the Unconfined Aquifer in that location is full, and overflowing, or because the Confined Aquifer at that location is full, *i.e.* had enough water to be at a high enough pressure to reject any additional recharge. In either case, if there was flow from Arroya/Diamond Springs, it would mean that the aquifer was full at that location and groundwater was spilling from the aquifer onto the land surface. *See id*. Furthermore, the fact that the flow at Arroya/Diamond Springs during the 1984-1987 period did not reach the flow levels that existed prior to 1950, suggests that changes other than groundwater diversions have reduced the irrigation return flows reaching Arroya/Diamond Springs.

234. Because the aquifers were essentially full in 1987, the contribution of well pumping to the decline in flows at Arroya/Diamond Springs prior to 1987 is not a question the Court needs to decide in this case. This is because the Response Function for the Alamosa-La Jara Response Area shows all lagged depletions from groundwater pumping end after 15 years, Exhibit SE-352 at 4, and the Response Function for the Conejos Response Area shows all lagged effects of groundwater pumping end after 16 years, Exhibit SE-652 at 40. Accordingly, it is unlikely that pumping that occurred 17 or more years ago affects Arroya/Diamond Springs today.

235. Finally, Dr. Schreüder did a quantitative analysis of the amount of depletions to the flow of Arroya/Diamond Springs that could conceivably have been caused by diversions from the Confined Aquifer under the conceptual understanding of the springs as presented by Mr. Gregory Sullivan and Mr. Harmon. This analysis showed that, at most, the pumping of Confined Aquifer wells in the vicinity of Arroya/Diamond Springs would have reduced the amount of water flow available at the springs by 0.6 c.f.s. Testimony of W. Schreüder, Feb. 14, 2018 (p.m.).

236. Dr. Schreüder first pointed out that the Confined Aquifer water level is not completely flat because we know that the head at Arroya/Diamond Springs is approximately 100 feet higher in elevation than the head at McIntire Springs. This indicates that the Confined Aquifer head, or pressure level, slopes downward from Arroya/Diamond Springs to the east toward McIntire Springs. We also know that if Arroya/Diamond Springs flowed prior to there being any irrigation in the area, as opined by Mr. Harmon and Mr. Gregory Sullivan, then the amount of recharge prior to irrigation was sufficient to sustain a gradient similar to the current gradient between Arroya/Diamond Springs and McIntire Springs. McIntire Springs is

approximately 12.5 miles east of Arroya/Diamond Springs making the gradient 100 feet/12.5 miles or 8 feet/mile.

237. The sources of recharge prior to the commencement of irrigation in the area would have been precipitation and rim recharge. Exhibit SE-722 shows that precipitation at the area of Arroya/Diamond Springs is approximately 0.4 inch per year and rim recharge is approximately 5.4 inches per year. In his example, Dr. Schreüder estimated that Arroya/Diamond Springs received precipitation and rim recharge from an area of about a square mile, which probably overestimates the area that actually affects the springs. But, calculating the volume of recharge from this area gives a total amount of average annual recharge to the springs of 346 acre feet. (.4 in./year + 5.4 in./year = 5.8 in./year x 640 acres in a square mile = 3,712 acre inches/year / 12 = 309 acre feet per year plus 37 acre feet/year of San Juan underflow). Exhibit SE-730; testimony of W. Schreüder, Feb. 14, 2018 (p.m.). 346 acre feet = 174 c.f.s. and 174 c.f.s. spread out over the course of the 365 days of a year is approximately 0.5 c.f.s. per day.

238. Dr. Schreüder then explained one can input these values into the Darcy's Law equation and make a rough calculation of the conductance value of the materials between Arroya/Diamond Springs and McIntire Springs. According to this calculation, the conductance value is approximately 43.2 acre miles per year.

239. According to the conceptual model Mr. Sullivan used, once Confined Aquifer wells were developed, they began draining water in the immediate vicinity of Arroya/Diamond Springs--what would have been rejected recharge flowing from the springs was instead draining into the Confined Aquifer. To account for this using Darcy's Law, the gradient would have had to have been increased since the conductance value would not change. Based on Exhibit SE-717, which shows an average 20-foot difference between the Confined Aquifer head at CON1

under current conditions and what it is predicted it would have been if there had been no Confined Aquifer well pumping, Dr. Schreüder estimated that this 20-foot difference in head level would manifest between the springs and the closest Confined Aquifer wells. On Exhibit 2J-006, the closest wells to Arroya/Diamond Springs are approximately one and a half to two miles distant. To simplify the calculation, Dr. Schreüder used the distance of two miles and determined the gradient as 20 feet/2 miles or 10 feet/mile.

240. Dr. Schreuder than re-calculated the Darcy's Law equation using the new gradient figure which determined that the flow rate, or Q, was 1.1 c.f.s. The difference between the flow rate after Confined Aquifer well-pumping and before Confined Aquifer well-pumping is 0.6 c.f.s. suggesting that the Confined Aquifer well-pumping was causing an additional 0.6 c.f.s. to drain into the Confined Aquifer and away from the springs. Dr. Schreüder explained that although this shows that Confined Aquifer well-pumping contributed a little bit to the decline in flow at Arroya/Diamond Springs, Confined Aquifer well-pumping could not have caused the dramatic decline that occurred between 1950 and 1970. Dr. Schreüder opined that the major reason for the decline in flow at Arroya/Diamond Springs was more likely a change in the amount of recharge available there because, as his calculation shows, the capacity of the Confined Aquifer withdrawals to actually reduce the flow in the immediate area of the springs is limited by Darcy's Law.

241. Based on the evidence presented, the Court finds that the 2J Group has not proved by a preponderance of the evidence that groundwater withdrawals from the Confined Aquifer were the primary cause of the decline in flow at Arroya/Diamond Springs.

D. <u>2J Group's Proposed Changes to the Model</u>

242. Mr. Gregory Sullivan testified that for the RGDSS Model to properly account for injurious depletions that groundwater withdrawals have caused to Arroya/Diamond Springs the study period should be extended back in time to at least 1950 and calibrated to the then-recorded flows of Arroya/Diamond Springs as well as to the recorded diversions from the Arroya Springs ditches. The reason Mr. Sullivan believes the RGDSS should be extended back to at least 1950 is because the major reduction in flow at Arroya/Diamond Springs occurred between 1950 and 1970, prior to the beginning of the current RGDSS study period. Mr. Sullivan also believes that the RGDSS Model can be calibrated to Arroya/Diamond Springs if the modelers will use not only the sparse few recorded measurements of flow at the springs but also the recorded irrigation season diversions of the Arroya Springs Ditches and then change the conductance parameter in the drain equation that the RGDSS Model uses to simulate the flow of the springs so that the RGDSS Model will predict the flows as estimated in this way. The Proponents disagree because they assert there is not sufficient reliable data from prior to 1970 to calibrate the Model to that time period and that using the Arroya Springs Ditch diversions as a proxy for the flow of the springs is not supported by the evidence in this case. Furthermore, there are not enough other measurements, particularly groundwater level measurements at Arroya/Diamond Springs, to make it possible to calibrate the Model to Arroya/Diamond Springs. Any attempt to do so with the sparse and estimated data currently available will provide results that are not scientifically reliable.

1. How Arroya/Diamond Springs is Represented in the Model

243. Arroya/Diamond Springs is simulated as a MODFLOW drain in the RGDSS Model. In MODFLOW, the flow from a drain is computed based on the simulated head in the

cell that contains the drain using the following equation:

Qdrain = C (hgw – hdrain)
where:
Qdrain = Computed drain flow (ft^3/day)
C = Conductance (ft^2/day)
hgw = Simulated head in the cell containing the drain (ft)
hdrain = Specified elevation of the drain (ft)

Exhibit 2J-004, G. Sullivan Report at 15; Testimony of Gregory Sullivan, Feb. 12, 2018 (a.m.). This equation is essentially an application of Darcy's Law. Testimony of W. Schreüder, Feb. 7, 2018 (a.m.). Flow from the drain is computed only when the simulated head is higher than the simulated drain elevation. If the simulated head falls below the drain elevation, then the drain flow is set to zero.

244. Arroya/Diamond Springs is simulated in Layer 2 in the 6P98 Model at Row 162 and Column 38. The simulated location is approximately one mile northeast of the actual location. The reason for this discrepancy is unknown, however, at trial Dr. Schreüder indicated that this error will be corrected in the next version of the RGDSS Model.

245. The flow of Arroya/Diamond Springs is simulated in the 6P98 Model using the following drain equation parameters:

C = 2,937.97 ft^/day
Hdrain = 7,635.9 feet

2. The 2J Group's Recommended Changes to the Drain Equation Parameters

246. Mr. Gregory Sullivan suggested that the RGDSS drain equation parameters for Arroya/Diamond Springs should be changed to cause the drain equation to predict the amount of flow at the springs that he estimated occurred during the time period 1970 to 2010. The RGDSS Version 6P98 predicts there was an average flow of approximately 0.3 c.f.s. at Arroya/Diamond Springs during this time period. In fact, there are a few individual measurements of spring flow

during that time that are higher than 0.3 c.f.s. But, because the measurements of flow at Arroya/Diamond Springs are so sparse, Mr. Sullivan used the diversion records for the Arroya Springs Ditches as a proxy for the amount of flow coming from the springs. Exhibit 2J-004, Figure 5-2. Essentially, Mr. Sullivan determined the amount of flow he believed the RGDSS Model should predict, based on his estimate of the springs flow using the ditch diversion records, and then he adjusted the conductance value, C, and the drain elevation, Hdrain, until the simulated spring flow the RGDSS Model predicted was similar to the actual estimated spring flow he had calculated. Ultimately, he obtained a predicted spring flow similar to his estimated spring flow when he increased the conductance value from C= 2,937.97 ft^2/day to C=108,000 ft^2/day and the elevation of the springs from Hdrain= 7,635.9 feet to Hdrain=7,640.2 ft. Mr. Sullivan did not actually run the RGDSS Model to obtain these results but, rather, made his calculations outside the Model.

247. Mr. Sullivan indicated that he did not advocate that the modelers simply modify the RGDSS Model to include these values but, rather, this exercise showed the problems with the current Model and would give the modelers a direction forward in adjusting the Model. Mr. Sullivan testified that adjusting the conductance value and drain elevation, alone, might not be enough to obtain reasonable results for spring flow at Arroya/Diamond Springs and that there could be a need to make other adjustments to areas outside of the Arroya/Diamond Springs area to ensure that the Model would simulate enough flow coming into this area to provide a flow out of the springs.

3. The 2J Group's Recommended Changes to the Conductance Value Will Result in Scientifically Unreliable Results

248. Because of a lack of groundwater level data at Arroya/Diamond Springs and the crucial role groundwater levels play in solving the Darcy's Law equation that is central to

groundwater modeling and model calibration, it is currently impossible for the modelers to calibrate the RGDSS Model to Arroya/Diamond Springs in a scientifically reliable way.

249. As discussed earlier in this order, Darcy's Law is the equation that describes the flow of fluid through porous media, such as in aquifers and the MODFLOW Drain Equation is an application of Darcy's Law. Darcy's Law can be expressed in various forms, but a complete expression of the equation is shown in exhibit SE-652 at page 13 as:

$Q = K \times A [(H_1 – H_2)/L]$, where
Q is groundwater flow,
K is hydraulic conductivity of the aquifer material,
A is the cross-sectional area over which the flow occurs,
H_1 is the groundwater level at the higher (up gradient) location,
H_2 is the groundwater level at the lower (down gradient) location, and
L is the length of the path.

250. Variables A and L can be measured. This leaves four unknown values in the equation. If we are using Darcy's Law to solve for the groundwater flow, *i.e.* Q (or the flow of water at Arroya/Diamond Springs), then it is necessary to know the values for the three remaining unknowns, K, H_1 and H_2. Without knowing the values of these three variables the Model cannot be calibrated to a specific location. This is because there are a wide variety of values that could be used for each of the variables that would give the same answer for Q. This results in what Mr. Slattery and Dr. Schreüder called a "non-unique solution." Testimony of J. Slattery, Feb. 1, 2018 (p.m.); Testimony of W. Schreüder, Feb. 6, 2018 (a.m.). The problem with non-unique solutions is that it is not possible to determine which of the many possible solutions is correct.

251. In groundwater modeling, all parties agree that the aquifer parameter hydraulic conductivity, K, (or the conductance value, C, in the MODFLOW drain equation) is often used as the parameter that is adjusted in an effort to have the model more accurately simulate

observed groundwater levels. K is a difficult value to measure directly, but it can be adjusted within scientifically justified ranges to help achieve calibration. However, to use K as the calibration parameter, it is necessary to have observed groundwater levels for H_1 and H_2. Without values for H_1 and H_2 the modelers will have three variables to solve for and so cannot be confident that their solution for the Darcy's Law equation is, in fact, unique, and, therefore, accurately represents the real world.

252. Furthermore, it is only appropriate to adjust the conductance value when there is an objective reason to do so. For example, as discussed in paragraph 126 above, the PRT adjusted the hydraulic conductivity parameter, or K, of the Rio Grande between Del Norte and the Rio Grande/Alamosa County line based on hydrogeologic field studies Mr. Harmon conducted of the area in which he determined the character of the soil was less permeable than the PRT had thought. But, with respect to Arroya/Diamond Springs, we do not have observation data indicating that the hydraulic conductivity parameter is set at an improper value so there is no scientifically reliable reason to adjust the conductance value.

253. The 2J Group also suggested that increasing the conductance value from 2,937.97 ft^2/day to108,000 ft^2/day was appropriate, in part, because Mr. Sullivan suggested that the modelers have significantly reduced the conductance parameter of the spring in successive phases of the Model, as summarized in Exhibit 2 J – 28, Table 5-1. In fact, however, this is a flawed understanding of what occurred in previous models. This table first lists the conductance value for Arroya/Diamond Springs in the Phase 1 RGDSS Model as 84,672 ft^2 /day. But, the reference to a Phase 1 RGDSS Model is an error because that was a separate and different model that the State Engineer prepared for use in the American Water Development, Inc. ("AWDI") litigation. Testimony of E. Harmon, Jan. 31, 2018 (p.m.); Testimony of W. Schreüder, Feb. 7,

2018 (a.m.) and Feb. 14, 2018 (p.m.). The AWDI model "hard wired" a fixed flow of 9.8 c.f.s. at Arroya/Diamond Springs, so the springs' flow could not vary and could not be depleted. Testimony of E. Harmon, Jan. 31, 2018 (p.m.). The springs' conductance value was effectively back-calculated from the fixed flow rate for the springs. Testimony of W. Schreüder, Feb. 7, 2018 (a.m.). Given that this value was "hard-wired" and was not based on observation data, but was simply a value input into that model, it does not assist in determining an appropriate value for the conductance parameter for the Arroya/Diamond Springs in a transient water model like the current RGDSS Model.

254. In addition, Table 5-1 lists 6,500 ft^2/day as the conductance value for Arroya/Diamond Springs in the Phase 4 RGDSS Model. But this value is in error because the State Engineer's documentation for the Phase 4 Model was in error. The actual value used in the Phase 4 Model was 2,938 ft^2/day which is also the value that has been used in phases 5 and 6 of the Model. *Id*. Dr. Schreüder explained that the modelers did not adjust the conductance value for Arroya/Diamond Springs during the calibration of phases 3 through 6 of the Model because there was no data to determine calibration targets for Arroya/Diamond Springs. *Id*. Thus, the Court finds that the 2J Group's claim that the conductance value at Arroya/Diamond Springs has been continuously reduced is in error, due in part to an error in the Model's documentation, and due in part to a lack of understanding of the operation of the State Engineer's AWDI Model.

255. Another problem with Mr. Sullivan's recommendation that the conductance parameter of the MODFLOW drain equation for Arroya/Diamond Springs be significantly adjusted is that his analysis relies on using historical diversions from the Arroya Springs Ditches as a proxy for the flow of Arroya/Diamond Springs. In fact, however, the water decreed to the various Arroya Springs Ditches is sourced not only from the flow of Arroya/Diamond Springs

but also from ditch seepage and return flow from irrigation. So, although the Court can see the benefit of looking at the ditch diversions to get a general idea of what the flow from Arroya/Diamond Springs might have been over the years, the Court does not believe it would be appropriate to calibrate the RGDSS to the ditch diversions as a proxy for the springs' flow.

256. In the decree from the 1903 general adjudication, dated May 8, 1903, the court found that the L.D. Eskridge and South Side Arroya Ditches derived their respective supplies of water from Arroya Creek and Spring Branch and that the appropriations for both ditches were from

> water arising from springs and seepage in that vicinity appearing since the former adjudication of priorities of water rights in said Water District, by reason of the use of water carried from the Conejos River through the Mogote Ditch.

Exhibit SE-0265 at 6–7, 11–12.

257. According to L.D. Eskridge's testimony before the referee at the 1903 general adjudication hearings the L.D. Eskridge Ditch derived its supply of water from Arroya Channel or Arroya Creek. SE-0711 at 223. He indicated that this supply of water came "[f]rom a certain spring laying above the Aroya [sic] near the Arroya and also seepage from other lands near the Arroya" and that this supply of water was in addition to the water that had been running in Arroya Creek prior to that time. *Id.* at 227-28. Mr. Eskridge testified that the seepage water that came into Arroya Creek came from "ditches for irrigating lands that join this arroya" and that the seepage comes in from both sides of the arroyo. *Id.* at 228-29. The spring and the seepage water "furnish[ed] practically a new supply of water" to Arroya Creek. *Id.* at 229. In response to questioning as to whether he claimed any water from Alamosa or La Jara Creeks, he testified that his claim was limited to seepage from the Alamosa and Conejos Rivers and spring water. *Id.* at 230. Thus, the decreed source of water for the L.D. Eskridge Ditch is both spring flow and water seeping into Arroya Creek below the springs.

258. Mr. Eskridge also testified in support of the claim for the South Side Arroya Ditch, offering the same descriptions of the flow of Arroya Creek before, during, and after 1889, and the same reasons for the change in flow as described in his testimony in support of his claim for the L.D. Eskridge Ditch. *Id.* at 239. Mr. Eskridge testified that the Miller & Sherwin Ditch also provided a portion of the seepage to Arroya Creek. *Id.* at 242. Accordingly, similar to the L.D. Eskridge Ditch, the decreed source of water for the Southside Arroya Ditch is both spring flow and water seeping into Arroya Creek below the springs.

259. The decree from the 1918 general adjudication, dated February 7, 1918, granted an additional 36 c.f.s. to the South Side Arroya Ditch and its First Enlargement and 19.5 c.f.s. to the Arroya Springs Ditch (which included 7 c.f.s. transferred by stipulation from the claimants of the South Side Arroya Ditch to the Arroya Springs Ditch claimants). Exhibit SE-0603 at 11 and 9-10 respectively. The 1918 decree identifies Arroya Creek as the source of supply for the South Side Arroya Ditch and its First Enlargement. *Id.* at 10–11. The decree identifies two sources of supply for the Arroya Springs Ditch, namely, "the La Jara Arroya Springs" and "seepage and underflow water from the land situate above said ditch." *Id.* at 9. The decree attributes 5 c.f.s. to "seepage and underflow water from the lands situate adjoining said ditch" and the remaining 14.5 c.f.s. to La Jara Arroya Springs. *Id.* at 9–10. Thus, again, the decreed source of water for the Southside Arroya Ditch and its First Enlargement is Arroya Creek, not the springs, and the decreed source for the Arroya Springs Ditch includes both water from the springs and seepage water flowing into the ditch below the springs.

260. The 1903 and 1918 decrees adjudicate a total of 71.19 c.f.s. to the L.D. Eskridge Ditch (6.5 c.f.s.), South Side Arroya Ditch (43.5 c.f.s.), Spring Overflow Ditch (1.69 c.f.s.), and Arroya Springs Ditch (19.5 c.f.s.) (collectively, "Arroya Springs Ditches"). The maximum

measured flow of Arroya/Diamond Springs (measured in Arroya Creek) – 58.3 c.f.s. – occurred on September 24, 1923, following a week of heavy rains. Exhibit SE-0519, 1923 Report of R.I. Meeker, at 30 (DWR0020540) (noting "Heavy rains week of Sept. 17"). Thus, the total water rights decreed to the Arroya Springs Ditches exceeds, by more than 12 c.f.s., the maximum recorded flow from Arroya/Diamond Springs, which occurred in unusually wet conditions.

261. In addition, in a comparison of the few measured daily flows of Arroya/Diamond Springs to the measured diversions of the Arroya Springs Ditches on the same days, there are days on which the measured diversions of the ditches are higher than the flow of the springs: *e.g.* April 14, 1936 (22 c.f.s. vs. 19.3 c.f.s.); April 6, 1950 (24 c.f.s vs. 20 c.f.s.); and May 9, 1950 (20 c.f.s. vs. 16.3 c.f.s.). Exhibit 2J-004, Table 3-1 "Daily Flow Measurements Arroya Springs and Diversions of Arroya Springs Ditches." The source of this additional water is unidentified; but its existence suggests there is other water, such as the seepage and tail water identified in the decrees for these ditches, that supplies the Arroya Springs Ditches in addition to water originating at Arroya/Diamond Springs. And, there are numerous (hundreds of) days over the course of nearly one hundred years, on which there is no measurement of the flow at Arroya/Diamond Springs to which to compare the diversions from the Arroya Springs Ditches. So, we do not know whether the flow on those days was only from Arroya/Diamond Springs or from the additional seepage and tailwater flowing into La Jara Arroya Creek below the springs.

262. Based on the foregoing, the Court finds that the Arroya Springs Ditches are supplied by both springs and seepage, not solely by Arroya/Diamond Springs. Both the decrees and the evidence in this case established that there are sources of supply other than Arroya/Diamond Springs that historically contributed to the water diverted by the Arroya Springs Ditches. For these reasons, diversion records for the Arroya Springs Ditches are not the

same as or necessarily a reliable proxy for historical flows from Arroya/Diamond Springs during the periods between the infrequent measurements of flow from Arroya/Diamond Springs.

263. Finally, the Court notes that in Figure 5-2 of his report, Exhibit 2J-004, Mr. Sullivan compared his simulated values to a number of other values including output from the so-called steady state models and the transient 6P98 Model and drew conclusions from those comparisons. The Court does not find this analysis persuasive. First, comparisons to the output of the steady state models are of little value because, as described above, the steady state models are not reliable for the purpose for which Mr. Sullivan sought to use them. *See* above at ¶ 75. Second, as Mr. Sullivan acknowledged, this simulation was not based on running the RGDSS Model, so it does not take into account other changes that would occur in the groundwater system as a result of changing the value of the conductance parameter at Arroya/Diamond Springs. Therefore, it also does not reliably show what amount of water might flow at Arroya/Diamond Springs in the absence of groundwater withdrawals. Third, since diversions by the Arroya Springs Ditches are not a reliable substitute for the flow of Arroya/Diamond Springs they cannot be used as a calibration target.

264. Furthermore, when Dr. Schreüder prepared a similar analysis using the 6P98 Model drain return package, Exhibit SE-23 at DWR0001450, Fig. 1, he found that the RGDSS predicted a much lower flow from Arroya/Diamond Springs than Mr. Sullivan had predicted. In fact, the flow was more like the flow Version 6 of the RGDSS currently predicts. To prepare his analysis, Dr. Schreüder went into the drain return package and changed the elevation of Arroya/Diamond Springs to 7,640.2 feet and changed the conductance value to 108,000 $ft.^2$/day as Mr. Sullivan suggested and then ran the RGDSS Model. Testimony of W. Schreüder, Feb. 14, 2018 (p.m.). Figure 1 of Dr. Schreüder's Rebuttal Expert Report is a graphical representation of

those results which also compares them to the predictions the 6P98 Model makes. Exhibit SE-23. That figure illustrates that using the 2J Group's proposed conductance value would not cause the RGDSS to replicate either the claimed Arroya Springs Ditches' diversions or the increased Arroya/Diamond Springs flow Mr. Gregory Sullivan illustrated in Figure 5-2 of his report. Rather, the predicted flow at Arroya/Diamond Springs, even using the proposed modified conductance value and elevation, is much closer to the flows the Model predicted than those Mr. Sullivan predicted in Figure 5-2 of his report.

265. The evidence does not support requiring the State to change the conductance value in the ways the 2J Group recommends. The evidence does not demonstrate that a different conductance value would be more reliable than the value the Model currently uses for Arroya/Diamond Springs. Furthermore, even if the State made the changes the 2J Group recommends, the results of the impact run—*i.e.* the no-pumping run--would not show much more predicted flow at Arroya/Diamond Springs than the current 6P98 Model predicts. Accordingly, the 2J Group has not proven the Model's simulation of Arroya/Diamond Springs is unreasonable.

4. The 2J Group's Recommended Change in the Time Period for the Model Will Result in Scientifically Unreliable Results

266. Mr. Sullivan also recommended that the Model be extended back in time to the 1950s in order to capture the changes in spring flow that occurred at Arroya/Diamond Springs between 1950 and 1970.

267. The evidence establishes that, in the early phases of the RGDSS, the goal was to have the Model extend back in time to 1950. But by phase 4 of the Model, the modelers had abandoned that goal due to the lack of groundwater level data with which to calibrate the Model. Testimony of E. Harmon, Jan. 31, 2018 (p.m.). Observed groundwater levels are typically taken

from observation wells. In the entire San Luis Valley there were fewer than 50 observation wells prior to 1967, and nearly all of those observation wells were in the Unconfined Aquifer. Exhibit SE-652 at 14. There were a spate of groundwater level measurements in the Confined and Unconfined Aquifers between 1967 and 1972. *Id.* The systematic and continuous collection of groundwater level data in the Confined and Unconfined Aquifers, however, did not begin until about 1974 and the number of observation wells being routinely measured has generally increased since that time. *Id.* There are now more than 600 wells from which groundwater levels are collected, approximately 140 of which are in the Confined Aquifer. *Id.* Because of the lack of groundwater measurements before 1970, the calibration period for the Model has been limited to 1970 forward: the time period during which Confined and Unconfined Aquifer groundwater level data began to be collected and compiled annually. *See* Exhibit SE-652 at 14.

268. Mr. Sullivan testified that even though there was little groundwater level data available for the period from 1950 through 1970, it would still be appropriate to extend the Model back to that time frame by calibrating to other data concerning the hydrology and water use in the Valley, as well as stream flow records and diversion records. He indicated that the modelers could use their intuition to help them fill in the missing water levels for that time period. Testimony of G. Sullivan, Feb. 12, 2018 (a.m.). In contrast, both Mr. Slattery and Dr. Schreüder opined that without groundwater level data, it would be impossible to calibrate the Model to the time-period 1950 to 1970, especially because water levels, or heads, are a necessary component of Darcy's Law, which is the foundation for the RGDSS Model.

269. In addition, Mr. Slattery and Dr. Schreüder testified that without groundwater level data at Arroya/Diamond Springs, it could not be a calibration point in the Model even if the Model were extended back to the 1950s. In earlier phases of the RGDSS Model, Mr. Harmon

had suggested that Arroya/Diamond Springs, Russell Springs and McIntire Springs be made calibration points in the Model. But, as Mr. Harmon explained with respect to Arroya/Diamond Springs, there is insufficient data to use Arroya/Diamond Springs as a calibration point. The historical flow reports are very sparse and there has been little or no flow from Arroya/Diamond Springs during the Model calibration period. In addition, the elevation of the springs is not known, the inflow to the springs is not well defined, and the groundwater level beneath Arroya/Diamond Springs is not known. Testimony of E. Harmon, Jan. 31, 2018 (p.m.). Due to the lack of sufficient scientifically reliable data, the modelers made neither Arroya/Diamond Springs nor Russell Springs calibration points in the Model.

270. In contrast, there is a longer and more complete record of flow from McIntire Springs. As described above, the available information on the geology of McIntire Springs and how it operates is also far more complete than that for Arroya/Diamond or Russell Springs. Because they have a greater level of understanding of McIntire Springs and have the ability to verify the reliability of the data with respect to the springs, it makes sense that the modelers use McIntire Springs as a calibration point for the RGDSS Model.

271. Based upon the evidence presented, the Court finds that the Model cannot reliably be extended back before 1970.

5. Because there is Insufficient Reliable Information, the State Engineer Cannot Determine Whether the RGDSS Predictions Concerning Arroya/Diamond Springs are Reliable

272. The 2J Group also claims that the State Engineer has admitted that the Model cannot reliably predict depletions to Arroya/Diamond Springs and therefore the Model and its lack of a Response Function for Arroya/Diamond Springs cannot form the basis for a finding of no depletions to Arroya/Diamond Springs from groundwater withdrawals. In fact, however,

while the Model does make predictions of aquifer levels at the cell containing Arroya/Diamond Springs, there is limited data regarding the hydrogeologic conditions and spring flows that can be used to evaluate the reliability of those predictions. In other words, due to the lack of reliable data during the 1970-2010 period, it cannot be determined whether or not the Model predictions at Arroya/Diamond Springs are correct and reliable. Thus, it is the lack of reliable data, not a lack of reliability of the Model, that is the reason the Model cannot reliably predict depletions to Arroya/Diamond Springs. When reliable data on Arroya/Diamond Springs becomes available, the State Engineer presumably will be able to determine whether, and to what extent, groundwater withdrawals deplete the flows of Arroya/Diamond Springs. The Court understands that the purpose of the planned well construction at Arroya/Diamond Springs is to begin to collect the needed reliable data.

273. The 2J Group asserts that the lack of reliable predictions of flow or injurious depletions at Arroya/Diamond Springs means the Response Functions for the Conejos and Alamosa-La Jara Response Areas are invalid. The evidence does not support this conclusion. As Dr. Schreüder explained, Arroya/Diamond Springs has either been dry or had a very small discharge during most of the 1970 to 2010 calibration period. The Model predicts a discharge of zero to approximately 0.3 c.f.s. during the calibration period as shown by the red line in Figure 1 of Exhibit SE-23. By comparison, the Model's overall water budget, *i.e.* the inflows and outflows in the Model Domain, are in excess of a million acre-feet per year. Arroya/Diamond Springs' discharge is a minor component of the overall flow system and therefore the Model's current representation of Arroya/Diamond Springs is reasonable for the purpose of predicting depletions to the other stream reaches from groundwater pumping. The fact that the Model, in its present form, has not been, and without reliable data cannot be, calibrated to the flow at

Arroya/Diamond Springs does not adversely affect the Response Functions' ability to reliably predict depletions to the existing administrative stream reaches. Exhibit SE-23 at DWR0001448; Testimony of Dr. Schreüder, Feb. 7 (a.m.). Mr. Slattery expressed essentially the same opinion as Dr. Schreüder, explaining the Model is the basis for the Response Functions, the Model is reasonably calibrated to the observation wells and base stream flows, and therefore the Model represents the aquifer systems in the San Luis Valley in a reasonable and reliable manner. Exhibit SE-20 at DWR0001398; Testimony of J. Slattery, Feb. 2, 2018 (a.m.). Based on this evidence, the Court finds that the Response Functions derived from the Model are reliable.

274. Moreover, while it may be helpful to understand each of the specific factors that combined to cause the decline in flow of Arroya/Diamond Springs, that is not a question the Court needs to resolve or should resolve in this case. The Court finds that the only way for the State Engineer to have a reliable scientific basis to determine whether and to what extent groundwater pumping is affecting the flow of Arroya/Diamond Springs is to have reliable site-specific data at Arroya/Diamond Springs. Mr. Slattery aptly described this as a "2 foot or 20 foot" problem. He explained that whether Arroya/Diamond Springs would flow in the absence of historical groundwater pumping will be determined, in large part, by the hydrogeology of the springs and the depth to groundwater beneath the springs. If the depth to groundwater is shallow, say two feet, the springs might flow in the absence of groundwater pumping; but if the depth to groundwater is greater, say twenty feet, the absence of groundwater pumping will not cause the springs to flow. Testimony of J. Slattery, Feb. 2, 2018 (a.m.). Without having at least this very basic data on the hydrogeology and depth to groundwater at Arroya/Diamond Springs, the State Engineer does not have the information needed to reliably predict whether, and to what extent,

groundwater pumping is depleting the quantity of water that would otherwise flow from Arroya/Diamond Springs under current hydrological conditions.

275. With respect to the 2J Group's challenges to the Rules, the question the Court must answer is whether there is sufficient scientifically reliable information for the State Engineer (1) to conclude that in the absence of historical well pumping (net consumptive use of groundwater) Arroya/Diamond Springs would flow, and if so, (2) to determine the amount of annual depletion to the springs' flow such pumping causes. The Court finds that there is not sufficient scientifically reliable information to make either of these determinations, and the State Engineer was justified in not preparing a Response Function for Arroya/Diamond Springs. The Court notes, however, that as a result of the planned Phase 7 investigations at Arroya/Diamond Springs, the State Engineer should begin to acquire the scientifically reliable information needed to make these determinations.

VII. HENDERSONS' CHALLENGE TO RULE 8

276. Karen and Colin Henderson filed a protest to Rule 8 and represented themselves on this issue. The Hendersons own senior surface water rights in the South Side Arroya Ditch and the L.D. Eskridge Irrigating Ditch, all sourced, at least in part, from Arroya/Diamond Springs. Some of these rights have an appropriation date as early as 1889.

277. The Hendersons challenged the way Rule 8 implements the aquifer sustainability requirements of subsections 37-92-501(4)(a)(I) through (IV), C.R.S., for the Confined Aquifer. With regard to the Confined Aquifer System, Rule 8.1 establishes a network of monitoring wells for the purposes of supplementing "the limited amount of water level and Artesian Pressure data currently available for the Confined Aquifer System." Rule 8.1.1. Rule 8.1.2 provides that the State Engineer, in cooperation with local water users and water use entities, will:

> [c]ollect additional data and investigate inflows and outflows from the Confined Aquifer System and the relationship between climatic conditions, hydrologic and geologic conditions, unconfined aquifer and Confined Aquifer System groundwater withdrawals and the water levels and Artesian Pressures of the Confined Aquifer System. The purpose of this additional data collection and investigation is to provide the State Engineer with the information needed to (a) more fully understand and model inflows to and outflows from the Confined Aquifer System, (b) better estimate the 1978 through 2000 water levels and Artesian Pressures in the Confined Aquifer System, and (c) further investigate the relationship between groundwater withdrawals, climatic conditions, movement of water through the system and the water levels and Artesian Pressures in the Confined Aquifer System.

Rule 8.1.3 further provides that no later than ten years from the effective date of the Rules, the State Engineer must prepare a report concerning the results of these investigations and determine the preferred methods to maintain a Sustainable Water Supply and manage the artesian pressures of the Confined Aquifer.

278. The Hendersons challenged this provision of Rule 8 because they believe the State Engineer has sufficient information to immediately begin to regulate and curtail wells in the vicinity of the Hendersons' property using the artesian pressure records for the time period 1978 to 2000 from monitoring well CON1 that is located near their farm. They argue that Rule 8's requirement that the State Engineer perform a complicated study of what is occurring in the Confined Aquifer will allow junior groundwater diverters to continue to illegally take water that belongs to senior surface water rights.

279. CON1 is a monitoring well which measures the water level or the pressure level in the Confined Aquifer. CON1 is located near the Hendersons' farm. The State began collecting data from this well in 1983.

280. Although the Hendersons claim that the State Engineer has sufficient information about the condition of the Confined Aquifer in the vicinity of Arroya/Diamond Springs, based on the groundwater measurements from monitoring well CON1, to allow the him to curtail junior

groundwater diversions in the vicinity, they presented no viable method to use the measurements from CON1 to establish and maintain Confined Aquifer pressures in the range that occurred during 1978 to 2000. The method they suggested was that the State Engineer curtail the most junior groundwater diversions and continue to curtail more of those diversions, in reverse order of their priority, until Arroya/Diamond Springs begins to flow again. As discussed below, in the Conclusions of Law, it would be illegal for the State Engineer to use this method.

281. In addition, as a factual matter, the evidence presented in this case does not establish that, under current hydrological conditions, Arroya/Diamond Springs will flow even if artesian pressures in the Confined Aquifer are increased to the levels that existed between 1978 and 2000. Since there was very little actual flow at the springs during the historical period of 1978 to 2000, it is not clear that returning the Confined Aquifer to the pressure levels that existed during those years will result in flow at Arroya/Diamond Springs.

282. Furthermore, the evidence at trial showed that the State Engineer does not have sufficient data to determine the effects of groundwater withdrawals on Confined Aquifer pressure levels as they existed during 1978 to 2000. By gathering additional data through these Rules, the State Engineer will be able to isolate other factors such as climate and water supply and calculate their impact on Confined Aquifer pressures. This will allow the State Engineer to determine the preferred method to regulate groundwater withdrawals to maintain Confined Aquifer pressures pursuant to statute.

283. The Hendersons presented evidence they claimed showed a correlation between the potentiometric head at CON1 and the flow at Arroya/Diamond Springs. Dr. Henderson testified that he believes Arroya/Diamond Springs will flow whenever the potentiometric head at CON1 is above 7,625 feet. Testimony of Dr. Henderson, Feb. 13, 2018 (p.m.); Exhibit H-1. He

arrived at this conclusion by comparing CON1 measurements with diversion records for the Arroya Springs Ditches. *Id.* The Court is not certain what the Hendersons are trying to prove with this information with respect to the requirements of Rule 8. Rule 8 is intended to bring the artesian pressures in the Confined Aquifer back to the levels that existed between 1978 and 2000. From the Hendersons' Exhibit H-1, it appears that if Dr. Henderson's hypothesis is correct, if the artesian pressures return to the levels that existed between 1983 and 2000, it is likely there will be some flow at Arroya/Diamond Springs. Thus, the fact that there may be a correlation between the flow at Arroya/Diamond Springs and the potentiometric head at CON1 does not suggest that Rule 8 is unreasonable or inappropriate.

284. The Court believes the Hendersons may be asking the Court to make a finding that, because of the apparent correlation between the potentiometric head at CON1 and the Arroya Springs Ditches' diversions, that the flow at Arroya/Diamond Springs is driven by changes in the pressure in the Confined Aquifer. Again, the Court is uncertain how such a finding makes any difference vis-à-vis the Hendersons' challenge to Rule 8. But, nevertheless, the Court is unable to make such a finding for several reasons. First, the Court has already determined that the Arroya Springs Ditch diversions are not a reliable proxy for the flow of Arroya/Diamond Springs. And, second, the Proponents' expert, Dr. Schreüder, presented credible evidence that contradicted such a finding. According to Dr. Schreüder, if the discharge from Arroya/Diamond Springs was driven by the Confined Aquifer head, we would expect the same pattern of flow at Arroya/Diamond Springs as we see in the measurements for the pressure levels at CON1. Testimony of W. Schreüder, Feb. 7, 2018 (a.m.). The CON1 measurements demonstrate that the pressure levels are lowest at the end of the irrigation season toward the end of the summer and they are highest in the wintertime when no water is being withdrawn for

irrigation. *Id.*; Exhibit SE-717. In contrast, the flow at Arroya/Diamond Springs tended to increase during the irrigation season. Exhibit 2J-04, Expert Report of Gregory Sullivan, at Table 3-1. From this, Dr. Schreüder concluded that either the spring discharge is not, in fact, driven by the pressure in the Confined Aquifer, or the recorded spring flows don't actually reflect discharge from the springs. Based on the evidence presented, the Court cannot draw reliable conclusions about the relationship between the measured flow at the CON1 Well and the flow at Arroya/Diamond Springs.

285. The Hendersons also object to the method the Rules specify for the State Engineer to calculate a Composite Water Head to determine pressure levels in the Confined Aquifer. They argue that Rule 8.1.4's provision requiring the State Engineer to use measurements collected in each February and March, starting in 2015, to develop a Composite Water Head is improper. A Composite Water Head is defined as

> . . . an area-weighted composite of water levels or Artesian Pressures of the Confined Aquifer System within a specified area. The Composite Water Head is derived from annual measurements, collected outside of the Irrigation Season, from multiple wells within specified areas.

Rule 4.4, Definition of "Composite Water Head." The Hendersons "dispute the February and March 2015 measurements be used as the 'composite head' in cases where there are actual 'composite head' measurements from monitoring wells taken during the 1978-2000 time period." *Hendersons' Closing Arguments* at 2. The Hendersons go on to explain they are concerned that the State Engineer will use the 2015 Composite Water Head to input data into the RGDSS Model to extrapolate backward to determine what the pressure levels were in the Confined Aquifer during 1978 through 2000 and that the actual measured values are more accurate.

286. From a review of the Rules and the evidence in this case, it appears that at least one purpose for annually determining the Composite Water Head is to have something to

compare to the pressure levels in the Confined Aquifer during 1978 through 2000 to determine whether the restrictions on junior groundwater diversions that the State Engineer has instituted are, in fact, returning the Confined Aquifer to the statutorily required pressure levels. This is a rational reason to calculate the Composite Water Head in the way set forth in the Rules.

287. Furthermore, the evidence in this case demonstrates that the modelers use the actual measurements of water and pressure levels in the various monitoring wells to allow them to calibrate the Model. Accordingly, the Court understands that the modelers will use the historical measurements for the CON1 Well together with the historical measurements that exist from all the other Confined Aquifer wells in the San Luis Valley to make sure that the RGDSS Model's predictions are accurate. Given that the RGDSS Model takes into account what is occurring throughout the Model Domain, it is more appropriate for the State Engineer to rely on the Model's results to make determinations concerning what needs to occur to bring the artesian pressure in the Confined Aquifer back to the levels that existed between 1978 and 2000, rather than to limit himself only to the historical information from one Confined Aquifer monitoring well. This is true even when the Court is only considering the effects of groundwater diversions on a localized area, such as Arroya/Diamond Springs. The evidence in this case made clear that there are many factors which affect the availability of water at a certain surface water feature including groundwater diversions located near and far from the surface water feature, evapotranspiration, the effect of drains, etc. Furthermore, the evidence in this case made clear that as one of these factors changes, the other factors may also change but, frequently, in a non-linear fashion. Thus, the State Engineer must rely on a computerized model such as the RGDSS Model to take all these factors, including their interplay among them, into account to determine whether groundwater diversions are depleting surface water supplies.

288. At trial, both Hendersons testified about the State's lack of response to their repeatedly voiced concerns about how the Rules would protect their senior surface water rights. As far back as 2008, the Hendersons were writing letters to the then Division Engineer, Michael Sullivan, and the General Manager of the Rio Grande Water Conservation District, Steve Vandiver, voicing their concerns. Ms. Henderson attended numerous meetings of the San Luis Valley Rules Advisory Committee beginning in 2010 and frequently raised her concerns. For some reason, unknown to the Court and not explained at trial, neither the State Engineer nor the Rio Grande Water Conservation District chose to respond to these letters and concerns. These facts are not a reason for the Court to disapprove Rule 8; but the Court notes that this lack of response prompted the Hendersons to proceed with their protest to the Rules, which, perhaps could have been avoided if the State or Division Engineer had engaged more openly with the Hendersons earlier in the process.

289. At trial, much of the Hendersons' testimony focused on alleged injury to their surface water rights. But, potential injury to the Hendersons' or anyone else's surface water rights is not the subject of Rule 8. The Hendersons acknowledged the separation of these issues when they stated that "damage to our senior rights will not ultimately be alleviated by bringing artesian pressures to those found between 1978 and 2000." Testimony of C. Henderson, Feb. 13, 2018 (p.m.). Thus, much of the Hendersons' challenge at trial did not amount to an attack on Rule 8. Instead, it was an argument to restore historical flows at Arroya/Diamond Springs, without reference to what the Confined Aquifer pressures were during 1978 to 2000. The Court has already dealt with this argument in its discussion of the 2J Group's challenges to the Rules.

VIII. CONCLUSIONS OF LAW

290. The Court will first discuss the legal standards and burdens of proof governing review of water rules and regulations. The Court will then discuss the legislative mandate for the Rules at issue in this case and will explain how these Rules generally implement the General Assembly's directive. The Court will then specifically address the challenges to the Rules—first the 2J Group's challenges and then the Hendersons' challenges.

A. Legal Standards and Burdens of Proof Governing Review of Rules and Regulations Adopted by the State Engineer

291. The State Engineer and Division Engineers must "administer, distribute, and regulate the waters of the state" in accordance with the constitution of the State of Colorado, the 1969 Act, and other applicable laws and may adopt rules and regulations to assist in the performance of these duties pursuant to section 37-92-501(1), C.R.S. This is generally referred to as the "water rule power" of the State Engineer. *See Kuiper v. Gould*, 583 P.2d 910, 913 (Colo. 1978); *Simpson v. Bijou Irrig. Co.*, 69 P.3d 50, 59 (Colo. 2003). The State Engineer is also empowered to adopt rules and regulations necessary to enforce interstate compacts pursuant to section 37-80-104, C.R.S. This is referred to as the "compact rule power." *Kuiper v. Gould*, 583 P.2d at 913; *Simpson v. Bijou Irrig. Co.*, 69 P.3d at 67–68.

292. The water judge has jurisdiction to decide protests to proposed rules and regulations adopted by the State Engineer. Section 37-92-501(3), C.R.S.; *Simpson v. Bijou Irrig. Co.*, 69 P.3d at 65. Determining the validity of rules and regulations of the State Engineer is a "water matter" within the exclusive jurisdiction of the state's specially appointed water judges. *Kuiper v. Well Owners Conservation Ass'n*, 490 P.2d 268, 273–74 (Colo. 1971).

293. Rules and regulations pertaining to groundwater withdrawals are "subject to the statement of opposition process for water cases." *Colorado Ground Water Comm'n v. Eagle*

Peak Farms, Ltd., 919 P.2d 212, 220 (Colo. 1996) "The court's role in conducting the review is to determine whether the rules 'have a reasonable basis in law.'" *Id.* Accordingly, those protesting groundwater rules because they claim they exceed statutory authority have the burden to show by a preponderance of the evidence that the rules lack a reasonable basis in law. *Kuiper v. Well Owners Conservation Ass'n*, 490 P.2d at 277; *Alamosa-La Jara Water Users v. Gould*, 674 P.2d at 925; Colo. R. Evid. 301.

294. The court must presume that the State Engineer's proposed rules and regulations are valid until shown otherwise by a preponderance of the evidence. *Kuiper v. Well Owners Conservation Ass'n,* 490 P.2d at 277. Those who challenge such rules must make the invalidity of such rules "so manifest that the court has no choice except to hold that the Secretary has exceeded his authority and employed means that are not at all appropriate to the end specified in the act." *Id.* (quoting *Boske v. Comingore*, 177 U.S. 459 (1900)).

295. None of the Protestors ask the Court to find that the Rules or the statutes pursuant to which the State Engineer promulgated them are unconstitutional. So, the Court will not discuss the burden of proof to prove that a statute is unconstitutional.

296. When reviewing a statute, a court's primary responsibility "is to give effect to the legislative intent motivating the enactment of the statute." *Simpson v. Bijou Irrig. Co.*, 69 P.3d at 59 (citing *People v. Norton*, 63 P.3d 339, 343 (Colo. 2003)). *Accord Colo. Water Conservation Board v. Upper Gunnison River Water Conservancy Dist.*, 109 P.3d 585, 593 (Colo. 2005). The Court "should give effect to each word and construe each provision in harmony with the overall statutory design, whenever possible." *Empire Lodge Homeowner's Ass'n v. Moyer*, 39 P.3d 1139, 1152 (Colo. 2001).

297. When the analysis involves a number of interrelated statutory provisions, the Court "must endeavor to give consistent, harmonious, and sensible effect to the statutory scheme as a whole." *Simpson v. Bijou Irrig. Co.*, 69 P.3d at 59. The Court should also consider "the General Assembly's course of action and intent when enacting, amending, and repealing statutes." *Empire Lodge Homeowner's Ass'n*, 39 P.3d at 1152; *Simpson v. Bijou Irrig. Co.*, 69 P.3d at 70–71 ("[S]tatutory directives do not exist in a vacuum; instead, statutes – and the authority they convey – are as interrelated to one another as the legislative objectives that motivated their enactment.").

B. <u>The Proposed Rules Comply with the Legislative Mandate and Authority for the Rules</u>

298. The legislative mandate for the Rules is generally contained in section 37-92-501(1), C.R.S. In that statute, the General Assembly has directed the State and Division Engineers that while administering, distributing and regulating the waters of the state, including when promulgating rules and regulations, they must not "allow groundwater withdrawal which would deprive senior surface rights of the amount of water to which said surface rights would have been entitled in the absence of such groundwater withdrawal." Section 37-92-501(1), C.R.S. However, the legislature has also indicated its intent that the State and Division Engineers not curtail groundwater diversions "for the benefit of surface right priorities, even though such surface right priorities be senior in priority date, when, assuming the absence of groundwater withdrawal by junior priorities, water would not have been available for diversion by such surface right under the priority system." *Id.*

299. The Court has already determined that the RGDSS Model is a reasonable and scientifically valid tool upon which the State Engineer can rely to require wells to remedy injurious Stream Depletions. Thus, the Rules have a reasonable basis in law because they

comply with the statutory mandate to limit future withdrawals of groundwater in Division 3 only when a scientifically valid tool, the RGDSS Model, predicts that in the absence of those withdrawals, water would have been available to senior surface water rights. *See* Rules 6 and 7. Furthermore, the Rules comply with the statutory mandate because they only permit continued use of such groundwater if the groundwater diverter replaces the predicted injurious depletions the groundwater diversions are causing to senior surface water rights, thus preventing material injury to senior surface rights. *Id.* So, the Rules meet the standards of section 37-92-501, C.R.S., to optimize the use of water through defined and scientifically reliable procedures for determining injurious depletions to surface streams caused by the withdrawal of groundwater and through detailed standards for the continued use of groundwater consistent with the preservation of the priority system. *See e.g.* Rules 6–12, 24.

300. The General Assembly specifically directed that when regulating the aquifers in Division 3, the State Engineer shall apply five principles:

(I) Use of the confined and unconfined aquifers shall be regulated so as to maintain a sustainable water supply in each aquifer system, with due regard for the daily, seasonal, and long-term demand for underground water.

(II) Unconfined aquifers serve as valuable underground water storage reservoirs with water levels that fluctuate in response to climatic conditions, water supply, and water demands, and such fluctuations shall be allowed to continue;

(III) Fluctuations in the artesian pressure in the Confined Aquifer system have occurred and will continue to occur in response to climatic conditions, water supply, and water demands. Subject to subparagraph (IV) of this paragraph (a), such pressure fluctuations shall be allowed with the ranges that occurred during the period of 1978 through 2000. Artesian pressures shall be allowed to increase in periods of greater water supply and shall be allowed to decline in periods of lower water supply in much the same manner and within the same ranges of fluctuation as occurred during the period of 1978 through 2000, while maintaining average levels similar to those that occurred in 1978 through 2000.

(IV) Nothing in subparagraph (I) or (II) of this paragraph (a) shall be construed either to relieve wells from the obligation to replace injurious Stream

> Depletions in accordance with the rules adopted by the state engineer or to permit the expanded use of underground water; and
>
> (V) Underground water use shall not unreasonably interfere with the state's ability to fulfill its obligations under the Rio Grande compact . . . with due regard for the right to accrue credits and debits under the compact.

Section 37-92-501(4)(a), C.R.S.

301. Rule 8 incorporates these principles in its regulation of withdrawals from the Confined and Unconfined Aquifers in Division 3. Rule 8 provides for the separate regulation of the aquifers in each of the Response Areas and for the separate regulation of the Confined and Unconfined Aquifers, thus complying with section 37-92-501(4)(a)(I) and (II) C.R.S. Rule 8.1.7 requires that within ten years of the approval of a groundwater management plan or plan for augmentation, the groundwater diverters involved in those plans must reduce their groundwater withdrawals to the average annual withdrawals during the years 1978 through 2000, thus making a significant step toward complying with section 37-92-501(4)(a)(III) C.R.S. In addition, the Rules require additional, in-depth study and gathering of data on the behavior of the Confined Aquifer which will provide the State Engineer with the scientifically reliable information he needs to impose additional regulation and limitation on withdrawals from the Confined Aquifer, if necessary. Thus, Rule 8 rationally and appropriately implements the statutory standard based on the information currently available to the State Engineer and provides a reasonable mechanism and timeline to collect additional data and conduct further studies to determine the preferred method for future implementation of this statutory directive.

302. Furthermore, the Rules comply with the statutory mandate to regulate groundwater diversions to maintain the artesian pressure in the Confined Aquifer in the ranges that occurred from 1978 through 2000 separately from the requirement that groundwater diverters replace the injurious depletions the RGDSS Model predicts they are causing to senior

surface water rights. The Court agrees with the 2J Group that the statutory "requirement to remedy injurious Stream Depletions and the requirement to maintain sustainable aquifers are clearly separate and distinct." *Rebuttal Closing Brief of 2J Ranches* at 12. This is made clear by section 37-92-501(4)(a)(IV), C.R.S., which indicates that compliance with the requirements to regulate the Confined and Unconfined Aquifers to maintain a sustainable water supply should not be construed to relieve wells from their duty to replace injurious depletions. This is also made clear by section 37-92-501(4)(a)(III), C.R.S., which indicates that the provision that requires the State Engineer to allow the artesian pressure in the Confined Aquifer to fluctuate within the ranges that occurred from 1978 to 2000 is subject to subparagraph (IV) and its provision that wells not be relieved from the obligation to replace injurious Stream Depletions.

303. This interpretation of the statute is supported by the Colorado Supreme Court's decision in *Well Augmentation Subdistrict v. Aurora*, 221 P.3d 399 (2009)("*WAS"*). In *WAS*, the Colorado Supreme Court held that in approving an augmentation plan, the water court properly required groundwater diverters to provide replacement water based on the amount of surface water that would be available to surface water rights were it not for the out-of-priority pumping of wells. *Id.* at 415. In that case, the water court determined that although Box Elder Creek was ephemeral under hydrologic conditions that existed at the time of the *WAS* hearing, there would have been an additional 14,000 acre feet of return flows and seepage from Box Elder Basin to the South Platte River under hydrological conditions that would have existed in the Box Elder Basin in the absence of historic well pumping. *Id.* Over WAS's objection, the water court required WAS to base its replacement obligations on the assumption that Box Elder Creek was a live stream. The supreme court agreed noting that "[i]f the water court were to base replacement obligations on present hydrological conditions in the basin, WAS would be given the benefit of

out-of-priority pumping of seepage and return-flow waters that belong to the South Platte River. *Id.* Thus, the supreme court agreed with the water court that WAS's replacement obligations should be determined based on the hydrological conditions that would have existed in the Box Elder Basin absent historic well pumping. *Id.*

304. In the current case, the evidence did not show that Arroya/Diamond Springs would flow in the absence of out-of-priority pumping of the Confined Aquifer. But all parties agree that future investigations, which have already begun, may provide sufficient data for the RGDSS Model to make such a prediction. The Proponents argued in both their *Closing Brief* and *Proponents' Response to 2J Group's Closing Brief* that the Rules would only require replacement of injurious depletions to the surface flow at Arroya/Diamond Springs if the RGDSS Model determined that water would have flowed from the springs in the absence of historical well pumping "*and* under artesian pressures in the Confined Aquifer" which occurred between 1978 and 2000. (emphasis added). But this additional condition—that injurious depletions only need to be replaced if they exist when the pressures in the Confined Aquifer are at the levels that existed between 1978 and 2000--is not supported by the law. Pursuant to *WAS*, the question is whether there are injurious depletions to the flow at Arroya/Diamond Springs under the hydrologic conditions that would have existed absent historic pumping with no additional conditions. Furthermore, none of the evidence presented to the Court suggested that the Rules or the RGDSS Model take the pressure levels in the Confined Aquifer into account when predicting the amount of water that would exist in a surface stream in the absence of groundwater diversions. Therefore, to the extent a future version of the RGDSS Model predicts that there are injurious depletions to Arroya/Diamond Springs caused by Confined (or Unconfined) Aquifer groundwater diversions, those junior groundwater diverters will have to

replace the predicted injurious depletions if the springs would have flowed absent those diversions without regard to whether the artesian pressures in the Confined Aquifer were within the ranges that existed between 1978 and 2000.

305. In adopting rules to regulate the withdrawal of groundwater in Water Division No. 3, the General Assembly also specifically directed the State Engineer to;

> (I) Recognize contractual arrangements among water users, water user associations, water conservancy districts, ground water management subdistricts, and the Rio Grande water conservation district, pursuant to which:
>
> (A) Water is added to the stream system to assist in meeting the Rio Grande compact delivery schedules or to replace depletions to stream flows resulting from the use of underground water; or
>
> (B) Subject to subparagraphs (I), (II), and (III) of paragraph (a) of this subsection (4), injury to senior surface water rights resulting from the use of underground water is remedied by means other than providing water to replace stream depletions;
>
> (II) Establish criteria for the beginning and end of the division 3 irrigation season for all irrigation water rights;
>
> (III) Not recognize the reduction of water consumption by phreatophytes as a source of replacement water for new water uses or to replace existing depletions, or as a means to prevent injury from new water uses; and
>
> (IV) Not require senior surface water right holders with reasonable means of surface diversion to rely on underground water to satisfy their appropriative water right.

section 37-92-501(4)(b), C.R.S.

306. Rule 5.1.2 as well as Rules 6, 9, 11 and 12 recognize contractual arrangements among water users and others to replace the injurious Stream Depletions caused by groundwater diversions of the member water users. Rule 14 establishes criteria for the beginning and end of the Division 3 irrigation season. The Rules do not recognize the reduction in water consumption by phreatophytes as a source of replacement water. The Rules also do not place requirements on senior surface water rights holders to make changes in their means of surface diversion. Accordingly, the Rules comply with the statutory direction in section 37-92-501(4)(b) C.R.S.

307. Finally, the General Assembly directed the State Engineer not to curtail underground water withdrawals in Division 3 if the groundwater diversions are included in a groundwater management subdistrict with an approved groundwater management plan. Section 37-92-501(4)(c), C.R.S. This provision grants water users who form a subdistrict a form of limited self-regulation. They have an opportunity to form subdistricts and propose groundwater management plans to reduce water use and protect senior appropriators and the Rio Grande Compact obligation without the requirement for individual augmentation plans. Rule 6 provides that underground water withdrawals in Division 3 may continue for groundwater diversions that are included in a groundwater management plan, thus complying with the statutory requirements. Under the statute, any such proposal must be approved by the State Engineer and submitted to the water court for approval. The Rules rationally and appropriately implement this provision through Rules 6 through 12.

C. The 2J Group's Challenges

308. The 2J Group specifically challenges the following rules: Rule 5.9, Rule 7.1, Rule 7.3, Rule 7.4, Rule 7.5 and Rule 24.1.

a. Rule 5.9 provides that the "RGDSS Model is presumed to be the most reliable Groundwater Model currently available for [determining Stream Depletions within the RGDSS Model Domain.]"

b. Rule 7.1 mandates that "the RGDSS Model must be used as the basis for predicting changes in the rate and direction of flow of groundwater, and determining Stream Depletions resulting from groundwater withdrawals within the RGDSS Model Domain."

c. Rule 7.3 requires that the Response Functions created from the RGDSS Model "for a Response Area must be used to determine the amount and timing of Stream Depletions to defined reaches of affected streams caused by diversions of tributary groundwater by [w]ells within the Response Area."

d. Rule 7.4 creates a "rebuttable presumption that the Stream Depletions predicted by use of the Response Functions correctly quantify the amount, time, and location of Stream Depletions, and that the streams for which the Response

Functions quantify Stream Depletions are the only streams to which Stream Depletions occur."

e. Rule 7.5 states that a Well User who wishes to use an alternative to the RGDSS Model must "demonstrate that the alternative to the RGDSS Model determines Stream Depletions resulting from groundwater withdrawals within the RGDSS Model Domain at least as reliably as the Stream Depletions calculated by use of the RGDSS Model."

f. Finally, Rule 24.1 provides that "[t]here is a rebuttable presumption that the RGDSS Model reliably determines . . . the amount, time, and location of Stream Depletions resulting from groundwater withdrawals within the RGDSS Model Domain . . ."

309. These rules establish a framework under which Well Users will use the RGDSS Model and the Response Functions to calculate injurious Stream Depletions caused by their groundwater withdrawals. These rules also establish the presumption that the RGDSS Model and the Response Functions reliably calculate injurious Stream Depletions caused by groundwater withdrawals and reliably determine that the only streams or surface water features on which there are injurious depletions are those for which the modelers developed Response Functions.

310. Many of the 2J Group's challenges concern their disagreement with the Proponents' factual contentions concerning the reliability of the RGDSS Model and whether the evidence supports a factual finding that groundwater withdrawals from the Confined Aquifer between 1950 and 1970 are the primary cause of the decline in flow of Arroya/Diamond Springs. The Court has considered and determined those issues in previous sections of this order and, particularly, the Court has decided that the evidence does not support a finding that groundwater withdrawals from the Confined Aquifer were the primary cause of the reduction in flow at Arroya/Diamond Springs. Rather, the Court has determined that there is insufficient evidence from which to determine what has and is occurring at Arroya/Diamond Springs and that the State is correct that more study is necessary to make it possible for the RGDSS Model to make

scientifically valid predictions of what would occur at Arroya/Diamond Springs under current hydrological conditions in the absence of groundwater pumping.

311. In addition, the Court has determined that, at least to some extent, the depletions to Arroya/Diamond Springs have been caused by changes in farming practices. As a matter of law, so long as no change of water rights is involved, neither the State Engineer nor this Court can require a water user to continue using a water right to maintain return flows relied upon by downstream appropriators. *See Tongue Creek Orchard Co. v. Town of Orchard City*, 280 P.2d 426, 429 (Colo. 1955).

312. The 2J Group argues, however, that if the Court finds there is insufficient scientifically reliable information to calibrate the RGDSS Model to Arroya/Diamond Springs or to allow the Model to reliably calculate whether there are injurious depletions at Arroya/Diamond Springs caused by groundwater withdrawals, the Rules are arbitrary and capricious because they impose a rebuttable presumption that there are no injurious depletions at the springs. The 2J Group also argues that the rebuttable presumption of no injury violates the requirements of Colorado water law that require junior groundwater users to bear the burden to prove an absence of injury to senior surface water rights if they wish to continue to divert groundwater. Finally, the 2J Group argues that the Court should not approve Rules that rely on an imperfect groundwater model because the "mere potentiality of future model improvements cannot legitimize the presumption of no depletions" to Arroya/Diamond Springs in the current Model and under the current Rules. The Court will consider these arguments in turn.

1. Rebuttable Presumption of No Injury is Not Arbitrary and Capricious.

313. The 2J Group argues that since the RGDSS Model is not calibrated to Arroya/Diamond Springs and, therefore, cannot reliably calculate depletions at Arroya/Diamond Springs, the above-listed Rules are arbitrary and capricious and violate the requirements of

section 37-92-501, C.R.S., which requires the Rules to be "consistent with preventing material injury to senior surface water rights;" "consistent with preservation of the priority system of water rights;" and "not be used to allow groundwater withdrawal which would deprive senior surface rights of the amount of water to which said surface rights would have been entitled in the absence of such groundwater withdrawal . . ." *Id.* at (4)(a), (2)(e) and (1).

314. To make this argument, however, the 2J Group relies heavily on the quoted language in the three subsections of section 37-92-501. But the quoted language of the three provisions is only half of what the General Assembly was saying. In each subsection the General Assembly also indicated that the State Engineer should permit the continued use of underground water if there would not be water available for the senior right in the absence of the junior diversion, and that the State Engineer shall require only the minimum reduction in the use of underground water necessary to prevent material injury to senior surface water rights and that there are two goals for rules: 1) "the optimum use of water" and 2) "the preservation of the priority system of water rights." *Id.*

315. As section 37-92-501 indicates, the State Engineer may only curtail groundwater withdrawals if he has evidence that in the absence of those withdrawals water would be available for senior surface water rights holders and, if he has such evidence, he may only require groundwater use to be reduced the minimum amount necessary to prevent material injury. The General Assembly has indicated the same concerns in subsections 37-92-102(2)(b) and (d), C.R.S., which, taken together, require the State Engineer to recognize, to the fullest extent possible, the existing use of groundwater and only to curtail the use of groundwater when doing so would increase the supply of water available to and required by senior priorities. Thus, when adopting groundwater regulations, the State Engineer can only limit groundwater withdrawals if

such limitation will make water available to surface water rights in accordance with the priority system.

316. Furthermore, the General Assembly recognized that Water Division No. 3 has unique geologic and hydrologic conditions and conjunctive use practices and so specifically granted the State Engineer, when adopting rules governing the use of groundwater in this division, "wide discretion to permit the continued use of underground water consistent with preventing material injury to senior surface water rights." Section 37-92-501(4)(a), C.R.S.

317. The Rules' reliance on the RGDSS Model, which the Court has found to be scientifically valid and reliable, is rational and the Rules' creation of a rebuttable presumption of no injury if the RGDSS Model does not predict injury is a rational method to implement the General Assembly's direction in the statutes. Furthermore, the fact that the Rules rely on the RGDSS Model and only require replacement of water when the Model predicts that groundwater withdrawals are causing, or have caused, injurious depletions to senior surface rights comports with prior precedent of the Colorado Supreme Court.

318. There is obvious tension between the State's goal to protect vested water rights and the State's goal to make the maximum utilization of the State's water. The Colorado Supreme Court has explained that it is the policy of the State "that the waters of our state are such a scarce and valuable resource that they must be administered in ways that effectuate the goal of 'maximum utilization,' including use of as much underground water as possible." *State Engineer v. Castle Meadows, Inc.*, 856 P.2d 496, 505 (Colo. 1993). But, as the court explained when it reviewed this Court's decision approving the Confined Aquifer New Use Rules, "while this court continues to recognize the goal of maximum utilization, 'including use of as much underground water as possible,' the cases of this court 'have always recognized that the

sometimes countervailing interest of protection of vested rights must be given effect 'in spite of the doctrine of maximum utilization." *Simpson v. Cotton Creek Circles*, 181 P.3d at 260 (quoting from *State Eng'r v. Castle Meadows, Inc.,* 856 P.2d at 505).

319. The Colorado Supreme Court first announced the doctrine of maximum utilization in *Fellhauer v. People*, 447 P.2d 986, 994 (Colo. 1968) where the court directed the State Engineer when regulating groundwater withdrawals: "[i]f by placing conditions upon the use of a well, or upon its owner, some or all of its water can be placed to a beneficial use by the owner without material injury to senior users, such conditions should be made." *Id*. at 993. The *Fellhauer* Court then explained the policy behind that rule: "It is implicit in [Article XVI, section 6 of the Colorado Constitution] that along with vested rights, there shall be maximum utilization of the water of this state." *Id*. at 994.

320. In *Fellhauer,* the Division Engineer in Water Division 2 curtailed the pumping of 39 wells out of 1,600 to 1,900 wells that were diverting more than 100 gallons per minute from the alluvium of the Arkansas River. 167 Colo. at 333, 447 P.2d at 992. The surface waters of the Arkansas River were over-appropriated before the wells were drilled, *id.* at 325, 447 P.2d at 988-89, and the removal of groundwater by these wells "materially and injuriously affected senior decreed rights." *Id.*at 331, 447 P.2d at 992. Fellhauer owned one of the curtailed wells and refused to stop pumping his well, causing the Division Engineer to file an injunction proceeding against him in water court. *Id.* at 325, 447 P.2d at 988. The Division 2 Water Court issued an injunction upholding the Division Engineer's order prohibiting Fellhauer from pumping his well. *Id.* On appeal, Fellhauer argued that there was no basis for the injunction or the Division Engineer's order curtailing his use of water because there was no evidence that groundwater withdrawals from his well were causing injury to any particular senior surface

water right. *Id.*at 329, 447 P.2d at 991. Although the Colorado Supreme Court agreed that there was no showing of a specific injury to a specific senior water right, the court said "whenever a court or water administration official can make a finding that the pumping of a junior well materially injures senior appropriators who are calling generally for more water, there exists a legitimate and constitutional ground and reason for the regulation of the well." *Id.* at 329-30, 447 P.2d at 991. But, the court found that the curtailment order in *Fellhauer* was arbitrary and capricious (as well as unconstitutional) because the Division Engineer did not have a sound scientific foundation for singling out the 39 wells he curtailed from the other 1,600 to 1,900 wells pumping over 100 gallons per minute from the same source. *Id.* at 333-34, 447 P.2d at 993.

321. The court then provided three requirements that must be met if the State or Division Engineer desired to regulate groundwater withdrawals:

> Interpreting the constitutionality of that Act (Groundwater Management Act) in *Fellhauer v. People*, 167 Colo. 320, 447 P.2d 986 (1968), this Court held that any regulation of wells must: (1) be in compliance with written rules and regulations; (2) cause a reasonable lessening of material injury to seniors; and (3) provide for conditional use of wells if water can be withdrawn and put to beneficial use without injury to seniors. *Fellhauer*, 167 Colo. at 334, 447 P.2d at 993. The court also articulated the need for maximum utilization of both the surface and subsurface waters of the state, and the necessity of determining 'how constitutionally that doctrine can be integrated into the law of vested rights.' *Fellhauer*, 167 Colo. at 336, 447 P.2d at 994."

Simpson v. Bijou Irrig. Co., 69 P.3d at 59–60.

322. Pursuant to *Fellhauer* then, the Rules in this case are only valid if they curtail the use of groundwater, or require the replacement of water, if the curtailment or replacement will lessen a material injury to senior surface water rights. This is what the Rules do because they rely on the scientifically valid RGDSS Model to predict whether diversions of groundwater will cause material injury to senior surface water rights. To the extent there is insufficient evidence to show that groundwater diversions are causing material injury to senior surface water rights,

Fellhauer prohibits the State Engineer from promulgating rules that would curtail those groundwater diversions.

323. The 2J Group repeatedly argues that promulgating rules that do not require the replacement of depletions to Arroya/Diamond Springs is inconsistent with preventing material injury to senior surface water rights and inconsistent with the preservation of the priority system of water rights. But, this argument assumes there are injurious depletions to Arroya/Diamond Springs as a result of the withdrawal of water from the Confined Aquifer by junior groundwater diverters. However, the evidence in this case is inconclusive and does not support a factual finding that this assumption is true.

2. The Rules Do Not Improperly Allow Junior Groundwater Diverters to Avoid the Requirement to Bear the Burden to Prove No Injury from Continued Groundwater Diversions.

324. The 2J Group cites section 37-92-304(3), C.R.S., for the proposition that under Colorado water law, junior groundwater users are supposed to bear the burden of proving an absence of injury to senior surface water rights. The 2J Group argues that the Rules' presumption of zero injurious depletions to any stream system for which there is no Response Function relieves junior groundwater users from having to prove their continued use of groundwater will not injure the senior surface water rights and thus prejudices senior surface water users to the benefit of junior groundwater users. In contrast, the Proponents argue that section 37-92-304(3), C.R.S., does not apply to the Court's decision whether to approve the Rules but, instead, only applies to cases involving a change of water right or for approval of a plan of augmentation. The Court agrees with the Proponents.

325. Section 37-92-304(3) concerns proceedings that are before the water judge either as the result of a ruling by the referee or a rereferral from the referee and indicates:

> The applicant shall appear . . . and shall have the burden of sustaining the application, whether it has been granted or denied by the ruling [of the referee] or has been rereferred by the referee, and in the case of a change of water right or a plan for augmentation the burden of showing absence of any injurious effect.

326. The 2J Group argues that if the Court approves the Rules, then applicants for a plan of augmentation to allow the continued diversion of junior groundwater rights will be able to use the Response Functions prepared from the RGDSS Model to determine the injurious depletions they need to replace. Those injurious depletions will not include any calculation of injurious depletions to Arroya/Diamond Springs and yet, the State Engineer cannot say that there are no injurious depletions to Arroya/Diamond Springs but can only say he does not know if there are injurious depletions to Arroya/Diamond Springs. The 2J Group argues that the burden should be on the junior groundwater diverter to come forward with evidence that there are no injurious depletions to Arroya/Diamond Springs and that the junior groundwater diverter should not be able to rely on the rebuttable presumption that there are zero injurious depletions to Arroya/Diamond Springs.

327. Factually, as the Court has already determined, it was reasonable for the State Engineer to determine that, based on the available scientifically reliable evidence, the depletions to Arroya/Diamond Springs from the diversion of underground water are zero. Furthermore, legally, section 37-92-304, C.R.S., does not apply to the Court's approval of rules and regulations. Instead, the Court must apply section 37-92-501, C.R.S., which does not require the Court to make a threshold no-injury finding as is required for the approval of augmentation plans and applications to change water rights. *See San Antonio, Los Pinos and Conejos River Acequia Pres. Ass'n v. Special Improvement Dist. No. 1 of the Rio Grande Water Conservation Dist.,* 270 P.3d 927, 945 (Colo. 2010).

328. In addition, while it is true that once the Rules go into effect, a junior groundwater diverter will be able to seek approval for an augmentation plan which will not, at present, require replacement of depletions to Arroya/Diamond Springs, such a presumption of zero depletions will be rebuttable and will be reviewable on an annual basis. *See* Rules 7.4, 10.5.1 and 10.5.2. Similarly, if a group of junior groundwater diverters joins together in a subdistrict and seeks approval of a groundwater management plan, under the current Response Functions there will be no requirement that the subdistrict replace injurious depletions to Arroya/Diamond Springs, but, again that presumption will be rebuttable and will be reviewable on an annual basis. *See* Rules 7.4, 11 and 12. And, as the supreme court noted in the Subdistrict No. 1 case,

> The burden of showing that the annual replacement plan [or augmentation plan] operates to protect adjudicated senior surface water users against material injury remains with the Subdistrict [or applicant for the augmentation plan]. When a surface water right holder properly alleges material injury under the Plan as decreed, the Subdistrict [or applicant for the augmentation plan] bears the burden under retained jurisdiction of going forward with evidence, as well as sustaining its burden of proof, to demonstrate non-injury.

San Antonio, Los Pinos and Conejos River Acequia Pres. Ass'n, 270 P.3d at 947. Just as the Colorado Supreme Court found that the Subdistrict No. 1 Plan of Water Management accorded with the statutory criteria for preventing injury to adjudicated senior surface water rights, even without the requirement of a threshold no-injury determination, so too do the Rules currently before the Court comply with the statutory requirements of section 37-92-501, C.R.S.

3. Rules that Rely on the Valid but Imperfect RGDSS Model are an Appropriate Way for the State Engineer to Integrate the Use of Surface and Groundwater in Division 3.

329. This Court has approved the use of prior versions of the RGDSS Model in the Confined Aquifer New Use Rules Decree and the Subdistrict No. 1 Decree. In both cases, this Court recognized that the then-current version of the RGDSS Model was imperfect but

conceptually sound and would be improved over time with the addition of more accurate data. Confined Aquifer New Use Rules Decree at ¶¶ 374-85; Subdistrict No. 1 Decree at ¶ 104. As this Court has found in earlier sections of this Order, the current version of the RGDSS Model, Version 6P98, is a much-improved version of the Model, that although imperfect, is conceptually sound and scientifically reliable and which the State Engineer will continue to improve over time.

330. The 2J Group argues that the way the State Engineer is using the RGDSS Model in the current case is different from the way he used it in the Confined Aquifer New Use Rules case and that that difference justifies, or even requires, this Court to disapprove the current Rules as arbitrary and capricious. The 2J Group points out that the Confined Aquifer New Use Rules were very protective of senior surface rights, setting up a rebuttable presumption that a new withdrawal from the Confined Aquifer would cause material injury to senior surface rights unless the applicant for the new withdrawal provided a one-for-one replacement for any Confined Aquifer water to be withdrawn. In contrast, the current Rules rely on the RGDSS Model to determine whether groundwater diverters are causing injurious depletions to senior surface water rights and, if so, to quantify the injurious depletions that must be replaced. Because the current version of the RGDSS Model does not have sufficient scientifically reliable data to determine whether there are depletions to some smaller water features, including Arroya/Diamond Springs, the State Engineer has determined that, for now, the injurious depletions caused to such surface water features are zero. The 2J Group argues that this presumption has the opposite effect of the rebuttable presumption in the Confined Aquifer New Use Rules and is harmful to senior surface right owners.

331. It is, however, because of the difference between the General Assembly's treatment of applications for new water rights, at issue in the Confined Aquifer New Use Rules case, and what the Legislature requires before the State Engineer can curtail the use of existing water rights, that the State Engineer's use of the RGDSS Model in the manner in which it is being used in the current Rules is appropriate. As the Colorado Supreme Court said, "there is a rational basis to distinguish between those who currently have the right to withdraw water from the Confined Aquifer and others who have not yet obtained a water right." *Simpson v. Cotton Creek Circles, LLC,* 181 P.3d at 264. It is appropriate to put significant restrictions and requirements on those who are attempting to obtain a new right to withdraw water from an already over-appropriated system. In contrast, the General Assembly has mandated that, with respect to previously adjudicated underground water rights, even though they are junior to senior surface rights, rules that require the reduction in underground water usage "shall be the minimum necessary to meet the standards" of section 37-92-501(4), C.R.S., and only may reduce underground water usage when there is a sound foundation upon which the State Engineer can determine that in the absence of the groundwater withdrawals there would have been water available to the senior priorities. Sections 37-92-501(4)(a) and (1), C.R.S.

332. The 2J Group also argues that prior versions of the RGDSS Model were approved for much narrower uses than the use the State Engineer is attempting to make of the RGDSS Model in the current Rules case. The 2J Group points out that the RGDSS Model was used in the Confined Aquifer New Use Rules case to justify the requirement that applicants for new water rights from the Confined Aquifer would have to replace any diversions from the Confined Aquifer, one for one. And, the 2J Group points out that the RGDSS Model was used in the Subdistrict No. 1 case to determine the injurious depletions to be replaced by junior groundwater

diverters located in a geographic area smaller than entire Water Division No. 3. These differences, however, are meaningless. The question is whether the RGDSS Model is appropriate and scientifically reliable for the purposes for which the State Engineer is using it and the Court has already determined, as a matter of fact, that it is. Furthermore, when the 2J Group argues that "[t]he mere potentiality of future model improvements cannot legitimize the presumption of no depletions to Arroya Springs . . ." they are, again, assuming that there are injurious depletions to Arroya/Diamond Springs. But, as the Court has determined, the evidence does not support that assumption.

333. The fact that the State Engineer and the modelers do not have all of the answers and have not been able to create a perfect groundwater model for Water Division No. 3 is not a reason for this Court to disapprove the Rules. As the Colorado Supreme Court has previously said in relation to the State Engineer's promulgation of rules and regulations for the use of underground water in Water Division No. 1:

> It is reflected throughout the record that the studies of the Platte River were not completed. There was testimony that far more would be known about underground flows in two years from the time of hearing (September 1969) as a result of studies then in progress. It would be an impossibility for the State Engineer in 1969 to promulgate regulations which would realize the maximum use of all of the surface and ground water of the Platte. All that can be expected is that he exercise his best judgment, using information then available to attempt to reach the goal of maximal use, of course without being arbitrary or capricious. . . . We refer to the aphorism that 'Rome wasn't built in a day' and hold that under the record as submitted the predominant showing was that the State Engineer proceeded in good faith to follow the policy of the statute and that he did substantially follow that policy.

Kuiper v. Well Owners Conservation Ass'n, 176 Colo. 119, 140, 490 P.2d 268, 278 (1971). Similarly, in the current case, the State Engineer proceeded in good faith to follow the policy of the statute, section 37-92-501, C.R.S, and he did substantially follow that policy in the promulgation of the current Rules.

334. In addition, in earlier sections of this Order, the Court has found, as a matter of fact, that the State Engineer lacks a reliable factual basis to determine whether Arroya/Diamond Springs would flow under current hydrologic conditions absent historical groundwater pumping. Sections 37-92-102(2)(b), 501(1), and 501(4), C.R.S., prohibit the State Engineer from curtailing the use of groundwater unless his failure to do so would deprive senior surface rights of the amount of water to which said surface rights would have been entitled in the absence of such groundwater withdrawal. The State Engineer currently lacks the necessary reliable factual basis to curtail groundwater withdrawals based on alleged groundwater depletions to Arroya/Diamond Springs because he cannot establish that "such reduction would increase the amount of water available to and required by water rights having senior priorities" that are supplied, in whole or in part, by Arroya/Diamond Springs. Section 37-92-102(2)(d), C.R.S.

335. At trial, the Deputy State Engineer testified to the concrete steps the State Engineer's office is taking, using funds provided by the Rio Grande Water Conservation District, to begin to collect sufficient reliable scientific information concerning Arroya/Diamond Springs that will enable him to determine whether Arroya/Diamond Springs would flow under current hydrologic conditions absent historical groundwater pumping. As soon as the State Engineer has sufficient reliable information to make this determination, if he determines that Arroya/Diamond Springs would flow absent historical groundwater pumping, Rule 24 requires him to generate appropriate Response Functions for Arroya/Diamond Springs and/or La Jara Arroyo Creek.

336. The Court finds as a matter of law that the 2J Group has failed to carry their burden of proof to establish the invalidity of the Rules.

D. The Hendersons' Challenges to the Rules

337. Colin and Karen Henderson challenge Rule 8 specifically as it applies to the Confined Aquifer. Rule 8 provides a means for determining the preferred methodology for maintaining a Sustainable Water Supply and maintaining the Confined Aquifer pressures within an average of the 1978 to 2000 levels. The Court has already determined that Rule 8 rationally and appropriately implements the statute based on the information currently available to the State Engineer and also provides a reasonable mechanism and timeline to collect additional data so the State Engineer can determine how to better implement the statute in the future.

338. The Hendersons made factual allegations concerning the existence of a relationship between the measured pressure levels at the CON1 Confined Aquifer monitoring well and pressure levels in the Confined Aquifer, as well as between the pressure levels in CON1 and the flow at Arroya/Diamond Springs. The Hendersons also made factual allegations concerning the sufficiency of the amount of information the State Engineer has available to him to determine the effects of groundwater withdrawal from the Confined Aquifer and claimed he has sufficient information, now, to allow him to regulate groundwater withdrawals to maintain Confined Aquifer pressures as required by statute. The Court has already determined that the Hendersons did not meet their burden of proof to prove these factual contentions by a preponderance of the evidence.

339. The Hendersons also argued that the State Engineer could use historical measured pressure levels at CON1 to regulate Confined Aquifer wells in the vicinity of CON1. Specifically, the Hendersons suggested that such junior groundwater diverters should be curtailed starting with the most junior, until Arroya/Diamond Springs begins to flow again. *Hendersons' Closing Arguments* at 7, ¶ 6; *Statement of Protest* at 4 ("The state must close down

wells, starting with the most junior well rights, until the Arroya Springs flow again.”). The Court has already determined, as a factual matter, that under current hydrological conditions, it is possible that Arroya/Diamond Springs would not flow once artesian pressures in the Confined Aquifer are returned to the levels that existed between 1978-2000. *See* ¶ 281 above. In addition, as noted in paragraph 315 above, as a matter of law the State Engineer may only curtail groundwater withdrawals if he has evidence that in the absence of those withdrawals water would be available for senior surface water rights holders and, if he has such evidence, he may only require groundwater users to reduce their diversions by the minimum amount necessary to prevent material injury. Curtailing junior groundwater diversions in the vicinity of Arroya/Diamond Springs until the springs begin to flow again would violate these statutory directives.

340. The Hendersons also challenged Rule 8.1.7 and the way it establishes a schedule for Well Users in Confined Aquifer Response Areas to limit their groundwater withdrawals so as not to exceed the average annual withdrawals for the period of 1978 through 2000. The Rule requires such Well Users to either reduce their pumping or offset their groundwater withdrawals with recharge to the Confined Aquifer, or both, so that by the tenth year after the Court has approved an annual replacement plan for a Subdistrict or a plan of augmentation for an individual Well User that the affected wells will be withdrawing no more water from the Confined Aquifer than the average annual withdrawals during the period 1978 through 2000 as determined based on a five-year running average.

341. The Hendersons object to the ten-year delay until the junior groundwater diverters must reduce their water withdrawals to the same amount of water, on average, as they were withdrawing during 1978 through 2000. In addition, the Hendersons argue that the evidence

shows that reducing the Confined Aquifer withdrawals to the same levels as occurred during 1978 through 2000 will not return the aquifer to its pressure levels during that time because the amount of water recharging the aquifer has been reduced by reductions in precipitation and changes in farming practices.

342. Section 37-92-501(4)(a)(III), C.R.S. establishes the standards that the State Engineer's rules must meet, but it does not prescribe how the rules must meet those standards. Although the Court may not defer to the State Engineer on questions of law, the selection of the best means to achieve the statutory objectives are policy decisions entrusted to the sound discretion of the State Engineer. *Alamosa-La Jara Water Users Protection Ass'n,* 674 P.2d at 928-29 and 935. So long as the method the State Engineer has chosen is rational and reasonably calculated to achieve the statutory standard within a reasonable time, the Court cannot second guess the State Engineer's policy decisions. Allowing a ten-year period of time to phase-in the reduction in groundwater withdrawals to the levels that existed between 1978 and 2000 is not unreasonable. In addition, given the State Engineer's lack of sufficient knowledge concerning the workings of the Confined Aquifer, the choice to first reduce groundwater diversions to the average levels of diversions that occurred between 1978 and 2000, while more closely studying the workings of the Confined Aquifer to determine if there is a better way to increase the pressure levels in the aquifer to the statutorily mandated levels, is not unreasonable.

343. The Court concludes, as a matter of law, that the method the State Engineer has chosen to implement the artesian pressure requirements of section 37-92-501(4)(a)(III), C.R.S., is rational and reasonably calculated to achieve the statutory standard within a reasonable time. Furthermore, as this Court has previously approved Rules by the State Engineer that employ a stepwise approach to implementing section 37-92-501(4), C.R.S., it is appropriate for the Court

to approve the same procedure in this case. Here, the State Engineer has established the need to gather more information to implement a data-driven approach to well regulation. This method is consistent with the General Assembly's instruction to use additional facts and operating experience to amend rules. Section 37-92-501(1)(f), C.R.S. Accordingly, the Hendersons have not met their burden to overcome the presumption that Rule 8 is valid or to show by a preponderance of the evidence that the Rule is invalid or does not conform to the statutory mandates.

IX. CONCLUSION

The Court concludes as a matter of law that the Rules, as promulgated by the State Engineer, are consistent with, comply with, and rationally and effectively implement each of the statutory standards governing rules and regulations for groundwater withdrawals and establishment of the irrigation season in Water Division No. 3. The Protestors have not shown that any of the contested Rules are invalid or fail to conform to the statutory requirements.

X. JUDGMENT AND DECREE

IT IS THEREFORE ORDERED that the Court denies the protests filed to the Rules and ORDERS that the *Rules Governing the Withdrawal of Groundwater in Water Division No. 3 (The Rio Grande Basin) and Establishing Criteria for the Beginning and End of the Irrigation Season in Water Division No. 3 for all Irrigation Water Rights* are hereby APPROVED as promulgated and filed with this Court on September 23, 2015, and are effective upon entry of this decree.

DONE this 15th day of March 2019.

BY THE COURT:

Pattie P. Swift, Water Judge, Water Division No. 3