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Rebuttal to Expert Report
Eastern Snake Plain Aquifer Ground Water Management Area
Docket No. AA-GWMA-2016-001

Prepared for:

Surface Water Coalition

January 13, 2020

1604FLE01

The technical material in this report was prepared by or under the supervision and direction of the undersigned, whose seal as a Professional Geologist is affixed below.

REGISTERED PROFESSIONAL GEOLOGIST
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STATE OF IDAHO

David C. Colvin, Senior Project Manager

The following members of the Leonard Rice Engineers, Inc. staff contributed to the preparation of this report.

Principal in Charge and Principal Geologist	Dave Colvin, PG, PMP
Staff Geologist	Matt Sparacino
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1 INTRODUCTION

This report summarizes my opinions regarding Bryce Contor's *Technical Report Regarding Final Order Designating the ESPA GWMA* (Contor, 2019) and Jennifer Sukow's response (Sukow, 2019). I have been retained by the Fletcher Law Office and Barker Rosholt & Simpson, on behalf of the Surface Water Coalition (A&B Irrigation District et al.). My qualifications, publications, and expert witness experience are summarized in my resume, which is included as **Attachment A**. I may have new, updated or revised opinions if new information becomes available.

The Idaho Department of Water Resources designated the Eastern Snake Plain Aquifer (ESPA) Ground Water Management Area (GWMA) pursuant to an Order issued by Director Gary Spackman (Spackman, 2016). The Order established a clear intent for managing the ESPA as a regional groundwater system hydraulically connected to the Snake River. IDWR has established the GWMA to define the area where a Ground Water Management Plan can be implemented to regionally manage the effects of groundwater withdrawals on hydraulically connected waters, including the ESPA, the Snake River, and tributary basins..

It is widely accepted that the regional ESPA system includes tributary basins that are also hydraulically connected to the Snake River. Tributary underflow and seepage account for 22% of ESPA recharge, and consumptive use in tributary basins reduces flow in streams tributary to the Snake River, or reduces underflow into the ESPA (Vincent, 2016). Tributary basins where water administration issues are initially being managed locally are excluded from the GWMA.

On November 25, 2019, Director Spackman issued a scheduling order limiting proceedings regarding the GWMA order to the following technical issue:

> *"1. Whether areas outside of the ESPA area of common ground water supply, as defined by CM Rule 50 (IDAPA 37.03.11.050), but included within the ESPA GWMA, are located in tributary basins and are otherwise sufficiently remote or hydrogeologically disconnected from the ESPA to warrant exclusion from the ESPA GWMA."* (Spackman, 2019)

The commonly accepted boundaries of the ESPA have evolved with the increased availability of scientific data and understanding (**Table 1**). The US Geological Survey's Regional Aquifer System Analysis (RASA) program was the basis for early interpretations of the extent of the ESPA. The Enhanced Snake Plain Aquifer Model (ESPAM) boundary was expanded to include several areas not originally included in the RASA ESPA boundary definition. The model boundary was changed to reflect hydraulic connectivity (or lack thereof) and the goal of creating an effective regional water management tool.

> *"While ESPAM was based on the U.S. Geological Survey's Regional Aquifer System Analysis (RASA) program, ESPAM was intended in large part to assist in conjunctive management of surface water and ground water resources under state law. The RASA*

> *boundaries were therefore modified in ESPAM 1.0 and 1.1 to include irrigated areas in the Kilgore, Rexburg Bench, American Falls, and Oakley Fan areas, and also the Big Lost River drainage up to Mackay Dam. The Twin Falls tract was excluded from ESPAM because the Snake River is deeply incised between Kimberly and King Hill, and there is little communication between the aquifers on the north and south sides of the Snake River"* (Spackman, 2016).

ESPAM further improved in 2013 (ESPAM2.1) and currently represents the best available science (Spackman, 2016).In essence, the ESPAM boundary definition has already addressed the Director's technical issue by relying on technical data to support hydraulic connectivity of tributary basins and other areas considered for inclusion in ESPAM. The Twin Falls tract was considered "hydrogeologically disconnected", and therefore not included in ESPAM. Several irrigated areas (including the Rexburg Bench) were included to *"assist in conjunctive management of surface water and ground water resources under state law"* (Spackman, 2016).

IDWR has developed ESPAM2.1, including the boundaries of the model, with guidance from the Eastern Snake Hydrologic Modeling Committee (ESHMC). The ESHMC represents a broad set of stakeholders and experts in the hydrology of the ESPA. Both Bryce Contor and Jennifer Sukow have been members of the ESHMC prior to the development of ESPAM2.1

In his technical report regarding the GWMA designation (Contor, 2019), Contor raises several issues in an attempt to justify the exclusion of the Rexburg Bench from the GWMA. Sukow provides her opinions on these issues in her response memo (Sukow, 2019). I am providing my opinions on these topics in the following sections.

2 DEFINITION OF THE REMAINING GWMA PROCEEDINGS TECHNICAL ISSUE

In his introductory comments, Contor attempts to redefine the technical issue at hand as whether the Rexburg Bench and ESPA are defined as a single groundwater basin, and if not, that the Rexburg Bench is then sufficiently remote or disconnected and warrants exclusion. He relies on the semantics and plurality of the word "basin" to move away from the intent of the Director's framing of the technical issue as pertaining to hydrogeologic connection or remoteness. Whether or not humans call two areas a single basin or multiple basins has no bearing on whether they are hydrogeologically connected. Furthermore, two identified basins can be hydrogeologically connected when one basin is tributary to the other, as is the case for the Rexburg Bench being tributary to the ESPA. A closed basin could be hydrogeologically disconnected from adjacent basins, but the Rexburg Bench is not a closed basin.

I disagree with Contor's interpretation of the technical issue related to these proceedings and will focus on the evaluation of the hydrogeologic connection or remoteness of the Rexburg Bench. Sukow provides additional information about the definition of a groundwater basin. She shows that Contor used limited quotes and that expanded quotes from the same references are less favorable to Contor's stated opinions regarding the definition of a groundwater basin.

Contor relies heavily on the CM Rule 50 common ground water supply boundary because it does not include the Rexburg Bench. The CM Rule 50 boundary is based on the RASA (IDWR, 1994). As Sukow points out, the RASA boundary refers to the "Eastern Snake River Plain" and does not define a basin boundary. For this reason, the CM Rule 50 boundary is inappropriate for Contor's "basin" discussion. In addition to being inconsistent with Contor's definition of a basin, the CM Rule 50 boundary is over 25 years old and has been superseded by decades of hydrologic studies and models.

Table 1 presents a lineage of the representation of the Rexburg Bench in ESPA models and the CM Rule 50 boundary. Where it is excluded from models (Garabedian, 1992 and Cosgrove et. al. 1999), it is still implicitly represented as quantified tributary underflow of 10,000 AF/yr or greater.

Table 1: Inclusion of Rexburg Bench in ESPA Models and the CM 50 Rule Boundary

Year	Author	Name	Rexburg Bench	Notes
1992	Garabedian	RASA Model	Partially included in 2D model; excluded in 3D model	Rexburg Bench is recognized as contributing tributary underflow to the regional aquifer. The regional aquifer, as defined here, does not include the Rexburg Bench. This model includes a tributary underflow estimate of 19,000 AF/yr (26 cfs).
1994	IDWR	Areas Determined to have a Common Ground Water Supply (CM Rule 50)	Excluded	The Area of Common Ground Water Supply is defined by the "Aquifer underlying the Eastern Snake River Plain...as defined in [Garabedian, 1992]"
1999	Cosgrove et al.	SRPAM	Excluded	Rexburg Bench is recognized as contributing tributary underflow to the regional aquifer. This model includes a tributary underflow estimate of 10,000 AF/yr
2006	Cosgrove et al.	ESPAM 1.1	Included	"Because the ESPAM is intended for the conjunctive management of ground- and surface-water resources, the SRPAM and RASA boundaries were evaluated based on inclusion of irrigated areas. Modifications were made to expand the original aquifer boundaries to include irrigated acreage in the Kilgore, **Rexburg Bench**, American Falls and Oakley Fan areas." This model includes a tributary underflow estimate of 16,000 AF/yr.
2013	IDWR	ESPAM 2.1	Included	No change to area near Rexburg Bench from ESPAM 1.1. This model includes a tributary underflow estimate of 15,351 AF/yr.

3 TOPOGRAPHY

Contor states that topography is related to geologic structures such as faults and contacts, and that such structures are boundaries that affect groundwater flow. Geologic structures can also create preferential pathways. He incorrectly states, *"...the Bench is structurally separated from the plain by faults along its entire shared margin with the ESPA."* Contor never states that the Rexburg Bench geologic structures or the topographic differences they create hydrogeologically separate it from the ESPA.

Contor points out that the Rexburg Bench topography is different than the ESPA, and that the topographic changes on the northeast side of the Bench are roughly coincident with the Conjunctive Management Rule 50 (CM Rule 50) boundary. The CM Rule 50 boundary as defined in 1994 was generally based on topographic differences such as those present at the Rexburg Bench (IDWR, 1994). The topographic definition of the plain does not define hydrogeologic connection. Extensive information has been presented before and since then to demonstrate that the Rexburg Bench is hydrogeologically connected to the ESPA, despite its topographic differences.

4 GEOLOGY AND HYDROGEOLOGY

The geology of the Rexburg Bench is complicated and creates a unique landform. Appropriate sources of geology and hydrogeology information include US Geological Survey (USGS) geologic maps, Idaho Geological Survey (IGS) geologic maps and the Haskett (1972) report referenced by both Contor and Sukow.

Haskett describes the Rexburg Bench as a 15 mile rectangular structural block with loess soil, rhyolite or basalt aquifers, isolated areas of fine grained lake deposit aquicludes, all underlain by pre-Tertiary marine sediments. He discusses faults and fault zones, but none of them are identified as barriers to groundwater flow or hydrogeologically isolating the Rexburg Bench from the ESPA.

Haskett identifies three major areas of clay deposits that create perched groundwater, but the perching layers are not uniform across the Rexburg Bench. The perched aquifers have limited extents and are hydrogeologically connected to the regional system at their edges where recharge water in excess of pumping can flow down to deeper aquifers. He characterizes the wells within the perched aquifers as "poor producers" because the perched aquifers are less permeable and have limited saturated thickness. Most of the abandoned wells have been in the clay areas, and high capacity wells target rhyolite or basalt layers under the perching layers where they exist. Compared to the basalt and rhyolite aquifers, the perched areas of the Rexburg Bench represent relatively minor aquifers and could not support the current irrigation of the Bench.

Haskett presents an analysis of target depths to produce a high capacity (4 cfs) well on the Rexburg Bench. He identifies three areas on the western edge of the Rexburg bench (Areas No. I and III, southern portions of Area II) where the depth is 150 to 400 feet deep, which is relatively shallow because the ground surface is sloping down and closer to the elevation of the plain below. The other areas identified are farther away from the western edge, covering the majority of the Bench and indicate target depths from 600 to greater than 1800 feet. Relatively high temperature well water in some areas of the Bench is additional indication of deeper groundwater being pumped.

In numerous locations in his report, Haskett points out that the recharge from precipitation is estimated at 35,000 AF, less than the 40,000 AF of pumping estimated in 1970. Haskett reports that the water table does not decline even when pumping exceeds recharge. This indicates that the Rexburg bench is not an isolated system and suggests that it is hydrogeologically connected to the ESPA and surface water recharge sources.

Haskett identifies three areas where surface water potentially recharges the Rexburg Bench: The Teton River near Newdale, the Snake River alluvium near Heise, and the Henry's Fork Valley alluvium. These are all local areas where Rexburg Bench groundwater pumping could deplete surface water flow in the Snake River and its tributaries. Additional depletion occurs through the regional ESPA.

5 WELL WATER LEVELS

Contor presents an analysis of water levels that is a comparison of static water levels to a projection of the ESPA ground surface under the Rexburg Bench. He claims that if a "*Snake Plain groundwater basin likewise continued uninterrupted beneath the Bench, the expectation would be a continuation of trends of depths to water relative to this surface...*".

I disagree with this concept for several reasons. Contor propagates his "basin" word play with this comment, and rather than try to determine the definition of a basin, I continue to focus on evaluating whether or not the Rexburg Bench is hydrogeologically disconnected or remote from the ESPA.

Contor presents Rexburg Bench water level data and states that the variations in depth to water are different from consistent patterns in the ESPA. Sukow presents 2013 water level data that are more reliable because they have been filtered for quality, are more recent, and represent a shorter, comparable time period. I agree with Sukow's response that Contor is relying on water level data with questionable quality, that his analysis is inconsistent with the Haskett (1972) analysis, and that her presentation of reliable water level data from 2013 are generally consistent with Haskett and do not show unexpected variability. Contor compares his water level data to an extension of the plain elevation. This comparison is not relevant to an evaluation of the hydrogeologic connection between the ESPA and the Rexburg Bench.

The complex geology of the Rexburg Bench will result in variations in water levels. As shown by Sukow, the water levels are generally higher to the southeast (near the mountain front boundary) and decrease in elevation towards the ESPA and the river valleys. The water levels near the Teton River and Snake River exhibit patterns indicating interaction between groundwater and the river, consistent with the hydrogeology section above. These water level patterns indicate a hydrogeologic connection between the Rexburg Bench, the Snake River and its tributaries, and the ESPA. Sukow also demonstrates that recent, reliable water level data do not show sharp changes in elevations near the edges of the Rexburg Bench and therefore do not indicate geologic structures disconnecting it from the ESPA.

6 ESPA GROUNDWATER MODELS

Over the decades, various numerical groundwater models have been developed to support investigation and management of surface water and groundwater resources on the Eastern Snake Plain. The models have evolved to incorporate new data and understanding of the ESPA hydrologic system. The models have explicitly or implicitly accounted for surface water and groundwater inflow from tributary basins.

Contor focuses on the SRPAM exclusion of the Rexburg Bench being consistent with the CM Rule 50 boundary. He also admits that the SRPAM implicitly incorporates inflow from the Rexburg Bench into the model through a flux boundary. SRPAM includes an estimate of 10,000 AFY of tributary underflow into the model from the Rexburg Bench. The SRPAM model was created in 1999 and has been superseded by ESPAM.

Contor has been involved in ESPA model development for many years, with his work at Rocky Mountain Environmental Associates, Inc., the Idaho Water Resources Research Institute (IWRRI), and as a member of ESHMC. He has contributed to the Rexburg Bench model representations and has co-authored a report on estimates of tributary underflow that quantifies the Rexburg Bench underflow to the ESPA (Taylor, et. al., 2011). This is inconsistent with his recent report (Contor, 2019) claiming that the Rexburg Bench should be excluded from the GWMA.

ESPAM1.1 and ESPAM2.1 both include the Rexburg Bench explicitly for reasons explained in Wyllie (2009). The rationale for explicit inclusion of a given tributary basin in the model included the availability of data to support the model, the hydrologic connectivity, and the sensitivity of the model to administration scenarios (curtailment). Wyllie (2009) summarizes the inclusion of the Rexburg Bench and other expansion areas as: "*This results in an expansion of the model domain into areas not included in previous models. The Rexburg Bench, Oakley Fan, and American Falls areas all have irrigated acreage not previously included in the IDWR/UI model, and these areas appear to be hydraulically connected.*" ESPAM2.1 is widely accepted as the best available science and includes the Rexburg Bench because it is hydraulically connected to the ESPA.

7 TRIBUTARY BASIN COMPARISONS

Contor presents a comparison of the Rexburg Bench to other tributary basins based on his characterization of whether they are more or less distinct from the ESPA. This is not relevant to Director Spackman's legislative charter for defining the boundary of the GWMA:

> *"3. Subsequent amendments to the Ground Water Act authorized a third option for addressing insufficient ground water supplies: "ground water management areas." Idaho Code§ 42-233b as enacted in 1982 and amended in 2000 and 2016 authorizes the Director to designate "ground water management areas," and approve "a ground water management plan for the area" that provides "for managing the effects of ground water withdrawals on the aquifer ... and on any other hydraulically connected sources of water." Idaho Code§ 42-233b; 1982 Idaho Sess. Laws 165; 2000 Idaho Sess. Laws 187; 2016 Idaho Sess. Laws 848."* (Spackman, 2016; Conclusion of Law No. 3)

The information discussed in the sections above shows that managing groundwater withdrawals from the Rexburg Bench will have an impact on the Snake River and its tributaries because it is a hydraulically connected source of water. IDWR (1997) reports that there was 925 cfs of authorized groundwater diversions for a 165 square mile (sq. mi.) drainage area of the Rexburg Bench. The average authorized groundwater rate per sq. mi. for the Rexburg Bench (5.6 cfs/sq. mi.) was five times higher than that of any of the other tributary basins considered in the study. IDWR (1997) also reported that the Rexburg Bench had 55% of the basin irrigated, which was 30% higher than the next highest percentage for any other tributary basin in the study. Sukow presents similar information in her analysis of groundwater development as presented in her Figure 7and the associated discussion.

The large amount of groundwater development on the Rexburg Bench, its thorough hydrogeologic characterization, and its connectivity to the ESPA are technical rationale for its inclusion in the GWMA.

8 SUMMARY OF OPINIONS

IDWR Director Spackman's 2016 Order designating the ESPA GWMA defined a boundary including the Rexburg Bench and other tributary basins. His November 25, 2019 scheduling order, he limited further GWMA technical proceedings to consideration of whether tributary basins outside of the CM Rule 50 common groundwater supply boundary are *"sufficiently remote or hydrogeologically disconnected from the ESPA to warrant exclusion from the ESPA GWMA."* (Spackman, 2019) Bryce Contor provided his opinions on this issue in his *Technical Report Regarding Final Order Designating the ESPA GWMA* (Contor, 2019) and Jennifer Sukow's provided a response on behalf of IDWR (Sukow, 2019).

My opinions on this technical issue are summarized in the list below.

1. The GWMA Order established a clear intent for managing the ESPA as a regional groundwater system hydraulically connected to the Snake River. IDWR has established the GWMA to define the area where a Ground Water Management Plan can be implemented to regionally manage the effects of groundwater withdrawals on hydraulically connected surface waters, including the Snake River.
2. It is widely accepted that the regional ESPA system includes tributary basins that are also hydraulically connected to the Snake River.
3. The Enhanced Snake Plain Aquifer Model, version 2.1 (ESPAM2.1) currently represents the best available science (Spackman, 2016). In essence, the ESPAM boundary definition has already addressed the Director's technical issue by relying on technical data to support hydraulic connectivity of tributary basins and other areas considered for inclusion in ESPAM.
4. IDWR has developed ESPAM2.1, including the boundaries of the model, with guidance from the Eastern Snake Hydrologic Modeling Committee (ESHMC). The ESHMC represents a broad set of stakeholders and experts in the hydrology of the ESPA.
5. I disagree with Contor's interpretation of the technical issue related to these proceedings. Rather than a discourse on the definition of the word basin, technical evaluation should focus on the hydrogeologic connection or remoteness of the Rexburg Bench.
6. The RASA boundary refers to the "Eastern Snake River Plain" and does not define a basin boundary. For this reason, the CM Rule 50 boundary is inappropriate for Contor's "basin" discussion.
7. Where the Rexburg Bench is excluded from models it is still implicitly represented as quantified tributary underflow of 10,000 AF/yr or greater.
8. Mapped faults have not been shown to represent barriers to groundwater flow.
9. The topographic differences of the Bench and the plain does not define hydrogeologic disconnection. Extensive information has been presented demonstrating that the Rexburg Bench is hydrogeologically connected to the ESPA, despite its topographic differences.
10. High capacity groundwater wells exist on the Rexburg Bench that produce water from a variety of geologic materials (rhyolite, basalt, and alluvium), from a variety of depths.
11. There are several areas of perched aquifers on the Bench, and yields of wells completed in them are limited by relatively low permeability and saturated thickness. Compared to the basalt and rhyolite aquifers, the perched areas of the Rexburg Bench represent relatively minor aquifers.
12. The perched aquifers have limited extents and are hydrogeologically connected to the regional system at their edges where recharge water in excess of pumping can flow down to deeper aquifers.
13. Haskett (1972) reports that estimates of groundwater pumping exceeds precipitation estimates with no observed water table decline. This indicates that the Rexburg Bench is hydraulically connected to the adjacent regional ESPA, the Snake River, and its tributaries.

14. Contor's analysis of static water levels is based on data with poor quality control, and is used to compare to a theoretical extension of the plain elevation. This comparison is not relevant to an evaluation of the hydrogeologic connection between the ESPA and the Rexburg Bench.
15. The Rexburg Bench water level data presented by Haskett (1972) and Sukow (2019) indicate a hydrogeologic connection between the Rexburg Bench, the Snake River, its tributaries, and the ESPA.
16. Over the decades, various numerical groundwater models have been developed to support investigation and management of surface water and groundwater resources on the Eastern Snake Plain. ESPAM2.1 is widely accepted as the best available science and includes the Rexburg Bench because it is hydraulically connected to the ESPA.
17. Contor has been involved in ESPA model development for many years, with his work at Rocky Mountain Environmental Associates, Inc., the Idaho Water Resources Research Institute (IWRRI), and as a member of ESHMC. He has contributed to the Rexburg Bench model representations and has co-authored a report on estimates of tributary underflow that quantifies the Rexburg Bench underflow to the ESPA (Taylor, et. al., 2011). This is inconsistent with his recent report (Contor, 2019) claiming that the Rexburg Bench should be excluded from the GWMA.
18. Contors presentation of a comparison of the Rexburg Bench to other tributary basins based on characterization of whether they are more or less distinct from the ESPA is not relevant to the criteria for inclusion of the Rexburg Bench in the GWMA.
19. The large amount of groundwater development on the Rexburg Bench, its thorough hydrogeologic characterization, and its connectivity to the ESPA are technical rationale for its inclusion in the GWMA.

9 REFERENCES

Contor, B.A., 2019. *Technical Report Regarding Final Order Designating the ESPA GWMA*; Rocky Mountain Environmental Associates, Inc.; prepared for Madison Ground Water District. December 5, 2019

Haskett, G. I., 1972. *Ground-Water Geology of Rexburg Bench, Second Phase, Lower Teton Division, Teton Basin Project, Idaho;* Bureau of Reclamation, Boise, Idaho.

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Taylor, S.L., Contor, B.A., Moore, G.L., 2011. *Estimating Tributary Basin Underflow to the Eastern Snake Plain Aquifer.* Idaho Water Resources Research Institute and Idaho Department of Water Resources. IWWRI Technical Completion Report 201103.

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Wyllie, A., 2009. *Model Boundary Revision 2, Eastern Snake Plain Aquifer Model Enhancement Model Design and Calibration Document Number DDM-002-R2.* Idaho Department of Water Resources, University of Idaho, May 8.

Appendix A - Curriculum Vitae for David C. Colvin

DAVID C. COLVIN, PG, PMP

Groundwater Team Leader / Senior Project Manager / Principal

PROFESSIONAL SUMMARY

Mr. Colvin is a Principal Hydrogeologist and Senior Project Manager with over 20 years of experience in groundwater hydrology, water resources, and environmental sciences. He supervises teams of diverse subject matter experts and provides technical leadership to solve today's water resource challenges.

EDUCATION

M.S. Environmental Science and Engineering
Colorado School of Mines
2002

B.S. Geology
Syracuse University
1996

PROFESSIONAL REGISTRATION

Professional Geoscientist
- Arizona RG#68926
- Idaho #PGL-1453
- Texas #11440
- Wyoming #PG-3602
- Kansas #958

Project Management Professional (PMP) #1749472

PROFESSIONAL ACTIVITIES

- AWRA Colorado – Past President (2017/18)
- Water Education Colorado – 2012 Water Leaders Program
- Colorado Water Congress – Communication Committee
- Groundwater Relief Volunteer
- National Groundwater Association (NGWA)
- Colorado Groundwater Association (CGWA)

EXPERIENCE

Leonard Rice Engineers, Inc., Denver, CO 2010-present
Groundwater Team Leader / Senior Project Manager

Dave serves as the LRE Groundwater Team Leader responsible for managing staff, resources, projects and schedules for a group of hydrogeologists. His technical expertise subject areas include aquifer characterization, groundwater modeling, surface water/groundwater interaction, riverbank filtration (RBF), soil aquifer treatment (SAT), managed aquifer recharge (MAR), aquifer storage and recovery (ASR), and subsidence caused by groundwater pumping. He conducts and supervises hydrogeologic investigations involving project management, aquifer testing, 3-D geologic modeling, groundwater modeling, uncertainty analysis, hydrogeophysics, expert testimony, environmental geology, regulatory support and water rights.

RELEVANT PROJECTS

Idaho Surface Water Coalition (2019-ongoing)
Technical representative providing litigation support related to water management of the Eastern Snake Plain Aquifer. Serves on the Eastern Snake Plain Hydrologic Modeling Committee supporting MODFLOW modeling activities related to complex surface water/groundwater management and water rights administration.

Salt River Project - Gila River Basin Adjudication, Arizona Superior Court Case W1-103, San Pedro Basin, AZ (2018-ongoing)
Hydrogeologist providing groundwater analysis and modeling in support of the adjudication of water rights in the San Pedro Basin. Tasks included oversight of groundwater modeling, calibration and uncertainty analysis, and trial/litigation support.

Salt River Project – Big Chino Cooperative Agreement #1 Groundwater Modeling and Field Data Collection Oversight; Prescott, AZ (2017-ongoing)
Technical Advisor providing oversight of groundwater modeling activities and hydrogeologic field investigation supporting a cooperative agreement between stakeholders evaluating the impacts of groundwater development on critical springs in the Upper Verde River watershed.

RELEVANT PROJECTS Continued ...

City of Aurora – ACRE Site ASR Feasibility Investigation; Adams County, CO (2018-2019)
Project Manager and lead hydrogeologist investigating the feasibility of recharging and storing water in the alluvial aquifer at the Aurora Center for Renewable Energy (ACRE).

City of Aurora – Horizontal Well Pilot Project; Weld County, CO (2019-ongoing)
Project Manager and lead hydrogeologist feasibility evaluation and planning of a pilot facility to test two or more horizontal well options for the City's Prairie Water System. Investigation will target increasing yield while maximizing riverbank filtration water quality improvements. Future phases include the design, construction, and operation of pilot facilities.

City of Aurora – Prairie Waters North Campus Master Plan; Adams and Weld Counties, CO (2017-ongoing)
Lead hydrogeologist providing master planning services for approximately 20 MGD expansion of the Prairie Waters Project – North Campus over the next 20 years. Facility expansion included riverbank filtration well field, pipelines, and storage reservoirs. Lead facilities operational planning, supported water resource planning, gap analysis, and capital improvements planning.

Town of Castle Rock – Groundwater Support; Douglas County, CO (2015-ongoing)
Project Manager and lead Hydrogeologist providing groundwater support. Projects have included:

- *Denver Basin Well Drilling and Testing* – Support includes Denver Basin well bid services, contractor management, construction oversight, well/pump design, aquifer testing, and CDPHE/DWR regulatory support.
- *Alluvial Well Field Expansion and Rehabilitation* - Projects aimed at improving yields in well fields affected by biofouling and other performance issues. Other tasks included oversight of horizontal directional drilling (HDD) of lateral wells installed to increase well field yield.

Eagle River Water and Sanitation District and Upper Eagle Regional Water Authority – Groundwater Support; Eagle County, CO (2010-ongoing)
Project Manager and lead Hydrogeologist for alluvial well field groundwater support. Projects have included:

- *GWUDI Evaluation* – Regulatory support, groundwater modeling and operational monitoring of alluvial well fields in support of CDPHE GWUDI evaluation
- *Lake Creek Well Field Planning* – Services included groundwater modeling, well drilling, aquifer testing, source water quality characterization, regulatory support for Eagle County 1041, CDPHE, and DWR permitting
- *Well field maintenance and rehabilitation support* – well rehabilitation in response to well issues including pump issues, casing holes, and water quality contamination

Dominion Water and Sanitation District – Groundwater Support; Douglas County, CO (2015-ongoing)
Denver Basin groundwater services including water rights evaluation, water quality assessment, well field yield estimation and project planning. Technical support included documentation for County hearings, interactions with local water agencies, and groundwater sale transactions.

Town of Erie – Water Supply Planning Support (2018-ongoing)
Lead hydrogeologist and Project Manager providing groundwater support related to water supply planning. Services include aquifer characterization and water quality studies to support horizontal

directionally drilled well designs and water rights. Prepared grant Colorado Water Conservation Board and Division of Local Affairs grant applications to obtain project funding.

Confidential Client – ASR Feasibility Evaluation (2019-ongoing)
Senior Technical Advisor for a project evaluating the feasibility of new and existing ASR projects in multiple aquifers. Included evaluation of water quality, aquifer characteristics, well construction/testing and planning information.

Denver Water – Aquifer Storage and Recovery (ASR) Pilot Project, City and County of Denver, CO (2016-2018)
Groundwater technical and project management for ASR feasibility investigation. Provided Denver Basin aquifer characterization including exploratory borehole drilling, hydrogeophysical investigation (Nuclear Magnetic Resonance and conventional methods), and 3-D geologic modeling.

Colorado Water Conservation Board - HB16-1256 South Platte Storage Study; CO (2018)
Lead hydrogeologist providing evaluation of underground water storage options for the Lower South Platte alluvial aquifer. Provided alluvial storage site evaluation, conceptual design, cost estimates, and comparison to surface storage options.

City of Steamboat Springs – Infiltration Gallery System Expansion; Routt County, CO (2018-ongoing)
Project Manager and lead hydrogeologist for feasibility expansion of alluvial groundwater supplies. Expansion options being considered include vertical and horizontal well options.

City of Aurora and Town of Castle Rock – Lost Creek Underground Storage Pilot Project; Lost Creek Designated Basin, CO (2017-2018)
Lead hydrogeologist and project manager for aquifer characterization and evaluation of recharge potential for underground water storage pilot project. Obtained grant funding and facilitated multiple stakeholder project planning and implementation.

Texas Water Development Board – Statewide Subsidence Risk Evaluation (2018)
Technical advisor for risk evaluation of subsidence due to groundwater pumping in all Texas major and minor aquifers. The project used well lithology data with model predicted water level declines to create a statewide risk map and prioritized table. Recommended follow up actions for identified areas of risk.

City of Phoenix – ASR Tracer Test Design; Maricopa County, AZ (2017)
Provided MT3D groundwater modeling to assist in aquifer characterization, travel time estimates, and the design of an ASR tracer injection test for feasibility. The testing was in support of the Northeast Phoenix Reclaimed Water Recharge and Recovery Study. The system is intended to create a potable water resource through Indirect Potable Reuse (IPR), provide additional non-potable supplies, and to mitigate land subsidence issues.

Groundwater Relief – Kutupalong Refugee Camp Groundwater Supplies; Cox's Bazaar, Bangladesh (2019-present)
Volunteer hydrogeologist providing well testing and water quality support to field geologists. The project is developing emergency water supplies for nearly 1 million Rohingya refugees who have fled religious persecution in Myanamar.

City of San Angelo – Riverbank Filtration Feasibility Evaluation; Tom Green County, TX (2018)
Provided feasibility evaluation, preliminary siting, design and costs for a potential riverbank filtration (RBF) well field near the Concho River. This information was used to evaluate RBF as an alternative for expansion of the City's water supply.

Tarrant Regional Water District – Cedar Creek Wetlands; Kaufman County, TX (2013)
Project manager and lead Hydrogeologist for riverbank filtration feasibility investigation along the Trinity River. Project tasks include geotechnical, hydrogeologic, and surface geophysical surveys, groundwater modeling, and design, construction and testing of riverbank filtration pilot test sites.

Village at Taos Ski Valley – Spring Water Supply Expansion; Taos County, NM (2018-ongoing)
Senior Technical Advisor providing groundwater evaluation into the management, protection and expansion of spring water supplies.

Rangen, Inc. – Water Rights Support; Gooding County, ID (2010-2016)
Expert witness providing testimony and trial support for a water rights hearing (IDWR Case No. CM-DC-2011-004) involving springs and complex surface water/groundwater interaction of the Eastern Snake Plain Aquifer. Represented a fish hatchery reliant on spring flow that was being impacted by groundwater pumping. Served on the Eastern Snake Plain Hydrologic Modeling Committee supporting MODFLOW modeling activities in the Eastern Snake Plain of Idaho.

Overturf, McGath, and Hull, P.C. – Stewart No. 1 Ditch Company; Pitkin County, CO (2017)
Expert witness support including expert and rebuttal reports, depositions, and settlement negotiations for a civil case involving alleged roadway water damage from ditch operations.

Fredrickson Law Offices – In-Play Golf; Weld County, CO (2017)
Expert witness providing expert and rebuttal reports, depositions, and trial support for a civil case involving alleged water damages from golf course irrigation.

Boulder Valley School District – Douglass Elementary Non-Tributary Well Support; Boulder County, CO (2018)
Project Manager for a non-tributary well application in the Boulder Complex Area of the Denver Basin Aquifers. Provided aquifer characterization and regulatory support leading to a non-tributary determination and permit approval.

Boulder County Parks and Recreation – Kenosha Ponds Groundwater Evaluation; Boulder County, CO (2016)
Expert witness providing hydrogeology water rights support for a Boulder County Parks and Recreation augmentation pond. Technical support included expert report writing and trial exhibit preparation for the hydrologic characterization of a recharge pond between two streams where the pond bottom was below the water table.

City of Burkburnett, Texas – Alluvial Well Field Evaluation; Wichita County, TX (2016)
Project Manager and groundwater lead for evaluation of underperforming well fields near the Red River. Wells ranged from 3-50 years old with a variety of issues causing low yields. Project tasks included well operational data integration, analysis, and development of alternatives to improve well yields.

Penrose Water District – Arkansas River Alluvial Well Field; Fremont County, CO (2016)
Groundwater technical management for planning, design, and construction of an alluvial well field for diversion of Arkansas River water rights. Tasks included aquifer characterization, water rights support, groundwater modeling, contractor management, well drilling, construction and testing.

Salt River Project – New River Agua Fria Underground Storage Project; Phoenix, AZ (2013)

Project involved optimization and in-channel expansion design for an existing recharge facility. Support included evaluation of operational data and adaptation of an existing MODFLOW model for operational optimization and feasibility testing.

City of San Marcos, Texas – Well Performance Investigation and Replacement Plan; Hays County, TX (2015)
Project Manager and groundwater lead for investigation into reduced yield problems for a well in the Edwards Aquifer. Well construction and operational data were analyzed to test viability of rehabilitation or equipment replacement. Provided ultimate solution of siting a replacement well in a more productive aquifer area.

Oakwood Homes – Neighborhood Scale Dewatering Systems and Water Rights; CO (2016)
Project Manager and groundwater lead for planning, design, and permitting of neighborhood scale dewatering systems. Managed project work including groundwater modeling, system design, data analysis, contractor coordination, DWR and CDPHE permitting, and water rights evaluations.

Winkler Services – Well Field Siting and Design; Wink County, Texas (2017)
Technical advisor for well field siting in the Pecos Valley Alluvium and Upper Dockum Aquifer. Support included project planning, aquifer characterization, and geologic modeling.

Donala Water and Sanitation District – Reuse Evaluation; El Paso County, CO (2015)
Preliminary feasibility investigation into riverbank filtration alternatives for indirect potable reuse. Evaluated hydrogeologic conditions for permitting, cost, and performance feasibility considerations.

Confidential Client; Groundwater Supply and Subsidence Analysis; AZ (2011)
Development of regional MODFLOW models used to estimate well field yield and land subsidence due to groundwater pumping in Arizona. Work included statewide study of subsidence-related empirical relationships and prediction methods, aquifer characterization, 3-D geologic and groundwater flow modeling, automated model calibration and predictive uncertainty analysis using PEST, and numerical MODFLOW subsidence modeling.

City of Scottsbluff – Well Field Uranium Investigation and Monitoring; Scotts Bluff County, NE (2016)
Technical advisor for a project aimed at reducing uranium concentrations in an alluvial groundwater supply. Provided aquifer characterization and uranium monitoring data analysis.

Confidential Client - Oilfield Produced Water Infiltration Modeling, San Luis Obispo County, CA (2010)
Lead Hydrogeologist for the development of an engineering design MODFLOW-SURFACT model with the goal of infiltrating 13 acre-feet of water per day into the subsurface of a 200 acre alluvial site. Performed model calibration using PEST software in a parallel processing environment utilized 50 geologic conceptualizations for stochastic predictions of system performance.

CDPHE – Summitville Superfund Site; Summitville, CO (2008)
Provided support for abandoned mine hydrology and geochemistry, field sampling, monitoring and mine facility inspection, and database support. The project goal was to monitor and minimize mine waste impacts on the Alamosa River.

Various Mines – Groundwater Modeling and Analysis; Basin and Range Province; NV (2010)
Provided MODFLOW modeling and water balance studies in support of mine water management and regulatory reporting. Analyses included point flow surface water modeling to evaluate stream gain/loss;

detailed water balance quantifications; well inventories and pumping estimates; groundwater underflow assessments.

Aurora Prairie Waters Project – North Campus; Weld County, CO (2008)
Supported City of Aurora's Prairie Waters project near the South Platte River, CO. Acted as team liaison for multi-consultant, multi-disciplinary project team. Field investigation and construction tasks included field oversight of drilling, well construction, pump/motor installation, aquifer testing, system start up testing, well field yield optimization, and geotechnical investigations. Support also included the design, construction, and operation of alluvial recharge and riverbank filtration pilot test facilities. Developed and implemented pilot test procedures, including tracer studies to assess flow paths, travel times, and stream/aquifer interaction.
MODFLOW modeling support for the Prairie Waters Project included development of regional groundwater model for Colorado Division 1 case 2006CW104. Performed parallel processing model calibration using UCODE. Prepared expert and rebuttal reports, exhibits and materials used in settlement negotiations for case 2006CW104.

Miron Construction - Laramie-Fox Hills Well; Hudson, Colorado (2008)
Assisted in design and field engineering for the construction and testing of a 960 foot deep, large capacity, municipal/industrial, Laramie-Fox Hills water supply well at the Hudson Correctional Facility.

Perini/US Army Corps of Engineers – Groundwater System Design and Optimization; Baghdad, Iraq (2007)
MODFLOW modeling support for the U.S. Agency for International Development in Baghdad, Iraq. Developed a numerical groundwater model for the optimization of water supply well locations and pumping operations. Main objectives were to maximize well yields while minimizing differential land subsidence across newly constructed East End Barracks.

Water For People Groundwater Management Project (Volunteer Position); San Pedro Sula, Honduras (2008)
Technical advisor for development of a scope of work for a participatory groundwater management plan aimed at restoring and protecting an over utilized alluvial aquifer in a developing region.

Colorado Haiti Project (Volunteer Position); Petit Trou de Nippes, Haiti (2013)
Technical advisor for aquifer development, management, and protection in a rural, developing area of Haiti.

ASARCO - California Gulch Superfund Site; Leadville, Colorado
Conducted environmental sampling for the Kids First Program to identify and address sources of lead exposure for children in residential areas. Provided statistical analysis and reporting for evaluation of program effectiveness. Designed sampling plan and performed soil sampling and analysis to delineate extent of metals contamination at the Arkansas Valley Smelter Operable Unit. Provided technical support for hydrogeological and geochemical characterization of the Apache Tailings site; and implemented the surface water and groundwater performance monitoring program to assess the effectiveness of the remedial action. Conducted synoptic surface water flow measurement and water quality sampling.

Asarco - Omaha Lead Site, Omaha, Nebraska.
Assisted in the development of program to identify sources of lead exposure for children in residential areas.

Mine Waste and Tailings Pile Sites, Various Locations, 2000-2004.
Performed hydrologic evaluation of remedial alternatives for repository evaluation using Hydrologic Evaluation of Landfill Performance (HELP) model.

Industrial Groundwater Contamination Sites, Various Locations, 2000-2005.
Performed groundwater modeling to assist design of groundwater extraction remediation wells using MODFLOW modeling code.

EPA - Vasquez Boulevard and Interstate 70 Superfund Site, Denver, Colorado.
Designed, directed, and performed environmental sampling for project intended to identify sources of lead and arsenic exposure for children in residential areas.

Hertz Rent-a-Car - Former Underground Storage Tank, Colorado Springs, CO (2002).
Project Hydrogeologist and technical lead for the characterization, monitoring, and remediation of hydrocarbon contaminated soils and groundwater at a former underground storage tank site. Performed quarterly monitoring and reporting; developed and implemented an in-situ chemical oxidation remediation program.

R&R Super Service - Former Underground Storage Tank, Arvada, CO (2002).
Project Manager and technical lead for the characterization and remediation of soils and groundwater contaminated by petroleum hydrocarbons at a former service station. Responsibilities included client and regulatory interaction; site characterization activities to delineate the nature and extent of contamination in soil and groundwater; modeling of vapor and mass extraction rates using VENT2D; respirometry testing to quantify biodegradation rates in vadose zone soils; startup testing; operating, maintaining, and monitoring of an air sparge/soil vapor extraction system.

City and County of Denver - Former Stapleton International Airport Remediation; Denver, CO (2000).
Served as a hydrogeologist conducting field investigations to define nature and extent of hydrocarbon contamination and to determine remediation. Field tasks included lithologic logging with a hollow-stem auger and direct-push drilling rigs; soil, groundwater, and soil vapor testing, remediation system construction/operation/maintenance, data evaluation and reporting.

National Park Service – Mt. Rainier National Park, Longmire, WA (1998)
Biologist and crew leader for aquatic ecosystem studies in Mt. Rainier National Park. Conducted field surveys in sub-alpine areas wetland monitoring. Performed aquatic field sampling, wetland classification, biological species identification, and aquatic laboratory analyses.

PRESENTATIONS & PUBLICATIONS

Colvin, Dave, 2019. "*Demonstrating Dominion and Control – Moving from Black Magic to Understandable Science.*" Denver CO

Colvin, Dave, 2019. "*Now We Know What We Don't Know: An ASR Regulatory Update*". Colorado Groundwater Association September Meeting. Denver, CO.

Colvin, Dave, 2019. "*The Evolution of Colorado Underground Water Storage Administration*". American Water Resource Association / Colorado Groundwater Association 2019 Joint Annual Symposium. Denver, CO.

Colvin, Dave, 2018. *"Technical Considerations for ASR Planning in Colorado's Front Range"*. American Groundwater Trust Annual Colorado Groundwater Conference. Denver, CO.

Colvin, Dave, 2018. *"ASR Panel Discussion: The Revolution of Subsurface Water Storage"*. American Water Works Association ACE18 Conference. Las Vegas, Nevada

Colvin, Dave, and Keester, Michael, 2017. *"Applying Web-Based Information Management Tools to Increase Efficiency and Expand Opportunities for Groundwater Conservation Districts"*. Texas Association of Groundwater Districts Groundwater Summit. San Marcos, TX. (https://www.regonline.com/custImages/240000/242434/2017%20TGS%20Presentations/KeesterandColvin.pdf)

Colvin, Dave, and Pence, Rachel, 2017. *"Using NMR and Hydrogeophysics to Evaluate ASR Feasibility in the Denver Basin"*. 2017 NGWA Conference on Hydrogeophysics and Deep Groundwater, Denver, CO. (https://ngwa.confex.com/ngwa/hdg2017/webprogram/Paper11286.html)

Colvin, Dave, and Justus, Heather, 2016. *"Benefits of Directionally Drilled Alluvial Well Lateral Arms in the Town of Castle Rock"*. 2016 RMSAWWA/RMWEA Joint Annual Conference, Keystone, CO.

Colvin, Dave, and Furnans, Jordan, 2016. *"Can/Should Texas learn from Colorado? A primer on groundwater-surface water interactions and regulation methods"*. 2016 Texas Water Conservation Association Spring meeting, Woodlands, TX. (http://www.slideshare.net/TWCA/twca-annual-convention-canshould-texas-learn-from-colorado-jordan-furnans-and-dave-colvin)

Colvin, Dave, 2015. *"Methods for Confident Model Predictions and Integration"*. Colorado Water Congress 2015 Annual Conference; DARCA Workshop Series, "The Next Step: Modeling Colorado's Water Plan", Denver, CO.

Colvin, Dave, 2014. *"Groundwater Challenges and Solutions for Colorado Watersheds."* 2014 Colorado Sustaining Watersheds Conference, Avon, CO.

Colvin, Dave and Loopesko, William, 2014. *"Advantages of Alluvial Aquifer Storage Alternatives for Managing Hydrologic Extremes and Future Water Supply Risks."* 2014 Upper Colorado River Basin Water Forum, Grand Junction, CO.

Colvin, Dave, 2014. *"Groundwater Solutions for Indirect Potable Reuse."* 2014 Rocky Mountain Water Reuse Workshop, Golden, CO.

Colvin, Dave, Bauer, Jacob, and Noack, Tim, 2013. *"Effective Tools and Project Planning for Riverbank Filtration Feasibility Investigation"* Poster session at 2014 Texas Water, Dallas, TX. (http://s3.amazonaws.com/eventmobi-assets/events/txwater14/documents/person/1366969/201404_RBF_Feasibility_Poster_Final.pdf)

Colvin, Dave, and Bauer, Jacob, 2013. *"Cost Effective Feasibility Investigation of Natural Subsurface Reuse Treatment Systems."* Poster session at the 2013 National Water Reuse Symposium, Denver, CO.

Colvin, Dave, and Neupauer, Roseanna, 2013. *"Riverbank Filtration Feasibility Modeling."* MODFLOW and More 2013. Integrated Groundwater Modeling Center. Golden, CO.

Colvin, David C., 2012. *"Comparison of One and Three Dimensional MODFLOW Subsidence Results."* 2012 Groundwater Summit, National Groundwater Association, Westerville, OH.

Colvin, David C., 2012. "*One Dimensional MODFLOW Modeling of Land Subsidence Due to Fluid withdrawal.*" GSA 2012 Cordilleran Section Meeting, Vol. 44, No. 3. Geological Society of America. Boulder, CO.

EXPERT TESTIMONY

Mr. Colvin has provided expert testimony in trial or depositions in the following cases.

Stewart No. 1 Ditch Company; Pitkin County Case No: 2014CV30084, Pitkin County Board of County Commissioners v. Brothers, et. al., September, 2015.

In-Play Golf, Inc; Weld County Case 12CV727, Helen Hawkins et. al. v. Vista Ridge Development Corporation et. al., August, 2015.

Rangen, Inc.; In the Matter of Application for Water Rights Permit No., 36-17011, February, 2015.

Rangen, Inc.; Idaho Department of Water Resources Case No. CM-DC-2011-004, Distribution of Water To Water Right Nos. 36-02551 and 36-07694, May, 2013.

EXPERT REPORTS

Mr. Colvin has performed groundwater analysis, provided assistance in settlement negotiations, and authored or contributed to reports in the following cases.

Salt River Project; AZ Big Chino Cooperative Agreement #1, Evaluation of Big Chino Water Ranch impacts on Upper Verde Springs discharge, 2016 - ongoing.

Salt River Project; AZ Gila River Adjudication Contested Case No. W1-103, Groundwater adjudication and subflow depletion evaluation, 2017 – ongoing.

In-Play Golf, Inc; Weld County Case 12CV727, Helen Hawkins et. al. v. Vista Ridge Development Corporation et. al., August, 2015.

Stewart No. 1 Ditch Company; Pitkin County Case No: 2014CV30084, Pitkin County Board of County Commissioners v. Brothers, et. al., September, 2015.

Rangen, Inc.; In the Matter of Application for Permit No., 36-17011, February, 2015.

Rangen, Inc.; Idaho Department of Water Resources Case No. CM-DC-2011-004, Distribution of Water To Water Right Nos. 36-02551 and 36-07694, May, 2013.

Boulder County Parks and Open Space; CO Division 1 Case No. 2010CW320, Change of Use and Plan for Augmentation for Kenosha Ponds Open Space, 2013.

City of Aurora; CO Division 1 Case No. 2006CW104, Aurora's Prairie Waters Project, 2007.