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Attorneys for Fremont Madison Irrigation District, Madison Ground Water District and Idaho Irrigation District

RECEIVED
FEB 10 2019
DEPARTMENT OF
WATER RESOURCES

BEFORE THE IDAHO DEPARTMENT OF WATER RESOURCES

IN THE MATTER DESIGNATING THE EASTERN SNAKE PLAIN AQUIFER GROUND WATER MANAGEMENT AREA	)	Docket No. AA-GWMA-2016-001 **FREMONT MADISON IRRIGATION DISTRICT, MADISON GROUND WATER DISTRICT AND IDAHO IRRIGATION DISTRICT'S EXHIBIT LIST**

COMES NOW, Fremont Madison Irrigation District, Madison Ground Water District and Idaho Irrigation District (collectively hereinafter referred to as "UV"), acting for and on behalf of their members, by and through undersigned counsel, and pursuant to the Scheduling Order For Hearing contained in the Idaho Department of Water Resources' *Deadline for IDWR's Submittal of Materials; Order on Motion Practice; Notice of Hearing and Scheduling Order; Order Authorizing Discovery*, dated September 25, 2019, UV hereby disclose the following exhibits at the hearing on this matter. UV reserves the right to supplement the list and to utilize any exhibits listed by any other party.

200. Membership list of Madison Ground Water District

201. Fremont Madison Irrigation District Wells

202. Technical Report Regarding Final Order Designating the ESPA GWMA

203. Reply to IDWR Response to Expert Report Regarding GWMA

204. Estimates of Tributary Basin Underflow for the East Snake Plain Aquifer Model Version 2

205. Model Boundary; Idaho Water Resources Research Institute Technical Report 04-016

206. Model Boundary Revision 2; Eastern Snake Plain Aquifer Model Enhancement Model Design and Calibration Document Number DDM-002-R2

DATED this 10th day of February, 2020.

Hyrum Erickson for
Jerry R. Rigby
of RIGBY, ANDRUS & RIGBY LAW, PLLC

CERTIFICATE OF SERVICE BY MAIL, HAND DELIVERY
OR FACSIMILE TRANSMISSION

I hereby certify that a true and correct copy of the foregoing document was on this date served upon the persons named below, at the addresses set out below their name, either by mailing, hand delivery or by telecopying to them a true and correct copy of said document in a properly addressed envelope in the United States mail, postage prepaid; by hand delivery to them; or by facsimile transmission.

DATED this 10th day of February, 2020.

RIGBY ANDRUS & RIGBY LAW, PLLC

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WMISNum	WR	Contact	2019 Volume AF
200407	22-7676, 227711	SUTTON, BRANDI; SUTTON, GARTH; SUTTON, JOLENE; SUTTON, RICK; SUTTON, SHANE; SUTTON, SUSAN	339.5
200408	22-7699	KYLE BYBEE (OWNER)	
200409	22-7227	SUTTON, GWEN A; SUTTON, KENT V; SUTTON, STEVE J	885.2000122
200522	22-11376, 22-2244, 22	ROBERT D & SUE HUSKINSON (OWNER)	166.8999939
200529	22-2156, 22-7510, 22-:	D S & S INC	234.5200043
200531	22-2166	RANDY HUSKINSON FAMILY LTD PARTNERSHIP	377.6099854
200532	22-7054A, 22-7054B, 2	D S & S INC	712.9199829
200533	22-4130	BYU IDAHO- UTAH CORPORATION (OWNER)	
200535	22-2147	TETON NEWDALE CEMETARY (OWNER)	16.62999916
200694	22-2174	BYU IDAHO- UTAH CORPORATION (OWNER)	156.1000061
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1002946	22-7127, 22-7222, 22-:	ARNOLD, BRUCE J	
1002947	22-7127, 22-7222, 22-:	ARNOLD, BRUCE J	
1002953	22-13572, 22-2197	BYU-IDAHO; Erikson, Guy; Erikson, Keith	230.2200012
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1002985		SCHWENDIMAN, DAVID	597.2999878
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1002995	22-2297, 22-7563	HARD WAY LP (OWNER)	243.6399994
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tabbies EXHIBIT 200

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1003046	22-13746, 22-13797, 2	B & B FARMS	159.7599945
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1003052	22-13278, 22-13280, 2	POCOCK, RAY R; THE RALPH R & BETH POCOCK FAMILY LTD PARTNERSHIP	330.6499939
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1003097	22-2195B, 22-7010, 22	WALTERS, MONA	399.8699951
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1003100	22-2180, 22-13461	SCHWENDIMAN, DIANE P; SCHWENDIMAN, VAL E	241.6199951
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1003117	22-7169	3B LLC	110.3399963
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1003144	22-7230, 22-7661	STEVECO CANYON FARMS INC	
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1003154	22-7654, 22-7706	BYRNE, J R	96.65000153
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1003160	22-7564	SCHWENDIMAN, JODY; SCHWENDIMAN, STAN	191.9199982
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1003203	22-7675	SUTTON, GARTH	854.9400024
1003233		FREMONT MADISON IRRIGATION DISTRICT (OWNER)	
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1003314	22-13670	BEVAN JEPPESEN (OWNER)	
1003316		SKYLINE FARMS	

Total AF -Incomplete-
65406.92961

EXHIBIT 201

Fremont-Madison Irrigation District Groundwater Diversion (Acre Feet)										
YEAR	WELL #1	WELL #2	WELL #3	WELL #4	WELL #5	WELL#6	WELL#7	WELL#8	WELL#9	TOTAL
2012	0	0	0	0	0	0	0	0	0	0
2013	10,278	6,744	2,674	2,157	7,500	0	0	0	0	29,353
2014	0	0	0	0	0	0	0	0	0	0
2015	3,341	1,642	651	0	1,658	0	0	0	0	7,292
2016	0	0	0	0	0	0	0	0	0	0
2017	0	0	0	0	0	0	0	0	0	0
2018	0	0	0	0	0	175	1	1	1	177

Rocky Mountain
ENVIRONMENTAL™
ASSOCIATES, INC.

Technical Report Regarding Final Order Designating the ESPA GWMA

Bryce A Contor, Sr. Hydrologist
RMEA Project # 19-0181
December 5, 2019

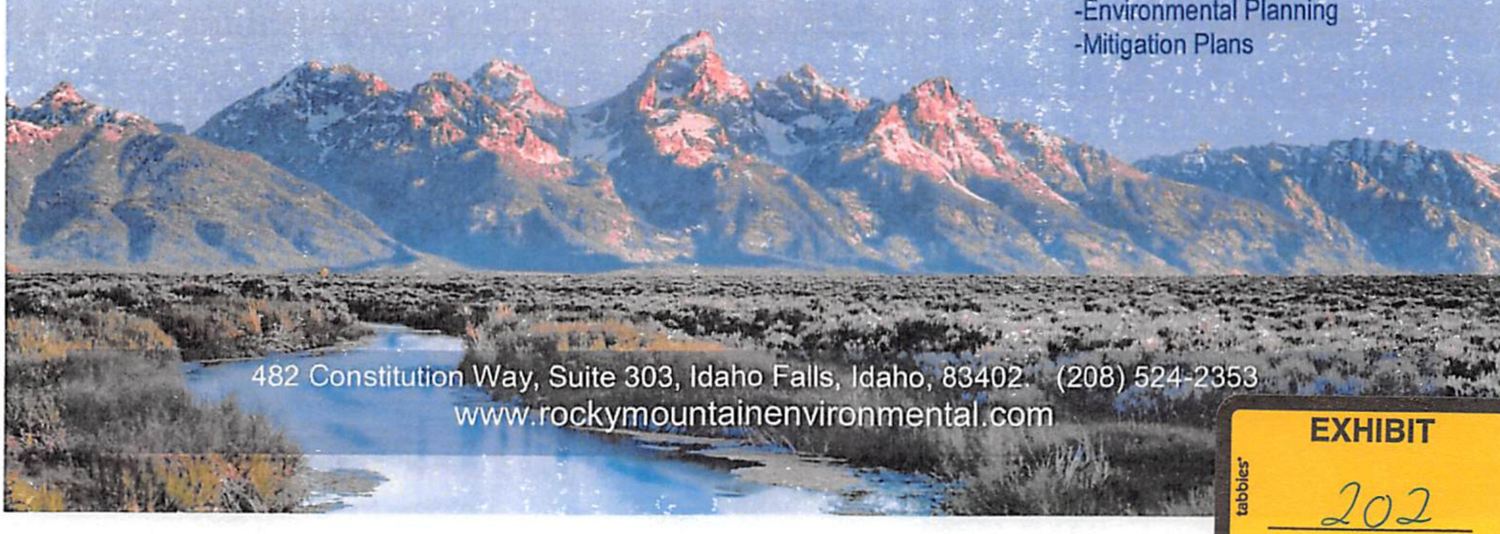
For Madison Ground Water District
c/o Jerry Rigby, Rigby, Andrus & Rigby Law, PLLC
PO Box 250
Rexburg, ID 83440

Environmental
- -Phase I, II, & III ESAs
- -Groundwater Monitoring
- -Underground Storage Tanks
- -Asbestos Inspections
- -Site Inspections & Remediation
- -Plans & Permitting

Water Rights
- -Water Right Due Diligences
- -Transfers & Applications
- -Mitigation Plans

Hydrology
- -Hydrologic Modeling
- -Flow Measurements
- -Well Design
- -Groundwater Supply
- -Aquifer Characterization
- -Recharge Studies

Wetlands
- -Wetland Delineations
- -Environmental Planning
- -Mitigation Plans



482 Constitution Way, Suite 303, Idaho Falls, Idaho, 83402. (208) 524-2353
www.rockymountainenvironmental.com

Table of Contents

Introduction 3
Topography 4
Geology and Hydrogeology 4
Static Water Levels in Wells 5
Representation of the ESPA in Numerical Groundwater Flow Models 6
Comparison to Basins Not Included in the GWMA 7
Discussion 8
References 10

FIGURES

Figure 1. Topography
Figure 2. Static Water Levels Relative to Land Surface
Figure 3. Static Water Levels Relative to Projected Surface
Figure 4. USGS RASA Model Boundary (hand digitized)
Figure 5. SRPAM Figure 11 Georeferenced, with CM Rule 50 Boundary
Figure 6. SRPAM Active Model Cells

Introduction

On September 25, 2019, Idaho Department of Water Resources (IDWR) issued an "Order Authorizing Discovery and Scheduling Order" (Order) (Spackman 2019) regarding an earlier *Final Order Designating the ESPA GWMA* (Eastern Snake Plain Aquifer Ground Water Management Area). The Order establishes a single technical issue that may be heard in the hearing scheduled by the Order:

> *"Whether areas outside of the ESPA area of common ground water supply, as defined by CM Rule 50 (IDAPA 37.02.11.050), but included within the ESPA GMWA, are located in tributary basins and are otherwise sufficiently remote or hydrogeologically disconnected from the ESPA to warrant exclusion from the ESPA GWMA."*

The concepts of tributary basin status, remoteness and hydrogeologic disconnection are technical questions. The concept of sufficiency to warrant exclusion is fundamentally a policy question. As this document is a technical and not a policy report, it relies on the core policy document, the code establishing the ability to create Ground Water Management Areas (Idaho Statutes 42-233b). The statute provides that such an area may be established in "any ground water *basin*" (emphasis added) meeting certain criteria. It is clear that the legislature intended the distinction between singular and plural, as the phrase "*basin or basins*" (emphasis added) is used later for a different provision in the same statute. As the plain-language interpretation is the most likely, the question of sufficiency for this report is phrased as: "Do the Rexburg Bench and the Eastern Snake Plain Aquifer (ESPA) comprise a single groundwater basin?" If "no," then the Bench is sufficiently remote or disconnected to warrant exclusion.

The concept of a groundwater basin is so basic and intuitive that often it is not defined formally, and has not been legally defined in Idaho (Spackman 2016). As not all Idaho legislators are hydrogeologists, the statutory meaning of "ground water basin" must be a plain-language meaning understood by lay persons. A definition cited by the Director in the order creating the GWMA (Spackman 2016) is compatible with this lay understanding, and indicates that a groundwater basin is a unit with "reasonably well-defined boundaries." The American Geological Institute echoes this criterion (Bates and Jackson 1984). Another source adds the refinement that these boundaries are discernable "in a lateral direction," and that lateral boundaries can be "features... such as rock or sediments with very low permeability or a geologic structure such as a fault" (California Department of Water Resources 2003). It also clarifies that basins can be "open at one or more places to other basins," underscoring that the separation does not have to be total to establish a different basin. A third source indicates that "groundwater basin" is "a rather vague designation pertaining to a groundwater reservoir which is more or less separate from neighboring groundwater reservoirs. A groundwater basin could be separated from adjacent basins by geologic boundaries or by hydrologic boundaries" (Fetter 1994).

Consistent with the clear legislative distinction between singular and plural and the definitions above, this report considers whether the Rexburg Bench is separate from the ESPA based on whether there are discrete and distinct differences over short lateral distances in any of the following:

- Topography
- Geology and Hydrogeology
- Static water levels in wells

It also considers:

- Representation of the ESPA in numerical groundwater flow models
- Comparison to basins not included in the GWMA

Topography

Topography per se is not a defining characteristic of a groundwater-basin boundary. However, topography is generally driven by underlying geologic structures, such as faults or the terminations of sedimentary facies against rock. These often comprise bounding features that affect groundwater flow. Figure 1 shows a hillshade depiction of land surface elevations in the Rexburg Bench vicinity, with the CM Rule 50 boundary and the Enhanced Snake Plain Aquifer Model Version 2.1 (ESPAM2.1) boundary. In the vicinity of the Rexburg Bench, the ESPAM2.1 boundary is identical to the Enhanced Snake Plain Aquifer Model Version 1.1 (ESPAM1.1) boundary and equivalent to the GWMA boundary.

A clear distinction in topography is readily apparent. It corresponds approximately to the CM Rule 50 boundary and separates the Rexburg Bench from the Snake River Plain.

Geology and Hydrogeology

The Geologic Map of the Rexburg Quadrangle, Madison County, Idaho (Phillips et al 2016) indicates that the surface geology of the plain is dominated by alluvial materials and the surface geology of the Bench is dominated by wind-blown deposits. Two cross sections are mapped. Both show hundreds of feet of sedimentary materials at surface on the plain, with an abrupt transition to volcanic materials extending nearly to land surface on the Rexburg Bench. The map shows the Rexburg Bench entirely bounded on the west by faults, and transected by numerous faults that do not extend into the surrounding plain. The primary separating fault between the Bench and the plain is the Rexburg Fault, which is mapped extending along the margin of the Bench from near

Newdale to near Ririe. Overlapping the Rexburg Fault slightly and extending south and east to the canyon of the South Fork of the Snake is the Heise Fault, also closely following the margin of the Bench.

Phillips et all describe the structure of the Rexburg Bench as follows:

> *"The map area lies on the eastern margin of the Snake River Plain near the termination of the Grand Valley normal fault* [This fault is aligned with the South Fork of the Snake River extending in a southeast direction from near Heise]. *As this major fault approaches the Snake River Plain it divides into NE-stepping splays that become increasingly N-S oriented....* [one of these is the] *Rexburg fault* [which] *is an arcuate normal structure along the boundary between the between the Snake River Plain and the Rexburg Bench. A 15 to 30 m ((50 to 100 ft) scarp in unit Tbr* [Basalt of Rexburg (Pliocene)] *is present along much of its trace. The Huckleberry Ridge Tuff is offset as much as 100 m (328 ft) across the structure."*

In 1972, US Bureau of Reclamation published a report on groundwater conditions in the Rexburg Bench (Haskett 1972). It describes the Bench as "part of a 15-mile wide rectangular structural block trending northwest between the Teton and Snake River valleys." It indicates that "the subsurface geology of the Rexburg Bench is unusually complex." In general terms it describes three areas of subsurface clay that support "perched water table[s] whose surface is 100 feet or more above the regional water table." Haskett indicates that "the various rock types which surround or extend beneath the clay pods act as a common reservoir," though "the performance of wells varies considerably in different rocks." Within this common reservoir, a basalt aquifer and three different rhyolite aquifers are specifically described.

Using data from the fall of 1970 "where available," Haskett concluded: "Regionally, the ground-water gradient is in a general west-southwest direction as it is across much of the Snake River Plain. Locally, under the Rexburg Bench the slope is to the northwest at approximately 5-½ feet per mile."

Static Water Levels in Wells

Figure 2 shows static water levels in wells, expressed as feet of depth to water below land surface. Static water levels were obtained from IDWR (2013-2), from a data set largely compiled from driller's logs. Locations are generally mapped to the center of the Public Land Survey System quarter-quarter or quarter-quarter-quarter section. This introduces some imprecision in depths-to-water derived for wells in areas of greater topographic variation in elevation.

Figure 2 is difficult to interpret because of the differences in elevation of land surface across the Bench and surrounding plain. It does show the Bench having more variability in depth to water than does the plain, and additionally having disparate depths to water in adjacent wells. These observations are consistent with Haskett's description of the Bench as geologically complex, and his indication of perched aquifer(s) on the Bench associated with "clay pods."

Figure 3 shows depth to water relative to a projected surface that represents the topography of the plain extended beneath the Bench. In Figure 3, negative numbers are depicted by warm-colored triangles. These indicate static water levels above the extended surface of the plain. Positive values are depicted by cool-colored circles and represent water levels below the extended surface of the plain.

If the 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 across the geographic boundary between the Bench and plain. Instead, the data generally indicate uniform gradation and transitions across the plain, and heterogeneity across the Bench. The change in character of depths relative to the projected surface is abrupt across the topographic divide between the Bench and the plain.

The extreme negative value is a well in the southeast part of the Bench that is indicated to have a static water level 935 feet above the extended surface. No negative values are observed on the plain. The extreme positive value is a well in the northeast corner of the group of wells considered, with a water surface indicated to be 590 feet below the extended surface. All wells shown with a water surface indicated greater than 200 feet below the extended surface are outside the CM Rule 50 boundary. In contrast, the greatest depth below the extended surface within the CM Rule 50 boundary is 159 feet.

Representation of the ESPA in Numerical Groundwater Flow Models

There is no reason that a numerical groundwater flow model must include an entire groundwater basin in its spatial extent. Likewise, there is no reason that adjacent basins with hydraulic communication cannot be included in the same model. Nevertheless, the boundaries selected and the descriptions given can be informative.

The U.S. Geological Survey groundwater flow model (Garabedian 1992) was part of the Regional Aquifer System Analysis program and consequently is known as the RASA Model. Its boundary is depicted in Figure 4. The RASA boundary in the figure was hand digitized from a paper copy of the report, and it is likely that minor deviations of the RASA boundary from the CM Rule 50 boundary are artifacts of georeferencing. Whitehead (1992) described the aquifer boundary for the RASA model, and focused primarily on describing the vertical extent of the aquifer. Whitehead indicates that the eastern margin is bounded by faults, and that the "areal extent of the Snake River Plain [as modeled] is based on geology and topography."

Figure 5 is a georeferenced excerpt from Figure 11 from the report describing the Snake River Plain Aquifer Model (SRPAM) (Cosgrove et al 1999) with the CM Rule 50 boundary superimposed. Slight discrepancies between the SRPAM aquifer depiction and the CM Rule 50 boundary likely are artifacts of georeferencing. Figure 6 shows the SRPAM active cells. The aquifer boundary is mapped as a smooth curve, representing the underlying geologic definition, while the selection of active cells must conform to the geometry of the model grid.

The developers' descriptions of the model extent and basin boundary are limited to "The Snake River Plain aquifer, underlying the eastern Snake River Plain, is hosted in layered basalts and interbedded sediments and is an integral part of the basin water resources.... The eastern plain is bounded structurally... by faulting on the southeast.... Specified flux boundaries are used to represent underflow from surrounding tributary valleys including... the Rexburg Bench."

ESPAM1.1 and ESPAM2.1 share a common boundary in the vicinity of the Rexburg Bench, illustrated in Figure 1. It is different from prior work and from all descriptions of the ESPA boundary. Neither report suggests that the model boundary represents the boundary of the ESPA groundwater basin; instead, both indicate the model boundary was expanded "to include irrigated acreage in the Kilgore, Rexburg Bench, American Falls and Oakley areas" (Cosgrove et al 2006, IDWR 2013-1). Project design documents clarify that this decision was taken "to support later administrative decisions," and indicated an "added advantage would be that these hydrologically connected areas can be administered similarly if necessary" (Wylie 2004, Wylie 2009). This writer distinctly recalls attending a meeting in his role as a member of the ESPAM1.1 modeling team, where IDWR personnel expressed in strong language a desire to have the Rexburg Bench included in the model purely for administrative reasons.

Comparison to Basins Not Included in the GWMA

This report is not intended to be an exhaustive evaluation of all the groundwater basins tributary and/or bordering the ESPA basin. The comparisons here are based on sources already cited and upon the understanding that topography is generally an expression of underlying structure. The division into classes could be refined, but it provides a general indication of the Bench's similarities to and differences from excluded basins.

The first general class of non-included basins is basins that are less distinct or different from the ESPA than is the Rexburg Bench. These are basins where alluvial valley fill likely grades into the interleaved sedimentary materials within the ESPA proper, without the distinct structural boundary that characterizes the Bench. These excluded basins include:

- Birch Creek
- The Little Lost River north of the main block of irrigated lands
- Raft River
- Rock Creek
- Lincoln & Ross Creeks

The second class is basins that share with the Rexburg Bench a similar degree of distinction from the ESPA. These are basins where the intersection of the basin with the ESPA is characterized by more abrupt topographic differences than the first class of basins. These include:

- Camas and Beaver Creeks
- Medicine Lodge Creek
- Little Wood River
- Thorn Creek
- Clover Creek
- Goose Creek
- Blackfoot River
- Willow Creek
- Snake River at Heise
- Teton River canyon area
- Henry's Fork (including Fall River)

The third class is basins whose separations from the ESPA groundwater basin include a horizontal-distance separation. These appear to be more distinctly separate from the ESPA than is the Rexburg Bench and include:

- Silver Creek
- Big Wood River
- Portneuf River
- Teton valley
- Big Lost River (above Mackay Dam)

Discussion

Groundwater basins are structurally and/or hydrologically delineated. Basins can be adjacent and partly open to one another without being the same basin, as long as they are more or less separate.

Topography is generally an expression of structure. The Rexburg Bench is topographically distinct from the adjacent plain.

Formal geologic work indicates that the geology of the Bench is distinct from the plain, and that the Bench is structurally separated from the plain by faults along its entire shared margin with the ESPA. Faults that transect the Bench are not mapped as extending into the plain.

The Bench exhibits complex geology with apparent multiple aquifers. Its general groundwater gradient is in a direction approximately at right angles to the gradient on the adjacent plain. Static groundwater elevations on the Bench generally are either much lower or much higher relative to an extrapolated surface consistent with the adjacent plain than are the static elevations within the plain itself.

Modeling documents that mention the Rexburg Bench explicitly describe it as a tributary basin. The only numerical groundwater flow models that include the Rexburg Bench within the model domain do so for administrative reasons, and written modeling documents never suggest that it is part of the same groundwater basin as the ESPA.

This report identifies 21 tributary basins that are not included in the GWMA and therefore are presumably sufficiently distinct from the ESPA to warrant exclusion. Sixteen of these are less or similarly distinct from the ESPA than is the Rexburg Bench.

Based on the combined weight of the information presented here, it is my professional opinion that *the Rexburg Bench is located within a tributary basin.* Because the Rexburg Bench and the Eastern Snake Plain Aquifer do not comprise a single groundwater basin. it is my professional opinion that *the Rexburg Bench is sufficiently remote or hydrogeologically disconnected from the ESPA to warrant exclusion from the ESPA GWMA.*

Bryce A. Contor

Bryce A. Contor

December 5, 2019

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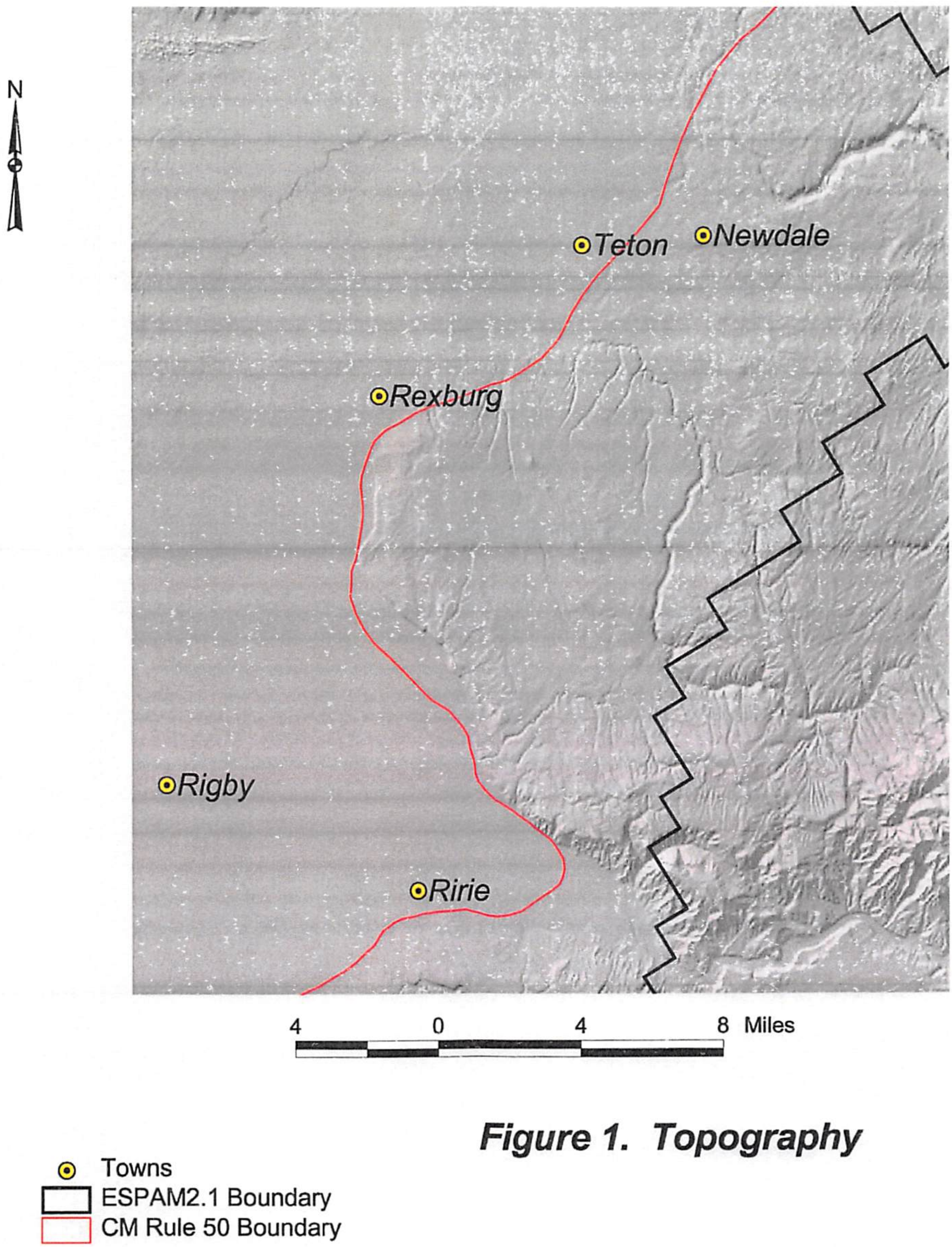


Figure 1. Topography

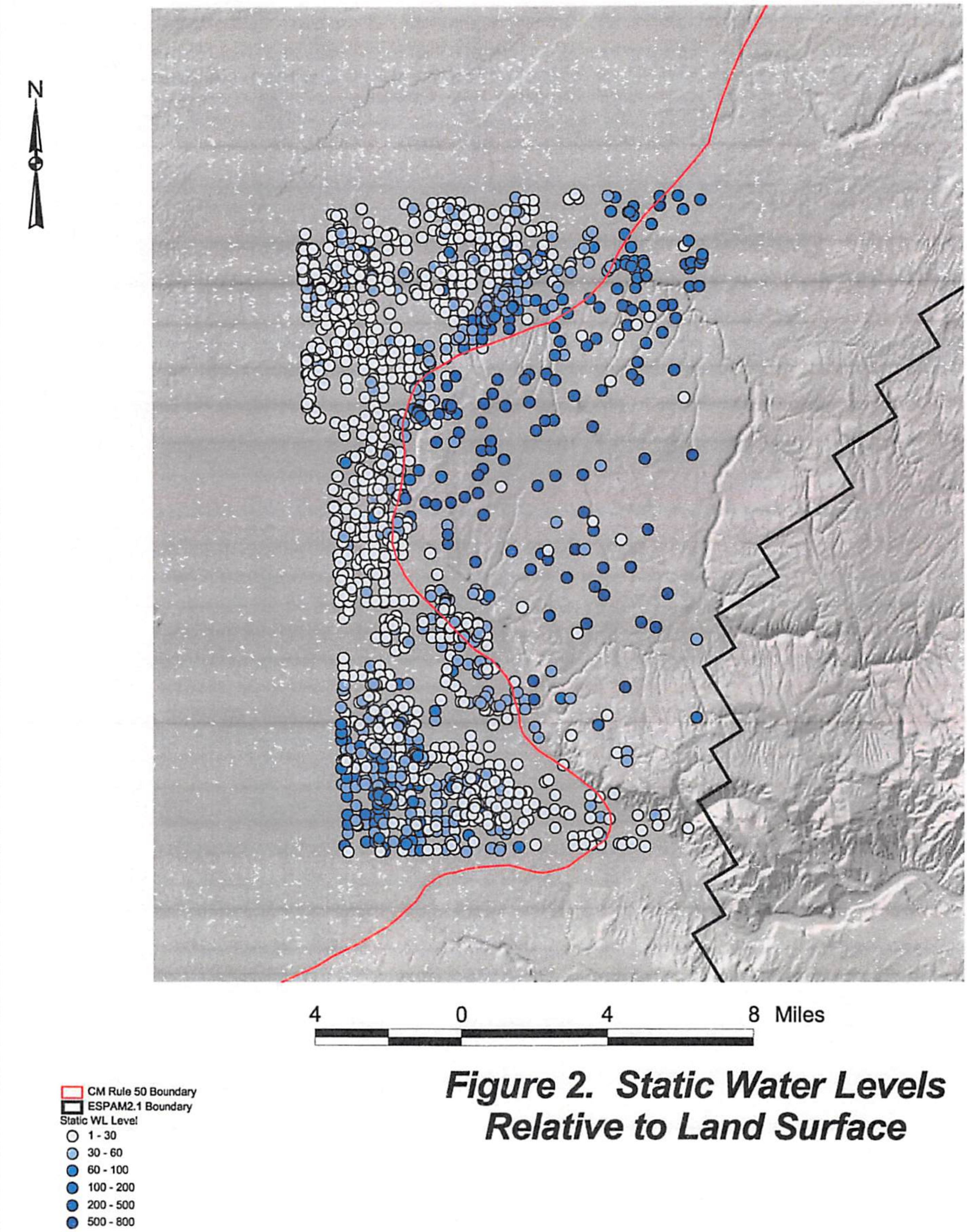


Figure 2. Static Water Levels Relative to Land Surface

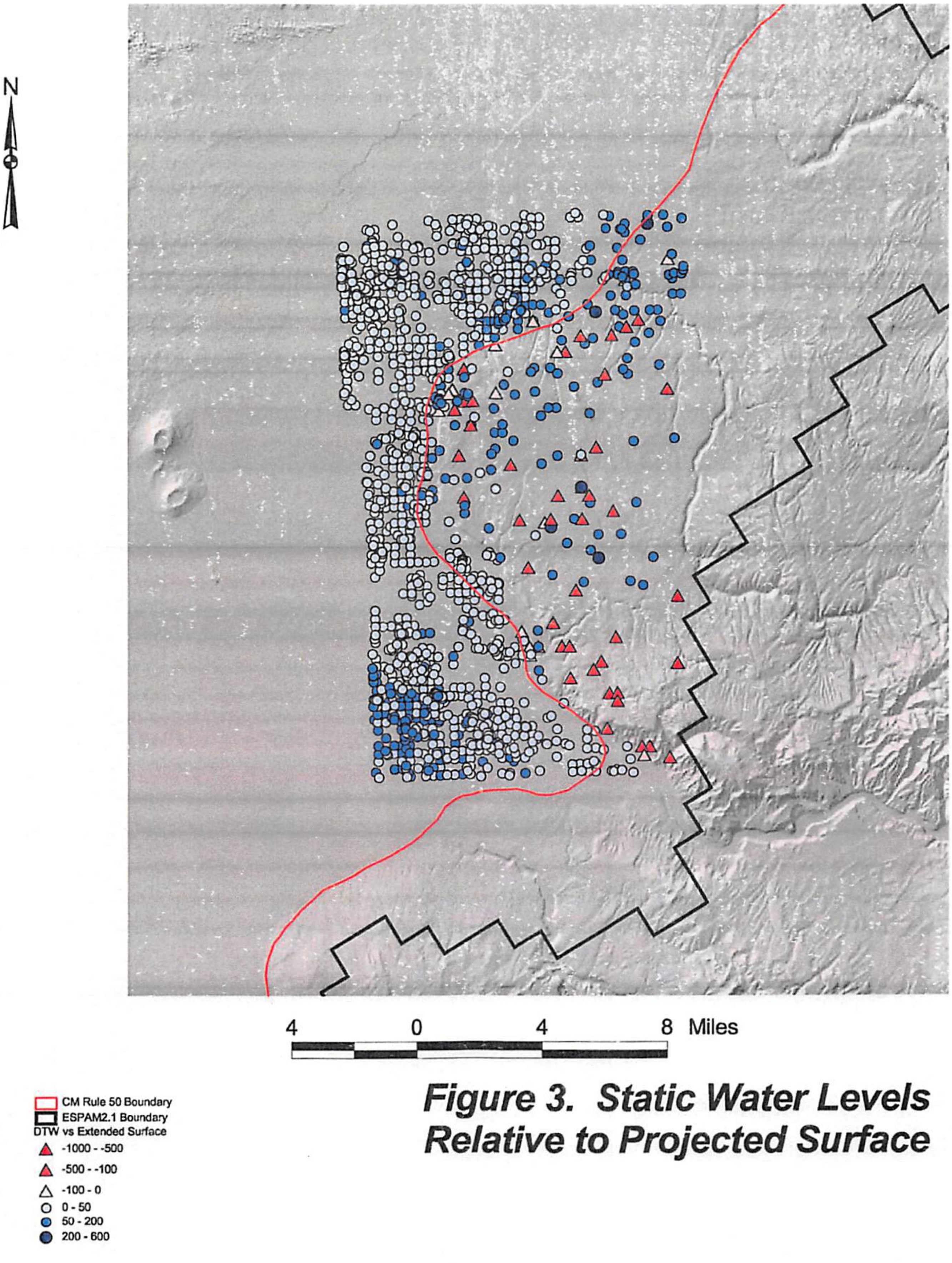


Figure 3. Static Water Levels Relative to Projected Surface

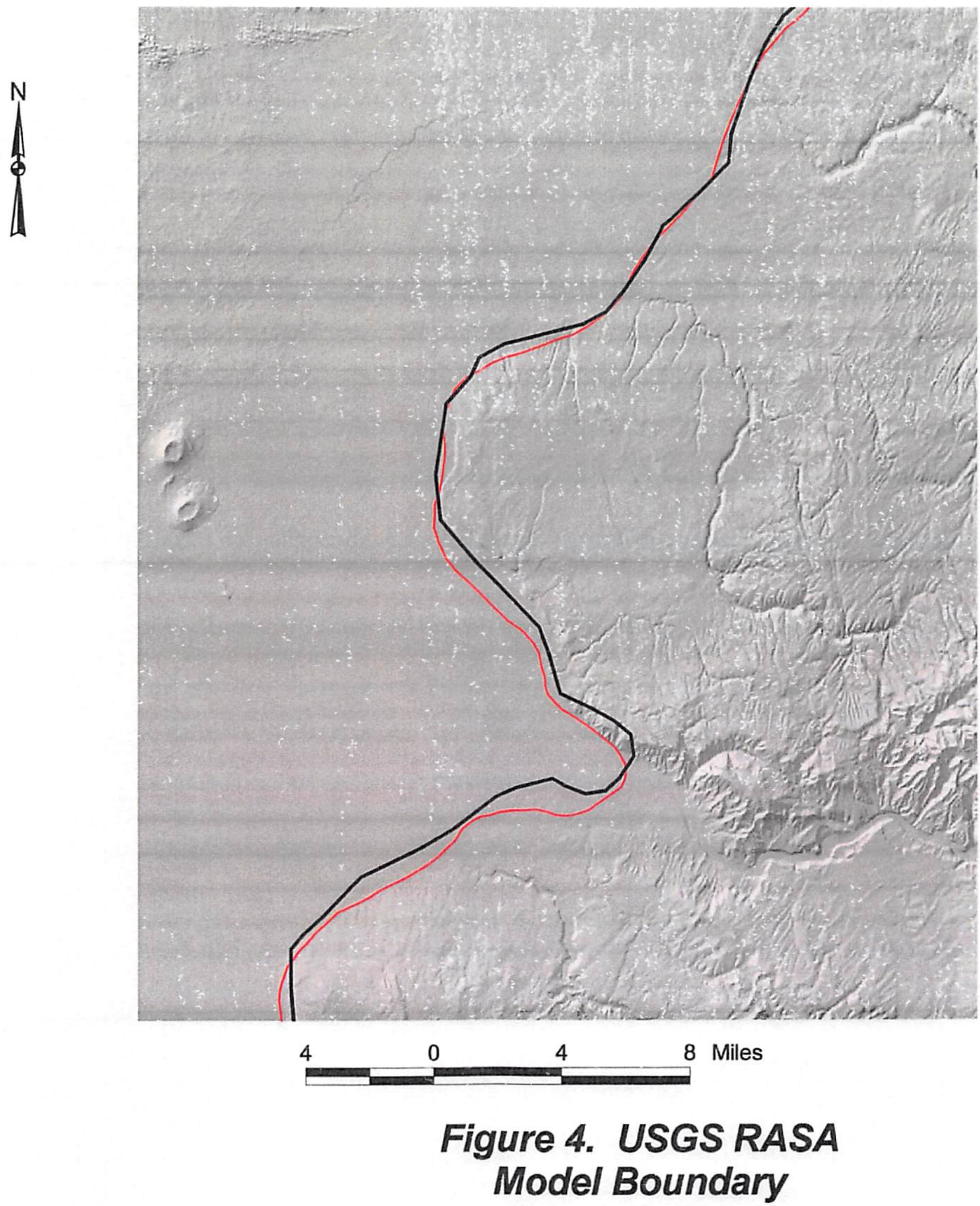


Figure 4. USGS RASA Model Boundary (hand digitized)

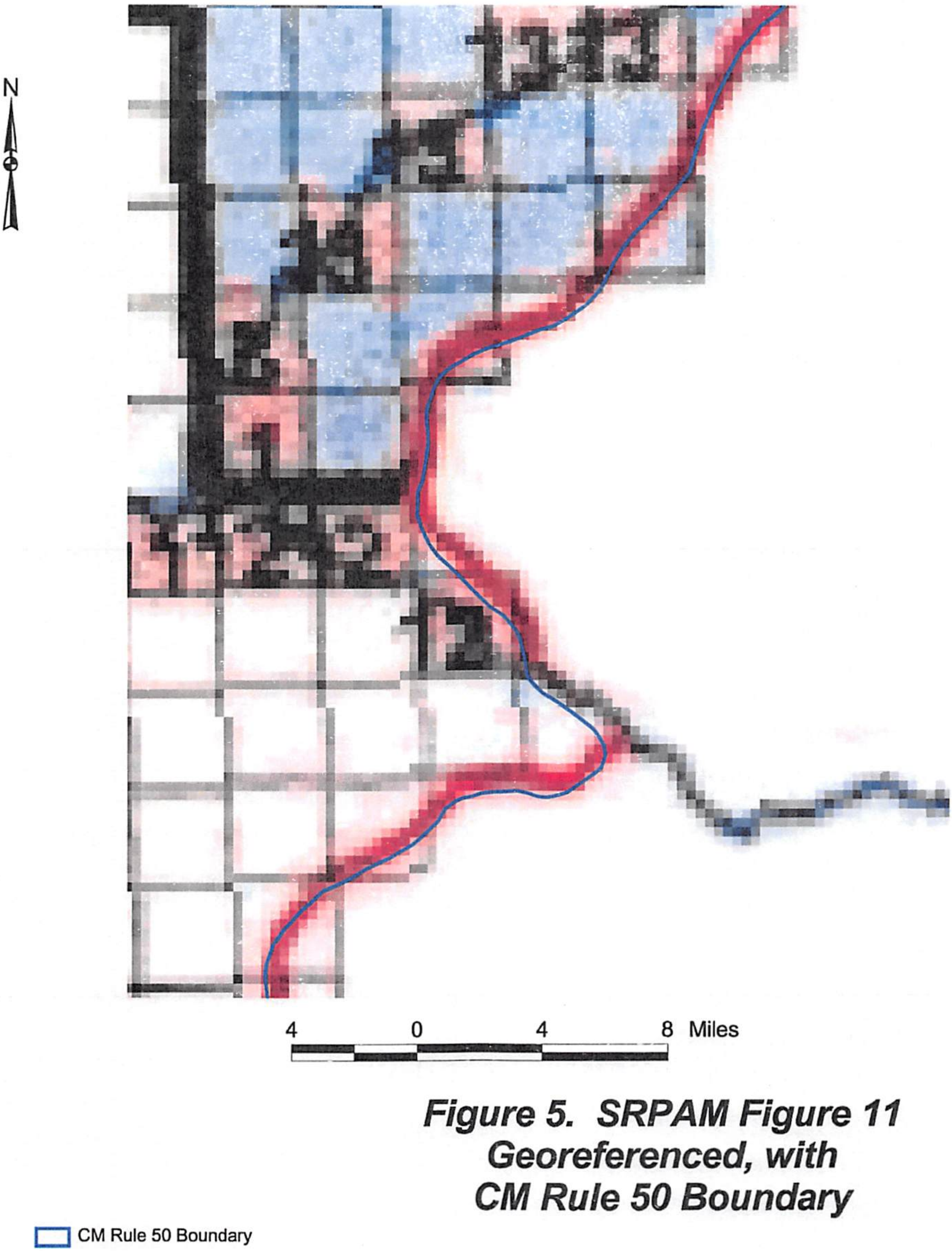


Figure 5. SRPAM Figure 11 Georeferenced, with CM Rule 50 Boundary

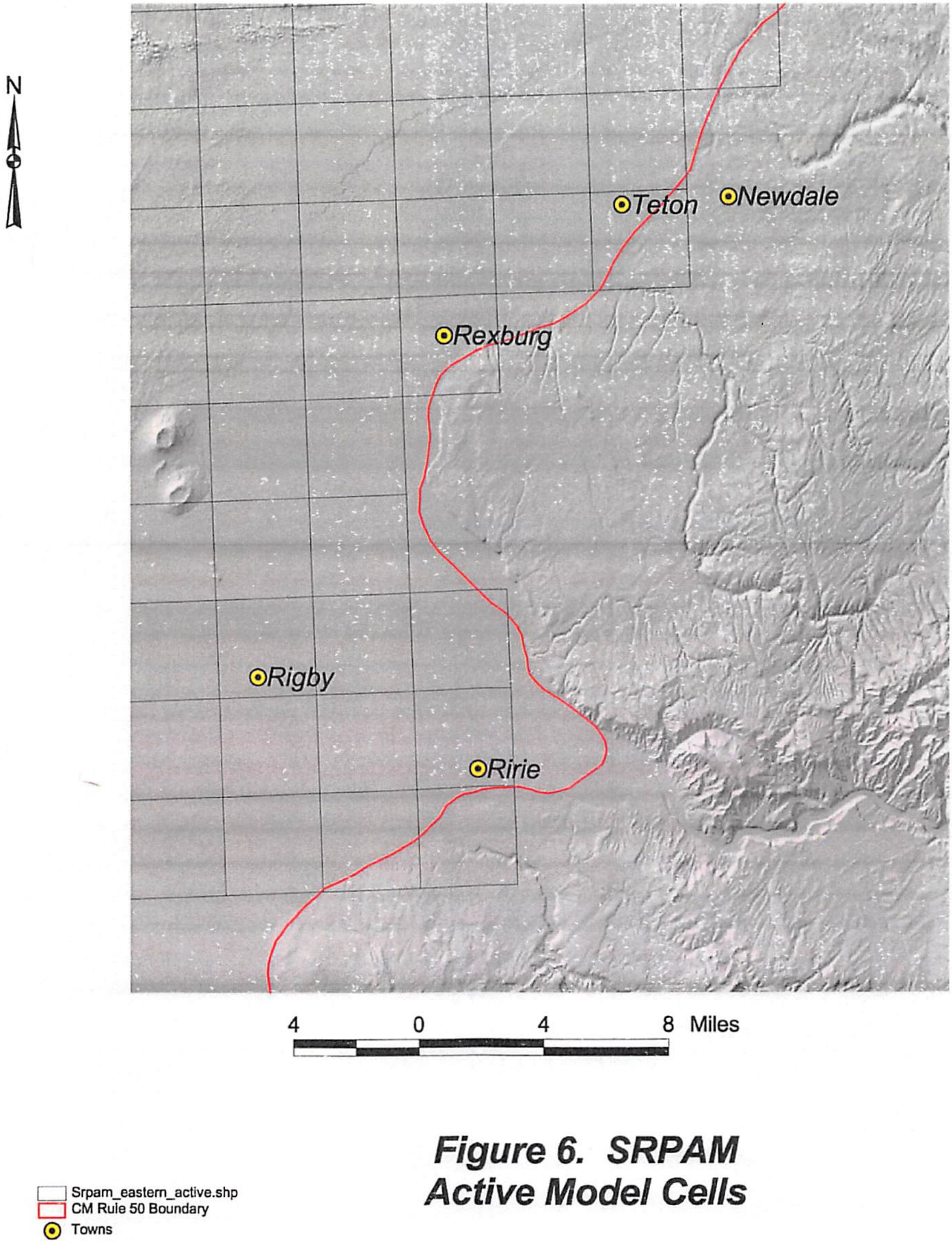


Figure 6. SRPAM Active Model Cells

Bryce Contor, *Senior Hydrologist, RMEA Consultant (former staff)*

Mr. Contor has over 20 years of professional hydrologic experience, including nine years with the Idaho Water Resources Research Institute (IWRRI), a Division of the University of Idaho, where he served as a research hydrologist, and five years with Idaho Department of Water Resources where he served as a Senior Water Resource Agent. Prior to that he farmed and served on the board of directors of a regional irrigation company. After 10 years of service to RMEA, Mr. Contor took a position with the Henry's Fork Foundation, but he continues to frequently support RMEA on a part time basis. While working with IWRRI, Mr. Contor served as principal investigator on hydrologic projects as diverse as preparing water budgets for large scale numerical aquifer models, investigating remote sensing of evapotranspiration on irrigated lands, developing tools to calculate the economic demand for irrigation water, and investigating managed recharge of aquifers. He has published in national peer-reviewed scientific journals and has authored numerous technical completion reports for the Idaho Water Resources Research Institute. While with the Idaho Department of Water Resources, Mr. Contor measured flow in pipelines and open channels, investigated water-right claims and made water- right recommendations in the Snake River Basin Adjudication.

Mr. Contor holds an M.S. Degree in Hydrology from the University of Idaho. His hydrologic specialties include groundwater/surface-water interactions and MODFLOW aquifer modeling, water-budget analysis, pipeline and open-channel flow measurement, and statistics. GIS specialties include aerial photography interpretation and manipulation of remote-sensing data. Economics specialties are water banking and economic demand for irrigation water.

W. Roger Warner, *Senior Hydrologist, Vice President*

Mr. Warner's professional experience includes a wide range of geologic, environmental, and water-rights projects conducted since the late 1980's. His experience has included time in the consulting industry as an engineering geologist and Hydrologist, as a governmental agency representative at the Idaho Department of Water Resources, and in academia as a geology instructor at Brigham young University Idaho. Mr. Warner has managed and conducted numerous and varied projects over the course of his career, and he brings to the table a diverse working knowledge of environmental and geological issues.

Mr. Warner holds an MS Degree in Hydrology from the University of Idaho and BS in Geology from Brigham Young University.

MEMO

Date: January 18, 2020
To: Jerry Rigby, Hyrum Erickson
From: Bryce A. Contor
Re: Reply to IDWR Response to Expert Report Regarding GWMA

Bryce A. Contor

This document is Bryce Contor's reply to Jennifer Sukow's December 31, 2019 memo (Memo), regarding "Response to expert report in the matter of designating the Eastern Snake Plain Aquifer Ground Water Management Area, Docket No. AA-GWMA-2016-001" (Report). Excerpts quoted from the Memo will be in Times New Roman type, with italicization and indentation as in the original. Citations from the Report are in Tahoma type (the font of this paragraph) and underlined. Contor's replies to the Memo are in Tahoma type and indented.

Page 1-2

Contor does not explicitly delineate the boundaries…. For this memorandum, the extent of the Rexburg Bench delineated by Haskett (1972) was used in conjunction with the ESPA area of common ground water supply and ESPAM2.1 boundaries to identify the approximate extent of the Rexburg Bench.

> Sukow's delineation is acceptable.

Page 2-3

Rather than directly addressing the issue identified above, Contor reformulates the issue, stating his report addresses the question, "*Do the Rexburg Bench and the Eastern Snake Plain Aquifer (ESPA) comprise a single groundwater basin*?" and argues if not, "*then the Bench is sufficiently remote or disconnected to warrant exclusion….*" A technical evaluation of the degree of remoteness and hydrogeological disconnection can be presented without offering an opinion on sufficiency…"

"Sufficiency" is the meat of the admissible question, and to ignore it would have been a gross reformulation. My approach was an attempt to honor the intent of the admissible question by finding and addressing the technical content of its key component.

Page 3

Contor's reformulation of the issue and his conclusion... do not appear to rely on a technical evaluation of remoteness or hydrogeological disconnection....

On the contrary, all of my data and analyses speak directly to hydrogeological disconnection, distinctness, or remoteness.

Page 3

Contor cites portions of the definition of groundwater basins from several sources, but omits other portions.... The concept of defining areas of aquifer recharge and aquifer discharge, and the hydrogeological connectivity between these areas, is an important consideration for the delineation of a groundwater basin."

How much of a source to cite is always a judgment call. The Report focused on hydrogeological connectivity and remoteness. The Report and/or my follow-up work fit Sukow's framework in the following ways:

- The Bench and the plain have different areas and mechanisms of recharge. The primary recharge mechanism on the ESPA, documented in modeling reports, is incidental recharge from irrigation. This mechanism is virtually absent on the Bench except for a few pump stations from the South Fork on the south and limited diversions from Canyon Creek on the north. Primary Bench recharge is provided by precipitation (rainfall as well as snowmelt), underflow from the mountains to the east, and probably seepage from Canyon Creek and Moody Creek.
- The primary discharge mechanisms for the ESPA are discharges to the Snake River and springs, and pumping for irrigation. The discharge

mechanisms for the Bench are underflow to the plain and pumping for irrigation.

- The data indicate differing host materials for the productive portions of the aquifers.
- Rhyolites under the Bench differ in character from rhyolites beneath the plain.
- The Bench is structurally separate and distinct from the plain.
- There is no administratively-meaningful difference in technical ability to represent the effects upon the ESPA of pumping in the Rexburg Bench and pumping in excluded tributary groundwater basins.

Page 3-4

Contor also cites a portion of a groundwater basin definition from the California Department of Water Resources (2003), "*lateral boundaries can be 'features...such as rock or sediments with very low permeability or a geologic structure such as a fault'*." The full definition reads, "*A groundwater basin is defined as an alluvial aquifer or a stacked series of alluvial aquifers with reasonably-defined boundaries in a lateral direction and a definable bottom. Lateral boundaries are features that significantly impede groundwater flow such as rock or sediments with very low permeability or a geologic structure such as a fault. Bottom boundaries would include rock or sediments of very low permeability if no aquifers occur below those sediments within the basin. In some cases, such as in the San Joaquin and Sacramento Valleys, the base of fresh water is considered the bottom of the groundwater basin.*" Although aspects of this definition are specific to groundwater conditions in the State of California, the concept of lateral and vertical boundaries based on features that significantly impede groundwater flow is a general concept that can be applied in other areas.

The Memo is also abbreviated, omitting the citation that groundwater basins can be "open at one or more places to other [groundwater] basins."

Though abbreviating the citation, I did not abbreviate discussion of the important lateral boundaries. Nevertheless, my discussion of vertical boundaries (aquifer bottom) could have been more complete. Both groundwater basins are likely underlain at depth by similar geologic structures, but the productive aquifer in the ESPA groundwater basin near the Bench is hosted in alluvium overlying fractured basalt, with unproductive rhyolite at greater depth. The productive aquifer in the Bench tributary groundwater basin is hosted fractured rhyolites and overlying fractured basalts.

Page 4

Topography, Geology, and Hydrogeology

As mentioned by Contor, Haskett (1972) describes the topography, geology, and hydrogeology of the Rexburg Bench. Haskett described the Rexburg Bench as a broad apron extending northwest from the Big Hole Mountains to the margin of the Snake River Plain, with elevations ranging from approximately 6,500 feet at the base of the mountains to about 5,000 feet at the margin of the bench.

While the geology of the Rexburg Bench is complex, very productive wells have been developed in both the basalt and rhyolite underlying the Rexburg Bench. Haskett noted yields ranging from 925 to 3,500 gallons per minute (gpm) in wells developed in basalt and from 800 to 3,600 gpm in wells developed in rhyolite. High well yields are common in Quaternary basalt underlying the Eastern Snake Plain, but highly productive wells developed in rhyolite are less common. Haskett noted the rhyolite underlying the Rexburg Bench yields greater volumes of water than is usually obtained from rhyolite wells drilled "elsewhere about the Snake Plain." Haskett mentions jointing, the presence of fragmental tuffs, and faulting and associated fracturing as possible explanations for the relatively high permeability of rhyolite underlying the Rexburg Bench.

I do not understand the purpose of this recitation. Nevertheless, the presence of productive wells in two locations does not require that the two be hydraulically connected.

This passage does document difference in character between the Bench rhyolites and the ESPA rhyolites, supporting my assertion of different aquifer hydraulic characteristics.

Page 5

A second possibility is suggested by the anamolous [spelling in Memo] *north and northwest directed gradient....*

The anomalous gradient is a hydrogeologic distinction between the Bench and the ESPA.

Page 6

Considerable groundwater development has occurred on the Rexburg Bench since Haskett's study. Records of groundwater rights developed for irrigation use on the Rexburg Bench show that groundwater development for irrigation has almost doubled since the end of the 1970 irrigation season. On the Rexburg Bench, licensed and decreed water rights developed solely for irrigation with priority dates of 1970 or earlier have a total authorized diversion rate of approximately 418 cfs, while those with priority dates of 1971 or later have a total authorized diversion rate of approximately 384 cfs. Groundwater irrigation water rights on the Rexburg Bench have a mean authorized diversion rate per well of approximately 540 gpm and a maximum authorized diversion rate per well of 3,870 gpm. These values are consistent with the well yields reported by Haskett and support the conclusion that groundwater beneath the Rexburg Bench has a strong hydrogeological connection with the regional Eastern Snake Plain aquifer system. While not all of the geologic materials beneath the Rexburg Bench have high permeability, substantial portions of the basalt and rhyolite rocks have very high permeability,...

The existence of highly-productive wells on the Bench is factually correct. However:

- Well productivity on the Bench is irrelevant to the question of remoteness and hydrogeologic disconnection. It does not follow that productive wells in two locations require communication between them.
- It is not part of the admissible question.
- The only information in this passage related to the admissible question is the indication that rhyolites beneath the Bench differ from those beneath the ESPA.

Page 5

... and the highly permeable deposits are well-connected with each other and with highly permeable sediment and basalt deposits outside of the Rexburg Bench.

Total isolation is not required between adjacent groundwater basins.

Page 7

Static Water Levels in Wells

Contor's analysis of static water levels relied on data obtained from well drillers' logs. Well drillers' logs can be a valuable source of information, but determining groundwater elevations based on a large number of well drillers' logs may be unreliable without substantial effort to verify each well location and the corresponding ground surface elevation. Well drillers' log data sets also include a large number of single-residence domestic wells, which only need very small yields and may or may not be connected to the regional aquifer system in which the irrigation wells are developed.

The vagaries of drillers' data are well known. However, the primary effect of these is to introduce variability into analysis, not bias. A strong advantage to drillers' data is a more robust spatial distribution.

Questions relating to domestic wells apply equally to the Bench and to the ESPA.

It is correct that some irrigation wells on the Bench are developed in the deeper rhyolite materials. It is also true that some irrigation wells on the plain are developed in deeper basalt materials. These facts of themselves do not inform whether the rhyolite wells are indeed in the regional aquifer system. Further, the term "regional aquifer system" could be inclusive of multiple groundwater basins, so this assertion does not require that the two groundwater basins be one. The statute did not use the term "regional aquifer system" but the singular term "ground water basin."

Page 7

Water level measurements collected by the U.S. Geological Survey, Bureau of Reclamation, or other water management agencies are generally better sources of data for evaluating groundwater levels.

These sources tend to produce data of higher quality and lower quantity than the IDWR database that the Report used.

Page 7

Haskett presented water level data collected from wells on the Rexburg Bench by the U.S. Geological Survey, Bureau of Reclamation, pump contractors, and well drillers. Contor's static water level analysis is inconsistent with water level information presented by Haskett.

I do not perceive inconsistencies between the Report's analysis and Haskett's water-level data. Other than asserting contradiction with Haskett, the Memo does not respond to the static water level analysis in the Report. The essence of the analysis is that if the ESPA groundwater basin continued uninterrupted beneath the Rexburg Bench; if the Rexburg Bench were just an unrelated topographic feature overlaid upon a continuous extensive groundwater basin; then the behavior of wells would be consistent with what the surface of the groundwater basin would have been absent the unrelated topographic feature laid upon it.

The analysis in the Report was done by using Geographic Information Systems (GIS) software to extend the surface of the plain to the east, by connecting elevation contours between points north and south of the bench and then interpolating those to a surface. On the plain, the projected surface is exactly equal to actual ground surface. The elevation of this surface was extracted at the location of each well, and subtracted from the recorded water-surface elevation. This yielded what the depth-to-water in the well would be, if the ground surface were at the surface of this projected plain. A positive result indicates the water surface is below land surface elevation, and is interpreted as depth to water, while a negative result indicates that the water-surface elevation is above where the surface of the plain would be if it extended uninterrupted into the space occupied by the Bench.

The Report presents the results as "Figure 3. Static Water Levels Relative to Projected Surface." This is perhaps mis-named, as the analysis was derived from water-surface elevations. The Report shows that static water elevations in wells on the plain tend to be relatively uniform relative to the surface of the plain itself, while on the Bench, those static water elevations are often either much deeper relative to the projected surface of the plain than in wells on the plain itself, or above the elevation of the projected surface. While the 2013 data were fewer in number than the data originally used in the Report, repeating the analysis on the same spatial extent using 2013 data produced a result qualitatively the same. Figure R-1 (attached) shows the results of the analysis with the smaller numbers of data available in the 2013 data set, with the same symbology as used in the Report. Consistent with the initial analysis, the following was found:

- The wells on the plain show water-surface elevations 10 to 83 feet below the projected surface.
- Between one-third and one-half the wells on the bench show water-surface elevations more than 83 feet below the projected surface.
- No wells on the plain show water-surface elevations above the projected surface.
- More than one-third of the wells on the Bench show water-surface elevations above the projected surface.
- Because the projected surface rises to the east, the water-surface elevations in those wells are even higher relative to the actual plain itself, than relative to the projected surface.

The 2013 data did not contradict the prior analysis that had been done using IDWR well-log data. Not all the 2013 data could be linked back to well-completion data, but a review of selected data suggests that for the most part, wells with water levels far above the projected surface are wells completed in shallower wells, probably in an upper aquifer with lower-permeability materials restricting downward movement of water. This confirms the geologic complexity of the Bench asserted by Haskett.

Other data support this complexity and difference between the Bench and the plain. Madison Groundwater District officers Bevan Jeppesen and Rhett Summers provided locations of wells they know personally to have disparate water levels and completion depths within relatively close proximity. While not an exhaustive search, the associated drillers' logs (attached) confirm these differences. I was able to use aerial photography to confirm the well locations mapped in IDWR's database.

Near the center of the Bench is the Dale Jeppesen irrigation well, drilled to 1340 feet in 1982, with a driller-reported static water level 550 feet below land surface and water temperature of 69 degrees F. Approximately 1350 feet to the east and 30 feet lower in elevation (to the precision of 20 foot contours on a USGS topographic map) is the Shawn Webster domestic well, drilled to 265 feet in 1993 with a driller-reported static water level of 175 feet and water temperature of 50 degrees F.

Near the north margin of the Bench is the Summerco irrigation well, drilled to 1215 feet in 2004, with a driller-reported static water level 324 feet below land surface. Approximately 490 feet to the northwest and ten feet higher in elevation (interpolated from 20-foot contours) is the Roy and Bart Summers irrigation well, drilled to 330 feet in 1960 with a driller-reported static water level of 270 feet. Neither log provides temperature information.

Page 7

Haskett's contour map shows groundwater flowing… from underneath the Rexburg Bench to underneath the Eastern Snake Plain along the western margin of the bench.

The hydrogeologic meaning of this fact is that the Rexburg Bench is tributary to the ESPA, as I assert.

Page 8

Representation of the EPSA in Numerical Groundwater Flow Models

The locations of the Rexburg Bench, the ESPA area of common ground water supply, and the ESPA GWMA are shown in Figure 1. The ESPA area of common ground water supply was defined by CM Rule 50 in 1994 as "*the aquifer underlying the Eastern Snake River Plain as the aquifer is defined in the report, Hydrology and Digital Simulation of the Regional Aquifer System, Eastern Snake River Plain, Idaho, USGS Professional Paper 1408-F, 1992 excluding areas south of the Snake River and west of the line separating Sections 34 and 35, Township 10 South, Range 20 East, Boise Meridian.*" This report was one of a series of seven reports published by the USGS on the Snake River Plain Regional Aquifer-System Analysis (RASA) and the boundary is commonly referred to as the RASA boundary.

> The whole point of a Regional Aquifer System Analysis is to evaluate a *regional* aquifer system. While the authors never explicitly state that their evaluation comprises the groundwater basin, they take great pains to justify separation of the eastern and western aquifer. Given this careful justification and lack of similar discussion of other boundaries, it is a stretch of the imagination to assert that this study explicitly represented as a *regional aquifer system analysis* was an analysis of only part of one groundwater basin.

Page 9

The RASA boundary delineated in Garabedian (1992) and other reports in the RASA series is referred to as the "boundary of Eastern Snake River Plain" and is not referred to as a "basin" boundary. Multiple figures in these reports show the delineation of the Eastern Snake River Plain boundary within the larger Snake River Basin boundary, Figure 5 is an example from Garabedian (1992).

> In the nearly 20 years I have been involved in discussions referring to this figure, it has always been implicitly assumed that "Boundary of Snake River Basin" refers to the *surface* water basin, and that the two regional aquifers described (eastern and western) comprise the groundwater basins. Nowhere in the RASA documentation is it indicated that the intent of the broader boundary was to

describe a single groundwater. It is my experience that unless explicitly identified as a *groundwater* basin, at least initially, the word "basin" refers to surface topography.

Page 10

I found no indication in the RASA reports that the delineation of the RASA boundary was intended to delineate the entirety of a groundwater basin.

The notion of entirety is implicit in the plain-language meaning of the title "Regional Aquifer System Analysis," the pains taken to justify separation of the eastern and western aquifers, and the lack of justification for any other omission. The words "regional" and "system" point to a notion of inclusivity and not exclusivity.

Nowhere in the documentation is it stated that (except for the east/west separation) the RASA model did *not* comprise an entire groundwater basin.

Page 10

Lindholm (1994) describes the predevelopment water supply in the Eastern Snake Plain aquifer system as follows:

"Before large areas were irrigated, total average annual recharge to and discharge from the ground-water system in the main part of the eastern plain was about 3.9 million acre-feet. About 60 percent of the total recharge was from tributary drainage basins, 25 percent was from Snake River losses, and 15 percent was from precipitation on the plain."

This designation of areas outside the plain as *tributary* is consistent with my assertion regarding the Bench.

Page 11

Goodell (1988) describes the impact of agricultural development in tributary drainage basins on water supply in the Eastern Snake Plain aquifer system as follows:

> *"In some tributary basins, agricultural development and consequent crop evapotranspiration of surface and ground water have reduced available water flowing to the plain. Most water available to the Snake River Plain originates as surface-water inflow and ground-water underflow from tributary basins. Kjelstrom (1984) estimated available water flowing from tributary basins to the eastern and western plain on the basis of (1) present irrigation development and (2) no development or reservoir storage in tributary basins. According to his figures, on the average, agricultural development in tributary basins has reduced annual available water flowing to the eastern plain by about 7 percent (10.972 MAF to 10.215 MAF)...for water years 1934-1980."*

This is simply a fact of the nature of tributary groundwater basins, and does not inform the admissible question.

Further, this citation does not distinguish the Bench from excluded groundwater basins.

Page 11

Garabedian (1992) used the RASA model to simulate the effect of changes in boundary flux (underflow from tributary drainage basins) on aquifer heads and aquifer discharge to the Snake River. For example, Figure 6 shows the predicted head response at a well located approximately 10 miles from the Rexburg Bench resulting from a 50% increase or a 50% decrease in boundary flux. Change in consumptive use of groundwater for irrigation within a tributary drainage basin is one example of a change in boundary flux. Garabedian's simulations illustrate that changes in consumptive use of water outside of the RASA boundary affect aquifer heads within the RASA boundary.

This is simply a hydrologic fact of the nature of tributaries, and does not inform the admissible question. It applies to all tributary groundwater basins.

Page 12

As mentioned by Contor, other groundwater flow models of the Eastern Snake Plain aquifer system were developed after the completion of the RASA project and the promulgation of CM Rule 50. Model boundaries were different for each model, but all of the models used specified flux

The definition of hydraulic connection is that signals propagate *both directions.* Choosing a specified-flux boundary guarantees that the model cannot represent propagation of effects from the model into a tributary groundwater basin, and so by definition represents the tributary as *not* hydraulically connected.

Page 12

The Snake River Plain Aquifer Model (SRPAM) developed by Cosgrove and others (1999) described the Eastern Snake Plain as follows:

"The eastern plain is bounded structurally by faulting on the northwest and downwarping and faulting on the southeast (Whitehead, 1986).

As acknowledged by Sukow, the Bench is separated from the plain by faulting.

Page 12

The plain is bounded by Yellowstone Group rhyolite in the northeast

The aquifer on the plain adjacent and near the bench is primarily hosted in sediments and underlying basalts. The aquifer on the Bench is hosted in rhyolites and overlying basalts.

Page 13

Cosgrove and others (1999) did not describe the SRPAM model boundary as a delineation of a groundwater basin. Conversely, they stated, "*The Snake River Plain aquifer, underlying the eastern Snake River Plain, is hosted in layered basalts and interbedded sediments and is an integral part of the basin water resources.*"

> A more likely interpretation is that Cosgrove and others used *basin* in the surface-water context that the RASA authors did; by convention, had they meant *groundwater* basin they would have said so. This is evidenced in Sukow's quote below, in which the authors refer to the desirability of a broader model to include both the "aquifer *and* the major tributaries" (emphasis added).

Page 13

Cosgrove and others specifically acknowledged that the SRPM model was not a basin-wide model and identify this as a limitation of the SRPAM. Cosgrove and others recommended:

> *"At some time in the future, it may be desirable to develop a basin-wide model representing the Snake River Plain aquifer and the major tributaries. This would allow prediction of impacts on the Snake River from scenarios incorporating changes in water management in both the plain and in tributary valleys."*

> To date, all the Snake Plain Aquifer models have been groundwater flow models. Calling for extension to a "basin-wide" model indicates an intent to link surface-water modeling to groundwater modeling. A derivative requirement may be to expand the horizontal extent of the model in order to capture the surface-water processes that extend over a larger horizontal landscape, necessarily requiring inclusion of tributary groundwater basins.

Page 13

While, the ESPAM2.1 model domain is still smaller than a basin-wide model, the expansion of the model domain into hydraulically-connected areas with significant irrigated acreage lessens the limitation described by Cosgrove and others. While the usefulness of the model as an administrative tool was considered in delineation of the model boundary for ESPAM, the expansion of the model into hydraulically-connected areas outside of the SRPAM and RASA model boundaries, including the Rexburg Bench, was scientifically sound and followed the recommendation of previous researchers.

> When we wrote the ESPAM1.1 report, we were very, very careful to avoid asserting that the newly included areas were part of the aquifer and the groundwater basin. We documented explicitly that the Rexburg Bench was a *tributary* incorporated for administrative convenience. Similar language appears in the ESPAM2.1 report.
>
> It is probably true that none of the model developers explicitly asserted that their model comprised the entire groundwater basin. However, neither did any assert that their model did *not* include an entire *groundwater* basin, except for the RASA authors' careful justification for separating the eastern and western plains.
>
> It is true that a groundwater model can be constructed to include a groundwater basin and adjacent tributary groundwater basins. For that matter, it could be constructed with a no-flow boundary separating two entirely unconnected aquifers in a single model, though it is hard to imagine a reason to do so.
>
> The discussions of groundwater-basin extent that *do* occur in model documentation highlight the implicit assumption that a regional aquifer model is intended to represent a groundwater basin:
>
> - The RASA authors carefully justify treating the western Snake Plain separately from the eastern Snake Plain.
> - The ESPAM1.1 and ESPAM2.1 authors carefully identify added areas as parts of *tributary* groundwater basins and avoid representing that they are part of the ESPA groundwater basin itself.

Page 13-14

Comparison to Areas Not Included in the GWMA

Contor identified 21 tributary basins (or portions of tributary basins) that are not included in the GWMA and states these areas are "*presumably sufficiently distinct* *from the ESPA to warrant exclusion. Sixteen of these areas are less or similarly distinct from the ESPA than is the Rexburg Bench."* This presumption is inconsistent with the order designating the GWMA[1], which clearly states these areas were excluded from the GWMA because they are outside of the ESPAM2.1 model boundary:

> *"The ESPAM2.1 boundary is a reasonable administrative area because the Department currently lacks similar modeling tools and hydrologic data to administer outside the ESPAM2.1 model boundary, except for the Big Wood River Basin. Moreover, most of the ground-water irrigated land within the upper Snake River basin is located within the model boundary or, in the case of the Big Wood River and Raft River basins, in established management areas outside the model boundary."*

The location of the model boundary and its relationship to inclusion within a GWMA is not part of the admissible question. Nevertheless, having been raised, technical aspects of the issue require a reply.

From an administrative viewpoint, there are three technical functions required in assessing the effects that pumping in any tributary groundwater basin would have upon surface-water bodies on the plain that are hydraulically connected to the aquifer: 1) To what extent does pumping in the tributary affect the ESPA? 2) What fraction of that effect propagates to a given surface-water body? 3) What is the timing of that propagation of effect?

For the Rexburg Bench, Oakley Fan and the Big Lost River below the Mackay Dam, model estimates perform these functions. For tributary groundwater basins outside the model, these functions can be addressed as follows: 1) It is already established that pumping in all the tributaries propagates to the ESPA. 2) The steady-state fraction of effect that reaches a particular surface-water body can be readily calculated by distributing pumping in the tributary to the model's tributary-underflow cells, with results as precise as any other modeling result. For wells near the boundary, the nearest cell may be appropriate. For wells distance, the entire set of tributary-underflow cells would be more appropriate. Unless the surface-water body of interest is near the tributary in question, the practical difference will be small. 3) I addressed the question of timing of effects for IDWR while at the Idaho Water Resources

[1] *Order Designating the Eastern Snake Plain Aquifer Ground Water Management Area*, Idaho Department of Water Resources, November 2, 2016, Conclusions of Law 18 through 21.

Research Institute, for an evaluation regarding flows at Swan Falls. I used a version of the Balmer/Glover/Jenkins analytical method adapted for no-flow boundaries (Contor 2011) to estimate the timing of effects from the point of pumping to the aquifer boundary, and used the transient version of the model to propagate that effect from the aquifer boundary to the surface-water body of interest. Other analytical methods such as the Cooper-Jacob method (1946) or image-well analysis (Ferris and others 1962, Freeze and Cherry 1979) could also be used. Due to calibration of model parameters, estimates of timing within the model domain are likely to be more precise than estimates for the part of the tributary outside the model. Nevertheless, it is my experience that precise estimates of timing are not critical; for most administrative questions the decision depends on the magnitude of effect that occurs, regardless of the temporal delay that may accompany its arrival.

The hydrogeologic fact remains that there are 16 excluded groundwater basins either less or equally distinct from the ESPA than is the Rexburg Bench. Because there is no technical reason to use the model boundary as a criterion for inclusion, it is my professional opinion that it is arbitrary to include the Rexburg Bench while excluding basins that are not more distinct from the ESPA.

Page 14

Other areas identified by Contor as being "*less or similarly distinct from the ESPA than is the Rexburg Bench*" have considerably less groundwater development than the Rexburg Bench.

The extent of groundwater development is irrelevant to the question of hydrogeologic distinction and is not part of the admissible question.

Page 14

As discussed previously, the ESPAM2.1 is not a basin-wide model...

It is not a model of an entire *surface-water* basin with linked surface-water and groundwater modeling.

...and groundwater use in tributary areas does affect groundwater and/or surface water inflow to the Eastern Snake Plain.

> This is simply a characteristic of tributary groundwater basins. It applies equally to the excluded groundwater basins and to the Bench.

Page 14

Conclusions of law 17 through 21 acknowledge that the GWMA designation only includes part of the groundwater basin and explain the reasoning for the delineation of the GWMA boundary.

> The order creates a novel concept of a macro groundwater basin comprised of aggregated adjacent groundwater basins. While the parallel reasoning to the accepted nesting of surface-water basins is attractive, the surface-basin nesting occurs in an environment of unambiguous and unchanging relationships of hydraulic gradients. I have never heard of the macro-groundwater-basin concept anywhere else and consequently know of no arguments for or against it. However, I do know the plain-language meaning of the singular word "basin" as used in the GWMA statute.
>
> The Memo accepts this novel macro-basin construction as settled hydrogeologic and administrative fact, presents analyses through that lens, and in so doing presupposes the outcome of the hearing.

Page 15

Conclusions

Although there are topographic, geologic, and structural differences between the Rexburg Bench and the Eastern Snake Plain, formal geologic work indicates there is a strong hydrogeological connection between groundwater underlying the bench and groundwater underlying the plain. Faulting and the presence of different geologic materials do not make an area hydrogeologically distinct from an adjacent area unless they significantly impede groundwater flow or result in a significantly different bulk permeability. High yields in wells developed in multiple rock types underlying the Rexburg Bench were documented by Haskett, and also are evident in the subsequent development of groundwater rights for irrigation.

Haskett indicates that the well productivity on the Bench is from rhyolite host materials and facilitated by fracturing within the rhyolite. This speaks to difference and not to similarity; production on the adjacent plain is from sedimentary deposits and inter-flow rubble zones.

Page 16

Groundwater development on the Rexburg Bench extends to the margin of the bench, immediately adjacent to the Eastern Snake Plain, indicating groundwater underlying the bench is not remote from the Eastern Snake Plain aquifer system.

Adjacency of wells to the edge of a groundwater basin alone does not provide information about its extent. There are places such as the Little Lost where groundwater development extends to the margin of an aquifer, without indicating that adjacent geologic materials are part of the groundwater basin.

Page 16

...model developers acknowledged that activities occurring outside of the active model domain do impact the boundary flux and affect aquifer heads within the model boundary.

This is simply evidence that the Rexburg Bench is tributary, as I assert.

Page 16

The developers of the SRPAM, which was the most recent model that excluded the Rexburg Bench from the active domain, specifically identified this as a limitation of the model and recommended a "basin-wide" model be developed in the future to allow predictions of impacts on the Snake River resulting from changes in water management in areas which affect the boundary flux.

From the beginning of my membership on the modeling team in 2001, when we referred to a "basin-wide" model, I thought we meant linked surface-water/groundwater modeling.

Page 16

More recent models of the Eastern Snake Plain aquifer system were expanded to partially address the recommendation of the SRPAM developers. The expansion of the active model domain included the Rexburg Bench and other areas that are hydraulically connected with the ESPA system.

> We were very careful in our documentation of ESPAM1.1 to indicate that the included areas were tributary, and not to represent them as part of the same groundwater basin. Authors of ESPAM2.1 used similar language.

Page 16

In my professional opinion, references to the Rexburg Bench and other areas as "tributary drainage basins" or "tributary basins" in model development reports do not exclude them from being part of a larger groundwater basin. It simply means they are tributary to the active model domain, which does not represent an entire groundwater basin. Further, the Rexburg Bench is located within the active model domain in recent models of the Eastern Snake Plain aquifer system and is not represented as a "tributary basin" in models developed within the last 20 years.

> Since there is no modeling-code designation of "tributary" area, it is true that those *models* cannot explicitly represent the Rexburg Bench as tributary. However, the model documentation *does* in both cases.

Page 16

In my professional opinion, available technical evidence indicates the Rexburg Bench is neither remote...

> I acknowledge that neither the Rexburg Bench nor most of the excluded tributaries are remote from the ESPA groundwater basin.

...nor hydrogeologically disconnected from the ESPA. In my professional opinion, the technical evidence indicates groundwater underlying the Rexburg Bench is hydrogeologically connected to groundwater underlying the Eastern Snake Plain, and both areas are located within the same groundwater basin.

> While the Bench is not as isolated as if it were in a porcelain bowl, porcelain bowls are rare in nature and some communication is expected between adjacent basins. Distinct lateral geologic boundaries, different sources and patterns of recharge and discharge, different hosting materials, different gradient directions, and different character of wells relative to a projected surface of the plain all indicate differences between the Rexburg Bench groundwater basin and the adjacent ESPA groundwater basin, and evidence limitations on full and unfettered communication.
>
> Other basins less distinct from the ESPA basin than is the Rexburg Bench have been arbitrarily excluded, despite the existence of technical methods to perform all analyses necessary for administration.

References

Contor, B. 2011. Adaptation of the Glover/Balmer/Jenkins Analytical Stream-Depletion Methods for No-flow and Recharge Boundaries. Idaho Water Resources Research Institute Technical Completion Report 201101.

Cooper, H.H. and C.E. Jacob, 1946. *A generalized graphical method for evaluating formation constants and summarizing well field history*, Am. Geophys. Union Trans., vol. 27, pp. 526-534.

Ferris, J.G., D.B. Knowles, R.H. Browne, and R.W. Stallman, 1962. Theory of aquifer tests. USGS WSP 1536-E

Freeze, R. A. and J.A. Cherry, 1979. Groundwater. Prentice-Hall, Inc., Englewood Cliffs, NJ, 604 pp.

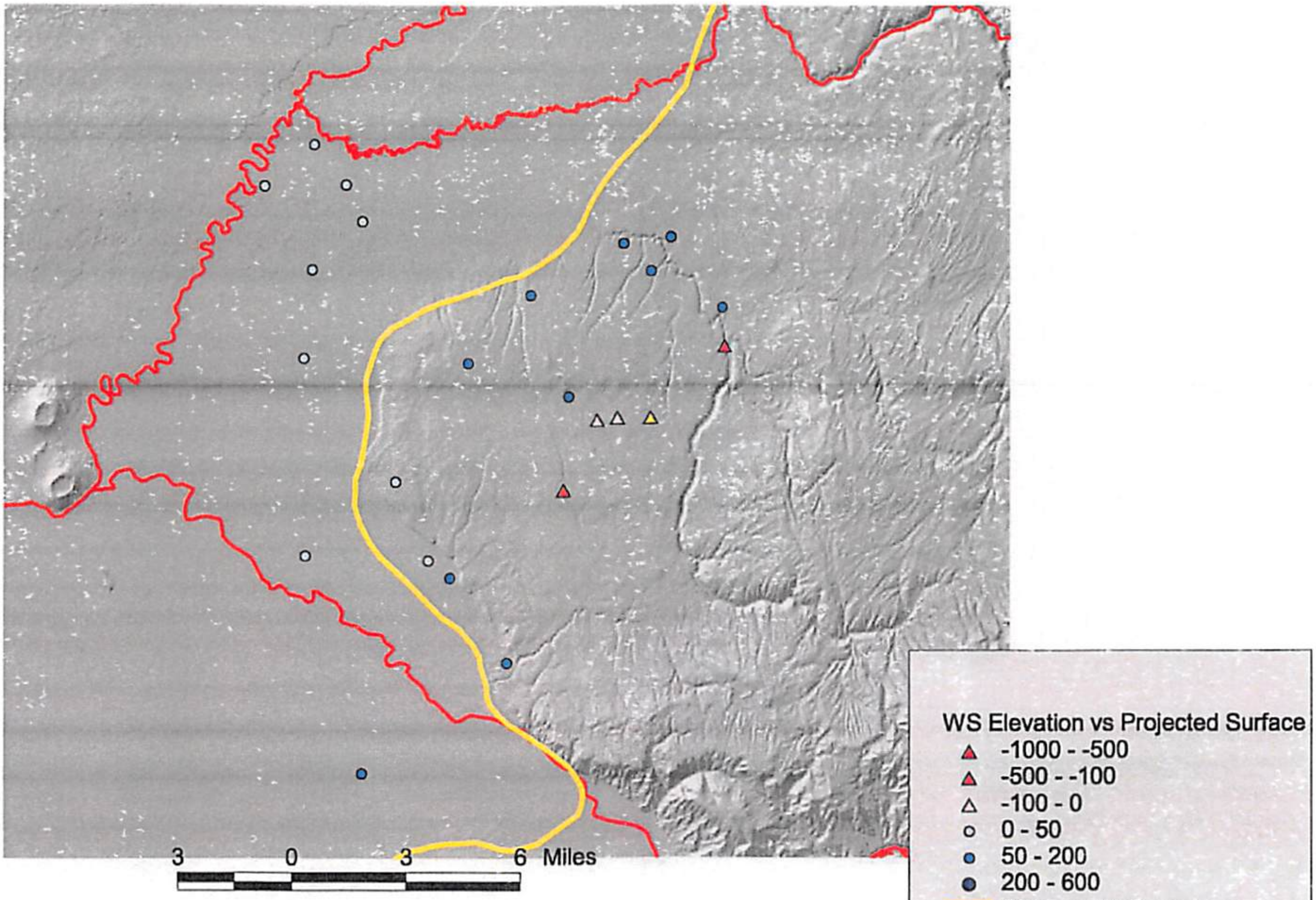


Figure R-1. Water Surface Elevation vs. Projected Surface Consistent with Plain - 2013 Data

Form 238-7
1/78

STATE OF IDAHO
DEPARTMENT OF WATER RESOURCES

WELL DRILLER'S REPORT

USE TYPEWRITER OR BALLPOINT PEN

State law requires that this report be filed with the Director, Department of Water Resources within 30 days after the completion or abandonment of the well.

RECEIVED JUL 7 1982
Department of Water Resources
Eastern District Office

1. WELL OWNER

Name Dale Jeppesen
Address North of Rexburg
Owner's Permit No. 22-7377

2. NATURE OF WORK

☒ New well ☐ Deepened ☐ Replacement
☐ Abandoned (describe method of abandoning)

3. PROPOSED USE

☐ Domestic ☒ Irrigation ☐ Test ☐ Municipal
☐ Industrial ☐ Stock ☐ Waste Disposal or Injection
☐ Other ______ (specify type)

4. METHOD DRILLED

☐ Rotary ☐ Air ☐ Hydraulic ☐ Reverse rotary
☒ Cable ☐ Dug ☐ Other

5. WELL CONSTRUCTION

Casing schedule: ☒ Steel ☐ Concrete ☐ Other

Thickness		Diameter		From		To	
.250	inches	20	inches	+ 2	feet	811	feet
.250	inches	16	inches	700	feet	865	feet
	inches		inches		feet		feet
	inches		inches		feet		feet

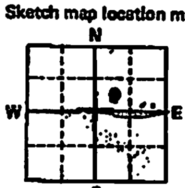
Was casing drive shoe used? ☒ Yes ☐ No
Was a packer or seal used? ☐ Yes ☒ No
Perforated? ☒ Yes ☐ No
How perforated? ☐ Factory ☒ Knife ☐ Torch
Size of perforation ______ inches by ______ inches

Number		From		To	
240	perforations	300	feet	850	feet
	perforations		feet		feet
	perforations		feet		feet

Well screen installed? ☐ Yes ☒ No
Manufacturer's name
Type ______ Model No.
Diameter ___ Slot size ___ Set from ___ feet to ___ feet
Diameter ___ Slot size ___ Set from ___ feet to ___ feet
Gravel packed? ☐ Yes ☒ No ☐ Size of gravel
Placed from ______ feet to ______ feet
Surface seal depth 300' Material used in seal: ☐ Cement grout ☐ Puddling clay ☒ Well cuttings
Sealing procedure used: ☐ Slurry pit ☒ Temp. surface casing ☒ Overbore to seal depth
Method of joining casing: ☐ Threaded ☒ Welded ☐ Solvent Weld ☐ Cemented between strata
Describe access port 2" pipe hook

6. LOCATION OF WELL

Sketch map location must agree with written location.



Subdivision Name
Lot No. ______ Block No. ______

County Madison County
SW ¼ NE ¼ Sec. 7, T. 5 N, R. 41 E

7. WATER LEVEL

Static water level 550 feet below land surface.
Flowing? ☐ Yes ☒ No G.P.M. flow
Artesian closed-in pressure ______ p.s.i.
Controlled by: ☐ Valve ☐ Cap ☐ Plug
Temperature 69 °F. Quality good

8. WELL TEST DATA

☒ Pump ☐ Bailer ☐ Air ☐ Other

Discharge G.P.M.	Pumping Level	Hours Pumped
800	700'	4 hrs.
2800	600'	4 hrs.

9. LITHOLOGIC LOG 079418

Hole Diam.	Depth From	Depth To	Material	Water Yes	Water No
24"	0	4	top soil		X
24"	4	85	black lava (blasting steady)		X
24"	85	102	clay + red + black lava		X
24"	102	120	brown rylite		X
24	120	140	red + brown rylite		X
24	140	155	hard gray rylite		X
24	155	170	black sticky clay (silty)		X
24	170	200	brown + black rylite		X
24	200	215	black + gray rylite		X
24	215	230	red black		X
24	230	255	black lava		X
24	255	260	brown clay		X
24	260	315	red + black lava 25 GPM	X	
20	315	360	brown clay		X
20	360	385	blue clay		X
20	385	475	grey + blue gumbo clay		X
20	475	518	shale + gravel 90 GPM.	X	
20	518	540	brown + grey sticky clay		X
20	540	720	blue + brown sticky clay		X
16	720	783	blue sticky clay		X
16	783	800	grey shale	X	
16	800	812	brown clay		X
16	812	835	black rylite		X
16	835	845	sand		X
16	845	890	black rylite (no cuttings)	X	
16	890	915	red cinder rock no cuttings	X	
16	915	1000	red + black rylite		X
16	1000	1020	red cinder rock no cuttings	X	
14	1020	1040	red clay		X
14	1040	1090	black hard rylite		
14	1090	1110	black cinders	X	
14	1110	1175	black rylite + grey rylite		X
14	1175	1200	black rylite (soft)	X	
14	1200	1215	brown rylite		X
14	1215	1300	black rylite	X	
14	1300	1340	cinders	X	

10.

Work started May 24, 1981 finished June 30, 1982

11. DRILLERS CERTIFICATION

I/We certify that all minimum well construction standards were complied with at the time the rig was removed.

Firm Name Rocky Mtn Well Drilling Firm No. 299
Address Box 756 Rexburg Date 6-30-82
Signed by (Firm Official) Marcus Franzen
and
(Operator) Marcus Franzen

USE ADDITIONAL SHEETS IF NECESSARY — FORWARD THE WHITE COPY TO THE DEPARTMENT

Form 238-7
6/93

IDAHO DEPARTMENT OF WATER RESOURCES
WELL DRILLER'S REPORT

Use Typewriter or Ball Point Pen

702333

1. DRILLING PERMIT NO. 22-93-E-132-000
Other IDWR No. ____

2. OWNER:
Name Shawn Webster
Address 4100 S 1100 E
City Rexburg State Id. Zip 83440

3. LOCATION OF WELL by legal description:
Sketch map location must agree with written location

T. 5 North [X] or South [ ]
R. 41 East [X] or West [ ]
Sec. 8 SE 1/4 NW 1/4 ____ 1/4
Gov't Lot ____ County ____

Address of Well Site 2000 S 5200 W
(Give at least Direction + Distance to Road or Landmark)

Lot No ____ Block No. ____ Subd Name ____

4. PROPOSED USE:
[X] Domestic [ ] Municipal [ ] Monitor [ ] Irrigation
[ ] Thermal [ ] Injection [ ] Other ____

5. TYPE OF WORK
[X] New Well [ ] Modify or Repair [ ] Replacement [ ] Abandonment

6. DRILL METHOD
[ ] Mud Rotary [X] Air Rotary [ ] Cable [ ] Other ____

7. SEALING PROCEDURES

SEAL/FILTER PACK Material	From	To	AMOUNT Sacks or Pounds	METHOD
bentonite	0	40	200	over bore

Was drive shoe seal tested? Y [ ] N [X] How? ____

8. CASING/LINER:

Diameter	From	To	Guage	Casing	Liner	Steel	Plastic	Welded	Threaded
10	-5	20	250			[X]	[ ]	[ ]	[ ]
6	2	238	250			[X]	[ ]	[ ]	[ ]
						[ ]	[ ]	[ ]	[ ]
						[ ]	[ ]	[ ]	[ ]

Final location of shoes 238'
Top Packer or Headpipe ____ Bottom Tailpipe ____

9. PERFORATIONS/SCREENS
[X] Perforations Method ____
[ ] Screens Type ____ Material ____

From	To	Slot Size	Number	Diameter	Tele/Pipe Size	Casing	Liner
200	238	3/16x3	40	6		[ ]	[X]
						[ ]	[ ]
						[ ]	[ ]
						[ ]	[ ]

10. WELL TESTS:
[ ] Pump [ ] Bailer [X] Air [ ] Flowing Artesian

Yield gal/min.	Drawdown	Pumping Depth	Time
30	3	175	1 hr.

Temperature of water 50 Was a water analysis done? Yes [ ] No [X]
By whom? ____
Water Quality (odor, etc.) ____
Bottom Hole Temperature ____

11. STATIC WATER LEVEL:
175 ft. below surface Depth artesian flow found ____
Artesian pressure ____ lb Describe access port well cap
Describe Controlling Devices: ____

12. LITHOLOGIC LOG: (Describe repairs or abandonment)

Bore Dia.	From	To	Remarks: Lithology, Water Quality & Temperature	GPM	SWL
10	0	11	clay		
10	11	40	black lava		
10	40	56	brown rylite		
10	56	60	broken rock		
10	60	180	brown rylite		
10	180	230	brown broken rylite		
10	230	235	brown clay		
10	235	245	brown rylite		
10	245	265	brown clay	30	175

RECEIVED
OCT 07 1993
Department of Water Resources

RECEIVED
SEP 30 1993
Department of Water Resources
Eastern District Office

OCT 26 1993

Date: Started 9-2-93 Completed 9-13-93

13. DRILLER'S CERTIFICATION
I/We certify that all minimum well construction standards were complied with at the time the rig was removed

Firm Name High Plains Firm No. 299
Firm Official Marcus Franken Date 9-28-93
and
Supervisor or Operator ____ Date ____
(Sign once if Firm Official & Operator)

FORWARD WHITE COPY TO WATER RESOURCES

Form 238-7 6/02

IDAHO DEPARTMENT OF WATER RESOURCES
WELL DRILLER'S REPORT

22

Office Use Only
Well ID No. ______
Inspected by ______
Twp ___ Rge ___ Sec ___
___ 1/4 ___ 1/4 ___ 1/4
Lat: : : Long: : :

1. WELL TAG NO. D D0032441
DRILLING PERMIT NO. ______
Water Right or Injection Well No. 22-7515

2. OWNER:
Name Sunimerco Inc
Address 27 North 3000E
City Sugar City State Id Zip 83448

3. LOCATION OF WELL by legal description:
You must provide address or Lot, Blk, Sub. or Directions to well.
Twp. 6 North ☑ or South ☐
Rge. 40 East ☑ or West ☐
Sec. 26, ___ 1/4 NW 1/4 NE 1/4
Gov't Lot ______ County Madison
Lat: : : Long: : :
Address of Well Site ______ City Sugar City
(Give at least name of road + Distance to Road or Landmark)
Lt. ______ Blk. ______ Sub. Name ______

4. USE:
☐ Domestic ☐ Municipal ☐ Monitor ☑ Irrigation
☐ Thermal ☐ Injection ☐ Other ______

5. TYPE OF WORK check all that apply (Replacement etc.)
☐ New Well ☐ Modify ☐ Abandonment ☐ Other Rep

6. DRILL METHOD:
☑ Air Rotary ☑ Cable ☐ Mud Rotary ☐ Other ______

7. SEALING PROCEDURES

Seal Material	From	To	Weight / Volume	Seal Placement Method

Was drive shoe used? ☑ Y ☐ N Shoe Depth(s) ______
Was drive shoe seal tested? ☐ Y ☐ N How? ______

8. CASING/LINER:

Diameter	From	To	Gauge	Material	Casing	Liner	Welded	Threaded
16"	505	696	.250	Steel	☐	☑	☑	☐
18"	+1	520	.250	Steel	☑	☐	☑	☐
14"	701	985	.250	Steel	☐	☑	☑	☐

Length of Headpipe ______ Length of Tailpipe ______
Packer ☐ Y ☐ N Type ______

9. PERFORATIONS/SCREENS PACKER TYPE
Perforation Method Roller Perforator
Screen Type & Method of Installation ______

	From	To	Slot Size	Number	Diameter	Material	Casing	Liner
16"	606	643	1"	3600	1/4	Steel	☐	☑
14"	750	770	1"	1200	1/4	Steel	☐	☑
14	825	860	1"	2700	1/4	Steel	☐	☑

10. FILTER PACK

Filter Material	From	To	Weight / Volume	Placement Method

11. STATIC WATER LEVEL OR ARTESIAN PRESSURE:
324 ft. below ground Artesian pressure ______ lb.
Depth flow encountered ______ ft. Describe access port or control devices: ______
New water level

12. WELL TESTS:
☐ Pump ☐ Bailer ☐ Air ☐ Flowing Artesian

Yield gal./min.	Drawdown	Pumping Level	Time

Water Temp. ______ Bottom hole temp. ______
Water Quality test or comments: ______
Depth first Water Encounter ______

13. LITHOLOGIC LOG: (Describe repairs or abandonment)

Bore Dia.	From	To	Remarks: Lithology, Water Quality & Temperature	Water Y	Water N
18"	660	696	Sandstone & Clay		
16"	696	708	Rhiolite Brown		
16"	708	735	Black Lava		
16"	735	737	Brown Clay		
16"	737	765	Hard Black Basalt		
16"	765	780	Decomposed Basalt		
16"	780	795	Black Lava		
	795	830	Red Clay Hard Sticky		✓
	830	865	Black Lava	✓	
	865	880	Red Clay Sticky		✓
	880	920	Black Rhiolite	✓	
	920	935	Red Clay Sticky		✓
	935	975	Black Rhyolite	✓	
14"	985	1097	Black Lava	✓	
12	1097	1120	Gray Rhiolite	✓	
12	1120	1127	Broken Rhiolite	✓	
12	1127	1195	Redish Rhiolite		✓
12	1195	1215	Broken Rhiolite	✓	
14"			Perf 879' to 922' (2400) Steel		
14"			Perf 939' to 975' (2160) Steel		

RECEIVED
JAN 05 2005
Department of Water Resources
Eastern Region

Completed Depth 1215 (Measurable)
Date: Started 3/23/04 Completed 12/29/04

14. DRILLER'S CERTIFICATION
I/We certify that all minimum well construction standards were complied with at the time the rig was removed.

Company Name Vollmer Well Drill Firm No. 383
Principal Driller [signature] Date 12/30/04
and
Driller or Operator II [signature] Date 12/30/04
Operator I [signature] Date 12/30/04
Principal Driller and Rig Operator *Required*.
Operator I must have signature of Driller/Operator II.

FORWARD WHITE COPY TO WATER RESOURCES

RECEIVED
APR 1 1960
Department of Reclamation

Log No.

Rec. ________, 19____

Well No.

Permit No. G-28492

(DO NOT FILL IN)

G28492 LOG AND REPORT TO THE STATE RECLAMATION ENGINEER OF IDAHO

~~Permit No.~~:

Owner Hoy and Bert Summers Address Rexburg, Idaho.

Driller Lee Harris Address Rexburg, Idaho Lic. No. 139

Location of Well: NE ¼ NE ¼ Sec. 26, T. 6 N/S, R. 40 E/W Madison County,
S.E.¼ of 2E. and S.W.¼ of 23 6N 40E. SE of S.W.¼ Sec. 23
and ____ feet N/S, and ____ feet E/W from ____ Corner of ____ ¼ ____ ¼ Sec.

Size of Drilled Hole 19 inch Total depth of Well 330 ft.

Give depth of standing water from surface 270 ft. Water Temp. 54 °Farenheit

On pumping test delivery was 1680 g.p.m. or ____ c.f.s. Drawdown was 0 feet.

Size of pump and motor used to make the test 8inch column 200 horse motor

Length of time pumped during check was 4 hr., ____ minutes.

If flowing well, give flow in c.f.s. ____ or g.p.m. ____ and shut in pressure ____

If flowing well, describe control works ____
(TYPE AND SIZE OF VALVE, ETC.)

Water will be used for irrigation Weight of casing per linear foot ____

Thickness of casing no casing in hole Casing material ____
E.G., PIPE, CONCRETE, WOOD.

Diameter, length and location of casing ____
(CASING 12" IN DIAMETER AND UNDER GIVE INSIDE DIAMETER; CASING OVER 12" IN DIAMETER GIVE OUTSIDE DIAMETER.)

Number and size of perforations ____ located ____ feet to ____ feet from surface of ground.

Other perforations ____

Date of commencement of well ____ Date of completion of well Feb. 5 1960.

Type of well rig 28L Bucyrus-Erie Spudder

CASING RECORD

DIAM. CASING	FROM FEET	TO FEET	LENGTH	"REMARKS" -- SEALS, GROUTING, ETC.

GENERAL INFORMATION—Pumping Test, Quality of Water, Etc.

6N-40E —— 26 NWNE (4676)

22

025193

WELL LOG

From Feet	To Feet	Type of Material	Drilling Time Hrs.	Drilling Time Min.	Water-bearing Formation Ans. Yes or No	Casing Perforated Ans. Yes or No
0	8	Topsoil				
8	70	Greysandstone med. hard				
70	80	Brown sand, hard				
80	86	Brown clay				
86	95	Brown and red sandy cinders				
95	130	Cinders and lava, crevices- cemented with 5 Yds. cement				
130	155	Grey lava				
155	175	Black and grey cinders				
175	190	Grey lava, crevices cemented with 3½ yds. cement				
190	200	Black lava, hard				
200	220	Brown cinders				
220	285	Brown, Grey and Red lava, very hard				
285	286	Soft spot, first water. Filled to 278'				
286	305	Black lava, sandy, very hard				
305	307	Soft break, water up to 270 ft.				
307	315	Black lava, very hard				
315	317	Hard shell				
317	330	Black cinders, soft				
		If more space is required use Sheet No. 2				

WELL DRILLER'S STATEMENT

This well was drilled under my jurisdiction and the above information is true and correct to the best of my knowledge and belief.

Signed Lee Harris

By

License No. 139

Dated 8 Feb. 1960

Estimates of

Tributary Basin Underflow

for the Eastern Snake Plain Aquifer Model

Version 2 – As Built

Prepared by Idaho Water Resources Research Institute

In fulfillment of the Water-Budget Component – Tributary Underflow

of Contract # CON00803

for

The Idaho Department of Water Resources

IDAHO WATER RESOURCES RESEARCH INSTITUTE

University of Idaho

Idaho Water Resources Research Institute

Stacey L. Taylor

November 2010

Idaho Water Resources Research Institute Technical Report 201010

ESPAM2 Design Document DDW-V2-13

Estimates of Tributary Basin Underflow for the Eastern Snake Plain Aquifer Model Version 2 – As Built

DESIGN DOCUMENT OVERVIEW

During calibration of the Eastern Snake Plain Aquifer Model Version 1.1 (ESPAM 1.1), a series of Design Documents were produced to document data sources, conceptual model decisions and calculation methods. These documents served two important purposes; they provided a vehicle to communicate decisions and solicit input from members of the Eastern Snake Hydrologic Modeling Committee (ESHMC) and other interested parties, and they provided far greater detail of particular aspects of the modeling process than would have been possible in a single final report. Many of the Design Documents were presented first in a draft form, then in revised form following input and discussion, and finally in an "as-built" form describing the actual implementation.

This report is a Design Document for the calibration of the Eastern Snake Plain Aquifer Model Version 2 (ESPAM2). Its goals are similar to the goals of Design Documents for ESPAM 1.1: To provide full transparency of modeling data, decisions and calibration; and to seek input from representatives of various stakeholders so that the resulting product can be the best possible technical representation of the physical system (given constraints of time, funding and personnel). It is anticipated that for some topics, a single Design Document will serve these purposes prior to issuance of a final report. For other topics, a draft document will be followed by one or more revisions and a final "as-built" Design Document. Superseded Design Documents will be maintained in a "superseded" file folder on the project Website, and successive versions will be maintained in a "current" folder. This will provide additional documentation of project history and the development of ideas.

INTRODUCTION

Tributary underflow is the discharge of subsurface water from a tributary basin into an area of interest, such as an aquifer. Tributary underflow to the Eastern Snake River Plain Aquifer is recognized in 22 surrounding basins. Because tributary underflow is flow beneath the surface, it is difficult to estimate yet it is an important component of recharge in the water budget for the Eastern Snake Plain Aquifer Model. The purpose of this design document is to briefly review how the values of tributary underflow were estimated in ESPAM1.1 and to explain how estimates were made for ESPAM2.

REVIEW OF ESPAM1.1

Estimates of underflow were based on Kjelstrom's (1986) estimates of underflow published in the Regional Aquifer-System Analysis (RASA) study performed by the USGS (Garabedian, 1992). Basin-yield equations were used to calculate average annual underflow rates from the tributary basins. The characteristics of the basins incorporated include drainage area, mean annual precipitation, and percentage of forest cover. As part of the water budget balancing process, all tributary underflow estimates were scaled by a factor of 0.97 (a net 3% reduction) in ESPAM 1.1. Tributary underflow varies seasonally and from year to year, so the average annual underflow values were scaled (dampened) using normalized values based on measured discharges at Silver Creek. Silver Creek was chosen as a proxy because it is almost entirely spring-fed and reflects temporal spring discharge from a basin similar to many of the Snake Plain tributary basins. At the July 2009 ESHMC meeting, Mike McVay reviewed the ESPAM 1.1 process of estimating tributary underflow. Figure 1 below shows how Silver Creek flux was dampened over time. Although this was chosen as the best method of estimating tributary underflow, this aspect of ESPAM 1.1 has a degree of limitation and uncertainty. One of three components of the aquifer budget for ESPAM 1.1 mentioned in the final report that has the greatest uncertainty is tributary underflow.

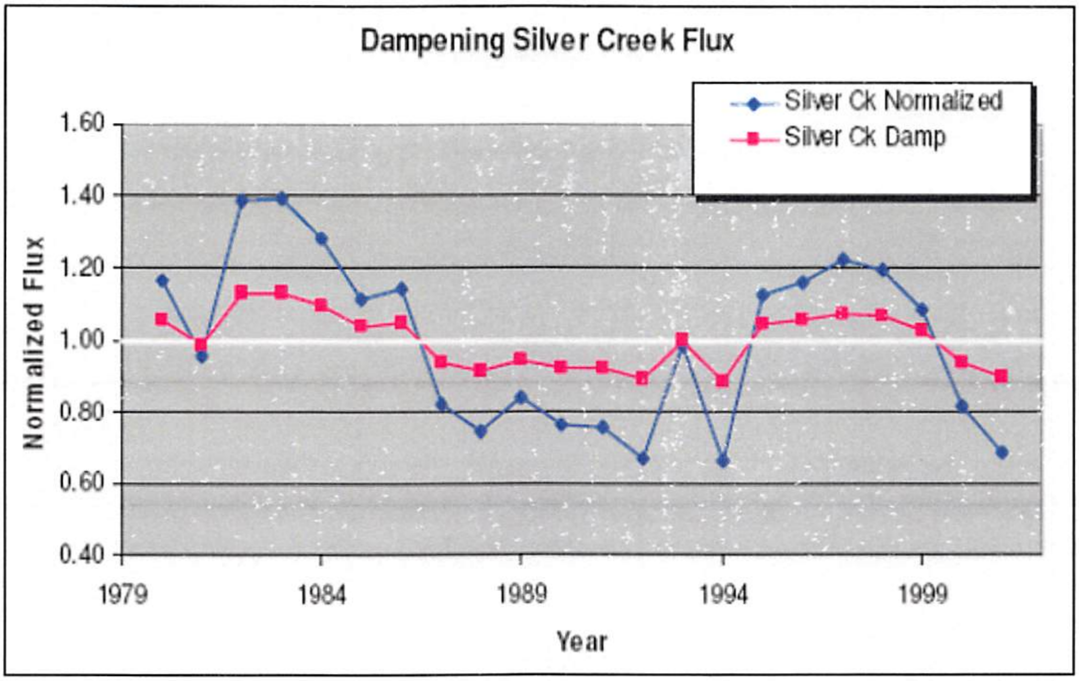


Figure 1. Silver Creek flux was normalized and dampened over time.

Adapted from Slide 6 of McVay (2009)

Figure 2 (adapted from Figure 22 of Cosgrove et al., 2006) shows the tributary basins that were recognized in ESPAM1.1. The highlighted squares (mostly red and some green) represent the individual model cells that were used to enter the specified flux for each tributary basin. The estimated flux for each tributary was evenly distributed across the model cells to that tributary in each stress period.

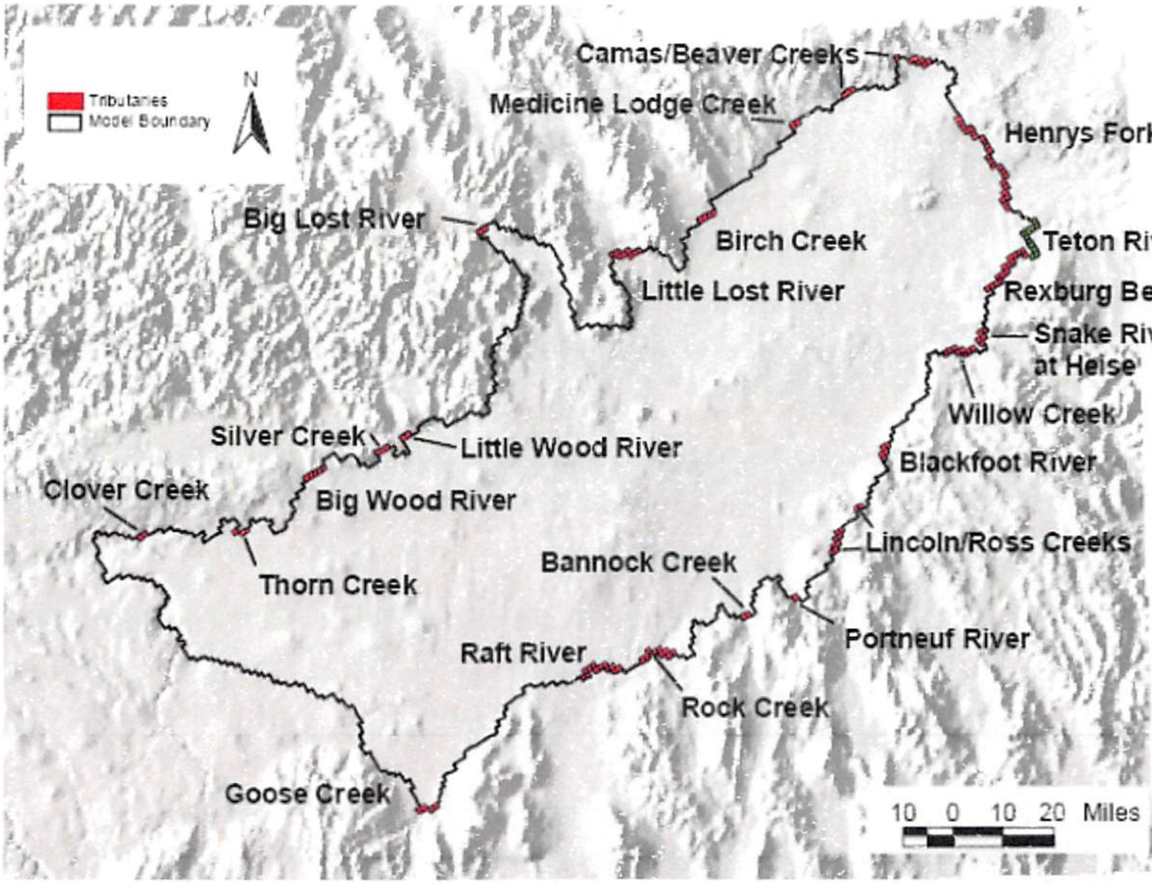


Figure 2. Tributary basins in ESPAM1.1

(adapted from Figure 22 of the final ESPAM1.1 report).

OVERVIEW OF ESPAM2

Time was not allotted to improve tributary underflow estimates for ESPAM2. Discharge measurements at Silver Creek were collected for 2002 through 2008 and tributary underflow estimates were calculated in the same fashion as they were in ESPAM1.1. The six-month stress period values of underflow used in ESPAM1.1 were adjusted to the one-month stress periods of ESPAM2. Monthly values were specifically calculated by dividing the value from ESPAM1.1 by the number of days in six months (182.625) and then multiplying by the number of days in the corresponding month (i.e. 31 days for January and 30 days for April).

Some changes were made to the tributary underflow shapefile since the model boundary has changed slightly since ESPAM1.1. The most notable change to the model boundary affecting the tributary underflow geometry is on the southeastern side of the Snake Plain as shown in Figure 3. In Figure 3, the blue cells represent active cells in ESPAM2 while the white cells were active cells that were included in ESPAM1.1 and no longer included as active cells in ESPAM2. Tributary underflow in ESPAM1.1 applied to all cells spanned by the black lines and the lines shown in blue are the changes that were made for ESPAM2.

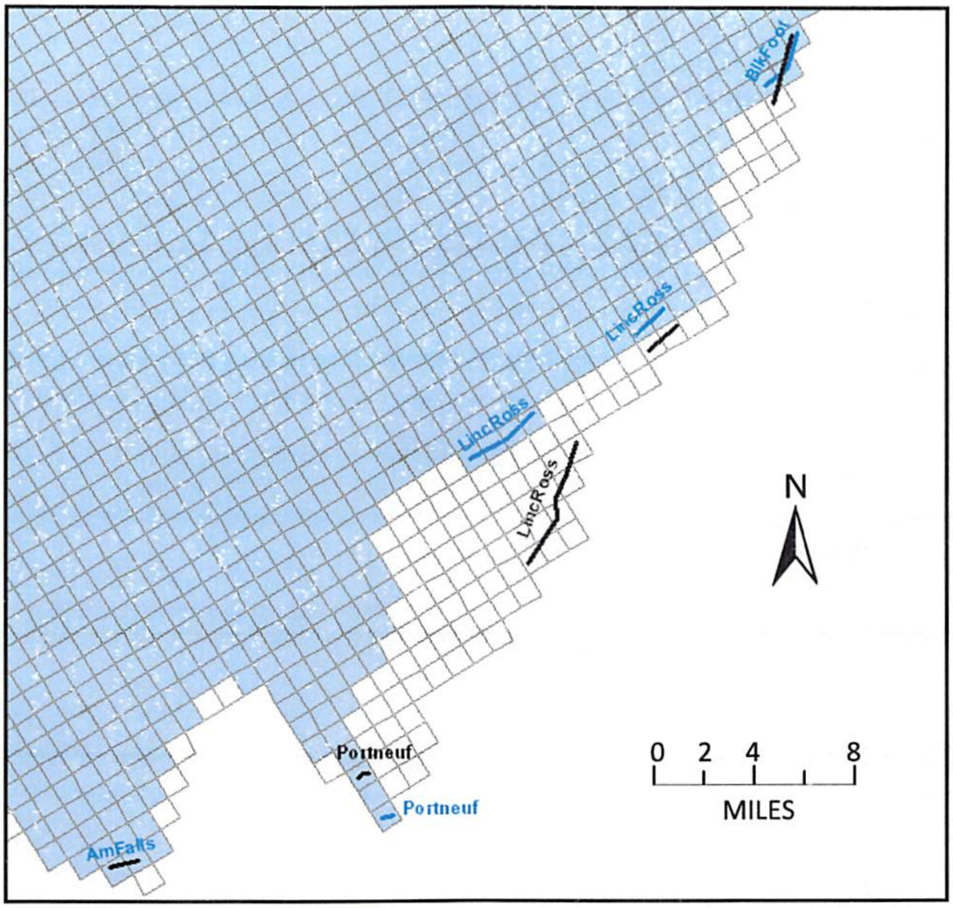


Figure 3. Southeastern edge of the ESPAM2 model boundary. Changes to the model boundary resulted in changes in the cells assigned flux from tributary underflow.

Figure 4 shows the active cells of the model in ESPAM2. The cells highlighted in red were assigned values of flux for underflow for the corresponding basin.

CHANGES IN THE PORTNEUF RIVER VALLEY

In the Portneuf River Valley, the model boundary was changed. This adjustment is shown in Figure 3. This is the only basin where changes were made to reflect different estimates of underflow for ESPAM2. In 2006, John Welhan released an updated study of the lower Portneuf River Valley. According to Welhan's report on the Portneuf basin, a value of 5.4 ± 0.1 billion gal/yr represents underflow from the Mink Creek, Gibson Jack Creek, and City-Cusick Creek watersheds through the Portneuf Gap. It is assumed that recharge from the eastern side of the basin is negligible. A value of 5.4×10^9 gal/yr was used as the underflow value for the Portneuf Basin for ESPAM2.

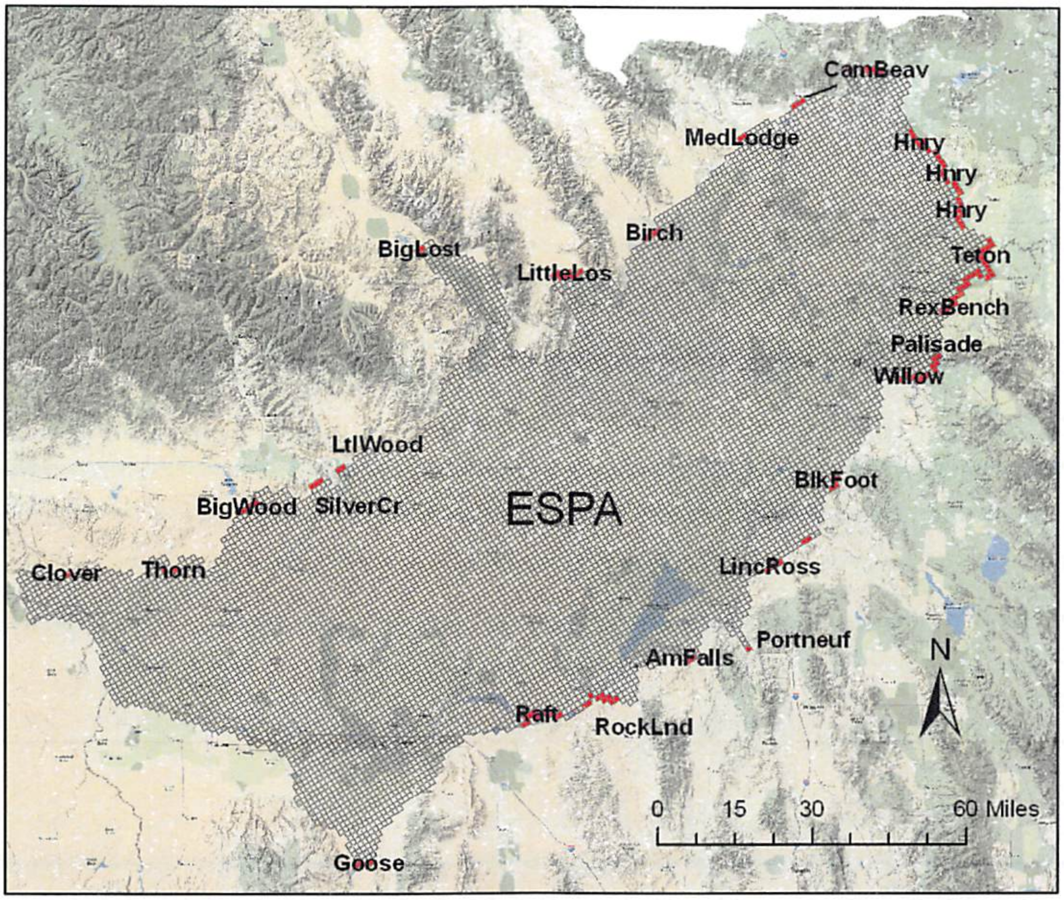


Figure 4. ESPAM2 cells assigned flux from tributary underflow.

CHECKING FOR ACCURACY

In July 2009, Mike McVay of the Idaho Department of Water Resources (IDWR) presented his work on tributary underflow estimates in the lower Portneuf River Valley. McVay discussed the use of Silver Creek gage measurements as a proxy to allow computation of underflow in basins where data are not available. He also showed that Silver Creek flow data reflects precipitation patterns in the Portneuf basin and concluded that, for the time being, Silver Creek may be a usable proxy for the temporal scaling of the Garabedian (1992) underflow estimates. Figure 5 below shows the result of dampening Silver Creek and the Portneuf River precipitation values.

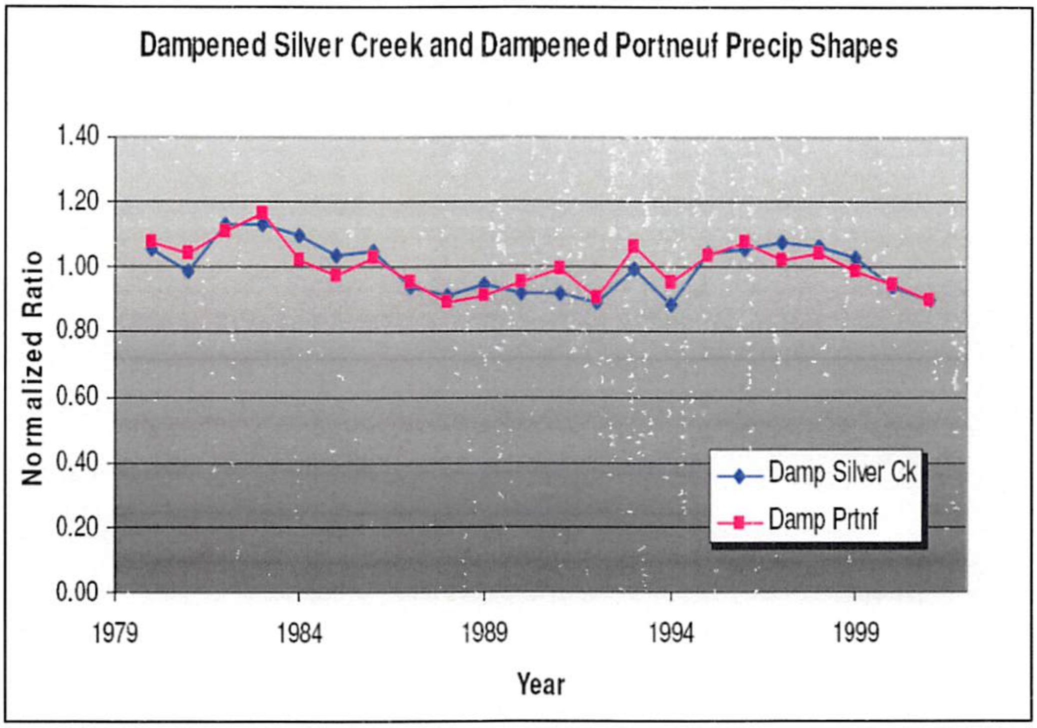


Figure 5. Comparing dampened precipitation values in the Silver Creek and Portneuf River basins.

(Adapted from Slide 11 of McVay (2009)).

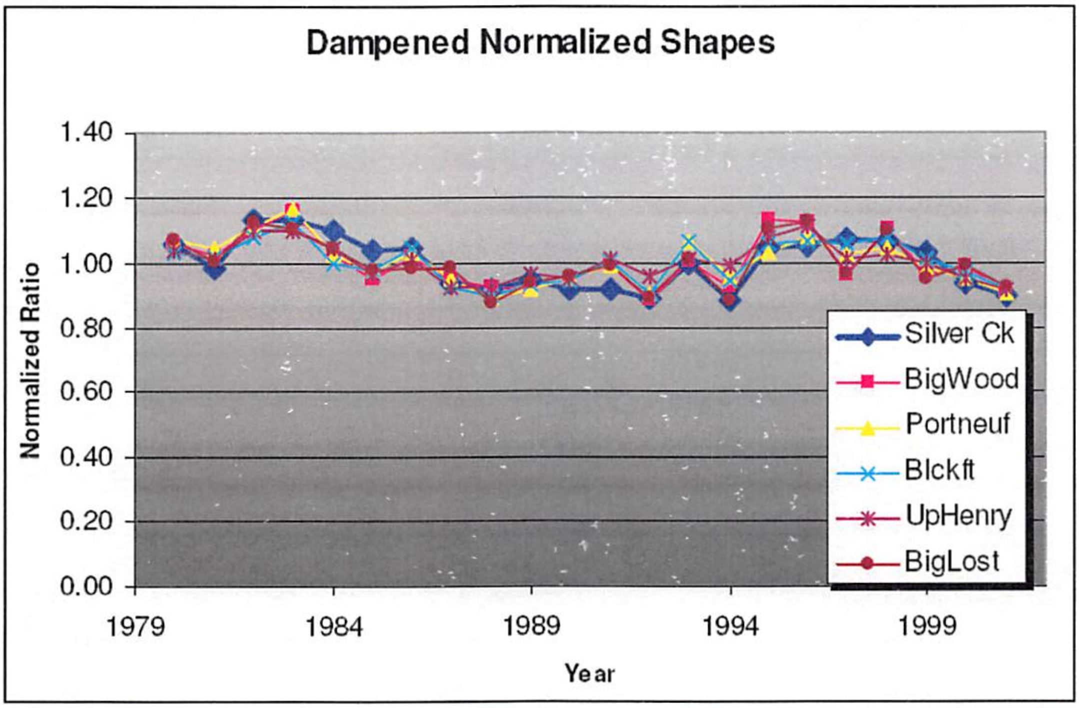


Figure 6. Comparing dampened precipitation values for several basins in the ESPA.

(Adapted from Slide 13 of McVay (2009)).

McVay also reviewed a Darcy approach to calculate tributary underflow. It is an appealing approach because of the simplicity of using the Darcy equation ($Q = -KA(dh/dl)$), but there are some drawbacks due to limited data and uncertainty in parameters. McVay also reviewed a mass balance approach for estimating tributary underflow, but concluded this seemingly simple procedure was truly complicated. The data needed to include basin boundaries, volume of applied surface water, total groundwater pumped, stream flow estimates, precipitation and evapotranspiration data, and basin data from other states. While some of these inputs are available, others are not making it difficult to estimate underflow with the mass balance approach. Both of these methods were applied in the Welhan (2006) study of the Portneuf basin. McVay performed calculations using Silver Creek for refining tributary underflow in the Portneuf basin and compared the estimates to the values in Welhan's report. McVay concluded the use of Silver Creek as a proxy was suitable for now when estimating tributary underflow and Welhan's estimates of underflow in the Portneuf basin would be appropriate for calculating tributary underflow for ESPAM2.

SUMMARY AND DESIGN DECISION

The ESPAM1.1 tributary underflow data were based on Kjelstrom's (1986) estimates of underflow found in the Regional Aquifer-System Analysis (RASA) study by the USGS (Garabedian, 1992). During the water budget balancing process, all tributary underflow estimates were scaled by a factor of 0.97 (a net 3% reduction) in ESPAM 1.1. Tributary underflow varies seasonally and from year to year, so the average annual underflow values were scaled using normalized values. Silver Creek was chosen as a proxy because it is mostly spring-fed and shows temporal spring discharge from a basin similar to several of the Snake Plain tributary basins. Although this was chosen as the best method of estimating tributary underflow, ESPAM 1.1 has a degree of limitation and uncertainty.

The ESPAM1.1 values were applied to ESPAM2 and new data was collected for performing the same calculations for underflow estimates for 2002 through 2008. Values of underflow for most basins were adjusted from the six-month stress periods to the one-month stress periods. Due to changes in the model boundary near the Portneuf River Valley and the Welhan (2006) study on the Portneuf River basin, more appropriate estimates of tributary underflow were applied. A preliminary investigation performed by Mike McVay of the IDWR indicated that Silver Creek may be an acceptable proxy for shaping underflow while using estimates of Welhan's study for underflow in the Portneuf basin.

Figure 7 displays the final estimates of tributary underflow for each stress period for ESPAM2. The names of the basins are provided on the right-hand side. Several of the names are abbreviated and these are the names provided in the actual file for the water budget. Refer to the appendix for the full name of these basins if any are unclear.

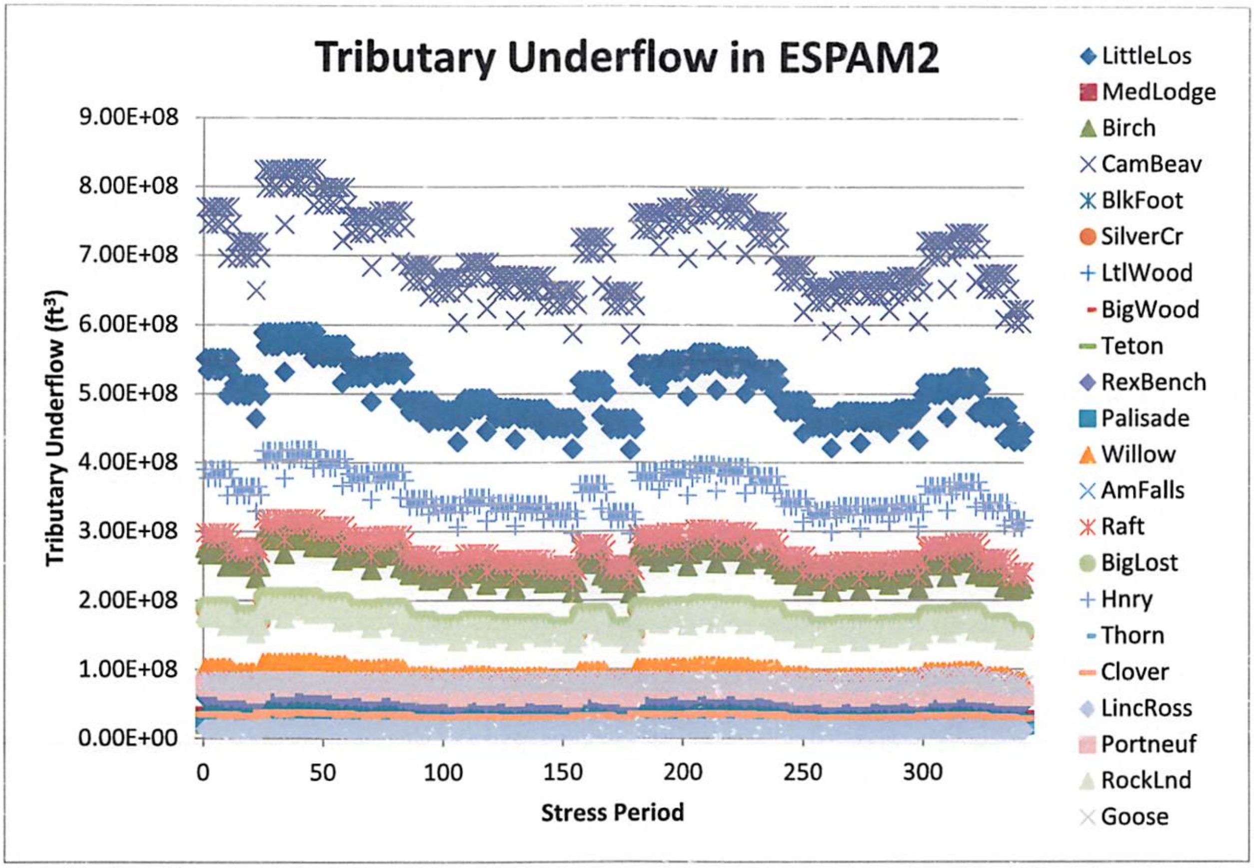


Figure 7. Estimates of tributary underflow per stress period for ESPAM2.

RECOMMENDATIONS

In Mike McVay's presentation to the ESHMC (2009), he also provided a list of recommendations to the committee to use in the future:

1. Perform a literature search.
2. Collect data for the individual tributary basins.
3. Rank the tributary basins based on data availability and model importance.
4. Perform Darcy calculations and/or mass balance calculations with available information.
5. Create a range or estimate error bars associated with tributary underflow values.

REFERENCES

Cosgrove, D.M., B.A. Contor, and G.S. Johnson. 2006. Enhanced Snake Plain Aquifer Model Final Report: Idaho Water Resources Research Institute Technical Report 06-002, Eastern Snake Plain Aquifer Model Enhancement Project Scenario Document Number DDM-019, 232 p.

Garabedian, S.P. 1992. Hydrology and Digital Simulation of the Regional Aquifer System, Eastern Snake River Plain, Idaho: U.S. Geol. Survey Professional Paper 1408-F.

Kjelstrom, L.C. 1986. Flow characteristics of the Snake River and Water Budget for the Snake River Plain, Idaho and eastern Oregon: U.S. Geol. Survey Hydrologic Investigations Atlas HA-680, scale 1:1,000,000, 2 sheets.

McVay, Mike. 2009. ESPA Tributary Basin Underflow Estimation – Preliminary Investigation Update. 8 July 2009. Presentation to the Eastern Snake Hydrologic Modeling Committee. <http://www.idwr.idaho.gov/Browse/WaterInfo/ESPAM/meetings/2009_ESHMC/7-8&9-2009/McVayl%20Tributary%20Groundwater%20Basins.pdf> Accessed 22 Oct 2010.

Welhan, J. 2006. Water Balance and Pumping Capacity of the Lower Portneuf River Valley Aquifer, Bannock County, Idaho; Idaho Geological Survey Staff Report 06-5.

APPENDIX

The following table provides the full names of the tributary basins abbreviated in several of the figures of this design document.

Abbreviated Name	Tributary Basin Name
LittleLos	Little Lost River
MedLodge	Medicine Lodge Creek
Birch	Birch Creek
CamBeav	Camas and Beaver Creek
BlkFoot	Blackfoot River
SilverCr	Silver Creek
LtlWood	Little Wood River
BigWood	Big Wood River
Teton	Teton River
RexBench	Rexburg Bench
Palisade	Palisade (Snake River)
Willow	Willow Creek
AmFalls	American Falls (Bannock Creek)
Raft	Raft River
BigLost	Big Lost River
Hnry	Henrys Fork
Thorn	Thorn Creek
Clover	Clover Creek
LincRoss	Lincoln Creek and Ross Creek
Portneuf	Portneuf River
RockLnd	Rock Creek
Goose	Goose Creek

Model Boundary

Idaho Water Resources

Research Institute

University of Idaho

Allan Wylie
November 15, 2004

Idaho Water Resources Research Institute
Technical Report 04-016

Eastern Snake Plain Aquifer Model Enhancement Project
Scenario Document Number DDM-002

EXHIBIT
tabbies
205

Eastern Snake Plain Aquifer Model Enhancement
Model Design and Calibration Document Number DDM-002

DESIGN DOCUMENTS

Design documents are a series of technical papers addressing specific design topics on the eastern Snake River Plain Aquifer Model upgrade. Each design document will contain the following information: topic of the design document, how that topic fits into the whole project, which design alternatives were considered and which design alternative is proposed. In draft form, design documents are used to present proposed designs to reviewers. Reviewers are encouraged to submit suggested alternatives and comments to the design document. Reviewers include all members of the Eastern Snake Hydrologic Modeling (ESHM) Committee as well as selected experts outside of the committee. The design document author will consider all suggestions from reviewers, update the draft design document, and submit the design document to the SRPAM Model Upgrade Program Manager. The Program Manager will make a final decision regarding the technical design of the described component. The author will modify the design document and publish the document in its final form in .pdf format on the SRPAM Model Upgrade web site.

The goal of a draft design document is to allow all of the technical groups which are interested in the design of the SRPAM Model Upgrade to voice opinions on the upgrade design. The final design document serves the purpose of documenting the final design decision. Once the final design document has been published for a specific topic, that topic will no longer be open for reviewer comment. Many of the topics addressed in design documents are subjective in nature. It is acknowledged that some design decisions will be controversial. The goal of the Program Manager and the modeling team is to deliver a well-documented, defensible model which is as technically representative of the physical system as possible, given the practical constraints of time, funding and manpower. Through the mechanism of design documents, complicated design decisions will be finalized and documented.

Final model documentation will include all of the design documents, edited to ensure that the "as-built" condition is appropriately represented.

INTRODUCTION

Some of the first decisions faced when beginning work on a model center around determining extent of the modeled area. This is the topic addressed in this Design Document.

Problem Statement

This section outlines the options considered in the process of establishing model boundaries.

The purpose of this model is to assist in managing the surface water and ground water resources within the Eastern Snake Plain Aquifer and the Snake River. Therefore the model boundaries should encompass the boundaries of the Eastern Snake Plain aquifer. Decisions regarding where to place the model boundary must be made where the Eastern Snake Plain aquifer interfaces with tributary aquifers. These decisions should be based on the model purpose and data availability.

Extending model boundaries to bedrock outcrops in tributary basins allows incorporation of seasonal and long-term changes into the model simulation rather than estimating them external to the model. Extending the boundaries to Include land with similar irrigation practices is desirable, if the resulting boundary does not cross a hydrologic barrier. However, there is little value in including a tributary aquifer if there are no data available for that aquifer. If aquifer geometry or aquifer head data do not exist, modeled fluxes and responses to stress in the tributary basin will likely be in error.

Considered Options

This section outlines the options considered when selecting the model boundary. Figure 1 shows the location of the Eastern Snake Plain. Figure 2 contains the model boundary for the previous version of the DWR/UI model (Cosgrove et al, 1999) along with the model boundary used in the Regional Aquifer-System Analysis (RASA) study (Garabedian, 1992). While great similarity exists between these boundary selections, they highlight the decisions that need to be made in this modeling effort. For example, the IDWR/UI model ignores the Twin Falls tract while it is included in the RASA model. The RASA model extends to King Hill while the IDWR/UI model terminates shortly west of Salmon Falls. Another difference is that the IDWR/UI model tends to extend up the tributary basins farther than the RASA model. Figure 2 also contains irrigated acres in 1992 and proposed options for the new model.

Figure 1. Location of the Eastern Snake River Plain

Ideally model boundaries are based on physical barriers to ground water flow. A model built in this manner will have all flux into the model as irrigation, surface water or as precipitation. Since surface water is much easier to measure than ground water, this limits potential water balance errors due to calculating flux from tributary aquifers. Sometimes it is not practical to extend the model to physical boundaries in every direction and artificial boundaries are imposed. In these instances the artificial boundaries must be located to minimize their impact on prediction uncertainties.

Effect

This section discusses the effect the various boundary options will have on the model. Boundary choices can affect model uncertainty, model run times and numerical stability.

The model boundary should include the portions of the aquifer germane to the issues driving model creation. These issues principally involve interactions between the Snake River and the Snake Plain Aquifer. The model is not sensitive to water use in the Twin Falls tract because the Snake River canyon effectively disconnects the area south of the river from the regional aquifer on the north. The model is sensitive to water use in this area only insofar as use offsets reach gains between Milner and King Hill. These gains can be estimated as part of the water budget. Therefore the Twin Falls tract does not need to be explicitly modeled.

Garabedian (1992) determined that tributary basin underflow represents about 20% of the water balance so the model will be sensitive to this flux. Water use in the tributary basins will directly affect water supply in the Eastern Snake Plain Aquifer, thus, questions arise concerning how far up the tributary basins to extend the boundary. Figure 2 shows irrigated acres along with the RASA, IDWR/UI and proposed new model boundaries. The gray areas represent irrigated agriculture.

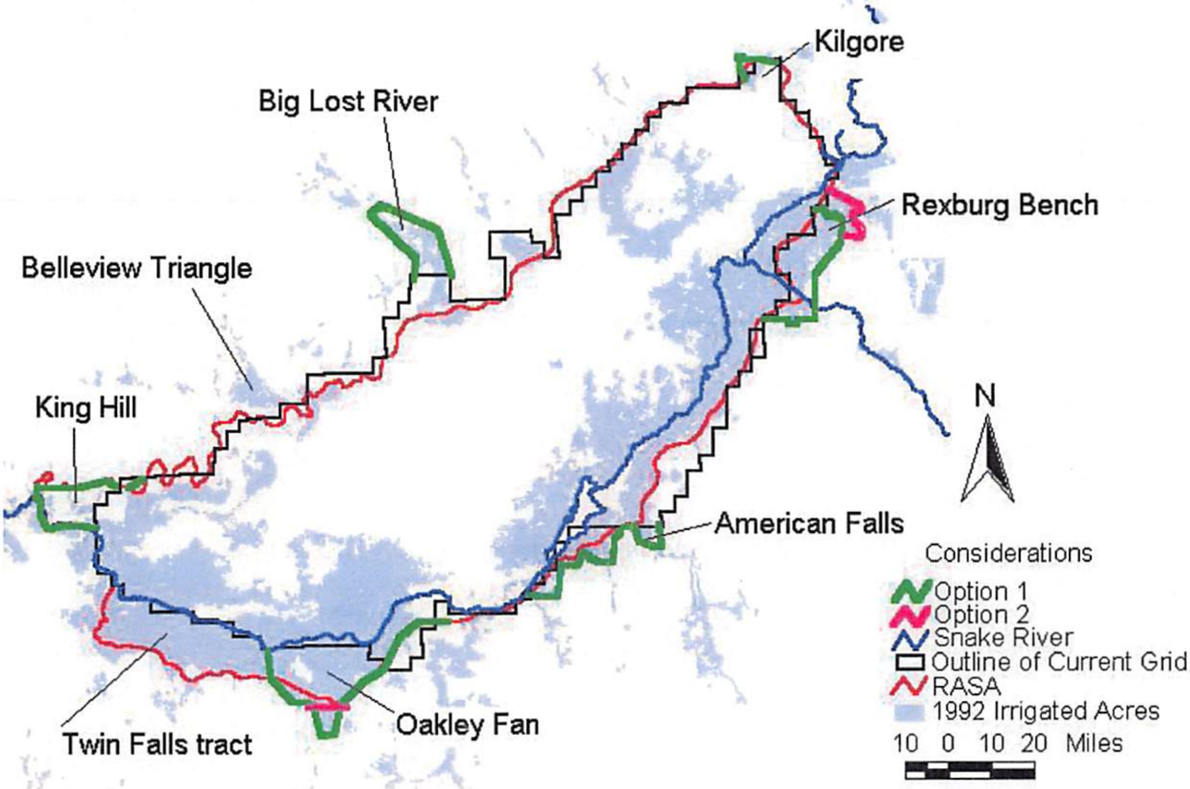


Figure 2. Proposed aquifer boundaries

The decisions made regarding the model boundary will affect the ability of the model to support later administrative decisions. For example, it will be impossible to administer areas outside the model using modeling results yet activities outside the model boundary can affect activities within the model boundary. Therefore, from a water management perspective, a goal should be to minimize the amount of irrigated agriculture dissected by the model boundary. 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. The added advantage would be that these hydrologically connected areas can be administered similarly if necessary.

The model boundary should extend to bedrock outcrops in tributary valleys to reduce the number of inflow parameters that must be estimated. Examples where this concept can be employed are in the Big Lost River drainage and the Belleview Triangle (Figure 2). This results in including the Big Lost River drainage up to Mackay Reservoir and excluding all of the Belleview Triangle. The effect of this decision will be to reduce water balance errors because the fluxes into the model area are measured instead of estimated, since all the flux at the proposed boundary occurs in surface streams.

Extending the model boundary up tributary basins for administrative purposes and to contacts with bedrock to minimize water balance errors is a worthwhile effort. However, it should be recognized that model calibration errors may be more substantial in tributary basins due to a decreased density of calibration data and or an uneven temporal distribution in data.

Design Decision

The model boundary will exclude the Twin Falls tract and include more of the tributary basins as illustrated in Figure 3. This boundary includes the recognized extent of the Snake Plain aquifer, with the exception of the Twin Falls tract, most of the irrigated agriculture immediately adjacent to the plain, and, where possible, extends the boundaries to contacts with bedrock. The boundary between the included Oakley Fan and the excluded Twin Falls tract will be a no-flow boundary.

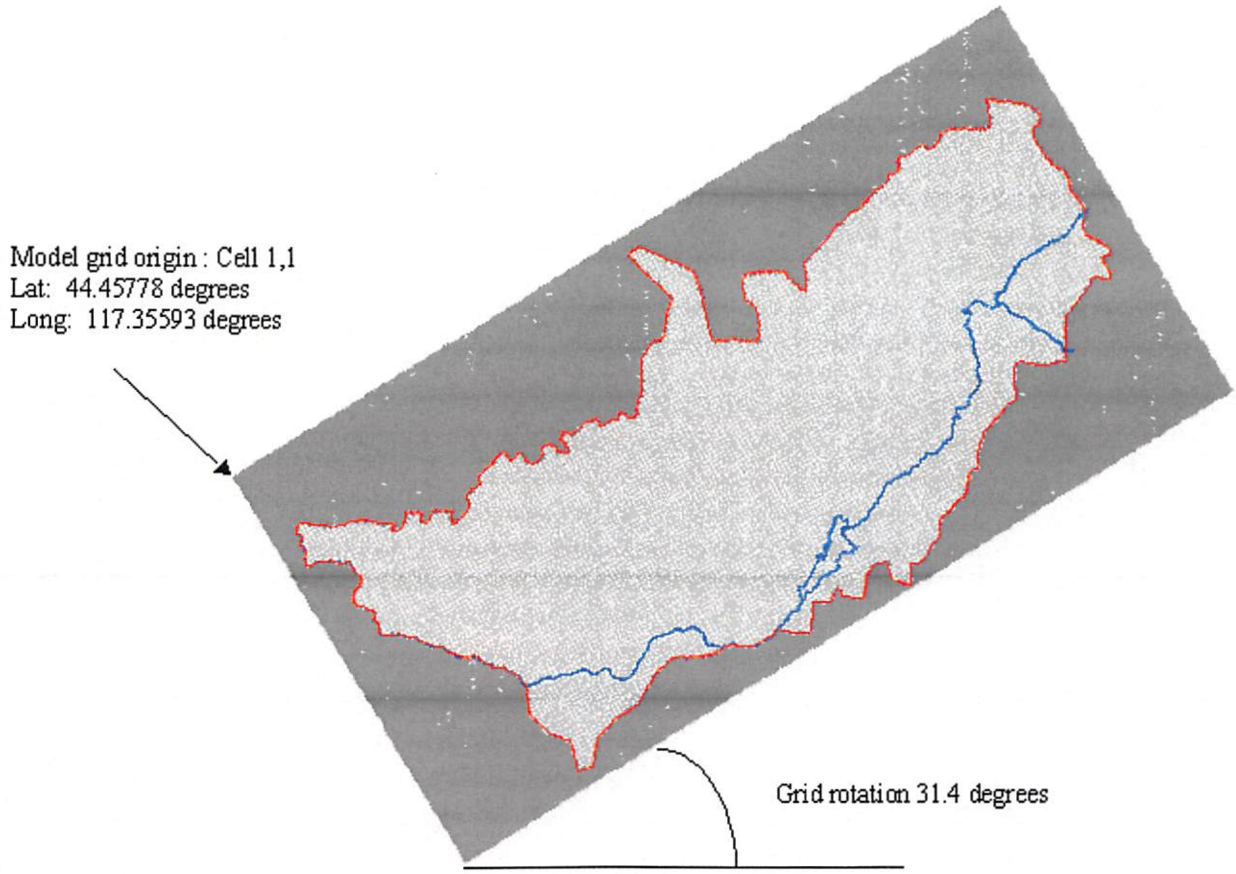


Figure 3. Grid orientation and rotation point.

References

Cosgrove, D.M., G.S. Johnson, S. Laney, and J. Lindgren, 1999. Description of the IDWR/UI Snake River Plain Aquifer Model (SRPAM). Idaho Water Resources Research Institute

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Model Boundary Revision 2

Idaho Department of

Water Resources

University of Idaho

Allan Wylie
May 8, 2009

Eastern Snake Plain Aquifer Model Enhancement
Model Design and Calibration Document Number DDM-002-R2

EXHIBIT
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206

DESIGN DOCUMENTS

Design documents are a series of technical papers addressing specific design topics on the eastern Snake River Plain Aquifer Model upgrade. Each design document will contain the following information: topic of the design document, how that topic fits into the whole project, which design alternatives were considered and which design alternative is proposed. In draft form, design documents are used to present proposed designs to reviewers. Reviewers are encouraged to submit suggested alternatives and comments to the design document. Reviewers include all members of the Eastern Snake Hydrologic Modeling (ESHM) Committee as well as selected experts outside of the committee. The design document author will consider all suggestions from reviewers, update the draft design document, and submit the design document to the SRPAM Model Upgrade Program Manager. The Program Manager will make a final decision regarding the technical design of the described component. The author will modify the design document and publish the document in its final form in .pdf format on the SRPAM Model Upgrade web site.

The goal of a draft design document is to allow all of the technical groups which are interested in the design of the SRPAM Model Upgrade to voice opinions on the upgrade design. The final design document serves the purpose of documenting the final design decision. Once the final design document has been published for a specific topic, that topic will no longer be open for reviewer comment. Many of the topics addressed in design documents are subjective in nature. It is acknowledged that some design decisions will be controversial. The goal of the Program Manager and the modeling team is to deliver a well-documented, defensible model which is as technically representative of the physical system as possible, given the practical constraints of time, funding and manpower. Through the mechanism of design documents, complicated design decisions will be finalized and documented.

Final model documentation will include all of the design documents, edited to ensure that the "as-built" condition is appropriately represented.

INTRODUCTION

Some of the first decisions faced when beginning work on a model center around determining extent of the modeled area. This is the topic addressed in this Design Document.

Problem Statement

This section outlines the options considered in the process of establishing model boundaries.

The purpose of this model is to assist in managing the surface water and ground water resources within the Eastern Snake Plain Aquifer and the Snake River. Therefore the model boundaries should encompass the boundaries of the Eastern Snake Plain aquifer. Decisions regarding where to place the model boundary must be made where the Eastern Snake Plain aquifer interfaces with tributary aquifers. These decisions should be based on the model purpose and data availability.

Extending model boundaries to bedrock outcrops in tributary basins allows incorporation of seasonal and long-term changes into the model simulation rather than estimating them external to the model. Extending the boundaries to Include land with similar irrigation practices is desirable, if the resulting boundary does not cross a hydrologic barrier. However, there is little value in including a tributary aquifer if there are no data available for that aquifer. If aquifer geometry or aquifer head data do not exist, modeled fluxes and responses to stress in the tributary basin will likely be in error.

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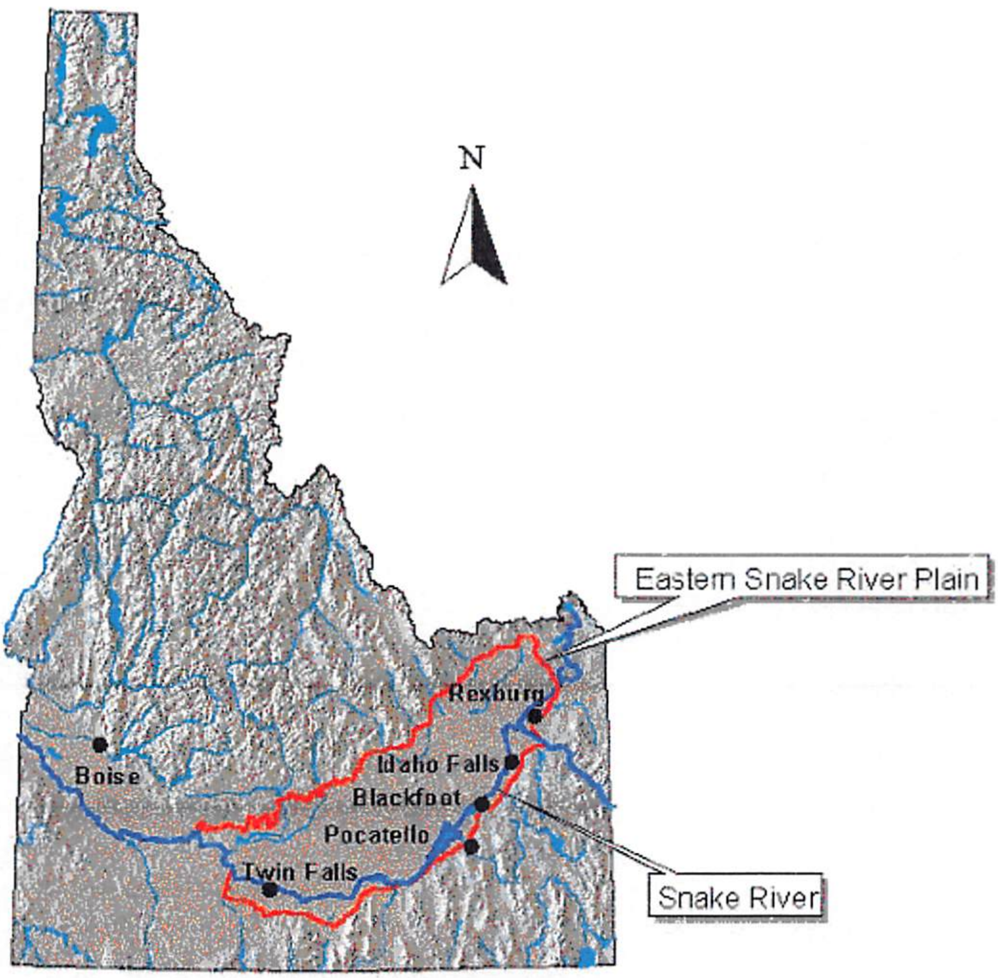

Figure 1. Location of the Eastern Snake River Plain

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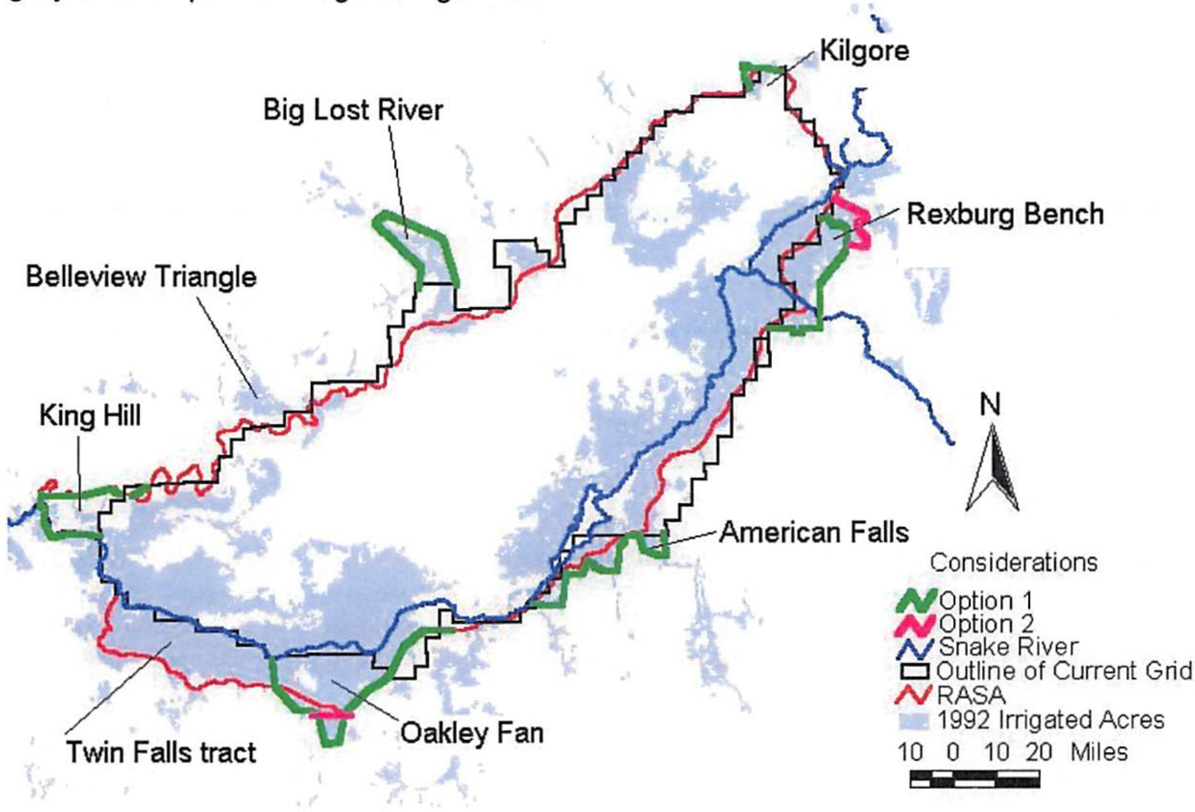

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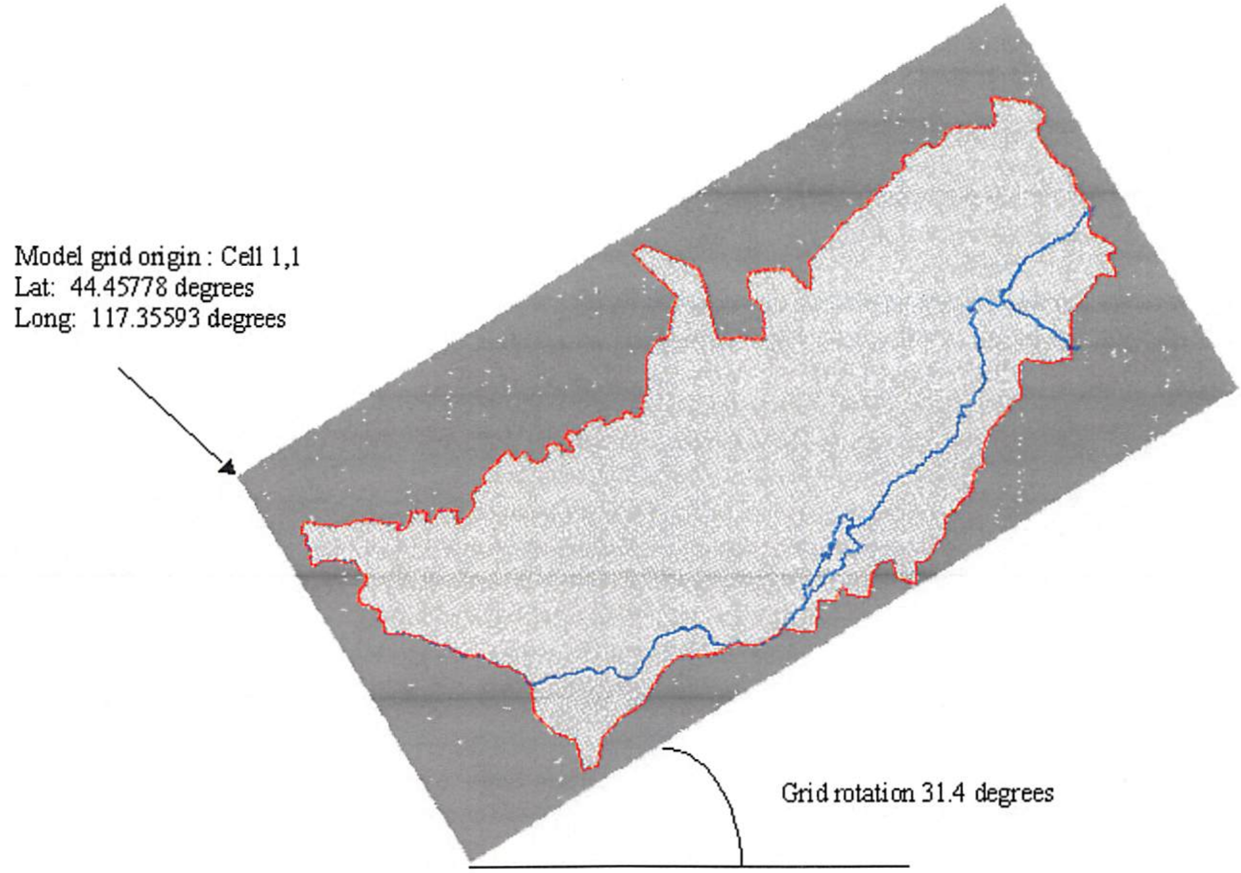

Figure 3. Grid orientation and rotation point.

References

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Revision 2

Introduction

In preparation for ESPAM V2 the ESHMC updated the grid projection to IDTM 83 and modified the model boundary to remove model cells below the rim in the Hagerman Valley and eliminate cells in the foothills north of Pocatello and in the foothills in the Big and Little Lost River valleys.

IDTM 83 Projection

The model grid was redrawn in IDTM83 with the origin at 8089081.6, 3904653.1 feet with a 31.4 degree counter-clockwise rotation as shown in Figure 1 below.

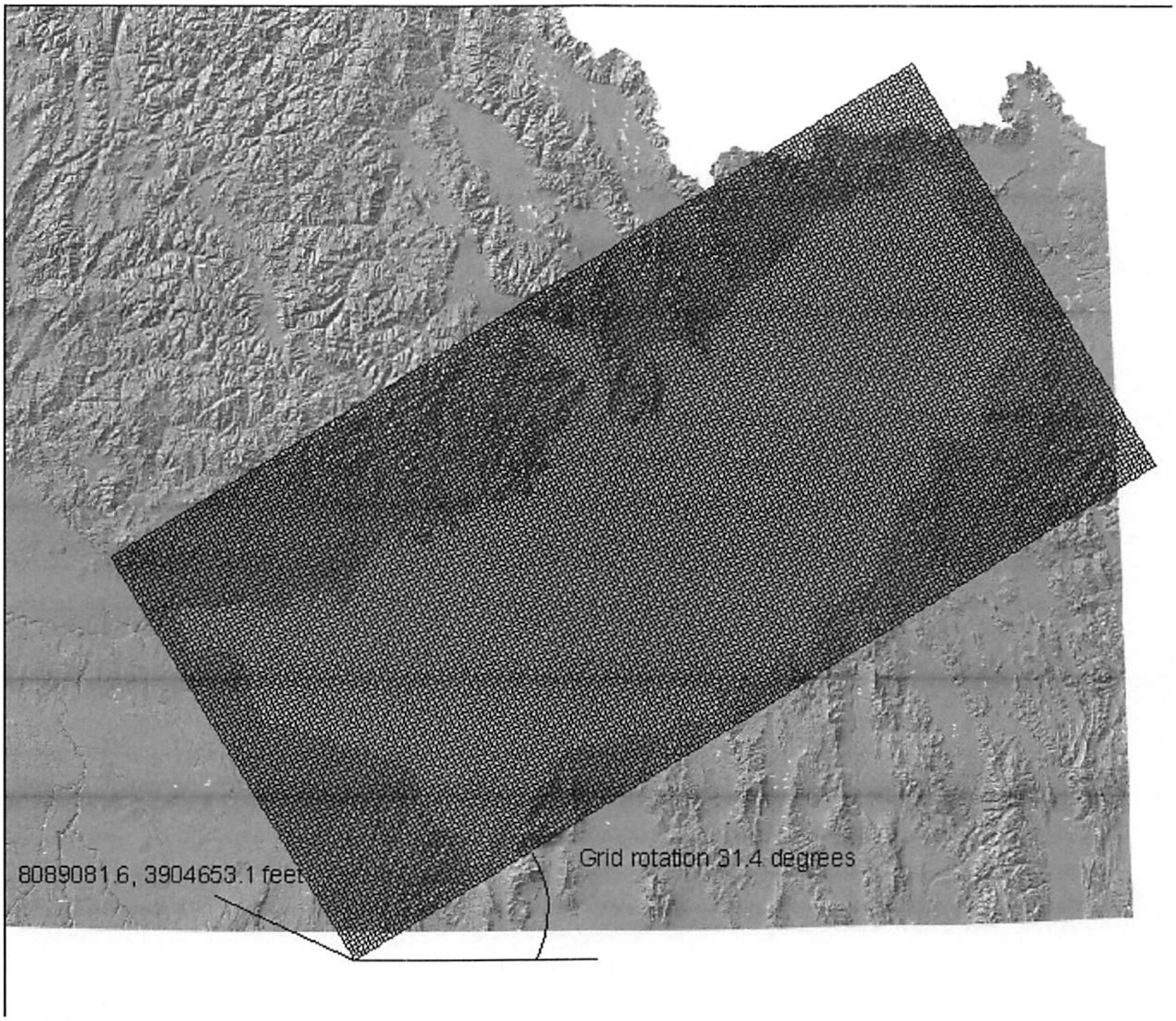

Figure 1. Grid orientation and rotation.

Hagerman Valley Changes

The ESHMC decided to remove cells below the Snake River Canyon rim as recommended by Ralston (2008). These model cells will be converted from active to inactive for version 2 of the ESPAM. Figure 2 shows the location of the removed cells.

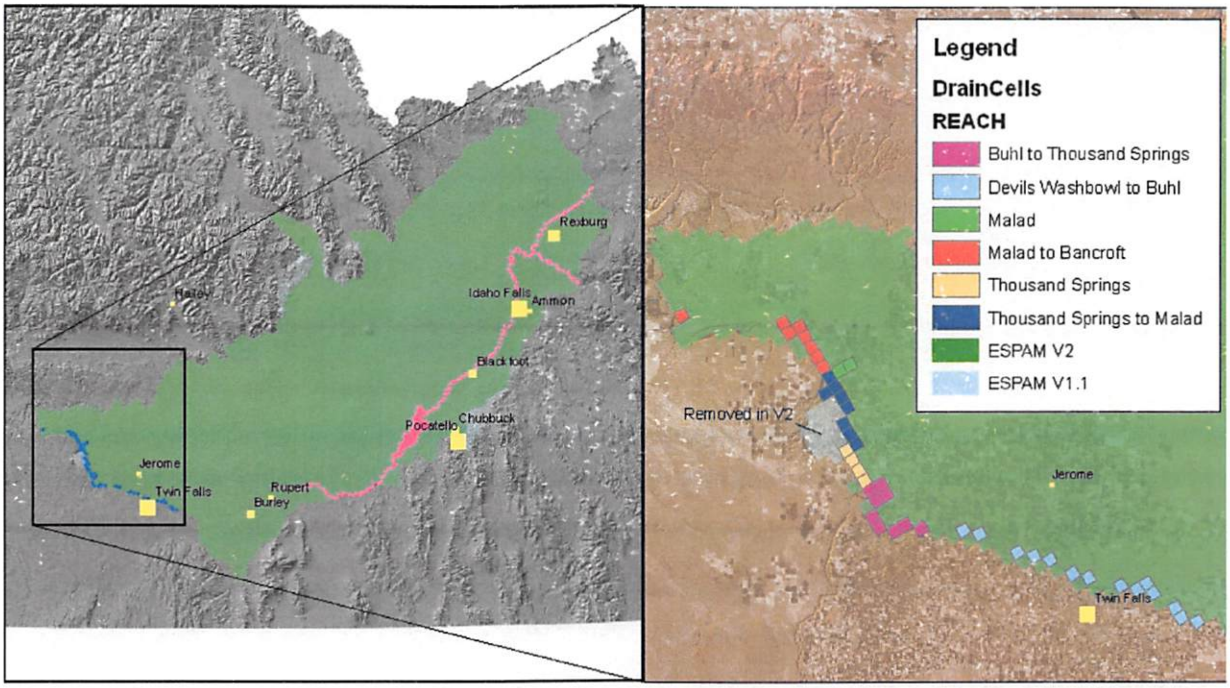

Figure 2. Model cells in the Hagerman Valley converted to inactive for version 2 of the ESPAM.

Pocatello Area Changes

The ESHMC decided to extend the active cells southeast along the Portneuf River and add one cell to allow connection of the Portneuf River to American Falls Reservoir as shown in Figure 2. The committee also decided to convert cells overlying un-irrigated foothills north and east of Pocatello to inactive (Sullivan, 2009; Wylie, 2009) as shown in Figure 3.

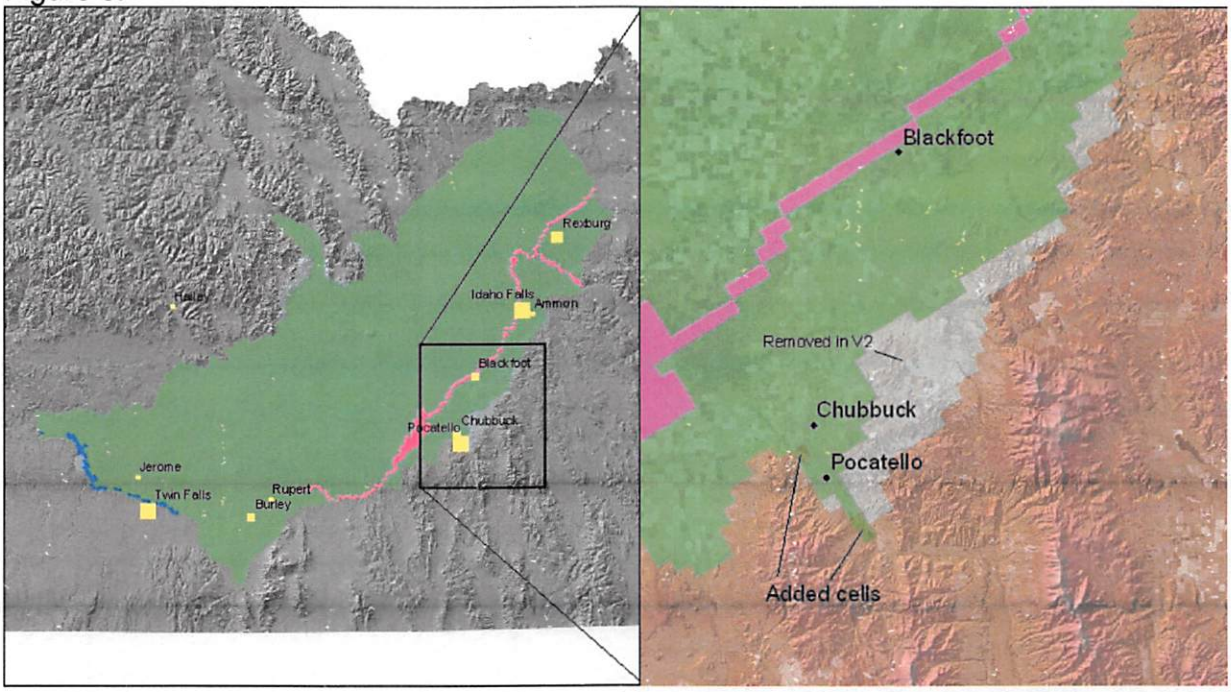

Figure 3. Pocatello area model grid changes.

Big and Little Lost River area Changes

As an outgrowth of the decision to convert cells overlying un-irrigated foothills to inactive, modifications were made in both the Big and Little Lost River drainages. Figure 4 illustrates the changes.

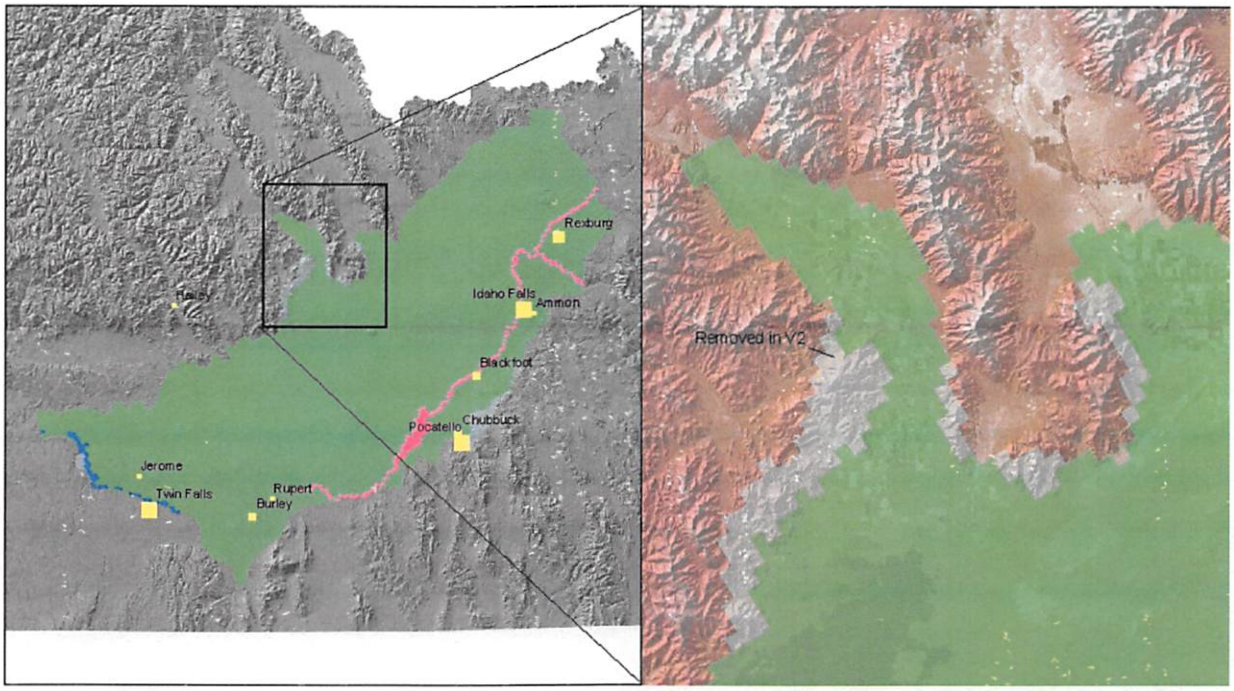

Figure 4. Changes to the model grid in the Big and Little Lost River drainages.

References

Ralston, D. 2008. Hydrology of the Thousand Springs to Malad Reach of the Enhanced Snake Plain Aquifer Model. IDWR Open File Report.

Sullivan, G. 2009. ESPAM Boundary near Pocatello. Presentation to the ESHMC at March 31-April 1, 2009 meeting.

Wylie, A. 2009. ESPAM updated Boundary. Memo to the ESHMC dated April 6, 2009.