PALOUSE BASIN AQUIFER committee

MEETING MINUTES

THURSDAY, NOVEMBER 17, 2022, 2:00 PM
UI, FACILITIES SERVICES CENTER, JACK'S CREEK MEETING ROOM
https://uidaho.zoom.us/j/84146537732 (Passcode: PBAC)

Attendance

X: In-person attendance **V:** Video attendance

X	Pullman: Cara Haley (Chair) City Engineer		Moscow: Tyler Palmer (Vice-Chair) Deputy Director, Public Works & Services
X	Pullman: Shawn Kohtz Director of Public Works	**V**	Moscow: Michael Parker Water Utility Manager
X	Pullman: Eileen Maccoll City Council Member	**X**	Moscow: Gina Taruscio City Council Member
X	Whitman County: Mark Storey Public Works Director/County Engineer	**X**	Latah County: Paul Kimmell Citizen/County Representative
X	Whitman County: Tom Handy County Commissioner	**X**	Latah County: Tom Lamar County Commissioner
	WSU: Jeff Lannigan Facilities Services	**X**	UI: Tim Link Professor of Hydrology
	WSU: Jason Sampson Asst Director, Environmental Services	**X**	UI: Rusty Vineyard Director of Facilities
X	WA, Dept of Ecology: Patrick Cabbage Unit Supervisor/Hydrogeologist		ID, Water Resources: Michelle Richman Regional Manager/Staff Engineer
	WA, Dept of Ecology: Chris Beard Hydrogeologist		ID, Water Resources: Daniel Sturgis Hydrogeologist

Others:
Céline Acord, PBAC Executive Director (X); Steve Robischon, PBAC Technical Advisor (V);
Robin Nimmer, Alta Science & Engineering (X); John Bush, UI Emeritus Professor of Geology (X)

Community Members:
Dale Ralston (X); Pamela Dunlap (X); Jeanne Elliot (X); David Hall, SEG Member (X), Diane Cornelius (V);
Sarah Dawson, UI Sustainability Director (V); Lana Cohen, UI (X); Jeff Langman, UI (X);
Brook Chase, Nez Perce Tribe (V); Cristin Reisenauer, City of Pullman (V);
Taylor Musburger, City of Pullman (V); Kyle Duckett, Alta Science & Engineering (V)

PALOUSE BASIN AQUIFER committee

**Denotes Action Items*

1) **Introductions**
   Meeting called to order at 2:00pm. Roundtable of introductions of in person and online participants.

2) ***Approval of Minutes *(Video Link 06:00)***
   a. **September 15, 2022, Meeting – Attached**

Motion:	Approve September 15, 2022, Minutes
Mover:	Gina Taruscio
Seconder:	Eileen Maccoll
Result:	**ALL IN FAVOR, MOTION CARRIED**

3) **Public Comment for Items not on Agenda**
   a. **None**

4) **Discussion *(Video Link 06:38)***
   a. **Water Summit Feedback – Survey Results**
      Committee reviewed survey results and provided feedback.

   b. **Leadership Roundtable Feedback**
      Committee members provided feedback. As laid out, the Roundtable was very open ended. Next time consider it to be more formalized with action items and specific purpose. Consider having it twice a year to keep the collaboration current. The one-pager provided could be edited to directly explain the preferred Alternative and use less words with more images.

   c. **IDWR Regional Water Sustainability Project Application – Website Info**
      The Idaho Water Resource Board (IWRB) has a formal process to be placed on the Water Sustainability Project List. Applications are due by December 1, 2022. PBAC will be submitting the report with the five alternatives. This will hopefully set the stage to provide funding in the future. A side note, IWRB's July meeting will be held in Moscow.

5) **Unfinished Business**
   a. **None**

6) ***New Business** ***(Video Link 38:30)***

   a. **Proposal for Infographics – Attached**
   The need for infographics will help communicate PBAC's mission – to educate about the aquifer and the need for an alternative water supply – in next year's public engagement process. The consultant has a team with backgrounds in natural and environmental sciences which lends to their expertize in assisting PBAC. The contract is for $9,000 and shall be paid from the Administrative budget.

Motion:	Approve Contract with Fuse, Inc.
Mover:	Paul Kimmel
Seconder:	Tom Handy
Result:	**ALL IN FAVOR, MOTION CARRIED**

7) **Presentation & Discussion** ***(Video Link 1:00:39)***

   a. **John Bush:** ***Review of Research from 2009 to the Present about Miocene Aquifers in the Moscow-Pullman Area and Basic Facts about the Aquifers* – Attached**
   John Bush presented on the previous research conducted regarding the Basin. He will be presenting additional talks the week after Thanksgiving. *[The talks were cancelled afterwards due to illness].*

8) **Subcommittee Reports** ***(Video Link 1:42:32)***

   a. **Communications** – presented by Subcommittee Chair Paul Kimmell
   The subcommittee will be working on collateral with Fuse before scheduling any public events. More to come in the new year.

   b. **Budget** – presented by Subcommittee Chair Rusty Vineyard
   The subcommittee is working through budget projections as more funds will be needed to continue standard operating procedures in the next 2-3 years. Ongoing discussions with UI regarding their research contributions and how to receive the awarded Latah County ARPA funding.

   c. **Research** – presented by Subcommittee Chair Shawn Kohtz
   During the subcommittee's last meeting Steve Robischon provided the subcommittee with an in-depth review of water volumes for a few of the alternatives. The subcommittee also discussed the recent modeling efforts that weren't as fruitful as expected. Discussions around working on another modeling effort were explored but ultimately the decision was to focus on any technical needs for the alternative water supply projects. To that end, the subcommittee might consider being renamed to "Technical Subcommittee".

9) **Other Reports and Announcements** ***(Video Link 1:55:57)***

   a. **FY23 Assessments**
   Have received assessments from Moscow, Pullman, WSU and UI (Admin only). Still have yet to receive Latah, Whitman and UI (Research).

   b. **AWRA Conference Update**
   Céline Acord provided an update on the American Water Resources Association conference she attended at the beginning of November.

   c. **UI Rep Tim Link Upcoming Sabbatical**
   Tim Link will be on sabbatical in spring 2023. Committee should consider a temporary replacement(s) and will take a formal vote at next month's meeting.

10) **Next PBAC Meeting:**

   a. **December's Meeting: Thursday, December 15th at 2:00pm**

11) **Adjourn** at 4:01pm

Motion:	Adjourn
Mover:	Shawn Kohtz
Seconder:	Rusty Vineyard
Result:	**ALL IN FAVOR, MOTION CARRIED**

Minutes Adopted at the January 1, 2023 PBAC Meeting

PALOUSE BASIN AQUIFER committee

DRAFT MEETING MINUTES

THURSDAY, SEPTEMBER 15, 2022, 2:00 PM
UI, FACILITIES SERVICES CENTER, JACK'S CREEK MEETING ROOM
https://uidaho.zoom.us/j/82719054247 (Passcode: PBAC)

Attendance
X: In-person attendance **V:** Video attendance

X	Pullman: Cara Haley (Chair), City Engineer	**X**	Moscow: Tyler Palmer (Vice-Chair), Deputy Director, Public Works & Services
V	Pullman: Shawn Kohtz, Director of Public Works	**V**	Moscow: Mike Parker Water Utility Manager
X	Pullman: Eileen Maccoll, City Council Member	**X**	Moscow: Gina Taruscio, City Council Member
	Whitman County: Mark Storey Public Works Director/County Engineer	**X**	Latah County: Paul Kimmell, Citizen/County Representative
V	Whitman County: Tom Handy, County Commissioner	**X**	Latah County: Tom Lamar, County Commissioner
V	WSU: Jeff Lannigan, Facilities Services	**X**	UI: Tim Link, Professor of Hydrology
	WSU: Jason Sampson, Asst Director, Environmental Services	**X**	UI: Rusty Vineyard, Director of Facilities
	WA, Dept of Ecology: Patrick Cabbage	**V**	ID, Water Resources: Michelle Richman Regional Manager/Staff Engineer
V	WA, Dept of Ecology: Chris Beard Hydrogeologist		ID, Water Resources: Daniel Sturgis, Hydrogeologist

Others:
Céline Acord, PBAC Executive Director (X)
Steve Robischon, PBAC Technical Advisor (V)
Robin Nimmer, Alta Science and Engineering (X)

Community Members:
Colt Shelton, JUB Engineers (V)
Cristin Reisenauer, City of Pullman (V)
David Hall, SEG Member (X)
Pamela Tetarenko (V)
Allison, Nez Perce Tribe (V)
Bridget Pechtel, Project Manager for Public Works Board, WA Dept of Commerce (V)

PALOUSE BASIN AQUIFER committee

**Denotes Action Items*

1) **Introductions**
   Meeting called to order at 2:01pm. Roundtable of introductions of in person and online participants.

2) ***Approval of Minutes**
   a. **August 18, 2022 Meeting** - *attached*

Motion:	Approve August 18, 2022, Minutes
Mover:	Gina Taruscio
Seconder:	Paul Kimmel
Result:	**ALL IN FAVOR, MOTION CARRIED**

3) **Public Comment for Items not on Agenda** ***(Video Link 04:17)***
   The attached letter was received in June. A response was provided from PBAC.

   There was an editorial in the Moscow-Pullman Daily News by Terrance Day. Discussion regarding the content, how or if PBAC should respond, etc. Co-Chair Tyler Palmer and Paul Kimmel will draft a response for the paper. Overall, the recent press is positive as it is starting a community conversation.

4) **Presentations/Discussion** ***(Video Link 09:22)***
   a. **Recap of Moscow and Pullman City Council Presentations**
   Overall, presentations were positive. PBAC should capture questions asked and follow up with answers for the councils and explain PBAC's next steps. These questions/answers will also help to craft an FAQ page.

   b. **Discuss Next Steps for Public Outreach & Research Refinement**
   Subcommittees will be meeting next week to dive deeper into these topics, but overall, both need to have a timeline.
   - Ideas for Outreach include: county fairs, 4th graders, girl/boy scouts, PCEI, Palouse Science Discovery Center, farmers market. Social media posts could include "question of the day" for the FAQs around the alternatives.
   - Ideas for Research include: prioritizing questions needed answered, potentially having a colloquium/workshop to work out data gaps/next steps

c. **Leadership Roundtable Goals**
The roundtable is slated for early November. Discussion of what PBAC is hoping to gain from it. An exercise in prioritization for leaders. PBAC should open with the positives (less decline even with population growth, average use is X but in the Palouse it's Y, etc.) while also explaining the necessity for moving an alternative forward. PBAC needs to provide talking points for leaders to take away with them – digestible Q&A facts based in science.

5) **Unfinished Business**
   a. **None**
6) **New Business**
   a. **None**
7) **Subcommittee Reports *(Video Link 55:29)***
   a. **Budget**
   Scheduled for October 3. Will discuss funding increases and if rewording the "research" budget would be beneficial.

   b. **Communications**
   Scheduled for September 19. Will have a brainstorm session to rename the alternatives, focus on public engagement planning, and preparing for the SEG meeting in October.

   c. **Research**
   Scheduled for September 20. Will discuss next steps with the groundwater model and research prioritization.

8) **Other Reports and Announcements *(Video Link 1:01:31)***
   a. **FY23 Assessments**
   All member entities were sent invoices in August. University of Idaho and City of Pullman has paid but no one else at this time.

   b. **Next Member Entity Presentations Scheduled in September**
   Presentations/Meetings with the Counties and Universities are in the next two weeks.

   c. **Upcoming October Events**
   Pullman Chamber Luncheon, SEG meeting and Water Summit are in October.

d. Other Items brought up
    - IDWR provide a status update of the Mountain View Park monitoring well project. Delay due to waiting list for a well driller. Potentially 1-2 years.
    - Discussion was had on the WDOE monitoring sites and battery replacement and if PBAC should insert their own loggers into the wells. Folks will bring together a proposal for PBAC to review.
    - IDWR had a Water College event on August 26. Michelle Richman provided a brief update/overview on the Basin.

9) Next PBAC Meetings:

a. October's Meeting cancelled due to Palouse Basin Water Summit

b. November's Meeting: Thursday, November 17th at 2:00pm

10) Adjourn at 3:22pm

FUSE CONSULTING

Palouse Basin Aquifer Committee

Aquifer Infographics Proposal

Palouse Basin Aquifer Committee

November 2022

CONTEXT

Céline Acord, Executive Director for the Palouse Basin Aquifer Committee (PBAC), contacted Fuse Consulting Ltd. to assist with the development of science communication pieces with regards to selecting an alternative water source in the Palouse Basin.

This proposal outlines approaches and costs associated with the project between PBAC and Fuse Consulting Ltd.

UNDERSTANDING OF SCOPE

The work completed by Fuse would include developing content and design of the decided upon science communications piece(s) that conveys the purpose of the project, and meets the needs of the users. This scope generally includes: researching and writing content; developing illustrations, and graphics; and the overall layout and design of the project.

Deliverables

The following deliverables are included in this proposal:

- **Alternative 5 Infographic (1-page):** Infographic explaining the selected "alternative," showing the map elements at multiple landscape scales to convey finer details. Will include illustration to communicate meaning of direct source.
- **Aquifer 101 Infographic (1-page)**: Orients reader to the Palouse Basin Aquifer, utilizing multiple perspectives to convey geographic extent in relation to familiar landmarks, how water cycles through the aquifer, as well as the relationship between upper and lower aquifers and differences in access.
- **4X Alternative Source Diagrams (4X half-page):** Diagrams showing each of four alternative water sources considered (but not selected). Each diagram will use the same base map, and will indicate whether the considered alternative involved direct sourcing vs aquifer recharge/recovery. Price quoted is for all four diagrams as a bundle.
- **Visual Assets Package:** Prepare maps and other illustrated graphics as individual assets for easy incorporation into other materials - e.g., ppt slides. Infographics prepared as stand-alone (e.g., w/ header and logos) and website/stripped-down versions to facilitate different uses.

Timelines

Outlined below are the proposed timelines for the deliverables:

- January 31, 2023 - Complete Alternative 5 Infographic and Aquifer 101
- February 28, 2023 - Complete the 4X Alternative Source Diagrams and provide the visual assets package

Note: Significant delays in feedback may impact the timelines and/or scope of the deliverables.

Feedback Process

In order for our team to deliver the highest quality work, we follow the guidelines below for the feedbackprocess between Fuse and the Palouse Basin Aquifer Committee:

First Round	Key Messages	Check for Accuracy, order of information, and level of technicality.
Second Round	First Draft Illustration	Edits may include minor text changes, typeface adjustments, colour palette, additions of logos/contact information, replacement of icons, and/or minor adjustments to large illustrations. Significant restructuring of the layout, creation of new large illustrations, and/or incorporation of new key messages are considered major edits and a change in scope.
Third Round	Revised Illustration	Minor edits - final adjustments to text and/or logos.

Payment Terms

Fuse will invoice per deliverable upon completion of said deliverable. The anticipated invoicing schedule isas follows:

- Deliverable #1: Alternative 5 Infographic - Invoice issued January 31, 2023 upon delivery of final product
- Deliverable #2: Aquifer 101 - Invoice issued January 31, 2023 upon delivery of final product
- Deliverable #3: 4X Alternative Source Diagrams - Invoice issued February 28, 2023 upon delivery of final product
- Deliverable #4: Visual Assets Package - Invoice issued February 28, 2023 upon delivery of final product

ABOUT FUSE CONSULTING

Since 2014, Fuse Consulting has helped our clients connect knowledge to practice through effective science communication products. Fuse was founded after Matthew Pyper and Shelagh Pyper recognized a need to improve the communication and application of scientific knowledge in conservation and resource management. Today, Fuse comprises a team of skilled science communicators and graphic designers who create visual and written products for a wide range of clients in the disciplines of conservation biology, marine biology, ecology, forestry, animal biology, and natural resource management.

In recent years, Fuse has become a leader in the emerging medium of infographics, creating tailored infographics on technical and nuanced research topics. Fuse team members have delivered several instructional workshops on the creation and innovative use of infographics, including at the 2018 Science Writers and Communicators of Canada conference and in a series of workshops delivered to Environment and Climate Change Canada in 2019 and 2020.

We believe there are three core areas in which our work, and our products, provide value to our clients:

- **We have backgrounds in science:** Our team of science communicators have backgrounds in science, combined with exceptional artistic talents. We can identify with the work and understand what elements need to be highlighted to enhance the messaging and design of the piece to meet the needs of both researchers and their target audiences.
- **We use internal reviews to minimize edits:** Your time is important to us. We reduce the effort you need to spend assessing the work by holding internal reviews with our team, asking the right questions, and addressing them first. That means you will see a more polished and thoughtful piece throughout the infographic design process.
- **We have a proven track record:** We have been a pioneer in the use of scientific illustrations and infographics since we founded our organization. We have been partnered with numerous academics and government and non-government organizations to assist with their science communication. We have also partnered with the American Society of Animal Sciences for over two years, and have been helping them deliver high quality, impactful infographics that are driving interest and exposure for three of their leading journals.

OUR APPROACH

At Fuse, we have developed a simple and clear approach for working on all our projects with our clients. We have found that this approach maximizes clarity between our team and the clients' team. We also find that this process helps ensure we are highlighting all the important elements in an infographic, fact sheet, or illustration before we begin the artistic process. This process has been shown to save time, maximize scientific accuracy, and minimize re-work in the later stages of projects.

Our process includes the following steps:

1. **Identification of Target Audience:** Knowing who we are trying to reach is the most important foundation of all our projects. We ask our clients questions to better understand who they are trying to reach, what we want the user to feel/experience, and what they want the user to do with the information.
2. **Identification of Key Messages:** Next, our team carefully reviews all source materials (reports, client meetings etc.) and identifies key messages that will be highlighted in each product. This allows us to identify the core messages that will resonate with the target audience and identifies the core topics of focus for our illustrations.
3. **Review and Approval of Key Messages by the Client:** Once the core messages are refined and vetted through our internal process, in which a second person on our team reviews the key messages for clarity and impact, we share these with our clients. This stage of review is important as it occurs early enough in the project to ensure clear alignment. If any major changes need to be made, it is easy to refine the key messages as opposed to re-doing illustrations later in the process.
4. **Graphic Design and Illustration:** With clear direction in hand, our designers then move to creating the illustrations and design of the products. This is where our team's blend their creativity with a clear eye to scientific credibility and accuracy. Its this combination of creativity and scientific accuracy that our clients repeatedly tell us sets us apart from our competitors.
5. **Client Review and Approvals:** Once the draft illustrations and designs are completed, they are vetted through our internal 'cold eyes' review process to catch any errors and to ensure the illustrations and designs are achieving maximum clarity. We then share the drafts with our clients and generally undertake 1-2 rounds of reviews. We find that our internal process minimizes the review time required for our clients, resulting in fewer iterations of graphics and saved time and energy for our clients.
6. **Final Design Changes and Production of Final Files:** Once the final design is approved, we share this with our clients in a range of image formats (e.g., png, pdf etc.) and assist them as required with promoting their work as broadly as possible. If desired, Fuse can use its social media channels to help raise awareness of the client's project and amplify awareness and uptake of the information.

OUR TEAM

Our team is composed of graphic designers, science communicators, ecologists and education practitioners. The diverse background of our team means that we can help develop meaningful communications that resonate deeply with our target audiences, while still clearly and creatively communicating the underlying information. It is a combination our clients tell us is rare, and it is what sets us apart from conventional communication agencies. We have worked with municipalities, provincial and federal governments, private companies and NGOs to help them meet their communication goals and reach new audiences with their information.

Matthew Pyper M.Sc., Principal, Fuse Consulting Ltd.

Matthew is an ecologist and science communicator whose work is focused on connecting ecological knowledge to policy and practice in the fields of forestry, conservation biology and sustainability. Matthew's in-depth knowledge about current research, policy and applications have helped him establish a solid reputation with his clients. His focus with every project is to clearly define the client's objectives and then bring creativity and credibility to the final deliverables.

Kate Broadley M.Sc., B.Sc. Hons., Director of Research Mobilization

Kate is an Ecologist and Science Communicator with Fuse Consulting and is focused on making information accessible and meaningful to her readers. She has been developing infographics, scientific figures, and other visual aides for science outreach for over five years. She has extensive experience developing infographics for science-based projects and her work has appeared in several important publications aimed at communicating complex information to diverse audiences. Kate also has a solid grounding in marine sciences, having completed courses on marine invertebrates, diversity of fishes, and marine microbiology as part of her undergraduate education at the University of British Columbia. She has also worked as a marine sciences educator at the Bamfield Marine Sciences Centre on Vancouver Island with their public education department. Kate will serve as the Artistic Director, providing all internal reviews and ensuring all products achieve both scientific accuracy and creativity.

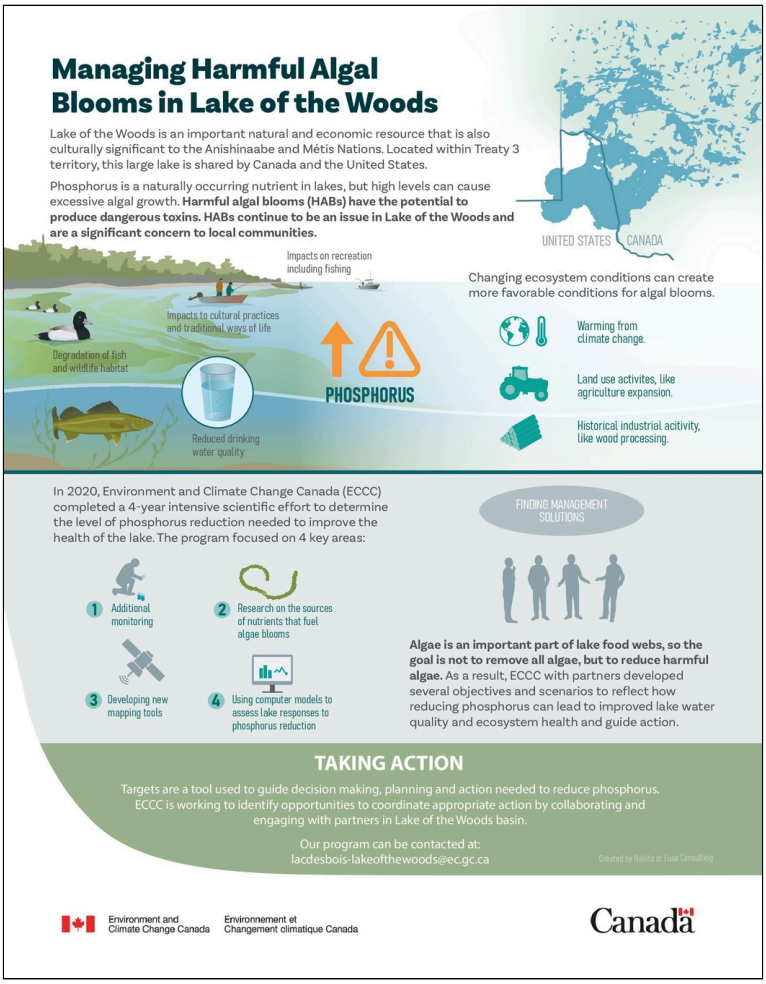
Kaitlyn Philip, B.A., Project Coordinator

Kaitlyn is Fuse's Project Coordinator. She guides projects to fruition by putting her organization and planning skills to work. From start to finish, she works closely with clients and the Fuse team to ensure project deliverables are met on time and within budget.

Kaitlyn has a unique background that intersects environmental studies, urban studies, and project management, Kaitlyn specializes in environmental project coordination. She brings both her passion and experience to each project she coordinates. Kaitlyn holds a Bachelor of Arts degree in Environmental Geography and Urban Studies from the University of Toronto. She has also completed online project management courses, and has a Certificate in Civic Ecology from Cornell University.

EXAMPLE INFOGRAPHICS

Half-page infographic



Full-page infographic

PROPOSED BUDGET

The following budget outlines the anticipated costs for various deliverables, as described above. Items not specifically listed below would be considered outside the scope of this budget.

Description	Subtotal
Alternative 5 infographic (1-page) - Project management and meetings - Research and content development - Graphic design, illustration and layout - Review and revisions	$2,750
Aquifer 101 infographic (1-page) - Project management and meetings - Research and content development - Graphic design, illustration and layout - Review and revisions	$2,750
4X alternative source diagrams (4X half-page) - Project management and meetings - Research and content development - Graphic design, illustration and layout - Review and revisions	$2,500
Visual Assets Package - Prepare maps and other illustrated graphics as individual assets for easy incorporation into other materials - e.g., ppt slides. Infographics prepared as stand-alone (e.g., w/ header and logos) and website/stripped-down versions to facilitate different uses.	$1,000
Total	$9,000

CLOSURE

Through our work, we have refined a process that helps ensure we capture important scientific nuances accurately, and that our illustrations connect with target audiences to maximize uptake of your work. The attached proposal showcases how we would approach this project, examples of previous work, and our estimated budget for this project.

We look forward to discussing this proposal with you and working with you on this important project.

Matthew Pyper, Principal
Fuse Consulting Ltd.

Kate Broadley, Director of Research Mobilization
Fuse Consulting Ltd.

REVIEW OF RESEARCH FROM 2009 TO THE PRESENT ABOUT MIOCENE AQUIFERS IN THE MOSCOW-PULLMAN AREA AND BASIC FACTS ABOUT THE AQUIFERS

John H. Bush
2022

INTRODUCTION

In 2007 the major entities of the Palouse Basin Aquifer Committee (PBAC) voted to increase their support of research on the Miocene aquifers of the Moscow-Pullman area. Discoveries and conclusions from these subsequent projects have greatly increased the knowledge and changed some of the concepts about the ground water resources of the area. In addition, two major State of Washington funded studies facilitated by PBAC greatly added to the knowledge base that has accumulated since 2009.

Over fifty publications and theses were completed on various aspects of the aquifer system. Most of these were by University of Idaho and Washington State University faculty and students. In addition to aiding in local research both universities benefited from the support of PBAC. The research products are tabulated by year in Table 1 and their results are summarized herein.

My review of the recent research revealed a problem that is common in any area of continued research studies. That problem is that changes in concepts are often overlooked or forgotten as time passes. Sometimes a few reports become the basis for myths or untruths that slow the progress of understanding. Knowledge and facts get lost and myths dominate. Asking someone to read and understand the thousands of papers on the rocks and aquifers of the Columbia River Basalt Group and associated sediment aquifers is not reasonable. It is quite a task even to read the hundreds of reports on the Palouse Basin. This report provides a brief overview of research since 2009; it also provides ten facts each on the upper and lower aquifers, iron pollution, and historical notes to help interested parties get a foundation in where we are today in our understanding of our water resources.

Table 1. Major research projects on the aquifer systems of the Palouse basin, 2009–present

Researchers	**Title**	**Product**
	2009	
Brad Bennett and Jim Osiensky	Strategically Designed Pumping to Maximize Induced Ground Water Recharge to the Wanapum Aquifer System in the Moscow, Idaho Area	poster
Bradley Bennett	Recharge Implications of Strategic Pumping of the Wanapum Aquifer System in the Moscow Sub-basin	M.S. thesis

Table 1 (cont.)

Researchers	Title	Product
	2009	
Brad Bennett	Recharge Implications of Strategic Pumping of the Wanapum Aquifer System in the Moscow Sub-basin	PDF slide show presentation
Lauren Carey and Jim Osiensky	Using Tritium Concentrations to Age Date Groundwater in the Palouse Basin	poster
Aaren Fiedler	Well Interference Effects in the Grande Ronde Aquifer System in the Moscow-Pullman Area of Idaho and Washington	PDF slide show presentation
Aaren Fiedler	Well Interference Effects in the Grande Ronde Aquifer System in the Moscow-Pullman Area of Idaho and Washington	M.S. thesis
Katie Moran	Long-Term, Basin-Wide Grande Ronde Aquifer Test	poster
Matthew Reeves	Estimating Recharge Uncertainty using Bayesian Model Averaging and Expert Elicitation with Social Implications	M.S. thesis
Kirk Sinclair and James Kardouni	Surface-water/Groundwater Interactions and Near-stream Groundwater Quality along the Palouse River, South Fork Palouse River, and Paradise Creek	publication
	2010	
Lauren Carey	Relative Age Dating of Groundwater in the Palouse Aquifer and Moscow Subbasin using Tritium and 0-18 Concentrations	Powerpoint slide show presentation
R. M. Conrey and J. A. Wolff	Basalt lava stratigraphy beneath Pullman and Moscow: implications for the flow of groundwater	poster
	2011	
Allyson Beall, Fritz Fiedler, Jan Boll and Barbara Cosens	Sustainable Water Resource Management and Participatory System Dynamics. Case Study: Developing the Palouse Basin Participatory Model	publication
Lauren R. Carey	Evaluation of Oxygen and Hydrogen Isotopes in Groundwater of the Palouse Basin and Moscow Sub-basin	M.S. thesis
Roel Dijksma, Erin S. Brooks and Jan Boll	Groundwater Recharge in Pleistocene Sediments Overlying Basalt Aquifers in the Palouse Basin, USA: Modeling of Distributed Recharge Potential and Identification of Water Pathways	publication and M.S. thesis
Attila J.B. Folnagy, Kenneth F. Sprenke and James L. Osiensky	Aquifer Storage Properties from Groundwater Fluctuations induced by Seismic Rayleigh Waves	poster
George Grader	Miocene Latah Formation and Subsurface Geology Along the Moscow Subbasin Margin: "Recharge from the East" Revisited	report to PBAC
Kathryn Moran	Interpretation of Long-Term Grande Ronde Aquifer Testing in the Palouse Basin of Idaho and Washington	M.S. thesis
Kathryn Moran	Evaluation of the Relationship Between Pumping and Water Level Declines in the Grande Ronde Aquifer of the Palouse Basin	report to PBAC
TerraGraphics Environmental Engineering, Inc., and Ralston Hydrologic Services	Palouse Ground Water Basin Framework Project Final Report	report to PBAC

Table 1 (cont.)

Researchers	Title	Product
	2012	
Attila Jonathan Bela Folnagy	Long-Term Grande Ronde Aquifer Stress Testing to Delineate Aquifer Compartmentalization and Water Level Responses in the Palouse Groundwater Basin	M.S. thesis
Nathan Moxley	Stable Isotope Analysis of Surface Water and Precipitation in the Palouse Basin: Hydrologic Tracers of Aquifer Recharge	M.S. thesis
TerraGraphics Environmental Engineering, Inc., and Ralston Hydrologic Services	Well Siting for Proposed Washington Department of Ecology Monitoring Wells in the Palouse Basin	report to PBAC
Andrew Spencer	Modeling Semi-Permeable Boundaries in the Palouse Groundwater Basin	Senior thesis
	2013	
Rick Conrey, Chris Beard and John Wolff	Geology of the Palouse Basin DOE test wells	PDF slide show presentation
Richard Conrey, Chris Beard and John Wolff	Columbia River Basalt Flow Stratigraphy in the Palouse Basin Department of Ecology Test Wells	report to PBAC
Attila J.B. Folnagy, James L. Osiensky, Daisuke Kobayashi and Kenneth F. Sprenke	Specific Storage from Sparse Records of Groundwater Response to Seismic Waves	publication
Dale Ralston, Robin Nimmer, and Chris Beard	WDOE Monitoring Well Installation Results	PDF slide show presentation
TerraGraphics Environmental Engineering, Inc., and Ralston Hydrologic Services	Draft Palouse Basin Monitor Well Construction Program	report to PBAC
	2014	
Erin Brooks, Jasper Candel, Roel Dijksma, Ricardo Sánchez-Murillo, Todd Anderson and Craig Woodruff	Identifying Hydrologic Recharge Connections in the Moscow Sub-basin Using Isotopic and Caffeine Tracers	progress report to PBAC
Jasper Candel	Identifying Hydrologic Recharge Connections in the Moscow Sub-basin	M.S. thesis
Rick Conrey and Kyler Crow	Basalt Stratigraphy of the Moscow #9 and UI #4 wells; Evidence for the Moscow Fault	PDF slide show presentation
Kyler Crow and Rick Conrey	The Clear Creek Fault at Glenwood Springs, WA	Powerpoint slide show presentation
Bryan J. Donaldson	Seasonal Evolution of Hydrologic Connectivity in a Tile-drained Agricultural Catchment; An Environmental Tracer Study	M.S. thesis

Table 1 (cont.)

Researchers	Title	Product
	2014	
Scott Ducar	Properties of the Grande Ronde Aquifer in the vicinity of Moscow, Idaho from the Synthesis of Aquifer Test Results with Seismic Groundwater Response	Senior thesis
Attila J.B. Folnagy, Kenneth F. Sprenke, James L. Osiensky and Daisuke Kobayashi	Generating Aquifer Specific Storage Properties from Groundwater Responses to Seismic Rayleigh Waves	poster
Mark W. Piersol and Kenneth F. Sprenke	Grande Ronde Basalt across the Kamiak Gap: the Gravity Model Revisited using Constraints from the DOE Butte Gap Monitoring Well	report to PBAC
	2015	
Mark W. Piersol and Kenneth F. Sprenke	A Columbia River Basalt Group Aquifer in Sustained Drought: Insight from Geophysical Methods [Revised May 2016]	publication
	2016	
E.S. Brooks, J. Candel, E. Verhoeff, M. Dobre, R. Sanchez-Murillo, G.W. Grader and R. Dijksma	Identifying Groundwater Recharge Pathways in the Moscow Sub-basin	PDF slide show presentation
John H. Bush, Dean L. Garwood and Pamela Dunlap	Geology and Geologic History of the Moscow-Pullman Basin, Idaho and Washington, from Late Grande Ronde to Late Saddle Mountains Time	publication
Jasper Candel, Erin Brooks, Ricardo Sánchez-Murillo, George Grader and Roel Dijksma	Identifying Groundwater Recharge Connections in the Moscow (USA) Sub-basin Using Isotopic Tracers and a Soil Moisture Routing Model	publication
	2018	
John H. Bush and Pamela Dunlap	Structure Contours on the Top of the Grande Ronde Basalt in the Moscow-Pullman Basin and Vicinity, Idaho and Washington	publication
John H. Bush, Pamela Dunlap, Stephen P. Reidel, and Daisuke Kobayashi	Geologic Cross Sections Across the Moscow-Pullman Basin, Idaho and Washington	publication
John H. Bush, Pamela Dunlap and Stephen P. Reidel	Miocene Evolution of the Moscow-Pullman Basin, Idaho and Washington	publication
John H. Bush and Pamela Dunlap	Geologic Interpretations of Wells and Important Rock Outcrops in the Moscow-Pullman Basin and Vicinity, Idaho and Washington	publication
	2019	
Kyle A. Duckett	Isotopic Discrimination of Aquifer Recharge Sources, Subsystem Connectivity and Flow Patterns in the South Fork Palouse River Basin, Idaho and Washington, USA	M.S. thesis

Table 1 (cont.)

Researchers	Title	Product
	2019	
Kyle A. Duckett, Jeff B. Langman, John H. Bush, Erin S. Brooks, Pamela Dunlap and Jeffrey M. Welker	Isotopic Discrimination of Aquifer Recharge Sources, Subsystem Connectivity and Flow Patterns in the South Fork Palouse River Basin, Idaho and Washington, USA	publication
Kyle A. Duckett, Jeff B. Langman, John H. Bush, Erin S. Brooks, Pamela Dunlap and Jessica R. Stanley	Noble Gases, Dead Carbon, and Reinterpretation of Groundwater Ages and Travel Time in Local Aquifers of the Columbia River Basalt Group	publication
John H. Bush, Pamela Dunlap, and Daisuke Kobayashi	A Collection of Geologic Maps, Cross Sections, and Schematic Diagrams that Illustrate the Subsurface Geology of the Moscow-Pullman Basin and Vicinity	report to PBAC
	2021	
Giacomo Medici, Nicholas B. Engdahl and Jeffery B. Langman	A Basin-Scale Groundwater Flow Model of the Columbia Plateau Regional Aquifer System in the Palouse (USA): Insights for Aquifer Vulnerability Assessment	publication
David Behrens	Tracing $\delta^{18}O$ and $\delta^{2}H$ in Source Waters and Recharge Pathways of a Fractured-Basalt and Interbedded-Sediment Aquifer, Columbia River Flood Basalt Province	M.S. thesis
David Behrens, Jeff B. Langman, Erin S. Brooks, Jan Boll, Kristopher Waynant, James G. Moberly, Jennifer K. Dodd and John W. Dodd	Tracing $\delta^{18}O$ and $\delta^{2}H$ in Source Waters and Recharge Pathways of a Fractured-Basalt and Interbedded-Sediment Aquifer, Columbia River Flood Basalt Province	publication
	2022	
John H. Bush, Steve Robischon, and Pamela Dunlap	Boundaries of the "Palouse Basin" Aquifer System in the Moscow-Pullman Area, Idaho and Washington	report to PBAC
Nicholas B. Engdahl	Critical Assessment and Recommendations for Future Research from the 2021 Moscow-Pullman Basin Aquifer Groundwater Model	report to PBAC
	2022, in progress	
Quinn Buzzard, Jeff B. Langman, David Behrens, Timothy C. Bartholomaus, and James G. Moberly	Monitoring the Ambient Seismic Field to Track Groundwater at a Mountain-Front Recharge Zone in the Columbia River Basalt Province	in progress for publication and M.S. thesis

OVERVIEW OF RECENT RESEARCH

1. Bennet (2009); Carey (2011)—These two University of Idaho theses added to and summarized earlier work on the upper aquifer in Moscow. The upper aquifer consists primarily of two parts the uppermost basalt of Lolo and the underlying Vantage sediments. These two portions are separated by a leaky aquitard consisting of the dense center of the basalt. Vertical recharge does occur from stream loss, overlying sediments of Bovill and soil percolation, but most of this water does not reach the lower aquifer. The upper aquifer recharges annually and is capable of being a renewable resource. The sediments are the primary producers which, by process of elimination, must receive significant lateral recharge.

2. Fiedler (2009); Moran (2011); Folnagy (2012)—These three University of Idaho theses used long term pump tests to determine several conclusions about the lower aquifer. Resources are compartmentalized but interconnected throughout the Palouse Basin on a long-term basis. Each study determined that significant recharge was occurring on an annual basis. There is not a major connection of this aquifer system with the Colfax area. Two authors believed that the lower aquifer in the City of Palouse area was connected to the Moscow-Pullman area while one questioned that connection. The aquifer system beneath Moscow is primarily a sediment, rather than a basalt, aquifer.

3. Conrey et al. (2010–2014)—Conrey (WSU GeoAnalytical Lab), with co-authors, made several presentations to PBAC. In addition to providing new and accurate well data they noted possible small, NW-trending faults and verified the existence of an up fold west of Pullman.

4. TerraGraphics and Ralston Hydrologic Services (2011, 2013)—These two reports provided a wealth of information and summaries of previous work. Their 2013 report showed the interconnection of the lower aquifer into the Union Flat Creek and City of Palouse area. The continued monitoring of water levels in wells that they established has provided crucial information on the rate of water decline.

5. Moxley (2012); Sinclair and Kardouni (2009); Piersol and Sprenke (2015 [2016])—The work by these researchers overlap and point to recharge in the lower aquifer in the Pullman area. In particular, recharge was noted along the South Fork River Palouse from Pullman to Albion. The reason for the recharge is the fact that the South Fork is located at the base of the basalt of Lolo and in the upper part of the Grande Ronde Basalt.

6. Grader (2011); Dijksma et al. (2011); Candel el al. (2016)—Grader discovered that geologic maps along the slopes of the western flanks of the southern Palouse Range are in error and many areas originally mapped as granite are, in fact, sediments and weathered granite. Erin Brooks (University of Idaho) with students from the Netherlands published articles reporting recharge into those sediments and weathered granites.

7. Bush et al. (2016–2022)—Five publications included a database of water well logs, a detailed geologic cross-section between Moscow and Pullman and a subsurface map illustrating geologic structures. Paleogeographic reconstructions show that the Palouse River, which once flowed north to south, reversed direction to flow north toward the City of Palouse via the Butte Gap area. Two reports to PBAC provided numerous illustrations on the geologic architecture of the subsurface and discussed the boundaries of the Palouse Basin.

8. Duckett (2019); Duckett et al. (2019); Behrens (2021); Behrens et al. (2021); Buzzard et al. (in progress)—These studies, lead by students of Jeff Langman (University of Idaho), reported on movement of ground water. Most important was the tracing of snowmelt waters from the southern Palouse Range to Pullman and the identification of dead carbon in lower aquifer wells which verified that the reported dates of carbon-14 for the groundwater are too old.

9. Medici et al. (2021); Engdahl (2022)—One publication and one report discussed numerical modeling of the Palouse Basin and noted the difficulty in predicting groundwater decline. The lack of data outside of the pumping centers was a major problem.

10. The continued reporting on monitoring wells and water-level trends by Steve Robischon (PBAC, 2009–2022) has been important to the understanding of the aquifer system. The most recent example is the comparison of the City of Palouse water-level decline trends to those recorded at the DOE Butte Gap well. The nearly perfect match of those trends verifies the groundwater connection between the two areas.

THE UPPER AQUIFER (WANAPUM AQUIFER), MOSCOW-PULLMAN—TEN FACTS

1. The upper aquifer is very compartmentalized, has variable water levels, and its pumping capacity ranges from <1 gpm to >1,300 gpm.

2. Upper aquifer waters are obtained from fractures in the basalt of Lolo and coarse-grained sediments in the Vantage Member in the Moscow-Pullman and City of Palouse areas.

3. Major municipal supplies are only obtainable from the upper aquifer in Moscow where the Vantage is thick and is recharged annually.

4. The basalt of Lolo averages 160 ft in thickness and extends over much of the Moscow-Pullman and surrounding areas. It has a dense, nearly impermeable center at most localities which prohibits significant vertical recharge.

5. The Vantage also extends over much of the area but is missing or is very thin (<5 ft) at some localities and can become very thick (> 250 ft) at others.

6. Most wells that penetrate only basalt produce low-yield domestic supplies.

7. The high-yield wells in Moscow are not connected to all wells in Moscow. Municipal pumping does not appear to affect upper aquifer wells in the Pullman area.

8. The thick Vantage beneath the Moscow area thins and consists mostly of clay west of the state line. The thin Vantage dominated by clays are in part the cause of upper aquifer low yield wells between Moscow and Pullman.

9. Recharge to the upper part of the basalt of Lolo in Moscow has been documented but most of these waters do not reach the base of the basalt.

10. West of Pullman in the Union Flat Creek area the upper aquifer consists of three basalt flows named from base upward as the Roza, the basalt of Lolo, and the Asotin. Interbeds are generally thin and the aquifer has produced domestic supplies only.

THE LOWER AQUIFER (GRANDE RONDE AQUIFER), MOSCOW-PULLMAN—TEN FACTS

1. Lower aquifer wells in Moscow and Pullman are some of the largest producers in the Columbia River Plateau.

2. Nearly all the municipal and university supplies are derived from the lower aquifer with water levels up to 150 ft below levels in the upper aquifer.

3. Water levels are similar from well to well but supplies are compartmentalized and not all wells are affected by other wells on a short-term basis.

4. Most new domestic wells between Moscow and Pullman obtain their waters from the lower aquifer.

5. The lower aquifer is connected to the Palouse city area and to the Union Flat Creek area west of Pullman. However, the nature of those connections are not well known.

6. In Pullman, the lower aquifer rocks consist mostly of basalt and are over 2,100 ft thick. However, the lower 1,100 ft does not contain the same prolific water producing zones as the upper 1,000 ft.

7. In Moscow, the lower aquifer rocks consist of mostly sediment and are about 800 ft in thickness. Basalt aquifers are thin and sediments are believed to be delivering waters to those aquifers.

8. The western slopes of the southern Palouse Range and streams in the Pullman area have been identified as areas of recharge.

9. Rubbly, fractured interflow zones and flow pinch outs in the lower Grande Ronde basalts are considered to be the mechanism by which waters move from the sediment areas on the east to the basalt areas on the west.

10. Lower aquifer waters do not flow toward the Snake River and the connection of the lower aquifer waters from Pullman to the Colfax area is not believed to be significant.

UPPER AQUIFER NATURAL IRON POLLUTION AND LATAH FORMATION SEDIMENTS, LATAH COUNTY, IDAHO—TEN FACTS

1. Many upper aquifer wells in Moscow and surrounding areas in Latah County produce waters that contain high amounts of iron and other elements. The water is often brown, smelly, and stains fixtures and containers.

2. Regionally, upper aquifer wells in basalt have higher concentrations of iron amounts than lower aquifer wells but not to the extent as those in Moscow.

3. The most contaminated wells have penetrated Latah sediments and are located close to higher elevation granitic basement rocks

4. Wells with excessive or high concentrations of iron west of Moscow in Washington are rare. Latah sediments are thin and/or are missing.

5. In the Palouse city area most domestic wells are in the base of the basalt of Lolo or in sands of the Vantage. Surrounding basement rocks are quartzitic rather than granitic. Excessive iron concentrations are rare.

6. In Moscow, iron in the upper aquifer is common despite continued recharge.

7. The upper Latah sediments are clay rich with layers, channels, and lenses of poorly-sorted iron-stained sand. Organic material and iron-cemented nodules are common throughout.

8. Weathered granitic rocks lack ferro-magnesium minerals common in non-weathered portions.

9. Weathering of the granitic rocks releases iron which precipitates as cement, stains and vesicle fillings. Where the iron comes in contact with organic material, iron bacteria form.

10. The iron, in general, does not reach the lower aquifer because of its removal (precipitation) out of the system.

TEN COMMON MYTHS ABOUT THE MOSCOW-PULLMAN AQUIFER SYSTEMS

1. MYTH: There is very little recharge. FACT: There are several research works in the past 13 years that documented significant recharge!

2. MYTH: Carbon-14 dates show that the groundwater is mostly old (Pleistocene). FACT: Reported dates are much too old and misleading!

3. MYTH: The aquifers are primarily basalt aquifers. FACT: Major aquifers are primarily sediments in Moscow and basalt and sediments in Pullman!

4. MYTH: The mountain slopes on the southern end of the Palouse Range (Moscow Mountain area) consist of granite underlying loess. FACT: Most of the area contains weathered granite or sediments overlying granite!

5. MYTH: The upper aquifer in Moscow dried up in the late 1950s. FACT: The upper aquifer was over pumped, not dried up, because it recharges 2–3 ft annually!

6. MYTH: If there is recharge to the lower aquifer it is vertical via the loess (or sediments of Bovill) and uppermost basalt flows. FACT: There is no significant vertical recharge over most of the central part of the Moscow-Pullman basin!

7. MYTH: All the aquifer rocks are horizontal. FACT: The rocks in western Pullman slope down to the west and northwest and are bent into upfolds and downfolds!

8. MYTH: Lower aquifer water in Pullman is not connected to Idaho. FACT: Snowmelt waters can be traced from the Moscow Mountain area to Pullman and from Moscow to Pullman!

9. MYTH: The rate of water decline is increasing each year. FACT: Water declines continue, but the rate of decline has been decreasing!

10. MYTH: The aquifers consist of subsurface lakes. FACT: The aquifers consist of saturated fractures and porous zones in basalt and sediment!

HISTORICAL NOTES ABOUT THE PALOUSE BASIN AQUIFERS

1. In the late 1800s and early 1900s, Moscow residents obtained their water from springs and shallow dug wells in the sediments of Bovill and the upper part of the basalt of Lolo. Water in the earliest basalt wells flowed out at the top into stream drainages. The city's first municipal well was hand dug into the sediments of Bovill and the upper part of basalt of Lolo.

2. In the 1920s, water levels dropped, and two new Moscow city wells were drilled in 1925 and the 1930s. The new wells penetrated the basalt and were completed in the Vantage Member. Prolific sources were obtained at the base of the Lolo and from the Vantage. These two wells provided the first evidence that the upper aquifer in Moscow consists of at least two major producing zones separated by a nearly impermeable center of the basalt of Lolo.

3. In the late 1800s and early 1900s, Pullman residents obtained their water from artesian wells (spouting up to 65 ft in height above ground) that were left flow into stream drainages. Those waters were derived from a zone that included the base of the basalt of Lolo, Vantage sediments and the uppermost Grande Ronde Basalt. Water level declines by the 1930s caused both the city and Washington State University to drill deeper into the Grande Ronde Basalts for additional supplies.

4. In the late 1940s, there was concern for water-level decline in the upper aquifer of Moscow. The general belief was that the aquifer was drying up but, in fact, the aquifer actually was being pumped beyond its annual recharge.

5. In 1955, deep wells into the lower aquifer were completed by the City of Moscow and the University of Idaho. Pumping from the city's upper aquifer wells was curtailed in the early 1960s after 35 years of continual use. A return to heavy pumping (<200 gallons/year) occurred in the early 1990's and ceased in 2017.

6. In the 1970s, there were several items of interest. Jones and Ross (1972) reported that the upper aquifer had not dried up and was recharging 2–3 ft each year. The Washington Department of Ecology drilled a test and observation well between Moscow and Pullman. Brown (1979) reported that the basalts were deformed in the Pullman area. Barker (1979) completed the first numerical model of the Moscow-Pullman area. He believed that there was a barrier to groundwater flow west of Pullman in the Union Flat Creek area. A committee made of individuals from both Washington and Idaho began to meet on a regular basis; this Moscow-Pullman Aquifer Committee later became PBAC.

7. In the 1980s: Klein et al. (1987) completed a geophysical survey of the Moscow-Pullman area. That study suggested the presence of a deep pre-basalt canyon and the possible existence of a subsurface high, possibly dikes, 5 miles southwest of Pullman. WSU well no. 7, a research-

production well completed to a depth of 2,205 ft, verified the presence of a deep pre-basalt canyon. The prolific water-bearing zones occurred above 1,000 ft in depth—in what was later determined to be in the R2 interval of the Grande Ronde Basalt.

8. In the 1990s: Lum et al. (1990) built a numerical model that suggested lowering of pumping would stabilize water decline. The two cities and universities went to considerable effort to reach those goals but water declines continued. One assumption in the model may have been the primary reason for its failure. The model assumed groundwater flow toward the Snake River canyon. Later studies showed that the basalts slope away from the canyon edges causing the water to flow to the northwest. Geologic mapping documented that loess in the Moscow area was underlain by thick Latah sediments (sediments of Bovill) on top of the basalt of Lolo. It was previously thought that thick loess covered both the basalt and granite beneath the City of Moscow. The Moscow-Pullman Aquifer Committee changed its name to the Palouse Basin Aquifer Committee. Moscow began annual pumping from the upper aquifer in the early 1990s.

9. In the early 2000s, a series of hearings and meetings occurred over a water-well permit for construction of a private well that could produce 3,000 gpm. The permit was eventually denied. The general belief developed from several research projects was that there was little or no modern recharge to the lower aquifer. That belief was later refuted.

10. In 2007, several government and university entities agreed to increase their annual fee to PBAC.

ACKNOWLEDGMENTS

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