


**Arizona Water Protection Fund
Application Cover Page
FY 2026**

WPF2604

Title of Project: Enhancing Rangeland and Riparian Health Along the Babocomari River													
Type of Project: <input checked="" type="checkbox"/> Capital or Other <input type="checkbox"/> Water Conservation <input type="checkbox"/> Research	Stream Type: <input type="checkbox"/> Perennial <input checked="" type="checkbox"/> Intermittent <input type="checkbox"/> Ephemeral												
Your level of commitment to maintenance of project benefits and capital improvements: <input type="checkbox"/> < 5 years <input type="checkbox"/> 5-10 years <input type="checkbox"/> 11-15 years <input checked="" type="checkbox"/> 16-20 years													
Applicant Information: Name/Organization: Arizona Department of Environmental Quality Address 1: 1110 W. Washington Street Address 2: City: Phoenix State: Arizona ZIP Code: 85007 Phone: 602.771.4565 Fax: Tax ID No.: XXXXXXXXXX													
Inside an AMA: Yes <input type="checkbox"/> No <input checked="" type="checkbox"/> If yes, which AMA: <input type="checkbox"/> Douglas <input type="checkbox"/> Phoenix <input type="checkbox"/> Pinal <input type="checkbox"/> Prescott <input type="checkbox"/> Santa Cruz <input type="checkbox"/> Tucson <input type="checkbox"/> Wilcox													
Type of Application: <input checked="" type="checkbox"/> New <input type="checkbox"/> Continuation													
Contact Person: Name: Jared Sprunger Title: Chief Financial Officer Phone: 602.771.0096 Fax: e-mail: sprunger.jared@azdeq.gov													
Any Previous AWPf Grants: <input checked="" type="checkbox"/> Yes <input type="checkbox"/> No If yes, please provide Grant #(s): 22-212 WPF													
Arizona Water Protection Fund Grant Amount Requested: \$372,978.63 If the application is funded, will the Grantee intend to request an advance: <input checked="" type="checkbox"/> Yes <input type="checkbox"/> No	Matching Funds Obtained and Secured: <table style="width:100%; border-collapse: collapse;"> <thead> <tr> <th style="text-align: left;"><u>Applicant/Agency/Organization:</u></th> <th style="text-align: right;"><u>Amount (\$):</u></th> </tr> </thead> <tbody> <tr> <td>1. Watershed Management Group</td> <td style="text-align: right;">8,350</td> </tr> <tr> <td>2. Arizona Land and Water Trust</td> <td style="text-align: right;">2,423</td> </tr> <tr> <td>3. Arizona Department of Environmental Quality</td> <td style="text-align: right;">20,000</td> </tr> <tr> <td></td> <td style="text-align: right;">application in process</td> </tr> <tr> <td align="right" colspan="2">Total: 30,773</td> </tr> </tbody> </table>	<u>Applicant/Agency/Organization:</u>	<u>Amount (\$):</u>	1. Watershed Management Group	8,350	2. Arizona Land and Water Trust	2,423	3. Arizona Department of Environmental Quality	20,000		application in process	Total: 30,773	
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	application in process												
Total: 30,773													
Has your legal counsel or contracting authority reviewed and accepted the Grant Award Contract General Provisions? <input type="checkbox"/> Yes <input type="checkbox"/> No <input checked="" type="checkbox"/> N/A													
Signature of the undersigned certifies understanding and compliance with all terms, conditions and specifications in the attached application. Additionally, signature certifies that all information provided by the applicant is true and accurate. The undersigned acknowledges that intentional presentation of any false or fraudulent information, or knowingly concealing a material fact regarding this application is subject to criminal penalties as provided in A.R.S. Title 13. The Arizona Water Protection Fund Commission may approve Grant Awards with modifications to scope items, methodology, schedule, final products and/or budget.													
Jared Sprunger	Chief Financial Officer 602.771.0096												
Typed Name of Applicant or Applicant's Authorized Representative	Title and Telephone Number												
	8/15/2025												
Signature	Date Signed												

Enhancing Rangeland and Riparian Health Along the Babocomari River

Executive Summary

The 25-mile stretch of the Babocomari River begins at the Mustang Mountains near Sierra Vista, Arizona, and joins the San Pedro River, one of the last, large undammed rivers in the Southwest. The watershed is home to millions of migrating birds per year and supports species unique to the Chihuahuan and Sonoran Deserts, like the jaguar and yellow-billed cuckoo. Both rivers are stressed, however, by drought and development.

The Arizona Department of Environmental Quality (ADEQ) has listed both rivers as impaired for E.coli, which means the presence of that parameter exceeds surface water quality standards protective of public health. E.coli contamination indicates the presence of fecal matter and potential pathogens, posing a serious risk of waterborne illness to humans and animals.

To reduce contamination and restore flows, ADEQ, Watershed Management Group (WMG), and the Arizona Land and Water Trust (ALWT) are partnering together for a project that will restore natural hydrological function and reduce erosion across 1,000 acres of private and state land within the Babocomari watershed and directly treat 0.6 miles of Babocomari River to enhance riparian health. Beginning in 2018, ADEQ initiated a comprehensive watershed assessment that characterized pervasive erosion, severe riparian degradation, and significant hydrologic impairments that critically impact the watershed's contribution to the vital upper San Pedro River system. Since then, ADEQ and WMG have implemented several restoration projects to reduce sediment, provide stormwater control, and better manage upland areas.

Together, along with a coalition of motivated private landowners, ADEQ and WMG are leveraging prior assessments and new field insights to guide targeted strategies that reduce sediment transport, improve channel stability, and support riparian vegetation recovery. These efforts directly align with the Arizona Water Protection Fund's mission by promoting improved watershed function, aquifer recharge, and long-term water resource sustainability in a region facing ecological and hydrologic stress.

Restoration actions will be conducted on private land and Arizona State Land to improve drainages, realign floodplain diversions, stabilize advancing headcuts, install in-channel post-assisted log structures, and remove invasive, water-intensive mesquite trees. The overarching goal is to reestablish broad, shallow surface flow—conditions typical of healthy desert floodplains—to enhance infiltration and reconnect riparian vegetation and stream channels. Long-term benefits include reduced vegetation stress, improved ecological function, and protection of downstream water quality.

Enhancing Rangeland and Riparian Health Along the Babocomari River

Project Overview

Background

The project area spans private lands and Arizona State Land Department parcels west of Huachuca City, extending along the Babocomari River, a discontinuous perennial–intermittent channel. Participating private parcels include the Emmerson, Pyeatt, and Babocomari Ranches, as well as a grazing lease held by Sid Kahla, which includes both the Emmerson parcel and adjacent Arizona State Land. The project areas within the private lands are under a conservation easement held by ALWT, a partner on this proposal.

This stretch of the Babocomari River and its three primary tributaries—Blacktail Draw, Tributary 2, and Tributary 3—show significant signs of anthropogenic disturbance. Observed impacts include headcuts, historic tank fills, road drainage-induced erosion, and altered flow paths.

The Arizona Department of Environmental Quality (ADEQ) originally listed Babocomari River as impaired for E.coli and sediment in 2019. The downstream reach of the San Pedro River (HUC 15050202-003) also remains impaired for E.coli and dissolved oxygen (DO), with listings dating back to 2004 and 2021, respectively. While the Babocomari River has shown water quality improvements, continued efforts are needed to maintain these gains and improve the downstream San Pedro River.

Numerous studies support the effectiveness of watershed restoration practices—such as grade control structures, riparian revegetation, and erosion control—in improving water quality and stream function. Research led by the University of Arizona (e.g., Biedenbender et al., 2020) has shown that re-establishing native vegetation and restoring upland hydrology can significantly reduce sediment and E. coli transport in semi-arid watersheds. Similarly, ASU's Central Arizona–Phoenix Long-Term Ecological Research (CAP LTER) has documented that natural infrastructure improves infiltration, slows runoff, and enhances microbial activity that helps degrade pollutants. These practices are particularly impactful in intermittent streams like the Babocomari, where restoring natural flow paths contributes to both ecological and water quality resilience.

This project builds on previous assessments and restoration plans by targeting mid-reach erosion and riparian degradation. It is supported by cooperating private landowners and agencies working to reduce nonpoint source pollution, improve water quality, and restore riparian ecosystem health.

Additionally, this project will help contribute to the collective conservation and restoration efforts across the Babocomari River watershed, as recorded in The Nature Conservancy's recent watershed assessment. This includes recently installed grade control structures along an adjacent drainage on the Emmerson parcel led by ALWT, removal of invasive bullfrogs along the Babocomari River, and herbicide treatments to reduce upland woody vegetation by the Emmerson and Arizona State Land grazing lessee.

Goals

Goal 1: Reduce sediment and E. coli contributions to downstream Babocomari River.

Goal 2: Enhance riparian stream health and habitat in an intermittent-perennial reach of Babocomari River.

Objectives

Objective 1.1: Restore historic sheet flow of upland floodplains and improve infiltration.

Objective 1.2: Arrest erosion headcuts to reduce downstream sediment loading.

Objective 2.1: Increase stream flow permanence, especially during dry years.

Objective 2.2: Increase riparian tree recruitment and habitat diversity.

Statement of Problems / Causes

The Babocomari watershed has legacy stock tanks, flow diversions, mesquite invasion, and concentrated flows caused by poor road drainage which have degraded the upland landscape and impaired instream habitat.

Natural flow patterns have shifted from sheet flows to concentrated, high energy flows due to legacy diversion structures.

Compacted upland floodplain soils and mesquite invasion have limited infiltration capacity and vegetative recovery resulting in erosive nickpoint headcuts carving out these upland floodplains and contributing to Babocomari River water quality impairments. Additionally, this shift in the upland hydrologic capacity has contributed to incision in the river, reduced instream floodplain connection, and decreased wetted extent during the dry season.

Statement of Solutions

The comprehensive approach of this project is focused on restoring natural hydrologic function of upland drainages to enhance river health from a water quality and water permanence perspective. This restoration of hydrologic function will have a positive feedback loop to improve upland vegetative and landscape health as well as improved riparian habitat health within the Babocomari River.

Upland tributary headcut controls will utilize rock and brush structures to assist with grade control and slowing and spreading concentrated flows. These are proven, cost effective structures that make use largely of locally sourced onsite materials and can be easily maintained.

Additional attention will be focused on the upland floodplain areas immediately prior to discharge to Babocomari River on both the Emmerson and Pyeatt Ranches. On the Emmerson Ranch this will include enhanced infiltration of the historic grassy bottomlands using Keyline plowing and mesquite removal. On the Pyeatt Ranch, concentrated flow paths will have rock and sacaton grass plugs installed to facilitate spreading of flows to wet a wider area of the sacaton bottomland and diminish erosive energy.

Lastly, in-stream post-assisted log structures (PALS) and pole plantings of riparian trees will help to slow river flows and support critical riparian habitat recovery. These PALS and pole planting strategies have proven effective downstream along the lower Babocomari River -- installed by Watershed Management Group -- and also the lower San Pedro River -- installed by Arizona Game and Fish Department. In both locations previously treated, the wetted extent during the dry season has increased.

Statement of Project Years of Benefit to the Resource and General Public

This 3-year Babocomari River project is expected to provide sustained ecological and water quality benefits for at least 15 to 20 years or longer. The Babocomari watershed is a valued resource for public enjoyment, education, and community engagement. Many people visit Babocomari Ranch and surrounding areas for recreational activities such as birdwatching, hiking, photography, horseback riding, and enjoying the scenic beauty of the unique riparian ecosystem.

As our project restores and stabilizes native vegetation, reduces sedimentation, and enhances streamflows, we anticipate improved wildlife habitat, increased biodiversity, and enhanced aesthetic values that the public greatly appreciates. Additionally, stabilized riparian areas lead to healthier watersheds, improved water quality, and reduced flood risk downstream, directly benefiting residents and visitors alike.

We believe public support and stewardship of water quality and riparian health are essential. Improved riparian health not only maintains vital ecosystem functions but also sustains the quality of life and recreational opportunities valued by local communities and visitors. We are committed to ongoing engagement and outreach to educate the public about these ecological and recreational benefits, fostering a lasting appreciation and commitment to conservation efforts.

ALWT who manages the conservation easement and serves as a key partner in this project, will assist in monitoring long-term ecological outcomes and ensuring ongoing public engagement beyond the formal project period.

Project Location & Environmental Contaminant Information FY 2026

Project Location Information			
1. County: <u>Cochise</u>	2. Section(s): <u>1, 2, 8, 11, 12, 18</u>	3. Township: <u>T21S</u>	4. Range: R19E
<p>5. Watershed: <u>Babocomari Watershed</u></p> <p>6. 8 or 10 Digit Hydrologic Unit Code (HUC) [hyperlink goes to US Geological Survey website]: <u>1505020208</u></p> <p>7. Name of USGS Topographic Map where project area is located: <u>Elgin 7.5 quad</u></p> <p>8. State Legislative District: <u>19</u> (Information available at: https://redistricting-irc-az.hub.arcgis.com/pages/official-maps)</p> <p>9. Land ownership of project area: <u>Emmerson, State Land, Pyeatt, Babocomari Ranches (Brophy's)</u></p> <p>10. Current land use of project area: <u>Grazing</u></p> <p>11. Size of project area (in acres): <u>1000</u></p> <p>12. Stream Name: <u>Babocomari River</u></p> <p>13. Length of stream through project area: <u>0.6 miles</u></p> <p>14. Miles of stream benefited: <u>3.5 miles</u></p> <p>15. Acres of riparian habitat: <u>984 of upland and riparian acres</u> will be:</p> <div style="margin-left: 40px;"> <input type="checkbox"/> Enhanced <input type="checkbox"/> Maintained <input checked="" type="checkbox"/> Restored <input type="checkbox"/> Created </div>			
<p>16. General description and/or delineation for the area of impact of the project within the watershed.</p> <p>The project area is located within the Babocomari River subwatershed (HUC 1505020208) in Cochise County, Arizona. The restoration footprint spans approximately 3.5 miles of upland ephemeral drainages and 10 acres of riparian habitat along the Babocomari River corridor. These areas are characterized by mesquite-encroached grasslands, intermittent stream channels, and degraded floodplain zones with reduced infiltration and gully erosion. The site falls within Township 21S, Range 18E, and includes historically grazed lands prioritized for vegetation recovery, infiltration enhancement, and sediment retention.</p>			
<p>17. Provide directions to the project site from the nearest city or town. List any special access requirements:</p> <p>From Huachuca City, AZ, travel south on Highway 90 for approximately 2 miles. Turn west onto a local ranch road (private or BLM access, depending on final project boundary) and continue for approximately 0.5 to 1 mile to reach the project staging area near the Babocomari River floodplain. Access is via private ranch roads and may require coordination with landowners. Four-wheel drive is recommended during wet conditions.</p>			
Environmental Contaminant Location Information			

1. Does your project site contain known environmental contaminants? **YES** **NO** If yes, please identify the contaminant(s) and enclose data about the location and levels of contaminants:
2. Are there known environmental contaminants in the project vicinity? **YES** **NO** If yes, please identify the contaminant(s) and enclose data about the location and levels of contaminants:
3. Are you asking for Arizona Water Protection Fund monies to identify whether or not environmental contaminants are present? **YES** **NO**

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Enhancing Rangeland and Riparian Health Along the Babocomari River

Scope of Work

Task # 1: Permits & Access Agreements

Task Description: Secure all necessary permissions from landowners, Arizona SHPO, 404/Nationwide 27, and relevant agencies. All private landowners and ALWT as the conservation easement holder have provided letters of support for access to their properties. ADEQ and WMG will work with Sid Kahla as the grazing lessee to submit and receive a permit from the Arizona State Land Department for proposed work on state lands. Obtain any necessary subcontract agreements with project contractors.

Task Purpose/Objective: To comply with all local, state, and federal permit requirements, environmental laws, and insure legal access to the project area for the project term.

Responsible Personnel: ADEQ, Liz Boettcher

Deliverable Description: Copies of all necessary permits, clearances, authorizations, and subcontract agreements with project contractors to implement the Scope of Work.

Deliverable Due Date: Prior to initiation of any applicable subcontracted work or any ground-disturbing activities. Estimated to be completed by July 2026.

Task Cost (rounded to the nearest dollar): \$43,688.61

Task # 2: Monitoring and Project Design

Task Description: Finalize project designs for road drainage improvements, arroyo realignment, and headcut stabilization structures, and establish and conduct pre-construction and annual monitoring for project areas.

WMG, in collaboration with ADEQ and ALWT, and in coordination with the grazing lessee, will develop a monitoring plan and detailed project plan and implementation schedule. The monitoring plan will include pre- and post- treatment photo monitoring and annual post-summer monsoon structure performance assessment which is intended to assess how structures respond to monsoon events, primarily through visual inspection at the end of the season. Photo monitoring will continue through the duration of the project. Long-term landscape health monitoring, following the project, will be documented as part of ALWT's existing annual conservation easement monitoring.

ADEQ and citizen scientists from the region will conduct water quality sampling to measure parameters including E. coli, dissolved oxygen, turbidity, pH, and conductivity, contingent upon sufficient surface flow conditions. Sampling will occur pre- and post-treatment, as well as periodically following the summer monsoon season to assess seasonal changes and evaluate project effectiveness. ADEQ may also support photo monitoring. Additional monitoring methods could include erosion pin measurements for tracking sediment movement, fixed-point photography to document visual site changes, and drone-based vegetation indexing to quantify improvements in vegetative cover over time.

Task Purpose/Objective: To develop appropriate plans and assess and measure improvements to riparian health and water quality of the Babocomari River.

Responsible Personnel: ADEQ and WMG Project Manager

Deliverable Description: ADEQ will submit the monitoring and project plans, and annual monitoring reports of the repeat photo observations, performance assessment notes, and any water quality sample results.

Deliverable Due Date: Monitoring and Project Plans will be submitted prior to the initiation of on-the-ground restoration activities. Project plans and initial monitoring plan estimated to be completed by June 2026. Annual monitoring reports will be submitted by October 31.

Task Cost (rounded to the nearest dollar): \$31,269

Task # 3: Project Implementation

Task Description: WMG, in collaboration with ADEQ, ALWT, and in coordination with the grazing lessee, will implement the Project Plans under Task #2. Other private landowners will be informed for coordination purposes and may participate informally. The planned actions include:

- A) Install grade control structures along up to 5 miles of priority ephemeral arroyo channels along the Arizona State Land and Emmerson parcels.
- B) Re-align incised drainage features contributing to downstream floodplain erosion on the Emmerson parcel.
- C) Implement in-channel post-assisted log structures and riparian tree pole plantings to slow flow and enhance infiltration along 3,500 linear feet of the Babocomari River on Babocamari Ranch lands.
- D) Remove encroaching mesquite to restore grassland vegetation and infiltration capacity within the historic upland floodplain on the Emmerson parcel.
- E) Implement channel spreaders to enhance sacaton bottomlands (330 acres) on the Pyeatt Ranch and reduce erosive, incised concentrated channel flows.

Overall, the project will address approximately 3.5 miles of upland ephemeral drainage, treat 16 acres of ephemeral floodplain, reduce gully headcutting, improve up to 10 acres of riparian habitat along the Babocomari River, and benefit up to 330 acres of sacaton floodplain upstream of the Babocomari River.

The erosion control and restoration plan will be implemented through a combination of WMG restoration staff, contracted restoration crew services, and volunteer labor. The ephemeral and upland restoration strategies will include channel and landscape restoration rock features such as loose-rock and brush grade control structures, media lunas, and shallow contour earthworks to facilitate spreading and soaking of flows across terraced floodplains.

The re-alignment of an incised drainage will consist of a rock vane structure to facilitate flows to re-engage the historic valley bottom to reduce pressure downstream of its current drainage pattern which is creating valley bottom headcuts.

Restoration strategies to enhance Babocomari River intermittent riparian reaches will include post-assisted log structures to facilitate floodplain connection, and pole-planting of riparian tree cuttings, and grass plugs in the channel. Reseeding of disturbed upland areas may be conducted depending on availability of local, native seed source.

The Pyeatt Ranch work which includes a small portion of the west end of the Babocomari Ranch will consist of sacaton plugs and rock structures. The plug and spreads will require a backhoe to implement. The structures will not impound water, simply force flows to spread across the valley bottom to increase infiltration and reduce erosion.

All features will be constructed in a manner that shall ensure that surface water is not retained or being prevented from flowing past the structures, or include any other feature which would otherwise require a surface water right.

Education-based workdays with restoration practitioners and volunteers will be incorporated into the construction activities to help grow shared knowledge and informed practice while building long-term stewardship needs and goals for Arizona's creeks and rivers.

Task Purpose/Objective: The expected objectives of all restoration strategies to be employed is to slow concentrated flows, enhance infiltration, and facilitate vegetative response, with the expected outcomes of improving water quality and intermittent stream drought resilience in the Babocomari River and upland vegetative resilience.

Responsible Personnel: WMG Project Lead

Deliverable Description: ADEQ will submit quarterly progress reports which describe and document restoration features, photos, location, and acreage of hydrologic impact.

Deliverable Due Date: Quarterly reports during project duration. Estimated project treatments to be completed by May 2028.

Task Cost (rounded to the nearest dollar): \$295,789

Task # 4: Final Report & Presentation

Task Description: Submit a final report documenting methods, outcomes, and recommendations. Present findings to stakeholders and AWPf board.

ADEQ and WMG will develop a final report and presentation to share project results and lessons learned with Arizona Water Protection Fund staff and commissioners. Project work and presentation will also be shared with the Ft. Huachuca Sentinel Landscape Restoration Partnership.

Task Purpose/Objective: To provide a comprehensive final report for public distribution that gives a description of the project and highlights its benefits to the State of Arizona.

Responsible Personnel: ADEQ and WMG Project Manager

Deliverable Description: Final presentation before the Commission and a Project final report

Deliverable Due Date: Project final report – by October 31, 2028; Final Presentation before the Commission – by Dec 31, 2028

Task Cost (rounded to the nearest dollar): \$2,232

NOTE: This table is provided as a guide to help develop your project budget and AWPf fund grant request.

Arizona Water Protection Fund Grant Application Detailed Budget

Proposal: Enhancing rangeland and riparian health along the Babocomari River

Task 1: Permits and Access Agreements				
	Quantity	Unit	Unit Cost	Total
Direct Labor Costs				
WMG Project Supervisor and Lead	200	per hour	\$ 50.00	\$10,000.00
WMG Fringe			35%	\$3,500.00
Direct Labor Subtotal				\$13,500.00
Outside Service Costs				
ALWT Conservation Manager	40	per hour	\$ 50.48	\$2,019.20
Archeological Survey for SHPO clearance	1	each	\$ 20,000.00	\$20,000.00
404 Permit Application Contractor	1	each	\$5,000.00	\$5,000.00
Outside Services Subtotal				\$27,019.20
Other Direct Costs				
Arizona State Land Office Permit Fee	1	each	\$151.00	\$151.00
Other Direct Subtotal				\$151.00
Capital Outlay, Equipment, Supplies, etc.				
<i>NOTE: Any reimbursement requested for costs related to travel, lodging, meals, and/or mileage must comply with the State of Arizona Accounting Manual rates and guidelines. (https://gao.az.gov/state-arizona-accounting-manual-saam)</i>				
<i>Personal vehicle mileage reimbursement is limited to sixty-seven cents (67¢) per mile.</i>				
WMG Vehicle mileage	1400	per mile	\$ 0.67	\$938.00
Other Direct Subtotal				\$938.00
Task Subtotal				\$41,608.20
Optional: AWPf Administrative Costs (not to exceed 5% of Task Subtotal)				\$2,080.41

Task 1 Total	\$43,688.61
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Task 2: Monitoring and Project Design				
	Quantity	Unit	Unit Cost	Total
Direct Labor Costs				
WMG Project Supervisor and Lead	400	per hour	\$ 50.00	\$20,000.00
WMG Fringe			35.00%	\$7,000.00
Direct Labor Subtotal				\$27,000.00
Outside Service Costs				
ALWT Conservation Manager	20	per hour	\$ 50.48	\$1,009.60
Outside Services Subtotal				\$1,009.60
Other Direct Costs				
ESRI ArcGIS license and credits	3	annual	\$215.00	\$645.00
Other Direct Subtotal				\$645.00

Capital Outlay, Equipment, Supplies, etc. <i>NOTE: Any reimbursement requested for costs related to travel, lodging, meals, and/or mileage must comply with the State of Arizona Accounting Manual rates and guidelines. (https://gao.az.gov/state-arizona-accounting-manual-saam)</i> <i>Personal vehicle mileage reimbursement is limited to sixty-seven cents (67¢) per mile.</i>				
WMG Vehicle Mileage	1680	per mile	\$ 0.67	\$1,125.60
Other Direct Subtotal				\$1,125.60
Task Subtotal				\$29,780.20
Optional: AWPf Administrative Costs (not to exceed 5% of Task Subtotal)				\$1,489.01

Task 2 Total	\$31,269.21
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Task 3: Project Implementation				
	Quantity	Unit	Unit Cost	Total
Direct Labor Costs				
WMG Project Lead	88	daily	\$ 800	\$70,400.00
WMG Project Assist	104	hourly	\$ 60.00	\$6,240.00
WMG Restoration Apprentices	60	daily	\$ 616.00	\$36,960.00
WMG Fringe (FTE)			35%	\$26,824.00
WMG Fringe (PTE)			20%	\$7,392.00
Direct Labor Subtotal				\$147,816.00
Outside Service Costs				
ALWT Conservation Manager	208	hour	\$ 50.48	\$10,499.84
Restoration Crew	32	daily	\$ 1,898.00	\$60,736.00
Restoration Contractor, Equipment operator	24	daily	\$ 1,500.00	\$36,000.00
Outside Services Subtotal				\$107,235.84
Other Direct Costs				
Excavator rental, insurance, and fuel	10	weekly	\$ 1,000.00	\$10,000.00
Riprap for erosion control and delivery	5	per truck	\$ 700.00	\$3,500.00
Restoration seed and grass plugs	1	total	\$ 2,000.00	\$2,000.00
Other Direct Subtotal				\$15,500.00
Capital Outlay, Equipment, Supplies, etc. <i>NOTE: Any reimbursement requested for costs related to travel, lodging, meals, and/or mileage must comply with the State of Arizona Accounting Manual rates and guidelines. (https://gao.az.gov/state-arizona-accounting-manual-saam)</i> <i>Personal vehicle mileage reimbursement is limited to sixty-seven cents (67¢) per mile.</i>				
WMG Vehicle mileage	5600	per mile	\$ 0.67	\$3,752.00
WMG travel reimbursement	90	overnights	\$ 60.00	\$5,400.00
Hand tools and PPE for crew and volunteers	1	total	\$ 2,000.00	\$2,000.00
Other Direct Subtotal				\$11,152.00
Task Subtotal				\$281,703.84
Optional: AWPf Administrative Costs (not to exceed 5% of Task Subtotal)				\$14,085.19

Task 3 Total	\$295,789.03
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Task 4: Final Report and Presentation				
	Quantity	Unit	Unit Cost	Total
Direct Labor Costs				
WMG Project Supervisor and Lead	30	hour	\$ 50.00	\$1,500.00
WMG Fringe			35.00%	\$525.00
Direct Labor Subtotal				\$2,025.00

Outside Service Costs				
Outside Services Subtotal				\$0.00
Other Direct Costs				
Other Direct Subtotal				\$0.00
Capital Outlay, Equipment, Supplies, etc.				
<i>NOTE: Any reimbursement requested for costs related to travel, lodging, meals, and/or mileage must comply with the State of Arizona Accounting Manual rates and guidelines. (https://gao.az.gov/state-arizona-accounting-manual-saam)</i>				
<i>Personal vehicle mileage reimbursement is limited to sixty-seven cents (67¢) per mile.</i>				
WVG Mileage	150	per mile	\$ 0.67	\$100.50
Other Direct Subtotal				\$100.50
Task Subtotal				\$2,125.50
Optional: AWPB Administrative Costs (not to exceed 5% of Task Subtotal)				\$106.28

Task 4 Total	\$2,231.78
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Arizona Water Protection Fund Grant Application Fund Request	\$372,978.63
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up to 4 trips per year to setup and conduct monitoring, including initial project plan refinement

Notes

estimated cost to support each field day of 1 staff, 10 days per mo, 3mo/yr, 2 years
Project assistance to engage community members, recruit and coordinate volunteers
estimated cost to support each field day of 2 apprentices for 10 days per mo, 3 mo/yr, 2 years
Includes fringe benefits at 35%
Includes fringe benefits at 20%

2hr per week for 2 years
includes travel, 3 person crew
includes travel, and reimburseable incidentals

supplemental rock for erosion control
seed to support revegetation of disturbed areas, and grass plugs to support in-channel
revegetation

up to 40 trips to support project implementation over 2 years
30 overnights for 3 staff over 2 years, \$60/overnight
tools and PPE to support project work

Notes

includes report development and presentation delivery
Includes fringe benefits at 35%

NOTE: This table is provided as a guide to help develop your project budget and matching funds / project cost share budget. Feel free to modify this table as needed to accurately describe your proposed budget details.

Matching Funds / Cost Share Budget

Task 1: Permits and Access Agreements					
	Quantity	Unit	Unit Cost	Total	Notes
Direct Labor Costs					
Direct Labor Subtotal				\$0.00	
Outside Service Costs					
Outside Services Subtotal				\$0.00	
Other Direct Costs					
Other Direct Subtotal				\$0.00	
Capital Outlay, Equipment, Supplies, Per Diem, Travel, etc.					
Other Direct Subtotal				\$0.00	
Task Subtotal				\$0.00	
Task 1 Total				\$0.00	

Task 2: Monitoring and Project Design					
	Quantity	Unit	Unit Cost	Total	Notes
Direct Labor Costs					
Direct Labor Subtotal				\$0.00	
Outside Service Costs					
ALWT Conservation Manager	6	days	\$403.84	\$2,423.04	estimated annual value for conservation easement parcel monitoring for 3 years
Outside Services Subtotal				\$2,423.04	
Other Direct Costs					
Other Direct Subtotal				\$0.00	
Capital Outlay, Equipment, Supplies, Per Diem, Travel, etc.					
Other Direct Subtotal				\$0.00	
Task Subtotal				\$2,423.04	
Task 2 Total				\$2,423.04	

Task 3: Project Implementation					
	Quantity	Unit	Unit Cost	Total	Notes
Direct Labor Costs					
Project Volunteers	240	hours	\$34.79	\$8,349.60	4 volunteer workshops, 6hrs, 10 persons
Direct Labor Subtotal				\$8,349.60	
Outside Service Costs					
Outside Services Subtotal				\$0.00	
Other Direct Costs					
ADEQ Lower Babocomari Restoration Grant to WMG	1	grant award	\$20,000.00	\$20,000.00	estimated remaining funds to coincide with grant time period
Other Direct Subtotal				\$20,000.00	
Capital Outlay, Equipment, Supplies, Per Diem, Travel, etc.					

	Other Direct Subtotal			\$0.00	
Task Subtotal				\$28,349.60	
			Task 3 Total	\$28,349.60	

Task 4: Final Report and Presentation					
	Quantity	Unit	Unit Cost	Total	Notes
Direct Labor Costs					
	Direct Labor Subtotal			\$0.00	
Outside Service Costs					
	Outside Services Subtotal			\$0.00	
Other Direct Costs					
	Other Direct Subtotal			\$0.00	
Capital Outlay, Equipment, Supplies, Per Diem, Travel, etc.					
	Other Direct Subtotal			\$0.00	
Task Subtotal				\$0.00	
			Task 4 Total	\$0.00	

NOTE: This table is provided as a guide to help develop your project budget and matching funds / project cost share budget. Feel free to modify this table as needed to accurately describe your proposed budget details.

Matching Funds / Cost Share Budget

Task 1: Permits and Access Agreements					
	Quantity	Unit	Unit Cost	Total	Notes
Direct Labor Costs					
Direct Labor Subtotal				\$0.00	
Outside Service Costs					
Outside Services Subtotal				\$0.00	
Other Direct Costs					
Other Direct Subtotal				\$0.00	
Capital Outlay, Equipment, Supplies, Per Diem, Travel, etc.					
Other Direct Subtotal				\$0.00	
Task Subtotal				\$0.00	
Task 1 Total				\$0.00	

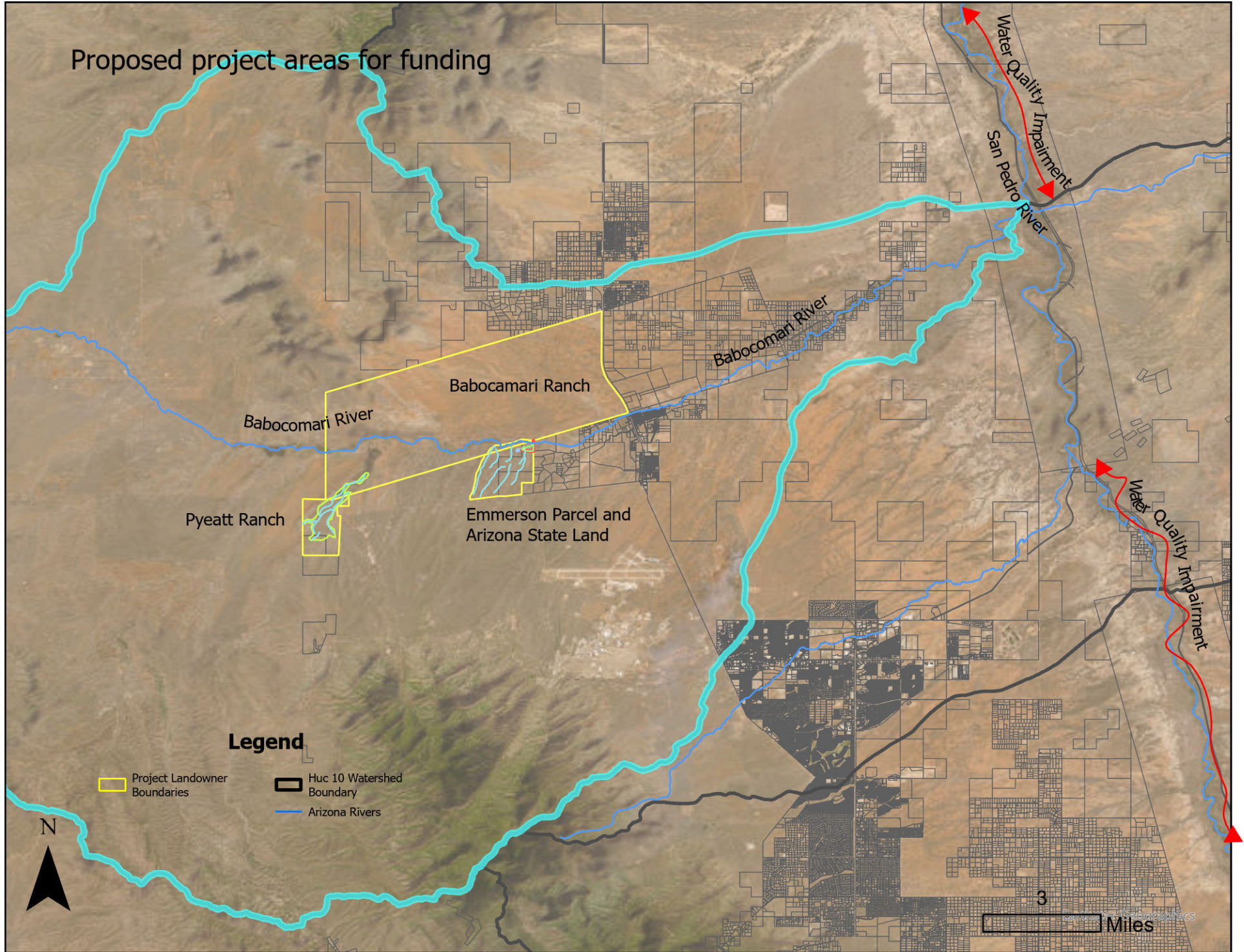
Task 2: Monitoring and Project Design					
	Quantity	Unit	Unit Cost	Total	Notes
Direct Labor Costs					
Direct Labor Subtotal				\$0.00	
Outside Service Costs					
ALWT Conservation Manager	6	days	\$403.84	\$2,423.04	estimated annual value for conservation easement parcel monitoring for 3 years
Outside Services Subtotal				\$2,423.04	
Other Direct Costs					
Other Direct Subtotal				\$0.00	
Capital Outlay, Equipment, Supplies, Per Diem, Travel, etc.					
Other Direct Subtotal				\$0.00	
Task Subtotal				\$2,423.04	
Task 2 Total				\$2,423.04	

Task 3: Project Implementation					
	Quantity	Unit	Unit Cost	Total	Notes
Direct Labor Costs					
Project Volunteers	240	hours	\$34.79	\$8,349.60	4 volunteer workshops, 6hrs, 10 persons
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Other Direct Costs					
ADEQ Lower Babocomari Restoration Grant to WMG	1	grant award	\$20,000.00	\$20,000.00	estimated remaining funds to coincide with grant time period
Other Direct Subtotal				\$20,000.00	
Capital Outlay, Equipment, Supplies, Per Diem, Travel, etc.					

Other Direct Subtotal				\$0.00	
Task Subtotal				\$28,349.60	
			Task 3 Total	\$28,349.60	

Task 4: Final Report and Presentation					
	Quantity	Unit	Unit Cost	Total	Notes
Direct Labor Costs					
Direct Labor Subtotal				\$0.00	
Outside Service Costs					
Outside Services Subtotal				\$0.00	
Other Direct Costs					
Other Direct Subtotal				\$0.00	
Capital Outlay, Equipment, Supplies, Per Diem, Travel, etc.					
Other Direct Subtotal				\$0.00	
Task Subtotal				\$0.00	
			Task 4 Total	\$0.00	

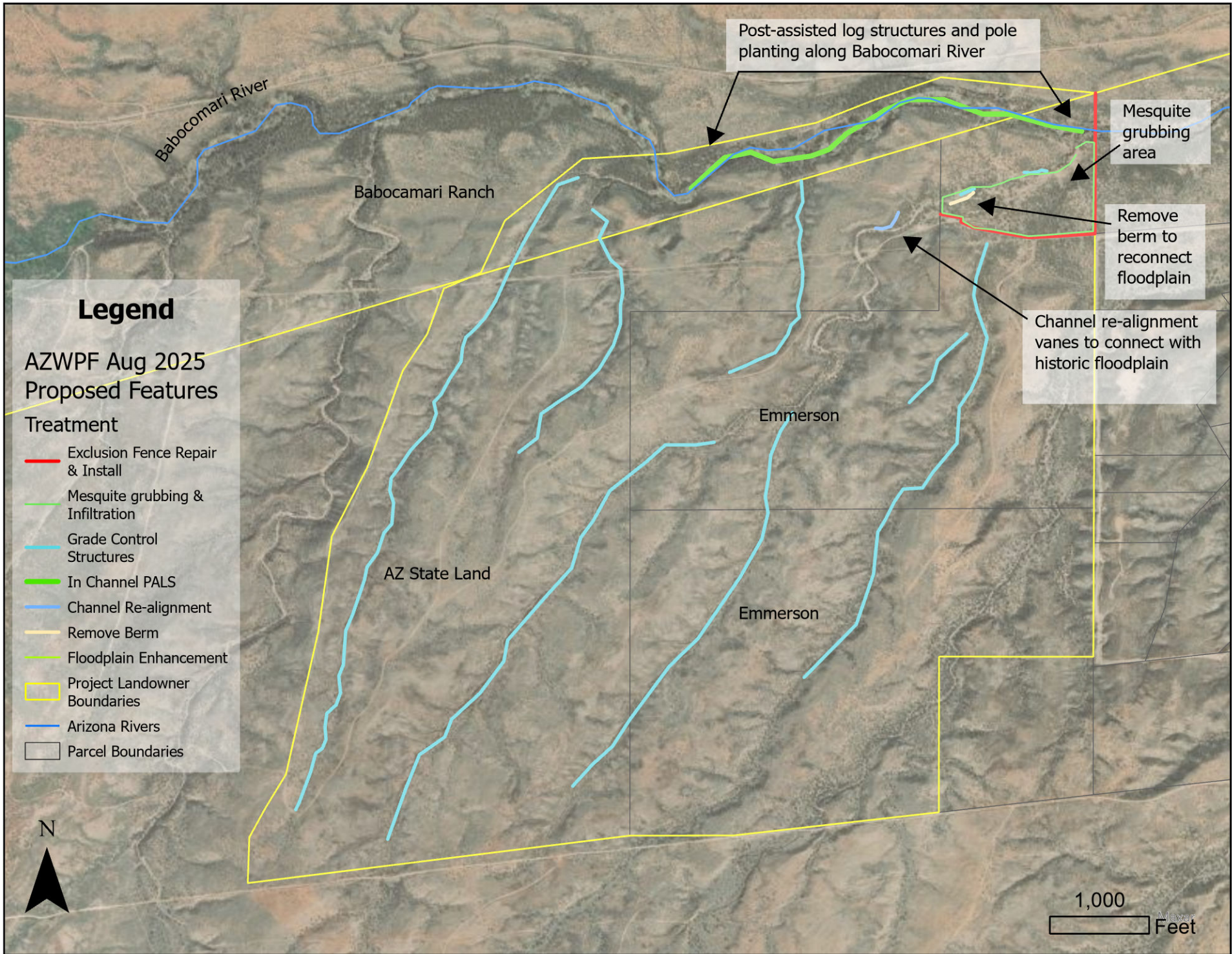
Proposed project areas for funding



Legend

-  Project Landowner Boundaries
-  Huc 10 Watershed Boundary
-  Arizona Rivers

3 Miles

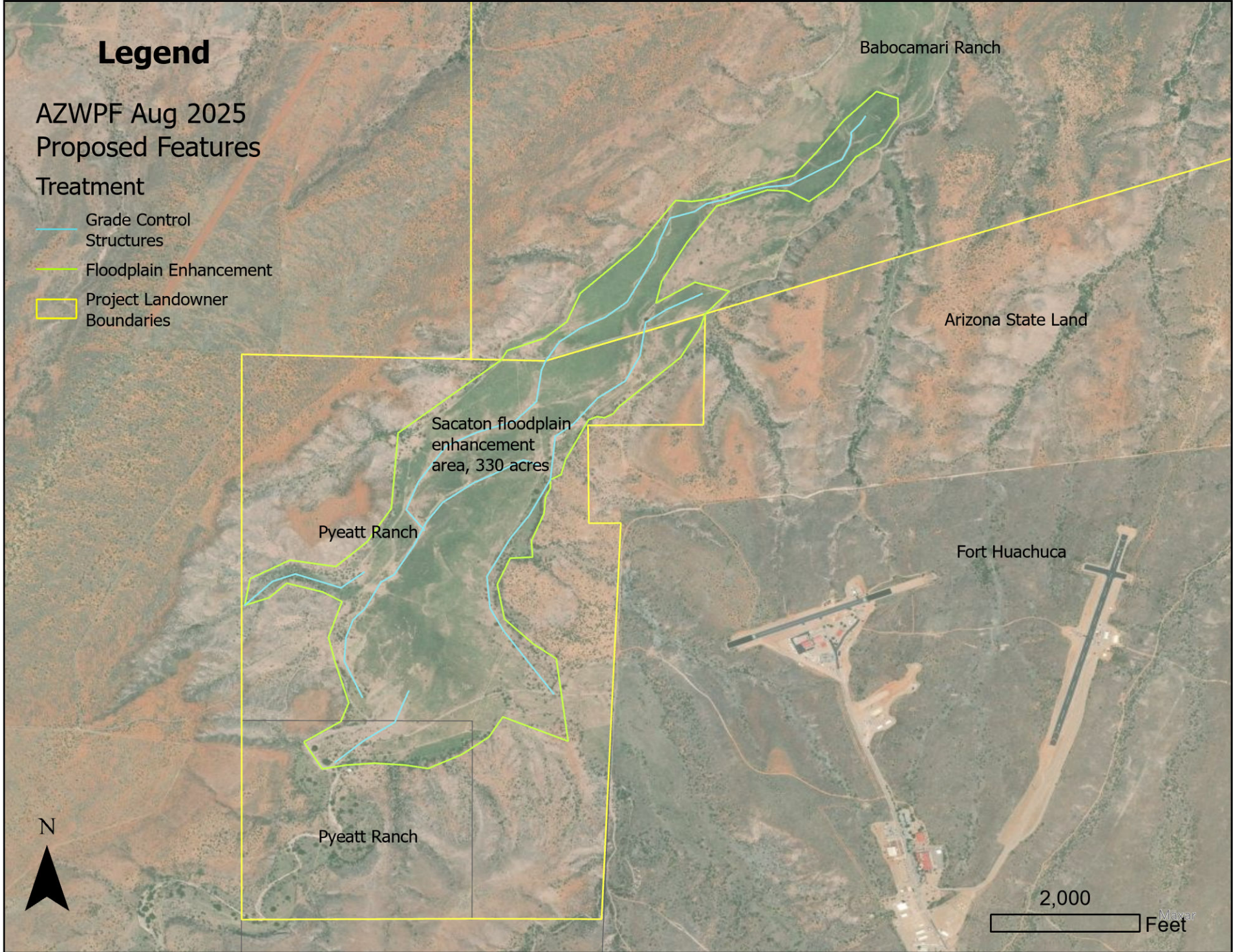


Legend

AZWPF Aug 2025 Proposed Features

Treatment

- Grade Control Structures
- Floodplain Enhancement
- Project Landowner Boundaries



Babocamari Ranch

Arizona State Land

Sacaton floodplain
enhancement
area, 330 acres

Pyeatt Ranch

Fort Huachuca

Pyeatt Ranch

2,000

Feet

Maxar

Enhancing Rangeland and Riparian Health Along the Babocomari River

Land Tenure

Project Site Work Authorization and/or Project Site Access

Please describe how the applicant will obtain permission for project work and/or access to the project site if they are not the landowner or land manager.

Arizona Land and Water Trust (ALWT) and Watershed Management Group (WMG) will obtain written authorization and letters of support from participating landowners to carry out project activities. Permission for site access and implementation will be formally secured from the Emmerson, Pyeatt, and Babocomari Ranches, as well as from Arizona State Land Department which encompass both private lands and Arizona State Land grazing leases. These landowners have previously collaborated with ALWT and WMG and are supportive of restoration efforts to improve rangeland and riparian conditions along Babocomari Creek.

STATE HISTORIC PRESERVATION OFFICE
Review Form

In accordance with the State Historic Preservation Act (SHPO), A.R.S. 41-861 *et seq.*, effective July 24, 1982, each State agency must consider the potential of activities or projects to impact significant cultural resources. Also, each State agency is required to consult with the State Historic Preservation Officer with regard to those activities or projects that may impact cultural resources. Therefore, it is understood that **recipients of state funds are required to comply with this law** throughout the project period. All projects that affect the ground-surface that are funded by AWPf require SHPO clearance, **including those on private and federal lands.**

The State Historic Preservation Office (SHPO) must review each grant application recommended for funding in order to determine the effect, if any, a proposed project may have on archaeological or cultural resources. To assist the SHPO in this review, the following information **MUST** be submitted with each application for funding assistance:

- A completed copy of this form, and
 - A United States Geological Survey (USGS) 7.5-minute map
 - A copy of the cultural resources survey report if a survey of the property has been conducted, and
 - A copy of any comments of the land managing agency/landowner (i.e., state, federal, county, municipal) on potential impacts of the project on historic properties.
- NOTE: If a federal agency is involved, the agency must consult with SHPO pursuant to the National Historic Preservation Act (NHPA); a state agency must consult with SHPO pursuant to the State Historic Preservation Act (SHPA),
- OR**
- A copy of SHPO comments if the survey report has already been reviewed by SHPO.

Please answer the following questions:

1. Grant Program: Arizona Department of Water Resources -Water Protection Fund 2026
2. Project Title: Enhancing Rangeland and Riparian Health Along the Babocomari River
3. Applicant Name and Address: Arizona Department of Environmental Quality, Watershed Improvement Unit, 1110 W. Washington St, Phoenix, AZ 85007
4. Current Land Owner/Manager(s): Emmerson, State Land, Pyeatt, and Babocomari Ranches (Brophy's)
5. Project Location, including Township, Range, Section: 31.634287, -110.383353 to 31.635804, -110.371847
6. Total Project Area in Acres (or total miles if trail, fence line, etc.): 480 Acres
7. Does the proposed project have the potential to disturb the surface and/or subsurface of the ground?
X YES NO
8. Please provide a brief description of the proposed project and specifically identify any surface or subsurface impacts that are expected:
WMG, in collaboration with ADEQ, Arizona Land and Water Trust, and the grazing lessee, will implement the Erosion Control and Restoration Plan under Task #2. The planned actions include:
 - A) Installing grade control structures along up to 5 miles of ephemeral arroyo channels
 - B) Re-aligning incised drainage features contributing to downstream floodplain erosion
 - C) Implementing post-assisted log structures to slow flow and enhance infiltration along 3,500 linear feet of the Babocomari River

D) Removing encroaching mesquite to restore grassland vegetation and infiltration capacity within the historic upland floodplain

Overall, the project will address approximately **3.5 miles of upland ephemeral drainage**, treat **16 acres of ephemeral floodplain**, reduce gully headcutting, and improve up to **10 acres of riparian habitat** along the Babocomari River.

9. Describe the condition of the current ground surface within the entire project boundary area (for example, is the ground in a natural undisturbed condition, or has it been bladed, paved, graded, etc.). Estimate horizontal and vertical extent of existing disturbance. Also, attach photographs of project area to document condition: Moderately to heavy disturbed primary due to ongoing livestock grazing as well as mesquite encroachment and hydrologic alternation.

10. Are there any known prehistoric and/or historic archaeological sites in or near the project area? YES NO

11. Has the project area been previously surveyed for cultural resources by a qualified archaeologist? YES NO UNKNOWN Survey work completed more than 10 years ago

If YES, submit a copy of the survey report. Please attach any comments on the survey report made by the managing agency and/or SHPO

12. Are there any buildings or structures (including mines, bridges, dams, canals, etc.), which are 50-years or older in or adjacent to the project area? YES NO

If YES, complete an Arizona Historic Property Inventory Form for each building or structure, attach it to this form and submit it with your application.

13. Is your project area within or near a historic district? YES NO

If YES, name of the district:

Please sign on the line below certifying all information provided for this application is accurate to the best of your knowledge.

Elizabeth Boettcher
Applicant Signature

/Date

Applicant Printed Name

FOR SHPO USE ONLY

SHPO Finding:

- Funding this project will not affect historic properties.
- Survey necessary – further GRANTS/SHPO consultation required (*grant funds will not be released until consultation has been completed*)
- Cultural resources present – further GRANTS/SHPO consultation required (*grant funds will not be released until consultation has been completed*)

SHPO Comments:

For State Historic Preservation Office:

Date:

**STATE OF ARIZONA
HISTORIC PROPERTY INVENTORY FORM**

Please type or print clearly. Fill out each applicable space accurately and with as much information as is known about the property.

PROPERTY IDENTIFICATION

For properties identified through survey: Site No. _____ Survey Area: _____

Historic Names (*enter the name(s), if any that best reflect the property's historic importance*): _____

Address: _____

City or Town: _____ Vicinity County: _____ Tax Parcel No.: _____

Township: _____ Range: _____ Section: _____ Quarters: _____ Acreage: _____

Block: _____ Lot(s): _____ Plat (Addition): _____ Year of plat (addition): _____

UTM Reference – Zone: _____ Easting: _____ Northing: _____

USGS 7.5' quadrangle map: _____

ARCHITECT: _____ not determined known Source: _____

BUILDER: _____ not determined known Source: _____

CONSTRUCTION DATE: _____ known estimated Source: _____

STRUCTURAL CONDITION

- Good (*well maintained; no serious problems apparent*)
- Fair (*some problems apparent*) Describe: _____
- Poor (*major problems; imminent threat*) Describe: _____
- Ruin/Uninhabitable

USES/FUNCTIONS

Describe how the property has been used over time, beginning with the original use: _____

Sources: _____

PHOTO INFORMATION

Date of photo: _____
View Direction (looking towards): _____

Attach a recent photograph of property in this space.
Additional photographs may be appended.

SIGNIFICANCE

To be eligible for the National Register, a property must represent an important part of the history or architecture of an area. The significance of a property is evaluated within its historic context, which are those patterns, themes, or trends in history by which a property occurred or gained importance. Describe the historic and architectural contexts of the property that may make it worthy of preservation.

A. HISTORIC EVENTS/TRENDS – *Describe any historic events/trends associated with the property:* _____

B. PERSONS – List and describe persons with an important association with the building: _____

C. ARCHITECTURE – Style: _____ no style

Stories: _____ Basement Roof Form: _____

Describe other character-defining features of its massing, size and scale: _____

INTEGRITY

To be eligible for the National Register, a property must have integrity (i.e. it must be able to visually convey its importance). The outline below lists some important aspects of integrity. Fill in the blanks with as detailed a description of the property as possible.

Location - Original Site Moved: Date: _____ Original Site: _____

DESIGN

Describe alterations from the original design, including dates: _____

MATERIALS

Describe the materials used in the following elements of the property:

Walls (structure): _____

Walls (sheathing): _____

Windows: _____

Roof: _____

Foundation: _____

SETTING

Describe the natural and/or built environment around the property: _____

How has the environment changed since the property was constructed? _____

WORKMANSHIP

Describe the distinctive elements, if any, of craftsmanship or method of construction: _____

NATIONAL REGISTER STATUS (if listed, check the appropriate box)

Individually Listed; Contributor; Non-contributor to _____ Historic District

Date Listed: _____ Determined eligible by Keeper of National Register (date: _____)

RECOMMENDATIONS ON NATIONAL REGISTER ELIGIBILITY (opinion of SHPO staff or survey consultant)

Property is is not eligible individually.

Property is is not eligible as a contributor to a listed or potential historic district.

More information needed to evaluate.

If not considered eligible, state reason: _____



Clean Water Act § 401 Water Quality Certification Application

This form shall be used for activities that require a § 401 Water Quality Certification in association with a Federal license or permit that authorizes any activity which may result in any discharge from a point source into waters of the U.S.

Contact Information

Project Proponent (applicant)		Agent (if applicable)	
Name	Elizabeth Boettcher	Name	N/A
Company	ADEQ	Company	
Address	1110 W. Washington St, Phoenix, AZ	Address	
Phone #	602-771-4565	Phone #	
Email	Boettcher.elizabeth@azdeq.gov	Email	

Agent Authorization (if applicable): I hereby authorize the following person(s) listed below to act in my behalf as my agent for the proposed activity:

Project Proponent Signature		Date	
------------------------------------	--	-------------	--

Project Activities / Location

Please provide a description of the project/activities.

This project will implement aquatic habitat restoration activities along the Babocomari River and its Tributaries including installation of rock and brush grade control structures, in-stream Post -assist log structures, mesquite removal and floodplain reconnection.

The purpose to reduce sedimentation and E.coli loading to the Babocomari River

What is the receiving water?

Is this waterbody Impaired Not-Attaining OAW Lake

Latitude 31.6650 N

Longitude 110.3550 W

Legal Description Cochise County west of Fort Huachuca

Other
Potential Pollutant Sources / Control Measures
Please provide a description of materials being discharged to or placed in the receiving water.
Only natural materials such as rock, untreated wood, and native vegetation will be used in the construction of
of restoration features.
Please provide a description of measures being implemented to control the discharge of pollutants (listed above) from reaching the receiving water.
Vegetation management will use manual removal where feasible and disturbed areas will be stabilized with
Native seed as needed.

Please include the following:

- A U.S. Geological Service (USGS) topographic map or other contour map of the project area, if available.
- A map delineating the ordinary high watermark of the receiving water affected by the project/activities.
- A copy of the federal permit or license for the project activities.

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gathered and evaluated the information submitted. Based on my inquiry of the operator or operators who manage the system, or those operators directly responsible for gathering information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

Project Proponent Signature

Elizabeth Balliett

Date

8/8/25

Catlow Shipek

catlow@watershedmg.org || 1137 N Dodge Blvd, Tucson, AZ || 520.396.3266x4

RELATED EXPERIENCE

Sr. Program Director. Watershed Management Group, Tucson, AZ. 2009 to present

- Administer River Restoration, Technical Trainings, and Watershed-based programs and staff including management of federal grant program funds and reports, and fee-based programs.
- Assess, plan, and lead implementation of nature-based strategies to improve health of riparian creeks, rivers, and wetlands including upland landscape and drainage treatments.
- Advise and lead technical, development code, and policy-based efforts related to urban sustainability issues including watershed planning, water conservation, green stormwater infrastructure and low impact development, river and landscape restoration, and environmental flows.
- Supervise and advise on community-based environmental endeavors, including international projects in Mexico to implement soil and water resource conservation practices and build community capacity.
- Instruct and develop curriculum for community and professional educational courses related to soil health, green stormwater infrastructure, water harvesting, and riparian restoration practices.

Co-founder and Board of Directors. 2002 - 2009 (Board Chairman 2007 – 2009)

- Managed and directed board of director's activities of a non-profit corporation.
- Provided oversight and ensured accountability of organizational activities.

Hydrological Technician. USDA ARS, Southwest Watershed Research Center, Tucson, AZ. 2003-2009.

- Assisted with applied rangeland restoration research projects in collaboration with local stakeholders.
- Assisted field operations and data analysis to meet soil erosion and sedimentation research objectives.

EDUCATION

MSc Watershed Management, University of Arizona, Tucson, AZ *May 2003*

BS Environmental Science, Principia College, Elsau, IL *May 2000*

PROFESSIONAL OUTREACH AND COMMUNITY ENGAGEMENT

- Santa Cruz Watershed Collaborative, Coordinating and Leadership Teams and Watershed Restoration Plan Task Team Lead, *2017 to present.*
- Tucson Department of Transportation Complete Streets Coordinating Council, *2019 to 2023.*
- Arizona Department of Environmental Quality, Onsite Wastewater Future State Technical Working Group, *Dec 2021 to 2023.*
- Tucson Water Citizen's Water Advisory Committee (CWAC), *2011 to 2019.*
 - Conservation & Education Sub-committee Chair, *2015-19*; Finance Sub-committee, *2014-19*
- Technical advisor and member of various City of Tucson policy stakeholder groups including:
 - *2018-19* City of Tucson Complete Streets Policy Task Force member
 - *2018-19* City of Tucson Green Stormwater Infrastructure Fund proposal review
 - *2013-14* Tucson Conservation Effluent Pool task force community representative
 - *2013* City of Tucson's Green Streets Policy development
 - *2013* Revision to City of Tucson's 2010 Residential Greywater Ordinance
 - *2012-13* Tucson Water's Rainwater Harvesting Rebate Program Development
- External Advisory Board to University of Arizona's School of Natural Resources and the Environment, *2016*
- Provided international watershed-based community assistance on projects including:
 - *2018* co-led 3-day Nepal training for local watershed managers, USFS International Programs.
 - *2005* led hands-on rural watershed restoration work in Costa Rica with local ranchers
 - *2008-09* served as a technical project advisor to an Engineers Without Borders project in Mali
 - *2012* provided hands-on programmatic review and assistance to WMG staff in Panchgani, India

J. M. Lankow, 2025

Jace M. Lankow
Resume

[REDACTED]
jlankow@watershedmg.org

Education

University of Arizona, Tucson, Arizona 85721

B.S. Natural Resources, Wildlife Conservation & Management, May 2013

Employment

Desert Rivers Restoration Manager – Watershed Management Group

February 2025 to present

Currently serving as a restoration manager within Watershed Management Group’s River Run Network program team, leading restoration, education, and community science efforts in support of WMG’s 50-year goal of restoring flow and ecological function to desert rivers and creeks in the Santa Cruz and San Pedro binational watersheds, with a focus on the greater Tucson area. Key initiatives of this position include:

- Leading watershed restoration projects focused on low-tech process-based restoration (LTPBR) strategies including the following structure implementations: one rock dams (ORDs), rock mulch rundowns, Zuni bowls, media lunas, post-assisted log structures (PALS), and beaver dam analogues (BDAs)
- Conducting watershed surveys to identify restoration and stormwater-enhanced recharge project opportunities, developing conceptual plans and designs, estimating costs, managing grants, overseeing contracted crews and volunteers, facilitating community workdays, and monitoring project effectiveness
- Leading/assisting grant funding development and partnership development to support restoration priorities, tracking project metrics, managing grant reporting, and tracking budgets and expenses
- Leading River Run Network Program’s annual binational beaver monitoring surveys by coordinating and training staff, interns, and volunteer survey leads, managing survey logistics with partners, and developing data analysis and summary reports
- Working with community members through WMG’s Flow365 flow monitoring program by leading monitoring of private wells in shallow groundwater areas to track seasonal groundwater level trends, connection to surface flows, and overall riparian health

Wildlife Biologist – University of Arizona School of Natural Resources and the Environment

March 2018 to February 2025

Assisted the U.S. Fish and Wildlife Service’s Chiricahua Leopard Frog Recovery Team as a wildlife biologist within recovery sites spanning from the Buenos Aires National Wildlife

J. M. Lankow, 2025

Refuge 60 miles southwest of Tucson to the Chiricahua Mountain basin of southwestern New Mexico. The Chiricahua leopard frog (*Rana chiricahuensis*) is a federally-listed as threatened species under the Endangered Species Act. Federally-permitted functions of this position include:

- Planning and leading projects related to creating and maintaining critical habitat for threatened native species by means of riparian vegetation restoration, erosion control, and wildlife pond creation and rehabilitation
- Collecting, inputting, and monitoring data on species abundance, vegetation composition, and water quality conditions through the Arizona Game and Fish Department's Visual Encounter Survey for Riparian Herpetofauna data sheet
- Translocating protected frogs, tadpoles, and egg masses to establish or re-establish populations
- Reducing threats to existing frog populations; mainly eradicating non-native organisms including American bullfrogs, predatory non-native fish, and crayfish
- Building support for the recovery effort through outreach and education by presenting project research progress and findings through Pima County NRPR programs and at the Tucson Festival of Books
- Mapping recovery sites using ArcGIS, BaseCamp, onX, and Google Earth programs
- Working closely with willing landowners to implement recovery on non-federal lands through Safe Harbor Agreements and Habitat Conservation Plans
- Receiving training, permit-holding, and experience with the environmental legislation and policies governing the study of threatened and endangered species (ESA, NEPA)
- Leading as a field instructor for the Chiricahua Leopard Frog Certification Workshop for statewide personnel
- Leading AmeriCorps volunteer groups in riparian habitat restoration
- Managing a team of 9 research technicians in the Babocomari River project
- Assisting in development of grant funding and budgeting for the NFWF America the Beautiful Challenge grant program and monitoring these funds for the REPI Challenge FY 2025 for continuing the Babocomari River project

Relevant Coursework

- University of Arizona coursework: Conservation Biology, Stream Ecology, Limnology, Field Botany, Rangeland Plant Communities of the Southwest, Applications of Geographic Information Systems, Natural Resources Policy and Law, Mammalogy, Herpetology, Avian Management, Grazing Ecology, and Rangeland Management
- Rutgers University Division of Continuing Studies: National Environmental Policy Act (NEPA) 101 Online Course

ELIZABETH BOETTCHER



Mission: Facilitate and lead environmental conservation and restoration initiatives to protect ecological integrity and enhance sustainability of natural ecosystems.

EXPERIENCE

PROJECT MANAGER: Arizona Department of Environmental Quality (Phoenix, AZ), 2004 – present

- Pioneered the transition to a direct-funded methodology for Clean Water Act Section 319 Nonpoint Source Pollution funding.
- Optimized project targeting through hydrological modeling to improve water quality outcomes.
- Managed pathogen reduction projects, reducing E. coli concentrations in Arizona's Oak Creek Watershed.
- Authored technical memorandums for the Cienega Creek project, addressing nonpoint source pollution from livestock.
- Environmental restoration project manager- led over 20 water quality improvement projects during competitive funding cycles.
- Reviewed and scientifically ranked grant proposals annually for funding recommendation and allocation.
- Directed cross-disciplinary teams to implement pollution control strategies effectively.
- Executed public outreach to improve stakeholder engagement and promote grant opportunities.

GROUNDWATER MONITORING SPECIALIST: Arizona Department of Environmental Quality (Phoenix, AZ), 1999 – 2004

- Designed and executed comprehensive groundwater monitoring protocols for southern Arizona aquifers.
- Developed and integrated communication strategies with rural communities to enhance data reporting and collaboration.
- Analyzed and contributed to technical documentation and assessed statewide groundwater studies, focusing on southern hydrologic basins.
- Compiled critical data to provide insights into water quality issues affecting Arizona's southern regions.

PROGRAM AND PROJECT COORDINATOR: Arizona Department of Environmental Quality (Phoenix, AZ), 1998 – 1999

- Launched ADEQ's citizen-based volunteer water quality monitoring program.

-
- Cultivated partnerships with stakeholders to support collaborative efforts in drinking water protection.
 - Prepared water quality work plans, performance reports, and strategic water division reports.
 - Coordinated cross-agency efforts to enhance water quality monitoring and protection across Arizona.

WATER QUALITY PLANNING INTERN: Arizona Department of Environmental Quality (Phoenix, AZ), 1996 – 1998

- Reviewed and wrote Clean Water Act 208 Consistency Reviews while earning my Master Degree in Environmental Planning.

CURRENT PROJECTS

Oak Creek – Co-led the successful application for Arizona Department of Environmental Resources and National Forest Foundation aimed at rehabilitating and closing social trails contributing to sediment and E coli loading. Co-led the Northern Arizona University DNA project to trace the sources of E. coli contamination.

Cienega Creek – Skillfully led the Nonpoint Source Pollution application on behalf of the nonprofit Watershed Management Group, successfully navigating the ADEQ approval process to support preservation of critical habitat along the Outstanding Arizona Waters of Cienega Creek. Project deliverables included an inventory of exclusion fencing to prevent cattle access. Supported NEPA proposal and erosion repair assessments for beaver reintroduction in the Santa Cruz Watershed.

Leave No Trace Messaging – Managing nonprofit to implement a public education campaign to raise awareness about E. coli contamination in Oak Creek and conducting visitor surveys to evaluate the effectiveness of the messaging. The initiative provided actionable steps for reducing environmental impacts.

EXPERTISE

Technical grant writing, Project report reviews, ranking, and awarding. Grant Coordination, project and watershed management, Public Outreach, Problem Solving collaboration, ALMS, and AMS. Permitting compliance, Nationwide Permits, 401, 404, SHPO consultation and archeological reviews. Best Management Practice implementation.

EDUCATION

MASTERS OF ENVIRONMENTAL PLANNING: *Arizona State University, GPA 3.86*

BACHELOR OF SCIENCE: *Outdoor Recreation Management, Arizona State University, GPA 3.73*

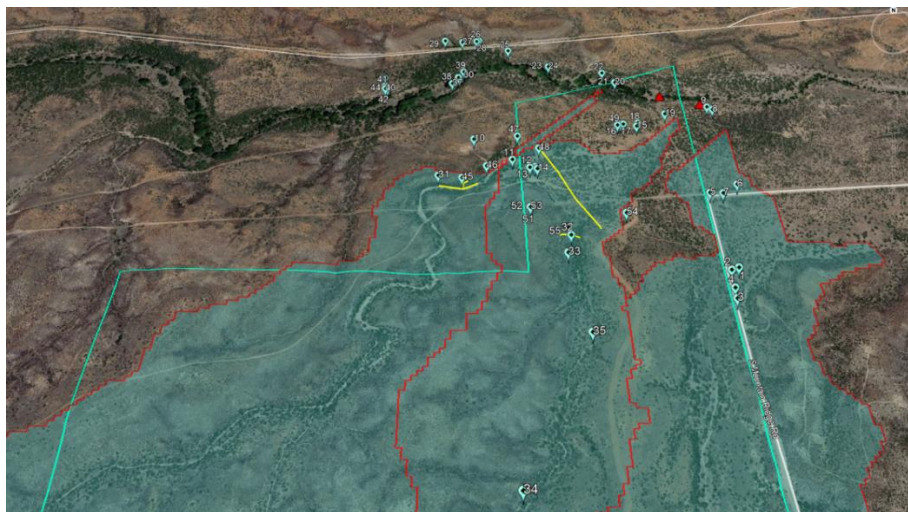
The areas outlined in red with a darker green highlighting show the three watersheds that drain through the property of interest, with Blacktail Wash hosting the largest drainage area of 5.71 mi².

Figure 1: Google Earth screen capture of contributing watersheds draining into the Emmerson property.



In Figure 2, the light-blue markers denote GPS points for points of interest for restoration work report. Yellow lines are laser level transects, and the red triangles point to areas of active headcutting. The three watersheds running through the property are referenced in this report as valley 1, 2, and 3 from left to right.

Figure 2: Closer view of Chase Emmerson property boundary showing points of interest and transects.



In Figure 3, the area to the right of the water tanks (on state land) is part of the Chase Emmerson property. This is a mesquite invaded grassland hosting cattle grazing, poorly drained roads, and failed water diversions. These feature concentrate stormwater flows, dry the landscape, and collectively put pressure on downstream headcuts.

Figure 3: Overview of site looking north from a ridge dividing Valley 2 and Valley 3, facing north from GPS point 53.



Figure 3a: Looking down at plunge pool of a major active headcut (vicinity of GPS point 9)



Figure 4: Valley-eating headcut looking up Blacktail Draw (GPS point 9)



Figure 5: Drone imagery of Valley-eating headcut in the vicinity of Figure 4 and red dots in Figure 2





Sediment buildup is starting to send flow into historic bottom (GPS point 46): Meanwhile, flows are still going toward the filled in dirt tank and contributing to headcuts downstream of the tank.



Eroded bowl contributing sediment to Tributary 3 (GPS point 10): This is a very small tributary valley on state land that is impacted by erosion. We speculate that this might be the route of a historic trail. One-rock dams in the mouth of this valley would cause it to aggrade and start to become grassed in again.



Old swale (GPS point 47): This is where the flows coming out of the bowl at GPS point 10 flow. This is a safe place for water to flow as it comes out at the angle berm discussed later.



Filled in dirt tank in historic valley floor (GPS point 11): Blue arrow points in down-valley direction. Three red arrows approximate where three headcuts are eroding the historic berm. It would be advantageous to direct flows away from this filled in dirt tank so that sediment contributions might assist in maintaining the historic bajada below here.



Erosion of the down-valley side of the berm for the mentioned dirt tank



Ditch drains overflow from filled tank away from road (GPS point 13): A rolling dip across the access road immediately up-valley from here would prevent water coming from a micro drainage between valley 2 and valley 3 from going across the road. Additional rolling dips along the access road all the way to the front gate would help manage flows and keep the road passable during inclement weather.



Looking downstream at sediment trapped by angle berm (GPS point 48): There is approximately 3 feet of sediment that has been trapped in this historic berm. The berm is about 378 feet long and goes from the dirt tank all the way to the toe of the left side of the valley. Our treatment idea for this location is to punch through this berm in several places to guide the water and sediment as far to the right as feasible to irrigate the now dried-up valley bottom and distribute this sediment to maintain sheet flow over the same.

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Historic valley bottom meets incised channel (GPS point 35): At a point several hundred feet upstream from here, small flows can escape the present day gully and flow along the historic valley bottom for several hundred feet. This area could use a more detailed survey to discern opportunities to enhance water harvesting and stability.



Valley 2 bottom (GPS point 33): The valley is not incised at this location. Sediment from upstream eroding reaches has managed to level out the cross section and optimize sheet flow.



Headcut (GPS point 32): Top of a headcut. This marks the upstream end of a growing discontinuous incision. The upper end is cutting up-valley, lengthening the incision. The middle reach is deepening. At the downstream end, sediment deposition is reestablishing sheet flow. We are unclear as to whether the rate of filling at the downstream end is happening faster than the cutting at the upstream end. We suspect this incision is getting longer and deeper, and thus needs to be treated.



Gullies in valley bottom at Tributary 2 cross section (GPS point 55): Photo is taken looking downstream. The white line is the tape from the cross section, which is graphed below.

AOI 4: Blacktail Wash and Road Drainage Issue



Blacktail Wash is captured in roadside ditch (GPS point 3): Our survey suggests that the flow from the wash crossed the alignment of the present day road toward a tank at GPS point 7. When the road was built, flow from Blacktail Wash was captured in a roadside ditch, causing erosion and sedimentation of the road in addition to increasing the rate of delivery of surface flows to the downstream valley-eating headcut (GPS Point 9). We propose to properly drain this road with a series of rolling-dip road drains to optimize water spreading and relieve the road from associated drainage issues.





Alluvial fan forming on road (GPS point 5): At the bottom of the hill, the slope of the road flattens out at the corner and the sediment collects, creating a drainage problem. This could be remedied by properly draining the road upslope from here.



Old filled in dirt tank (GPS point 7): Theo discovered this old filled in dirt tank that still has a spillway that is concentrating flows. We propose to further analyze this situation to plan a new flow path that would recreate the historic sheet flow in this area.



Grassland that could benefit from proper road drainage (GPS point 6): This photo was taken north looking toward the headcut on the left terrace of the Babocomari, which is 850 feet away. Proper road drainage with judiciously placed rolling dips, starting 1800 feet up the road from this location would slow flows before in order to relieve pressure on the valley-eating headcut.

AOI 5: Bajada Incision (Coalescing Alluvial Fans Impacted by Headcut)



Top of headcut draining bajada (GPS point 49): It appears that legacy dirt work may have concentrated tailwater from the historic dirt tanks toward this drainage. Evidence suggests that this side valley has greatly enlarged in the last 75 years or so.



Close-up of start of headcut, showing substrate (GPS point 50): In order to relieve pressure on this feature, we proposed to work much higher up in the valley in order to spread water across the historic bajada.



Looking upstream in headcut drainage channel (GPS point 17): This view shows recent enlargement of the associated channel.



Further downstream in collector channel (GPS point 16): The location of this straight channel segment, being immediately adjacent to the left side of the bajada strongly suggests anthropogenic influence.



Preferred site to spread water diverted by upstream projects (GPS point 15): In this vicinity, we mapped an area of approximately 3 acres where we propose to uproot mesquite trees so that we can host a keyline plow and seeding project to optimize infiltration and grass regeneration.



Location further downstream in collector channel (GPS point 18): Within the channel at this location we propose to use existing boulders to build grade controls such as one rock dams and Zuni bowls by hand.



Cattle trails draining the landscape and contributing to major headcut (GPS point 19): Impacts to this location must be addressed through an appropriate livestock grazing management plan coupled with keyline plowing.



Photo shows end of form boards at historic right bank (GPS point 42): The end of the form boards suggests that the right side of the concrete dam was keyed into a trench cut into fragile sediments along the right bank of the Babocomari.



Showing how far right bank has eroded since dam failure (GPS point 41): The right bank is now over 200 feet south of where it was the day of construction of this legacy infrastructure.



Dam where it is still keyed into left bank of Babocomari (GPS point 43): Here, we found evidence that the spillway was overtopped before any sediment was trapped behind the dam (i.e. the dam failed during the first significant flow event).



Observed debris in channel upstream of headcut (GPS point 37): The channel may be stable against downcutting at this point due to a bedrock outcrop downstream from here. In order to monitor the channel morphology, we suggest installing several monumented cross sections on Brophy property with landowner permission.



Channel is against stone toe of valley (GPS point 38): We are uncertain if this stone outcrop runs across the creek bottom under a thin layer of alluvium or not. This merits further investigation since it may influence strategies for grade control and headcut relief.



Site of major headcut in Babocomari (GPS point 30): This headcut may have arrested itself upon encountering the stone toe of the valley wall. Further investigation and monitoring will determine whether a treatment is necessary here to stop the Babocomari headcut from proceeding up-valley.



Looking down into the major headcut (GPS point 39): If this headcut is not self-stabilizing, this could pose an extremely serious resource damage point that could threaten stream channel stability, groundwater level, and water quality through increased sediment contributions. We recommend further investigation of the geology to better understand if grade control is happening naturally.



Water table elevation in headcut (GPS point 36): This is the only place we saw surface water in the Babocomari on January 28, 2020.



Incised channel, looking upstream (GPS point 23): The shape of the banks at this location indicates that the headcut passed through here during a recent large storm. It may have been the extremely large storm that hit Canelo Hills on September 25, 2019. (During an initial site visit in October, 2019, we also witnessed evidence of cattle through this reach. Hoof action may also explain the lack of geomorphic diversity through this reach as per notes collected by ADEQ during our initial survey.)



Looking downstream at recently incised channel (GPS point 24): This is near the downstream end of the recent incision, where the depth of the incision is less pronounced.



Old railroad grade on left terrace of Babocomari (GPS point 29): The railroad grade through this part of Arizona heavily impacted the watercourses through cut hills, filled valleys, and cut-off natural drainages. Respective activities concentrated flows throughout the entire watersheds into culvert focal points. These contributed to massive headcuts that are visibly growing through the present.



Headcut was started in the hosting tributary by a railroad culvert (GPS point 27): This headcut is extremely active, and will continue to lengthen this gully with every passing rainstorm.



Looking upstream at incised tributary caused by railroad (GPS point 25): Flows from the respective culvert contributed to downcutting resulting in this massive headcut.



Google earth screen capture showing how the railroad-caused gully has a positive feedback loop with the incision of the Babocomari, creating an entirely different landscape.



Babocomari has stabilized within historic incision (GPS point 22): The Babocomari has incised approximately 18 feet over the many years since the heavy handed manipulation of the stream channel. It has finally reached a new equilibrium by eroding laterally to create a tiny floodplain within the incised channel. This stability may be threatened by headcuts and [lack of] land management in the upper watershed.



Piping and sapping feature, now abandoned by erosion (GPS point 21): This was the only example of soil piping encountered on site where perhaps a rotten tree root or other conduit captured flows the contributing subwatershed. During the course of the survey, we discovered that upstream erosion has shifted the flows away from this feature.

















Assessment Summaries

Enhancing Rangeland and Riparian Health Along the Babocomari

1. Babocomari Chase Emmerson Assessment Report (2020)

Stream Dynamics conducted a site-specific walking and drone-assisted assessment of the Chase Emmerson property within the Babocomari watershed. The report documents legacy erosion caused by roads, cattle trails, and failed diversion infrastructure, with a focus on tributaries and bajadas feeding into Blacktail Wash and the Babocomari Creek. Treatment recommendations include rolling-dip road drains, keyline plowing, berm and swale restoration, and headcut stabilization. The findings support restoration actions aimed at reducing sediment and E. coli loads, promoting groundwater recharge, and restoring ecological resilience through improved stormwater management and vegetative cover.

2. 250707 - Babocomari Tributary Channel Assessment (2025)

This report presents a comprehensive geomorphic assessment of tributaries to the Babocomari River conducted by Watershed Management Group and partners. It identifies priority erosion areas contributing to sedimentation and channel incision in the watershed. The study uses drone imagery, field surveys, and cross-section data to characterize degraded flow paths, valley-eating headcuts, and opportunities for restoring floodplain connectivity. It recommends treatment strategies such as sediment detention features, channel realignment, and grassland restoration to enhance infiltration, reduce sediment loading, and support water quality improvements that benefit downstream resources, including the impaired San Pedro River.

3. The Nature Conservancy (TNC) Babocomari Watershed Assessment (2025)

Prepared by The Nature Conservancy in collaboration with regional stakeholders, this 2025 report synthesizes hydrologic, geomorphic, and ecological data across the Babocomari watershed. It identifies landscape-scale impairments due to altered hydrology, erosion, and land cover changes. The assessment prioritizes areas for restoration and outlines scalable interventions to restore sheet flow, reconnect tributaries, and reduce sediment delivery. Emphasis is placed on using nature-based solutions and collaborative management strategies to improve water quality and support long-term aquifer recharge. The findings directly inform project selection and prioritization for ADWR and ADEQ restoration efforts.



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Babocomari Chase Emmerson property assessment report

March 16, 2020

Executive Summary

During the week of January 27th to 31st, Van Clothier and Theo Keller of Stream Dynamics, Inc., guided by Hans Huth of ADEQ, completed a reconnaissance level walking assessment of the Chase Emmerson property and surrounding areas. Our task was to determine the state of the watershed and come up with possible treatment strategies for chronic erosion problems that had been previously identified by Hans Huth. We looked at gully erosion and flow concentration caused by local roads, legacy infrastructure such as old dirt tanks, diversion channels and berms, and the old railroad. We traced flowpaths of water contributing to erosion. Excellent maps and a drone survey of the local watershed provided by ADEQ proved invaluable to our efforts. We identified several key features that needed more detailed information and followed up with a laser level survey of several cross sections and longitudinal profiles. We were able to determine how and why the erosion was happening, and have come up with several treatment strategies.

Our prescription calls for restoring historic flow paths to maximize the potential for stormwater infiltration on the range. We propose installing rolling-dip road drains to prevent flows from Blacktail Draw from being captured by a roadside ditch that is putting pressure on a severe valley-eating headcut. We propose restoring arroyo flow to the historic valley bottom of tributary 3, and getting it to spread on the floodplain with a combination of small berms and keyline plowing.

Stream Dynamics also recommends setting up a monumented cross sections and a longitudinal profile in the vicinity of the large headcut in Babocomari Creek to monitor this feature over time.

I. Introduction

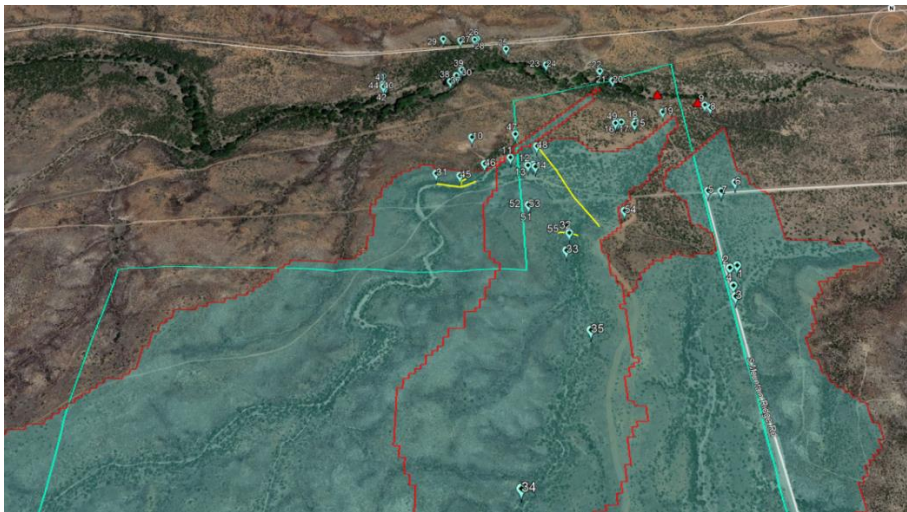
Mr. Emmerson's property encompasses approximately 480 acres about three miles west of Highway 90 and Huachuca City. In Figure 1, Mr. Emmerson's property is highlighted in light green. The airport in Fort Huachuca is visible to the southeast hosting a runway that extends 2.5 miles for scale. Sierra Vista is located southeast of the runway. The areas outlined in red with a darker green highlighting show the three watersheds that drain through the property of interest, with Blacktail Wash hosting the largest drainage area of 5.71 mi².

Figure 1: Google Earth screen capture of contributing watersheds draining into the area assessed.



In Figure 2, the light-blue markers denote GPS points for points of interest detailed in the body of this report. Yellow lines are laser level transects, and the red triangles point to areas of active headcutting. The three watersheds running through the property are referenced in this report as valley 1, 2, and 3 from left to right.

Figure 2: Closer view of Chase Emmerson property boundary showing points of interest and transects.



In Figure 3, the area to the right of the water tanks (on state land) is part of the Chase Emmerson property. This is a mesquite invaded grassland hosting cattle grazing, poorly drained roads, and failed water diversions. These feature concentrate stormwater flows, dry the landscape, and collectively put pressure on downstream headcuts.

Figure 3: Overview of site looking north from a ridge dividing Valley 2 and Valley 3, facing north from GPS point 53.



II. Ongoing Challenges

Figures 4 and 5 demonstrates where Blacktail Wash discharge over the right terrace of the incised Babocomari River, creating a severe erosional feature called a headcut. The discharge off the terrace creates a downstream pool that undercuts the terrace, further accelerating erosion and loading runoff with sediment. Taking a measurement of the landform and its distance from the centerline of the Babocomari River, the headcut has consumed approximately 200 feet of the valley of Blacktail Wash since the Babocomari River became incised 50-100 years ago. Therefore, the average velocity of the headcut complex is approximately 2-4 feet per year.

A Google Earth screen capture is presented in Figure 6. The cross section running through GPS point 40 reveals an old channel to the left of the present channel identified by a red arrow. This suggests the Babocomari has incised approximately 18 feet during the Anthropocene, which started in this part of Arizona in the late 1800's. The incision was caused by a combination of grazing, fire suppression, water diversions, and roads, including the railroad. The incision has reached equilibrium in many reaches, but a few are still downcutting. This poses serious challenges for the watershed, the water table, water quality, stormwater management, and the ecology of the San Pedro.

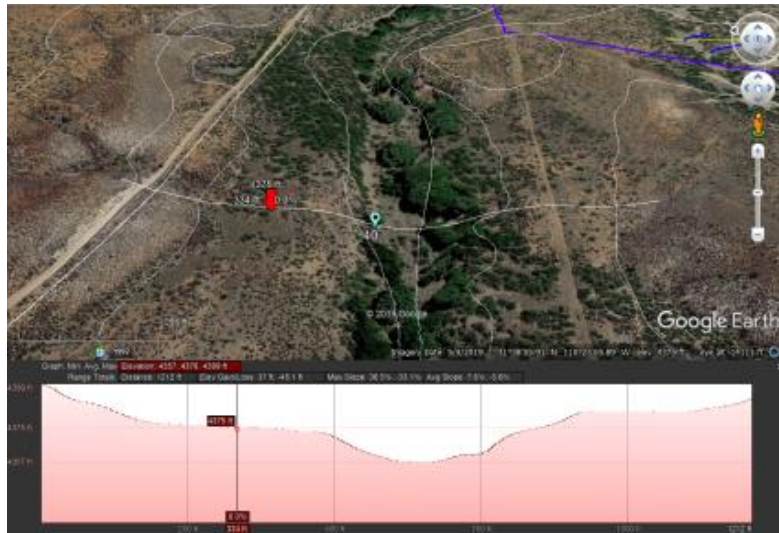
Figure 4: Valley-eating headcut looking up Blacktail Draw (GPS point 9)



Figure 5: Drone imagery of Valley-eating headcut in the vicinity of Figure 4 and red dots in Figure 2



Figure 6: Google Earth screen capture near failed dam (GPS point 40) with cross section inset.



Tributaries draining into the Babocomari are also impacted by the historic downcutting. Within our study area, the ancient bajada created by the confluence of the alluvial fans of Blacktail Wash, Tributary 2, and Tributary 3 is now a hanging valley. Present day erosion is slowly cutting away at this bajada and creating a wide drop-off, or “Valley-Eating Headcut”. This erosion happens when surface flows arrive to the site of the drop-off, where they become waterfalls that scour material from the face and base of the drop-off, causing it to move upstream in response to hard rains (Figure 7). This is a natural geologic leveling of the landscape resulting from the watershed coming into equilibrium with recent land use practices and influences.

Figure 7: Looking down at plunge pool of a major active headcut (vicinity of GPS point 9)



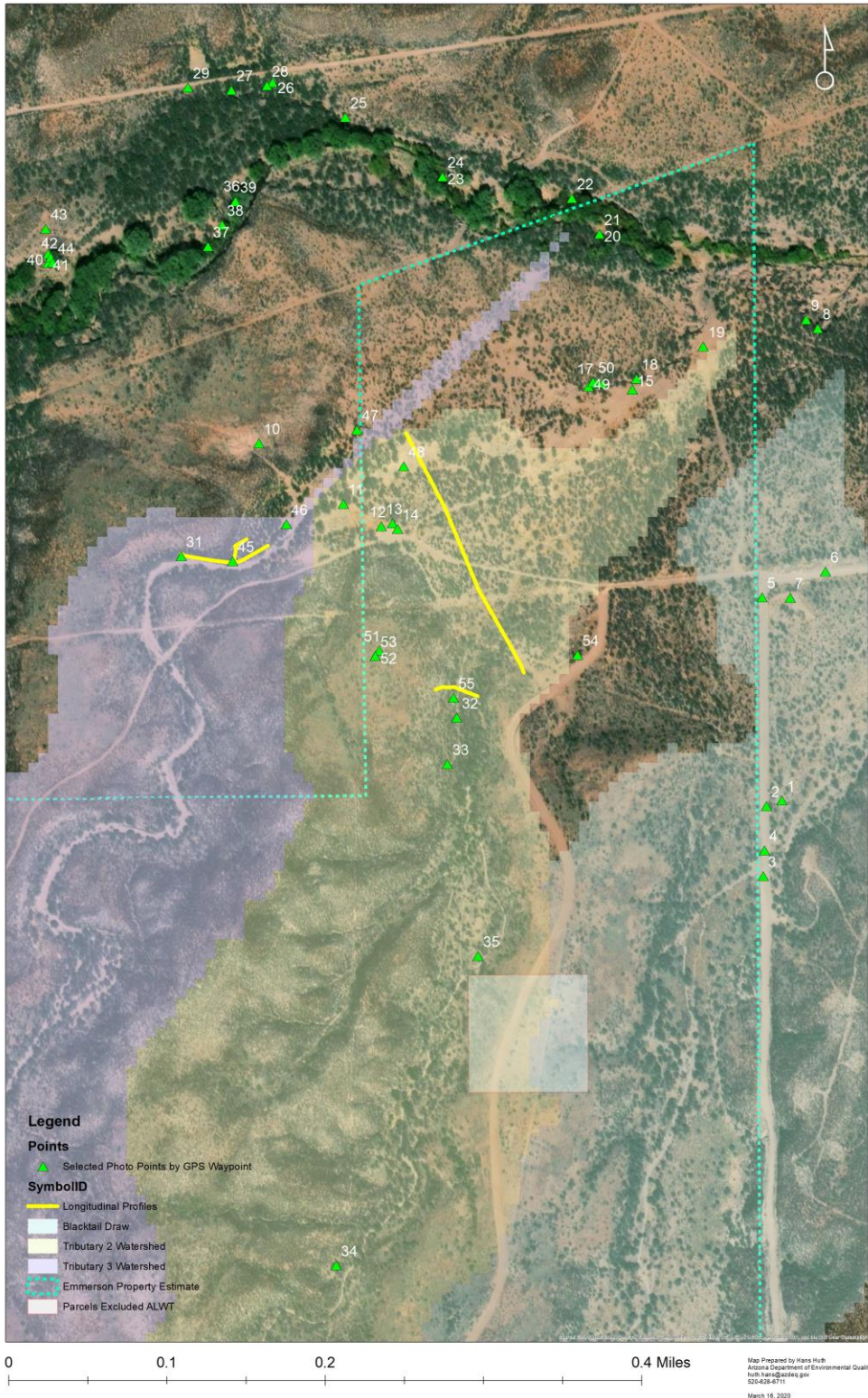
III. Suggested Remedies Summary

Stream Dynamics has been informed by ADEQ that suspended sediment in the water column is a concern as it relates to observed correlations with increased E.coli. This is a problem because the Babocomari is recognized as contributing both to the impaired San Pedro River. Although the natural processes responsible for valley headcutting cannot be halted entirely, sustainable best management practices that decelerate erosion can slow the loading of contaminants at and downstream of the property in question. If given enough time, improved watershed conditions will prompt a new equilibrium that is more favorable to water quality, quantity, and ecological concerns. In this context, the following bullets summarize existing challenges and prescriptions that can be executed immediately on the property in question:

- Roads that run up-valley along existing tributaries are concentrating flows towards valley-eating headcuts. Proper road drainage can greatly reduce the pressure on these unstable features.
- Old dirt tanks have filled with sediment. These features now host eroding spillways that are concentrating flow downvalley. Stream Dynamics has developed and successfully tested landscape treatments designed to mitigate this legacy infrastructure.
- Cattle grazing has compacted the soil in some areas. Compaction reduces infiltration and increases surface flows towards the headcut. Rest from grazing coupled with keyline plowing can improve percolation, thus relieving stormwater pressure on downstream headcuts.
 - Keyline plowing is recommended for a section of compacted bare ground near several problematic headcuts. This will improve percolation and increase surface armoring to resist erosion.
- Increased soil moisture from improved percolation coupled with rest from grazing will help with grassland recruitment. This can help armor the headcut for resiliency, trap sediment, and help the headcut to lay back over time.
 - A possible collaboration between the adjacent state lands lessee and the Emmerson property offers an opportunity to properly rest the property from grazing without endangering existing tax rates tied to agriculture.
- Mesquite invasion of historic grasslands creates conditions that accelerate the erosion of downstream headcuts. Mesquite control is recommended, but can be resource intensive and is difficult to address sustainably unless root-cause factors are properly addressed (e.g. cattle grazing, fire suppression).

IV. Map for Assessment Reference


Longitudinal Profiles and Selected Photos by Waypoint





V. Assessment with Photos

In the section below, for each point we assessed, a photograph, with its associated GPS point is displayed, along with a description of the watershed issue associated with that point. Hans Huth has the respective shapefiles and photos filed on ADEQ's server.

Key to arrows

Red arrow denotes problem or erosion area 

Blue arrow denotes present flow direction 

Green arrow denotes proposed new flow direction 

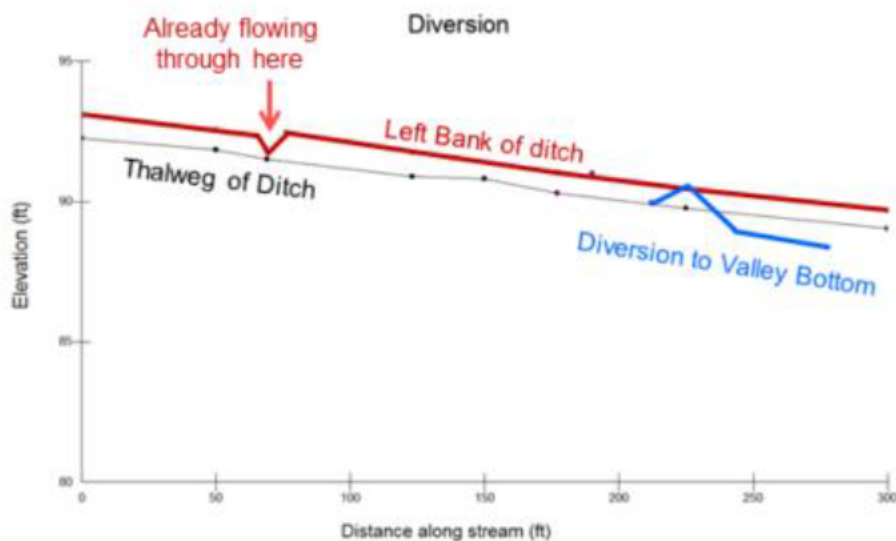
Area of Interest (AOI) 1: Tributary 3 Walking Downstream



Looking downstream along ditch that has captured Tributary 3 (GPS point 31): This is a sand filled diversion ditch that cribs to valley right and has diverted Tributary 3 out of its valley bottom toward the completely sediment filled dirt tank on state land immediately upstream of Chase Emmerson.



Opportunity to recapture flow into historic valley bottom (GPS point 45): The aggradation of the diversion ditch has created several opportunities to put the flow back in the original valley bottom. This would prevent erosion at the site of the filled in dirt tank and also give the water more surface area to spread out and sink into the ground before it arrives at the headcut.



We completed a longitudinal profile of the Tributary 3 valley bottom and diversion ditch. In the above diagram, the ditch is in black; the left bank of the ditch is red; and the possible realignment of the flow into the historic valley bottom is in blue. The peak in the blue profile can be removed with an excavator, allowing flow to once again irrigate the historic valley bottom.



Sediment buildup is starting to send flow into historic bottom (GPS point 46): Meanwhile, flows are still going toward the filled in dirt tank and contributing to headcuts downstream of the tank.



Eroded bowl contributing sediment to Tributary 3 (GPS point 10): This is a very small tributary valley on state land that is impacted by erosion. We speculate that this might be the route of a historic trail. One-rock dams in the mouth of this valley would cause it to aggrade and start to become grassed in again.



Old swale (GPS point 47): This is where the flows coming out of the bowl at GPS point 10 flow. This is a safe place for water to flow as it comes out at the angle berm discussed later.



Filled in dirt tank in historic valley floor (GPS point 11): Blue arrow points in down-valley direction. Three red arrows approximate where three headcuts are eroding the historic berm. It would be advantageous to direct flows away from this filled in dirt tank so that sediment contributions might assist in maintaining the historic bajada below here.



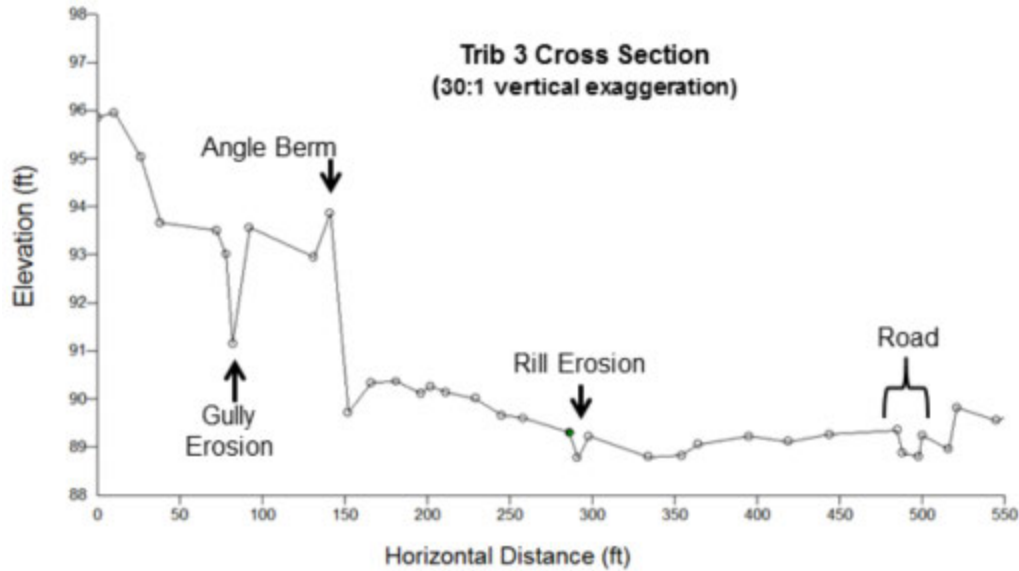
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Ditch drains overflow from filled tank away from road (GPS point 13): A rolling dip across the access road immediately up-valley from here would prevent water coming from a micro drainage between valley 2 and valley 3 from going across the road. Additional rolling dips along the access road all the way to the front gate would help manage flows and keep the road passable during inclement weather.



Looking downstream at sediment trapped by angle berm (GPS point 48): There is approximately 3 feet of sediment that has been trapped in this historic berm. The berm is about 378 feet long and goes from the dirt tank all the way to the toe of the left side of the valley. Our treatment idea for this location is to punch through this berm in several places to guide the water and sediment as far to the right as feasible to irrigate the now dried-up valley bottom and distribute this sediment to maintain sheet flow over the same.



Above is a valley wide cross section across Tributary 3 determined by a laser level. A 30:1 vertical exaggeration was used to highlight subtle features that are influencing water flow. We propose to intercept the gully that is cutting through the angle berm and redirect this water and sediment toward the original valley bottom and away from the headcut. Additionally, we propose to build a series of berms and swales to reinstate sheet flow and block the rill erosion that appears at many places along the historic valley floor.

AOI 2: Tributary 2 Walking Downstream



Van is standing in historic valley bottom (GPS point 34): This location is one-half mile up Tributary 2 from the road. Our walking tour discovered that this tributary has legacy issues due to old roads and trails that straightened the arroyo and caused it to downcut. At present, the drainage is trying to fix itself by eroding its banks and re-meandering. There are additional locations where the arroyo is still

cutting deeper. It will take a very long time of rest from grazing for this system to reach equilibrium again. There is a potential for a project here using hand labor to build grade control in these upper reaches to arrest downcutting and assist the arroyo in its progression of self-healing.



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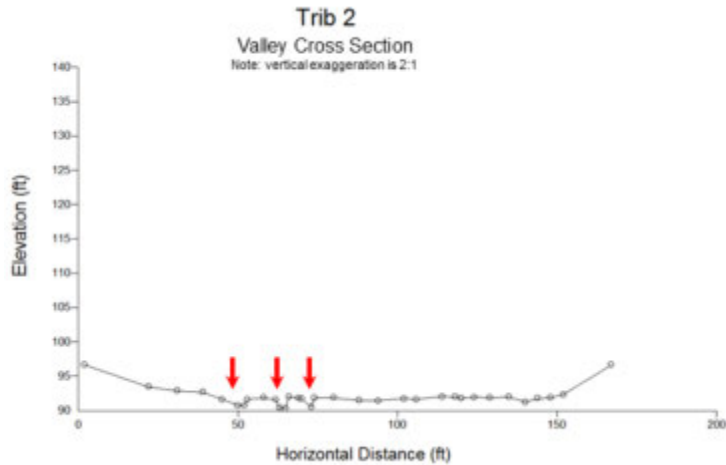
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Gullies in valley bottom at Tributary 2 cross section (GPS point 55): Photo is taken looking downstream. The white line is the tape from the cross section, which is graphed below.



Tributary 2 cross section: The three red arrows represent three channels in a valley bottom that were probably caused by livestock trailing up and down the valley. We propose to correct this erosional issue by transplanting giant sacaton grass plants to plug these gullies in order to reinstate sheet flow.

AOI 3: Road Installed On Ridge between Blacktail Draw and Tributary 2



Significant erosion destroying steep road (GPS point 54): Poor drainage design is causing this road to self-destruct. We suspect these roads were installed immediately before the 2008 economic collapse. We propose to drain this road in three places to reduce its negative impact on the watershed with the understanding that if plans for the associated subdivision restart, it could pose serious challenges for the watershed especially if careful consideration is not given to increased runoff and proper spreading of downstream flows through fragile soils.

AOI 4: Blacktail Wash and Road Drainage Issue



Blacktail Wash is captured in roadside ditch (GPS point 3): Our survey suggests that the flow from the wash crossed the alignment of the present day road toward a tank at GPS point 7. When the road was built, flow from Blacktail Wash was captured in a roadside ditch, causing erosion and sedimentation of the road in addition to increasing the rate of delivery of surface flows to the downstream valley-eating headcut (GPS Point 9). We propose to properly drain this road with a series of rolling-dip road drains to optimize water spreading and relieve the road from associated drainage issues.





Looking down road. Sign has contact info for realtor. (GPS point 4): Since this road is not on Mr. Emerson's property, repairs would require approval from the adjacent-property owner. Perhaps Ms. Debby Coste could help us secure permission from this property owner to facilitate our prescription to relieve pressure on the valley-eating headcut.



Location where we propose diverting water from the road ditch (GPS point 1): GPS point 1 is to the east of the road. It would be relatively easy to design and build rolling dips on the road to redirect the flow to a safe place where the water could slow down, spread out, and sink into the ground more than it currently does, thus relieving pressure on the valley-eating headcut.



Alluvial fan forming on road (GPS point 5): At the bottom of the hill, the slope of the road flattens out at the corner and the sediment collects, creating a drainage problem. This could be remedied by properly draining the road upslope from here.



Old filled in dirt tank (GPS point 7): Theo discovered this old filled in dirt tank that still has a spillway that is concentrating flows. We propose to further analyze this situation to plan a new flow path that would recreate the historic sheet flow in this area.



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Cattle trails draining the landscape and contributing to major headcut (GPS point 19): Impacts to this location must be addressed through an appropriate livestock grazing management plan coupled with keyline plowing.

AOI 5: Babocomari Main Stem Survey – Upstream to Downstream



Historic infrastructure (GPS point 40): This is an old dam across the Babocomari. ADEQ communication with the property owner suggests this one of many features installed throughout the area to help mitigate soil loss between 1935 and 1940. Features on the concrete suggests it was keyed into both banks of the stream channel at the time of construction. We suspect this feature was likely overtopped early in its career resulting in catastrophic failure and causing the right bank to erode significantly while contributing a huge sediment load to the system. At present, the right bank of the Babocomari is over 200 feet away from the concrete dam. The feature is still keyed in to bedrock on the left bank.



Drainage pipe at base of old dam (GPS point 44): We suspect the original engineers planned to relieve base flow of the flashy desert stream through this 9" diameter pipe at the base of the dam where Van is sitting. ADEQ informs us that the contributing watershed area at this location is 168 square miles.



Photo shows end of form boards at historic right bank (GPS point 42): The end of the form boards suggests that the right side of the concrete dam was keyed into a trench cut into fragile sediments along the right bank of the Babocomari.



Showing how far right bank has eroded since dam failure (GPS point 41): The right bank is now over 200 feet south of where it was the day of construction of this legacy infrastructure.



Dam where it is still keyed into left bank of Babocomari (GPS point 43): Here, we found evidence that the spillway was overtopped before any sediment was trapped behind the dam (i.e. the dam failed during the first significant flow event).



Observed debris in channel upstream of headcut (GPS point 37): The channel may be stable against downcutting at this point due to a bedrock outcrop downstream from here. In order to monitor the channel morphology, we suggest installing several monumented cross sections on Brophy property with landowner permission.



Channel is against stone toe of valley (GPS point 38): We are uncertain if this stone outcrop runs across the creek bottom under a thin layer of alluvium or not. This merits further investigation since it may influence strategies for grade control and headcut relief.



Site of major headcut in Babocomari (GPS point 30): This headcut may have arrested itself upon encountering the stone toe of the valley wall. Further investigation and monitoring will determine whether a treatment is necessary here to stop the Babocomari headcut from proceeding up-valley.



Looking down into the major headcut (GPS point 39): If this headcut is not self-stabilizing, this could pose an extremely serious resource damage point that could threaten stream channel stability, groundwater level, and water quality through increased sediment contributions. We recommend further investigation of the geology to better understand if grade control is happening naturally.



Water table elevation in headcut (GPS point 36): This is the only place we saw surface water in the Babocomari on January 28, 2020.



Incised channel, looking upstream (GPS point 23): The shape of the banks at this location indicates that the headcut passed through here during a recent large storm. It may have been the extremely large storm that hit Canelo Hills on September 25, 2019. (During an initial site visit in October, 2019, we also witnessed evidence of cattle through this reach. Hoof action may also explain the lack of geomorphic diversity through this reach as per notes collected by ADEQ during our initial survey.)



Looking downstream at recently incised channel (GPS point 24): This is near the downstream end of the recent incision, where the depth of the incision is less pronounced.



Old railroad grade on left terrace of Babocomari (GPS point 29): The railroad grade through this part of Arizona heavily impacted the watercourses through cut hills, filled valleys, and cut-off natural drainages. Respective activities concentrated flows throughout the entire watersheds into culvert focal points. These contributed to massive headcuts that are visibly growing through the present.



Headcut was started in the hosting tributary by a railroad culvert (GPS point 27): This headcut is extremely active, and will continue to lengthen this gully with every passing rainstorm.



Failing railroad culvert and massive erosion (GPS point 28): The installed splash pad was not engineered to handle the respective flow concentration from this culvert. The splash pad was laterally flanked, causing flood flows to erode the fine grained soil resulting in catastrophic failure.



Another view of old railroad culvert (GPS point 26): This shows a post and concrete splash pad that has now collapsed 20 feet behind the structure.



Looking upstream at incised tributary caused by railroad (GPS point 25): Flows from the respective culvert contributed to downcutting resulting in this massive headcut.



Google earth screen capture showing how the railroad-caused gully has a positive feedback loop with the incision of the Babocomari, creating an entirely different landscape.



Babocomari has stabilized within historic incision (GPS point 22): The Babocomari has incised approximately 18 feet over the many years since the heavy handed manipulation of the stream channel. It has finally reached a new equilibrium by eroding laterally to create a tiny floodplain within the incised channel. This stability may be threatened by headcuts and [lack of] land management in the upper watershed.



Piping and sapping feature, now abandoned by erosion (GPS point 21): This was the only example of soil piping encountered on site where perhaps a rotten tree root or other conduit captured flows the contributing subwatershed. During the course of the survey, we discovered that upstream erosion has shifted the flows away from this feature.

Treatment Plan

Contributing factors meriting attention are sourced both upslope and downslope from Chase Emmerson property.

- Although most of Blacktail Draw is on the Emmerson property, the road that is concentrating flow is not. Furthermore, most of the valley-eating headcut associated with Blacktail Draw is off the property. A cost-effective project will require coordination and permission of adjacent landowners and/or lease holders.
- Road drainage remedies and the keyline plowing will require a small bulldozer
- Mesquite control can be leveraged by a local restoration crew such as those managed by Borderlands Restoration, under Stream Dynamics' direction.

Changes in Current Land Management Practices

During our surveys, we introduced ourselves to Mr. Sid Khala—a local rancher. We learned that Mr. Khala is currently in negotiations to take ownership of the state-land lease immediately adjacent and upstream of the Emmerson property. Given ongoing challenges, Mr. Khala voiced concerns about trespass livestock impacting his lease from downstream properties, and is interested in supporting activities that can realize a buffer via the Emmerson property. Pending further discussion, Mr. Khala may be open to helping with fencing installation and repair as well as maintenance of the same.

Should this avenue materialize, ADEQ has an opportunity to host restoration activities in a livestock-free environment which would certainly improve grass cover, increase infiltration, and subsequently relieve pressure on downstream water resources. Stream Dynamics believes that having a local willing partner with a vested interest will leverage the sustainability of this project moving forward while providing a unique opportunity to measure impacts from the same over time. Given this context, we believe this is one of the most significant outcomes of our work.

Contact:

Mr. Sid Khala
Double Diamond ranch supply
doublediamondrs@gmail.com
(520) 604-2677

Road Drainage with Bulldozer

ADEQ has an opportunity to relieve pressure on downstream erosion by improving road drainage of several roads including South Mountain Ridge Road; the access road to the windmill on State Land, and the road that traverses the ridge between Tributary 2 and Blacktail Wash. On the Emmerson property, there is need for about 8-10 rolling dips, and on other land there is the need for about 4-6 rolling dips. This task would require coordination and permission from property and conservation easement holders hosting respective roads. The actual road work could be accomplished in one week or less with a Cat D4 bulldozer.

Cat D4 5 days

Keyline plowing with bulldozer

Under guidance from my colleague Gordon Tooley of Tooleys Trees, a regional keyline plowing expert, we propose the following treatment. First, we will use the laser level and place pin flags in the dirt along exact contours. Using a Cat D4 bulldozer (the smallest available rental), we would rip the area on exact contours following the pin flags. We would seed at the same time as we rip.

The proposed keyline plowing polygon is approximately 3 acres that is relatively clear of mesquite. This could be done in 2 days with a D4, including time spent with a laser level to set grade.

Cat D4 2 days

Flow diversion to old valley bottom

Our overall treatment plan includes a bit of work on state land on Tributary 3 immediately upstream of Chase Emmerson property. We propose to break through the berm separating the diversion channel from the historic valley bottom. This is a small amount of earthmoving that could be accomplished with a small piece of equipment in a few hours. If SHPO is an issue, or if the project makes more sense to do with workers instead of heavy equipment, this work could be accomplished by a work crew with hand tools. This task is not absolutely essential to the success of the project because all of the flow goes downvalley to our site anyway, yet it would be beneficial to start spreading the flows higher up in the watershed at this point.

Work Crew 2 days

Restoring sheet flow to historic valley bottom

Redistribution of sheet flow to the bajada of Tributary 2 and Tributary 3 includes breaking through an anthropogenic angle berm and building several swales to divert surface flows to the original valley bottom. At the same time, we suggest blocking the many small rills that are destroying sheet flow by speeding water down valley. The angle berm has filled in with sandy soil that is easily movable by work crews.

Work Crew 2 days

Erosion control in collector channel

We propose building one rock dam grade controls in the collector channel. This could be a week worth of hand work.

Work Crew 5 days

Plug Rills in Tributary 2

Using hand tools and strong workers, we can transplant the very large Giant Sacaton grass plants that dominate the valley in the vicinity of the erosional rills. They can be relocated to block the rills and restore sheet flow to the system. We estimate this will take 2 days.

Work Crew 2 days

Monitoring Headcuts

We highly recommend installing several monumented cross sections and a longitudinal profile of the headcut in the Babocomari, with rebar pins for monitoring the movement of the headcut up-valley given that it is unclear if the instability has been halted by the occurrence of large boulders in the channel bottom. Since cattle grazing in the channel of the Babocomari may also be contributing to headcutting, we also recommend installing monitoring points for the very wide valley-eating headcuts, perhaps with an accurate line feature describing the present location of these features. Conducting this survey would take half a day.

Work Crew 1 day

Mesquite-invaded grassland mitigation

Historic, present and intended future land management (fire suppression, cattle grazing) is contributing to mesquite encroachment on the range, thus converting an historic grassland to mesquite thickets. In addition, precipitation patterns have shifted towards winter rains that favor trees and shrubs. Mesquite removal is not an approach that Stream Dynamics, Inc. has expertise in, so Hans Huth consulted with Dr. Ron Tiller (ADEQ ecologist) about mesquite removal options- this is what he learned:

- Tebuthiuron won't work on mesquite – it only works on creosote and other shallow rooted shrubs. As such, it will not help on the Chase Emerson property.
- There is an experimental product called Sendero manufactured by DOW Chemical. It is a Mesquite specific herbicide. ADEQ funded a project in Altar Valley to evaluate effectiveness. Preliminary data suggests that for the goals of this project (complete mesquite removal for grasslands restoration), the approach may require two or three treatments which can be expensive.
- Cutting with a chainsaw and spraying stumps - requires retreatment year over year only with only 50 - 80% effectiveness.
- ADEQ is in consultation with neighboring ranchers within the Hereford NRCO regarding the effectiveness of Sendero 2 on private property near the border with Mexico. Meetings are planned or in progress at this time.

Given these challenges and for the purposes of this project, the best option is to pluck standing mesquite out of the ground. This treatment is 90% effective, but expensive. Ground disturbance is a concern where heavy equipment is involved, but may not be an issue on the Emerson property since we are dealing with well distributed fine soils in the bottomlands. The recently acquired ADEQ Drone deploy imagery could assist a tree removal contractor to come up with a cost proposal.

Dealing and managing this thorny species is problematic using hand labor given risks to limbs and eyes. However, we can deal with it efficiently using heavy equipment. Stream Dynamics would uproot the trees with an excavator and transport it with a track-skid loader with grabbers instead of a bucket, and migrate the debris to the portion of the drainage channel that we intend to block off. This would be done with a Cat 308 excavator and a JCB trackskid loader with a logging grapple. This treatment would open up parts of the bajada for keyline plowing.

We hesitate to recommend this option due to the large amount of disturbance for treatment of a relatively small are of rangeland invaded by mesquite. As such, we propose spending only two days pursuing this removal strategy on the Emmerson property. If approved, such a project requires careful consideration of our goals for the appearance of the finished job, and how to dispose of the enormous amount of material that this activity will generate. The proper solution is the elimination of the root causes linked to fire suppression and cattle grazing.

Stream Dynamics used this JCB “Robot” track-skid loader with logging grapple attachment on several jobs. It does a fantastic job of moving uprooted trees. At Cloverdale Ciénega Stream Dynamics uprooted 200 juniper trees from a tree invaded meadow with a Cat 315 excavator and the loader shuttled them quickly to grade control sites in the creek. We then used the material to build 45 weirs with this locally collected material. The meadow was restored to tree-free condition, and the creek bed was raised back to floodplain elevation with the tree material. This piece of equipment is available for rent at a reasonable price from a contractor in Silver City.

Cat 308 excavator, JCB loader 2 days

JCB loader with logging grapple



Cat 308 excavator with thumb



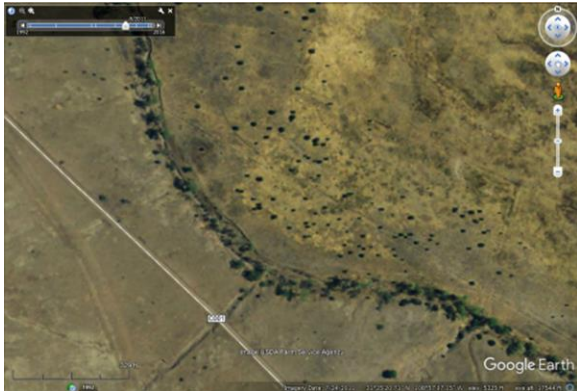
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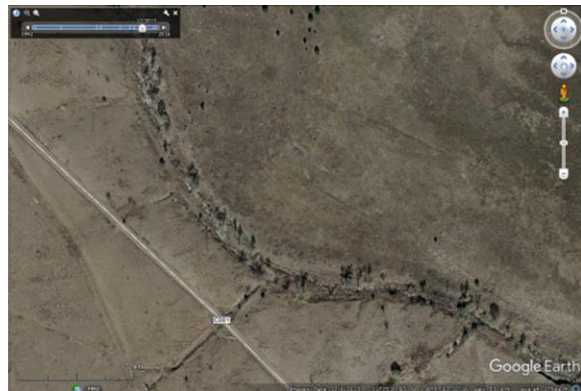
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Meadow before



Meadow after



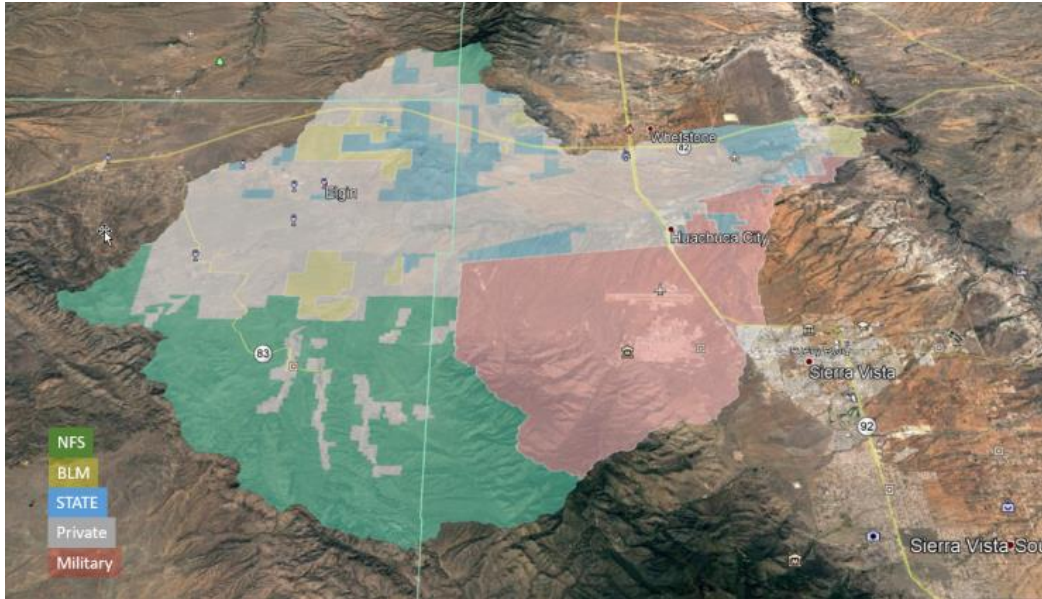
Customer Needs and Project Considerations

As communicated by Hans Huth, Stream Dynamics understands that the goal of the Arizona Department of Environmental Quality is to identify and implement sustainable prescriptions that will protect water quality while also balancing the social and economic needs of the areas being served. Over the course of this project, ADEQ has requested our guidance on basin-wide strategies that will support of this goal.

In regards to landscape strategies, Stream Dynamics is proposing prescriptions that have proven effective and sustainable in New Mexico for areas protected from agricultural and development. To be clear, *Stream Dynamic's record of success is credited to our careful selection of projects that host the right mix of stakeholder engagement and ownership coupled with appropriate land uses. These are critical elements to ensure sustainable returns of ADEQ's investments.*

Although we believe the Emmerson project hosts elements for success, we caution that external influences may challenge the sustainability of similar investments elsewhere. Within your targeted watershed, we observe that the Arizona State Land Department, the National Forest Service, and Bureau of Land Management jurisdictions are significant in extent. Respective jurisdictions administer

agricultural and recreational activities that may host detrimental impacts on soil conservation and water quality within the watershed you are trying to restore.



The associated potential for soil compaction, decreased land cover, and improper road maintenance are root-cause factors that can realize watershed-scale impacts beyond the local benefits of the modest project like the one presented here. We understand that recreational and agricultural activities support local and state economies through permit, lease, and commercial revenues, but also recognize that respective activities can realize significant costs requiring intervention.

In regards to a recommendation for a sustainable strategy moving forward, we suggest evaluating agricultural and recreational receipts against the investments required by ADEQ for restoring watersheds in areas impacted by associated activities. We recommend you then engage with partner agencies and stakeholders regarding ADEQ investments so that more sustainable and equitable policies can be developed moving forward. By approaching these challenges holistically, we believe you will create an environment that will ensure the benefits of this project can stand out as an example that can be replicated and sustained over time.





AZ ROC CR-21 300910

**BABACOMARI RESTORATION PROJECT - PHASE 1:
COLLECTION AND ANALYSIS OF GEOMORPHIC & HYDROLOGICAL
DYSFUNCTION AND OPPORTUNITIES
BABACOMARI RANCH,
SANTA CRUZ COUNTY, ARIZONA**

07/07/2025

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Stewardship Manager

Arizona Land and Water Trust

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In this document we will present the bulleted tasks below for the Babacomari Ranch Restoration Project Phase 1. Phase 1 can be defined as the collection and analysis of geomorphic and hydrological dysfunction and opportunities within areas identified as high priority by the client. Our analysis will include 12 channels, Vaughn Canyon and briefly Babacomari Creek.

PHASE 1 TASKS

- Define projects goals and objectives with input from Arizona Land and Water Trust and stakeholders
- Identify necessary techniques and materials needed for treatments
- Map locations of project activities
- Approximate materials, equipment and rough costs

This report includes a general landscape assessment which discusses alluvial fans, roads, headcuts, and maintenance. Following the general assessment we present a detailed assessment of selected priority drainages, all of which lead into the mainstem of the Babacomari Creek. The drainages on the north side of Babacomari Creek are labeled from west to east as C1-C12. Vaughn Canyon and Babacomari Creek are discussed following C1-C12. Finally, we will provide a priority list of treatment areas, photos, and a link to a map of treatments.

PROJECT GOALS

- Increase the ability to wet the valley/channel bottoms
- Increase storage area access, such as alluvial fans.
- Prevent problematic headcuts from growing.
- Identify opportunities to push water up out of the channel
- Opportunistic rainwater harvesting
- Reduced road maintenance.

The work recommended to achieve these goals will be done in the efforts to not only affect the channel where the work is done but also set up for future work within the Babacomari.

PROJECT TECHNIQUES

The techniques and methods that will be suggested include but not limited to:

- NIDS
- Media Lunas
- Plug and Spreads
- Removing impediments (berms, rail)
- Induced meandering (elongate and slow)

We suggest both machine and hand work. We recommend using onsite materials of rock and woodie material, only importing rock and material as needed.

GENERAL LANDSCAPE ASSESSMENT

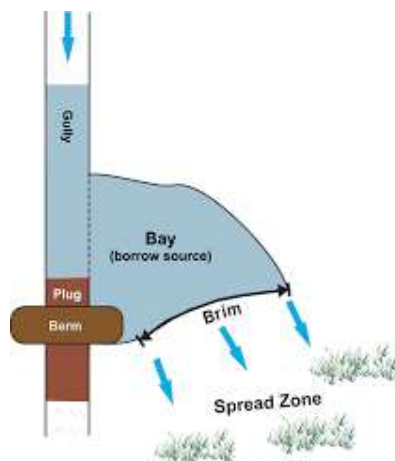
ALLUVIAL FANS

Alluvial fans function as major sedimentation zones within mountain fluvial systems, storing sediment supplied by mountain catchments (Harvey, 1997). Fans occur where confined mountain streams lose power, typically at mountain-front, tributary junction or intermontane basin situations. They are the geologic feature that stores the most water in a landscape. Fans also typically hold fertile soil because of the lack of high energy flows, soils are able to build. The coarse sediment allows for water to infiltrate and form aquifers.

When an alluvial fan becomes damaged and channelized it becomes dehydrated and fragile. The fans of the Babocomari watershed are critical in the health of the valley and its role in ecological services. We can see how fragile and important they are in this landscape. Not only by holding water and soil for plant health but by keeping the velocity of the incoming flows from the tributaries in check which keeps the tributaries from incising, increasing its holding capacities.

We have observed many of the fans in the project area have been damaged, impeded, and some are in threat of being channelised. Some of the locations of these fans are easier than others to access. Our treatment priority list is organized by evaluating the storage capacity of the alluvial fan, the volume of water discharged, and the cost of installation and maintenance. Cost factors vary by accessibility, equipment needed, materials needed, maintenance and potential risk factors.

Typical repairs of alluvial fans include strategies known as Plug and Spread and repairing headcuts with Zuni bowls, rock rundowns or log stepdowns. Plug and Spreads are built by building a large earthen plug in the current channel and opening a lead out channel for the water. The soil produced by the lead out or “borrow pit” is used for the Plug which protrudes to an elevation approximately 2’ above the top of the channel. The Borrow area, known as a Bay is level and wide so the water remains slow and spreads. At the end of the Bay there is a “Brim” which ensures an even distribution of water to the landscape (see **Figure 1**; [Quivara Coalition, 2018](#)).



There are three alluvial fans that are a priority for repair. The most damaged, and therefore highest priority, is in the tributary we refer to as C2, followed by C4 and C9.

Figure 1

ROADS

Roads have a significant impact on watersheds, therefore the design and maintenance is critical to land hydration. Hot spots for road impacts are anywhere roads follow vertically up a grade, not perpendicular or following the contour. Roads that climb ridges will also dredge a watershed by capturing water and running straight down the road causing erosion and keeping water from the landscape. Over time the detrimental effects are obvious.

Installing rolling dips, berms and lead outs as often as possible and where practical will keep the water on the landscape and reduce erosion. We found several places where roads can be treated to prevent further erosion, particularly on the road that loops from C8, west along the railroad berm, then north to a solar well, and to the northern property line where it continues east over a saddle and then back around to C8. This road also has two crossings that have culverts which are no longer functioning to their full capacity and are causing erosion to the road.

Rolling dips, and berm treatments are fairly simple structures to install and maintain. These treatments could be installed by ranch employees (with our assistance) if the ranch has the capacity.

Road crossings are more involved to install than rolling dips. They would require imported materials if the goal is to have the road function as a vehicle accessed road. This work can be achieved either by reinstalling culverts or by building a road crossing with rocks that would also function as a grade control for the tributaries.

UPLANDS

In this project area, the uplands are intact and look healthy with a diversity in plant species and ground cover. Lehmann lovegrass has established itself well on the ranch as it has on most of the grasslands in the area. Eradication would be costly with current techniques available to us. We would recommend focusing on supporting communities of native grasses keeping them healthy in the hopes they can someday outcompete the Lehmann lovegrass.

There are areas where the cattle tend to congregate and leave the ground bare. These areas are around water tanks and shade. In these areas where the slope is greater than 2% we recommend that a series of "media lunas"(MLs) made of 1"-6" rock be installed. The MLs would slow runoff from the bare areas preventing rills from forming and allowing more grass to take hold.

There are a few areas where “semi-circles” (berm and basins) could be installed to collect water allowing more infiltration, plant growth and support for established trees and shrubs. These would be best suited for slopes less than 2%.

HEADCUTS

There were several headcuts observed in the project area and outside of the area. Most of the headcuts are associated with alluvial fans and the tributaries. Many of these headcuts are very large in size which would require a large expense of resources to repair. We recommend prioritizing headcuts that either threaten healthy, productive plant communities or infrastructure. Reinforcing and repairing alluvial fans and roads will take care of many of the headcut issues. The sediment produced by the headcut will aggregate the channel slowing the water and erosion of the headcut. Road work will reduce the amount of water going over the head cut and support new plant growth that will contribute to slope stabilization.

Direct repair work to headcuts is typically achieved by reducing the vertical drop to a 3:1 or gentler slope and then adding rock to slow water going down the slope. Another direct headcut treatment is known as “starving” where water is rerouted so that minimal water will flow over the headcut.

MAINTENANCE

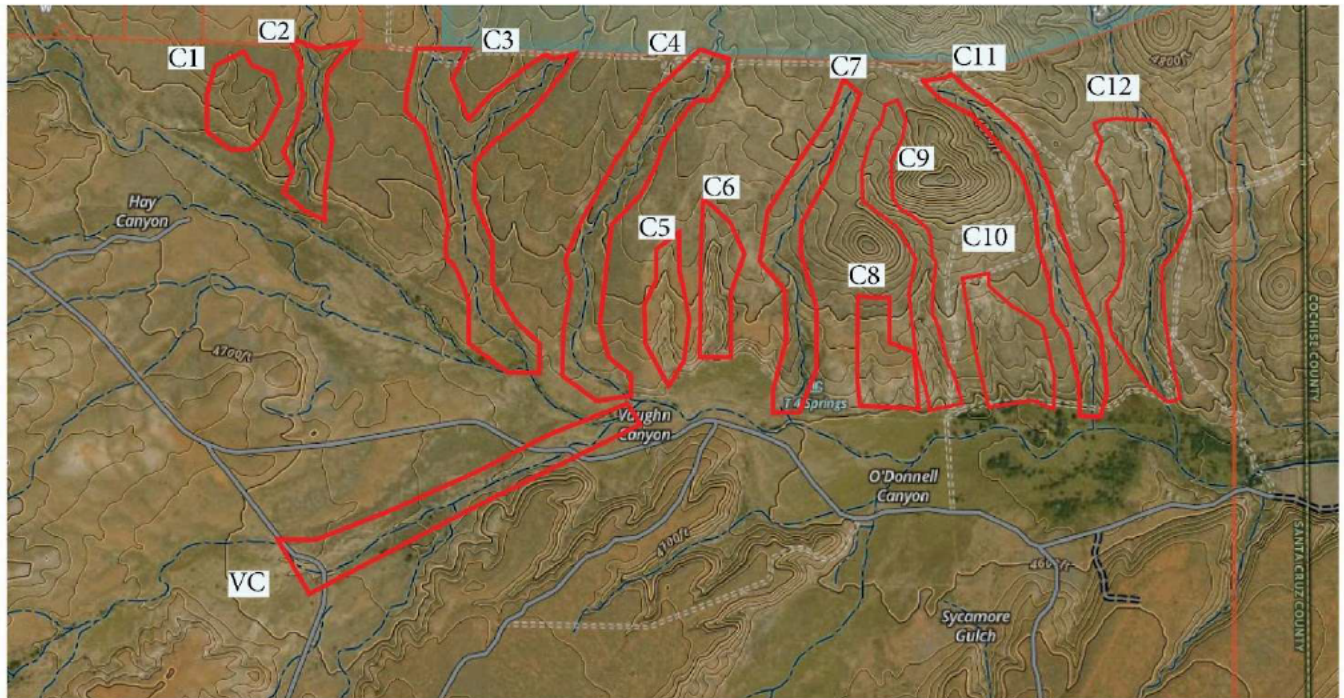
These treatments suggested in this assessment are designed to require no to minimal maintenance. The objective is for them to be self-maintaining until they return to their part of a functioning watershed. For example, the treatment to a damaged alluvial will be stable and built to scale for the largest predicted flows. As sediment builds and fills voids, the alluvial fans will take its natural form and transport water and sediment in a natural process. Road treatments will require the most frequent maintenance due to the nature of their use, but they are also the easiest to monitor. While road treatments may require periodic reinforcement and adjustments, the cost in time and money is low.

Adaptive management is the practice of monitoring and evaluating the effectiveness of planned treatments, keeping in mind the multiple variables that can influence the process of recovery. The post-installation monitoring and evaluating process takes time to determine if adjustments need to be made. In the design phase considerations of adaptive management are accounted for so the design can address foreseeable problematic areas. One major strategy to address this is to make sure that redundancy is built into the treatments. This approach to design ensures future adaptations and maintenance are kept to a minimum. There are continuously changing aspects to each treatment because each site is unique with different unknown influences. Learning by doing is a rewarding part of all restoration projects. Monitoring is key to a successful

rehabilitation project. As new techniques and technology are discovered they can be used to further the recovery.

DETAILED ASSESSMENT OF EACH CHANNEL (OUTLINED IN RED)

https://webmap.onxmaps.com/hunt/share/content?share_id=01JZKJ985FT2HZ8R8E9WC70PGH



C1. The first set of channels that we have been tasked to look at begins near the westside of Babacomari Rd. Road work needed to the north, headcuts at the top and bottom. This cluster of 3 drainages have similar patterns. Relatively short length of channel with opportunities in the uplands before the channelization begins to keep the water up longer. Headcuts tend to follow with a transportation zone that is slightly incised that leads to a partial intact alluvial fan. We suggest that the fan be restored.

C2. Large drainage that enters the property, encounters a bank that has narrowed the channel due to the overburden from a road and also merges with another drainage. There are active headcuts at the top and bottom. The transportation zone in between the headcuts has exposed bed rock. It continues down to the confluence of a side drainage which contributes significant water and sediment. In this reach the channel is confined between two hillsides which restricts it from moving laterally. The alluvial fan at the base of this drainage is severely damaged. We suggest that this tributary receive several treatments to the channel as part of the treatment to restore the alluvial fan. The bed is made up of large cobble and some bedrock, keeping the channel from

incising. There are floodplains that are accessible to the water but soon after the confluence it picks up speed and straightens out. In this straight reach, the flood plains are still accessible with some help. As the valley opens up, the incision of the channel deepens making the floodplain inaccessible. There is an opportunity to cut a new floodplain but this needs a more detailed look during design. This is also where the channel first becomes braided and where the alluvial fan treatment could start, by periodically plugging the channel and spreading it into the sacaton flats. As the channel's grade flattens and the valley opens, it braids into a Sacaton dominated flats with a main channel continuing down the eastside of the valley. The channel continues to deepen its incision as it travels along the railroad berm and meets the Babocomari.

- C3. Large drainage with multiple road crossings. Although the slope of the drainage is slight, it is incising an area with potential for reconnection to floodplain within the drainage. An existing berm in-channel is cutting on one side and causing erosion by narrowing. The Fan is disrupted by the railroad berm. We suggest that road treatments be done along with fan restoration at the bottom.
- C4. Larger drainage leading down from the Mustang Mountains. This channel has a wide valley bottom with many opportunities to rehydrate. The channel is mostly intact with a few places where it has incised but recovers quickly. The channel bottom is also made up of large cobble and bedrock with a few sections of aggregation. Where the tributary meets with the railroad grade it pinches(narrows) and has caused significant damage to the alluvial fans via head cuts. There are many options to explore for treatments and areas to rehydrate.
- C5. The channel begins to incise and headcut after it crosses the road to the north and west. We suggest work above this drainage and around the stock tank area to slow and store water.
- C6. Short channel with a large collection area that leads to a canyon-like headcut/waterfall. Suggest work above this drainage to slow and store water before it reaches the headcut.
- C7. This channel contains the T-4 Spring. We want to further investigate with Laura Norman about best ways to support the spring. We suggest opportunistic water harvesting along with repair and enhancement of existing structures.
- C8. Larger drainage that begins in the hills and starts to channelize near the top with a short and steep transportation zone. The drainage fans out at the bottom. Some impediment

to function here with the road. We suggest reestablishing the fan and installing media lunas in the uplands. There are several roads that meet at the confluence which has influenced the tributary and its alluvial fan. The tributary's channel is incised and gets trapped on the eastside of the tributary. The incision starts approximately 500 yards upstream of the confluence. There is an opportunity to stop the incision and spread the water onto the fan at the beginning of the incision and support that treatment a few more times before it gets to the confluence and road. Reestablishing and supporting this fan would be beneficial to the road and would rehydrate approximately one acre of previously sacaton dominated area. Currently the zone has been colonized by acacia and other xeric plant communities. By treating the fan, the road would require less maintenance after rain events.

C9. Confined drainage with exposed bed rock. Relatively steep. Intersection/Road crossing at the bottom. We suggest treatment at road crossing and in uplands.

C10. Headcuts at the top of this drainage are encroaching on sacaton. Failed culvert at road crossing. We suggest road crossing work with upland work to protect sacaton and roads.

C11. This drainage has many large headcuts along the top near the road. There is a lot of energy in the channel. Narrow and steep with lots of exposed bed rock. Leads to an intact fan at base. Suggest Road work and some upland work to reduce the flow to headcuts.

C12. Larger drainage leading down from the Mustang Mountains. Has a windmill and feed area in the floodplain. Multiple road crossings. Suggest that water be slow near the stock tank and continue road work.

Vaughn Canyon (VC) - Identified 5 gabion structures, 3 older post structures. West of the road is a large headcut created by the road and stock tank, also many ORDs above the headcuts. Suggest that the gabions be repaired but mainly recommend enhancements and many supportive structures in between.

Babacomari Creek - Much of this channel has eroded to bed rock. The evidence provided by the living trees indicated that this level has been stable for a long time. The channel cannot get deeper in many spots but would benefit from greater connection to the sacaton flood plain along with the creation of pools for sustained water availability in the channel and its

surrounding uplands. There are a couple of existing Gabions within the Babacomari creek near the west edge of our work area. These Gabions are in need of repair and supportive structures.

TREATMENT AREA PRIORITIES

Priority	Treatment Area
1	Road Crossings & nearby upland work including media lunas
2	C4
3	C2
4	VC
5	C9
6	C7
7	C3
8	C1
9	C5
10	C6
11	C10
12	C11
13	C12
14	C8



**MONTGOMERY
& ASSOCIATES**

Water Resource Consultants



**Natural Channel Design
Engineering Inc.**
ncdengineeringinc.com

REPORT

June 2025

Babocomari Watershed Assessment

Prepared for:

The Nature
Conservancy 
nature.org



1550 East Prince Road, Tucson, AZ 85719
elmontgomery.com

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1 EXECUTIVE SUMMARY

The Babocomari Watershed, located in southeastern Arizona, is a vital ecological and hydrological system encompassing approximately 200,000 acres across Cochise, Santa Cruz, and Pima Counties. This region supports diverse habitats—including grasslands, riparian corridors, ciénegas, and perennial streams—that are home to numerous species. However, the watershed faces mounting threats from groundwater depletion, climate change, land development, and historical land use practices such as overgrazing.

The Nature Conservancy (TNC) commissioned Montgomery & Associates and Natural Channel Design Engineering to conduct a comprehensive watershed assessment. The goals were to evaluate current watershed conditions, identify restoration opportunities, and foster collaborative conservation planning. The assessment integrated stakeholder engagement, geospatial analysis, and field visits to develop a science-based understanding of the watershed’s hydrogeology, surface water dynamics, ecological conditions, and land use impacts. Key findings include:

Groundwater and Surface Water: Groundwater recharge is primarily via mountain front processes, with shallow aquifers supporting critical ecosystems. However, groundwater levels are declining near urban centers due to pumping, which threatens baseflows and riparian habitats.

Channel and Ecological Conditions: Many stream channels are incised or actively eroding due to historical and current watershed disturbances, contributing to sedimentation and habitat degradation. There are restoration opportunities to stabilize channels, enhance infiltration, and support vegetation recovery.

Stakeholder Collaboration: Over 30 agencies and organizations participated in surveys, workshops, and field visits. Approximately 3 dozen potential restoration projects across 7 watershed zones have goals such as groundwater recharge, erosion control, habitat enhancement, and infrastructure repair. These projects serve as a starting point; additional project concepts are expected to be developed as opportunities emerge in the future.

Implementation Strategy: This report outlines permitting pathways, funding sources, and prioritization criteria to guide project development and execution. It also recommends further assessments, including groundwater budgeting, ciénega health studies, and invasive species management.

This assessment provides a foundation for coordinated long-term watershed restoration and resilience planning. By aligning solid scientific information with stakeholder priorities, it aims to protect the Babocomari Watershed’s ecological integrity and water resources for future generations.

2 INTRODUCTION

The Babocomari Watershed, located in southeastern Arizona, represents an important ecological and hydrological system featuring diverse vegetation types that support rare ecological habitats. The watershed faces significant threats: groundwater depletion from increased pumping, climate change impacts (e.g., rising temperatures, drought, fire, and flood), land development (e.g., decreased recharge for urbanization, water quality degradation, erosion, and habitat fragmentation), and residual impacts from historical cattle grazing (e.g., erosion and vegetation changes). Restoration is important in a watershed like the Babocomari that has extremely limited surface water or other renewable water supplies such as treated effluent. Addressing these challenges to enhance and preserve the watershed will require not only a solid scientific understanding of the watershed conditions but also collaborative conservation efforts among the many federal, state, and private landowners and managers.

2.1 Motivation

This report is the result of a recent initiative aimed at identifying and assessing conservation actions to protect and enhance watershed health within the Babocomari Watershed. The Babocomari Watershed is ecologically rich and diverse, encompassing high-quality grasslands, riparian ecosystems, ciénegas, springs, and stretches of perennial flow. These habitats support a wide array of biodiversity, including several listed endangered or threatened species. This ecological significance, combined with the watershed's role in regional hydrology, underscores the importance of focused conservation efforts.

In addition to its natural value, the watershed has been the focus of extensive conservation and research efforts over the years. Numerous federal agencies, conservation organizations, and research institutions have been active in the area, contributing valuable knowledge and management experience. However, there remains a need for a cohesive platform to integrate these efforts and facilitate comprehensive discussions about the entire watershed.

The Nature Conservancy (TNC) has maintained a longstanding presence in this region, including stewardship of the Canelo Hills Preserve on O'Donnell Creek—a tributary of the Babocomari—as well as several conservation easements along the main stem. The Babocomari Watershed is also a significant hydrologic contributor to the Upper San Pedro River, an area where TNC has had a significant conservation footprint for many years. TNC seeks to identify key opportunities to support watershed health, engage partners to pursue projects, and lay the groundwork for future collaboration. Through this collaborative process and the development of this report, TNC aims to foster a shared understanding of watershed priorities, strengthen partnerships, and inform strategic, science-based conservation planning that can guide future actions across the Babocomari Watershed.

2.2 Scope of Watershed Assessment

TNC contracted with Montgomery & Associates (M&A) and Natural Channel Design Engineering (NCDE) to conduct the Babocomari Watershed assessment. M&A is a Tucson-based water resource consulting firm that specializes in groundwater management, modeling, and surface water-groundwater interactions. NCDE is a Flagstaff-based civil engineering firm providing services in river restoration and conservation engineering, environmental assessment, permitting and compliance, restoration ecology, and natural resource planning.

The team provided an integrated approach to watershed assessment by evaluating watershed function and identifying potential projects to benefit the long-term health of the watershed. Their objective was to identify opportunities to improve hydrologic function, enhance ecosystems, and support long-term watershed resilience through research, stakeholder engagement, geospatial analysis, and field assessments. This report describes the physical setting including groundwater, surface water, and vegetation conditions and identifies areas of the watershed that are impacted by channel erosion, declining streamflow, groundwater depletion, and habitat degradation and that could be targeted for improvement through specific project implementation. The work was completed between January and June 2025.

2.2.1 Stakeholder Engagement

The watershed assessment and potential projects were informed by engaging stakeholders to incorporate lessons learned from previous watershed research and restoration efforts, strengthen partnerships by identifying shared conservation goals, and develop project materials that serve as a foundation for future conservation initiatives.

The assessment was guided by 5 shared goals: enhancing hydrologic function, managing habitats and species, improving water management and source water protection, ensuring water quality, and supporting community engagement. These goals, along with their associated sub-goals listed in Table 1, provided the framework for stakeholder input and project evaluation.

Stakeholder organizations that were engaged and participated in any stakeholder engagement aspect of this project are listed in Table 2. Those that participated in any aspect of this project are denoted; however, lack of participation does not necessarily indicate lack of interest as some were not contacted or were unavailable in the relatively short timeframe available for this initial outreach effort. Stakeholder engagement involved 4 components, described below.

Table 1. Goals for Watershed Management

Watershed Goal (survey rank)	Subcategory (survey rank, top 10)
Hydrologic Function (1)	Slowed flows for erosion control, revegetation, water infiltration for groundwater recharge, and surface flow extension (1)
	Healthy & connected floodplains (4)
Habitat & Species Management (2)	Freshwater ecosystems (5)
	Riparian areas (2)
	Grasslands (3)
	Woodlands & forest
	Wildlife corridors & habitat connectivity (10)
	Increase landscape productivity
Water Management & Source Water Protection (3)	Regional water security
	Flood mitigation (6)
	Shallow groundwater to support freshwater & groundwater-dependent ecosystems (7)
	Stormwater and effluent management for water recharge (8)
	Water management for cattle and/or wildlife (stock tanks)
Water Quality (4)	E.coli impairment
	Other concerns e.g., turbidity, dissolved oxygen
Community (5)	Working lands & rural livelihoods (9)
	Local economy
	Resilient communities & infrastructure

Ranking results shown in parentheses are from the stakeholder survey.

Table 2. Stakeholder Organization

Federal Agencies	State Agencies
U.S. Dept. of Defense, Fort Huachuca	AZ Dept. of Environmental Quality
U.S. Fish and Wildlife Service	AZ Dept. of Forestry and Fire Management
Natural Resources Conservation Service	
U.S. Forest Service, Coronado National Forest	
Bureau of Land Management	
U.S. Geological Survey	
Fort Huachuca Sentinel Landscape Partnership	
U.S. Dept. of Agriculture, Agricultural Research Service	
Local Entities (County, Municipal, Other)	Conservation Organizations/Private Entities
Town of Huachuca City	Arizona Land and Water Trust
Santa Cruz Natural Resource Conservation District	Borderlands Restoration Network
Santa Cruz County Flood Control District	Desert Botanical Garden
Cochise Conservation and Recharge Network	National Audubon Society -Audubon Southwest
Private landowners and ranch managers	Sky Island Alliance
University of Arizona researchers	The Nature Conservancy, Arizona
Cochise County Engineering & Natural Resources	Watershed Management Group
	Arizona Antelope Foundation

2.2.1.1 Introduction to the Watershed

A virtual introductory session was held for stakeholders in February 2025. Approximately 50 people were invited, and it was attended by approximately 20 people. A recording of the meeting and copy of the slides were made available to those who could not attend.

2.2.1.2 Survey

A survey of stakeholders was conducted during February and March 2025 to gather information on stakeholder priorities and projects. There were 17 individual responses to the survey, and 10 follow-up interviews were conducted by the project team to learn more about specific projects and priorities.

Of the 5 main goals listed in Table 1, Hydrologic Function ranked the highest among survey respondents, followed by Habitat & Species Management, and Water Management & Source Water Protection. From the subcategories listed in Table 1, the top ranked were slowed flows, riparian habitat, and grasslands habitat.

Using Survey123, a geographic mapping tool developed by ESRI, survey respondents were also able to identify the locations of completed or planned projects and upload photos. A total of 20 potential projects and 24 existing projects were identified by stakeholders.

2.2.1.3 Workshop

An in-person workshop was held at the Appleton-Whittell Research Ranch of the National Audubon Society (Audubon) in March 2025. The team presented an overview of the watershed and discussed potential projects. The meeting was attended by over 20 individuals from over a dozen organizations.

2.2.1.4 Field Visit

On the ground field inspections were conducted in May 2025. The project team targeted potential project sites to evaluate conditions and opportunities for improvement. The team was also able to ground-truth and refine some of the remote sensing analysis.

2.2.2 Web Map

In addition to this report, the team created a custom web application. The Babocomari Watershed Web Map is available at <https://arcg.is/1L8ife1>. The mapping tool has a customizable user interface to display pertinent geographic, hydrologic, and ecological datasets.

2.3 Watershed Overview

The Babocomari Watershed shown on Figure 1 covers approximately 200,000 acres in parts of Cochise, Santa Cruz, and Pima Counties. The watershed drains to the Babocomari River, which begins on the western boundary of the watershed near the town of Elgin and flows approximately 32 miles to the east where it joins with the San Pedro River downstream of Huachuca City. It is bordered by the Mustang Mountains and the southern end of the Whetstone Mountains to the north, and the Canelo Hills and Huachuca Mountains to the south. Surface water flow in most of the Babocomari River is intermittent, meaning it does not flow continuously throughout the year and may only have water during certain seasons or periods of rainfall; however, stretches of the stream contains year-round, or perennial flow. Elevation ranges from 8,416 feet above mean sea level (amsl) in the Huachuca Mountains at the northern boundary to 3,825 feet amsl at the junction with the San Pedro River at the far eastern edge of the watershed.

2.3.1 Land Ownership

There are federal, state, and private lands within the watershed. Federal agencies managing portions of the watershed are the U.S. Forest Service (USFS), Bureau of Land Management (BLM), and U.S. Department of Defense, Army (Fort Huachuca). Fort Huachuca and the USFS are each slightly over 22% of the watershed and the BLM is approximately 5% of the area. The watershed is 10% Arizona State Land and 40% private land. Huachuca City and Elgin are incorporated towns with population centers in the watershed, and part of the City of Sierra Vista is in the watershed. The Babacomari Ranch (spelled differently than Babocomari River) is the largest private landowner in the watershed. TNC and Audubon are conservation organizations that own and manage lands in the watershed.

2.3.2 Watershed Zones

The watershed boundary shown on Figure 1 is defined by the U.S. Geological Survey (USGS) Watershed Boundary Dataset (WBD) as Hydrologic Unit Code (HUC) 10-1505020208. For this assessment, the watershed was divided into 7 watershed zones based on distinct hydrogeologic, hydrologic, vegetative, and/or geomorphic characteristics. The zones are labeled on Figure 1 and are described in detail in Chapter 4. Chapters 2 and 3 establish the hydrogeologic and watershed conditions that define distinct watershed zones, respectively. Chapter 5 provides project lists and implementation considerations.

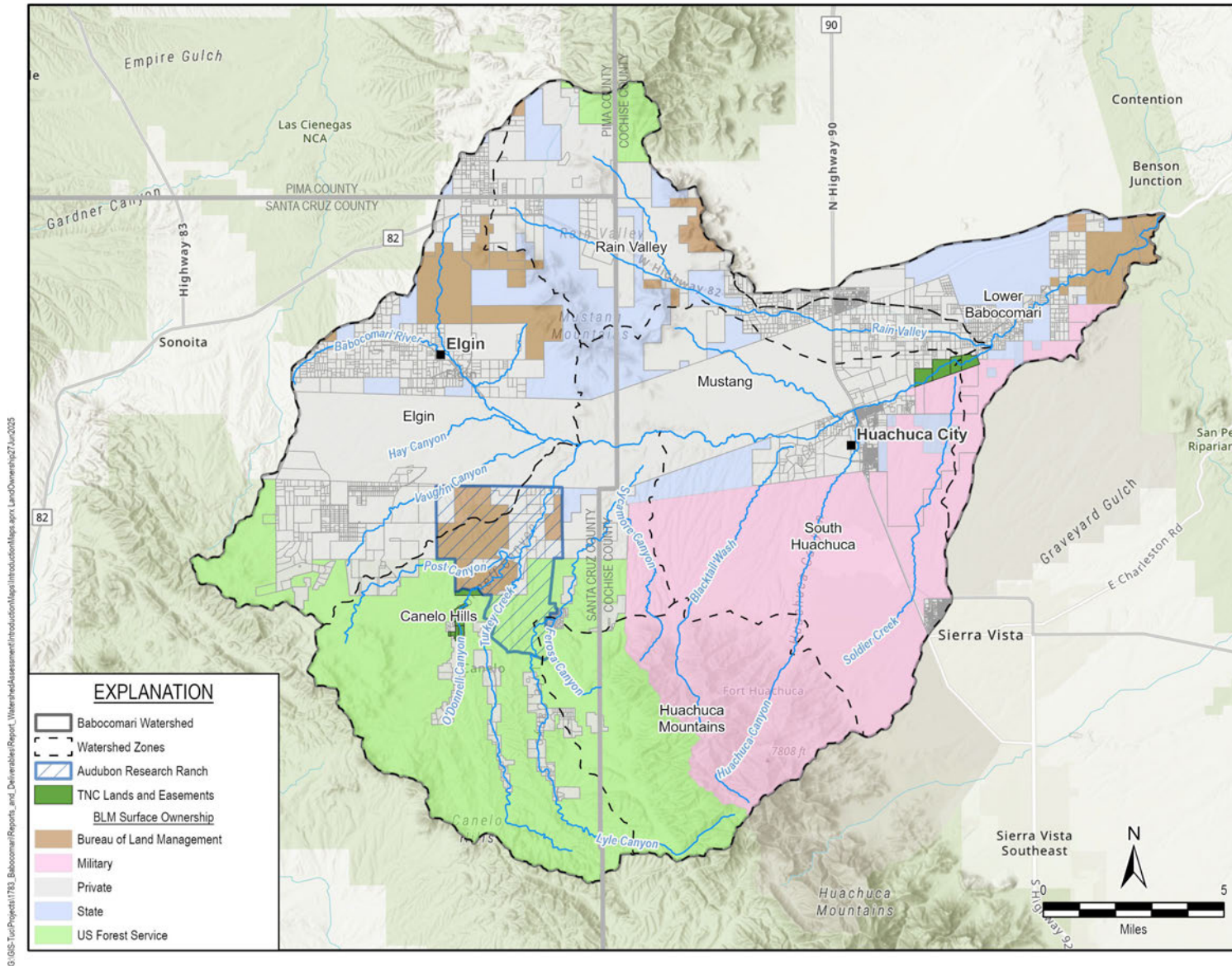


Figure 1. Watershed Features and Land Ownership

3 HYDROGEOLOGIC SETTING

The hydrogeologic setting is influenced by precipitation and defined by the occurrence of groundwater.

3.1 Climate and Precipitation

The climate of the Babocomari Watershed is semi-arid with bimodal precipitation patterns. In the winter, there is rain at lower elevation and snow at higher elevations; in late summer, there is monsoon-related rainfall across the entire watershed (PRISM, 2025). Annually, lower elevations around Elgin, Huachuca City, Fort Huachuca, and the Babocomari River receive an average 14 inches of precipitation while higher elevation areas in the Huachuca, Whetstone, and Mustang Mountains receive an average of 26 inches (Figure 2 and Figure 3) (PRISM, 2025).

Within Arizona, many watersheds are biased to winter precipitation based on isotopic studies of precipitation and groundwater (Eastoe and Towne, 2018). However, some areas of southern Arizona—including the Babocomari Watershed—have higher average annual summer monsoonal precipitation than many parts of Arizona, and the relative amount of winter to summer precipitation is variable (Eastoe and Towne, 2018; Kennedy and Gungle, 2010). Summer monsoons are often intense precipitation events that drive sediment transport and surface water flow within ephemeral washes. These storms provide groundwater recharge that can sustain flow to riparian ecosystems, especially during the summer months when evapotranspiration rates are high (Kennedy and Gungle, 2010).

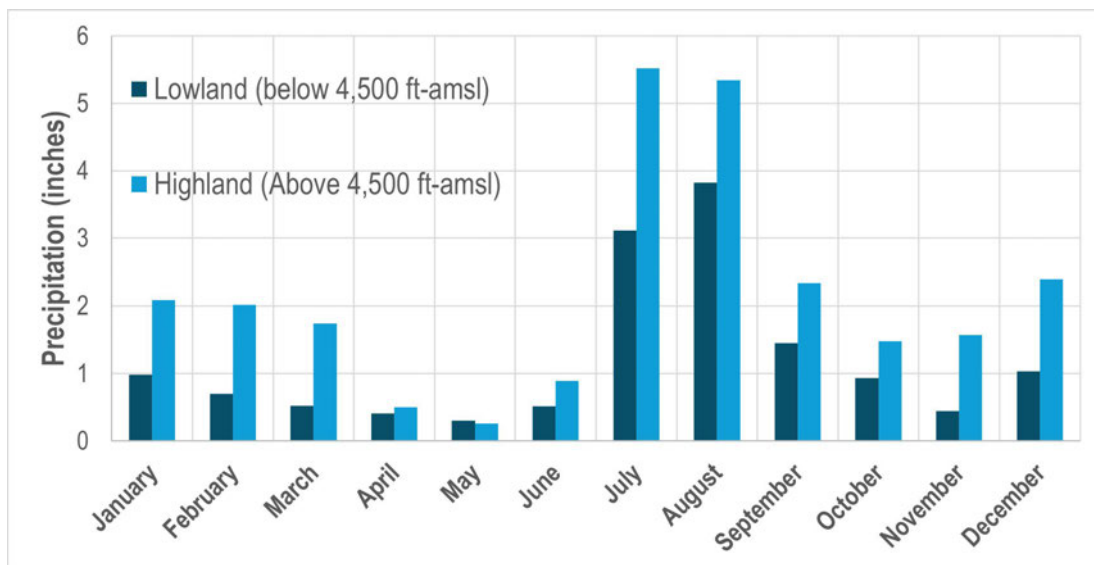


Figure 2. Average Monthly Precipitation (30 years) by Elevation

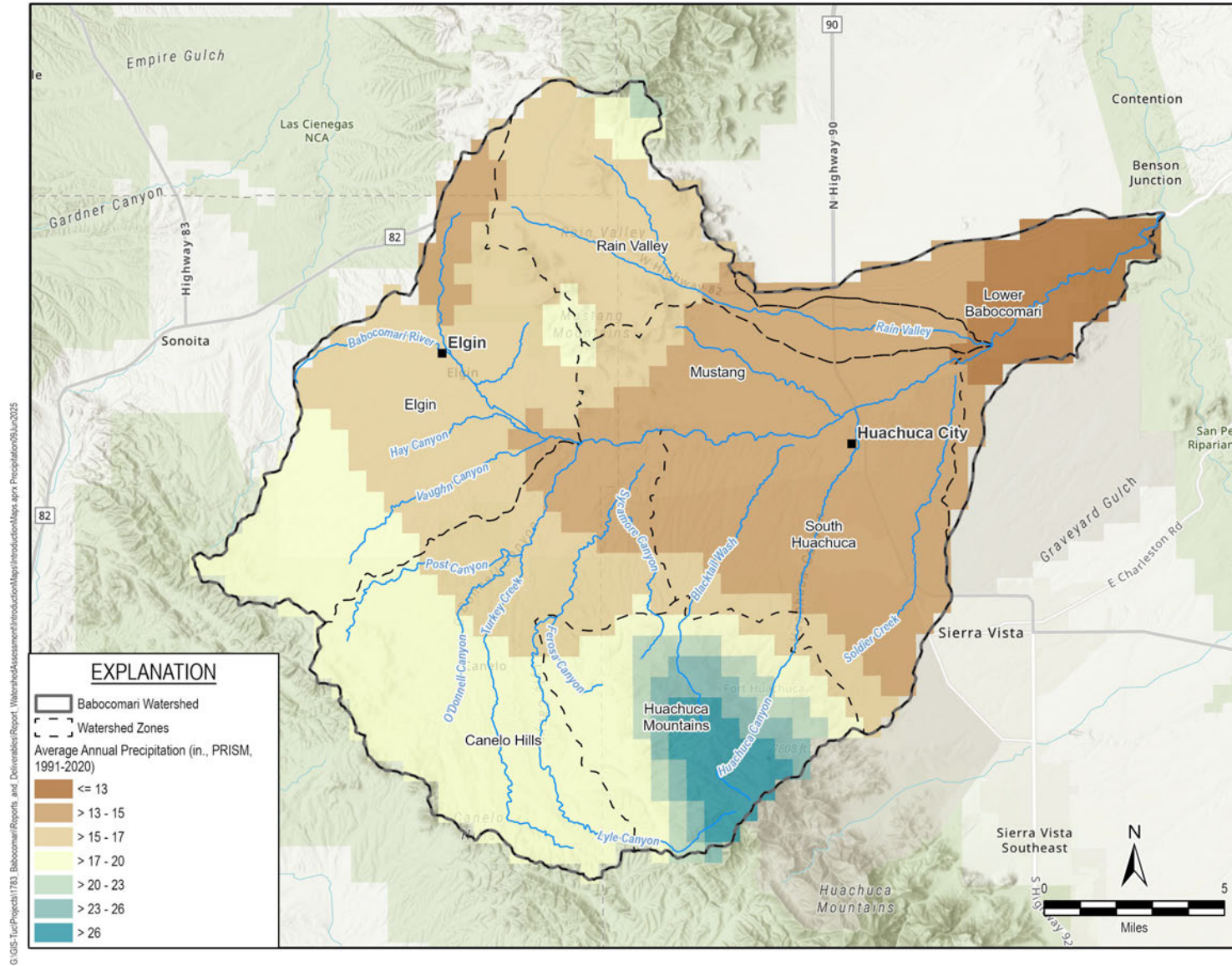


Figure 3. Annual Average Precipitation

3.2 Hydrogeology

The Babocomari Watershed is within the Sierra Vista sub-basin aquifer of Upper San Pedro Watershed (Kennedy and Gungle, 2010). Groundwater dependent ecosystems (GDEs) such as springs, ciénegas, and riparian areas are present within the watershed and are sustained by groundwater. Groundwater also sustains the baseflow of perennial sections of the Babocomari River (Norman *et al.*, 2019). Understanding where and how groundwater is recharged, stored, and flows is important for understanding where projects that benefit groundwater recharge should be sited.

3.2.1 Hydrostratigraphic Units

The geology of the watershed is shown on Figure 4. Groundwater within the watershed occurs in 2 primary settings: unconsolidated alluvial basin-fill in lowland areas and fractured bedrock aquifers in the surrounding mountains. The Quaternary alluvial units along stream channels and the Babocomari River are of variable thickness in the watershed and influence groundwater flow and storage (Schwartzman, 1990; Norman *et al.*, 2019). Less permeable bedrock occurs in the higher elevation mountains. Groundwater in bedrock units are generally restricted to highly fractured zones or lithologies with increased porosity, such as sandstone and carbonate formations (USGS, 1983) (Figure 4). Watershed-wide, underlying bedrock influences flow paths and limits groundwater storage. Springs and ciénegas form where less permeable bedrock units force groundwater to the surface within alluvial deposits (Stratman, 2022). Springs emerge along the transition between bedrock and alluvial deposits in the Whetstone and Huachuca Mountains, particularly in mountain-front and faulted areas (Springs Stewardship Institute [SSI], 2025) (Figure 4).

The extent of alluvial deposits, the location and orientation of structural geologic features such as faults, and hydrogeologic properties of the aquifer influence groundwater flow and storage capacity and are important factors for identifying watershed restoration strategies in each area.

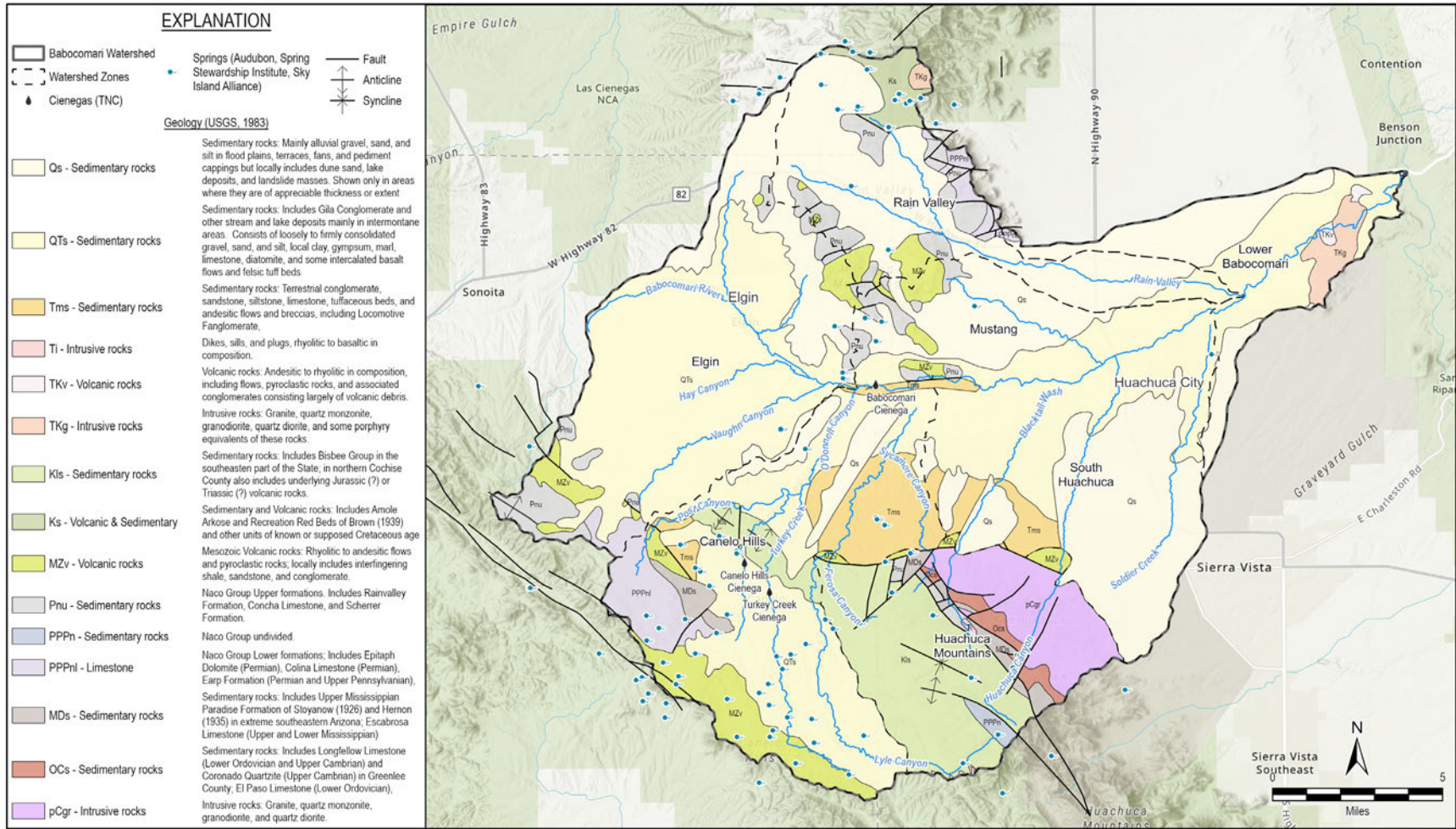


Figure 4. Geologic Map with Locations of Groundwater Dependent Ecosystems

3.2.2 Groundwater Levels

Groundwater levels across the watershed provide an understanding of groundwater flow direction and depth to water and are shown on Figure 5 as elevation and depth below ground surface (bgs). The groundwater elevation surface was derived from the Arizona Department of Water Resources (ADWR) Groundwater Site Inventory (GWSI) and well registration databases (ADWR GWSI, 2025; ADWR, 2025) for data collected between 1980 and 2024. Groundwater levels across the watershed have been relatively stable (Kennedy and Gungle, 2010) and the use of a broad date range provides more data points for creating the groundwater level contour surface. Land surface elevation was used as control points at the locations of perennial streams, springs outside of the mountain block, and ciénegas because these features indicate areas where groundwater is at the land surface. Depth to water was calculated by subtracting groundwater level elevation from a 1-meter digital elevation model (DEM) of the terrain from 2018 (USGS, 2025).

Groundwater flow direction is generally from high to low elevations toward the Babocomari River and northeast toward its confluence with the San Pedro (Figure 5). In the Huachuca Mountains, groundwater flows north converging with groundwater flowing south from the Mustang Mountains. This intersection of groundwater flow paths and shallow bedrock results in the emergence of groundwater and sustained surface water at and near the Babocomari Ranch Pond. In the Elgin area, groundwater level elevation contours indicate that some areas near Elgin have groundwater flow directions to the west toward the Las Cienegas and Sonoita Creek Watersheds, part of the ADWR delineated Cienega Creek groundwater subbasin (ADWR, 2022). The Babocomari River's surface watershed is part of the Upper San Pedro groundwater subbasin (ADWR, 2022). Additional data collection and modeling is required to refine the extent of the Cienega Creek subbasin capture zone with the Babocomari Watershed.

Depth to groundwater is greatest in areas of groundwater pumping around the population centers of Huachuca City and Sierra Vista where groundwater pumping has created cones of depression (Figure 5). Previous studies have shown a decline in groundwater derived baseflows to the Babocomari River (Kennedy and Gungle, 2010).

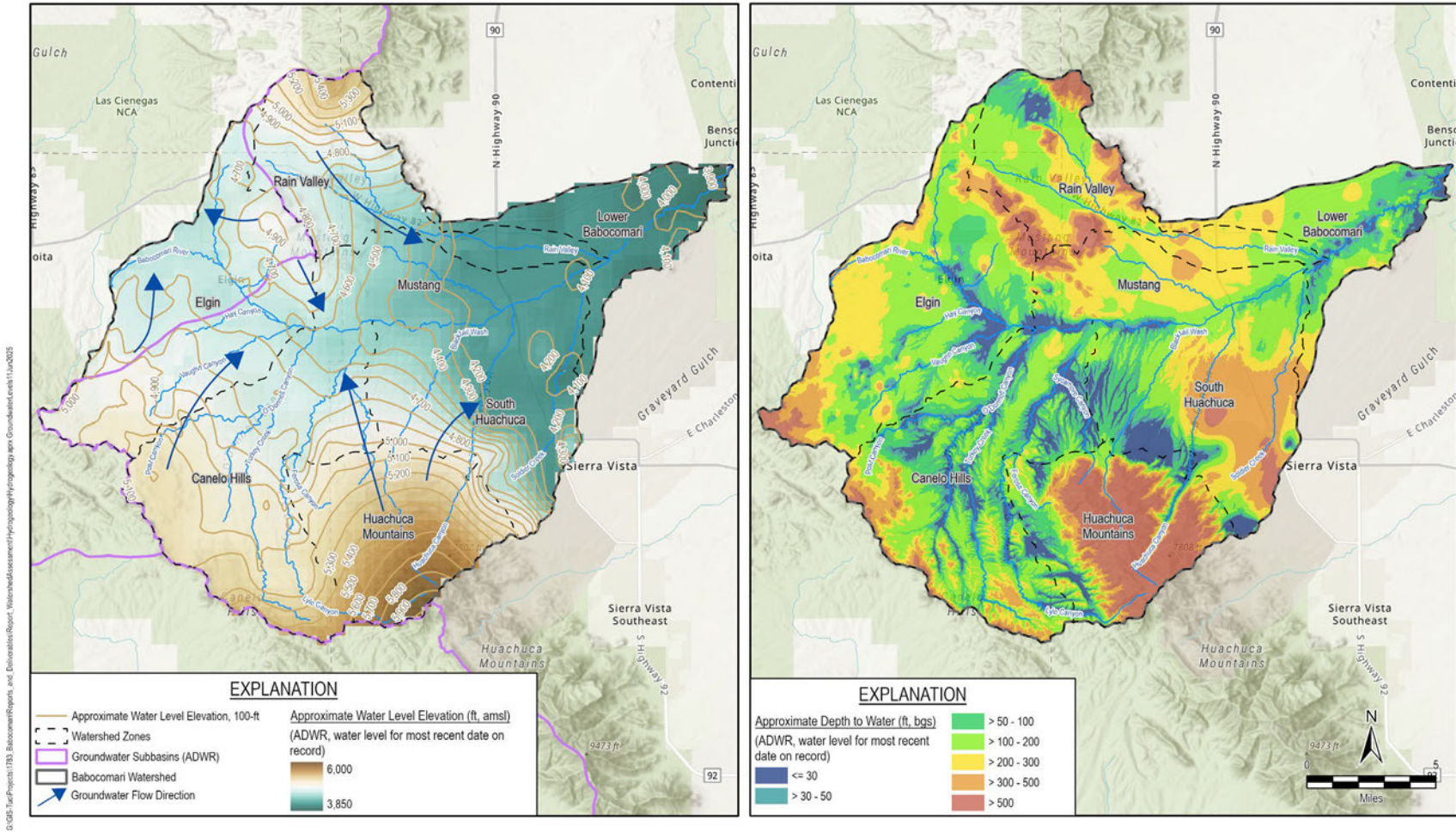


Figure 5. Groundwater Elevation and Depth

3.2.3 Groundwater Recharge

Groundwater recharge occurs primarily as mountain front recharge; precipitation falls in the mountains, surface water runs off over bedrock, infiltrates into unconsolidated sediments (alluvial fans or alluvium) at the base of the mountains, and enters the groundwater system (Schwartzman, 1990). Radiocarbon and tritium dating from multiple locations indicate that groundwater within the watershed is generally less than 500 years old (Stratman, 2022; Hasenstab, 2025). This relatively young groundwater highlights connectivity between shallow groundwater and deeper groundwater flow systems, with mountain-front recharge to unconsolidated alluvial sediment (Stratman, 2022).

Anderson (1991) integrates precipitation, groundwater modeling, baseflow separation, and watershed-scale water balance to estimate basin the percentage of precipitation that recharges in southwestern U.S. groundwater basins. The study concluded that over 90% of precipitation is lost to evapotranspiration (ET) processes. Applying these constraints to the Babocomari Watershed, PRISM-derived precipitation provides an estimate that between 1 and 3% of precipitation is recharged to groundwater, with higher percentages in the mountainous areas where ET is lower and precipitation is higher (Figure 6). Recharge patterns in the watershed are similar to the watershed precipitation pattern, with greater recharge potential at high elevations areas and lower recharge potential at lower elevations. Several limitations impact the recharge analysis, including coarse resolution data (800 meters), aquifer complexity, and anthropogenic influences. Once recharge patterns are better established, recharge values can be incorporated into a watershed-wide groundwater balance study, using USGS streamflow gage data from the Babocomari River alongside available well pumping records to enhance hydrologic modeling accuracy.

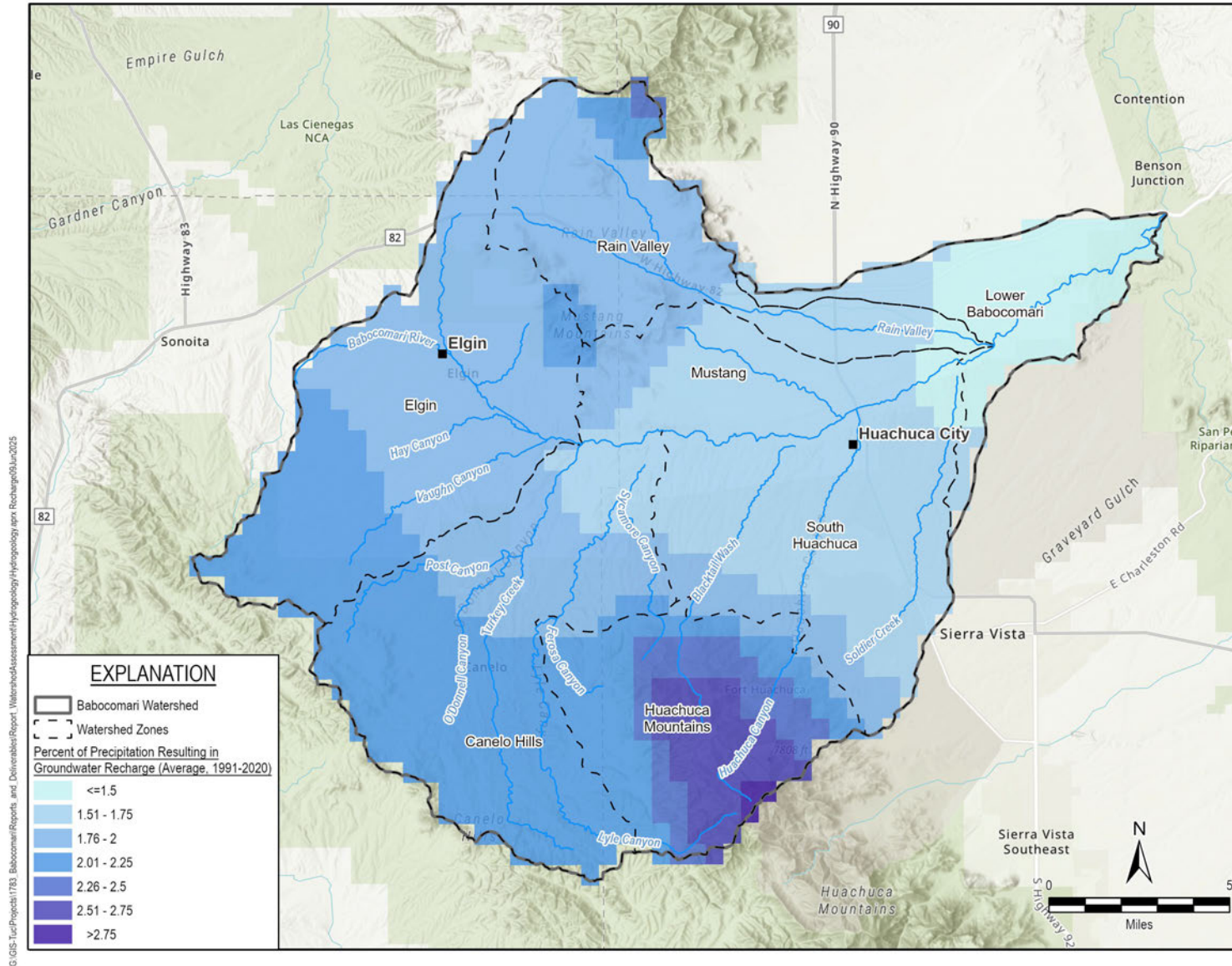


Figure 6. Percentage of Precipitation Resulting in Groundwater Recharge

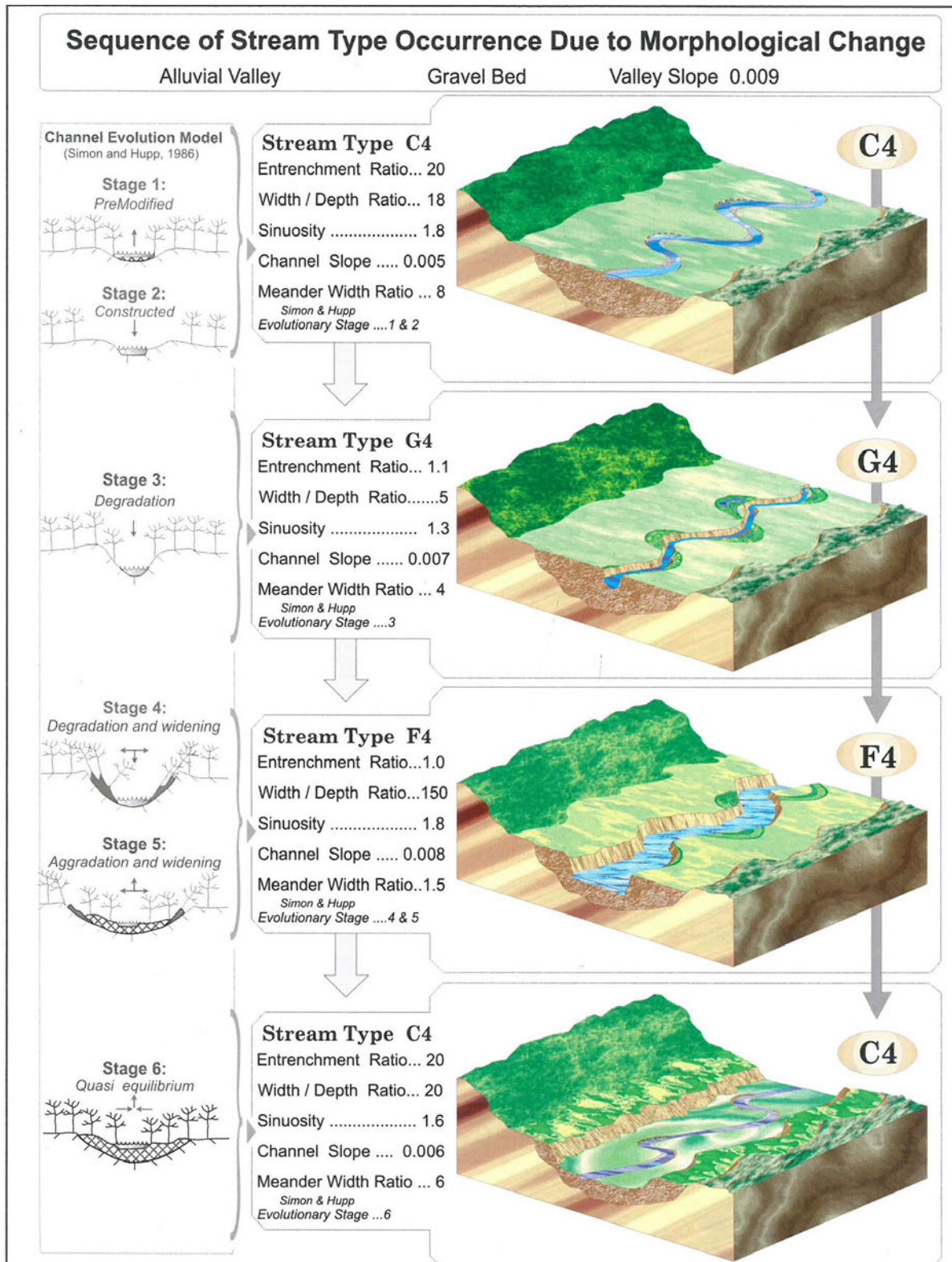
Within the Babocomari Watershed, projects to recharge stormwater/effluent and to preclude pumping in areas closest to stream channels will enhance groundwater baseflow contributions to the Babocomari River (Cochise County, 2002). Based on aquifer properties, modeling projections along the San Pedro River show that groundwater recharge benefits stream flows in areas closest to groundwater-dependent streams (Leake *et al.*, 2008). A variety of watershed restoration techniques and strategies have the potential to sustain mountain-front recharge and augment groundwater supplies to GDEs by storing excess surface water flows in channel banks, floodplains, and areas of unconsolidated sediment (Fan *et al.*, 2015; Norman *et al.*, 2025). Within the Babocomari Watershed, similar projects have been successfully implemented with documented hydrogeologic benefit of augmenting groundwater storage in areas proximal to restoration work (Norman *et al.*, 2019; CCRN, 2024).

4 WATERSHED CONDITIONS

Surface hydrology, groundwater, sediment transport, and ecological functions including vegetation and faunal habitat are all related via channel condition (Rosgen, 1999), which directly relates to watershed conditions. Anthropogenic disturbances and wildfire can affect the surface hydrology and degrade channels and associated watershed ecosystems.

4.1 Channel Conditions

At the watershed scale, channel evolution stages describe the process of gully erosion and recovery for a channel reach, and therefore can identify which processes should be slowed or sped up to reach a relative stable condition to support higher ecological function (Simon and Hupp, 1986; Rosgen, 1999). This process is shown schematically on Figure 7. Channel evolution begins when some event causes a channel headcut (Stage 3). Headcuts are abrupt, vertical drops in the bed of a stream channel, and are points where active headward erosion is taking place. This process deepens the channel over time, leading to channel incision, which is the progressive downcutting of the streambed relative to its floodplain. Incised channels become disconnected from their floodplains, reducing floodwater storage, destabilizing banks, and often increasing sediment transport downstream. As headcuts migrate upstream, they become steep-sided channels that are difficult to restore and lead to increased erosion. Controlling headcut progression protects riparian habitats and maintains hydrologic function. After incising, the channel bottom begins to widen (Stage 4) through bank erosion, then the channel begins the process of re-forming a stable low flow channel with a floodplain (Stage 5) large enough to handle flood flows within the incised channel.



Note: modified from Simon and Hupp (1986) and Rosgen (1999)

Figure 7. Channel Evolution Model

Several of the areas visited (Rain Valley, Babocomari River mainstem, and Lower Vaughn Canyon downstream of Research Ranch Road) were well along in the channel evolution process and had reached Stage 5, and the channel was no longer incising and was relatively stable. The areas all had well-developed floodplain, a meandering channel, and bank erosion was occurring at a much slower pace. Other locations such as Vaughn Canyon upstream of Research Ranch Road, were actively headcutting and incising (Stage 2). In general, places where active incision occurs are ideal for restoration work to prevent further incision, erosion, and habitat loss.

A reconnaissance level assessment was conducted to prioritize areas from a sediment and watershed perspective that have the potential to contribute to watershed degradation and downstream sedimentation. Geographic Information Systems (GIS) and modeling methods were used to screen areas for high likelihood of channel disturbance such as headcuts and incised channels, and the potential for high or low sediment transport capacity. Sediment source and transport at the assessment level were inferred from geomorphic features such as channel dimension, valley type, and potential channel condition. The results are shown on Figure 8.

Channel degradation from incision or widening, especially in softer alluvial materials, can create chronic sediment sources as the channel evolves to a more stable condition. Unstable channels yield much higher rates of sediment discharge, while some channel types and alluvial fans are functionally intact, capable of slowing/aggrading sediment transport. Identification of valley settings and potential channel types are key to identifying areas with erosion potential and management of sediment transport because they provide relatable ways to compare geomorphic condition across the watershed. Valley and channel type models were used to understand geomorphic condition and erosiveness throughout the watershed's stream network (Figure 8). This process helped understand watershed conditions and contribute to site selection for ground truthing fieldwork and siting of restoration projects.

An algorithm was used to identify headcuts throughout the landscape using slope breaks in stream channels. Mapped headcuts were initially identified using a GIS-based algorithm and subsequently verified through manual inspection of the digital elevation model (DEM). Field verifications were conducted for many of these headcuts to evaluate detection accuracy under current conditions. With the exception of headcuts occurring on bedrock, the process achieved high levels of accuracy. The headcut analysis identified approximately 150 headcuts, which are identified on Figure 8 by size of slope break and density.

To distinguish between historic and active degradation, historic aerial imagery could be compared to assess the rate that headcuts are advancing toward watershed features, for example, a *ciénega*. Observed channel instability generally aligns with mapped channel and valley types, reflecting modeled factors related to planform geometry and the forms typically associated with equilibrium or disequilibrium within specific valley settings.

In this analysis, the combined approach helped pinpoint locations where headcuts and degraded channel conditions are situated near high-priority watershed features. Not every headcut can or should be remediated. Rather, their distribution was used to guide prioritization, focusing on areas most in need of intervention. For instance, regions with high headcut density near shallow groundwater and alluvial sediment present opportunities for targeted restoration. This type of setting is well suited to mitigating headcut propagation; enhancing channel stability and reducing erosion, protecting groundwater storage areas, and producing other broader watershed benefits.

4.2 Ecological Conditions

Ecological conditions reflected in this analysis include critical habitats and vegetation. To evaluate ecological conditions within the Babocomari Watershed, a combination of open-source ecological data and remote sensing analysis was used.

4.2.1 Critical Habitats

The USFWS identifies critical habitat for the Gila chub, beardless chinchweed, yellow-billed cuckoo, jaguar, Mexican spotted owl, Huachuca water umbel, and northern Mexican garter snake (USFWS, 2025) (Figure 9). Many of the mapped habitat areas overlap with regions identified as GDEs. Restoration efforts at these locations within the watershed have the potential to enhance conditions for these species by improving groundwater recharge, expanding surface water availability, enhancing wildlife corridors, and supporting overall ecosystem resilience.

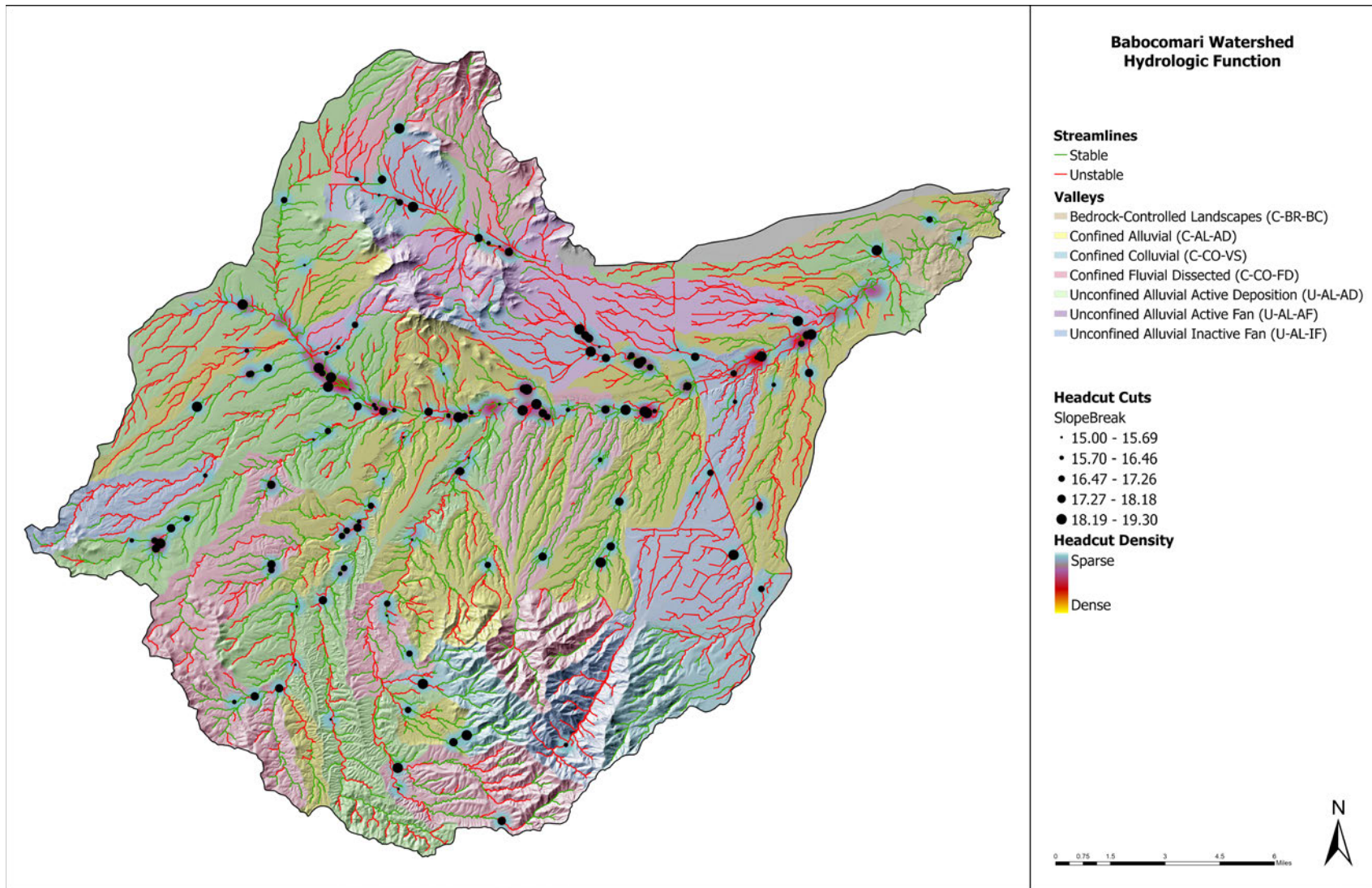


Figure 8. Valley and Channel Type and Locations of Headcuts

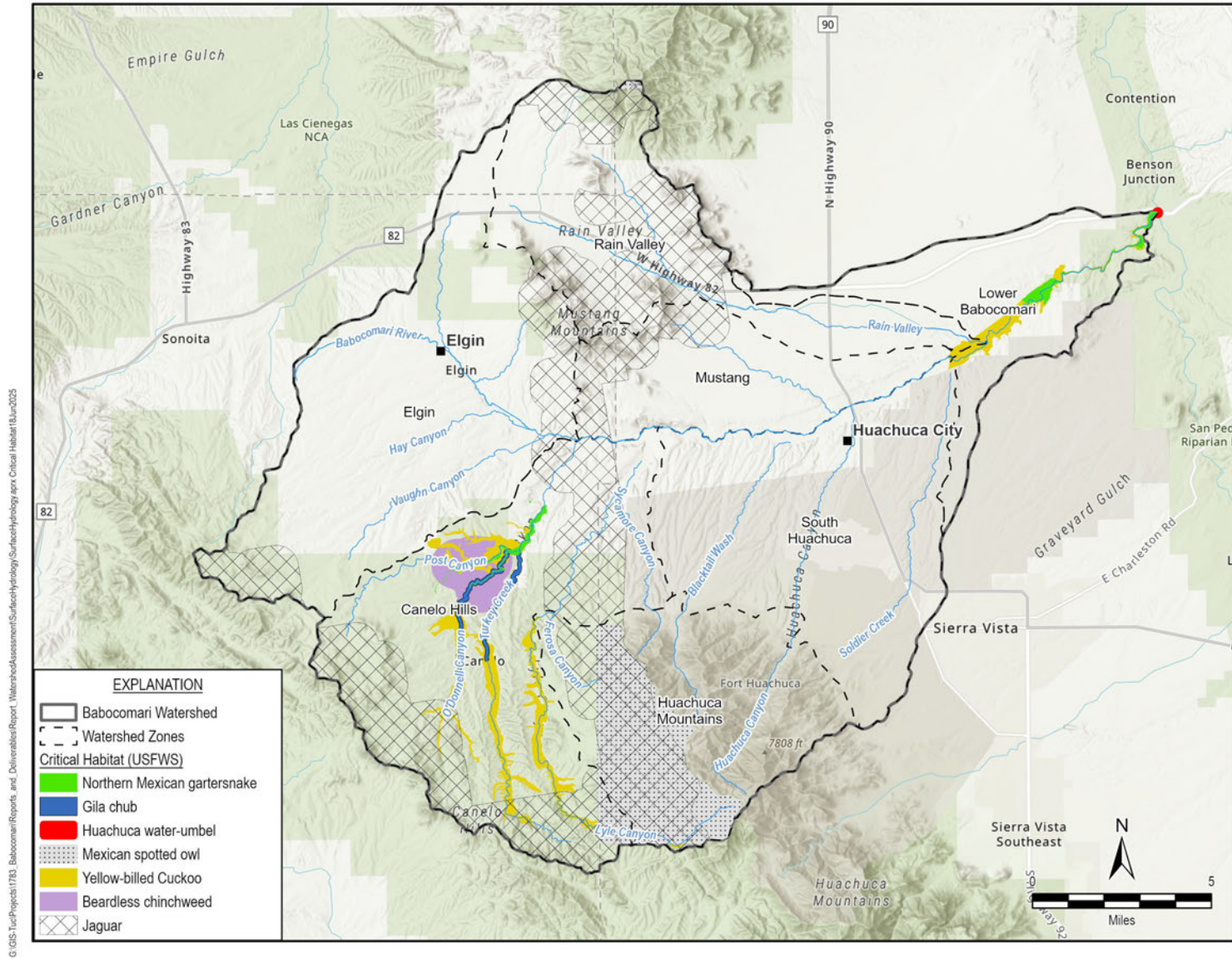


Figure 9. Critical Habitats and Groundwater Dependent Ecosystems

4.2.2 Vegetation

Functional vegetation groups were generated using a supervised classification model applied to 2023 National Agriculture Imagery Program (NAIP) imagery (USDA, 2023). Vegetation group classification spans the entire watershed—including both riparian and upland areas—and consists of 5 vegetation classes (Figure 10). These datasets benchmark vegetation health and distribution. This analysis was for a single year; however, NAIP imagery can be used for future analyses that incorporate timeseries or change detection to assess shifts in vegetation cover and health over a longer period.

Projects that support riparian vegetation both in upland and lower elevation areas have been the focus of conservation activities by various agencies and organizations (Robinett and Kennedy, 2009). To inform this effort, the normalized difference vegetation index (NDVI) for the trees functional group was examined along the riparian corridor of the Babocomari River. This analysis identified areas with relatively low NDVI values, suggesting potential vegetation stress or sparse canopy cover within the tree groupings. A detailed site-level assessment of these areas was not conducted; the geospatial analysis remained at a broader watershed scale to delineate broad, watershed-wide vegetation types and identify areas with lower NDVI values. Future efforts could benefit from on-the-ground verification to better understand site conditions, which would aid in selecting vegetation restoration areas. For example, an area with lower NDVI values downstream of the Babacomari Cienega was identified in the analysis; and several dead cottonwood trees were observed along the Babocomari River during the field visit, indicating that the low NDVI value may be pointing to an area of increased vegetative stress.

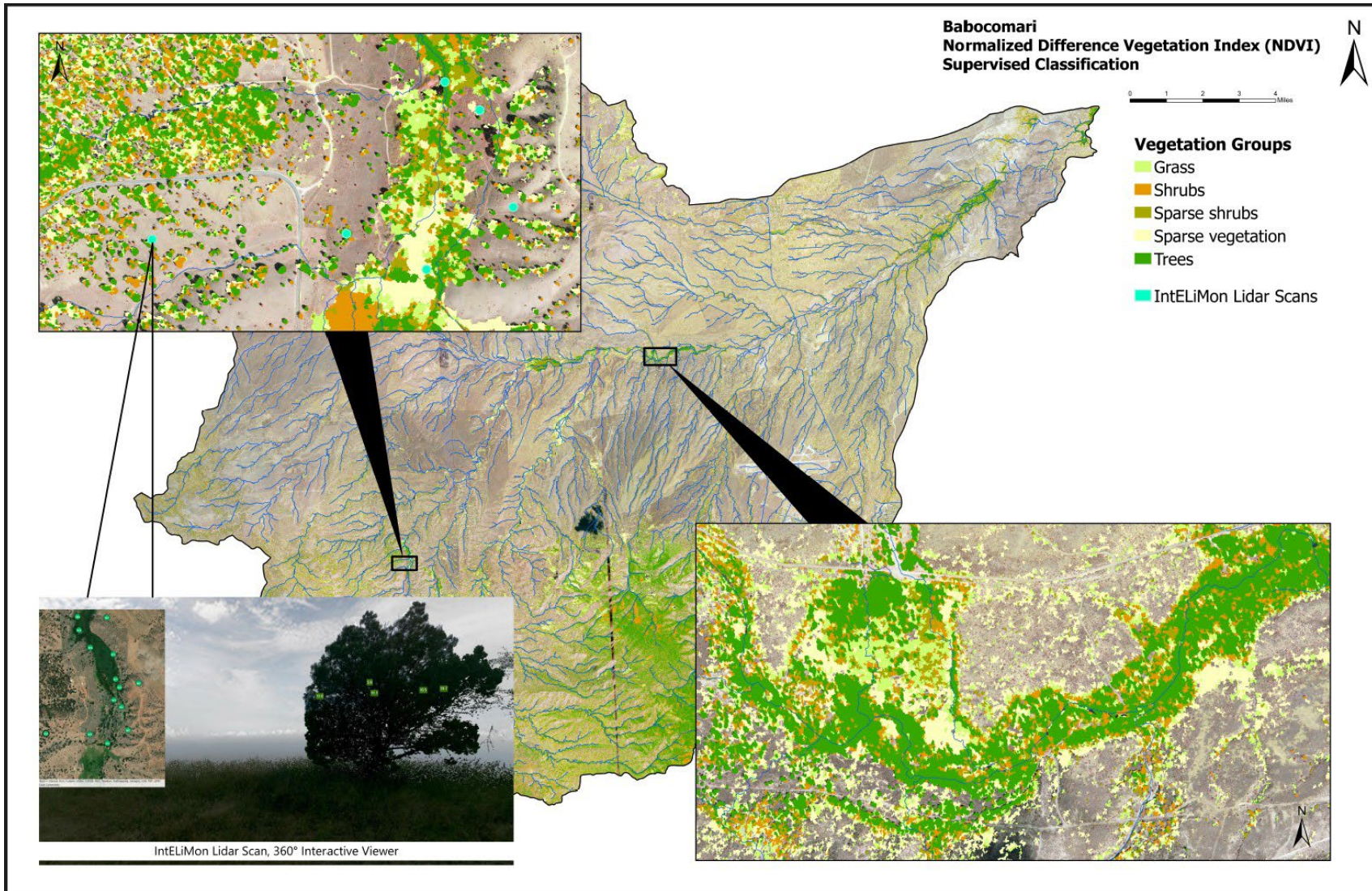


Figure 10. Vegetation Classification

4.3 Surface Water Conditions

The Babocomari Watershed is characterized primarily by ephemeral washes that flow only in response to precipitation events, particularly during the summer monsoon season when intense rainfall can lead to flash flooding. While much of the watershed is dominated by these ephemeral flow regimes, several sections of perennial surface water persist along the Babocomari River and its key tributaries, including Turkey Creek and O’Donnell Creek. These perennial reaches are sustained by discharge of shallow groundwater and provide important hydrologic and ecological functions but are limited in extent based on groundwater conditions.

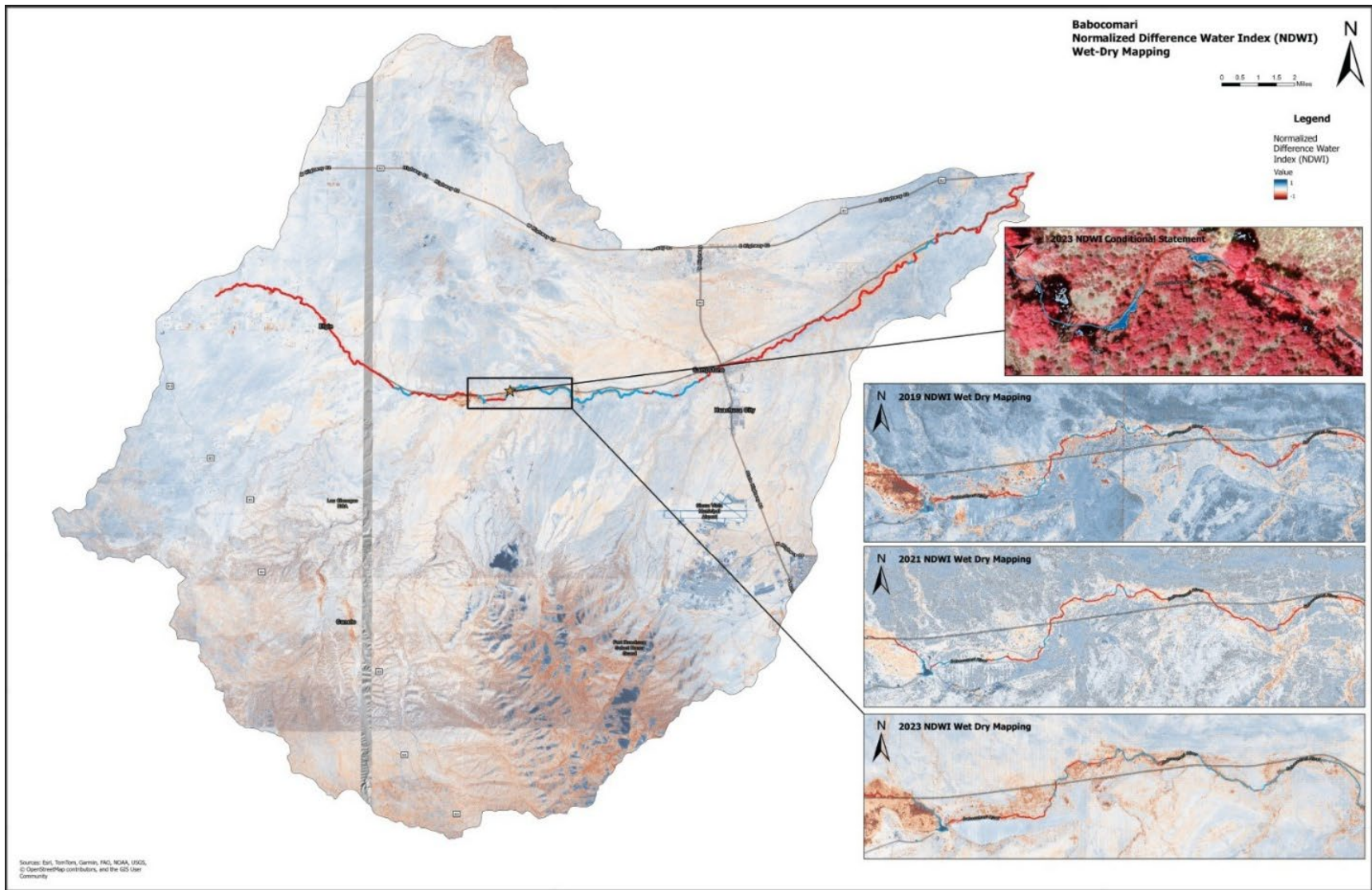
Historically, widespread overgrazing across the watershed has contributed to a reduction in surface water availability by degrading riparian and upland vegetation, compacting soils, and destabilizing streambanks (Robinett and Kennedy, 2009). These impacts have increased the vulnerability of stream channels to incision and the formation of headcuts because of surface hydrology changes, which continually degrade the watershed.

Wet and dry mapping of the Babocomari River was done using NAIP aerial imagery for 2019, 2021, and 2023 (Figure 11 and Table 3). Using different thresholds to best identify the spectral reflectance range of surface water for the 3 years, the Babocomari River was mapped as “wet,” indicating the presence of water or “dry,” indicating the absence of water. TNC wet and dry mapping results were also used to calibrate our 2019 findings, as the aerial imagery was captured in June, the same month the ground-based mapping was conducted (TNC, 2024).

Table 3. Lengths of the Babocomari River Classified as Wet or Dry

Year	Dry Length (miles)	Wet Length (miles)
2019	32.32	3.49
2021	32.59	3.22
2023	27.26	8.56

Wet and dry mapping using NAIP imagery is a tool that can be continually implemented as new imagery is collected from the national dataset. The advantage of this process is that results can be compared through time without commissioning additional data collection or field time. Wet and dry mapping with NAIP imagery could be further supplemented with repeated drone imagery and areas could be augmented where field mapping is difficult due to terrain or environmental hazards. For the Babocomari Watershed, this process was effective to track changes in surface water in perennial reaches of the Babocomari River. In this analysis, this tool highlights areas that are likely perennial based on persistent water in those reaches. These locations are likely GDEs, connected to the broader Babocomari River groundwater flow system.



(July 2019, October 2021 and October 2023)

Figure 11. Surface Water Occurrence

5 WATERSHED ZONES AND RESTORATION GOALS

The Babocomari Watershed was split into 7 watershed zones based on the analyses presented in sections 2 and 3. The watershed zones are shown on Figure 1. Each watershed is defined by its hydrologic characteristics, specifically groundwater and surface waters conditions, and the watershed condition and watershed restoration goals.

5.1 Canelo Hills

Part of the Huachuca Mountains, the Canelo Hills follows a southeast-northwest structural trend, with sandstone and shale exposures cropping out midway along Turkey and O'Donnell Creeks, north of Highway 83 (USGS, 1983). Bedrock acts as a hydrogeologic barrier, restricting lateral groundwater movement and forcing subsurface discharge to the surface, forming shallow groundwater (< 100 feet below ground surface [ft bgs]), perennial springs, and ciénegas and providing groundwater for these GDEs (Figure 5).

Residential wells in the area use shallow groundwater sources, but further downstream, depth to groundwater increases significantly within lower alluvial deposits, often exceeding 200 ft bgs. Groundwater remains deep until reaching the Babocomari River near Babacomari Ranch, where groundwater is relatively shallow. The Canelo Hills watershed zone contributes baseflow to the Babocomari River, supporting perennial springs, ciénegas, and surface water reaches that sustain riparian habitat (Stratman, 2022).

Groundwater recharge originates in the higher elevations of the western Huachuca Mountains, where fractured sandstone and shale formations facilitate mountain block recharge, while mountain front recharge occurs as surface water infiltrates unconsolidated alluvial deposits.

The higher elevations of the Canelo Hills are underlain primarily by carbonate formations that generally dip southwestward, away from the Babocomari Watershed. These structural controls likely affect groundwater movement by shifting a component of groundwater flow southwest toward the San Rafael Valley.

5.1.1 Watershed Restoration Goals

GDEs rely on both higher elevation recharge from the Huachuca Mountains and localized infiltration along alluvial deposits. Sustaining these recharge mechanisms by maintaining mountain front recharge from the Huachuca Mountains and ensuring favorable surface water conditions for infiltration along O'Donnell and Turkey Creeks can enhance aquifer sustainability and water supply to GDEs. This watershed zone contributes to Babocomari River baseflows (Stratman, 2022). Restoration efforts such as sediment stabilization and recharge-enhancing

structures will help maintain regional hydrologic conditions and support baseflow to GDEs. Further sediment transport analysis and small-scale interventions, including aggradation structures and headcut stabilization, may help reduce erosion and better support groundwater retention.

5.2 Elgin

Groundwater depths in the Elgin watershed zone vary between 150 ft bgs and 250 ft bgs with areas of shallow groundwater (less than 30 ft bgs) along the Babocomari River main stem (Figure 5). Limited higher elevation recharge areas exist within this watershed zone, with most recharge occurring locally through direct infiltration into alluvial deposits.

The Elgin watershed zone is the watershed divide between Las Cienegas, Sonoita Creek, and the Babocomari River and is predominantly composed of alluvial deposits. Active incision and erosional processes (Figure 8) in the Las Cienegas and Sonoita Creek watersheds are gradually advancing into the alluvial deposits on the watershed divide and into the Babocomari Watershed, which is experiencing comparatively less active erosion.

A buffered transition zone exists in the Elgin watershed zone of the Babocomari Watershed, where groundwater extraction could impact all 3 watersheds, and recharge efforts could provide hydrologic benefits across multiple systems.

Residential wells are widespread within alluvial deposits with some evidence of cumulative pumping effects with localized areas of relatively deeper groundwater. In areas where groundwater is shallow (less than 30 ft bgs), riparian vegetation such as cottonwoods persists, particularly along the main stem of the Babocomari River, the confluence of Hay Canyon, and Vaughn Canyon.

The watershed zone consists of predominantly unconfined alluvial valleys with confined (bedrock bound) alluvial sections. Sediment production and transport are significant, exacerbated by channel incision (Figure 8). The uppermost Babocomari River transitions in this zone from an undefined wash to a more channelized system where groundwater depths are less than 30 ft bgs. Low vegetation and disconnected floodplain conditions indicate significant incision, with numerous headcuts identified downstream of Elgin. The stretch along the railroad corridor is highly entrenched but is far along in the channel evolution process and has re-formed a meandering channel with an accessible floodplain.

5.2.1 Watershed Restoration Goals

Restoration projects aimed at enhancing recharge to the Babocomari Watershed water resources should be strategically placed downstream of the watershed capture zone to maximize retention

within the Babocomari Watershed. Near the intersection of Research Ranch Road and Vaughn Canyon, advancing headcuts and channel incision threaten infrastructure, with berms failing and gabions deteriorating. This erosion places the roadway, rural lands, and upstream bottomlands at risk. Targeted restoration efforts such as repairing failing gabion check dams could raise the channel elevation, increase surface water retention, and enhance channel-floodplain connectivity downstream of Elgin and within lower Hay and Vaughn Canyons. Addressing headcut advancement in Vaughn Canyon, and off Research Ranch Road could protect healthy bottomlands. Low-tech structures in the upper watershed, including one-rock dams (ORDs) or larger rock structures, could further stabilize sediment transport, slow surface water flow velocities, and aid channel recovery. Due to the limited recharge areas that exist within this watershed zone, groundwater conservation actions could be implemented in areas along the Babocomari River floodplain. Additionally, recharging stormwater runoff from roads and infrastructure near Elgin is another opportunity to maintain groundwater resources.

5.3 Huachuca Mountains

The Huachuca Mountains watershed zone represents the highest elevation portion of the Babocomari Watershed and is an important recharge area due to its substantial precipitation. Groundwater occurrence and movement within this sub-watershed are driven by structural geology, lithologic properties, and regional hydrologic gradients between mountainous areas and adjacent lowlands. Recharge processes are primarily governed by mountain block infiltration, where fractured meta-sedimentary, carbonate, and siliciclastic bedrock formations facilitate recharge, and mountain front recharge, where surface water runoff infiltrates unconsolidated alluvial deposits at the valley margin (Schwartzman, 1990; Hasenstab, 2025).

Numerous springs discharge from the bedrock within this sub-watershed, largely controlled by faulting, fracturing, and bedrock exposure of local perched aquifer systems (SSI, 2025). Huachuca Canyon, in the southeastern portion of the watershed, represents the largest groundwater discharge zone, supporting perennial-to intermittent flow and sustaining riparian vegetation.

The Huachuca Mountain watershed zone contains the most extensive vegetative cover within the Babocomari Watershed consisting of mixed pine forests and shrub-dominated zones that play a role in regulating infiltration and surface runoff. However, high-severity wildfires pose a major risk, as widespread vegetation loss can increase runoff, diminish infiltration, and alter recharge dynamics.

5.3.1 Watershed Restoration Goals

Strategic watershed restoration efforts, including vegetation management and targeted sediment stabilization, can enhance mountain recharge processes. Low-tech structures in upper reaches may improve shallow groundwater retention and mitigate sedimentation, while addressing incision and repairing significant headcuts can help restore connectivity between surface water and groundwater systems. Ensuring continuity of recharge, especially mountain front recharge along the Huachuca Mountains and alluvial recharge near key surface water tributaries, will be essential for maintaining long-term hydrologic resilience in the Babocomari Watershed.

5.4 Mustang

Portions of this watershed zone extend across the southern slopes of the Mustang Mountains, bordering Rain Valley. In these higher-elevation areas, groundwater depth is variable (Figure 5). Adjacent to the Mustang Mountains, alluvial deposits host groundwater at more consistent depths less than 100 ft bgs, indicating connection to the regional groundwater system.

Downgradient, groundwater depths rapidly shallow due to sub-flow contributions along the Babocomari River and dropping topography. The region is characterized by dissected fluvial landscapes and widespread ephemeral channels.

5.4.1 Watershed Restoration Goals

Restoration measures should prioritize efforts to slow flows near the Babocomari River and enhance recharge potential through strategic interventions. Like Rain Valley, the watershed zone presents a viable opportunity for watershed restoration and aquifer recharge. Targeted interventions could augment groundwater storage and contribute to the lower Babocomari Watershed zone. Strategic recharge planning in the Mustang watershed zone could mitigate localized drawdown effects along the Babocomari River and improve overall aquifer sustainability.

5.5 Lower Babocomari

The Lower Babocomari watershed zone has relatively shallow groundwater depths, generally less than 100 ft bgs along the Babocomari River (Figure 5). Alluvial deposits originating from the upper areas of the Babocomari Watershed form a wedge-shaped geometry, gradually thinning and pinching out against surficial volcanic bedrock near the confluence of the Babocomari and San Pedro Rivers (Richard *et al.*, 2007). Bedrock units crop out at this downgradient boundary and serve as structural controls on groundwater movement, marking the terminus of the Babocomari Watershed's alluvial aquifer system. This process promotes shallow

groundwater conditions, supporting extensive riparian ecosystems and sustaining perennial and intermittent reaches of the Babocomari River.

Several hydrologic stressors affect groundwater availability and sustainability. Reduced groundwater contributions from upgradient portions of the Babocomari Watershed pose a challenge to maintaining adequate groundwater levels (Kennedy and Gungle, 2010). Groundwater extraction near Sierra Vista and Fort Huachuca has formed a pronounced cone of depression. Regional sub-flow dynamics within the San Pedro River also play a role in sustaining groundwater conditions. Multiple agencies have implemented groundwater management strategies to stabilize groundwater gradients within the San Pedro River subflow area, recognizing its direct influence on groundwater availability to GDEs (CCRN, 2024).

Widespread rural development has necessitated regulatory oversight to mitigate the impacts of growth and groundwater extraction on adjacent GDEs (Cochise County, 2002). In certain areas, particularly along alluvial hillslopes, significant channel incision and headcutting reduce infiltration capacity, disrupt in-channel recharge, and impair the watershed zone's ability to recharge groundwater locally. The entrenched main channel of the Babocomari River, likely impacted by development, has undergone sufficient deposition over time, allowing a new floodplain to form with healthy riparian vegetation, as confirmed by NDVI analysis. This suggests that despite human impact, portions of the watershed zone continue to function effectively.

5.5.1 Watershed Restoration Goals

Restoration efforts could prioritize strategies that enhance groundwater recharge and promote sustainable water use. Slowing surface water movement can increase infiltration and reduce runoff losses, while enhancing recharge near riparian habitats will help sustain baseflows and groundwater-dependent ecosystems. Mitigating and sustainably managing development impacts through land-use planning and conservation measures is essential, as is implementing erosion control practices to stabilize incised channels and improve infiltration efficiency.

Floodplain protection projects aim to prevent development within the Lower Babocomari floodplain. Downstream efforts should focus on vegetation management rather than structural interventions until upstream watershed treatments are implemented. While scattered headcuts are present, none appear significant, though targeted mitigation may be warranted.

5.6 Rain Valley

Groundwater depths in Rain Valley are highly variable (Figure 5). In the northern portion of the watershed area the southern Whetstone Mountains and the highest elevations of the Mustang Mountains provide mountain front recharge. Surficial bedrock in this portion of the watershed

props up groundwater levels to less than 30 ft bgs. This area also hosts several low-yield springs. As groundwater moves downgradient, depths increase to approximately 200 to 300 ft bgs in lower portions of Rain Valley due to substantial alluvial fill. At lower elevations along the Babocomari River groundwater levels are generally less than 30 ft bgs. Groundwater development is low-moderate in this watershed zone, and groundwater use is predominately from small domestic wells.

Fluvial dissected valley types dominate the upper watershed, contributing to high sediment production and transport (Figure 8). Analyses confirms active surface erosion, with rilling, incision, and heavy sediment loads originating from the first major northern tributary, increasing downstream sedimentation. Multiple headcuts along the mainstem stream promote sedimentation and erosion and are opportunities for stabilization. Southern slopes are prevalent throughout this zone and support distinct vegetation assemblages that influence watershed hydrodynamics.

5.6.1 Watershed Restoration Goals

Strategic watershed restoration projects with a recharge emphasis could mitigate localized drawdown from rural groundwater use and support baseflow to the Babocomari River. This could be accomplished by implementing small-scale runoff control structures in upper watershed areas where groundwater is shallow near springs. Projects such as these could facilitate channel aggradation, enhance recharge through slowed flows, and maintain and/or increase spring discharge in low-yield springs. Given the results of groundwater capture mapping and other modeling work within the Upper San Pedro Watershed, targeted recharge near the perennial and intermittent reaches of the Babocomari River may help sustain baseflow (Leake *et al.*, 2008). Upland restoration projects include those that improve watershed conditions, vegetative conditions (grasslands), soil conditions (reducing erosion), protect or maintain infrastructure, and improve water quality and quantity at low-yield springs.

5.7 South Huachuca

Groundwater occurs primarily within alluvial deposits that drape over the north and eastern flanks of the Huachuca Mountains and slope downgradient toward the confluence of the Babocomari and San Pedro Rivers. These alluvial deposits form a wedge-shaped geometry, with variable depths and geometries near the mountain base and increasing in depth distally before pinching out near the San Pedro River (Richard *et al.*, 2007). In the northeastern portion near Blacktail Wash, surficial bedrock composed of siliciclastic units such as sandstone and shale promotes shallow groundwater conditions. Near Fort Huachuca and Sierra Vista, sustained high-volume extraction has formed a pronounced cone of depression with groundwater depths exceeding 300 ft bgs. Shallow groundwater is along the Babocomari River; however, near Fort Huachuca, depths increase abruptly from approximately 5 feet to over 100 ft bgs due to

pumping-induced drawdown. Huachuca Canyon supports locally shallow groundwater gradients along its length until intersecting the cone of depression capture zone. Urbanization near Fort Huachuca and Sierra Vista has significantly altered surface recharge, with widespread impervious surfaces restricting infiltration.

This watershed zone also features relatively steep, fluvial-dissected landscapes that contribute high sediment loads downgradient to the Babocomari River. Sediment supply remains high, as evidenced by the braided channel morphology, which transitions into an incised channel in North Huachuca Canyon where road confinement and urbanization limit lateral movement. Few headcuts are observed, but channel incision is widespread. The dissected landscape south of the Babocomari River, between the pond at Babacomari Ranch and Huachuca City, may provide a suitable location for small structures aimed at improving recharge and mitigating sediment transport.

5.7.1 Watershed Restoration Goals

Watershed restoration techniques in this zone could focus on stabilizing the lateral extent of the cone of depression and implementing recharge enhancement measures downstream of the drawdown zone. Strategic managed aquifer recharge between the cone of depression and the Babocomari River could increase groundwater contributions to the Babocomari River, possibly contributing baseflow. Presently, groundwater flows from the Babocomari River toward Sierra Vista, an inversion of the natural hydrologic regime toward the Babocomari River from the Huachuca Mountains.

6 PROJECT IMPLEMENTATION AND RECOMMENDATIONS

Approximately 3 dozen watershed projects were identified through stakeholder input, geospatial and remote sensing analyses, and field inspection. These projects serve as a starting point and additional project concepts are expected to be developed as opportunities emerge in the future. These projects are summarized in this section.

6.1 Potential Projects

The watershed projects are described according to the watershed zones, and classified according to project type and goals, land ownership, and project origin. Watershed restoration projects are categorized by the 6 categories listed in Table 4. Projects are also categorized by the 5 goals listed in Table 5 in terms of a primary and secondary goal, if applicable. Projects were comparatively ranked for benefits and feasibility based on available information. The expected watershed benefits for projects were identified as high, medium, and low. Project feasibility is also ranked as high, medium, and low based on landowner interest, design, engineering requirements, and expected permitting requirements. The watershed projects are listed in Table 6 and shown on Figure 12.

Table 4. Watershed Project Types

Project Type	Description
Recharge	Projects that promote groundwater recharge
Assessment	Projects that require further study to evaluate watershed conditions
Channel Restoration	Projects that enhance channel function for recharge, sediment retention, or habitat
Outreach	Projects with a goal of informing and/or working with stakeholders
Repair Infrastructure	Projects that repair or restore current infrastructure
Habitat	Projects that promote or enhance riparian or upland habitats

Table 5. Watershed Project Focus

Focus	Description
Groundwater Recharge	Projects with practices that promote shallow groundwater recharge through increased or prolonged soil moisture retention, and infiltration
Water Quality/Water Sources	Projects with practices that promote and enhance water quality, especially to groundwater dependent ecosystems
Erosion	Projects with practices that reduce erosion and transport, especially reducing anthropogenic erosion near important watershed features
GDE Habitats and Vegetation	Projects with practices that support GDEs (ciénegas, springs), and other surface water habitats; practices that support aquatic habitat
Upland Habitats and Vegetation	Projects that promote better vegetative and habitat in upland areas through vegetation management and channel restoration

Table 6. List of Potential Projects

Map ID	Benefit	Feasibility	Project Name	Description	Project Type, primary	Project Type, secondary	Focus, primary	Focus, secondary	Project Origin
BR 1	High	Medium	Babocomari Main Stem Gabion Repair	Repair existing gabion investment; raise channel bottom and facilitate groundwater recharge by encourage broad surface water flows	Repair Infrastructure	Recharge	Erosion	Groundwater Recharge	Stakeholder
BR 2	High	High	Babacomari Ranch Outreach, Communication	Coordination and outreach to find mutually beneficial ways to use water rights	Outreach	Recharge	Water Quality, Water Sources	Groundwater Recharge	Stakeholder
BR 3	High	High	Babacomari Pond Monitoring	Implement monitoring system aimed at ensuring adequate water levels in the ciénega, pond height, and seasonal outflow	Recharge	Habitat	Water Quality, Water Sources	GDE Habitats & Vegetation	Stakeholder
BR 4	High	High	Phased Projects Erosion Control Project	ALWT helping implement small channel restoration structure aimed at broad watershed restoration and sediment retention; 2500 acre project area, 11-15 channels with a total length of 12 miles	Channel Restoration	Habitat	Erosion		Stakeholder
BR 5	High	High	Channel and Watershed Restoration on Alluvial Fans North of Ft Huachuca	Alluvial drainages to the north and west of Fort Huachuca pose ideal places to implement restoration activities; promote recharge and better watershed conditions	Channel Restoration	Recharge	Upland Habitats & Vegetation	Groundwater Recharge	Stakeholder
BR 6	High	Low	Alluvial Floodplain Restoration	Good place to slow water and facilitate groundwater recharge along the mainstem of the Babocomari River	Recharge	Channel Restoration	Groundwater Recharge		Analysis
BRW 2	High	Medium	Road Drainage Improvement	Watershed wide, install erosion control in roadside drainage in areas with paved and unpaved county, and federal roads; all road sections greater than 1,000 feet in length with a slope greater than 5% should be considered	Channel Restoration	Channel Restoration	Erosion	Water Quality, Water Sources	Site Visit
CH 1	High	High	Canelo Hills Cienega Restoration and Enhancement	Small, hand-built structures could help preserve/prevent further channel incision and watershed issues adjacent to Canelo Hills Cienega	Recharge	Habitat	Erosion	Water Quality, Water Sources	Site Visit
CH 2	Medium	High	Watershed Grassland Density and Erosion Model (NRCS)	Pilot study evaluating grassland density and diversity; compare existing condition to idealized watershed condition; suggest measures to restore upland grassland health	Habitat	Outreach	GDE Habitats & Vegetation		Site Visit
CH 3	Medium	Medium	Turkey Creek Cienega	Engage with private land owner to a) restore and/or prevent channel erosion in the lower reach of Turkey Creek Cienega, b) promote adequate habitat in ciénega (open water and wetland)	Habitat	Channel Restoration	GDE Habitats & Vegetation	Water Quality, Water Sources	Analysis
CH 4	High	High	Stream Restoration, Enhancement on Upper O'Donnell Creek	Slow surface water flows along the channels; implement channel restoration structures	Recharge	Channel Restoration	Groundwater Recharge	Water Quality, Water Sources	Analysis
CH 5	High	High	Stream Restoration, Enhancement on Upper Turkey Creek	Slow surface water flows along the channels; implement channel restoration structures	Recharge	Channel Restoration	Groundwater Recharge	Water Quality/Water Sources	Analysis
CH 6	High	High	Stream Restoration, Enhancement on Upper Lyle Canyon	Slow surface water flows along the channels; implement channel restoration structures	Recharge	Channel Restoration	Groundwater Recharge	Water Quality, Water Sources	Analysis
CH 7	Medium	High	Enhance Fish Barrier on O'Donnell Creek	In collaboration with BLM and Borderlands Restoration Network, we aim to use low-impact erosion control methods to increase the longevity of an existing fish barrier on O'Donnell Creek; enhance with channel restoration work upstream of the barrier and downstream if needed	Habitat	Channel Restoration	GDE Habitats & Vegetation	Erosion	Stakeholder
CH 8	High	High	Sacaton Grassland Restoration	ALWT conservation easement with large sacaton grassland and surrounding channels that are eroding, incision beginning in sacaton bottom	Channel Restoration	Habitat	Erosion	GDE Habitats & Vegetation	Stakeholder
E 1	High	Medium	Middle Vaughn Headcut Mitigation and Channel Restoration	Install rock structures to repair headcuts, prevent further channel incision, raise channel, improve floodplain connection, and reduce erosion	Channel Restoration	Recharge	Erosion		Stakeholder
E 2	High	Medium	Lower Vaughn Canyon Headcut Complex	Direct surface water flow to a selection of hardened locations (large, engineered rock rundowns for example) to arrest headcuts	Channel Restoration	Recharge	Erosion		Stakeholder
E 3	High	Medium	Lower Vaughn Canyon Gabions	Repair and restore existing gabion investment; protect against future headcutting and upstream channel degradation	Repair Infrastructure	Recharge	Erosion		Stakeholder

Map ID	Benefit	Feasibility	Project Name	Description	Project Type, primary	Project Type, secondary	Focus, primary	Focus, secondary	Project Origin
E 4	High	Medium	Vaughn Canyon Watershed Restoration	Restore channel and adjacent degraded watershed from its headwaters to the Babocomari River; potential to restore and enhance existing feature restoration work	Channel Restoration	Recharge	Erosion	Upland Habitats & Vegetation	Site Visit
E 5	High	Medium	Elgin Stormwater Management	Suggest stormwater practices via an easy to digest memo; difficult to disseminate given the rural population; helpful for ensuring infiltration of stormwater in developed areas	Outreach	Recharge	Water Quality, Water Sources	Groundwater Recharge	Analysis
E 6	Medium	Low	Elgin Road Maintenance	At 2 locations along U.S. 83, road runoff and a lower water crossing have propagated downstream channel instability and headcutting; proposed engineered solutions to restore these areas	Repair Infrastructure	Channel Restoration	Erosion	Upland Habitats & Vegetation	Site Visit
E 7	Medium	Medium	Elgin Plug and Spread	Fix incision and failed earthen berm tanks in a shallow valley in the Elgin area; install plug and spread structures to induce meandering and spread surface water flow	Recharge	Habitat	Erosion	Groundwater Recharge	Site Visit
E 8	High	Low	Groundwater Conservation in Floodplain Connected to Babocomari River	Expand on Leake <i>et al.</i> recharge capture modeling to incorporate the Babocomari Watershed; suggest sustainable groundwater management in important areas; check in with Santa Cruz County Floodplain manager on priorities and goals; concerns about future development in these parcels	Recharge	Outreach	Groundwater Recharge	Water Quality, Water Sources	Stakeholder
E 9	Low	Low	Conservation Easement Erosion Control	Several eroding channels requiring attention in this area, ALWT leading this initiative	Channel Restoration	Habitat	Erosion	GDE Habitats & Vegetation	Stakeholder
HM 1	Medium	Low	Huachuca Canyon Channal and Riparian Area Restoration and Enhancement	Assess Huachuca Canyon for areas beneficial for channel and vegetation restoration enhancement; focus on techniques that promote aquatic habitats	Channel Restoration	Recharge	GDE Habitats and Vegetation	Water Quality, Water Sources	Analysis
LB 1	High	High	Hand Crew Restoration on Ephemeral Channels in SPRNCA/BLM	NEPA on SPRNCA land to work on low-tech structures. Identify problem areas and then evaluate watershed size for implementation of rock structures	Channel Restoration	Recharge	GDE Habitats and Vegetation	Groundwater Recharge	Stakeholder
LB 2	High	High	Hand Crew Restoration on Ephemeral Channels Adjacent and Upstream to SPRNCA	Work with stakeholders to implement channel restoration and enhancement in areas adjacent to SPRNCA along the Babocomari River; promote slower flows and infiltration	Channel Restoration	Recharge	Groundwater Recharge	Erosion	Analysis
LB 3	Low	Low	Roadway Crossing	Sanders/Bowers crosses pretty riparian vegetation and a flowing reach of Babocomari River; is there a possibility for an alternative road crossing here? Broadly, consider other areas in the watershed where this is occurring.	Habitat	Channel Restoration	Erosion	GDE Habitats & Vegetation	Stakeholder
LB 4	Low	Low	Preclude Pumping Between CCRN and SPRNCA	Wetted length is in decline. Funding may be available to acquire land, preclude future development especially within the floodplain	Outreach	Recharge	Water Quality, Water Sources	Groundwater Recharge	Stakeholder
M 1	Medium	High	Mustang Watershed Zone Channel Restoration	Complete installations of hand channel and watershed restoration structures in ephemeral channels to the north of the Babocomari River	Channel Restoration	Recharge	Water Quality, Water Sources	Groundwater Recharge	Stakeholder
RV 1	High	Medium	Rain Valley Gravel Pit Recharge	Repurpose gravel pit at lower end of Rain Valley just south of Highway 82; possible channel diversion to move surface water into gravel pit to increase infiltration	Recharge	Habitat	Groundwater Recharge	Water Quality, Water Sources	Site Visit
RV 2	High	Medium	Rain Valley Main Stem Channel Restoration	Rock structures to prevent further headcutting; promote groundwater recharge through increased infiltration	Channel Restoration	Recharge	Erosion	Groundwater Recharge	Analysis
RV 4	Low	Low	Reduce Impact of Flooding on Rain Valley	Flooding has caused incision of the floodway and mitigation here could prevent further degradation of channel and floodplain	Channel Restoration	Recharge	Erosion	Groundwater Recharge	Stakeholder
SH 1	High	Medium	Huachuca City Stormwater Management	Suggest stormwater practices via an easy to digest memo; difficult to disseminate given the rural population; helpful for ensuring infiltration of stormwater in developed areas	Outreach	Recharge	Groundwater Recharge	Water Quality, Water Sources	Analysis
SH 3	High	Low	Effluent Recharge Siting Analysis	Conduct study of effluent from Ft. Huachuca and Huachuca City; site locations for recharge within Soldier Creek	Recharge	Habitat	Water Quality, Water Sources	Groundwater Recharge	Stakeholder

Map ID	Benefit	Feasibility	Project Name	Description	Project Type, primary	Project Type, secondary	Focus, primary	Focus, secondary	Project Origin
SH 4	Medium	High	Restoration and Erosion Control	Grazing lease - restoration project and erosion control; 2 Phases of LTPBR covering the length of 1 upland channel already complete. 3rd phase planned for another channel	Channel Restoration	Habitat	Erosion	Upland Habitats & Vegetation	Stakeholder

Map ID refers to numbered projects in watershed zones shown on Figure 12: BR: Babocomari River Mainstem, CH: Canelo Hills, E: Elgin, HM: Huachuca Mountains, LB: Lower Babocomari, M: Mustang, RV: Rain Valley, SH: South Huachuca

SPRNCA = San Pedro Riparian National Conservation Area

NEPA = National Environmental Policy Act

LTPBR = low-tech process-based restoration

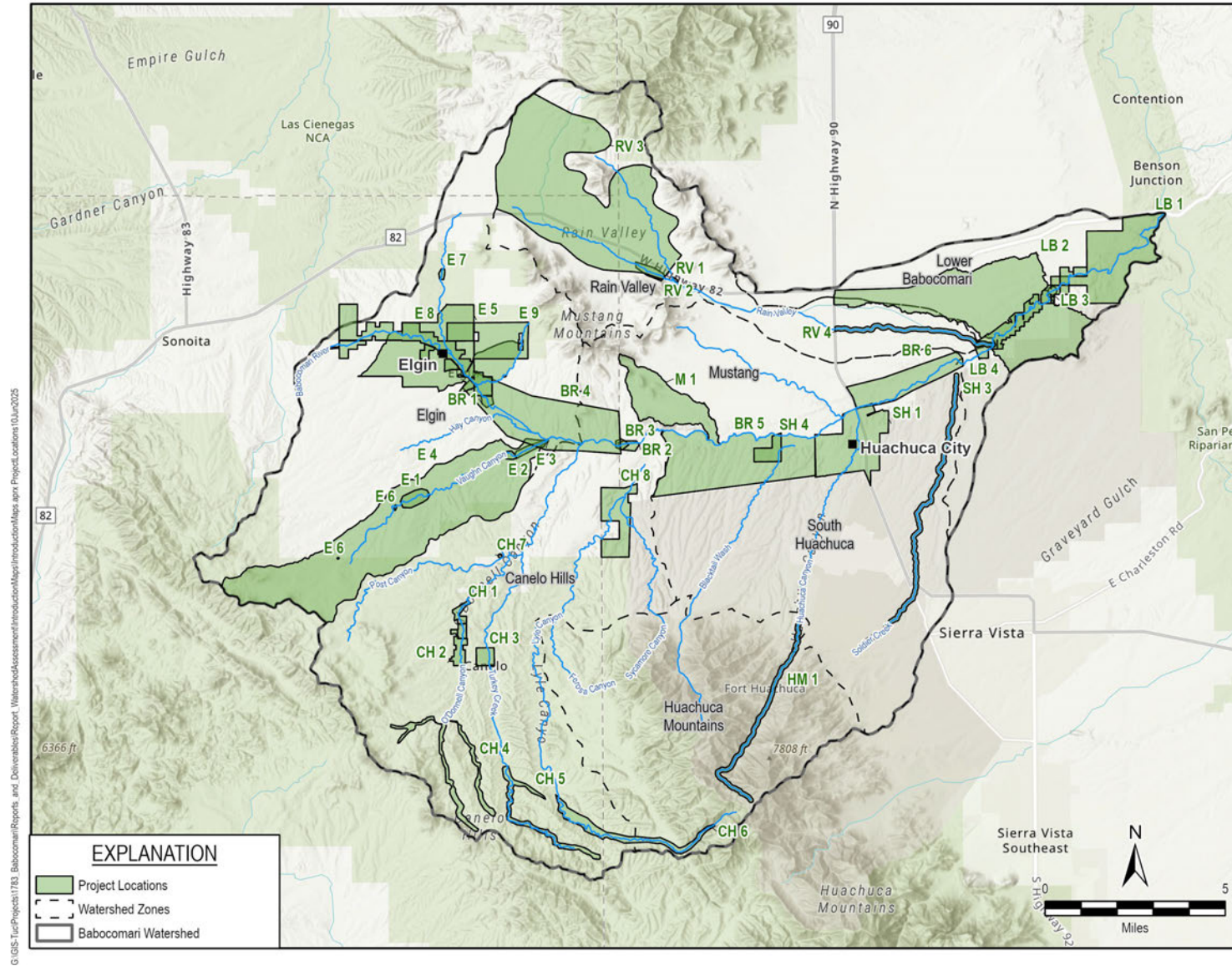


Figure 12. Locations of Potential Projects

6.2 Implementation

The projects have been categorized by priority and feasibility. Implementing projects requires consideration of permitting, cost, and landowner willingness – factors that contribute the qualitative ranking of feasibility (Table 6). A summary of general permitting considerations and potential funding sources are provided below as a guide. Each project needs to be evaluated individually based on current information.

6.2.1 Permitting Considerations

Federal, state, and local permitting considerations for watershed projects are listed in Table 7. This is not a comprehensive list, and individual projects must be evaluated for the specific permitting requirements.

Table 7. Permitting Considerations

Permit or Landowner	Considerations
FEMA Regulated Floodway	No-Rise Certification required
	Project can't increase flood height demonstrated through modeling
	Work with Community Floodplain Manager (County or City)
404 Permit (U. S. Army Corps of Engineers) *	Perennial or Intermittent Stream – 404 permit required to work in Waters of the U.S.
	Ephemeral Stream - no 404 Permit required, but landowner and/or FEMA requirements may apply
Federal Lands	Requires NEPA permit
	Work through a Federal Agency
State Land	Work with State Land Department
	Defers floodplain management to Community Floodplain Manager
Private Property	Community Flood Ordinances / County** Floodplain Use Permit
	May require Grading Permit

* 404 permit considerations are based on current understanding in 2025

** Santa Cruz County is in the S-SW portion of the watershed, Pima County is in a small north-west portion of the Watershed, and Cochise County occupies the entire watershed west of the Babacomari Ranch. *Permitting will vary by county*

6.2.2 Potential Funding Sources

Potential funding sources include state and federal agencies as well as private or nonprofit organizations. Some of these sources are listed below. This is not a comprehensive list, and individual projects should be evaluated for applicability to currently available funding sources.

6.2.2.1 State Funding Sources

- [ADEQ 604\(b\) Water Quality Grant Program](#) provides funding to regional planning organizations for regional water quality management planning activities. Project proposals must be focused on water quality management planning, not implementation.
- [Arizona Water Protection Fund](#) supports projects that develop or implement on-the-ground measures that directly maintain, enhance, and restore Arizona's river and riparian resources.

6.2.2.2 Federal Funding Sources

- [USFWS Partners for Fish and Wildlife Program](#) provides free technical and financial assistance to landowners, managers, tribes, corporations, schools and nonprofits interested in improving wildlife habitat on their land.
- [Clean Water Act Section 319 Grants administered through ADEQ Nonpoint Source Program](#) targets pollution from stormwater runoff due to roads, urbanization, over-grazing and other land management practices.
- [NRCS Environmental Quality Incentives Program \(EQIP\)](#) funds projects in agricultural areas to improve water and air quality, conserve ground and surface water, soil health and reduce soil erosion and sedimentation, improve or create wildlife habitat, and mitigate against drought and increasing weather volatility.
- [U.S. Department of the Interior WaterSMART Program](#) through the U.S. Bureau of Reclamation (Reclamation) funds a variety of projects and initiatives to increase water supply reliability through investments in existing infrastructure and planning.
- [USFWS Neotropical Migratory Bird Conservation Act Grants](#) support projects for climate resilience that leverage partnerships and support land conservation and biodiversity efforts.
- [The Environmental Protection Agency solicits applications](#) to provide training and technical assistance to rural, small, and Tribal municipalities, publicly owned wastewater treatment works, and decentralized wastewater treatment systems for the prevention, reduction, and elimination of pollutions. Each application must address only 1 of the following 4 priorities: (1) acquisition of finance/funding; (2) protect water quality and compliance assistance; (3) training and technical assistance focused specifically on Tribes; and (4) decentralized systems.
- [The Small Surface and Groundwater Storage Program](#) (Small Storage Program) administered through the U.S. Bureau of Reclamation promotes Federal assistance to

enhance water storage opportunities in support of stakeholder efforts to stretch scarce water supplies and avoid conflicts over water.

- Delivered through the Fish and Aquatic Conservation Program (FAC), [the National Fish Passage Program](#) (NFPP) provides direct technical and financial assistance to remove instream barriers and restore aquatic organism passage and aquatic connectivity. Activities proposed under this award may include project planning and feasibility studies, permitting, near-term implementation monitoring, and project outreach. Applicants must contact the appropriate [NFPP Regional Coordinator](#) to determine eligibility.
- The U.S. Fish & Wildlife Service's [Habitat Conservation Plan Land Acquisition Grant Program F25AS00035](#) is authorized through the Cooperative Endangered Species Conservation Fund and funded through the Land and Water Conservation Fund. The program aims to reduce conflicts between the conservation of listed species and competing land uses on specific parcels of land through fee simple acquisition or permanent conservation easements.
- The U.S. Fish & Wildlife Service's [Habitat Conservation Plan Land Acquisition Grant F25AS00034](#), funded through the Cooperative Endangered Species Conservation Fund, promotes state and federal cooperation to acquire specific parcels of land in support of recovery plans for every listed species.
- [The Agriculture Conservation Experienced Services \(ACES\) Program](#) enlists experienced Natural Resources Conservation Service workers age 55 and older to provide technical services that support conservation-related programs.
- [AmeriCorps State and National Competitive Grants](#) award organizations that engage AmeriCorps members in evidence-based or evidence-informed interventions to strengthen communities.
- The Environmental Protection Agency's [Farmer to Farmer](#) 2024 BIL funding opportunity aims to enhance water quality, habitat, and environmental education within the Gulf of Mexico watershed. The grant program will support innovative farming practices with a focus on collaboration and outreach, including habitat restoration.
- Funded by the National Science Foundation, the [Environmental Sustainability](#) program's goal is to promote sustainable engineered systems that support human well-being and that are also compatible with sustaining natural environmental systems.

- [IRA Vegetation & Watershed Management](#) provides funds through the United States Forest Service (NFS) for projects on NFS land in accordance with a water source management plan or a watershed protection and restoration plan (WRAP).
- The U.S. Fish and Wildlife Service’s (USFWS) [Partners for Fish and Wildlife Program](#) provides technical and financial assistance to a variety of partners including private landowners, Tribes, nonprofits, corporations, and schools. The goal of this program is to improve wildlife habitat by helping to plan, design, supervise, and monitor customized habitat restoration projects. Focused areas of concern include upland forests, wetlands, native prairies, marshes, rivers, and streams.
- [The Watershed and Flood Prevention Operations \(WFPO\) Program](#)—funded through the U.S. Department of Agriculture’s Natural Resources Conservation Service (NRCS)—helps units of federal, state, local, and federally recognized tribal governments protect and restore watersheds. Project criteria include public sponsorship, watershed projects of less than 250,000 acres, and agricultural benefits must be more than 20% of the total benefits for the project.
- The U.S. Department of Agriculture’s Natural Resources Conservation Service’s (NRCS) [Conservation Stewardship Program](#) offers annual payments and helps customize a plan to improve existing conservation efforts while strengthening agricultural operations. Available practices and practice standards vary by state.
- The National Science Foundation’s (NSF) [Environmental Sustainability Program](#) supports engineering research that seeks to balance ecological protection while maintaining stable economic conditions.

6.2.2.3 Other Funding Sources

- Private foundations and conservation organizations
- Carbon offset programs for mesquite removal and grassland restoration
- Water utility conservation programs

6.2.3 Approach to Further Assessment

The data products from this watershed scale analysis that were used to develop the project list are the building blocks of the Babocomari Watershed Assessment. Many of those datasets were used to identify project or future research and are starting points for further assessment. In a future phase of work, some of those datasets can be combined or built upon for further analysis and project development. Some considerations for how these building blocks can be applied are described in this section.

6.2.3.1 Depth to Water

Areas with shallow groundwater often support ecosystems that are reliant on that persistently available water. Sustaining water levels in these areas by slowing flow and encouraging groundwater recharge can support goals of habitat and species management, hydrologic function, and water management and source water protection. The depth to groundwater dataset can be used to identify those areas of shallow groundwater and local groundwater level data can be collected to monitor the presence, absence, and changes in shallow groundwater in those areas.

6.2.3.2 Headcuts

Headcuts identified through the GIS model signal land and/or channel degradation. Some of these sites were verified using imagery or site visits, however further verification of large headcuts and clusters of headcuts will provide more insight about the location, scale, and potential causes. Restoration projects in these areas would accomplish goals of hydrologic function and habitat and species management. Individual headcuts and clusters of headcuts can be used to site channel restoration projects, restoration and improved management of upland areas, or infrastructure repair.

6.2.3.3 Ciénegas

Long-term monitoring and increased research on ciénega function and dependencies can improve overall understanding of their importance within the watershed and southeastern Arizona. Additionally, increasing groundwater recharge and maintenance of hydrologic function upstream of ciénegas should be prioritized to ensure their persistence. Locations of ciénegas along with depth to groundwater and channel types can be used to site projects upstream.

6.2.3.4 Road Runoff

Several areas within the watershed contain paved roads with extended non-horizontal grades, leading to increased erosion, subsequent sediment displacement, and headcut formation in adjacent channels. To assess and mitigate these impacts, an analysis is recommended to identify high-risk locations. The proposed methodology would involve:

- Identifying road segments with steep grades
- Evaluating adjacent watershed conditions, noting signs of erosion, vegetation loss, and incision
- Prioritizing sites where erosion has compromised hydrologic function, signaling the need for restoration and improved management strategies

This analysis will help pinpoint key intervention areas, supporting targeted erosion control, and watershed restoration efforts.

6.2.3.5 Existing Infrastructure

Throughout the watershed there are many structures that serve to detain water and trap sediment such as large gabions check dams. These structures should be monitored and maintained as their failure could lead to channel degradation and loss of productive landscapes.

6.2.3.6 Channel Function and Groundwater Condition Overlay Analysis

Identify locations where headcuts are clustered or higher magnitude headcuts coincide with shallow groundwater (0 to 50 ft bls). Slowing flow at these locations through channel restoration and headcut repairs will arrest headcut development and channel degradation while increasing infiltration and recharge of shallow groundwater. Slowing of surface flows and increasing infiltration will provide more water for ecosystems reliant on shallow groundwater, springs, ciénegas, and perennial streams.

6.3 Recommended Additional Watershed Assessments

This high-level overview of the watershed resulted in identifying specific projects that could be implemented. In addition, several watershed-wide assessments were identified that would provide a deeper understanding of the watershed, the interaction between groundwater and riparian ecosystems, and that have potential to guide future projects. These recommendations for additional watershed assessments are listed in Table 8.

Table 8. Recommended Additional Watershed Assessments

Project Name	Description	Benefit	Feasibility	Goals
Groundwater Budget	Prepare a groundwater budget with recharge, evapotranspiration, and pumping	High	High	Groundwater Recharge
Vegetation Health vs Groundwater Conditions	Evaluate groundwater levels and cottonwood/riparian vegetation recruitment as it relates to channel condition	Medium	Medium	GDE Habitats and Vegetation
Watershed Wide Ciénega Assessment	Compare Babacomari, Turkey Creek, and Canelo Hills ciénegas to understand ciénega health, especially saturated area and cottonwood density	Medium	Medium	GDE Habitats and Vegetation
Watershed Wide Springs Assessment	Review springs and habitat surrounding springs; explore connection to ciénegas	Medium	Medium	GDE Habitats and Vegetation
Invasive Species Management	Evaluate invasive plant encroachment throughout Babocomari Watershed adversely affecting native vegetation	Low	Low	GDE Habitats and Vegetation, Upland Habits and Vegetation

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ACRONYMS & ABBREVIATIONS

ADEQArizona Department of Environmental Quality
ADWR	.....Arizona Department of Water Resources
amsl	.....above mean sea level
bgs	.....below ground surface
BLM	.....U.S. Bureau of Land Management
DEM	.....digital elevation model
ET	.....evapotranspiration
ft/bgs	.....feet below ground surface
GDEs	.....groundwater dependent ecosystems
GIS	.....geographic information systems
GWSI	.....groundwater site inventory
HUC	.....Hydrologic Unit Code
LTPBR	.....low-tech process-based restoration
M&A	.....Montgomery & Associates
NAIP	.....National Agriculture Imagery Program
NCDE	.....Natural Channel Design Engineering
NDVI	.....normalized difference vegetation index
NEPA	.....National Environmental Policy Act
ORD	.....one-rock dam
PRISM	.....Parameter-elevation Regressions on Independent Slopes Modl
SPRNCA	.....San Pedro Riparian National Conservation Area
TNC	.....The Nature Conservancy
USDA	.....U.S. Department of Agriculture
USFS	.....U.S. Forestry Service
USFWS	.....U.S. Fish and Wildlife Service
USGS	.....U.S. Geological Survey
WBD	.....Watershed Boundary Dataset

Assessment Summaries

Enhancing Rangeland and Riparian Health Along the Babocomari

1. Babocomari Chase Emmerson Assessment Report (2020)

Stream Dynamics conducted a site-specific walking and drone-assisted assessment of the Chase Emmerson property within the Babocomari watershed. The report documents legacy erosion caused by roads, cattle trails, and failed diversion infrastructure, with a focus on tributaries and bajadas feeding into Blacktail Wash and the Babocomari Creek. Treatment recommendations include rolling-dip road drains, keyline plowing, berm and swale restoration, and headcut stabilization. The findings support restoration actions aimed at reducing sediment and E. coli loads, promoting groundwater recharge, and restoring ecological resilience through improved stormwater management and vegetative cover.

2. 250707 - Babocomari Tributary Channel Assessment (2025)

This report presents a comprehensive geomorphic assessment of tributaries to the Babocomari River conducted by Watershed Management Group and partners. It identifies priority erosion areas contributing to sedimentation and channel incision in the watershed. The study uses drone imagery, field surveys, and cross-section data to characterize degraded flow paths, valley-eating headcuts, and opportunities for restoring floodplain connectivity. It recommends treatment strategies such as sediment detention features, channel realignment, and grassland restoration to enhance infiltration, reduce sediment loading, and support water quality improvements that benefit downstream resources, including the impaired San Pedro River.

3. The Nature Conservancy (TNC) Babocomari Watershed Assessment (2025)

Prepared by The Nature Conservancy in collaboration with regional stakeholders, this 2025 report synthesizes hydrologic, geomorphic, and ecological data across the Babocomari watershed. It identifies landscape-scale impairments due to altered hydrology, erosion, and land cover changes. The assessment prioritizes areas for restoration and outlines scalable interventions to restore sheet flow, reconnect tributaries, and reduce sediment delivery. Emphasis is placed on using nature-based solutions and collaborative management strategies to improve water quality and support long-term aquifer recharge. The findings directly inform project selection and prioritization for ADWR and ADEQ restoration efforts.



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Babocomari Chase Emmerson property assessment report

March 16, 2020

Executive Summary

During the week of January 27th to 31st, Van Clothier and Theo Keller of Stream Dynamics, Inc., guided by Hans Huth of ADEQ, completed a reconnaissance level walking assessment of the Chase Emmerson property and surrounding areas. Our task was to determine the state of the watershed and come up with possible treatment strategies for chronic erosion problems that had been previously identified by Hans Huth. We looked at gully erosion and flow concentration caused by local roads, legacy infrastructure such as old dirt tanks, diversion channels and berms, and the old railroad. We traced flowpaths of water contributing to erosion. Excellent maps and a drone survey of the local watershed provided by ADEQ proved invaluable to our efforts. We identified several key features that needed more detailed information and followed up with a laser level survey of several cross sections and longitudinal profiles. We were able to determine how and why the erosion was happening, and have come up with several treatment strategies.

Our prescription calls for restoring historic flow paths to maximize the potential for stormwater infiltration on the range. We propose installing rolling-dip road drains to prevent flows from Blacktail Draw from being captured by a roadside ditch that is putting pressure on a severe valley-eating headcut. We propose restoring arroyo flow to the historic valley bottom of tributary 3, and getting it to spread on the floodplain with a combination of small berms and keyline plowing.

Stream Dynamics also recommends setting up a monumented cross sections and a longitudinal profile in the vicinity of the large headcut in Babocomari Creek to monitor this feature over time.

I. Introduction

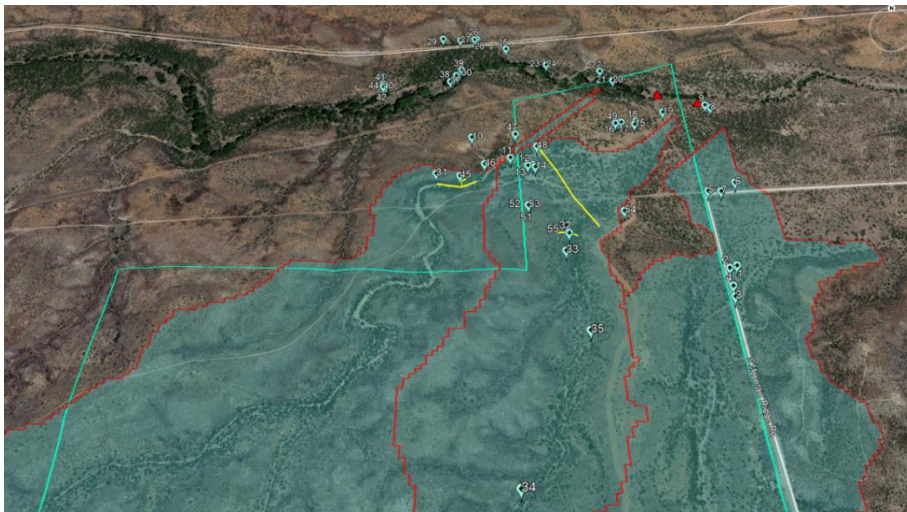
Mr. Emmerson's property encompasses approximately 480 acres about three miles west of Highway 90 and Huachuca City. In Figure 1, Mr. Emmerson's property is highlighted in light green. The airport in Fort Huachuca is visible to the southeast hosting a runway that extends 2.5 miles for scale. Sierra Vista is located southeast of the runway. The areas outlined in red with a darker green highlighting show the three watersheds that drain through the property of interest, with Blacktail Wash hosting the largest drainage area of 5.71 mi².

Figure 1: Google Earth screen capture of contributing watersheds draining into the area assessed.



In Figure 2, the light-blue markers denote GPS points for points of interest detailed in the body of this report. Yellow lines are laser level transects, and the red triangles point to areas of active headcutting. The three watersheds running through the property are referenced in this report as valley 1, 2, and 3 from left to right.

Figure 2: Closer view of Chase Emmerson property boundary showing points of interest and transects.



In Figure 3, the area to the right of the water tanks (on state land) is part of the Chase Emmerson property. This is a mesquite invaded grassland hosting cattle grazing, poorly drained roads, and failed water diversions. These feature concentrate stormwater flows, dry the landscape, and collectively put pressure on downstream headcuts.

Figure 3: Overview of site looking north from a ridge dividing Valley 2 and Valley 3, facing north from GPS point 53.



II. Ongoing Challenges

Figures 4 and 5 demonstrates where Blacktail Wash discharge over the right terrace of the incised Babocomari River, creating a severe erosional feature called a headcut. The discharge off the terrace creates a downstream pool that undercuts the terrace, further accelerating erosion and loading runoff with sediment. Taking a measurement of the landform and its distance from the centerline of the Babocomari River, the headcut has consumed approximately 200 feet of the valley of Blacktail Wash since the Babocomari River became incised 50-100 years ago. Therefore, the average velocity of the headcut complex is approximately 2-4 feet per year.

A Google Earth screen capture is presented in Figure 6. The cross section running through GPS point 40 reveals an old channel to the left of the present channel identified by a red arrow. This suggests the Babocomari has incised approximately 18 feet during the Anthropocene, which started in this part of Arizona in the late 1800's. The incision was caused by a combination of grazing, fire suppression, water diversions, and roads, including the railroad. The incision has reached equilibrium in many reaches, but a few are still downcutting. This poses serious challenges for the watershed, the water table, water quality, stormwater management, and the ecology of the San Pedro.

Figure 4: Valley-eating headcut looking up Blacktail Draw (GPS point 9)



Figure 5: Drone imagery of Valley-eating headcut in the vicinity of Figure 4 and red dots in Figure 2



Figure 6: Google Earth screen capture near failed dam (GPS point 40) with cross section inset.



Tributaries draining into the Babocomari are also impacted by the historic downcutting. Within our study area, the ancient bajada created by the confluence of the alluvial fans of Blacktail Wash, Tributary 2, and Tributary 3 is now a hanging valley. Present day erosion is slowly cutting away at this bajada and creating a wide drop-off, or “Valley-Eating Headcut”. This erosion happens when surface flows arrive to the site of the drop-off, where they become waterfalls that scour material from the face and base of the drop-off, causing it to move upstream in response to hard rains (Figure 7). This is a natural geologic leveling of the landscape resulting from the watershed coming into equilibrium with recent land use practices and influences.

Figure 7: Looking down at plunge pool of a major active headcut (vicinity of GPS point 9)



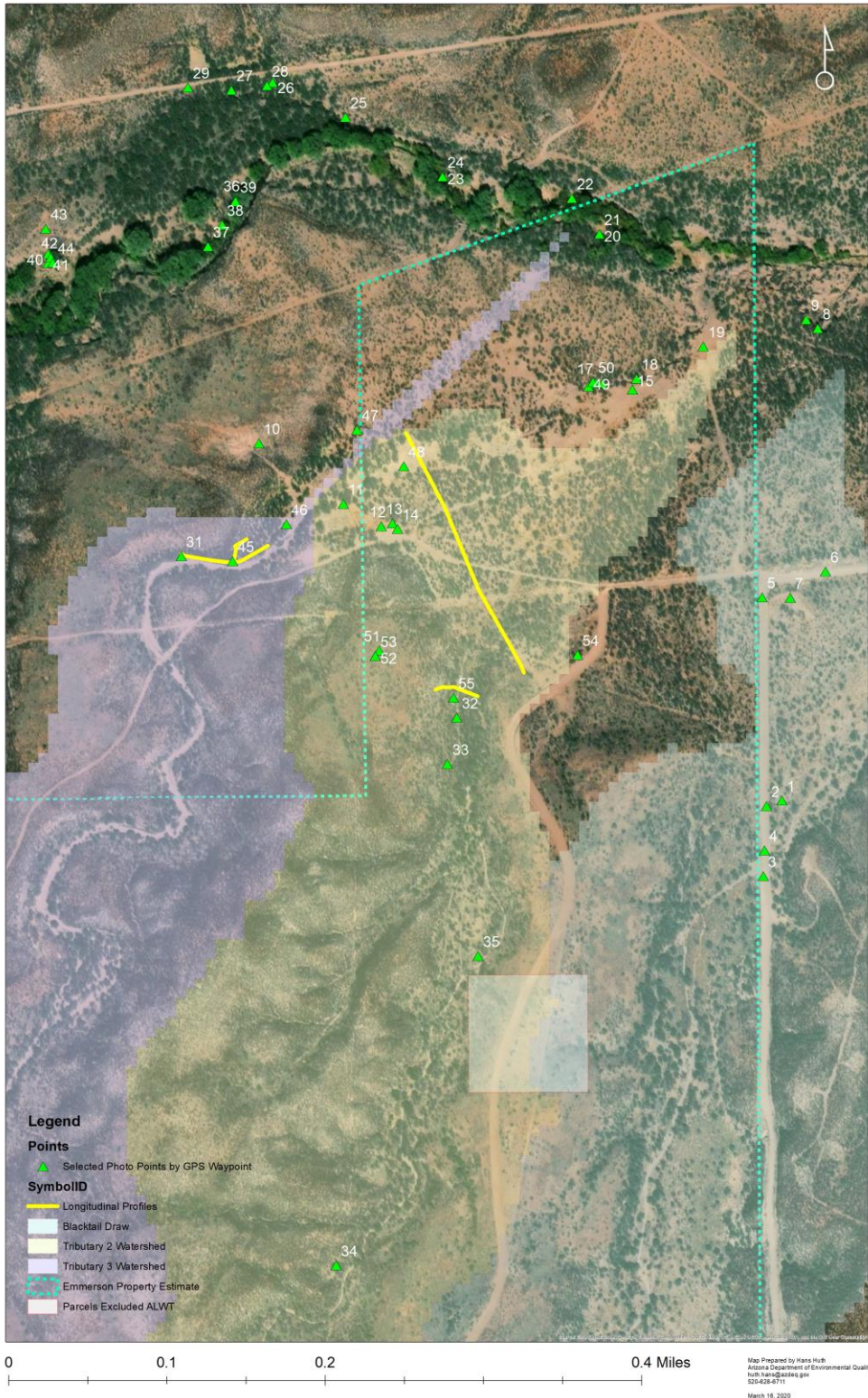
III. Suggested Remedies Summary

Stream Dynamics has been informed by ADEQ that suspended sediment in the water column is a concern as it relates to observed correlations with increased E.coli. This is a problem because the Babocomari is recognized as contributing both to the impaired San Pedro River. Although the natural processes responsible for valley headcutting cannot be halted entirely, sustainable best management practices that decelerate erosion can slow the loading of contaminants at and downstream of the property in question. If given enough time, improved watershed conditions will prompt a new equilibrium that is more favorable to water quality, quantity, and ecological concerns. In this context, the following bullets summarize existing challenges and prescriptions that can be executed immediately on the property in question:

- Roads that run up-valley along existing tributaries are concentrating flows towards valley-eating headcuts. Proper road drainage can greatly reduce the pressure on these unstable features.
- Old dirt tanks have filled with sediment. These features now host eroding spillways that are concentrating flow downvalley. Stream Dynamics has developed and successfully tested landscape treatments designed to mitigate this legacy infrastructure.
- Cattle grazing has compacted the soil in some areas. Compaction reduces infiltration and increases surface flows towards the headcut. Rest from grazing coupled with keyline plowing can improve percolation, thus relieving stormwater pressure on downstream headcuts.
 - Keyline plowing is recommended for a section of compacted bare ground near several problematic headcuts. This will improve percolation and increase surface armoring to resist erosion.
- Increased soil moisture from improved percolation coupled with rest from grazing will help with grassland recruitment. This can help armor the headcut for resiliency, trap sediment, and help the headcut to lay back over time.
 - A possible collaboration between the adjacent state lands lessee and the Emmerson property offers an opportunity to properly rest the property from grazing without endangering existing tax rates tied to agriculture.
- Mesquite invasion of historic grasslands creates conditions that accelerate the erosion of downstream headcuts. Mesquite control is recommended, but can be resource intensive and is difficult to address sustainably unless root-cause factors are properly addressed (e.g. cattle grazing, fire suppression).

IV. Map for Assessment Reference


Longitudinal Profiles and Selected Photos by Waypoint





V. Assessment with Photos

In the section below, for each point we assessed, a photograph, with its associated GPS point is displayed, along with a description of the watershed issue associated with that point. Hans Huth has the respective shapefiles and photos filed on ADEQ's server.

Key to arrows

Red arrow denotes problem or erosion area 

Blue arrow denotes present flow direction 

Green arrow denotes proposed new flow direction 

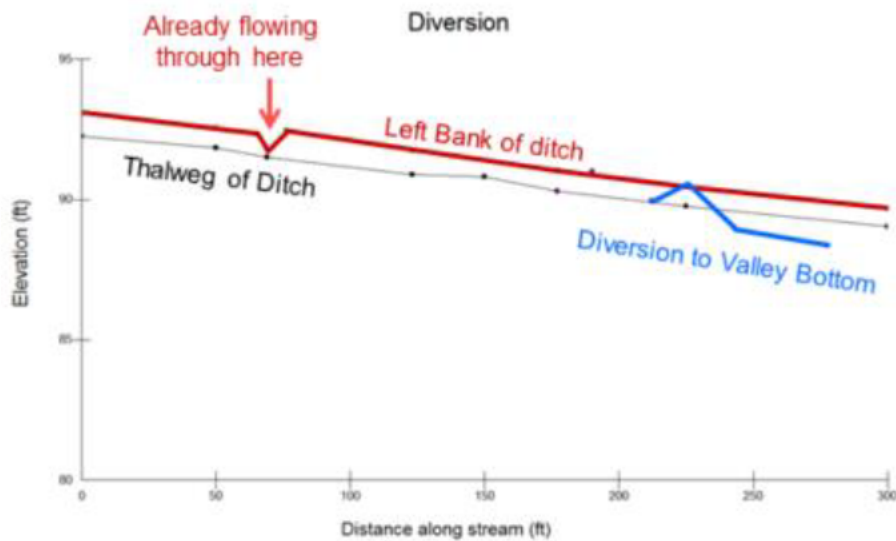
Area of Interest (AOI) 1: Tributary 3 Walking Downstream



Looking downstream along ditch that has captured Tributary 3 (GPS point 31): This is a sand filled diversion ditch that cribs to valley right and has diverted Tributary 3 out of its valley bottom toward the completely sediment filled dirt tank on state land immediately upstream of Chase Emmerson.



Opportunity to recapture flow into historic valley bottom (GPS point 45): The aggradation of the diversion ditch has created several opportunities to put the flow back in the original valley bottom. This would prevent erosion at the site of the filled in dirt tank and also give the water more surface area to spread out and sink into the ground before it arrives at the headcut.



We completed a longitudinal profile of the Tributary 3 valley bottom and diversion ditch. In the above diagram, the ditch is in black; the left bank of the ditch is red; and the possible realignment of the flow into the historic valley bottom is in blue. The peak in the blue profile can be removed with an excavator, allowing flow to once again irrigate the historic valley bottom.



Sediment buildup is starting to send flow into historic bottom (GPS point 46): Meanwhile, flows are still going toward the filled in dirt tank and contributing to headcuts downstream of the tank.



Eroded bowl contributing sediment to Tributary 3 (GPS point 10): This is a very small tributary valley on state land that is impacted by erosion. We speculate that this might be the route of a historic trail. One-rock dams in the mouth of this valley would cause it to aggrade and start to become grassed in again.



Old swale (GPS point 47): This is where the flows coming out of the bowl at GPS point 10 flow. This is a safe place for water to flow as it comes out at the angle berm discussed later.



Filled in dirt tank in historic valley floor (GPS point 11): Blue arrow points in down-valley direction. Three red arrows approximate where three headcuts are eroding the historic berm. It would be advantageous to direct flows away from this filled in dirt tank so that sediment contributions might assist in maintaining the historic bajada below here.



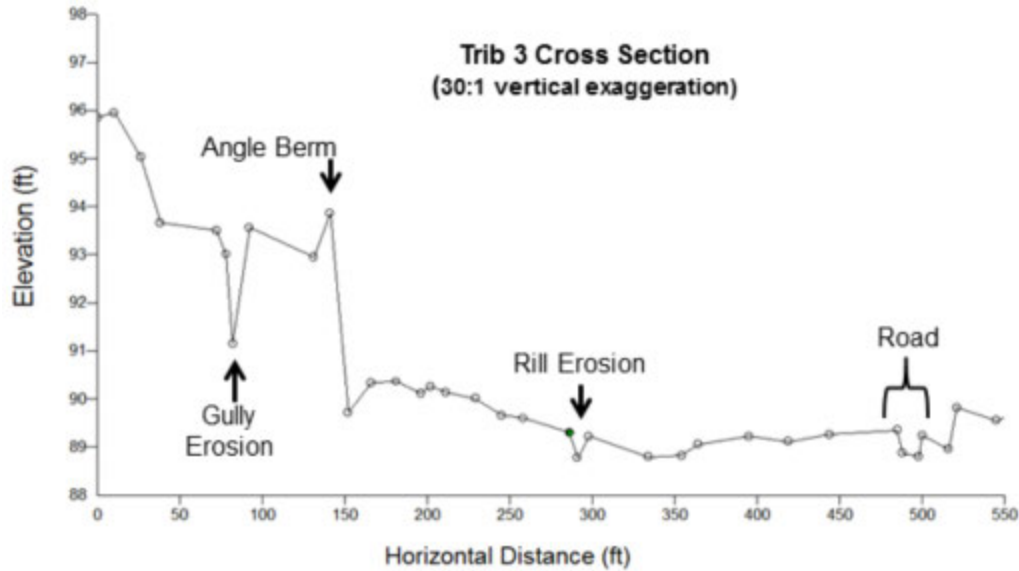
Erosion of the down-valley side of the berm for the mentioned dirt tank



Ditch drains overflow from filled tank away from road (GPS point 13): A rolling dip across the access road immediately up-valley from here would prevent water coming from a micro drainage between valley 2 and valley 3 from going across the road. Additional rolling dips along the access road all the way to the front gate would help manage flows and keep the road passable during inclement weather.



Looking downstream at sediment trapped by angle berm (GPS point 48): There is approximately 3 feet of sediment that has been trapped in this historic berm. The berm is about 378 feet long and goes from the dirt tank all the way to the toe of the left side of the valley. Our treatment idea for this location is to punch through this berm in several places to guide the water and sediment as far to the right as feasible to irrigate the now dried-up valley bottom and distribute this sediment to maintain sheet flow over the same.



Above is a valley wide cross section across Tributary 3 determined by a laser level. A 30:1 vertical exaggeration was used to highlight subtle features that are influencing water flow. We propose to intercept the gully that is cutting through the angle berm and redirect this water and sediment toward the original valley bottom and away from the headcut. Additionally, we propose to build a series of berms and swales to reinstate sheet flow and block the rill erosion that appears at many places along the historic valley floor.

AOI 2: Tributary 2 Walking Downstream



Van is standing in historic valley bottom (GPS point 34): This location is one-half mile up Tributary 2 from the road. Our walking tour discovered that this tributary has legacy issues due to old roads and trails that straightened the arroyo and caused it to downcut. At present, the drainage is trying to fix itself by eroding its banks and re-meandering. There are additional locations where the arroyo is still

cutting deeper. It will take a very long time of rest from grazing for this system to reach equilibrium again. There is a potential for a project here using hand labor to build grade control in these upper reaches to arrest downcutting and assist the arroyo in its progression of self-healing.



Historic valley bottom meets incised channel (GPS point 35): At a point several hundred feet upstream from here, small flows can escape the present day gully and flow along the historic valley bottom for several hundred feet. This area could use a more detailed survey to discern opportunities to enhance water harvesting and stability.



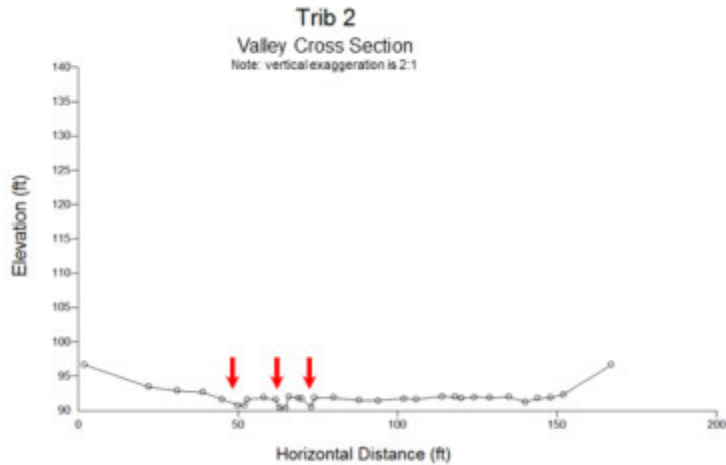
Valley 2 bottom (GPS point 33): The valley is not incised at this location. Sediment from upstream eroding reaches has managed to level out the cross section and optimize sheet flow.



Headcut (GPS point 32): Top of a headcut. This marks the upstream end of a growing discontinuous incision. The upper end is cutting up-valley, lengthening the incision. The middle reach is deepening. At the downstream end, sediment deposition is reestablishing sheet flow. We are unclear as to whether the rate of filling at the downstream end is happening faster than the cutting at the upstream end. We suspect this incision is getting longer and deeper, and thus needs to be treated.



Gullies in valley bottom at Tributary 2 cross section (GPS point 55): Photo is taken looking downstream. The white line is the tape from the cross section, which is graphed below.



Tributary 2 cross section: The three red arrows represent three channels in a valley bottom that were probably caused by livestock trailing up and down the valley. We propose to correct this erosional issue by transplanting giant sacaton grass plants to plug these gullies in order to reinstate sheet flow.

AOI 3: Road Installed On Ridge between Blacktail Draw and Tributary 2



Significant erosion destroying steep road (GPS point 54): Poor drainage design is causing this road to self-destruct. We suspect these roads were installed immediately before the 2008 economic collapse. We propose to drain this road in three places to reduce its negative impact on the watershed with the understanding that if plans for the associated subdivision restart, it could pose serious challenges for the watershed especially if careful consideration is not given to increased runoff and proper spreading of downstream flows through fragile soils.

AOI 4: Blacktail Wash and Road Drainage Issue



Blacktail Wash is captured in roadside ditch (GPS point 3): Our survey suggests that the flow from the wash crossed the alignment of the present day road toward a tank at GPS point 7. When the road was built, flow from Blacktail Wash was captured in a roadside ditch, causing erosion and sedimentation of the road in addition to increasing the rate of delivery of surface flows to the downstream valley-eating headcut (GPS Point 9). We propose to properly drain this road with a series of rolling-dip road drains to optimize water spreading and relieve the road from associated drainage issues.





Looking down road. Sign has contact info for realtor. (GPS point 4): Since this road is not on Mr. Emerson's property, repairs would require approval from the adjacent-property owner. Perhaps Ms. Debby Coste could help us secure permission from this property owner to facilitate our prescription to relieve pressure on the valley-eating headcut.



Location where we propose diverting water from the road ditch (GPS point 1): GPS point 1 is to the east of the road. It would be relatively easy to design and build rolling dips on the road to redirect the flow to a safe place where the water could slow down, spread out, and sink into the ground more than it currently does, thus relieving pressure on the valley-eating headcut.



Alluvial fan forming on road (GPS point 5): At the bottom of the hill, the slope of the road flattens out at the corner and the sediment collects, creating a drainage problem. This could be remedied by properly draining the road upslope from here.



Old filled in dirt tank (GPS point 7): Theo discovered this old filled in dirt tank that still has a spillway that is concentrating flows. We propose to further analyze this situation to plan a new flow path that would recreate the historic sheet flow in this area.



Grassland that could benefit from proper road drainage (GPS point 6): This photo was taken north looking toward the headcut on the left terrace of the Babocomari, which is 850 feet away. Proper road drainage with judiciously placed rolling dips, starting 1800 feet up the road from this location would slow flows before in order to relieve pressure on the valley-eating headcut.

AOI 5: Bajada Incision (Coalescing Alluvial Fans Impacted by Headcut)



Top of headcut draining bajada (GPS point 49): It appears that legacy dirt work may have concentrated tailwater from the historic dirt tanks toward this drainage. Evidence suggests that this side valley has greatly enlarged in the last 75 years or so.



Close-up of start of headcut, showing substrate (GPS point 50): In order to relieve pressure on this feature, we proposed to work much higher up in the valley in order to spread water across the historic bajada.



Looking upstream in headcut drainage channel (GPS point 17): This view shows recent enlargement of the associated channel.



Further downstream in collector channel (GPS point 16): The location of this straight channel segment, being immediately adjacent to the left side of the bajada strongly suggests anthropogenic influence.



Preferred site to spread water diverted by upstream projects (GPS point 15): In this vicinity, we mapped an area of approximately 3 acres where we propose to uproot mesquite trees so that we can host a keyline plow and seeding project to optimize infiltration and grass regeneration.



Location further downstream in collector channel (GPS point 18): Within the channel at this location we propose to use existing boulders to build grade controls such as one rock dams and Zuni bowls by hand.



Cattle trails draining the landscape and contributing to major headcut (GPS point 19): Impacts to this location must be addressed through an appropriate livestock grazing management plan coupled with keyline plowing.

AOI 5: Babocomari Main Stem Survey – Upstream to Downstream



Historic infrastructure (GPS point 40): This is an old dam across the Babocomari. ADEQ communication with the property owner suggests this one of many features installed throughout the area to help mitigate soil loss between 1935 and 1940. Features on the concrete suggests it was keyed into both banks of the stream channel at the time of construction. We suspect this feature was likely overtopped early in its career resulting in catastrophic failure and causing the right bank to erode significantly while contributing a huge sediment load to the system. At present, the right bank of the Babocomari is over 200 feet away from the concrete dam. The feature is still keyed in to bedrock on the left bank.



Drainage pipe at base of old dam (GPS point 44): We suspect the original engineers planned to relieve base flow of the flashy desert stream through this 9" diameter pipe at the base of the dam where Van is sitting. ADEQ informs us that the contributing watershed area at this location is 168 square miles.



Photo shows end of form boards at historic right bank (GPS point 42): The end of the form boards suggests that the right side of the concrete dam was keyed into a trench cut into fragile sediments along the right bank of the Babocomari.



Showing how far right bank has eroded since dam failure (GPS point 41): The right bank is now over 200 feet south of where it was the day of construction of this legacy infrastructure.



Dam where it is still keyed into left bank of Babocomari (GPS point 43): Here, we found evidence that the spillway was overtopped before any sediment was trapped behind the dam (i.e. the dam failed during the first significant flow event).



Observed debris in channel upstream of headcut (GPS point 37): The channel may be stable against downcutting at this point due to a bedrock outcrop downstream from here. In order to monitor the channel morphology, we suggest installing several monumented cross sections on Brophy property with landowner permission.



Channel is against stone toe of valley (GPS point 38): We are uncertain if this stone outcrop runs across the creek bottom under a thin layer of alluvium or not. This merits further investigation since it may influence strategies for grade control and headcut relief.



Site of major headcut in Babocomari (GPS point 30): This headcut may have arrested itself upon encountering the stone toe of the valley wall. Further investigation and monitoring will determine whether a treatment is necessary here to stop the Babocomari headcut from proceeding up-valley.



Looking down into the major headcut (GPS point 39): If this headcut is not self-stabilizing, this could pose an extremely serious resource damage point that could threaten stream channel stability, groundwater level, and water quality through increased sediment contributions. We recommend further investigation of the geology to better understand if grade control is happening naturally.



Water table elevation in headcut (GPS point 36): This is the only place we saw surface water in the Babocomari on January 28, 2020.



Incised channel, looking upstream (GPS point 23): The shape of the banks at this location indicates that the headcut passed through here during a recent large storm. It may have been the extremely large storm that hit Canelo Hills on September 25, 2019. (During an initial site visit in October, 2019, we also witnessed evidence of cattle through this reach. Hoof action may also explain the lack of geomorphic diversity through this reach as per notes collected by ADEQ during our initial survey.)



Looking downstream at recently incised channel (GPS point 24): This is near the downstream end of the recent incision, where the depth of the incision is less pronounced.



Old railroad grade on left terrace of Babocomari (GPS point 29): The railroad grade through this part of Arizona heavily impacted the watercourses through cut hills, filled valleys, and cut-off natural drainages. Respective activities concentrated flows throughout the entire watersheds into culvert focal points. These contributed to massive headcuts that are visibly growing through the present.



Headcut was started in the hosting tributary by a railroad culvert (GPS point 27): This headcut is extremely active, and will continue to lengthen this gully with every passing rainstorm.



Failing railroad culvert and massive erosion (GPS point 28): The installed splash pad was not engineered to handle the respective flow concentration from this culvert. The splash pad was laterally flanked, causing flood flows to erode the fine grained soil resulting in catastrophic failure.



Another view of old railroad culvert (GPS point 26): This shows a post and concrete splash pad that has now collapsed 20 feet behind the structure.



Looking upstream at incised tributary caused by railroad (GPS point 25): Flows from the respective culvert contributed to downcutting resulting in this massive headcut.



Google earth screen capture showing how the railroad-caused gully has a positive feedback loop with the incision of the Babocomari, creating an entirely different landscape.



Babocomari has stabilized within historic incision (GPS point 22): The Babocomari has incised approximately 18 feet over the many years since the heavy handed manipulation of the stream channel. It has finally reached a new equilibrium by eroding laterally to create a tiny floodplain within the incised channel. This stability may be threatened by headcuts and [lack of] land management in the upper watershed.



Piping and sapping feature, now abandoned by erosion (GPS point 21): This was the only example of soil piping encountered on site where perhaps a rotten tree root or other conduit captured flows the contributing subwatershed. During the course of the survey, we discovered that upstream erosion has shifted the flows away from this feature.

Treatment Plan

Contributing factors meriting attention are sourced both upslope and downslope from Chase Emmerson property.

- Although most of Blacktail Draw is on the Emmerson property, the road that is concentrating flow is not. Furthermore, most of the valley-eating headcut associated with Blacktail Draw is off the property. A cost-effective project will require coordination and permission of adjacent landowners and/or lease holders.
- Road drainage remedies and the keyline plowing will require a small bulldozer
- Mesquite control can be leveraged by a local restoration crew such as those managed by Borderlands Restoration, under Stream Dynamics' direction.

Changes in Current Land Management Practices

During our surveys, we introduced ourselves to Mr. Sid Khala—a local rancher. We learned that Mr. Khala is currently in negotiations to take ownership of the state-land lease immediately adjacent and upstream of the Emmerson property. Given ongoing challenges, Mr. Khala voiced concerns about trespass livestock impacting his lease from downstream properties, and is interested in supporting activities that can realize a buffer via the Emmerson property. Pending further discussion, Mr. Khala may be open to helping with fencing installation and repair as well as maintenance of the same.

Should this avenue materialize, ADEQ has an opportunity to host restoration activities in a livestock-free environment which would certainly improve grass cover, increase infiltration, and subsequently relieve pressure on downstream water resources. Stream Dynamics believes that having a local willing partner with a vested interest will leverage the sustainability of this project moving forward while providing a unique opportunity to measure impacts from the same over time. Given this context, we believe this is one of the most significant outcomes of our work.

Contact:

Mr. Sid Khala
Double Diamond ranch supply
doublediamondrs@gmail.com
(520) 604-2677

Road Drainage with Bulldozer

ADEQ has an opportunity to relieve pressure on downstream erosion by improving road drainage of several roads including South Mountain Ridge Road; the access road to the windmill on State Land, and the road that traverses the ridge between Tributary 2 and Blacktail Wash. On the Emmerson property, there is need for about 8-10 rolling dips, and on other land there is the need for about 4-6 rolling dips. This task would require coordination and permission from property and conservation easement holders hosting respective roads. The actual road work could be accomplished in one week or less with a Cat D4 bulldozer.

Cat D4 5 days

Keyline plowing with bulldozer

Under guidance from my colleague Gordon Tooley of Tooleys Trees, a regional keyline plowing expert, we propose the following treatment. First, we will use the laser level and place pin flags in the dirt along exact contours. Using a Cat D4 bulldozer (the smallest available rental), we would rip the area on exact contours following the pin flags. We would seed at the same time as we rip.

The proposed keyline plowing polygon is approximately 3 acres that is relatively clear of mesquite. This could be done in 2 days with a D4, including time spent with a laser level to set grade.

Cat D4 2 days

Flow diversion to old valley bottom

Our overall treatment plan includes a bit of work on state land on Tributary 3 immediately upstream of Chase Emmerson property. We propose to break through the berm separating the diversion channel from the historic valley bottom. This is a small amount of earthmoving that could be accomplished with a small piece of equipment in a few hours. If SHPO is an issue, or if the project makes more sense to do with workers instead of heavy equipment, this work could be accomplished by a work crew with hand tools. This task is not absolutely essential to the success of the project because all of the flow goes downvalley to our site anyway, yet it would be beneficial to start spreading the flows higher up in the watershed at this point.

Work Crew 2 days

Restoring sheet flow to historic valley bottom

Redistribution of sheet flow to the bajada of Tributary 2 and Tributary 3 includes breaking through an anthropogenic angle berm and building several swales to divert surface flows to the original valley bottom. At the same time, we suggest blocking the many small rills that are destroying sheet flow by speeding water down valley. The angle berm has filled in with sandy soil that is easily movable by work crews.

Work Crew 2 days

Erosion control in collector channel

We propose building one rock dam grade controls in the collector channel. This could be a week worth of hand work.

Work Crew 5 days

Plug Rills in Tributary 2

Using hand tools and strong workers, we can transplant the very large Giant Sacaton grass plants that dominate the valley in the vicinity of the erosional rills. They can be relocated to block the rills and restore sheet flow to the system. We estimate this will take 2 days.

Work Crew 2 days

Monitoring Headcuts

We highly recommend installing several monumented cross sections and a longitudinal profile of the headcut in the Babocomari, with rebar pins for monitoring the movement of the headcut up-valley given that it is unclear if the instability has been halted by the occurrence of large boulders in the channel bottom. Since cattle grazing in the channel of the Babocomari may also be contributing to headcutting, we also recommend installing monitoring points for the very wide valley-eating headcuts, perhaps with an accurate line feature describing the present location of these features. Conducting this survey would take half a day.

Work Crew 1 day

Mesquite-invaded grassland mitigation

Historic, present and intended future land management (fire suppression, cattle grazing) is contributing to mesquite encroachment on the range, thus converting an historic grassland to mesquite thickets. In addition, precipitation patterns have shifted towards winter rains that favor trees and shrubs. Mesquite removal is not an approach that Stream Dynamics, Inc. has expertise in, so Hans Huth consulted with Dr. Ron Tiller (ADEQ ecologist) about mesquite removal options- this is what he learned:

- Tebuthiuron won't work on mesquite – it only works on creosote and other shallow rooted shrubs. As such, it will not help on the Chase Emerson property.
- There is an experimental product called Sendero manufactured by DOW Chemical. It is a Mesquite specific herbicide. ADEQ funded a project in Altar Valley to evaluate effectiveness. Preliminary data suggests that for the goals of this project (complete mesquite removal for grasslands restoration), the approach may require two or three treatments which can be expensive.
- Cutting with a chainsaw and spraying stumps - requires retreatment year over year only with only 50 - 80% effectiveness.
- ADEQ is in consultation with neighboring ranchers within the Hereford NRCO regarding the effectiveness of Sendero 2 on private property near the border with Mexico. Meetings are planned or in progress at this time.

Given these challenges and for the purposes of this project, the best option is to pluck standing mesquite out of the ground. This treatment is 90% effective, but expensive. Ground disturbance is a concern where heavy equipment is involved, but may not be an issue on the Emerson property since we are dealing with well distributed fine soils in the bottomlands. The recently acquired ADEQ Drone deploy imagery could assist a tree removal contractor to come up with a cost proposal.

Dealing and managing this thorny species is problematic using hand labor given risks to limbs and eyes. However, we can deal with it efficiently using heavy equipment. Stream Dynamics would uproot the trees with an excavator and transport it with a track-skid loader with grabbers instead of a bucket, and migrate the debris to the portion of the drainage channel that we intend to block off. This would be done with a Cat 308 excavator and a JCB trackskid loader with a logging grapple. This treatment would open up parts of the bajada for keyline plowing.

We hesitate to recommend this option due to the large amount of disturbance for treatment of a relatively small are of rangeland invaded by mesquite. As such, we propose spending only two days pursuing this removal strategy on the Emmerson property. If approved, such a project requires careful consideration of our goals for the appearance of the finished job, and how to dispose of the enormous amount of material that this activity will generate. The proper solution is the elimination of the root causes linked to fire suppression and cattle grazing.

Stream Dynamics used this JCB “Robot” track-skid loader with logging grapple attachment on several jobs. It does a fantastic job of moving uprooted trees. At Cloverdale Ciénega Stream Dynamics uprooted 200 juniper trees from a tree invaded meadow with a Cat 315 excavator and the loader shuttled them quickly to grade control sites in the creek. We then used the material to build 45 weirs with this locally collected material. The meadow was restored to tree-free condition, and the creek bed was raised back to floodplain elevation with the tree material. This piece of equipment is available for rent at a reasonable price from a contractor in Silver City.

Cat 308 excavator, JCB loader 2 days

JCB loader with logging grapple



Cat 308 excavator with thumb



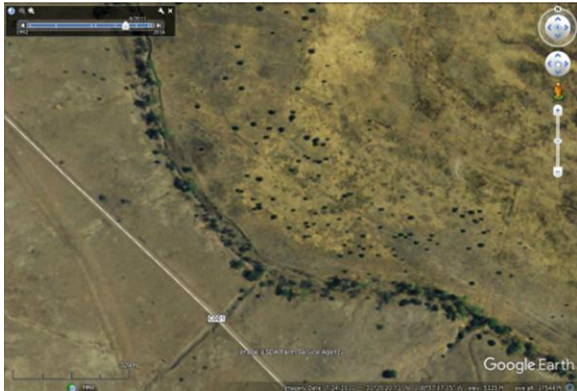
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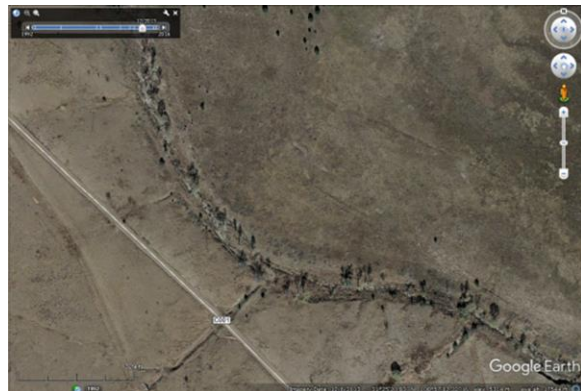
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Meadow before



Meadow after



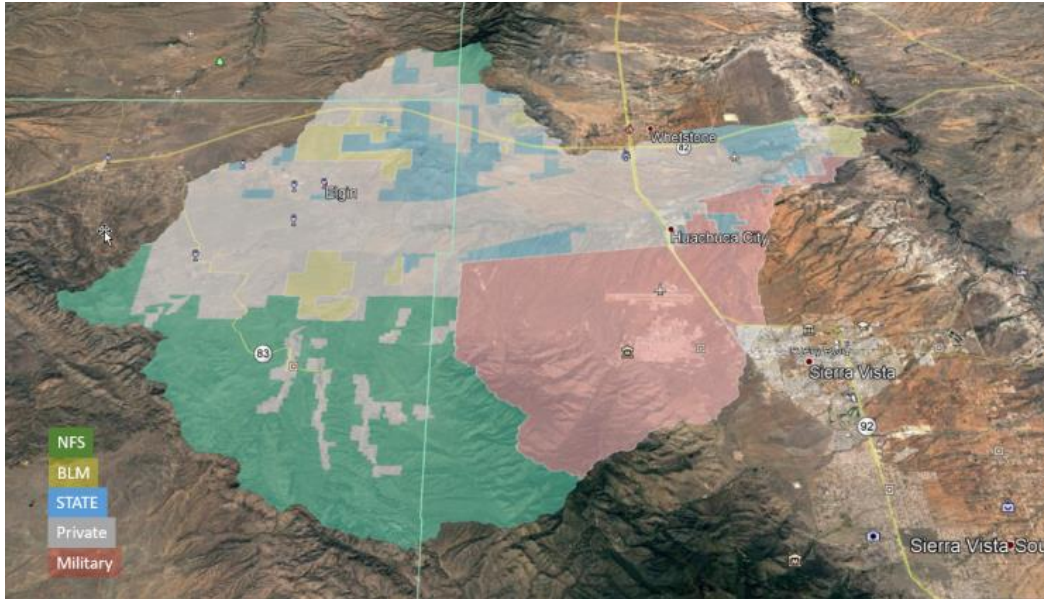
Customer Needs and Project Considerations

As communicated by Hans Huth, Stream Dynamics understands that the goal of the Arizona Department of Environmental Quality is to identify and implement sustainable prescriptions that will protect water quality while also balancing the social and economic needs of the areas being served. Over the course of this project, ADEQ has requested our guidance on basin-wide strategies that will support of this goal.

In regards to landscape strategies, Stream Dynamics is proposing prescriptions that have proven effective and sustainable in New Mexico for areas protected from agricultural and development. To be clear, *Stream Dynamic's record of success is credited to our careful selection of projects that host the right mix of stakeholder engagement and ownership coupled with appropriate land uses. These are critical elements to ensure sustainable returns of ADEQ's investments.*

Although we believe the Emmerson project hosts elements for success, we caution that external influences may challenge the sustainability of similar investments elsewhere. Within your targeted watershed, we observe that the Arizona State Land Department, the National Forest Service, and Bureau of Land Management jurisdictions are significant in extent. Respective jurisdictions administer

agricultural and recreational activities that may host detrimental impacts on soil conservation and water quality within the watershed you are trying to restore.



The associated potential for soil compaction, decreased land cover, and improper road maintenance are root-cause factors that can realize watershed-scale impacts beyond the local benefits of the modest project like the one presented here. We understand that recreational and agricultural activities support local and state economies through permit, lease, and commercial revenues, but also recognize that respective activities can realize significant costs requiring intervention.

In regards to a recommendation for a sustainable strategy moving forward, we suggest evaluating agricultural and recreational receipts against the investments required by ADEQ for restoring watersheds in areas impacted by associated activities. We recommend you then engage with partner agencies and stakeholders regarding ADEQ investments so that more sustainable and equitable policies can be developed moving forward. By approaching these challenges holistically, we believe you will create an environment that will ensure the benefits of this project can stand out as an example that can be replicated and sustained over time.





AZ ROC CR-21 300910

**BABACOMARI RESTORATION PROJECT - PHASE 1:
COLLECTION AND ANALYSIS OF GEOMORPHIC & HYDROLOGICAL
DYSFUNCTION AND OPPORTUNITIES
BABACOMARI RANCH,
SANTA CRUZ COUNTY, ARIZONA**

07/07/2025

Andrew Quarles

Stewardship Manager

Arizona Land and Water Trust

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In this document we will present the bulleted tasks below for the Babacomari Ranch Restoration Project Phase 1. Phase 1 can be defined as the collection and analysis of geomorphic and hydrological dysfunction and opportunities within areas identified as high priority by the client. Our analysis will include 12 channels, Vaughn Canyon and briefly Babacomari Creek.

PHASE 1 TASKS

- Define projects goals and objectives with input from Arizona Land and Water Trust and stakeholders
- Identify necessary techniques and materials needed for treatments
- Map locations of project activities
- Approximate materials, equipment and rough costs

This report includes a general landscape assessment which discusses alluvial fans, roads, headcuts, and maintenance. Following the general assessment we present a detailed assessment of selected priority drainages, all of which lead into the mainstem of the Babacomari Creek. The drainages on the north side of Babacomari Creek are labeled from west to east as C1-C12. Vaughn Canyon and Babacomari Creek are discussed following C1-C12. Finally, we will provide a priority list of treatment areas, photos, and a link to a map of treatments.

PROJECT GOALS

- Increase the ability to wet the valley/channel bottoms
- Increase storage area access, such as alluvial fans.
- Prevent problematic headcuts from growing.
- Identify opportunities to push water up out of the channel
- Opportunistic rainwater harvesting
- Reduced road maintenance.

The work recommended to achieve these goals will be done in the efforts to not only affect the channel where the work is done but also set up for future work within the Babacomari.

PROJECT TECHNIQUES

The techniques and methods that will be suggested include but not limited to:

- NIDS
- Media Lunas
- Plug and Spreads
- Removing impediments (berms, rail)
- Induced meandering (elongate and slow)

We suggest both machine and hand work. We recommend using onsite materials of rock and woodie material, only importing rock and material as needed.

GENERAL LANDSCAPE ASSESSMENT

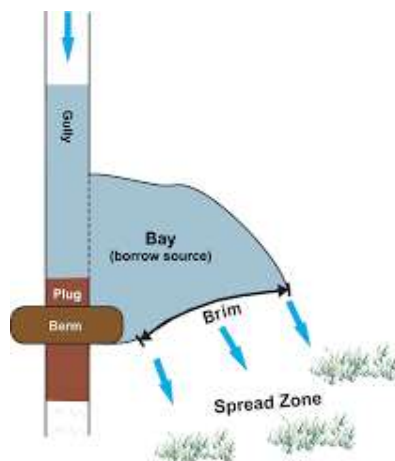
ALLUVIAL FANS

Alluvial fans function as major sedimentation zones within mountain fluvial systems, storing sediment supplied by mountain catchments (Harvey, 1997). Fans occur where confined mountain streams lose power, typically at mountain-front, tributary junction or intermontane basin situations. They are the geologic feature that stores the most water in a landscape. Fans also typically hold fertile soil because of the lack of high energy flows, soils are able to build. The coarse sediment allows for water to infiltrate and form aquifers.

When an alluvial fan becomes damaged and channelized it becomes dehydrated and fragile. The fans of the Babocomari watershed are critical in the health of the valley and its role in ecological services. We can see how fragile and important they are in this landscape. Not only by holding water and soil for plant health but by keeping the velocity of the incoming flows from the tributaries in check which keeps the tributaries from incising, increasing its holding capacities.

We have observed many of the fans in the project area have been damaged, impeded, and some are in threat of being channelised. Some of the locations of these fans are easier than others to access. Our treatment priority list is organized by evaluating the storage capacity of the alluvial fan, the volume of water discharged, and the cost of installation and maintenance. Cost factors vary by accessibility, equipment needed, materials needed, maintenance and potential risk factors.

Typical repairs of alluvial fans include strategies known as Plug and Spread and repairing headcuts with Zuni bowls, rock rundowns or log stepdowns. Plug and Spreads are built by building a large earthen plug in the current channel and opening a lead out channel for the water. The soil produced by the lead out or “borrow pit” is used for the Plug which protrudes to an elevation approximately 2’ above the top of the channel. The Borrow area, known as a Bay is level and wide so the water remains slow and spreads. At the end of the Bay there is a “Brim” which ensures an even distribution of water to the landscape (see **Figure 1**; [Quivara Coalition, 2018](#)).



There are three alluvial fans that are a priority for repair. The most damaged, and therefore highest priority, is in the tributary we refer to as C2, followed by C4 and C9.

Figure 1

ROADS

Roads have a significant impact on watersheds, therefore the design and maintenance is critical to land hydration. Hot spots for road impacts are anywhere roads follow vertically up a grade, not perpendicular or following the contour. Roads that climb ridges will also dredge a watershed by capturing water and running straight down the road causing erosion and keeping water from the landscape. Over time the detrimental effects are obvious.

Installing rolling dips, berms and lead outs as often as possible and where practical will keep the water on the landscape and reduce erosion. We found several places where roads can be treated to prevent further erosion, particularly on the road that loops from C8, west along the railroad berm, then north to a solar well, and to the northern property line where it continues east over a saddle and then back around to C8. This road also has two crossings that have culverts which are no longer functioning to their full capacity and are causing erosion to the road.

Rolling dips, and berm treatments are fairly simple structures to install and maintain. These treatments could be installed by ranch employees (with our assistance) if the ranch has the capacity.

Road crossings are more involved to install than rolling dips. They would require imported materials if the goal is to have the road function as a vehicle accessed road. This work can be achieved either by reinstalling culverts or by building a road crossing with rocks that would also function as a grade control for the tributaries.

UPLANDS

In this project area, the uplands are intact and look healthy with a diversity in plant species and ground cover. Lehmann lovegrass has established itself well on the ranch as it has on most of the grasslands in the area. Eradication would be costly with current techniques available to us. We would recommend focusing on supporting communities of native grasses keeping them healthy in the hopes they can someday outcompete the Lehmann lovegrass.

There are areas where the cattle tend to congregate and leave the ground bare. These areas are around water tanks and shade. In these areas where the slope is greater than 2% we recommend that a series of "media lunas"(MLs) made of 1"-6" rock be installed. The MLs would slow runoff from the bare areas preventing rills from forming and allowing more grass to take hold.

There are a few areas where “semi-circles” (berm and basins) could be installed to collect water allowing more infiltration, plant growth and support for established trees and shrubs. These would be best suited for slopes less than 2%.

HEADCUTS

There were several headcuts observed in the project area and outside of the area. Most of the headcuts are associated with alluvial fans and the tributaries. Many of these headcuts are very large in size which would require a large expense of resources to repair. We recommend prioritizing headcuts that either threaten healthy, productive plant communities or infrastructure. Reinforcing and repairing alluvial fans and roads will take care of many of the headcut issues. The sediment produced by the headcut will aggregate the channel slowing the water and erosion of the headcut. Road work will reduce the amount of water going over the head cut and support new plant growth that will contribute to slope stabilization.

Direct repair work to headcuts is typically achieved by reducing the vertical drop to a 3:1 or gentler slope and then adding rock to slow water going down the slope. Another direct headcut treatment is known as “starving” where water is rerouted so that minimal water will flow over the headcut.

MAINTENANCE

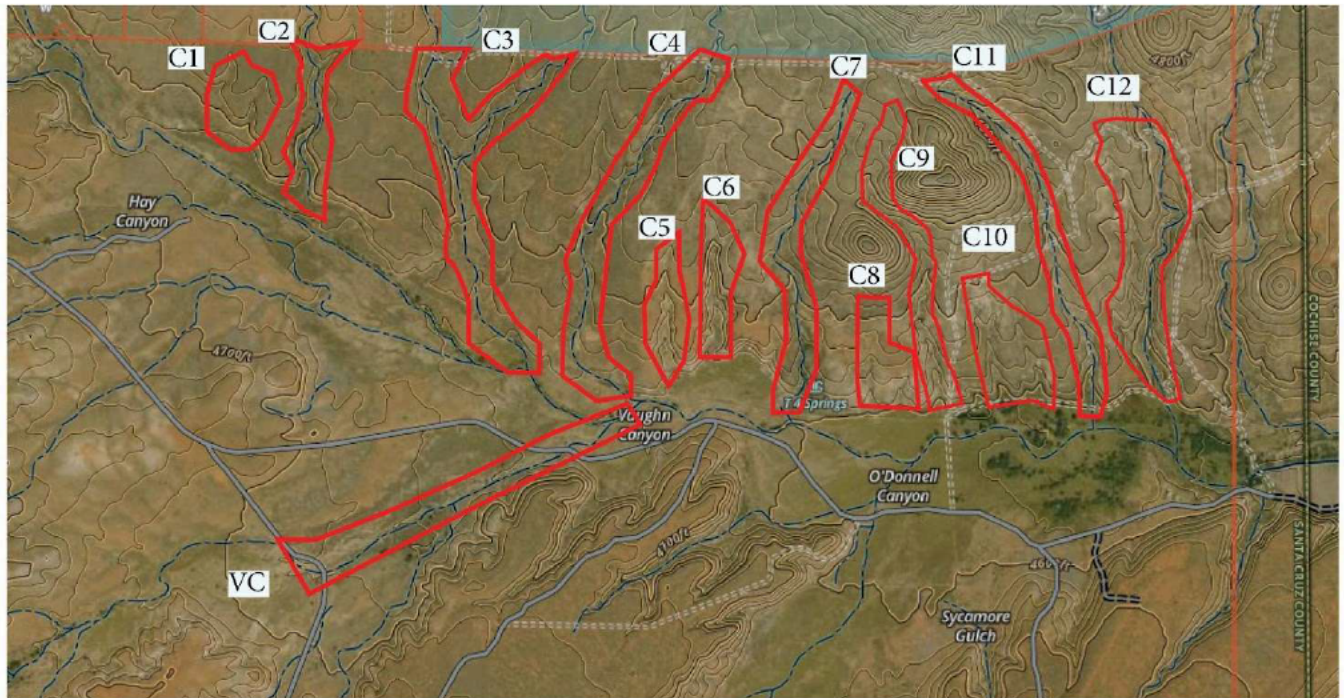
These treatments suggested in this assessment are designed to require no to minimal maintenance. The objective is for them to be self-maintaining until they return to their part of a functioning watershed. For example, the treatment to a damaged alluvial will be stable and built to scale for the largest predicted flows. As sediment builds and fills voids, the alluvial fans will take its natural form and transport water and sediment in a natural process. Road treatments will require the most frequent maintenance due to the nature of their use, but they are also the easiest to monitor. While road treatments may require periodic reinforcement and adjustments, the cost in time and money is low.

Adaptive management is the practice of monitoring and evaluating the effectiveness of planned treatments, keeping in mind the multiple variables that can influence the process of recovery. The post-installation monitoring and evaluating process takes time to determine if adjustments need to be made. In the design phase considerations of adaptive management are accounted for so the design can address foreseeable problematic areas. One major strategy to address this is to make sure that redundancy is built into the treatments. This approach to design ensures future adaptations and maintenance are kept to a minimum. There are continuously changing aspects to each treatment because each site is unique with different unknown influences. Learning by doing is a rewarding part of all restoration projects. Monitoring is key to a successful

rehabilitation project. As new techniques and technology are discovered they can be used to further the recovery.

DETAILED ASSESSMENT OF EACH CHANNEL (OUTLINED IN RED)

https://webmap.onxmaps.com/hunt/share/content?share_id=01JZKJ985FT2HZ8R8E9WC70PGH



C1. The first set of channels that we have been tasked to look at begins near the westside of Babacomari Rd. Road work needed to the north, headcuts at the top and bottom. This cluster of 3 drainages have similar patterns. Relatively short length of channel with opportunities in the uplands before the channelization begins to keep the water up longer. Headcuts tend to follow with a transportation zone that is slightly incised that leads to a partial intact alluvial fan. We suggest that the fan be restored.

C2. Large drainage that enters the property, encounters a bank that has narrowed the channel due to the overburden from a road and also merges with another drainage. There are active headcuts at the top and bottom. The transportation zone in between the headcuts has exposed bed rock. It continues down to the confluence of a side drainage which contributes significant water and sediment. In this reach the channel is confined between two hillsides which restricts it from moving laterally. The alluvial fan at the base of this drainage is severely damaged. We suggest that this tributary receive several treatments to the channel as part of the treatment to restore the alluvial fan. The bed is made up of large cobble and some bedrock, keeping the channel from

incising. There are floodplains that are accessible to the water but soon after the confluence it picks up speed and straightens out. In this straight reach, the flood plains are still accessible with some help. As the valley opens up, the incision of the channel deepens making the floodplain inaccessible. There is an opportunity to cut a new floodplain but this needs a more detailed look during design. This is also where the channel first becomes braided and where the alluvial fan treatment could start, by periodically plugging the channel and spreading it into the sacaton flats. As the channel's grade flattens and the valley opens, it braids into a Sacaton dominated flats with a main channel continuing down the eastside of the valley. The channel continues to deepen its incision as it travels along the railroad berm and meets the Babocomari.

- C3. Large drainage with multiple road crossings. Although the slope of the drainage is slight, it is incising an area with potential for reconnection to floodplain within the drainage. An existing berm in-channel is cutting on one side and causing erosion by narrowing. The Fan is disrupted by the railroad berm. We suggest that road treatments be done along with fan restoration at the bottom.
- C4. Larger drainage leading down from the Mustang Mountains. This channel has a wide valley bottom with many opportunities to rehydrate. The channel is mostly intact with a few places where it has incised but recovers quickly. The channel bottom is also made up of large cobble and bedrock with a few sections of aggregation. Where the tributary meets with the railroad grade it pinches(narrows) and has caused significant damage to the alluvial fans via head cuts. There are many options to explore for treatments and areas to rehydrate.
- C5. The channel begins to incise and headcut after it crosses the road to the north and west. We suggest work above this drainage and around the stock tank area to slow and store water.
- C6. Short channel with a large collection area that leads to a canyon-like headcut/waterfall. Suggest work above this drainage to slow and store water before it reaches the headcut.
- C7. This channel contains the T-4 Spring. We want to further investigate with Laura Norman about best ways to support the spring. We suggest opportunistic water harvesting along with repair and enhancement of existing structures.
- C8. Larger drainage that begins in the hills and starts to channelize near the top with a short and steep transportation zone. The drainage fans out at the bottom. Some impediment

to function here with the road. We suggest reestablishing the fan and installing media lunas in the uplands. There are several roads that meet at the confluence which has influenced the tributary and its alluvial fan. The tributary's channel is incised and gets trapped on the eastside of the tributary. The incision starts approximately 500 yards upstream of the confluence. There is an opportunity to stop the incision and spread the water onto the fan at the beginning of the incision and support that treatment a few more times before it gets to the confluence and road. Reestablishing and supporting this fan would be beneficial to the road and would rehydrate approximately one acre of previously sacaton dominated area. Currently the zone has been colonized by acacia and other xeric plant communities. By treating the fan, the road would require less maintenance after rain events.

C9. Confined drainage with exposed bed rock. Relatively steep. Intersection/Road crossing at the bottom. We suggest treatment at road crossing and in uplands.

C10. Headcuts at the top of this drainage are encroaching on sacaton. Failed culvert at road crossing. We suggest road crossing work with upland work to protect sacaton and roads.

C11. This drainage has many large headcuts along the top near the road. There is a lot of energy in the channel. Narrow and steep with lots of exposed bed rock. Leads to an intact fan at base. Suggest Road work and some upland work to reduce the flow to headcuts.

C12. Larger drainage leading down from the Mustang Mountains. Has a windmill and feed area in the floodplain. Multiple road crossings. Suggest that water be slow near the stock tank and continue road work.

Vaughn Canyon (VC) - Identified 5 gabion structures, 3 older post structures. West of the road is a large headcut created by the road and stock tank, also many ORDs above the headcuts. Suggest that the gabions be repaired but mainly recommend enhancements and many supportive structures in between.

Babacomari Creek - Much of this channel has eroded to bed rock. The evidence provided by the living trees indicated that this level has been stable for a long time. The channel cannot get deeper in many spots but would benefit from greater connection to the sacaton flood plain along with the creation of pools for sustained water availability in the channel and its

surrounding uplands. There are a couple of existing Gabions within the Babacomari creek near the west edge of our work area. These Gabions are in need of repair and supportive structures.

TREATMENT AREA PRIORITIES

Priority	Treatment Area
1	Road Crossings & nearby upland work including media lunas
2	C4
3	C2
4	VC
5	C9
6	C7
7	C3
8	C1
9	C5
10	C6
11	C10
12	C11
13	C12
14	C8



**MONTGOMERY
& ASSOCIATES**

Water Resource Consultants



**Natural Channel Design
Engineering Inc.**
ncdengineeringinc.com

REPORT

June 2025

Babocomari Watershed Assessment

Prepared for:

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Conservancy 
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1 EXECUTIVE SUMMARY

The Babocomari Watershed, located in southeastern Arizona, is a vital ecological and hydrological system encompassing approximately 200,000 acres across Cochise, Santa Cruz, and Pima Counties. This region supports diverse habitats—including grasslands, riparian corridors, ciénegas, and perennial streams—that are home to numerous species. However, the watershed faces mounting threats from groundwater depletion, climate change, land development, and historical land use practices such as overgrazing.

The Nature Conservancy (TNC) commissioned Montgomery & Associates and Natural Channel Design Engineering to conduct a comprehensive watershed assessment. The goals were to evaluate current watershed conditions, identify restoration opportunities, and foster collaborative conservation planning. The assessment integrated stakeholder engagement, geospatial analysis, and field visits to develop a science-based understanding of the watershed’s hydrogeology, surface water dynamics, ecological conditions, and land use impacts. Key findings include:

Groundwater and Surface Water: Groundwater recharge is primarily via mountain front processes, with shallow aquifers supporting critical ecosystems. However, groundwater levels are declining near urban centers due to pumping, which threatens baseflows and riparian habitats.

Channel and Ecological Conditions: Many stream channels are incised or actively eroding due to historical and current watershed disturbances, contributing to sedimentation and habitat degradation. There are restoration opportunities to stabilize channels, enhance infiltration, and support vegetation recovery.

Stakeholder Collaboration: Over 30 agencies and organizations participated in surveys, workshops, and field visits. Approximately 3 dozen potential restoration projects across 7 watershed zones have goals such as groundwater recharge, erosion control, habitat enhancement, and infrastructure repair. These projects serve as a starting point; additional project concepts are expected to be developed as opportunities emerge in the future.

Implementation Strategy: This report outlines permitting pathways, funding sources, and prioritization criteria to guide project development and execution. It also recommends further assessments, including groundwater budgeting, ciénega health studies, and invasive species management.

This assessment provides a foundation for coordinated long-term watershed restoration and resilience planning. By aligning solid scientific information with stakeholder priorities, it aims to protect the Babocomari Watershed’s ecological integrity and water resources for future generations.

2 INTRODUCTION

The Babocomari Watershed, located in southeastern Arizona, represents an important ecological and hydrological system featuring diverse vegetation types that support rare ecological habitats. The watershed faces significant threats: groundwater depletion from increased pumping, climate change impacts (e.g., rising temperatures, drought, fire, and flood), land development (e.g., decreased recharge for urbanization, water quality degradation, erosion, and habitat fragmentation), and residual impacts from historical cattle grazing (e.g., erosion and vegetation changes). Restoration is important in a watershed like the Babocomari that has extremely limited surface water or other renewable water supplies such as treated effluent. Addressing these challenges to enhance and preserve the watershed will require not only a solid scientific understanding of the watershed conditions but also collaborative conservation efforts among the many federal, state, and private landowners and managers.

2.1 Motivation

This report is the result of a recent initiative aimed at identifying and assessing conservation actions to protect and enhance watershed health within the Babocomari Watershed. The Babocomari Watershed is ecologically rich and diverse, encompassing high-quality grasslands, riparian ecosystems, ciénegas, springs, and stretches of perennial flow. These habitats support a wide array of biodiversity, including several listed endangered or threatened species. This ecological significance, combined with the watershed's role in regional hydrology, underscores the importance of focused conservation efforts.

In addition to its natural value, the watershed has been the focus of extensive conservation and research efforts over the years. Numerous federal agencies, conservation organizations, and research institutions have been active in the area, contributing valuable knowledge and management experience. However, there remains a need for a cohesive platform to integrate these efforts and facilitate comprehensive discussions about the entire watershed.

The Nature Conservancy (TNC) has maintained a longstanding presence in this region, including stewardship of the Canelo Hills Preserve on O'Donnell Creek—a tributary of the Babocomari—as well as several conservation easements along the main stem. The Babocomari Watershed is also a significant hydrologic contributor to the Upper San Pedro River, an area where TNC has had a significant conservation footprint for many years. TNC seeks to identify key opportunities to support watershed health, engage partners to pursue projects, and lay the groundwork for future collaboration. Through this collaborative process and the development of this report, TNC aims to foster a shared understanding of watershed priorities, strengthen partnerships, and inform strategic, science-based conservation planning that can guide future actions across the Babocomari Watershed.

2.2 Scope of Watershed Assessment

TNC contracted with Montgomery & Associates (M&A) and Natural Channel Design Engineering (NCDE) to conduct the Babocomari Watershed assessment. M&A is a Tucson-based water resource consulting firm that specializes in groundwater management, modeling, and surface water-groundwater interactions. NCDE is a Flagstaff-based civil engineering firm providing services in river restoration and conservation engineering, environmental assessment, permitting and compliance, restoration ecology, and natural resource planning.

The team provided an integrated approach to watershed assessment by evaluating watershed function and identifying potential projects to benefit the long-term health of the watershed. Their objective was to identify opportunities to improve hydrologic function, enhance ecosystems, and support long-term watershed resilience through research, stakeholder engagement, geospatial analysis, and field assessments. This report describes the physical setting including groundwater, surface water, and vegetation conditions and identifies areas of the watershed that are impacted by channel erosion, declining streamflow, groundwater depletion, and habitat degradation and that could be targeted for improvement through specific project implementation. The work was completed between January and June 2025.

2.2.1 Stakeholder Engagement

The watershed assessment and potential projects were informed by engaging stakeholders to incorporate lessons learned from previous watershed research and restoration efforts, strengthen partnerships by identifying shared conservation goals, and develop project materials that serve as a foundation for future conservation initiatives.

The assessment was guided by 5 shared goals: enhancing hydrologic function, managing habitats and species, improving water management and source water protection, ensuring water quality, and supporting community engagement. These goals, along with their associated sub-goals listed in Table 1, provided the framework for stakeholder input and project evaluation.

Stakeholder organizations that were engaged and participated in any stakeholder engagement aspect of this project are listed in Table 2. Those that participated in any aspect of this project are denoted; however, lack of participation does not necessarily indicate lack of interest as some were not contacted or were unavailable in the relatively short timeframe available for this initial outreach effort. Stakeholder engagement involved 4 components, described below.

Table 1. Goals for Watershed Management

Watershed Goal (survey rank)	Subcategory (survey rank, top 10)
Hydrologic Function (1)	Slowed flows for erosion control, revegetation, water infiltration for groundwater recharge, and surface flow extension (1)
	Healthy & connected floodplains (4)
Habitat & Species Management (2)	Freshwater ecosystems (5)
	Riparian areas (2)
	Grasslands (3)
	Woodlands & forest
	Wildlife corridors & habitat connectivity (10)
	Increase landscape productivity
Water Management & Source Water Protection (3)	Regional water security
	Flood mitigation (6)
	Shallow groundwater to support freshwater & groundwater-dependent ecosystems (7)
	Stormwater and effluent management for water recharge (8)
	Water management for cattle and/or wildlife (stock tanks)
Water Quality (4)	E.coli impairment
	Other concerns e.g., turbidity, dissolved oxygen
Community (5)	Working lands & rural livelihoods (9)
	Local economy
	Resilient communities & infrastructure

Ranking results shown in parentheses are from the stakeholder survey.

Table 2. Stakeholder Organization

Federal Agencies	State Agencies
U.S. Dept. of Defense, Fort Huachuca	AZ Dept. of Environmental Quality
U.S. Fish and Wildlife Service	AZ Dept. of Forestry and Fire Management
Natural Resources Conservation Service	
U.S. Forest Service, Coronado National Forest	
Bureau of Land Management	
U.S. Geological Survey	
Fort Huachuca Sentinel Landscape Partnership	
U.S. Dept. of Agriculture, Agricultural Research Service	
Local Entities (County, Municipal, Other)	Conservation Organizations/Private Entities
Town of Huachuca City	Arizona Land and Water Trust
Santa Cruz Natural Resource Conservation District	Borderlands Restoration Network
Santa Cruz County Flood Control District	Desert Botanical Garden
Cochise Conservation and Recharge Network	National Audubon Society -Audubon Southwest
Private landowners and ranch managers	Sky Island Alliance
University of Arizona researchers	The Nature Conservancy, Arizona
Cochise County Engineering & Natural Resources	Watershed Management Group
	Arizona Antelope Foundation

2.2.1.1 Introduction to the Watershed

A virtual introductory session was held for stakeholders in February 2025. Approximately 50 people were invited, and it was attended by approximately 20 people. A recording of the meeting and copy of the slides were made available to those who could not attend.

2.2.1.2 Survey

A survey of stakeholders was conducted during February and March 2025 to gather information on stakeholder priorities and projects. There were 17 individual responses to the survey, and 10 follow-up interviews were conducted by the project team to learn more about specific projects and priorities.

Of the 5 main goals listed in Table 1, Hydrologic Function ranked the highest among survey respondents, followed by Habitat & Species Management, and Water Management & Source Water Protection. From the subcategories listed in Table 1, the top ranked were slowed flows, riparian habitat, and grasslands habitat.

Using Survey123, a geographic mapping tool developed by ESRI, survey respondents were also able to identify the locations of completed or planned projects and upload photos. A total of 20 potential projects and 24 existing projects were identified by stakeholders.

2.2.1.3 Workshop

An in-person workshop was held at the Appleton-Whittell Research Ranch of the National Audubon Society (Audubon) in March 2025. The team presented an overview of the watershed and discussed potential projects. The meeting was attended by over 20 individuals from over a dozen organizations.

2.2.1.4 Field Visit

On the ground field inspections were conducted in May 2025. The project team targeted potential project sites to evaluate conditions and opportunities for improvement. The team was also able to ground-truth and refine some of the remote sensing analysis.

2.2.2 Web Map

In addition to this report, the team created a custom web application. The Babocomari Watershed Web Map is available at <https://arcg.is/1L8ife1>. The mapping tool has a customizable user interface to display pertinent geographic, hydrologic, and ecological datasets.

2.3 Watershed Overview

The Babocomari Watershed shown on Figure 1 covers approximately 200,000 acres in parts of Cochise, Santa Cruz, and Pima Counties. The watershed drains to the Babocomari River, which begins on the western boundary of the watershed near the town of Elgin and flows approximately 32 miles to the east where it joins with the San Pedro River downstream of Huachuca City. It is bordered by the Mustang Mountains and the southern end of the Whetstone Mountains to the north, and the Canelo Hills and Huachuca Mountains to the south. Surface water flow in most of the Babocomari River is intermittent, meaning it does not flow continuously throughout the year and may only have water during certain seasons or periods of rainfall; however, stretches of the stream contains year-round, or perennial flow. Elevation ranges from 8,416 feet above mean sea level (amsl) in the Huachuca Mountains at the northern boundary to 3,825 feet amsl at the junction with the San Pedro River at the far eastern edge of the watershed.

2.3.1 Land Ownership

There are federal, state, and private lands within the watershed. Federal agencies managing portions of the watershed are the U.S. Forest Service (USFS), Bureau of Land Management (BLM), and U.S. Department of Defense, Army (Fort Huachuca). Fort Huachuca and the USFS are each slightly over 22% of the watershed and the BLM is approximately 5% of the area. The watershed is 10% Arizona State Land and 40% private land. Huachuca City and Elgin are incorporated towns with population centers in the watershed, and part of the City of Sierra Vista is in the watershed. The Babacomari Ranch (spelled differently than Babocomari River) is the largest private landowner in the watershed. TNC and Audubon are conservation organizations that own and manage lands in the watershed.

2.3.2 Watershed Zones

The watershed boundary shown on Figure 1 is defined by the U.S. Geological Survey (USGS) Watershed Boundary Dataset (WBD) as Hydrologic Unit Code (HUC) 10-1505020208. For this assessment, the watershed was divided into 7 watershed zones based on distinct hydrogeologic, hydrologic, vegetative, and/or geomorphic characteristics. The zones are labeled on Figure 1 and are described in detail in Chapter 4. Chapters 2 and 3 establish the hydrogeologic and watershed conditions that define distinct watershed zones, respectively. Chapter 5 provides project lists and implementation considerations.

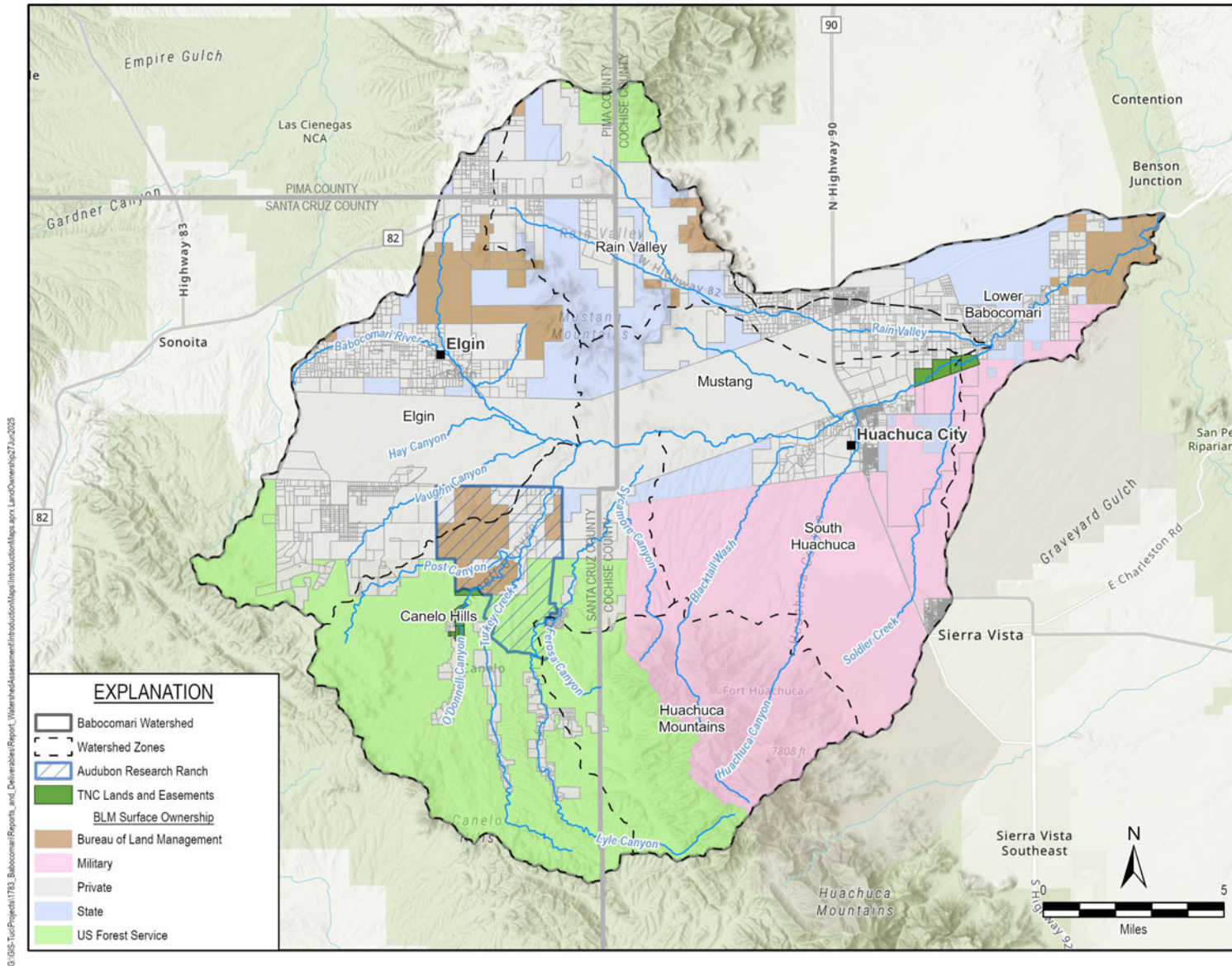


Figure 1. Watershed Features and Land Ownership

3 HYDROGEOLOGIC SETTING

The hydrogeologic setting is influenced by precipitation and defined by the occurrence of groundwater.

3.1 Climate and Precipitation

The climate of the Babocomari Watershed is semi-arid with bimodal precipitation patterns. In the winter, there is rain at lower elevation and snow at higher elevations; in late summer, there is monsoon-related rainfall across the entire watershed (PRISM, 2025). Annually, lower elevations around Elgin, Huachuca City, Fort Huachuca, and the Babocomari River receive an average 14 inches of precipitation while higher elevation areas in the Huachuca, Whetstone, and Mustang Mountains receive an average of 26 inches (Figure 2 and Figure 3) (PRISM, 2025).

Within Arizona, many watersheds are biased to winter precipitation based on isotopic studies of precipitation and groundwater (Eastoe and Towne, 2018). However, some areas of southern Arizona—including the Babocomari Watershed—have higher average annual summer monsoonal precipitation than many parts of Arizona, and the relative amount of winter to summer precipitation is variable (Eastoe and Towne, 2018; Kennedy and Gungle, 2010). Summer monsoons are often intense precipitation events that drive sediment transport and surface water flow within ephemeral washes. These storms provide groundwater recharge that can sustain flow to riparian ecosystems, especially during the summer months when evapotranspiration rates are high (Kennedy and Gungle, 2010).

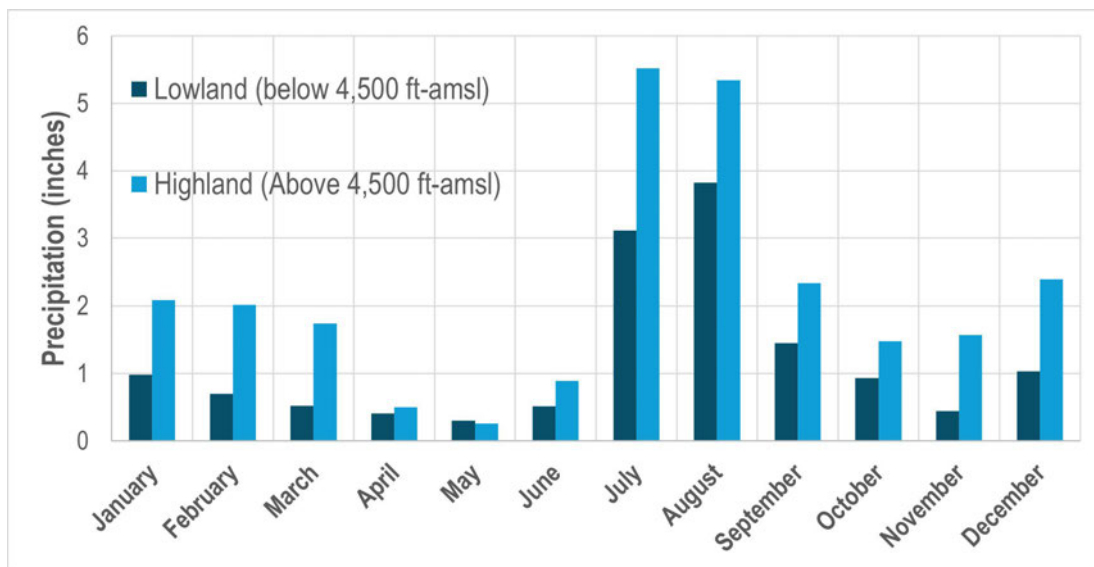


Figure 2. Average Monthly Precipitation (30 years) by Elevation

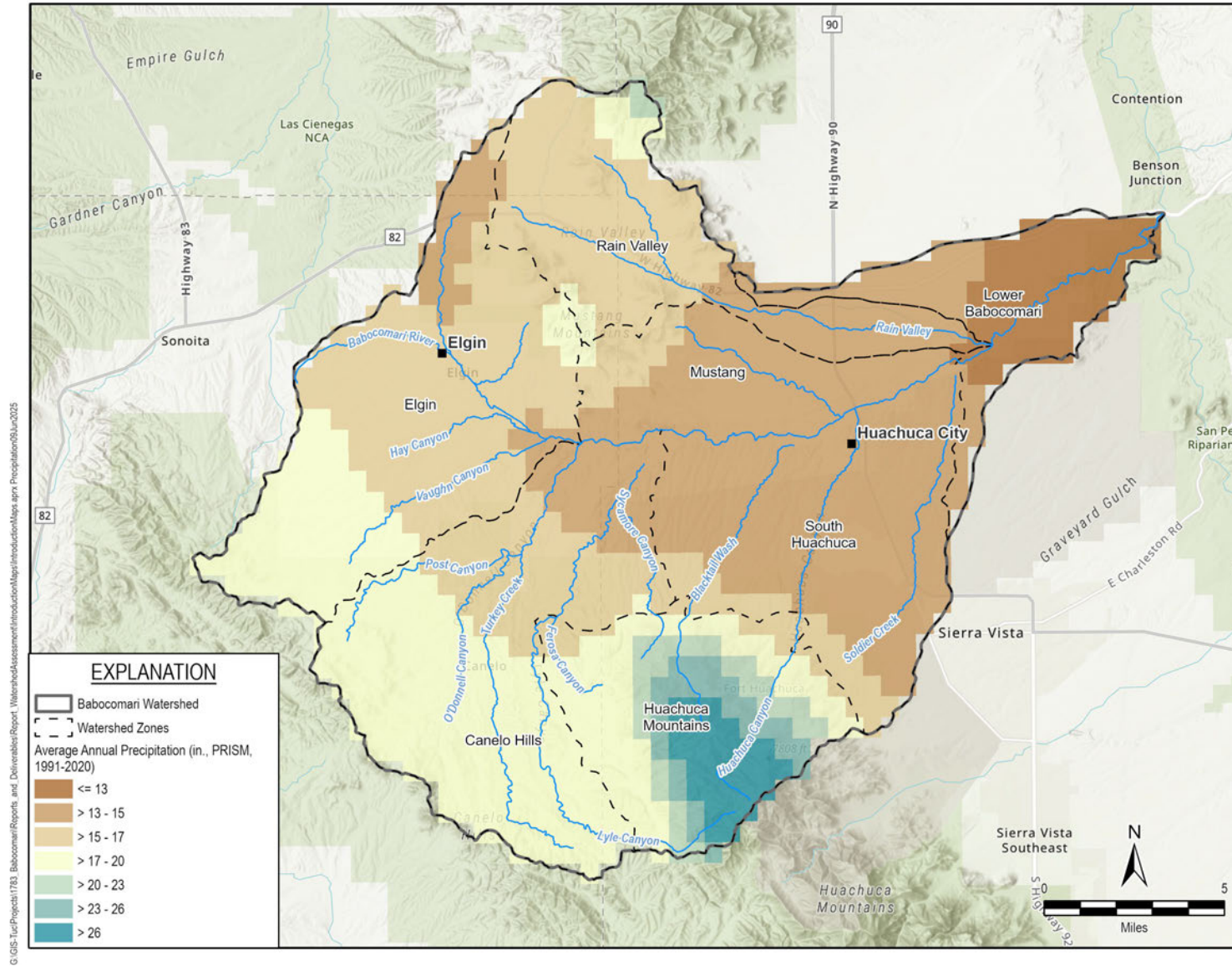


Figure 3. Annual Average Precipitation

3.2 Hydrogeology

The Babocomari Watershed is within the Sierra Vista sub-basin aquifer of Upper San Pedro Watershed (Kennedy and Gungle, 2010). Groundwater dependent ecosystems (GDEs) such as springs, ciénegas, and riparian areas are present within the watershed and are sustained by groundwater. Groundwater also sustains the baseflow of perennial sections of the Babocomari River (Norman *et al.*, 2019). Understanding where and how groundwater is recharged, stored, and flows is important for understanding where projects that benefit groundwater recharge should be sited.

3.2.1 Hydrostratigraphic Units

The geology of the watershed is shown on Figure 4. Groundwater within the watershed occurs in 2 primary settings: unconsolidated alluvial basin-fill in lowland areas and fractured bedrock aquifers in the surrounding mountains. The Quaternary alluvial units along stream channels and the Babocomari River are of variable thickness in the watershed and influence groundwater flow and storage (Schwartzman, 1990; Norman *et al.*, 2019). Less permeable bedrock occurs in the higher elevation mountains. Groundwater in bedrock units are generally restricted to highly fractured zones or lithologies with increased porosity, such as sandstone and carbonate formations (USGS, 1983) (Figure 4). Watershed-wide, underlying bedrock influences flow paths and limits groundwater storage. Springs and ciénegas form where less permeable bedrock units force groundwater to the surface within alluvial deposits (Stratman, 2022). Springs emerge along the transition between bedrock and alluvial deposits in the Whetstone and Huachuca Mountains, particularly in mountain-front and faulted areas (Springs Stewardship Institute [SSI], 2025) (Figure 4).

The extent of alluvial deposits, the location and orientation of structural geologic features such as faults, and hydrogeologic properties of the aquifer influence groundwater flow and storage capacity and are important factors for identifying watershed restoration strategies in each area.

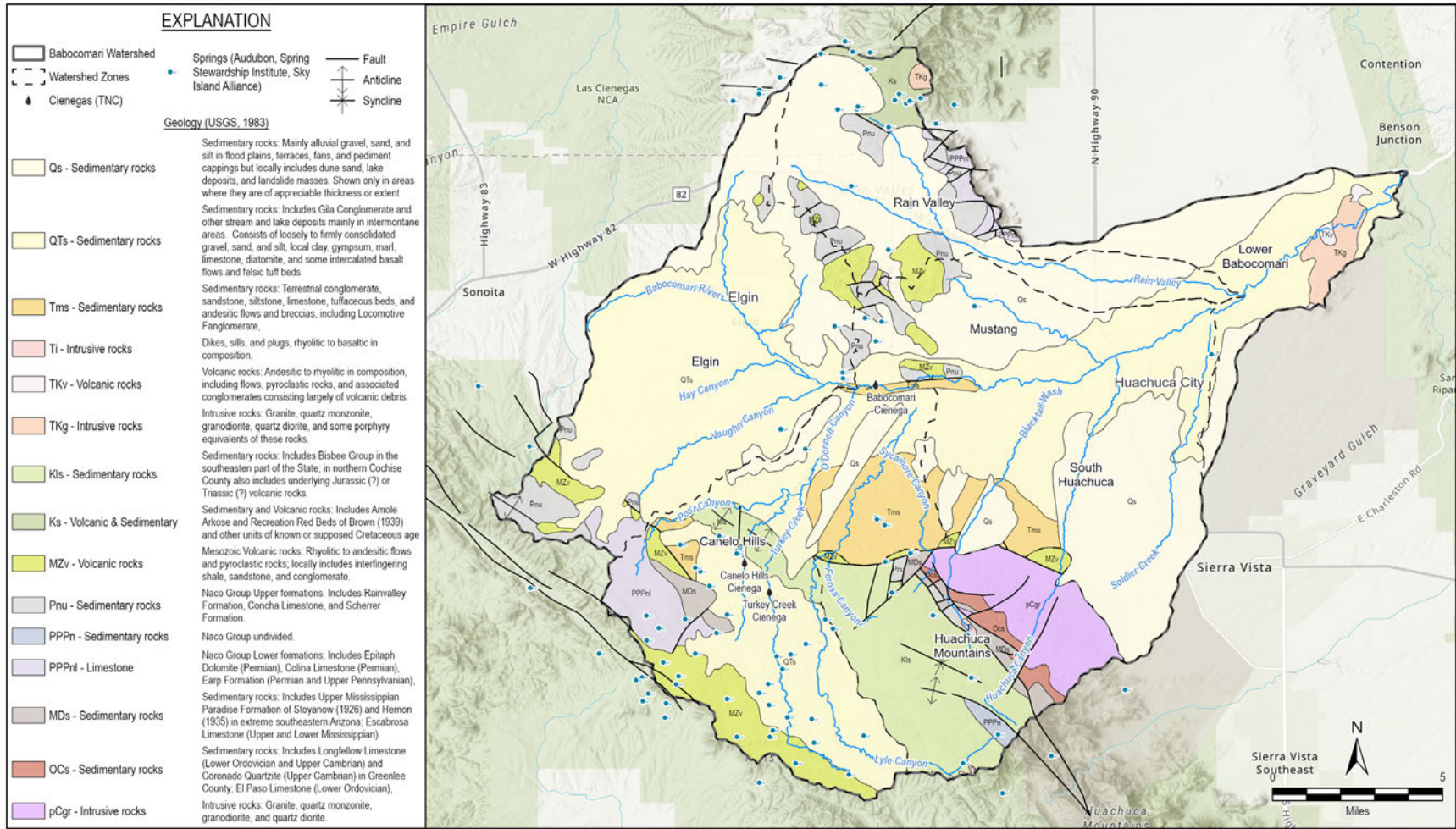


Figure 4. Geologic Map with Locations of Groundwater Dependent Ecosystems

3.2.2 Groundwater Levels

Groundwater levels across the watershed provide an understanding of groundwater flow direction and depth to water and are shown on Figure 5 as elevation and depth below ground surface (bgs). The groundwater elevation surface was derived from the Arizona Department of Water Resources (ADWR) Groundwater Site Inventory (GWSI) and well registration databases (ADWR GWSI, 2025; ADWR, 2025) for data collected between 1980 and 2024. Groundwater levels across the watershed have been relatively stable (Kennedy and Gungle, 2010) and the use of a broad date range provides more data points for creating the groundwater level contour surface. Land surface elevation was used as control points at the locations of perennial streams, springs outside of the mountain block, and ciénegas because these features indicate areas where groundwater is at the land surface. Depth to water was calculated by subtracting groundwater level elevation from a 1-meter digital elevation model (DEM) of the terrain from 2018 (USGS, 2025).

Groundwater flow direction is generally from high to low elevations toward the Babocomari River and northeast toward its confluence with the San Pedro (Figure 5). In the Huachuca Mountains, groundwater flows north converging with groundwater flowing south from the Mustang Mountains. This intersection of groundwater flow paths and shallow bedrock results in the emergence of groundwater and sustained surface water at and near the Babocomari Ranch Pond. In the Elgin area, groundwater level elevation contours indicate that some areas near Elgin have groundwater flow directions to the west toward the Las Cienegas and Sonoita Creek Watersheds, part of the ADWR delineated Cienega Creek groundwater subbasin (ADWR, 2022). The Babocomari River's surface watershed is part of the Upper San Pedro groundwater subbasin (ADWR, 2022). Additional data collection and modeling is required to refine the extent of the Cienega Creek subbasin capture zone with the Babocomari Watershed.

Depth to groundwater is greatest in areas of groundwater pumping around the population centers of Huachuca City and Sierra Vista where groundwater pumping has created cones of depression (Figure 5). Previous studies have shown a decline in groundwater derived baseflows to the Babocomari River (Kennedy and Gungle, 2010).

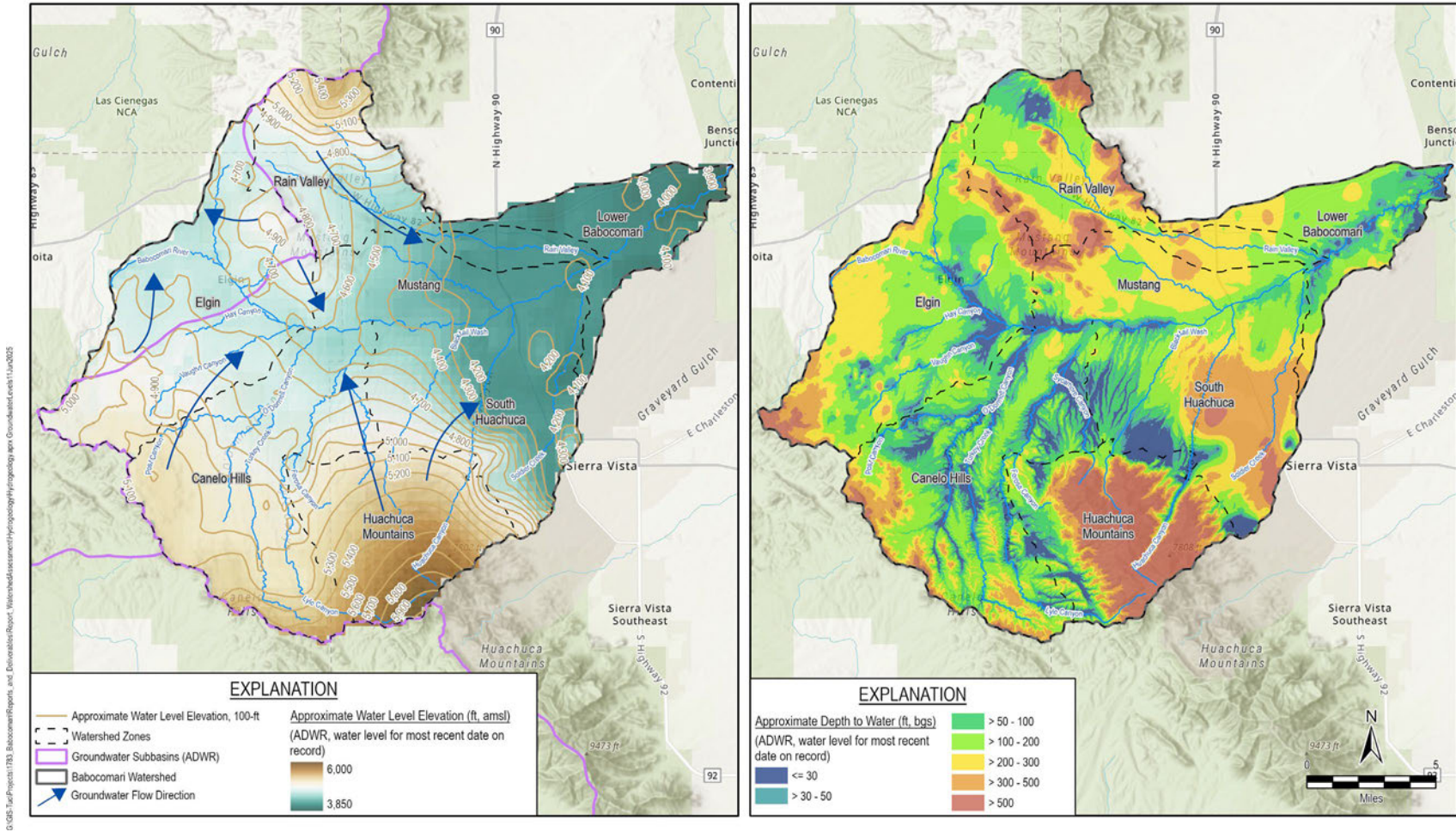


Figure 5. Groundwater Elevation and Depth

3.2.3 Groundwater Recharge

Groundwater recharge occurs primarily as mountain front recharge; precipitation falls in the mountains, surface water runs off over bedrock, infiltrates into unconsolidated sediments (alluvial fans or alluvium) at the base of the mountains, and enters the groundwater system (Schwartzman, 1990). Radiocarbon and tritium dating from multiple locations indicate that groundwater within the watershed is generally less than 500 years old (Stratman, 2022; Hasenstab, 2025). This relatively young groundwater highlights connectivity between shallow groundwater and deeper groundwater flow systems, with mountain-front recharge to unconsolidated alluvial sediment (Stratman, 2022).

Anderson (1991) integrates precipitation, groundwater modeling, baseflow separation, and watershed-scale water balance to estimate basin the percentage of precipitation that recharges in southwestern U.S. groundwater basins. The study concluded that over 90% of precipitation is lost to evapotranspiration (ET) processes. Applying these constraints to the Babocomari Watershed, PRISM-derived precipitation provides an estimate that between 1 and 3% of precipitation is recharged to groundwater, with higher percentages in the mountainous areas where ET is lower and precipitation is higher (Figure 6). Recharge patterns in the watershed are similar to the watershed precipitation pattern, with greater recharge potential at high elevations areas and lower recharge potential at lower elevations. Several limitations impact the recharge analysis, including coarse resolution data (800 meters), aquifer complexity, and anthropogenic influences. Once recharge patterns are better established, recharge values can be incorporated into a watershed-wide groundwater balance study, using USGS streamflow gage data from the Babocomari River alongside available well pumping records to enhance hydrologic modeling accuracy.

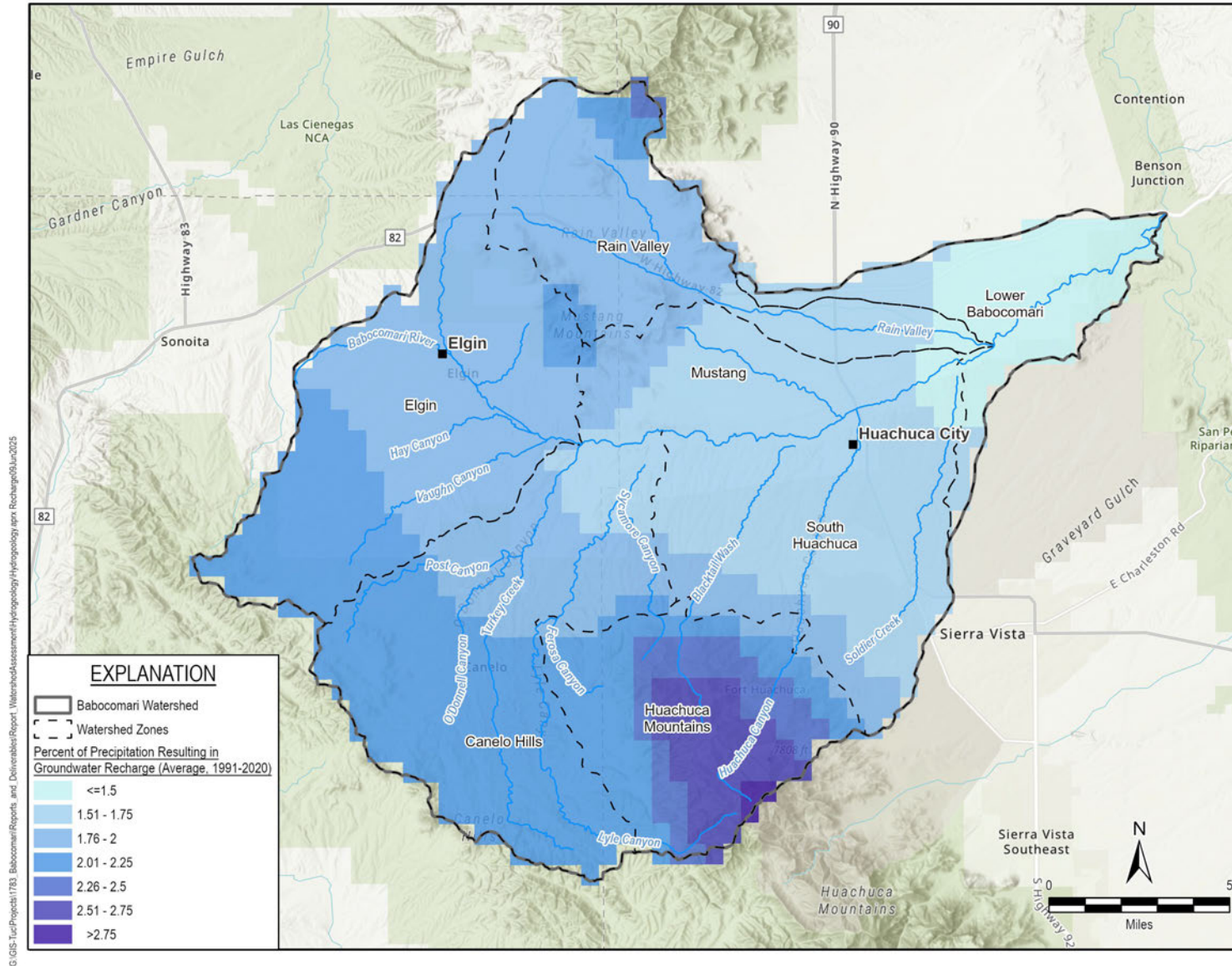


Figure 6. Percentage of Precipitation Resulting in Groundwater Recharge

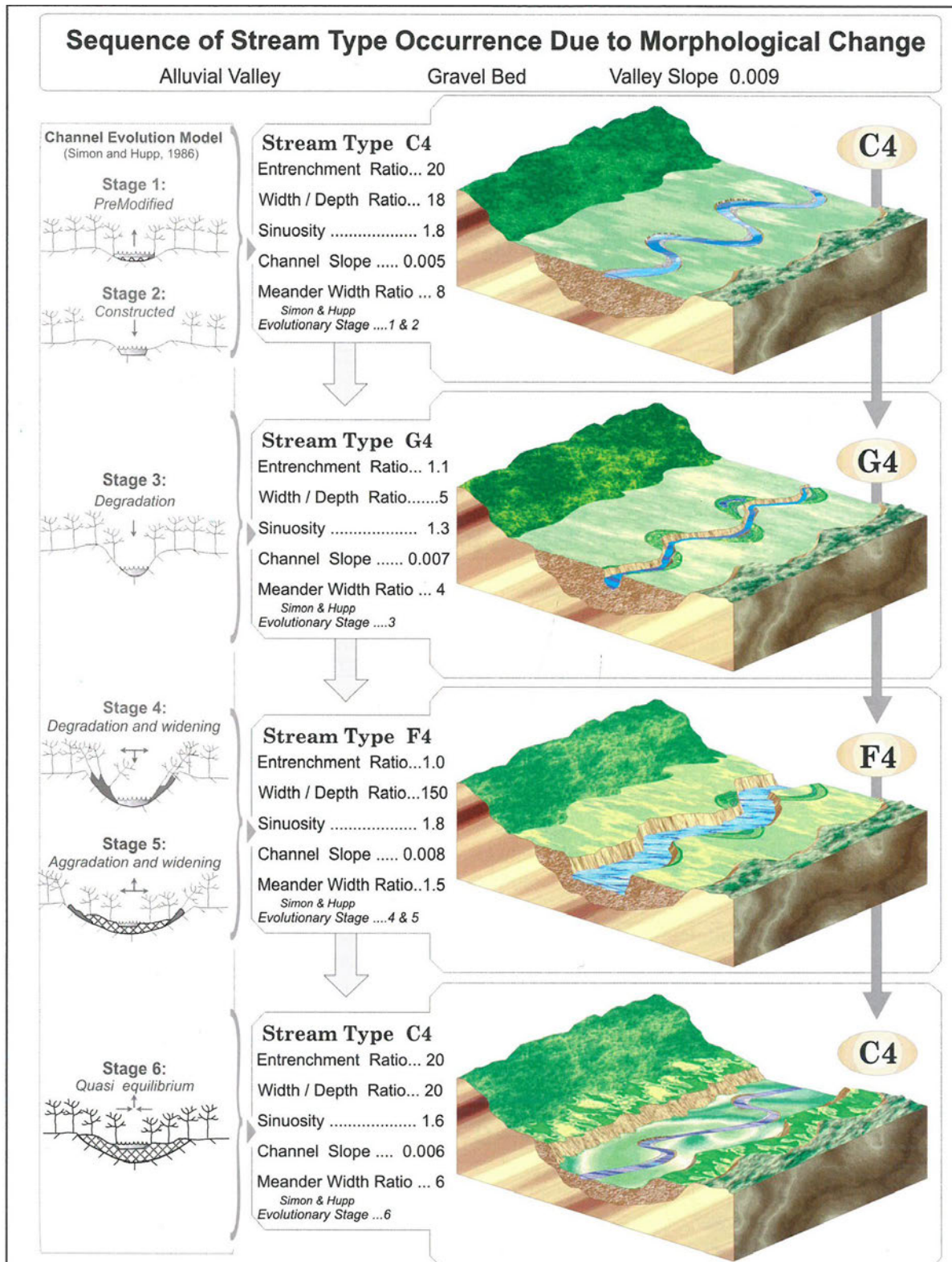
Within the Babocomari Watershed, projects to recharge stormwater/effluent and to preclude pumping in areas closest to stream channels will enhance groundwater baseflow contributions to the Babocomari River (Cochise County, 2002). Based on aquifer properties, modeling projections along the San Pedro River show that groundwater recharge benefits stream flows in areas closest to groundwater-dependent streams (Leake *et al.*, 2008). A variety of watershed restoration techniques and strategies have the potential to sustain mountain-front recharge and augment groundwater supplies to GDEs by storing excess surface water flows in channel banks, floodplains, and areas of unconsolidated sediment (Fan *et al.*, 2015; Norman *et al.*, 2025). Within the Babocomari Watershed, similar projects have been successfully implemented with documented hydrogeologic benefit of augmenting groundwater storage in areas proximal to restoration work (Norman *et al.*, 2019; CCRN, 2024).

4 WATERSHED CONDITIONS

Surface hydrology, groundwater, sediment transport, and ecological functions including vegetation and faunal habitat are all related via channel condition (Rosgen, 1999), which directly relates to watershed conditions. Anthropogenic disturbances and wildfire can affect the surface hydrology and degrade channels and associated watershed ecosystems.

4.1 Channel Conditions

At the watershed scale, channel evolution stages describe the process of gully erosion and recovery for a channel reach, and therefore can identify which processes should be slowed or sped up to reach a relative stable condition to support higher ecological function (Simon and Hupp, 1986; Rosgen, 1999). This process is shown schematically on Figure 7. Channel evolution begins when some event causes a channel headcut (Stage 3). Headcuts are abrupt, vertical drops in the bed of a stream channel, and are points where active headward erosion is taking place. This process deepens the channel over time, leading to channel incision, which is the progressive downcutting of the streambed relative to its floodplain. Incised channels become disconnected from their floodplains, reducing floodwater storage, destabilizing banks, and often increasing sediment transport downstream. As headcuts migrate upstream, they become steep-sided channels that are difficult to restore and lead to increased erosion. Controlling headcut progression protects riparian habitats and maintains hydrologic function. After incising, the channel bottom begins to widen (Stage 4) through bank erosion, then the channel begins the process of re-forming a stable low flow channel with a floodplain (Stage 5) large enough to handle flood flows within the incised channel.



Note: modified from Simon and Hupp (1986) and Rosgen (1999)

Figure 7. Channel Evolution Model

Several of the areas visited (Rain Valley, Babocomari River mainstem, and Lower Vaughn Canyon downstream of Research Ranch Road) were well along in the channel evolution process and had reached Stage 5, and the channel was no longer incising and was relatively stable. The areas all had well-developed floodplain, a meandering channel, and bank erosion was occurring at a much slower pace. Other locations such as Vaughn Canyon upstream of Research Ranch Road, were actively headcutting and incising (Stage 2). In general, places where active incision occurs are ideal for restoration work to prevent further incision, erosion, and habitat loss.

A reconnaissance level assessment was conducted to prioritize areas from a sediment and watershed perspective that have the potential to contribute to watershed degradation and downstream sedimentation. Geographic Information Systems (GIS) and modeling methods were used to screen areas for high likelihood of channel disturbance such as headcuts and incised channels, and the potential for high or low sediment transport capacity. Sediment source and transport at the assessment level were inferred from geomorphic features such as channel dimension, valley type, and potential channel condition. The results are shown on Figure 8.

Channel degradation from incision or widening, especially in softer alluvial materials, can create chronic sediment sources as the channel evolves to a more stable condition. Unstable channels yield much higher rates of sediment discharge, while some channel types and alluvial fans are functionally intact, capable of slowing/aggrading sediment transport. Identification of valley settings and potential channel types are key to identifying areas with erosion potential and management of sediment transport because they provide relatable ways to compare geomorphic condition across the watershed. Valley and channel type models were used to understand geomorphic condition and erosiveness throughout the watershed's stream network (Figure 8). This process helped understand watershed conditions and contribute to site selection for ground truthing fieldwork and siting of restoration projects.

An algorithm was used to identify headcuts throughout the landscape using slope breaks in stream channels. Mapped headcuts were initially identified using a GIS-based algorithm and subsequently verified through manual inspection of the digital elevation model (DEM). Field verifications were conducted for many of these headcuts to evaluate detection accuracy under current conditions. With the exception of headcuts occurring on bedrock, the process achieved high levels of accuracy. The headcut analysis identified approximately 150 headcuts, which are identified on Figure 8 by size of slope break and density.

To distinguish between historic and active degradation, historic aerial imagery could be compared to assess the rate that headcuts are advancing toward watershed features, for example, a *ciénega*. Observed channel instability generally aligns with mapped channel and valley types, reflecting modeled factors related to planform geometry and the forms typically associated with equilibrium or disequilibrium within specific valley settings.

In this analysis, the combined approach helped pinpoint locations where headcuts and degraded channel conditions are situated near high-priority watershed features. Not every headcut can or should be remediated. Rather, their distribution was used to guide prioritization, focusing on areas most in need of intervention. For instance, regions with high headcut density near shallow groundwater and alluvial sediment present opportunities for targeted restoration. This type of setting is well suited to mitigating headcut propagation; enhancing channel stability and reducing erosion, protecting groundwater storage areas, and producing other broader watershed benefits.

4.2 Ecological Conditions

Ecological conditions reflected in this analysis include critical habitats and vegetation. To evaluate ecological conditions within the Babocomari Watershed, a combination of open-source ecological data and remote sensing analysis was used.

4.2.1 Critical Habitats

The USFWS identifies critical habitat for the Gila chub, beardless chinchweed, yellow-billed cuckoo, jaguar, Mexican spotted owl, Huachuca water umbel, and northern Mexican garter snake (USFWS, 2025) (Figure 9). Many of the mapped habitat areas overlap with regions identified as GDEs. Restoration efforts at these locations within the watershed have the potential to enhance conditions for these species by improving groundwater recharge, expanding surface water availability, enhancing wildlife corridors, and supporting overall ecosystem resilience.

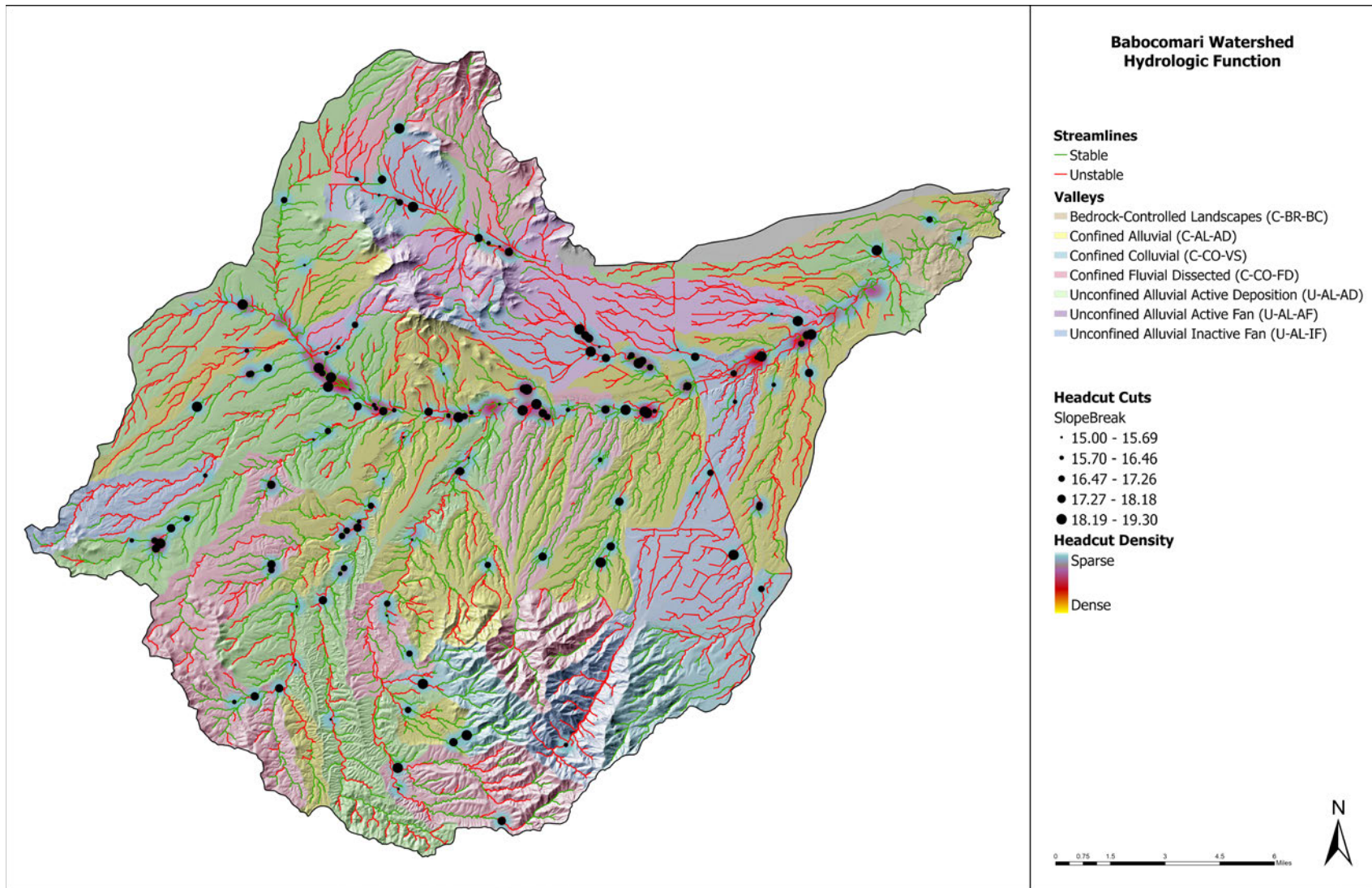


Figure 8. Valley and Channel Type and Locations of Headcuts

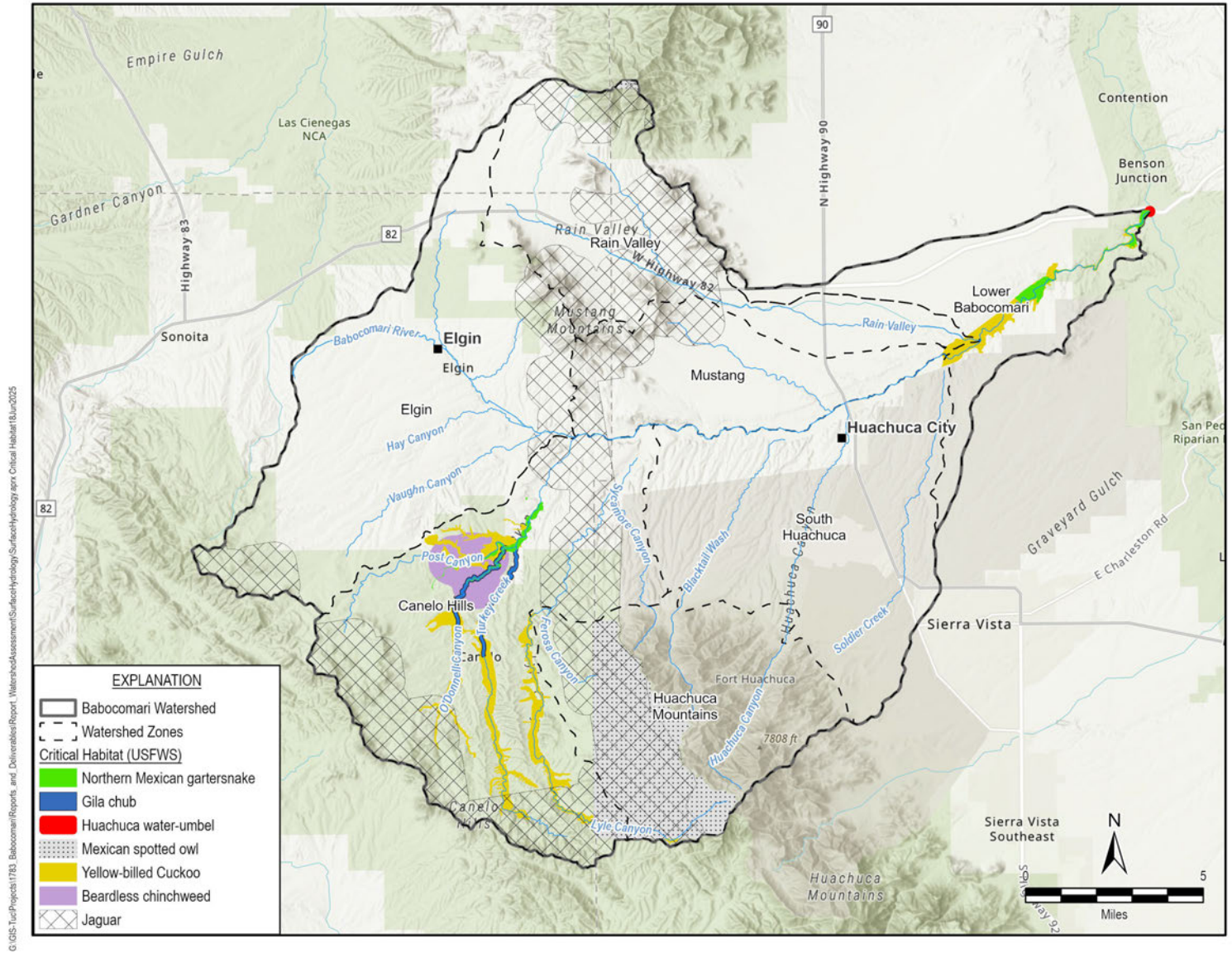


Figure 9. Critical Habitats and Groundwater Dependent Ecosystems

4.2.2 Vegetation

Functional vegetation groups were generated using a supervised classification model applied to 2023 National Agriculture Imagery Program (NAIP) imagery (USDA, 2023). Vegetation group classification spans the entire watershed—including both riparian and upland areas—and consists of 5 vegetation classes (Figure 10). These datasets benchmark vegetation health and distribution. This analysis was for a single year; however, NAIP imagery can be used for future analyses that incorporate timeseries or change detection to assess shifts in vegetation cover and health over a longer period.

Projects that support riparian vegetation both in upland and lower elevation areas have been the focus of conservation activities by various agencies and organizations (Robinett and Kennedy, 2009). To inform this effort, the normalized difference vegetation index (NDVI) for the trees functional group was examined along the riparian corridor of the Babocomari River. This analysis identified areas with relatively low NDVI values, suggesting potential vegetation stress or sparse canopy cover within the tree groupings. A detailed site-level assessment of these areas was not conducted; the geospatial analysis remained at a broader watershed scale to delineate broad, watershed-wide vegetation types and identify areas with lower NDVI values. Future efforts could benefit from on-the-ground verification to better understand site conditions, which would aid in selecting vegetation restoration areas. For example, an area with lower NDVI values downstream of the Babacomari Cienega was identified in the analysis; and several dead cottonwood trees were observed along the Babocomari River during the field visit, indicating that the low NDVI value may be pointing to an area of increased vegetative stress.

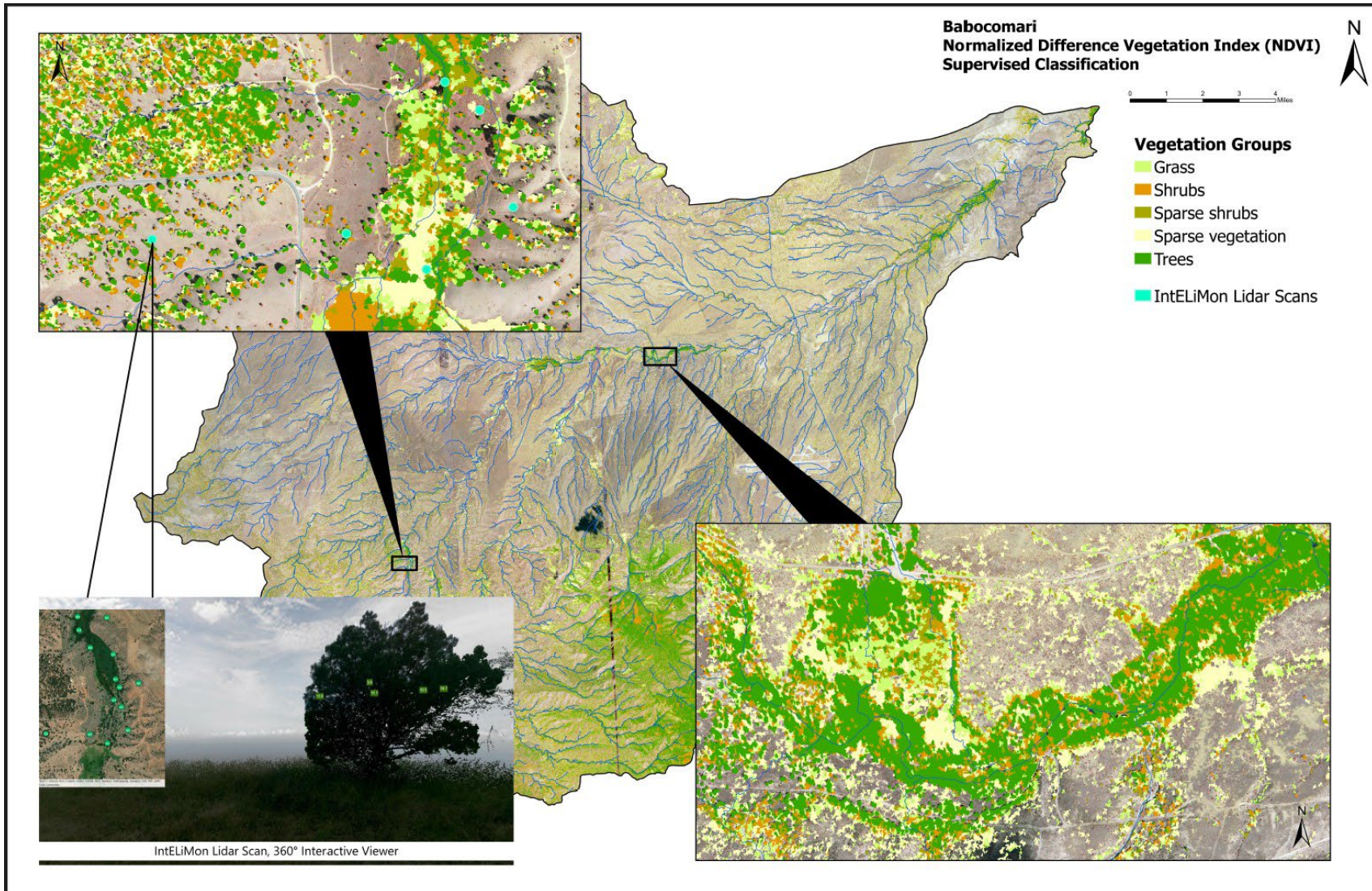


Figure 10. Vegetation Classification

4.3 Surface Water Conditions

The Babocomari Watershed is characterized primarily by ephemeral washes that flow only in response to precipitation events, particularly during the summer monsoon season when intense rainfall can lead to flash flooding. While much of the watershed is dominated by these ephemeral flow regimes, several sections of perennial surface water persist along the Babocomari River and its key tributaries, including Turkey Creek and O’Donnell Creek. These perennial reaches are sustained by discharge of shallow groundwater and provide important hydrologic and ecological functions but are limited in extent based on groundwater conditions.

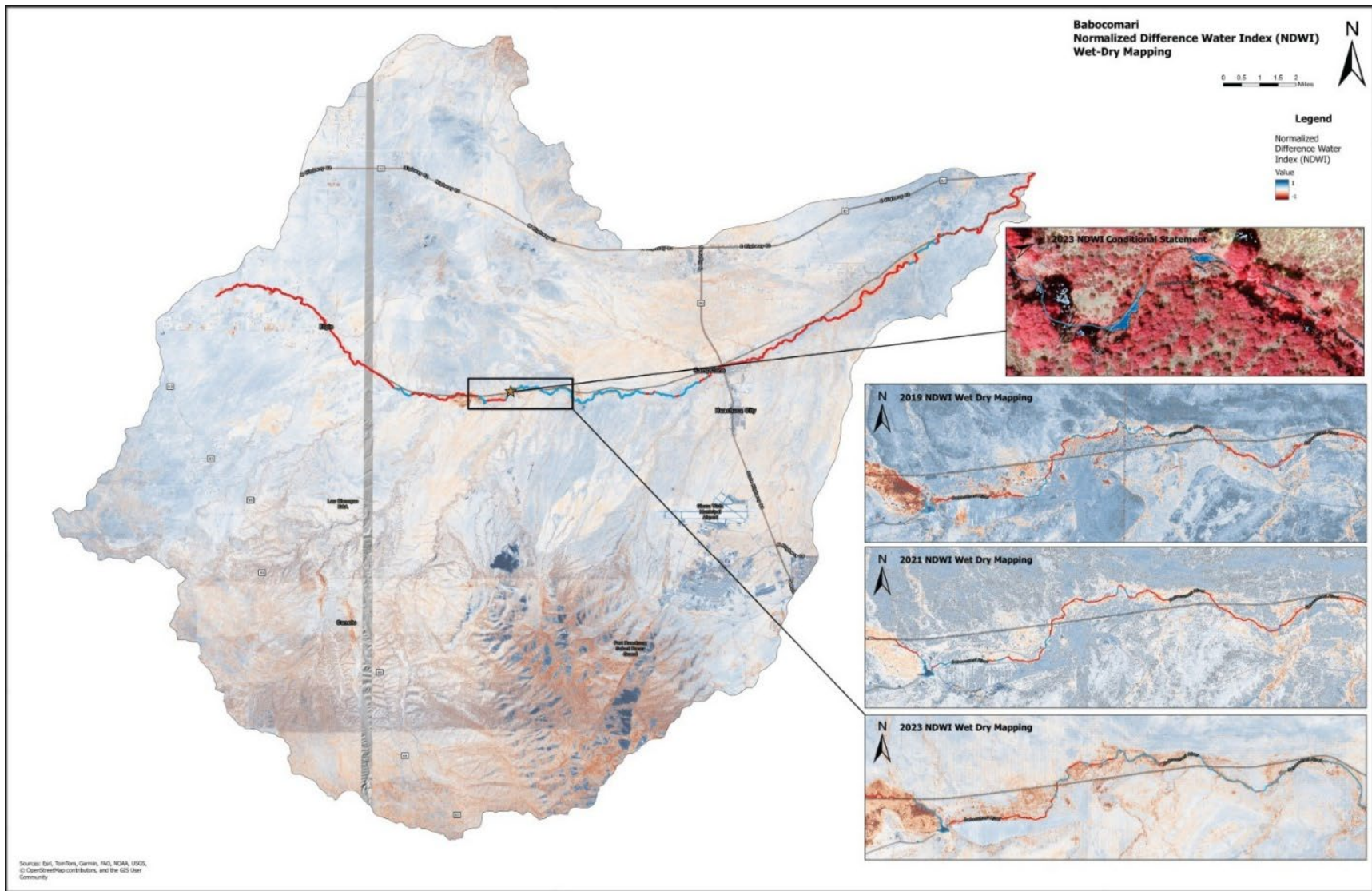
Historically, widespread overgrazing across the watershed has contributed to a reduction in surface water availability by degrading riparian and upland vegetation, compacting soils, and destabilizing streambanks (Robinett and Kennedy, 2009). These impacts have increased the vulnerability of stream channels to incision and the formation of headcuts because of surface hydrology changes, which continually degrade the watershed.

Wet and dry mapping of the Babocomari River was done using NAIP aerial imagery for 2019, 2021, and 2023 (Figure 11 and Table 3). Using different thresholds to best identify the spectral reflectance range of surface water for the 3 years, the Babocomari River was mapped as “wet,” indicating the presence of water or “dry,” indicating the absence of water. TNC wet and dry mapping results were also used to calibrate our 2019 findings, as the aerial imagery was captured in June, the same month the ground-based mapping was conducted (TNC, 2024).

Table 3. Lengths of the Babocomari River Classified as Wet or Dry

Year	Dry Length (miles)	Wet Length (miles)
2019	32.32	3.49
2021	32.59	3.22
2023	27.26	8.56

Wet and dry mapping using NAIP imagery is a tool that can be continually implemented as new imagery is collected from the national dataset. The advantage of this process is that results can be compared through time without commissioning additional data collection or field time. Wet and dry mapping with NAIP imagery could be further supplemented with repeated drone imagery and areas could be augmented where field mapping is difficult due to terrain or environmental hazards. For the Babocomari Watershed, this process was effective to track changes in surface water in perennial reaches of the Babocomari River. In this analysis, this tool highlights areas that are likely perennial based on persistent water in those reaches. These locations are likely GDEs, connected to the broader Babocomari River groundwater flow system.



(July 2019, October 2021 and October 2023)

Figure 11. Surface Water Occurrence

5 WATERSHED ZONES AND RESTORATION GOALS

The Babocomari Watershed was split into 7 watershed zones based on the analyses presented in sections 2 and 3. The watershed zones are shown on Figure 1. Each watershed is defined by its hydrologic characteristics, specifically groundwater and surface waters conditions, and the watershed condition and watershed restoration goals.

5.1 Canelo Hills

Part of the Huachuca Mountains, the Canelo Hills follows a southeast-northwest structural trend, with sandstone and shale exposures cropping out midway along Turkey and O'Donnell Creeks, north of Highway 83 (USGS, 1983). Bedrock acts as a hydrogeologic barrier, restricting lateral groundwater movement and forcing subsurface discharge to the surface, forming shallow groundwater (< 100 feet below ground surface [ft bgs]), perennial springs, and ciénegas and providing groundwater for these GDEs (Figure 5).

Residential wells in the area use shallow groundwater sources, but further downstream, depth to groundwater increases significantly within lower alluvial deposits, often exceeding 200 ft bgs. Groundwater remains deep until reaching the Babocomari River near Babacomari Ranch, where groundwater is relatively shallow. The Canelo Hills watershed zone contributes baseflow to the Babocomari River, supporting perennial springs, ciénegas, and surface water reaches that sustain riparian habitat (Stratman, 2022).

Groundwater recharge originates in the higher elevations of the western Huachuca Mountains, where fractured sandstone and shale formations facilitate mountain block recharge, while mountain front recharge occurs as surface water infiltrates unconsolidated alluvial deposits.

The higher elevations of the Canelo Hills are underlain primarily by carbonate formations that generally dip southwestward, away from the Babocomari Watershed. These structural controls likely affect groundwater movement by shifting a component of groundwater flow southwest toward the San Rafael Valley.

5.1.1 Watershed Restoration Goals

GDEs rely on both higher elevation recharge from the Huachuca Mountains and localized infiltration along alluvial deposits. Sustaining these recharge mechanisms by maintaining mountain front recharge from the Huachuca Mountains and ensuring favorable surface water conditions for infiltration along O'Donnell and Turkey Creeks can enhance aquifer sustainability and water supply to GDEs. This watershed zone contributes to Babocomari River baseflows (Stratman, 2022). Restoration efforts such as sediment stabilization and recharge-enhancing

structures will help maintain regional hydrologic conditions and support baseflow to GDEs. Further sediment transport analysis and small-scale interventions, including aggradation structures and headcut stabilization, may help reduce erosion and better support groundwater retention.

5.2 Elgin

Groundwater depths in the Elgin watershed zone vary between 150 ft bgs and 250 ft bgs with areas of shallow groundwater (less than 30 ft bgs) along the Babocomari River main stem (Figure 5). Limited higher elevation recharge areas exist within this watershed zone, with most recharge occurring locally through direct infiltration into alluvial deposits.

The Elgin watershed zone is the watershed divide between Las Cienegas, Sonoita Creek, and the Babocomari River and is predominantly composed of alluvial deposits. Active incision and erosional processes (Figure 8) in the Las Cienegas and Sonoita Creek watersheds are gradually advancing into the alluvial deposits on the watershed divide and into the Babocomari Watershed, which is experiencing comparatively less active erosion.

A buffered transition zone exists in the Elgin watershed zone of the Babocomari Watershed, where groundwater extraction could impact all 3 watersheds, and recharge efforts could provide hydrologic benefits across multiple systems.

Residential wells are widespread within alluvial deposits with some evidence of cumulative pumping effects with localized areas of relatively deeper groundwater. In areas where groundwater is shallow (less than 30 ft bgs), riparian vegetation such as cottonwoods persists, particularly along the main stem of the Babocomari River, the confluence of Hay Canyon, and Vaughn Canyon.

The watershed zone consists of predominantly unconfined alluvial valleys with confined (bedrock bound) alluvial sections. Sediment production and transport are significant, exacerbated by channel incision (Figure 8). The uppermost Babocomari River transitions in this zone from an undefined wash to a more channelized system where groundwater depths are less than 30 ft bgs. Low vegetation and disconnected floodplain conditions indicate significant incision, with numerous headcuts identified downstream of Elgin. The stretch along the railroad corridor is highly entrenched but is far along in the channel evolution process and has re-formed a meandering channel with an accessible floodplain.

5.2.1 Watershed Restoration Goals

Restoration projects aimed at enhancing recharge to the Babocomari Watershed water resources should be strategically placed downstream of the watershed capture zone to maximize retention

within the Babocomari Watershed. Near the intersection of Research Ranch Road and Vaughn Canyon, advancing headcuts and channel incision threaten infrastructure, with berms failing and gabions deteriorating. This erosion places the roadway, rural lands, and upstream bottomlands at risk. Targeted restoration efforts such as repairing failing gabion check dams could raise the channel elevation, increase surface water retention, and enhance channel-floodplain connectivity downstream of Elgin and within lower Hay and Vaughn Canyons. Addressing headcut advancement in Vaughn Canyon, and off Research Ranch Road could protect healthy bottomlands. Low-tech structures in the upper watershed, including one-rock dams (ORDs) or larger rock structures, could further stabilize sediment transport, slow surface water flow velocities, and aid channel recovery. Due to the limited recharge areas that exist within this watershed zone, groundwater conservation actions could be implemented in areas along the Babocomari River floodplain. Additionally, recharging stormwater runoff from roads and infrastructure near Elgin is another opportunity to maintain groundwater resources.

5.3 Huachuca Mountains

The Huachuca Mountains watershed zone represents the highest elevation portion of the Babocomari Watershed and is an important recharge area due to its substantial precipitation. Groundwater occurrence and movement within this sub-watershed are driven by structural geology, lithologic properties, and regional hydrologic gradients between mountainous areas and adjacent lowlands. Recharge processes are primarily governed by mountain block infiltration, where fractured meta-sedimentary, carbonate, and siliciclastic bedrock formations facilitate recharge, and mountain front recharge, where surface water runoff infiltrates unconsolidated alluvial deposits at the valley margin (Schwartzman, 1990; Hasenstab, 2025).

Numerous springs discharge from the bedrock within this sub-watershed, largely controlled by faulting, fracturing, and bedrock exposure of local perched aquifer systems (SSI, 2025). Huachuca Canyon, in the southeastern portion of the watershed, represents the largest groundwater discharge zone, supporting perennial-to intermittent flow and sustaining riparian vegetation.

The Huachuca Mountain watershed zone contains the most extensive vegetative cover within the Babocomari Watershed consisting of mixed pine forests and shrub-dominated zones that play a role in regulating infiltration and surface runoff. However, high-severity wildfires pose a major risk, as widespread vegetation loss can increase runoff, diminish infiltration, and alter recharge dynamics.

5.3.1 Watershed Restoration Goals

Strategic watershed restoration efforts, including vegetation management and targeted sediment stabilization, can enhance mountain recharge processes. Low-tech structures in upper reaches may improve shallow groundwater retention and mitigate sedimentation, while addressing incision and repairing significant headcuts can help restore connectivity between surface water and groundwater systems. Ensuring continuity of recharge, especially mountain front recharge along the Huachuca Mountains and alluvial recharge near key surface water tributaries, will be essential for maintaining long-term hydrologic resilience in the Babocomari Watershed.

5.4 Mustang

Portions of this watershed zone extend across the southern slopes of the Mustang Mountains, bordering Rain Valley. In these higher-elevation areas, groundwater depth is variable (Figure 5). Adjacent to the Mustang Mountains, alluvial deposits host groundwater at more consistent depths less than 100 ft bgs, indicating connection to the regional groundwater system.

Downgradient, groundwater depths rapidly shallow due to sub-flow contributions along the Babocomari River and dropping topography. The region is characterized by dissected fluvial landscapes and widespread ephemeral channels.

5.4.1 Watershed Restoration Goals

Restoration measures should prioritize efforts to slow flows near the Babocomari River and enhance recharge potential through strategic interventions. Like Rain Valley, the watershed zone presents a viable opportunity for watershed restoration and aquifer recharge. Targeted interventions could augment groundwater storage and contribute to the lower Babocomari Watershed zone. Strategic recharge planning in the Mustang watershed zone could mitigate localized drawdown effects along the Babocomari River and improve overall aquifer sustainability.

5.5 Lower Babocomari

The Lower Babocomari watershed zone has relatively shallow groundwater depths, generally less than 100 ft bgs along the Babocomari River (Figure 5). Alluvial deposits originating from the upper areas of the Babocomari Watershed form a wedge-shaped geometry, gradually thinning and pinching out against surficial volcanic bedrock near the confluence of the Babocomari and San Pedro Rivers (Richard *et al.*, 2007). Bedrock units crop out at this downgradient boundary and serve as structural controls on groundwater movement, marking the terminus of the Babocomari Watershed's alluvial aquifer system. This process promotes shallow

groundwater conditions, supporting extensive riparian ecosystems and sustaining perennial and intermittent reaches of the Babocomari River.

Several hydrologic stressors affect groundwater availability and sustainability. Reduced groundwater contributions from upgradient portions of the Babocomari Watershed pose a challenge to maintaining adequate groundwater levels (Kennedy and Gungle, 2010). Groundwater extraction near Sierra Vista and Fort Huachuca has formed a pronounced cone of depression. Regional sub-flow dynamics within the San Pedro River also play a role in sustaining groundwater conditions. Multiple agencies have implemented groundwater management strategies to stabilize groundwater gradients within the San Pedro River subflow area, recognizing its direct influence on groundwater availability to GDEs (CCRN, 2024).

Widespread rural development has necessitated regulatory oversight to mitigate the impacts of growth and groundwater extraction on adjacent GDEs (Cochise County, 2002). In certain areas, particularly along alluvial hillslopes, significant channel incision and headcutting reduce infiltration capacity, disrupt in-channel recharge, and impair the watershed zone's ability to recharge groundwater locally. The entrenched main channel of the Babocomari River, likely impacted by development, has undergone sufficient deposition over time, allowing a new floodplain to form with healthy riparian vegetation, as confirmed by NDVI analysis. This suggests that despite human impact, portions of the watershed zone continue to function effectively.

5.5.1 Watershed Restoration Goals

Restoration efforts could prioritize strategies that enhance groundwater recharge and promote sustainable water use. Slowing surface water movement can increase infiltration and reduce runoff losses, while enhancing recharge near riparian habitats will help sustain baseflows and groundwater-dependent ecosystems. Mitigating and sustainably managing development impacts through land-use planning and conservation measures is essential, as is implementing erosion control practices to stabilize incised channels and improve infiltration efficiency.

Floodplain protection projects aim to prevent development within the Lower Babocomari floodplain. Downstream efforts should focus on vegetation management rather than structural interventions until upstream watershed treatments are implemented. While scattered headcuts are present, none appear significant, though targeted mitigation may be warranted.

5.6 Rain Valley

Groundwater depths in Rain Valley are highly variable (Figure 5). In the northern portion of the watershed area the southern Whetstone Mountains and the highest elevations of the Mustang Mountains provide mountain front recharge. Surficial bedrock in this portion of the watershed

props up groundwater levels to less than 30 ft bgs. This area also hosts several low-yield springs. As groundwater moves downgradient, depths increase to approximately 200 to 300 ft bgs in lower portions of Rain Valley due to substantial alluvial fill. At lower elevations along the Babocomari River groundwater levels are generally less than 30 ft bgs. Groundwater development is low-moderate in this watershed zone, and groundwater use is predominately from small domestic wells.

Fluvial dissected valley types dominate the upper watershed, contributing to high sediment production and transport (Figure 8). Analyses confirms active surface erosion, with rilling, incision, and heavy sediment loads originating from the first major northern tributary, increasing downstream sedimentation. Multiple headcuts along the mainstem stream promote sedimentation and erosion and are opportunities for stabilization. Southern slopes are prevalent throughout this zone and support distinct vegetation assemblages that influence watershed hydrodynamics.

5.6.1 Watershed Restoration Goals

Strategic watershed restoration projects with a recharge emphasis could mitigate localized drawdown from rural groundwater use and support baseflow to the Babocomari River. This could be accomplished by implementing small-scale runoff control structures in upper watershed areas where groundwater is shallow near springs. Projects such as these could facilitate channel aggradation, enhance recharge through slowed flows, and maintain and/or increase spring discharge in low-yield springs. Given the results of groundwater capture mapping and other modeling work within the Upper San Pedro Watershed, targeted recharge near the perennial and intermittent reaches of the Babocomari River may help sustain baseflow (Leake *et al.*, 2008). Upland restoration projects include those that improve watershed conditions, vegetative conditions (grasslands), soil conditions (reducing erosion), protect or maintain infrastructure, and improve water quality and quantity at low-yield springs.

5.7 South Huachuca

Groundwater occurs primarily within alluvial deposits that drape over the north and eastern flanks of the Huachuca Mountains and slope downgradient toward the confluence of the Babocomari and San Pedro Rivers. These alluvial deposits form a wedge-shaped geometry, with variable depths and geometries near the mountain base and increasing in depth distally before pinching out near the San Pedro River (Richard *et al.*, 2007). In the northeastern portion near Blacktail Wash, surficial bedrock composed of siliciclastic units such as sandstone and shale promotes shallow groundwater conditions. Near Fort Huachuca and Sierra Vista, sustained high-volume extraction has formed a pronounced cone of depression with groundwater depths exceeding 300 ft bgs. Shallow groundwater is along the Babocomari River; however, near Fort Huachuca, depths increase abruptly from approximately 5 feet to over 100 ft bgs due to

pumping-induced drawdown. Huachuca Canyon supports locally shallow groundwater gradients along its length until intersecting the cone of depression capture zone. Urbanization near Fort Huachuca and Sierra Vista has significantly altered surface recharge, with widespread impervious surfaces restricting infiltration.

This watershed zone also features relatively steep, fluvial-dissected landscapes that contribute high sediment loads downgradient to the Babocomari River. Sediment supply remains high, as evidenced by the braided channel morphology, which transitions into an incised channel in North Huachuca Canyon where road confinement and urbanization limit lateral movement. Few headcuts are observed, but channel incision is widespread. The dissected landscape south of the Babocomari River, between the pond at Babacomari Ranch and Huachuca City, may provide a suitable location for small structures aimed at improving recharge and mitigating sediment transport.

5.7.1 Watershed Restoration Goals

Watershed restoration techniques in this zone could focus on stabilizing the lateral extent of the cone of depression and implementing recharge enhancement measures downstream of the drawdown zone. Strategic managed aquifer recharge between the cone of depression and the Babocomari River could increase groundwater contributions to the Babocomari River, possibly contributing baseflow. Presently, groundwater flows from the Babocomari River toward Sierra Vista, an inversion of the natural hydrologic regime toward the Babocomari River from the Huachuca Mountains.

6 PROJECT IMPLEMENTATION AND RECOMMENDATIONS

Approximately 3 dozen watershed projects were identified through stakeholder input, geospatial and remote sensing analyses, and field inspection. These projects serve as a starting point and additional project concepts are expected to be developed as opportunities emerge in the future. These projects are summarized in this section.

6.1 Potential Projects

The watershed projects are described according to the watershed zones, and classified according to project type and goals, land ownership, and project origin. Watershed restoration projects are categorized by the 6 categories listed in Table 4. Projects are also categorized by the 5 goals listed in Table 5 in terms of a primary and secondary goal, if applicable. Projects were comparatively ranked for benefits and feasibility based on available information. The expected watershed benefits for projects were identified as high, medium, and low. Project feasibility is also ranked as high, medium, and low based on landowner interest, design, engineering requirements, and expected permitting requirements. The watershed projects are listed in Table 6 and shown on Figure 12.

Table 4. Watershed Project Types

Project Type	Description
Recharge	Projects that promote groundwater recharge
Assessment	Projects that require further study to evaluate watershed conditions
Channel Restoration	Projects that enhance channel function for recharge, sediment retention, or habitat
Outreach	Projects with a goal of informing and/or working with stakeholders
Repair Infrastructure	Projects that repair or restore current infrastructure
Habitat	Projects that promote or enhance riparian or upland habitats

Table 5. Watershed Project Focus

Focus	Description
Groundwater Recharge	Projects with practices that promote shallow groundwater recharge through increased or prolonged soil moisture retention, and infiltration
Water Quality/Water Sources	Projects with practices that promote and enhance water quality, especially to groundwater dependent ecosystems
Erosion	Projects with practices that reduce erosion and transport, especially reducing anthropogenic erosion near important watershed features
GDE Habitats and Vegetation	Projects with practices that support GDEs (ciénegas, springs), and other surface water habitats; practices that support aquatic habitat
Upland Habitats and Vegetation	Projects that promote better vegetative and habitat in upland areas through vegetation management and channel restoration

Table 6. List of Potential Projects

Map ID	Benefit	Feasibility	Project Name	Description	Project Type, primary	Project Type, secondary	Focus, primary	Focus, secondary	Project Origin
BR 1	High	Medium	Babocomari Main Stem Gabion Repair	Repair existing gabion investment; raise channel bottom and facilitate groundwater recharge by encourage broad surface water flows	Repair Infrastructure	Recharge	Erosion	Groundwater Recharge	Stakeholder
BR 2	High	High	Babacomari Ranch Outreach, Communication	Coordination and outreach to find mutually beneficial ways to use water rights	Outreach	Recharge	Water Quality, Water Sources	Groundwater Recharge	Stakeholder
BR 3	High	High	Babacomari Pond Monitoring	Implement monitoring system aimed at ensuring adequate water levels in the ciénega, pond height, and seasonal outflow	Recharge	Habitat	Water Quality, Water Sources	GDE Habitats & Vegetation	Stakeholder
BR 4	High	High	Phased Projects Erosion Control Project	ALWT helping implement small channel restoration structure aimed at broad watershed restoration and sediment retention; 2500 acre project area, 11-15 channels with a total length of 12 miles	Channel Restoration	Habitat	Erosion		Stakeholder
BR 5	High	High	Channel and Watershed Restoration on Alluvial Fans North of Ft Huachuca	Alluvial drainages to the north and west of Fort Huachuca pose ideal places to implement restoration activities; promote recharge and better watershed conditions	Channel Restoration	Recharge	Upland Habitats & Vegetation	Groundwater Recharge	Stakeholder
BR 6	High	Low	Alluvial Floodplain Restoration	Good place to slow water and facilitate groundwater recharge along the mainstem of the Babocomari River	Recharge	Channel Restoration	Groundwater Recharge		Analysis
BRW 2	High	Medium	Road Drainage Improvement	Watershed wide, install erosion control in roadside drainage in areas with paved and unpaved county, and federal roads; all road sections greater than 1,000 feet in length with a slope greater than 5% should be considered	Channel Restoration	Channel Restoration	Erosion	Water Quality, Water Sources	Site Visit
CH 1	High	High	Canelo Hills Cienega Restoration and Enhancement	Small, hand-built structures could help preserve/prevent further channel incision and watershed issues adjacent to Canelo Hills Cienega	Recharge	Habitat	Erosion	Water Quality, Water Sources	Site Visit
CH 2	Medium	High	Watershed Grassland Density and Erosion Model (NRCS)	Pilot study evaluating grassland density and diversity; compare existing condition to idealized watershed condition; suggest measures to restore upland grassland health	Habitat	Outreach	GDE Habitats & Vegetation		Site Visit
CH 3	Medium	Medium	Turkey Creek Cienega	Engage with private land owner to a) restore and/or prevent channel erosion in the lower reach of Turkey Creek Cienega, b) promote adequate habitat in ciénega (open water and wetland)	Habitat	Channel Restoration	GDE Habitats & Vegetation	Water Quality, Water Sources	Analysis
CH 4	High	High	Stream Restoration, Enhancement on Upper O'Donnell Creek	Slow surface water flows along the channels; implement channel restoration structures	Recharge	Channel Restoration	Groundwater Recharge	Water Quality, Water Sources	Analysis
CH 5	High	High	Stream Restoration, Enhancement on Upper Turkey Creek	Slow surface water flows along the channels; implement channel restoration structures	Recharge	Channel Restoration	Groundwater Recharge	Water Quality/Water Sources	Analysis
CH 6	High	High	Stream Restoration, Enhancement on Upper Lyle Canyon	Slow surface water flows along the channels; implement channel restoration structures	Recharge	Channel Restoration	Groundwater Recharge	Water Quality, Water Sources	Analysis
CH 7	Medium	High	Enhance Fish Barrier on O'Donnell Creek	In collaboration with BLM and Borderlands Restoration Network, we aim to use low-impact erosion control methods to increase the longevity of an existing fish barrier on O'Donnell Creek; enhance with channel restoration work upstream of the barrier and downstream if needed	Habitat	Channel Restoration	GDE Habitats & Vegetation	Erosion	Stakeholder
CH 8	High	High	Sacaton Grassland Restoration	ALWT conservation easement with large sacaton grassland and surrounding channels that are eroding, incision beginning in sacaton bottom	Channel Restoration	Habitat	Erosion	GDE Habitats & Vegetation	Stakeholder
E 1	High	Medium	Middle Vaughn Headcut Mitigation and Channel Restoration	Install rock structures to repair headcuts, prevent further channel incision, raise channel, improve floodplain connection, and reduce erosion	Channel Restoration	Recharge	Erosion		Stakeholder
E 2	High	Medium	Lower Vaughn Canyon Headcut Complex	Direct surface water flow to a selection of hardened locations (large, engineered rock rundowns for example) to arrest headcuts	Channel Restoration	Recharge	Erosion		Stakeholder
E 3	High	Medium	Lower Vaughn Canyon Gabions	Repair and restore existing gabion investment; protect against future headcutting and upstream channel degradation	Repair Infrastructure	Recharge	Erosion		Stakeholder

Map ID	Benefit	Feasibility	Project Name	Description	Project Type, primary	Project Type, secondary	Focus, primary	Focus, secondary	Project Origin
E 4	High	Medium	Vaughn Canyon Watershed Restoration	Restore channel and adjacent degraded watershed from its headwaters to the Babocomari River; potential to restore and enhance existing feature restoration work	Channel Restoration	Recharge	Erosion	Upland Habitats & Vegetation	Site Visit
E 5	High	Medium	Elgin Stormwater Management	Suggest stormwater practices via an easy to digest memo; difficult to disseminate given the rural population; helpful for ensuring infiltration of stormwater in developed areas	Outreach	Recharge	Water Quality, Water Sources	Groundwater Recharge	Analysis
E 6	Medium	Low	Elgin Road Maintenance	At 2 locations along U.S. 83, road runoff and a lower water crossing have propagated downstream channel instability and headcutting; proposed engineered solutions to restore these areas	Repair Infrastructure	Channel Restoration	Erosion	Upland Habitats & Vegetation	Site Visit
E 7	Medium	Medium	Elgin Plug and Spread	Fix incision and failed earthen berm tanks in a shallow valley in the Elgin area; install plug and spread structures to induce meandering and spread surface water flow	Recharge	Habitat	Erosion	Groundwater Recharge	Site Visit
E 8	High	Low	Groundwater Conservation in Floodplain Connected to Babocomari River	Expand on Leake <i>et al.</i> recharge capture modeling to incorporate the Babocomari Watershed; suggest sustainable groundwater management in important areas; check in with Santa Cruz County Floodplain manager on priorities and goals; concerns about future development in these parcels	Recharge	Outreach	Groundwater Recharge	Water Quality, Water Sources	Stakeholder
E 9	Low	Low	Conservation Easement Erosion Control	Several eroding channels requiring attention in this area, ALWT leading this initiative	Channel Restoration	Habitat	Erosion	GDE Habitats & Vegetation	Stakeholder
HM 1	Medium	Low	Huachuca Canyon Channal and Riparian Area Restoration and Enhancement	Assess Huachuca Canyon for areas beneficial for channel and vegetation restoration enhancement; focus on techniques that promote aquatic habitats	Channel Restoration	Recharge	GDE Habitats and Vegetation	Water Quality, Water Sources	Analysis
LB 1	High	High	Hand Crew Restoration on Ephemeral Channels in SPRNCA/BLM	NEPA on SPRNCA land to work on low-tech structures. Identify problem areas and then evaluate watershed size for implementation of rock structures	Channel Restoration	Recharge	GDE Habitats and Vegetation	Groundwater Recharge	Stakeholder
LB 2	High	High	Hand Crew Restoration on Ephemeral Channels Adjacent and Upstream to SPRNCA	Work with stakeholders to implement channel restoration and enhancement in areas adjacent to SPRNCA along the Babocomari River; promote slower flows and infiltration	Channel Restoration	Recharge	Groundwater Recharge	Erosion	Analysis
LB 3	Low	Low	Roadway Crossing	Sanders/Bowers crosses pretty riparian vegetation and a flowing reach of Babocomari River; is there a possibility for an alternative road crossing here? Broadly, consider other areas in the watershed where this is occurring.	Habitat	Channel Restoration	Erosion	GDE Habitats & Vegetation	Stakeholder
LB 4	Low	Low	Preclude Pumping Between CCRN and SPRNCA	Wetted length is in decline. Funding may be available to acquire land, preclude future development especially within the floodplain	Outreach	Recharge	Water Quality, Water Sources	Groundwater Recharge	Stakeholder
M 1	Medium	High	Mustang Watershed Zone Channel Restoration	Complete installations of hand channel and watershed restoration structures in ephemeral channels to the north of the Babocomari River	Channel Restoration	Recharge	Water Quality, Water Sources	Groundwater Recharge	Stakeholder
RV 1	High	Medium	Rain Valley Gravel Pit Recharge	Repurpose gravel pit at lower end of Rain Valley just south of Highway 82; possible channel diversion to move surface water into gravel pit to increase infiltration	Recharge	Habitat	Groundwater Recharge	Water Quality, Water Sources	Site Visit
RV 2	High	Medium	Rain Valley Main Stem Channel Restoration	Rock structures to prevent further headcutting; promote groundwater recharge through increased infiltration	Channel Restoration	Recharge	Erosion	Groundwater Recharge	Analysis
RV 4	Low	Low	Reduce Impact of Flooding on Rain Valley	Flooding has caused incision of the floodway and mitigation here could prevent further degradation of channel and floodplain	Channel Restoration	Recharge	Erosion	Groundwater Recharge	Stakeholder
SH 1	High	Medium	Huachuca City Stormwater Management	Suggest stormwater practices via an easy to digest memo; difficult to disseminate given the rural population; helpful for ensuring infiltration of stormwater in developed areas	Outreach	Recharge	Groundwater Recharge	Water Quality, Water Sources	Analysis
SH 3	High	Low	Effluent Recharge Siting Analysis	Conduct study of effluent from Ft. Huachuca and Huachuca City; site locations for recharge within Soldier Creek	Recharge	Habitat	Water Quality, Water Sources	Groundwater Recharge	Stakeholder

Map ID	Benefit	Feasibility	Project Name	Description	Project Type, primary	Project Type, secondary	Focus, primary	Focus, secondary	Project Origin
SH 4	Medium	High	Restoration and Erosion Control	Grazing lease - restoration project and erosion control; 2 Phases of LTPBR covering the length of 1 upland channel already complete. 3rd phase planned for another channel	Channel Restoration	Habitat	Erosion	Upland Habitats & Vegetation	Stakeholder

Map ID refers to numbered projects in watershed zones shown on Figure 12: BR: Babocomari River Mainstem, CH: Canelo Hills, E: Elgin, HM: Huachuca Mountains, LB: Lower Babocomari, M: Mustang, RV: Rain Valley, SH: South Huachuca

SPRNCA = San Pedro Riparian National Conservation Area

NEPA = National Environmental Policy Act

LTPBR = low-tech process-based restoration

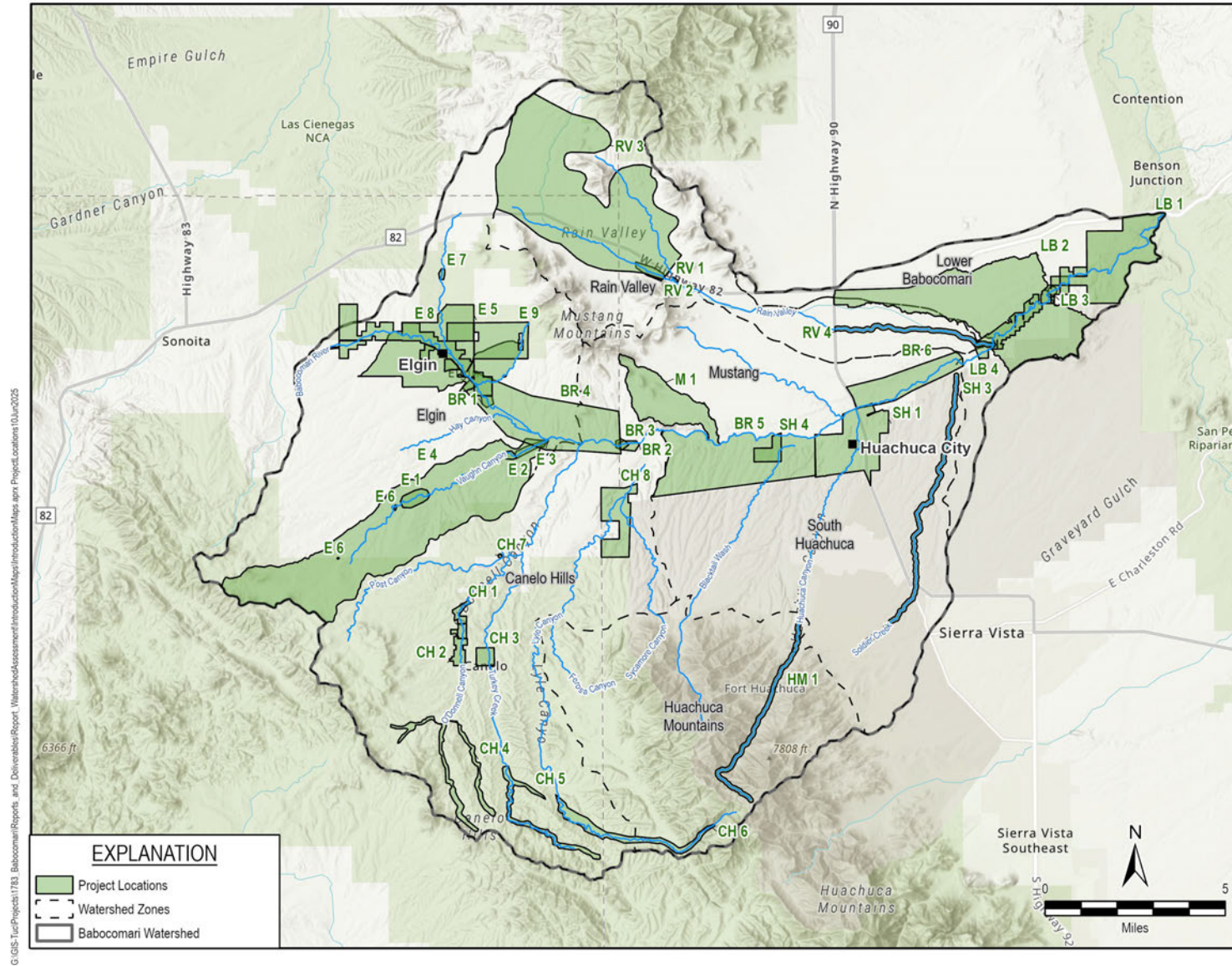


Figure 12. Locations of Potential Projects

6.2 Implementation

The projects have been categorized by priority and feasibility. Implementing projects requires consideration of permitting, cost, and landowner willingness – factors that contribute the qualitative ranking of feasibility (Table 6). A summary of general permitting considerations and potential funding sources are provided below as a guide. Each project needs to be evaluated individually based on current information.

6.2.1 Permitting Considerations

Federal, state, and local permitting considerations for watershed projects are listed in Table 7. This is not a comprehensive list, and individual projects must be evaluated for the specific permitting requirements.

Table 7. Permitting Considerations

Permit or Landowner	Considerations
FEMA Regulated Floodway	No-Rise Certification required
	Project can't increase flood height demonstrated through modeling
	Work with Community Floodplain Manager (County or City)
404 Permit (U. S. Army Corps of Engineers) *	Perennial or Intermittent Stream – 404 permit required to work in Waters of the U.S.
	Ephemeral Stream - no 404 Permit required, but landowner and/or FEMA requirements may apply
Federal Lands	Requires NEPA permit
	Work through a Federal Agency
State Land	Work with State Land Department
	Defers floodplain management to Community Floodplain Manager
Private Property	Community Flood Ordinances / County** Floodplain Use Permit
	May require Grading Permit

* 404 permit considerations are based on current understanding in 2025

** Santa Cruz County is in the S-SW portion of the watershed, Pima County is in a small north-west portion of the Watershed, and Cochise County occupies the entire watershed west of the Babacomari Ranch. *Permitting will vary by county*

6.2.2 Potential Funding Sources

Potential funding sources include state and federal agencies as well as private or nonprofit organizations. Some of these sources are listed below. This is not a comprehensive list, and individual projects should be evaluated for applicability to currently available funding sources.

6.2.2.1 State Funding Sources

- [ADEQ 604\(b\) Water Quality Grant Program](#) provides funding to regional planning organizations for regional water quality management planning activities. Project proposals must be focused on water quality management planning, not implementation.
- [Arizona Water Protection Fund](#) supports projects that develop or implement on-the-ground measures that directly maintain, enhance, and restore Arizona's river and riparian resources.

6.2.2.2 Federal Funding Sources

- [USFWS Partners for Fish and Wildlife Program](#) provides free technical and financial assistance to landowners, managers, tribes, corporations, schools and nonprofits interested in improving wildlife habitat on their land.
- [Clean Water Act Section 319 Grants administered through ADEQ Nonpoint Source Program](#) targets pollution from stormwater runoff due to roads, urbanization, over-grazing and other land management practices.
- [NRCS Environmental Quality Incentives Program \(EQIP\)](#) funds projects in agricultural areas to improve water and air quality, conserve ground and surface water, soil health and reduce soil erosion and sedimentation, improve or create wildlife habitat, and mitigate against drought and increasing weather volatility.
- [U.S. Department of the Interior WaterSMART Program](#) through the U.S. Bureau of Reclamation (Reclamation) funds a variety of projects and initiatives to increase water supply reliability through investments in existing infrastructure and planning.
- [USFWS Neotropical Migratory Bird Conservation Act Grants](#) support projects for climate resilience that leverage partnerships and support land conservation and biodiversity efforts.
- [The Environmental Protection Agency solicits applications](#) to provide training and technical assistance to rural, small, and Tribal municipalities, publicly owned wastewater treatment works, and decentralized wastewater treatment systems for the prevention, reduction, and elimination of pollutions. Each application must address only 1 of the following 4 priorities: (1) acquisition of finance/funding; (2) protect water quality and compliance assistance; (3) training and technical assistance focused specifically on Tribes; and (4) decentralized systems.
- [The Small Surface and Groundwater Storage Program](#) (Small Storage Program) administered through the U.S. Bureau of Reclamation promotes Federal assistance to

enhance water storage opportunities in support of stakeholder efforts to stretch scarce water supplies and avoid conflicts over water.

- Delivered through the Fish and Aquatic Conservation Program (FAC), [the National Fish Passage Program](#) (NFPP) provides direct technical and financial assistance to remove instream barriers and restore aquatic organism passage and aquatic connectivity. Activities proposed under this award may include project planning and feasibility studies, permitting, near-term implementation monitoring, and project outreach. Applicants must contact the appropriate [NFPP Regional Coordinator](#) to determine eligibility.
- The U.S. Fish & Wildlife Service’s [Habitat Conservation Plan Land Acquisition Grant Program F25AS00035](#) is authorized through the Cooperative Endangered Species Conservation Fund and funded through the Land and Water Conservation Fund. The program aims to reduce conflicts between the conservation of listed species and competing land uses on specific parcels of land through fee simple acquisition or permanent conservation easements.
- The U.S. Fish & Wildlife Service’s [Habitat Conservation Plan Land Acquisition Grant F25AS00034](#), funded through the Cooperative Endangered Species Conservation Fund, promotes state and federal cooperation to acquire specific parcels of land in support of recovery plans for every listed species.
- [The Agriculture Conservation Experienced Services \(ACES\) Program](#) enlists experienced Natural Resources Conservation Service workers age 55 and older to provide technical services that support conservation-related programs.
- [AmeriCorps State and National Competitive Grants](#) award organizations that engage AmeriCorps members in evidence-based or evidence-informed interventions to strengthen communities.
- The Environmental Protection Agency’s [Farmer to Farmer](#) 2024 BIL funding opportunity aims to enhance water quality, habitat, and environmental education within the Gulf of Mexico watershed. The grant program will support innovative farming practices with a focus on collaboration and outreach, including habitat restoration.
- Funded by the National Science Foundation, the [Environmental Sustainability](#) program’s goal is to promote sustainable engineered systems that support human well-being and that are also compatible with sustaining natural environmental systems.

- [IRA Vegetation & Watershed Management](#) provides funds through the United States Forest Service (NFS) for projects on NFS land in accordance with a water source management plan or a watershed protection and restoration plan (WRAP).
- The U.S. Fish and Wildlife Service’s (USFWS) [Partners for Fish and Wildlife Program](#) provides technical and financial assistance to a variety of partners including private landowners, Tribes, nonprofits, corporations, and schools. The goal of this program is to improve wildlife habitat by helping to plan, design, supervise, and monitor customized habitat restoration projects. Focused areas of concern include upland forests, wetlands, native prairies, marshes, rivers, and streams.
- [The Watershed and Flood Prevention Operations \(WFPO\) Program](#)—funded through the U.S. Department of Agriculture’s Natural Resources Conservation Service (NRCS)—helps units of federal, state, local, and federally recognized tribal governments protect and restore watersheds. Project criteria include public sponsorship, watershed projects of less than 250,000 acres, and agricultural benefits must be more than 20% of the total benefits for the project.
- The U.S. Department of Agriculture’s Natural Resources Conservation Service’s (NRCS) [Conservation Stewardship Program](#) offers annual payments and helps customize a plan to improve existing conservation efforts while strengthening agricultural operations. Available practices and practice standards vary by state.
- The National Science Foundation’s (NSF) [Environmental Sustainability Program](#) supports engineering research that seeks to balance ecological protection while maintaining stable economic conditions.

6.2.2.3 Other Funding Sources

- Private foundations and conservation organizations
- Carbon offset programs for mesquite removal and grassland restoration
- Water utility conservation programs

6.2.3 Approach to Further Assessment

The data products from this watershed scale analysis that were used to develop the project list are the building blocks of the Babocomari Watershed Assessment. Many of those datasets were used to identify project or future research and are starting points for further assessment. In a future phase of work, some of those datasets can be combined or built upon for further analysis and project development. Some considerations for how these building blocks can be applied are described in this section.

6.2.3.1 Depth to Water

Areas with shallow groundwater often support ecosystems that are reliant on that persistently available water. Sustaining water levels in these areas by slowing flow and encouraging groundwater recharge can support goals of habitat and species management, hydrologic function, and water management and source water protection. The depth to groundwater dataset can be used to identify those areas of shallow groundwater and local groundwater level data can be collected to monitor the presence, absence, and changes in shallow groundwater in those areas.

6.2.3.2 Headcuts

Headcuts identified through the GIS model signal land and/or channel degradation. Some of these sites were verified using imagery or site visits, however further verification of large headcuts and clusters of headcuts will provide more insight about the location, scale, and potential causes. Restoration projects in these areas would accomplish goals of hydrologic function and habitat and species management. Individual headcuts and clusters of headcuts can be used to site channel restoration projects, restoration and improved management of upland areas, or infrastructure repair.

6.2.3.3 Ciénegas

Long-term monitoring and increased research on ciénega function and dependencies can improve overall understanding of their importance within the watershed and southeastern Arizona. Additionally, increasing groundwater recharge and maintenance of hydrologic function upstream of ciénegas should be prioritized to ensure their persistence. Locations of ciénegas along with depth to groundwater and channel types can be used to site projects upstream.

6.2.3.4 Road Runoff

Several areas within the watershed contain paved roads with extended non-horizontal grades, leading to increased erosion, subsequent sediment displacement, and headcut formation in adjacent channels. To assess and mitigate these impacts, an analysis is recommended to identify high-risk locations. The proposed methodology would involve:

- Identifying road segments with steep grades
- Evaluating adjacent watershed conditions, noting signs of erosion, vegetation loss, and incision
- Prioritizing sites where erosion has compromised hydrologic function, signaling the need for restoration and improved management strategies

This analysis will help pinpoint key intervention areas, supporting targeted erosion control, and watershed restoration efforts.

6.2.3.5 Existing Infrastructure

Throughout the watershed there are many structures that serve to detain water and trap sediment such as large gabions check dams. These structures should be monitored and maintained as their failure could lead to channel degradation and loss of productive landscapes.

6.2.3.6 Channel Function and Groundwater Condition Overlay Analysis

Identify locations where headcuts are clustered or higher magnitude headcuts coincide with shallow groundwater (0 to 50 ft bls). Slowing flow at these locations through channel restoration and headcut repairs will arrest headcut development and channel degradation while increasing infiltration and recharge of shallow groundwater. Slowing of surface flows and increasing infiltration will provide more water for ecosystems reliant on shallow groundwater, springs, ciénegas, and perennial streams.

6.3 Recommended Additional Watershed Assessments

This high-level overview of the watershed resulted in identifying specific projects that could be implemented. In addition, several watershed-wide assessments were identified that would provide a deeper understanding of the watershed, the interaction between groundwater and riparian ecosystems, and that have potential to guide future projects. These recommendations for additional watershed assessments are listed in Table 8.

Table 8. Recommended Additional Watershed Assessments

Project Name	Description	Benefit	Feasibility	Goals
Groundwater Budget	Prepare a groundwater budget with recharge, evapotranspiration, and pumping	High	High	Groundwater Recharge
Vegetation Health vs Groundwater Conditions	Evaluate groundwater levels and cottonwood/riparian vegetation recruitment as it relates to channel condition	Medium	Medium	GDE Habitats and Vegetation
Watershed Wide Ciénega Assessment	Compare Babacomari, Turkey Creek, and Canelo Hills ciénegas to understand ciénega health, especially saturated area and cottonwood density	Medium	Medium	GDE Habitats and Vegetation
Watershed Wide Springs Assessment	Review springs and habitat surrounding springs; explore connection to ciénegas	Medium	Medium	GDE Habitats and Vegetation
Invasive Species Management	Evaluate invasive plant encroachment throughout Babocomari Watershed adversely affecting native vegetation	Low	Low	GDE Habitats and Vegetation, Upland Habits and Vegetation

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ACRONYMS & ABBREVIATIONS

ADEQArizona Department of Environmental Quality
ADWR	.....Arizona Department of Water Resources
amsl	.....above mean sea level
bgs	.....below ground surface
BLM	.....U.S. Bureau of Land Management
DEM	.....digital elevation model
ET	.....evapotranspiration
ft/bgs	.....feet below ground surface
GDEs	.....groundwater dependent ecosystems
GIS	.....geographic information systems
GWSI	.....groundwater site inventory
HUC	.....Hydrologic Unit Code
LTPBR	.....low-tech process-based restoration
M&A	.....Montgomery & Associates
NAIP	.....National Agriculture Imagery Program
NCDE	.....Natural Channel Design Engineering
NDVI	.....normalized difference vegetation index
NEPA	.....National Environmental Policy Act
ORD	.....one-rock dam
PRISM	.....Parameter-elevation Regressions on Independent Slopes Modl
SPRNCA	.....San Pedro Riparian National Conservation Area
TNC	.....The Nature Conservancy
USDA	.....U.S. Department of Agriculture
USFS	.....U.S. Forestry Service
USFWS	.....U.S. Fish and Wildlife Service
USGS	.....U.S. Geological Survey
WBD	.....Watershed Boundary Dataset



Since 1978

7.31.25

Arizona Water Protection Fund
1802 W Jackson St. Box #79
Phoenix, AZ 85007

Re: Support for proposal "Enhancing rangeland and riparian health along the Babocomari River"

Dear Mr. Teran and the Arizona Water Protection Fund Commissioners,

I am writing on behalf of Arizona Land and Water Trust (ALWT) to convey our support for Arizona Department of Environmental Quality's grant proposal to the Arizona Water Protection Fund titled "Enhancing rangeland and riparian health along the Babocomari River". Our organization holds the conservation easements for two of the parcels, Emmerson Ranch and the Pyeatt Ranch, where restoration activities are proposed.

ALWT has been preserving Southern Arizona's western landscapes, farms and ranches, wildlife habitat and the waters that sustain them since 1978. To date we have helped to conserve over 70,000 acres of high conservation value lands in Southern Arizona. The Trust also has a proven track record of going beyond just conserving these farms and ranches to planning, administering, and completing projects which restore and protect these critical habitats.

ALWT will be an active partner in this restoration effort, steward the conservation easements, and facilitate access to the restoration project team. ALWT is committed to the long-term health of the rangeland and creeks which drain to the Babocomari River. ALWT has completed two upland restoration projects in adjacent drainages. Projects investments surpassed \$250,000 and were funded by the United States Forest Service and the Department of Defense.

These projects successfully addressed severe erosion concerns that were threatening forage production and ranch infrastructure and were reducing water quality and riparian health. Funding received from the Arizona Water Protection Fund will enable an expansion of restoration treatments along several eroded drainages currently impacting the water quality and riparian health of the Babocomari. Additionally, on-the-ground restoration actions as proposed will help to grow local appreciation for the benefits of healthy and working rural landscapes and riparian areas, as well as support the steady growth in the local Arizona restoration practitioner workforce.

Sincerely,

A handwritten signature in black ink, appearing to read "Andrew Quarles", written in a cursive style.

Andrew Quarles
Stewardship Manager
aquarles@alwt.org
(520) 577-8564 x102

President
Diana Freshwater

Vice President
Ben Brophy

Secretary
George Ruyle

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Charlotte Hanson
Pat Lopez, III
Rob Marshall
Amber Morin
Nanette Pageau
Karen Riggs
Peggy Rowley
Bill Shaw

Executive Director
Cameron Becker

Babocomari Ranch Company LLLP
July 31st, 2025

Arizona Water Protection Fund
1802 W Jackson St. Box #79
Phoenix, AZ 85007

Re: Support for proposal "Enhancing rangeland and riparian health along the Babocomari River"

To Mr. Teran and Arizona Water Protection Fund Commissioners,

I am writing on behalf of the Babocomari Ranch to convey our support for Arizona Department of Environmental Quality's (ADEQ) grant proposal to the Arizona Water Protection Fund titled "Enhancing rangeland and riparian health along the Babocomari River". The Babocomari Ranch is an active cattle ranch with lands encompassing and including much of the upper Babocomari River and has a proven record of supporting conservation efforts.

The Babocomari Ranch will coordinate and provide access to the restoration project team for the proposed project area for the duration of the project. Funding received from the Arizona Water Protection Fund will enable restoration treatments along our downstream section of the Babocomari River which flows seasonally.

As a long-time working ranch, we are committed to the health of our rangelands and riparian areas and continues to work with a range of partners to help in restoring rangeland and river health.

Sincerely,

A handwritten signature in black ink, appearing to read "Ben Brophy", written in a cursive style.

Ben Brophy



July 30, 2025

Re: Support for proposal "Enhancing rangeland and riparian health along the Babocomari River"

To Whom It May Concern,

I am the landowner of private land, under a conservation easement with Arizona Land and Water Trust, and associated State Trust Land grazing lease along the Babocomari River. I am writing to convey my support for Arizona Department of Environmental Quality's (ADEQ) grant proposal to the Arizona Water Protection Fund titled "Enhancing rangeland and riparian health along the Babocomari River".

I will provide access to the restoration project team in coordination with Arizona Land and Water Trust for the proposed project area for the duration of the project. Funding received from the Arizona Water Protection Fund will enable restoration treatments along upland drainages which pass through my parcels and drain into the Babocomari River where it flows seasonally.

As our lands have been historically grazed and continue to be grazed, we are committed to the health of our rangelands and riparian areas and continues to work with a range of partners to help in restoring rangeland and river health.

Sincerely,

Chase Emmerson

A handwritten signature in blue ink, appearing to be 'Chase', followed by a long horizontal line extending to the right.

Pyeatt Ranch
July 31st, 2025

Arizona Water Protection Fund
1802 W Jackson St. Box #79
Phoenix, AZ 85007

Re: Support for proposal "Enhancing rangeland and riparian health along the Babocomari River"

Dear Mr. Teran and Arizona Water Protection Fund Commissioners,

I am the landowner of the Pyeatt Ranch which is protected through a conservation easement with Arizona Land and Water Trust (ALWT). The Pyeatt Ranch spans several large drainages which feed into the Babocomari River. We have worked with ALWT on one restoration project addressing severe erosion near critical ranch infrastructure and a second phase is planned to begin soon. The success I have seen from this project is why I am excited to convey my support for Arizona Department of Environmental Quality's grant proposal to the Arizona Water Protection Fund titled "Enhancing rangeland and riparian health along the Babocomari River".

I will provide access to the restoration project team in coordination with Arizona Land and Water Trust for the proposed project area for the duration of the project. Funding received from the Arizona Water Protection Fund will enable restoration treatments along upland drainages which pass through my parcels and drain into the Babocomari River where it flows seasonally. These restoration activities will support and improve rangeland health and benefit my ranching operation.

As our lands have been historically grazed and continue to be grazed, we are committed to the health of our rangelands and riparian areas and continues to work with a range of partners to help in restoring rangeland and river health.

Sincerely,



Manuel Murrieta
Pyeatt Ranch LLC, Owner

Walking S Ranch & Livestock

Sidney & Kathleen Kahla

46 Upper Elgin Road, Elgin, Arizona 85611

Re: Support for proposal "Enhancing rangeland and riparian health along the Babocomari River"

To Whom It May Concern,

I, Sid Kahla, am a grazing lessee which includes leased lands of the Emerson parcel and the Arizona State Land Department (AZSLD) Trust lands immediately adjacent to the Emerson parcel and the Babocomari River. I am writing to convey our support for the grant proposal to the Arizona Water Protection Fund titled "Enhancing rangeland and riparian health along the Babocomari River".

If funds are awarded, I as a grazing lessee to the AZSLD, will assist the project team in submitting the proposed restoration treatment plan for the necessary AZSLD permit. My lease is 005-000912-00

As a long-time rancher, we are committed to the health of our rangelands and riparian areas. Funding received from the Arizona Water Protection Fund to implement on-the-ground restoration treatments will benefit the continuation of our livelihood for the next generation and will help to grow local appreciation for the benefits of healthy and working rural landscapes and riparian areas.

Sincerely,

Sidney Kahla



Since 1978

7.31.25

Arizona Water Protection Fund
1802 W Jackson St. Box #79
Phoenix, AZ 85007

Re: Support for proposal "Enhancing rangeland and riparian health along the Babocomari River"

Dear Mr. Teran and the Arizona Water Protection Fund Commissioners,

I am writing on behalf of Arizona Land and Water Trust (ALWT) to convey our support for Arizona Department of Environmental Quality's grant proposal to the Arizona Water Protection Fund titled "Enhancing rangeland and riparian health along the Babocomari River". Our organization holds the conservation easements for two of the parcels, Emmerson Ranch and the Pyeatt Ranch, where restoration activities are proposed.

ALWT has been preserving Southern Arizona's western landscapes, farms and ranches, wildlife habitat and the waters that sustain them since 1978. To date we have helped to conserve over 70,000 acres of high conservation value lands in Southern Arizona. The Trust also has a proven track record of going beyond just conserving these farms and ranches to planning, administering, and completing projects which restore and protect these critical habitats.

ALWT will be an active partner in this restoration effort, steward the conservation easements, and facilitate access to the restoration project team. ALWT is committed to the long-term health of the rangeland and creeks which drain to the Babocomari River. ALWT has completed two upland restoration projects in adjacent drainages. Projects investments surpassed \$250,000 and were funded by the United States Forest Service and the Department of Defense.

These projects successfully addressed severe erosion concerns that were threatening forage production and ranch infrastructure and were reducing water quality and riparian health. Funding received from the Arizona Water Protection Fund will enable an expansion of restoration treatments along several eroded drainages currently impacting the water quality and riparian health of the Babocomari. Additionally, on-the-ground restoration actions as proposed will help to grow local appreciation for the benefits of healthy and working rural landscapes and riparian areas, as well as support the steady growth in the local Arizona restoration practitioner workforce.

Sincerely,

A handwritten signature in black ink, appearing to read "Andrew Quarles".

Andrew Quarles
Stewardship Manager
aquarles@alwt.org
(520) 577-8564 x102

President
Diana Freshwater

Vice President
Ben Brophy

Secretary
George Ruyle

Treasurer
Clint Mabie

Laura Brown
Les Corey
Nicole Fyffe
Charlotte Hanson
Pat Lopez, III
Rob Marshall
Amber Morin
Nanette Pageau
Karen Riggs
Peggy Rowley
Bill Shaw

Executive Director
Cameron Becker

Babocomari Ranch Company LLLP
July 31st, 2025

Arizona Water Protection Fund
1802 W Jackson St. Box #79
Phoenix, AZ 85007

Re: Support for proposal "Enhancing rangeland and riparian health along the Babocomari River"

To Mr. Teran and Arizona Water Protection Fund Commissioners,

I am writing on behalf of the Babocomari Ranch to convey our support for Arizona Department of Environmental Quality's (ADEQ) grant proposal to the Arizona Water Protection Fund titled "Enhancing rangeland and riparian health along the Babocomari River". The Babocomari Ranch is an active cattle ranch with lands encompassing and including much of the upper Babocomari River and has a proven record of supporting conservation efforts.

The Babocomari Ranch will coordinate and provide access to the restoration project team for the proposed project area for the duration of the project. Funding received from the Arizona Water Protection Fund will enable restoration treatments along our downstream section of the Babocomari River which flows seasonally.

As a long-time working ranch, we are committed to the health of our rangelands and riparian areas and continues to work with a range of partners to help in restoring rangeland and river health.

Sincerely,

A handwritten signature in black ink, appearing to read "Ben Brophy", written in a cursive style.

Ben Brophy



July 30, 2025

Re: Support for proposal "Enhancing rangeland and riparian health along the Babocomari River"

To Whom It May Concern,

I am the landowner of private land, under a conservation easement with Arizona Land and Water Trust, and associated State Trust Land grazing lease along the Babocomari River. I am writing to convey my support for Arizona Department of Environmental Quality's (ADEQ) grant proposal to the Arizona Water Protection Fund titled "Enhancing rangeland and riparian health along the Babocomari River".

I will provide access to the restoration project team in coordination with Arizona Land and Water Trust for the proposed project area for the duration of the project. Funding received from the Arizona Water Protection Fund will enable restoration treatments along upland drainages which pass through my parcels and drain into the Babocomari River where it flows seasonally.

As our lands have been historically grazed and continue to be grazed, we are committed to the health of our rangelands and riparian areas and continues to work with a range of partners to help in restoring rangeland and river health.

Sincerely,

Chase Emmerson

A handwritten signature in blue ink, appearing to be 'Chase', followed by a long horizontal line extending to the right.

Pyeatt Ranch
July 31st, 2025

Arizona Water Protection Fund
1802 W Jackson St. Box #79
Phoenix, AZ 85007

Re: Support for proposal "Enhancing rangeland and riparian health along the Babocomari River"

Dear Mr. Teran and Arizona Water Protection Fund Commissioners,

I am the landowner of the Pyeatt Ranch which is protected through a conservation easement with Arizona Land and Water Trust (ALWT). The Pyeatt Ranch spans several large drainages which feed into the Babocomari River. We have worked with ALWT on one restoration project addressing severe erosion near critical ranch infrastructure and a second phase is planned to begin soon. The success I have seen from this project is why I am excited to convey my support for Arizona Department of Environmental Quality's grant proposal to the Arizona Water Protection Fund titled "Enhancing rangeland and riparian health along the Babocomari River".

I will provide access to the restoration project team in coordination with Arizona Land and Water Trust for the proposed project area for the duration of the project. Funding received from the Arizona Water Protection Fund will enable restoration treatments along upland drainages which pass through my parcels and drain into the Babocomari River where it flows seasonally. These restoration activities will support and improve rangeland health and benefit my ranching operation.

As our lands have been historically grazed and continue to be grazed, we are committed to the health of our rangelands and riparian areas and continues to work with a range of partners to help in restoring rangeland and river health.

Sincerely,



Manuel Murrieta
Pyeatt Ranch LLC, Owner

Walking S Ranch & Livestock

Sidney & Kathleen Kahla

46 Upper Elgin Road, Elgin, Arizona 85611

Re: Support for proposal "Enhancing rangeland and riparian health along the Babocomari River"

To Whom It May Concern,

I, Sid Kahla, am a grazing lessee which includes leased lands of the Emerson parcel and the Arizona State Land Department (AZSLD) Trust lands immediately adjacent to the Emerson parcel and the Babocomari River. I am writing to convey our support for the grant proposal to the Arizona Water Protection Fund titled "Enhancing rangeland and riparian health along the Babocomari River".

If funds are awarded, I as a grazing lessee to the AZSLD, will assist the project team in submitting the proposed restoration treatment plan for the necessary AZSLD permit. My lease is 005-000912-00

As a long-time rancher, we are committed to the health of our rangelands and riparian areas. Funding received from the Arizona Water Protection Fund to implement on-the-ground restoration treatments will benefit the continuation of our livelihood for the next generation and will help to grow local appreciation for the benefits of healthy and working rural landscapes and riparian areas.

Sincerely,

Sidney Kahla

Enhancing Rangeland and Riparian Health Along the Babocomari River

Land Tenure

Project Site Work Authorization and/or Project Site Access

Please describe how the applicant will obtain permission for project work and/or access to the project site if they are not the landowner or land manager.

Arizona Land and Water Trust (ALWT) and Watershed Management Group (WMG) will obtain written authorization and letters of support from participating landowners to carry out project activities. Permission for site access and implementation will be formally secured from the Emmerson, Pyeatt, and Babocomari Ranches, as well as from Arizona State Land Department which encompass both private lands and Arizona State Land grazing leases. These landowners have previously collaborated with ALWT and WMG and are supportive of restoration efforts to improve rangeland and riparian conditions along Babocomari Creek.