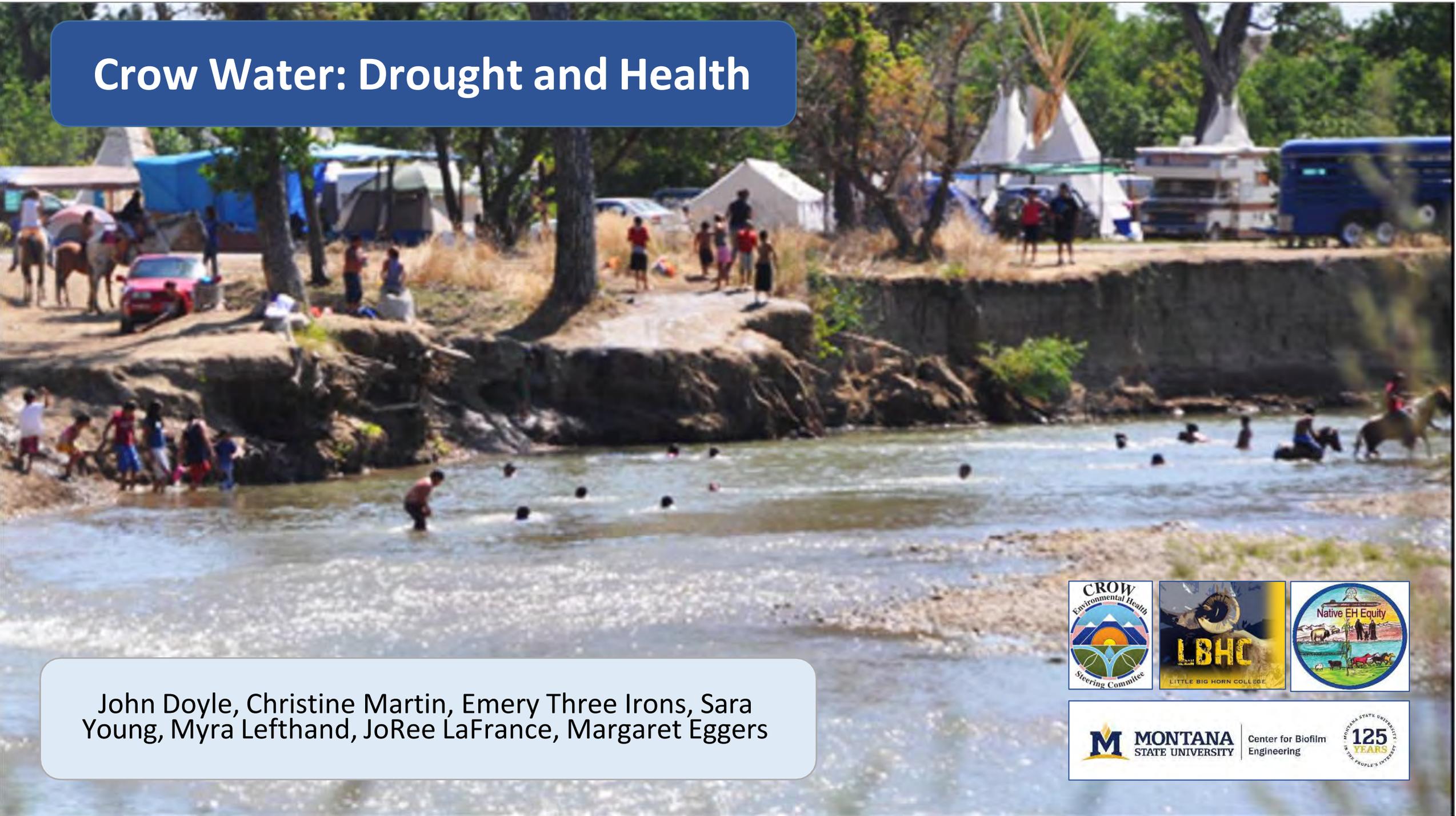
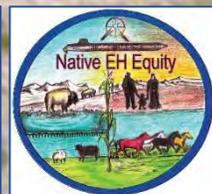
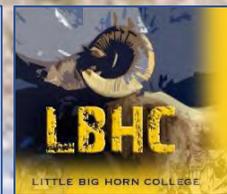


Crow Water: Drought and Health



John Doyle, Christine Martin, Emery Three Irons, Sara Young, Myra Lefthand, JoRee LaFrance, Margaret Eggers

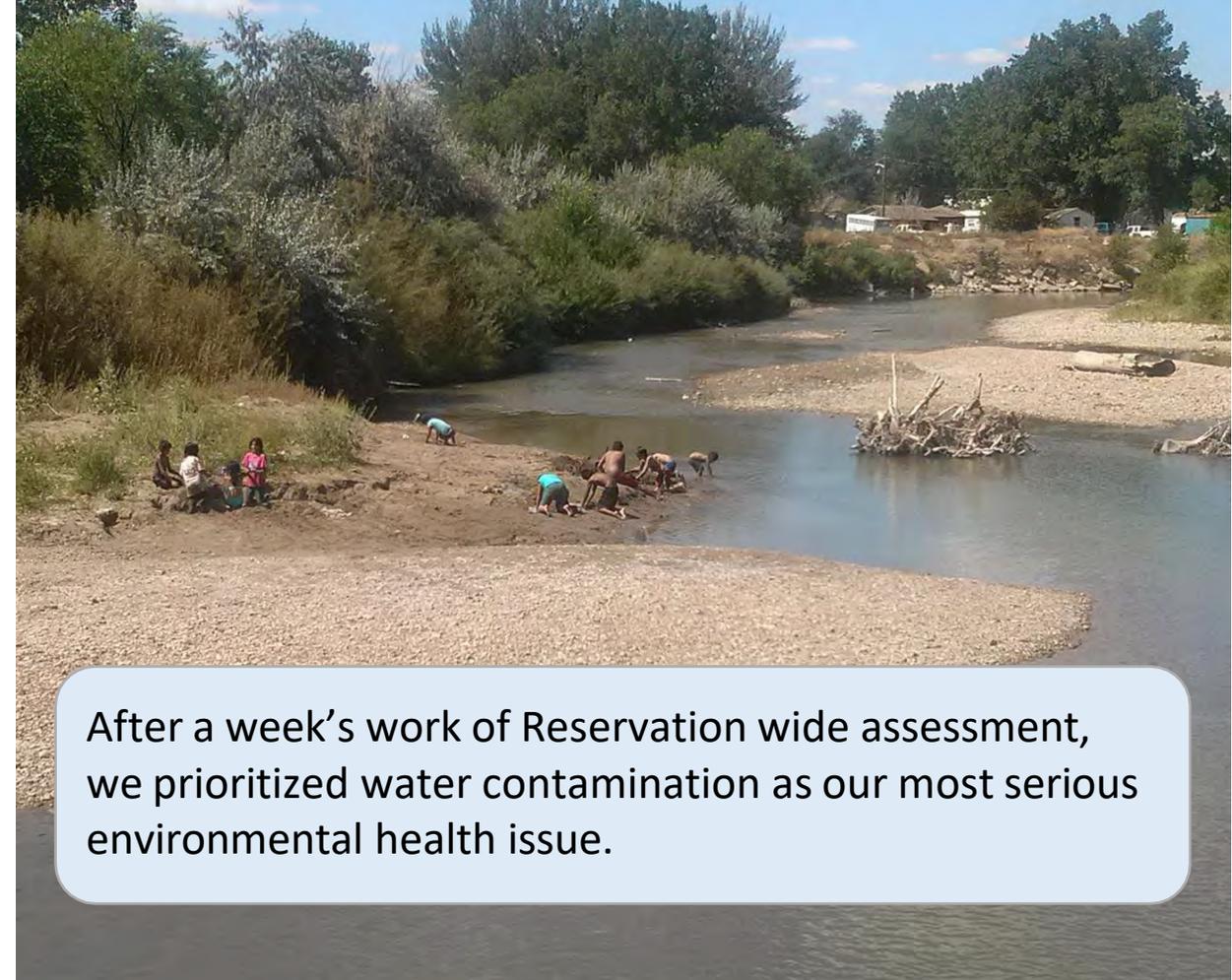
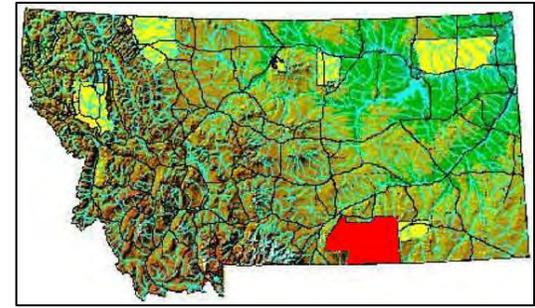


MONTANA
STATE UNIVERSITY

Center for Biofilm
Engineering



2005 Indian Country Environmental Health Assessment Program (Little Big Horn College - EPA)

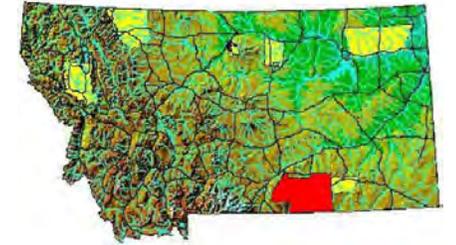


After a week's work of Reservation wide assessment, we prioritized water contamination as our most serious environmental health issue.



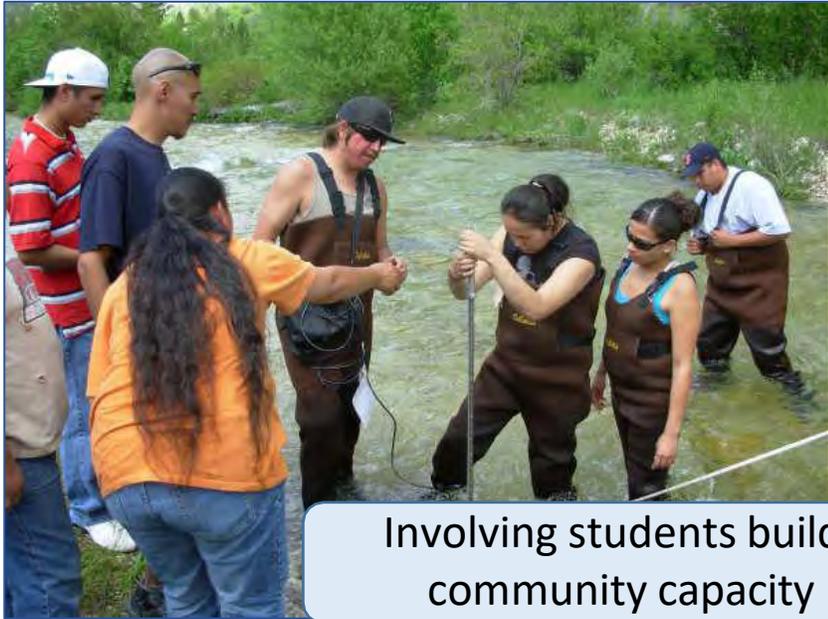
Crow Environmental Health Steering Committee, 2005 – present

We are still addressing our Tribal EH priority: water & health





We research home well water, surface water, and the impacts of climate change on water & health. We work to increase families' access to safe drinking water.



Involving students builds community capacity

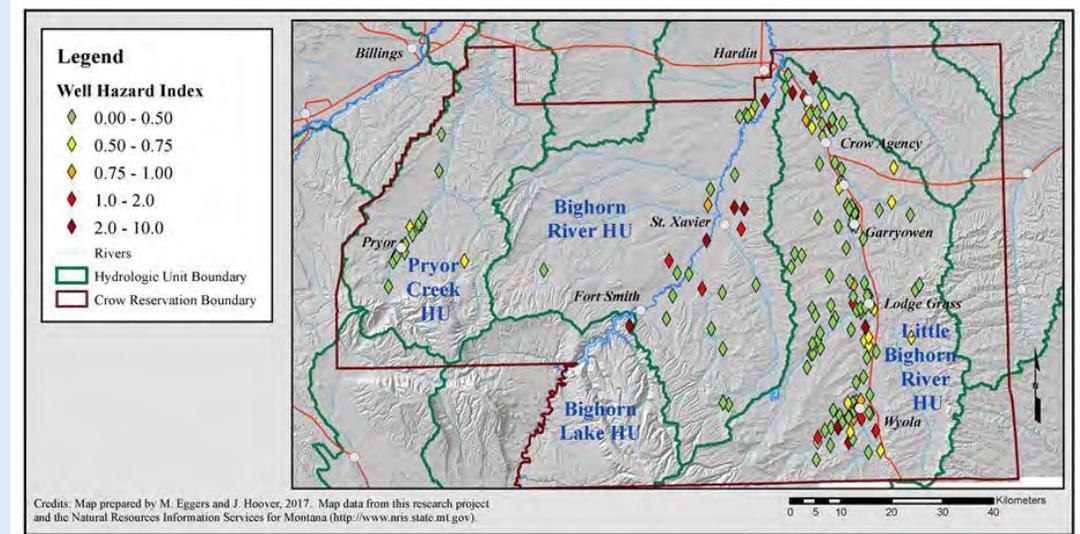


Our multiple water and health challenges



Spring flooding, late summer drought

Cumulative health risk from uranium, arsenic, nitrate and manganese in home well water. (We mitigate with well testing and home water coolers.)



Failing home plumbing, including wells and septic systems. (We collaborate with Plenty Doors CDC on funding home repairs.)

Deteriorating public water and wastewater infrastructure. (Our research supports the Tribal Water and Wastewater Authority, which has made \$20M worth of progress here.)



Understanding and addressing climate change impacts by combining Western science and community ecological expertise

Traditional Ecological Knowledge (TEK):

Qualitative research design

In depth interviews with tribal members on climate and ecological changes observed over their lifetime

Content Analysis of interviews

Collection of themes revealed by interviews

Comparing with western data

Western Science (WS):

Historical data (quantitative)

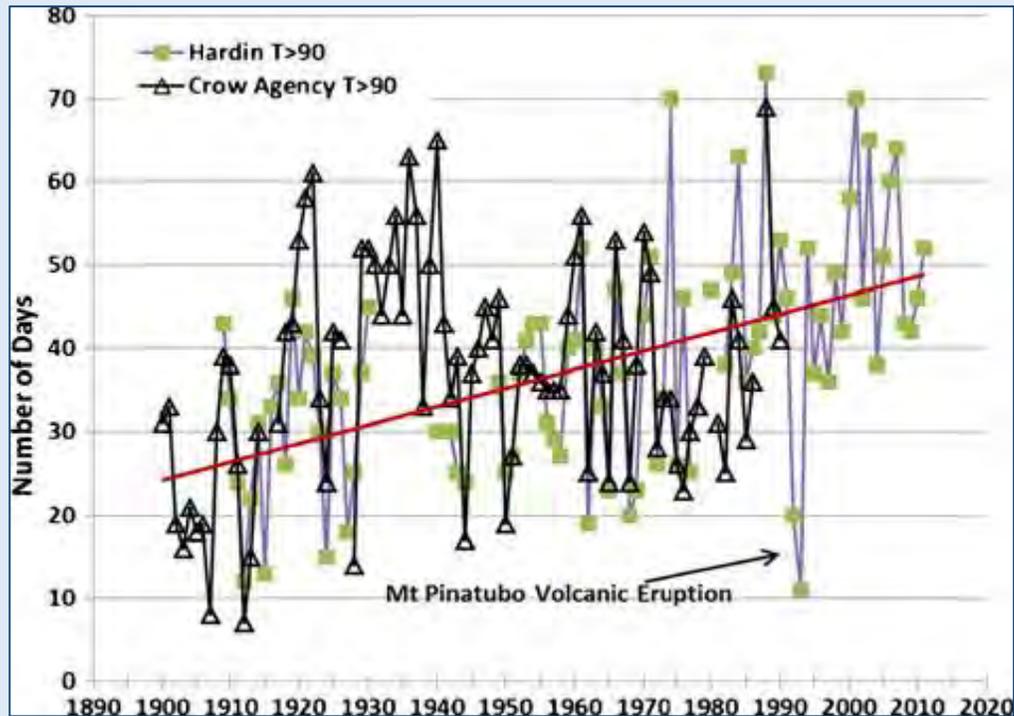
Climate projections

Graphing

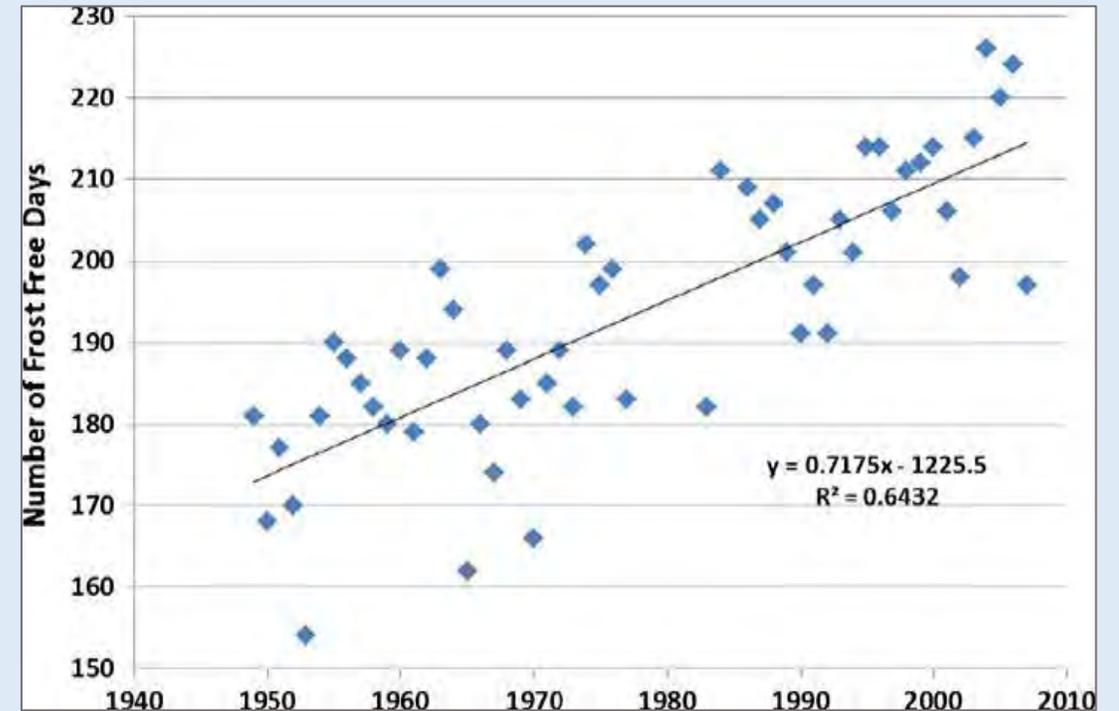
Comparing with Traditional Ecological Knowledge

These knowledge sources are complementary and both are essential to addressing environmental health issues in our community. TEK: "We are born into this way of knowing. Our youth are losing this spiritual way of understanding."

Climate change and heat in Crow: Western science



Number of days per year with temperature exceeding 90 °F (32 °C) has doubled in the past century in Hardin and Crow Agency, MT.



Number of frost free days per year in Hardin, MT, calculated from historic daily observations. (Data source: National Climate Data Center.)

Doyle, J.T., Redsteer, M.H., Eggers, M.J. 2013. Exploring effects of climate change on Northern Plains American Indian health. *Climatic Change*. 120:643–655. doi:10.1007/s10584-013-0799-z. <http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3831579/>

TEK: Winters are milder

“I think that the winters are different. There’s fewer days that are subzero that I would observe. It seems to me that I used to count on a month of subzero weather maybe 6-weeks especially in January and February. And not before Christmas or not before the holiday or the new year. I remember a lot more snow but maybe it’s just because of the hard work that you have to do when there’s snow.”



TEK: Winter Weather Patterns are Changing

“Winter is coming later. Snowfall is coming later in the fall. The freezing period for the fall is coming later so the leaves are falling later as well. Warmer temperatures in the fall. Decrease in precipitation for the spring indicated by the amount of mud outside. Snowpack in the mountains is melting sooner so you are able to go into the mountains in June when they would usually go up in July.”



TEK: Longer, Hotter Summers

“We have a few days of hot weather in March, then some in April but the hot weather comes in June and lasts until September, it’s longer, the heat, it appears to me to be longer and hotter real or more uncomfortable.”



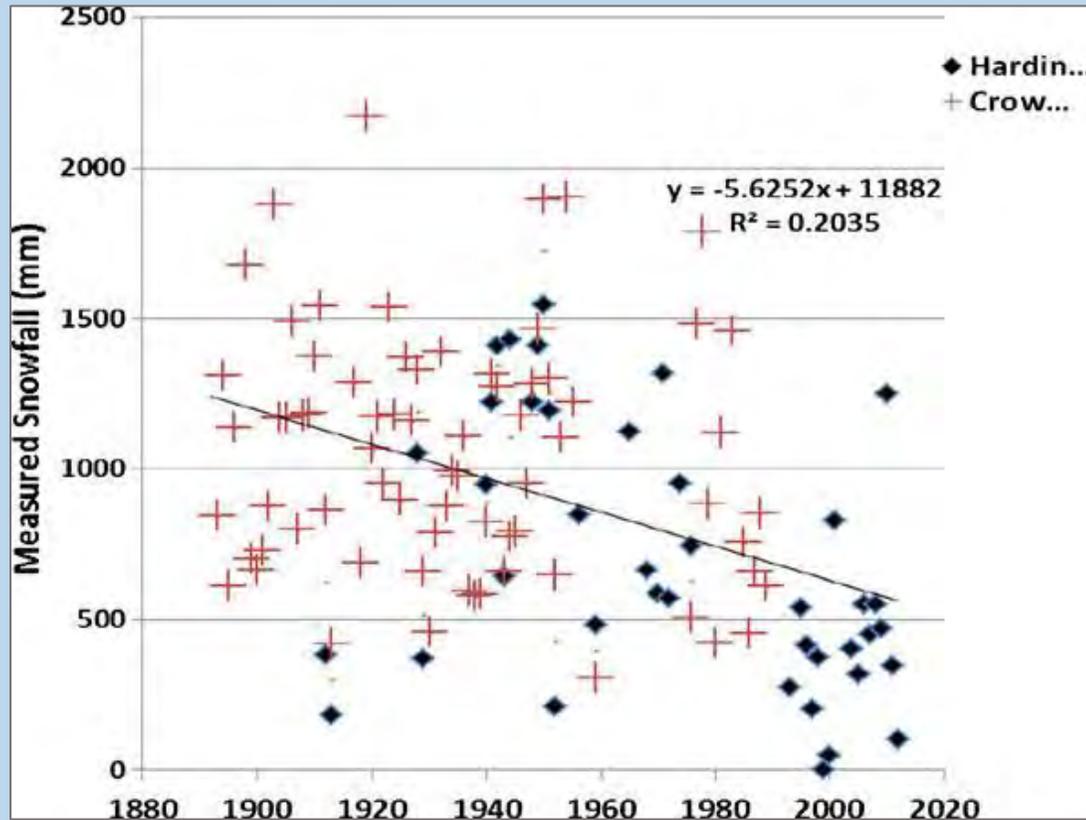
TEK: Increasing wildfires

“There are more fires now days and they’re more severe and more widespread and they do more damage. To me it’s all obvious and apparent that we in fact are in global warming... When it rains, the mud slides washes away everything...”

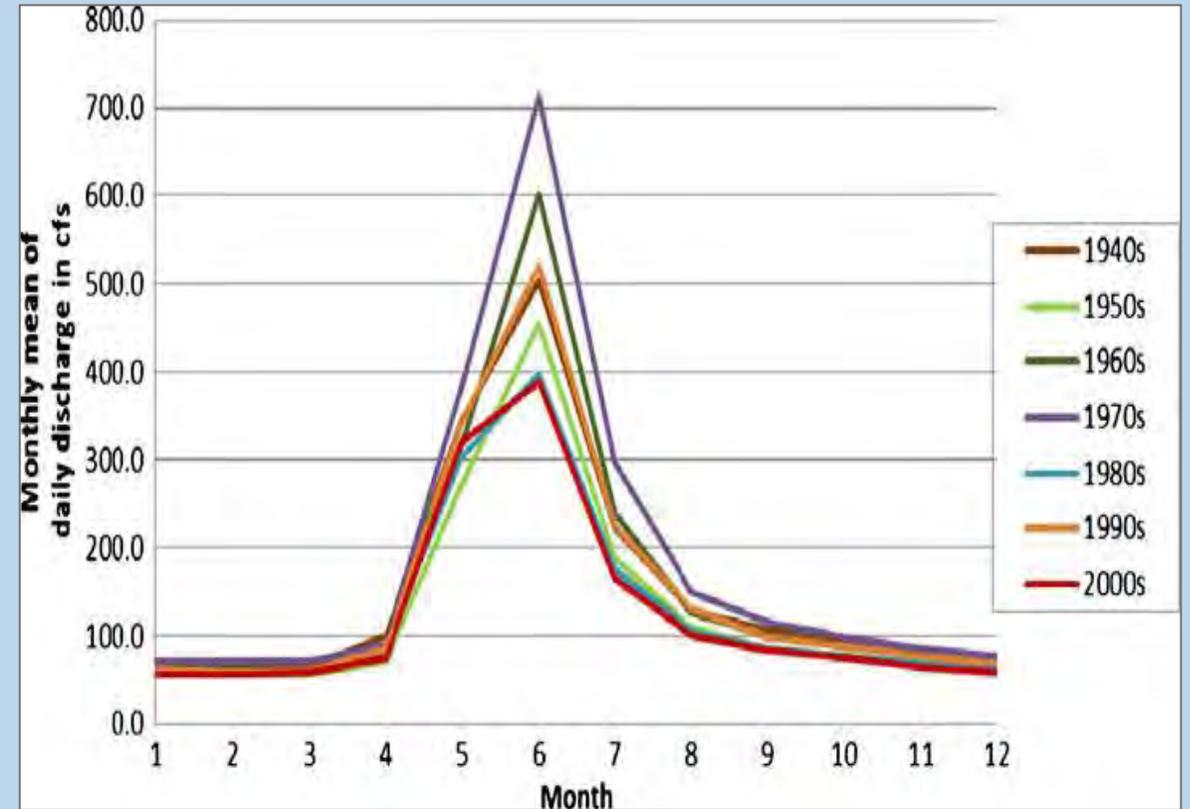


2012 fires just east of Crow Agency

Climate change and water in Crow

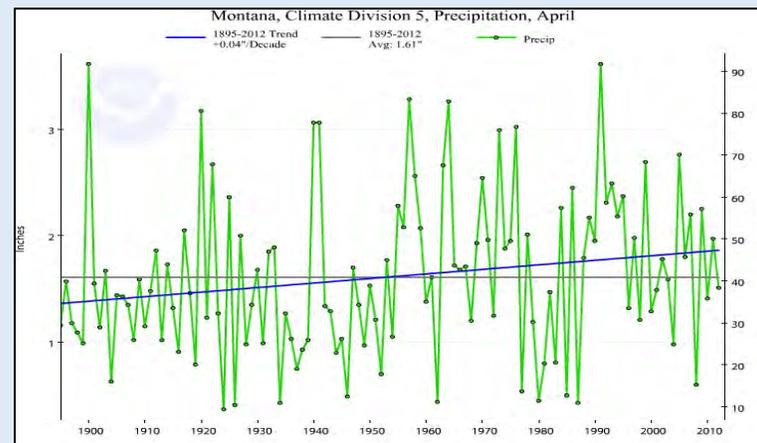
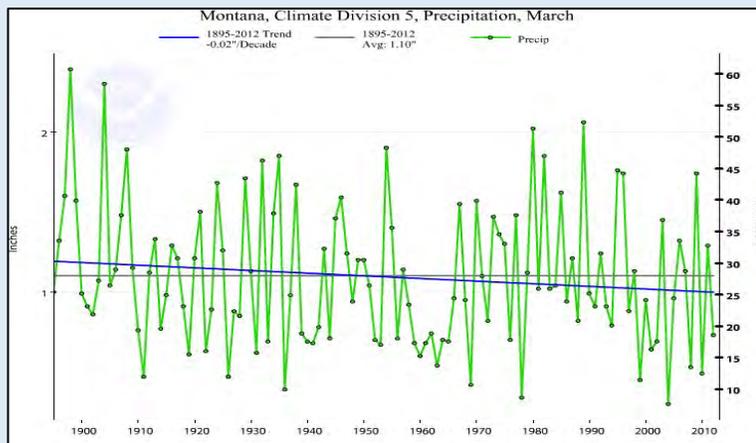
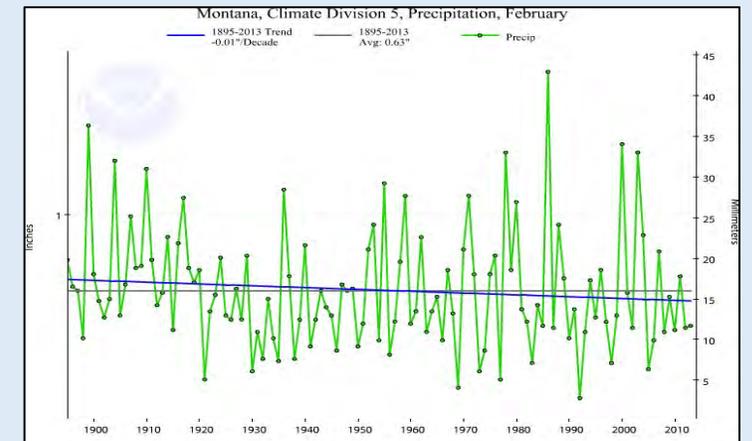
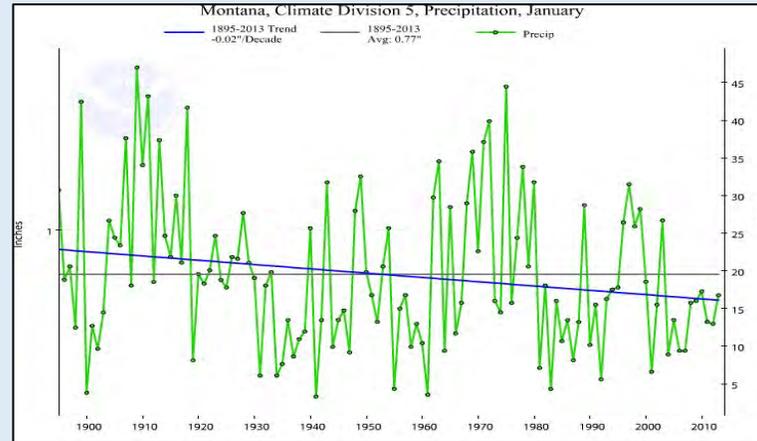
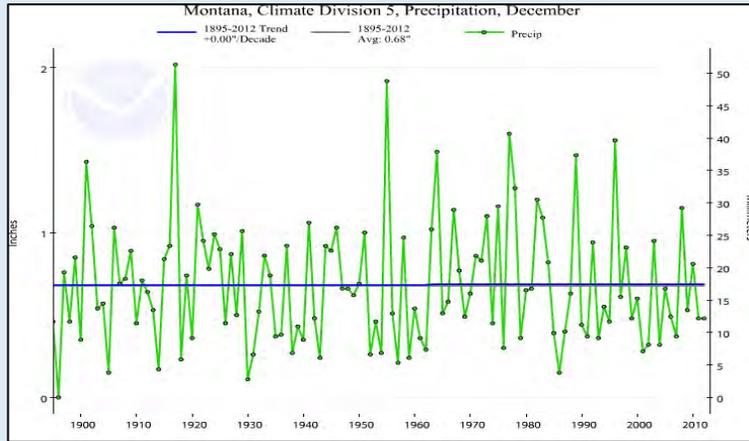


Annual snowfall in millimeters from Hardin MT (1912–2012) and Crow Agency MT (1895–1990) observation sites, calculated in water years.



Monthly averages of daily mean discharge by decade for Little Bighorn River at State Line near Wyola, Montana (station 06289000). (Data source: USGS 2012) ★ lowest years

WS: Declining annual precipitation



The decline in winter snowpack is not being made up during other seasons; average annual precipitation in MT Climate District 5 has been declining by 0.11" per decade.

TEK: Winter snowfall is declining

“When I was a child back in the ‘70s the snow was very deep every year to where I remember there was snow drifts every year and they were at least 3-6 feet high. We used to build tunnels in them every year when we were kids. Nowadays, in the winter, we don’t see that drift that high. Nowadays, the snow drifts are about 6 inches to a foot high.”



TEK: Severe spring floods are more frequent

“... that floodwater came through their houses, and that house is condemned. For people that is such a hardship because we just don't have to money to relocate. So they just had to let their house dry out and move back in, even with the same carpet. So that was a community health concern.”



TEK: Spring ice break-up has become ice melt

“Ice break-up is a rare commodity. I recall a time when they would float down the river on ice chunks that were about 9-inches thick and the size of a car hood. Ice jams haven’t occurred for years. The ice break-ups don’t happen like they used to and if they do, the timing is off..”



Photo by J. Doyle

TEK: Less rainfall

“We’re losing the annual precipitation that we enjoyed in the years that have gone by. All we can do is just have memories and hope that eventually the cycle will come back to that time when we had ample moisture and we were at leisure with plant life, berry picking, root gathering and other ceremonial activities that go on here year after year.”



TEK: Loss of plants, riparian plants



“I think when my family was younger we did a lot of just going around in the mountains, hunting and camping. When I get next to the rivers, what I am doing is usually searching for things. Like I am looking for mint or I am picking berries of different kinds. Or maybe I am looking for wild onions and carrots and things. And those things changed, they’ve changed a lot. I feel like I can hardly ever find mint where I would use to find it a lot. And that is really usually along waterways. So there is a difference in growth. Why? I don’t know. But why plants move around so much, I just don’t know. But I do think that it probably has to do with water and the season of time when the water is available. There are places where I used to constantly go for certain things that I have had to look for new places because things just aren’t growing where they [used to be].”

TEK: Loss of amphibians

“When we were little we used to catch and release frogs and that was part of our activity at the river... there would just be tons of frogs in those little water holes next to the river, and turtles and salamanders... We used to see who could find the most... there was about 5 or 6 of us playing that game where we could each collect our own frogs... But now when I go over there, the frogs are still there but they’re not all along the river like they used to be... you kind of have to hunt them out.”



TEK: Loss of riparian berries

“There used to be a bunch of patches of raspberries and now they only know of one or two patches...The chokecherries weren’t as delicious, they weren’t as sweet. None of them are as sweet as they used to be. That might have something to do with the decrease in bees... or the frost and thawing period, or it could be the late precipitation. Because if you are not getting the water then you are not growing as early in the season...”





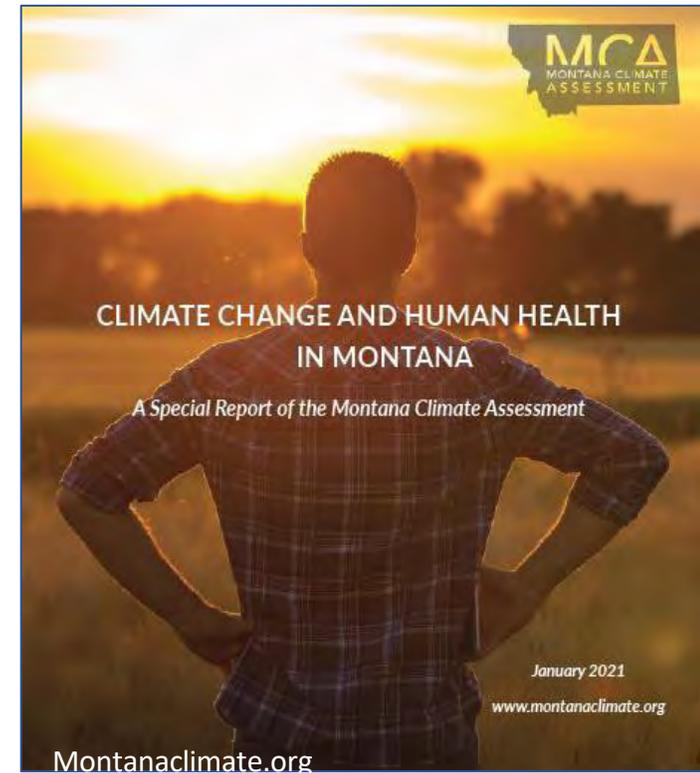
J doyle photo



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Climate change, water & health

- Traditional Ecological Knowledge (TEK) and Western science concur on many changes in climate.
- TEK includes awareness of additional ecological changes and human impacts, going beyond what Western science has ever measured in our region.
- *We must prepare for late summer droughts becoming increasingly worse.*



Installing weather station for Crow

Tribal Waters: Jurisdictional issues are multiple, complex, challenging and time consuming to resolve

Policy and regulatory challenges stem particularly from Tribal/federal/state/county jurisdictional issues on Reservations, further complicated by overlapping responsibilities of the Tribe, Indian Health Service and Bureau of Indian Affairs (BIA). Ongoing access to legal counsel is essential.



Funding public water and wastewater infrastructure

- With no ability to form a unified public water and wastewater authority which can tax all residents, infrastructure repairs and upgrades rely on grants.
- The Tribal Authority has secured more than 50 different grants and loans totaling > \$20 million for this work.



Tribal Sovereignty

Funding agencies want disputes to go to District Court. The Tribe wants them to go to Tribal Court, and then Federal Court if need be. The procedure for settling disputes has to be negotiated and included in contracts. Arbitration can help.



Obtaining Rights of Way for distribution lines

- **Obtaining Rights of Way** is complicated by Tribal and individual Trust lands administered by the BIA, in addition to the usual federal/state/county/railroad/private mix of land ownership.
- The Tribe does not have clear eminent domain authority.
- The County was blocked from using its eminent domain authority to help the Tribe.



Vanderbilt University

Historic and ongoing lack of infrastructure planning

- Housing, including federally funded housing, is still being built without adequate infrastructure planning or funding. This leaves the Tribal Water and Wastewater Authority to solve the problems created and foot the bill.
- One consequence: an entire HUD neighborhood had to switch to outhouses for months, because the homes had been built without identifying who would be responsible for maintaining and repairing the water and wastewater infrastructure. Wastewater overflowed into the neighborhood's streets.



Absence of climate change adaptation planning

There is no planning for climate change impacts of increased spring flooding, worsening summer droughts, wells drying up nor municipal surface water sources being entirely depleted by increased irrigation:

- Summer '22: Home wells are drying up, leaving families to haul water for all uses.
- Surface water source for our largest town's public water supply is close to drying up entirely in late summer.



The Indian Health Service Hospital was closed for months when spring flooding swamped the public water supply lift station located in an old river oxbow. The standing water in acidic soils then corroded and destroyed the metal distribution system pipes.

Poor environmental enforcement

- Below the ground surface, there is a dumping ground resulting from a century of neglect and abandonment.
- Cleaning up unanticipated underground hazards is costly and delays water line installation schedules.
- Severe microbial contamination of the river during spring runoff challenges the water treatment plant.

Abandoned underground storage tank discovered across the street from the elementary school during the water line project. Owner would neither test it nor remove it.



Conclusion

Crow faces water insecurity for both public and private water supplies. Climate changes are only making this worse.

Obstacles to addressing these challenges include:

- lack of knowledge of infrastructure funding sources;
- the need for many kinds of expertise, including legal;
- the lack of long term stability of Tribal government personnel;
- the complex jurisdictional issues affecting many aspects of infrastructure design, contracting and construction;
- regulatory gaps where there is no Tribal or federal equivalent to State laws and regulations;
- a legacy of no infrastructure planning and poor environmental enforcement;
- severely limited funding for infrastructure operation and maintenance.

Legislative and policy changes could remove some of the many obstacles Tribes face in providing safe drinking water for their members.



Publications

- [Martin C, Simonds VW, Young SL, Doyle J, Lefthand M, Eggers MJ. Our Relationship to Water and Experience of Water Insecurity among Apsáalooke \(Crow Indian\) People, Montana. Int J Environ Res Public Health. 2021 Jan 12;18\(2\). doi: 10.3390/ijerph18020582. PubMed PMID: 33445579; PubMed Central PMCID: PMC7827827.](#)
- Adams A, Byron R, Maxwell B, Higgins S, Eggers M, Byron L, Whitlock C. Climate Change and Human Health in Montana 1 ed. Bozeman, MT: Montana Institute on Ecosystems; 2021. 216p.
- Doyle J, Martin C, Young SL, Lefthand MJ, Three Irons E, Eggers MJ. Graduate Research Serving Apsáalooke Communities. In: Atalay S, McCleary A, editors. The Community-Based PhD 1 ed. Tucson, AZ: University of Arizona Press; 2021. Chapter 15; p.in press.
- Martin C, Doyle J, LaFrance J, Lefthand MJ, Young SL, Three Irons E, Eggers MJ. Change Rippling through Our Waters and Culture. Journal of Contemporary Water Research and Education. 2020; 169:61-78.
- Hamner S, Brown BL, Hasan NA, Franklin MJ, Doyle J, Eggers MJ, Colwell RR, Ford TE. [Metagenomic Profiling of Microbial Pathogens in the Little Bighorn River, Montana.](#) Int J Environ Res Public Health. 2019 Mar 27;16(7). doi: 10.3390/ijerph16071097. PubMed PMID: 30934749; PubMed Central PMCID: PMC6479903.
- [Richards CL, Broadaway SC, Eggers MJ, Doyle J, Pyle BH, Camper AK, Ford TE. Detection of Pathogenic and Non-pathogenic Bacteria in Drinking Water and Associated Biofilms on the Crow Reservation, Montana, USA. Microb Ecol. 2018 Jul;76\(1\):52-63. doi: 10.1007/s00248-015-0595-6. Epub 2015 Mar 22. PubMed PMID: 25796498; NIHMSID:NIHMS674577.](#)
- [Doyle JT, Kindness L, Realbird J, Eggers MJ, Camper AK. Challenges and Opportunities for Tribal Waters: Addressing Disparities in Safe Public Drinking Water on the Crow Reservation in Montana, USA. Int J Environ Res Public Health. 2018 Mar 21;15\(4\). doi: 10.3390/ijerph15040567. PubMed PMID: 29561815; PubMed Central PMCID: PMC5923609.](#)
- [Eggers MJ, Doyle JT, Lefthand MJ, Young SL, Moore-Nall AL, Kindness L, Medicine RO, Ford TE, Dietrich E, Parker AE, Hoover JH, Camper AK. Community Engaged Cumulative Risk Assessment of Exposure to Inorganic Well Water Contaminants, Crow Reservation, Montana. Int J Environ Res Public Health. 2018 Jan 5;15\(1\). doi: 10.3390/ijerph15010076. PubMed PMID: 29304032; PubMed Central PMCID: PMC5800175.](#)
- Eggers, M.J., Moore-Nall, A.L., Doyle, J.T., Lefthand, M.J., Young, S.L., Bends, A.L., Crow Environmental Health Steering Committee, Camper, A.K. 2015. Potential Health Risks from Uranium in Home Well Water: An Investigation by the Apsaalooke (Crow) Tribal Research Group. Geosciences. 5:67-94. doi:10.3390/geosciences5010067.
- [McOliver CA, Camper AK, Doyle JT, Eggers MJ, Ford TE, Lila MA, Berner J, Campbell L, Donatuto J. Community-based research as a mechanism to reduce environmental health disparities in american Indian and alaska native communities. Int J Environ Res Public Health. 2015 Apr 13;12\(4\):4076-100. doi: 10.3390/ijerph120404076. PubMed PMID: 25872019; PubMed Central PMCID: PMC4410234.](#)
- [Hamner S, Broadaway SC, Berg E, Stettner S, Pyle BH, Big Man N, Old Elk J, Eggers MJ, Doyle J, Kindness L, Good Luck B, Ford TE, Camper AC. Detection and source tracking of Escherichia coli, harboring intimin and Shiga toxin genes, isolated from the Little Bighorn River, Montana. Int J Environ Health Res. 2014 Aug;24\(4\):341-62. doi: 10.1080/09603123.2013.835030. Epub 2013 Sep 17. PubMed PMID: 24044742.](#)
- Doyle JT, Redsteer MH, Eggers MJ. ["Exploring Effects of Climate Change on Northern Plains American Indian Health"](#). Clim Change. 2013 Oct;120(3). doi: 10.1007/s10584-013-0799-z. PubMed PMID: 24265512; PubMed Central PMCID: PMC3831579.
- [Cummins C, Doyle J, Kindness L, Lefthand MJ, Bear Dont Walk UJ, Bends AL, Broadaway SC, Camper AK, Fitch R, Ford TE, Hamner S, Morrison AR, Richards CL, Young SL, Eggers MJ. Community-based participatory research in Indian country: improving health through water quality research and awareness. Fam Community Health. 2010 Jul-Sep;33\(3\):166-74. doi: 10.1097/FCH.0b013e3181e4bcd8. PubMed PMID: 20531097; PubMed Central PMCID: PMC3070444.](#)



It takes a whole community and continued contact



Our thanks and appreciation to the many dedicated community members and student interns who have participated or are participating in this project.

Thank you to our collaborators

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25+ LBHC Science majors over past years

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Dr. Rebecca Mueller & colleagues

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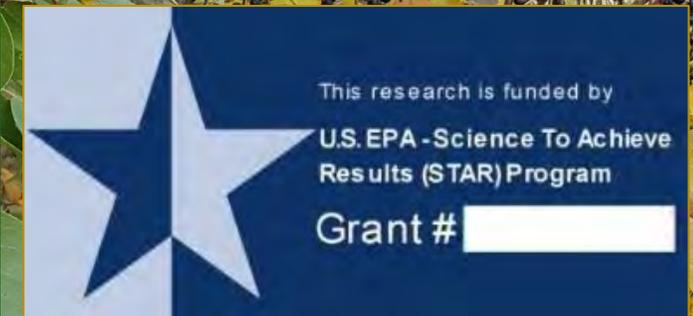
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Questions?

