2017 HAWAII UNIVERSITY INTERNATIONAL CONFERENCES
SCIENCE, TECHNOLOGY & ENGINEERING, ARTS, MATHEMATICS & EDUCATION JUNE 8 - 10, 2017
HAWAII PRINCE HOTEL WAIKIKI, HONOLULU, HAWAII

ENVIRONMENTAL EDUCATION IN ONE OF THE LARGEST SUPERFUND SITES IN AMERICA

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CLARK FORK WATERSHED EDUCATION PROGRAM
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Environmental Education in One of the Largest Superfund Sites in America

Synopsis:

How do you teach the next generation about Superfund, and its associated environmental damage and repair? How do you talk about the science of toxic waste effects on a local ecology and environment? How do you engage a community and their beliefs to encourage stewardship of the land? As STEAM program providers, we will describe how we do this work, our opportunities for improvement, as well as our pedagogical *minds-on* and *hands-on* approach to this tackle this complex issue.

Environmental Education in One of the Largest Superfund Sites in America

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Cfwep.Org

Abstract

The Upper Clark Fork River Basin (UCFRB) suffered damages from toxic waste generated from over 100 years of underground and open-pit mining. As a result, our watershed has three designated Superfund sites. Together these three sites form the largest complex of Superfund sites in the country. In 2006 educators and researchers came together to create the Clark Fork Watershed Education Program (Cfwep.Org). The mission of Cfwep.Org is to teach the current and next generation of UCFRB citizens about how and why these environmental damages occurred; the science behind the effects of toxic waste on the local ecology and environment; and to inspire and encourage stewardship of the restored and remediated lands and waters. We work towards this mission by utilizing a multi-pronged approach to environmental education that includes classroom visits, field trips and tours, as well as presentations at community-based groups and clubs, public events and festivals, and college courses and seminars. We describe here how we do this work, our successes and opportunities for improvement, as well as our pedagogical approach to this complex issue. We have a program development attitude of never being satisfied and always looking to improve content, remain relevant, and stay up-to-date on information. The growth and change in the curriculum have recently lead us to work with a *minds-on* and *hands-on* approach. Through this combined approach, we aim to inspire students to be more considerate of STEAM disciplines as they relate to environmental issues, as well as build multi-generational stewardship of our Superfund sites. Ultimately, we aspire to help our communities make better decisions regarding balancing the need for industry with the need to protect our health and natural resources.

Environmental Education in One of the Largest Superfund Sites in America

The Upper Clark Fork River Watershed and Mining

The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) was passed in 1980. CERCLA, or Superfund, was developed as a nationwide program to manage emergency responses dealing with: information gathering and analysis; establishment of liability for responsible parties; and site cleanup. It is responsible for cleaning oil spills, environmental emergencies, and natural disasters. In order to finance emergency responses and cleanups, a trust fund, or Superfund, was created. Superfund was funded by "polluter pays" fees from companies that as a rule generated hazardous wastes [Peltomaa & Brandl (Connole), 2016]. The Upper Clark Fork River Basin (UCFRB) has three designated Superfund sites resulting from over 100 years of underground and open-pit mining.

Prospectors settled in Butte and began mining in 1864 with the discovery of gold first, followed by silver, and lastly by what would make Butte "The Richest Hill on Earth," copper (Freeman, 1900). Waste produced from the mining and milling processes were spread throughout the UCFRB in two ways. First local creeks, Silver Bow Creek and Warms Springs Creek in Butte and Anaconda, respectively, were used to wash away acidic and metal-laden mine wastes for over 100 years (https://www.epa.gov/). Secondly, the Flood of 1908 carried millions of cubic yards of toxic mine waste 120 miles downstream to Milltown where they were stopped by the Milltown Dam (CTEC, 2012). The Flood also spread wastes onto floodplains and throughout wetlands.

In 1983 parts of our watershed were deemed toxic and dangerous to human health and the environment, and were listed under Superfund. A total of three mega Superfund sites were

designated, including most of the city of Butte. The Silver Bow Creek/Butte Area, the Anaconda Smelter, and the Milltown Reservoir/Clark Fork River sites together form 120-miles of the largest complex of Superfund sites in the country (Figure 1) and include damages to freshwater, groundwater and terrestrial natural resources (Montana Steward, 2016). Within this complex is a watershed containing several communities, ones with different backgrounds and beliefs.

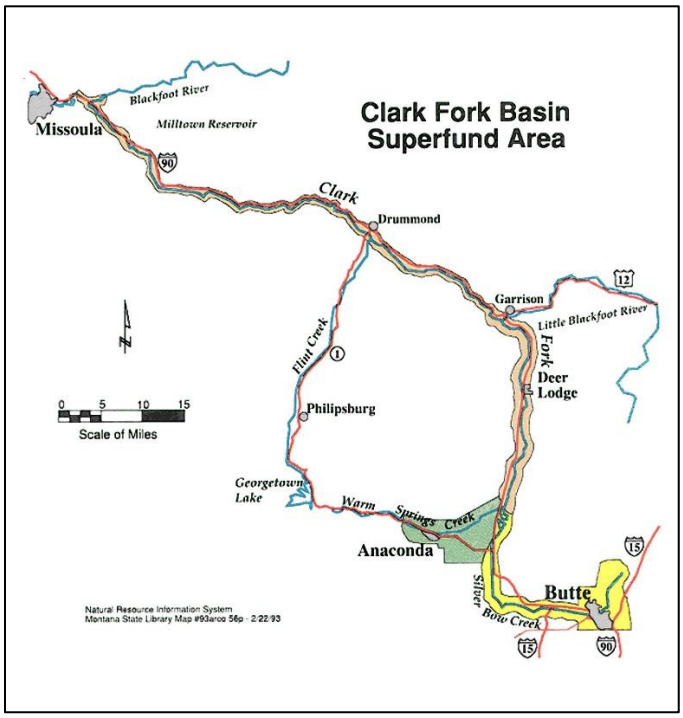

Figure 1. The UCFRB Superfund Complex consisting of the Silver Bow Creek/Butte Area, the Anaconda Smelter Area, and the Milltown Reservoir Sediments/Clark Fork River. (http://nris.mt.gov/nris/nris.asp)

Out of the Nation's Largest Superfund Complex, Cfwep.org is Born

In 2006 concern about misconceptions regarding our Superfund status and the desire for stewardship of the associated clean-up, inspired a small team of educators and researchers from

Butte to create the Clark Fork Watershed Education Program (Cfwep.Org). The mission of Cfwep.Org is to foster environmental stewardship and scientific decision-making through place-based learning. Cfwep.Org aims to teach the current and next generation of citizens about how and why the damages from mining occurred; the science of toxic waste effects on the local ecology and environment; as well as inspire and encourage stewardship of the restored and remediated lands and waters. Cfwep.Org works with people of all ages to understand Superfund, and the constantly evolving science and clean-up procedures that occur in our communities.

Successes and Opportunities

Each year we serve between 2,000 and 4,000 students. As of December 2016, Cfwep.Org has served over 40,000 students. We serve all ages through a variety of venues and mediums. We provide a 5-day Restoration Education Program (REP); a 1-day program about trout; a 3-day program called Bringing Research Into the Classroom that focuses on microbes; a clean-up event on the stream called Clean-Up Blacktail Stream (CUBS), involving local schools and the community; a fly-fishing camp in the summer and multiple presentations to various community groups. We also participate in and provide educational opportunities at the Montana Folk Festival, Evel Knievel Days, and local summer camps. For this paper, we have focused on our 5-Day REP.

Restoration Education Program (REP)

During the inception of Cfwep.Org, the founders realized that K-12 students are a great avenue to share knowledge with and to utilize for spreading the story of our watershed. Out of this realization, REP was born. REP is a five-day intensive program that teaches watershed science, which includes the sciences, the social sciences, and the arts. We employ the basic

principles of place-based education (PBE), which emphasizes teaching about both the natural and built environments of students' local areas (Sobel, 2005). We utilize a mix of teaching strategies that include inquiry-based learning, *minds-on* and *hands-on* techniques, and Next Generation Science Standard (NGSS) framework. *Minds-on* involves students' accessing their current schema and trying to make sense of a new idea presented to them. Once they do that, we ask them to show or tell us what they think the new idea is. From here we can perceive any misconceptions and build on current knowledge. The National Research Council (NRC) recommends giving students time to examine their misconceptions within the structure of NGSS. Rather than simply memorizing facts about science, NGSS demands a higher standard of cognition for students, in other words, students engage their minds in solving and puzzling out problems, which is much more than simply doing a cookbook lab or standard hands-on activity (National Research Council, 2012).

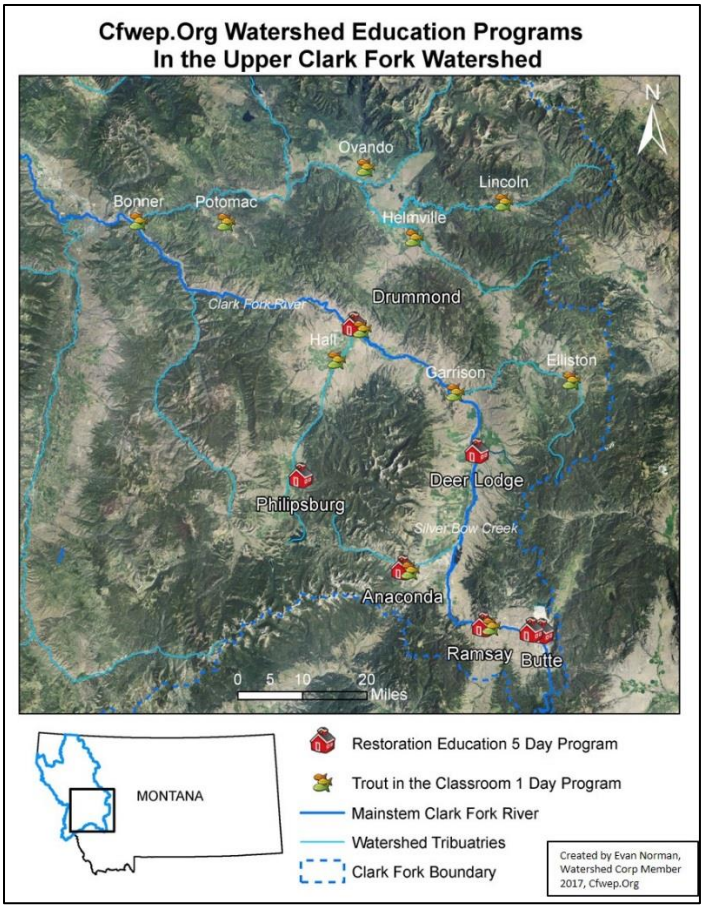

Figure 2. Programs offered by Cfwep.Org to the schools within the UCFRB.

Through REP, we serve all 7th-grade public schools and 5th – 6th-grade private school students in the UCFRB (Figure 2). In most cases, the program starts with four days in the classroom, where students are exposed to information through presentations and hands-on activities. On the fifth day of the program, students go on a field trip to a local restored riparian area on Silver Bow Creek to conduct scientific tests and to collect data with local scientists. The students test water quality, assess the riparian zone's health, and evaluate the community of aquatic macroinvertebrates. Data is collected using worksheets. After their time in the field is concluded, students are taken to a local remediated site at Foreman's Park in Butte for a tour. The purpose of the tour is for the students to view a remediated site first-hand, as well as learn

more history of mining in Butte. Lastly, we take the students to a classroom at our local college, Montana Tech in Butte, to review their data and summarize their findings. We then ask them to draw conclusions from their findings about the health of the creek. In this way, the students get to experience the science process from beginning to end. We end the day with a discussion about stewardship and responsibility.

The clean-up of our Superfund sites is very complex and involves two types of clean-up that we try to stress to students, remediation and restoration. These two types of clean-up are often integrated together to achieve the highest level of clean-up possible. Remediation refers to the clean-up of an area of toxic waste to certain legal standards that are protective for human health (https://www.epa.gov/). Restoration, as defined by CERLCA, means to restore, replace, or acquire the equivalent of natural resources injured or services lost by the release of hazardous substances (https://www.epa.gov/). Much of the sites within the city of Butte (such as Foreman's Park) are considered areas of remediation because they have been cleaned up minimally to reduce the impact to human health. In most instances, the remediation is "waste in place" with vegetative caps. The clean-up process that occurred on Silver Bow Creek (the riparian area that students collect data from) is considered to be an area of restoration because attempts were made to remove all mine waste from the area and restore it to its pre-mining state. Between the two sites that we visit, students' see first-hand the two types of clean-up as well as the science involved in both types clean-up.

Throughout our time with each student, we hope to connect them to their surroundings and inspire stewardship to take care of the restored and remediated areas armed with the knowledge they gained. They are encouraged to share their new knowledge as well as come up with ways they can inspire others to help care for the remediated and restored areas. We

earnestly believe this program is critical to ensure that the level of damage and loss of natural resources does not happen again in our area.

Growth and Change in Curriculum

Currently, our program consists of teaching about riparian habitats, our watershed's history, the clean-up efforts in our watershed, and stewardship. We continuously review our REP curriculum, including our successes and triumphs; self-identified and teacher-informed opportunities for improvement; and our pedagogical approaches considering our complex environmental situation. Assessment of our program is done through a pre- and post-test. Both attitude and knowledge are studied by asking questions related to how we run the program, attitudes towards science and environmental issues, and information relating the science of our Superfund.

We maintain a program development attitude of never being satisfied and always looking to improve content, remain relevant, and stay up-to-date on information. We are currently working on revamping our curriculum to fully embrace the three dimensions of NGSS; to move towards serving more as facilitators and less as instructors; and to hand over the job of learning to the students. We also seek to inspire students to be more considerate of STEAM disciplines as they relate to environmental issues, in acknowledgement of how students of all interests and inclinations can be involved in environmental education. One direction we are taking to fulfill a facilitator role is using a *minds-on* and *hands-on* approach to our curriculum.

Minds-on and Hands-On

To illustrate how we have employed *minds-on* and *hands*-on, the following is an example of a curriculum re-vamp utilizing both. In presenting our curriculum, we found that our students

were not grasping the important concept of what a watershed is. Prior to this current school year, we would start this lesson by asking "What is a watershed?" and let the students respond. Then, before giving them the answer, we would engage them in a *hands-on* activity consisting of a plastic, topographical relief map of the state of Montana. We would use droppers with blue-colored water to "rain" on certain mountains or areas of the state and then we would ask the students to comment on which direction the water was traveling, where the water moved to and why they thought it behaved as it did. We would engage in a discussion about all of this and then allow the students to "rain" on the map to further cement the idea. After returning to their seats, we would tell the students what a watershed is and have them write it down, and sometimes engage in some kinesthetic movement to assist in memory retention. Unfortunately, in our post-tests and in discussions with the students afterwards, it was revealed that the concept was still not understood with this methodology. Thus the start of working with a *minds-on* and *hands-on* approach.

For the same watershed lesson, we now start with again asking "What is a watershed?" Now, however, we give the students paper and markers to draw and label what they think a watershed is. After a few minutes, one of the facilitators walks around the classroom to review the students' work and to instruct the other facilitator to write down the features of the watershed that the students are presenting such as: water, land, deer, fish, a building that filters water, etc. We then start to introduce what a watershed is and throughout this, we ask the students their thoughts until we finally come to an acceptable definition of watershed. The process has been very dynamic and appears to aid the students in conceptualizing watersheds.

The other components of the REP program, as stated above, have also been re-vamped using this *minds-on* and *hands-on* approach. The question remains, is this model effective and/or

does it accomplish the program's goals? We have collected student outcome data related both to attitudes toward the environment and to knowledge gains about the watershed topics presented during the class visits and field trips. In a recent analysis of our data collected from over 2,000 students in years 2012 to 2016, it is clear that students are making significant gains in knowledge and are gaining a positive attitude toward the environment. Students gain significantly on knowledge surveys, with a 30% overall gain pre- to post-test. The student knowledge gains were strongly statistically significant ($p<0.00001$). Students also moved toward greater positive responses in both attitudes toward science and disposition toward caring for the environment [Brandl (Connole), personal communication)].

Inspiring Students for Generations to Come

The future direction for our curriculum and program is to further create and inspire stewards of our watershed. Through additional events we provide such as CUBS and the Montana Folk Festival and Evel Knievel Days, we aim to reach as many citizens as possible and educate through numerous venues. Our mantra is "early and often" to cement the information we are providing.

The implications of our program are to encourage a scientifically-literate community and promote overall awareness of our Superfund sites and the associated clean-up. We also hope that programs like ours can spread to other communities to inspire citizen scientists and to encourage the teaching of place-based education. Our community has already been a part of the Superfund process for over 30 years and has participated in conversations about our sites. By giving our community more knowledge and education about the science, history, and processes of our Superfund sites, we hope more and more citizens will participate and become stewards to help ensure the success and future of our communities. With great knowledge, comes great

responsibility – this phrase could not be more fitting for our communities and the citizens who live here and want to continue to do so for many generations to come.

Acknowledgements

We would like to thank Kayla Lappin for her review and editing of this manuscript. We would also like to thank Evan Norman for the map contribution. Finally we would like to thank the Cfwep.Org founders, Dr. Colleen Elliott, Mr. Joe Griffin, Mr. Bill Callaghan, and Ms. Amy Verlanic. And a special thanks to Padraig Cunneen for his guidance, technical support, and inspiration.

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