Opportunities for Landscape Architecture in Mining Reclamation

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Project Introduction

Mining reclamation is an evolving process that includes many aspects of the Landscape Architecture discipline. The products of mining in the US play an important role in our everyday lives. We mine for valuable minerals such as gold, silver, and copper, and we mine for fuels such as oil and natural gas. Many people believe that mining is a major industry in the US, but it is actually one of the smaller industries, disrupting 0.02-0.1% of land in the United States. Although this is a very small percentage of the land area, mining operations can dramatically impact natural systems, including wildlife habitat, water systems, and landform. Mining has been practiced for thousands of years, however, reclamation has been regulated and enforced by the government for only about 30-40 years through the Mining Reclamation Act of 1977. Historically many sites were abandoned and continue to cause injury or harm to humans and natural ecosystems.

Estimates of abandoned mine sites in the US range from 300,000 to 500,000—and 100,000 of those are likely ripe for reclamation—but because reclamation costs often exceed net profits from mineral extraction, companies often declare bankruptcy rather than clean up after themselves. This project has evolved over two semesters. The initial project intent was to find a role for landscape architects in the mining reclamation process. Extensive research and literature review was conducted with the end product being recommendations for roles landscape architects can play in the reclamation process, while also creating design criteria when taking on a large reclamation project. The second semester was choosing a site, developing a plan with real life potential applications and showcase the roles in reclamation recommended through the design process. This document is intended to show justification to and bring together both semesters into one compiled executive document.
Research Paper

The following is the initial research paper that fueled the final design project. This is the paper in its entirety:

**Landscape Architecture’s Role in Hard Rock mining Reclamation**

**Project Introduction**

Mining reclamation is an evolving process that includes many aspects of the Landscape Architecture discipline. Many people do not understand the time and effort involved in reclamation and the disciplines and technology involved. This research addresses these issues and illustrates how a landscape architect can contribute to the different aspects of mining reclamation. Reclamation is the reformation, rehabilitation, and restoration leading to use or recovery (Webster, 2015). With this definition in mind, this paper focuses on four research questions:

1. **What impacts do mining operations have on surrounding areas during operations and after closure?**
2. **Which stages of mining reclamation can landscape architects be involved in and how can they enhance the site to be more functional, natural, sustainable, and/or purposeful?**
3. **What existing and emerging technologies are used to reclaim sites efficiently?**
4. **What socio-economic and ecological benefits can the work of landscape architects bring to mining reclamation projects?**

The goals of this project are to answer the questions and find a role for landscape architecture in reclamation projects. Through a literature review and case studies design criteria will be generated for application to future reclamation site to be determined. This project will also show how mining reclamation can lead to more resilient landscapes when teams of engineers, landscape architects, and government agencies work together to create reclamation mining plans.

**Mining reclamation Introduction**

The products of mining in the US play an important role in our everyday lives. We mine for valuable minerals like gold, silver, and copper, and we mine for fuels such as oil and natural gas. Many people believe that mining is a major industry in the US, but it is actually one of the smaller industries, disrupting 0.02-0.1% of land in the United States (Miningfacts.org). Although this is a very small percentage of the land area, mining operations can dramatically impact natural systems, including wildlife habitat, water systems, and landform.

Although mining has been practiced for thousands of years, reclamation has been regulated and enforced by the government for only about 30-40 years through the Mining Reclamation Act of 1977. Historically many sites were abandoned and continue to cause injury or harm to humans and natural ecosystems. In the US today a reclamation plan must be presented in order to secure mining permits for most modern mining operations (Miningfacts.org, 2005). These plans often do not predict the final result but show good faith on the part of the mining company. The plan linked to the permit illustrates that there is a plan to reclaim and not abandon the site. More often mining companies reclaim disturbed landscapes to the standards established by the EPA and other government agencies. Often these standards result in landscapes far below their reclamation potential. Current reclamation activities are often heavily engineered with little consideration of natural eco types and native habitats. With that being said, the potential to bring
in Landscape architects and engineers is greatly needed to give the site some function and usefulness in surrounding landscape.

Methodology

The research for this paper is being done using case study examples and a review of related literature. There is a lot of books, journals, and peer reviewed articles that discuss mining reclamation. Early review of literature on mining reclamation showed many areas of concern for such projects. For the purpose of this project multiple focus areas were taken into consideration in these case studies that Landscape Architects could be involved in in the reclaim process. These areas include:

- Landform
- Site purpose/function
- Vegetation
  - Restoring native plant associations
  - Phytoremediation
- Habitat- restoring old or creating new native eco-type
- Storm water and erosion mitigation for sites under reclamation

Different resources were searched for information on mining reclamation and landscape architecture. Most sources have been obtained from google scholar and are peer reviewed literature articles, journals or books. However, some sources were obtained through different websites like EPA.gov or cornerstone magazine. Below is a summary of the literature reviewed chosen to best answer the research questions and areas outlined above.

Literature reviewed

There is a vast variety of literature on mining reclamation available via journals, books, articles and websites dedicated to different case by case reclamation. However very little literature on how landscape architects should be involved in the reclamation process although much of the literature reviewed states the need for a knowledgeable team focusing on landscape design and landscape performance. The literature reviewed offers several examples where a landscape architect may be able to offer some expertise in the areas listed above.

Site Purpose/Function

Estimates of abandoned mine sites in the US range from 300,000 to 500,000—and 100,000 of those are likely ripe for reclamation—but because reclamation costs often exceed net profits from mineral extraction, companies often declare bankruptcy rather than clean up after themselves (MIT, 2015). These numbers show an apparent need for good landscape design and planning in future years to come. While most mines have to have a closure plan before granted permitting for mining, if they claim bankruptcy the closure plan with potential reclamation in it is basically thrown out and it is typically up to the new landowner to decide if a reclaim is appropriate. However, most mining companies are good about returning the land to a safe level for humans and wildlife. Creating landscapes that provides for human health and safety is usually the highest goal (McKenna, 2002) when a company is closing. They take this responsibility very seriously due to the fact that there are approximately two dozen fatalities every year at abandoned US mines (Mine Safety and Health Administration, 2002). This shows that mines should not be abandoned and instead reclaimed or repurposed for other uses even though the concern for human health and safety is taken so serious by most operations currently today, it may be that we need to look into the abandoned mines and find a way to create safer more purposeful landscapes with them.
Landform and Landscape Design

With the statistics and numbers recognized above there is vast knowledge on how closed or closing mines can affect humans and wildlife, but little on what is appropriate for landscape design. Adams (1983) does a good job at giving various examples of landform and different principles of landscape design for the “typical” land owner. Carolyn Adams is a landscape architect and offers a LA’s point of view in the 1980s for reclaiming mining lands. She has strong recommendations on how to begin a plan and evaluate what the site needs with an evaluation form that any owner can go out and conduct on their land. She also recommends design elements and offers diagrams and pictures on what to do and what not to do in certain situations. This is a good example of what this project hopes to incorporate and in her article in 1983 does show and state that you may need to get different professionals help and opinions when reclaiming mine site. Most of the literature reviewed agrees that there is a need for better integration of professionals to form teams to get a reclaim done correctly.

Much of the literature is in agreeance that the landform is done, in most cases, pretty well or at least up to the minimum standards set out by government agencies in accordance to safety and hazard regulations. Sources also agree however that landform is typically much engineered with little to know thought of aesthetic value to how they reform the disturbed land. Adams again offers various input and diagrams on how to form different features using tailings piles or left over overburden.

Vegetation

Vegetation in reclamation plays a large role for any project. Revegetation of mining activities is one of the most advanced technologies reclamation has to offer, however, it is also one that is severely lacking unique approaches. Most stakeholders are concerned about having sites that have good, self-sustaining vegetation – for most people, lush greenery is a significant indicator of good landscape performance (McKenna, 2002). That statement shows a lack of concern for reclamation performance as a whole. To think that most mines are only concerned about establishing a green lush landscape is a rather concerning thought.

Typically mines achieve this by introducing a mixture of native and nonnative grass and legume species. These are more represented by an agricultural cover crop than what once was in the area. Due to high expenses in laying cover soils to promote healthy growth most mine reclaims are direct seeded on mine wastes or tailings and due to rapid germination and spread of grasses and legumes this helps with erosion stabilization but gives large open fields that have no design or function for future users, unless heavy grazing might be the end use.

Most sources agree that green lush areas prove good performance but also think that landscape performance should not solely be judged on lush greenery. Biro and Georgescu (2000) state that areas allowed to naturally invade is better than those formally reclaimed and revegetated. Some regulatory agencies (e.g. Alberta Environment, EPA, and a few state agencies) are restricting mines to using native species and requiring patch-like mosaics of plantings to produce more sustainable and diverse vegetation and wildlife habitat (McKenna, 2002). Regulators often prefer local native species for revegetation because native species are better adapted to local conditions, wildlife are adapted to native vegetation, and there are concerns about introduction of exotics into native ecosystems (Oil Sands Vegetation Reclamation Committee, 1998). Although the regulators push for use of native species and natural reclaims it is tough because very few areas in the world actually have a reclamation standard that requires that. Mines typically use the grasses and legumes because they are cheap and establish fast which is a quick way to stabilize cut banks and prove that they have met the minimal standards.
Creating forested and shrub areas are especially lacking in mine reclamation. Most mines are not required to plant trees and few that have attempted to push themselves on the verge of bankruptcy. Planting thousands of trees is very expensive and not necessarily required by any law or regulatory action so mines typically do not. Some do a very good job of planting thousands of saplings to try to reestablish areas once covered in forest land. Although this is an expensive action most sources agree it would be a good idea to incorporate some tree and shrub patches within the reclamation site.

There is a knowledge base and substantial research being conducted to evaluate how vegetation performs on completed reclamation. Research continues on many sites across the globe to see what works best in different situations. Various revegetation technologies have emerged and most mines practice the more successful technologies. One of these is series reclamation, where owners are able to reclaim sections of a mine during the operational lifespan of the mine. This works well because the reclamation team can judge the vegetation performance and enhance it over time. Some mines install a test plot to see how well the selected plants perform or make monitor growth, coverage and other parameters from already reclaimed section to guide them in their subsequent planning. Since serial reclamation is beneficial and many mines practice this method, it is an opportunity for landscape architects to become involved in reclamation as the team leader or member planning, designing, developing construction documents and monitoring the vegetation aspect. Through interdisciplinary effort, revegetation could be enhanced to produce higher levels of landscape performance than have been evident in the past.

Habitat

Habitat is closely related to the choices made in the revegetation phase of mined lands. During operations wildlife and ecosystems are often completely decimated on the sites. Mine operators don’t want wildlife around when operating machinery and but they also do not want to kill the native species. Most mines are securely fenced so large mammals cannot gain access. However, stakeholders and landowners realize that the presence of wildlife is an indicator of good landscape performance of the reclaimed site, but there is little guidance on how to design reclaimed landscapes to create permanent wildlife habitat (McKenna, 2002).

Reclamation efforts have attempted to restore habitat. Some have planted what have been called "ecosites". These are patches mimicking the range of natural vegetation and topography (Bissonette, 1997). The ecosite patches are often just a temporary measure without long-term habitat value. Creative and researched based habitat restoration solutions are necessary to replace the expedient revegetation techniques now employed. According to McKenna using local traditional environmental knowledge is an untapped resource. Johnson (1992) says that traditional environmental knowledge tends to focus on plants, ecology, and restoring the land’s spirituality. Incorporation of this knowledge in preparing landscape designs to construct the landscape would require an alternate design methodology but may be important to successful reclamation at many mine sites.

Storm water

Storm water management is a factor in any landscape design, it is especially important in the mining industry due to the increased runoff and the contaminants in it. Storm water is often handled very well during mining operations. The EPA establishes pollution discharge levels appropriate to local environmental conditions and human health hazards. The EPA then issues the mine discharge permits allowing the discharge of polluted water below these levels. Even very small variations from the pollution discharge permit can generate fines that can accumulate daily. There...
are many new stormwater treatment technologies that the landscape architecture profession is developing that could be used in both mining operations and reclamation of sites after closure.

Mining and environmental engineers typically produce storm water treatment areas that are heavily engineered but meet the standards set by regulatory officials for the control of runoff during the operations stage. Many sources claim that water draining from the mining site during operations is actually cleaner than water from natural runoff, since most mines have elaborate treatment systems. Some mines have, or plan to, incorporate wetlands (Mckenna, 2002), such as free water surface marshes as part of their treatment sequence. New environmental engineering research illustrates that other wetland technologies successively treat mine drainage (Whitehead, 2005). As with planning for revegetation a pre-mining assessment of the geology and geochemistry of the ore, as well as a post-mining study of the mining waste, biogeochemical reactions, ore processing and local climate are key to successful planning of operation and post-operation stormwater treatment. Nassim Md Anawar (2015) developed a model to guide these assessments. This decision model is supported by the characterization of

Some are even looking into different types of wetlands that can act as bioremediations for everything from sediment, to acid, to salts and metals. A novel approach is the co-treatment of coal mine drainage, after closure, with sewage treatment in free water surface wetlands (Younger, 2014). The treatment of storm water can be greatly enhanced by creating a team of engineers, planners, and landscape architects among various other parties.

Case Study examples

There are many good and bad examples in the United States of mine reclamation projects. This section will review two case studies that are very popular and relevant today. These two more popular mining reclamation are The French Gulch Reclamation site, located outside of Breckenridge Co. in Summit County, and Chambers Bay Golf Course, home of the 2015 US Open located in University Place, Washington. These two sites were mined for different materials but both are good examples of how a disturbed site can be repurposed and functional in the act of reclamation of mining lands. French gulch was a heavily mined area in the Rocky Mountains for gold using various techniques such as stripping, dredging, open-pit/cutting (form of placer mining), and underground load mining. Chambers Bay was strip mined and was previously used as a sand and gravel quarry operation for many years.

Case study 1: French Gulch and Wellington Neighborhood

Location: Town of Breckenridge and Summit County, Colorado.

Objective: To clean up heavy metal contamination from the Wellington-Oro Mine in and around French Gulch, and to acquire mining company property for community open space and affordable housing.


Summary: French Gulch is located in the Rocky mountain range east of the town of Breckenridge, Colorado. This area was heavily forested and the French Gulch stream was filled with cutthroat trout and created native riparian habitat for much of the areas native wildlife. In the 1850s the Colorado gold rush began to flood the area with many miners. "Extensive placer and underground lode mining occurred in French Gulch from the late1850s to the 1960s. Placer-gold mining began in French Gulch in 1859 with small gravity-separation operations; the dredging operations that
followed continued until the 1940s. The dredging operations resulted in forty to fifty foot high piles and ridges of cobbles and gravel size placer tailings throughout the valley floor. Underground lode mining began in 1889 and continued through the 1960s. The underground mines typically produced high-grade zinc-lead-silver ores, as well as some gold ores. Underground mining left numerous shafts, adits, waste rock, and tailings throughout the Gulch” (P-Rex, 2015).

One of the largest mining operations in the area was called the Wellington-Oro mine company. It began working in the area in the early 1900s and by 1934 consisted of over 12 miles of underground tunnels (Little, 2005). With all this area and the remanence of early mining operations from abandoned sites there seemed to arise an issue in the gulch. This issue was the devastation of riparian and aquatic habitat in the area and high concentrations of chemicals from operations virtually annihilating the fish and aquatic life in the stream below them. With the loss of fish and other aquatic species beginning to be noticed a concern of elevated concentrations of lead, arsenic and other wastes could potentially pose a threat to human health and safety of the town of Breckinridge. "By 1995, federal and state agency officials had compiled enough information about the environmental destruction at the French Gulch mine site to begin cleaning it up, and were considering listing the Wellington-Oro Mine as a Superfund site to gain access to the funding they knew it would require. That caught the attention of local officials. They feared a repeat of the top-down and often harrowing Superfund process that was playing out in nearby Leadville and other historic mining communities. From a local perspective, the EPA imposed mandates that often stripped small towns of power and limited their choices. To prevent that, Breckenridge and Summit County leaders organized to help gather information, identify funding sources, and develop cleanup strategies. They called themselves the French Gulch Remediation Opportunities Group, shortened to FROG in a droll reference to the historic name of the creek that was their focus. FROG’s first goal was to address water quality and other environmental issues stemming from the mine” (Little, 2005).

FROG began to form a team of professionals to clean the area and reclaim sites. A Developer stepped in seeing a need for affordable housing in the area and they began planning to reclaim mine sites to an affordable housing sector and create usable outdoor space in the area for wildlife and recreation. The average cost of a single family home at that time in Breckinridge was around 725,000 dollars. The community saw this as an issue and wanted to make sure that local hard working individuals could stay in the area at affordable rates, thus, the Wellington Neighborhood was planned and developed. "The result is Wellington Neighborhood, a compact community of 124 homes with pitched roofs and Victorian details in keeping with the historic style of Western mining towns. Eighty percent of the homes are reserved for people who work in Summit County, and sell for around one-third the cost of the median-priced housing in Breckenridge. A 20-acre area is designated green space in the development that stresses connections within the community, to neighboring Breckenridge, and to the backcountry B & B mine property beyond. The Town of Breckenridge and Colorado Planning Department won an EPA 2002 national Smart Growth Achievement award. Wellington Neighborhood also won a Sunset Magazine Western Home Award” (Little, 2005). The town and county and forest service have since reclaimed numerous abandoned sites in the Gulch and are aiming to set the standard for what can be done. They have created various new riparian habitats, fish have returned, they completed a water treatment plant in 2008 (P-Rex, 2015), and have brought in the P-Rex team to create a landscape plan for the neighborhood and the environment that will benefit everyone in the area.

This is a great example of how experts in different fields have come together to make reclamation of a mine devastated area acceptable and purposeful. It shows what a good plan of action can come to be and how landscape architects can get involved with reclaiming projects in multiple ways. It was a strong effort that took a lot of years to realize the problem but is leading
the way in showing what reclamation is capable of with the right resources and cohesion of experts in different fields.

Case 2: Chambers Bay Golf Course, University Place, Washington

Location: University Place, Pierce County, Washington (Puget Sound)
Objective: Master Site Plan in 1997 to govern the reclamation and restoration of various property on the shoreline for the benefit of the public and native habitat for the unique area that is the Puget Sound
Participants: Pierce County Parks and Recreation along with Public Works and Utilities, Pierce County planning, Robert, Trent Jones II (Golf Course Architect)

Summary: Chambers Bay is a unique area located in the state of Washington on the Puget Sound. Located in Pierce County by University Place, Washington, the area offers a variety of opportunities for public land use activities. This area has a very unique history as described by Pierce County website:

“The first settlers of the area were the Steilacoom Indian Tribe, a small group of Puget Salish speakers who lived along the east shore of Puget Sound in the current location of the Town of Steilacoom. An ancient summer fishing village was identified in the southern-most portion of the area within the historic entrance to Chambers Bay. The arrival of the Hudson Bay Company and its Puget Sound Agricultural Company (PSAC) in 1832 was the start of the European settlement in the area. Fort Steilacoom, built just south of the properties across Chambers Creek, was the PSAC headquarters and commercial trading settlement until it became a US Army outpost established to help keep the peace following establishment of the Canada-US Boundary in 1846. Many of the historic fort buildings are still in existence today.

Industrial development of the region began in the 1850s with grist mills and small-scale timber activities supporting nearby agricultural and lumber mills. In the early 1890s, the federal government selected Pacific Bridge Company to construct Fort Casey, Fort Warden and Fort Flagler, strategic military locations guarding the entrance to Puget Sound. Pacific Bridge was one of the two fledgling gravel mines operating on the site where the Chambers Bay golf course now lies. Subsequent owners over the next century enjoyed the rich gravel deposits found there. By 1992, Lone Star Northwest had merged all the gravel mining into the single largest producer of sand and gravel in the nation. Large scale mining continued until December 2003 when commercial mining ended and reclamation of the Chambers Creek properties began.”

This is a well-organized plan of reclamation by the county. They brought on Robert Trent Jones II to design a world class golf course at Chambers Bay that has various awards and was the first course in the Pacific Northwest to host the 2015 US Open. The course has won many awards including: Golf Inc. Development of the Year, Golf Course Industry Builder Excellence Award, Best New Course, and the Audubon International Certified Silver Signature Sanctuary Course. Apart from the golf course the master site plan has implemented, full restoration of habitats and enhancement, miles of trails, and public access and recreation. They have expanded the regional park to 930 acres and plan to restore and develop more opportunities as funding continues to come in.
Major success of this reclamation can be attributed to the hard work and dedication of the County officials. They did a good job of realizing the potential for the area and seeking the right advice from various experts on what that potential could be. They did well at offering a wide variety of options for the public and this is where the success lies, by reclaiming and repurposing the lands to public access and not private, creating one of the most unique regional parks in the US today.

Other Cases of Successful Mine Reclamations (Examples from Cornerstone Magazine)

Ereen Mine, Mongolia

Mining site in northern slopes of Mongolia, reclaimed by Peabody Energy with consultant reclamation expert Vern Pfannenstiel. Unique opportunity to work with native people to produce a useful site. They did not reclaim it to native habitat but instead decided to repurpose it to farm use for the native people. Cost around one million US dollars but they were able to convert the 44 acre mine to grassland for livestock and hay production and give the people freshwater supply source that was not available in the area previously in the form of a well that separates the communities and livestock’s water.

Huehnerwasser Catchment at Welzow-South Coal Mine, Germany

Open pit coal mine successfully filled in with regional sediment, and given a natural grade. The unique opportunity and success of this reclaim is that it has never been seeded, instead it was left for a natural ecosystem to develop on its own. There are various scientists, foresters, ecologists, and soil scientists studying the natural growth of the native ecosystem to see what species come out of this minimalist approach. They have been able to observe and take not producing over 70 published papers about the site development and ecosystem since its beginning in 2005 and will continue to do so in the course of the 12 year study currently being done.

Northumberlandia, Newcastle, England

This is a very successful reclaim in England. It is considered a restoration first to many people. Landscape Architect Charles Jencks was the lead designer of this new park which he designed using material excavated from the mine to create a public park shaped like a nude woman. The park opened in 2012 and is one of northern England’s most visited attractions which is free to enter. This shows what a landscape architect is capable of visualizing for a reclaim and how he was able to repurpose the site for public use and enjoyment.

Recommendations for LA Roles

There is a lot of evidence that shows how landscape architects can by utilized on a team of reclamation experts. Through the case study and literature analysis one can determine that there is a need for a variety of expertise in mining reclamation. The initial areas of interest can all include the role of a landscape architect. Certain firms are niche experts in many of these areas of interest. Landscape architects can and should be included all aspects of the mining reclamation process. They have input that is valuable to any team.

The first stage of mining reclamation is having a closure plan. Engineers can begin this plan but may need assistance in how the plan will function after closure. Landscape experts can help in the preliminary planning stages by researching the site history and recommend better options for restoration of habitat and ecosystem functions. Most landscape architecture firms work closely with conservation specialists and different plant and animal experts on large scale projects.
already, so would in turn have the connections they need to help the mining companies create a plan of action for post closure operations and designs. The planning stage can be a lengthy time consuming part of a reclamation but would provide jobs for landscape architects over the course of the mine life. This could be a good opportunity to be involved and know the site in and out from the beginning of mining to the final stages of closure, creating a position that is new and unique to the landscape architecture profession. This would also save the mine time and money in the long run due to the fact that they would have the advantage of focusing on mining and be able to leave the architect and team in charge of stage reclamation during the life of the mine, or in laymen’s terms kill two birds with one stone, as in mine for minerals in one area of the site and begin reclamation in another area.

Once the mine is closed, whether it is out of money, material, or resources of any sort the landform stage is next and considered one of the more important parts of mine reclamation. Often mines have numerous steep slopes or sheer drop offs left over from operations. Typically one can spot a mine reclamation from miles away due to the rather engineered landscape and design. Landscape architects are trained in landform practices and the right ones can create blended slopes and land features from piles of overburden and tailings that seem more natural to the site. The engineers and landscape architects will have to work closely together to make sure that erosion and runoff are controlled appropriately and the site is safe for future use, e.g. human and wildlife.

Once the slopes and landforms are taken care of on a reclamation site the revegetation planning is the next largest step. The literature reviewed and case studies showed how important this step is in the reclaim process. This tends to be the least lacking area of reclamation that is due for some change. Landscape architects and environmental/conservation managers can play a large role in this step of the process. With the right research and knowledge of the area these reclamations can be restored to native vegetative cover and habitat or a new ecotype can be introduce that is site appropriate. Currently nonnative agricultural cover crops, grasses, and legumes are being introduced to areas, they typically would not be, but are due to their fast germination rates and spread. While this may be appropriate in some areas of the United States where grazing and agriculture is largely used in most cases this just introduces invasive nonnative species to the area that is not good for human use and especially native ecosystems. Thus, this area proves to play one of the most key roles in the reclamation process and again the right team should be used to get the vegetation correct and appropriate for the area.

Closely related to the revegetation of a reclaim is the habitat which one intends to introduce to the site. This is managed a little better than the vegetation but habitats tend to be temporary for animals that are native to the area. Typically they keep sections of the mine natural for the animals to live in but animals tend to be attracted to operations and often mines deal with animals on site during the life span of the mine. This can be due to a number of factors but mostly due to the fact that the animals have lived there for so long they do not want to leave the area. After a mine is closed the natural habitat and native species need to be recognized. The animals want a place to live and survive and we can enhance their native habitats greatly with restoration designs or even create new habitats that other ecotypes can move into like in case study examples of the housing development and forest restorations of Colorado offering new habitats for aquatics, fauna, and human. With that being said many landscape architects are more than capable of designing functional sites that benefit wildlife and human aspects so the opportunity in habitat revitalization/restoration is vast for any LA or reclamation team.

The final area of interest for this research is the storm water area. This is an evolving niche for many landscape architecture firms and environmental engineers. The engineers have the knowledge to ensure that the storm water is treated up to environmental standards as well as the landscape architects, but the architects can give it a style that fits into the regional topology. Many
Storm water treatment facilities are heavily engineered and look out of place. There are many examples today that landscape architects have rehabilitated wetlands and other storm water segments to look more natural but perform just as well if not better than an engineered one. This give opportunity to select appropriate vegetation, habitat, and landform all in one and with the new era of the green technologies movement, will play a key role in future mine sites during operations and for a reclaim or restoration. The major factor in storm water and wetland design is to figure out if the design will actually be functional and useful for the site and how much water each system is capable of holding and treating and whether or not the treatment will meet regulations and performance standards typically set by the EPA.

The literature and recommendations show that landscape architects can play a large role in multiple phases of a mining reclamation process. It is recommended that for the purpose of this research that landscape architects should be involved in these steps if not in the whole process from start to finish. Mines will always need to be reclaimed as we continue to mine from precious resources. Recommended roles for LAs include but are not limited to:

- Consulting on closure plans
- In depth research on area and affected region
- Landform design and restoration
- Site purpose and function planning and design
- Habitat recommendation and restoration
- Vegetation and ecosystem selection (case by case)
- Storm water treatment and management designs

This is not suggesting that the landscape architecture profession should be solely responsible for all aspects of mining reclamation. However, there would be more benefits to the use of landscape architectural knowledge and expertise in reclamation projects. The major recommendation for mining reclamation that this paper is suggesting is these areas that Landscape architects should be involved in and can help improve upon. However, the need for well-organized multi-professional teams should be the major focus of any mine reclamation. The success and use of a reclamation site is heavily dependent on a well-organized multi-faceted team who work together to make the area functional, safe, and regionally appropriate, if this is done we can see a dramatic increase of scared land rehabilitation and useful reclamations.

Criteria for designs

This section covers criteria which the research has led to suggest is appropriate for a mining reclamation project. The above section outlines where landscape architects would fit into the reclamation process the following will describe recommended design criteria when choosing a site and doing a master plan for a reclamation site. This process will be used to determine an appropriate site and design for next semester’s project for the landscape master’s program. It has been determined through the research that the best protocol for design criteria is to set the process out in multiple steps to get a completed design the following is those steps and criteria.

Step 1: Site Location and Suitability Study

Appropriate site selection is important in any design. With an estimated 100,000 plus mine sites ready to reclaim there are plenty of options for a landscape architect to choose from. The first step in the process is to choose a suitable site location. This will be done by conducting a GIS analysis of potential candidates in the western United States. Mines will be located on a map and multiple layers will help to determine the best candidate for a reclamation. Aspects such as land cover, population density, historical data, and wildlife habitat will be considered. To select the most appropriate site for the project end user use will be considered among the highest priority. If
a mine is close to large populations of people the function and safety of the site will be heavily considered, thus, different locations and options for reclamation will be considered based on the GIS suitability study and site selection. The project will focus on reclaiming a hard rock mine site, e.g. gold, silver, coal, or precious minerals that are mined by strip or open pit mining operations. This type of mining was chosen because they tend to degrade the land the worst and are in more need of reclamation attention for this project.

Step 2: Preliminary Planning and Design

Once an appropriate opportunity is determined the preliminary planning process can begin. This step on of the most important processes for a mining reclamation. In depth research of the area will be conducted to determine the most applicable design for the site. During the historical data collection and functionality study a site inventory and analysis will be conducted. The case study examples show there are vast options for a reclamation project. It is up to the reclamation team to determine the best use for the end result of a selected site. Adams (1983) describes this step well in her article. To summarize:

1. State the objective of the project
2. Inventory and evaluate landscape conditions
3. Identify potential problems and opportunities for site and adjacent areas (residential, community, etc.)
4. Determine planning and design objectives
5. Identify alternatives that would accomplish objectives
6. Assess each alternative

Once the preliminary planning occurs and the suitability of the site end use is determined preliminary designing can occur. This should be done by drafting ideas and roughly designing each alternative.

Step 3: Design

This step will generate a master plan for the site. It would take into account all the preliminary planning and research to create an appropriate reclamation site. The plan will closely follow design principles for the areas of interest outlined above which are: landform, site purpose and function, vegetation, habitat, and storm water and erosion mitigation.

Landform is a good starting point for reclamation. This step is often done well in mine closure to create safe and stable slopes, however, it is often heavily engineered and offers little variety and functionality for future use. The land needs to be engineered but also designed to blend in with the surrounding areas. The shape of a reclamation site and contours of the land often depict a large scare on the earth’s surface and there is a unique opportunity for design to enhance how the landscape looks. The site purpose and function will ultimately determine the landform aspect as well. It is up to the reclamation team or designer to choose the best most useful option for the reclaim project. This project is considering a reclamation project of a hard rock mine that would resemble a nature preserve with recreational and educational opportunities about wildlife habitat, native restoration, and mining history and education if possible, this is not the only option and the reclaim will be site specific for best end use once a site is selected. Vegetation selection will be a case by case situation as well. The vegetation should enhance the site, natural plant design schemes should be used. This will offer a variety of plants and habitats for wildlife to enjoy. It is largely suggested that native plants be incorporated into a design and should be used in a project such as this. Vegetation variety in turn promotes different habitats and ecosystems on a site. Depending on the site selection one should consider offering multiple habitats for the native species in the area. These habitats could include large mammals like deer and elk, or riparian and
aquatic species if there is appropriate areas for wetlands, ponds, or streams. Finally storm water design and new technologies should be considered. Research shows that new technologies are lacking but often storm water management is gaining popularity on operating and closed sites. If appropriate these new integrated systems should be considered for site design.

**Step 4: Master Plan**

The final step is to produce a master plan. This plan will include all the aspects of the designer’s research and ideas. The plan should be site appropriate and create a functional, well designed space for the end use, and selected users’ enjoyment. Grading, drainage, plant selection, and the overall form and function on the site should be shown to generate excitement for the project and gain final approval from stakeholders or investors backing the reclamation project.

**Conclusions**

Mining will continue to be a valuable aspect of our society for many years. We cannot create these valuable resources in laboratories, thus we will continue to seek them out of the earth and mining reclamation will be necessary to clean up the effects of mining. This land can be reclaimed to enhance the environment and create valuable and functional sites that are safe for humans and wildlife. With hundreds of thousands of abandoned sites the opportunity to reclaim is vast and should be sought after. While mining is considered a small impact on our land use in the US it can and does affect our everyday lives and each mine plays important roles in affecting its surrounding areas environment during and after closure. If a reclaim is done correctly and planned and designed properly the effects on the surrounding area can be very positive. There are multiple examples outlined in the paper that show how landscape architecture could play a key role in multiple stages of mining reclamation projects and should begin to become involved in the process. The right team of experts should be assembled for reclamation projects and with a variety of knowledge and expertise reclamation could make a turn for the better. Sites should be carefully researched to create site appropriate area suitable designs that are not only safe, but also serve a purpose and are functional for the end users. With the right considerations and designs mining reclamation can offer a niche market to many firms around the US, and by getting teams of experts together new technologies and standards can be produced to show the people that mining reclamation can be unique and worthwhile.

**From research to Site Selection**

Consideration of all the research and information obtained was utilized when seeking out a site for a planning process.

- Multiple sites were considered for design for the project
- Wanted to select a site that had real life applications
- Many discussions with mine managers led to choosing a site that I was very familiar with
- Golden Reward, in the Black Hills of South Dakota was selected
Golden Reward Site Context

LOCATION AND HISTORY.

The Golden Reward gold mine was established in 1887 on a claim staked ten years earlier at the peak of the Black Hills gold rush. The mine is located at the base of Terry Peak, 4 miles south of Lead in the northern Black Hills. The Black Hills was home to some of the most well-known names of the old west such as wild Bill Hickok and Calamity Jane, who lived in the historic town of Terry for most of her life where the Golden Reward mine resides today. The only remnants of the town of Terry are the Terry cemetery which rests an estimated 120 souls, and some building foundation remains and the occasional pan or other typical artifact found from an old town site. The cemetery has been focus of concern for many years since large scale operations began in the late 1980s concluding in 1996 with an estimated production of approximately 280,000 ounces of gold and 365,000 ounces of silver between 1989 and 1996 according to Wharf Resources, which is currently owned by Coeur Mining.

GEOLOGY AND SOILS.

The Black Hills geological setting consists of an elongated dome, about 60 miles wide by 120 miles long, that was uplifted from the surrounding plains approximately 60 million years ago. The uplift consists of a core of Precambrian metamorphic and igneous rocks surrounded by Paleozoic and Mesozoic sedimentary rocks. Tertiary igneous rocks have intruded both the Precambrian and Paleozoic rocks in the northern part of the Black Hills.

Soils native to the area are consistent throughout the Black Hills in the conifer forest habitat. These soils mainly consistent of gravelly silt loam profiles with average good topsoil depth around 6 inches. Topsoil depth of on the golden reward site varies from 4 to 12 inches throughout the entire site but native soils used to cover the tailings used for pit backfill promote healthy growth for native and invasive species. These soils are a mixture of Hisega loam, Goldmine loam, and Grizzly very gravelly silt loam which were stockpiled during the stripping of the mine, thus mixed together.
and used for backfill. Current mine operations to the north for Wharf are readily available for use at golden reward.

**RECLAMATION.**

Reclamation efforts of Golden reward were begun after closure of the mine in 1996. Pits were backfilled with native soils and tailings from operations and average depth of good topsoil added to site averages around 6 inches which is typical for the region which contains mostly gravelly silt loam profiles typical of the region and conifer forests of the hills.

The reclamation efforts at golden reward have been a long process. To simplify: when a mine opens they need a closure plan, which shows in good faith they have plans to create a healthy safe environment and do some form of reclamation. After closing Golden Reward was put on bond which holds them liable for reclamation efforts until state standards are reached. In 2009 Golden reward liability was lifted from 400 acres of the site and since has been monitored and almost another 10 acres have been removed from the bond. This is one of the few examples where mining reclamation by a company has been greatly successful for getting release from a state bond and Coeur Mining takes pride in their reclamation and land stewardship efforts.

**VEGETATION.**

The company did extensive research on habitat and ecosystems around the site, as well as having a relatively successful revegetation rate of grass lands and native shrubs. The reclamation shows a good effort at establishing plant communities but has little effect on integrating the mine land with the surrounding areas. Woody plants were hand planted and seeded in different plots as shown but there is no major indication of purpose with plots of plants other than to establish barricades around high walls and to stabilize some slopes. Some natural occurring stands of ponderosa pine
and white spruce/aspen/birch mix were saved from clearing as seen in the central northern areas around the cemetery and to the south in patches as well.

IDENTIFIED LOCAL VEGETATION HABITATS

The Black Hills is home to over 12 native Tree species, certain habitats were identified in the surrounding area for a baseline report the major habitats included and consist of:

**Ponderosa pine—creeping juniper**
- The dominant shrubs in the understory included creeping juniper, common juniper (Juniperus communis), kinnikinnick (Arctostaphylos uva-ursi), and Oregon grape (Mahonia repens).
- Common grasses that were present within the understory included prairie sandreed (Calamovilfa longifolia), green needlegrass (Nassella viridula), Kentucky bluegrass (Poa pratensis), and Sandberg bluegrass (Poa secunda).
- Common forbs that existed within the understory included western yarrow (Achillea millefolium), field chickweed (Eravestrum arvense), northern bedstraw (Galium boreale), and golden banner (Thermopsis rhombifolia).

**Ponderosa pine—common snowberry**
- The dominant shrubs in the understory included: common snowberry, kinnikinnick, creeping juniper, and Saskatoon serviceberry (Amelanchier alnifolia).
- Common grasses and grass-like species included Sandberg bluegrass, prairie sandreed, smooth brome (Bromus inermis), rough-leaved ricegrass (Oryzopsis asperifolia), and Ross sedge (Carex rossii).
- Common forbs that were present included western yarrow, Virginia strawberry (Fragaria virginiana), and Mountain blue violet (Viola adunca).

**White Spruce**
- Dominant shrubs that were present in the understory included common snowberry, Saskatoon serviceberry, gorse whortleberry (Vaccinium scoparium), and chokecherry (Prunus virginiana).
- Green needlegrass and smooth brome were the common grass species present, along with common forbs such as heartleaf arnica (Arnica cordifolia) and bluebell bellflower (Campanula rotundifolia).

**Quaking aspen—birch**
- The dominant shrubs in the understory included woods rose (Rosa woodsii), Saskatoon serviceberry, and wild raspberry (Rubus idaeus).
- Common grasses included prairie sandreed, rough-leaved ricegrass, smooth brome, green needlegrass, and western wheatgrass (Elymus smithii).
- Forb species that were most abundant included false Solomon’s seal (Smilacina stellata), dogwood (Dyssoxia papposa), fetid marigold (Dyssoxia papposa), and wild lily-of-the-valley (Maianthemum canadense).

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<table>
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<td>Rocky Mt. Penstemon</td>
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TOPOGRAPHY

Topography is an important aspect of mining reclamation. Most states require a minimum of a 3:1 slope for regrading finished landscapes that will have potential for future use on site unless the master plan is approved for something different as long as it doesn’t have the potential to cause injury to humans and can withstand rapid erosion.
Master Plan Development

ISSUES/PROBLEMS

Review of the site context produced the opportunities outlined in the paper for landscape architects to help improve upon and repurpose the reclamation. Although the Golden Reward site has been one of the most successful reclamation sites in the state, there is a need from stakeholders and general public for improvements to the site. Coeur mining provided extensive data and literature on the Golden Reward site and have even expressed that they are looking for ways to improve upon the site. The scale of this site offers unlimited opportunities once it is clear for development in the future. The major issue with any reclamation site is deciding on how what the end use is going to be. There is a need for thorough consideration of the land, natural systems, human implications, and socio-economic and ecological systems. This site also included issues such as: The site is well developed from a REQUIRED reclamation stand point and has potential to be a unique feature in the area.

- Many people are concerned with aesthetics of the site as it currently sits
- Coeur Mining is looking for a solution to enhance the environment and surrounding economy
- The site is lacking a functional use currently and sits as an empty underutilized space which happens to most of these reclaimed mine sites
- The main issue here to resolve is giving this site purpose and function

This is a great space for a landscape architect to repurpose.

OPPORTUNITIES AND CONSTRAINTS AT GW

Opportunities:
- General consensus for a more aesthetically pleasing landscape
- Prior reclamation practice and success promoting healthy vegetation base
- Multiple use types and areas in site
- Partnership with largest ski resort in the state
- Open canvas for multiple ideas
- Historical and educational experiences
- Natural habitat restoration and enhancement
- Outdoor recreation (hunting, fishing, winter sports, and trail system)
- Proximity to Mickelson trail

Constraints:
- Difference in opinion on site function
- Zoning and permitting
- Bond holds on land
- Money and time Private and public land ownership

GOALS TOWARD A PLAN OF ACTION

- Create a design that couples human and natural systems and promotes interactions between them
- Add economic growth opportunities for the area
- Showcase the uniqueness of the Black Hills region
- Promote partnerships with adjoining land owners
Enhance and create opportunities for native species of plants and animals to establish ecotypes throughout the site

CONCEPTUALIZING TO MASTER PLANNING

When conceptualizing the end use of the site multiple situations were considered. Both have opportunities to promote different aspects. Concept 1 is a strongly conservation approach restoring the site to dense forest much like the surrounding areas of the Black Hills national forest with limited trail systems throughout for human use. Concept 2 was a look at how to maximize profits with residential and mixed use developments with little recognition of habitat and wildlife. Neither concept touched on all of the major goals for this project so the master plan is a combination of the two promoting a more natural system but also providing multiple levels of human interaction and enjoyment.
CONCEPT 1: CONSERVATION/RESTORATION
CONCEPT 2: ECONOMICAL APPROACH
Master Plan

GOLDEN REWARD MASTER SITE PLAN
Master Plan Elements

HABITAT DIVERSITY

Baseline reports were conducted by the mine and certain wildlife and plant habitats were identified on and surrounding the current site. The Hills are dominated by ponderosa pine habitat typically on steep slopes and higher elevations. Secondary to ponderosa stands in the Hills are white spruce and the unique black hills spruce stands. These are typically mixed with other dominant species of aspen and birch in certain areas. Natural streams and ponds on site provide for unique riparian habitats also. The plan was intended to mimic the hills and provide a diversity of vegetative habitat and wildlife habitat. Ponderosa stands are in green, spruce/aspen/birch stands are more blue green.

HUMAN INTERACTION AND CIRCULATION

There is a variety of opportunities for outdoor recreation and wildlife viewing via the human corridors. Trails include: hiking, mountain biking, x-country skiing, equine, snow mobile and downhill skiing. The intention of trail design was to allow for multiple use activities as well as keep human corridors and animal corridors combined and separated for animals to feel more secure when human activity is dense on site.
GRADING

Grading is important to all sites. Although the state requires 3:1 grading the plan doesn’t always allow for that such as in nature. The park is graded to showcase how a 3:1 slope can be implemented into design on sections of the tiers.

Side by side comparison to original grade of mine to master plan
Master Plan Features

CENTRAL PARK AREA

The park is the central focus for the master plan. This park is designed to be a showcase of Black Hills native species and habitat. Its form was designed to illustrate an engineered open mine pit typically designed in tiers which step down gradually. The form was inspired by researching open pit mines and it is a play on modernistic design with linear form and hard angle geometry which causes visitors to slow down and stop in spaces. Each tier is designated habitat for different native woody species found within the black hills. It is a play on an arboretum for the Black Hills. The grading was designed to show the required minimum slope of 3:1 in different sections the woody shrub areas are 30 feet wide with a 10 foot vertical change. The goal is to educate people on mining reclamation and to function as a showcase of native woody species to the area. The following are the major tree species native to the area found in each section of the park with a smaller tier of appropriate understory shrubs listed earlier in the vegetation section of the site context. Ponderosa tier would combine the two natural understory types.

Pine tier
- Ponderosa pine
- Limber pine
- Lodgepole pine

Spruce tier
- White spruce
- Black Hills spruce
- Colorado blue spruce
- Norway spruce

Deciduous tier and stream meadow
- Paper birch
- Willow
- Bur oak
- Hawthorn
- Green ash
- Crab apple
CASINO/RESORT

Terry peak is one of the most popular destinations in the Black hills for visitors in the winter. This plan gives opportunity to experience the area year round and a resort that is closer to the mountain will help create a space that people can stay in year round boosting income to the area and allowing jobs. Deadwood and lead are popular casino towns as well and an addition of another casino here is an option as well.

SKI RUNS AND HIGHWALLS

Extensions of little hope and red chair lift runs as well as two brand new runs for the mountain leading to a new lodge and recreational visitor’s center. The high walls can further enforce history of the site with one containing a historic mine shaft which can be viewed from the lodge, and the large wall and field can be used for large outdoor events as an amphitheater. The large field offers gentle slopes for sledding or tubing and large gatherings.

Relating Research to Design

This section is the process of how I used the research to relate it to the design principles utilized for the master planning of the site. The paper broke down areas of concern for current reclamation practices that could be improved upon by landscape architects, and also recommended roles LAs can be a part of in the whole process of reclaiming mined lands. There were two important approaches to consider when this site was selected. As a designer you have to see multiple option for a site like this. One may ask is the site so far from restoration that it needs to be repurposed and not restored or after reviewing site conditions and appropriate uses is the site design choice appropriate and functional for end use results. Many sites to be reclaimed be them mines, brownfields, or other degraded landscapes cannot always be returned to prior states. My intent was to enhance an unused site and repurpose it so that ecological systems economic benefits and human interaction could potentially couple and interact in an interesting landscape. The end result is felt to do such things. A summary of how each role and area of concern from the research in relation to the master site plan is addressed below.

COMBINING OF AREAS OF CONCERN AND ROLES IN RECLAMATION TO THE MASTER PLAN DESIGN PRINCIPLES AND LAYOUT

Areas of concern for reclamation were found through the initial research and the roles recommended for landscape architects to take are closely related to these areas of interest. The areas of concern are:

- Landform
- Site purpose/function
- Vegetation
  - Restoring native plant associations
  - Phytoremediation
- Habitat- restoring old or creating new native eco-type
- Storm water and erosion mitigation for sites under reclamation

While the Roles LAs could take are:
- Consulting on closure plans
- In depth research on area and affected region
- Landform design and restoration
- Site purpose and function planning and design
- Habitat recommendation and restoration
- Vegetation and ecosystem selection (case by case)
- Storm water treatment and management designs

The follow is justification of each and how they were expressed in the master plan design.

**Consulting on closure plans**

This project was treated as if I was involved in a closure plan and reclamation process. I theoretically played the role of lead designer for the site after reclamation standards had been obtained for Golden Reward. This project was a good example at how a closure plan could be enhanced and accepted by utilizing teams of multiple professions.

**Research of area and affected region**

The area of GW and the surrounding area and region were heavily researched for this project. Luckily I was very familiar with the region context of the site but also was able to obtain multiple sources of information about the site and surrounding areas through contacts at the mine, internet publications, and local knowledge of myself and friends and family. By looking at the research I was able to come up with one solution that would help not only the mine, but also to allow for human and natural system coupling, provide opportunities for new economic factors, recreation, and ecosystems. The site is very large and there needed to be a balance of all the factors to justify a repurpose and function for it.

**Landform**

The form of the land on this site was one of the most unique variables for me to work with. I was given the topography of the mine as it was during its final year of operation and also a draft of what it was after closure. I decided to incorporate natural land form and the engineered mine aspects to showcase different parts of the master plan and also provide educational value about mines and reclamation to the site. Although standard of 3:1 slope was not created at every juncture of the site we know from nature that this is not the case either, thus I wanted to tie the mined topography and naturally occurring landscape topography into one coexisting unit. The showcase park was an attempt to show mines what could be possible in a pit area by taking into consideration the required minimum 3:1 slopes for the understory vegetation sections of the tiers. (See grading section above)

**Site Purpose/Function**

The project’s intent was to allow this large unused site to be used for multiple areas of interest. Overall this site offers multiple functions and uses that are intended to enhance human and wildlife benefit. The human aspect of the master plan incorporates trails for multiple recreational activities. The site is not intended to be fully restored to a natural state. Instead multiple functions were chosen that would ultimately justify the design. These functions incorporate education, economical, ecological, and recreation. Education is found on site through various aspects. The park is designed to educate people on native vegetative associations of the black hills as well as educating how mining reclamation can be done for pits with the required landform standards. The site also educates by showing historical high walls which were saved or repurposed to show how
mining is done in the hills. The Casino offers a large economical function as well as being roughly designed to mimic a typical mine pit as a play on showcasing the rich mine history of the area. The ecological factors incorporate strategic plant associations and animal corridors. The recreational opportunities are vast as well. These create partnerships and revenue for the site with future application through ski fees and South Dakota trail fees.

Vegetation and Habitat

Vegetation and habitat typically go together in any design process and consideration. The Golden Reward vegetation was selected to enhance habitat. Initial thoughts were to provide an elk preserve, but after more research it was felt that more species would be able to utilize the site based on vegetation habitat types. There is a variety of habitat types which are all intended to function as small ecostites and with proper management and allowed growth they could be individual ecosystems on the site. The park vegetation, as previously explained, was intended to showcase the unique woody species of the black hills region. Natural mountain meadow corridors dominate the site, with Ponderosa and spruce/deciduous habitat to attempt to restore what would naturally occur in the area.

Storm water and Erosion Mitigation

Storm water was handled well on the site prior to master planning. Well monitoring is in place as well as surface water monitoring to make sure that the mine is not polluting natural systems. Storm water collection for the old heap and leach pads was altered in the form of the showcase park. The PMP pond was redesigned to fit into the more naturalized setting and a stream and riparian mountain meadow area was added for further filtration. The pond can still be accessed by Terry Peak ski resort for snow making. Filtration will occur with the added plant scheme to the site and for years with extreme amount of precipitation that floor of the showcase park is intended to handle flooding and overflow. Added benefit will be filtration of storm water going into the PMP pond. Extreme slopes were viewed and vegetated with typical native plant associations to reduce erosion.

Concluding thoughts

Overall this project has been a learning experience

Many issues and massive amounts of data were sorted through to come up with a solution to create a functional valuable site both economically and ecologically.

This is one solution and idea to showcase native habitat, historical events, and educate people on mining in general.
Appendix

SUPPORTIVE DRAWINGS

PARK WALK PERSPECTIVE

RESORT PERSPECTIVE
HIGH WALL AMPHITHEATER PERSPECTIVE

SOUTHERN END PERSPECTIVE
Before and after

VIEW FROM TERRY PEAK PERSPECTIVE
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Special thanks to Ron Waterland of Coeur mining for collection and sharing extensive information on golden reward