SUSTAINABILITY WORKBOOK

Understanding the impacts of facility relocation and operation

ABSTRACT

A sustainability toolkit and key recommendations for the integrated redesign of municipal shop and roadwork facilities in Butte-Silver Bow County, Montana.

Columbia | Sustainability Management Capstone

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CLIENT

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EXECUTIVE SUMMARY

Butte, Montana is simultaneously the largest Superfund clean-up site and the most extensive *National Historic Landmark* in the United States. As part of the ongoing clean-up, the city's maintenance shops (and potentially their asphalt plant) will be relocated away from their current site along the former course of Silver Bow Creek. BSB's maintenance shops are used for vehicle storage and fueling, fleet logistics, routine maintenance and washing, and major repair services. The asphalt plant includes a rock crusher, hot-mix asphalt blender, areas for asphalt feedstock storage, and areas for sand storage (used to de-ice roadways). Relocation is necessary so that underlying soil can be remediated, and the creek re-established.

BSB has targeted these pending civil projects as an opportunity to turn away from utilitarian industrial design, and pivot toward urban renewal by viewing the relocation project(s) through a sustainability lens. To support BSB, a literature review, desk-based research, site visit, and interviews with BSB employees were completed. Results are summarized in this workbook and its contents, a site selection rubric, limited stakeholder mapping, and a searchable research compendium.

Five candidate sites were assessed using an adaptable site selection rubric that considers relative impacts of 10 key criteria covering technical, environmental and social feasibility. Scores are based on a stop-light analysis (i.e., high, moderate, or low impact) with adjustable weighting factors. Because the candidate sites are spread across city (and in one case, outside the city) relative impact on travel times was also assessed.

Opportunities to improve sustainability performance were identified for in lighting, water management, HVAC and ventilation and space management. Case studies are provided for each of these operational topics, including pros, cons, and applicability to BSB. In addition, opportunities for improvement in energy resource management and roadway fabrication (and maintenance) are described, along with applicable case studies.

Two preliminary frameworks to facilitate stakeholder engagement were developed: (i) a conceptual view of stakeholders interested in the location and design of BSB's shops and asphalt plant, and (ii) a guide to help BSB assemble public information and education tools.

This workbook is designed to be updated by BSB throughout the lifecycle of their re-location projects as more information becomes available.

1.0 INTRODUCTION

1.1 ABOUT THE CLIENT

Butte, Montana is simultaneously the largest Superfund clean-up site and the most extensive *National Historic Landmark* in the United States. Its national significance relates to a long mining history -- Butte's copper production was critical to industrialization -- and played a key role in development of the US labor union movement. However, mine tailings and other byproducts can be found in most areas of the city as a consequence mining practices of the late 19th and early 20th Centuries. These areas, along with the Berkeley Pit, which dominates the local landscape, require remediation.

As part of the ongoing clean-up, the city's maintenance shops will be relocated away from their current site along the former course of Silver Bow Creek. Relocation is necessary so that underlying soil can be remediated, and the creek re-established. Similarly, the city's asphalt plant ultimately may be redesigned and relocated as part of Silver Bow Creek's restoration. (Note that the *City of Butte* and *County of Silver Bow* are governed jointly.)

1.2 OBJECTIVES AND SCOPE

Butte-Silver Bow (BSB) is in the process of redefining its relationship with its mines, its environment and its economy. BSB has targeted these pending civil projects as an opportunity to turn away from utilitarian industrial design, and pivot toward urban renewal by viewing the relocation project(s) through a sustainability lens. As part of its relocation planning effort, BSB requested insight and support from Columbia University's *Sustainability Management* Program. Hence, this Capstone project was developed. The objectives of this Capstone project are to:

- Identify and focus on aspects of the relocation project(s) that offer opportunities to enrich sustainability;
- Identify and describe case studies where applicable sustainability initiatives have been implemented successfully;
- Develop a planning tool (i.e., this workbook) that helps guide BSB through the pre-design and procurement phases of their project;
- Provide an easy-to-use, searchable resource with relevant information on each phase of BSB's project; and
- Build flexibility into the workbook tool so that BSB can adapt it for future projects.

The Capstone was designed to mimic BSB's relocation project phases, including:

- Site Selection;
- Design and Operation of Facilities; and
- End Use (i.e., Roadway Design and Maintenance).

The Capstone team conducted a literature review and desk-based research, visited BSB from March 26-29, 2015, and conducted information-gathering interviews with city employees in order to gain insight into the needs of the county and planning department. Deliverables for this project include:

- This workbook and its contents
- A site selection rubric
- A stakeholder mapping
- A searchable research compendium

Results are summarized in Sections 3 through 7 herein. Applicable references are included at the end of each section. Selection of a suitable site or sites for the relocation project(s) was quickly identified as a critical need. Therefore, in collaboration with BSB, five candidate sites were identified and evaluated. A customizable rubric for site selection was then developed. The rubric was subsequently transmitted to BSB under separate cover for use on future projects.

Given the sensitivity of this project, the Capstone team was unable to interact directly with many of the stakeholders affected by the project. Instead of collecting primary data and conducting a stakeholder analysis, the team conducted a preliminary stakeholder screening exercise, which can be found in Section 8.

1.3 COLLABORATION WITH MONTANA STATE UNIVERSITY

Throughout this project, students from *Montana State University's* undergraduate architecture program, under the direction of Professor Bradford Watson, collaborated with the Capstone team. Their invaluable work and support are incorporated herein.

2.0 BACKGROUND

2.1 REGIONAL SETTING

BSB sits in the Rocky Mountains at the Continental Divide (Figure 2-1). The city's core drains to Silver Bow Creek -- which, at one time, was engineered to serve as BSB's metro storm drain. Silver Bow Creek empties into the Clark Fork River, which in turn, is part of the Columbia River watershed. Because of its ecological importance, the channel is being transformed back into a creek that begins a 25-mile greenway extending from BSB to Anaconda, Montana. In addition to ecological value, restoration of the creek will also provide an outdoor community amenity that can be leveraged for tourist appeal.

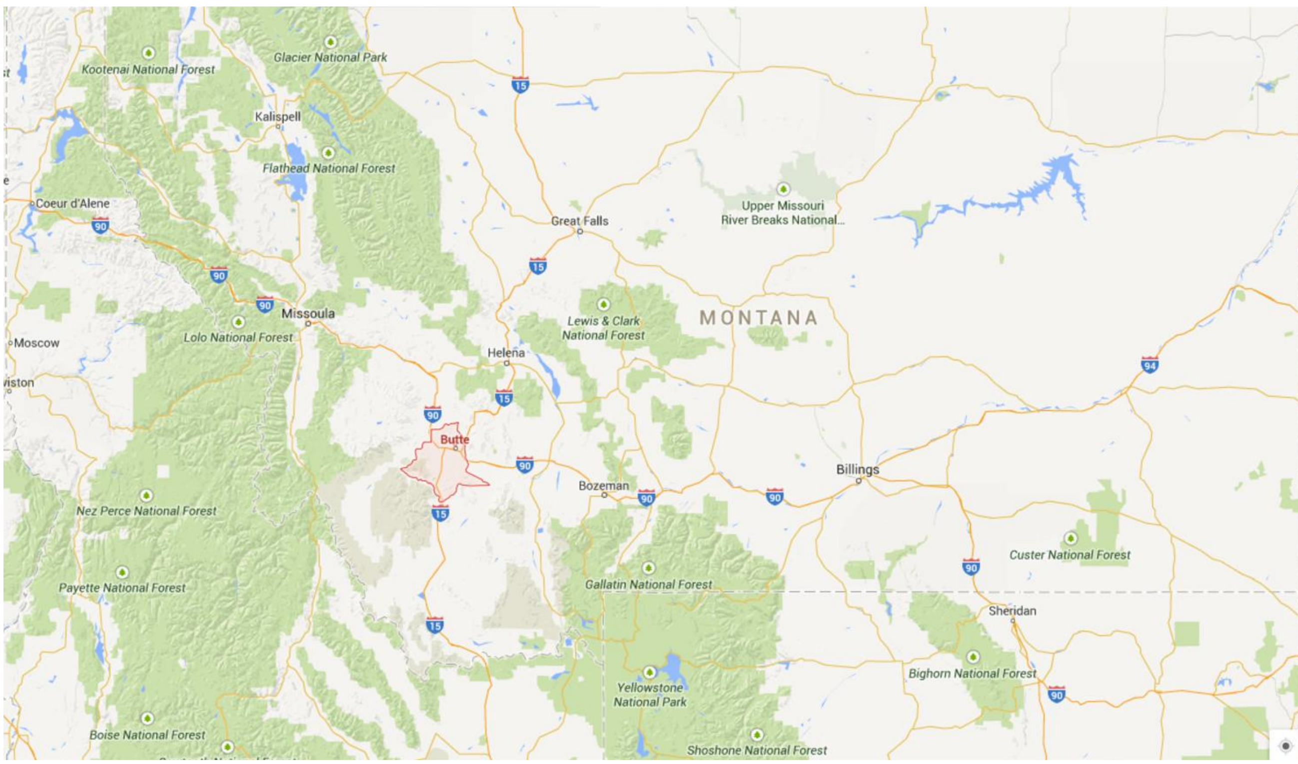

Figure 2-1 Butte Location Map

As a result of historical mining activities, area groundwater contains elevated concentrations of metals and other mining wastes. Groundwater in areas where mine tailings were landfilled is particularly degraded. In addition to tailings, waste rock and other mining debris were historically used as fill. These waste materials have largely been removed from residential areas (where appropriate). However, in commercial and industrial areas, remedial measures typically included installation of a soil cover to prevent exposure to mining waste, and prevent surface water runoff from accumulating waste materials. Thus, land use and storm water management are key considerations for any BSB development.

2.2 CURRENT OPERATIONS

BSB's *City Public Works Shops* are also known as municipal shops, county shops, and maintenance shops, and hereinafter are referred to as "shops." They cover approximately 12.5 acres in the northeast part of the city, between historic Uptown and the more residential Flats (Figure 2-2). Based on information provided by BSB, the shops include the following facilities:

- Vehicle Services
  - Service and Wash Bays
  - Painting and Welding Bays
- Storage Rooms (e.g., parts, tires, tools, stock oil/ fluids, repair manuals)
- Heated Vehicle Storage
- Fueling Station
- Administration Offices
- Employee Facilities/ Staff Rooms (e.g., training, lunch area, rest rooms, locker room)

BSB's vehicle fleet includes asphalting machines, heavy construction vehicles, snowplows, vacuum trucks, street sweepers, buses, light, medium and heavy-duty trucks, and police cars. In addition to storage and fueling, work performed at the shops includes fleet logistics, routine maintenance and washing, and major repair services (e.g., painting and welding). The shops are described more fully in Section 4.

BSB's asphalt plant is located in the central part of the city, adjacent to I-90, and also sits between Uptown and the Flats. It covers approximately 17.5 acres, and includes a rock crusher, hot-mix asphalt blender, areas for asphalt feedstock storage, and areas for sand storage (used to de-ice roadways). Based on information provided by BSB, current operations are described in Section 5 and summarized in Table 2-1 (below).

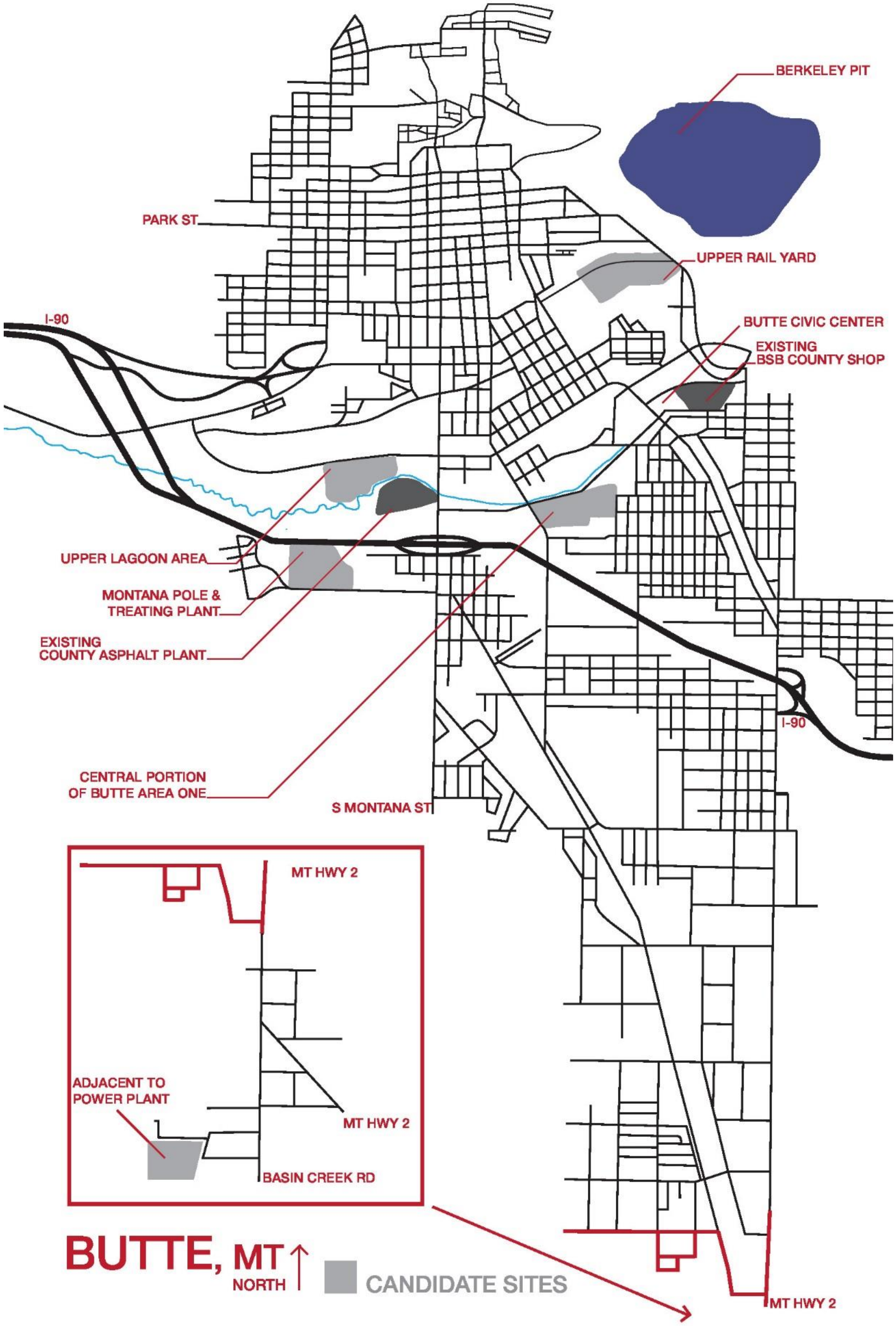

Figure 2-2 Butte Layout and Candidate Sites

Table 2-1. Facility Inventory

Function	Current Operations
Asphalt Paving	• 9,000 tons of asphalt each summer; 15,000 tons planned for 2015 • Four trucks making 2-3 trips from the plant per hour during paving projects • Water trucks and other metro trucks make 2-3 trips per hour for other summer projects
De-icing Sand	• Haul in sand for 3 full weeks during summer to stockpile street sand for winter • Sanding during storms yields 64 individual trips/ day/ snow storm
Topsoil and Gravel Stockpiling	• 1,500 cubic yards of topsoil stockpiled on site • 1,500 cubic yards of road mix gravel stockpiled on site

3.0 SITE SELECTION

Maintenance shops and an asphalt plant are crucial to BSB's day-to-day operations, and these operations are most effective and efficient when they are located within or near their service areas. Before selecting a site, however, a broad spectrum of issues must be carefully considered so that BSB's overarching objectives are achieved. To help facilitate BSB's site selection process, a qualitative assessment tool (i.e., rubric) has been developed. This rubric is a high-level screen of important criteria that the BSB community has considered or will consider as part of site selection. This section of the workbook describes:

- Five candidate sites for either the maintenance shops, an asphalt plant, or both;
- The rubric used to assess each site's adequacy; and
- The screening results

3.1 SELECTION PROCESS AND RUBRIC

Five candidate sites sufficiently large enough for BSB's planned maintenance shops and/ or asphalt plant (Figure 2-2) were screened utilizing a pros/ cons approach to help differentiate them. For example, whereas BSB's current layout and its zoning plan include centralized industrial areas, industrial operations carry a negative stigma when trying to preserve the city's historical charm. Similarly, additional traffic burden from maintenance shops and/ or an asphalt plant will exacerbate congestion at nearby intersections, and traffic conditions will dramatically impact service response times and fuel costs. Conversely, siting municipal facilities too far from their demand areas incurs operating costs that may overwhelm the benefits of a distant location.

The rubric is based on the following principles:

- Both project feasibility and opportunity to improve sustainability are vital;
- Site rankings are qualitative, based on our understanding of BSB' landscape of issues, and are intended to facilitate BSB's comparison of site's suitability;
- Highly detailed siting issues can be grouped into a manageable number (i.e., less than a dozen) of representative criteria;
- To the extent practical, interrelationships between criteria are ignored (for example, changing *Ecosystem Impact* will not automatically change *Sustainability*); and
- Each criterion is weighted equally, although weighting factors could be adjusted as new information becomes available.

The rubric, its categories, and brief descriptions of each category are provided in Table 3-1. The rubric compares, on a relative basis, negative impacts that could result from operations of

BSB's maintenance shops and/ or asphalt plant. For each site, each criterion is assigned a rank of 1-3. For the purpose of this evaluation, a score of 1 (i.e., low) implies very little risk of impact from future operations. For example, storage of dry goods represents relatively low risk of impact, whereas hazardous materials storage represents a higher risk. Criteria ranks are then added so that each site's total score can be compared.

TABLE 3-1. Site Selection Rubric

Type	Criteria	Description	Potential Results
Technical Feasibility	Schedule	Level of effort to acquire parcel	High = 3 Moderate = 2 Low = 1
	Design Constraints	Level of effort to convert parcel for development	High = 3 Moderate = 2 Low = 1
	Overnight Cost	Cost to obtain and convert a parcel	High = 3 Moderate = 2 Low = 1
	Accessibility	Distance to infrastructure and heavy roads	High = 3 Moderate = 2 Low = 1
	Sustainability	Level of effort to implement BMPs/ alternatives	High = 3 Moderate = 2 Low = 1
Environmental & Social Feasibility	Stakeholders	Likelihood of community backlash	High = 3 Moderate = 2 Low = 1
	Ecosystem Impact	Potential to impact sensitive eco-receptors	High = 3 Moderate = 2 Low = 1
	Emissions/ Dust Impact	Potential for emissions/ dust to impact neighbors	High = 3 Moderate = 2 Low = 1
	Noise/ Vibration Impact	Potential for noise/ vibration to impact neighbors	High = 3 Moderate = 2 Low = 1
	Visibility	Level of effort to make attractive	High = 3 Moderate = 2 Low = 1
Lowest Negative Impact = 10. Highest Negative Impact = 30.			

Several of the candidate sites are impacted by past industrial activities, and are listed on US EPA's *National Priorities List* (NPL). Sites on the NPL are known colloquially as Superfund sites because, unattended, they represent excess risk to human health and/or the environment. These sites were included because redevelopment of Superfund sites represents an opportunity to return a parcel to productive/beneficial use. Accordingly, remediation status was factored into the screening process.

3.1.1 Limitations

The site selection rubric is weighed against a fictional baseline wherein the site would be occupied by low-impact development such as a residential building. Restated, it is assumed that residential land use would score differently than commercial or industrial land use. Similarly, industrial development likely will have design challenges that differ from a residential parcel of equal size (or complexity).

Notwithstanding the assumptions described above, it must be further noted that standard individual residential lots are substantially smaller than individual commercial/ industrial operations. For example, a 16-acre parcel (i.e., the size of the current maintenance shops) could have up to 64 quarter-acre residential lots. Because impacts from a single business operation is far easier to control, the maintenance shops *theoretically* could score better than the combined impacts from 64 residences throughout the rubric.

Therefore, when utilizing the rubric to assess site suitability, the following limitations apply:

- *Context* for the rubric's inputs and resulting scores must be carefully considered; and
- The rubric is a high-level screen and is not comprehensive; thus, stop-light scores (i.e., rankings) are qualitative, and should not be construed to represent detailed numerical risk analysis.

3.1.2 Summary of Results

Screening results are summarized in Table 3-2. Descriptions of each site and its potential pros and cons, along with site-specific screening results, are provided below. Note that scores should be reviewed and modified as new information becomes available.

Site Selection Summary
Sustainability Assessment of Relocated Maintenance Shops and Roadwork Facilities
Butte, Montana

Target Sites Candidate Site	**Central Portion of Butte Area One** Site #1	**Montana Pole & Treating Plant** Site #2	**Upper Rail Yard** Site #3	**Upper Lagoon Area** Site #4	**Adjacent to Power Plant** Site #5
Current Use	Undeveloped brownfield, unauthorized recreational area	Undeveloped brownfield, nearing final closure	Undeveloped brownfield, in O&M phase of remedy	Undeveloped brownfield, near industrial facilities	Undeveloped greenfield
Pros	Already cleared, flat, and suitable for building (pending excavation of upper soil column), central location	Large site, close to I-90	Good truck access, central location, some existing infrastructure, potential for greenway linking football field and gym	Central location, existing infrastructure, current industrial use	Zoned heavy industrial, large site, no adjacent sensitive receptors, opportunity to use waste heat from adjacent power plant, good truck access on SH 393/2
Cons	Located within Butte-Anaconda green corridor, conversion from (unauthorized) parkland to industrial is inconsistent with community's current land use	Access requires significant road upgrades, CERCLA remedy imposes design constraints, residential areas east and west	Highly visible viewshed, adjacent to community and health centers that attract both local and non-local visitors	Small site, adjacent to Silver Bow Creek, highly visible viewshed, interference with proposed I-90 exit	Four miles south of I-90, requires rail crossing, no historical development

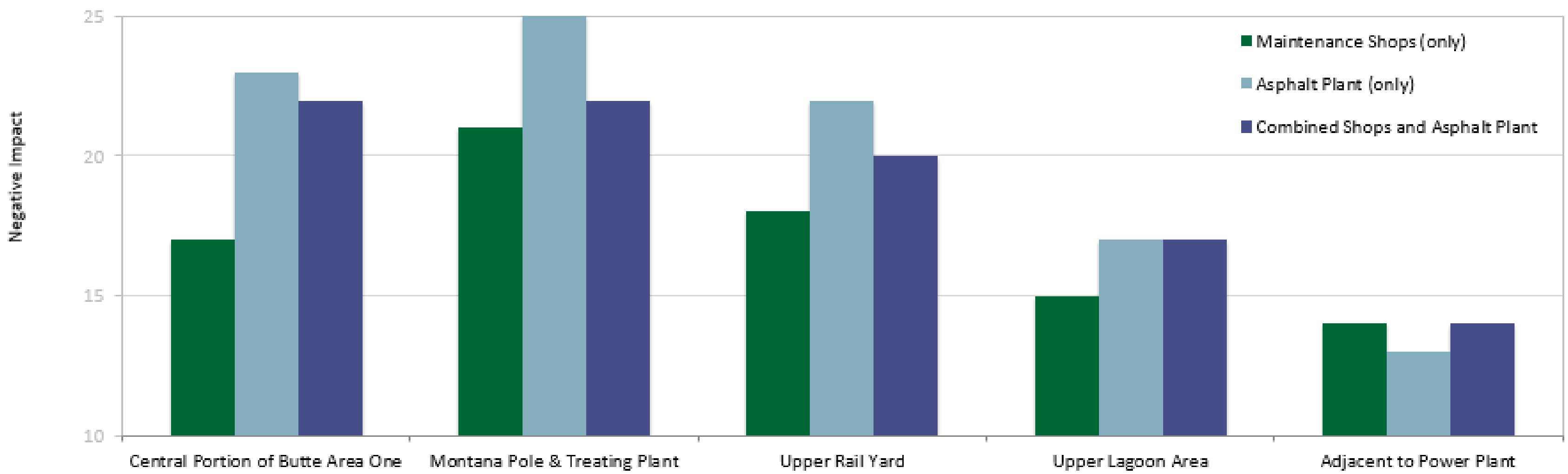

Table 3-2 Site Selection Results

As supplemental information, the relative impact on travel times for municipal vehicles was assessed, and is summarized below:

Candidate Site	**Impact on Travel Time Relative to Current Location**
Central BAO	Low Impact (i.e., rank of 1) centrally located between Uptown and the Flats
MPTP	Moderate Impact (i.e., rank of 2) closer to Uptown than the Flats
Upper Rail Yard	Moderate Impact (i.e., rank of 2) closer to Uptown than the Flats
Upper Lagoon Area	Moderate Impact (i.e., rank of 2) closer to Uptown than the Flats
Adjacent to Power Plant	High Impact (i.e., rank of 3) closer to the Flats than to Uptown; furthest from city center

3.2 CANDIDATE SITES

Of the many sites available for immediate relocation of facilities shops and subsequent relocation of the asphalt plant, several parcels stood out as worthy of closer scrutiny. These were the central portion of Butte Area One, the Montana Pole and Treating Plant, the Upper Rail Yard, the Upper Lagoon Area, and adjacent to Basin Creek Power Plant. Below, each of these sites is outlined and a detailed scoring of weighted criteria can be found in Appendix A.

3.2.1 Central Portion of Butte Area One

Candidate site #1 is the central portion of the *Butte Area One* Superfund site (a.k.a. Central BAO), shown in Figure 3-1. (Note that the entirety of Butte Area One is also referred to as *Silver Bow Creek Greenway*). Central BAO straddles both a historical wetland and a historical tailings impoundment. Central BAO is a 25-acre semi-rectangular parcel located in central Butte, just north of I-90/ I-15 and south of Business 90. It is bordered by George Street to the north, Kaw Avenue to the west, Cobban Street to the south, and Utah Avenue to the east. The area around this site is predominantly zoned as residential, with the exception of a commercial campground directly across Kaw Avenue.

Central BAO occupies a fundamental geographic node in the BSB community. Butte is bisected by I-90, separating historic Uptown areas to the north from suburban sprawl in the “Flats” to the south. Kaw Avenue is a north-south connector traversing underneath I-90, and Central BAO is near a key intersection north of I-90. Therefore, development may reinforce connectivity between Uptown and the Flats.

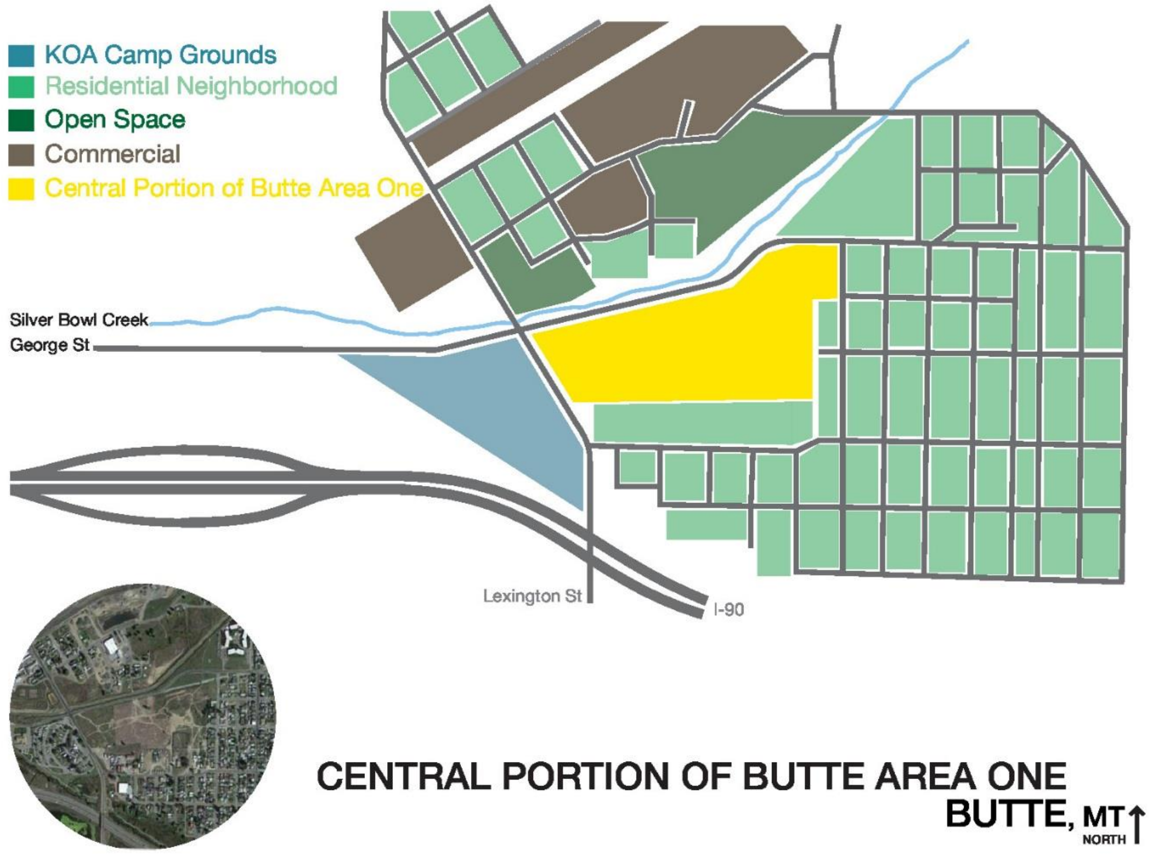

Figure 3-1, Central BAO

In addition, Central BAO is located near the confluence of Blacktail Creek and Historic Silver Bow Creek. Together, these two water bodies form the bulk of the *Silver Bow Creek Greenway*. In fact, the *Blacktail Creek Trail* is a recreational facility north of the target parcel along the Historic Silver Bow Creek. Current use of this trail, together with unauthorized recreational use of Central BAO, drives this parcel's ranking to be relatively high (i.e., high potential impact).

Screening results are provided in Appendix A (Table A-1). Based on screening results, it appears that Central BAO may be suitable for light industry and heavy commercial use, but likely is unsuitable for heavy industrial applications (e.g., asphalt production).

3.2.2 Montana Pole & Treating Plant

Candidate site #2 is the 60-acre *Montana Pole & Treating Plant* (MPTP) site, located at 202 West Greenwood Avenue, just west of South Montana Street and south of I-90 in a transitional urban-rural part of Butte (Figure 3-2). As a result of historical wood treating operations that were separate from local mining operations, MPTP was added to the NPL in July 1987. Wood treating compounds and their breakdown products impacted surface soil, subsurface soil, surface water, and groundwater. Importantly, these compounds also seeped into Silver Bow Creek, which is located off site, adjacent to the northern MPTP boundary. To date, several remediation phases have been completed, including:

- Limited (albeit large scale) soil removal;
- Construction of a Land Treatment Unit (LTU) to stimulate biodegradation in soil; and
- Installation of on-site monitoring and pumping wells, as well as a treatment system for recovered groundwater on a separate parcel north of I-90.

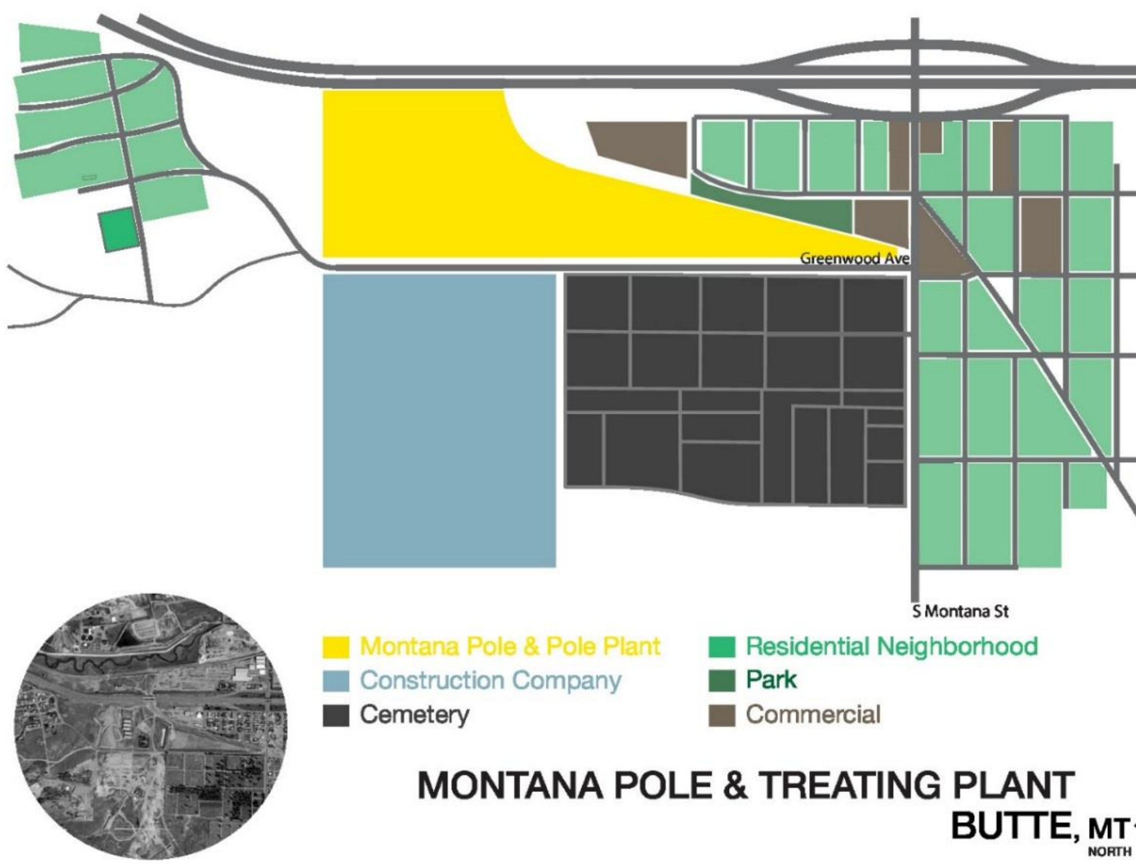

Figure 3-2, MPTP

Additional activities are being planned in anticipation of final closure. Pending closure activities will likely include (a) consolidation of soil from the LTU that does not meet treatment goals into an on-site capped landfill, and (b) long-term ground water monitoring. As a result, land use constraints and institutional controls (e.g., access for post-remedy monitoring) will be required by Montana DEQ and US EPA. In addition, because MPTP is so close to Silver Bow Creek, rigorous surface water runoff controls from any industrial operations on site will be needed.

MPTP is adjacent to a residential area that includes some intact housing and a cemetery; in this context, siting a noisy, dusty, and unsightly asphalt operation at MPTP might create unnecessary conflict within the community. In addition, MPTP is near a high-traffic transportation node studied previously [Ref 3-1]. In summary, this traffic area is near capacity. Therefore, light/ heavy industrial re-development near this interchange may add to the existing traffic burden, or ultimately, could alleviate traffic burden if additional infrastructure is funded and built.

Screening results are provided in Appendix A (Table A-2).

3.2.3 Upper Rail Yard

Candidate site #3 (Figure 3-3), the Upper Rail Yard, is part of a 54-acre commercial property owned by BNSF Railway Company. The candidate parcel and surrounding area is commonly called the warehouse district and is zoned for heavy manufacturing land use. The Upper Rail Yard is southwest of the Berkeley Pit, bordered by Shields Avenue to the east, Madison Street to the north, East Second Street to the south, and South Arizona Avenue to the west.

The candidate site is a linear terrace separated from an upper terrace by a 5%-grade (or, in places, greater) slope. The upper terrace includes an indoor/ outdoor recreational facility. The Upper Rail Yard and the terrace above have been remediated and are in post-closure monitoring. Remedial measures at the candidate site include a vegetated cover to prevent exposure to underlying soil and, in one area, an asphalt cap. At times, surface water runoff from the upper terrace erodes the Upper Rail Yard's remedial cover.

The terrace below the candidate site has an active rail spur. Notably, the candidate site and terrace below (with the rail spur) are part of a single land parcel.

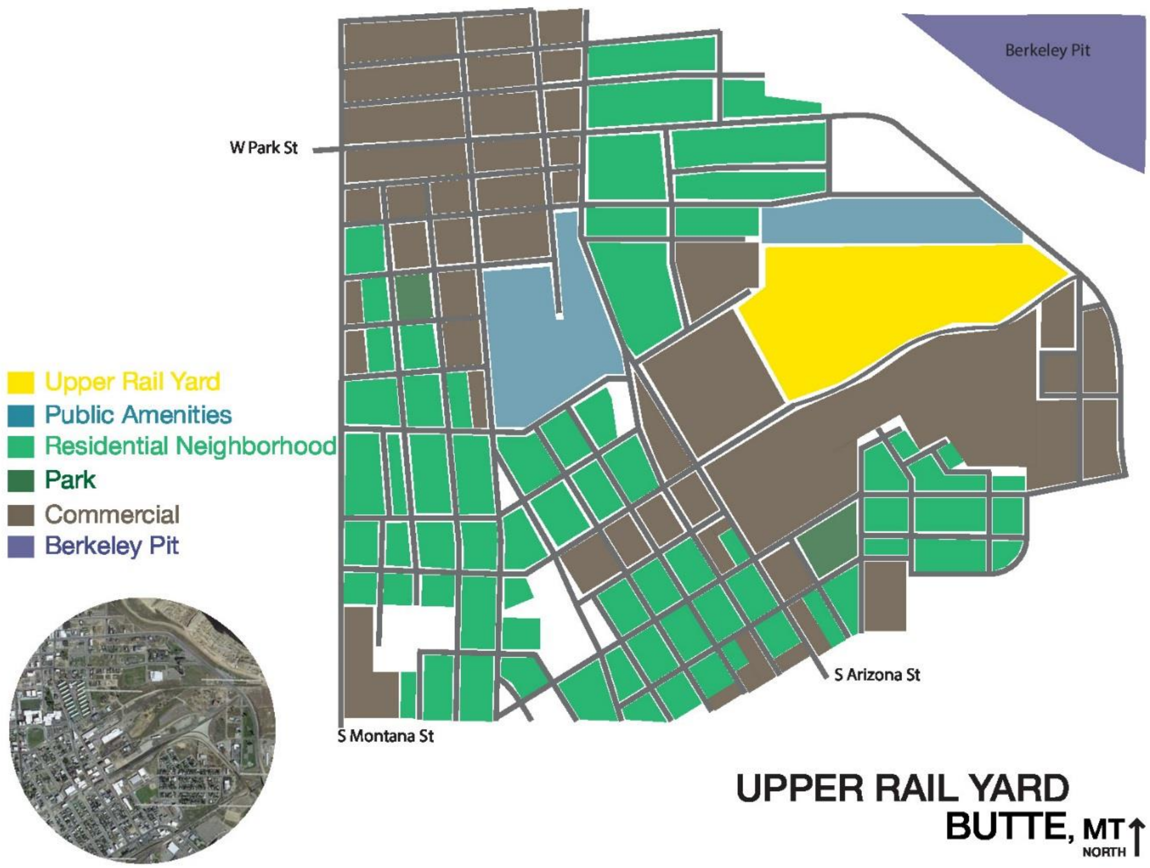

Figure 3-3, Upper Rail Yard

Because this location has good access to central roads, it is attractive for municipal/ public works operations. However, the Upper Rail Yard is in direct line-of-sight of a nearby residential community; thus, stakeholders located nearby and down gradient of the Upper Rail Yard may oppose industrial development.

Screening results are provided in Appendix A (Table A-3).

3.2.4 Upper Lagoon Area

Candidate site #4 is adjacent to BSB's water treatment facility, located at 830 Centennial Avenue, just on the north side of I-90, opposite of MPTP (Figure 3-4). The Upper Lagoon Area is directly upstream of the water treatment plant and adjacent to the north bank of Silver Bow Creek. This site was part of early remediation efforts at the greenway, and its upstream proximity to the water treatment plant makes it attractive for co-locating heavy industry near a major transportation node. The Upper Lagoon Area occupies 40 acres of flat lowland; however, it is not clear how much of that parcel can be developed. If the entirety of the area is not available due to other land use constraints, then additional parcels across Centennial Avenue may be needed. (Both the asphalt plant and the municipal shops occupy parcels larger than 10 acres each.) Development plans may be hampered by the steep grade of those parcels (greater than 5%) and potential construction of an interstate off-ramp 2,000-3,000 feet north, at South Excelsior Avenue.

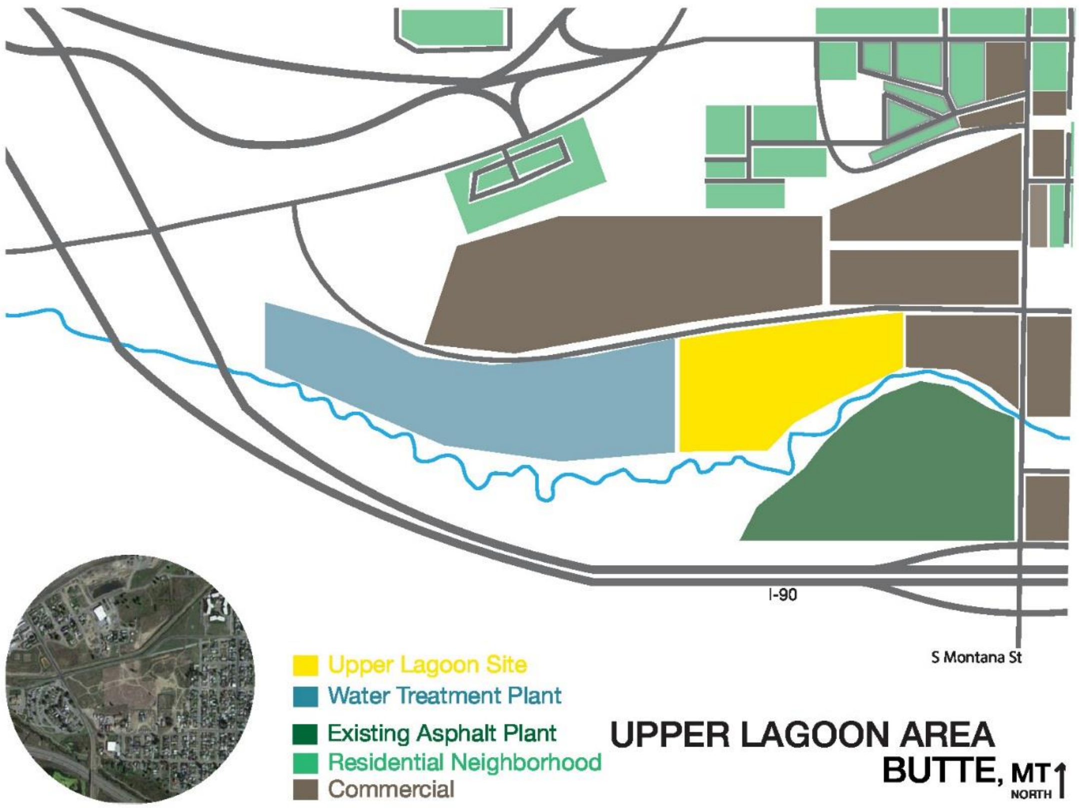

Figure 3-4, Upper Lagoon Area

Development at Upper Lagoon Area likely would have little impact (i.e., rubric score of 16), and offers exceptional opportunity for facility co-location and industrial campus design. However, risk of releasing hazardous substances into Silver Bow Creek, thus and overwhelming the water treatment plant's capacity, should be carefully weighed before proceeding with developing this location further. For example, local stakeholders that are concerned with waterways restoration may perceive the risk to be unwarranted. Also, compliance with environmental permitting requirements needed for the maintenance shops' fuel underground storage tanks and the asphalt plant's aboveground storage tanks may be burdensome.

Screening results are provided in Appendix A (Table A-4).

3.2.5 Adjacent to Power Plant

Candidate site #5 is immediately south of Northwestern Energy's power plant at Basin Creek, which is located at 200 Technology Way, just west of Basin Creek Road and State Highway 2 (Figure 3-5). It is a 60-acre vacant owned by Butte Local Development Corporation (BLDC) in an area known as the Butte Industrial Park. The candidate site sits atop a hill (less than 1% grade) straddling two drainage streams - Sand Creek and Basin Creek - both of which drain into Silver Bow Creek four miles downstream. The parcel is abutted by a railroad on its eastern boundary. The railroad easement creates a convenient barrier for surface water runoff that is directed northward into a culvert. The parcel occupies the westernmost part of the industrial park and requires that a wind study be performed to ensure that air emissions, dust, and noise do not inhibit other commercial activity at the park. The parcel is within a one-mile view shed of rural residences to the south, which presents a stakeholder challenge. Finally, the parcel is four miles south of the interstate interchange at Harrison Avenue, adding inefficiencies to municipal operations by virtue of increased distance to and from operations sites.

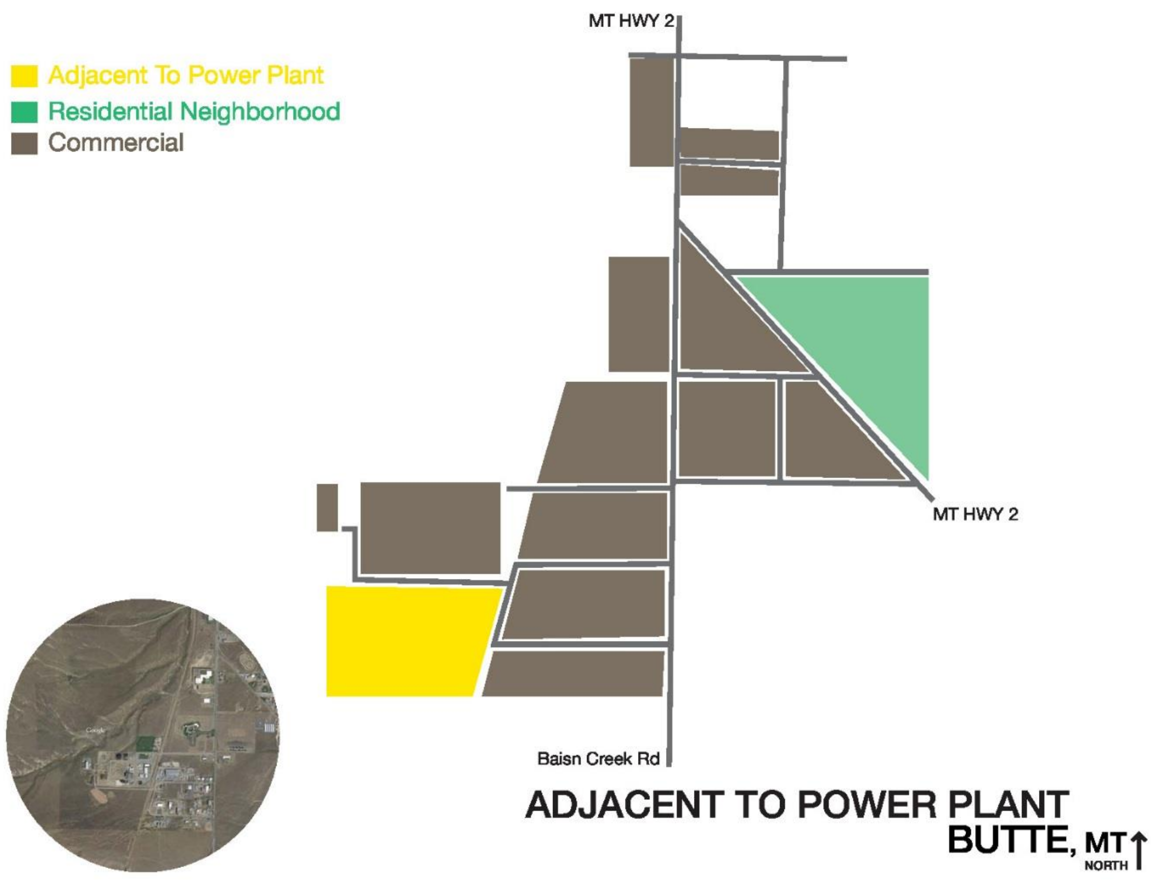

Figure 3-5, Adjacent to Power Plant

However, proximity to the power plant allows for another industrial colocation study. Development on this site will have access to all the necessary infrastructure and environmental controls associated with heavy industry. Further, the ecologic relationship between the operational processes of the power plant and the asphalt plant forms a basis for an industrial symbiosis related to waste heat. There exists a significant operational cost savings potential from a conventional fuel expenditure management standpoint and a future minimization of risk exposure associated with heat pollution. Advantages of waste heat re-use and facility co-location are described in the Section 4 herein.

This site received the most favorable score in the rubric, primarily due to its perceived lack of negative impacts over the local community stakeholders. But it bears pointing out that development in this direction facilitates sprawl, does not utilize Brownfields efficiently, and does little to maintain a sustainable balance between municipal industrial mix, environmental preservation, and economic growth within the BSB community.

Screening results are provided in Appendix A (Table A-5).

3.3 LAND USE CLASSIFICATION

Zoning and land use classification(s) are administered under Title 17 of BSB's *Municipal Code* and the following are pertinent to site selection:

- Light manufacturing, such as the maintenance shops (Chapter 17.28);
- Heavy manufacturing, such as the asphalt plant (Chapter 17.30);
- Rural manufacturing, which is any transportation related industry requiring siting near major transportation nodes similar to highways and railroads (Chapter 17.31);
- Associated special provisions (Chapter 17.38).

Siting these facilities separately or together requires careful consideration of the overall zoning plan, especially when considering other potential stakeholder impacts. BSB's own zoning ordinance attempts to account for economic development, ecologic impact, and social equity as part of its land use mandate. For example, light and heavy manufacturing are administered differently when the two are near important transportation hubs, and by implication, near dense peri-urban centers. Specifically, in addressing rural manufacturing land use situated near transportation hubs, states that:

> *Because of the impacts associated with industrial and commercial activities, residential and general retail activities are discouraged from locating within this district while ancillary light*

industrial uses and commercial activities incidental and related to the industrial uses shall be considered consistent with the purpose and intent of this zone. (Chapter 17.31.010).

By comparison, merely siting light or heavy industry in Butte is fairly straight forward, provided that friction with commercial and residential stakeholders is minimized.

Combining the shops with the asphalt plant and siting them near transportation hubs and nodes carries with it the risk of alienating the citizen base if a variance for co-locating with residential zones is granted. Such variance becomes necessary when one considers Butte's current layout. Siting industrial facilities near roads yet far from residences requires that the sites be situated far from the population that relies on municipal services. Case in point, the Continental Energy Low Impact Subdivision and Butte Industrial Park are two main areas where heavy manufacturing is sited near road infrastructure; yet, these industrial campuses are situated far from residential areas. The current sites' strengths are their proximity to residential areas, which means that future sites will require variances from land use regulations, and subsequently a comprehensive strategy for identifying and addressing appropriate stakeholder needs.

3.4 CASE STUDIES FOR SITE SELECTION

3.4.1 Freshkills Park (US, 2008)

Description - Freshkills was an active landfill 1947 to 2001. Its initial plan was for a temporary, 20-year landfill that would later be developed for civic benefit. If not closed, it was forecasted to become the highest point in elevation on the east coast. At its height, the landfill swallowed up 20 barges per day, each loaded with 650 tons of garbage. Freshkills was once the largest man made structure on earth [Ref 3-2].

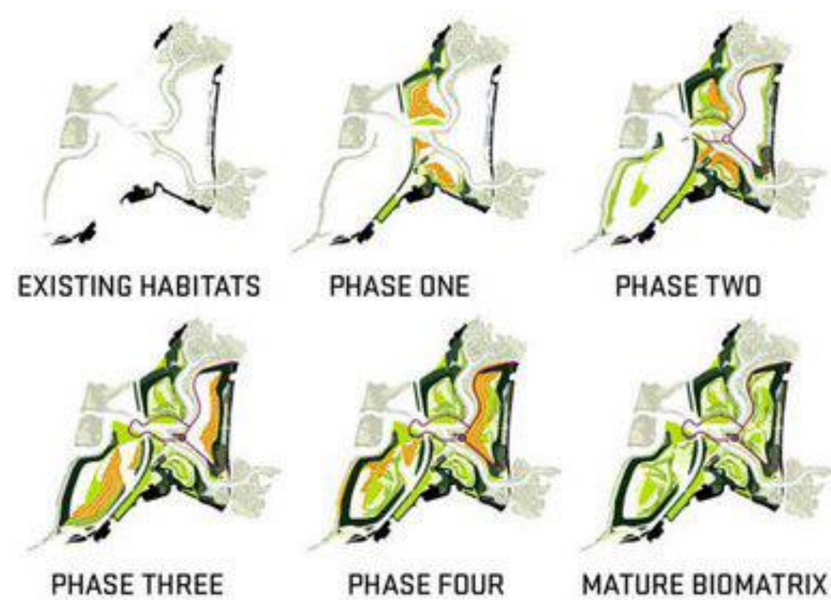

Figure 3-6 Freshkills Phases

Pros- The EPA is capping the landfill in sections – to be developed into six park districts with a total of 2,200 acres. The project will incorporate a 46-acre solar array, equestrian trails, mountain biking, kayaking, and large-scale public art. It will also include a monument to the September 11, 2001 tragedy, as much of the remains are buried in the landfill. Finally, restoration of wildlife will bring over 200 species back to the area.

Cons – BSB already has an abundance of open recreation space.

Why does this matter to Butte? The project takes advantage of a highly contaminated brownfield because of its prime location, providing much-needed greenspace for the urban environment as well as vital amenities. Through Butte may not necessarily be looking for more public parks, this is an opportunity to use Brownfields productively and safely.

3.4.2 Olympic Sculpture Park (USA, 2007)

Description - A 9-acre sculpture park with waterfront access turned a contaminated brownfield into culturally rich public greenspace. The difficult site, with a 40-foot grade change, was handled by using a z-shaped green form to reconnect the urban core to the revitalized waterfront [Ref 3-3].

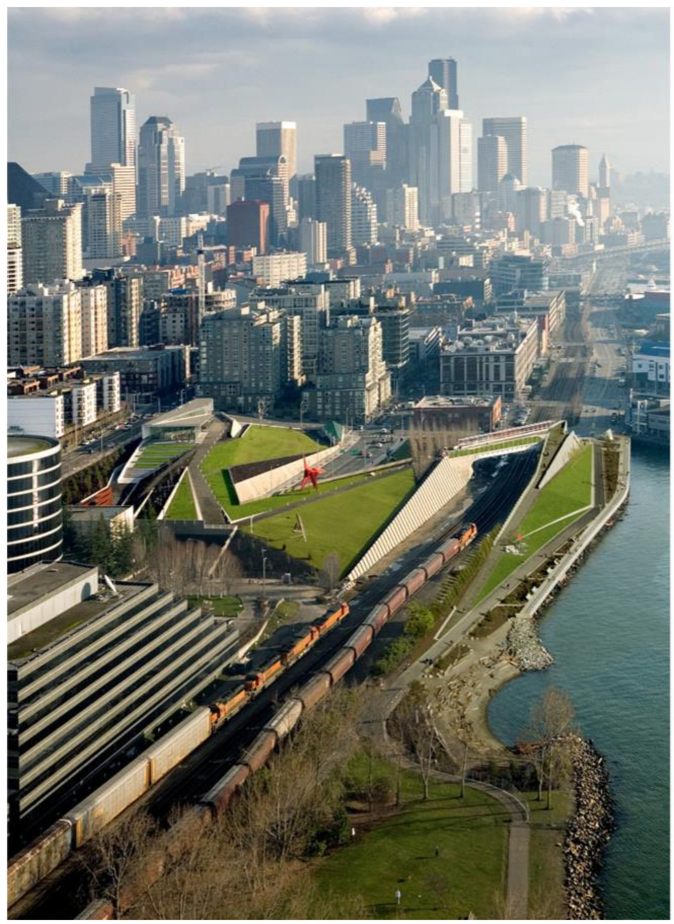

Figure 3-7 Olympic Sculpture Park

Pros- The project integrates natural Storm water management, brownfield reclamation, and cultural vitality. It deals with the noise of a high-traffic road and the need for accessible routes by carefully folding the landscape.

Cons - BSB already has an abundance of open recreation space.

What does this mean for Butte? The Olympic Sculpture Park provides precedent for productive use of brownfield sites. It successfully integrates environmental and social function with aesthetic appeal.

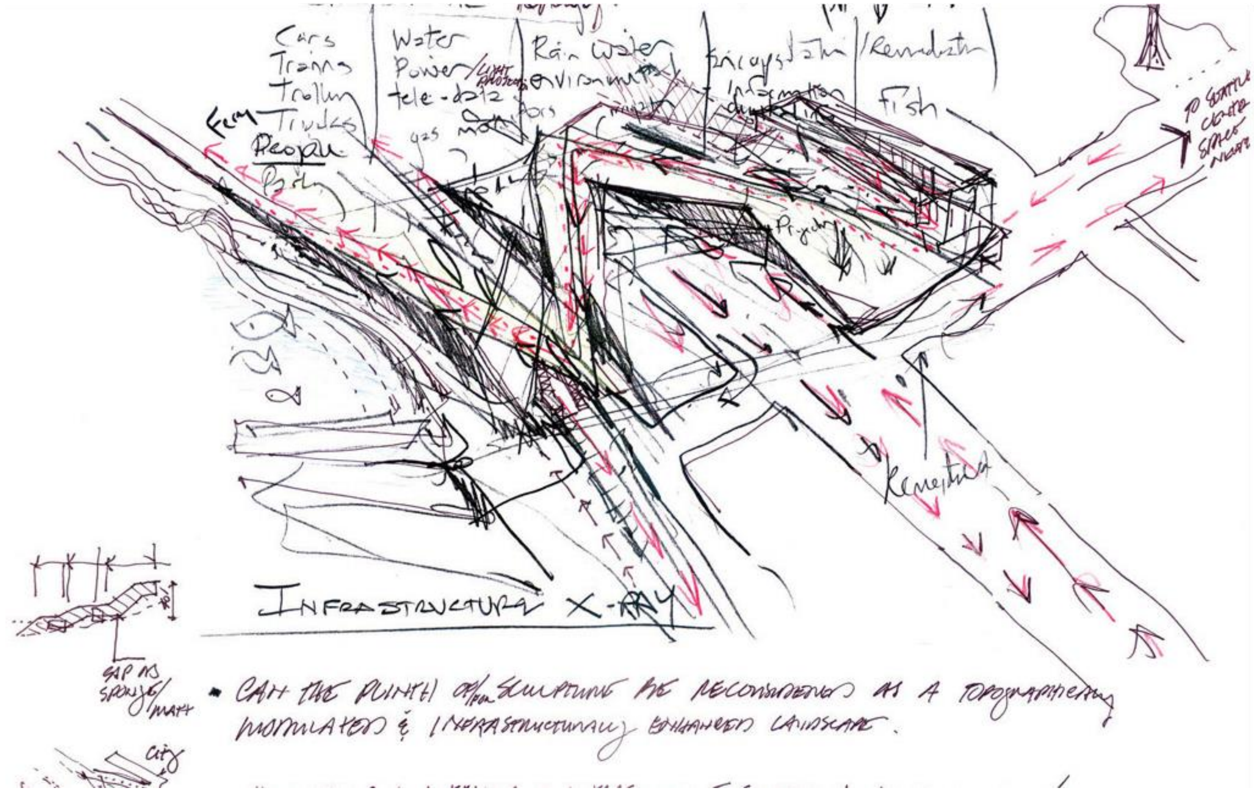

Figure 3-8 Olympic Sculpture Park

3.4.3 WASTE2PLACE (USA, 2015)

Description - WASTE2PLACE is an offshoot of MIT's *Project for Reclamation Excellence* (PREx), which aims to "provide a new public model for design on reclaimed mine sites" [Ref 3-4]. The project consists of a pamphlet and website that lay out principles and guidelines for action at Superfund sites that require special treatment. WASTE2PLACE's principles are:

1. *Conservation of Energy and Mass in Site Transformation*: Material movements should approach equilibrium. Contaminated soils should be consolidated for *in-situ* integration.
2. *Adaptive Use of Site Conditions*: Designers must adapt by disturbing the disturbance.
3. *Plant Ecology and Vegetation Strategy*: Designers must assess whether any disturbance-adapted plant species have local populations.
4. *Interactive Landscape Circulation and Infrastructure*: Design to avoid hazard and risk exposure.

Pros - The goal of this project is to empower communities to take action in their own backyard or neighborhood. The guidelines integrate sound environmental practices, health concerns, and civic benefit in order to create truly regenerative solutions for Superfund cleanup.

Cons - BSB already has an abundance of open recreation space.

What does this mean for Butte? On their website, WASTE2PLACE has a series of case studies that provide a model for appropriate reclamation action. One of them, the Old Works Golf Course [below], sits in Anaconda, Montana – a neighbor of Butte. The project also provides a model for Butte citizens to take action, or for the government to proceed with sound practices.

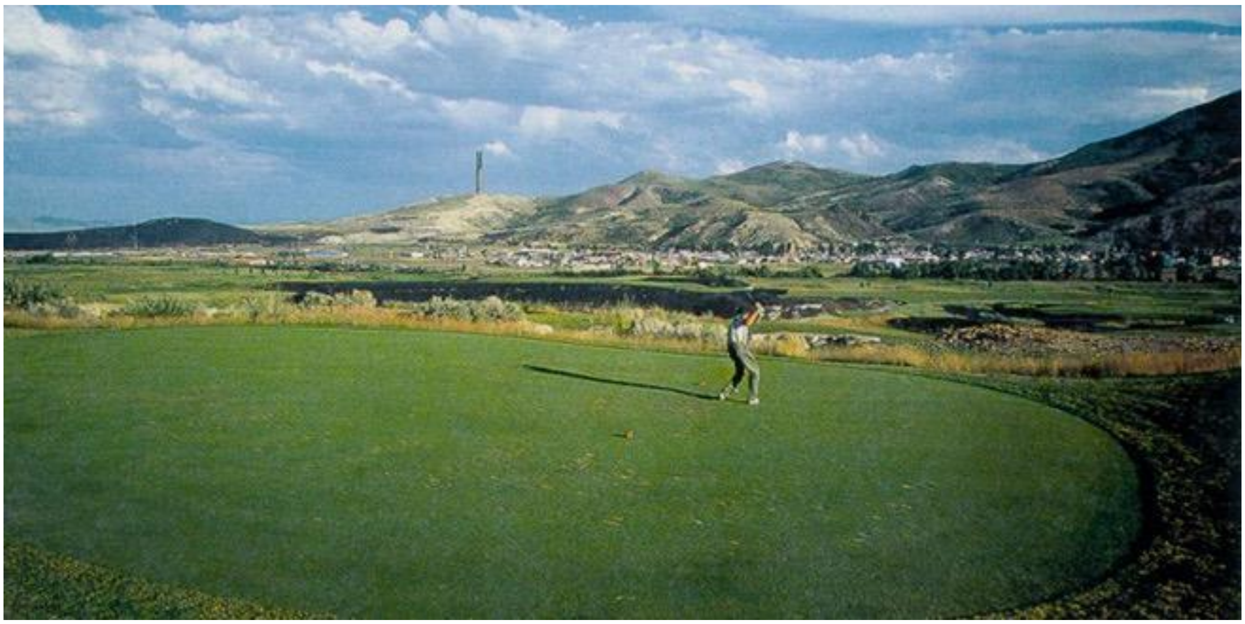

Figure 3-9 WASTE2PLACE

3.4.4 Collective Coffee on Humbolt (USA, 2010)

Description - In 2010, the city of Milwaukee acquired 3 separate brownfield properties through tax foreclosure. The properties were former fuel depots, and were highly contaminated with diesel, gasoline, and petroleum volatile range organic compounds. A major barrier to redevelopment was the concern that any disturbed soil would move contamination off-site to adjacent residential properties and ultimately the Milwaukee River [Ref 3-5].

The Collective Coffee redevelopment capped the most contaminated area underneath a parking lot, and constructed a roasting/distribution warehouse on one property, with a coffee shop and leasable office/ retail space on the other. On-site monitoring wells were incorporated into the design of the warehouse.

Pros - The project is important because it effectively addresses issues of on-site waste remediation while allowing space for retail and industrial food production.

Cons - This, like the other case studies in this section, is not explicitly relevant to industrial facility brownfield transformation but can be used as an example for best-practice land conversion regardless of the end-use of the parcel.

What does this mean for Butte? Waste in place can be a design hindrance, or it can serve necessary infrastructure functions while allowing for commercial and industrial activity. The scale of this project is appropriate for BSB, and it proves that remediation infrastructure can be incorporated into site and building design.

Figure 3-10 Collective Coffee

3.5 REFERENCES FOR SITE SELECTION

Ref 3-1. Simonich G., Laity C., James D., Cormier T., Joyce S., Salle J., Peterson J., Stratton D., Nicolai S. (2005). The 2005 Butte-Silver Bow Transportation Plan Update. Butte Silver Bow Department of Planning. Retrieved from http://www.co.silverbow.mt.us/626/Long-Range-Plans

Ref 3-2 FRESHKILLS PARK. (n.d.). Retrieved April 27, 2015, from http://www.fieldoperations.net/project-details/project/freshkills-park.html

Ref 3-3 ASLA (2013). Weiss/Manfredi: Seattle Art Museum: Olympic Sculpture Park. (2007, January 1). Retrieved April 27, 2015, from http://www.weissmanfredi.com/project/seattle-art-museum-olympic-sculpture-park

Ref 3-4 WASTE2PLACE (2015). Case Studies. Accessed March 1, 2015 from http://waste2place.mit.edu/case-studies/

Ref 3-5 Colectivo Coffee on Humboldt. (n.d.). Retrieved April 27, 2015, from http://city.milwaukee.gov/DCD/BrownfieldsRedevelopment/Successstories.htm#.VT6vpCFVhBd

4.0 DESIGN AND OPERATIONS: MAINTENANCE SHOPS

4.1 OVERVIEW

BSB's maintenance shops face a diverse range of environmental and operational challenges and opportunities, particularly in the winter when cold temperatures and snowfall increase the demand for vehicle and roadway. A detailed list of environmental, social, and economic considerations relevant to design and operations is summarized in Appendix B. Specific opportunities to improve sustainability performance in the following areas are described below:

- Lighting
- Water Management
- HVAC and Ventilation; and
- Space.

4.2 LIGHTING

4.2.1 Current State

During the site visit, the lighting system was observed, and employees disclosed that improved lighting could positively influence productivity, particularly during winter months when daylight hours are limited. Currently, the facility utilizes a number of standard shop high bay fixtures each fitted with four t12 fluorescent lamps. The lighting is supplemented by day-lighting from a number of skylights. However the glass skylights are not regularly cleaned which limits the amount of light that penetrates the facility. As recommended by the *Illumination Engineering Society*, light levels for repair areas in garages must be a minimum of 100 footcandles (Ref 4-1). Though not measured during the site visit, facility lighting was estimated to be lower than 100 footcandles and it is recommended that lighting brightness is tested to ascertain necessary improvements.

4.2.2 Improvement Opportunities

The first and most cost-effective way to increase the amount of light within the shops is to maintain the skylight windows, cleaning regularly to allow natural light to shine through. In a new facility, skylights designed for easy access will allow for more regular cleaning. While increasing daylight will improve the light levels during daytime hours, there is still a need to increase the artificial lighting within the shops.

The current lighting fixtures and lamps are obsolete with regards to fluorescent high bay technology and upgrading these fixtures will increase the quality of lighting within the shops. First, replacing the fixtures with newer models allows for the introduction of newer reflector technology thus optimizing the output of the lamps, and new lenses allow more light to exit the fixture. Next, either retrofitting the current fixtures or replacing them with fixtures that utilize high output T5 lamps will both increase the footcandle rating of the shop and decrease electricity bills. A standard T5 HO lamp uses approximately 54w, whereas the T12s currently use closer to 100w. Furthermore, new T5 lamps have also increased their output and in some cases can replace up to 2 T12 lamps (Ref 4-2). A further increase in savings can be made by upgrading to LED. However, the upfront costs must be factored in before deciding whether or not a switch is economically viable.

4.2.3 Environmental Implications

Upgrading lighting fixtures reduces the demand for electricity, thereby reducing the environmental impact of greenhouse gas emissions and air pollutants used in the generation of electricity.

4.2.4 Economic Implications

Increasing daylighting and upgrading to new light fixtures will decrease energy bills related to lighting. It is recommended that a cost-benefit analysis be conducted before an increase in daylighting to assess the economic risks and payback.

4.2.5 Case Study for Lighting

Stikeman Elliott, Lighting Retrofit Project (Toronto, 2011)

Description - Stikeman Elliott Toronto occupies a commercial space of 174,378 square feet which is a LEED Gold certified building. In order to acquire LEED accreditation the firm needed to upgrade their lighting system and in doing so upgraded 3,100 fixtures from T12 to T5 lamps and electrical ballasts. Doing so was able to net them 443,943 kWh/year in energy savings (Ref 4-3).

Pros - Energy efficient lighting provides the same quality while using a fraction of the energy. Major energy and carbon footprint savings can be gained yielding a quick payback.

Cons - The initial capital cost of fixtures and maintenance to install or retrofit is significant.

Why does it matter for Butte? - Improving lighting capacity in municipal facilities is "low hanging fruit" when it comes to infrastructure updates and cost saving projects that can be adopted in the short-term (i.e., one year or less).

4.3 WATER MANAGMENT

4.3.1 Current State

Butte's mile high location in the Rocky Mountains contributes to an occasional winter temperature dip of -52F. At such extremes, fluids expand, steel becomes brittle to the point of failure, and deployment of critical equipment like ambulances becomes very challenging. To date, the solution for extreme temperature drops at Butte's facilities shops was to store critical equipment in heated storage bays. The current facilities are steel shells with heavy insulation and natural gas-fired space heaters mounted at ceiling level. This type of installation is a conventional approach to maintaining acceptable internal temperatures in expansive operating spaces.

Part of the functions performed by the city year-round is the maintenance of water drains that divert potentially toxic surface runoff to treatment facilities. When a drain freezes during a winter event, the damage, if left unattended, necessitates costly repairs later in the year and places the fragile BSB ecosystem at risk. Part of the city's response to frozen/ clogged drains is the deployment of water pump trucks that use highly pressurized water as a cutting/ clearing fluid. Trucks are unable to rely solely on remote supplies of water such as a fire hydrant during extreme weather, and as such carry a predetermined amount of water on board.

Currently, the shop uses water on-site for vehicle washing and for filling water trucks. The water is pumped from the underground water table and after on-site use it receives remedial treatment in the oily water separator and is later sent to the municipal water treatment facility. Traditionally, oily water separators become neglected by the operators and subject facility managers to substantial EPA fines.

4.3.2 Improvement Opportunities

For each candidate site, physical layout(s) of the maintenance shops and/ or asphalt plant will (ultimately) be determined as part of BSB's civil and environmental engineering design. That is, site-specific assessment of these criteria is outside the scope of this workbook. However, strategic objectives for storm water control could, at BSB's discretion, be incorporated into a basis of design, including:

- Reducing runoff to prevent soil erosion in general, and deterioration of remedial covers where applicable;
- Reducing runoff to protect surface water (e.g., Silver Bow Creek);
- In areas of known groundwater impact from historical industrial operations, reducing infiltration to reduce ground water head (i.e., gradient and flow), thereby reducing solute flux; and
- Re-using storm water as conservation measure and/ or reduce water resource loss from direct discharge of storm water.

Other improvement opportunities are described below.

Greywater Recycling

To improve how water is managed at the facility, it is recommended that “greywater" be upcycled into the radiant heating system or used to fill the water trucks for use instead of disposal. By utilizing upcycling as an approach to on-site greywater management, anomalies can be easily identified. Additionally, the load on municipal water treatment can be reduced, or at a minimum, managed more efficiently. Such a strategy increases the productivity of one unit of water. In such manner, the facilities manager can address any issues concerning water demand and supply without having to rely on a centralized water delivery/ treatment system. In fact, when combined with rainwater harvesting and dual plumbing, greywater reuse contributes measurably to the supply side of the water equation (Ref 4-4).

Storage of Water Trucks

Ensuring that roadway maintenance trucks are properly maintained during winter is critical to Butte’s overall strategy for dealing with pollutants penetrating the ground water table. Ideally, all equipment is to be stored indoors to avoid run-off of contaminants from vehicles into nearby soil during a rain event.

Figure 4-1 On Site Water (Courtesy of Lynnette Widder)

4.3.3 Environmental Impacts

Adequate water management techniques can help improve the biodiversity and quality of local waterways, reduce pollution, and reduce water consumption.

4.3.4 Economic Implications

Re-using grey water can help reduce utility bills.

4.3.5 Case Studies for Water Management

Potential of Greywater Systems to Aid Sustainable Water Management (US, 2010)

Description **-** This case study identifies how greywater can be used and recycled (Ref 4-5). Municipality facilities can use greywater to reduce the need for fresh water, reducing the need for municipal water and thereby improving environmental performance. Catchment, treatment, and recycling infrastructure must be installed for greywater re-use to be possible and economical. In the case of the municipal shops, captured water could be used to irrigate and keep green the surrounding landscape, particularly a line of trees (as discussed in the Space section). Typical household water system infrastructure, which is similar to the shops, is shown below. Cost estimates are from Southern California.

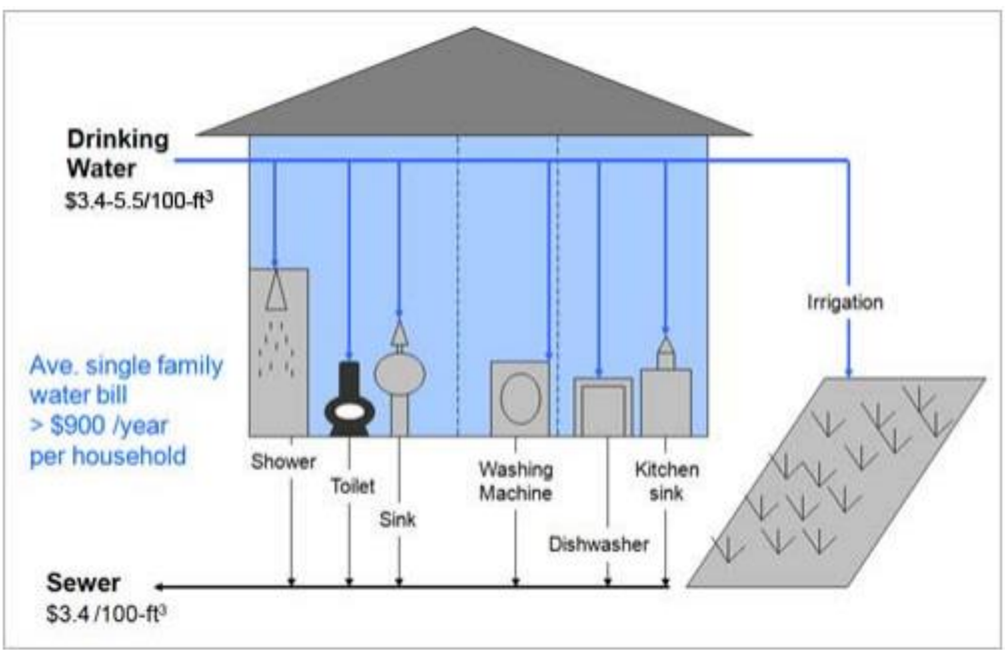

Figure 4-2 Water recycling system

Pros - Capturing, treating, and re-using water can save money, and helps to avoid environmental impacts. These practices exhibit examples of water management "best practices" of how to manage greywater on site.

Cons - There is an upfront cost of capital to establish a water catchment and recycling system.

Why does this matter to Butte? - The shops can adopt greywater capture to provide water and improve the vegetation on site as well as reduce pressure on the water system in a region that sources its water over long distances.

4.4 HEATING, VENTILATION, AND AIR CONDITIONING

4.4.1 Current State

During a site visit, employees disclosed that the municipal shop facilities lack adequate ventilation systems. Without adequate ventilation, employees are more susceptible to hay fever, dust mite and pollen allergies, and asthma from breathing in polluted air. The *American Society of Heating, Refrigerating and Air-Conditioning Engineers* (ASHRAE) conducted research suggesting that improving ventilation systems increases the performance of employees. Typically, HVAC systems are responsible for over 40% of a total facilities electricity use. BSB does not currently track and record the energy demand of its heating, ventilation, and air conditioning (HVAC) system relative to the rest of the building's power draw (Ref 4-6).

4.4.2 Improvement Opportunities

There are various options to consider for improved ventilation systems.

Hybrid Ventilation

One option for improved HVAC performance is “Hybrid Ventilation”. Hybrid ventilation is when a building's ventilation system integrates both natural (i.e., passive) and mechanical (i.e., active) ventilation components to achieve high efficiency (Ref 4-7). A hybrid system uses the earth's natural systems (e.g., the ground or wind) to power the ventilation system. Only when natural resources cannot meet the required ventilation levels does the system resort to a high-efficiency mechanical system. Because of its energy reduction implications, hybrid ventilation has been used extensively by the Passive Haus Institute (Ref 4-8). Hybrid ventilation systems work best when the building has access to the earth's natural systems. An area of land large enough for placing earth tubes and the building being located where there are extreme weather conditions, hot or cold.

Stack Ventilation

Another option is stack ventilation. Stack ventilation uses temperature differences (thermal buoyancy) throughout a facility to move air (Ref 4-9). Benefits of stack ventilation include low running cost, zero energy consumption, and low maintenance. Stack ventilation is regarded as being healthy, having fewer hygiene problems than with ducts, and filters. The “natural” feeling of the system has also been identified as a psychological benefit.

Bernoulli’s Principle

Bernoulli’s Principle uses wind to move air. Given how abundant wind is in Montana, this is a highly feasible option for cooling and ventilation. The faster air moves, the lower its pressure. Air further from the ground moves faster, therefore, is lower pressure, and helps to “suck” air naturally through a building (Ref 4-9).

Solar Chimneys

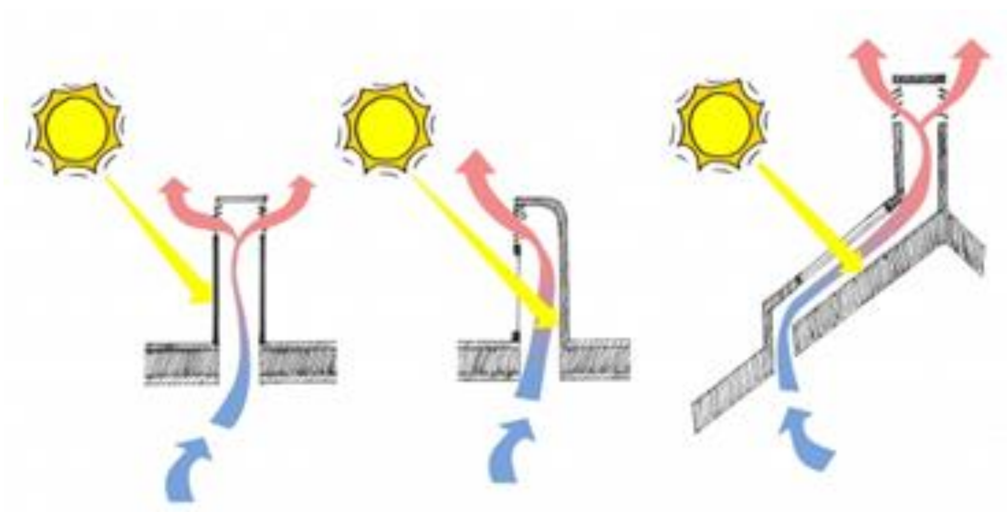

Figure 4-3 Solar Chimneys

Solar chimneys use the sun’s heat to pull air through a chimney using the stack effect. Solar chimneys are also known as thermal chimneys or thermosyphons (Ref 4-9).

4.4.3 Environmental Implications

Reducing the fuel and electricity required to support ventilation systems by adopting any combination of the techniques listed in Section 6 will help reduce GHG emissions, VOCs, SOx, and NOx, among others.

4.4.4 Economic Implications

Reducing the fuel and electricity required to support ventilation systems by adopting any combination of the techniques listed in Section 6 will help lower energy bills. It is recommended that before considering or adopting any ventilation techniques, a feasibility study should be conducted, and an economic cost-benefit analysis considering all of the risks and opportunities of a given system.

4.4.5 Case Studies for HVAC

Beddington Zero Energy Development ***(United Kingdom, 2002)***

Description - Beddington Zero Energy Development (BedZED) is the UK’s largest low carbon community. Bernoulli’s principle has been adopted throughout the facility to achieve low-energy HVAC performance, along with the integration of other energy conservation measures and sustainable technology. The adoption of wind cowls provides passive ventilation (Ref 4-10).

Pros - The passive ventilation system requires no energy or fuel to run. The ventilation system is therefore economically viable and contributes little to negative environmental impacts.

Cons - To provide adequate round-the-clock ventilation requires specific elements in a building's design. Many buildings may not be physically or aesthetically suited to include such design elements. The incorporation of these elements must be considered and included during the design process of any building to be integral to the design.

Why does this matter to Butte? - Adopting a similar passive ventilation system could help the municipality achieve environmental benefits, economic savings and improve the wellbeing of employees.

Figure 4-4 Beddington Zero Facility (Ref 4-10)

4.5 SPACE

4.5.1 Current State

During the site visit, a number of areas for improvement were identified throughout the facility. First, service bays are undersized to service current fleet. Vehicle sizes and capacity demand has increased since the shops were constructed. Additionally, ad-hoc work areas (e.g., in center aisles) are used as stop-gap because an insufficient number and size of service bays are available. This condition interrupts workflow, decreases efficiency, and creates safety hazards. The limited number and size of service bays does not allow mechanics and services that are performed to be organized by like type or category (e.g., police cars). This situation interrupts workflow, decreases efficiency, and creates safety hazards. Poor traffic flow impedes circulation, reduces productivity and creates safety hazards. Finally, the current facilities have insufficient vehicle storage space both heated and non-heated.

4.5.2 Improvement Opportunities

With the relocation of the maintenance shops pending as a result of remediation activities, BSB can incorporate strategic space-management design concepts that will enhance the sustainability of future operations. Hence, it is recommended that design objectives for BSB's new shops include:

Table 4-1: Design Objectives

Objective		Specific Purpose	Proposed Improvements
1	Work flow optimization	• De-bottleneck traffic into, within, and out of shops • Minimize vehicle movements while on site	Rigorous space planning and configuration
2	Reduce occupational hazards and/or risk of injury or loss	• Reduce safety hazards • Reduce risk of vehicle exposure/ damage/loss	Larger and more work bays
3	Reduce environmental risk	• Facilitate strategic (i.e., sustainable) lighting, ventilation, and water management	See *Lighting*, *Ventilation*, and *Water Management* initiatives, above
4	Integrate with local surroundings	• Visual appeal and community value • Minimize travel to service areas	Property line vegetation (e.g., trees)

4.5.3 Environmental Implications

Rigorous space planning and configuration can reduce fuel consumption, accidents, and spills, which in turn reduce GHG emissions. Property line vegetation can improve air quality by sequestering GHG emissions.

4.5.4 Economic Implications

Rigorous space planning and configuration reduces fuel costs and the cost of vehicle damage. BSB will undergo minor (incremental) design costs if larger bays are constructed, in addition to the cost of planning and maintaining a new larger facility, particularly one with vegetation that requires irrigation and maintenance.

4.5.5 Case Studies for Space

Case studies illustrating these types of improvements, and potential pros and cons of implementing them at BSB’s new shops are described below.

Air Force Design Guide for Vehicle O&M (US, 1999)

Description - The Air Force Design Guide for Vehicle O&M (Ref 4-11) case study focuses on the interrelationships between departments and work zones. Stand-alone vehicle maintenance support areas were designed specifically to support local base functions and mission requirements. These considerations are described in Chapter 4, Section E, pp 27-31.

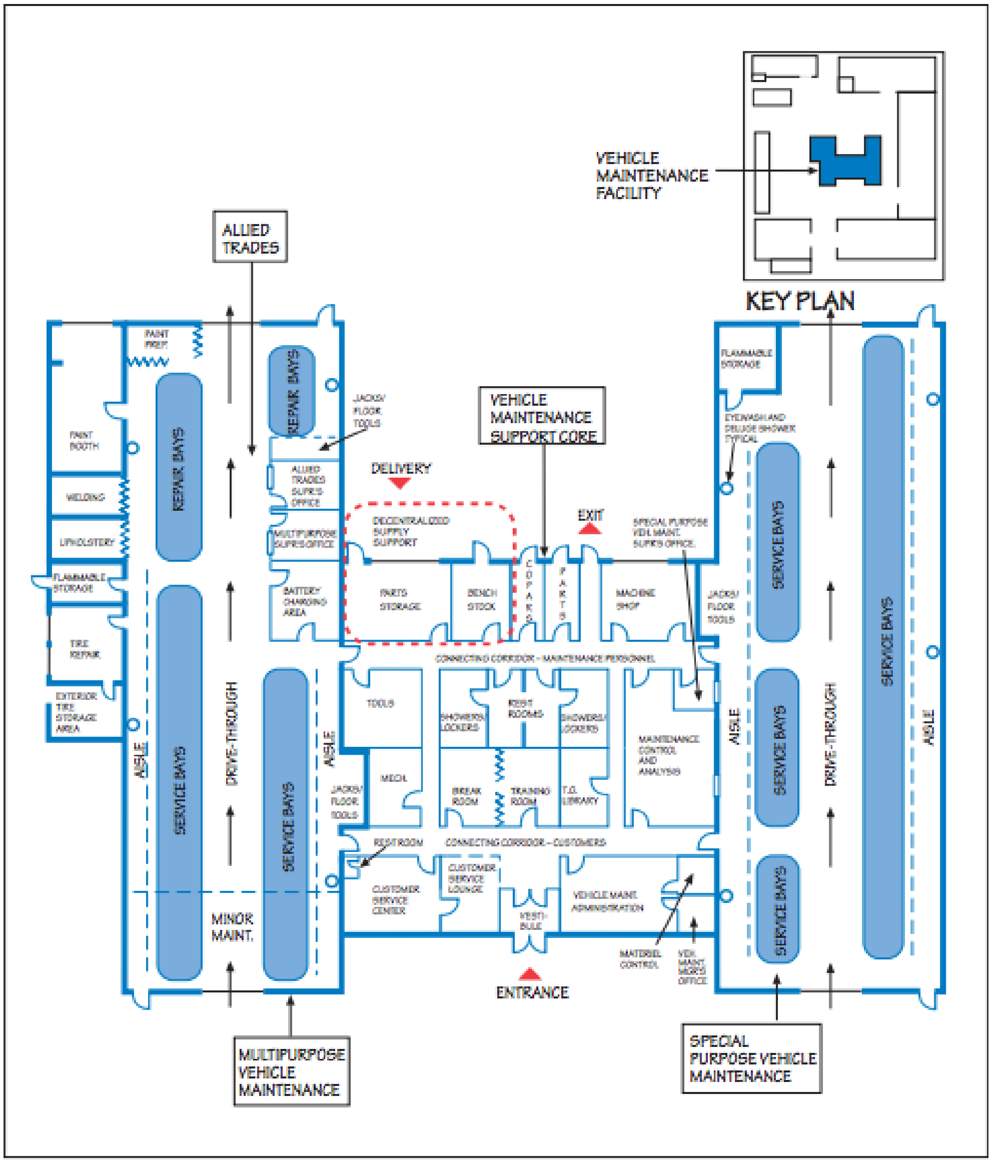

Figure 4-5 Illustrative Floor Plan for the Vehicle Maintenance Facility (Ref 4-11)

Additional requirements for multi-purpose vehicle maintenance areas are described in in Chapter 4, Section F (pp 32-33). For example, (a) Furnishings and Equipment, and (b) Technical Requirements are listed for Service Bays, Aisle Circulation Spaces, and Drive-Through Bays.

Pros - Maximizing spatial design helps achieve operational efficiencies and, therefore, reduces costs.

Cons - The initial cost of "smart design" requires investment. In areas where an existing building is being retrofitted or "revamped," there are sometimes limited options for design within the constraints of the existing building footprint.

What does this mean for Butte? - BSB is in a unique position to completely re-design its shops if they are relocated to another site. If relocated, utilizing design approaches, and best practices from this case study can improve operational efficiencies.

Shop Design Considerations (US, 2009)

Items that are important to consider in shop design are listed in "Shop Design Considerations" (Ref 4-12). "Getting the Bay Size Right" is highlighted because providing the most working bays may seem like a natural default. However, for the bays to be useful adequate space for mechanics and technicians to safely and efficiently circulate around the vehicle with tools, parts and equipment. Specifically, if a fleet includes many full-size pickups, adequate numbers of larger bays (e.g., 14-foot width, 27-foot length) is recommended. See previous case study for *Pros*, *Cons*, and *Implications*.

USACE Tactical Equipment Maintenance Facilities Standard Design (US, 2010)

USACE Tactical Equipment Maintenance Facilities (TEMPF) focuses on best practices for deign of repair areas, vehicle corridor/ maintenance areas, and repair area bay doors (Ref 4-13). A useful site adjacency diagram is included. See previous case study for *Pros*, *Cons*, and *Implications*.

4.6 REFERENCES FOR MAINTENANCE SHOPS (DESIGN AND OPERATIONS)

Ref 4-1. Howard, L. (2013, January 14). Recommended Minimum Lighting Levels. Retrieved April 9, 2015, from http://www.howard-lighting.com/Documents/ProductLiterature/FootcandleApplicationRecommendations.pdf

Ref 4-2. Green Savings Co. (2009, December 15). Changing from T12 to T5. Retrieved April 9, 2015, from http://greensavingsco.com/2009/12/changing-from-t12-to-t5/

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5.0 DESIGN AND OPERATIONS: ASPHALT PLANT

The purpose of the asphalt plant facility is to manufacture asphalt concrete from a number of different aggregates that are heated, coated with a binder, and then kept warm and trucked to its final use location. The other focus of the plant is to reclaim and crush recycled asphalt to create recycled asphalt pavement (RAP) for further use as pavement or roadbeds. The BSB Asphalt Plant produces approximately 9,000 tons of asphalt each summer for their roads and is looking to expand to 15,000 tons over the next five years. The facility also stockpiles sand for the county to use in the winter to sand the roads. See the Roadway Maintenance section for more detail.

5.1 CURRENT STATE

5.1.1 Inventory and Equipment

The components listed below have been culled from a literature review (see bibliography and spread sheet index). The information does not reflect an on-site inspection of Butte's current plant nor is this information all-inclusive (Ref 5-1).

Table 5-1 Typical Asphalt Plant Equipment

Buildings and Equipment	Major Supplies Used and Housed

• Plant Operations Office or Booth
• Batch Tower and Pugmill
• Cold Feed Bins
• Crusher
• Asphalt cement shearer
• Drying Drum
  - Heater
  - Drum mixer
  - Dryer burner
• RAP Cold Feed Bin
• Emission Control System
• Particulate Storage Tank
• Asphalt Cement Storage Tanks
• Conveyor Belt and Storage Silo (Hot Mix Asphalt)
	• Crushed rock
	• Fine or coarse asphalt aggregates
	• Petroleum compounds
	• Mineral fillers
	• Additives that reduce binder thickness
	• Asphalt binders
	• Asphalt cement shearer
	• Water
	• Soap-like chemicals

5.1.2 Environmental Impacts

Air Pollution

The production of asphalt creates a number of different airborne pollutants that are seriously regulated at both the federal and state level. The most common air pollutants from hot mix asphalt plants are:

- Particulate matter (PM_{10})
- Sulfur dioxide (SO_2)
- Nitrogen dioxides (NO_x)
- Volatile organic compounds (VOCs)
- Carbon Monoxide (CO)
- And hazardous air pollutants (HAPs)

Particulate matter is defined as a complex mixture of extremely small particles that once inhaled can have an adverse effect on the heart and lungs, causing serious health defects (Ref 5-1). PM_{10} is specifically targeted because these are particulates that have a diameter of 10 microns or less allowing them to be absorbed by the human body more effectively. Montana code requirements for the specific particulate matter limits discharged into the atmosphere from fuel burning equipment are listed in Appendix C.

VOCs, or volatile organic compounds, are defined by the USGS are, "organic compounds . . . many [of which] are human-made chemicals that are used and produced in the manufacture of paints, adhesives, petroleum products, pharmaceuticals, and refrigerant" (Ref 5-2). These compounds are usually toxic, and many are known as human carcinogens. Therefore, it is important to keep these emissions to a minimum for the health and safety of all stakeholders.

HAPs, or hazardous air pollutants, are exactly what their name implies. The US EPA describes them as pollutants that cause or may cause cancer or other serious health effects, birth defects, or adverse environmental or ecological effects. Currently, the EPA controls 187 different HAPs, the majority of which are traced to human-made sources (Ref 5-3). Similar to VOCs, in order to maintain the health of various stakeholders, hazardous air pollutant emissions should be minimized.

The remainder of the pollutants produced by asphalt plants is those common to other industrial practices. For that reason, they are also commonly regulated at the federal level. The National Ambient Air Quality Standards limit SO_2, NO_x, and CO in order to protect public health. For SO_2 the NAAQS limits emissions to over 75 parts per billion on a one-hour average. For NO_x

the limit for emissions is 100 parts per billion on a one-hour average. Finally, for CO, emissions cannot exceed 35 parts per million on a one-hour average (Ref 5-4).

Water Pollution

Water pollution is another source of negative emissions from asphalt production. Water runoff and pollution on site from chemicals used during the lifecycle of asphalt production are large sources of contamination of water sources, especially for facilities sited in the vicinity of a wetland (e.g. Silver Bow Creek). One major contributor to this type of pollution is the antifreeze used in the large machinery. Since this machinery is difficult to move, there is a greater chance of localized toxic spills. Furthermore, the various petroleum based chemicals and binders on site have the potential to spill as well if not properly stored. The frequent travel to and from the plant by heavy vehicles poses yet another source of water pollution. No matter what the pollutant may be, all have the potential to be picked up by rainwater and washed away – especially during periods of heavy precipitation (Ref 5-5).

Furthermore, any water used during the production of asphalt, such as to moisten aggregate to reduce dust, must be captured and removed properly. The capture and removal of water also applies to any water that may come into contact with the aggregate while it is being stored, including rainwater if the aggregate is not covered. Hence, proper groundwater management is needed in order to combat the possibility of runoff pollution.

Noise Pollution

Since the production of asphalt includes the crushing, grinding, and mixing of stone aggregate, noise pollution from these types of facilities is inevitable. Noise is a sensitive issue especially if there are neighbors close by to the asphalt plant. There are numerous sources of noise within asphalt plants including the motors for the beltways, the dryers for the aggregate, the burner to heat the aggregate, exhaust fans, etc. All of these sources of noise pollution can be abated to a certain extent by means discussed below, and by following industry best practice an asphalt plant can run quite quietly (Ref 5-6).

5.2 IMPROVEMENT OPPORTUNITIES

Newest and future generation asphalt plant technology differs greatly from what is seen commonly throughout the United States today. Through technical engineering, consumer demand for environmental performance, and the quest to achieve maximum efficiency, asphalt plants are being transformed from noisy eyesores into cleaner and better thought out facilities.

The main goals driving asphalt plant technology include reducing atmospheric emissions, noise levels, and energy consumption and the ability to create multiple forms of product using different materials and techniques including RAP. By specifically looking at these factors, specific recommendations for a resource-smart asphalt plant come into focus.

Atmospheric Emissions Reduction

As was already noted, the main source of pollution from asphalt facilities is their atmospheric emissions. Due to the inherent nature of asphalt plants the output of dust is inevitable. Dust forms at every stage of the asphalt mixing process until the aggregate is mixed with a binder. Therefore minimizing dust inherently minimizes the amount of particulate matter, HAPs, and VOCs emitted through operations. In order to minimize dust emissions, some of the industry best practices are (Ref 5-7):

- Contain the aggregate on at least three sides, as well as a roof covering;
- Moisten high traffic areas, especially during loading and unloading;
- Cover belts that transport aggregate;
- Cover the cold feeders;
- Add small amounts of binder at the end of the production cycle to absorb any dry material.

A great example of methods to prevent other airborne pollutants from asphalt plants was created by the Missouri Department of Natural Resources. The report outlines best practices to follow in the development, operation, and maintenance of hot mix asphalt facilities. The primary, albeit simple, method of pollutant prevention is to simply reduce the amount of waste by improving the efficiency of the equipment being used, and by looking for other asphalt mixes that are less polluting than the current mix. Reducing waste has a number of benefits including but not limited to: improved environmental and safety performance, reduced liability, reduced regulatory requirements, improved environmental protection, and enhanced marketing and public relations. While airborne pollution is important to monitor, there are other forms of pollution from asphalt plants that can easily be prevented. Based on a case study from the state of Missouri, the following actions can also reduce even the smallest amounts of unnecessary pollution that include (Ref 5-5):

- Include the cost of disposal when making purchasing decisions;
- Buy aggregate as needed – leftovers may become waste;
- Purchase the least toxic or hazardous products available;
- Use the oldest items brought in first (first-in, first-out);
- Return unneeded material to supplier if possible;

- Use drip pans and splash guards where spills frequently occur – especially important for the truck loading areas;
- Fix leaks as they occur & regularly inspect storage tanks and areas for leaks;
- Store wastes separately and ensure they are properly labeled so they can either be recycled or disposed of properly.

Again, many of these seem simple and straightforward, but keeping a close eye on all of these aspects of pollution translates into more efficient management. In 2010, a company called Aggregate Industries created a 'Centennial facility,' which it proclaimed as the state of the art to the asphalt industry. The facility was built in Denver and features a fully enclosed system that has ready mixed concrete and asphalt products, as well as recycling operations. The design of the plant allows the company to offer seven different aggregates, including RAP. It even has a truck washout system that recycles the wash water from cleaning trucks back into the concrete batching process thus eliminating unneeded waste. However, the main benefit of enclosing the plant has been the ability to reduce overall emissions (Ref 5-8).

The first way that enclosed design increases the efficiency of the plant is by continuously keeping the stored aggregate warm and dry. By completely encasing the different aggregates, excess moisture from rain and humidity is kept out of the mix, allowing the plant to expand the number of aggregate mixes that it can use. Without this extra moisture in the aggregate, the drying period before the aggregate can be heated and mixed with a binder is shorter and less energy intensive. The Centennial Facility also captures emissions from the machines and feeds them into a loop where the air can be scrubbed to reduce emissions (Ref 5-8).

Figure 5-1 The Centennial Facility (Ref 5-8)

Water Pollution Reduction

The most effective way to avoid water pollution from the operations of the asphalt plant is through good housekeeping practices, minimizing exposure, sediment control, and runoff management. First and foremost best practices in housing pollutant materials must be taken in order to reduce the chances of leakage. By reducing spills and minimizing the amount of pollutants that storm water can potentially reach it inherently reduces the risk for runoff pollution. Similarly, there should be scheduled pickups for waste materials and monitoring of their containers. Keeping up this routine forces employees to monitor continually the site for pollution and will aid in avoiding it altogether (Ref 5-9).

Minimizing exposure of potential pollutants to rainwater is another essential step in minimizing water pollution. Reducing this exposure, similar to housing pollutants properly will prevent contaminated storm water runoff by not giving it a chance to contaminate rainwater from the very start. Covering aggregates or housing them in permanent structures is the best way to minimize exposure (Ref 5-9).

Finally, the proper management of runoff to divert, infiltrate, and reuse storm water is imperative for proper water pollution abatement. There are a number of different ways in which this can occur, however for industrial areas like asphalt plants capture, filtration, and reuse is the best option. The plant should be designed in such a manner that curbs and berms prevent water from flowing off of the paved areas, and should follow the gradation of the land where a drain should capture it. From this, some water should be captured and treated with an on-site treatment system to give the plant all of the water that it needs for its operations. This practice reduces the need to use fresh water when it is not necessary and will help divert some of the pollution from runoff (Ref 5-9). Through performing all of these practices, the asphalt plant will be best positioned to have minimal water pollution.

Noise Pollution Reduction

To attack the issue of noise pollution at industrial plants such as an asphalt plant, one must begin at the design stage and incorporate different methods to insulate noise. Utilizing the existing aspects of the land being built on natural methods of screening can be used, such as using existing hills as screening mounds for the facility (Ref 5-6). Furthermore simple placement of the plant within the site chosen to develop is another simple way to reduce noise from the design stage. By placing the plant the furthest distance away from any nearby stakeholders and positioning the machinery so that noise may diminish or totally mitigate the impact of noise to the neighbors (Ref 5-6).

Another way of reducing noise pollution is through equipment selection. Due to a number of laws passed over the past few decades manufacturers are required to display the sound output levels of the machinery used on site. If looking to purchase new machinery acquiring models with the lowest output rating would best minimize the amount of noise from the shop and asphalt plant operations. Furthermore, other choices in equipment can be made based on the operation – such as switching from using dump trucks to transport aggregate across a site to utilizing conveyor belts instead (Ref 5-6).

Finally, placement and housing of certain machinery can greatly reduce the amount of noise produced from the asphalt plant. Since conveyor belts are responsible for transporting aggregate across the site, they are typically running constantly. Taking the motors for these belts and enclosing them would reduce the amount of noise escaping into the atmosphere. This effect can be multiplied through enclosing the entire asphalt plant keeping most noise making machinery confined to inside thus reducing the amount of noise emitted (Ref 5-6).

5.2.3 Case Studies for Asphalt Operations

Gallagher Asphalt Corporation (Joliet, Illinois 2012)

Description - At the Gallagher Asphalt Corporation location, Gallagher's main goal when redesigning the plant was to reduce noise pollution (Ref 5-10). There were frequent complaints about the noise levels at the plant. One of the first steps was to alter the design of the conveyor system. The alterations made allowed greater flexibility with regards to changing mixes, and also allowed them to house the motors and main drive chains to be sealed to minimize noise. Furthermore, a few pieces of machinery were identified as being overly noisy, especially the drum burner. By installing a new totally enclosed, variable drive burner, the plant can run the burner at only the speed and heat needed for the particular mix to reduce both air and noise emissions. In fact, it is so successful, "[the] burner runs so quiet that it's often difficult to determine if it is running or not" (Ref 5-10). Overall through careful design and thoughtful equipment choices the Gallagher Asphalt Corporation's redesign of this facility was successful in reducing the overall noise output of their facility.

Pros - Minimizing noise from the plant machinery reduces the amount of noise pollution being produced by the plant. Steps taken to minimize noise, can result in fewer negative perceptions and averting 'not in my backyard' issues from the surrounding community.

Figure 5-2 Gallagher Asphalt Corporation (Ref 5-10)

Cons - In order to maximize sound reduction, investments in new quieter equipment, building enclosures, and a new overall plan requires significant capital investment. Rearranging the overall layout of the plant may also aid in reducing carrying additional capital costs.

What does this mean for Butte? - In Butte's case, when the asphalt plant is moved there is a chance that at least some of the equipment will need to be replaced. Using the move can be an opportunity to revamp fully the systems in place without further production disruption.

Conway Company (UK, 2011)

Description - The Conway Company built a state of the art facility known as the Benninghoven asphalt plant. By completely enclosing the plant and providing appropriate insulation, the company has realized major fuel savings through heat retention while simultaneously reducing emissions and noise levels. The Conway Company was also able to contain both the mixing plant as well as the recycling plant under one roof, which further reduced emissions now captured and scrubbed together. Numerous studies have pointed out the benefits of enclosing plants as a stand-alone strategy and have estimated an average of approximately 8% fuel savings per year (Ref 5-11). Enclosing the plant and generating as much asphalt as it can from RAP creates significant emissions reductions and increases efficiencies.

Pros - Enclosing the entirety of the asphalt plant helps retain heat that increases the efficiency of the plant. Furthermore, aggregates will be kept protected from the elements keeping them dry and reducing the need for further drying and unnecessarily expending energy. The plant enclosure also keeps the majority of sound from operations contained and from escaping.

Cons - A cost-benefit analysis must be conducted to justify the capital costs accompanied with enclosing a plant. Enclosing the plant may also create a larger visible eyesore to the community.

What does this mean for Butte? - If Butte were to enclose their asphalt plant, it may help to resolve many of the current issues with the existing plant such as noise and air pollution. Simultaneously, they can also increase their energy efficiency thereby reducing the costs spent on fuel for the plant.

5.3 REFERENCES FOR ASPHALT PLANT (DESIGN AND OPERATIONS)

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6.0 DESIGN AND OPERATIONS: ENERGY RESOURCES

Energy resources are a significant area of opportunity for both the shops and the asphalt plant and as such, this section provides an overview of energy solutions and options that could be applied to either facility. See Appendix D for a comprehensive list of Montana State energy subsidies.

6.1 ENERGY SOURCES

Currently, the shop and asphalt plant source their energy from the electricity grid and from fuels such as natural gas, diesel, and petroleum. Alternative energy sources that could help reduce BSB's energy costs and/ or enhance sustainability are described below.

Cogeneration - Combined Heat & Power Systems

Combined heat and power (CHP), also known as cogeneration, is the simultaneous production of electricity and heat from a single fuel source. The fuel source may be: natural gas, biomass, biogas, coal, waste heat, or oil. In most combustion power plants, more than half of the thermal energy released from burning fuel is not exploited for electricity generation but is lost as excess heat due to the fundamental laws of thermodynamics. This heat is usually released through cooling towers.

Solar Energy

Harnessing the sun and its power can greatly reduce the grid electricity demand of facilities. According to an article from constructionpros.com, enclosed, partially solar powered asphalt plants are a way to the future. Enclosing the space offers much potential to cover the large roof areas with solar arrays. In some plants, solar mirrors can be used to help heat the hot oil that is used in asphalt production (Ref 6-1). In addition, the asphalt cement storage tank can act as a battery, absorbing the solar heat and excess heat from the asphalt production in the tank for later use. Heat from the binder tank can then be used at night or on non-sunny days when heat is required.

Alternately, solar energy could potentially be used to power lights in the parking areas during the night or to help light and power the shops when asphalt is not in production. Solar energy would provide a clean alternative source of energy all year round. Solar installations can also help the county shops combat some or all of their electrical expenses depending on load demand and the amount of panels needed. In addition, solar installations would help BSB avoid peak energy prices in the summer allowing for the allocation of funds elsewhere. By avoiding peak demand periods through the use of solar energy, BSB would be contributing less CO2 into the atmosphere as well as taking further stress off of aging power infrastructure.

Wind Turbines

Wind turbines, very much like solar, allows BSB to again create off the grid electricity thus reducing their environmental impact as well their overall electricity bill. Wind power technology captures the natural wind in our atmosphere and converts it into mechanical energy and then into electricity. Due to technological advancements, today's wind turbine is a highly evolved version of a windmill. Most wind turbines have three blades and sit atop a steel tubular tower. The towers range in height from 80-foot-tall turbines that can power a single home to utility-scale turbines that are over 260 feet tall capable of powering hundreds of homes. The US has a strong wind resource across the entire country. The current estimate of wind energy potential is ten times the amount of electricity consumption for the entire country. By the end of 2013, the US had over 46,000 operating wind turbines across 39 states and Puerto Rico. The combined production amounted to 61,110 megawatts (MW); enough to power over 15.5 million homes, roughly the number of homes in six states. The United States gets 4.1 percent of its electricity from wind overall, but certain states use much more (Ref 6-2). Based on the potential for wind power in BSB it would be advantageous to take into consideration wind power for both the asphalt plant and shops.

6.2 ENERGY MANAGEMENT & ELECTRICITY

6.2.1 Current State

During the site visit, the team ascertained that the shops do not have an Environmental Management System in place with smart meters to adequately measure and track electricity consumption in-house. It is of the county’s best interest to seek efficient design strategies, power distribution systems, and electrical equipment that can best increase the building energy efficiency and reduce energy consumption and therefore costs.

6.2.2 Improvement Opportunities

Technical strategies to reduce electrical load demand (Ref 6-3) include:

- *Equipment specification.* Specify energy efficient office equipment, including computers, printers, and copy machines. Select equipment with the Energy Star label. For computers, consider liquid crystal display screens in lieu of conventional monitors.

- *Distortion minimization*. Minimize the distortion effects of non-linear loads (personal computers, etc.) on the power distribution system by using harmonic filters.
- *Power factor*. Improve the power factor by specifying appropriate equipment as required.
- Procure "right sized" equipment for the job, not too large or too small.
- *Transformers.* Use K-Rated transformers, which are specifically designed to handle non-linear loads, to serve non-linear equipment.
- *Efficient motors*. To reduce energy use, consider premium efficiency motors, controls, and variable frequency drives for motors greater than one horsepower.
- *Direct current utilization*. Utilize direct current (DC) from the photovoltaic system, fuel cell, or another source in lieu of conversion to alternating current (AC). DC may be appropriate for certain applications such as discrete lighting circuits or computer equipment.
- *Avoid electromagnetic pollution/exposure*. Locate high concentrations of electricity (such as panel boards, transformers, or motors) away from building occupants/personnel. If necessary, install electromagnetic field (EMF) shielding.

Management of Peak Demand

Traditionally, energy efficiency savings are measured in terms of annual energy in kilowatt-hours per year. However, in order to make a true assessment and create a higher value of savings, it is necessary to consider peak demand (usually mid-summer) and the implementation of time-differentiated savings (Ref 6-4).

- *Engineering Algorithms.* Peak demand savings can be estimated using algorithms. There is a rich amount of literature on power-down mechanisms, ranging from algorithmic, stochastic and learning based approaches. Many hardware and system engineers have longed explored new directions to reduce energy consumption. As a result of peak demand and the need to reduce energy consumption from processes, there has been an uptick in considerable research interested in creating algorithmic techniques to save energy.
- *Hourly Building Simulation Modeling.* Hourly building simulation modeling can produce hourly savings estimates for whole buildings as well as for specific end uses. These models can be produced in a wide array of software services. In addition, building simulation modelling is a means of estimating peak demand and time-differentiated energy savings. A building energy simulation model combines building characteristic data and weather data to calculate energy flows.

- *Billing Data Analysis.* Billing data analysis can be used to develop monthly estimates of savings. This type of analysis entails statistical comparison of pre- and post-participation and participant or nonparticipant or both participant and nonparticipant billing data to estimate savings. A complex statistical analysis may be required to control for non-programmatic influences, such as weather and economic conditions. Also, isolating the impacts of a specific measure can be difficult because the meter measures usage for an entire building. Scrutinizing and comparing billing data gives cities and counties like Butte a place to begin to understand where potential savings may be gained. This analysis gives insight as to how they can better utilize energy and identify saving projects they may implement to their best advantage. It is important to note that prices and programs vary based on location, equipment, and demand just to name a few. Interpreting and tracking bills is the first step in understanding how energy is being used.
- *Interval Metered Data Analysis.* Utility revenue interval meters can measure usage at in increments of 15 minutes or less. Because consumption during different periods may be billed at different rates, these meters provide a means for analyzing a customer's load pattern. The interval meter data analysis is essentially the billing data analysis discussed above but with a finer time resolution. It can help Butte and the county shops better utilize their electrical demand based upon lower rates for service providers.
- *End-Use Metered Data Analysis.* End-use metering data analysis is known as an excellent means of estimating peak demand or time-differentiated energy savings. As with billing and interval data analysis, end-use metering data analysis entails a statistical comparison of pre- and post-participation and participant or nonparticipant or both participant and nonparticipant billing data. However, end-use metering eliminates most—if not all—of the difficulty of isolating the impacts of specific measures.

6.2.3 Environmental Implications

The generation of renewable energy displaces the use of conventional fossil fuels and/or grid electricity and therefore reduces environmental impacts such as GHG emissions, air pollutants, and reduces water consumption. Adopting energy reduction strategies and improving energy management systems will reduce GHG emissions and air pollutants. These strategies of improved tracking yield increased benchmark performance relating to direct fuel consumption (Scope 1 emissions) and electricity consumption (Scope 2 emissions).

6.2.4 Economic Implications

Table 6-1 (below) summarizes relative cost and accuracy of several energy management approaches. Reducing energy consumption for both fuel and electricity reduces the cost of energy to BSB. Therefore, if renewable on-site generation is installed, utility bills will likely decrease. To quantify potential financial savings associated with renewable energy production, technology-specific cost-benefit analyses are recommended.

Table 6-1 Energy Management Approaches (Ref 6-5)

Approach	Relative Cost	Potential Accuracy	Comments
Engineering Algorithms	Low	Low-Moderate	Accuracy depends on the quality of the input assumptions as well as the algorithm
Hourly Simulation Modeling	Moderate	Moderate	Input assumptions are again important, especially for HVAC and shell measures
Billing Data Analysis	Moderate	Moderate	Typically not useful for peak demand or on/off-peak energy analysis
Interval Meter Data Analysis	Moderate	High	Though not universally available, advanced metering infrastructure (AMI) is becoming more common

6.3 CASE STUDIES FOR ENERGY RESOURCES

6.3.1 Combined Heat and Power (US, 2015)

Description - Combined heat and power (CHP) is not a single technology; rather, it is an integrated energy system that can be modified depending upon the needs of the energy end user. CHP provides:

- Onsite generation of electrical, mechanical power or both;
- Waste-heat recovery for heating, cooling, dehumidification, or manufacturing process applications; and
- Seamless system integration for a variety of technologies, thermal applications, and fuel types into existing building infrastructure.

The two most common CHP system configurations are (a) gas turbine or engine with heat recovery unit, and (b) steam boiler with steam turbine. Figure 6-1 illustrates the process of a "gas turbine" or "engine with heat recovery" unit.

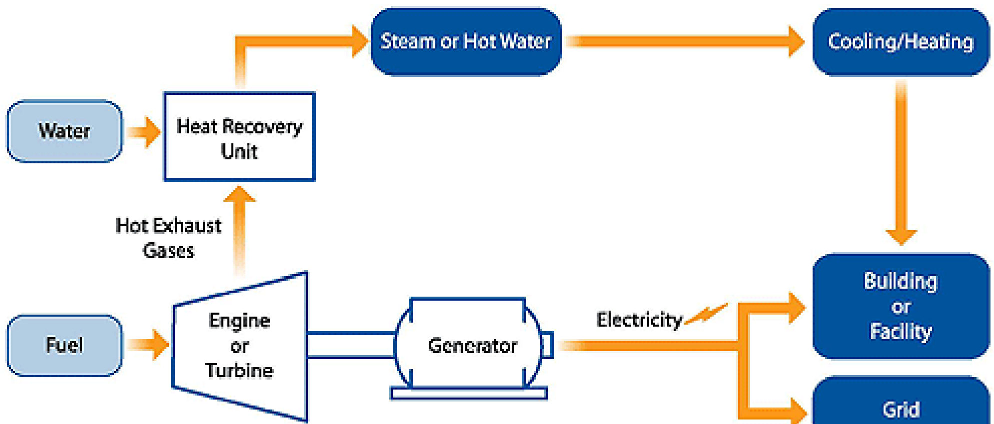

Figure 6-1: Gas Turbine Unit (Ref 6-6)

Gas turbine or reciprocating engine CHP systems generate electricity by burning fuel (natural gas or biogas) to generate electricity and then use a heat recovery unit to capture heat from the combustion system's exhaust stream. This heat is converted into useful thermal energy, usually in the form of steam or hot water. Gas turbines/engines are ideally suited for large industrial or commercial CHP applications requiring ample amounts of electricity and heat.

Pros - CHP systems achieve a fuel use efficiency of up to 85% compared to best thermal plant efficiencies of 55%. Additionally, they achieve a net reduction in the greenhouse emissions, air, and water pollution. In cold climates, cogeneration is one of the most cost-beneficial techniques of lowering carbon emissions for heating. Due to the proximity of CHP plants to where the power is needed, massive production outages are less probable because it is less dependent on transmission systems, which can be overloaded. Shorter transmission lines are needed, and transmission power loss is reduced for the same reason.

Cons - In order for CHP plants to be most viable, a certain match between electricity and heating needs is required. While larger CHP plants are most cost-effective in terms of electricity cost, because of rapid heat loss over distance and high cost for insulating pipes, smaller CHP plants with more expensive electricity generation are constructed. The capital and maintenance cost for a CHP plant construction is higher than those for a conventional plant. Regulatory barriers in some countries (e.g. in the US, present a major issue for the spread of CHP systems).

Why does it matter to Butte? - The industrial park on the city's southern edge may prove to be a logical location for the asphalt plant (Section 3). Proximity to the existing power plant at Basin Creek offers an excellent opportunity to harvest waste heat for immediate use and to supply electricity with less dependence on transmission networks. Waste heat is of real interest for two reasons:

- *Winter scenario*: Waste heat from the power plant can be used to heat the occupied portion of the asphalt plant. The shops and other commercial, institutional and industrial buildings located in the Park could also be heated.
- *Summer scenario*: During the time that the asphalt plant is most in demand, waste heat from the power plant can be used to pre-heat the asphalt mix. Pre-heating the mix can significantly reduce the demand for dedicated combustion in the asphalt preparation process by (Ref 6-7).

6.3.2 Hydrogen Powered Asphalt Plant (US, 2011)

Description - This Iowa State University case study assesses the installation of a wind turbine on site at a hot mix plant (HMA), which will harness energy from the blowing wind. The goal is to use the power generated from the wind turbine to meet the load demand of all components (or at least the major energy consumers) of the HMA plant.

The study explains how excess wind power will be diverted to an electrolyzer to generate hydrogen that can be stored using different options, the most feasible ones being compressed energy storage and metal hydride hydrogen storage. A hydrogen storage wind energy technology constructed on site would house the hydrogen storage tanks (Figure 6-2).

The installation process would go as follows: one or more wind turbines are installed at the site. Electricity derived from wind energy is then stored chemically in the form of hydrogen, which can later be used to generate electricity via a fuel cell when needed. In times of excess wind, electrical energy is generated and stored in hydrogen tanks as noted above. When required, hydrogen is then discharged from the tanks and is routed to the drum mixer and fuel cell stack. The drum mixer then uses the hydrogen as its main fuel for the burner instead of the traditional use of fossil fuels.

Pros - An advantage is the use of free, readily available wind energy. The wind energy will reduce, and in some cases eliminate the electricity drawn down from the conventional power grid and offset the use of fossil fuel for drum mixer operations. Through the use of hydrogen-based energy, the primary sources of greenhouse gas emissions from the HMA plant and can be significantly reduced and the resulting cost savings can be significant.

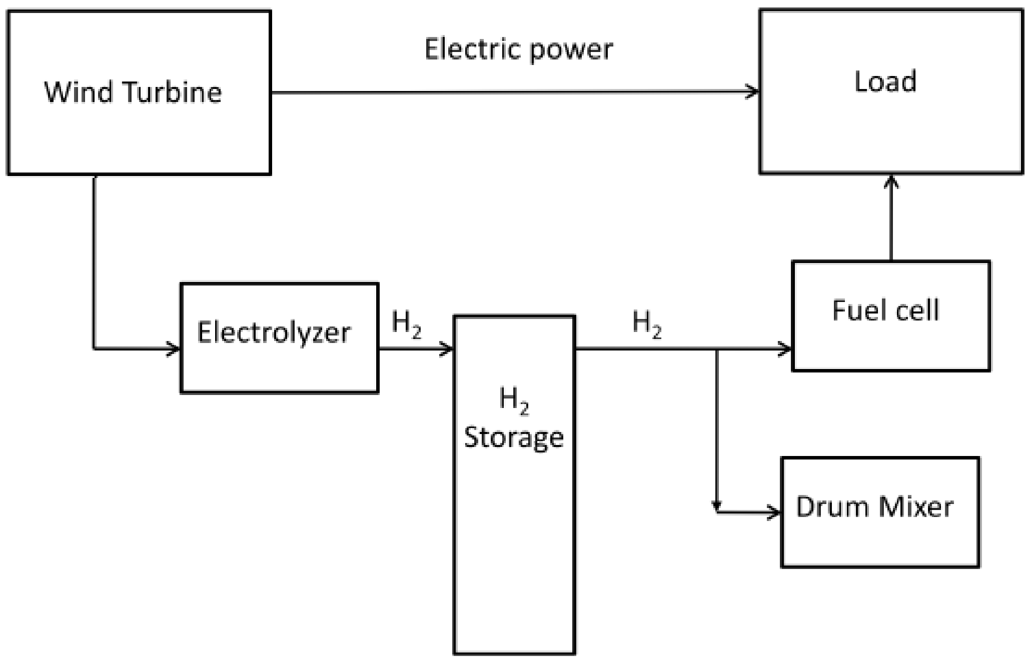

Figure 6-2: Schematic of Hot-Mix Plant Powered by Hydrogen-Based Wind Energy (Ref 6-8)

Cons – This technology has yet to be implemented in practice and is a feasibility study. The study proposes different types of energy storage, but these methods require further testing for efficiency and application purposes.

What this means for Butte? - It is important to investigate further wind potential from site to site as well as some of the negative externalities that exist (noise disturbance, potential loss of bird population, visual impact). Lastly, this is a very progressive theoretical study that has much potential for BSB to be a pioneer in the wind energy field.

6.3.3 Solar Covered Asphalt Plants (US, 2011)

Utilization of solar energy through installation of photovoltaic (PV) panels presents a great opportunity for BSB at both facilities. A variety of partners and providers provide financing and capital so that installation of panels can take place at a relatively low upfront cost. Solar World USA and Solar City are leading solar PV installation and leasing companies.

Examples of Solar World USA's successful projects include:

- *UT Medical Center, San Antonio.* This 248 kWp SolarWorld system serves the University of Texas Medical Center in San Antonio, Texas. The system was installed in 2011, combining parking canopy and rooftop solar arrays. In the first year of operation, the system exceeded the expected energy output by 5%.

- *El Dorado Irrigation District.* This 1 MWp system serves the El Dorado Irrigation District in El Dorado Hills, California. The system has been producing energy to support the district's needs since January of 2008 with remarkable performance. Predicted energy output has been exceeded by 10% in the seasonal climate of Northern California.
- *Oregon National Guard, Christmas Valley.* This 150 kWp rooftop system serves the Oregon National Guard in Christmas Valley, Oregon. The system stands on three emergency response support facilities and has been performing well above expectations during the first seven months of operation. Actual energy output has exceeded predicted energy output by 12%.

Examples of Solar City’s successful projects include:

- City of Sacramento, Los Angeles Unified School District, eBay, and Walmart.
- Solar City are also known for their high-quality products and service and have received an “A” rating from the Better Business Bureau. One of Solar City’s core competencies is its proprietary solar panel mounting technology called Zep. Zep solutions substantially reduce the cost and complexity of designing, shipping, warehousing and installing PV systems.

Figure 6-3 Solar City Solar Panels in Sacramento [Ref 6-9]

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7.0 ROADWAY FABRICATION AND MANAGEMENT

Both the shops and the asphalt plant are integral to roadway fabrication and management throughout BSB. This section addresses the most significant environmental impacts associated with roadway fabrication and management, discusses how these services can be managed more efficiently, and identifies case studies to showcase best practice and technological innovation opportunities.

Figure 7-1, adapted from the U.S. Department of Transportation Federal Highway Administration (Ref 7-1) identifies the life cycle stages of pavement. Each stage of the life cycle contains environmental risks and opportunities, from production techniques, to maintenance, to transportation, to disposal and should be considered during procurement and operational decision-making.

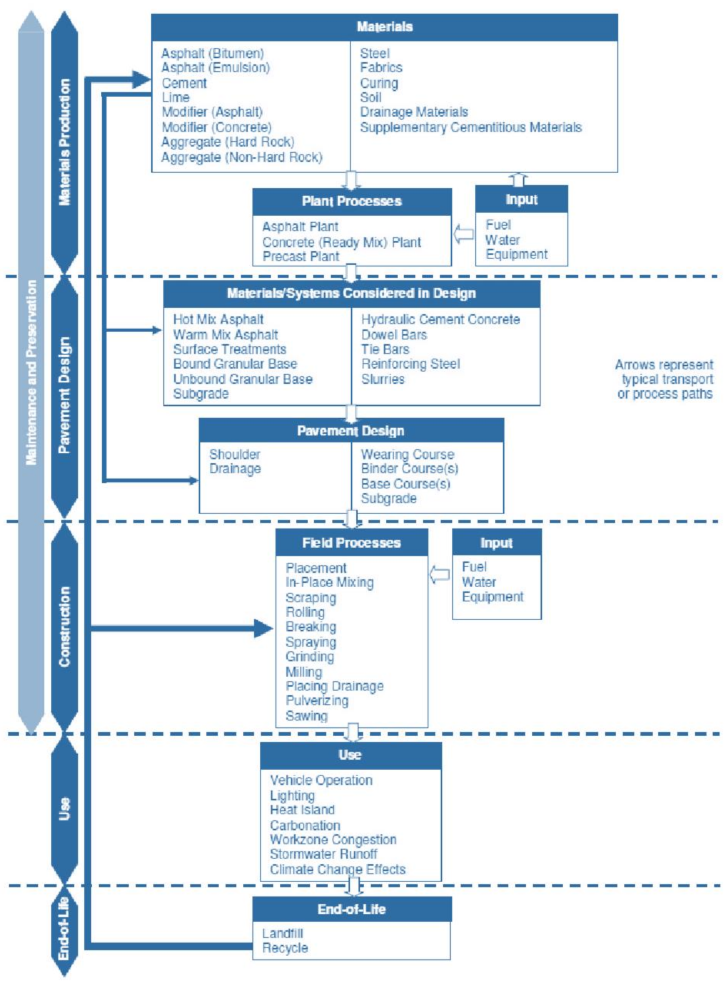

Figure 7-1 Pavement Life Cycle Stages

7.1 AIR EMISSIONS RELATING TO FABRICATION

7.1.1 Air Emissions Overview

According to US EPA, the majority of air emissions that occur from roadway paving activities are volatile organic compounds (VOCs) and hazardous air pollutants (HAPs) (Ref 7-2) Emissions associated with VOCs can be calculated using readily available factors. Emissions associated with HAPs are less standardized and require specific asphalt content information to be estimated.

7.1.2 Types of Asphalt by Impact

The way in which asphalt is manufactured effects its emissions. (Ref 7-2) Figure 7-2 illustrates relative impacts of emissions from four typical asphalt-manufacturing processes.

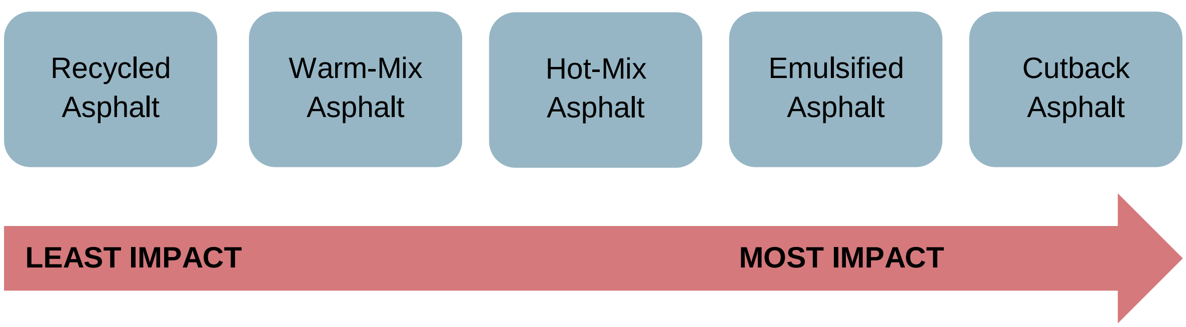

Figure 7-2 Impact Rank by Asphalt Types

7.2 WATER POLLUTION RELATING TO ROADWAYS

7.2.1 Water Pollution Overview

According to the US EPA (Ref 7-3) runoff pollution occurs when rainwater or melting snow washes over roads, bridges, parking lots, and other paved surfaces. Pollutants which accumulate on these surfaces including dirt, dust, metal deposits, road salts, antifreeze, engine oil, pesticides, fertilizers, discarded cups, plastic bags, cigarette butts, pet waste and other litter are flushed into the surrounding ecosystems and groundwater during a rain or snow event. Table 7-1 summarizes roadway contaminants and their effects.

Table 7-1: Roadway Contaminants and Their Effects (Ref 7-3)

Contaminant	Description	Effect
Sediment Erosion	Sediment is produced when soil particles are eroded from the land and transported to surface waters.	Erosion around bridge structures, road pavements, and drainage ditches can damage and weaken these structures.
Fertilizers, Pesticides & Herbicides	If these are applied excessively or improperly, fertilizers, pesticides, and herbicides can be carried by rain waters from the green parts of public rights-of-way.	In rivers, streams, lakes, and bays, fertilizers contribute to algal blooms and excessive plant growth, and can lead to eutrophication. Pesticides and herbicides can be harmful to human and aquatic life.
Oils and Grease	Oils and grease are leaked onto road surfaces from car and truck engines, spilled at fueling stations, and discarded directly onto pavement or into storm sewers instead of being taken to recycling stations.	Rain and snowmelt transport these pollutants directly to surface waters.
Heavy Metals	Heavy metals come from some "natural" sources such as minerals in rocks, vegetation, sand, and salt. Heavy metals also come from car and truck exhaust, worn tires, engine parts, and rust.	Heavy metals are toxic to aquatic life and can potentially contaminate ground water.
Debris	Grass and shrub clippings, pet waste, food containers, and other household wastes and litter.	Unsightly and polluted water. Pet waste from urban areas can add enough nutrients to estuaries to cause premature aging, or "eutrophication."
Road Salts	In the snow belt, road salt can be a major pollutant in both urban and rural areas.	Snow runoff containing salt can produce high sodium and chloride concentrations in ponds, lakes, and bays. This can cause unnecessary fish kills, changes to water chemistry, and harm vegetation.

7.2.2 Managing Water Pollution from Runoff

According to US EPA (Ref 7-4), management techniques to reduce pollution from runoff include but are not limited to:

- Programs, education and campaigns
  - Pollution prevention plans to reduce the amount of pollutants released
  - Protect areas that provide important water quality benefits or are particularly susceptible to erosion or sediment loss.
- Built environment/physical provisions
  - Storm water retention/ detention ponds
  - Slope protection
  - Grass strips
  - Temporary sediment traps
  - Silt fences
  - Diversion trenches
- Behavioral changes
  - Provisions for washing vehicles before they leave the construction site
  - Limit land disturbance such as clearing and grading and cut fill to reduce erosion and sediment loss.
  - Ensure proper storage and disposal of toxic materials.
- Planning, construction and implementation
  - Limit disturbance of natural drainage features and vegetation.
  - Place bridge structures so that sensitive and valuable aquatic ecosystems are protected.
  - Incorporate pollution prevention into operation and maintenance procedures to reduce pollutant loadings to surface runoff.
  - Develop and implement runoff pollution controls for existing road systems to reduce pollutant concentrations and volumes.

7.3 RECYCLING

7.3.1 Recycling Overview

Recycling of roadways saves money and natural resources. Though up to 98% of asphalt is recyclable (Ref 7-5) BSB’s asphalt plant currently only incorporates around 20% of recycled materials into its asphalt production.

7.3.2 US EPA's Waste Reduction Model

US EPA's *Waste Reduction Model* (WARM) is an online tool that allows users to estimate greenhouse gas (GHG) emissions based on waste management practices associated with asphalt. The model uses factors for landfill, incineration, recycling, and transportation emissions associated with asphalt's end-of-life. Figure 6-3 visualizes the boundaries of the WARM model. It is recommended that BSB refer to this tool when establishing best practice and setting baseline environmental performance targets for roadway recycling.

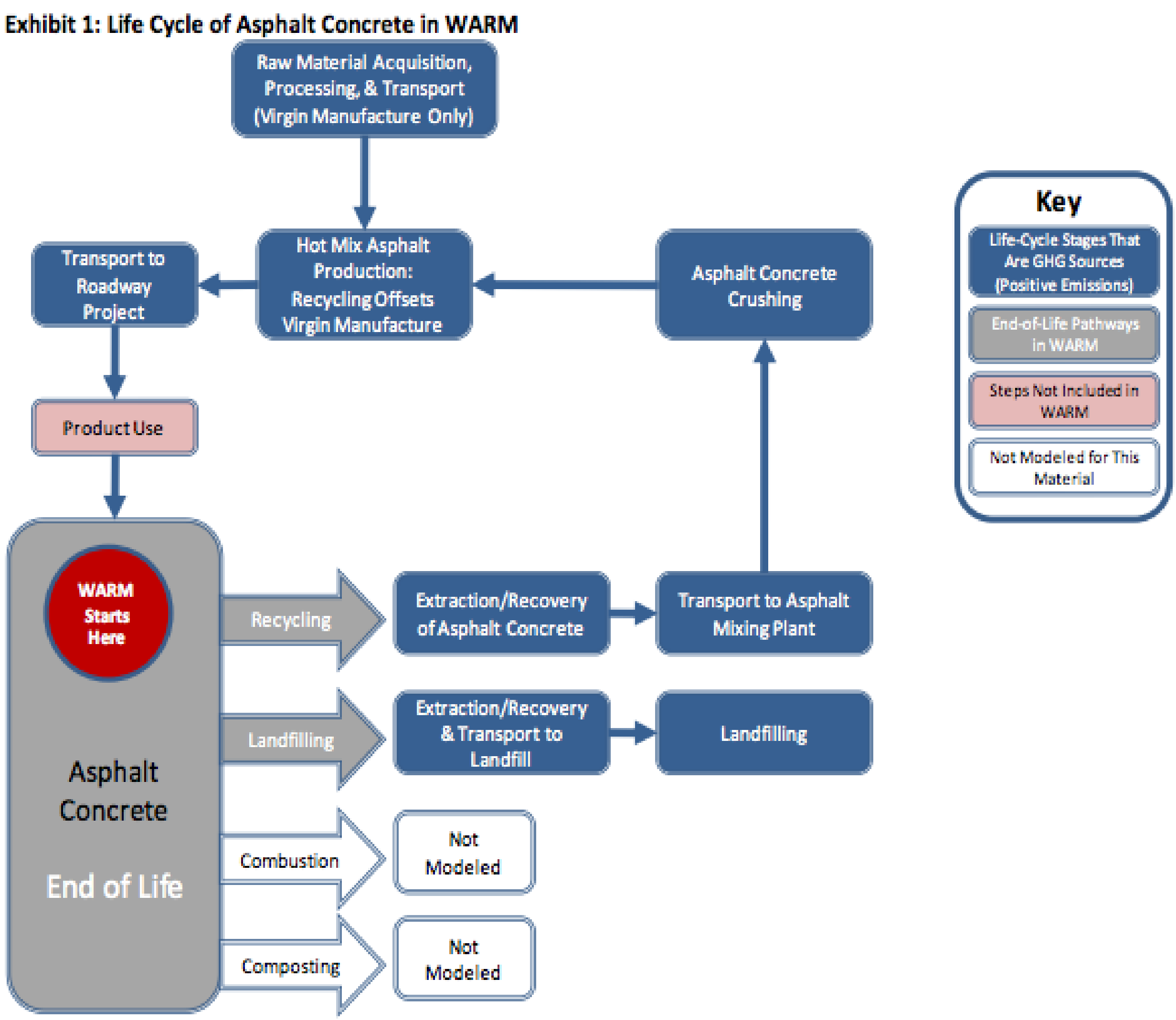

Figure 7-3 Life Cycle of Asphalt Concrete in WARM (Ref 7-6)

7.4 MAINTENANCE ALTERNATIVES

7.4.1 De-Icing Approaches

Using road salt as a winter ice management tool on infrastructure can lead to a number of issues including roadway damage and increased need for maintenance, harm to local animals, plant life, humans, and pets.

Alternative de-icers that are less harmful to infrastructure and the environment include**,** calcium magnesium acetate, calcium chloride, magnesium chloride, beet or corn solution, potassium acetate, and solar roads. Alternatives include sand, Calcium Magnesium Acetate, Calcium Chloride, Magnesium Chloride, Beet or Corn Solution, and Potassium Acetate, all of which are described below.

Sand - Sand does not melt ice, but it's widely used alongside salt and other de-icers to create traction. Economically, sand costs less than all major de-icing chemicals, including salt. Though it is a cheap alternative material, sand can clog storm drains, which can increase costs to municipalities for clean up and flood management. Additionally, sand loses its effectiveness after it becomes embedded in snow and ice. Sand also clouds up streams and other waterways, preventing sunlight from reaching some aquatic plants and burying life on stream beds (Ref 7-7).

Calcium Magnesium Acetate (CMA) - CMA is the most eco-friendly according to the University of Michigan's *Salt Use Improvement Team* (Ref 7-8) CMA has low toxicity, which reduces the damage to plants and microbes often caused by salt. CMA works in the same temperature range as salt (down to 15-20 ^{o} F). From an economic standpoint, CMA is more expensive than salt and requires approximately twice as much product to achieve the same de-icing results. Large amounts of CMA can lower dissolved oxygen levels in soils and water bodies, which has been proven to harm aquatic life (Ref 7-9).

Calcium Chloride - Calcium chloride is effective down to -25^{o} F, compared to salt which only works to approximately 15^{o} F. Calcium chloride is less harmful to plants and soil than salt, though there is scientific evidence it may damage roadside evergreen trees (Ref 7-10). Calcium chloride releases heat as it dissolves (Ref 7-11). Using calcium chloride can reduce road-salt usage by 10-15%. Disadvantages include high cost compared to salt, corrosivity to concrete and metals, and residue damage to carpets when tracked indoors by users.

Magnesium Chloride - Magnesium chloride works at temperatures as low as -13^{o} F. It is less harmful to plants, animals, soil and water than salt, and does not require post application cleanup. It attracts moisture from the air, which speeds up the process of dissolving and melting, and is typically mixed with sand, brine or other de-icers before it's sprayed in liquid form onto roads. Disadvantages include corrosivity to metal, and high cost compared to salt.

Beet or Corn Solution - Beet juice and agricultural by products from alcohol distilleries are carbohydrate-based liquids that help block ice formation. Beet and corn solutions, when mixed into a brine (a liquid combination including salt), can work better than salt alone. These compounds work at temperatures as cold as -25^{o} F, similar to calcium chloride, but do not have the same environmental risks as other chemicals. Beet and corn solutions do not corrode metal and pose no major threat to wildlife or people. Since they're made from organic matter, they may have a strong odor (Ref 7-12).

Potassium Acetate - Best used as a pre-wetting agent for solid de-icers, potassium acetate works in temperatures as low as -75 degrees Fahrenheit. Potassium acetate is non-corrosive and biodegradable, and requires fewer applications than many other de-icers. Disadvantages are that potassium acetate it can make road surfaces slick and lower oxygen levels in water. Cost is the largest disadvantage, potassium acetate costing on average about eight times more than salt (Ref 7-13).

7.4.2 Management Techniques

Apart from selecting less impactful de-icing agents, more efficient use of de-icers can result in environmental benefits. *Road-Weather Information Systems* (RWIS) are particularly beneficial. They use roadside sensors to collect data on air and surface temperatures, precipitation levels, and the amount of de-icing chemicals already on the road. Data from road-weather information systems are collated and used alongside weather forecasts to predict changes in pavement temperatures, which allow municipalities to better estimate the road area, timeframe, and amount of de-icing agents needed to manage extreme weather adequately. According to the Federal Highway Administration, the Massachusetts Highway Authority saved $53,000 on salt and sand costs the first year alone after employing RWIS, including $21,000 during a single storm salt (Ref 7-14).

7.4.3 Technology

Rebuilding and maintenance of roadways can be done with two different methods. One is to lay a new base, which requires more man-hours, vehicles, and materials. The other is called Full-Depth Remediation, which reuses the old asphalt and base material to build the new road. This method eliminates the need to haul in aggregate or haul out old material for disposal. Truck traffic is reduced, and there is little to no waste. Figure 7-4 shows relative performance of both Full-Depth Reclamation and New Base across indicators including "number of trucks needed," "new roadway materials," "material landfilled," and "diesel fuel consumed" (Ref 7-15). It is important to note the significant savings associated with full-depth reclamation compared to new base.

Figure 7-4 Full Depth v. New Base

7.5 ROADWORK CASE STUDIES

7.5.1 Cement Hydration Kinetics (US, 2010)

Description - The purpose of this project was to develop cement hydration kinetics modeling research (Ref 7-16). The focus will be on defining the causes at the onset and end of the induction period of alite, which controls set, strength, and subsequent microstructural development. The researchers will also use new experimental methods capable of measuring chemical and microstructural changes on the nanometer to micron scale during hydration.

Pros - The goal is to use this insight to improve the ability of NIST's HydratiCA model to predict hydration kinetics and microstructure in the presence of supplementary cementing materials

(SCMs). SCMs include fly ash, slag and metakaolin, and can be found in organic admixtures. The model will then inform road management in the future.

Cons – Study ends July 5, 2015 and results not yet available.

What does this mean for Butte? - The findings report is to be published in July 2015, which will summarize new asphalt mixture options and mixture design, which could be adopted by Butte.

7.5.2 Composite Pavements (Germany, 2015)

Description - The amount and content of heavy traffic with high axle loads on motorways is steadily increasing (Ref 7-17). To date, municipalities most often use traditional asphalt and concrete pavement surfaces when building roadways. They are designed for a service life of 30 years, if necessary maintenance measures are implemented. To guarantee mobility in the future, and to maximize the service life of roadways, necessary maintenance procedures must be made with a minimum of traffic interruption will be needed. Traditional pavement structures may not be able to fulfill these requirements in the future. Going forward, asphalt and concrete in combination (composite structure) with new techniques and technology can provide a potential solution to how we may build roads that have increased longevity.

Pros – Improved composite structure increases lifespan of roadways and reduces maintenance and operational costs.

Cons – Composite structures have higher upfront cost. Findings from German pilot study not yet published.

What does this mean for Butte? - Butte might consider utilizing the findings of this study to make the business case for expanding production of composite pavement mixtures and improving road performance, thereby reducing the environmental impact of roads.

7.5.3 Design for Extreme Weather (Netherlands, 2015)

Description - The project (Ref 7-18) assesses at the implications of:

- Drainage and treatment (pit) system capacity;
- Water absorption and drainage capacity of roadside soils;
- Geotechnical parameters for road constructions in relationship to drought, heavy rainfall, freezing; and
- Integrated design parameters to cope with all weather systems.

Pros – The project will allow for adoption of design features known to reduce negative impacts from extreme weather conditions.

Cons – High upfront costs.

What does this mean for Butte?
Butte might consider adopting some or all of the final design strategies to manage extreme weather, particularly winter weather.

7.5.4 Geothermally Heating Roads (Germany, Netherlands, US, and Japan, 2007)

Description - Outside surfaces can be heated geothermally with hydronic heat exchangers installed directly in to in the pavement. The heat exchangers absorb heat from the roadway that has been heated by the sun. Heating capacity depends on the climatic conditions and the system specifications installed. Snow melting requires higher system temperatures than what is required to prevent ice-formation. Low system temperatures implicate an anticipatory operation control (Ref 7-19).

There are various system designs that are suitable. Various sources may be used: direct use with geothermal hot water (normally bound to special geothermal conditions); direct use of warm or cold groundwater; direct use of borehole heat exchangers or energy piles. A combination system with a heat pump may also be considered.

Pros - Geothermal snow melting or de-icing system is a smart and environmentally-friendly alternative to the common mechanical and/ or chemical winter maintenance. There is also a big advantage to this method since the heat is available in the day as well as at night, eliminating the need of a costly stand-by emergency provisions. During heavy snow fall, the geothermal heating prevents the freezing of the roadway surfaces. Mechanical clearing becomes easier and less costly even during periods of low temperatures.

Cons- This method of geothermal de-icing works best on a flat roadbed. BSB roadways are, for the most part, at a gradient.

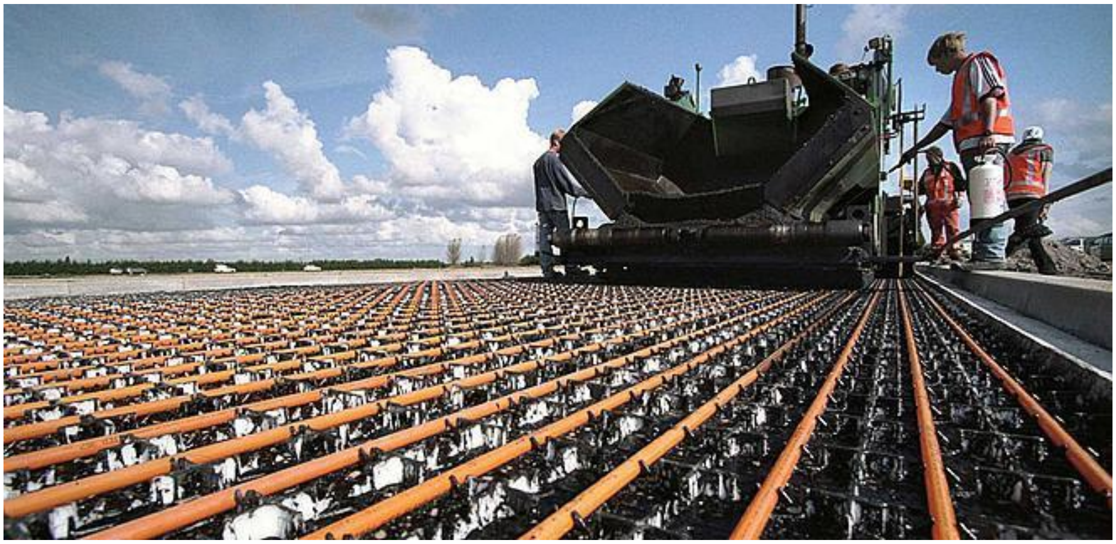

Figure 7-5 Geothermal de-icing

What does this mean for Butte? - If Butte were to consider a geothermal heating option for their roads, they would be able to avoid costly repairs (roads & equipment), reduce labor hours, as well as avoid environmental concerns of using deicers.

7.5.5 Solar Roads (United Kingdom, 2005)

***Description* -** Interseasonal Heat Transfer (IHT™) invented, developed and patented by London-based sustainable energy firm ICAX Ltd is a low-cost, low-maintenance process that collects solar energy from road systems and stores it in ThermalBanks for use in clearing ice from road surfaces in winter (Ref 7-20). Figure 7-7 shows ThermalBanks near the Toddington, M1, here where solar energy is captured from the road in summer.

Pros- Black roads tend to absorb the heat of the sun up to the point when they radiate heat as quickly as they are absorbing it: the surface temperature of roads in direct sunshine can often reach 59° F higher than the ambient air temperature. ICAX collects heat using fluid circulating through an array of pipes embedded in the surface of the road and deposits it in ThermalBanks constructed beneath the insulated foundation of buildings. The temperature across a large ThermalBank can be increased from its natural temperature of 10°C (50°F) to over 25°C (77°F) in the course of the summer months.

Cons – Installation upfront costs can be high.

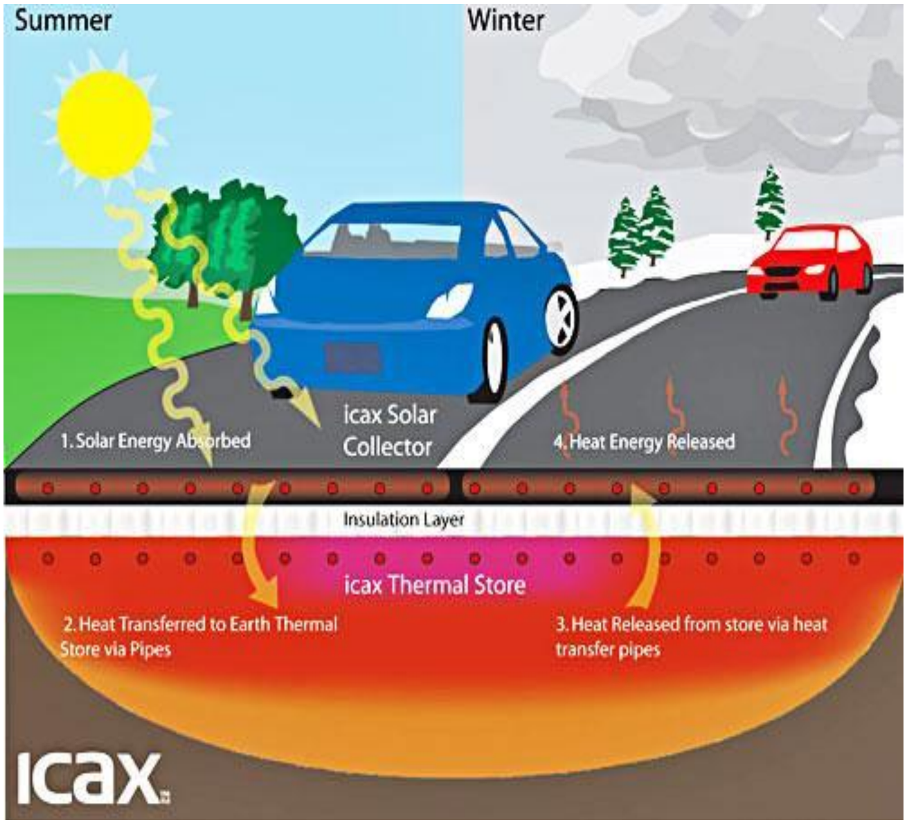

Figure 7-6 Solar Roadways Diagram

Figure 7-7 Toddington M1 Thermal Bank

What does this mean for Butte? - The technology, which uses underground ThermalBanks to store solar energy collected via the Asphalt Solar Collector in the road surface into usable power, could make a significant contribution to reducing global warming by cutting fossil fuel use while providing a clear road by eliminating what is considered as standard and routine maintenance. Further, the use of ThermalBanks can also extend the life of roads by reducing peak summer temperatures and increasing low winter temperatures at the road surface.

7.5.6 Induction Healing on Roads (Netherlands, 2010)

Description - This article illustrates that the healing capacity of porous asphalt concrete with steel wool fiber is enhanced by induction heating. Porous asphalt concrete fortified or strengthened with steel wool fiber can greatly restore its stiffness and strength. Steel wool fibers were incorporated into asphalt mastic and porous asphalt concrete to make roadways electrically conductive and suitable for induction heating. The electrical conductivity and induction heating speed of asphalt mastic and porous asphalt concrete were first studied in this research (Ref 7-21).

Pros – Longer lifetime of asphalt.

Cons – Increased energy cost from heating energy demands.

What does this mean for Butte? - This study is based on a thesis paper where trials were conducted on Dutch motorway A58 and, despite its theoretical success, the science still needs some more studying. This study can be used as a reference or used as a motivational tool to think outside of the box. If the technology were employed it would help limit the amount of repairs on the road and possibly reduce the amount of time it takes to make a repair.

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8.0 STAKEHOLDERS

8.1 PROPOSED PROCESS

Stakeholders are both groups and individuals that have an interest in the objectives and actions of an organization (e.g., a community). A community's character is defined in part by the types of stakeholders engaged in its issue and the depth of their engagement. A conceptual view of stakeholders interested in the location and design of BSB's shops and asphalt plant is shown in Figure 8-1. The intent of this stakeholder map is to illustrate the types (or groups) of stakeholders impacted by the scope of this project as well as a representative cross-section of participants. This map highlights both the centrality of BSB's citizenry, and the diversity of BSB's stakeholders, including (for example) individuals, community organizations, government representatives, and businesses. A detailed analysis of BSB's stakeholders, their motivations, and their potential influences was beyond the scope of this capstone project. However, an exemplar approach from the *Center for Urban Pedagogy* (CUP) is described below (see www.welcometocup.org).

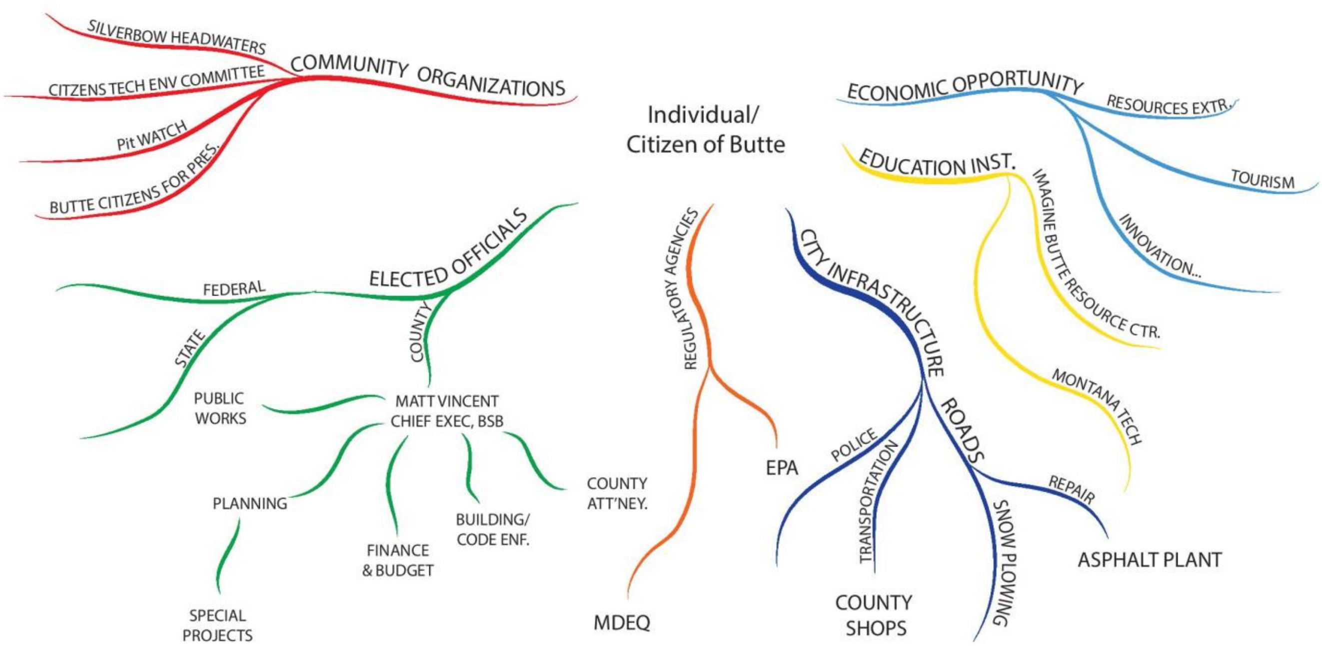


Figure 8-1 Stakeholder Map

CUP is a nonprofit organization based in New York, New York that specializes in improving the quality of public participation and education concerning urban planning and community design. Their designers and advocates produce tools, workshops, and publications that explain complex policies or processes for specific audiences. CUP's approach is to blend data analysis, design, and art to convey critical information to stakeholders. CUP's methodology is summarized in Table 8-1.

Table 8-1 CUP Methodology

Goal	Criteria and Examples
Speak the language of the audience	• Make sure questions, and informational tools are meaningful and easy to understand • Examples: community organizations, educators, and/or residents
Identify key stakeholders	• Interact directly with community members • Examples: individuals, community organizations, local institutions, and/or government representatives
Collect and record community input	• Get feedback on the decision-making process and topics of interest, and use interactions to gather support and begin building consensus • Examples: interviews and workshops
Create visual communication products	• Develop tools that are useful in the "real world" • Examples: posters, flyers, comic books, and videos
Make the information accessible	• Engage the target audience in their language • Examples: tactile tools, humorous and other non-intimidating approaches, and distribute widely

An example of CUP's output is provided in Appendix E. For the purpose of this capstone, CUP's ideas for a public information tool were adapted into a concept tool. The proposed tool is described in Table 8-2 (below). BSB can use this tool as a way to educate and engage with stakeholders. Theoretically, the tool's concepts and examples would be represented in an info-graphic used to convey (a) why the shops and asphalt plant are needed, (b) what moving the shops and asphalt would mean to BSB.

Table 8-2 Stakeholder Considerations

Concept	Examples
Transparency of process	• Stakeholder engagement • Public comment process
Preserve history, and move toward future	• Economic growth • Celebration of history
Scale of utility to community	• Miles driven by BSB vehicles (total) - Miles plowed - Miles patrolled by police • Miles of road resurfaced • Number of cleanouts at hydrodynamic devices
Impact of operations on townspeople's daily lives and convenience	• Improve safety/ reduce accidents • Avoid travel delays • Avoid vehicle damage
Things to consider	• Schedule • Design Constraints • Cost to Construct • Accessibility • Sustainability Opportunities • Shareholder Impact • Ecosystem Impact • Emissions/ Dust Impact • Noise/ Vibration Impact • Visibility
Ideas to reduce negative impacts	• Renewable onsite energy generation • Modular facility design • Alternative de-icing agents

8.2 SUMMARY OF LOCAL STAKEHOLDERS

The stakeholder output is based on information gathered during the site visit, while conducting interviews with stakeholders, and while consulting with external experts on stakeholder engagement. Relationships between stakeholders were mapped using an interest-influence grid, which is a common stakeholder analysis tool [Ref 8-1 and Ref 8-2]. Key stakeholders, by type, and their respective perspectives are provided for each candidate site in Appendix F (Tables F-1 through F-5).

8.3 REFERENCES FOR STAKEHOLDERS

Ref 8-1. Eden, C. (1996). The stakeholder/ collaborator strategy workshop. Creating collaborative advantage. London: Sage, 44-56.

Ref 8-2. Thompson, R. (2012). Stakeholder Analysis. Retrieved March 15, 2012. http://82.223.242.55/Lists/Informes/Attachments/711/stakeholder_analysis.pdf

9.0 CONCLUSIONS AND RECOMMENDATIONS

9.1 CONCLUSIONS

An analysis of sustainability impacts associated with industrial facility relocation was completed as a *Sustainability Management* Capstone Project. Results are based on a literature review and desk-based research, and a site visit that included interviews with BSB employees.

These results are summarized in this *Sustainability Workbook*, which is intended to be a resource during the relocation project(s), and throughout the facility's lifecycle(s). The workbook is designed to be adaptable and updateable by BSB as more information becomes available (i.e., a living workbook), and includes:

- A research database that is searchable by key word;
- Summaries of the sustainability aspects of BSB's current operations and relocation project;
- Case studies applicable to site selection, facility design, operation, and product end-use;
- A dynamic spreadsheet-based site selection rubric; and
- Preliminary assessment of stakeholders and a template for further evaluation.
- The following case studies:

Site Selection	Potential of Greywater Systems to Aid Sustainable Water Management
	Olympic Sculpture Park - Brownfield Redevelopment
	MIT's Project for Reclamation Excellence
	Collective Coffee - Brownfield Redevelopment
Design and Operations: Maintenance Shops	Toronto Lighting Retrofit
	Potential of Greywater Systems to Aid Sustainable Water Management
	Beddington Zero Energy Development
	Air Force Design Guide for Vehicle O&M Areas
	Shop Design Considerations
	USACE Tactical Equipment Maintenance Facilities Standard Design
Roadwork Maintenance	Cement Hydration Kinetics
	Composite Pavements
	Design for Extreme Weather
	Geothermally Heating Roads
	Solar Roads
	Induction Heating on Roads

This workbook can be utilized to support BSB's planning activities, including:

- Requests for Proposals (RPFs) and procurement of services;
- Environmental and social assessments;
- Operations management from a holistic or sustainable viewpoint; and
- Filling data gaps.

9.2 RECOMMENDATIONS FOR NEXT STEPS

Based on the data and information described herein, the following next steps are recommended:

- Maintain and adapt the tools provided in this workbook;
- Complete detailed cost-benefit analyses for site section, facility design, operational improvements, and roadway maintenance;
- Complete a detailed stakeholder analysis and develop innovative, targeted public communication tools; and
- Complete pre-design programming and/ or engineering studies for the new facilities.

APPENDIX A - SITE SELECTION RUBRIC RESULTS

Table A-1 - Central Portion of BAO

Type	Criteria	Description	Potential Negative Impact (Relative)	Candidate Site #1: Central Portion of Butte Area One Shops Score	Asphalt Score	Comb'd Score	Notes
Technical Feasibility	Schedule	Level of effort to acquire parcel	High = 3 Moderate = 2 Low = 1	2	2	2	Requires CERCLA remedy prior to acquisition, requires zoning change, owned by ARCO
	Design Constraints	Level of effort to convert parcel for development	High = 3 Moderate = 2 Low = 1	1	2	2	Remedy will lower grade 5' (assume site will be restored to grade), near existing infrastructure
	Overnight Cost	Cost to obtain and convert a parcel	High = 3 Moderate = 2 Low = 1	1	1	1	Assume site will be donated, RP's responsible to get ready for re-use
	Accessibility	Distance to infrastructure and heavy roads	High = 3 Moderate = 2 Low = 1	1	1	1	Close to I-90, close to residential Flats, strengthens link between Uptown and Flats
	Sustainability	Level of effort to implement BMPs/ alternatives	High = 3 Moderate = 2 Low = 1	1	2	1	Relatively open space, amenable to construction projects
Environmental & Social Feasibility	Stakeholders	Likelihood of community backlash	High = 3 Moderate = 2 Low = 1	2	3	3	Adjacent to residential and recreational areas (e.g., trail system)
	Ecosystem Impact	Potential to impact sensitive eco-receptors	High = 3 Moderate = 2 Low = 1	2	3	3	Adjacent to Blacktail and Silver Bow creeks, reduces ecosystem services by fragmenting it, interrupts green corridor running Butte-Anaconda
	Emissions/ Dust Impact	Potential for emissions/ dust to impact neighbors	High = 3 Moderate = 2 Low = 1	2	3	3	Heavy equipment, fuel storage
	Noise/ Vibration Impact	Potential for noise/ vibration to impact neighbors	High = 3 Moderate = 2 Low = 1	2	3	3	Heavy equipment, fuel storage
	Visibility	Level of effort to make attractive	High = 3 Moderate = 2 Low = 1	3	3	3	Adjacent recreational area (e.g., trail, KOA camp), neighborhoods relatively close, central/ high-visibility location
			TOTALS	***17***	***23***	***22***	*Lowest Negative Impact = 10. Highest Negative Impact = 30.*

Table A-2 - Montana Pole and Treating Plant

Type	Criteria	Description	Potential Negative Impact (Relative)	Candidate Site #2: Montana Pole & Treating Site			
				Shops Score	**Asphalt Score**	**Comb'd Score**	**Notes**
Technical Feasibility	Schedule	Level of effort to acquire parcel	High = 3 Moderate = 2 Low = 1	2	2	2	Requires CERCLA remedy prior to acquisition, owned by Montana Pole & Treating
	Design Constraints	Level of effort to convert parcel for development	High = 3 Moderate = 2 Low = 1	3	3	3	High pressure gas line, CERCLA remedy, existing infractstructure (e.g., power line easement), neighbors
	Overnight Cost	Cost to obtain and convert a parcel	High = 3 Moderate = 2 Low = 1	1	1	1	Assume site will be donated, RP's responsible to get ready for re-use
	Accessibility	Distance to infrastructure and heavy roads	High = 3 Moderate = 2 Low = 1	3	3	3	Greenwood needs to be rebuilt, constrained by rail spur, need traffic control at Montana intersection
	Sustainability	Level of effort to implement BMPs/ alternatives	High = 3 Moderate = 2 Low = 1	1	1	1	Relatively open space, amenable to construction projects
Environmental & Social Feasibility	Stakeholders	Likelihood of community backlash	High = 3 Moderate = 2 Low = 1	3	3	3	Adjacent Williamsburg and Boulevard neighborhoods
	Ecosystem Impact	Potential to impact sensitive eco-receptors	High = 3 Moderate = 2 Low = 1	2	3	3	Adjacent to Silver Bow Creek (albeit with controls already in place), steeply sloped grade = storm water mgt challenge
	Emissions/ Dust Impact	Potential for emissions/ dust to impact neighbors	High = 3 Moderate = 2 Low = 1	2	3	2	Large site could allow for setbacks
	Noise/ Vibration Impact	Potential for noise/ vibration to impact neighbors	High = 3 Moderate = 2 Low = 1	2	3	2	Large site could allow for setbacks
	Visibility	Level of effort to make attractive	High = 3 Moderate = 2 Low = 1	2	3	2	Adjacent to residences and I-90, thus requiring viewshed management
			TOTALS	***21***	***25***	***22***	*Lowest Negative Impact = 10. Highest Negative Impact = 30.*

Table A-3 - Upper Rail Yard

Type	Criteria	Description	Potential Negative Impact (Relative)	Candidate Site #3: Upper Rail Yard			
				Shops Score	**Asphalt Score**	**Comb'd Score**	**Notes**
Technical Feasibility	Schedule	Level of effort to acquire parcel	High = 3 Moderate = 2 Low = 1	1	2	2	Owned by BNSF Railroad, potential delay from transaction with railroad
	Design Constraints	Level of effort to convert parcel for development	High = 3 Moderate = 2 Low = 1	2	2	2	Required to maintain cover, steep slopes at north boundary, storm water control needed, some existing infrastructure
	Overnight Cost	Cost to obtain and convert a parcel	High = 3 Moderate = 2 Low = 1	2	2	2	Remediation is complete, but procurement cost is unknown and drainage system may need upgrades
	Accessibility	Distance to infrastructure and heavy roads	High = 3 Moderate = 2 Low = 1	1	1	1	Easily accessible, water and sewer lines in place, will need access road
	Sustainability	Level of effort to implement BMPs/ alternatives	High = 3 Moderate = 2 Low = 1	1	1	1	Relatively open space, amenable to construction projects, potential for greenway linking football field and gym, candidate for innovative storm water control and solar PV
Environmental & Social Feasibility	Stakeholders	Likelihood of community backlash	High = 3 Moderate = 2 Low = 1	2	3	2	Railroad ownership needs clarification, school and HUD are nearby
	Ecosystem Impact	Potential to impact sensitive eco-receptors	High = 3 Moderate = 2 Low = 1	2	3	3	Highly visible viewshed, adjacent to community and health centers that attract both local and non-local visitors
	Emissions/ Dust Impact	Potential for emissions/ dust to impact neighbors	High = 3 Moderate = 2 Low = 1	3	3	3	Heavy equipment, fuel storage
	Noise/ Vibration Impact	Potential for noise/ vibration to impact neighbors	High = 3 Moderate = 2 Low = 1	3	3	3	Heavy equipment, fuel storage
	Visibility	Level of effort to make attractive	High = 3 Moderate = 2 Low = 1	1	2	1	Slope can help preserve sight lines, central/ high-visibility location, inconsistent with adjacent sports and health facilities
			TOTALS	***18***	***22***	***20***	*Lowest Negative Impact = 10. Highest Negative Impact = 30.*

Table A-4 - Upper Lagoon Area

Type	Criteria	Description	Potential Negative Impact (Relative)	Candidate Site #4: Upper Lagoon Area Shops Score	Asphalt Score	Comb'd Score	Notes
Technical Feasibility	Schedule	Level of effort to acquire parcel	High = 3 Moderate = 2 Low = 1	1	1	1	No major remediation needed, eastern plot not subject to public scrutiny, owned by ARCO
	Design Constraints	Level of effort to convert parcel for development	High = 3 Moderate = 2 Low = 1	2	2	2	No existing infrastructure, eastern plot has no grading issues, western plot has steep grade approaching road
	Overnight Cost	Cost to obtain and convert a parcel	High = 3 Moderate = 2 Low = 1	1	1	1	Assume owned by BSB, western plot needs grading
	Accessibility	Distance to infrastructure and heavy roads	High = 3 Moderate = 2 Low = 1	1	1	1	Close to high-capacity roads, close to water treatment, distant from residences, low congestion
	Sustainability	Level of effort to implement BMPs/ alternatives	High = 3 Moderate = 2 Low = 1	2	2	2	Candidate for innovative storm water control, candidate for solar PV deployment, wind potential unknown
Environmental & Social Feasibility	Stakeholders	Likelihood of community backlash	High = 3 Moderate = 2 Low = 1	1	1	1	Potential interference with proposed I-90 exit/ DoT, small enclave several hundred feet north
	Ecosystem Impact	Potential to impact sensitive eco-receptors	High = 3 Moderate = 2 Low = 1	3	3	3	Adjacent to Silver Bow Creek
	Emissions/ Dust Impact	Potential for emissions/ dust to impact neighbors	High = 3 Moderate = 2 Low = 1	1	3	3	Hill and adjacent industry provide buffer, but small enclave several hundred feet north
	Noise/ Vibration Impact	Potential for noise/ vibration to impact neighbors	High = 3 Moderate = 2 Low = 1	1	1	1	Hill and adjacent industry provide buffer
	Visibility	Level of effort to make attractive	High = 3 Moderate = 2 Low = 1	2	2	2	Visible from I-90, adjacent to industrial facilities
			TOTALS	***15***	***17***	***17***	*Lowest Negative Impact = 10. Highest Negative Impact = 30.*

Table A-5 - Adjacent to Power Plant

Type	Criteria	Description	Potential Negative Impact (Relative)	Candidate Site #5: Adjacent to Power Plant Shops Score	Asphalt Score	Comb'd Score	Notes
Technical Feasibility	Schedule	Level of effort to acquire parcel	High = 3 Moderate = 2 Low = 1	1	1	1	Already zoned appropriately, already owned by BSB Development Corp
	Design Constraints	Level of effort to convert parcel for development	High = 3 Moderate = 2 Low = 1	1	1	1	Flat, no infrastructure constraints, adjacent power plant has utilities in place
	Overnight Cost	Cost to obtain and convert a parcel	High = 3 Moderate = 2 Low = 1	1	1	1	Assumed assessment value $3k
	Accessibility	Distance to infrastructure and heavy roads	High = 3 Moderate = 2 Low = 1	3	2	3	On state route that is adequate for heavy vehicles, 4 miles south of I-90 not sited for municipal use
	Sustainability	Level of effort to implement BMPs/ alternatives	High = 3 Moderate = 2 Low = 1	1	1	1	0.5 miles upstream of Sand Creek and Little Basin Creek, 40 feet higher than downstream SW, candidate for combined waste heat regeneration and carbon footprint reduction
Environmental & Social Feasibility	Stakeholders	Likelihood of community backlash	High = 3 Moderate = 2 Low = 1	1	1	1	Zoned industrial, no adjacent sensitive receptors (e.g., residential, surface water)
	Ecosystem Impact	Potential to impact sensitive eco-receptors	High = 3 Moderate = 2 Low = 1	2	2	2	No previous development (green field), distance from town center will increase fuel use and emissions
	Emissions/ Dust Impact	Potential for emissions/ dust to impact neighbors	High = 3 Moderate = 2 Low = 1	2	2	2	Any impacts are determined by wind strength, direction, and frequency; immediate commercial neighbors are close and possibly down wind
	Noise/ Vibration Impact	Potential for noise/ vibration to impact neighbors	High = 3 Moderate = 2 Low = 1	1	1	1	Remote location
	Visibility	Level of effort to make attractive	High = 3 Moderate = 2 Low = 1	1	1	1	Remote location, appropriate screening from above, potential infringement on viewshed of west-bound traffic
			TOTALS	***14***	***13***	***14***	*Lowest Negative Impact = 10. Highest Negative Impact = 30.*

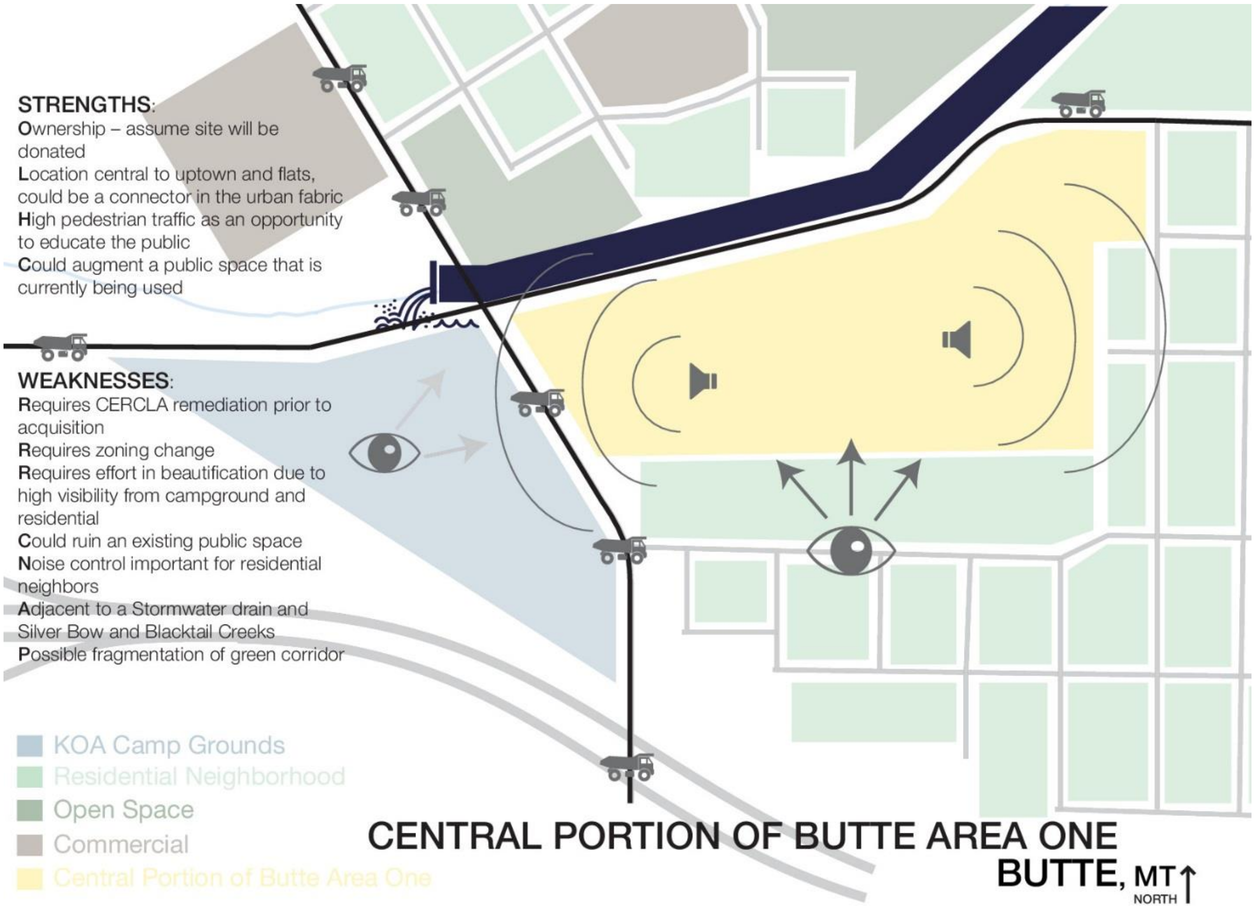


Figure A-1 - Central Portion of Butte Area One

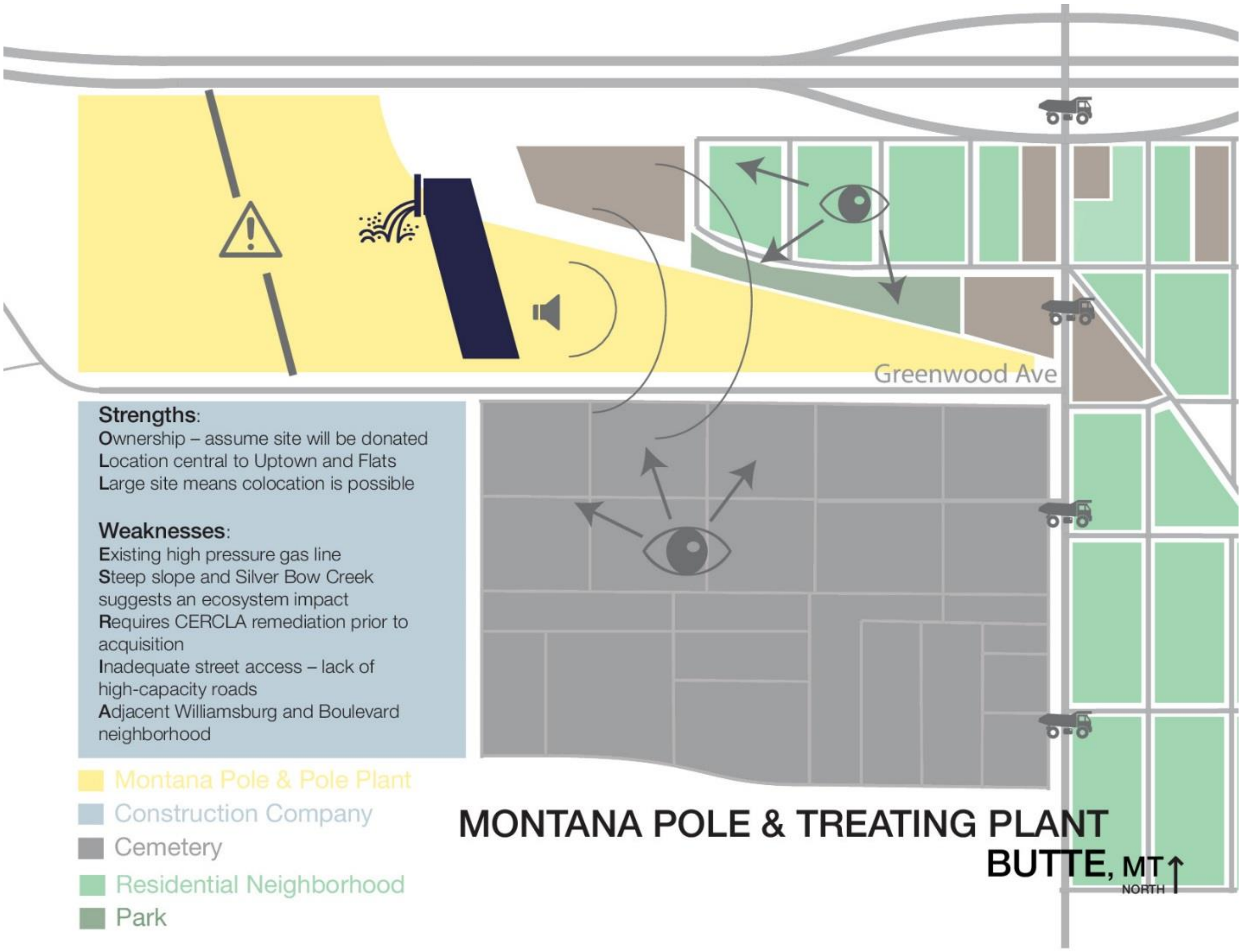


Figure A-2 - Montana Pole and Treating Plant

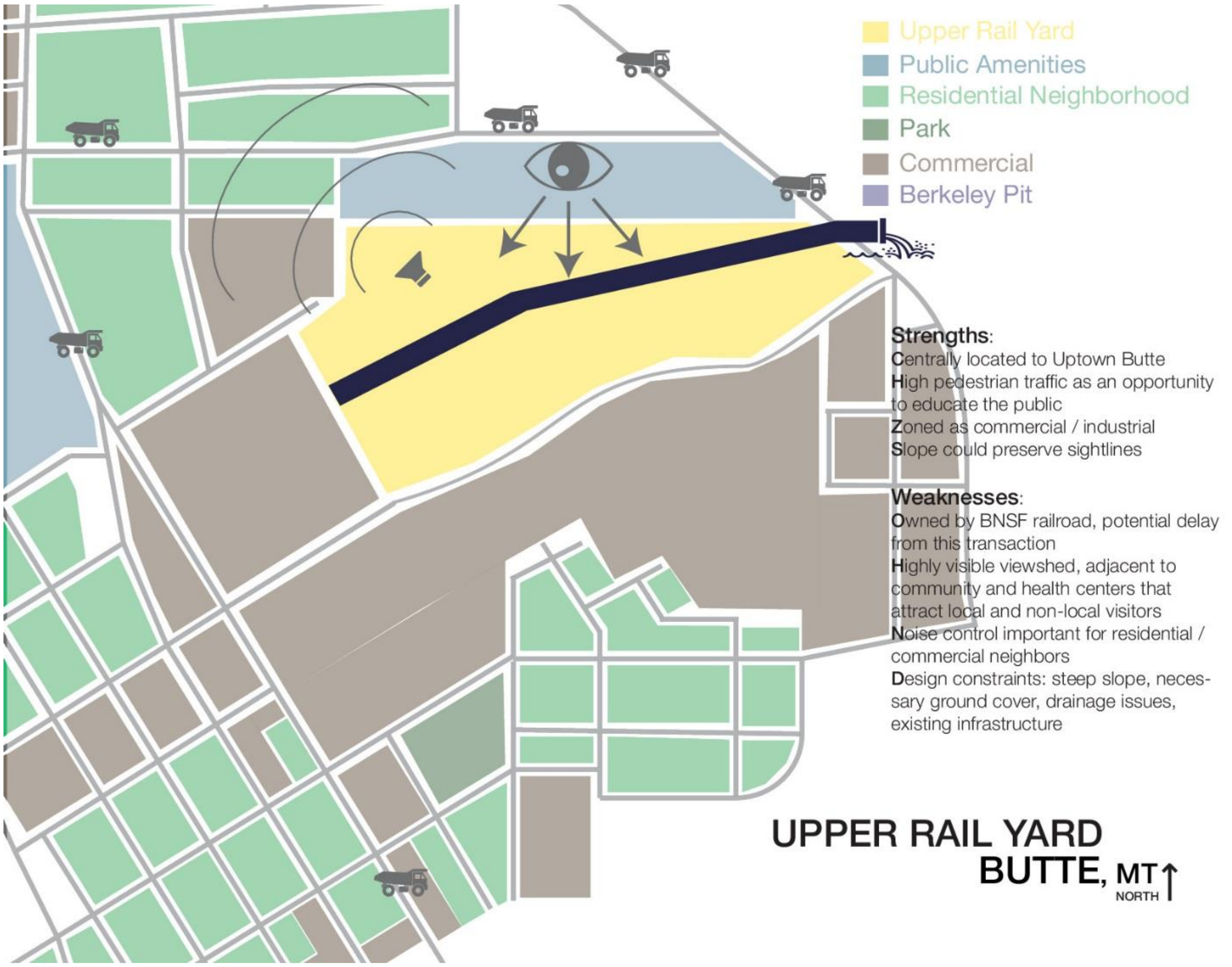


Figure A-3 - Upper Rail Yard

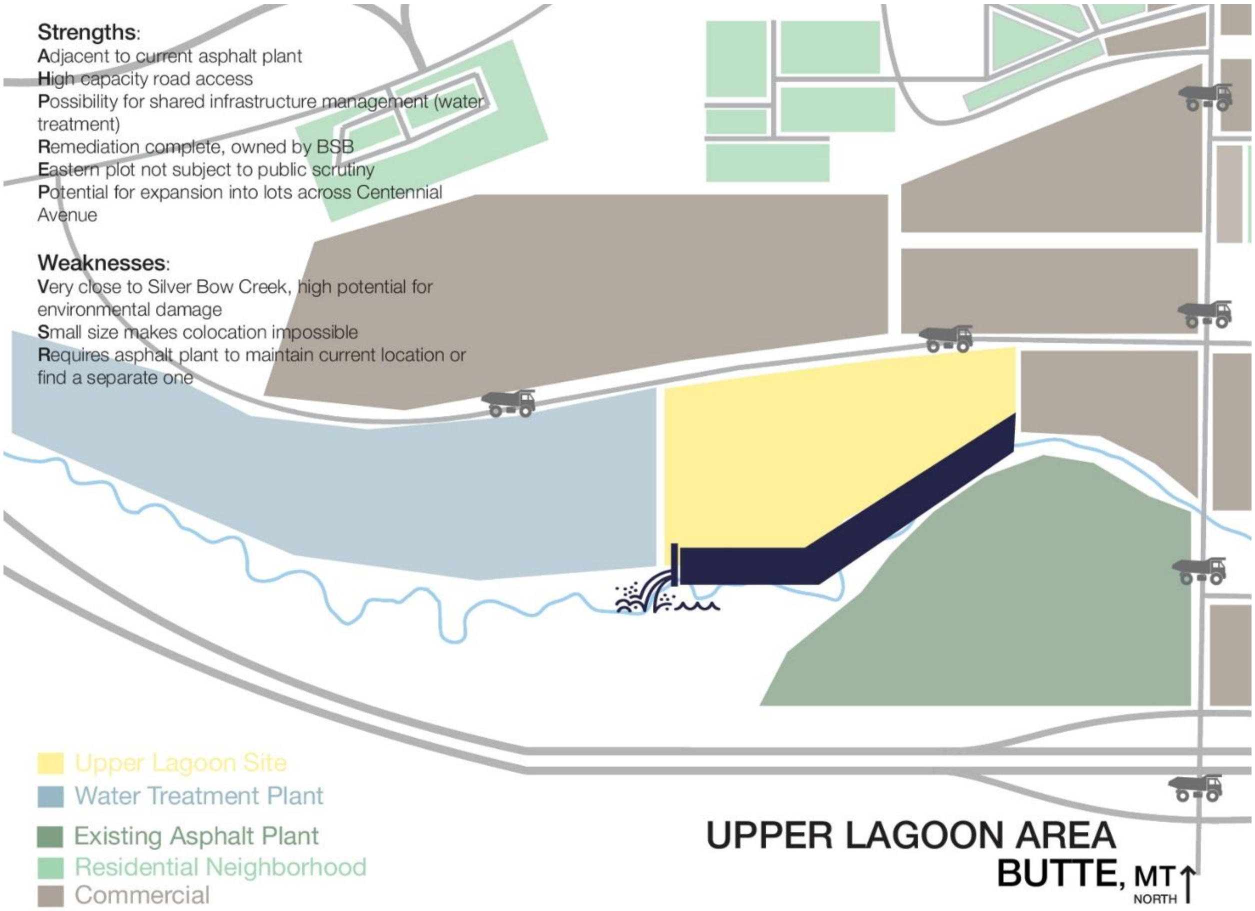


Figure A-4 - Upper Lagoon Area

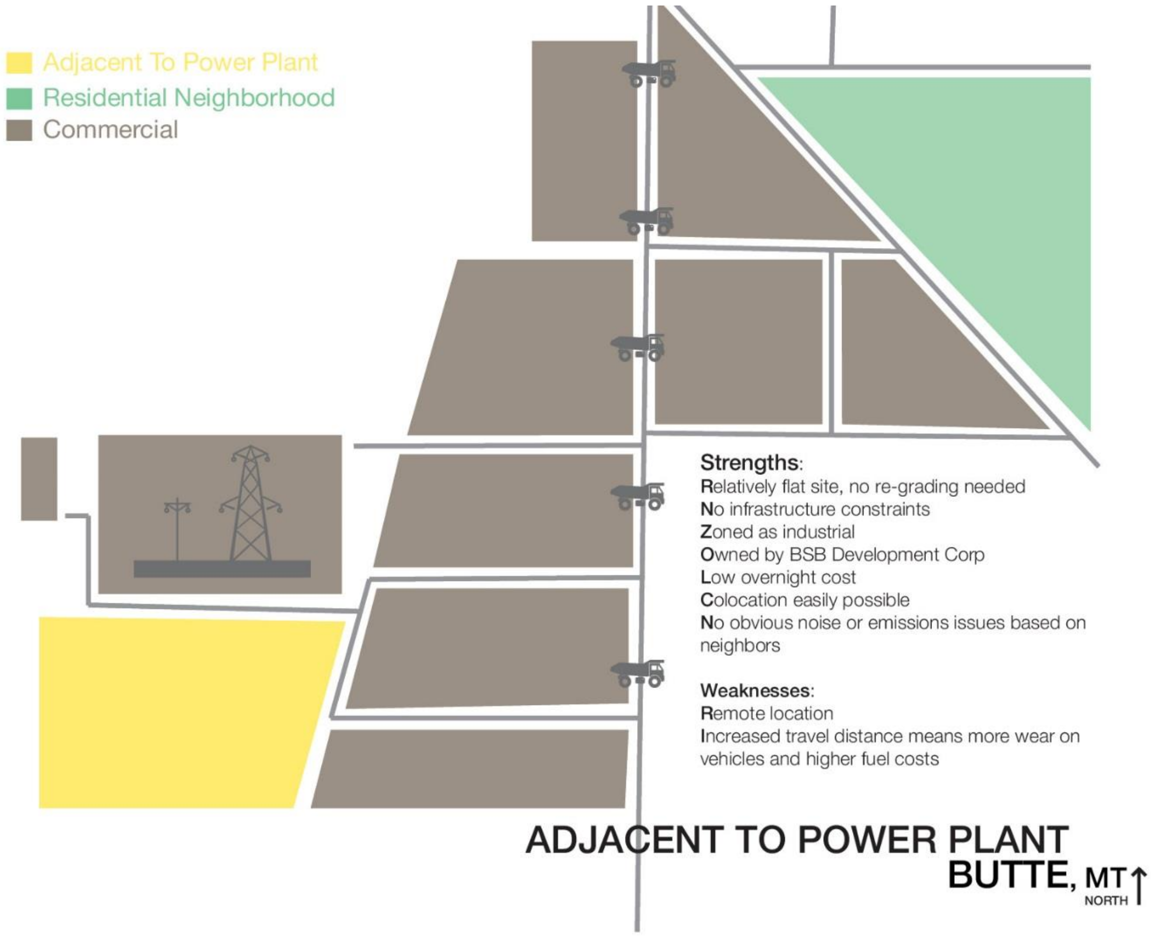


Figure A-5 - Adjacent to Power Plant

APPENDIX B – FLEET GARAGE

NEW MUNICIPAL FLEET SUSTAINABLE GARAGE

DEPARTMENT/AREA/COMPONENT
MAIN BUILDING

FLEET SERVICE BAYS

SUSTAINABLE INITIATIVES/FEATURES

ENVIRONMENT

Minimize the environmental impact from the garage and the services that it provides
Maximize municipal benefit of the fleet garage
Instill green practices, mindsets and attitudes: conservation and environmental stewardship

INPUTS - RESOURCES

LAND SITE/SOIL
Protect site from contamination from service, spills or accidents

ENERGY
Reduce energy demand
Increase energy efficiency
Conserve energy
Reduce fuel demand
Increase fuel efficiency
Conserve fuel
Seek alternative fuels for use in fleet vehicles

RENEWABLE/ON SITE GENERATION
Utilize solar photo-voltaic (PV) panels
Utilize geothermal energy to heat space from floor

AIR
Protect the air
Design for passive ventilation, for example: clerestory windows to provide a natural draw on air from floor

LIGHT
Utilize daylight to increase light levels inside garage and bays specifically
- clerestory windows
- glass garage doors

LIGHTING, SUPPLEMENTAL ELECTRIC LIGHT
Reduce the need for light by providing more daylight
Utilize high light -low energy lamps for general ambient light
Utilize high light -low energy lamps for task lighting

WATER
Protect the water
Reduce water demand
Reduce the demand for potable water
Reserve potable water for use in vehicle operating systems
Harvest rain water to use when spraying down bay floors and pits
Utilize spray aerators to reduce the amount of water used

OUTPUTS

WASTE STREAM
Reduce waste
Manage waste

EMISSIONS AND EXHAUST
- **AIR EMISSIONS**

PROTECT WATER
- **WATER WASTE**

- PROTECT
- **LAND SITE/SOIL**

SPILLAGE OF OIL OR TOXIC and CONTAMINATED FLUIDS or MATERIALS
Reduce likelihood of spillage
Provide for faciltiation of spillage occurences
- reduce risk of spillage
- containment
- harm
- injury

dedicated catchment that is separtate from water waster for filtration of sediment and water treatment
before releasing into waste water stream

CAMPUS | VEHICLE SERVICE | VEHICLE WASH | WELDING & PAINTING | FUELING & FILLING | STORAGE | EMPLOYEE FACILITIES

Normal View Ready Sum=0

NEW MUNICIPAL FLEET SUSTAINABLE GARAGE

DEPARTMENT/AREA/COMPONENT
MAIN BUILDING
FLEET SERVICE BAYS

SOCIO

Benefit community
Benefit employees

ASPECT | IMPACT

EMPLOYEE WORK ENVIRONMENT
mechanic comfort and well being
safety for the employees
training and education

BUILT MECHANICAL WORKING ENVIRONMENT

LIGHTING more efficient bulbs, brighter, $$ savings, daylighting
NATURAL LIGHT
TAKE ADVANTAGE OF THE NATURAL LIGHT TO IMPROVE LIGHT INTENSITY WITH LOW COST — clerestory windows
ACCESS IMPROVE ACCESS TO PERFORM WORTK ON VEHICLES — glass garage doors
AS WORK TALENT AGES, AGILITY DECREASES. PROVIDE FOR INCREASED ACCESSIBILITY

Reduce risk to employees and municipal liability
work efficiencies configuration, juxtapositioning organizationally,
SAFETY
HAZARDOUS EYE WASH BODY SHOWERS ETC...

THERMAL
- **HVAC**
- efficient heating
- radiant floor heating

ECONO

Maximize municipal benefit of the fleet garage
Minimize the environmental impact from the garage and the services that it provides

CAPITAL

reduce employee risk
O&M
REDUCE COSTS

BY UTILIZING TECHNOLOGY
INVENTORYING
FLEET MANAGEMENT
- VEHICLE TRACKING
- TRACK SERVICE INTERVALS FOR VEHICLES
- TRACK DRIVER PERFORMANCE

MEASURED PERFORMANCE MAY YIELD COST SAVINGS
reduce energy demand
By utilizing geothermal heat
By utilizing solar energ

lighting (more efficient bulbs, brighter, $$ savings, daylighting)

PROTECT PHYSICAL ASSETS
HVAC
keeping trucks warm
- maintian vehicles POISED TO BE ON THE READY FOR SERVICE
- Prevent tanks in vehicles filled with water from freezing

CAMPUS | VEHICLE SERVICE | VEHICLE WASH | WELDING & PAINTING | FUELING & FILLING | STORAGE | EMPLOYEE FACILITIES

Normal View | Ready | Sum=0

(see attachment "Appendix B" for access to all tabs and data)

APPENDIX C – PARTICULATE MATTER DISCHARGE LIMITS

Maximum Hourly Allowable Emissions of Particulate Matter	
Process Weight Rate, tons/hr	**Lb/hr check**
0.05	0.551
0.1	0.877
0.2	1.4
0.3	1.83
0.4	2.22
0.5	2.58
0.75	3.38
1	4.1
1.25	4.76
1.5	5.38
1.75	5.96
2	6.52
2.5	7.58
3	8.56
3.5	9.49
4	10.4
4.5	11.2
5	12

Maximum Hourly Allowable Emissions of Particulate Matter	
Process Weight Rate, tons/hr	**Lb/hr check**
6	13.6
8	16.5
9	17.9
10	19.2
15	25.2
20	30.5
30	40
35	41.3
40	42.5
45	43.6
50	44.6
60	46.3
70	47.8
80	49
100	51.2
500	69
1000	77.6
3000	92.7

Source: Montana ARM Title 17, Chapter 8.3

APPENDIX D – ENERGY INCENTIVES IN MONTANA STATE

The adoption, implementation, or purchase of renewable energy options in Montana presents numerous tax incentives outlined below.

Sourced directly from Montana DEQ

Incentive Type	Description
Lower property tax rates for transmission lines carrying renewable energy: 15-6-157 MCA	Transmission lines with firm contracts to carry electricity from certain renewable energy facilities are eligible to be classified as in class fourteen, which is taxed at 3% of its market value.
Property tax exemption for renewable generating facilities under 1 MW; 15-6-225 MCA	New generating facilities with nameplate capacity of less than 1 MW and using an alternative renewable energy source are exempt from property taxes for 5 years after start of operation.
Property tax reduction for renewable generating facilities of 1 MW or greater; 15-24-1401 et seq. MCA	Generating plants producing 1 megawatt or more by means of an alternative renewable energy source are eligible for the new or expanded industry property tax reduction on the local mill levy during the first nine years of operation, subject to approval by the local government. If so approved, the facility is taxed at 50 percent of its taxable value in the first five years after the construction permit is issued. Each year thereafter, the percentage is increased by equal percentages until the full taxable value is attained in the tenth year. The tax reduction applies only to taxes levied for the local high schools and elementary schools and for the local government offering the reduction.
Property tax abatement for renewable energy generating facilities; 15-24-3101 et seq. MCA	Certain renewable energy facilities and equipment are eligible for a property tax abatement of 50 percent for up to 19 years. This abatement applies to all mills levied against the qualifying facility or equipment. Renewable energy research and development equipment, up to the first $1 million of value, also is eligible to receive the abatement.
New or expanded industry tax credit; 15-31-124 et seq. MCA	Businesses engaged in the production of energy by means of an alternative renewable energy source are eligible for the new or expanded industry tax credit against corporate income tax. To be considered an expanding industry, total full-time jobs must increase by 30 percent or more. The credit is equal to 1 percent of new wages

	paid in state during the first three years of operation. No carryback or carryover is allowed for this credit.
Personal income tax credits for installing a residential geothermal system 15-32-115 MCA	A resident individual taxpayer who installs a geothermal or geothermal heat-pump system in the taxpayer's principal dwelling, or the builder of a house, can claim a tax credit based on the installation costs of the system, not to exceed $1,500. Credit not used in the year in which the system is installed may be carried forward for the 7 succeeding tax years. The credit can only be claimed once on any given house.
Tax credits for individuals installing nonfossil forms of generation; 15-32-201 et seq. MCA	Resident individuals may claim an income tax credit of up to $500 for installing a recognized nonfossil form of energy generation or heating, including low-emission wood or biomass combustion devices, in their principal residence. If necessary, the credit may be carried over for up to four years after the first year it is claimed.
Alternative energy investment tax credit; 15-32-401 et seq. MCA	Commercial and net metering alternative energy investments of $5,000 or more are eligible for up to 35 percent tax credit against individual or corporate tax on income generated by the investment. The credit may only be taken against net income produced by the eligible equipment or by certain associated business activities. Associated facilities, manufacturing plants producing alternative energy equipment and new or expanded businesses using the energy generated by the alternative energy investment may use the tax credit. The tax credit must be taken the year the equipment is placed in service; however, any portion of the tax credit that exceeds the amount of tax to be paid may be carried over and applied against state tax liability for the following 7 years. A project of 5 MWs or larger on a reservation may carry the credit over for 15 years, if it has an employment agreement with the tribal government. Taxpayers may not take this credit in conjunction with any other state energy or state investment tax benefits, or with the property tax exemption for nonfossil energy property 15-6-224. This credit is available to taxpayers purchasing an existing facility as well as to those building a new facility.
Renewable resource grant and loan program; 85-1-601 et seq. MCA	The renewable resource grant and loan program is administered by the Department of Natural Resources and Conservation. Historically the program primarily has funded water projects, but it does offer grants to renewable energy projects of state, local, or tribal

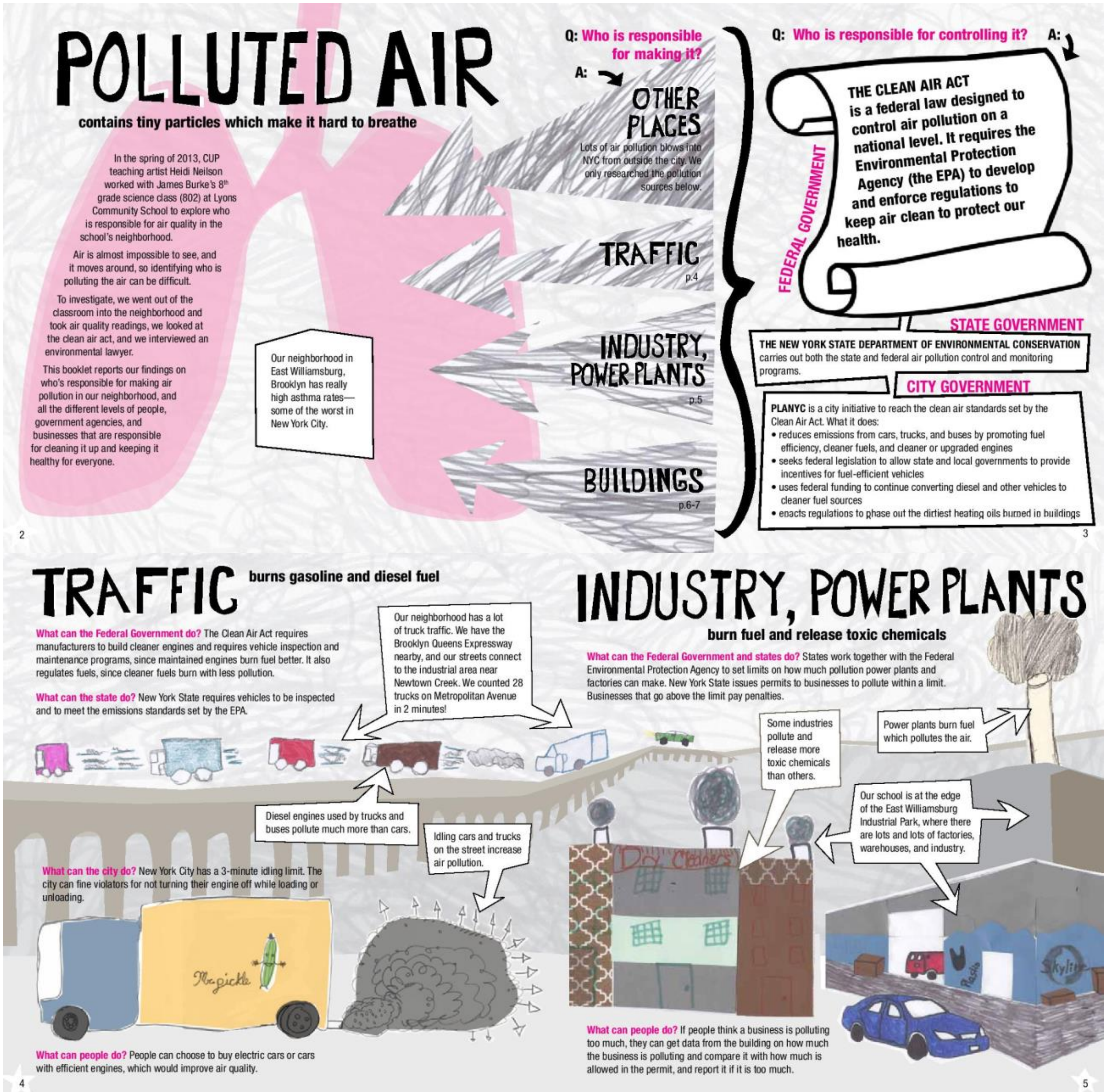
	government entities. On a biennial basis, DNRC evaluates and recommends projects to the Legislature for funding.
Grants for renewable research and development; 90-3-1001 et seq. MCA	The board of research and commercialization technology gives grants for renewable resource research and development projects, among other types, to be conducted at research and commercialization centers located in Montana.
Local government revenue bonds; 90-5-101 et seq. MCA	Limited obligation local government bonds ("special revenue bonds") may be issued for qualified electric energy generation facilities, including those powered by renewables. These bonds generally are secured by the project itself. The taxing power or general credit of the government may not be used to secure the bonds. Local governments may not operate any project financed by the sale of revenue bonds as a business except to lease it to some other party. These bonds are exempt from state taxes and may qualify for federal tax incentives. The tax-exemption feature allows funds to be borrowed at a significantly lower rate (1-2 percent) than possible with taxable bonds. There are various restrictions on how such bonds may be used. Because of the legal complexity of a bond issue, retaining bond counsel is important. The total amount of special revenue bonds that can be issued by state and local governments combined is capped, which theoretically could limit a government's ability to issue new bonds for a generation facility.
Alternative energy revolving loan program; 75-25-101 et seq. MCA	The alternative energy revolving loan program offers low-interest loans for up to $40,000 with repayment up to ten years. The loans are for the purpose of installing alternative energy systems that generate energy for the building occupant's own use or for net metering. Energy conservation measures may also be financed along with the alternative energy project. The number of loans that will be made is subject to funding availability. The projects must be located in Montana.
Net metering; 69-8-601 et seq. MCA	Net metering is an arrangement that allows surplus energy generated by the customer's renewable energy system to go back onto the utility electric system. The customer's meter measures the electricity the customer uses from the utility system less the electricity the customer's system puts back. The customer receives "credit" at retail rates for the electricity put back on the system, up to the amount of power the customer actually consumes at the location.

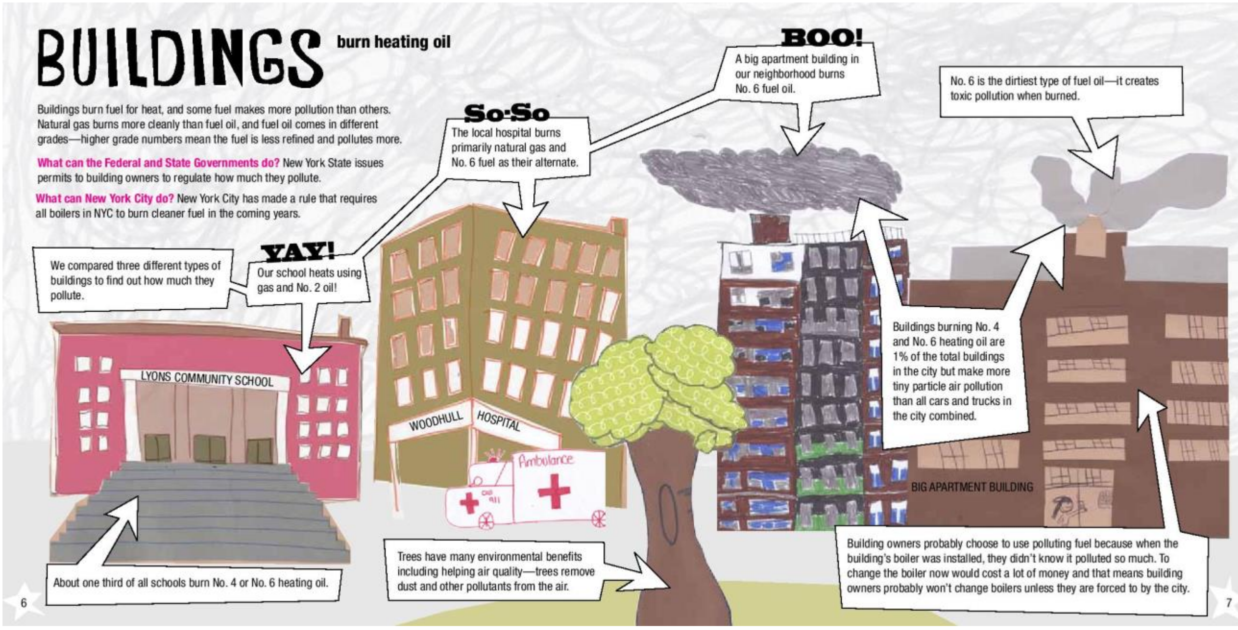
Wind easements; 70-17-401 et seq. MCA	A wind easement is an interest in real property to ensure access to wind. A property owner may grant a wind easement in the same manner and with the same effect as the conveyance of an interest in real property. The wind easement runs with the real property on and over which the wind resource flows and may not be severed from the property. A wind easement doesn't affect rights belonging to or the dominance of the mineral estate. It is not an easement or grant of right of way for transmission lines.
Use of ethanol-blended fuel by state vehicles; 2-17-414 MCA	All branches of state government and state institutions of higher education owning or operating a motor vehicle capable of burning ethanol-blended fuel shall take all reasonable steps to ensure that those vehicles use ethanol-blended fuel if that fuel is commercially available and competitively priced.
Income tax credit for alternative fuel motor vehicle conversion; 15-30-2320 MCA	An individual or business is allowed a state income tax credit for equipment and labor costs incurred to convert a motor vehicle licensed in Montana to operate on alternative fuel. The maximum credit that may be claimed in a year is up to 50 percent of the equipment and labor costs incurred but no more than $500 for conversion of a vehicle with a gross weight of 10,000 pounds or less or $1,000 for heavier vehicles. "Alternative fuel" means natural gas, liquefied petroleum gas, liquefied natural gas, hydrogen, electricity or any other fuel if at least 85 percent of the fuel is methanol, ethanol or other alcohol, ether, or any combination of them. The credit allowed under this section may not exceed the taxpayer's income tax liability and there is no carryback or carryforward of the credit.

Source: *Montana Department of Environmental Quality*

APPENDIX E – EXAMPLE OF CUP's OUTPUT

Air It Out




BUILDINGS burn heating oil
Buildings burn fuel for heat, and some fuel makes more pollution than others. Natural gas burns more cleanly than fuel oil, and fuel oil comes in different grades—higher grade numbers mean the fuel is less refined and pollutes more.
What can the Federal and State Governments do? New York State issues permits to building owners to regulate how much they pollute.
What can New York City do? New York City has made a rule that requires all boilers in NYC to burn cleaner fuel in the coming years.
We compared three different types of buildings to find out how much they pollute.
YAY!
Our school heats using gas and No. 2 oil!
LYONS COMMUNITY SCHOOL
About one third of all schools burn No. 4 or No. 6 heating oil.
So-So
The local hospital burns primarily natural gas and No. 6 fuel as their alternate.
WOODHULL HOSPITAL
Ambulance
Trees have many environmental benefits including helping air quality—trees remove dust and other pollutants from the air.
BOO!
A big apartment building in our neighborhood burns No. 6 fuel oil.
No. 6 is the dirtiest type of fuel oil—it creates toxic pollution when burned.
Buildings burning No. 4 and No. 6 heating oil are 1% of the total buildings in the city but make more tiny particle air pollution than all cars and trucks in the city combined.
BIG APARTMENT BUILDING
Building owners probably choose to use polluting fuel because when the building's boiler was installed, they didn't know it polluted so much. To change the boiler now would cost a lot of money and that means building owners probably won't change boilers unless they are forced to by the city.
6
7

The Center for Urban Pedagogy (CUP) is a nonprofit organization that uses the power of design and art to increase meaningful civic engagement.

City Studies are CUP's project-based in-class and afterschool programs that use design and art as tools to research the city.

To learn more about CUP, visit welcometocup.org

Lyons Community School is small school in East Williamsburg, Brooklyn, committed to providing a broad, stimulating experience in the liberal arts, and preparing students in grades 6 – 12 for college, healthy adulthood and life-long learning.

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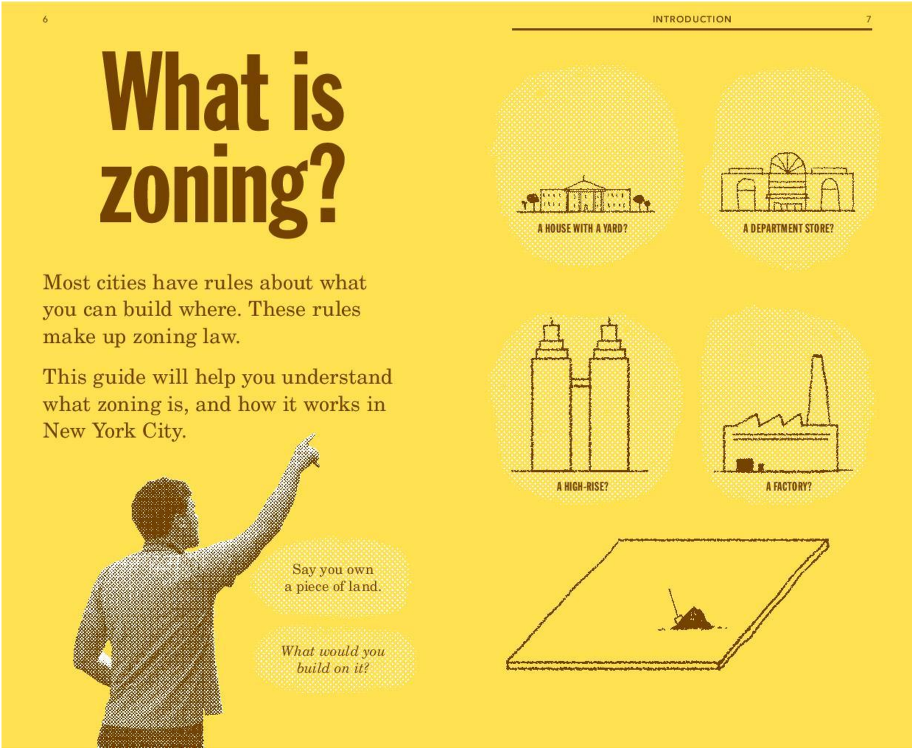
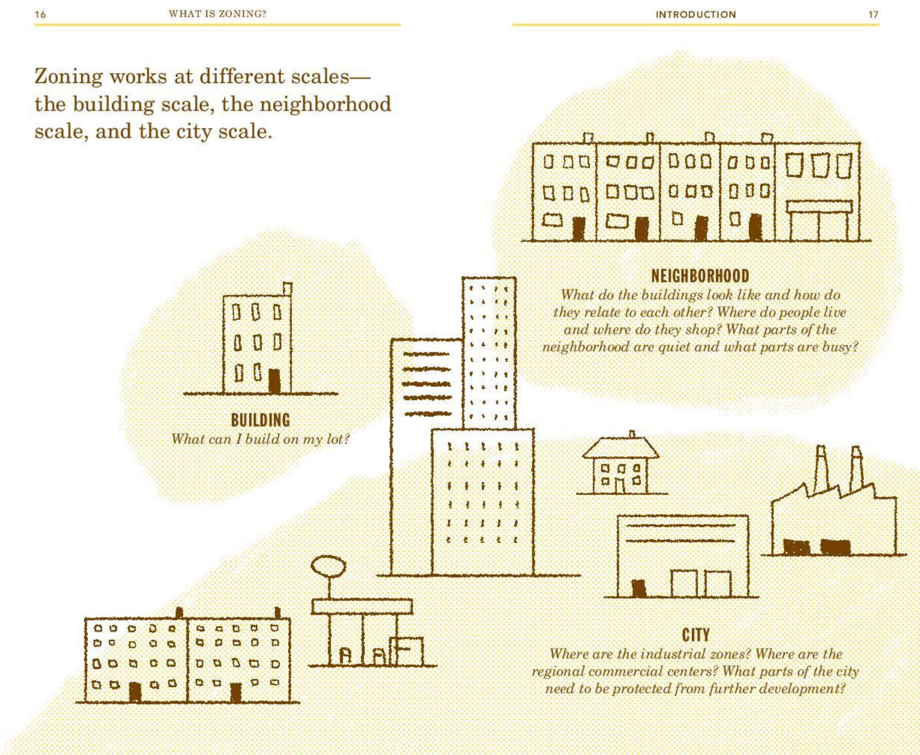
What is Zoning?





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USE ZONING 23

How does zoning affect land use?

"Use zoning" guides which types of building uses can go in different areas. New York City has four land use categories:

Residential

Commercial

Manufacturing

Special Purpose

28 WHAT IS ZONING?

USE ZONING 29

Commercial zones are for businesses where people do office work or buy and sell things.

That covers a lot of different establishments—bodegas, boutiques, beauty parlors, restaurants, grocery stores, law firms, banks, plumbing shops, hotels, movie theaters, department stores, offices, auto repair shops, sports arenas, shopping malls... you name it.

Source: Center for Urban Pedagogy

APPENDIX F – STAKEHOLDER IDENTIFICATION

Table F-1 - Central Portion of Butte Area One

Central Portion of Butte Area One				
Stakeholder Type	***Stakeholders***	***Core Interest***	***Potential Benefits***	***Potential Disadvantages***
Residential Community	Adjacent Residents	Maintain current quality of life for their families	Possible construction of an adjacent park with preservation of biking trails	Noise/air pollution and unpleasant visibility
Commercial Companies	Contractors	Obtain contracts for work pertaining to facilities operations	Obtain revenue from operations contracts	May not receive contracts
Recreational Facility	KOA Camp Site	Provide camping and recreational activities for community	Utilization of new park features for improved camping experience	Noise/air pollution and unpleasant visibility
Nonprofit Organizations	Non-Governmental Organizations	Provide expertise in relocation and operations logistics	Implementation of sustainability initiatives	Its particular vested interests may not be fully realized
County Government Employees	Chief Executive	Ensure smooth transition of relocation	Site is large enough to accommodate plant and county shops	May face resistance from adjacent residents
	County Attorney	Ensure relocation is in compliance with state/federal laws	Can provide advice to mitigate legal risk	May have to grapple with unanticipated legislation
	Water Treatment Plant Management	Ensure consistent quality of water supply	Goodwill from community for treating additional water runoff	May exceed its capacity in treating additional water runoff
	Plant and Shop Employees	Ensure efficient maintenance of county roadways	Closer proximity to main roadways	May face opposition from adjacent residents due to pollution/visibility issues
County Government Agency	Public Works	Ensure consistent maintenance of remediated site	Can prepare for optimal use of remediated site	May have to deal with bad weather effects on site
	City Planning	Attempt to create jobs for county residents	Goodwill from residents for providing employment	May not be able to create sufficient employment
	Special Projects	Coordinate need for unique relocation initiatives	Able to handle non-routine but urgent operations	May not handle such operations in a timely manner

	City Budget	Ensure availability of adequate funding for relocation	May have discretion to coordinate various funding strategies	May raise inadequate funds from such strategies
	City Buildings	Implement sustainability initiatives in construction process	Can choose from an array of suitable energy efficient options	May be hampered by the high cost of installing energy efficient technology
	City Revitalization	Ensure relocation is in coordination with county development	Can introduce installation aesthetics into the relocation process	May not have sufficient political support for such radical ideas
State Government Agency	MDEQ	Ensure continued stability of remediated site	Less monitoring and testing activity required	Integrity of remediated soil may be compromised
Federal Government Agency	US EPA	Provide Superfund grants to ensure compliance with Federal law	Continuous application of EPA legislation	Possible shortfall of Federal funds

Table F-2 - Montana Pole and Treating Plant

Montana Pole and Treating Plant				
Stakeholder Type	***Stakeholders***	***Core Interest***	***Potential Benefits***	***Potential Disadvantages***
Residential Community	Boulevard Community	Maintain current quality of life for their families	Possible access road linking site to I-90	Noise/air pollution and vibrations from asphalt plant
	Williamsburg Residents	Maintain current quality of life for their families	Avoid contaminated water runoff issue	Unpleasant visibility of facilities
Commercial Company	Adjacent Construction Company	Obtain contract for facilities construction	Obtain revenue from construction contract	May not receive contract
	Contractors	Obtain contracts for facilities operations	Obtain revenue from operations contracts	May not receive contracts
Nonprofit Organizations	Non-Governmental Organizations	Provide expertise in relocation and operations logistics	Implementation of sustainability initiatives	Its particular vested interests may not be fully realized
County Government Employees	Chief Executive	Ensure smooth transition of facilities relocation	Able to put remediated site to good use	Resistance from vocal residential community
	County Attorney	Ensure relocation is in compliance with state/federal laws	Can provide advice to mitigate legal risk	May have to grapple with unanticipated legislation
	Water Treatment Plant Management	Ensure consistent quality of water supply	Construction of treatment system of water runoff	Possibly handling excess contaminated water runoff
	Plant and Shop Employees	Ensure efficient maintenance of county roadways	Easier transport to facilities via new access road	Mitigating increased contaminated water runoff
County Government Agency	Public Works	Ensure consistent maintenance of remediated site	Can prepare for optimal use of remediated site	May have to deal with bad weather effects on site
	City Planning	Attempt to create jobs for county residents	Goodwill from residents for providing employment	May not be able to create sufficient employment
	Special Projects	Coordinate need for unique relocation initiatives	Able to handle non-routine but urgent operations	May not handle such operations in a timely manner
	City Budget	Ensure availability of adequate funding for relocation	May have to coordinate various funding strategies	May raise inadequate funds from such strategies
	City Buildings	Implement sustainability initiatives in construction	Can choose from an array of energy efficient options	May be hampered by the high cost of installing energy efficient technology

	City Revitalization	Ensure relocation is in line with county development	Can introduce aesthetics into the relocation process	May not have sufficient political support for such radical ideas
State Government Agency	MDEQ	Ensure continued stability of remediated site	Less monitoring and testing activity required	Possible compromise of integrity of remediated soil
Federal Government Agency	US EPA	Provide Superfund grants and ensure compliance with Federal law	Continuous application of EPA legislation	Possible shortfall of Federal funds

Table F-3 - Upper Rail Yard

Upper Rail Yard				
Stakeholder Type	***Stakeholders***	***Core Interest***	***Potential Benefits***	***Potential Disadvantages***
Residential Community	Adjacent Residents	Maintain current quality of life for their families	No perceived advantage	Noise/air pollution and unpleasant visibility
Public Facility	Civic Center	Provide an outlet for social interaction	Possible increased utilization of civic center and sports facility	Noise/air pollution and unpleasant visibility
Commercial Company	BNSF Railroad	Has ownership of the site	Revenue gain from sale of site	No perceived disadvantage
	Contractors	Obtain contracts for facilities operations	Obtain revenue from operations contracts	May not receive contracts
	Adjacent Companies	Ensure sufficient utilities for its operations	Provide justification to county to build access road to this vicinity	Increased traffic flow may hamper its own operations
Nonprofit Organizations	Non-Governmental Organizations	Provide expertise in relocation and operations logistics	Implementation of sustainability initiatives	Its particular vested interests may not be fully realized
County Government Employees	Chief Executive	Ensure smooth transition of relocation	Able to utilize existing water and sewer lines	May have to deal with possible excess surface water runoff issue
	County Attorney	Ensure relocation is in compliance with state/federal laws	Can provide advice to mitigate legal risk	May have to grapple with unanticipated legislation
	Plant and Shop Employees	Ensure efficient maintenance of county roadways	Improved quality of life due to easier access to facilities	No perceived disadvantage
	Water Treatment Plant Management	Ensure consistent quality of water supply	Goodwill from community for treating additional water runoff	May exceed its capacity in treating additional water runoff
County Government Agency	Public Works	Ensure consistent maintenance of remediated site	Can prepare for optimal use of remediated site	May have to deal with bad weather effects on site
	City Planning	Attempt to create jobs for county residents	Goodwill from residents for providing employment	May not be able to create sufficient employment
	Special Projects	Coordinate need for unique relocation initiatives	Able to handle non-routine but urgent operations	May not handle such operations in a timely manner
	City Budget	Ensure availability of adequate funding for relocation	May have to coordinate various funding strategies	May raise inadequate funds from such strategies
	City Buildings	Implement sustainability initiatives in construction process	Can choose from an array of energy efficient options	May be hampered by the high cost of installing energy efficient technology

	City Revitalization	Ensure relocation is in line with county development	Can introduce aesthetics into relocation process	May not have sufficient political support for such radical ideas
State Government Agency	MDEQ	Ensure continued stability of remediated site	Monitoring soil remediation integrity may be mitigated	May face opposition from adjacent residents
Federal Government Agency	US EPA	Provide Superfund grants to ensure compliance with Federal law	Continuous application of EPA legislation	Possible shortfall of Federal funds

Table F-4 - Upper Lagoon Area

Upper Lagoon Area				
Stakeholder Type	***Stakeholders***	***Core Interest***	***Potential Benefits***	***Potential Disadvantages***
Residential Community	Adjacent Residents	Maintain current quality of life for their families	Contaminated and stormwater runoff not an issue due to higher elevation	Noise/air pollution and unpleasant visibility
Commercial Companies	Contractors	Obtain contracts for work pertaining to facilities operations	Obtain revenue from operations contracts	May not receive contracts
Nonprofit Organizations	Non-Governmental Organizations	Provide expertise in relocation and operations logistics	Implementation of sustainability initiatives	Its particular vested interests may not be fully realized
County Government Employees	Chief Executive	Ensure smooth transition of relocation	May reap benefits of solar energy collection due to site's southwards facing location	May face resistance from residential community due to access road construction
	County Attorney	Ensure relocation is in legal compliance with state/federal laws	Can provide advice to mitigate legal risk	May have to grapple with unanticipated legislation
	Water Treatment Plant	Ensure consistent quality of water supply	Goodwill from community for treating additional water runoff	Have to determine if there is sufficent capacity to treat extra water runoff
	Plant and Shop Employees	Ensure efficient maintenance of county roadways	Reduction of electricity costs if solar panels are installed on roofs	Increased traffic flow may hamper transport of raw maierials to plant
County Government Agency	Public Works	Ensure consistent maintenance of remediated site	Can prepare for optimal use of remediated site	May have to deal with bad weather effects on site
	City Planning	Attempt to create jobs for county residents	Goodwill from residents for providing employment	May not be able to create sufficient employment
	Special Projects	Coordinate need for unique relocation initiatives	Able to handle non-routine but urgent operations	May not handle such operations in a timely manner
	City Budget	Ensure availability of adequate funding for relocation	May have discretion to coordinate various funding strategies	May raise inadequate funds from such strategies
	City Buildings	Implement sustainability initiatives in construction process	Can choose from an array of suitable energy efficient options	May be hampered by the high cost of installing energy efficient technology
	City Revitalization	Ensure relocation is in coordination with county development	Can introduce installation aesthetics into the relocation process	May not have sufficient political support for such radical ideas
State Government Agency	Montana Department of Transportation	Ensure optimal traffic flow on state roadways	Construct access road from highway to western plot to ease traffic flow	May face opposition to access road from residents in this area

	MDEQ	Ensure continued stability of remediated site	Monitoring activities in soil remediation integrity may be mitigated	May also face opposition from adjacent residents
Federal Government Agency	US EPA	Provide Superfund grants and ensure compliance with Federal law	Continuous application of EPA legislation	Possible shortfall of Federal funds

Table F-5 - Adjacent to Power Plant

Adjacent to Power Plant				
Stakeholder Type	***Stakeholders***	***Core Interest***	***Potential Benefits***	***Potential Disadvantages***
Residential Community	Commercial Residents	Maintain current quality of life for their families	Possible increase in business due to heavier human traffic flow	Possible disruption of business due to increased flow of transport vehicles
External Public Community	Highway Traffic	May visit as tourists if incentives are provided	Can avoid unpleasant visibility of facilities	Have to share roadways with increased number of county vehicles
Commercial Companies	Contractors	Obtain contracts for work pertaining to facilities operations	Obtain revenue from operations contracts	May not receive contracts
Nonprofit Organizations	Non-Governmental Organizations	Provide expertise in relocation and operations logistics	Implementation of sustainability initiatives	Its particular vested interests may not be fully realized
County Government Employees	Chief Executive	Ensure smooth transition of relocation	Increased community interaction arising from increased business	Deal with extra security precautions due to its close proximity to the power plant
	County Attorney	Ensure relocation is in legal compliance with state/federal laws	Can provide advice to mitigate legal risk	May have to grapple with unanticipated legislation
	Plant and Shop Employees	Ensure efficient maintenance of county roadways	Possible access to waste heat generation from power plant as renewable energy source	Increased transportation time due to more remote location
County Government Agency	Public Works	Ensure consistent maintenance of remediated site	Can prepare for optimal use of remediated site	May have to deal with bad weather effects on site
	City Planning	Attempt to create jobs for county residents	Goodwill from residents for providing employment	May not be able to create sufficient employment
	Special Projects	Coordinate need for unique relocation initiatives	Able to handle non-routine but urgent operations	May not handle such operations in a timely manner
	City Budget	Ensure availability of adequate funding for relocation	May have discretion to coordinate various funding strategies	May raise inadequate funds from such strategies
	City Buildings	Implement sustainability initiatives in construction process	Can choose from an array of suitable energy efficient options	May be hampered by the high cost of installing energy efficient technology
	City Revitalization	Ensure relocation is in coordination with county development	Can introduce installation aesthetics into the relocation process	May not have sufficient political support for such radical ideas

State Government Agency	Montana Department of Transportation	Ensure optimal traffic flow on state roadways	May consider access road construction to ease traffic congestion	May face opposition from existing industrial residents due to increased traffic flow
	MDEQ	Ensure continued stability of remediated site	Less or no need for soil monitoring due to industrial nature of location	May face opposition from existing industrial residents due to increased pollution
Federal Government Agency	US EPA	Provide Superfund grants to ensure compliance with Federal law	Continuous application of EPA legislation	Possible shortfall of Federal funds

(see attachment "Appendix F" for source data)