WESTERN MONTANA CORRIDOR

Site Selection and Supply Chain Analysis
Volume III

Northwest Advanced Renewables Alliance

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NARA is led by Washington State University and supported by the Agriculture and Food Research Initiative Competitive Grant no. 2011-68005-30416 from the USDA National Institute of Food and Agriculture.

3.1.0 SITE SELECTION AND SUPPLY CHAIN ANALYSIS

3.1.0.1 NARA Supply Chain Defined

A supply chain is a system to move products or services from supplier to consumer and includes organizations, people, technology, activities, information and resources (Vitasek 2010). Activities along the supply chain transform raw materials into a finished product delivered to the end consumer. For the NARA process, forest residues must go through several processes to be converted into isobutanol and ultimately biojet fuel. These processes include chipping the woody biomass into a usable feedstock, chemically and biologically converting the feedstock into isobutanol, and refining into fuel and co-products. Companies and facilities that can perform these operations are needed throughout the supply chain and can exist in integrated or dispersed manufacturing scenarios while maximizing efficiency and minimizing costs. Supply chain analysis has been acknowledged as one of the vital assessments for stimulating renewable energy development (Council 2011).

A supply chain can be evaluated as regions, nodes and linkages. A biofuels supply chain initially requires a region rich in biomass. For NARA, the biomass of interest is forest residuals, however, construction and demolition debris (C&D waste) could potentially become and additional source of feedstock, especially in urban regions. Feedstock materials are refined from this raw biomass, at specific nodes that we call 'depots' and 'conversion' sites. These nodes may exist at a landing of a forest harvest operation or at a nearby facility such as a sawmill or chipping yard. At depot sites, the forest residuals are sorted, ground, and loaded for transport to other nodes, that is conversion facilities where the chips undergo mechanical, chemical, and biological treatments to produce isobutanol. Finally, linkages are transport systems that enable the transfer of materials between nodes (e.g., forest roadside pickup from slash piles, highway, rail and pipelines).

The NARA project treats isobutanol as the primary final product produced from a conversion facility. It is assumed, but not necessary, that the catalytic conversion of isobutanol to iso-paraffin kerosene (i.e. jet fuel) would be conducted at a petroleum refinery. It is important to know that alternative processing scenarios may evolve that could prove more cost effective. For instance, specialized conversion facilities could be established that concentrate the carbohydrates from wood residuals, which could then be shipped to another facility for conversion to isobutanol and other products. In analyzing the Western Montana Corridor (WMC) supply chain, the starting point is considered to be where the forest residuals are generated. Here forest residuals are collected and either preprocessed at the landing or transported by truck to a pre-processing depot. The potential unit operations employed in the pre-conversion process include: sorting, size reduction (i.e. grinding, chipping, hammer milling, etc.), cleaning, and shipping. Conversion facilities will generally receive the preprocessed residuals in the form of chips, which are similar to but less refined than the feedstock provided in a typical pulping operation. At the conversion facility, the feedstock is then 'pretreated' so that the cellulose component of wood is accessible to enzymes, which convert the cellulose into its constituent simple sugars. The simple sugars are subsequently fermented into an alcohol (isobutanol), which is transported from the conversion facility via pipe, rail or truck to a petroleum refinery for final conversion into biojet fuel. Figure 3.1.1 illustrates the varied processing steps in the supply chain.

Figure 3.1.1 Steps involved in the supply chain for conversion of wood residues to bio-jet fuel

3.1.1 CONVERSION FACILITY SITES

3.1.1.1 Asset Analysis and Overview

Based on asset analysis and on the recommendations of regional stakeholders, two potential sites for conversion facilities were identified for the Western Montana Corridor region (WMC). One site is located in Libby, Montana and the other at the former Smurfit-Stone pulp and paper mill site near Frenchtown, Montana. These potential conversion site locations contain much of the existing infrastructure required such as utilities, transportation access, wastewater treatment facilities, permits and a large feedstock storage yard. The use of existing facilities was important to reduce the capital expenditure costs associated with new development.

3.1.1.2 Conversion Site Resource Flow System Diagram

The process of converting wood chips to isobutanol requires many inputs and results in both positive and negative outputs. A system diagram for a conversion facility is illustrated in figure 3.1.2. Wood chips, brought from the depot sites, are made of cellulose fibers bound by lignin. Electricity is a vital input for the conversion process. It is important that the conversion facility have adequate, constant and affordable electricity. a source of affordable electricity, such as a hydroelectric dam, would be an important asset to identify when siting a conversion plant. Water, human labor, equipment and infrastructure are also inputs needed in the conversion process.

There are many useful co-products that are produced as a result of converting wood into isobutanol, which can be economic assets to the conversion site. High value co-products can replace petroleum-based products such as plastics and solvents. Other outputs could include beauty bark and animal bedding. Treated wastewater, various types of air and thermal pollution are negative outputs from the conversion process. Isobutanol is the major resulting product in this process that will then be transported via rail or pipeline to the refinery to be refined and mixed with petroleum jet fuel.

3.1.1.3 Conversion Site Details Requirements

A biomass conversion site can be divided into four key areas: a biomass feedstock yard, a chip yard, a pretreatment facility, and a hydrolysis and fermentation facility. The biomass feedstock yard may receive the raw biomass (i.e., slash) straight from harvest site landings or depot (biomass consolidation) sites, but to be economic, the harvesting must be within 20-30 miles of the facility. In addition to storage capacity, this portion of site operations also has sorting and grinding equipment that reduces the slash and removes bark and needles. The chip yard stores ground chips that are produced on site as well as those that are delivered. It is common for a biomass facility to keep a 30-day supply of feedstock and chips on site (EPA 2007). This sizable quantity can allow the plant to function through seasonal supply shortages and inclement weather conditions. Our analysis determined that the feedstock yard would require 5 to 12 acres, and a chip yard would need 3 to 7 acres. The calculated range of values was based on the premise that biomass feedstock and wood chips can be stacked to a height ranging from 12 to 32 feet (EPA 2007; Garstang et. al. 2002).

The buildings where pretreatment (preparing chips for the hydrolysis and fermentation process) and conversion (pretreated materials are converted to isobutanol) processes occur must also be considered in determining the minimum acreage necessary for locating a conversion facility. Because the biomass conversion process is similar to that of the ethanol conversion process, existing ethanol plants were used as models to determine the area required for pretreatment, hydrolysis and fermentation (Ethanol Producer Magazine 2013). Several sites for existing ethanol hydrolysis and fermentation plants were evaluated resulting in an average site area of 10 acres. From the ethanol facility studies, it is assumed that the pretreatment process will require about the same amount of space. Woody biomass conversion site assumptions are listed in Table 3.1.1.

CONVERSION SITE SYSTEMS

OVERVIEW

In the process of converting wood chips to isobutanol there are many inputs and outputs both positive and negative. Wood chips, brought from the depot sites, are made of cellulose fibers bound by lignin. Electricity is an imperative input. It is important that the plant be near a an energy source such as a hydroelectric dam. Water, electricity, human labor, equipment and infrastructure are also inputs needed in this conversion process. There are many useful co-products that are produced in this process that can be economic assets to the conversion site. These co-products can replace petroleum-based products such as plastics and solvents, as well as being used as a supplement for non-ruminant animal feed. Treated wastewater, various types of air pollution and thermal pollution are negative outputs from the conversion process. Isobutanol slurry is the major resulting product in this process that will then be sent to the refinery to be refined and mixed with the jet fuel.

BRAIN BELEAU
WSU - CIVIL ENGINEERING
BRACKEN CAPEN
WSU - CIVIL ENGINEERING
GRAHAM BRITTAIN
UI - LANDSCAPE ARCHITECTURE
SAM KNITTLE
WSU - CIVIL ENGINEERING
MATT RAMICH
UI - LANDSCAPE ARCHITECTURE
CODY WILLIAMS
UI - LANDSCAPE ARCHITECTURE
TESS WOLFENSON
UI - BIOREGIONAL PLANNING

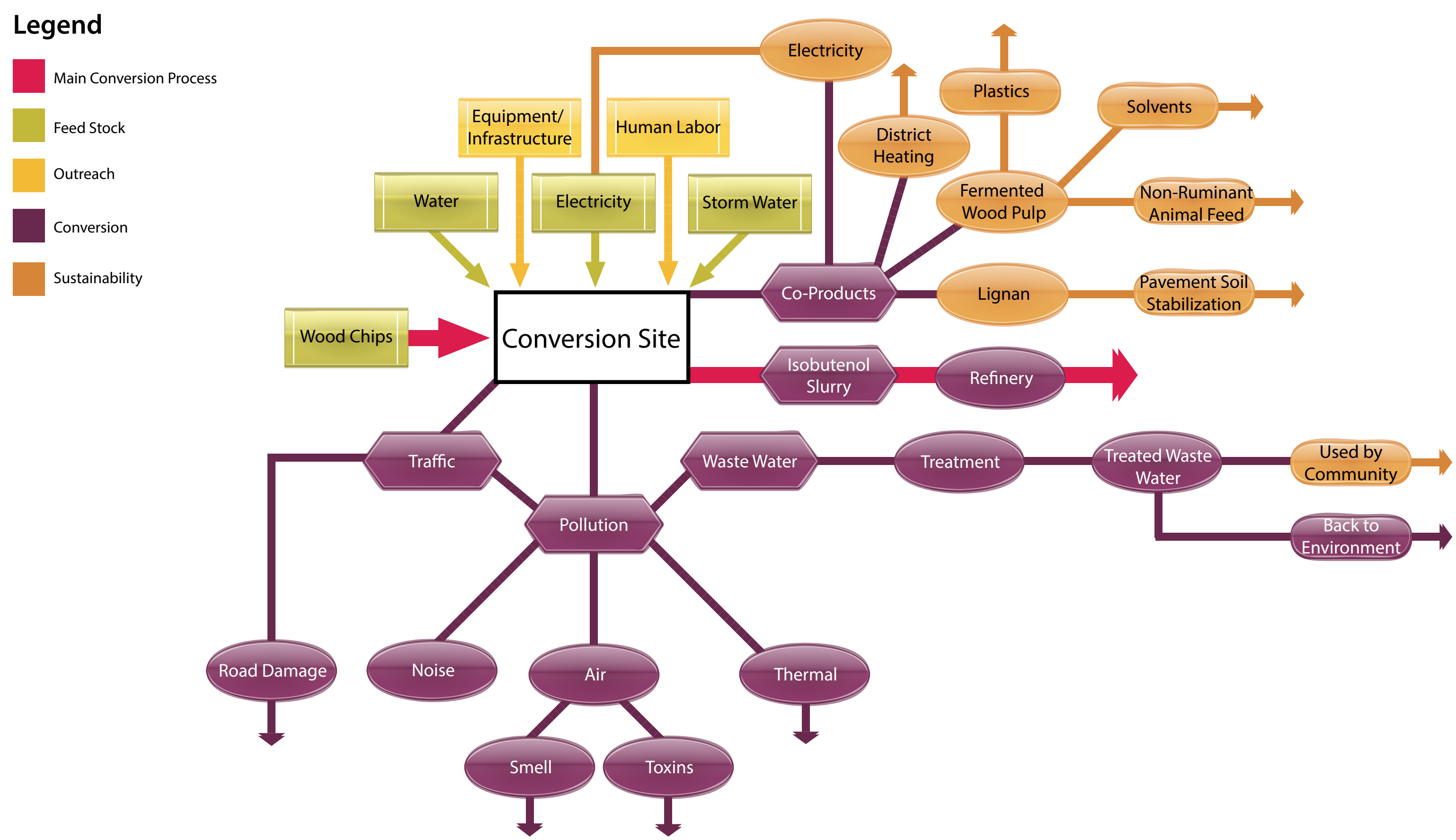

Fig 1: Composite Layers

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Figure 3.1.2 WMC Conversion System Diagram

Table 3.1.1. Conversion site requirements

Conversion Site: Space Requirements for Facilities and Activities	
General Assumptions	
1 million BDT/year 30 Green Tons/Truck Site operation 365 days/year 16 hour days (2 shifts) Receiving 4,128 tons of biomass material each day 30-day supply in feedstock and chip yards (123,840 tons)	1 ton = 2000 lb Raw biomass (slash pile) density = 40 pcf Loose wood chip density = 70 pcf Moisture Content = 50% Feedstock and chip yard material height = 12 to 32 ft Producing 56 million gallons of isobutanol/year
Feedstock Yard: Storage of slash pile and all other raw biomass materials	
Area Range: 4.5 to 11.8 acres (for 32 ft and 12 ft heights) Comparable: 3.5 to 9 football fields Facility Description: Uncovered space with concrete pad, truck tipper, and conveyor system	
Chip Yard: Storage of chipped biomass materials	
Area Range: 2.5 to 6.7 acres (for 32 ft and 12 ft heights) Comparable: 2 to 5 football fields Facility Description: Uncovered space with concrete pad, truck tipper, and conveyor system	
Pretreatment: Biomass materials are prepared for hydrolysis and fermentation	
Area: Currently unknown, use 10.3 acres modeling pretreatment as a similar process to hydrolysis and fermentation Facility Description: Covered structure with appropriate equipment inside	
Hydrolysis and Fermentation: Pretreated materials are converted into isobutanol	
Average Area: 10.3 acres Comparable: 8 football fields Facility Description: Covered and uncovered structures, tanks, pumps, lines and dispensers	

3.1.2 CASE STUDY: LIBBY CONVERSION SITE

Libby is a community with 2,600 residents; approximately 12,000 people live within a ten mile radius of Libby. Libby is located in northwest Montana, 35 miles east of Idaho at the junction of Interstate 2 and State Highway 37. Libby is the largest urbanized area and most densely developed city in Lincoln County (pop. 19,491). The potential conversion site is a former mill property, approximately 175 acres in size, and part of the 400 acre Kootenai Business Park. The Kootenai Business Park is adjacent to the city limits of Libby (Figure 3.1.3).

Like many western Montana communities, Libby got its start as a mining town, but as time passed logging quickly became an important part of the Libby and Lincoln County economic base. As the timber industry waned, some of the area's mills closed. In 2003, the Stimson Lumber Company donated their former 400 acre mill site to the Lincoln County Port Authority, which the county developed into the Kootenai Business Park (City of Libby Comprehensive Plan, 2010).

3.1.2.1 Site Opportunities and Constraints

There are several opportunities and constraints associated with the Libby conversion site. Opportunities include the existing concrete pads and wood-related equipment and industrial infrastructure (i.e. a truck scale, wastewater retention/settling/fire water ponds with active permits), a 25 megawatt (mw) electrical substation which is nearly complete, and an 11 million gallon per day (mgd) water plant with proximity to a large river and creek. Figure 3.1.4 highlights physical assets and attributes of the site.

Reusing the Libby site provides an opportunity to remediate the site, as well as to protect sensitive natural resources, community aesthetics, and the surrounding population. For this site, the surrounding landscape includes the Kootenai River to the north, a forested hill and creek to the east, a pond and dirt bike track to the south, and a vibrant town to the west. Integrating a design that incorporates these environmental aspects into the overall conversion site design is essential to foster positive public opinions about this new industrial use being located on the property. A possible constraint of the Libby conversion site is that it is within the Kootenai Business Park which has super-fund status. The US Environmental Protection Agency (US EPA) has an ongoing cleanup operation for groundwater contamination associated with a closed and capped landfill within the park. Also, there is interest to develop recreational opportunities in and around the site, including a proposed motocross track and a public fishing pond. These amenities may enhance the site's potential for redevelopment, but also could require coordination among the developers to have heavy to light industrial properties in close proximity to recreational use.

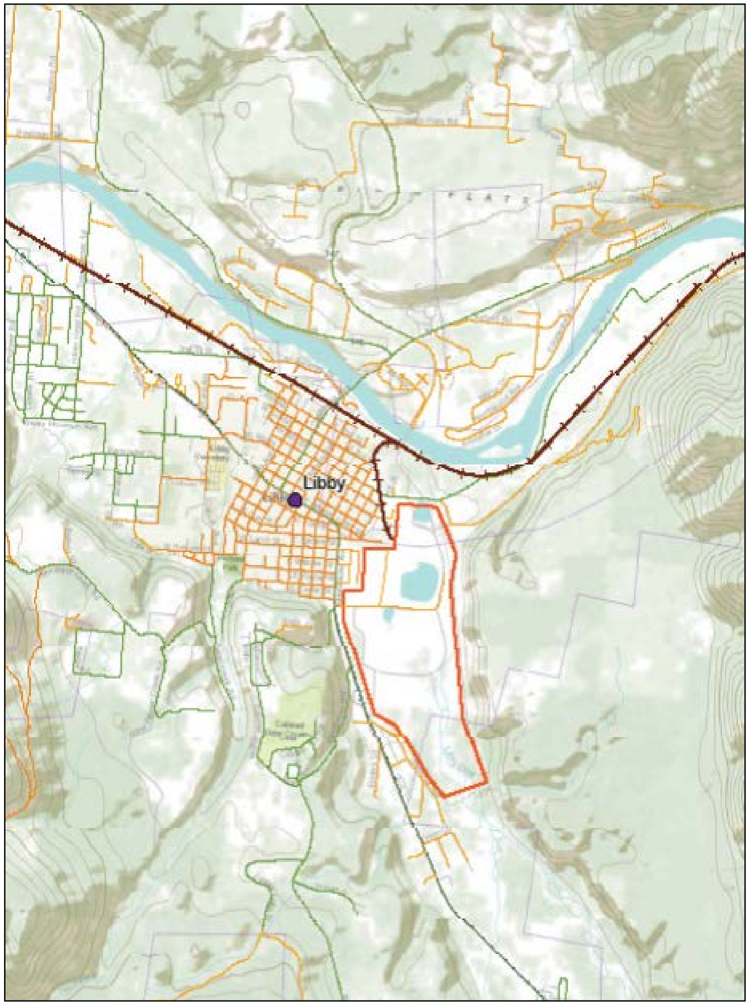


Figure 3.1.3. Libby Conversion site location map

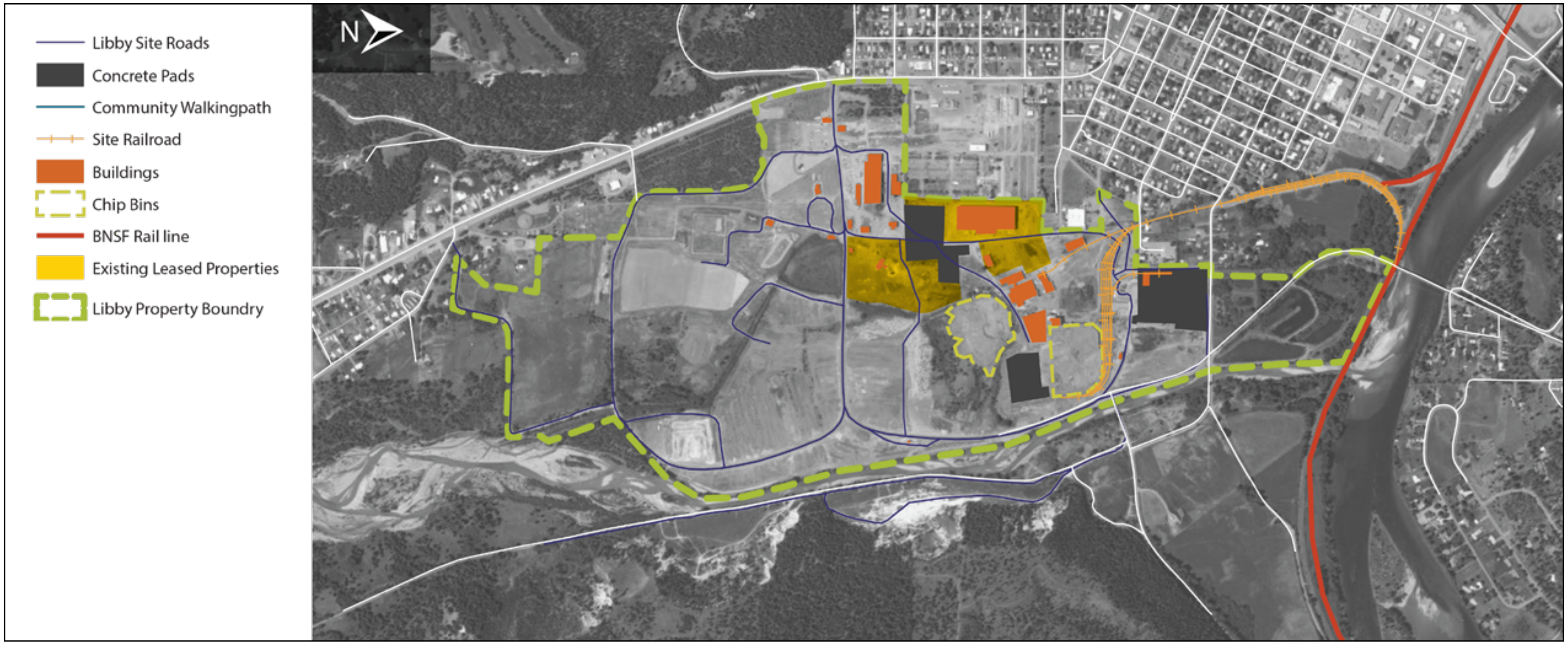


Figure 3.1.4 Libby Conversion Site Physical Attributes

Figure 3.1.5 Libby Conversion Site Opportunities and Constraints

3.1.2.2 Libby Site Suitability

After analyzing the opportunities and constraints of the Libby site, it was evaluated for suitability as a conversion facility. Figures 3.1.5 and 3.1.6 suggest areas where development should occur and where environmental restoration should take place. The areas suggested for development are based on existing infrastructure and proximity to local roads and rail. Two areas on the site labeled landfill and environmental concern will most likely require rehabilitation measures. These measures include vegetative buffering to retain and clean pollutants and masking from public view.

3.1.2.3 Libby Site Master Plan

Figure 3.1.7 shows how a conversion facility could be developed in the Kootenai Business Park based on activities associated with the conversion process.

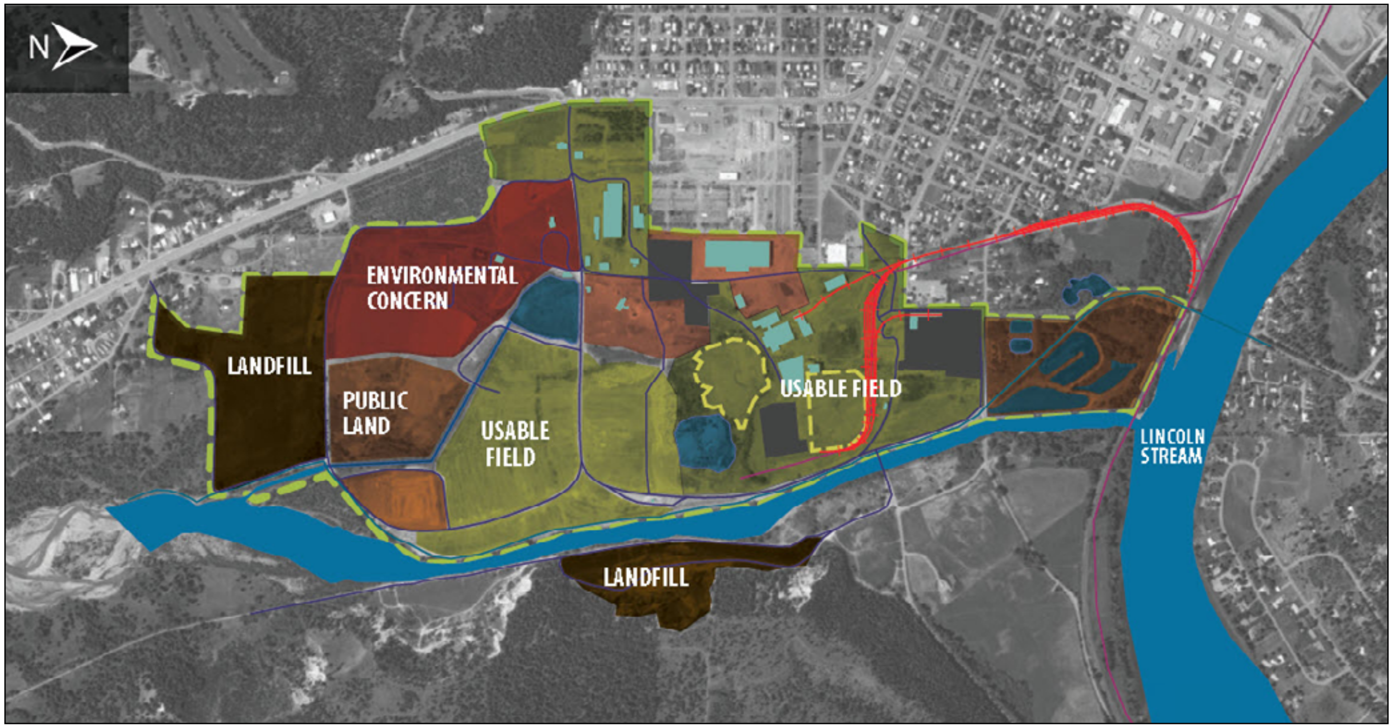


Figure 3.1.6 Libby Conversion Site Suitability Analysis

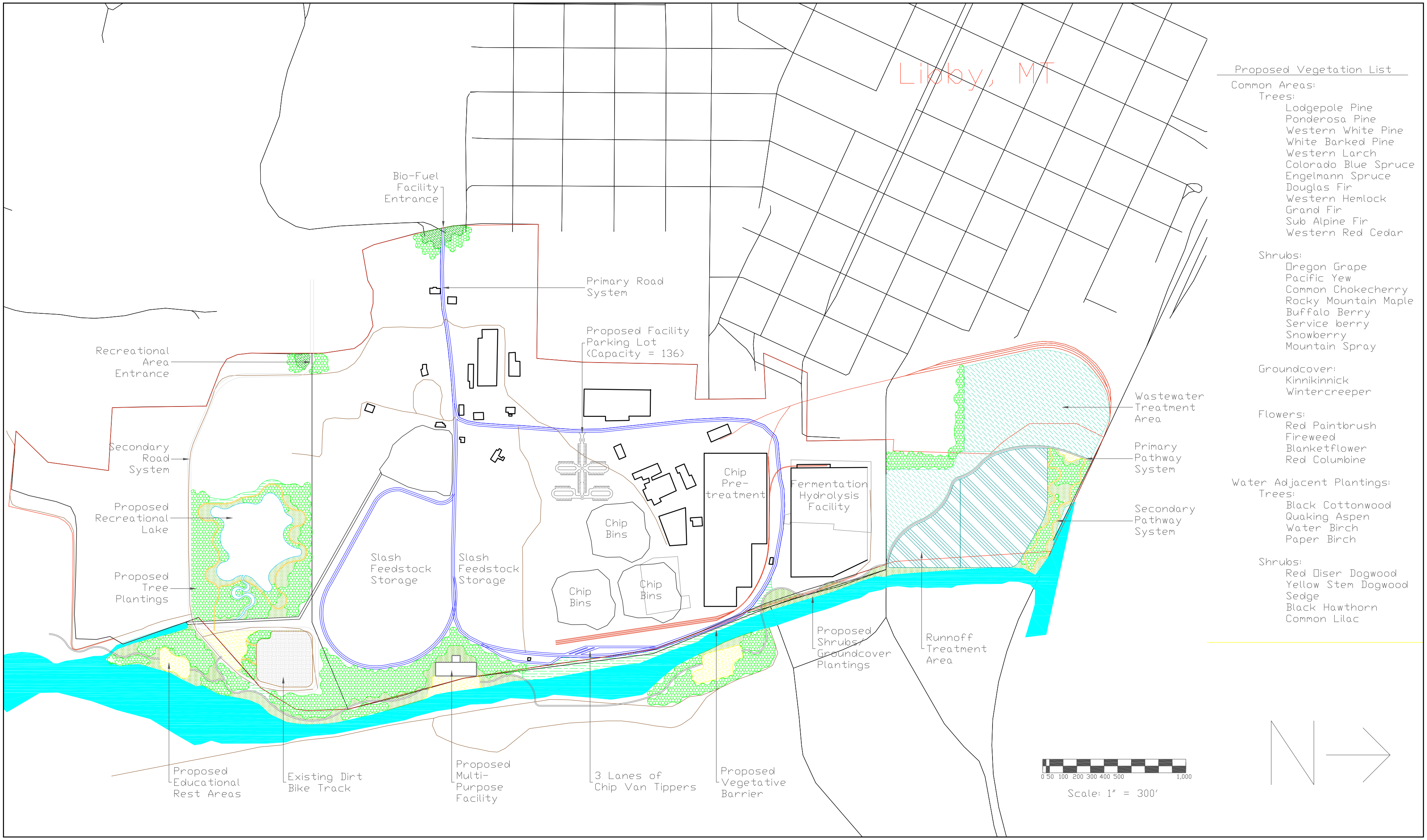


Figure 3.1.7 Libby Conversion Site Master Plan

3.1.3 CASE STUDY: FRENCHTOWN CONVERSION SITE

The second recommended conversion site is located in the Frenchtown Technology and Industrial Center, located about 12 miles west of Missoula, Montana and about 5 miles east of Frenchtown, Montana. It is located in Missoula County, which is home to 110,138 residents. The Frenchtown site, which is 3,200 acres, is currently owned by Green Investment Group Inc. It was formerly owned and operated by Smurfit-Stone, which had employed 417 workers until it closed on December 31, 2009. Figure 3.1.8 shows the Frenchtown conversion site location.

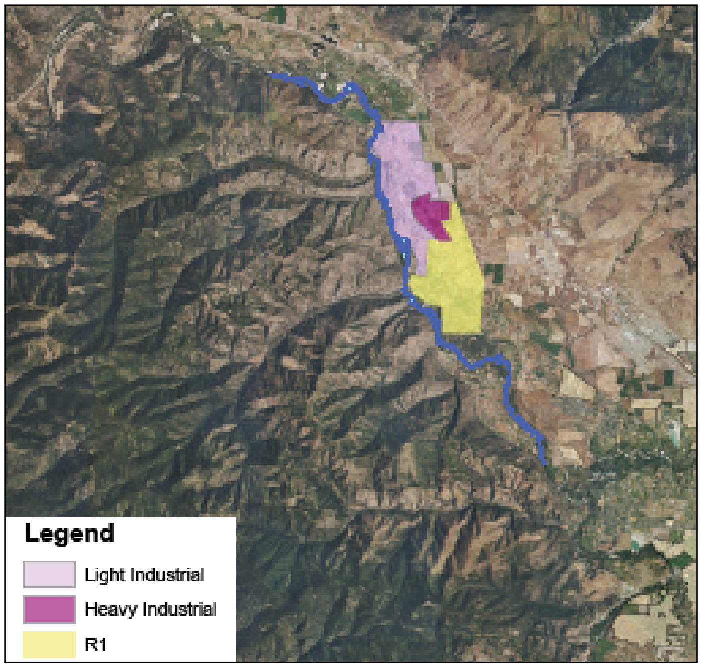


Figure 3.1.8. Frenchtown Conversion Site Map

3.1.3.1 Site Opportunities and Constraints

The Frenchtown conversion site has many physical attributes that make it suitable for development as a conversion facility. Figure 3.1.9 highlights the Frenchtown conversion site opportunities and constraints. These include highway and rail access on site, river and streams needed for industrial effluent discharge, wetlands for natural water purification, and an on-site waste water treatment plant. In addition, the site is zoned for light and heavy industrial use and vegetation surrounding the river provides a natural buffer for excess runoff. It is located just a few miles from Interstate 90 and has rail access to many areas around the site. The remaining infrastructure includes offices, werehouses, and processing facilities, truck dumps, a scale, and a multi-fuel boiler which could all be adapted to facilitate an operation to convert forest residuals into chemical products.

There are three wells on the property that draw water from the aquifer below the site; these aquifers have a production capacity of roughly 30 million gallons of water per day. The previous Smurfit-Stone operation had a National Pollution Discharge Elimination System (NPDES) permit that outlines the standards for storm water discharge from their industrial operation to the Clark Fork river. There are three discharge pipes on-site that could be repurposed. Pipes 1, 2, and 3 are covered under the existing NPDES permit that outlines acceptable effluent standards such as biological oxygen demand (BOD) and Total Suspended Solids (TSS). Existing permits may present an opportunity if they are in good standing and transferable to the new site operator with oversight and approval by the appropriate regional, state and federal regulatory agencies.

Some challenges facing the site include the possibility of flooding from the river and streams, and the potential pollution issues to the nearby river and wetlands. Furthermore, due to historic industrial operations, a portion of the site is under consideration by the US EPA as a Superfund site. The regional EPA headquarters in Denver is supportive of the new owners, who will not be responsible for the clean up costs of past activities. The cleanup is complicated by the size of the site and proximity to the river. Depending on which portions of the site actually get designated with ‘Superfund Status’ site redevelopment into a conversion operation may be complicated. At a minimum, Superfund Status is likely to reduce the amount of available acreage for redevelopment related to biofuels production (i.e. biomass storage/chipping, etc.). Furthermore, it is likely that a Superfund assessment and cleanup could take several years to complete.

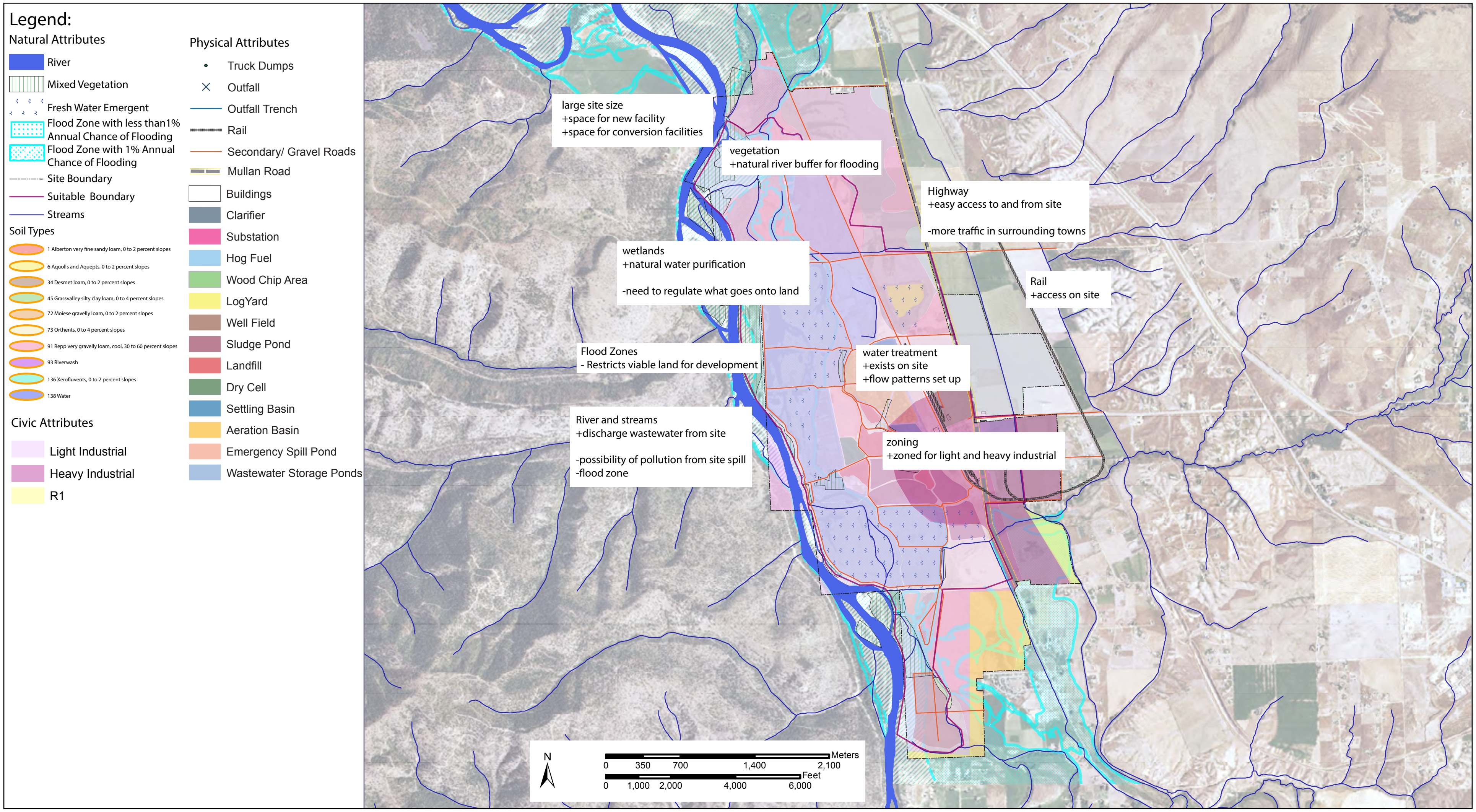


Figure 3.1.9. Frenchtown Conversion Site Opportunities and Constraints

3.1.3.2 Frenchtown Site Suitability

Because of the previous development of the Frenchtown site as a pulp mill, the site has many existing assets that can be repurposed to serve the needs of a biofuels conversion site. For instance, the western portion of the Frenchtown site has a wastewater treatment facility, which can be modified and used for treating the wastewater from the conversion process. Furthermore, the extensive greyfield area in the middle of the site provides more than enough space for the wood yard, pretreatment, fermentation, and hydrolysis equipment that would need to be built for the conversion process. (See figure 3.1.10).

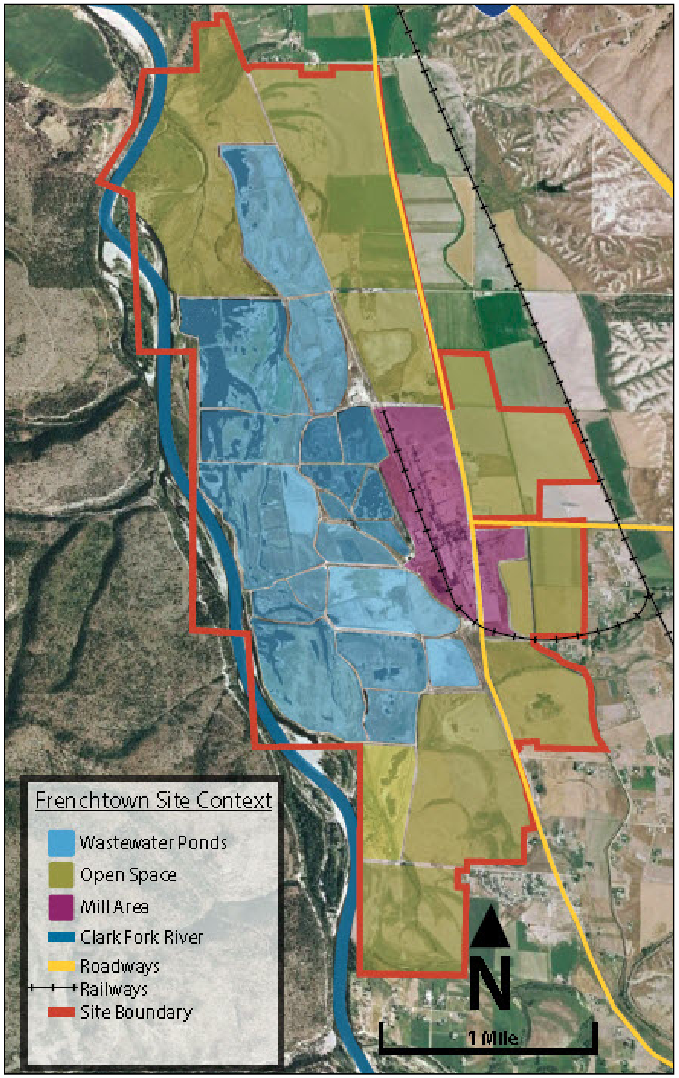


Figure 3.1.10 Frenchtown Conversion Site Suitability Map

3.1.3.3 Frenchtown Master Plan

In order to minimize the footprint of a new conversion facility development at the Frenchtown Technology and Industrial Center, the area developed previously for the main mill operations has been parceled to accommodate the different facilities and processes involved with a conversion site. The site suitability analysis performed by the IDX team suggests that the area previously used for log storage and wood chipping should remain as the wood yard for the conversion facility. The wood yard will host processes such as unloading trucks, grinding biomass, and biomass storage. The area set aside for these processes is approximately 60 acres. From the wood yard, the biomass would move to pretreatment facilities located to the southeast in the previous hog fuel area. This area is approximately 40 acres. From the pretreatment facility, the biomass would move west to the fermentation and hydrolysis area where it would be converted to isobutanol. The area set aside for these processes is approximately 25 acres. It is important to note that both the wood yard and the fermentation and hydrolysis areas have road and rail access allowing for easy transportation of materials to and from the site by either mode.

Figure 3.1.11a Frenchtown Conversion Site Master Plan

Perspective of truck staging area

Perspective of truck staging building with outdoor seating

Perspective of guest parking and beginning trail system

Figure 3.1.11b Frenchtown Conversion Site Master Plan

3.2.0 DEPOT FACILITY SITES

3.2.0.1 Depot Site Overview

Depots are facilities where woody biomass feedstock is delivered from forested lands to undergo sorting and densification (e.g., chips or pellets). Through our work in the WMC region, we identified the role of biomass depots for increasing feedstock supply to potential conversion sites. The role of existing supply chain assets, including both functioning and dormant mill sites, is essential in decreasing capital expenditure requirements for an advanced biofuels process.

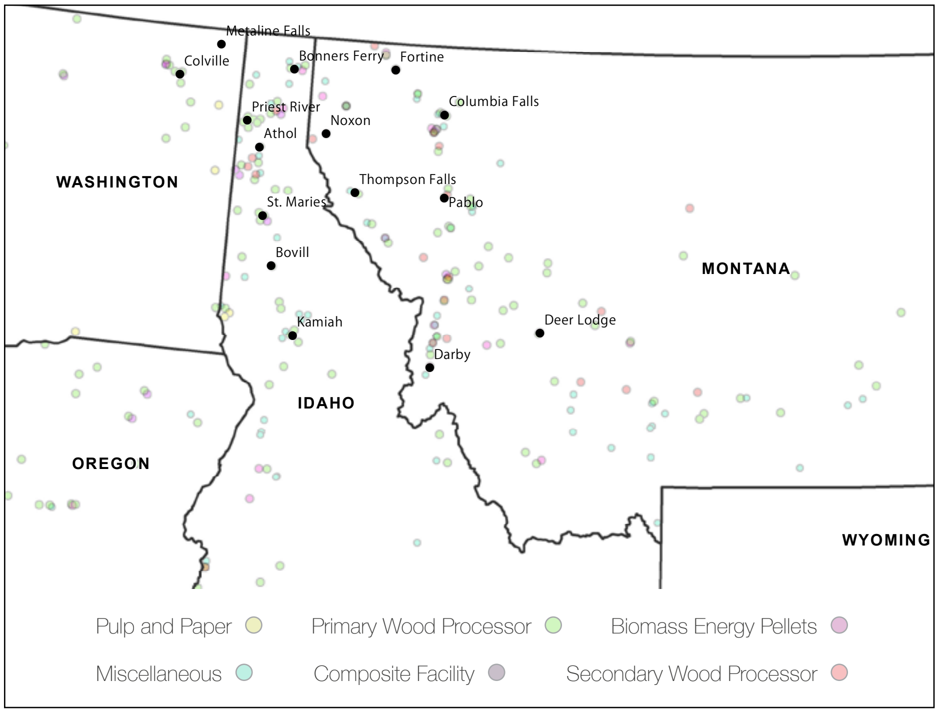


Figure 3.2.1 WMC potential depot site locations

3.2.0.2 Depot Site Typology

The first step in identifying depots for supplying the Libby and Frenchtown conversion facilities included an analysis of existing and dormant mill sites in the WMC region. Once potential depot sites were identified, each site was ranked based on their access to biomass and their size. Depots require between 20 and 100 acres depending on megawatt capacity and the necessary buffer areas between the industrial activities and surround land uses identified in local ordinances; between 8 and 20 acres are needed for raw material and finished product (e.g., chips) storage (The Federal Woody Biomass Utilization Working Group).

These potential sites were then clustered based on physical characteristics including: site classification, operating status, access, proximity to city limits, and proximity to the conversion facility.

Site classification categorizes sites as Brownfield, Greenfield, or Greyfield

- Brownfield sites are vacant or mothballed with some infrastructure and existing facilities that have a known presence of site or soil contamination.
- Greyfield sites are similar to brownfields in terms of existing infrastructure, however there are no traces of soil or other contaminates on-site.
- Greenfields are sites with no prior development

Operating status categorizes sites as Working, Idle, or Decommissioned.

- A working mill site is currently processing wood products.
- An idle site denotes a site with infrastructure, but that is not currently operational.
- A decommissioned site means that the site has very little or no infrastructure left from past operations.

Site access considers road and rail lines that service the site.

Proximity to city limits determines if the site is located in or directly adjacent to the city limits or outside city limits.

Proximity to conversion facility considers the travel time from the depot site to conversion site and is divided into the following categories:

- High = ½ hour to 1 hour drive time
- Medium = 1 hour to 2 hour drive time
- Low = less than a ½ hour and/or greater than a 2 hour drive time from a conversion site.

Note: If biomass was less than a ½ hour from conversion site, then a depot model would not need to be used. Direct transport to the conversion site would be employed.

Based on these analyses, 15 potential depot sites were identified (Figure 3.2.1). Figure 3.2.2 shows site typology categorized by site characteristics. One depot from each of the four major typology types was selected for in depth review, to serve as an illustrative case study for how each of these depot types could be adapted to house a depot on the site. The four depot case studies selected were as follows:

- Greyfield Working Mill: Vaagan Brothers Lumber Inc, Colville, Washington
- Greyfield Idle, with Infrastructure: Kootenai River Lumber Company, Bonners Ferry, Idaho
- Greyfield Decommissioned, with no Infrastructure: Riley Creek/JD LLC, Thompson Falls, Montana
- Brownfield Idle, with Infrastructure: former Plum Creek Logging Company site, Pablo, Montana

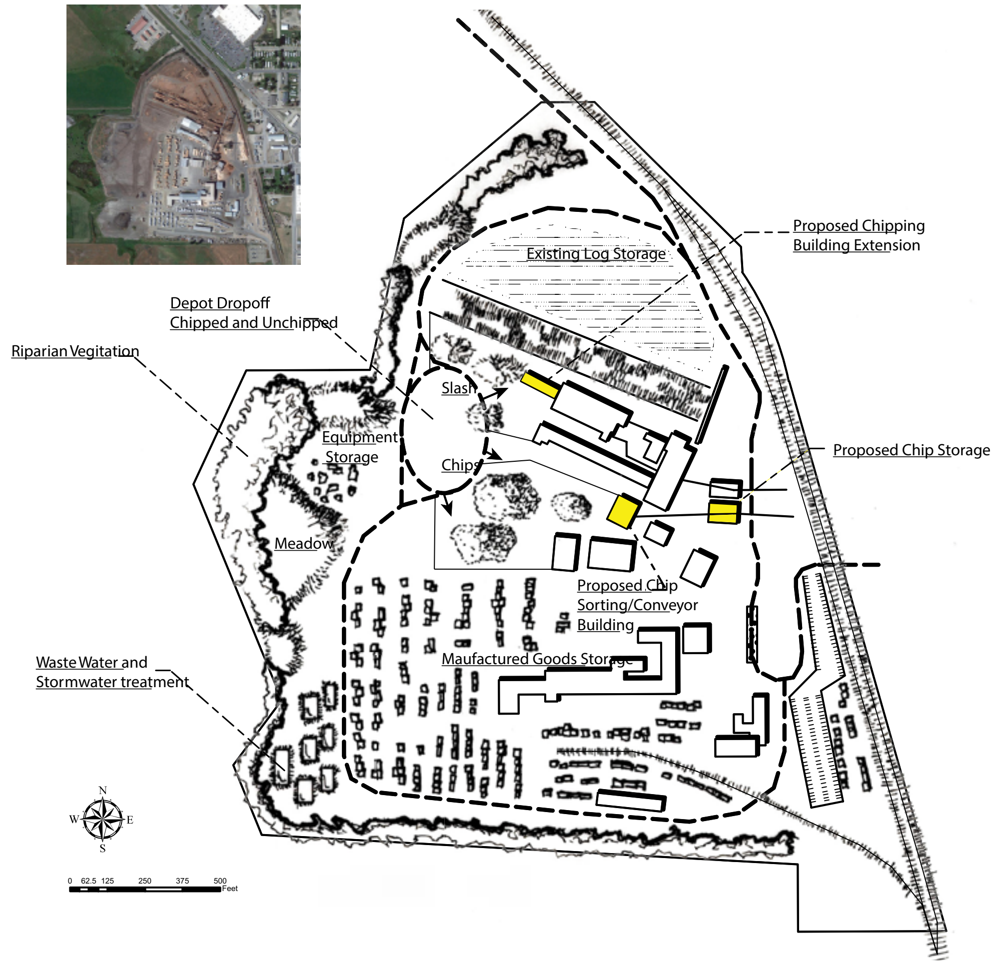
Each case study provides a brief description of the site; site opportunities and constraints related to depot operations; and a proposed site layout (e.g., master plan) for a proposed depot facility.

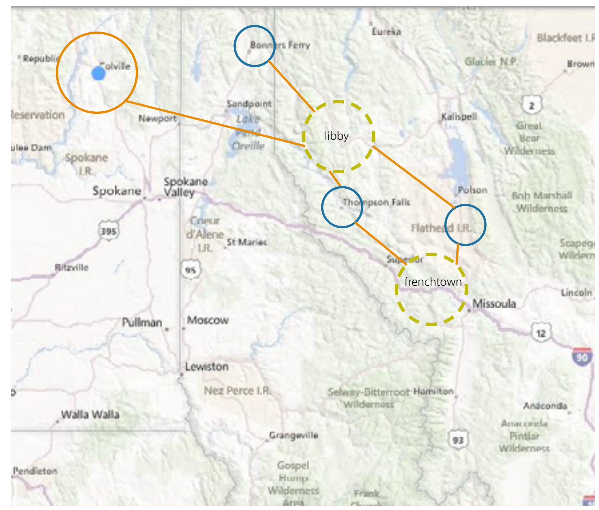
Figure 3.2.2. Depot Site Typology

3.2.1 CASE STUDY: COLVILLE, WA DEPOT SITE

Colville is the largest city in Stevens County, WA , with a population of 4,673 people. It is approximately 70 miles north of Spokane, WA (City of Colville, Washington 2011). Principal industries in Colville and nearby areas are timber, agriculture, manufacturing, and tourism. The potential depot site would be co-located on the 70 acre Colville Mill property, currently owned and operated by Vaagen Brothers, Inc. This site is identified as a greyfield working mill.

Currently Vaagen Brothers Lumber harvests over 30,000 acres a year on Federal, State, Tribal, and Private lands removing 800,000 tons of biomass and small logs. Small saw logs and pulp logs are harvested and hauled by conventional methods and the remaining fiber is ground into fuel for Avista's bioenergy plant at Kettle Falls, WA . Some of the solid material is chipped and sold to pulp and paper mills. The larger diameter material is converted into solid dimensional lumber products (Vaagen Brothers Lumber 2012). Figure 3.2.3 shows an overview of the Colville Mill site.





Above: The Colville site is 1 of 4 proposed depot sites within the Western Montana Corridor.

-The other 3 sites, circled in blue are located in Bonners Ferry ID, Thomson Falls MT, and Pablo MT.
-Circled in green are the 2 proposed Conversion sites located in Frenchtown and Libby MT.

Left: schemetic design of the site is shown as it currently exists with the addition of a number of proposals.

Figure 3.2.3 Colville Site background overview

3.2.1.1 Site Opportunities and Constraints

Site opportunities and constraints were compiled through the analysis of the natural, physical and civic attribute inventories to develop possible scenarios for the integration of depot operations on the site. Opportunities include possible site expansion, environmental enhancements, and fluid operations on the site. Constraints include limitation to expansion in certain directions, limitations on traffic volume loads and truck sizes, possible negative environmental impact, and possible negative community interaction. The purpose for the site opportunities and constraints exercise is to explore the possibilities of site layout and design for a holistic approach. Refer to figure 3.2.4 for an overall outline of identified opportunities and constraints at the Colville site.

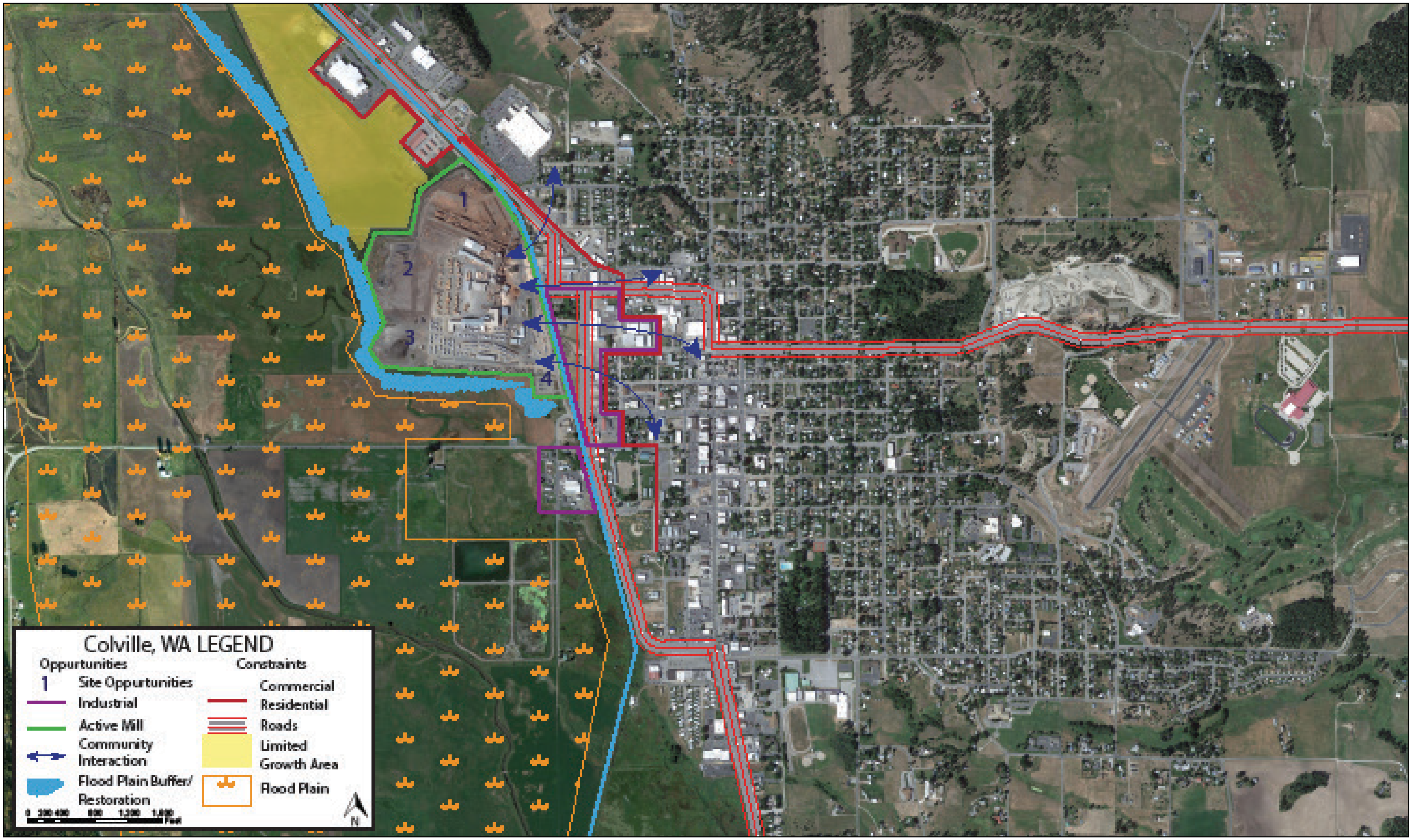


Figure 3.2.4 Colville site opportunities and constraints

3.2.1.2 Site Master Plan

The Colville depot site master plan shows the designed layout of the entire site to maximize depot operations, reduce impact of the current Vaagan Brothers Lumber Mill operations, and integrate into the city of Colville, WA. Refer to figure 3.2.5 for the Colville Master Plan.

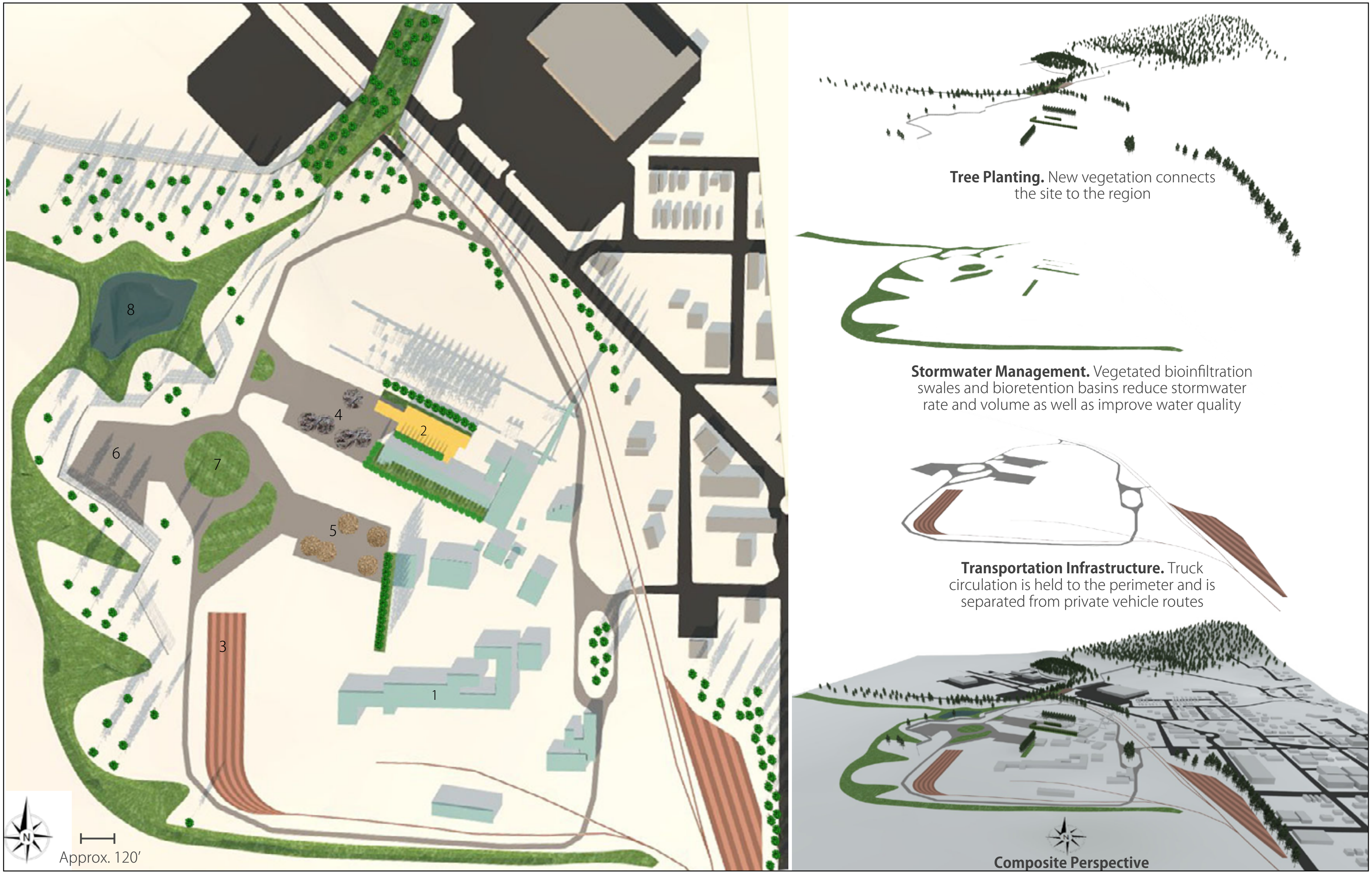


Figure 3.2.5 Colville site master plan

3.2.2 CASE STUDY: BONNERS FERRY, ID DEPOT SITE

Bonners Ferry is in Boundary County, Idaho's most northern county. The county is home to 2,500 residents. The potential depot site, owned by the Kootenai River Lumber Company, consists of three parcels of land totaling 70.27 acres. Of which, the 22.62 acre parcel is an idle mill site adjacent to the south side of Kootenai River. The mill, previously owned by Louisiana Pacific Corp., closed its doors in 2003 due to lumber prices falling below the production costs of the mill. This closure resulted in a loss of 130 jobs in the area. The site is zoned industrial.

3.2.2.1 Site Opportunities and Constraints

Site opportunities and constraints were identified based on analysis of natural, physical and civic attributes of the site. The Bonners Ferry idle mill site presents opportunities to reuse the site for activities similar to what it had been used for in the past. Direct access to Highways 95 and 2, as well as the rail lines, makes transport of materials to and from the site more efficient. The shallow slope of the site adds to the ease of mill activities and natural buffers exist between the site and the adjacent residential areas. The river buffer will also help to provide a noise barrier between adjacent parcels and site activities. A reopening of the mill site for depot activities would create jobs in the area and boost the local economy.

Because of the proximity to the Kootenai River, pollutant discharge to surface water or groundwater should be minimized to prevent environmental damage. This can be addressed with a variety of solutions including but not limited to: on-site storm-water treatment, green roofs, rainwater catchment, and pavers. Creating a buffer from the river is essential and can also be viewed as an opportunity for public outreach. Currently, the elevation of the dike (under the roadway) is approximately four to eight feet higher than the mill property, which prevents surface water from the mill site from reaching the kootenai river. The Boundary County Strategic Plan addresses the desire for a river walk along the banks of the Kootenai River in downtown Bonners Ferry. Extending this trail to the front of the mill site would add enhance this public amenity. Incorporating the river walk and addressing the lack of vegetation on the site would be simple ways to increase public approval. Refer to figure 3.2.6 for an overall outline if identified opportunities and constraints at the Bonners Ferry site.

Summary

Opportunities

A Gentle slope to the open area of existing mill site, requires minimal leveling and site prep for new operations.

B Multiple access points exist on site already. This reduces construction needed to make site operational.

C Area buffered to nearby residential area which will reduce light and noise pollution from the site.

D Located within city limits, allows shorter commute times for employees.

Constraints

E Location on waterfront creates a need to address any pollutants before they enter the river or water table causing environmental damage. This can be addressed with a variety of 'green' solutions including but not limited to; storm water treatment, green roof, rainwater catchment, pavers, etc.

F There currently are contaminents on site that could spread into the river, possibly damaging the environment. Stream bank restoration and site remediation of soils and water would address this issue.

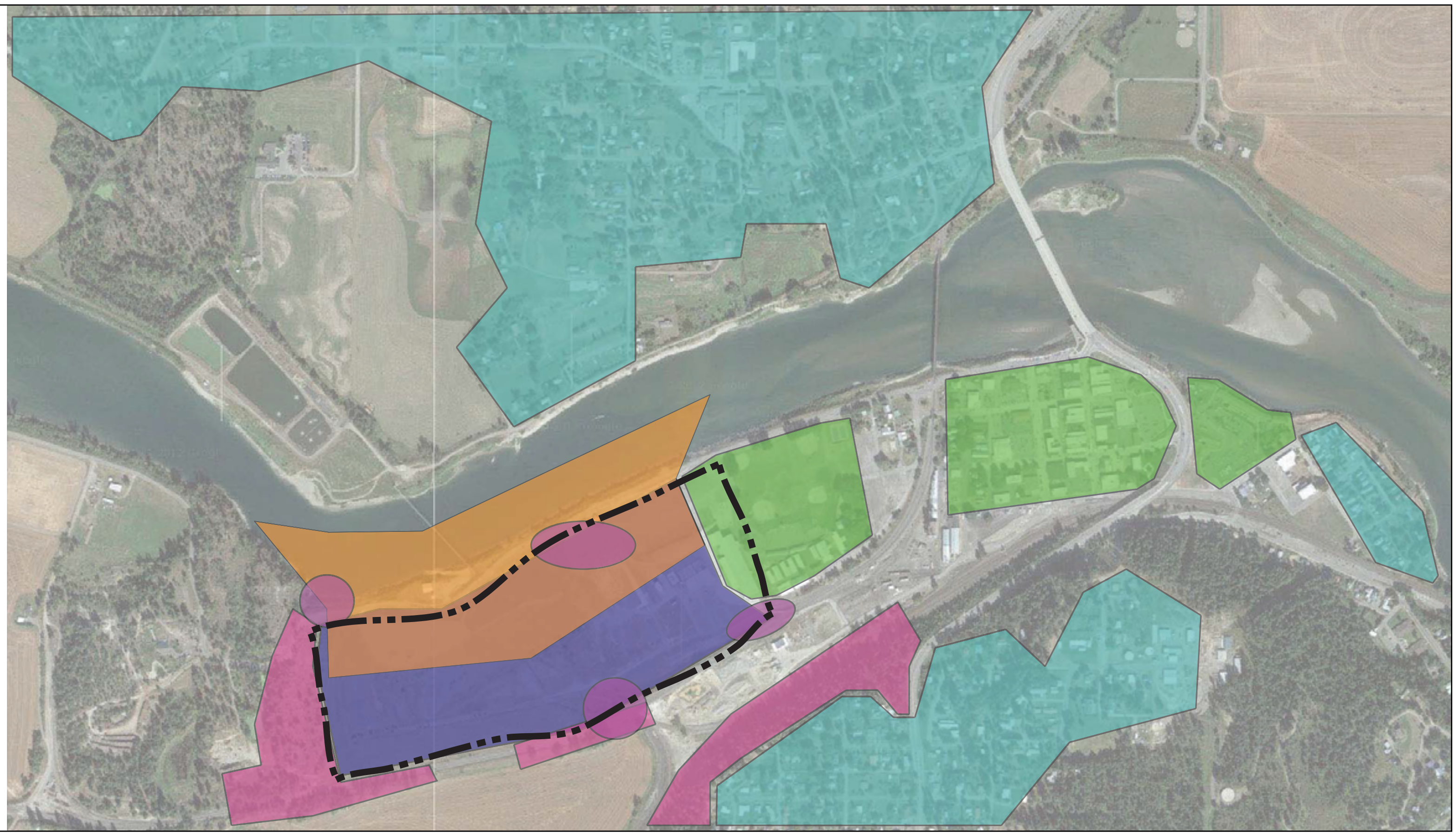


Figure 3.2.6 Bonners Ferry Depot Site Opportunities and Constraints

3.2.2.2 Site Master Plan

The Bonners Ferry Depot Site Master Plan includes areas for machinery, storage, administration, visitor, employee, habitat remediation and storm-water. For machinery, there is a building for storage and maintenance and all access points are designed wide enough for clearance of multiple styles of equipment. Storage on site includes chip and slash storage at a weekly height of 20 feet, and a daily height of 9 feet. It also includes an outdoor natural drying/storage area and an indoor drying storage area that could be the future location of a pellet mill. The administration building is designed for office space, as well as an area for visitors.

The break or gathering area by the formal pond, located just south of the administration building, is ideal for outdoor meetings or gatherings. The employee areas include an area for break rooms and specific maintenance tasks, an outdoor break area with seating, and pathways for circulation throughout the site. Habitat remediation and storm-water features go hand in hand throughout the site. Their goal is to collect and move storm-water away from buildings and biomass storage areas while creating habitat and filtering water (see figure 3.2.7 for the Bonners Ferry Master Plan).

Figure 3.2.7 Bonners Ferry Depot Master Plan

3.2.3 CASE STUDY: THOMPSON FALLS, MT DEPOT SITE

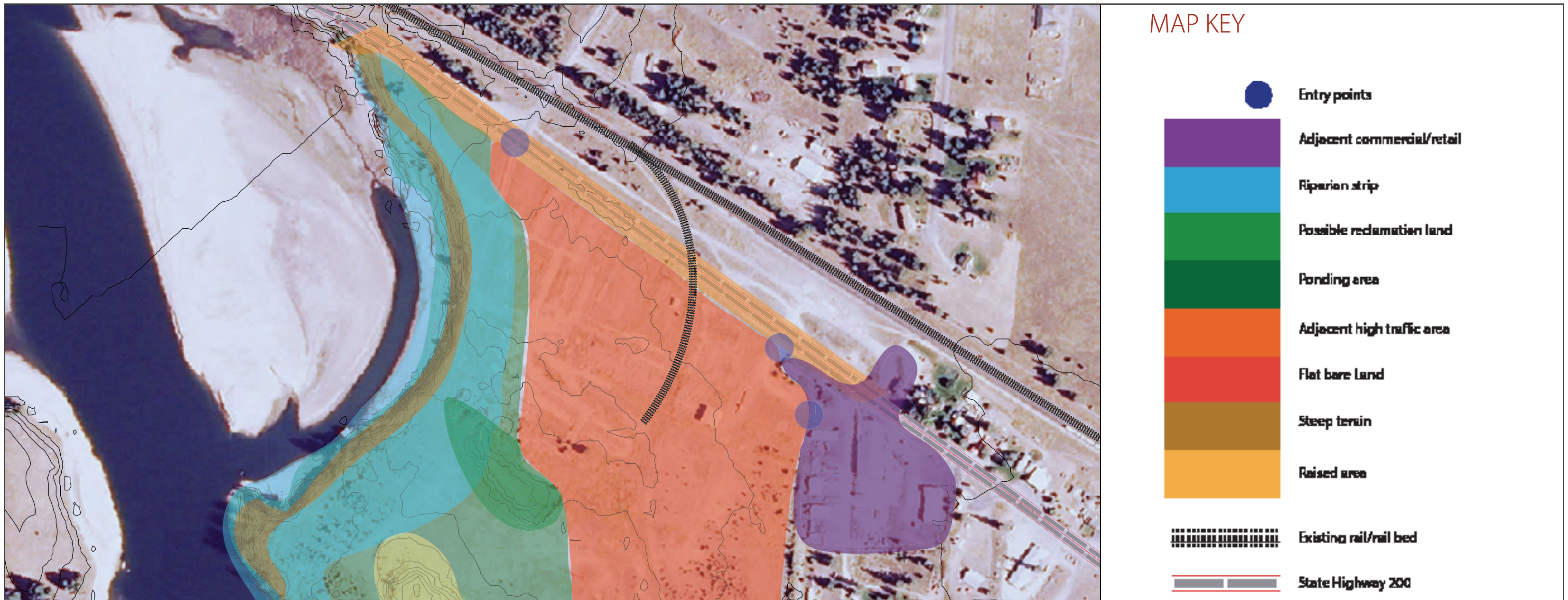
Thompson falls has a population of 1,313, making it the largest town in Sanders County , which has a population of 11,440. Thompson Falls is 91 miles north of Libby, MT. The proposed depot site, which is the former site of a mill operation, is currently owned by Riley Creek/JD (RCJD), LLC from Laclede, Idaho. Total acreage is 115.9 acres. Utilities currently on site are electricity, water, and sewer.

3.2.3.1 Site Opportunities and Constraints

Site opportunities and constraints were based on analysis of natural, physical and civic attributes. Due to an excess of usable land and the need for onsite storm-water treatment, there is a strong potential for wetland and river bank restoration along the river corridor. There is also an opportunity to include a multiple-use path along the river. This path would run through the newly restored area and would be accessible to the northwest of the site at an existing historical marker on Highway 200. This path could help integrate the new development into the community and help offset any detrimental aspects of the development, such as increased noise and traffic.

Depot site operations are being considered at the north end of the site, adjacent to the highway. This avoids development in the center of the site, which is the lowest point in the property and would have a tendency to accumulate water and possibly experience flooding issues.

About one-third of the site is not needed for depot operations. This space could be utilized as increased storage capacity in instances of large biomass feedstock inflows. The area could also accommodate separate industrial or commercial activities that could partially offset the costs of running and maintaining the depot site. figure 3.2.8 shows the opportunities and constraints for the Thompson Falls site.



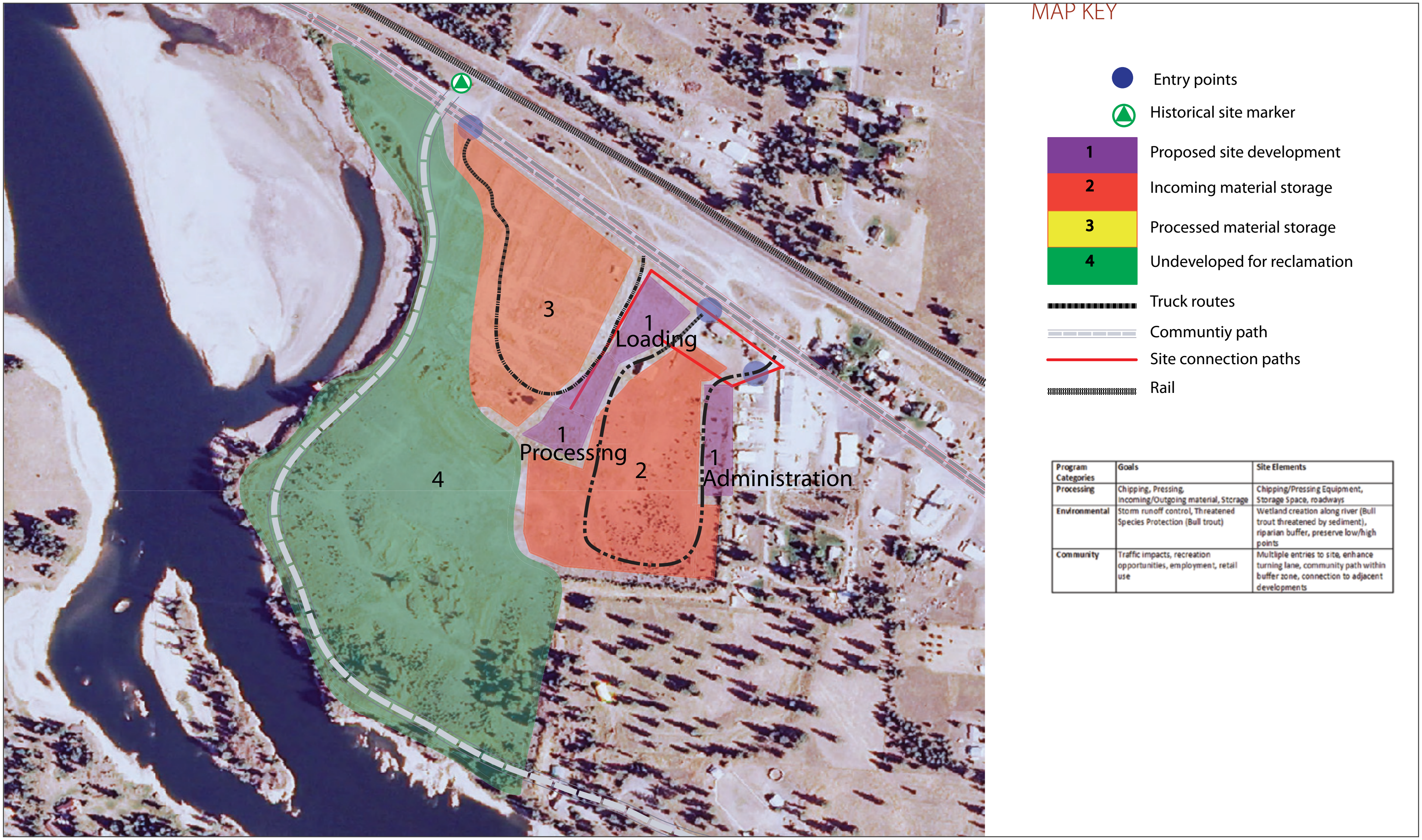
Sanders and Parts of Lincoln and Flathead Counties, Montana							
Map symbol and soil name		Bim - mechanical treatment, shredder	Eng - small commercial buildings	Bim -soil restoration potential	For - construction limitations for haul roads/log landings	Bim- reclamation suitability (mt)	For - mechanical site preparation (surface)
472B—Elkrock gravelly ashy silt loam, moist, 0 to 4 percent slopes		Well suited	Somewhat limited	High potential	Slight	Moderately suited	Well suited
	Limiting factor		Large stones			Droughtiness	

The soil on site provides potential for a number of restoration as well as development options.

Figure 3.2.8 Thompson Falls Depot Opportunities and Constraints

3.2.3.2 Site Master Plan

The Thompson Falls site schematic plan shows the designed layout of the entire site, highlighting the river restoration area, and how the site integrates with the surrounding area. Refer to figure 3.2.9 for the Thompson Falls Programming Diagram.



Program Categories	Goals	Site Elements
Processing	Chipping, Pressing, Incoming/Outgoing material, Storage	Chipping/Pressing Equipment, Storage Space, roadways
Environmental	Storm runoff control, Threatened Species Protection (Bull trout)	Wetland creation along river (Bull trout threatened by sediment), riparian buffer, preserve low/high points
Community	Traffic impacts, recreation opportunities, employment, retail use	Multiple entries to site, enhance turning lane, community path within buffer zone, connection to adjacent developments

Figure 3.2.9 Thompson Falls Depot Site Programming Diagram

3.2.4 CASE STUDY: PABLO, MT DEPOT SITE

Pablo, Montana is a town located in Lake County, MT. The population is approximately 2,254. According to the US Census, the majority (57%) of the people living in the area are classified as American Indian/Alaska Native. Pablo is the seat of government for the Flathead Indian Reservation and home to the Confederated Salish and Kootenai tribes. The potential depot site is a 92 acre brownfield site that is currently idle and which was previously used by Plum Creek Logging Company.

3.2.4.1 Site Opportunities and Constraints

Site opportunities and constraints were identified based on analysis of natural, physical and civic attributes. Physical opportunities for the site include several buildings used in lumber mill operations, such as lumber storage buildings. The site also is large enough that it could accommodate a co-located pellet mill that could not only provide pellets for biofuels production but also pellets that could be used by the community as a sustainable and alternative heating source. The site has direct access to highway 93 as well as light rail nearby. Natural or environmental opportunities include average air quality and biomass availability. The topography of the site slopes toward the south, where there is a potential to develop a wetland-like area to be used as habitat or as a park, capitalizing on the proximity to the community. A large portion of Pablo is zoned as tribal land and is subject to tribal rules and regulations. Redevelopment at the site should ensure the protection of adjacent residential and reservation communities and their traditional ways of life. Industrial development at the site could adversely affect the community by increased traffic from industrial operations along highway 93. Traffic and other potential impacts will need to be addressed in the development plan. Opportunities and constraints for the Pablo site are displayed in figure 3.2.10.

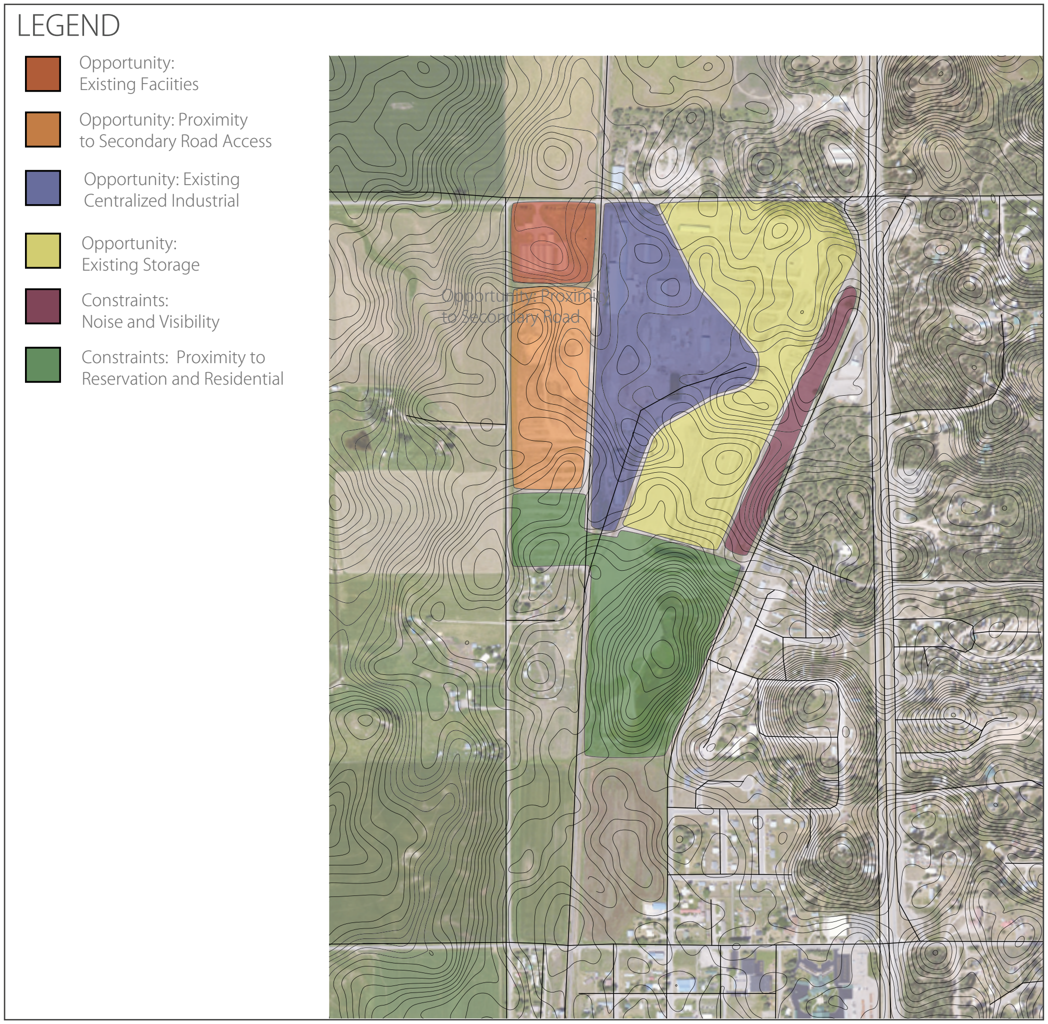


Figure 3.2.10 Pablo Depot Site Opportunities and Constraints

3.2.4.2 Site Opportunities and Constraints

The proposed design for the Pablo depot site features space for three months of slash and chip storage, a wetland, an experimental forest, an employee break area and park with a storm-water storage area. A buffer along the east side of the site will also be provided for the mitigation of noise, dust and visual impact to the surrounding area. The 52 acre experimental forest will provide both woody biomass for the depot and function as an examination of native tree species in a production setting. The wetland will treat the storm-water captured from the site for two days through 7 cells of horizontal subsurface treatment and direct it to the storm-water storage area in the park. The 28 acre park provides 1.8 miles of walking and bike paths as well as picnicking areas. The vegetated area of both the buffer and the park provides a corridor for urban wildlife to increases the bio-diversity on site, fitting into the overall character of the community. The information is displayed in figure 3.2.11.

FIGURE 1. MASTER PLAN

KEY

Experimental Forest	1
Pelleting Facility	2
Treated Strom Water Storage	3
Chip Storage	4
Slash Storage	5
Rain Garden	6
Buffer	7
Railline	8
Break Area	9

FIGURE 2. (9) THE EMPLOYEE BREAK AREA UTILIZES THE EXISTING CONCRETE SLAB FORM THE PREVIOUS SITE USE AND PROVIDES A PLACE FOR EMPLOYEES TO HAVE LUNCH AND RELAX.

FIGURE 3. (9) THE VEGETATED SWALES CAPTURE STORMWATER OFF OF THE BUILDING AND BREAK AREA.

FIGURE 4. (9) THE EMPLOYEE BREAK AREA LOOKS OUT ONTO AN OPEN MEADOW WITH MIXED NATIVE VEGETATION.

North

Figure 3.2.11 Pablo Depot Site Master Plan

3.3.0 SUPPLY CHAIN ANALYSIS

3.3.0.1 Introduction

The analyses in this section estimate the amount of forest residual biomass available annually as feedstock to supply a conversion facility in either Libby or Frenchtown, Montana. The forest residual biomass in this case would come from private, state and tribal lands; biomass from federally owned lands was not considered because it does not currently qualify for Renewable Fuel Standards market benefits.

Either conversion facility would be serviced by 15 depots. Each depot would receive forest residual biomas from the landing and further process the biomass for efficient transport.

Supply curves were developed to indicate the amount of available forest residuals available within varied drive times for each depot site and the two conversion facilities.This data is used to determine the amount of forest residuals avaialble to either conversion facility based on a maximum one-way transport cost of $40/ bone dried ton (BDT) using either road or rail transport.

3.3.1 METHODOLOGY

This section explains the steps used to determine the amount of forest residues available per conversion site.

3.3.1.1 Nodes, Biomass, and Transportation Costs

STEP 1: IDENTIFY NODES

First, all pulp and paper mills, primary and secondary wood processors, biomass energy pellet facilities, miscellaneous mills and composite facilities were identified within the WMC region and screened for suitability under a number of constraints (reviewed in section 3.2.0) . Communities with active primary wood processing facilities and road/rail access were listed as potential depot sites along with the two potential conversion sites in Libby and Frenchtown, Montana (figure 3.3.1).

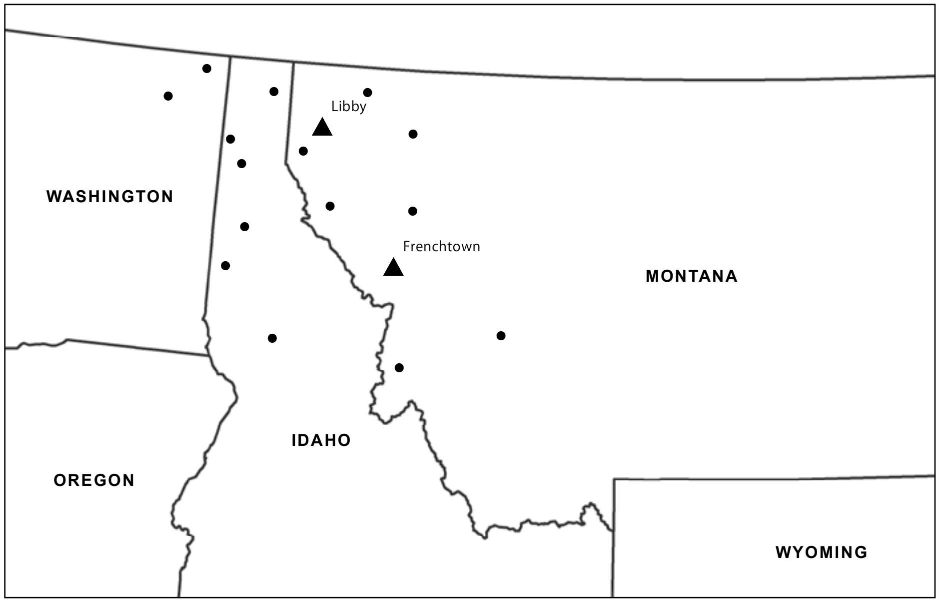


Figure 3.3.1. Potential depot sites (circles) and conversion sites (triangles) in the WMC region.

STEP 2: OVERLAY FOREST RESIDUAL FEEDSTOCK DENSITY

The potential residual biomass per county in the WMC region was then calculated. The darker the county, the more dense the woody biomass (figure 3.3.2). All forest residual biomass estimates for this analysis were calculated from timber harvest data presented by the Bureau of Business and Economic Research (BBER).

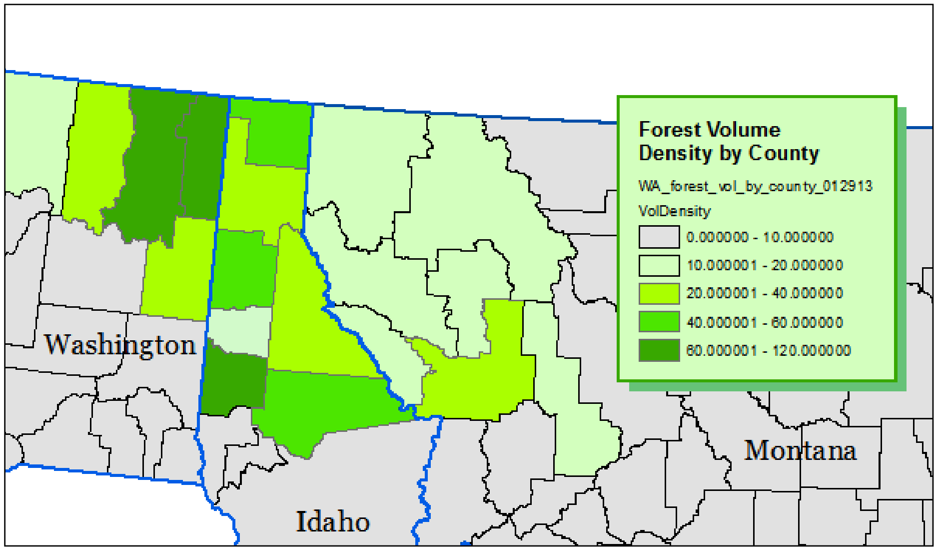


Figure 3.3.2. Forest residual feedstock density by county

STEP 3: OVERLAY RAIL LINES AND ROADS

Roads and rail lines were added (figure 3.3.3).

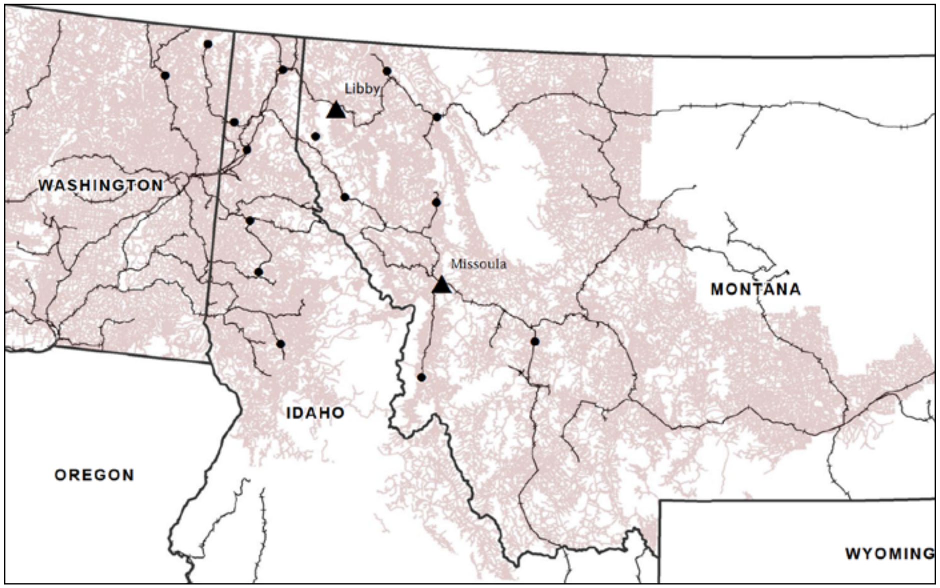


Figure 3.3.3. Rail lines (black lines) and roads (red lines) overlaid with potential depot and conversion sites in the WMC.

STEP 4: OVERLAY FOREST LAND OWNERSHIP

Forest residuals are anticipated from privately owned, tribal and state lands (denoted by the three shades of green). It is anticipated that limited or no forest residuals will be obtained from BLM and USFS lands.

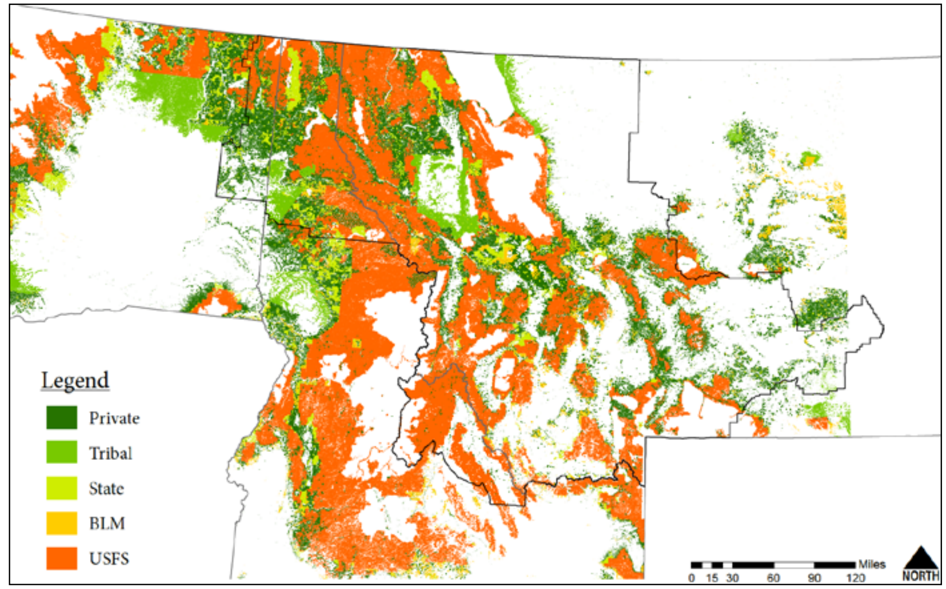


Figure 3.3.4. Forest Land Ownership in WMC Region

3.3.1.2 Determine Biomass Radii

Once the depot and conversion sites were geolocated and the roads were mapped and clipped to the available forest coverage regions, the ArcGIS tool network analyst could be used to develop what is termed biomass radii.

ArcGIS Network Analyst is an extension that provides network based spatial analysis including routing, travel directions, closest facility, and service area analysis. Using a sophisticated network data model, networks can be built from geographic information system GIS data. Network analyst enabled modeling of realistic network conditions, including turn restrictions, speed limits, height restrictions and traffic conditions at different times of day (http://www.esri.com/library/brochures/pdfs/arcgisnetworkanalyst.pdf).

Two relatively simple approaches were used to demonstrate the amount of forest residual biomass available to conversion facilities and depots. One approach calculates the amount of forest biomass available based on one-way drive times from the forest residual landing site to the conversion/depot facility. The other approach calculates the amount of biomass available based on a $40 transportation cost limit.

STEP 5: ESTIMATE RESIDUAL SUPPLY WITHIN VARIED DRIVE TIMES

To determine the amount of forest residuals near each depot site, supply curves were developed and are shown in figures 3.3.5-3.3.19. Using the supply curve data, forest residual biomass quantities or “biomass sheds” were determined for various distances from the depots and conversion facility sites (figures 3.3.20, 3.3.21) and listed in tables 3.3.1 and 3.3.2. Drive time distances were determined using Google Maps.

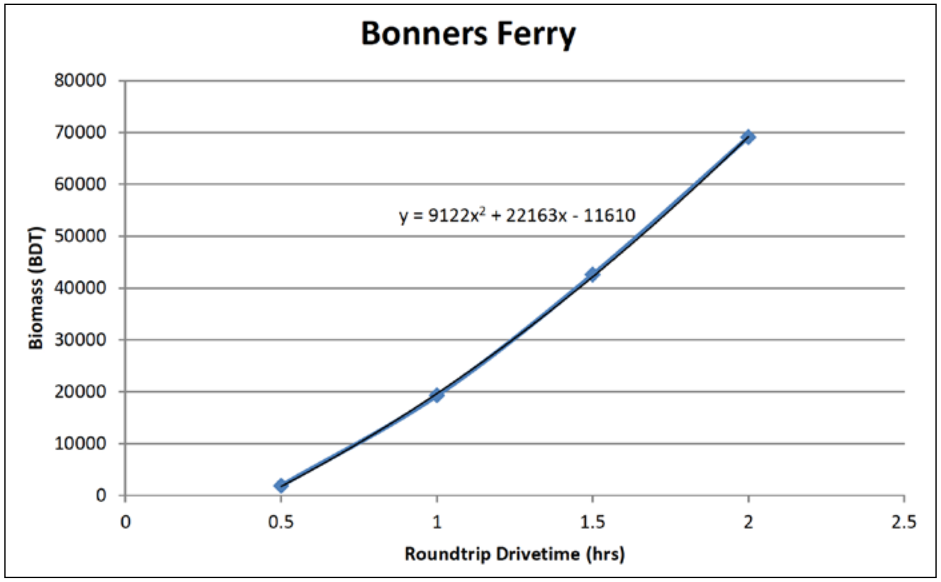


Figure 3.3.5. Bonners Ferry Supply Curve

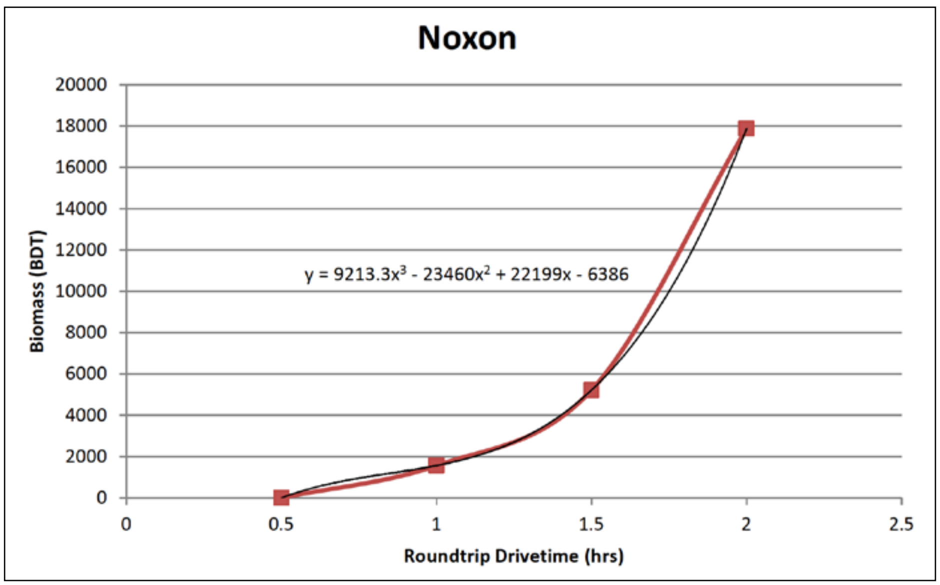


Figure 3.3.6. Noxon Supply Curve

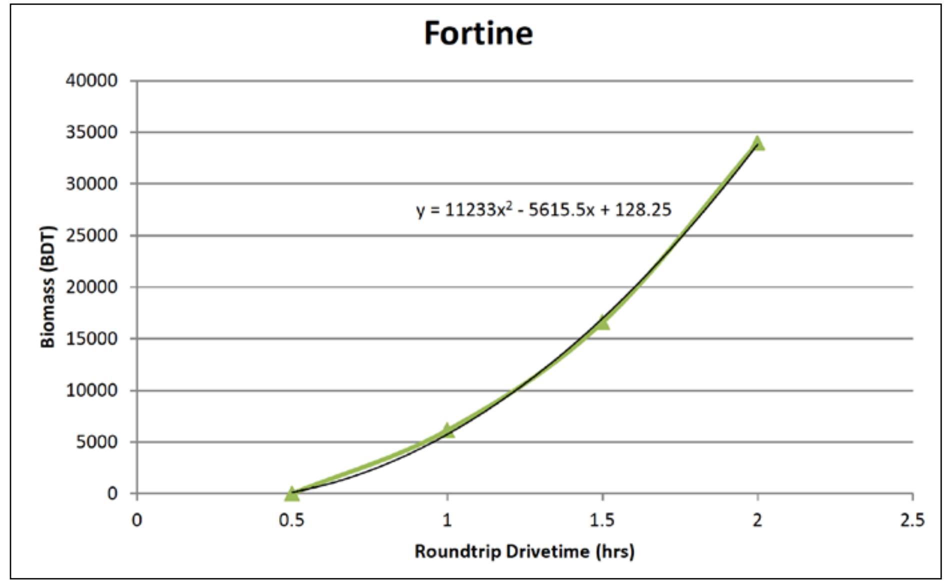


Figure 3.3.7. Fortine Supply Curve

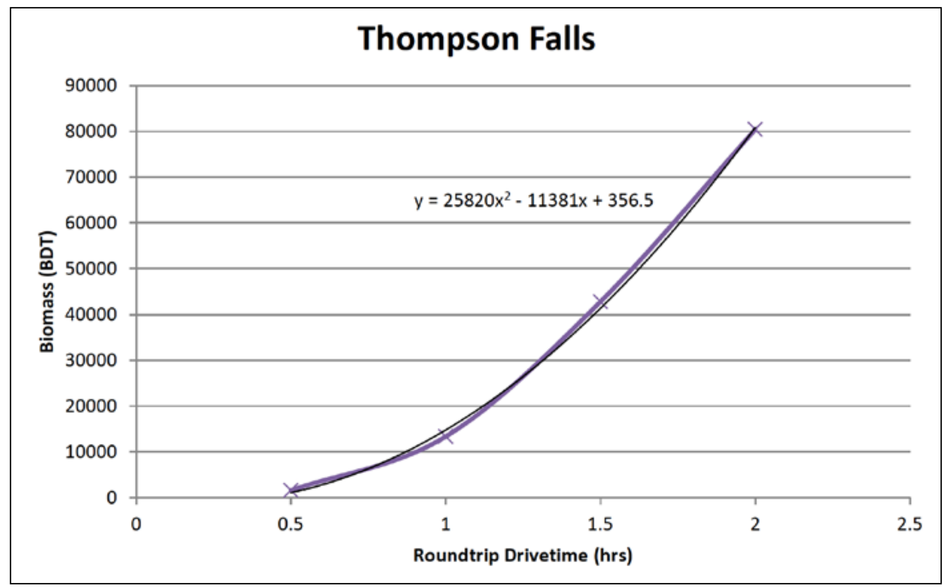


Figure 3.3.8. Fortine Supply Curve

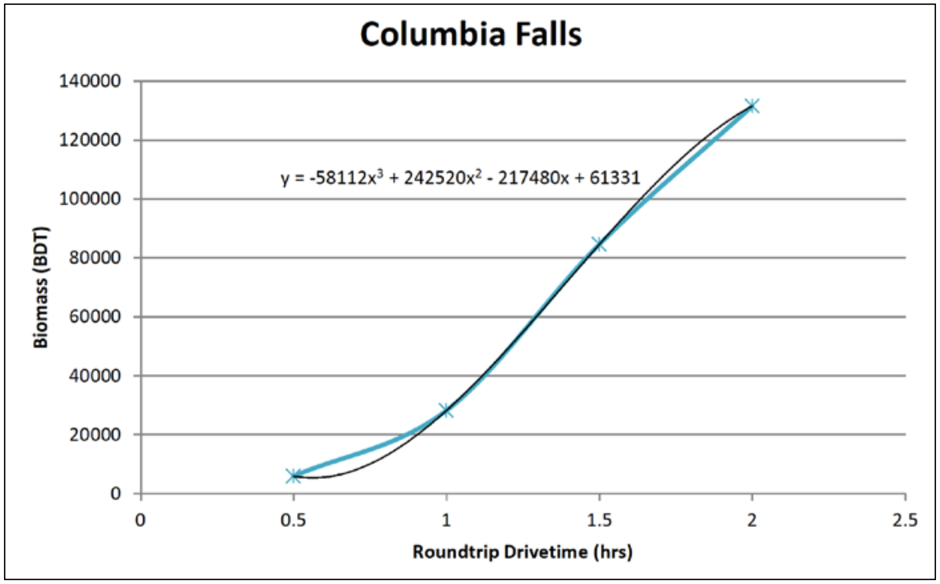


Figure 3.3.9. Fortine Supply Curve

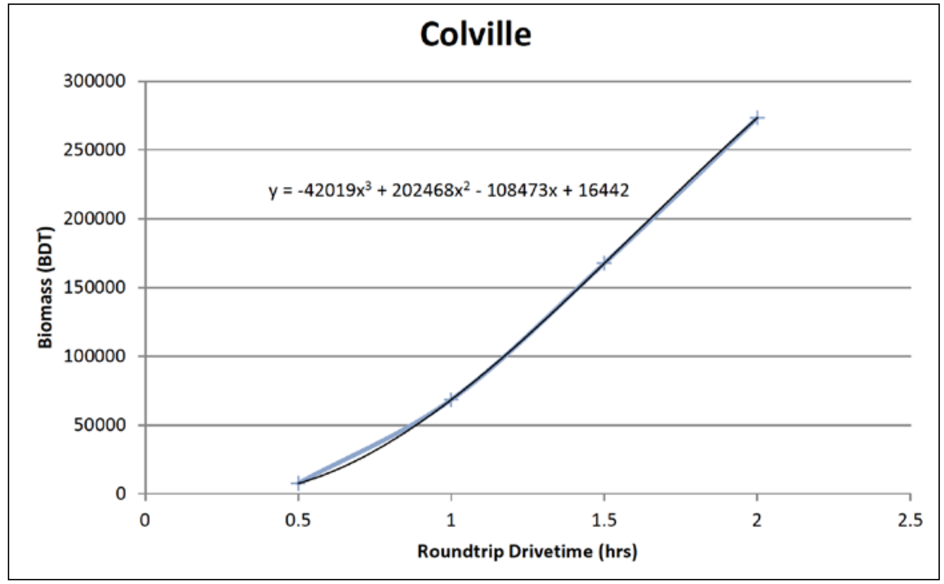


Figure 3.3.11. Colville Supply Curve

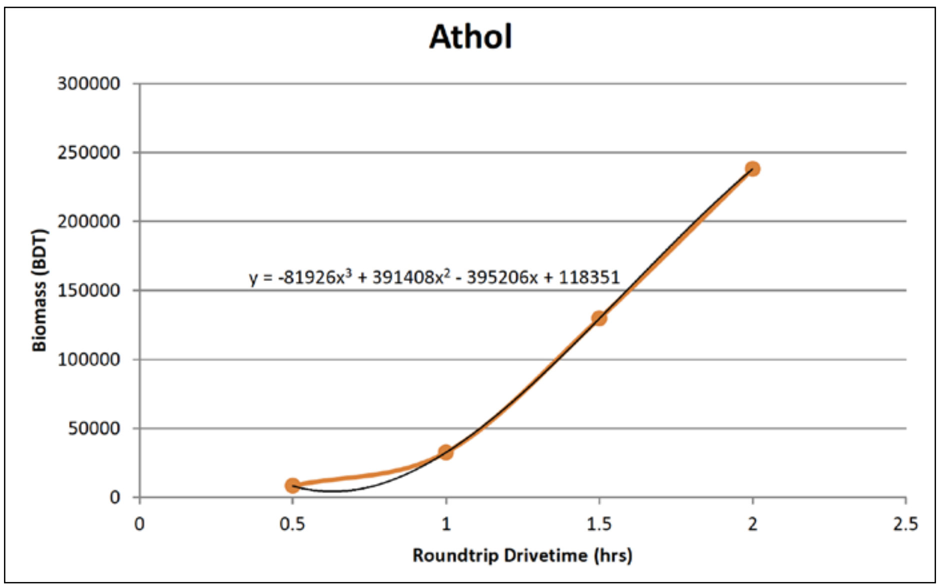


Figure 3.3.10. Fortine Supply Curve

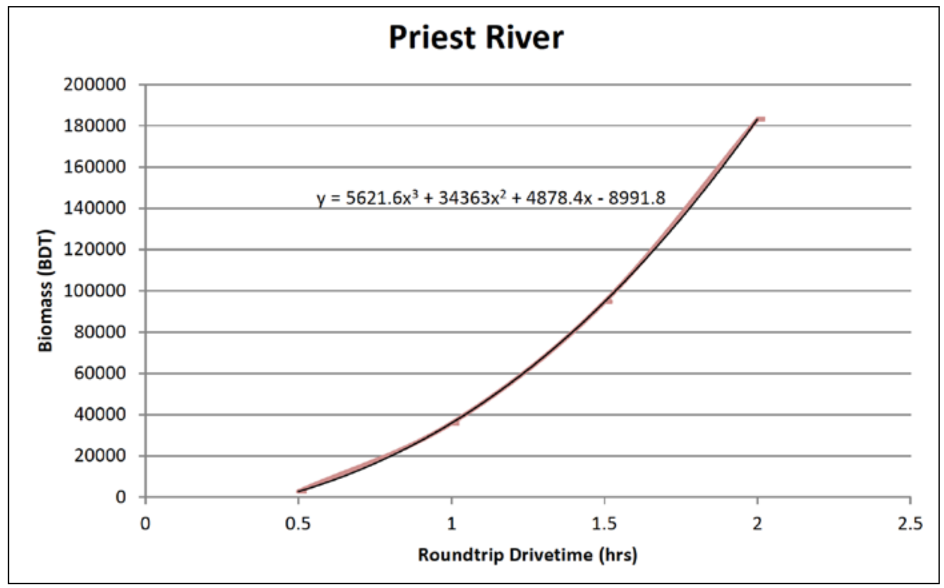


Figure 3.3.12. Priest River Supply Curve

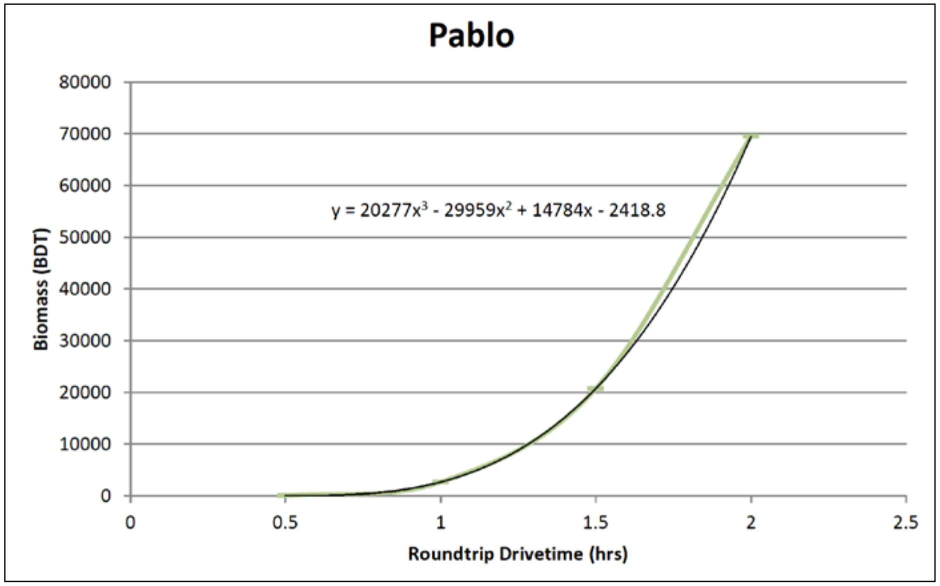


Figure 3.3.13. Pablo Supply Curve

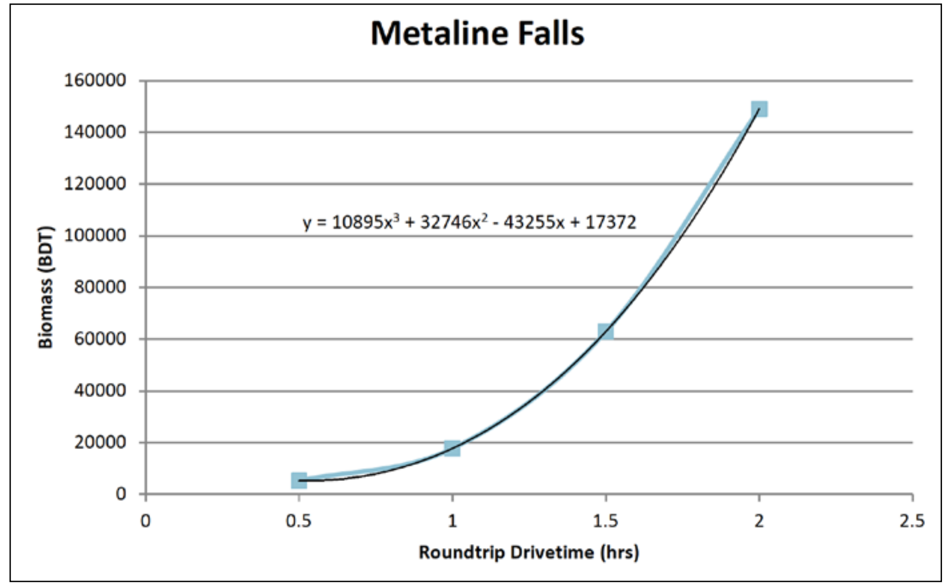


Figure 3.3.15. Metaline Falls Supply Curve

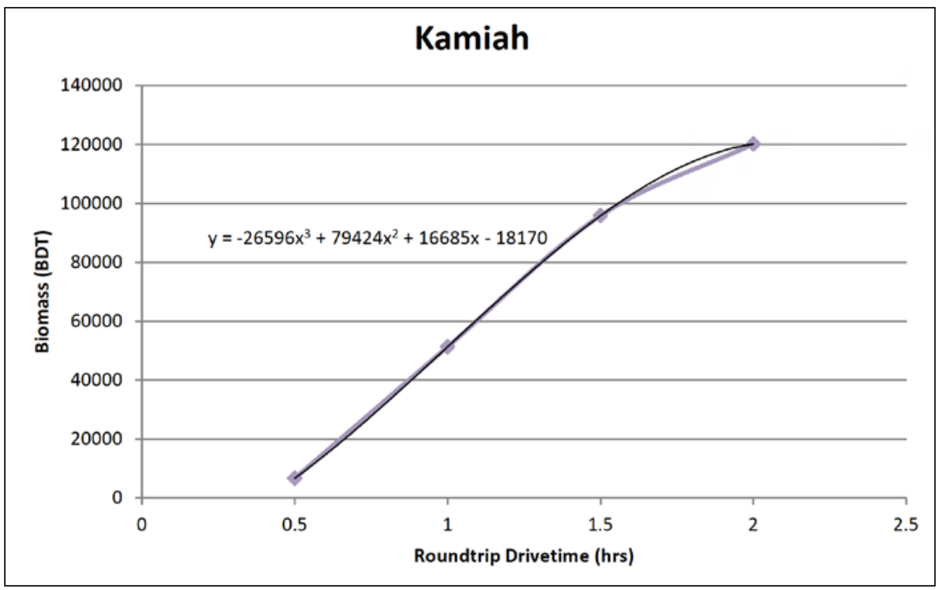


Figure 3.3.14. Kamiah Supply Curve

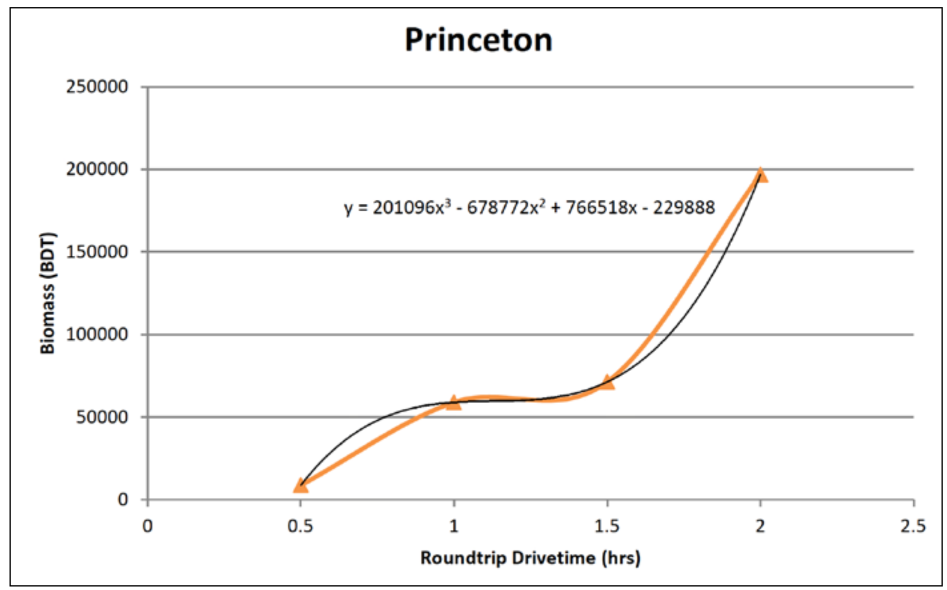


Figure 3.3.16. Princeton Supply Curve

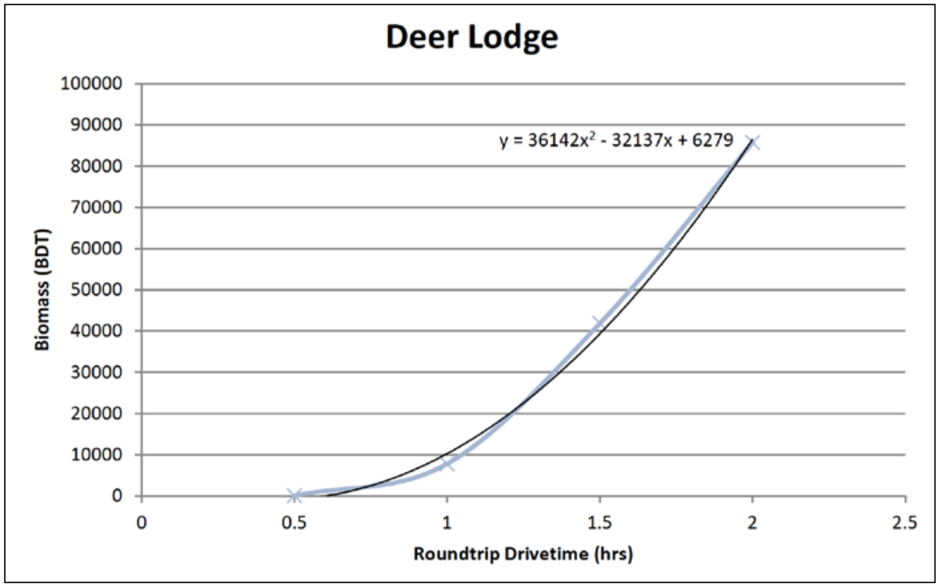


Figure 3.3.17. Deer Lodge Supply Curve

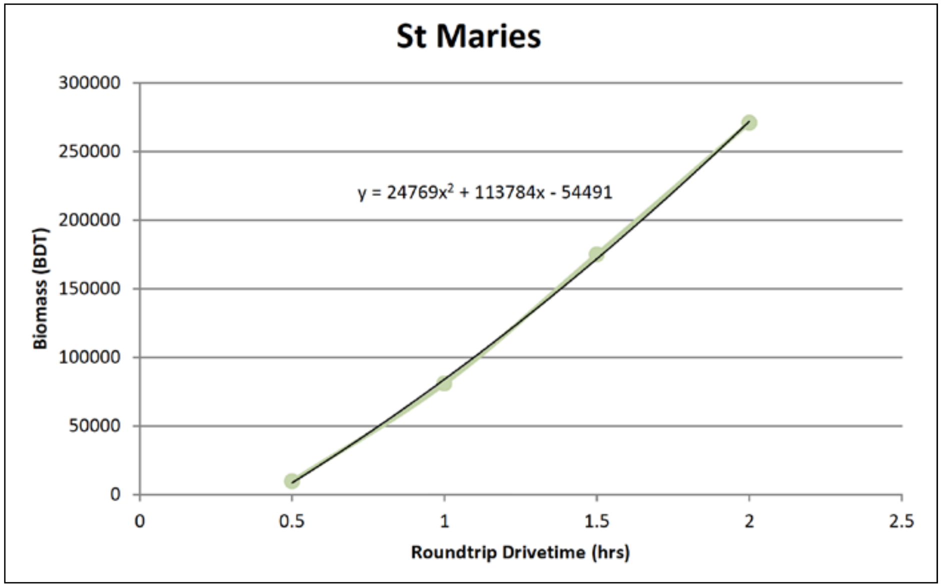


Figure 3.3.19. St. Maries Supply Curve

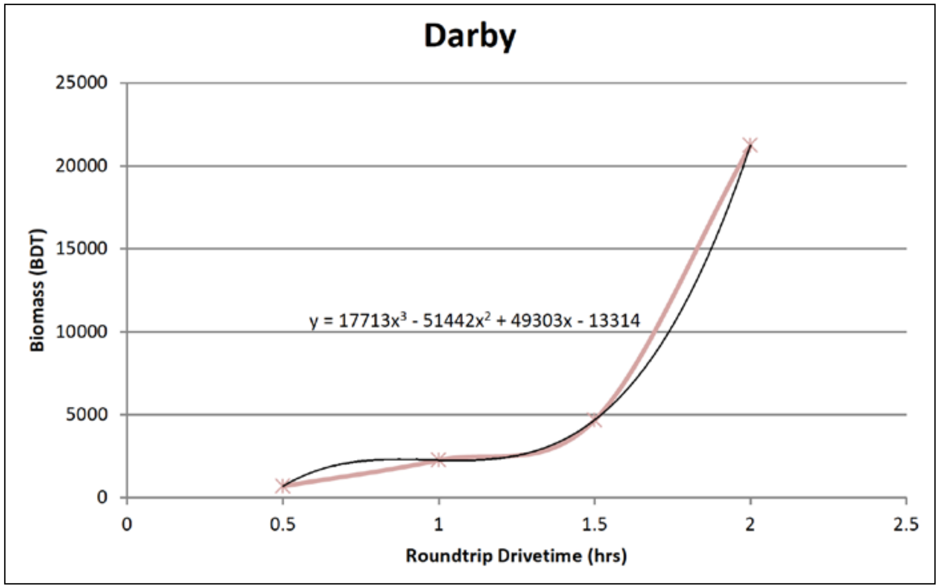


Figure 3.3.18. Darby Supply Curve

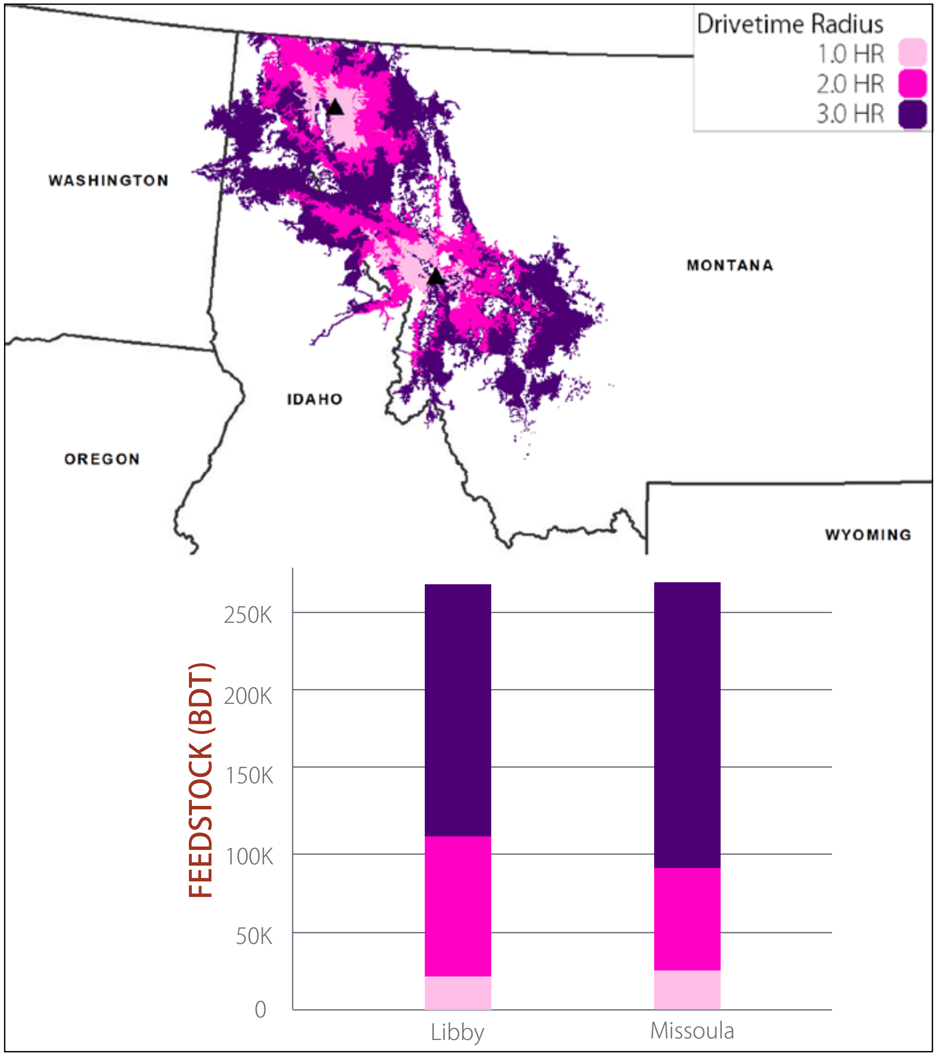


Figure 3.3.20. Biomass Availability by Drive Time for the Libby and Frenchtown Conversion Sites

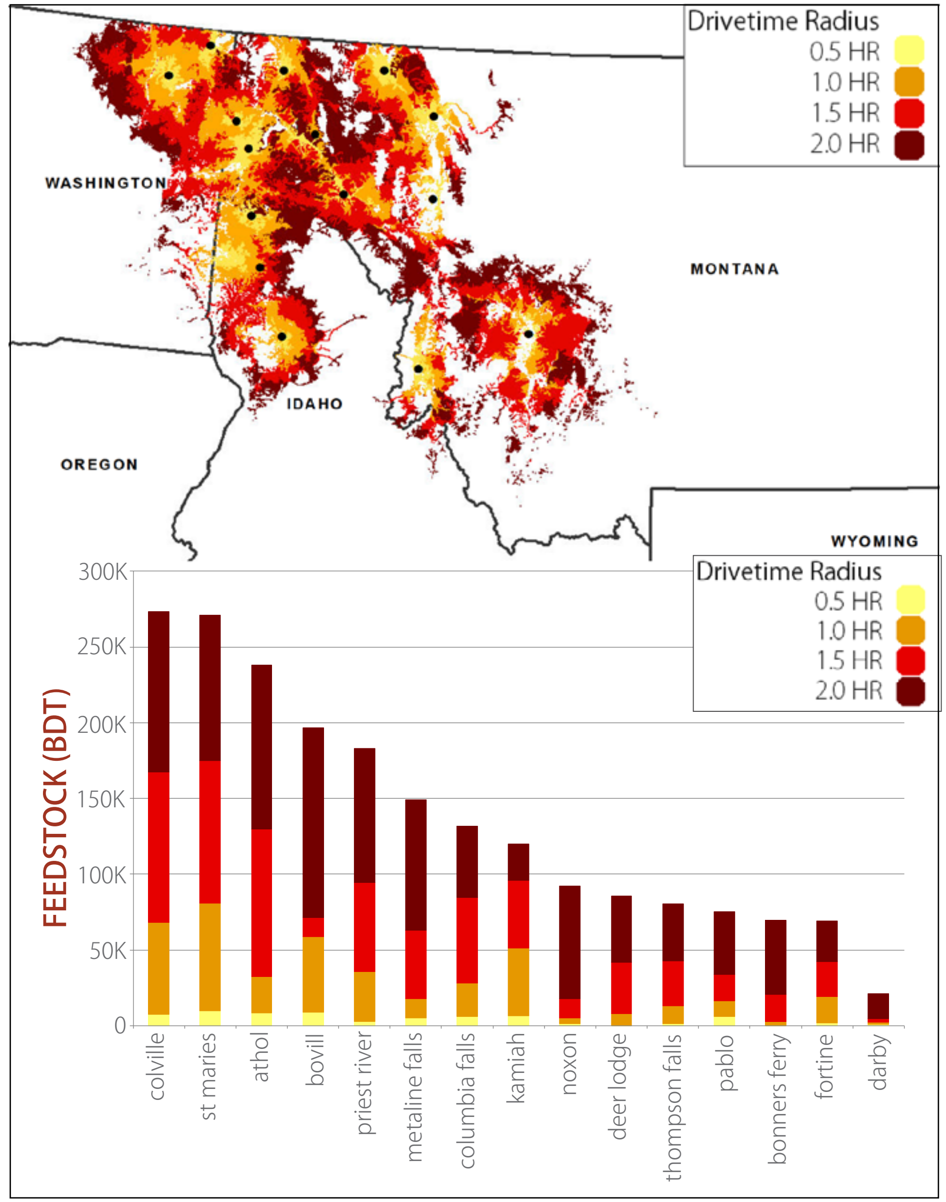


Figure 3.3.21. Biomass Availability by Drive Time - Depot Sites

Table 3.3.1. Estimated Feedstock Availability by Conversion Site

Conversion Site	1 hour	2 hours	3 hours
Libby	22607	110486	267612
Frenchtown	25495	89913	268241

Table 3.3.2. Estimated Feedstock Availability by Depot

	Feedstock Availability (BDT)			
Depot Site	0.5 hr	1 hr	1.5 hr	2 hr
Bonners Ferry	1884	19280	42555	69073
Noxon	1566	5222	17878	92253
Fortine	6132	16593	33958	75401
Thompson Falls	1597	13367	42808	80398
Columbia Falls	5957	28259	84653	131555
Athol	8359	32627	129709	238162
Colville	7570	68418	167472	273218
Priest River	2741	35871	94615	183189
Pablo	18	2683	20785	69531
Kamiah	6704	51343	95800	120128
Metaline Falls	5293	17758	62938	149004
Princeton	8815	58954	71351	196828
Deer Lodge	70	7812	41864	85748
Darby	691	2260	4678	21230
St. Maries	9645	80908	175070	271102
Total (BDT)	67042	441356	911064	2056820
Total (overlap)				1068211

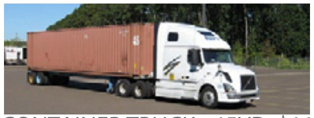
STEP 6: DETERMINE ROAD AND RAIL TRANSPORTATION COSTS

To determine the transportation costs of moving forest residues from the landing site to the depot or conversion facilities, both rail and road options were analyzed. Trucking fees were based on survey data from trucking companies and average fees are shown in figure 3.3.22. These fees were used to generate an Excel-based costs calculator (figure 3.3.23). Rail prices were difficult to determine as they are negotiated privately between customers and the rail company. For the purpose of this analysis, published single-car rates from BNSF were used from a web-based calculator shown in figure 3.3.24. These rates established the “high rate” for rail costs shown in tables 3.3.3 and 3.3.4. The low range for rail costs is based on unit coal train prices for coal transport from mining states to coal consuming states. Truck and rail transportation costs generated from the road and rail calculators are compiled in tables 3.3.3 and 3.3.4 and provide transport costs between the 15 depot sites and the two conversion facilities. In addition, road and rail costs are plotted in figures 3.3.25 and 3.3.26 to illustrate the optimal transportation option relative to the distance from the conversion facility.

TRUCK TYPE

TRUCK - 9YD: $85/HR

TRUCK AND TRAILER - 18YD: $110/HR



CONTAINER TRUCK - 45YD: $115/HR

TRUCK AND TRAILER - 90YD: $115/HR

CHIP VAN - 120/150YD: $110/120/HR

TREE TYPE

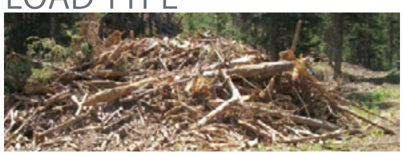
PONDEROSA PINE - SLASH: 306LB/CY
CHIPS: 379 LB/CY

GRAND FIR/SPRUCE - SLASH: 194 LB/CY
CHIPS: 259 LB/CY

DOUGLAS FIR - SLASH: 267 LB/CY
CHIPS: 356 LB/CY

WESTERN LARCH - SLASH: 284 LB/CY
CHIPS: 378 LB/CY

LOAD TYPE



SLASH

CHIPS

UTILIZATION FACTOR

TRAVEL TIME

$/BDT

Figure 3.3.22. Cost Calculator Variables

Truck Type	Container Truck and Trailer	
Truck Capacity	90	CY
Truck Cost	115	$/HR
Tree Type	Ponderosa/Lodgepole Pine	
Load Type	Slash	
Load Density	306	LB/CY (Bonedry)
One-Way Travel Time	1.5	HR
Utilization	65	%
One-Way Cost	19.27	$/BDT
Roundtrip Cost	36.62	$/BDT

Figure 3.3.23. Excel-based Cost Calculator

Origin: MISSOULA, MT
Route: BNSF   Est Transit Time: 4-5 days
Rail Miles: 215
Highway Miles: 167

☐	$2834.00 per car	$81.70	$2915.70	Boxcars PVT or RR Owned	LE 160000 lbs
	BNFFL 93	Terms & Conditions			
☐	$3272.00 per car	$81.70	$3353.70	Boxcars PVT or RR Owned	Greater than 160000 lbs
	BNFFL 93	Terms & Conditions			

Figure 3.3.24. BNSF Cost Estimator

Table 3.3.3. Libby Drivetimes and Transportation Costs to Potential Depot Sites

Libby (US-2 W and Minnesota Ave)	Drivetime (mins)	Road Distance (mi)	Roundtrip Cost ($/BDT)	Rail Distance (mi)	Cost (per railcar)	Rail Cost ($/BDT)-High	Rail Cost ($BDT)-Low	Rail Cost ($BDT) Average	Recommended Transport
Bonners Ferry (Riverside St)	59	52.4	$12.13	50	$2,904.00	$29.04	$5.03	$17.04	ROAD
Noxon (NF-150 and MT-200 E)	71	57.7	$14.60	130	$2,932.80	$29.33	$5.70	$17.52	ROAD
Fortine (US-93 S)	88	81.7	$18.10	83	$2,915.88	$29.16	$5.31	$17.23	ROAD
Thompson Falls (MT-200 E)	106	92.3	$21.80	171	$2,947.56	$29.48	$6.05	$17.76	ROAD
Priest River (Riley Creek Park Rd)	112	99	$23.03	105	$2,923.80	$29.24	$5.49	$17.37	ROAD
Columbia Falls (N Fork Rd)	115	105	$23.65	109	$2,925.24	$29.25	$5.53	$20.19	ROAD
Athol (E Parks Rd and Old Hwy 95)	121	111	$24.80	111	$2925.96	$29.26	$5.55	$17.40	ROAD
Pablo (Old US Hwy 93)	158	143	$32.50	254	$3,363.44	$33.63	$6.75	$20.19	RAIL
Metaline Falls (Box Canyon Rd)	208	174	$41.13	-	-	-	-	-	-
St Maries (Mill Rd)	207	179	$42.57	-	-	-	-	-	-
Frenchtown (MT-474 W/Co Rte 12)	211	187	$43.40	276	$3,371.36	$33.71	$6.93	$20.32	RAIL
Colville (W 5th Ave)	222	178	$45.66	235	$3,356.60	$33.57	$6.59	$20.08	RAIL
Princeton (ID-6)	223	203	$45.86	-	-	-	-	-	-
Darby (US-93 S)	286	255	$58.82	339	$3,781.04	$37.81	$7.46	$22.64	RAIL
Deer Lodge Greehouse Rd)	287	276	$59.03	351	$3,785.36	$37.85	$7.56	$22.71	RAIL
Kamiah (Woodland Rd)	345	306	$70.96	334	$3,779.24	$37.79	$7.42	$22.61	RAIL

Table 3.3.4. Frenchtown Drivetimes and Transportation Costs to Potential Depot Sites

Frenchtown (MT-474 W/Co Rte 12)	Drivetime (mins)	Road Distance (mi)	Roundtrip Cost ($/BDT)	Rail Distance (mi)	Cost (per railcar)	Rail Cost ($/BDT)-High	Rail Cost ($BDT)-Low	Rail Cost ($BDT) Average	Recommended Transport
Darby (US-93 S)	87	74.7	$17.89	82	$2,915.52	$29.16	$5.30	$17.23	ROAD
Pablo (Old US Hwy 93)	88	59.2	$18.10	73	$2,912.28	$29.12	$5.23	$17.17	ROAD
Deer Lodge (Greenhouse Rd)	90	94	$18.51	94	$2,918.84	$29.20	$5.40	$17.30	ROAD
Thompson Falls (MT-200 E)	121	97.4	$21.89	105	$2,924.85	$29.25	$5.49	$17.37	ROAD
Noxon (NF-150 and MT-200 E)	154	149	$21.67	148	$2,940.02	$29.40	$5.84	$17.62	ROAD
Athol (E Parks Rd)	172	173	$35.58	219	$3,353.08	$33.53	$6.45	$19.99	ROAD
Columbia Falls (N Fork Rd)	176	166	$35.20	385	$3,801.82	$38.02	$7.85	$22.94	ROAD
St Maries (Mill Rd)	184	177	$36.01	-	-	-	-	-	-
Kamiah (Woodland Rd)	185	182	$38.05	442	$4,355.54	$43.56	$8.13	$25.84	ROAD
Libby (US-2 W and Minnesota Ave)	211	187	$43.00	276	$3,574.12	$35.74	$8.93	$22.34	RAIL
Priest River (Riley Creek Park Rd)	217	213	$44.05	217	$3,352.28	$33.52	$6.44	$19.98	RAIL
Princeton (ID-6)	225	207	$46.28	-	-	-	-	-	-
Fortine (US-93 S)	227	230	$46.09	260	$3,792.20	$37.92	$7.62	$22.78	RAIL
Bonners Ferry (Riverside St)	233	232	$47.92	227	$3,355.90	$33.56	$6.52	$20.04	RAIL
Colville (W 5th Ave)	260	255	$53.47	343	$3,782.48	$37.82	$7.49	$22.65	RAIL
Metaline Falls (Box Canyon Rd)	275	250	$55.56	-	-	-	-	-	-

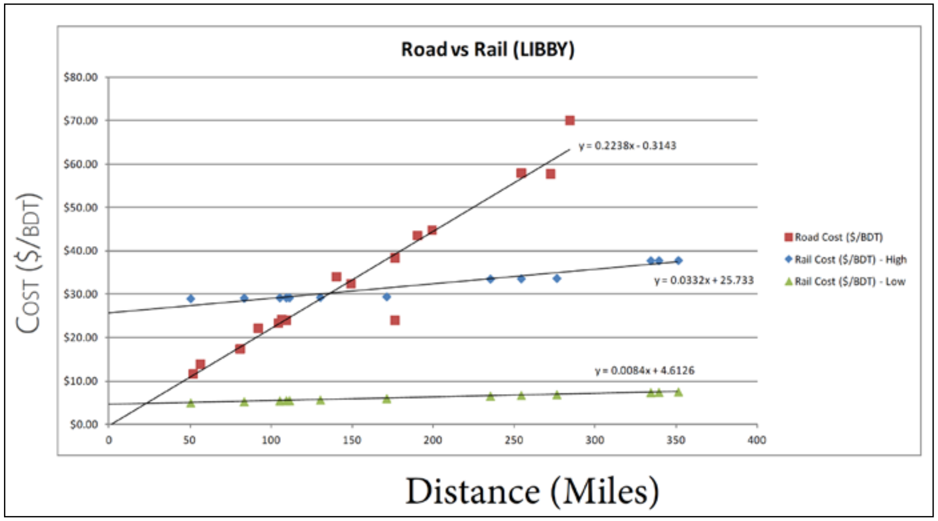


Figure 3.3.25. Cost/BDt vs Distance Traveled for Rail and Road Transportation to Libby, Montana

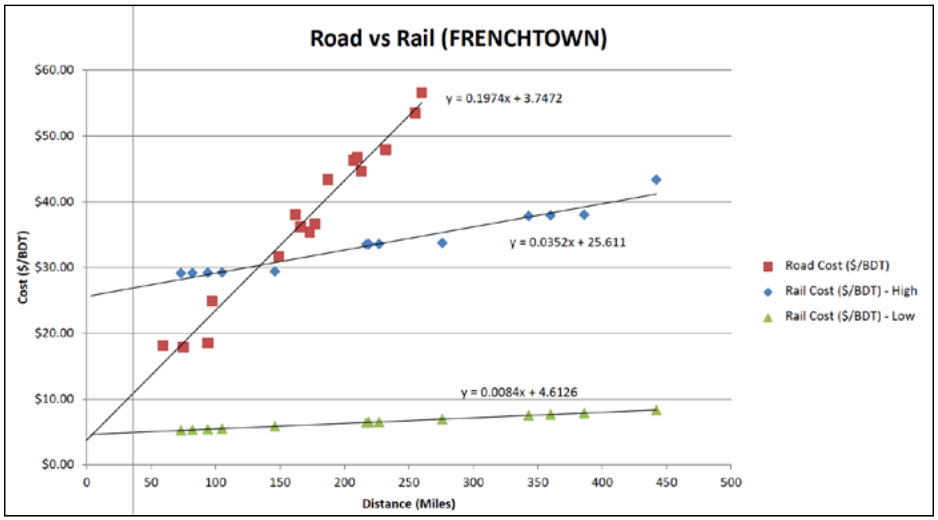


Figure 3.3.26. Cost/BDt vs Distance Traveled for Rail and Road Transportation to Frenchtown, Montana

STEP 7: DETERMINE BIOMASS AVAILABILITY BASED ON $40 TRANSPORT COST

Here, as in step five, the supply curve data supplied in Figures 3.3.5-3.3.19 were used to calculate the amount of forest residuals available from each depot site and conversion facility based on drive times. By incorporating the available forest residual amounts with transportation costs determined in step 6, the annual feedstock supply for each conversion facility was determined based on a $40 per bone-dried ton (BDT) one-way transport cost (figures 3.3.27-3.3.30)

3.3.1.3 Supply Chain Scenarios

The supply chain scenarios represented in figures 3.3.27 through 3.3.30 show different amounts of forest residual feedstock available to the conversion facility based on transportation options.

For both the Libby and Frenchtown conversion facilities, the use of rail transport allows for a greater annual amount of forest residual feedstock than road-only transport when transport costs are set at $40.00 /BDT. It is interesting to note that this analysis assigns a roughly equal amount of forest residual availability (~400,00 BDT) to the Libby or Frenchtown conversion sites based on using rail transport. Based on this data, site selection between a Libby or Frenchtown conversion facility should focus on criteria other than biomass availability such as capital costs, available workforce, social and environmental considerations and costs to distribute final products to market.

The assumptions listed earlier in this report (table 3.1.1) place an annual supply of forest residual feedstock at 1 million BDT per conversion facility. Conversion facility feedstock volume assumptions used in the NARA Techno-Economic Analysis (Volume 4, Chapter 1 of the WMC Supply Chain Study) place the minimum amount of feedstock at 770,000 BDT. The 770,000 figure was adopted from the feedstock assumptions used for a techno-economic analysis conducted by the National Renewable Energy Laboratory (NREL) for generating ethanol from cellulosic materials (Humbird et al 2011).

Though the amount of available forest residuals for either the Libby or Frenchtown conversion facility sites is significantly lower that the 1 million or 770,000 annual BDT assumptions, a conversion facility processing ~400,000 BDT/year is not unrealistic. Current facilities built to convert cellulosic feedstocks to ethanol project ethanol output at a range of 25 to 50 million gallons per year (see Table 3.3.5). Based on NARA's conversion estimates listed on Figure 3.1.1, 400,000 BDT of forest residuals will produce ~ 24 million gallons of isobutanol annually, which has a higher energy density than ethanol. 24 million gallons of isobutanol translates to ~18 million gallons of iso-paraffinic kerosene (IPK). This amount of IPK will most likely be used with fossil fuels in blends up to 50%, which would supply up to 36 million gallons of jet fuel (USDA 2013).

In 2009, the Spokane Airport and Fairchild Air Force Base in Spokane consumed 13.1 million and 17 million gallons of jet fuel respectively (Sustainable Aviation Fuels Northwest, 2011). The amount of blended biojet fuel produced from a conversion facility processing 400,000 BDT of residuals annually would potentially supply 100% of the jet fuel needs for both of these airports based on 2009 levels.

The supply chain analysis methods and assumptions used by the IDX group will continue to be refined in the coming years, including adding more detailed cost estimates to transportation and estimating policy impacts such as renewable identification numbers (RINs) attached to feedstocks. Currently, the IDX group is analyzing intermediate facilities that produce carbohydrates from wood in liquid solution. It may be, given further analysis, that the WMC could support one or more of these intermediate 'liquid' depots. The output from these facilities, which has much higher energy densities, could be transported at greatly reduced costs via rail or pipeline to receiving facilities outside of the region for conversion to isobutanol and other products.

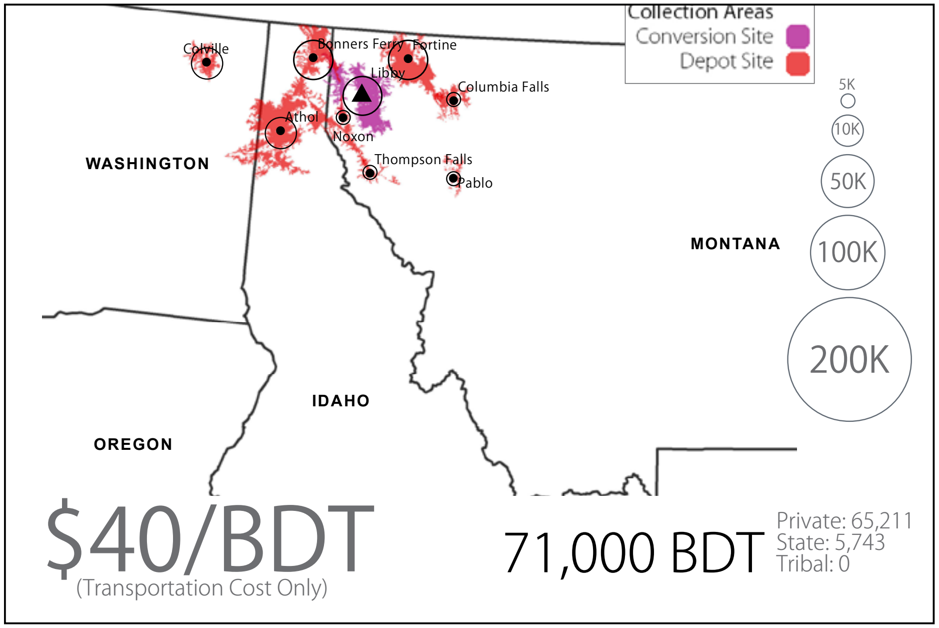


Figure 3.3.27. Libby Conversion Site $40/BDT Road Scenario

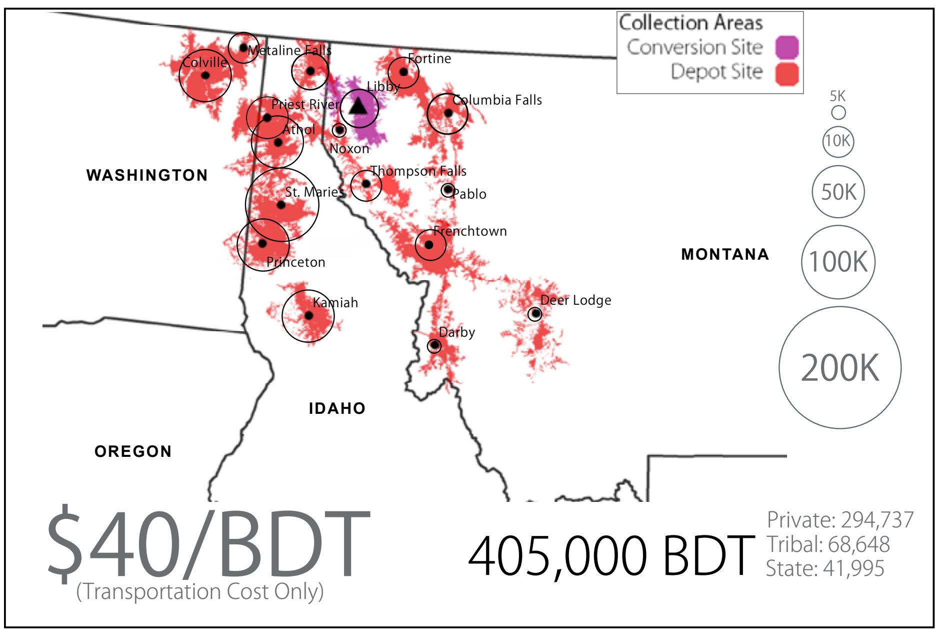


Figure 3.3.28. Libby Conversion Site $40/BDT Rail Scenario

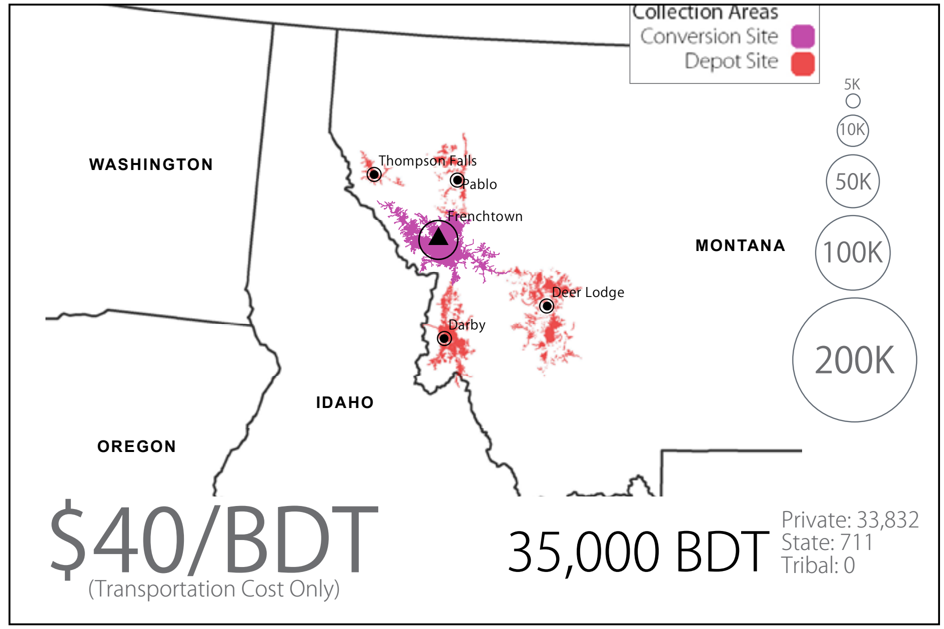


Figure 3.3.29. Frenchtown Conversion Site $40/BDT Road Scenario

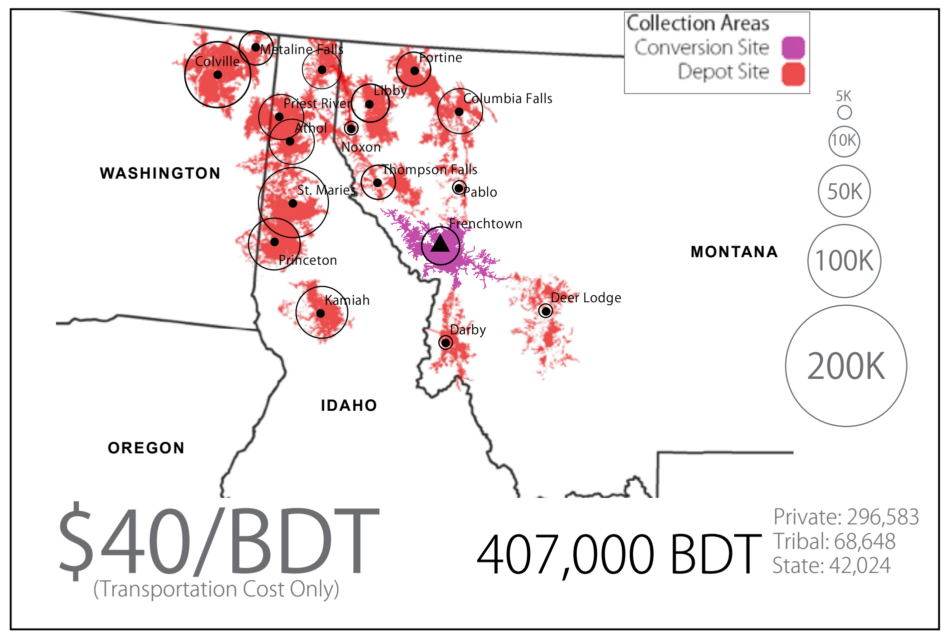


Figure 3.3.30. Frenchtown Conversion Site $40/BDT Rail Scenario

Table 3.3.5. Summary of commercial cellulosic biofuels projects

Source	Facility	Process	Fuel Product	Feedstock	Rated Capacity (million gal/yr)	CapEx (million)	CapEx/ Capacity (per gal capacity)
Brown and Brown	Kior	pyrolysis & hydrotreat	hydrocarbons	loblolly pine residuals	41	$350	$8.54
2013	ClearFuels	gasification & FT	hydrocarbons	woody biomass	20	$200	$10.00
	Sundrop Fuels	gasification and MTG	hydrocarbons	mixed biomass & NG	50	$500	$10.00
	ZheaChem	acid hydr & ac. acid syn	ethanol	poplar & ag residue	25	$391	$15.64
	Abengoa	enzymatic hydrolysis	ethanol	corn stover	25	$350	$14.00
	Beta Renewables	enzymatic hydrolysis	ethanol	Arundo donax	20	$170	$8.50
	DuPont Biofuels	enzymatic hydrolysis	ethanol	corn stover	25	$276	$11.04
	POET	enzymatic hydrolysis	ethanol	corn stover & cob	25	$250	$10.00
Lane 2013a	Aggregated				266	$2,719	$10.22
Lane 2013b	Estimate						$6 to $12
NARA TEA	Integrated Greenfield	enzymatic hydr to IPK	IPK	forest residuals	32	$881	$27.24
		enzymatic hydr to IBA	IBA	forest residuals	45	$881	$19.39
		enzymatic hydr to IBA	EtOH Equiv	forest residuals	68	$881	$13.02

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