Appendix A.1

Ecological Resources Summary
(November 2014)

1 Smith Ranch, Highland, and Reynolds Ranch Ecological Studies Summary

1.1 Vegetation

1.1.1 Baseline Study History and Methods

1.1.1.1 Smith Ranch

Previous owner, Kerr-McGee Corporation (Kerr-McGee), and consultants conducted baselines vegetation surveys at the Smith Ranch ISL Project (Smith Ranch) in 1976, 1978, and 1979. While applicable to the permit area at the time, the 1978 study boundary is not longer applicable to the current permit area. Additional baseline survey work was completed in the summer of 1990 and 1992, and a final baseline vegetation assessment was prepared in 1997. Detailed information on the aforementioned studies can be found in Appendix D8 (A1 to A3) of the revised 2011 Smith Ranch Wyoming Department of Environmental Quality (WDEQ) Permit. A summary of these studies and associated methods is provided below:

- Woodward-Clyde Consultants, 1976: Vegetation surveys included a quantitative analysis of dominant vegetation types using line-intercept transects to measure cover, circular plots to measure density, and quadrants to measure production. A list of all plant species expected to occur in the area during the time of the 1976 surveys is provided in Appendix D8 of the revised 2011 Smith Ranch WDEQ Permit.
- Woodward-Clyde Consultants, 1979: Additional vegetation surveys were conducted in 1979 and included measurements of cover, annual productivity, and shrub height. Control areas were also established for future comparison to areas disturbed by mining.
- Beartooth Environmental, 1990: Vegetation mapping in the permit area was conducted in 1990. Review of aerial photographs and pedestrian-based surveys were conducted to complete the mapping.
- BKS Environmental Associates, Inc. (BKS), 1992: BKS performed a vegetation inventory according to WDEQ/LQD methodology in 1992.
- BKS, 1997: BKS conducted an updated baseline inventory on a proposed permit extension, i.e., Reynolds Ranch, to the original WDEQ Smith Ranch Permit. More information on this inventory is provided below in Section *1.1.1.3 Reynolds Ranch*.

1.1.1.2 Highland

Highland ISL Project (Highland) was originally permitted as an ISR operation by the Everest Minerals Corporation (Everest). Eggleston, Homes and Associates completed a vegetation assessment in the Highland permit area in 1998. United Nuclear Corporation (United) also completed a vegetation inventory for lands comprising the North Morton property, and this information was utilized in the Section 14 Amendment area and for portions of the Highland permit area. The aforementioned vegetation inventories are referenced in Appendix D8 (B1 to B3) of the revised 2011 Smith Ranch WDEQ Permit.

1.1.1.3 Reynolds Ranch

A vegetation inventory (including mapping) for the Reynolds Ranch Satellite ISL Project (Reynolds Ranch) was conducted in 1996 and 1997, at which time the project was under Rio Algom Mining

Corporation (RAMC) ownership. After 1997, the surface area of Reynolds Ranch was reduced such that the 1996 and 1997 inventory and mapping efforts encompassed a greater area than the current Reynolds Ranch boundary. Details on the aforementioned vegetation inventory and mapping efforts can be found in Appendix D8 (C1 to C3) of the revised 2011 Smith Ranch WDEQ Permit and Appendix D8-1 of the Reynolds Ranch Amendment.

Preliminary baseline vegetation mapping of Reynolds Ranch was conducted in the fall of 1996. A vegetation inventory was conducted in 1997 to determine species composition. Plant identification was confirmed by the Rocky Mountain Herbarium in Laramie, Wyoming. Any encountered T&E species, state plants of concern, noxious weeds, and primary selenium indicators were also identified.

1.1.2 Study Update

1.1.2.1 Smith Ranch

Appendix D8 of the revised 2011 WDEQ Permit for Smith Ranch explains that the current owner of Smith Ranch, Highland, and Reynolds Ranch (Cameco Corporation [Cameco]) contracted Hayden-Wing Associates (HWA) to complete updated vegetation surveys in the spring of 2011. Details on these surveys are provided in the 2011 Vegetation Types, Rare Plants, and Noxious Weeds Survey Report. Vegetation surveys included the following components:

- Digitizing and ground truthing vegetation types within the entire permit area.
- Delineating and surveying potential Ute ladies'-tresses (*Spiranthes diluvialis*) habitat during the bloom period for this species.
- Surveying for suitable blowout penstemon (*Penstemon haydenii*) habitat.
- Surveying for BLM sensitive plant species and suitable habitat on BLM land, and opportunistically throughout the permit area.
- Surveying for noxious weeds within disturbed areas of the entire permit area.
- Surveying for selenium indicator and accumulator plants where water contamination was a possibility.

Wetland surveys were also conducted between June 20 and June 30, 2011 in accordance with U.S. Army Corps of Engineers (USACE) regulations. The purpose for these surveys was to determine whether wetlands are present within the proposed mine units; full delineations would be required if dredge or fill into jurisdictional wetlands and waters of the U.S. could result from ISR activities. A survey of 19 potential wetland sites and drainages were surveyed.

1.1.2.2 Highland

See Section *1.1.2.1 Smith Ranch.*

1.1.2.3 Reynolds Ranch

See Section *1.1.2.1 Smith Ranch.*

1.1.3 Baseline Study Results

1.1.3.1 Smith Ranch

Based on baseline vegetation surveys, grassland covered approximately 56 percent of the ground and accounted for 82 percent of all vegetative cover at Smith Ranch. The dominant grass and grass-like species were western wheatgrass (*Pascopyrum smithii*), blue grama (*Bouteloua gracilis*), sedge (*Carex* spp.), and needle-and-thread grass (*Hesperostipa comate*). Shrubs covered an average of less than eight percent of the ground. Big sagebrush (*Artemisia tridentata*) was the dominant shrub species. Other less common shrubs included fringed sagebrush (*Artemisia frigida*), birdfoot sagebrush (*Artemisia pedatifida*), rabbitbrush (*Ericameria nauseosa*), plains prickly pear cactus (*Opuntia polyacantha*), and snakeweed (*Gutierrezia sarothrae*). Forbs were the least dominant form of vegetation, covering less than five percent of the ground.

Eleven noxious weed species were encountered during baseline surveys: western ragweed (*Ambrosia psilostachya*), white-leaved ragweed (*Ambrosia dumosa*), common burdock (*Arctium minus*), Canada thistle (*Cirsium arvense*), poverty weed (*Iva axillaris*), field bindweed (*Convolvulus arvensis*), quackgrass (*Elymus repens*), Russian knapweed (*Acroptilon repens*), hounds tongue (*Cynoglossum officinale*), tansy mustard (*Descurainia pinnata*), and wild oat (*Avena fatua*). In addition, two selenium indicator species were encountered, two-grooved milkvetch (*Astragalus bisulcatus*) and golden weed (scientific name unknown), which were occasionally found but relatively uncommon in the Smith Ranch permit area during the time of baseline studies.

1.1.3.2 Highland

Results of the 1987 vegetation study at Highland indicate that the permit area, during the time of the study, was dominated by the sagebrush-grassland vegetation community. This community was characterized by variable populations of big sagebrush combined with blue grama, common buffalo grass (*Bouteloua dactyloides*), prairie junegrass (*Koeleria macrantha*), needle-and-thread grass, threadleaf sedge (*Carex filifolia*), and sagewort (*Artemisia annua*).

A drainage vegetation community was at Highland and was characterized by a sagebrush rim assemblage consisting of big sagebrush and the occasional silver sagebrush (*Artemisia cana*); a grass bottomland characterized by a high percentage of vegetative cover consisting of meadow barley (*Hordeum brachyantherum*), western wheatgrass, Kentucky bluegrass (*Poa pratensis*), common dandelion (*Taraxacum officinale*), yellow sweet clover (*Melilotus officinalis*), and mintleaf beebalm (*Monarda fistulosa*) in the drier areas and Nebraska sedge (*Carex nebrascensis*) in the wetter areas; and various grasses in the bottoms of deep sand bottomed ravines. Only one small cluster of trees (*Populus deltoides and Populus angustifolia*) was found along a major drainage.

Playas in the permit area ranged from one small playa to very shallow structures only recognizable as slightly greener spots compared to surrounding grasslands. The most active playa at the time of surveys was outside the permit area and associated plant species included slender spike rush (*Eleocharis tenuis*), squirrel tail grass (*Hordeum jubatum*), western wheatgrass, Kentucky bluegrass, and common dandelion.

1.1.3.3 Reynolds Ranch

Baseline vegetation surveys at Reynolds Ranch indicate that two primary native vegetation types were present: well drained, upland vegetation (characterized by grassland on ridge tops) and flat area vegetation (characterized by sagebrush/grassland on sloped areas and drainages). Table 1 in Addendum D8-C of the Reynolds Ranch Amendment indicates that grassland was the dominant vegetation type in the permit area during baseline surveys (54 percent), followed by sagebrush/grassland (45 percent), rock outcrops (0.6 percent), and playa vegetation (0.1 percent).

1.1.4 Results Update (Smith Ranch, Highland, and Reynolds Ranch)

The following is a summary of results from the 2011 updated vegetation study for Smith Ranch, Highland, and Reynolds Ranch:

- Vegetation Types: Nine vegetation types were identified. Sagebrush-grassland, grassland, and disturbed/reclaimed land were most common vegetation type, comprising 90 percent of the permit area. Other less common vegetation types were characterized by agricultural land, bare/sand, drainage, deciduous forest, playa, and reservoir.
- Noxious Weeds: Cheatgrass (*Bromus tectorum*) (a county-listed noxious weed species) was common and present at 423 of 500 weed survey points. Curlycup gumweed (*Grindelia squarrosa*) and wavyleaf thistle (*Cirsium undulatum*) were also common county-listed noxious weed species. Additional county-listed noxious weeds included buffalo bur (*Solanum rostratum*), common cocklebur (*Xanthium strumarium*), common mullein (*Verbascum thapsus*), common sunflower (*Helianthus annuus*), halogeton (*Halogeton glomeratus*), rush skeletonweed (*Chondrilla juncea*), teasel (*Dipsacus fullonum*), and western sticktight (*Lappula occidentalis*). The most common state-listed species were Canada thistle and musk thistle (*Carduus nutans*). Additional state-listed noxious weed species included common burdock (*Arctium minus*), field bindweed, houndstongue (*Cynoglossum officinale*), Russian knapweed, Russian olive (*Elaeagnus angustifolia*), and Scotch thistle (*Onopordum acanthium*).
- Selenium indicator species: No selenium indicator species were observed; however, five selenium accumulator plant species were identified: arrow grass (*Triglochin maritime*), curlycup gumweed, povertyweed (*Iva axillaris*), spiny hopsage (*Grayia spinosa*), and winterfat (*Krascheninnikovia lanata*).

1.1.5 Ecological Impacts

Grasslands and sagebrush make up most of the vegetation cover in the permit area. ISR operations will temporarily reduce vegetation within the permit area. Both short- and long-term disturbances will be revegetated within two years of the disturbance (See TR Sections 6.2.6 and 6.2.7 for more information regarding surface disturbance and reclamation).

Noxious weeds were present in the permit areas during the baseline and updated vegetation studies. It is possible that increased development over the years has and may continue to increase the spread of noxious weeds or possibly introduce other non-native species to the site. Surface disturbance and reclamation procedures and mitigation measures are described in TR Sections 6.2.6 and 6.2.7.

1.1.6 Future Studies (Including T&E Species)

Cameco will continue to revise vegetation conditions at the Smith Ranch, Highland, and Reynolds Ranch sites by periodically:

- Updating vegetation maps,
- Updating the plant species list through opportunistic surveys,
- Identifying any wetlands in the permit area, and
- Identifying the potential for any T&E plant species to occur in the permit area.

1.2 Wildlife

1.2.1 Baseline Study History and Methods

1.2.1.1 Smith Ranch

Baseline wildlife and wildlife habitat studies were performed in 1976, 1979, and 1990 at Smith Ranch. This information is verified in the revised 2011 Smith Ranch WDEQ Permit. Multiple ground surveys were completed to address seasonality of species with a minimum of four separate surveys performed over the span of one year in 1979, 1979, and 1990. Additionally, a series of three aerial surveys were conducted over a portion of the permit area in February, August, and December 1990 to record numbers, distribution and habitat affinity, as well as pre- and post-hunt population statistics. The wildlife studies conducted at Smith Ranch can be found in Appendix D9 (A1 to A3) of the revised 2011 Smith Ranch WDEQ Permit.

1.2.1.2 Highland

Wildlife surveys were performed at Highland in 1987 and 1989. Multiple ground surveys were completed to survey wildlife species. A minimum of four separate surveys were performed over a period of one year in 1987 and 1989. Additionally, a series of three aerial surveys were conducted over a portion of the permit area in February, August, and December 1990 to record numbers, distribution, and habitat affinity, as well as pre- and post-hunt population statistics. The wildlife studies conducted at Highland are detailed in Appendix D9 (B1 to B3) of the revised 2011 Smith Ranch WDEQ Permit.

1.2.1.3 Reynolds Ranch

Baseline wildlife surveys were conducted at Reynolds Ranch in January of 1997 and 1998. In 1997, Reynolds Ranch was under RAMC ownership. After 1997, the surface area of Reynolds Ranch was reduced such that the study performed in 1997 encompassed a greater area than the contemporary Reynolds Ranch boundary.

Additional baseline wildlife surveys were completed at Reynolds Ranch in the winter, spring, and summer of 2007 and 2008 by Cameco and their predecessors. These surveys investigated wildlife use on site and in a one-kilometer (0.5 mile) observation area surrounding the project boundary. Observations were conducted to document the presence or absence of big game, T&E species, migratory birds, nesting raptors, greater sage-grouse (*Centrocercus urophasianus*), and wildlife habitat. The wildlife surveys conducted at Reynolds Ranch are detailed in Addendum C3 of Appendix D9 in the revised 2011 Smith Ranch WDEQ Permit.

1.2.2 Study Update

1.2.2.1 Smith Ranch

Cameco contracted HWA and Grouse Mountain Environmental Consulting (GMEC) to complete an updated wildlife study in the spring of 2011 in the combined Smith Ranch, Highland, and Reynolds Ranch permit area. Methods are described in Appendix D9 of the revised 2011 WDEQ Permit for Smith Ranch and are summarized below:

The following wildlife surveys were conducted: greater sage-grouse leks surveys, raptor nest surveys, black-tailed prairie dog (*Cynomys ludovicianus*) presence/absence surveys and mapping, bald eagle (*Haliaeetus leucocephalus*) winter roost surveys, and wetland monitoring.

- Greater Sage-Grouse: Two ground count surveys were conducted at the Sand Creek 2 and Turner Divide leks, which were identified via an aerial survey and one ground count earlier in the season.
- Raptors: Ground surveys were performed to document nest status after GMEC identified nest locations via an aerial survey within a one-mile buffer of the permit area. On the ground, nests were observed from a distance, using binoculars and scopes.
- Black-Tailed Prairie Dog: previous wildlife survey reports and WGFD database inquiries were made to determine the locations of existing prairie dog colonies in the permit area, if present. These colonies, if present, were then opportunistically searched for during other wildlife surveys.
- Wetland Monitoring: The USFWS expressed concerns regarding selenium concentrations in wastewater produced during in-situ uranium mining. As such, HWA monitored wildlife use at three different locations within the permit area on a monthly basis: Purge storage reservoir 2 (PSR-2) (wetland/pond monitoring site #1), PSR-2 pivot irrigation field (wetland/pond monitoring site #14), and two lined settling ponds (wetland/pond monitoring site #11). Locations of these sites are described in the 2011 Smith Ranch-Highland/Reynolds Wildlife Report.
- Bald Eagle Winter Roosts: Three aerial surveys were conducted to locate bald eagle winter roost sites. The first two flights were conducted in the morning and the last flight was conducted in the evening.

Opportunistic observations of animals classified as "target species" were also documented. A target species was identified as such if it was designated as a T&E species or a WGFD species of concern. Target species with potential to occur in the area during the time of the 2011 surveys were black-tailed prairie dog; swift fox (*Vulpes velox*); certain bat species; small rodents including Ord's kangaroo rat (*Dipodomys ordii*), thirteen-lined ground squirrel (*Spermophilus tridecemlineatus*), olive-backed pocket mouse (*Perognathus fasciatus*), northern grasshopper mouse (*Onychomys leucogaster*), sagebrush vole (*Lemmiscus curtaitus*), least chipmunk (*Neotamias minimus*), yellow-pine chipmunk (*Neotamias ameonus*), and deer mouse (*Permyscus maniculatus*); greater sage-grouse; mountain plover (*Charadrius montanus*), raptors including bald eagle, golden eagle (*Aquila chrysaetos*), ferruginous hawk (*Buteo regalis*), burrowing owl (*Athene cunicularia*), merlin (*Falco columbarius*), short-eared owl (*Asio flammeus*), Swainson's hawk (*Buteo swainsonii*), and peregrine falcon (*Falco peregrinus*); and reptiles/amphibians.

1.2.2.2 Highland
See Section *1.2.2.1 Smith Ranch* for more details.

1.2.2.3 Reynolds Ranch
See Section *1.2.2.1 Smith Ranch* for more details.

1.2.3 Baseline Study Results

1.2.3.1 Smith Ranch
The following is a summary of results for the baseline wildlife studies completed for Smith Ranch. These results also apply to Highland and Reynolds Ranch. Detailed results are available in Appendix D9 of the 2011 WDEQ Permit.

- Big game: pronghorn antelope (*Antilocapra americana*) and mule deer (*Odocoileus hemiones*) were observed in the permit area during baseline studies. Pronghorn antelope numbers in the area were considered moderate and fluctuated between seasons. The permit area was classified as year-round pronghorn antelope range. Pronghorn antelope made use of every type of habitat in the permit area but most often occurred in sagebrush-dominated habitats. Mule deer were distributed throughout the permit area, but were most commonly found near drainages, like Willow Creek and Box Creek, and their tributaries.
- Small and Medium Sized Mammals: cottontail (*Sylvilagus floridanus*) and white-tailed jackrabbit (*Lepus townsendii*) were the most abundant herbivores in the permit area. Other rodents observed included thirteen-lined ground squirrel, deer mouse, olive-backed pocket mouse, and northern grasshopper mouse. These rodent species were "target species" for subsequent surveys due to their Wyoming species of concern status (see Section *1.2.2.1*). The presence of coyote (*Canis latrans*), red fox (*Vulpes vulpes*), striped skunk (*Mephitis mephitis*), long-tailed weasel (*Mustela frenata*), and American badger (*Taxidea taxus*) was also observed.
- Birds: Primary passerines found breeding within the permit area included horned lark (*Eremophila alpestris*), lark bunting (*Calamospiza melanocorys*), western meadowlark (*Sturnella neglecta*), and Brewer's sparrow (*Spizella breweri*). Several species of waterfowl, upland game birds, raptors, and other migratory birds were also observed. Mallard ducks (*Anas platyrhynchos*) were the most commonly observed waterfowl species. Mourning doves (*Zenaida macroura*) and greater sage-grouse were the two most common upland game birds in the permit area.

  For greater sage-grouse leks, activity was observed at two leks during the spring of 1990. Five male sage-grouse were observed at a lek in Section 9, T36N, R74W on the morning of April 24, and two males were observed at this lek on May 1. Three males were observed on a lek located in Section 13 on the morning of April 27. No other leks were found.

  Several raptor species were identified, including eagles. In addition, some raptor nests were located. Four golden eagle nests area discussed in detail in the baseline reports. Two of these nests produced young (one chick successfully fledged from one nest and two from the other). The status of the third nest was undetermined due to lack of landowner access, and the fourth nest appeared abandoned.

- Reptiles and Amphibians: largely due to lack of suitable habitat, reptiles and amphibians were less common in the permit area than birds and mammals. The eastern short-horned lizard (*Phrynosoma douglassii brevirostra*) and several snakes including the common garter snake (*Thamnophis sirtalis*), gopher snake (*Pituophis cateifer*), bull snake (*Pituophis catenifer sayi*), and prairie rattlesnake (*Crotalus viridis*) were observed in the permit area.

1.2.3.2 Highland
See section *1.2.3.1 Smith Ranch.*

1.2.3.3 Reynolds Ranch
See section *1.2.3.1 Smith Ranch.*

In addition, the following are results from the 2007 and 2008 surveys completed specifically for Reynolds Ranch.

- Big game: mule deer and pronghorn antelope were observed in the permit area. They were seen throughout Reynolds Ranch during every site visit, and year-round habitat was available in the permit area; browse forage was abundant. The WGFD had not identified crucial winter range within 10 miles of the permit area during the time of baseline studies. Numerous mule deer were also observed throughout the permit area and throughout the year. Fawns were frequently seen during summer and fall visits to the permit area.
- Small and Medium Sized Mammals: species observed included coyote, red fox, cottontail rabbit, and jack rabbit. No black-tailed prairie dog colonies were observed in the permit area.
- Birds: In addition to the information for Smith Ranch described above, baseline study results indicate that Reynolds Ranch provided nesting and brood rearing habitat for several ground and tree nesting birds. There was limited nesting habitat for shrub and low tree nesters such as raptors, sage thrasher (*Oreoscoptes*), and loggerhead shrike (*Lanius ludovicianus*).
- Reptiles and Amphibians: reptiles observed in the Reynolds permit area during baseline surveys included prairie rattlesnake, common garter snake, bull snake, short-horned lizard (*Phrynosoma hernadesi*), northern prairie lizard (*Plestiodon septentrionalis*), and northern sagebrush lizard (*Sceloporus graciosus graciosus*). Very little amphibian habitat was found in the permit area.

1.2.4 Results Update (Smith Ranch, Highland, and Reynolds Ranch)

The following is a summary of results from the 2011 wildlife surveys completed for the combined Smith Ranch, Highland, and Reynolds Ranch permit area:

- Greater Sage-Grouse: The Sand Creek 2 lek was confirmed to be active during the 2011 ground surveys; six males were observed on April 28, 2011 and seven males were observed on May 5, 2011. The Turner Divide lek was unoccupied and appeared to be located in typically unsuitable habitat for greater sage-grouse. Additional information on the locations of these leks is available in the 2011 Wildlife Survey Report.
- Raptors: forty-eight nest sites were documented in and within a one-mile buffer of the permit area. Nests included those of four red-tailed hawks, two golden eagles, 11 ferruginous hawks, eight Swainson's hawks, and 7 unknown raptor species; 16 nests had deteriorated beyond use. Ten of the previously listed nests were active; six nests produced young. Additional information on the locations of these nests is available in the 2011 Wildlife Survey Report.
- Black-Tailed Prairie Dog: no black-tailed prairie dog colonies were found in the permit area.
- Wetland Monitoring: wetland/pond monitoring site #1 was the only site where waterfowl and shorebirds were observed. Although not classified as waterfowl or shorebirds, red-winged blackbirds (*Agelaius phoeniceus*) and barn swallows (*Hirundo rustica*) were observed frequently feeding and showing courtship displays at this reservoir. Six mule deer were also observed feeding approximately 40 yards from the shore of the reservoir. At wetland/pond monitoring site #11, non-waterfowl and shorebird avian species were observed feeding on insects around the edges of the ponds. At site #14, two raptor species were observed: northern harrier (*Circus cyaneus*) and rough-legged hawk (*Buteo lagopus*); both were hunting in the area. Mule deer were also observed feeding near this site.

- Bald Eagle Roosts: No bald eagles were observed during aerial surveys, but two bald eagles were opportunistically observed feeding on a sheep carcass in the southwestern portion of the permit area, and one bald eagle was observed feeding on a deer carcass south of the permit area. These observations were made during wetland monitoring.

1.2.5 Ecological Impacts

Construction activities at Smith Ranch have been ongoing for 25 years, and as is typical with an ISR operation, disturbance is limited in both areal and temporal extent. Wildlife impacts have likely been greatest in vegetative communities where clearing is required to construct wells, access roads, header houses, and pipelines. In general, most wildlife, including the larger and more mobile animals, have likely dispersed from the disturbed area during construction activities. However, some may have acclimated to the activities and returned to use available habitats in and near the combined permit area.

Any habitat lost during construction will continue to be reclaimed. Furthermore, Cameco employs wildlife friendly fencing wherever fencing is required (see ER Section 5.5.2 for more information regarding wildlife and fencing). The likelihood of impacts resulting from injury or mortality for wildlife is greatest during construction due to increased levels of traffic. Traffic will persist during production, but should occur at a reduced and possibly more predictable level. Speed limits have been and will continue to be reduced and enforced during all mining activities, particularly during the breeding season.

1.2.6 Future Studies (Including T&E Species)

According to the 2011 draft Wildlife Monitoring Plan for Smith Ranch, Highland, and Reynolds Ranch, the following surveys were proposed in and near the permit area on an annual basis:

- January through December: conduct monthly survey of wetlands/ponds to monitor presence and use of wetland areas by all wildlife, especially shorebirds and waterfowl. Record presence, location, numbers, and activity.
- January and February: three aerial flights will be conducted to search for bald eagle winter roosting sites within the permit areas and one-mile buffer. The locations and number of birds observed will be recorded.
- Late March to Early May: conduct one aerial survey in the permit areas and 2-mile buffer to search for previously undocumented greater sage-grouse leks. Surveys will be performed from sunrise to one hour after sunrise in a fixed-wing aircraft at an altitude of 100 to 200 feet above the ground at an airspeed of 60 to 70 miles per hour. Transects will be located approximately 0.5 mile apart and will be flown in a north-south direction. In addition, conduct three ground counts of known leks and any new leks discovered. These surveys will be conducted seven to 10 days apart, from 0.5 hour before sunrise to one hour after sunrise.
- Late April to Early May: conduct one aerial survey in the permit areas and one-mile buffer to determine the activity status of known raptor nests and to search for new or previously undocumented nests.
- April to August: search the permit areas for black-tailed prairie dog colonies. In addition, search the permits areas and 0.25-mile buffer for mountain plover habitat.
- Early May to Mid-June: if mountain plover habitat is discovered, presence/absence and nesting surveys will be conducted following USFWS protocol.

- Late May to Early June: conduct ground survey of raptor nests that were active or not located during the aerial survey.
- Late June to Early July: conduct ground survey to determine productivity of active raptor nests.

In addition to the above listed surveys, surface acres of habitats disturbed will be monitored and documented annually. Surface acres of wildlife habitats reclaimed each year will also be documented.

1.3 Fisheries and Other Aquatic Species (Smith Ranch, Highland, and Reynolds Ranch)

1.3.1 Baseline Study History and Methods

According to the revised 2011 Smith Ranch WDEQ Permit, no specific studies were conducted for fisheries or other aquatic resources due to the lack of suitable habitat in the Smith Ranch, Highland, and Reynolds Ranch permit areas.

1.3.2 Study Results

Aquatic habitats are primarily limited to ephemeral stream courses, stock ponds and playas. Most stock ponds that contain water experience low to no water during much of the year. According to Appendix D9 of the revised 2011 Smith Ranch WDEQ Permit, none of the identified water bodies in the permit area provided stable habitat for fish life. Previous studies conducted on a small pond south of the permit area, along the North Fork of Box Creek, collected the following aquatic invertebrates: true flies, mayflies, true bugs, damselflies, dragonflies, caddis flies, scuds, water mites, aquatic earthworms, leeches, snails, and clams. Periphyton collected at the same site included four genera of grass-green algae, 14 diatoms, three blue-green algae, and one species from the water hyacinth family.

1.4 Threatened and Endangered Species

1.4.1 Baseline Study History and Methods (Smith Ranch, Highland, and Reynolds Ranch)

For vegetation, and according to Appendix D8 of the revised 2011 Smith Ranch WDEQ Permit, the Smithsonian Institution (1975) listed several T&E plant species that may have occurred in Wyoming during the time of the baseline studies. Appendix D8 explains that although some of these T&E species may have occurred in the Smith Ranch permit area during the baseline studies, it was unlikely that they would actually occur in the permit area.

For wildlife, black-footed ferret (currently endangered), peregrine falcon (currently delisted), and bald eagle (currently delisted) had ranges that overlapped the permit areas during the time of the baseline studies. Opportunistic sightings of individuals and habitats were made during baseline studies. In addition, systematic observations of avifauna were made via road transect methods.

1.4.2 Study Update (Smith Ranch, Highland, and Reynolds Ranch)

Blowout penstemon and Ute ladies'-tresses were identified as T&E plant species with potential to occur in the permit areas. Surveys for blowout penstemon were occurred in mid-June to early-July of 2011, which is the flowering period in Wyoming. Prior to initiating surveys, consultation with Wyoming Natural Diversity Database (WYNDD) was initiated to determine if a proposed model of the plant's potential distribution in the permit area is available; ground truthing of the results occurred afterwards. Similar methodology was used to survey for Ute ladies'-tresses except that the surveys occurred in early-

August, when the plant normally blooms in Wyoming. In the event that either plant species was found within the permit area, the USFWS and other appropriate agencies would be notified to determine an appropriate management/mitigation plan.

For wildlife, opportunistic observations of animals classified as "target species" were documented. A target species was identified as such if it was designated as a T&E species or a WGFD species of concern. Target species with potential to occur in the area during the time of the 2011 surveys are listed above under Section *1.2*.

1.4.3 Baseline Study Results (Smith Ranch, Highland, and Reynolds Ranch)

For vegetation, the Smith Ranch WDEQ Permit (Appendix D8 of the revised 2011 Smith Ranch WDEQ Permit) explains that no T&E species, listed as such during the time, were encountered during baseline surveys.

For wildlife, the black-foot ferret (endangered), peregrine falcon (delisted), bald eagle (delisted), and Preble's meadow jumping mouse (threatened) were listed as T&E species with potential to occur in the permit area. Baseline survey results indicate that of these species, only bald eagles were observed. Habitat or sign thereof was not present for the other species.

1.4.4 Results Update (Smith Ranch, Highland, and Reynolds Ranch)

For vegetation, botanists visited 226 sites of potential Ute ladies'-tresses habitat during the bloom period in 2011. None of these sites were found to be suitable for Ute ladies'-tresses. No individual Ute ladies-tresses were observed. For blowout penstemon, seven sites of potential habitat were surveyed. None of these sites contained suitable habitat and no blowout penstemon were observed.

According to the 2011 wildlife survey report, no T&E wildlife species (i.e., black-footed ferret) were observed. Other target species (state species of concern) observed during the 2011 surveys included: greater sage-grouse, bald eagle, golden eagle, ferruginous hawk, and Swainson's hawk.

1.4.5 Ecological Impacts (Past and Future)

Based on available resources (i.e., baseline study results), no T&E plant or wildlife species have been observed in the permit area; therefore, there are no known impacts to T&E species at this time. Some state wildlife species of concern have been observed in the combined permit area, and impacts likely have been and would continue to be similar to those described in Section 1.2.5 above.

1.4.6 Future Studies

See Sections 1.1.6 and 1.2.6 for vegetation and wildlife T&E future studies.

1.5 References

Cameco Resources (Cameco). 2010. Wildlife Monitoring Plan. 7 pages.

Cameco. 2011. Smith Ranch-Highland/Reynolds Ranch In-Situ Uranium Recovery Project. 2011 Wildlife Survey Report. 13 pages.

Cameco. 2012. Nuclear Regulatory Commission Source Material License No. SUA-1548 License Renewal Application Environmental Report. 247 pages.

HWA. 2011a. Smith Ranch Highland/Reynolds In-Situ Recovery Project. Wildlife Surveys – Spring 2011. 7 pages.

HWA. 2011b. Smith Ranch Highland/Reynolds In-Situ Recovery Project. Vegetation Types, Rare Plants, and Noxious Weeds Surveys – 2011. 20 pages.

Power Resources. 2004. Reynolds Ranch Amendment Permit to Mine No. 1548 – Smith Ranch-Highland Uranium Project. Appendix D8 and D9.

Power Resources. 2011. Smith-Highland/Reynolds Amendment Permit No. 633. Appendix D8 and D9.

2 North Butte Ecological Studies Summary

2.1 Vegetation

2.1.1 Baseline Study History and Methods

A baseline vegetation study was conducted at the North Butte ISL Satellite Project (North Butte) in 1979. Information on this study can be found in Attachment D8-1 of Appendix D8 of the North Butte 2006 Wyoming Department of Environmental Quality (DEQ) Permit. Major vegetative cover types were delineated from aerial photographs, and then transferred to a topographic base map. Field surveys were then conducted to verify the mapped cover types and to inventory plant species present in the North Butte permit area.

Prior to the sale of North Butte to Pathfinder in early 1990, Uranerz, used existing data from the 1979 baseline study and other regional studies and generally confirmed the 1979 results, updated threatened and endangered (T&E) species surveys, and verified the plant species list through field visits. Based on an agreement between Wyoming DEQ Land Quality Division (LQD) and Uranerz, specific vegetation production and cover data did not need to be collected as long as Uranerz implemented the Extended Reference Area (EXREFA) concept. Under this concept, Uranerz agreed to purchase a piece of land adjacent to the North Butte permit area with similar vegetation communities. The EXREFA was used as a control site (i.e., a site unaltered from mining activities) to help determine reclamation and vegetation success of disturbed areas.

Although it was determined that site specific production and cover data would not need to be collected for North Butte, Uranerz agreed to and completed the development of an updated baseline vegetation map, description of vegetation communities and plant species in the permit area, and a comparison of vegetation studies previously conducted in the region. Further, Wyoming DEQ LQD and Uranerz agreed that existing vegetation data from the 1979 baseline study and other regional studies were acceptable in lieu of new data provided that they were generally confirmed, that threatened and endangered (T&E) species surveys were updated, and that the plant species list was updated and verified.

2.1.1.1 Study Update

The current owner of North Butte, Cameco Resources (Cameco), submitted an amendment application to the North Butte WDEQ Permit in 2011. Appendix D8 of this application explains that Cameco met with Wyoming DEQ LQD on May 11, 2010 to discuss requirements for updating baselines vegetation surveys.

Cameco agreed to and completed field surveys in June, July, and August of 2010 and 1) prepared a new vegetation map, 2) updated the plant species list, 3) identified any wetlands in the permit area, and 4) identified the potential for any T&E plant species to occur in the permit area.

2.1.2 Study Results

Four primary vegetation communities were identified and mapped in the permit area: sagebrush/grassland (62.2 percent), grassland (34.5 percent), bottomland (2.5 percent), and juniper/sagebrush (0.8 percent). 120 total plant species were documented in the permit area. It was determined through review of existing data that the bottomland vegetation community type had the greatest production and most vegetation cover in the permit area. Five of the observed plant species were identified as noxious weeds: quackgrass (*Elymus repens*), western ragweed (*Ambrosia psilostachya*), burdock (*Asteraceae* sp.), Canada thistle (*Cirsium arvense*), cheatgrass (*Bromus tectorum*), tansy mustard (*Descurainia pinnata*), and American licorice (*Glycyrrhiza lepidota*). Also, one selenium indicator, two-grooved milkvetch (*Astragalus bisulcatus*), was encountered in the permit area.

2.1.2.1 Results Update

All plant species observed in the permit area during the baseline study and the updated 2010 study are listed in Table D6-1.1 in the 2011 North Butte DEQ Permit. The four vegetation communities discussed above (sagebrush/grassland, grassland, bottomland, and juniper/sagebrush) were also identified during the 2010 surveys. In addition, the production and cover data remained unchanged from the 1979 baseline study as described in the 2006 WDEQ Permit.

Twenty-five noxious weeds were observed in the permit area, significantly more than the five observed during the baseline study. Table D6-1.3 in the 2011 North Butte DEQ Permit lists these noxious weeds and their occurrence in the permit area. Also, as noted during the baseline study, two-grooved milkvetch, a selenium indicator, was observed in the permit area.

2.1.3 Ecological Impacts

Small portions of vegetation cover have been disturbed and will continue to be disturbed during ISR development. The anticipated disturbances for the life of the mine are expected to be approximately 3,370 acres (37 percent of total area). To minimize impacts, all disturbed areas will be revegetated within two years of the disturbance (See TR Sections 6.2.6 and 6.2.7 for more information regarding surface disturbance and reclamation).

Noxious weeds were present at North Butte during the baseline and updated vegetation study. It is possible that increased development over the years at North Butte has and may continue to increase the spread of noxious weeds or possibly introduce other non-native species to the site. Surface disturbance and reclamation procedures and mitigation measures are described in TR Sections 6.2.6 and 6.2.7.

2.1.4 Future Studies

Cameco will continue to document vegetation conditions at the North Butte site by periodically:

- Updating vegetation maps,
- Updating the plant species list through opportunistic surveys,
- Identifying any wetlands in the permit area, and
- Identifying the potential for any T&E plant species to occur in the permit area.

2.2 Wildlife

2.2.1 Baseline Study Methods

Detailed information on the wildlife baseline study for North Butte is contained in Appendix D9 of the North Butte 2006 Wyoming DEQ Permit. Applied Ecosystems initiated a baseline study for wildlife in the fall of 1987. In addition, data collected by Bio/West in 1978 to 1979 were used to supplement the baseline study. Applied Ecosystems conducted the following surveys for the baseline study:

- Site Reconnaissance: A vehicle and foot site reconnaissance of the North Butte permit area was completed in the fall of 1987 and spring of 1988 to determine locations of habitat types and opportunistically map important wildlife areas (e.g., raptor nest habitat).
- Survey of Existing Information: Applied Ecosystems compiled existing data on wildlife and their resources using information obtained from the Wyoming Game and Fish Department (WGFD), Bureau of Land Management (BLM), ranchers, and publically available information.
- Big Game Surveys: Vehicle and foot-based surveys were conducted in the winter, spring, and summer of 1988.
- Medium and Small-Sized Mammal and Predator Inventory: A preliminary list of medium and small-sized mammals and predators with potential to occur in the permit area was developed through review of existing literature. In addition, presence of medium and small-sized mammals and predators from direct observations of animals or sign thereof during other surveys was recorded.
- Avifauna Surveys: raptor nest surveys were conducted via vehicle and foot in the spring of 1988. In addition, winter raptor use was evaluated in January of 1988 and opportunistically during big game surveys.

2.2.1.1 Study Update

In 2010, Cameco contracted Hayden-Wing Associates, LLC (HWA) to conduct a wildlife study in and near the North Butte permit area. A list of surveys completed by HWA is provided below. Note that the mountain plover (*Charadrius montanus*), black-tailed prairie dog (*Cynomys ludovicianus*), swift fox (*Vulpes velox*), and greater sage-grouse (*Centrocercus urophasianus*) surveys described below were not conducted during the baseline study.

- Raptor Nest Surveys: aerial and ground-based nest surveys were conducted within a 1-mile buffer of the permit area in the spring of 2010.
- Mountain Plover Surveys: potential habitats for mountain plover were evaluated via ATV and/or foot in and within a 0.25-mile buffer of the permit area on June 3, 2010.
- Black-Tailed Prairie Dog Colony Surveys: these surveys were conducted in June of 2010 to help determine the presence or absence of prairie dogs and associated wildlife such as mountain plover, burrowing owls, swift fox, hawks, and eagles. If colonies were found, the boundaries were delineated using handheld GPS units.
- Swift Fox Surveys: spotlight surveys to determine the presence of swift fox were conducted on June 30 and 31, 2010 in and within a 0.25-mile buffer of the permit area.
- Greater Sage-Grouse Lek Surveys: To minimize disturbance to leks, HWA coordinated with other wildlife consultants conducting surveys in the area for an adjacent coal bed methane project in April of 2010 and used their data for North Butte.

2.2.2 Baseline Study Results

The following are results for the surveys implemented for the baseline wildlife study at North Butte:

- Big Game Surveys: Pronghorn antelope (*Antilocapra americana*) and mule deer (*Odocoileus hemiones*) were the only big game species observed.
  - Pronghorn Antelope: During winter surveys, pronghorn antelope were sighted north and east of the permit area and group sizes ranged from four to 56 individuals. Smaller groups and individuals were observed on the eastern third of the permit area during the spring and summer. The production surveys resulted in counts of 77 fawns to 100 doe and 25 bucks to 100 doe.
  - Mule Deer: Mule deer were observed in the permit area throughout the year, and all sightings were on North Butte and its flanks, unnamed drainages, and Willow Creek. Pre-hunt production counts yielded the following ratios: 63 fawns to 100 doe and 16 buck to 100 doe. The baseline study indicated that WGFD did not reveal the presence of any migration corridors or critical habitat during consultation.
- Medium and Small-Sized Mammal and Predator Inventory: No active prairie dog colonies were observed within 0.5-mile buffer of the permit area.
- Raptor Nest Surveys: No raptor nests were identified in the permit area. Several nest sites were located outside but within a 1-mile buffer of the permit area, but none were active during the 1988 survey. Golden eagles (*Aquila chrysaetos*) were frequently observed flying over or roosting on fence posts and power poles in the permit area, but no nests were found. Bald eagles (seven total individuals) were only observed in the permit area in the winter; no roosts or winter concentrations were found. Other raptors observed included the red-tailed hawk (*Buteo jamaicensis*), northern harrier (*Circus cyaneus*), ferruginous hawk (*Buteo regalis*), Swainson's hawk (*Buteo swainsoni*), rough-legged hawk (*Buteo lagopus*), American kestrel (*Falco sparverius*), and peregrine falcon (*Falco peregrinus*).
- Greater Sage-Grouse Lek Surveys: No leks were found in the permit area. Two previously identified leks were located in the vicinity of the permit area: North Butte lek and Gilbertz III lek. The baseline study noted that while these leks are not located in the permit area, some birds from the lek may forage or nest in the permit area.

2.2.2.1 Results Update

The following are results for the 2010 surveys completed at North Butte:

- The 2010 survey methods do not indicate that big game surveys were conducted.
- Raptor Surveys: Twenty-seven raptor nests were identified in and within a 1-mile buffer of the permit area. These nests included those of five red-tailed hawk, three long-eared owl, three great horned owl, one golden eagle, and 15 unknown species. No bald eagle nests were located.
- Mountain Plover Surveys: No habitats suitable for mountain plovers were located in or within a 0.25-mile buffer of the permit area. No individual plovers were observed.
- Black-Tailed Prairie Dog Surveys: no prairie dog colonies were found in the permit area.
- Swift Fox Surveys: No swift foxes or sign thereof were observed. In addition, as mentioned above, no prairie dog colonies were observed with which swift foxes are closely associated.
- Greater Sage-Grouse Lek Surveys: Prior to surveys, WGFD data indicated that four known leks were located within two miles of the permit area. All four known lek locations were surveyed in

April. Grouse were only observed at one lek, Dry Willow, which had a peak count of three males. This lek was new from the baseline study. No new or previously undocumented leks were discovered within two miles of the permit area.

2.2.3 Ecological Impacts

Compared to baseline conditions, wildlife habitats in the permit area have been and will continue to be minimally and temporarily diminished from construction activities. Any habitat lost during construction will be reclaimed. Furthermore, Cameco employs wildlife friendly fencing wherever fencing is required (see ER Section 5.5.2 for more information regarding wildlife and fencing).

Increased human activities and noise may influence animals to relocate outside the permit area. However, these impacts are generally limited to the construction phase, and will likely subside after ISR construction is complete. The likelihood of impacts resulting from injury or mortality for wildlife is greatest during the construction phase due to increased levels of traffic. Traffic will persist during production, but should occur at a reduced and possibly more predictable level. Speed limits have been and will continue to be reduced and enforced during all mining activities, particularly during the breeding season.

Results of wildlife surveys conducted within the last 10 years have shown little to no changes in wildlife population or of individual species within or near any operations area. Impacts to wildlife have been insignificant because no unique or critical habitats are present in the permit area, there are no important wildlife migration routes, mining activities disturb relatively minor amounts of land surface, areas disturbed by well field activities are quickly revegetated after construction, restricted fencing is limited to isolated areas which do not significantly impeded wildlife movements, and vehicular traffic is limited and reduced speed limits are utilized to decrease the potential for vehicle-wildlife collisions. In the event that it becomes necessary to disturb T&E species or other important wildlife, Cameco will consult with Wyoming DEQ LQD, BLM, USFWS, and WGFD to develop an appropriate mitigation action plan.

2.2.4 Future Studies (Including T&E Species)

According to the Wildlife Monitoring Plan for North Butte, the following surveys will continue to be implemented at North Butte on an annual basis:

- Raptor Nest Surveys: late April to early May, aerial survey in and within 1-mile buffer of permit area. Late May to early June, ground survey to identify status of raptor nests. Late June to early July, ground survey to determine productivity of active nests.
- Mountain Plover Surveys: early May to Mid-June, presence/absence of breeding plovers in and within 0.25-mile buffer of permit area.
- Avian Point-Count Surveys: April to June, conduct point-count surveys in each habitat type in permit area for three consecutive mornings.
- Swift Fox Surveys: April to August, spotlight surveys in and within 0.25-mile buffer of permit area.
- Black-Tailed Prairie Dog Surveys: April to August, search for and map prairie dog colonies.
- Greater Sage-Grouse Lek Surveys: late March to early May, one aerial survey in and within a 2-mile buffer of the permit area, three ground counts (spaced 7-10 days apart) will follow.

In addition to the above listed surveys, surface acres of habitats disturbed will be monitored and documented annually. Surface acres of wildlife habitats reclaimed each year will also be documented.

2.3 Fisheries and Other Aquatic Species

2.3.1 Baseline and existing conditions

According to the 2006 and 2011 Wyoming DEQ Permits for North Butte, no studies were conducted for fisheries or other aquatic resources due to the lack of suitable habitat in the permit area.

2.4 Threatened and Endangered Species

2.4.1 Baseline Study Methods

For vegetation, Uranerz updated T&E species surveys from the 1979 baseline study as described above. For wildlife, T&E species listed for the permit area at the time of the baseline study were bald eagle (*Haliaeetus leucocephalus* [now delisted]), peregrine falcon (*Falco peregrinus* [now delisted]), and black-footed ferret (*Mustela nigripes* [endangered]). These species were accounted for during raptor nest, winter raptor use, and black-tailed prairie dog surveys, the methods for which are described above.

2.4.1.1 Study Update

For vegetation, Cameco identified the potential for any T&E plant species to occur in the permit area in 2010 through a habitat assessment and desktop/field-based plant species inventory. Ute ladies'-tresses (*Spiranthes diluvialis*) and blowout penstemon (*Penstemon haydenii*) were identified as having potential to occur in the permit area during the time of the study.

For wildlife, particular attention was given to document the status of T&E species and WGFD Species of Special Concern (SOC). At the time of the 2010 study, T&E species and SOC with potential to occur in the permit area included black-footed ferret (endangered), swift fox (SOC), greater sage-grouse (currently proposed threatened, SOC), mountain plover (SOC), eagles (SOC), other raptors, some migratory birds, and mice and voles. The 2010 wildlife surveys described in North Butte wildlife Section 2.2.2 (above) allowed biologists to evaluate the presence/absence of these species and their habitats in the permit area.

2.4.2 Study Results

No threatened or endangered plants were observed during the vegetation baseline study. For wildlife, bald eagles (now delisted, but protected under the Bald and Golden Eagle Protection Act) were observed in the near the permit area at Pumpkin Buttes during winter months of the study period. These buttes provide roosting habitat for bald eagles. According to the baseline study report, live streams or large bodies of water that bald eagles would forage in are lacking in the permit area. No nesting areas for bald eagles were known in the permit area during the time of the study. The study results indicated that there is suitable nesting habitat for peregrine falcons (now delisted, but protected under the Migratory Bird Treaty Act) on North Butte in the permit area; however, the results noted that peregrine falcons are rare migrants and winter visitants in the area, and there were no known nest sites at the time of the baseline study. Black-footed ferrets were not observed and are not expected to occur in the permit area due to lack prairie dog colonies.

2.4.2.1 Results Update

For vegetation, T&E species with potential to occur in the permit area at the time of the 2010 study were Ute ladies'-tresses (currently listed as threatened) and blowout penstemon (currently listed as endangered). 2010 study results indicate that suitable habitat for either species was lacking in the permit area, and no individual plants were observed during the study. For wildlife, no T&E species were observed during the time of the 2010 study. Fifty WGFD SOC had potential to occur in the North Butte permit area. Three of these SOC were observed: Brewer's sparrow, lark bunting, and golden eagle. Only one golden eagle was observed; however, Brewer's sparrows and lark buntings were frequently encountered in the permit area.

2.4.3 Ecological Impacts (Past and Future)

For vegetation, according to the most recent surveys completed, no T&E plant species have been observed in the permit area; therefore, there are no known impacts to T&E species.

There have been no known impacts to T&E wildlife species in the permit area. Future impacts are expected to be insignificant as no currently listed T&E species or sign thereof have been documented in the permit area (based on the baseline and updated studies). Some SOC that have been observed in or near the permit area include the greater sage-grouse (also currently proposed for federal listing as a threatened species), mountain plover, bald eagle, golden eagle, several other raptors, and swift fox. Cameco will continue to implement an annual wildlife monitoring plan (see below) to evaluate wildlife in and near the permit area.

2.4.4 Future studies

See Sections 2.1.4 and 2.2.4 for vegetation and wildlife T&E future studies.

2.5 REFERENCES

Power Resources, Inc. (Power Resources). 2005a. North Butte ISR WDEQ Permit No. 632. Appendix D8. 25 pages.

Power Resources, Inc. (Power Resources). 2005b. North Butte ISR WDEQ Permit No. 632. Appendix D9. 6 pages.

Power Resources, Inc. (Power Resources). 2006. North Butte ISL Satellite Project. Volume I. Supportive Information for Wyoming DEQ Permit to Mine and USNRC Source Material License Amendment. 711 pages.

Power Resources, Inc. (Power Resources). 2011a. North Butte ISR WDEQ Permit No. 632 Update. Appendix D8. 154 pages.

Power Resources, Inc. (Power Resources). 2011b. North Butte ISR WDEQ Permit No. 632 Update. Appendix D9. 100 pages.

Uranerz U.S.A., Inc. (Uranerz). 1989. Ruth ISL Project and North Butte ISL Project. Volume IV (Vegetation Supplement). Supportive Information for Wyoming DEQ Permit to Mine Application and U.S.N.R.C. Source Material License Application. Uranerz, Casper, Wyoming. 107 pages.

Uranerz U.S.A., Inc. (Uranerz). 1990. Environmental Assessment in Consideration of Application for Ruth and North Butte Commercial In-Situ Leach Operations. Uranerz, Casper, Wyoming. 70 pages.

3 Gas Hills Ecological Studies Summary

3.1 Vegetation

3.1.1 Baseline Study History and Methods

Power Resources, Inc. (Power Resources, now owned by Cameco Resources [Cameco]) contracted Intermountain Resources to complete a baseline vegetation study at the Gas Hills Satellite ISL Project (Gas Hills) from 1992 to 1994. Study components included mapping vegetation types, file and field searches for threatened and endangered (T&E) plant species, field sampling to determine cover and shrub densities, and preparation of a plant species list.

In 1996, Power Resources contracted BKS Environmental Associates, Inc. (BKS) to conduct a site visit to locate suitable reference areas for a vegetation study at Gas Hills in 1997. A summary of methods for the 1997 study follows:

- Vegetation Type Determination and Mapping: BKS reviewed previously designated vegetation types in the permit area, mapped them, and verified their locations and boundaries in the field.
- Species Identification: BKS compiled a plant species list for the permit area. BKS also documented T&E species and other special status species (Wyoming Species of Concern and Bureau of Land Management [BLM] Sensitive Species), noxious weeds, and selenium indicator plants. Rocky Mountain Herbarium personnel in Laramie, Wyoming verified plant species identification, when needed.
- Quantitative Sampling: BKS gathered vegetation cover data along 50-meter line transects and shrub density data along 50-meter belt transects in each of the mapped habitat types in the permit area.

These data were included in the revised 1998 Wyoming Department of Environmental Quality (WDEQ) - Land Quality Division (LQD) Permit to Mine Application, Appendix D-8 (Vegetation).

3.1.1.1 Study Update

BKS completed supplemental vegetation studies in two comparison areas (COMAs) for Cameco in 2007. BKS classified and mapped vegetation communities prior to entering the field using various publically available resources; BKS preliminarily mapped five vegetation communities in the COMAs and then sampled them in the field: big sage shrubland, mixed shrub grassland, rough breaks east (east half of the permit area), rough breaks west (west half of the permit area), and disturbed land. Plant species were identified along 50-meter line transects in each of the five aforementioned vegetation communities. Point-intercept methods along transects were also used to estimate ground cover, and shrub density was collected in conjunction with the line-transect surveys.

As part of the permit updating process in 2011, Cameco contracted Hayden-Wing Associates, Inc. (HWA) to conduct studies for special status plant species in 2010 and 2011 throughout the permit area and a road upgrade right-of-way (ROW), respectively. Target special status species included three T&E species: blowout penstemon (*Penstemon haydenii*), desert yellowheard (*Yermo xanthocephalus*), and Ute ladies'-tresses (*Spiranthes diluvialis*). Target BLM Sensitive Species included: Nelson's milkvetch (*Astragalus nelsonianus*), persistent-sepal yellowcress (*Rorippa calycina*), Rocky Mountain twinpod (*Physaria saximontana* var. *saximontana*), Cedar Rim thistle (*Cirsium aridum*), and Beaver Rim plox (*Phlox pungens*).

HWA conducted surveys to locate potentially suitable habitat for the aforementioned T&E species. Presence/absence surveys followed pending identification of suitable habitat. Note that prior to entering the field, HWA visited the Rocky Mountain Herbarium in Laramie to inspect and become familiar with plant specimens for which they were surveying. For the target BLM Sensitive Species, HWA obtained distribution models for each species from the Wyoming Natural Diversity Database (WYNDD). HWA then randomly distributed 60 survey sites throughout the permit area and meandering pedestrian surveys were conducted within 200 meters of each survey site to determine the presence/absence of the Sensitive Species.

3.1.2 Study Results

Four native vegetation types were identified in the permit area during the 1997 baseline study:

- Bottomland Sagebrush (Big Sagebrush): Major species included big sagebrush (*Artemesia tridentata*), Cusick bluegrass (*Poa cusickii*), and thickspike wheatgrass (*Agropyron dasytachum*). Some willows (*Salix* spp.) and cottonwoods (*Populus deltoides*) were also found along the upper portion of West Canyon Creek. Absolute total vegetation cover was 63.4 percent. Total shrub density was 12,017/acre.
- Mixed Sagebrush Grassland (Mixed Shrub Grassland): vegetation and topography were diverse, ranging from dense patches of sagebrush to small patches of transitional grasslands. Major species included big sagebrush, thickspike wheatgrass, and threadleaf sedge (*Carex filifolia*). Absolute total vegetation cover was 55.3 percent. Total shrub density was 15,277/acre.
- Rough Breaks: this habitat type was found on slopes, ridges, hilltops, and side slopes of steep draws. Rock outcrops and steep, bare slopes were also present. Major species included big sagebrush, threadleaf sedge, thickspike wheatgrass, and bluebunch wheatgrass (*Agropyron spicatum*). A few limber pines (*Pinus flexilis*) were also present. Absolute total vegetation cover ranged from 38 to 49 percent. Total shrub density ranged from 7,750 to 14,423/acre.
- Upland Grass: this vegetation type occurred in Mixed Sagebrush Grassland with saline soil conditions. Major species included threadleaf sedge, birdfoot sagebrush (*Artemisia pedatifida*), and thickspike wheatgrass. Absolute total vegetation cover was 51 percent. Total shrub density was 18,473/acre.

Other less dominant habitat types in the permit area included reclaimed areas, disturbed land, reservoirs (stock ponds and mine impoundments), and wetlands. Table 28 of Appendix D8 of the 1998 WDEQ-LQD Permit lists all plant species encountered.

No primary noxious weeds (as listed by the Agricultural Experiment Station, University of Wyoming) were encountered. Observed prohibited noxious weeds included musk thistle (*Carduus nutans*), Canada thistle (*Cirsium arvense*), hoary cress (*Cardaria draba*), and field bindweed (*Convolvulus arvensis*). Restricted noxious weeds included tansymustard (*Descurainia pinnata*), little blue mustard (*Chorispora tenella*), and American licorice (*Glycyrrhiza lepidota*); these weeds species were common along drainages, roadsides, and disturbed areas. The only premium selenium indicator species observed in the permit area was multistem goldenweed (*Haplopappus multicaulis*). Past documentation also suggests two-grooved milkvetch (*Astragalus bisulcatus*) and woody aster (*Aster xylorrhiza*) have occurred in the permit area.

3.1.2.1 Results Update

The following is a summary of results from 2007 vegetation sampling in two COMAs near the permit area (COMA 1 and COMA 2):

- COMA 1: Absolute total vegetation cover was 46.3 percent and total ground cover was 79.3 percent. COMA 1 was most dominated by cool season perennial grasses, followed by full shrubs, perennial forbs, perennial sub-shrubs, annual grasses, and succulents. Mean shrub density was 9,689/acre; the main contributor was black sagebrush (*Artemisia nova*). A breakdown of vegetation cover, species composition, and shrub density for each plant community is provided in Appendix D8 of the 2008 WDEQ - LQD Permit to Mine Application.
- COMA 2: Absolute total vegetation cover was 28.6 percent and ground cover was 72.7 percent. Sandberg bluegrass (*Poa secunda*) provided the highest relative vegetation cover. Species composition was dominated by cool season perennial grasses followed by full shrubs, perennial forbs, perennial sub-shrubs, annual forbs, annual grasses, and introduced perennial grasses. The mean shrub density was 7,040.3/acre and the main contributor was birdfoot sagebrush. A breakdown of vegetation cover, species composition, and shrub density for each plant community is provided in Appendix D8 of the 2008 WDEQ - LQD Permit to Mine Application.

The following is a summary of results from the 2010 and 2011 HWA special status plant species surveys.

- T&E Species (Blowout Penstemon, Desert Yellowhead, and Ute Ladies'-Tresses): no suitable habitat for blowout penstemon, desert yellowhead, or Ute ladies'-tresses was found within the permit area or road upgrade ROW. Therefore, no T&E species were observed.
- BLM-Sensitive Plant Species: no BLM sensitive plant species were observed within 200 meters of any sampling point in the permit area.

3.1.3 Ecological Impacts

Sagebrush and grasslands make up most of the vegetation cover in the permit area. ISR operations have and will temporarily reduce vegetation within the permit area. Both short- and long-term disturbances have and will be revegetated within two years of the disturbance (See TR Sections 6.2.6 and 6.2.7 for more information regarding surface disturbance and reclamation).

Noxious weeds were present in the permit areas during the baseline and updated vegetation study. It is possible that increased development over the years has and may continue to increase the spread of noxious weeds or possibly introduce other non-native species to the site. Surface disturbance and reclamation procedures and mitigation measures are described in TR Sections 6.2.6 and 6.2.7.

3.1.4 Future Studies (Including T&E Species)

Cameco will continue to revise vegetation conditions at the Gas Hills site by periodically:

- Updating vegetation maps,
- Updating the plant species list through opportunistic surveys,
- Identifying any wetlands in the permit area, and
- Identifying the potential for any T&E plant species to occur in the permit area.

3.2 Wildlife

3.2.1 Baseline Study History and Methods

Power Resources contracted Intermountain Resources to conduct a baseline wildlife study at Gas Hills in 1996 and 1997 for the revised 1998 WDEQ - LQD Permit to Mine Application, Appendix D-9 (Wildlife). Intermountain Resources also previously completed a study from 1992 to 1994. Methods for the 1996 to 1997 study are summarized below:

- File Searches: File searches were the initial sources for data collection. Intermountain Resources obtained available data on raptor nest locations, greater sage-grouse (*Centrocercus urophasianus*) lek locations, prairie dog colony locations, big game ranges, and T&E species occurrences from the Lander offices of the BLM and Wyoming Game and Fish Department (WGFD). Intermountain Resources also reviewed WGFD and U.S. Fish and Wildlife Service (USFWS) publications and online sources as well as an Abandoned Mine Land (AML) study report completed in 1990 that covered the permit area; this study report was used as an initial survey reference for the permit area for T&E species, migratory birds, and raptor nests.
- Field Surveys: Intermountain Resources conducted surveys throughout the permit area to identify T&E species or habitat thereof, migratory birds, raptor nests, big game species and ranges, greater sage-grouse leks, and general wildlife species and their habitats.

3.2.1.1 Study Update

Cameco contracted Shell Valley Consulting Associates, Inc. (SVC) to conduct an updated wildlife study from 2006 to 2008 for the revised 2009 WDEQ - LQD Permit to Mine Application, Appendix D-9 (Wildlife). SVC conducted surveys to evaluate the presence/absence of and habitat use by a pre-established list of target species: greater sage-grouse, raptors, mountain plover (*Charadrius montanus*), black- and white-tailed prairie dogs (*Cynomys ludovicianus, C. leucurus*), black-footed ferret (*Mustela nigripes*), songbirds, short-eared and burrowing owl (*Asio flammeus, Athene cunicularia*), swift fox (*Vulpes velox*), northern leopard frog (*Lithobates pipiens*), and long-billed curlew (*Numenius americanus*). A target species indicated one with a federal or state protection status. Of the previous listed target species, only the black-footed ferret has a USFWS status (endangered). The other species are BLM Sensitive Species (some of which are also Wyoming Species of Concern).

In 2009, Cameco contracted HWA to conduct a study for many of aforementioned target species (greater sage-grouse, raptors, mountain plover, white-tailed prairie dog, and big game). Biologists also added pygmy rabbit (*Brachylagus idahoensis*, a BLM Sensitive Species) to their list of target species. A summary of the 2009 study components is provided below:

- Greater Sage-Grouse: HWA conducted aerial and follow-up ground-based surveys to identify new nests and verify the locations and statuses of historic leks. HWA also identified suitable nesting habitat in and near the permit area.
- Raptors: HWA conducted aerial and follow-up ground surveys to locate raptor nests and determine their statuses (i.e., active or inactive) and their productivity.
- Mountain Plover: HWA mapped potential mountain plover breeding habitats within a 0.25 mile buffer of the permit area. Presence/absence surveys followed.
- White-Tailed Prairie Dog: HWA identified and delineated colonies in the permit area, if present.
- Pygmy Rabbit: HWA identified and mapped potential pygmy rabbit habitat within a 0.25 mile buffer of the permit area. Presence/absence surveys followed to identify rabbits, burrows, or sign thereof.
- Big Game: HWA made incidental observations of big game during other wildlife surveys.

HWA also completed updated studies in 2010 and 2011. HWA implemented similar methods as those listed above for the 2009 study and also addressed a few new target species (all BLM Sensitive Species; no T&E species).

- Burrowing Owls: HWA conducted early morning surveys in known prairie dog colonies to evaluate the presence/absence of burrowing owls and/or burrows.
- Amphibians: HWA conducted surveys to evaluate presence/absence of three BLM Sensitive Species: northern leopard frog (*Rana pipiens*), Great Basin spadefoot toad (*Spea intermontana*), and boreal toad (*Bufo boreas*). Biologists surveyed suitable breeding habitats (e.g., ponds, reservoirs, puddles, etc.). Dip nets were pulled through larger bodies of water to sample deeper areas not accessible from the bank.
- Bats: biologists stood near potential bat use areas (cliffs, standing water, and abandoned buildings) in the early evening and watched for bats until dark. Target species included long-eared myotis (*Myotis lucifugus*), spotted bat (*Euderma maculatum*), and Townsend's big-eared myotis (*Corynorhinus townsendii*).
- Dwarf Shrew: because great horned owls were known to nest and roost within the permit area, HWA collected 50 owl pellets at two known nest sites and dissected them for presence/absence of dwarf shrew bones._Because shrew mandables are diagnostic for the identification of species, these bones were the focus of the dissections.
- Sage Trasher, Loggerhead Shrike, Brewer's Sparrow, and Baird's Sparrow: no formal surveys were completed for these birds, but opportunistic observations were made.
- Waterfowl: no formal surveys were completed, but opportunistic observations were made.
- White-Faced Ibis and Long-Billed Curlew: no formal surveys were completed for these birds, but opportunistic observations were made.

In 2011, HWA used methods described for the 2009 and 2010 surveys to conduct greater sage-grouse, raptor, mountain plover, white-tailed prairie dog, and burrowing owl surveys. The target species list was reduced from 2010 study list as per suggestions from the BLM-Lander Field Office.

3.2.2 Baseline Study Results

The following are results for the surveys implemented for the 1992 to 1994 and 1996 to 1997 baseline wildlife studies at Gas Hills:

- Big Game: Pronghorn antelope (*Antilocapra americana*) and mule deer (*Odocoileus hemiones*) were commonly observed in the permit area. Pronghorn antelope generally frequented habitats dominated by big sagebrush while mule deer frequented rough breaks and some sagebrush habitat. Most of the proposed permit area was classified as spring-summer-fall range for pronghorn antelope; the remainder of the permit area was classified as year-long range. Most of the permit area consisted of year-long mule deer range, while portions on the north and west boundaries were identified as winter-yearlong and spring-summer-fall mule deer range.
- Other Mammals: A total of 14 other mammal species were recorded in the permit area. The most common species observed were the Wyoming ground squirrel (*Urocitellus elegans*) and least chipmunk (*Tamias minimus*). The coyote (*Canis latrans*) was the most abundant predator and rabbit populations were low. HWA did not identify any prairie dog colonies in or near the permit area.
- Upland Game Birds: Mourning doves (*Zenaida macroura*) and greater sage-grouse were the only upland game birds observed. A greater sage-grouse lek was located north of the Permit Area (see details on its location in Appendix D9 of 2009 WDEQ - LQD Permit to Mine Application). Three males were recorded on the lek on April 13, 1996. No other leks were found.
- Waterfowl and Shorebirds: Habitat for waterfowl and shorebirds was not abundant in the permit area. The best habitat for waterfowl and shorebird species was at Cameron Springs Reservoir. Due to the small size of the reservoir, the number of breeding pairs of waterfowl or shorebirds was expected to be limited. HWA did not expect that waterfowl and shorebirds would use the permit area during late fall or winter.
- Raptors: File searches identified five previously documented raptor nests within the permit area. In addition, 59 new raptor nest sites were identified. Nests included eight red-tailed hawk (*Buteo jamaicensis*) nests representing six pairs of birds, 45 ferruginous hawk (*Buteo regalis*) nests representing 16 territories, three golden eagle (*Aquila chrysaetos*) nests of two pairs, and three prairie falcon (*Falco mexicanus*) nests. Production was recorded for red-tailed hawks and ferruginous hawks. Other raptor species incidentally observed included: Swainson's hawk (*Buteo swainsoni*), rough-legged hawk (*Buteo lagopus*), bald eagle (*Haliaeetus leucocephalus*), northern harrier (*Circus cyaneus*), American kestrel (*Falco sparverius*), and turkey vulture (*Cathartes aura*).
- Passerines: A total of 33 other bird species were recorded during surveys. The most common species were homed lark (*Eremophila alpestris*), vesper sparrow (*Pooecetes gramineus*), and western meadowlark (*Sturna neglecta*). Most passerine species were recorded various sagebrush shrublands which dominated the permit area. However, the best diversity of bird species was observed in scattered pine - rough breaks shrublands due to the high diversity of plant species and topography.

3.2.2.1 Results Update

The following is a summary of results from the 2006 to 2008 SVC Study:

- Greater Sage-Grouse: No active leks were identified in or near the permit area. However, a large group of males and sign were observed on Beaver Rim on May 31, 2008, which may have indicated a lek was in the area.

- Raptors: raptor species observed included the great horned owl (*Bubo virginianus*), golden eagle, red-tailed hawk, ferruginous hawk, rough-legged hawk, prairie falcon, merlin (*Falco columbarius*), and American kestrel. A large nest on Butt Pit high wall was occupied by golden eagles in 2007 and 2008. No eggs, young, or sign thereof were seen in the nest. Other raptor nests included those of great horned owls, ferruginous hawks, red-tailed hawks, and American kestrels.
- Mountain Plover: no mountain plovers were observed.
- Black- and White-Tailed Prairie Dogs: no prairie dog colonies were observed.
- Black-Footed Ferret: No black-footed ferrets were observed.
- Songbirds (Including Brewer's Sparrow, Sage Sparrow, Lewis Woodpecker, Loggerhead Shrike, and Juniper Titmouse): Sagebrush steppe habitat was abundant in the permit area, and Brewer's sparrows (*Spizella breweri*), sage sparrows (*Artemisiospiza nevadensis*), and loggerhead shrikes (*Lanius* ludovicianus) were seen in this habitat and presumable nested in the area.
- Short-Eared Owl and Burrowing Owl: short-eared owls were not observed; however due to their nocturnal nature, observations of this species would have been difficult. No burrowing owls were observed presumably because of the lack of prairie dog colonies in the permit area.
- Swift Fox: no swift foxes or dens were observed.
- Northern Leopard Frog: no northern leopard frogs were identified.
- Long-Billed Curlew: no long-billed curlews were observed; habitat was limited in the permit area.

The following is a summary of results from the 2009 HWA wildlife surveys:

- Greater Sage-Grouse: two previously identified leks (according to WGFD records) were located within two miles of the permit area (Puddle Springs Lek and West Canyon Lek) and confirmed to be active during the 2009 surveys. Seven total greater sage-grouse habitat patches were identified and mapped within core area habitat in the permit area (see Appendix D9 of 2009 WDEQ - LQD Permit to Mine Application for maps).
- Raptors: many incidental raptor observations were made. No new raptor species were recorded. Thirty-three raptor nests were documented in and within a one mile buffer of the permit area including: one American kestrel, 13 ferruginous hawk, one great horned owl, two golden eagle, two red-tailed hawk, one prairie falcon, and 13 nests of unknown raptor species. Seven of the 33 nests were active.
- Mountain Plover: forty-two potential mountain plover breeding patches were identified in and near the permit area. Mountain plovers were observed on 18 occasions; they were observed on eight of the 42 habitat patches. Two mountain plover nests were also identified. Both nests contained three eggs, and indirect evidence suggested that the nests were successful. The locations of habitat patches and nests are described in Appendix D9 of the 2009 WDEQ - LQD Permit to Mine Application. Note that no mountain plovers were observed during past surveys.
- White-Tailed Prairie Dog: eight total white-tailed prairie dog colonies were located in 2009, six of which were active. The colonies were relatively small, ranging in size from 0.2 acre to 6 acres and totaling approximately 18.6 acres. Each colony was occupied by only a few prairie dogs. Additional information on the locations of the colonies is provided in Appendix D9 of the 2009 WDEQ - LQD Permit to Mine Application. Note that prairie dog colonies were not observed during past surveys.

- Pygmy Rabbits: twenty-two pygmy rabbit habitat patches were mapped; however, no pygmy rabbits or sign thereof were observed.
- Big Game: incidental observations of mule deer, pronghorn, and elk (*Cervus elaphus*) were made in and near the permit area. Mule deer observations were sparse and they were typically made near the Beaver Rim around badlands and rough breaks. Pronghorn antelope were very abundant throughout the entire permit area. Elk were sighted approximately four miles west of the permit area.

The following is a summary of results from the 2010 HWA wildlife surveys:

- Greater Sage-Grouse: Puddle Springs Lek (#1) and West Creek Lek (#2) were again active in 2010. In addition, one large group of roosting males was observed on top of Beaver Rim during aerial surveys, but no birds were observed during follow-up ground checks. No new leks were identified, but seven potential nesting habitat patches were identified and mapped within core area habitat in the permit area. Individual birds, broods, and roosting males were observed throughout sage steppe habitat, although some brood observations were also made in mesic habitat near the reservoir.
- Raptors: no new raptor species were identified in 2010. Thirty-nine total nest sites were documented including those of two American kestrels, 14 ferruginous hawks, two great horned owls, two golden eagles, one red-tailed hawk, one prairie falcon, and 17 unknown species. Six of the 39 nests were new from the 2009 surveys. Only four nests were active compared to seven in 2009.
- Bald Eagles: No bald eagles were observed.
- Mountain Plover: similar to the 2009 surveys, mountain plovers were observed on 18 occasions and were observed on nine of the 42 previously mapped habitat patches. However, no nests were found in 2010.
- White-Tailed Prairie Dog: the eight colonies identified in 2009 were confirmed in 2010. One additional colony was located on the northeastern edge of the permit area in 2010 for a total of nine colonies; however, only four were active.
- Pygmy Rabbits: no pygmy rabbits were observed.
- Burrowing Owls: no burrowing owls or burrows were observed.
- Amphibians: none of the target species were observed (northern leopard frog, Great Basin spadefoot, and boreal toad); however, tiger salamanders (*Ambystoma tigrinum*) and boreal chorus frogs (*Pseudacris maculata*) were observed on several occasions.
- Bats: no bats were observed.
- Big Game: similar observations of pronghorn antelope and mule deer were made as those in 2009. In addition, an elk herd of 25 individuals was documented in the northeastern edge of the permit area in limber pine (*Pinus flexilis*) habitat. This was the first time that elk were documented in the permit area (in a survey report).
- Dwarf Shrew: Although owl pellets contained small shrew bones, no mandibles were found, making identification to species impossible. Therefore, no evidence was found to confirm dwarf shrews occur within the permit area.
- Sage Thrasher, Loggerhead Shrike, Brewer's Sparrow, Sage Sparrow, and Baird's Sparrow: only Brewer's sparrows and loggerhead shrikes were observed in the permit area. Brewer's sparrows

were observed commonly in sage steppe habitat, and two loggerhead shrike observations were made in this habitat.

- Waterfowl: Several species of waterfowl were observed during wildlife surveys in 2010, including gadwalls (*Anas strepera*), green-winged teals (*Anas crecca*), mallards (*Anas platyrhynchos*), northern pintails (Anas acuta), and Canada geese (Branta canadensis). All observations of these waterfowl were in the southwestern portion of the Permit Area in or near a reservoir with the exception of one occurrence. No waterfowl were observed swimming or standing in the Buss Pits.
- White-Faced Ibis and Long-Billed Curlew: no white-faced ibis or long-billed curlews were observed.

2011 HWA wildlife study results were similar to past studies except that three new raptor nests were identified (for a total of 40 nests), no mountain plovers or nests were identified within the road upgrade ROW, and only one active prairie dog colony was identified in the road upgrade ROW (only five of the nine previously documented colonies fell within the boundary of the ROW).

3.2.3 Ecological Impacts

Wildlife may potentially be directly affected by mining activities from collisions with vehicular traffic. Controlled speed limits will continue to be implemented to reduce potential impacts to wildlife throughout the year, but particularly during the breeding season (see ER Section 5.5.2 for more impacts and mitigation of impacts to wildlife). Indirect impacts of temporary habitat loss, displacement, and harassment have likely been more significant. Wildlife displaced from otherwise suitable habitats in the permit area may 1) find equally suitable habitat elsewhere that is not occupied by other animals, 2) occupy suitable habitat elsewhere that is already being used by other animals, or 3) occupy poorer quality habitat. Noise, dust, and increased human presence have likely caused some localized avoidance of otherwise suitable wildlife habitat in the mine area. However, some wildlife may become conditioned to mining disturbances and return to use suitable habitats in the area.

Impacted wildlife habitats will continue to be mitigated following mining by establishing vegetation in accordance with the approved reclamation plan (see ER Section 5.5.2. for more impacts and mitigation of impacts to wildlife). Raptor nest sites will not be removed; however, temporary mitigation may be needed for nest sites where operations are near enough to preclude successful reproduction. Mitigation will be carried out as approved by the USFWS and WGFD under the appropriate permits obtained from those agencies. Fences will be maintained and constructed to meet WGFD standards. Employees will continue to be educated about wildlife protection, sensitive species, and game laws through use of applicable publications and during safety meetings.

3.2.4 Future Studies (Including T&E Species)

Annual wildlife surveys similar to those conducted by HWA in 2010 will continue to be conducted for the life of the project. T&E and other special status species lists will continue to be updated and surveyed. In addition, surface acres of habitats disturbed will be monitored and documented annually. Surface acres of wildlife habitats reclaimed each year will also be documented.

3.3 Fisheries and Other Aquatic Species

3.3.1 Baseline Study History and Methods

No specific surveys were conducted for fisheries. Surveys for amphibians are described above in Section 3.2.1.

3.3.2 Baseline Study Results

According to Appendix D9 of the 1998 and 2008 permit applications, specific surveys for fish and other aquatic species were not conducted. Information on amphibians is provided in Section 3.2.2.

3.4 Threatened and Endangered Species

3.4.1 Baseline Study History and Methods

Baseline and updated studies as described above in Sections 1.1 and 1.2. These studies allowed for observation of special status plant and wildlife species, including T&E species, BLM Sensitive Species, and Wyoming Species of Concern. See Sections 1.1 and 1.2 for more details on special status species survey methods.

3.4.2 Baseline Study Results

No T&E species were observed. Results from surveys for BLM Sensitive Species and Wyoming Species of Concern are discussed under Section 3.1.2 and 3.2.2.

3.4.3 Ecological Impacts

As T&E species have not been documented in the permit area, there have been no known impacts. Cameco will continue to conduct surveys for T&E species. If identified, impacts would be similar to those described for vegetation and wildlife above; however, would be more significant due to their reduced population sizes and sensitivity to impacts.

3.4.4 Future Studies

See Sections 3.1.4 and 3.2.4 for vegetation and wildlife T&E future studies.

3.5 References

Hayden-Wing Associates, Inc. (HWA). 2010. Cameco Resources Gas Hills Uranium In-Situ Project Wildlife and Plant Surveys – 2010. 27 pages.

Hayden-Wing Associates, Inc. (HWA). 2011. Cameco Resources Gas Hills Uranium In-Situ Project Wildlife and Plant Surveys – 2011. 27 pages.

Shell Valley Consulting (SVC). 2008. Cameco Resources Gas Hills In-Situ Recovery Project Wildlife Investigations, 2008 Summary Report. 33 pages.

Power Resources, Inc. (Power Resources). 2009. Gas Hills ISR WDEQ Permit No. 687 Update. Appendix D7, D8, D9, D10, and D11. 363 pages.

Power Resources, Inc. (Power Resources). 1998a. WDEQ - LQD Permit to Mine Application. Appendix D8. 97 pages.

Power Resources, Inc. (Power Resources). 1998b. WDEQ - LQD Permit to Mine Application. Appendix D9. 357 pages.

Appendix B

Smith Ranch Meteorological Analysis
(Revised November 2014)

Smith Ranch Uranium Project
Meteorology Analysis

Cameco Resources
Casper, Wyoming

May 2012

Prepared by:

INTER-MOUNTAIN LABS

IML Air Science
a division of Inter-Mountain Laboratories, Inc.
555 Absaraka
Sheridan, WY 82801
(307) 674-7506

Table of Contents

Figures

Tables

Appendices

Introduction

The Smith Ranch Project in east-central Wyoming is located in a semi-arid or steppe climate. The area is characterized by abundant sunshine, low relative humidity, and sustained winds which lead to high evaporative demand. The region is characterized seasonally by cold winters, warm dry summers, and cool springs and autumns. Temperature extremes range from approximately -30° F in the winter to over 100° F in the summer. There are also large diurnal variations in temperature. The “last freeze” typically occurs during mid to late May and the “first freeze” in early to mid-September.

Yearly precipitation typically averages around 12 inches. The Smith Ranch Project area is prone to severe thunderstorm events throughout the spring and early summer months. Spring snowstorms and spring/summer thunderstorm events account for the majority of the precipitation during this time period. In a typical year, the region experiences 3 or 4 severe thunderstorm events (as defined by the National Weather Service criteria) and 30 to 40 thunderstorm days. Snow falls in the region throughout late fall, winter and early spring months, totaling around 70 inches per year but varying widely with location and elevation. Snowfall contributes substantially to the annual precipitation totals.

Windy conditions are fairly common to the region. Average annual wind speeds range from 10 mph to 15 mph depending on elevation and surrounding topography. Higher average wind speeds occur during the fall and winter months. The predominant wind direction is generally from the west-southwest and southwest throughout the Smith Ranch Project area.

For the regional analysis, meteorological data were compiled for five sites surrounding the Smith Ranch Project area. Hourly average data were acquired from the National Weather Service (NWS) Casper and Douglas airport sites through the National Climate Data Center (NCDC, 2012). Hourly average data from the Antelope and Glenrock surface coal mines were acquired from the IML meteorological monitoring database, and Cameco supplied a year’s worth of hourly data from the North Butte project site. The Glenrock Mine site is less than 8 miles west of the Smith Ranch Project site, at nearly the same elevation, and is therefore used to supplement on-site data in this report. Among the regional sites, the Douglas airport is the closest NWS weather station to the Smith Ranch Project site (24 miles away). Another NWS weather station at the Casper airport lies approximately 40 miles from the Smith Ranch Project site. Despite being farther away, Casper is deemed more representative of the Smith Ranch Project site than Douglas due to its higher elevation and its proximity to the northern Laramie Range.

For the site-specific analysis, hourly data from the Glenrock Mine and the Smith Ranch Project site were used. The on-site data were collected during an approximately one-year baseline monitoring period extending from November 2, 2010 through December 31, 2011. Meteorological data from the Smith Ranch site include wind speed, wind direction, temperature, barometric pressure, relative humidity, precipitation, and solar radiation. Since the Smith Ranch meteorological tower is less than 10 meters high, the baseline meteorological data were supplemented with 14 years of hourly data from the 10-meter tower at the Glenrock Mine, which was closed in 2009. The Glenrock Mine meteorological monitoring station supplied hourly average wind speed, wind direction, standard deviation of wind direction, temperature and precipitation.

Table 2.5-1 lists the regional and on-site meteorological stations used for this analysis, along with coordinates, elevation, and period of record.

Name	Agency	Long	Lat	Z (ft)	Years of Data
Casper	NWS	-106° 28'	42° 54'	5,318	1997 - 2011
Douglas	NWS	-105° 23'	42° 48'	4,922	2003 - 2011
Glenrock Mine	IML	-105° 50'	43° 03'	5,674	1996 - 2009
Smith Ranch	Cameco	-105° 41'	43° 03'	5,592	2011 - 2012
North Butte	Cameco	-105° 56'	43° 46'	5,100	2011 - 2012
Antelope Coal	IML	-105° 19'	43° 30'	4,675	1986 - 2011

Table 2.5-1. Meteorological Stations Included in Climate Analysis.

These sites have been analyzed collectively to provide a regional range of monthly average temperatures, wind speeds and directions, precipitation, relative humidity, evaporation and snowfall. The Casper, Douglas, North Butte and Antelope Mine sites form a quadrilateral that surrounds the Smith Ranch Project site and the nearby Glenrock Mine site (Figure 2.5-1).

Regional and Site Specific Meteorological Characterization

In the information that follows, a regional overview is presented first. This section includes a discussion of the maximum and minimum temperature and relative humidity, annual precipitation including snowfall estimates, evaporation, and a brief wind speed and direction summary. A combination of monitoring stations is analyzed for the regional overview of temperature, humidity, snowfall and total precipitation.

A site specific analysis follows the regional overview. This analysis is based on both on-site monitoring data from the baseline year and historical data from the nearby Glenrock Mine site. An in-depth wind analysis summarizes average wind speeds and directions, wind roses, wind speed frequency distributions, and a joint (wind speed and direction) frequency distribution to characterize the wind data for the Glenrock Mine site by atmospheric stability class. The method of stability class determination is described and illustrated. A discussion of monthly and seasonal data is included for the temperature, precipitation, evaporation and wind parameters. General upper atmosphere data from the National Weather Service station at Lander, Wyoming are used to represent mixing heights at the project site.

The site specific meteorological analysis includes a justification for using the Glenrock Mine site data to supplement data from the Smith Ranch Project site. The site specific analysis also includes a justification for using wind data from the baseline monitoring year to predict meteorological conditions over the long term. This is necessary to validate air sampling locations and MILDOS dispersion modeling inputs. The short and long term wind data from the Casper airport site are correlated for this purpose.

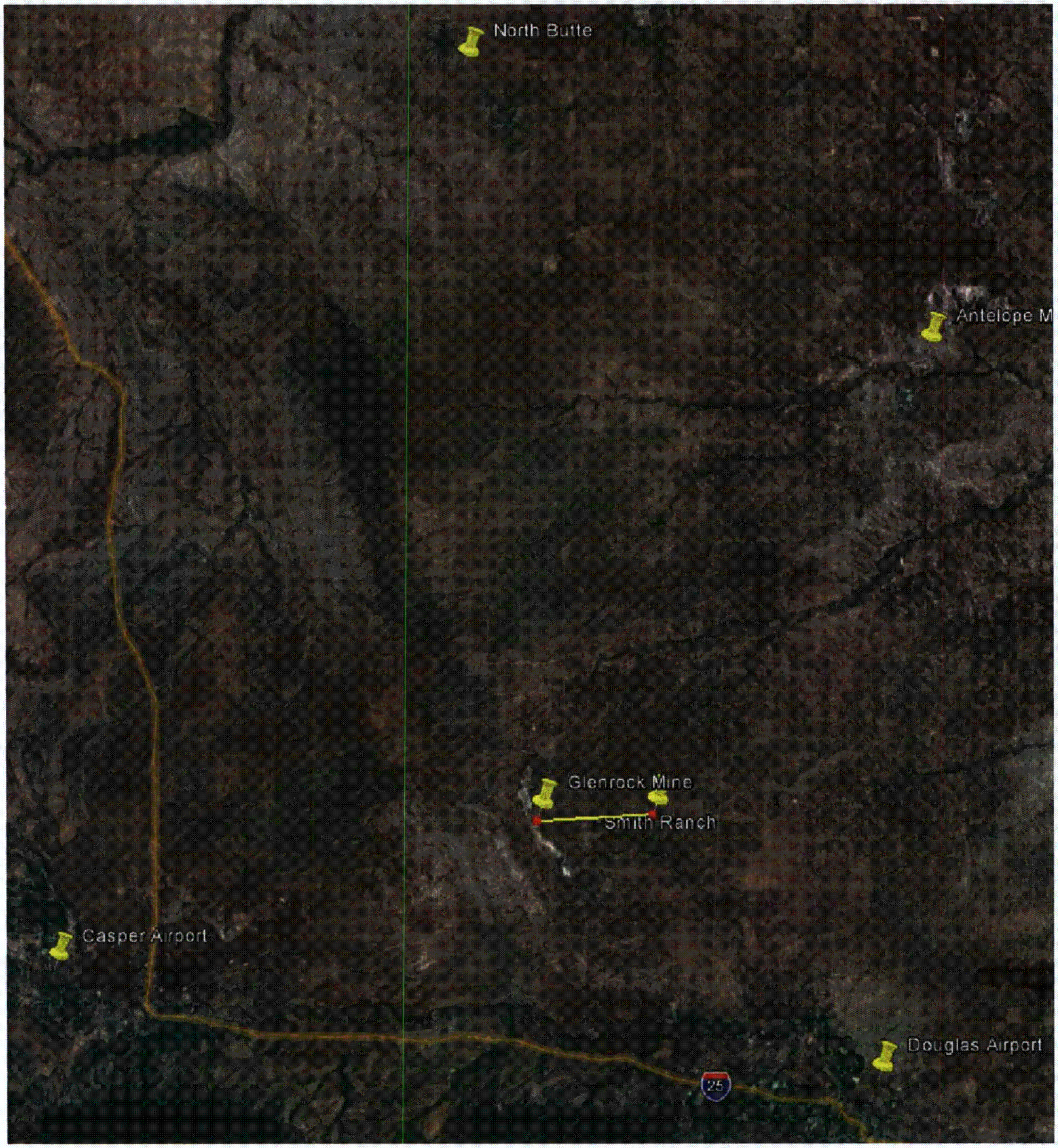


Figure 2.5-1. Regional Meteorological Stations

Regional Overview

Temperature

The annual average temperature is quite uniform throughout the region containing the Smith Ranch Project site. The Casper airport has an annual average temperature of 46° F; the Douglas airport also averages 46° F and the Glenrock Mine site averages 45° F.

Figure 2.5-2 graphs monthly average temperatures, monthly average daily high and low temperatures and monthly high and low temperatures for the Casper airport site. These temperature statistics are taken from the last 15 years. July typically has the highest average monthly temperature (72.1° F), followed by August. December typically records the lowest average temperatures for the year (24.9° F), followed by January. Table 2.5-2 shows monthly temperature statistics for the Casper airport. Low temperatures in Casper have dropped to -28° F, while high temperatures have reached 102° F.

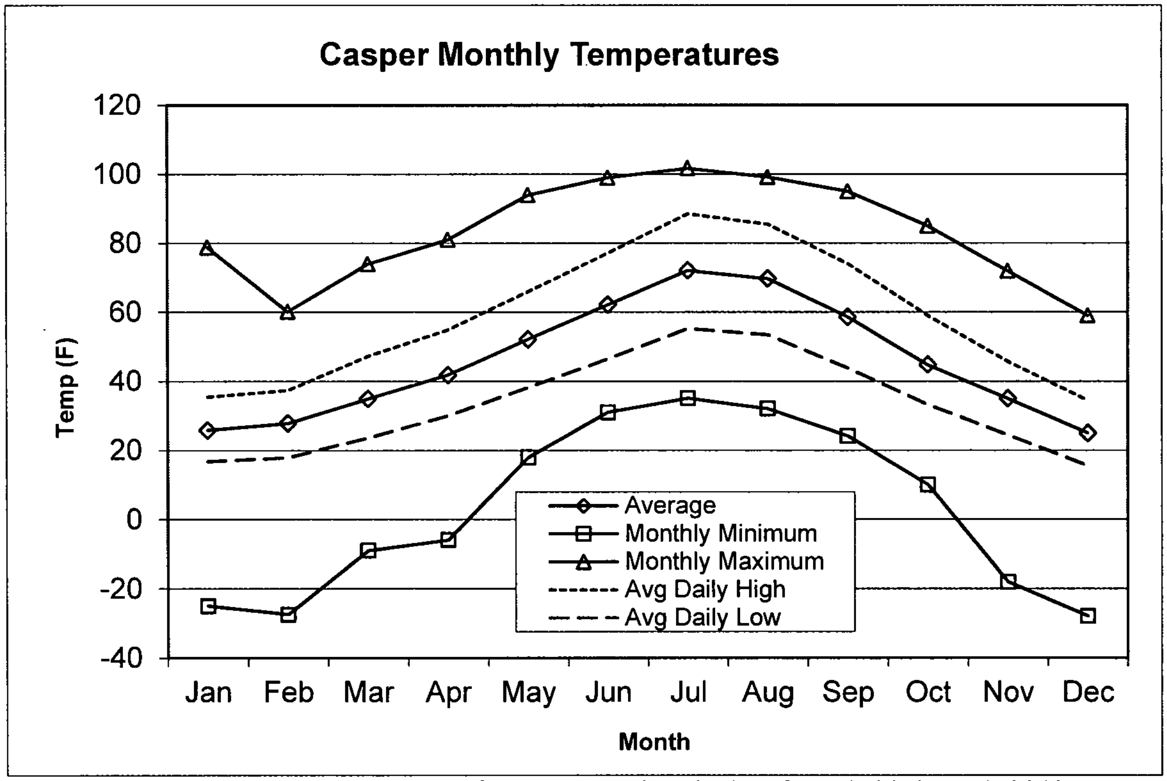
Large diurnal temperature variations occur in the region due in part to its high altitude and low humidity. Figure 2.5-3 depicts the seasonal diurnal temperature variation for the Casper airport from January, 1997 through December, 2011. Spring and summer daily variations of 25° F are typical, with maximum temperature variations exceeding 40° F during extremely dry periods. Less diurnal variation is observed during the cooler portions of the year as fall and winter have average variations of less than 15° F. This can be attributed to the more uniform atmospheric conditions in the region and the reduced solar heating during the fall and winter months.

Figure 2.5-4 shows average daily high and low temperatures, by month, for the Casper airport, Douglas airport and Glenrock Mine meteorological stations. Very little difference in temperature extremes is observed among these sites. This may be attributed to the prominent west-southwesterly winds in the region, which promote uniform atmospheric mixing and inhibit the development of surface temperature anomalies.

Month	Temperature Statistics (° F)				
	Monthly Average	Monthly Maximum	Monthly Minimum	Average Daily High	Average Daily Low
Jan	25.7	79	-25	35.4	16.8
Feb	27.7	60	-28	37.4	18.0
Mar	34.9	74	-9	47.3	23.6
Apr	41.8	81	-6	54.9	29.9
May	52.2	94	18	65.8	38.1
Jun	62.1	99	31	77.2	46.6
Jul	72.1	102	35	88.4	55.3
Aug	69.7	99	32	85.5	53.5
Sep	58.6	95	24	74.1	43.9
Oct	44.8	85	10	59.0	33.1
Nov	35.0	72	-18	45.8	24.4
Dec	24.9	59	-28	34.4	15.6

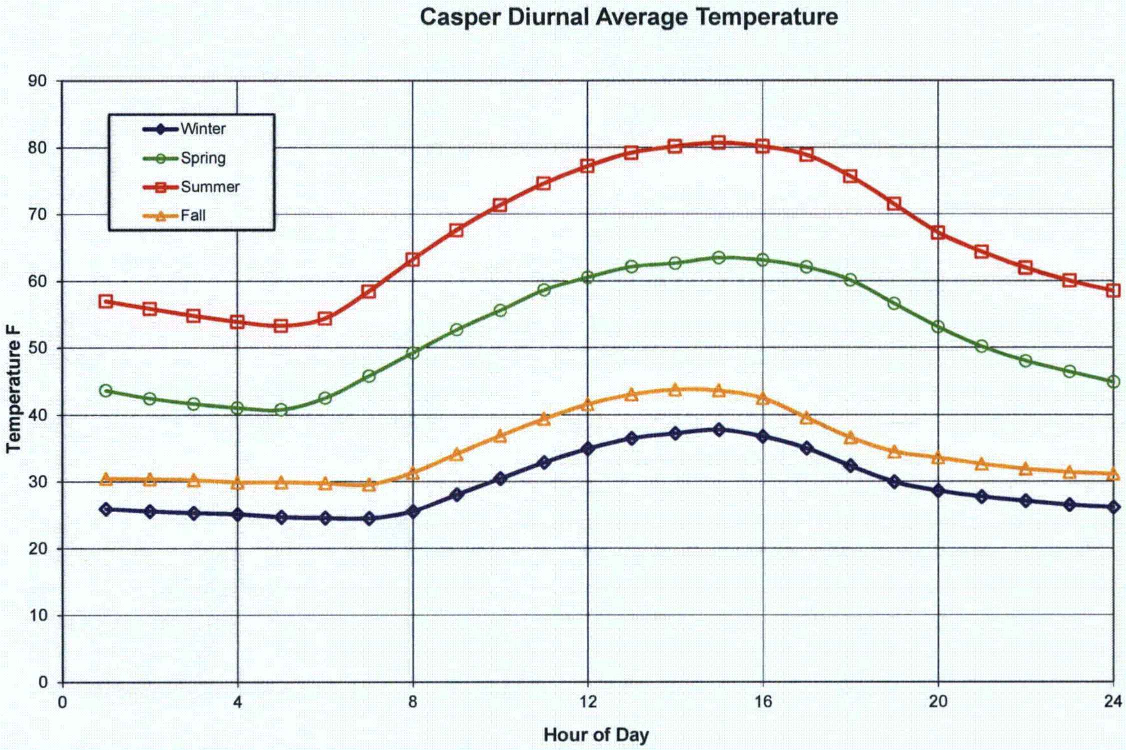
Source: National Climate Data Center, 2012, hourly data from 1996 through 2012

Table 2.5-2. Annual and Monthly Temperature Statistics for the Casper Airport.



Source: National Climate Data Center, 2012, hourly data from 1996 through 2012

Figure 2.5-2. Casper Airport Monthly Temperature Statistics



Source: National Climate Data Center, 2012, hourly data from 1996 through 2012

Figure 2.5-3. Casper Airport Seasonal Diurnal Temperature Variations.

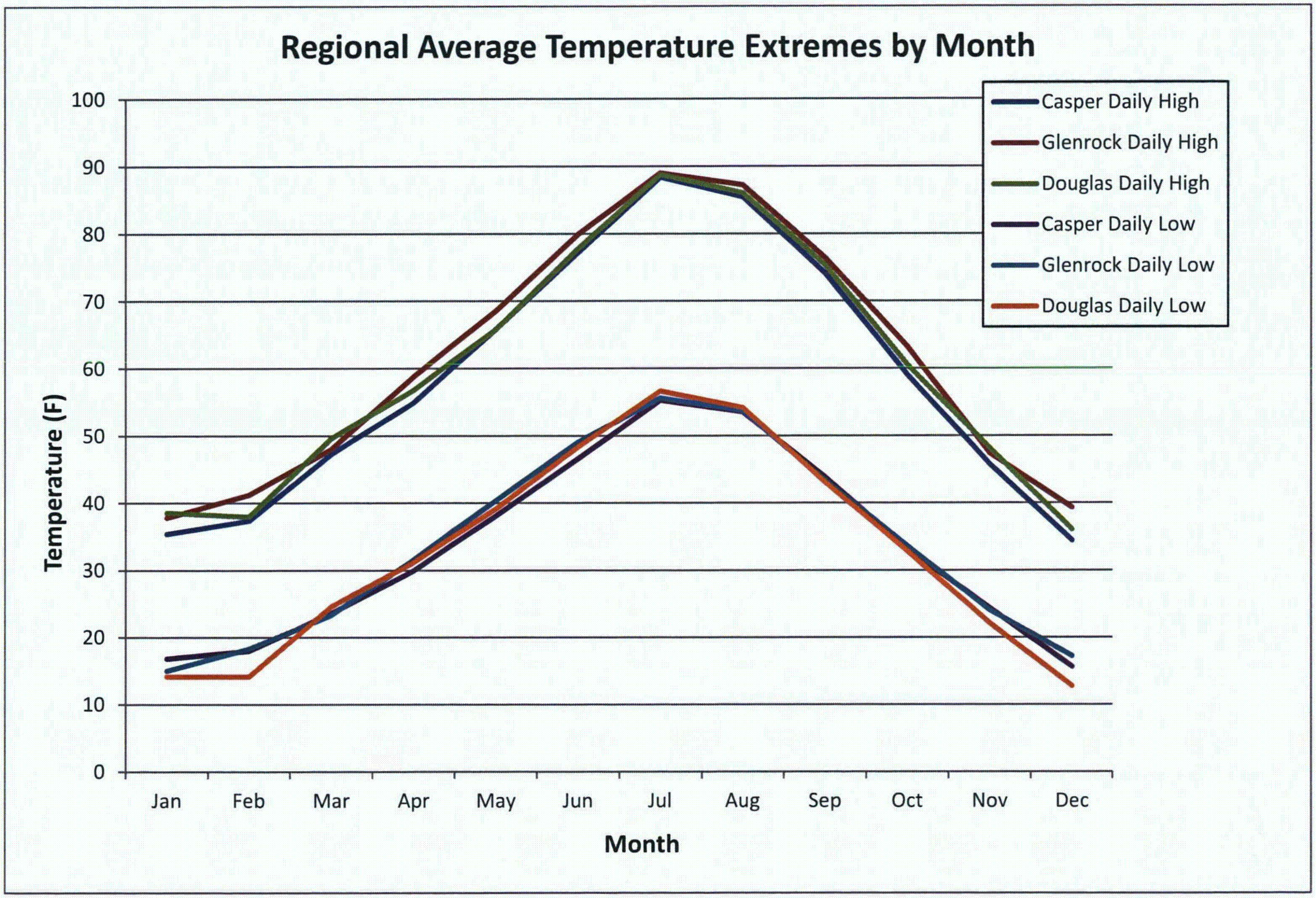
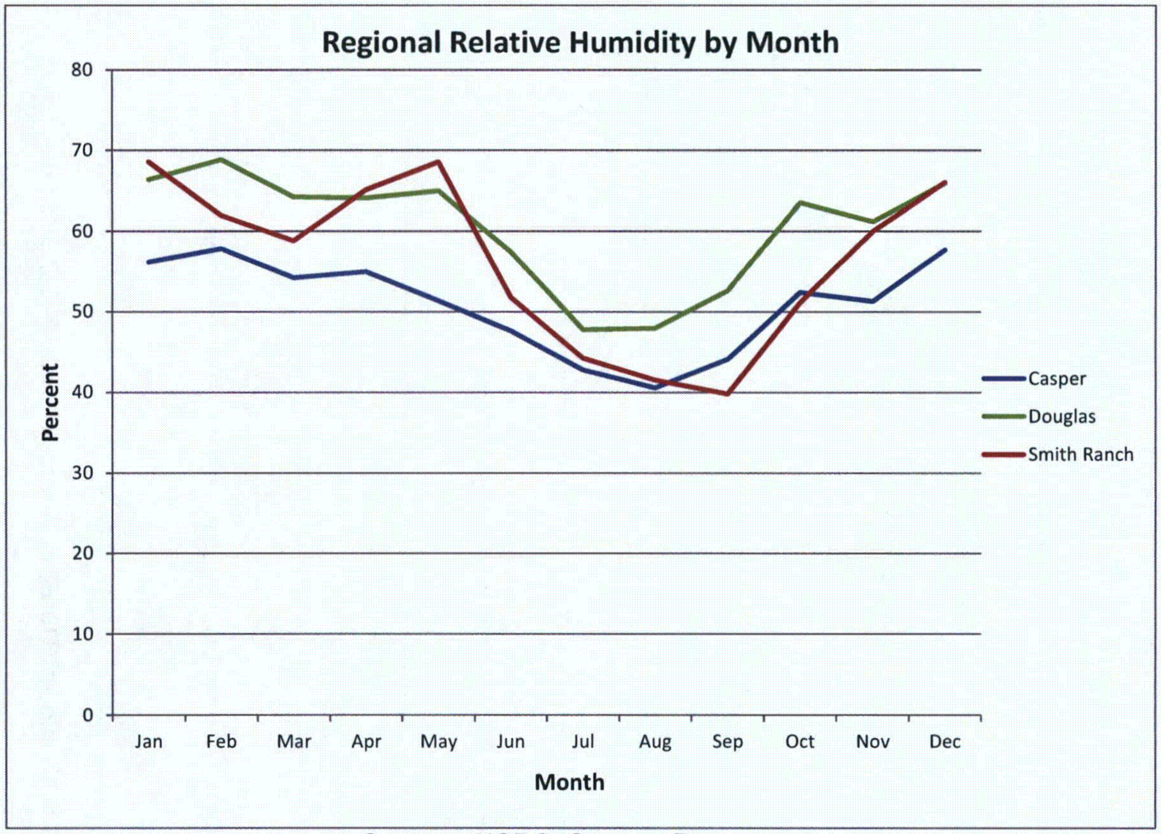


Figure 2.5-4. Regional Monthly Average Daily High and Low Temperatures.

Relative Humidity

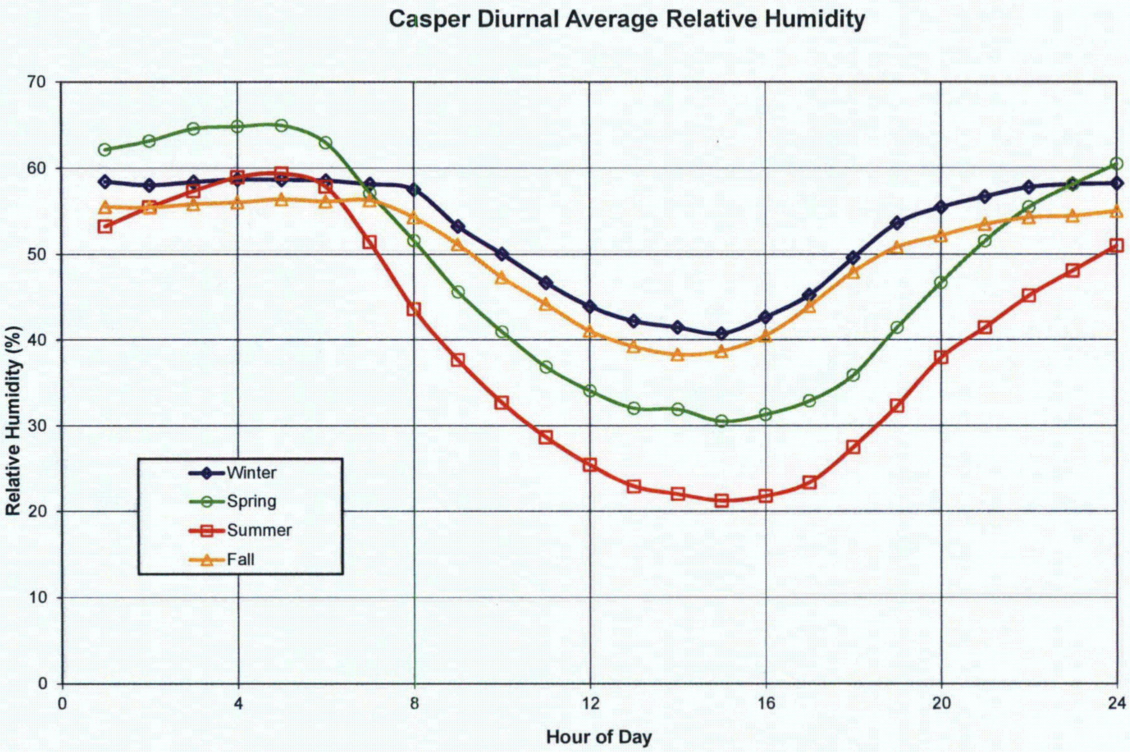
The Douglas and Casper airport sites record hourly average relative humidity. Figure 2.5-5 charts monthly average relative humidity values for these two sites. The Douglas airport lies less than two miles from the North Platte River, perhaps accounting for its higher average relative humidity. For reference, Figure 2.5-5 also shows the Smith Ranch Project on-site relative humidity averages. It can be seen that July and August have the driest air with relative humidity averaging around 40 to 50%. The winter months of December, January and February make up the most humid part of the year, with average relative humidity between 60% and 70%. The annual average relative humidity is 51% at the Casper airport.



Sources: NCDC, Cameco Resources

Figure 2.5-5. Monthly Relative Humidity Statistics for the Region

Relative humidity is a temperature based calculation which reflects the fraction of moisture present relative to the amount of moisture for saturated air at that temperature. Warmer air holds more moisture at saturation than colder air. For a given amount of moisture in the air, then, maximum relative humidity values occur more frequently in the cooler, early mornings while minimum values typically occur during the warmer, mid-afternoon hours. The summer months exhibit a much greater variation in relative humidity between morning and afternoon values due to greater temperature variations. Figure 2.5-6 shows the diurnal variations in relative humidity at the Casper airport, by season.

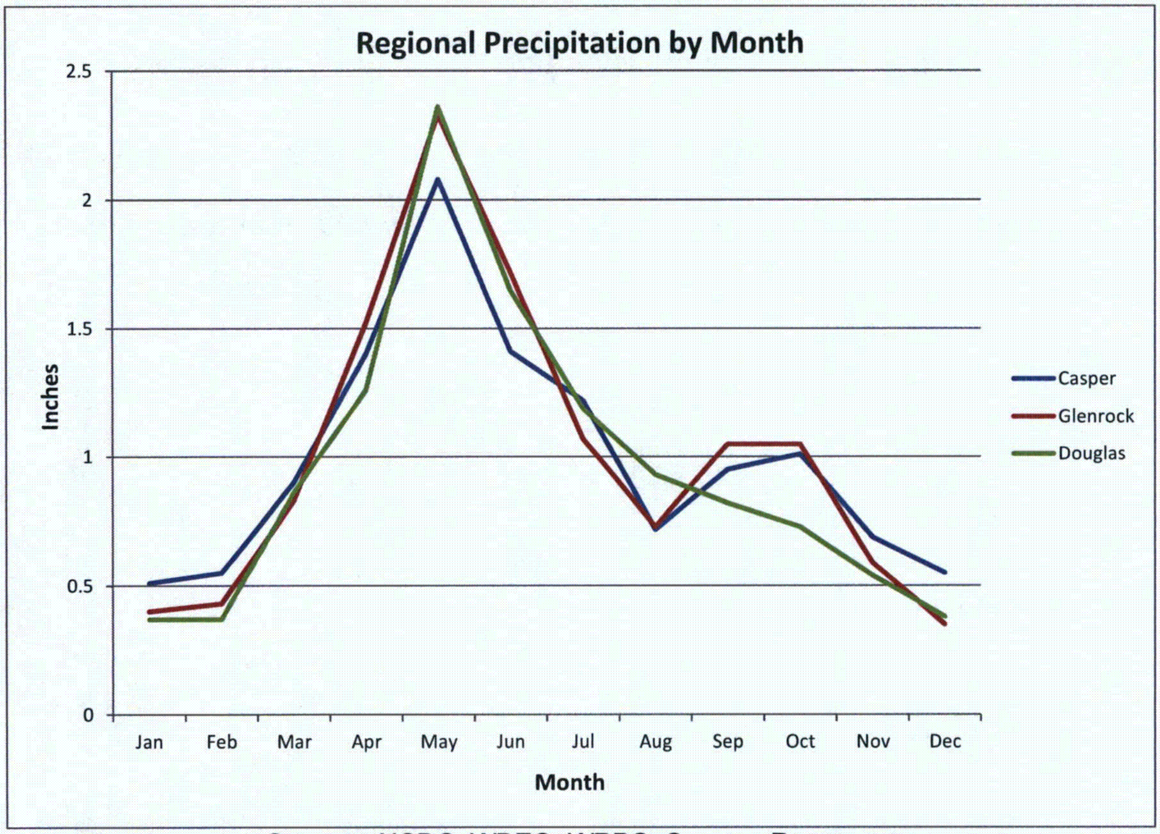


Source: National Climate Data Center, 2012, hourly data from 1997 through 2011.

Figure 2.5-6. Seasonal Diurnal Relative Humidity Variation for Casper Airport

Precipitation

The region is semi-arid and characterized by mostly dry conditions. The Casper airport received measurable (>0.01 in) precipitation on an average of 100 days per year between 1997 and 2011 (NCDC, 2012). Average annual precipitation during that period was 12 inches per year. In general, the region has an annual precipitation average of approximately 10.5 to 12.5 inches. Typical of the region, spring snowstorms, showers and thunderstorms during April through July produce approximately half of the precipitation at the Casper, Glenrock and Douglas stations (Figure 2.5-7). May is typically the wettest month of the year; with most of the region receiving an average of over 2 inches for that month. January, in contrast, is the driest month of the year with precipitation typically averaging one half inch or less. The winter months (Dec-Feb) typically account for less than 15% of the yearly precipitation totals. Only moderate precipitation occurs in late summer, when atmospheric conditions are more stable and the absence of convective activity limits storm development.

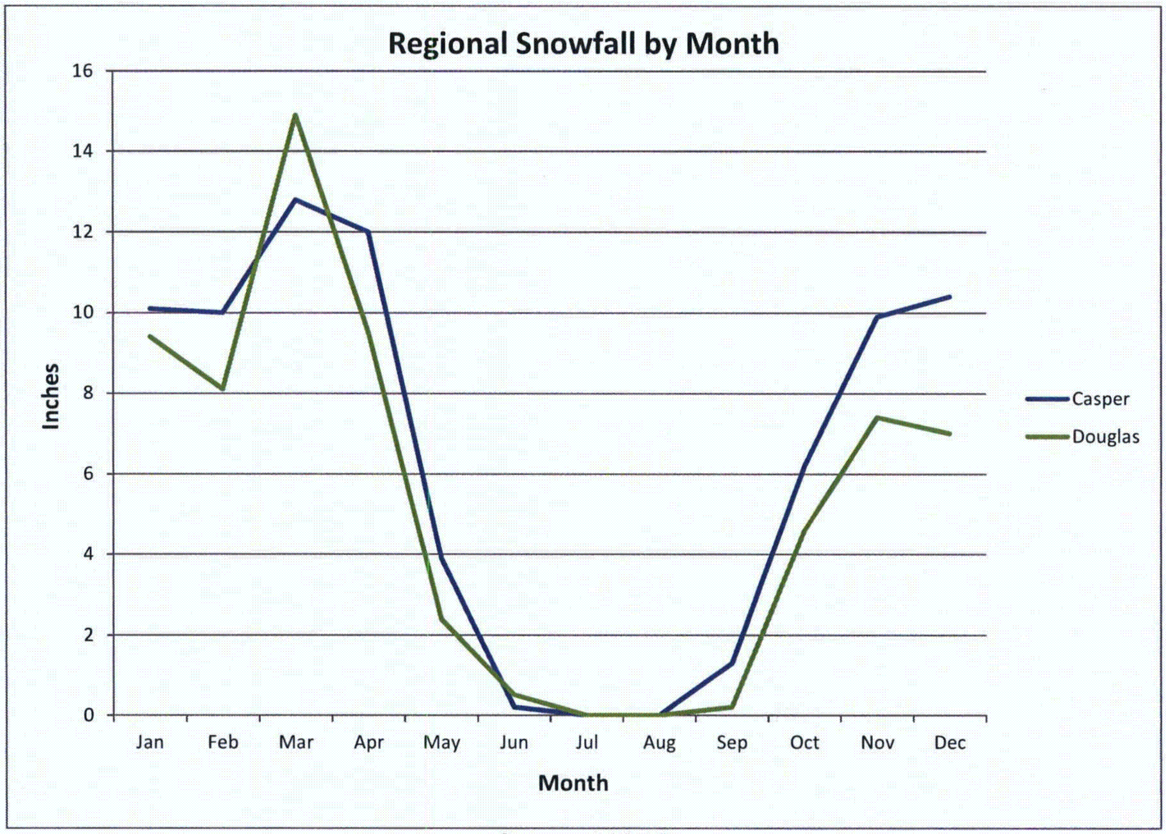


Sources: NCDC, WDEQ, WRDS, Cameco Resources

Figure 2.5-7. Monthly Average Precipitation in Region

Severe weather occurs throughout the region, but is limited on average to 5 or 6 severe events per year. These severe events are generally split between hail, blizzards and damaging wind events.

Annual snowfall averages about 70 inches at both the Casper and Douglas stations, although snowfall totals vary widely from year to year and from one location to another. Monthly average snowfall is depicted in Figure 2.5-8. Major snowstorms (more than 5 in/day) are relatively infrequent in the region, which typically experiences less than three major snowstorms per year. Monthly average snow amounts in Figure 2.5-8 show the highest snowfall in March and April.



Source: NCDC

Figure 2.5-8. Regional Average Monthly Snowfall.

Wind Patterns

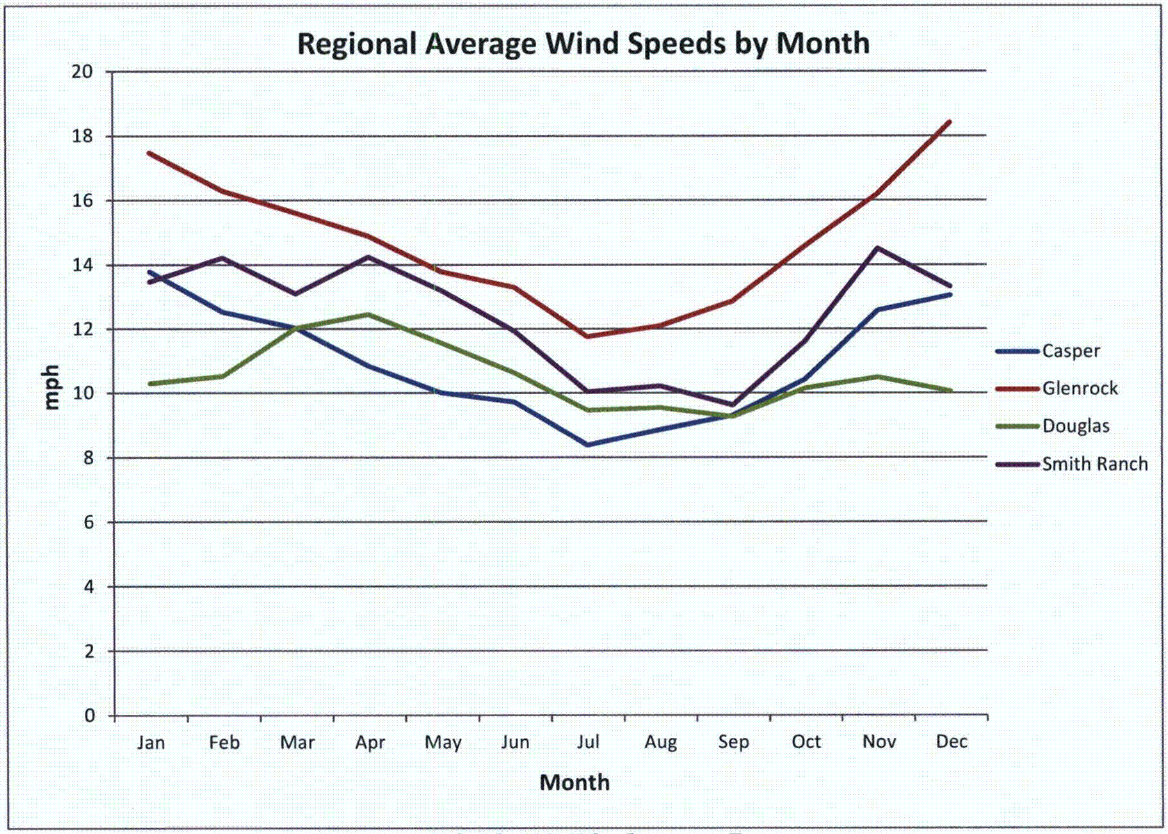
Year-round wind speeds in the area average between 10 and 15 mph. Table 2.5-3 shows monthly averages for the Casper airport. The overall average wind speed at this site was 11 mph for the 1997-2011 period analyzed in this study. It is important to note that this average is skewed downward by the high anemometer starting threshold at Casper's NWS station. Wind speeds less than 3 mph are reported as zero (NCDC, 2012). Mean monthly average wind speeds are lowest in the summer months and highest in late fall and winter. This is typical of the region, as shown in Figure 2.5-9.

Month	Hourly Average Wind Speeds (mph)		
	Monthly Average	**Monthly Maximum**	**Monthly Minimum**
Jan	13.8	52	0
Feb	12.5	47	0
Mar	12.0	47	0
Apr	10.8	41	0
May	10.0	55	0
Jun	9.7	42	0
Jul	8.4	41	0
Aug	8.8	38	0
Sep	9.3	51	0
Oct	10.4	43	0
Nov	12.6	48	0
Dec	13.0	51	0

Source: National Climate Data Center, 2011, hourly data from 1997 through 2011

Table 2.5-3. Casper Airport Monthly Wind Speed Summary.

Figure 2.5-9 also shows that monthly average wind speeds are higher at the Smith Ranch Project and Glenrock Mine sites, than at the Casper and Douglas airport sites. In addition to the high starting threshold at the NWS sites (Casper and Douglas), this may also be attributable to higher elevations at Glenrock and Smith Ranch. Figure 2.5-10 shows that even at the Casper airport station, hourly average wind speeds exceed 15 mph 80% of the time (NCDC 2012).



Sources: NCDC, WDEQ, Cameco Resources

Figure 2.5-9. Regional Average Wind Speeds

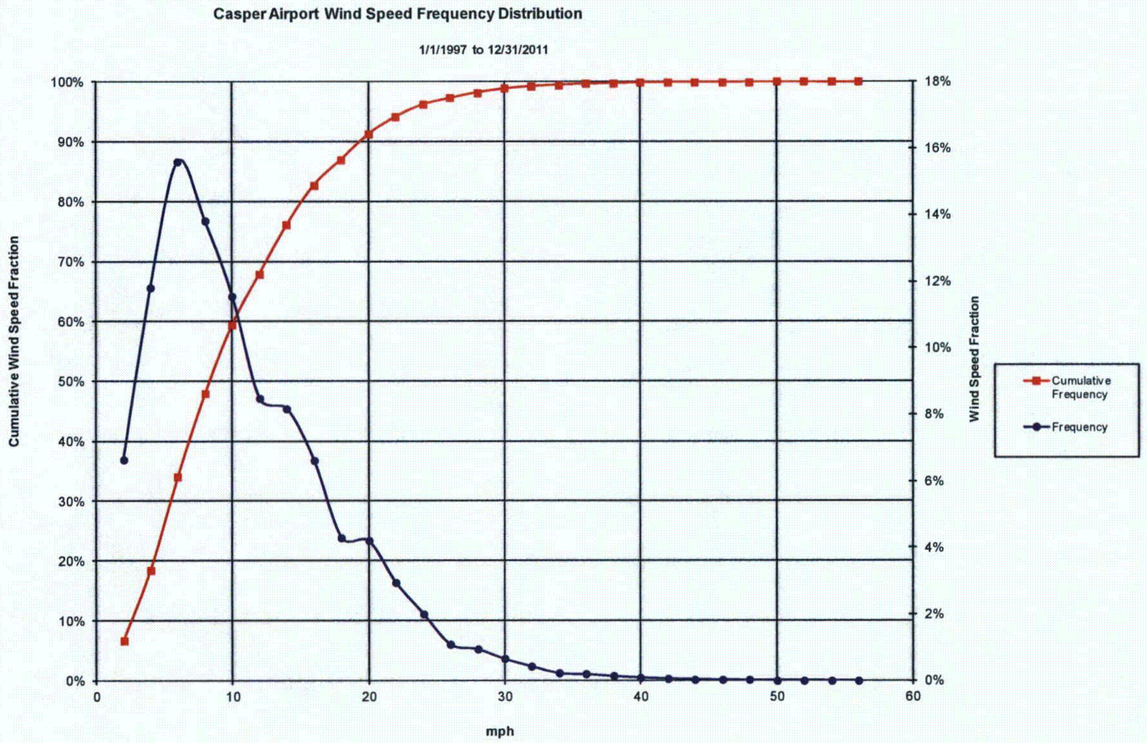
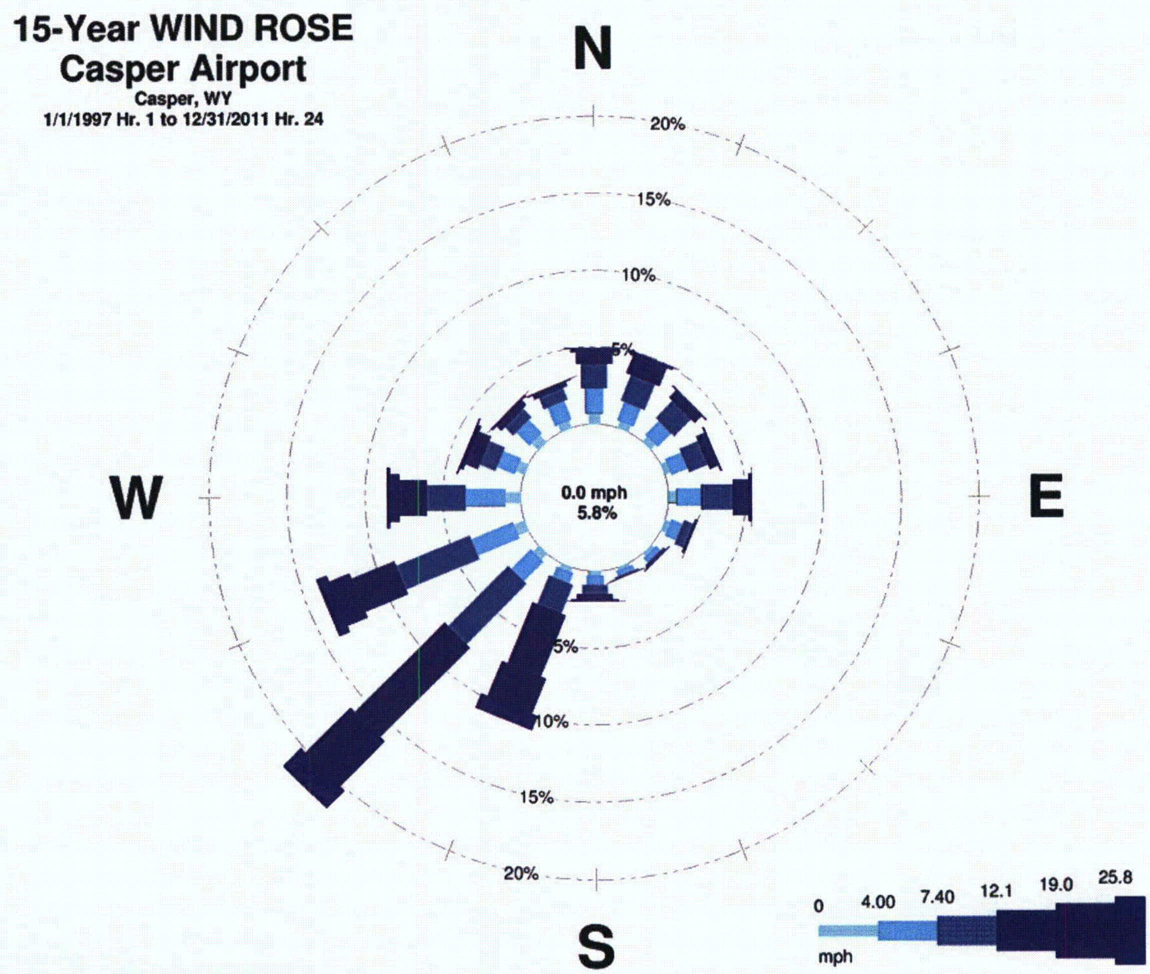


Figure 2.5-10. Casper 15-Year Wind Speed Frequency Distribution

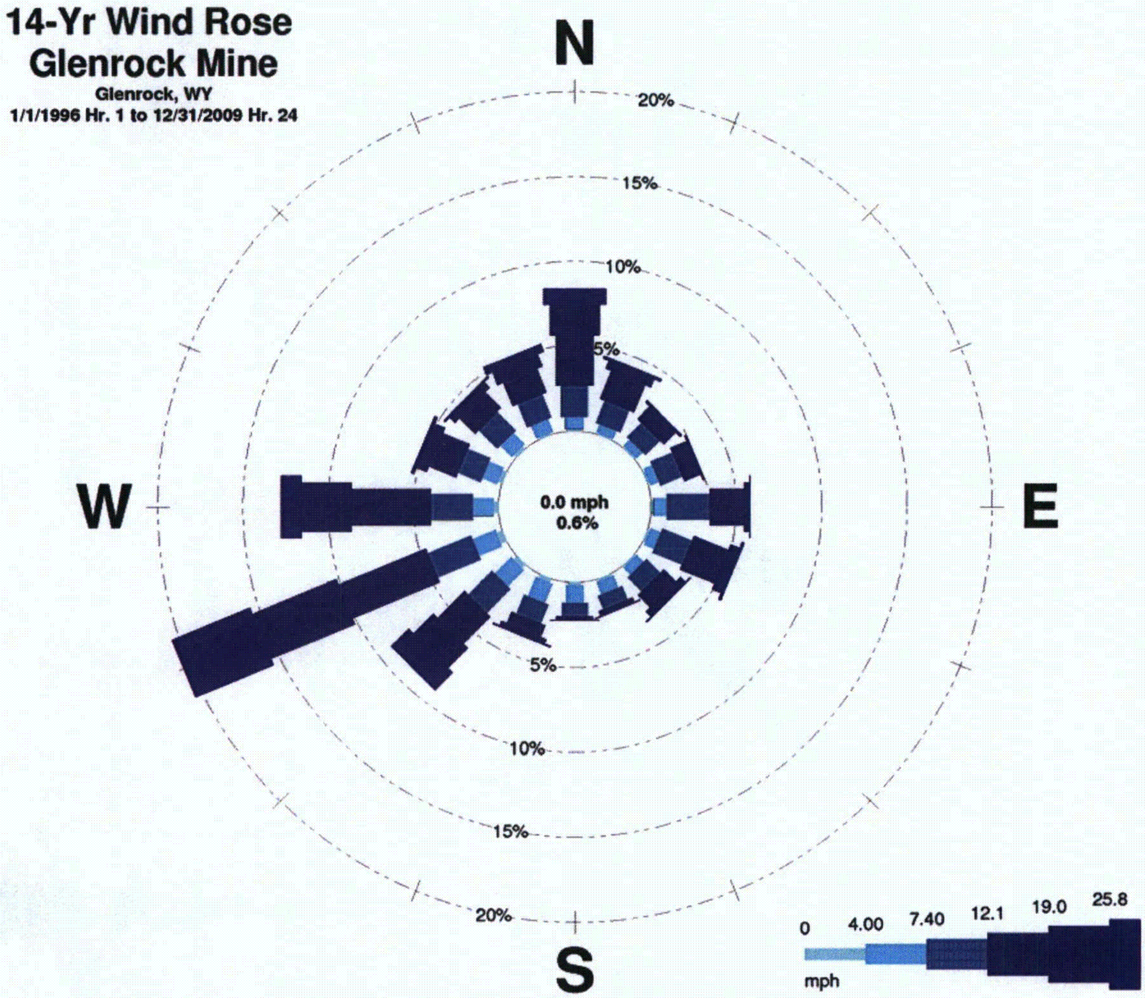
Figure 2.5-11 shows the 15-year wind rose for the Casper airport site. Predominant winds are generally from the southwesterly to west-southwesterly direction. Figure 2.5-12 shows a 14-year wind rose for the Glenrock Mine site. The wind pattern is similar to Casper although west-southwesterly winds dominate, with a secondary node from the northerly direction.

Figure 2.5-13 shows a 9-year wind rose for the Douglas airport. Douglas experiences dominant westerly to northwesterly winds, with a strong secondary mode from the southeast. Douglas is located in a transition zone between the mountain ranges of central Wyoming and the plains of southeastern Wyoming. As such, it is more susceptible to southeasterly flow from high pressure systems that center over the northern Great Plains during warm weather conditions. This phenomenon, along with differences in terrain and elevation across the region may explain the variations in wind patterns. Based on elevation, proximity to the northern Laramie Range, and the similarity between the Casper airport and Glenrock Mine wind roses, it is believed that the Casper airport is more representative of the Smith Ranch Project site than is the Douglas airport station.



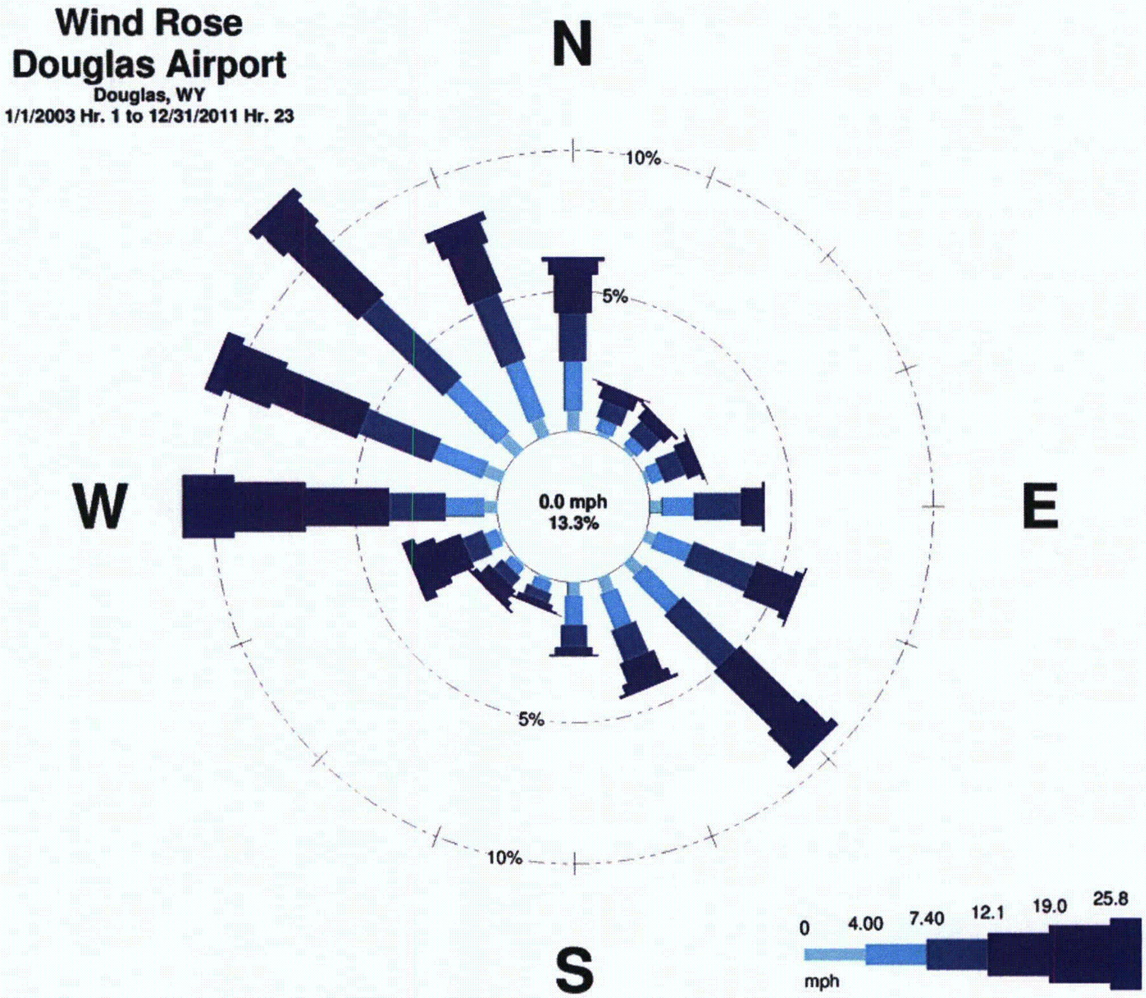
Source: National Climate Data Center, 2012, hourly data from 1997 through 2011

Figure 2.5-11. Casper Airport 15-Year Wind Rose



Source: WDEQ, hourly data from 2007 through 2011

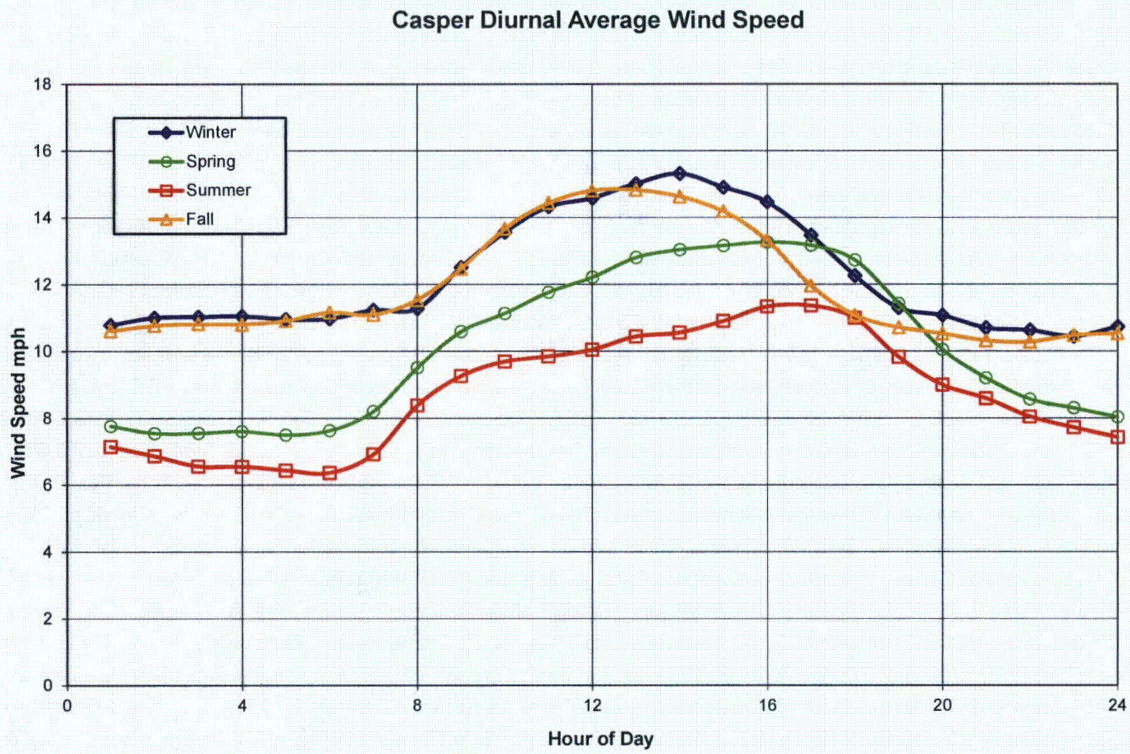
Figure 2.5-12. Glenrock Mine 14-Year Wind Rose



Source: NCDC, hourly data from 2004 through 2011

Figure 2.5-13. Douglas 9-Year Wind Rose

Winds throughout the region exhibit a diurnal pattern. Figure 2.5-14 shows this pattern at the Casper airport for each season of the year. Wind speeds peak during the early afternoon during the spring and summer seasons, and late afternoon for fall and winter seasons. This is largely due to the predominant effect of solar heating on wind speeds. Figure 2.5-14 also shows that the highest average wind speeds occur during the fall and winter seasons. The lowest wind speeds occur during summer, when the atmosphere is the most stable.



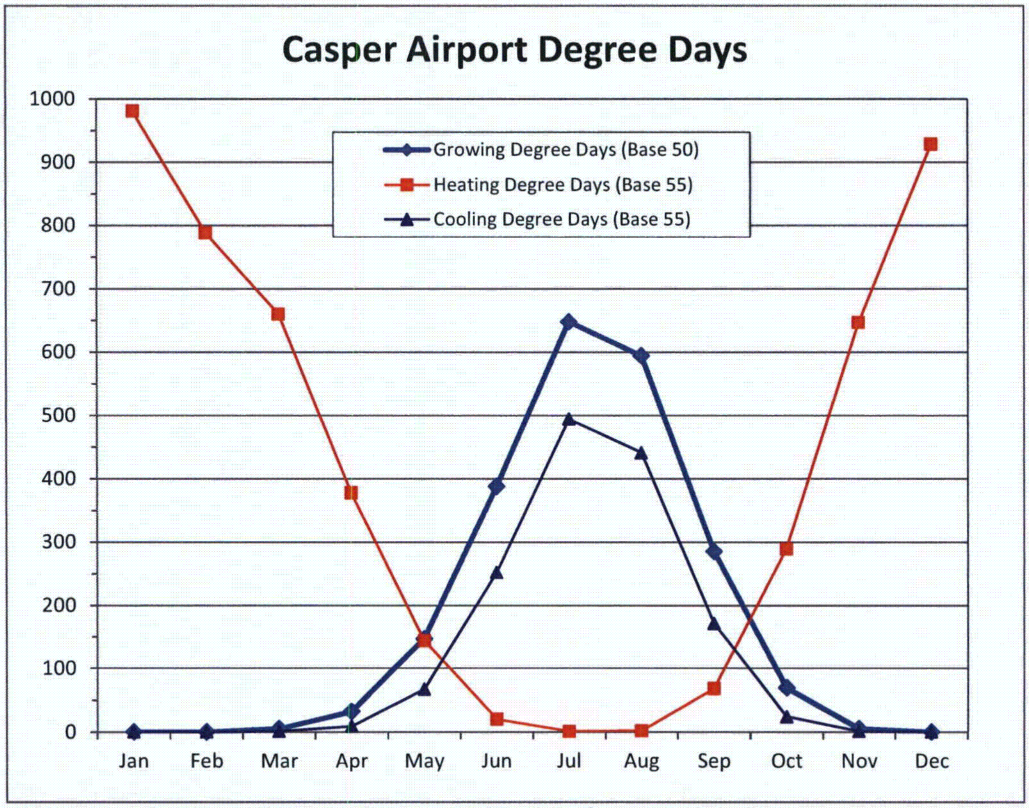
Source: National Climate Data Center, 2012, hourly data from 1997 through 2011

Figure 2.5-14. Casper Airport Diurnal Wind Speeds by Season

Heating, Cooling and Growing Degree Days

Figure 2.5-15 summarizes the monthly cooling, heating, and growing degree days for the Casper airport. The heating and cooling degree days are included to show deviation of the average daily temperature from a predefined base temperature. In this case, 55° F has been selected as the base temperature for computation of heating and cooling degree days. The base temperature for computing growing degree days is 50° F. The number of heating degree days is computed by taking the average of the high and low temperature occurring that day and subtracting it from the base temperature. The calculation for growing and cooling degree days is the same, except that the base temperature is subtracted from the average of the high and low temperature for the day. Negative values are disregarded for both calculations.

As expected, the graphs of heating degree days and cooling degree days are inversely related and the growing and cooling degree days are directly related. The maximum number of heating degree days occurs in December and January, at approximately 1,000 degree days per month. This coincides with the months having the lowest minimum average temperatures. Conversely, July registers the most growing degree days with nearly 650, and the most cooling degree days at less than 500. This also corresponds to July having the highest average temperature.



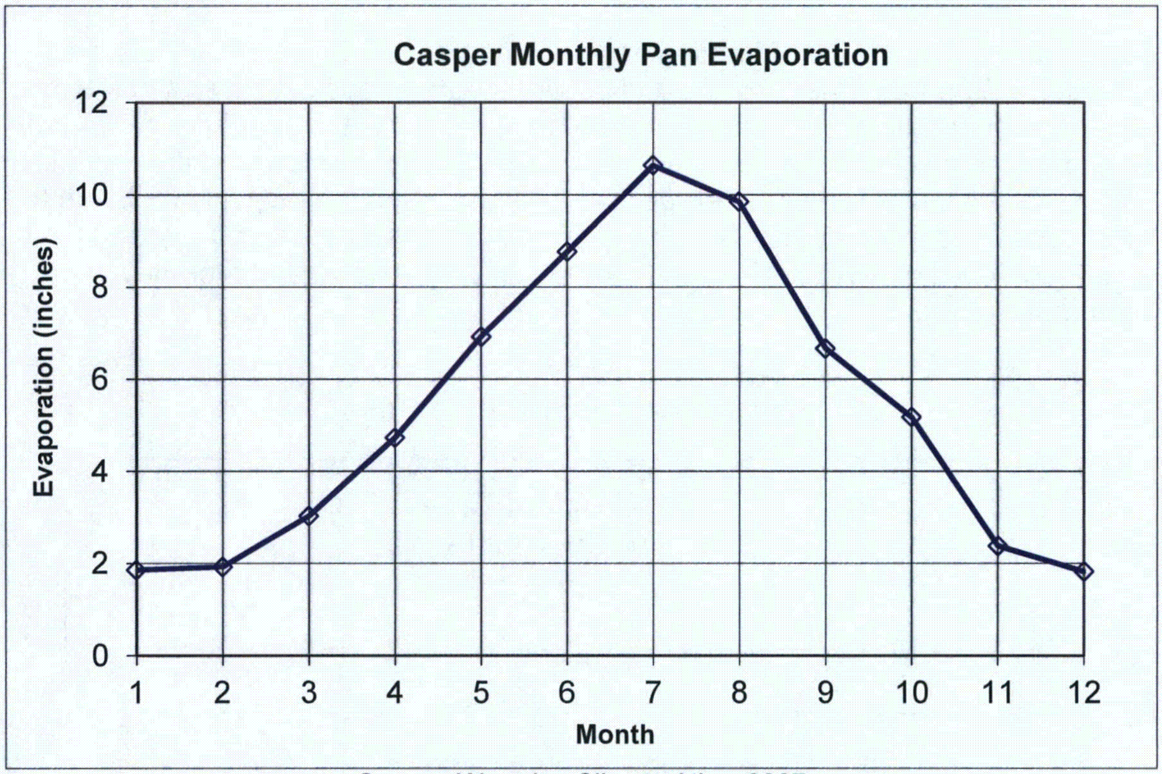
Source: Western Regional Climate Center, 2012, data from 1948 to 2010

Figure 2.5-15. Casper Airport Cooling, Heating, and Growing Degree Days.

Evapotranspiration

The region is characterized by high evaporative demand during much of the year. This demand is related to dry air (low dew points), warm daytime temperatures and moderate to high wind speeds. Historical evaporation data from the Casper airport, approximately 40 miles west of the Smith Ranch project site, is believed to be representative of the Smith Ranch Project area.

Figure 2.5-16 graphs monthly pan evaporation rates, measured in inches of water per month, at the Casper airport. Evaporation rates are highest in July, at over 10 inches, and lowest in December through February. Annual evaporation at the Casper airport averages nearly 64 inches per year.



Source: Wyoming Climate Atlas, 2007

Figure 2.5-16. Casper Pan Evaporation.

Site Specific Analysis

Background

The site specific discussion is based on two data sources. These are the Smith Ranch on-site meteorological data collected for the baseline monitoring period of November 2, 2010 through December 31, 2011, and hourly average meteorological data from the Glenrock Mine site, approximately 8 miles to the west (Figure 2.5-1). Compared to the Smith Ranch Project data, the Glenrock Mine data represent a longer period of record, include all parameters necessary to support MILDOS modeling, and conform to NRC guidance for meteorological tower heights.

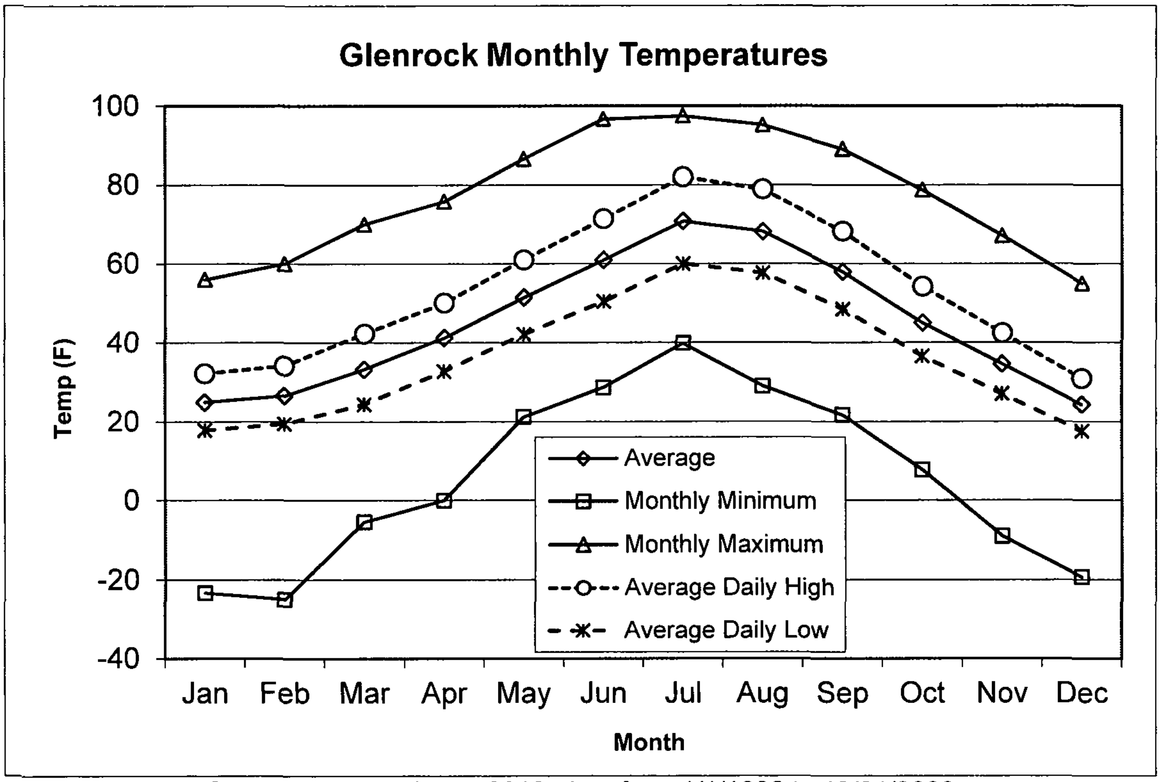
Monitoring at the Glenrock Mine was conducted by IML between 1996 and 2009, in accordance with EPA's On-Site Meteorological Program Guidance for Regulatory Modeling Applications (EPA, 2000). Data from the Glenrock Mine include standard deviation of wind direction (σ_θ), which was not recorded at the Smith Ranch Project meteorological station but is needed to derive atmospheric stability class for MILDOS model inputs. In addition, wind speed and direction data at the Smith Ranch Project site were obtained at an approximate height of 4 meters. The Glenrock Mine site used a standard, 10-meter tower, as stipulated in NRC Regulatory Guide 3.63 (NRC, 2008). The functional equivalence between the Glenrock Mine and Smith Ranch Project sites is demonstrated in the following analysis.

Long-term data from the Casper airport are also included in the on-site discussion to demonstrate that for this region, winds during the baseline monitoring period are representative of the longer term. The Casper airport is approximately 40 miles west of the Smith Ranch Project site.

Temperature

The maximum temperature for the baseline monitoring year at the Smith Ranch Project site was 94° F and the minimum temperature was -21° F. At 44.7° F, the baseline-year average temperature at Smith Ranch is nearly identical to the long-term average temperature at the Glenrock Mine of 44.9° F. It is also similar to the regional, year-round average temperature of approximately 46° F. Since temperature statistics from the Glenrock Mine represent a longer period, and since the mine is located less than 8 miles from the project site at nearly the same elevation, the following analysis of on-site temperatures is based on the Glenrock Mine monitoring history.

Figure 2.5-17 shows the monthly average, monthly minimum, monthly maximum, monthly average daily high and monthly average daily low temperatures for the Glenrock Mine. Table 2.5-4 provides the same data in tabular form. Daily average temperatures range from near 24° F in the winter months to near 70° in the summer months.



Source: IML Database, 2012, data from 1/1/1996 to 12/31/2009

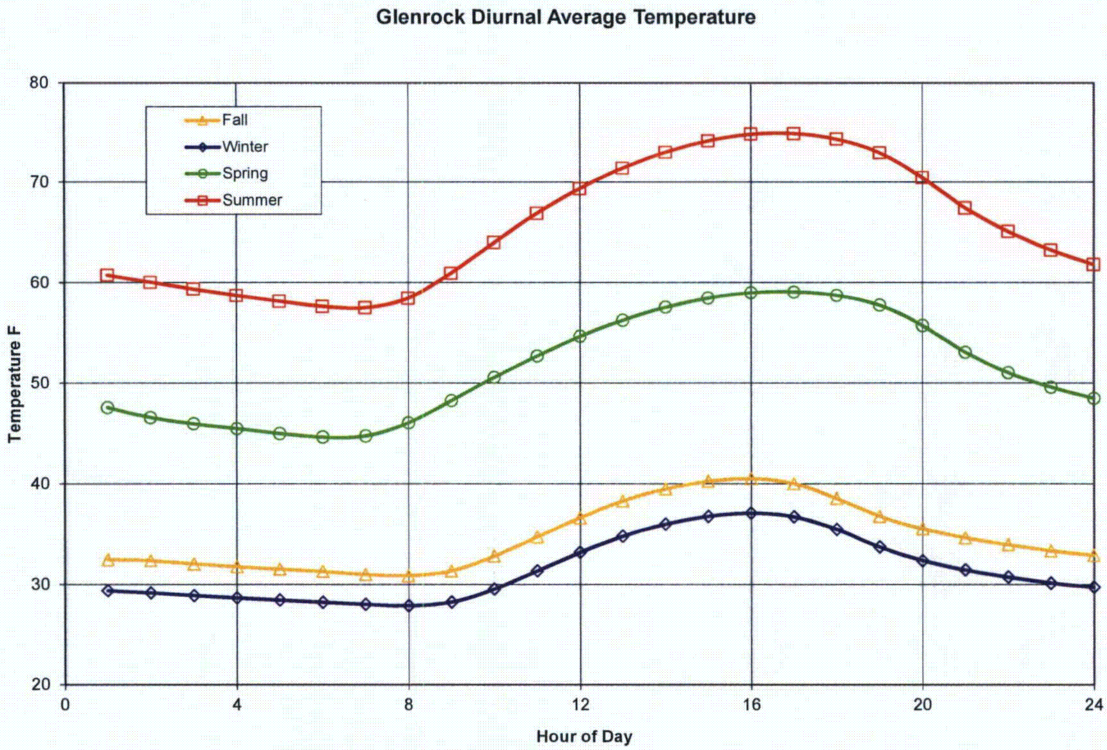
Figure 2.5-17. Glenrock Mine Monthly Temperatures.

Month	Temperature Statistics (° F)				
	Monthly Average	Monthly Maximum	Monthly Minimum	Average Daily High	Average Daily Low
Jan	24.9	56	-23	32.2	17.8
Feb	26.6	60	-25	34.1	19.5
Mar	33.2	70	-5	42.3	24.4
Apr	41.2	76	0	50.1	32.7
May	51.4	87	21	61.0	42.1
Jun	60.9	97	29	71.4	50.5
Jul	70.8	97	40	82.0	60.0
Aug	68.2	95	29	78.9	57.7
Sep	57.9	89	22	68.2	48.5
Oct	45.0	79	8	54.2	36.5
Nov	34.6	67	-9	42.4	27.0
Dec	24.3	55	-19	30.9	17.6

Source: IML Database, 2012, data from 1/1/1996 to 12/31/2009

Table 2.5-4. Glenrock Mine Max, Min, and Avg Monthly Temperatures

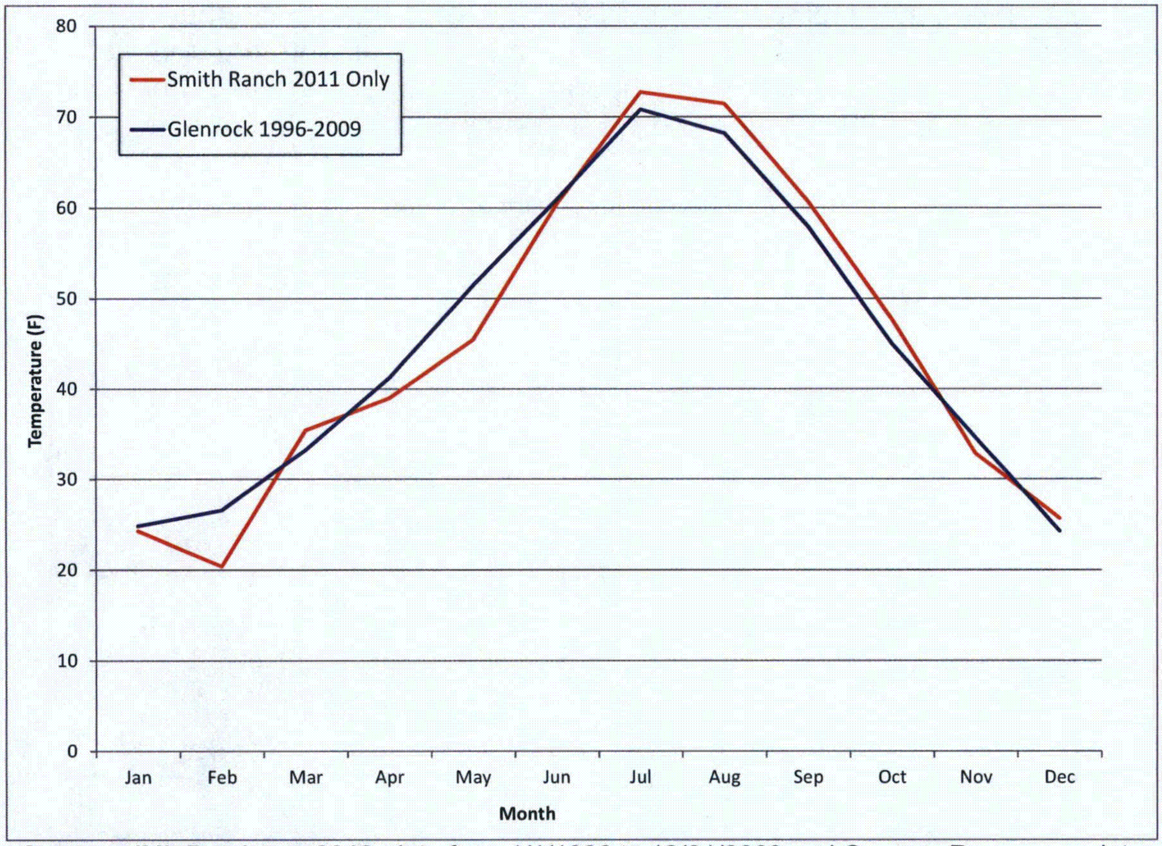
Similar to the monthly temperature statistics presented above, diurnal temperature variations at the Smith Ranch Project site are inferred from data collected at the Glenrock Mine site. Figure 2.5-18 shows average diurnal swings ranging from under 20° F in the summer to less than 10° F in the winter.



Source: IML Database, 2012, data from 1/1/1996 to 12/31/2009

Figure 2.5-18. Glenrock Mine Diurnal Temperatures by Season.

Figure 2.5-19 demonstrates general equivalence between monthly average temperatures recorded over 14 years at the Glenrock Mine, and those recorded during the baseline monitoring year at the Smith Ranch Project site. The average temperatures observed in February and May of 2011 were significantly lower than long-term monthly averages for the entire region. Therefore, even though the Glenrock Mine meteorological station was not in operation during 2011, it is reasonable to assume that temperatures there would also have measured lower than average in February and May of 2011.



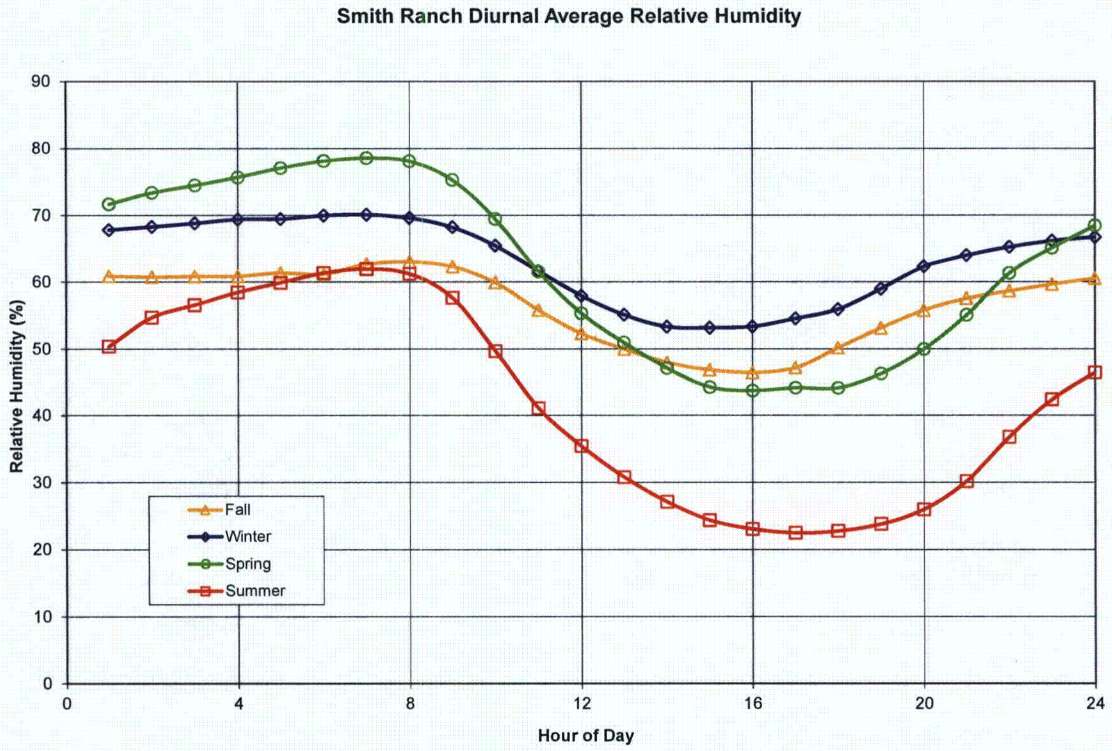
Sources: IML Database, 2012, data from 1/1/1996 to 12/31/2009 and Cameco Resources, data from 1/1/2011 to 12/31/2011

Figure 2.5-19. Glenrock Mine vs. Smith Ranch Monthly Average Temperatures

<u>Relative Humidity</u>

The annual average Smith Ranch site relative humidity is 56.5%. On-site monthly average relative humidity values are graphed along with regional averages in Figure 2.5-5 above. The graph shows that relative humidity at the Smith Ranch Project site mirrors regional trends.

As discussed above, relative humidity is a temperature based calculation which reflects the fraction of moisture present relative to the amount of moisture for saturated air at that temperature. Warmer air holds more moisture at saturation than colder air. For a given amount of moisture in the air, maximum relative humidity values occur more frequently in the cooler, early morning hours while minimum values typically occur during the warmer, mid-afternoon hours. The summer months exhibit a much greater variation in relative humidity between morning and afternoon due to greater temperature variations. Summer also exhibits lower overall relative humidity values due to higher average temperatures. This is confirmed by Figure 2.5-20, which graphs average relative humidity by time of day and season.



Source: Cameco Resources, data from 1/1/2011 to 12/31/2011

Figure 2.5-20. Smith Ranch Diurnal Relative Humidity.

Source: Cameco Resources, 2012, data from 1/1/2011 to 12/31/2011

provides a meteorological summary for the Smith Ranch Project site for the baseline monitoring year. The averages, maximums, and minimums are specified for each parameter recorded at the site along with the data recovery rate for each. The recovery rates were nearly 100% for all parameters except solar radiation and barometric pressure.

Smith Ranch

Meteorological Data Summary

1/1/2011 - 12/31/2011

Hourly Data

	Average/Total	Max	Min
Wind Speed (m/sec)	5.6	19.4	0.0
Sigma-Theta (°)	0.0	0.0	0.0
Temperature (C)	7.1	34.4	-29.4
Relative Humidity (%)	55.8	96.2	0.0
Precipitation (mm)	304.58	12.12	
Bar. Pressure (Kpa)	24.6	25.0	24.2
Solar Radiation (w/m^2)	157.0	1,066.9	

Predominant wind direction was from the WSW sector, accounting for 16.3% of the possible winds

Data Recovery

Parameter	Possible (hours)	Reported (hours)	Recovery
Wind Speed	8760	8758	99.98%
Wind Direction	8760	8758	99.98%
Sigma-Theta	8760	8758	99.98%
Temperature	8760	8758	99.98%
Relative Humidity	8760	8758	99.98%
Precipitation	8760	8758	99.98%
Bar. Pressure	8760	3544	40.46%
Solar Radiation	8760	7571	86.43%

Source: Cameco Resources, 2012, data from 1/1/2011 to 12/31/2011

Table 2.5-5. Smith Ranch Meteorological Summary.

Wind Patterns

Figure 2.5-21 presents a wind rose for the Smith Ranch project site during the 12-month baseline monitoring period. Figure 2.5-22 presents a wind rose for the nearby Glenrock Mine site during the 14-year period of record. In both cases, the predominant wind direction is west-southwesterly, with a secondary mode from the north or north-northwest. The Glenrock Mine shows higher overall wind speeds and less variability in wind direction. This may be partially explained by the difference in tower height. Assuming average surface roughness (wind shear exponent of 0.15), wind speeds at 10 meters can be expected to exceed wind speeds at 3 meters by about 20%. Indeed, the 3-meter, baseline-year average wind speed of 12.2 mph at the Smith Ranch Project site projects to 14.6 mph at 10 meters – nearly identical to the 14.8 mph long-term average at the Glenrock Mine. To utilize the standard tower height, as well as the availability of all needed wind parameters and a longer period of record, the Glenrock Mine data were selected to represent on-site wind speed, wind direction and atmospheric stability class.

Figure 2.5-23 shows seasonal wind roses for the Glenrock Mine site. Spring and summer experience the greatest variability in wind direction with secondary northerly wind modes as a result of the synoptic scale transition period that occurs during this time. Fall and winter exhibit less variability along with higher wind speeds.

Figure 2.5-24 presents a diurnal graph of wind speeds at the Glenrock Mine site by season. Wind speeds peak during mid to late afternoon due to solar heating. The summer season exhibits the lowest average diurnal variation, although all seasons show approximately 5 mph difference between daytime and nighttime wind speeds.

Figure 2.5-25 shows the time distribution of wind speeds at the Glenrock Mine site. Half of the time wind speeds are more than 12 mph, while winds exceed 20 mph 18% of the time. Table 2.5-6 provides a breakdown of wind speeds by wind direction at the Glenrock Mine site. Wind speeds averaged 14.8 mph during the 14 years of monitoring, but increased to nearly 20 mph on average when the wind blew from the west-southwest. A secondary maximum occurs for northerly winds, which averaged nearly 16 mph. Southerly winds averaged less than 8 mph.

The Joint Frequency Distribution (JFD) provides more detail on wind speed distribution by wind direction and atmospheric stability class. The distribution shows the frequencies of hourly average wind speed for each direction based on stability class. Tables 2.5-7 and 2.5-8 list the average annual JFD for the Glenrock Mine meteorological station. Tables 2.5-9 through 2.5-16 list the average quarterly JFD's. A majority of the winds at the project site fall into stability class D which represents near neutral to slightly unstable conditions. The light-to-calm winds which accompany stable environments are reflected in the stability class F summary.

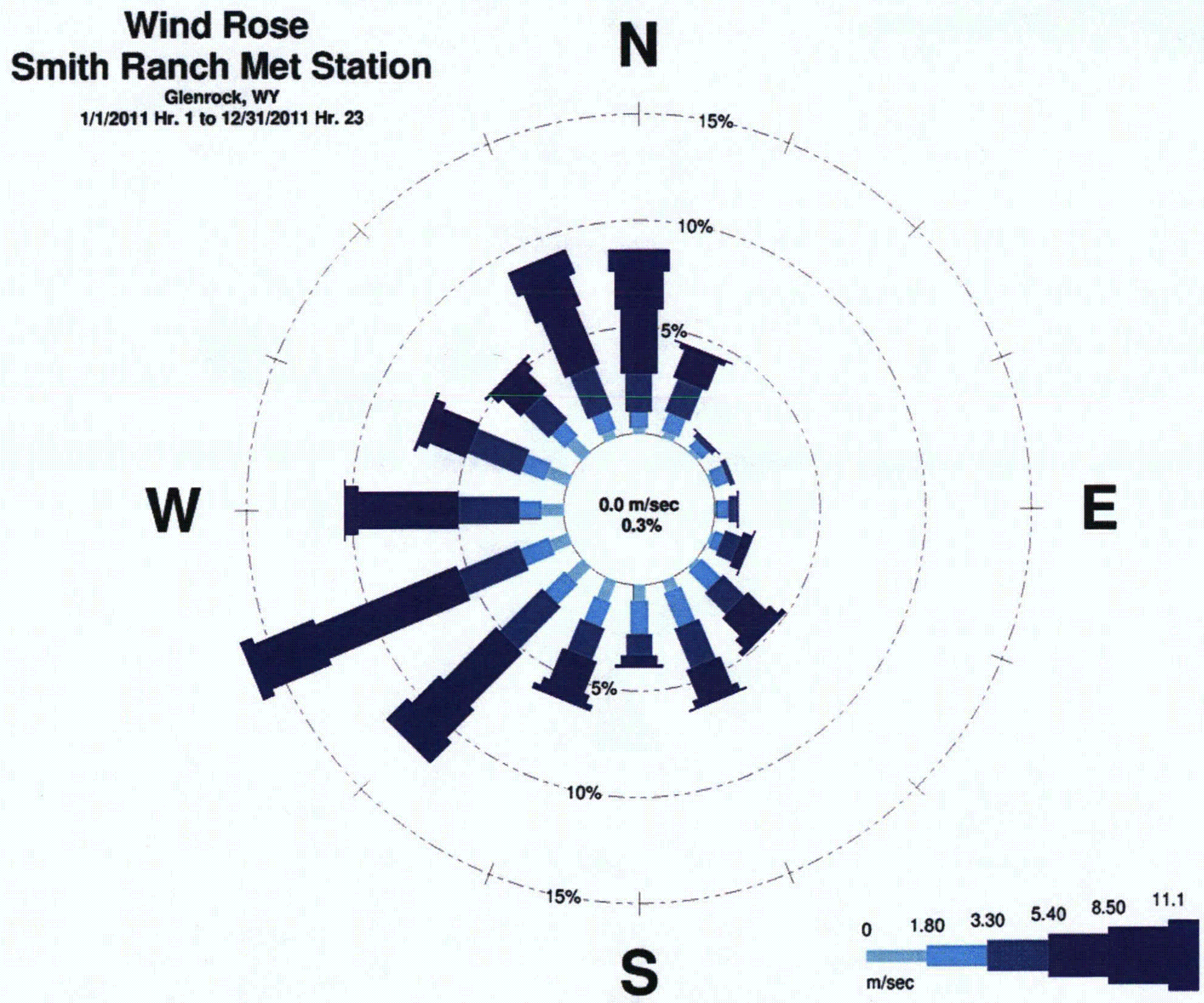


Figure 2.5-21. Smith Ranch Wind Rose.

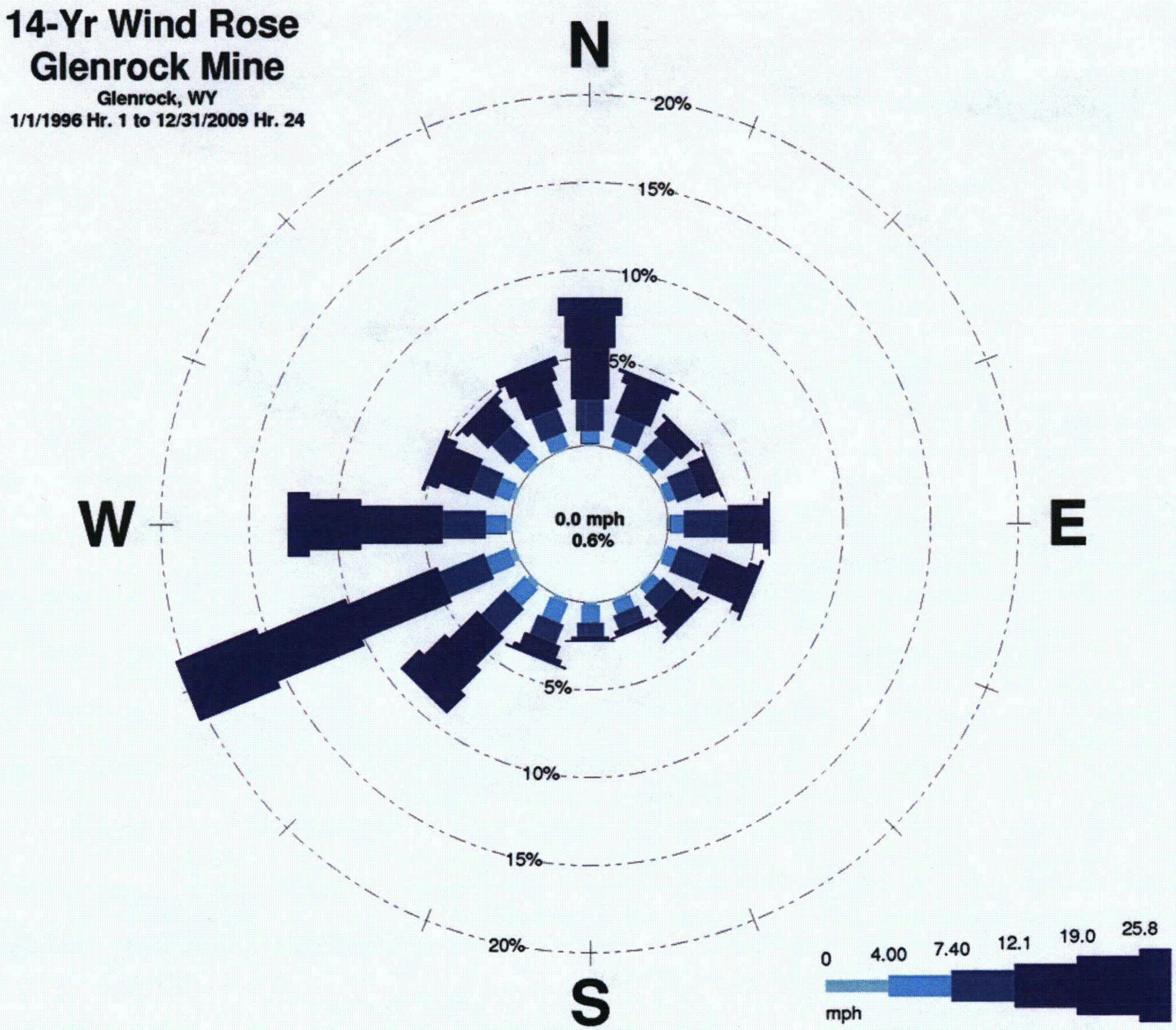


Figure 2.5-22. Glenrock Mine Wind Rose.

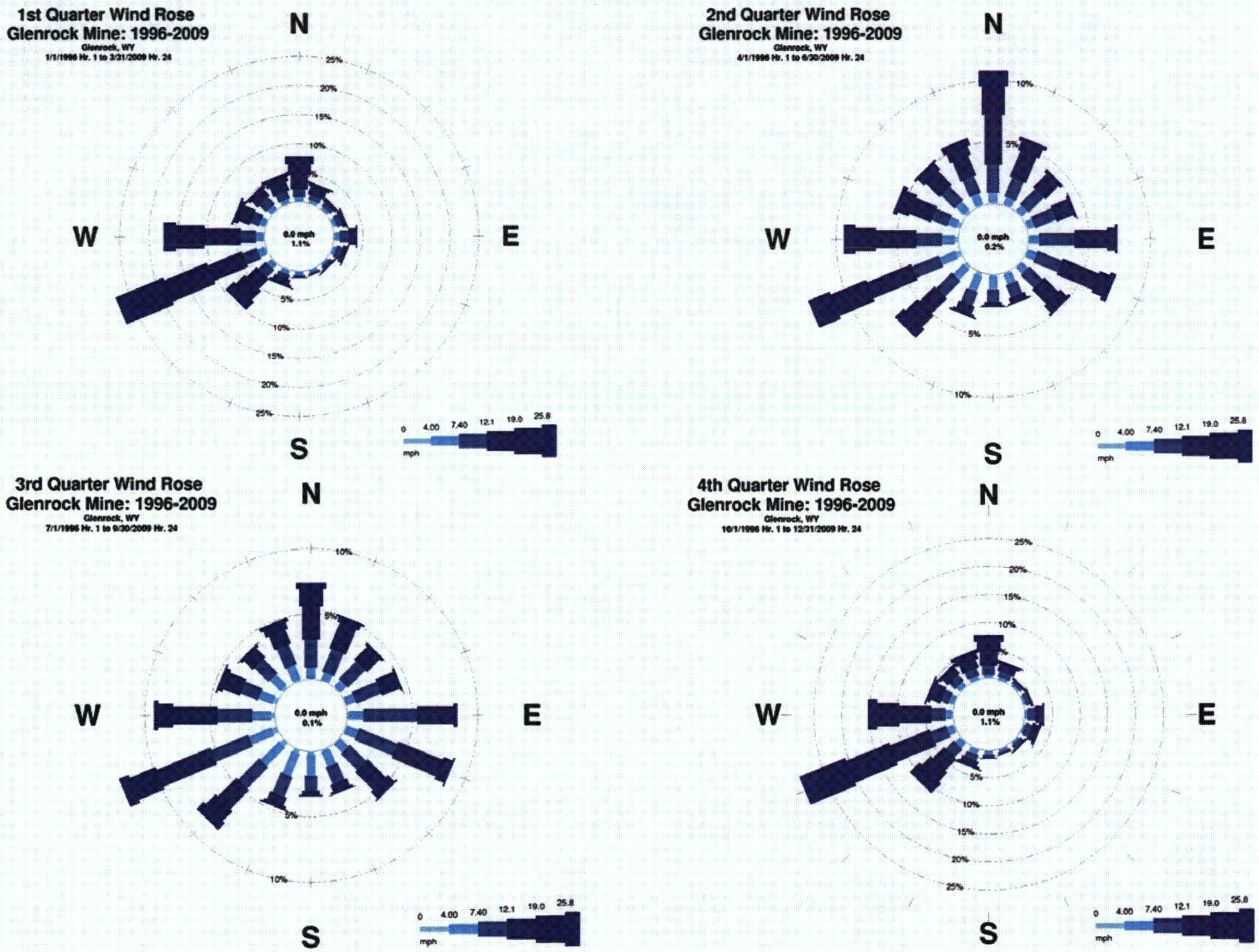
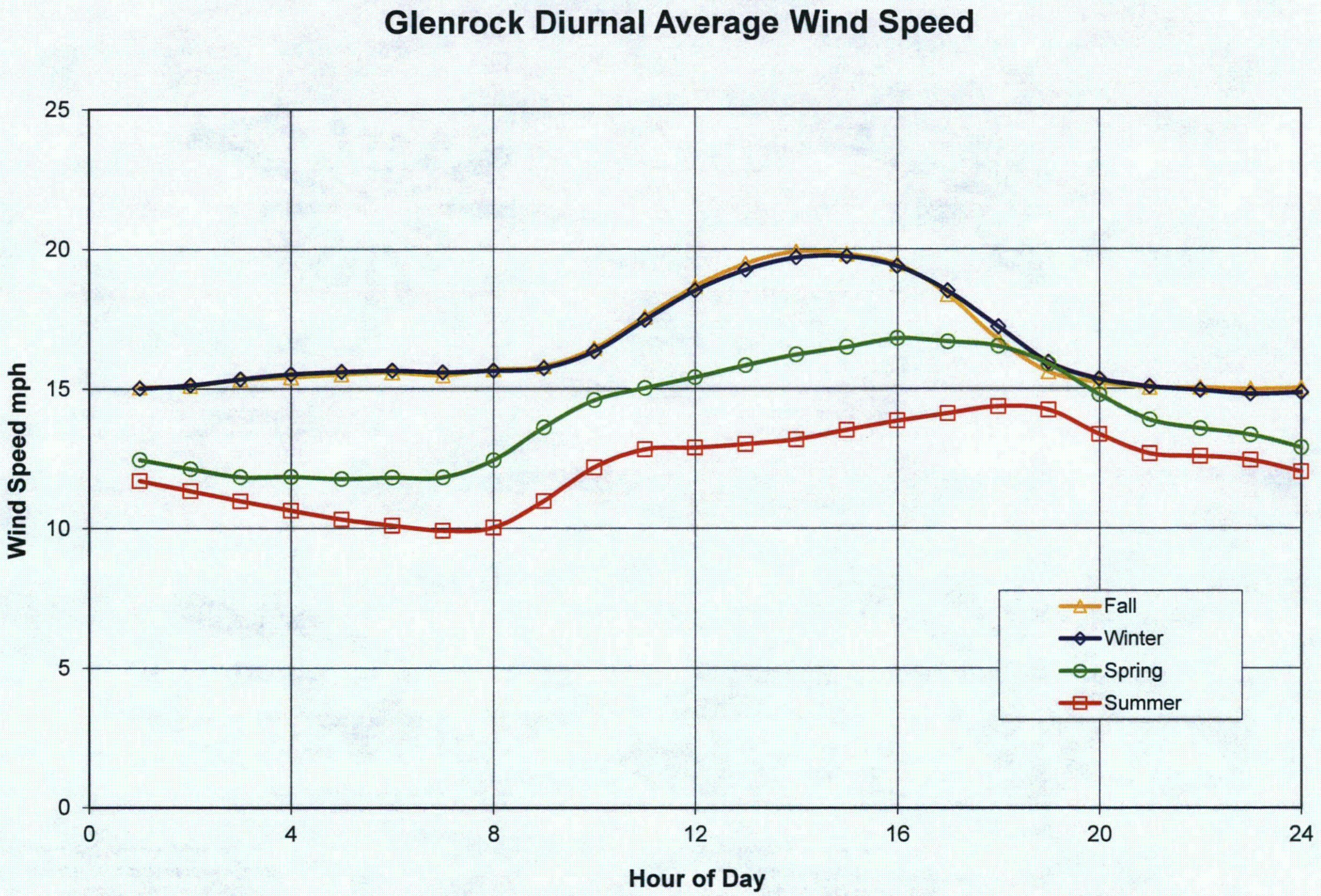
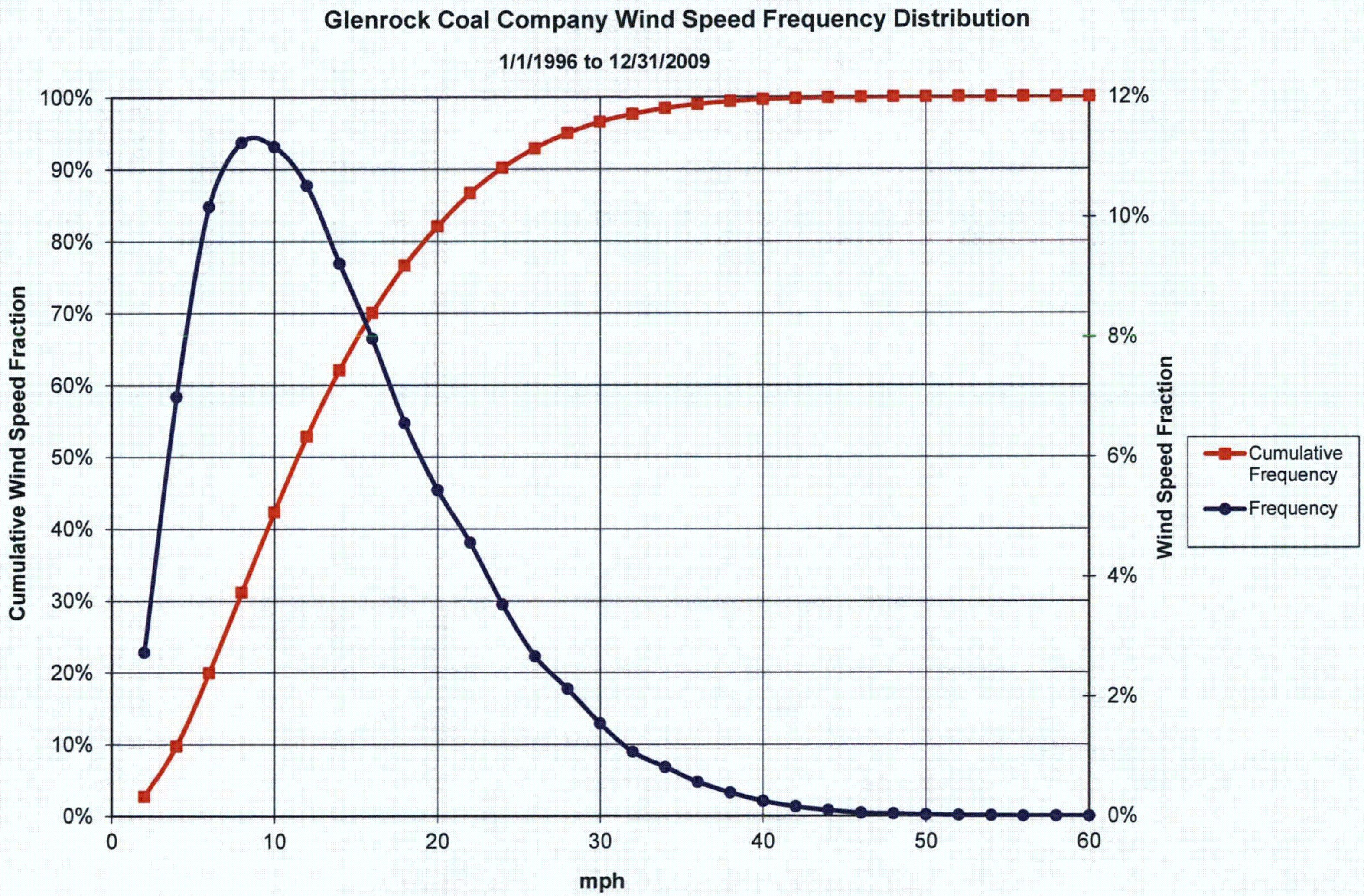


Figure 2.5-23. Glenrock Mine Seasonal Wind Roses.



Source: IML Database, 2012, data from 1/1/1996 to 12/31/2009

Figure 2.5-24. Glenrock Mine Diurnal Wind Speeds.



Source: IML Database, 2012, data from 1/1/1996 to 12/31/2009

Figure 2.5-25. Glenrock Mine Wind Speed Distribution.

Glenrock Coal Company

Wind Data Summary

1/1/1996 - 12/31/2011

Hourly Data

		Average	Max	Min
Wind Speed (mph)		14.78	59.42	-
Sigma Theta (°)		10.85	79.30	-
Wind Direction				
	N	15.65	52.70	-
	NNE	13.40	38.22	-
	NE	11.13	30.90	-
	ENE	10.96	29.80	-
	E	11.59	37.15	0.10
	ESE	13.08	38.80	-
	SE	12.48	39.44	-
	SSE	8.89	35.83	0.10
	S	7.94	34.50	-
	SSW	10.39	37.46	-
	SW	16.31	55.58	-
	WSW	19.66	59.42	-
	W	16.05	51.80	-
	WNW	12.72	44.90	0.10
	NW	11.81	40.95	0.00
	NNW	14.31	45.46	-

Predominant wind direction was from the WSW sector, accounting for 20.4% of the winds, the average wind direction was 270°.

Data Recovery

	Possible (hours)	Reported (hours)	Recovery
Wind Speed	140256	116446	83.02%
Sigma Theta	140256	113299	80.78%
Wind Direction	140256	116534	83.09%

Source: Cameco Resources, 2012, data from 12/8/2010 to 1/27/2012

Table 2.5-6. Glenrock Mine Wind Summary.

Stability Class	Wind Direction	Wind Speed (mph) - 14 Years						Row Total
		< 3	4 - 7	8 - 12	13 - 18	19 - 24	> 24	
A	N	0.000266	0.001222					0.001489
	NNE	0.000236	0.000921					0.001157
	NE	0.000328	0.000877					0.001205
	ENE	0.000297	0.000974					0.001271
	E	0.000307	0.001196					0.001503
	ESE	0.000348	0.001107					0.001456
	SE	0.000277	0.000824					0.001100
	SSE	0.000400	0.000957					0.001356
	S	0.000430	0.001399					0.001830
	SSW	0.000574	0.001727					0.002301
	SW	0.000523	0.001700					0.002223
	WSW	0.000564	0.001603					0.002167
	W	0.000533	0.001284					0.001817
	WNW	0.000584	0.001311					0.001895
	NW	0.000553	0.001603					0.002156
	NNW	0.000410	0.001523					0.001933
B	N	0.000031	0.001497	0.000195				0.001722
	NNE	0.000041	0.001213	0.000186				0.001440
	NE	0.000061	0.001293	0.000062				0.001417
	ENE	0.000051	0.000974	0.000106				0.001132
	E	0.000061	0.001337	0.000106				0.001505
	ESE	0.000082	0.001408	0.000089				0.001579
	SE	0.000061	0.001019	0.000062				0.001142
	SSE	0.000051	0.001240	0.000133				0.001424
	S	0.000123	0.001302	0.000115				0.001540
	SSW	0.000123	0.001444	0.000133				0.001699
	SW	0.000215	0.001860	0.000151				0.002226
	WSW	0.000266	0.002081	0.000319				0.002667
	W	0.000225	0.001957	0.000390				0.002573
	WNW	0.000154	0.001523	0.000186				0.001863
	NW	0.000133	0.001842	0.000266				0.002241
	NNW	0.000041	0.001692	0.000186				0.001919
C	N	0.000102	0.000691	0.004216				0.005009
	NNE	0.000051	0.000487	0.002462				0.003001
	NE	0.000031	0.000425	0.001568				0.002024
	ENE	0.000061	0.000372	0.001435				0.001868
	E	0.000123	0.000611	0.001842				0.002576
	ESE	0.000051	0.000753	0.002453				0.003257
	SE	0.000082	0.000850	0.002391				0.003324
	SSE	0.000092	0.000638	0.001736				0.002466
	S	0.000102	0.000903	0.000957				0.001962
	SSW	0.000143	0.001116	0.002090				0.003350
	SW	0.000246	0.001364	0.004269				0.005879
	WSW	0.000307	0.001515	0.005792				0.007614
	W	0.000215	0.001178	0.006023				0.007416
	WNW	0.000174	0.000841	0.003924				0.004939
	NW	0.000143	0.000788	0.003746				0.004678
	NNW	0.000072	0.000824	0.003481				0.004376

Source: IML Database, 2012, 1/1/1996 through 12/31/2009

Table 2.5-7. Glenrock Mine Year-Round Joint Frequency Distribution.

Stability Class	Wind Direction	Wind Speed (mph) - 14 Years						
		< 3	4 - 7	8 - 12	13 - 18	19 - 24	> 24	Row Total
D	N	0.000348	0.004978	0.018449	0.026659	0.013418	0.006882	0.070733
	NNE	0.000225	0.002737	0.012054	0.012851	0.003339	0.001045	0.032252
	NE	0.000389	0.002577	0.009858	0.005633	0.000762	0.000053	0.019272
	ENE	0.000359	0.002595	0.010726	0.005686	0.000549	0.000053	0.019968
	E	0.000359	0.004048	0.020805	0.011735	0.001630	0.000292	0.038868
	ESE	0.000236	0.004269	0.017696	0.016279	0.003277	0.001125	0.042881
	SE	0.000133	0.004296	0.007927	0.008299	0.002577	0.000593	0.023825
	SSE	0.000410	0.004411	0.003738	0.001727	0.000416	0.000080	0.010781
	S	0.000461	0.005438	0.002914	0.001382	0.000248	0.000018	0.010460
	SSW	0.000810	0.006634	0.006581	0.003605	0.001019	0.000372	0.019019
	SW	0.001004	0.008325	0.013259	0.018130	0.012435	0.011815	0.064968
	WSW	0.001404	0.010336	0.027146	0.059393	0.046374	0.040121	0.184775
	W	0.000840	0.008688	0.026579	0.044222	0.021363	0.008441	0.110133
	WNW	0.000717	0.006359	0.012019	0.014162	0.004216	0.001346	0.038819
	NW	0.000779	0.005792	0.011142	0.009610	0.003056	0.000877	0.031255
	NNW	0.000523	0.004730	0.010929	0.012311	0.006191	0.003738	0.038421
E	N	0.000328	0.002117	0.002010				0.004455
	NNE	0.000174	0.002391	0.003180				0.005745
	NE	0.000154	0.002161	0.003091				0.005406
	ENE	0.000215	0.002772	0.004482				0.007469
	E	0.000307	0.005128	0.008786				0.014221
	ESE	0.000174	0.002613	0.004322				0.007109
	SE	0.000266	0.002294	0.002072				0.004633
	SSE	0.000389	0.003498	0.001603				0.005491
	S	0.000594	0.004685	0.001461				0.006741
	SSW	0.000758	0.004898	0.001851				0.007507
	SW	0.000707	0.004552	0.002436				0.007695
	WSW	0.001066	0.003693	0.002542				0.007301
	W	0.000748	0.003047	0.002905				0.006700
	WNW	0.000666	0.002542	0.001453				0.004661
	NW	0.000441	0.003224	0.002188				0.005852
	NNW	0.000287	0.002958	0.002480				0.005725
F	N	0.000369	0.000381					0.000750
	NNE	0.000369	0.000523					0.000891
	NE	0.000348	0.000416					0.000765
	ENE	0.000420	0.000593					0.001014
	E	0.000359	0.000664					0.001023
	ESE	0.000400	0.000496					0.000896
	SE	0.000389	0.000443					0.000832
	SSE	0.000461	0.000531					0.000993
	S	0.000430	0.000611					0.001042
	SSW	0.000471	0.000514					0.000985
	SW	0.000748	0.000638					0.001386
	WSW	0.000789	0.000957					0.001746
	W	0.000820	0.001010					0.001830
	WNW	0.000994	0.000762					0.001756
	NW	0.000646	0.000664					0.001310
	NNW	0.000318	0.000638					0.000955

Source: IML Database, 2012, 1/1/1996 through 12/31/2009

Table 2.5-8. Glenrock Mine Annual Joint Frequency Distribution (cont.).

Stability Class	Wind Direction	Wind Speed (mph) - 14 Years, 1st Quarter						Row Total
		< 3	4 - 7	8 - 12	13 - 18	19 - 24	> 24	
A	N	0.000160	0.000244					0.000404
	NNE	0.000160	0.000203					0.000363
	NE	0.000213	0.000244					0.000457
	ENE	0.000320	0.000325					0.000645
	E	0.000267	0.000244					0.000511
	ESE	0.000427	0.000325					0.000752
	SE	0.000160	0.000447					0.000607
	SSE	0.000160	0.000366					0.000526
	S	0.000213	0.000406					0.000620
	SSW	0.000213	0.000285					0.000498
	SW	0.000267	0.000163					0.000429
	WSW	0.000213	0.000406					0.000620
	W	0.000267	0.000244					0.000511
	WNW	0.000213	0.000285					0.000498
	NW	0.000267	0.000447					0.000714
	NNW	0.000374	0.000528					0.000902
B	N		0.000203					0.000203
	NNE	0.000107	0.000244					0.000351
	NE	0.000053	0.000122					0.000175
	ENE	0.000107	0.000244					0.000351
	E		0.000732					0.000732
	ESE	0.000053	0.000488					0.000541
	SE	0.000053	0.000366					0.000419
	SSE		0.000488	0.000041				0.000528
	S	0.000213	0.000285					0.000498
	SSW	0.000053	0.000406	0.000041				0.000501
	SW	0.000213	0.000650	0.000041				0.000905
	WSW	0.000374	0.000325	0.000041				0.000739
	W	0.000053	0.000650	0.000081				0.000785
	WNW	0.000160	0.000528	0.000041				0.000729
	NW	0.000160	0.000732	0.000122				0.001014
	NNW		0.000163	0.000081				0.000244
C	N	0.000107	0.000325	0.000894				0.001326
	NNE	0.000107	0.000447	0.000366				0.000920
	NE		0.000203	0.000081				0.000285
	ENE	0.000053	0.000325	0.000081				0.000460
	E	0.000213	0.000325	0.000163				0.000701
	ESE	0.000107	0.000488	0.000285				0.000879
	SE	0.000107	0.000366	0.000569				0.001042
	SSE	0.000053	0.000325	0.000447				0.000826
	S	0.000213	0.000244	0.000325				0.000783
	SSW	0.000053	0.000488	0.001098				0.001639
	SW	0.000320	0.000732	0.001667				0.002718
	WSW	0.000107	0.000935	0.001545				0.002586
	W	0.000160	0.000894	0.001382				0.002436
	WNW	0.000213	0.000935	0.001585				0.002734
	NW	0.000160	0.000569	0.001748				0.002477
	NNW	0.000053	0.000650	0.001016				0.001720

Source: IML Database, 2012, 1/1/1996 through 12/31/2009

Table 2.5-9. Glenrock Mine 1st Quarter Joint Frequency Distribution.

Stability Class	Wind Direction	Wind Speed (mph) - 14 Years, 1st Quarter						Row Total
		<3	4-7	8-12	13-18	19-24	>24	
D	N	0.000587	0.004471	0.017520	0.025812	0.015812	0.008536	0.072739
	NNE	0.000534	0.002764	0.007723	0.010243	0.002927	0.001382	0.025573
	NE	0.000747	0.002520	0.005894	0.003414	0.000650		0.013226
	ENE	0.001121	0.002317	0.006910	0.005040	0.000488		0.015876
	E	0.001067	0.004268	0.012845	0.008292	0.000894		0.027367
	ESE	0.000534	0.003658	0.008780	0.005000	0.000976	0.000081	0.019029
	SE	0.000160	0.003333	0.003333	0.001667	0.000488	0.000610	0.009591
	SSE	0.000801	0.003414	0.001341	0.000285	0.000041		0.005882
	S	0.000480	0.003862	0.002480	0.000610	0.000041		0.007472
	SSW	0.000747	0.004471	0.005284	0.002602	0.000528	0.000285	0.013917
	SW	0.000801	0.007154	0.011707	0.017398	0.014105	0.016056	0.067221
	WSW	0.001654	0.009959	0.028373	0.075525	0.073777	0.074672	0.263961
	W	0.001014	0.011300	0.034836	0.069916	0.039876	0.015812	0.172755
	WNW	0.001121	0.008902	0.016869	0.017560	0.004471	0.001626	0.050550
	NW	0.000587	0.007235	0.014024	0.011463	0.003658	0.001748	0.038716
	NNW	0.000267	0.004675	0.012642	0.013251	0.007073	0.003821	0.041729
E	N	0.000480	0.001829	0.001789				0.004098
	NNE	0.000160	0.002114	0.002276				0.004550
	NE	0.000213	0.001992	0.002236				0.004441
	ENE	0.000427	0.002805	0.003414				0.006646
	E	0.000694	0.004675	0.005244				0.010612
	ESE	0.000534	0.002845	0.002642				0.006021
	SE	0.000534	0.001260	0.001016				0.002810
	SSE	0.000534	0.002032	0.001016				0.003582
	S	0.000480	0.002642	0.000894				0.004017
	SSW	0.000801	0.002886	0.001341				0.005028
	SW	0.000747	0.003862	0.002439				0.007048
	WSW	0.001121	0.003089	0.002886				0.007096
	W	0.000747	0.004187	0.003821				0.008755
	WNW	0.000801	0.003536	0.001789				0.006126
	NW	0.000374	0.003902	0.002927				0.007203
	NNW	0.000267	0.003496	0.003252				0.007015
F	N	0.000534	0.000325					0.000859
	NNE	0.000374	0.000488					0.000861
	NE	0.000374	0.000406					0.000780
	ENE	0.000801	0.000894					0.001695
	E	0.000267	0.000813					0.001080
	ESE	0.000480	0.000894					0.001375
	SE	0.000480	0.000325					0.000806
	SSE	0.000427	0.000285					0.000711
	S	0.000374	0.000447					0.000821
	SSW	0.000427	0.000285					0.000711
	SW	0.000587	0.000528					0.001115
	WSW	0.001281	0.001016					0.002297
	W	0.000801	0.001057					0.001857
	WNW	0.000961	0.000528					0.001489
	NW	0.000534	0.000569					0.001103
	NNW	0.000160	0.000325					0.000485

Source: IML Database, 2012, 1/1/1996 through 12/31/2009

Table 2.5-10. Glenrock Mine 1st Quarter Joint Frequency Distribution (cont.).

Stability Class	Wind Direction	Wind Speed (mph) - 14 Years, 2nd Quarter						Row Total
		< 3	4 - 7	8 - 12	13 - 18	19 - 24	> 24	
A	N	0.000382	0.001679					0.002061
	NNE	0.000344	0.001168					0.001512
	NE	0.000496	0.001314					0.001810
	ENE	0.000458	0.000839					0.001298
	E	0.000458	0.001496					0.001955
	ESE	0.000535	0.001460					0.001995
	SE	0.000458	0.000912					0.001371
	SSE	0.000687	0.001277					0.001965
	S	0.000458	0.001788					0.002247
	SSW	0.000687	0.002263					0.002950
	SW	0.000420	0.002190					0.002610
	WSW	0.000840	0.002190					0.003030
	W	0.000726	0.001715					0.002441
	WNW	0.000955	0.001350					0.002305
	NW	0.000840	0.001825					0.002665
	NNW	0.000611	0.001752					0.002363
B	N	0.000038	0.001569	0.000146				0.001754
	NNE	0.000038	0.001277	0.000328				0.001644
	NE	0.000038	0.001642	0.000073				0.001754
	ENE	0.000115	0.000949	0.000146				0.001210
	E	0.000153	0.001533	0.000073				0.001759
	ESE	0.000153	0.001971	0.000146				0.002270
	SE	0.000115	0.001569	0.000146				0.001830
	SSE		0.001314	0.000182				0.001496
	S	0.000115	0.001277	0.000182				0.001575
	SSW	0.000229	0.001350	0.000182				0.001762
	SW	0.000191	0.002117	0.000073				0.002381
	WSW	0.000115	0.003212	0.000255				0.003582
	W	0.000420	0.002591	0.000438				0.003450
	WNW	0.000038	0.001642	0.000219				0.001900
	NW	0.000229	0.002409	0.000255				0.002894
	NNW		0.001460	0.000255				0.001715
C	N	0.000115	0.000657	0.007446				0.008217
	NNE	0.000076	0.000839	0.003431				0.004347
	NE	0.000038	0.000511	0.002774				0.003323
	ENE	0.000076	0.000328	0.002153				0.002558
	E	0.000076	0.000803	0.002737				0.003617
	ESE	0.000038	0.000912	0.002847				0.003798
	SE	0.000115	0.001423	0.003540				0.005078
	SSE	0.000076	0.000803	0.002591				0.003471
	S	0.000038	0.001131	0.001204				0.002374
	SSW	0.000076	0.001168	0.002883				0.004128
	SW	0.000191	0.001241	0.005621				0.007053
	WSW	0.000229	0.001642	0.007044				0.008916
	W	0.000038	0.001058	0.007190				0.008287
	WNW	0.000076	0.000620	0.005402				0.006099
	NW	0.000191	0.000620	0.005657				0.006469
	NNW	0.000076	0.000949	0.005183				0.006208

Source: IML Database, 2012, 1/1/1996 through 12/31/2009

Table 2.5-11. Glenrock Mine 2nd Quarter Joint Frequency Distribution.

Stability Class	Wind Direction	Wind Speed (mph) - 14 Years, 2nd Quarter						
		< 3	4 - 7	8 - 12	13 - 18	19 - 24	> 24	Row Total
D	N	0.000115	0.005730	0.022775	0.036025	0.016644	0.008979	0.090267
	NNE	0.000306	0.003066	0.015330	0.017337	0.005219	0.001715	0.042973
	NE	0.000382	0.002701	0.014636	0.009234	0.001350	0.000073	0.028377
	ENE	0.000306	0.003175	0.015038	0.008358	0.001022	0.000219	0.028118
	E	0.000229	0.004051	0.024418	0.017264	0.004197	0.001131	0.051291
	ESE	0.000076	0.004380	0.021680	0.025403	0.005511	0.003796	0.060847
	SE	0.000076	0.004781	0.010256	0.013724	0.005219	0.001350	0.035407
	SSE	0.000191	0.004562	0.004927	0.002518	0.000620	0.000182	0.013002
	S	0.000344	0.005621	0.003650	0.002153	0.000511	0.000036	0.012315
	SSW	0.000840	0.006351	0.006205	0.003942	0.001168	0.000620	0.019126
	SW	0.000993	0.007081	0.011315	0.015476	0.011497	0.007336	0.053698
	WSW	0.001489	0.008687	0.020439	0.037630	0.024637	0.014052	0.106935
	W	0.000764	0.006278	0.017520	0.028360	0.012373	0.006424	0.071718
	WNW	0.000726	0.004489	0.010439	0.015585	0.006022	0.002190	0.039451
	NW	0.000764	0.004161	0.010110	0.012446	0.004562	0.000730	0.032773
	NNW	0.000573	0.004745	0.010767	0.013249	0.005621	0.004818	0.039773
E	N	0.000420	0.002482	0.002409				0.005311
	NNE	0.000191	0.002482	0.003285				0.005958
	NE	0.000191	0.002701	0.004270				0.007162
	ENE	0.000115	0.002956	0.005548				0.008619
	E	0.000153	0.005110	0.009563				0.014825
	ESE	0.000038	0.002664	0.004745				0.007447
	SE	0.000191	0.002701	0.002518				0.005410
	SSE	0.000191	0.003942	0.001496				0.005629
	S	0.000420	0.004672	0.001642				0.006734
	SSW	0.000687	0.004818	0.001971				0.007476
	SW	0.000573	0.003613	0.001788				0.005975
	WSW	0.000993	0.003358	0.001569				0.005920
	W	0.000955	0.002591	0.001715				0.005262
	WNW	0.000687	0.001752	0.001241				0.003680
	NW	0.000344	0.002847	0.001569				0.004760
	NNW	0.000191	0.002956	0.001971				0.005118
F	N	0.000153	0.000693					0.000846
	NNE	0.000458	0.000766					0.001225
	NE	0.000344	0.000620					0.000964
	ENE	0.000420	0.000438					0.000858
	E	0.000229	0.000474					0.000704
	ESE	0.000306	0.000547					0.000853
	SE	0.000306	0.000365					0.000671
	SSE	0.000420	0.000547					0.000968
	S	0.000267	0.000438					0.000705
	SSW	0.000496	0.000474					0.000971
	SW	0.000649	0.000584					0.001233
	WSW	0.000764	0.000839					0.001603
	W	0.000611	0.000949					0.001560
	WNW	0.000878	0.000620					0.001499
	NW	0.000649	0.000949					0.001598
	NNW	0.000267	0.000620					0.000888

Source: IML Database, 2012, 1/1/1996 through 12/31/2009

Table 2.5-12. Glenrock Mine 2nd Quarter Joint Frequency Distribution (cont.).

Stability Class	Wind Direction	Wind Speed (mph) - 14 Years, 3rd Quarter						Row Total
		< 3	4 - 7	8 - 12	13 - 18	19 - 24	> 24	
A	N	0.000259	0.002552					0.002811
	NNE	0.000259	0.002013					0.002272
	NE	0.000369	0.001761					0.002131
	ENE	0.000259	0.002372					0.002631
	E	0.000406	0.002229					0.002635
	ESE	0.000332	0.001941					0.002274
	SE	0.000259	0.001474					0.001732
	SSE	0.000406	0.001869					0.002275
	S	0.000591	0.002732					0.003323
	SSW	0.000850	0.003415					0.004264
	SW	0.001034	0.003630					0.004665
	WSW	0.000776	0.002983					0.003759
	W	0.000554	0.002804					0.003358
	WNW	0.000702	0.003199					0.003901
	NW	0.000517	0.003235					0.003752
	NNW	0.000369	0.003127					0.003497
B	N	0.000037	0.003595	0.000503				0.004135
	NNE	0.000037	0.002732	0.000395				0.003164
	NE	0.000148	0.002912	0.000144				0.003203
	ENE		0.002049	0.000216				0.002265
	E		0.002372	0.000252				0.002624
	ESE	0.000111	0.002660	0.000180				0.002951
	SE		0.001582	0.000072				0.001653
	SSE	0.000111	0.002588	0.000288				0.002986
	S	0.000074	0.002768	0.000252				0.003093
	SSW	0.000111	0.003019	0.000288				0.003418
	SW	0.000222	0.003379	0.000431				0.004032
	WSW	0.000406	0.003702	0.000719				0.004828
	W	0.000111	0.003954	0.000863				0.004927
	WNW	0.000259	0.003307	0.000359				0.003925
	NW	0.000074	0.003379	0.000647				0.004100
	NNW	0.000074	0.004062	0.000324				0.004459
C	N	0.000111	0.000935	0.007333				0.008378
	NNE	0.000037	0.000431	0.005572				0.006040
	NE	0.000037	0.000467	0.003127				0.003631
	ENE	0.000074	0.000647	0.002912				0.003632
	E	0.000074	0.000863	0.003523				0.004459
	ESE	0.000037	0.000719	0.005464				0.006220
	SE	0.000037	0.001114	0.004960				0.006112
	SSE	0.000185	0.000935	0.003487				0.004606
	S	0.000111	0.001438	0.001653				0.003202
	SSW	0.000222	0.001510	0.003271				0.005002
	SW	0.000259	0.002229	0.007369				0.009856
	WSW	0.000517	0.002229	0.011287				0.014033
	W	0.000480	0.001582	0.011970				0.014032
	WNW	0.000222	0.001042	0.006434				0.007698
	NW	0.000148	0.001042	0.005679				0.006870
	NNW	0.000074	0.001006	0.005895				0.006975

Source: IML Database, 2012, 1/1/1996 through 12/31/2009

Table 2.5-13. Glenrock Mine 3rd Quarter Joint Frequency Distribution.

Stability Class	Wind Direction	Wind Speed (mph) - 14 Years, 3rd Quarter						
		< 3	4 - 7	8 - 12	13 - 18	19 - 24	> 24	Row Total
D	N	0.000369	0.003595	0.015672	0.021927	0.009058	0.003271	0.053892
	NNE		0.002516	0.015133	0.014234	0.002696	0.000539	0.035119
	NE	0.000185	0.002912	0.013983	0.007800	0.001006	0.000036	0.025922
	ENE	0.000111	0.002983	0.015564	0.006758	0.000791		0.026207
	E	0.000111	0.005607	0.030230	0.014055	0.000899	0.000036	0.050938
	ESE	0.000259	0.005320	0.028900	0.025126	0.003846	0.000359	0.063810
	SE	0.000074	0.005248	0.013192	0.015025	0.004062	0.000467	0.038068
	SSE	0.000259	0.006686	0.006290	0.003451	0.000899	0.000144	0.017728
	S	0.000702	0.007872	0.003307	0.002157	0.000431	0.000036	0.014505
	SSW	0.000850	0.009166	0.007584	0.004745	0.001582	0.000431	0.024358
	SW	0.001182	0.011251	0.013264	0.017901	0.008196	0.005176	0.056969
	WSW	0.001219	0.011538	0.023580	0.040546	0.014127	0.005715	0.096726
	W	0.000739	0.008267	0.020669	0.025270	0.007261	0.001977	0.064182
	WNW	0.000443	0.004565	0.007692	0.009561	0.002193	0.000431	0.024886
	NW	0.000776	0.005356	0.007081	0.005500	0.001438	0.000180	0.020330
	NNW	0.000369	0.005068	0.008519	0.008447	0.004457	0.002013	0.028874
E	N	0.000259	0.001510	0.001402				0.003170
	NNE	0.000074	0.002085	0.003055				0.005214
	NE	0.000074	0.002121	0.004098				0.006292
	ENE	0.000111	0.002840	0.005751				0.008702
	E	0.000185	0.007045	0.013659				0.020889
	ESE	0.000111	0.003630	0.006506				0.010247
	SE	0.000111	0.002840	0.003091				0.006042
	SSE	0.000406	0.004565	0.002157				0.007128
	S	0.000591	0.006902	0.001941				0.009434
	SSW	0.000887	0.006866	0.002444				0.010196
	SW	0.000554	0.006362	0.002372				0.009289
	WSW	0.000739	0.004170	0.002408				0.007317
	W	0.000554	0.002552	0.002229				0.005335
	WNW	0.000628	0.002336	0.000683				0.003647
	NW	0.000517	0.002552	0.001078				0.004148
	NNW	0.000369	0.002372	0.001618				0.004359
F	N	0.000332	0.000395					0.000728
	NNE	0.000222	0.000395					0.000617
	NE	0.000406	0.000395					0.000802
	ENE	0.000259	0.000683					0.000942
	E	0.000591	0.001042					0.001633
	ESE	0.000369	0.000503					0.000873
	SE	0.000259	0.000647					0.000906
	SSE	0.000480	0.000647					0.001127
	S	0.000517	0.001006					0.001524
	SSW	0.000480	0.000683					0.001163
	SW	0.000739	0.000791					0.001530
	WSW	0.000776	0.001042					0.001818
	W	0.000628	0.000971					0.001598
	WNW	0.001404	0.001006					0.002410
	NW	0.000739	0.000827					0.001566
	NNW	0.000369	0.000683					0.001052

Source: IML Database, 2012, 1/1/1996 through 12/31/2009

Table 2.5-14. Glenrock Mine 3rd Quarter Joint Frequency Distribution (cont.).

Stability Class	Wind Direction	Wind Speed (mph) - 14 Years, 4th Quarter < 3	4 - 7	8 - 12	13 - 18	19 - 24	> 24	Row Total
A	N	0.000282	0.000324					0.000606
	NNE		0.000202					0.000202
	NE	0.000169	0.000202					0.000372
	ENE	0.000169	0.000121					0.000291
	E		0.000445					0.000445
	ESE	0.000056	0.000243					0.000299
	SE	0.000226	0.000283					0.000509
	SSE	0.000282	0.000162					0.000444
	S	0.000282	0.000526					0.000808
	SSW	0.000395	0.000769					0.001164
	SW	0.000113	0.000729					0.000842
	WSW	0.000282	0.000607					0.000889
	W	0.000395	0.000243					0.000638
	WNW	0.000338	0.000486					0.000824
	NW	0.000508	0.000405					0.000912
	NNW	0.000226	0.000283					0.000509
B	N		0.000202	0.000040				0.000243
	NNE		0.000526					0.000526
	NE		0.000202					0.000202
	ENE		0.000243					0.000243
	E	0.000113	0.000364					0.000477
	ESE		0.000486	0.000040				0.000526
	SE	0.000113	0.000364					0.000477
	SSE		0.000364					0.000364
	S	0.000113	0.000567	0.000040				0.000720
	SSW		0.000526	0.000040				0.000567
	SW	0.000226	0.001134					0.001359
	WSW	0.000169	0.000567	0.000081				0.000817
	W	0.000226	0.000486	0.000202				0.000914
	WNW	0.000113	0.000445	0.000081				0.000639
	NW	0.000113	0.000688	0.000040				0.000842
	NNW	0.000113	0.000607					0.000720
C	N		0.000445	0.000972				0.001417
	NNE		0.000243	0.000445				0.000688
	NE	0.000056	0.000283	0.000121				0.000461
	ENE	0.000056	0.000243	0.000283				0.000583
	E	0.000113	0.000405	0.000769				0.001287
	ESE		0.000729	0.000526				0.001255
	SE	0.000056	0.000486	0.000567				0.001109
	SSE		0.000324	0.000283				0.000607
	S	0.000113	0.000810	0.000324				0.001246
	SSW	0.000282	0.000769	0.001093				0.002144
	SW	0.000226	0.001093	0.001579				0.002898
	WSW	0.000338	0.001012	0.002429				0.003780
	W	0.000226	0.001093	0.002024				0.003343
	WNW		0.000769	0.001174				0.001943
	NW	0.000113	0.000769	0.001255				0.002137
	NNW		0.000729	0.001336				0.002065

Source: IML Database, 2012, 1/1/1996 through 12/31/2009

Table 2.5-15. Glenrock Mine 4th Quarter Joint Frequency Distribution.

Stability Class	Wind Direction	Wind Speed (mph) - 14 Years, 4th Quarter						
		< 3	4 - 7	8 - 12	13 - 18	19 - 24	> 24	Row Total
D	N	0.000451	0.004980	0.018866	0.023765	0.013684	0.007368	0.069115
	NNE	0.000113	0.002146	0.008300	0.009636	0.002955	0.000810	0.023959
	NE	0.000395	0.001660	0.004049	0.002186	0.000081	0.000081	0.008451
	ENE	0.000113	0.001457	0.004534	0.002794			0.008898
	E	0.000226	0.001579	0.013563	0.007895	0.000810	0.000040	0.024112
	ESE	0.000113	0.003077	0.010364	0.008502	0.003077	0.000445	0.025578
	SE	0.000169	0.003360	0.003968	0.002065	0.000567	0.000040	0.010169
	SSE	0.000620	0.002834	0.002227	0.000324	0.000040		0.006045
	S	0.000338	0.003684	0.002389	0.000567	0.000040		0.007019
	SSW	0.000902	0.005789	0.007449	0.003482	0.000850	0.000243	0.018716
	SW	0.000959	0.007814	0.016721	0.022672	0.017976	0.021498	0.087639
	WSW	0.001354	0.011336	0.037045	0.086397	0.077328	0.069676	0.283135
	W	0.000902	0.009514	0.033482	0.056275	0.029231	0.012267	0.141672
	WNW	0.000902	0.007571	0.013522	0.014049	0.004049	0.001296	0.041388
	NW	0.001072	0.006316	0.013036	0.009879	0.003198	0.001134	0.034634
	NNW	0.000677	0.004291	0.012065	0.013806	0.007571	0.004575	0.042984
E	N	0.000226	0.002429	0.002470				0.005124
	NNE	0.000338	0.002429	0.004089				0.006857
	NE	0.000169	0.001457	0.001660				0.003287
	ENE	0.000282	0.002632	0.002955				0.005869
	E	0.000282	0.002753	0.005101				0.008136
	ESE	0.000169	0.001538	0.002996				0.004704
	SE	0.000226	0.002227	0.001781				0.004234
	SSE	0.000451	0.002915	0.002065				0.005431
	S	0.000620	0.004332	0.001579				0.006531
	SSW	0.000508	0.004413	0.001417				0.006338
	SW	0.000902	0.004534	0.003077				0.008514
	WSW	0.001692	0.004291	0.003603				0.009587
	W	0.000902	0.003239	0.004372				0.008514
	WNW	0.000620	0.002874	0.002510				0.006005
	NW	0.000508	0.004211	0.003279				0.007997
	NNW	0.000169	0.002874	0.003320				0.006364
F	N	0.000508	0.000162					0.000670
	NNE	0.000113	0.000324					0.000437
	NE	0.000113	0.000243					0.000356
	ENE	0.000282	0.000202					0.000484
	E	0.000338	0.000405					0.000743
	ESE	0.000620	0.000121					0.000742
	SE	0.000395	0.000364					0.000759
	SSE	0.000451	0.000445					0.000897
	S	0.000620	0.000648					0.001268
	SSW	0.000451	0.000486					0.000937
	SW	0.001015	0.000526					0.001541
	WSW	0.000395	0.000891					0.001285
	W	0.001241	0.001215					0.002455
	WNW	0.000790	0.000972					0.001761
	NW	0.000677	0.000364					0.001041
	NNW	0.000451	0.000810					0.001261

Source: IML Database, 2012, 1/1/1996 through 12/31/2009

Table 2.5-16. Glenrock Mine 4th Quarter Joint Frequency Distribution (cont.).

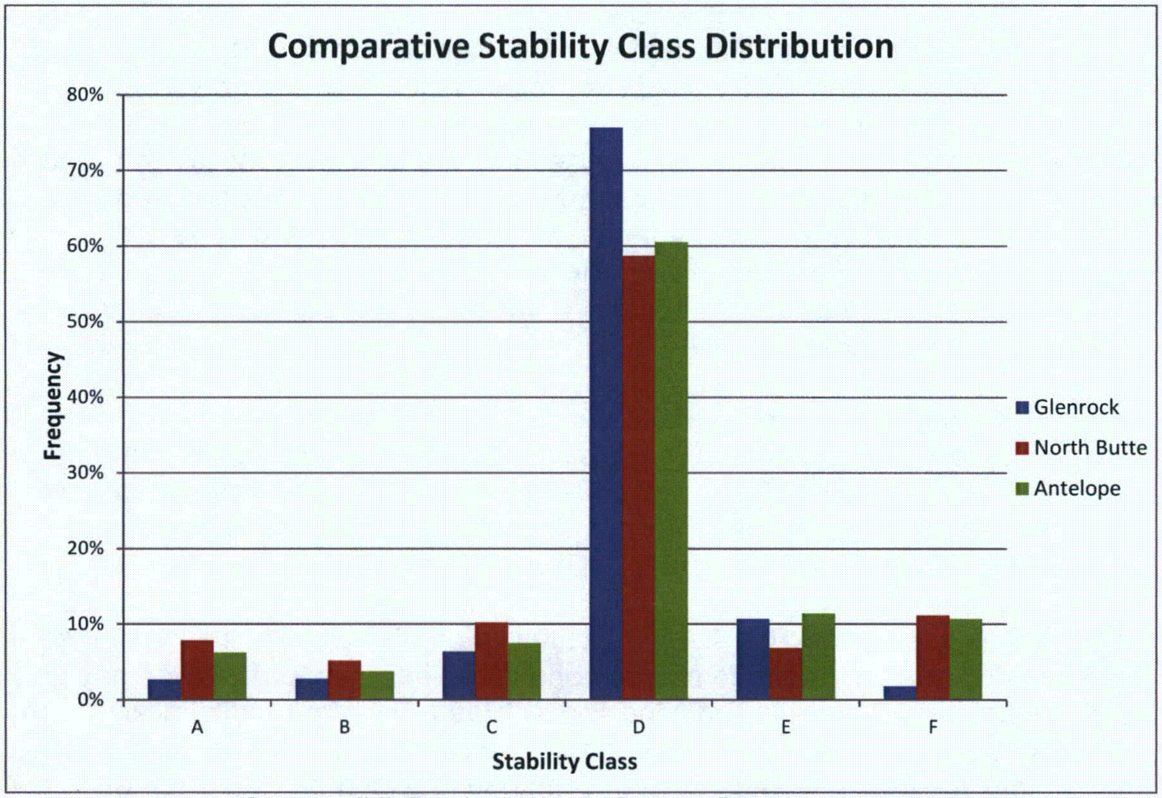
Atmospheric Stability Class

The σ_θ method was used to determine the Pasquill-Gifford stability class, where σ_θ refers to the standard deviation of the horizontal wind azimuth angle in degrees. This method is also referred to as the σ_A method (EPA 2000). It is a lateral turbulence based method which uses the standard deviation of the wind direction in combination with the scalar mean horizontal wind speed. Wind speed and direction data are recorded hourly at a height of 10 meters. To minimize the effects of wind meander, the 1-hour σ_θ is defined using 15-minute σ_θ values which are in turn based on more frequent sampling of wind direction (e.g. every five seconds).

According to this method, initial stability classes are assigned based solely on standard deviation of wind direction, or σ_θ. The initial assignments are then adjusted for horizontal wind speed. The magnitude of this adjustment depends on whether the measurement is taken during daylight or nighttime hours, a diurnal dependency that varies with the time of year.

Regulatory Guide 3.63 (NRC, 1988) states: "For obtaining an indication of the atmospheric stability, a method such as one of the following (Refs. 1-4) may be used: insolation cloud cover and wind speed (Pasquill-Gifford and similar methods), temperature lapse rate method, wind fluctuation method, split-sigma method, or Richardson Number." The σ_θ method is based on wind fluctuation and therefore its application to data from the nearby Glenrock Mine qualifies as an appropriate method for the Smith Ranch Project.

In order to demonstrate its reliability, a comparison was made between atmospheric stability class distributions in the Smith Ranch Project region using the σ_θ method. Figure 2.5-26 compares stability class distributions between the Glenrock Mine site, the North Butte Project site, and the Antelope Mine site. It can be seen that stability class D (neutral to slightly unstable air) dominates at all three sites, although it is even more dominant at Glenrock Mine. The most stable air, represented by stability class F, is more common at the North Butte Project and Antelope Mine than at the Glenrock Mine. This may be attributed to Glenrock's higher elevation and higher average wind speeds that promote atmospheric mixing.

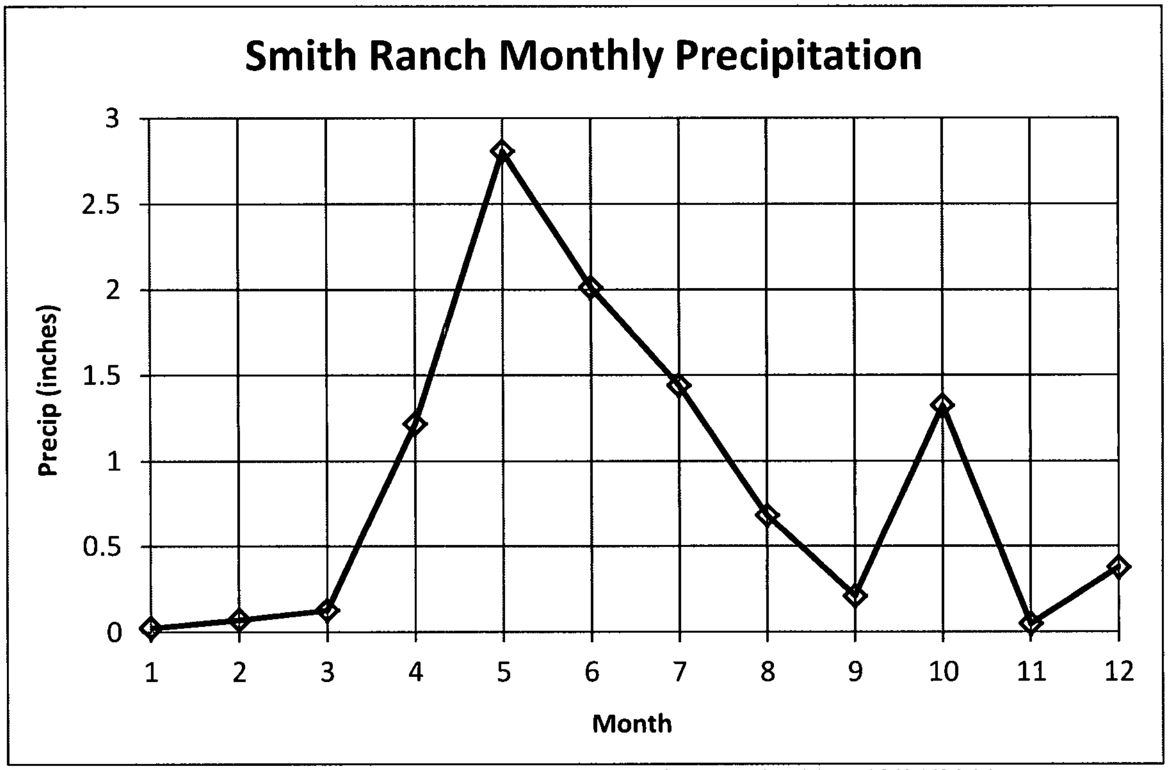


Sources: IML Database, 2012, Cameco Resources, 2012

Figure 2.5-26. Stability Class Distributions.

Precipitation

Figure 2.5-27 shows monthly precipitation at the Smith Ranch Project site during the baseline monitoring year. Total precipitation was slightly less than 10.3 inches, with nearly half of that falling during the months of May and June. Very little precipitation fell during the late summer and winter months. The site received 1.3 inches of precipitation in October. Based on long-term records at other weather stations in the region that show annual averages around 12 inches (Figure 2.5-7), precipitation recorded during the baseline monitoring year may be slightly less than that expected over the long term.

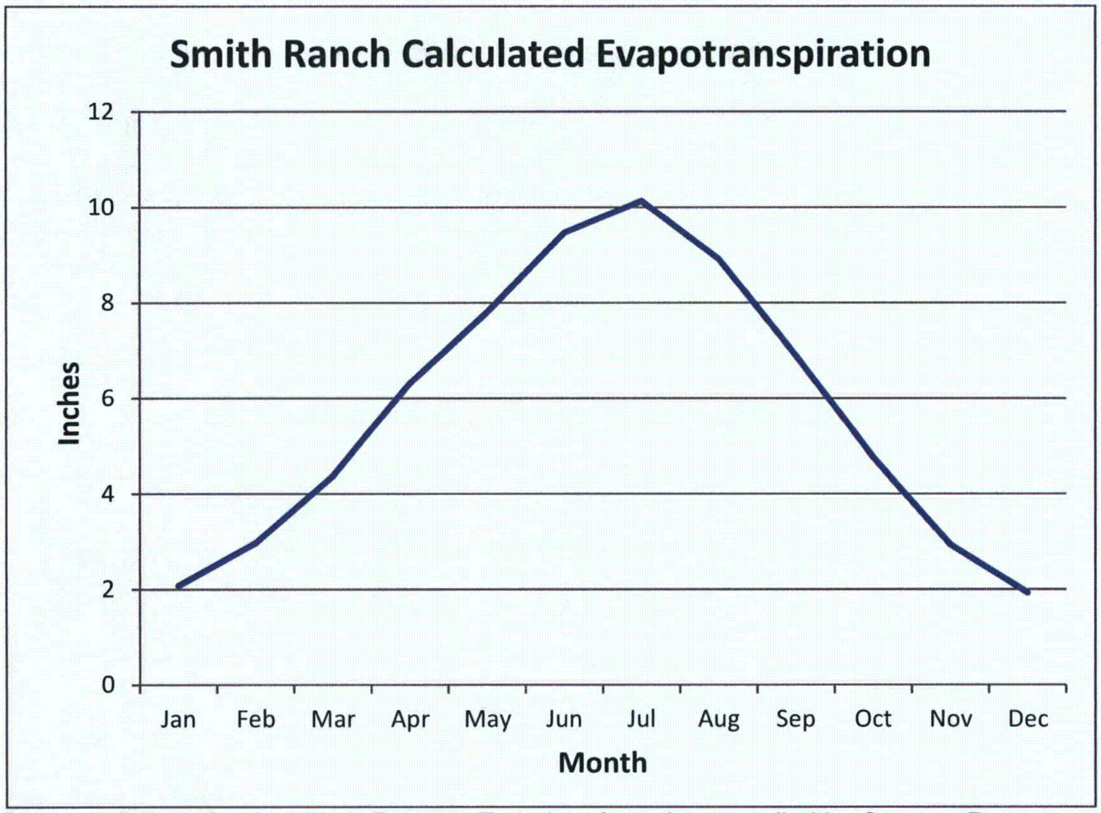


Source: Cameco Resources, 2012, data from 1/1/2011 to 12/31/2011

Figure 2.5-27. Smith Ranch Monthly Precipitation.

Evapotranspiration

No pan evaporation measurements were available at Cameco's Smith Ranch meteorological station or at the Glenrock Mine. Instead, daily evapotranspiration rates were calculated for the site by applying Penman's equation to recorded solar radiation, wind speed, temperature and relative humidity data. These calculations were then summed for each month. Figure 2.5-28 shows projected monthly evapotranspiration at the project site during the baseline monitoring period. From these calculations, annual evapotranspiration is projected at 68.6 inches. This total compares reasonably well to the long-term average pan evaporation of 63.7 inches at the Casper airport.



Sources: Calculation based on Penman Equation, from data supplied by Cameco Resources, from 1/1/2011 to 12/31/11

Figure 2.5-28. Smith Ranch Potential Monthly Evapotranspiration.

Justification of Baseline Year as Representative of Long Term Conditions

The Smith Ranch Project site is situated in east-central Wyoming. The baseline meteorological monitoring period extended approximately one year, from November 2, 2010 through December 31, 2011. Since wind data from the Smith Ranch Project site were not complete (lacking σ_{θ}) and the tower is less than 10 meters high, longer-term, hourly average wind data from the Glenrock Mine were utilized. This mine recently closed operations, so the data record extends from 1996 through 2009. The two sites are less than 8 miles apart and differ in elevation by only 82 ft.

Since the Glenrock Mine wind data span 14 years, they are believed to represent the long term. In order to demonstrate that they are also representative of the Smith Ranch Project site, a correlation analysis was conducted between the baseline wind data from Smith Ranch and the 14-year wind data from the Glenrock Mine.

To accomplish this, wind speed and wind direction frequency distributions were constructed. This constitutes a statistical methodology for assessing the degree to which the distributions of wind speed class and wind direction frequencies from one site represent those at a nearby site. For the joint frequency wind distribution used in the MILDOS-AREA model, wind speeds are divided into six classifications ranging from mild (0 – 3 mph) to strong (> 24 mph), as illustrated in Table 2.5-7 and Figure 2.5-28 above. Likewise, wind directions are divided into 16 categories corresponding to the compass directions illustrated in the wind roses presented above and in Figure 2.5-29.

The percent of the time that winds occur in each of the six wind speed categories can be calculated to produce a wind speed frequency distribution. The percent of the time that winds blow from each of the sixteen directions can be calculated to produce a wind direction frequency distribution. For each parameter, the frequency distributions can then be compared between two sites.

Comparison	Correlation Coefficient
Smith Ranch with Casper airport Long Term Wind Speeds	0.92
Smith Ranch with Casper airport Long Term Wind Directions	0.63
Smith Ranch with Glenrock Mine Long Term Wind Speeds	0.93
Smith Ranch with Glenrock Mine Long Term Wind Directions	0.79

Table 2.5-17. Glenrock Mine Fall Joint Frequency Distribution (cont.).

Table 2.5-17 summarizes the results of such a comparison of wind speed distributions and wind direction distributions. The comparison is made between the Smith Ranch Project site and the Casper airport site, and between the Smith Ranch Project site and the Glenrock Mine site. In both comparisons, wind speed distributions correlate very strongly (correlation coefficient greater than 0.9). The wind direction distributions correlate strongly (correlation coefficient between 0.7

and 0.9) when comparing Smith Ranch to the Glenrock Mine, but only moderately (0.4 to 0.7) when comparing Smith Ranch to the Casper airport. The strong correlation between Smith Ranch and the Glenrock Mine, for both wind speeds and wind directions, is proposed as justification for using the Glenrock Mine wind data.

It should be noted that this correlation would probably be even stronger if the two tower heights were the same. A 10-meter tower would be expected to measure higher wind speeds and less variability in wind direction than a 3-meter tower. Both these effects are observed in comparing the 10-meter tower data from the Glenrock Mine to the 3-meter tower data from the Smith Ranch Project site.

A second question must also be answered. Does the baseline year of wind data at Smith Ranch, which was used in the above comparison, represent the longer term? To answer this question, an analysis was performed comparing the baseline-year and the long-term wind speed and direction distributions at the Casper airport, 40 miles away.

Figure 2.5-29 shows wind roses for the Casper airport. The wind rose on the left reflects the last 15 years of monitoring, while the one on the right reflects the Smith Ranch Project site baseline year monitoring period only. It can be seen that wind speeds and directions are very similar between the 15-year and one-year monitoring periods.

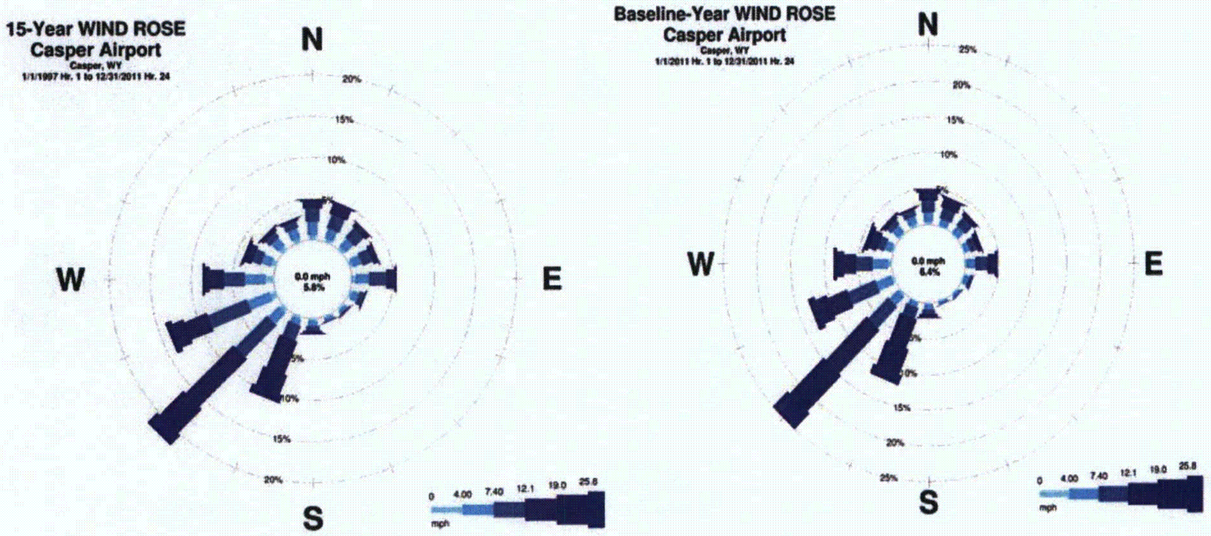
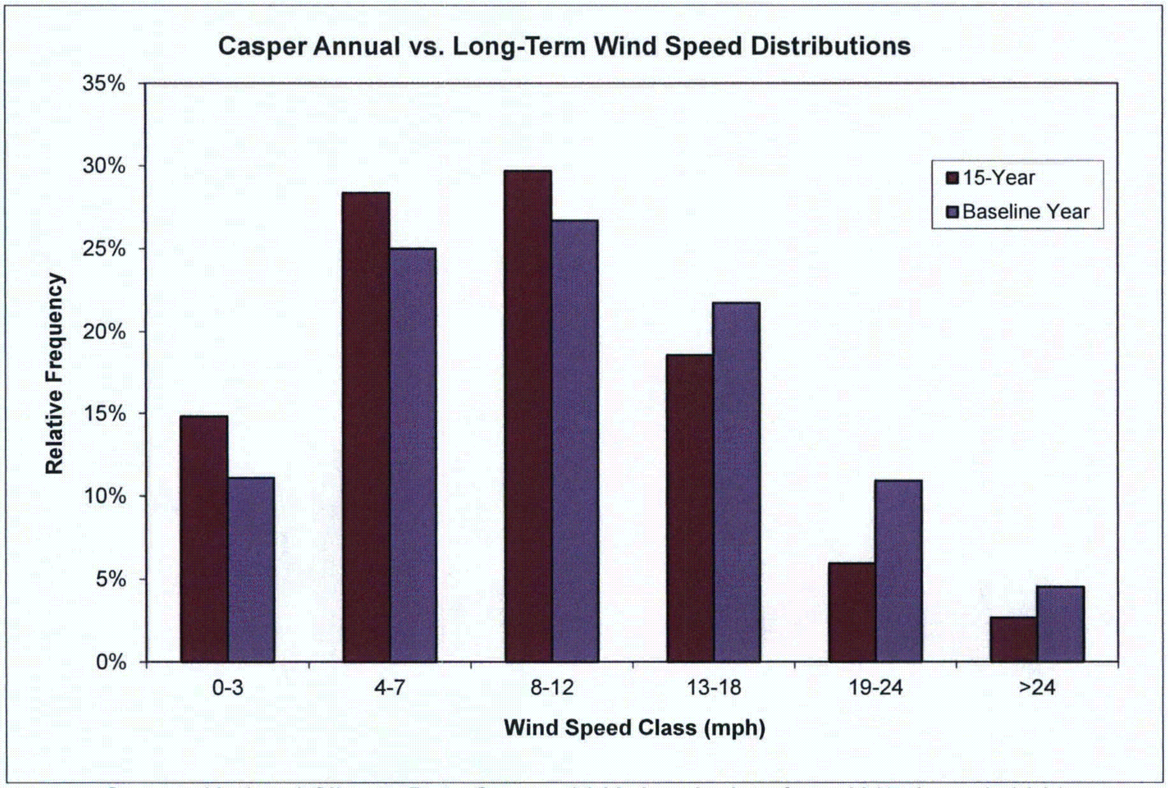


Figure 2.5-29. Casper Airport 15-Year vs Baseline Year Wind Roses.

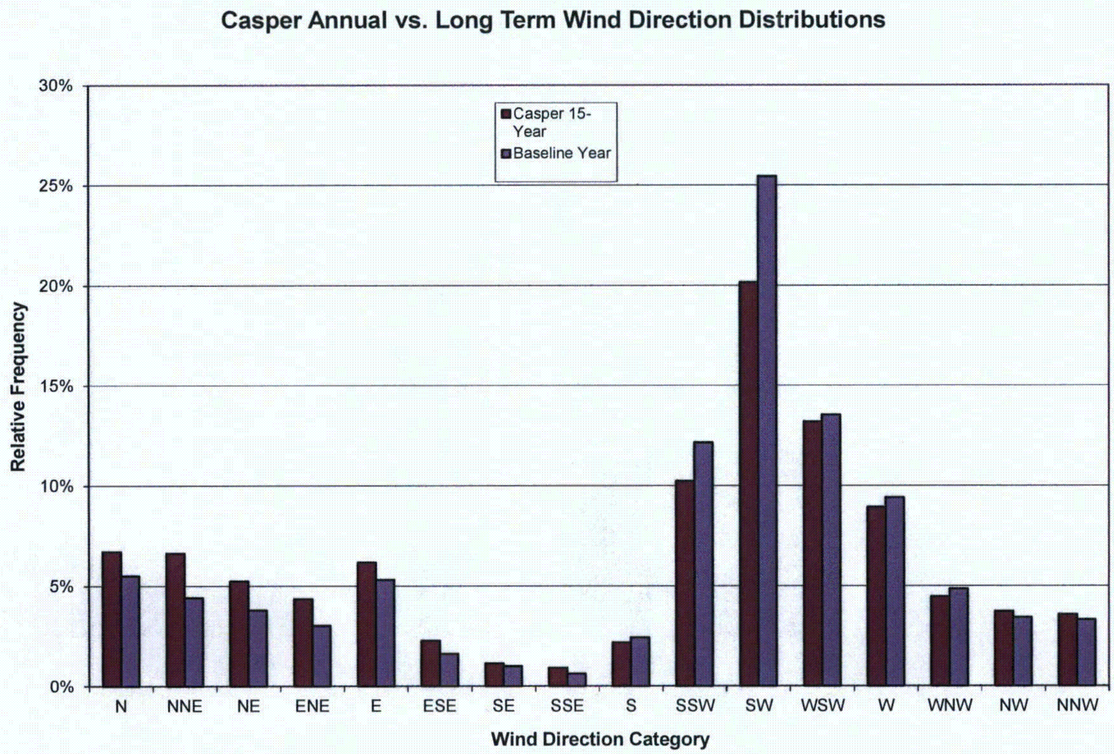
Figure 2.5-30 compares the wind speed frequency distributions between the 15-year and the baseline year periods at the Casper airport. The percent of the time the wind blows in each of the six wind speed categories shown, is quite similar for the two monitoring periods.



Source: National Climate Data Center, 2012, hourly data from 1997 through 2011

Figure 2.5-30. Casper Airport 15-Year vs Baseline Year Wind Speeds.

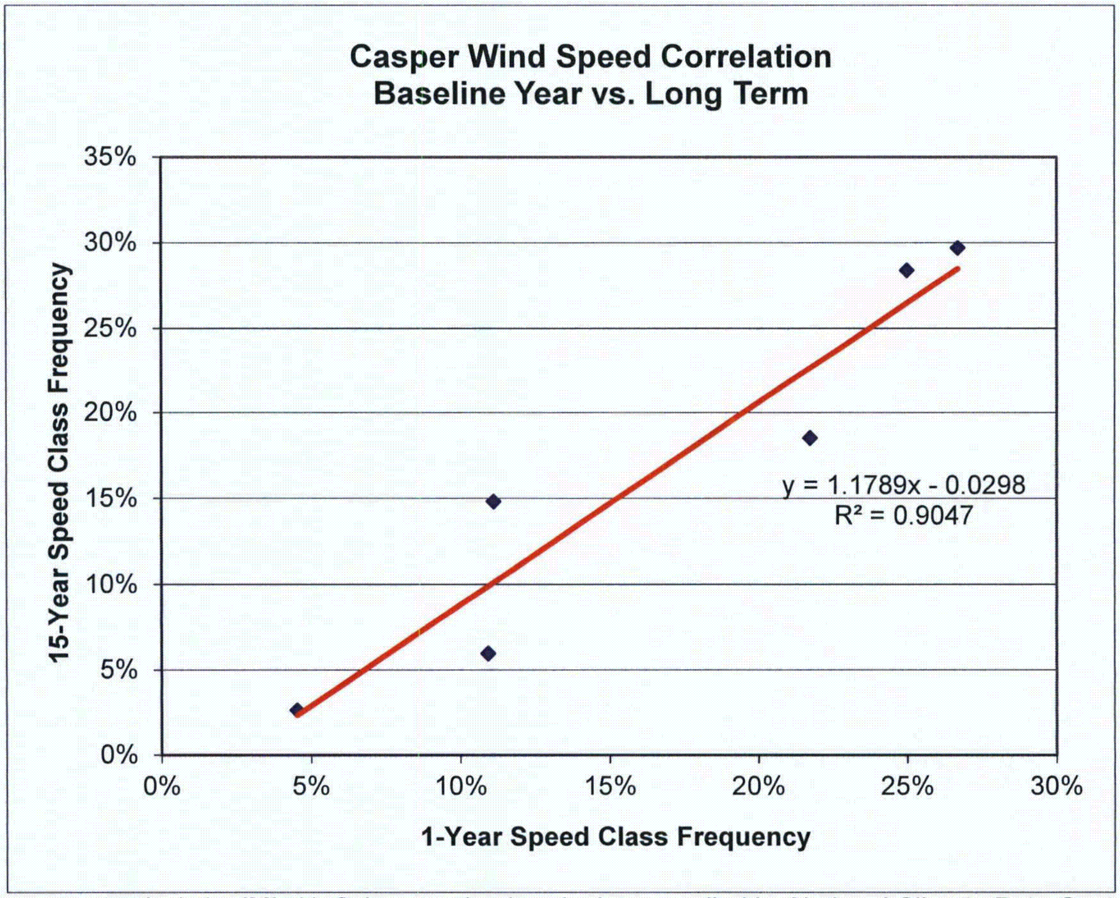
Figure 2.5-31 compares the wind direction frequency distributions between the 15-year and baseline periods at the Casper airport. The percent of the time the wind blows from each of the sixteen wind directions shown, is quite similar for the two monitoring periods.



Source: National Climate Data Center, 2012, hourly data from 1997 through 2011

Figure 2.5-31. Casper Airport 15-Year vs Baseline Year Wind Directions.

Figure 2.5-32 presents a linear regression analysis for the short and long term wind speed distributions at the Casper airport. Each point represents one of the six wind speed classes. The “x” coordinate corresponds to the percent of the one-year period during which the wind speed fell in a given class, while the “y” coordinate corresponds to the percent of the 15-year period during which the wind speed fell in that same class.



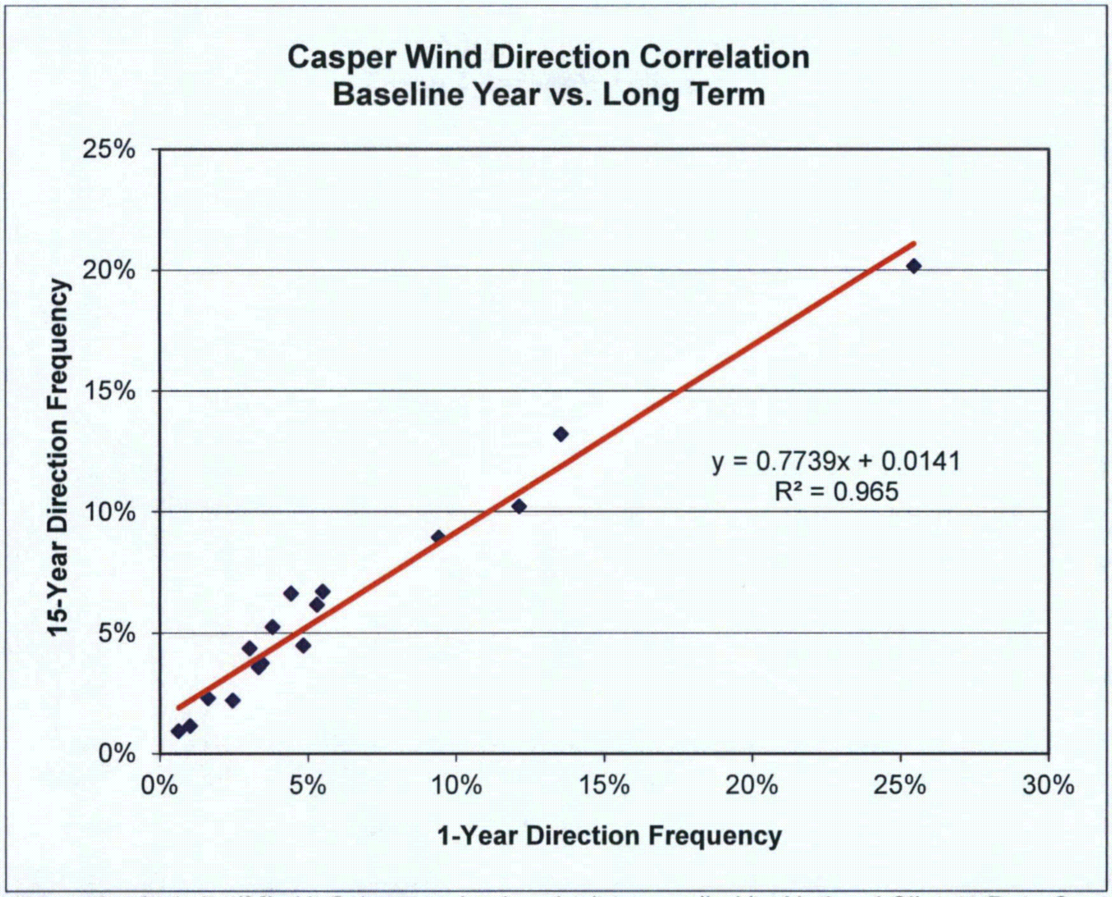
Sources: Analysis by IML Air Science using hourly data supplied by National Climate Data Center from 1997 to 2011

Figure 2.5-32. Casper Airport 15-Year vs Baseline Year Wind Speed Distributions.

The regression line (red) in Figure 2.5-32 represents the least-squares fit to the six data points. The corresponding R^2 value of 90.5% implies very strong linear correlation.

A similar analysis can be performed for wind direction frequencies. Figure 2.5-33 presents this regression analysis, again for the Casper airport site. Each point represents one of the sixteen wind direction categories. The "x" coordinate corresponds to the percent of the one-year period during which the wind blew from a given direction, while the "y" coordinate corresponds to the percent of the 15-year period during which the wind blew from that same direction.

The regression line (red) in Figure 2.5-33 represents the least-squares fit to the sixteen data points. The corresponding R^2 value of 96.5% implies very strong linear correlation between short and long term wind directions.



Sources: Analysis by IML Air Science using hourly data supplied by National Climate Data Center from 1996 to 2012

Figure 2.5-33. Casper Airport 15-Yr vs Baseline Yr Wind Direction Distributions.

Figures 2.5-29 through 2.5-33 offer conclusive evidence that the 2011 baseline monitoring year adequately represents the last 15 years at Casper.

Since the one-year wind data serve as reliable predictors of the long-term wind conditions at the Casper airport, and since the Smith Ranch site experiences similar regional weather patterns, it is proposed here that the Smith Ranch one-year baseline monitoring represents long-term meteorological conditions at the Smith Ranch Project site. It is further proposed that since the 14-year Glenrock Mine wind data correlate strongly with the baseline-year data from the Smith Ranch Project site, the Glenrock Mine provides a surrogate site from which to generate valid joint frequency distributions for MILDOS modeling.

Surrogate On-Site Meteorological Instrument Specifications

Table 2.5-18 lists the meteorological instruments employed at the Glenrock Mine meteorological monitoring station. The table shows instrument models, accuracy specifications, and instrument heights above the ground. Specifications for the meteorological instruments are contained in Appendix A to this document.

Meteorological data collection, management and reporting methods at the Glenrock Mine site conformed to NRC atmospheric dispersion modeling requirements for uranium milling operations, and meet the acceptance criteria established in the NRC's NUREG-1569. Hourly average values for wind speed, wind direction, sigma theta, temperature, and precipitation were generated by field instruments and recorded by continuous data loggers. Data recovery exceeded 93% for all parameters during the 14-year monitoring period from 1996 through 2009. All hourly data were downloaded to a relational database for quality assurance, statistical analysis and reporting purposes.

Glenrock (GCC)	10m tower	CR10 Data Logger		Lat: 43° 03' 36" Long: -105° 50' 24"	Elev. 5,674 ft
Parameter	**Instrument**	**Range**	**Accuracy**	**Threshold**	**Instrument Height**
Wind Speed	RM Young Wind Monitor AQ	0-112 mph	±0.4 mph or 1% of reading	0.9 mph	10 meters
Wind Dir	RM Young Wind Monitor AQ	0-360°	±3°	1.0 mph	10 meters
Temp	Fenwall Electronics Model 107	Temp: -35°-50° C	±0.5° C @ given Range	--	2 meters
Precip	Met One 8" tip	0 - 8"	±0.5% @ 0.5 in/hr rate	--	1 meter

Source: IML, 2012

Table 2.5-18. Glenrock Mine Monitoring Details

Upper Atmosphere Characterization

Mixing height is the height of the atmosphere above the ground that is well mixed due either to mechanical turbulence or convective turbulence. The air layer above this height is stable. Higher mixing heights are associated with greater dispersion, all other parameters being the same. Stable periods have much lower mixing heights and accompanying lapse rates allowing for less temperature variation. The MILDOS-AREA model uses mixing height, along with other wind parameters, to predict pollutant dispersion. Unstable air leads to more dispersion, which leads to lower predicted impacts on ambient air quality. The default mixing height used by MILDOS-AREA is 100 meters, a very conservative value.

The nearest upper-air data available from the National Weather Service are from Lander, Wyoming, approximately 150 miles west of the site. Average mixing heights were derived from the AERMOD calculations used for dispersion modeling, based on hourly data obtained from the National Weather Service station in Lander (upper air). The AERMOD calculation is based on a combination of mechanically and convectively driven boundary layer processes. The results of these calculations are provided for morning and afternoon periods in Table 2.5-19. The 24-hour annual average mixing height is 916 meters.

Time Period (Filtered)	**Average Mixing / Inversion Height**
Morning (2 am – 7 am)	579 meters
Afternoon (2 pm – 7 pm)	1,123 meters

Sources: IML computation based on data from National Climate Data Center, 2011

Table 2.5-19. Lander Mixing Heights.

The mixing or inversion heights are entered as inputs to the MILDOS-AREA model for pollutant dispersion modeling. For the Smith Ranch Project, the MILDOS modeling run used the default mixing height of 100 meters, which is more conservative than the measured mixing heights at Lander.

Bodies of Water and Special Terrain Features

The nearest significant body of water to the proposed Smith Ranch project is the North Platte River, approximately 16 miles south of the project site. It is unlikely that the influence of this river could be measured 16 miles away with a standard humidity probe.

The nearest mountain range to the Smith Ranch site is the Laramie Mountain Range, approximately 24 miles to the south. The northern portion of this range is oriented in an east-west direction, with elevations ranging from 6,000 to nearly 8,000 ft. It is believed that the northern Laramie Range impacts meteorology at the Smith Ranch Project site, channeling westerly and northwesterly flow that characterizes the region in general. The Laramie Range also shields the Smith Ranch Project site from a secondary southeasterly flow that is evident at the Douglas airport to the east. These influences result in higher average wind speeds and less variability in wind direction.

Conclusion

The Smith Ranch Project in east-central Wyoming is located in a semi-arid or steppe climate. The area is characterized by abundant sunshine, low relative humidity, and sustained winds which lead to high evaporative demand. The region has large diurnal and annual variations in temperature.

Five meteorological stations were used to characterize regional weather patterns. The region experiences average daily maximum temperatures near 90° in July and average daily minimum temperatures near 15° F in January. There are large diurnal and annual variations in temperature. The region has cold harsh winters, warm dry summers, and cool springs and autumns. Temperature extremes range from approximately -30° F in the winter to over 100° F in the summer. The on-site average temperature during the baseline monitoring year at Smith Ranch was 44.7° F with extremes of -21° to +94° F. The region generally receives little precipitation with annual averages between 10.5 and 12.5 inches. Spring and early summer precipitation events are responsible for over half of the yearly average.

The region is characterized by annual average wind speeds of 10 to 15 mph. Based on long-term monitoring at the Glenrock Mine, winds at the Smith Ranch site (10 meters above the ground) are expected to average nearly 15 mph annually, with summer averages dipping to near 11 mph and winter averages approaching 18 mph. The predominant wind directions are from the west-southwest and southwest.

It has been demonstrated that annual average 10-meter wind speeds at the Glenrock Mine and the Smith Ranch Project site are substantially equivalent. It has been further demonstrated that despite the difference in tower heights, the wind direction distributions between the two sites correlate strongly. These two facts justify the use of the Glenrock Mine meteorological monitoring data as a surrogate for on-site wind conditions. Having established a relationship between on-site and surrogate wind data, the Casper airport meteorological station was added to the site specific analysis to validate the temporal representativeness of on-site wind data. This was achieved by linear regression, comparing hourly average Casper airport wind data from a 15-year period of record to hourly average Casper airport data from the baseline year of 2011. The evidence strongly supports the assertion that winds during the baseline year at the Smith Ranch Project site are representative of the long term, thereby validating the similarities drawn between short-term, on-site data and long-term, Glenrock Mine data.

References

Curtis, J. and K. Grimes, 2007: *Wyoming Climate Atlas.* Available: http://www.wrds.uwyo.edu/wrds/wsc/climateatlas/ [2007,May 2].

National Climatic Data Center (NCDC), 2012: *Surface Data, Monthly Extremes.* Available: https://nes.ncdc.noaa.gov/sub-login.html [2012].

M. E. Jensen, R. D. Burman, and R. G. Allen 1990. Evapotranspiration and Irrigation water Requiremtnts , ASCE manuals and Reports on Engineering Practice NO.70 American Society of Civil Engineers NY 1-332.

Cameco Resources, Smith Ranch On-Site Meteorological Monitoring Data, November 2, 2010 through December 31, 2011.

Western Regional Climate Center (WRCC), *Pan Evaporation by State*, 2012. Available: http://www.wrcc.dri.edu/htmlfiles/westevap.final.html

Mesowest, *Wyoming Climate Observations and Summaries*, 2012. Available: http://raws.wrh.noaa.gov/roman/states/WY_state_frame.html

NRC, *NUREG-1569, Standard Review Plan for In Situ Leach Uranium Extraction License Applications, Final Report*, June 2003.

NRC, *Regulatory Guide 3.63, Onsite Meteorological Measurement Program for Uranium Recovery Facilities – Data Acquisition and Reporting*, March 2008.

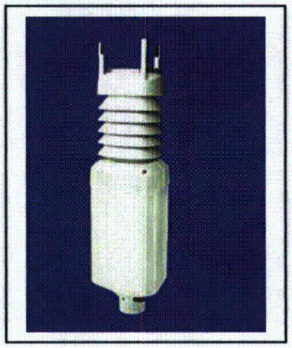
U.S. EPA, *On-Site Meteorological Program Guidance for Regulatory Modeling Applications*, February 2000.

Appendix A

Smith Ranch Meteorological Station Specifications

WeatherHawk Series 500 Specifications

Weather Station



Temperature Range:	-40 to +122F (-40 to +50C)
Data Storage:	60 days of hourly data
I/O:	Direct connection RS232 Optional Wireless RF
I/O Data Rate:	9600 baud
Wireless Frequency:	Spread Spectrum 916 MHz
Battery:	Integrated 2.9 AHr Lead-Acid GelCel
Charging Voltage:	16 t0 22 VDC
Current Drain:	10 mA w/o heater 1.1 A with heater

Sensors

Air Temperature:		Capacitive ceramic
	Range	-60 to +140F (-52 to +60 C)
	Accuracy:	+/-0.9 F @ -40 to 125 F (+-0.5 C @-40 to 52 C)
	Resolution:	0.1 F (0.1 C)
Relative Humidity:		Capacitive thin-film polymer
	Range	0-100%
	Accuracy:	+/- 3% @ 0-90%RH; +/- 5% @ 90-100%RH
	Resolution:	0.1%
Barometric Pressure:		Capacitive Silicon
	Range:	17.72-32.48 inHg (60-110 kPa)
	Accuracy:	.015 inHg @+32 to +86 F (+-.05 kPa @0-32 C)
	Resolution:	.03 inHg @-60 to +140 F (+-.1 kPa @-52 to +60 C)
Solar Radiation:		Silicon pyranometer
	Spectral Range	300 to 1100 nm
	Reproducibility	+/-2%
	Output	.2 mV per W/m^2
	Range	0 to 1000 W/m^2
	Temp. Range	-40 to 130 F (-40 to +55 C)
Rain:		Piezoelectric
	Collecting Area	9.3 in^2 (60 cm^2)
	Range	0 to 7.87 in/hr (0 to 200 mm/hr)
	Accuracy:	<5% (weather dependant)
	Resolution	.001 in (.01 mm)
Wind Direction:		Ultrasonic
	Azimuth:	0-360 deg
	Response Time:	250 ms
	Accuracy:	+- 2 deg
	Resolution:	1 deg
Wind Speed:		Ultrasonic
	Range:	0-134 mph (0-60 m/s)
	Response Time:	.25 s
	Accuracy:	+-.67 mph (+- 0.3m/s) or +-2% which ever is greater
	Resolution:	.22 mph (0.1 m/s)

WeatherHawk, 185 West 1800 North, Logan, UT
International: 435-750-1802 TOLL FREE USA: 866-670-5982 FAX: 435-750-1749
http://www.weatherhawk.com sales@weatherhawk.com

Appendix C

North Butte Remote Satellite Meteorological Analysis

(Revised November 2014)

North Butte Remote Satellite Uranium Project Meteorology Analysis

Cameco Resources
Casper, Wyoming

July 2012

Prepared by:

INTER-MOUNTAIN LABS

IML Air Science
a division of Inter-Mountain Laboratories, Inc.
555 Absaraka
Sheridan, WY 82801
(307) 674-7506

Table of Contents

Figures

Tables

Appendices

Introduction

The North Butte Remote Satellite in northeastern Wyoming is located in a semi-arid or steppe climate. The area is characterized by abundant sunshine, low relative humidity, and sustained winds, which lead to high evaporative demand. The region is characterized seasonally by cold winters, warm, dry summers, and cool springs and autumns. Temperature extremes range from approximately -40° F in the winter to 100° F in the summer. There are also large diurnal variations in temperature. The "last freeze" occurs in mid to late-May and the "first freeze" in early to mid-September.

Yearly precipitation typically averages between 8 and 14 inches. The North Butte area is prone to severe thunderstorm events throughout the spring and early summer months. Spring snowstorms and spring/summer thunderstorm events account for the majority of the precipitation during this time period. In a typical year, the region will see 3 or 4 severe thunderstorm events (as defined by the National Weather Service criteria) and 30 to 40 thunderstorm days. Snow falls in the region throughout late fall, winter and spring, totaling approximately 56 inches per year but varying widely with location and elevation. Snowfall contributes substantially to the annual precipitation totals.

Windy conditions are common to this region. Annual wind speeds average from approximately 9.0 to 12.5 mph, with lower wind speeds observed during the summer months. The predominant wind direction is from the west-southwest, with stronger western components at Antelope Mine and stronger southwestern components in the North Butte Remote Satellite area.

For the regional analysis, meteorological data were compiled for three sites surrounding the North Butte Remote Satellite area. Hourly average data were acquired from the National Weather Service (NWS) Gillette airport (AP) site, through the National Climate Data Center (NCDC, 2012). Data from the Antelope and Wyodak surface coal mines were acquired from the IML meteorological monitoring database. Pan evaporation and degree day data from Gillette were obtained from the Western Region Climate Center (WRCC). Snowfall data from Gillette were obtained from the High Plains Regional Climate Center (HPRCC). Among these regional sites, the Antelope Mine site is the closest, at just 36 miles away; the Gillette AP site is the closest NWS weather station to the North Butte Remote Satellite (approximately 41 miles away).

For the site-specific analysis, meteorological data from Cameco's North Butte Remote Satellite meteorological station were used. These data were collected during an approximately one-year baseline monitoring period extending from December 21, 2010 through January 5, 2012. Meteorological data from the North Butte site include wind speed, wind direction, temperature at 2 meters height, relative humidity, precipitation, solar radiation, and temperature at 10 meters height.

Table 2.5-1 lists the regional and on-site meteorological stations used for this analysis, along with coordinates, elevation, and period of record.

Name	Agency	Long	Lat	Z (ft)	Years of Data
Gillette	NWS	-105° 32'	44° 20'	4354	2005 - 2012
Antelope Coal Mine	IML	-105° 20'	43° 28'	4680	1986 - 2012
Wyodak Mine	IML	-105° 22'	44° 16'	4601	2003 - 2012
North Butte On-Site	Cameco	-105° 55'	43° 46'	5100	2010 - 2012

Table 2.5-1. Meteorological Stations Included in Climate Analysis.

These sites have been analyzed collectively to provide a regional range of monthly average temperatures, wind speeds and directions, precipitation, relative humidity, evaporation and snowfall. The Gillette, Wyodak, and Antelope sites form a north-south transect east of the North Butte project site. **Figure 2.5-1** shows the locations of these sites, along with the North Butte Remote Satellite site. On-site evapotranspiration rates were calculated for the North Butte project site by applying Penman's equation to available solar radiation, wind speed, temperature and relative humidity data.

Regional and Site Specific Meteorological Characterization

In the information that follows, a regional overview is presented first. This section includes a discussion of the maximum and minimum temperature and relative humidity, annual precipitation including snowfall estimates, and a brief wind speed and direction summary. Data from a combination of monitoring stations has been analyzed for the regional overview of temperature, snowfall, and total precipitation.

A site specific analysis follows the regional overview. Most of this analysis is based on the on-site monitoring. An in-depth wind analysis summarizes average wind speeds and directions, wind roses, wind speed frequency distributions, and a joint (wind speed and direction) frequency distribution to characterize the wind data for the North Butte site by atmospheric stability class. The method of stability class determination is described and illustrated. A discussion of monthly and seasonal data is included for the temperature, precipitation, evapotranspiration and wind parameters. General upper atmosphere data from the National Weather Service station at Lander, Wyoming were used to represent mixing heights at the project site. The site specific analysis includes a justification for using wind data from the baseline monitoring year to predict meteorological conditions over the long term. This is necessary to validate air sampling locations and MILDOS dispersion modeling inputs. The short and long term wind data from the Antelope Mine site are correlated for this purpose.

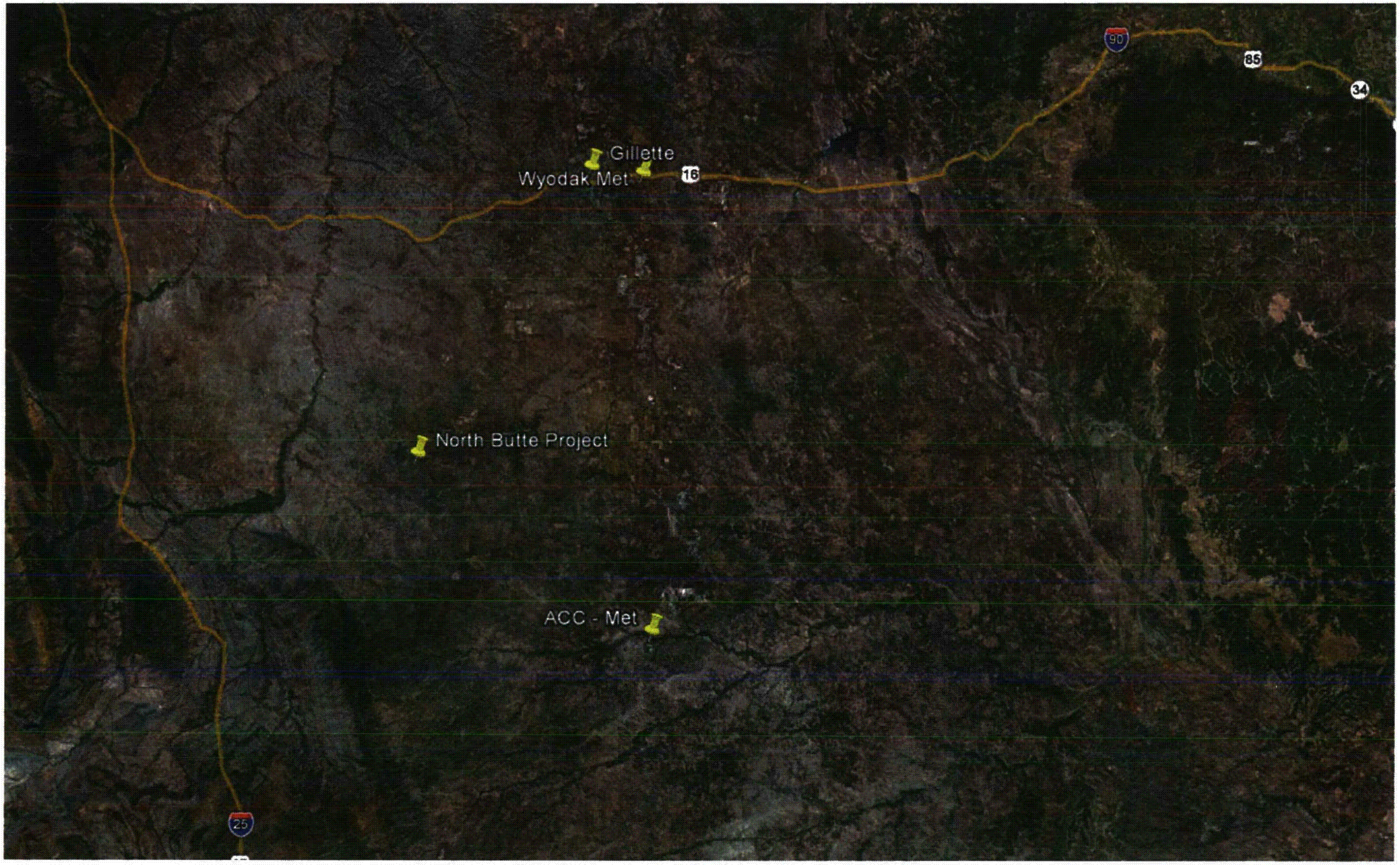


Figure 2.5-1. Regional Meteorological Stations.

Regional Overview

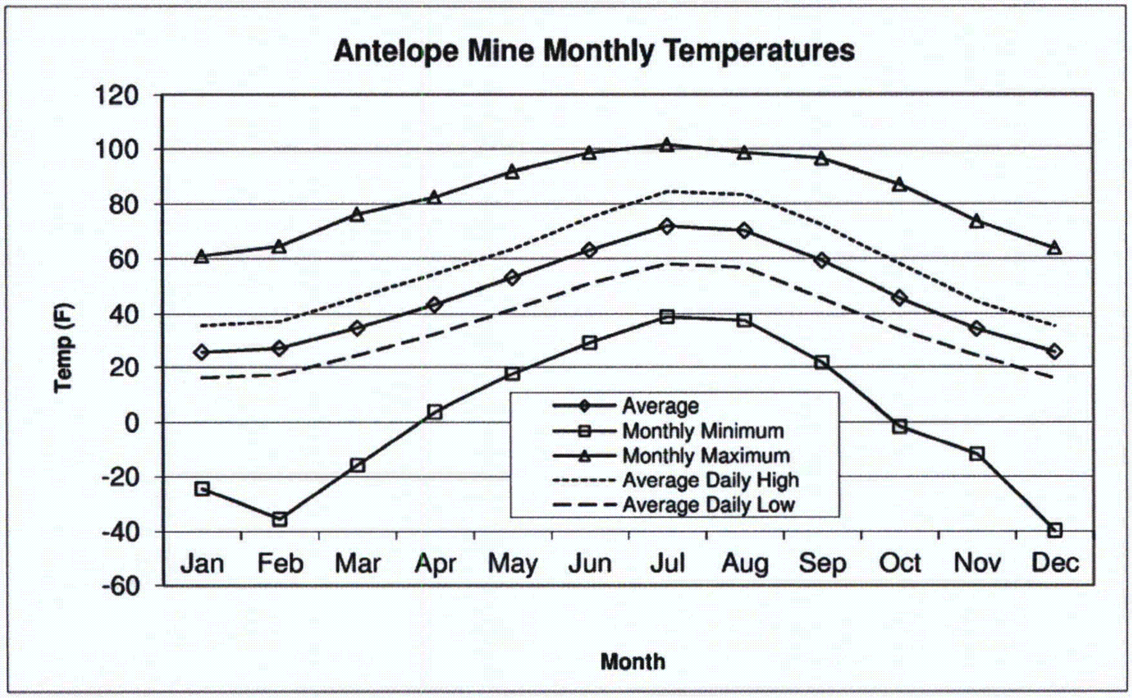
Temperature

The annual average temperature for the region containing the North Butte project site ranges from 46.1° F at Antelope Mine (elevation 4,680 ft) to 45.0° at North Butte (elevation 5,100 ft).

Figure 2.5-2 shows monthly average temperatures for the Antelope Mine site, monthly average daily highs and lows, and the monthly maximum and minimum temperatures over the last 25 years. July typically has the highest average monthly temperature (71.9° F), followed by August. January typically records the lowest average temperatures for the year (25.6° F), followed by December. **Table 2.5-2** shows monthly temperature statistics for the Antelope Mine site. Temperature extremes at Antelope Mine during the 26 period of record ranged from -25° F to 97° F. Low temperatures in the region can drop to -40º F, while high temperatures can be as high as 105° F.

Large diurnal temperature variations occur in the region due in part to its high altitude and low humidity. **Figure 2.5-3** depicts the monthly diurnal temperature variation for the Antelope Mine site from January, 1986 through January, 2012. Spring and summer daily variations of 20-25° F are typical, with maximum temperature variations exceeding 40° F during extremely dry periods. Less daily variation is observed during the cooler portions of the year as fall and winter have average variations of approximately 15° F. This can be attributed to more stable atmospheric conditions in the region during the fall and winter months. Stable periods have much lower mixing heights and accompanying lapse rates, allowing for less temperature variation.

Figure 2.5-4 shows monthly temperature statistics for the Antelope Mine meteorological station, with the Cameco North Butte on-site station included for reference. On a seasonal basis, temperatures in the region average between approximately 20° and 27° F during winter months and between 60° and 73° F during summer months.



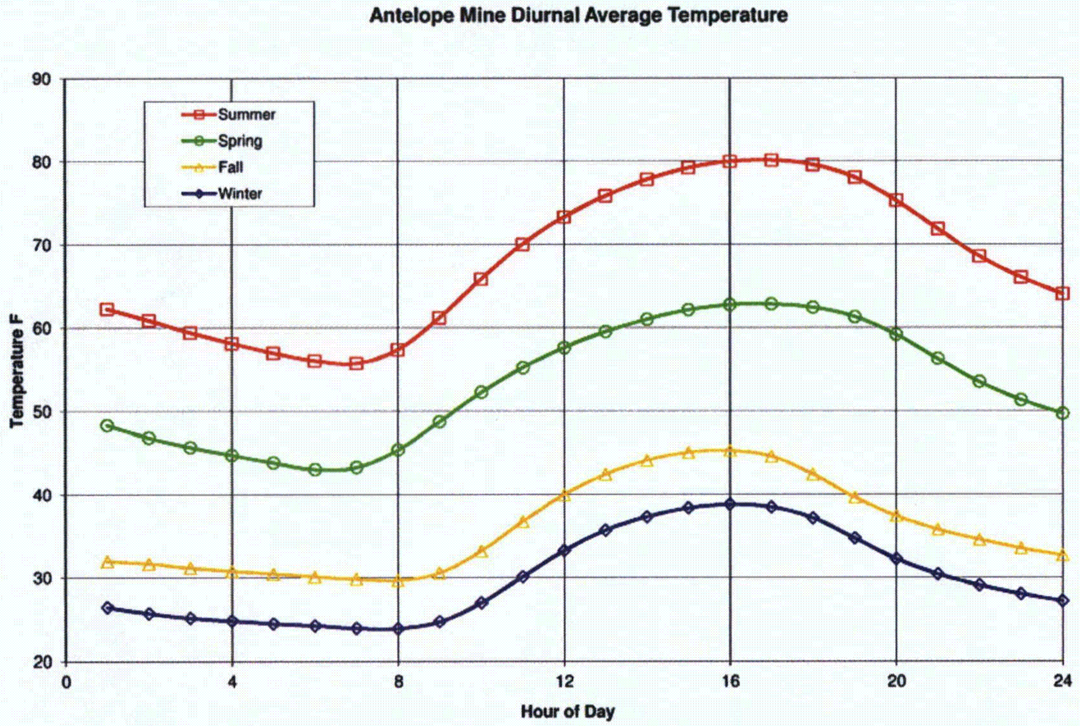
Source: Inter-Mountain Labs, 2012, hourly data from 1986 through 2012.

Figure 2.5-2. Antelope Mine Monthly Temperature Statistics.

Month	Temperature Statistics (° F)				
	Monthly Average	Monthly Maximum	Monthly Minimum	Average Daily High	Average Daily Low
Jan	24.9	56	-23	32.2	17.8
Feb	26.6	60	-25	34.1	19.5
Mar	33.2	70	-5	42.3	24.4
Apr	41.2	76	0	50.1	32.7
May	51.4	87	21	61.0	42.1
Jun	60.9	97	29	71.4	50.5
Jul	70.8	97	40	82.0	60.0
Aug	68.2	95	29	78.9	57.7
Sep	57.9	89	22	68.2	48.5
Oct	45.0	79	8	54.2	36.5
Nov	34.6	67	-9	42.4	27.0
Dec	24.3	55	-19	30.9	17.6

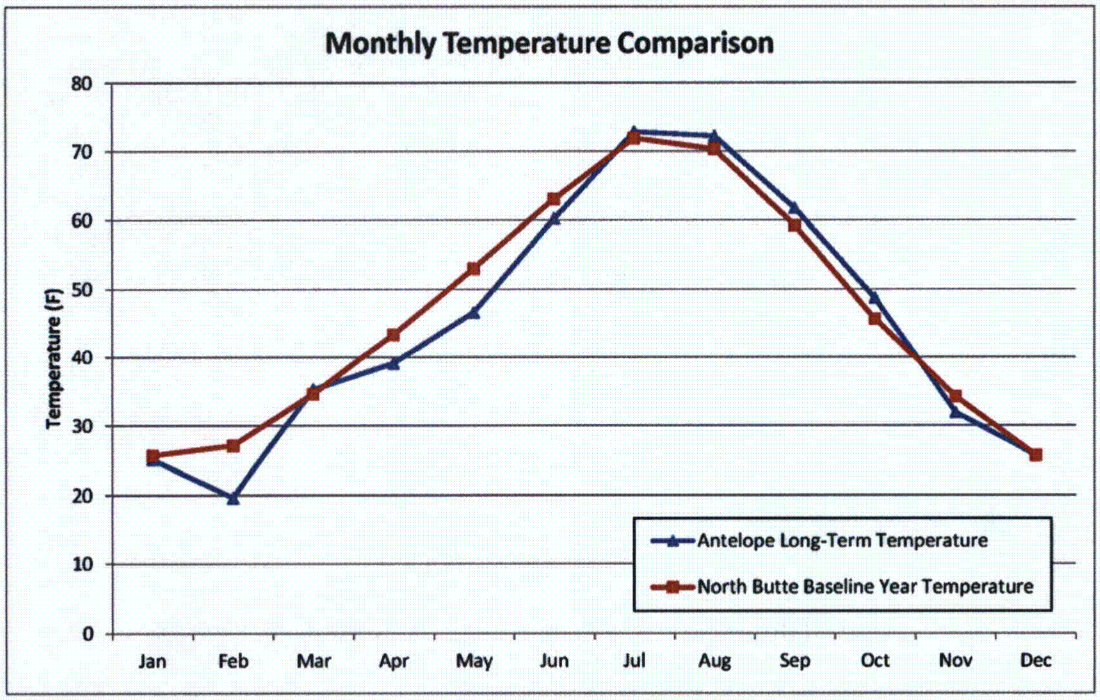
Source: Inter-Mountain Labs, 2012, hourly data from 1986 through 2012.

Table 2.5-2. Annual and Monthly Temperature Statistics for Antelope Mine.



Source: Inter-Mountain Labs, 2012, hourly data from 1986 through 2012.

Figure 2.5-3. Antelope Mine Seasonal Diurnal Temperature Variations.

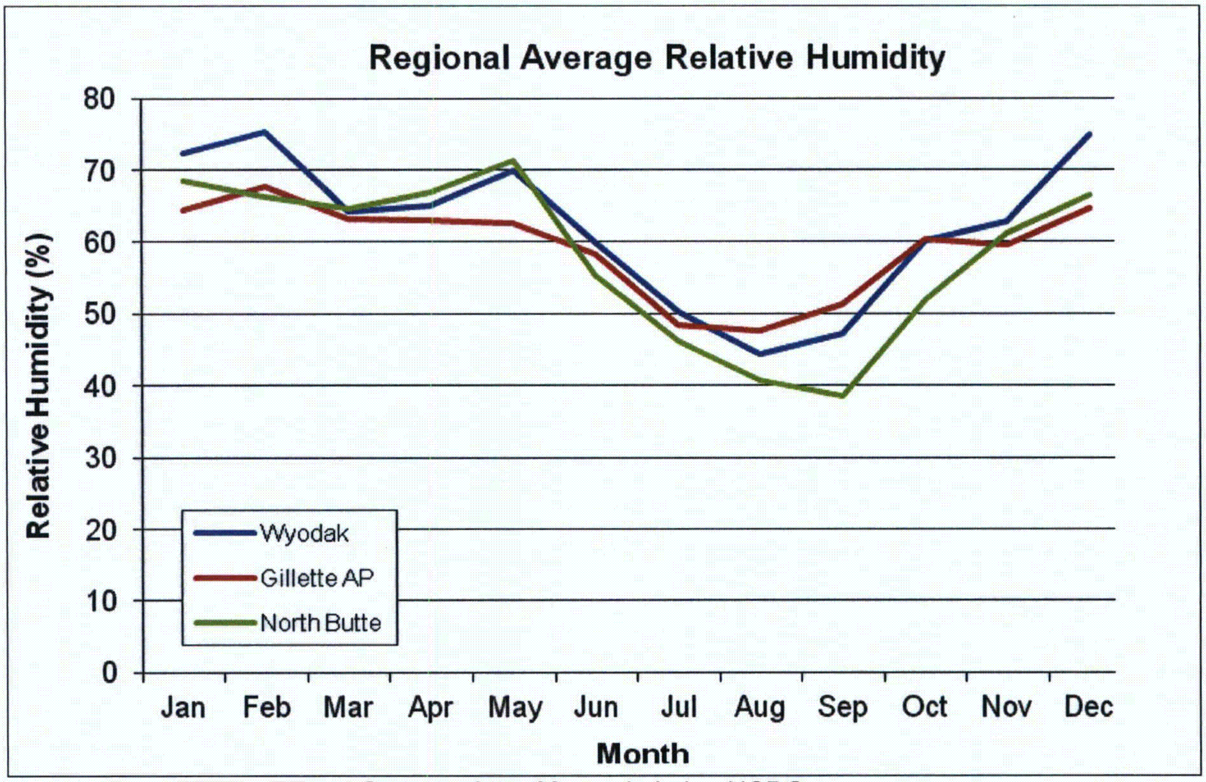


Source: Inter-Mountain Labs, Cameco Resources.

Figure 2.5-4. Regional Monthly Average Temperatures.

Relative Humidity

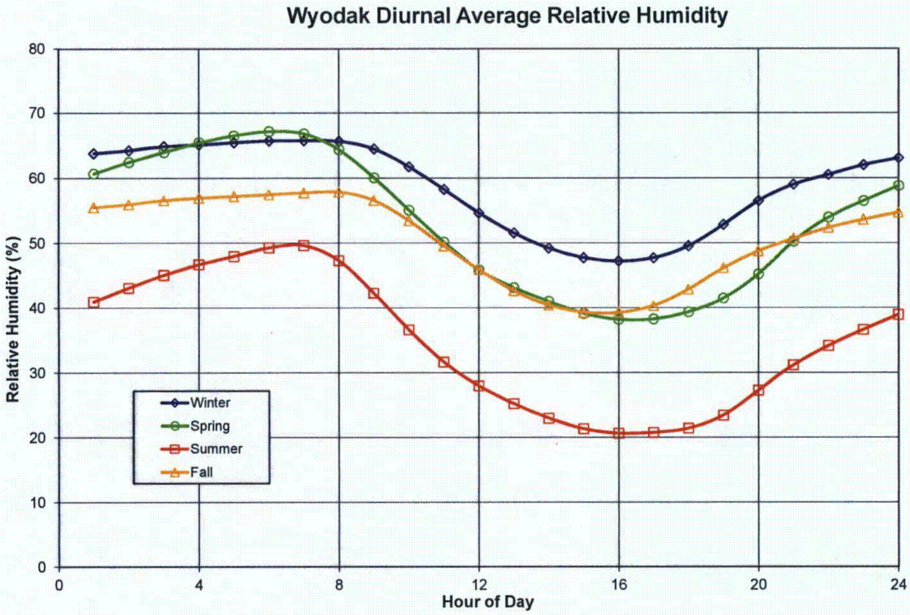
The Wyodak Mine and Gillette AP sites record hourly average relative humidity. **Figure 2.5-5** shows monthly average relative humidity values for these sites. The Cameco on-site (North Butte) relative humidity averages are also shown for reference. July, August, and September have the driest air with relative humidity averaging around 40-50%. The winter months of December, January and February make up the most humid part of the year, with average relative humidity between 65% and 75%. The annual average relative humidity is 62% at the Wyodak Mine site, 59% at the Gillette AP site, and 58% at North Butte.



Sources: Inter-Mountain Labs, NCDC.

Figure 2.5-5. Monthly Relative Humidity Statistics for the Region

Relative humidity is a temperature based calculation which reflects the fraction of moisture present relative to the amount of moisture for saturated air at that temperature. Warmer air holds more moisture at saturation than colder air. For a given amount of moisture in the air, maximum relative humidity values occur more frequently in the early mornings while minimum values typically occur during the mid afternoon hours. The summer months exhibit a much greater variation in relative humidity between morning and afternoon values due to greater temperature variations. **Figure 2.5-6** shows the diurnal variations in relative humidity at Wyodak Mine, by season.

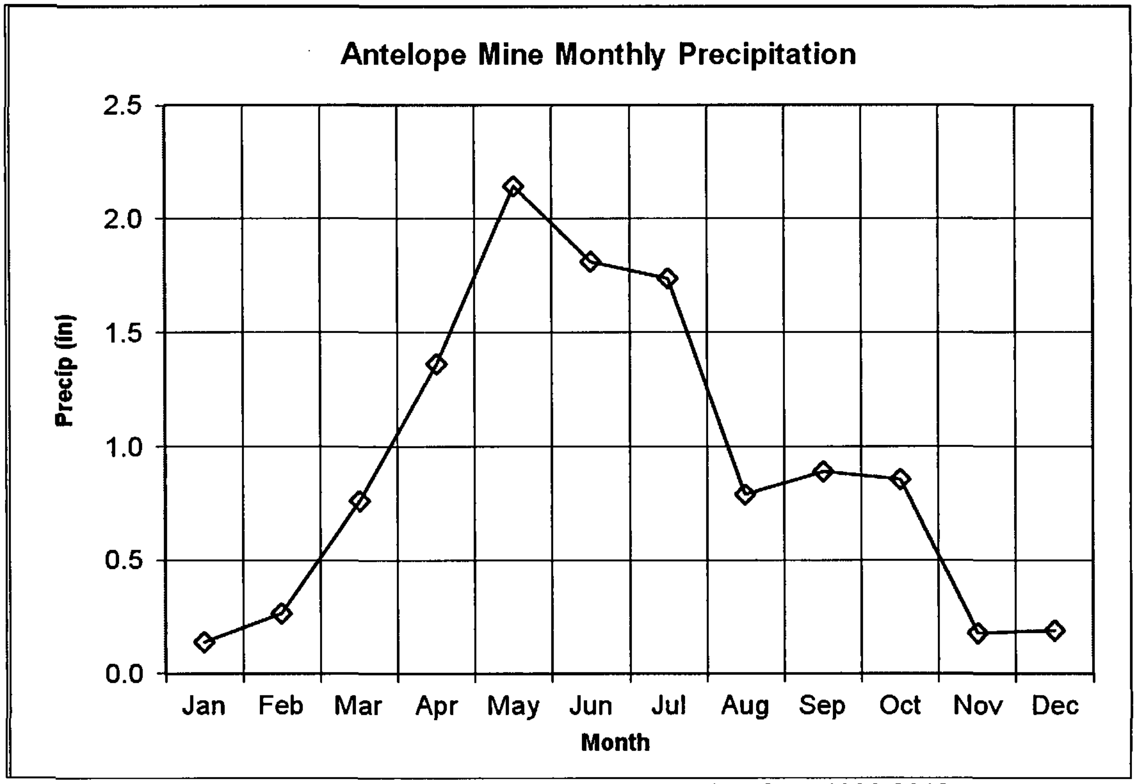


Source: Inter-Mountain Labs, 2012, hourly data from 2003 through 2012.

Figure 2.5-6. Diurnal Variation in Relative Humidity for Wyodak by Season.

Precipitation

The region is semi-arid and characterized by mostly dry conditions. The Antelope Mine site received measurable (>0.01 in) precipitation on an average of 80 days per year between 1986 and 2011. Average annual precipitation during that period was 11.1 inches per year. Between 1986 and 2011, the annual precipitation at Antelope Mine ranged from 3.8-19.3 inches per year. Typical of the region, spring snowstorms, showers, and thunderstorms during April through July produce over half the year's precipitation on average (**Figure 2.5-7**). May is typically the wettest month of the year, with an average of approximately 2 inches of precipitation for that month. January, in contrast, is the driest month of the year with precipitation typically averaging less than one quarter inch. The winter months (December-February) typically account for less than 10% of the yearly precipitation totals. Only moderate precipitation occurs in late summer and early fall, when atmospheric conditions are more stable and the absence of convective activity limits storm development.

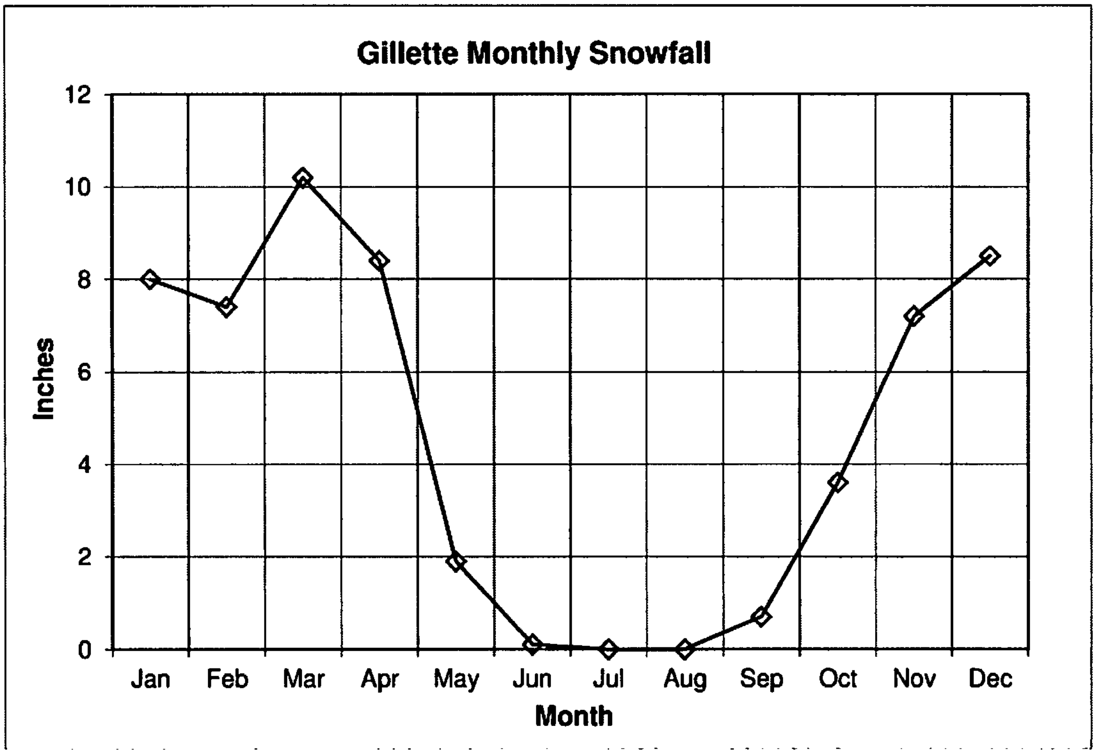


Sources: Inter-Mountain Labs, 2012, hourly data from 1986-2012.

Figure 2.5-7. Monthly Average Precipitation in Region.

Severe weather occurs throughout the region, but is limited on average to 5 or 6 severe events per year. These severe events are generally split between hail, blizzards and damaging wind events.

Average annual snowfall for the Gillette AP site is depicted in **Figure 2.5-8**. The highest snowfall occurs in March (10.2 inches on average), followed by April and December, with an annual total averaging approximately 56 inches of snow. Major snowstorms (more than 5 in/day) are relatively infrequent in the region and occur less than three times per year.



Sources: High Plains Regional Climate Center, 2011, data from 1902 to 2010.

Figure 2.5-8. Average Monthly Snowfall for Gillette AP.

Wind Patterns

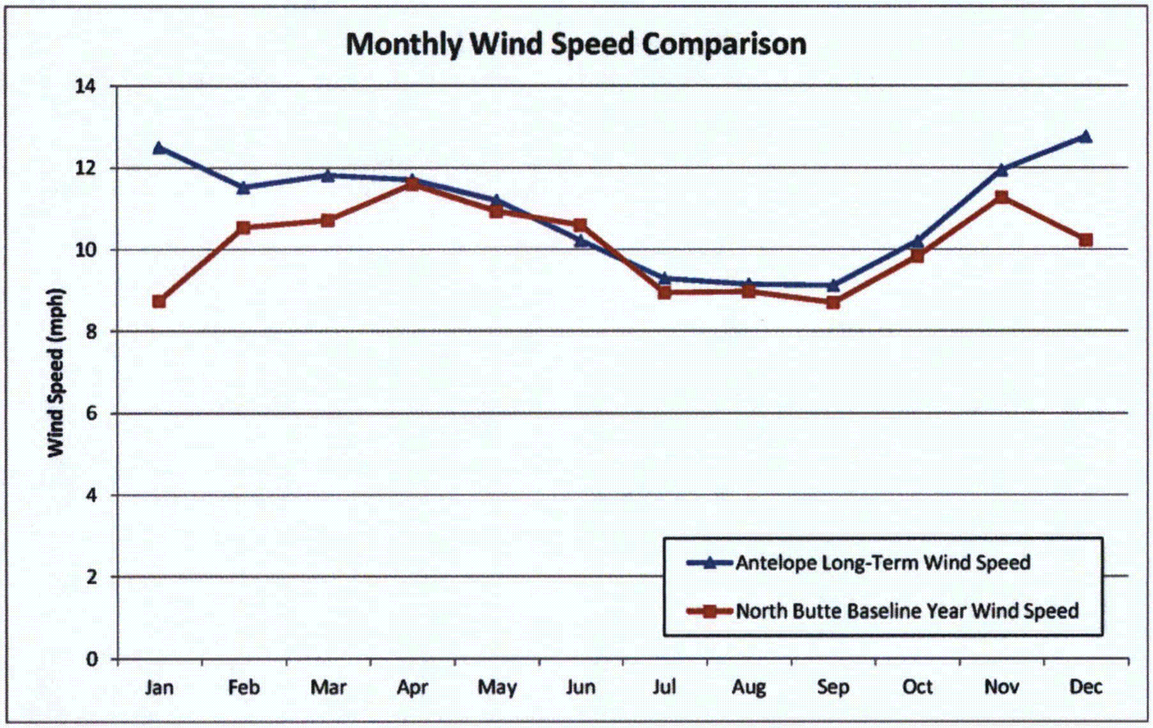
Table 2.5-3 shows monthly average wind speeds for the Antelope Mine site. The highest average wind speeds were seen in December, at 12.8 mph on average, with the lowest average speeds seen during the summer months. The average wind speed for the 1986-2012 period analyzed in this study was 10.9 mph.

Month	**Hourly Average Wind Speeds (mph)**		
	Monthly Average	**Monthly Maximum**	**Monthly Minimum**
Jan	12.5	51	0
Feb	11.5	44	0
Mar	11.8	51	0
Apr	11.7	45	0
May	11.2	46	0
Jun	10.2	43	0
Jul	9.3	42	0
Aug	9.1	47	0
Sep	9.1	42	0
Oct	10.2	43	0
Nov	11.9	42	0
Dec	12.8	52	0

Source: Inter-Mountain Labs, 2012, hourly data from 1986 through 2012.

Table 2.5-3. Antelope Mine Monthly Wind Parameters Summary.

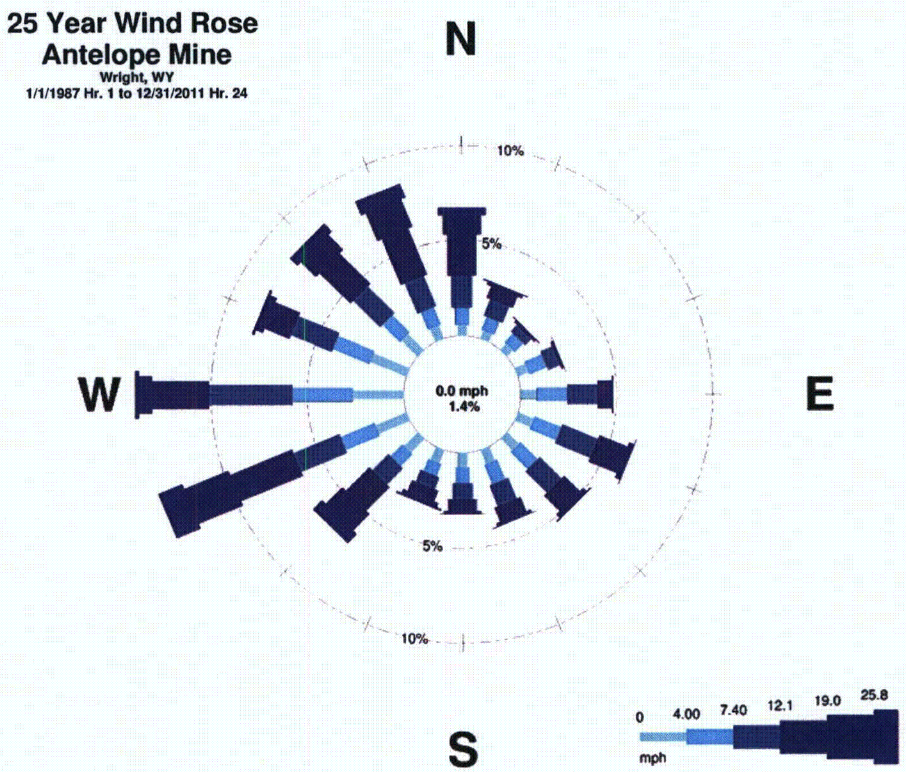
Figure 2.5-9 shows monthly average wind speeds for Antelope Mine, with data from the North Butte site shown as a comparison. The trend of lower wind speeds in the summer, as shown above at Antelope Coal Mine, is also seen at the North Butte site. High wind events occurred from late fall to early spring at both sites.



Sources: Inter-Mountain Labs, Cameco Resources.

Figure 2.5-9. Regional Average Wind Speeds.

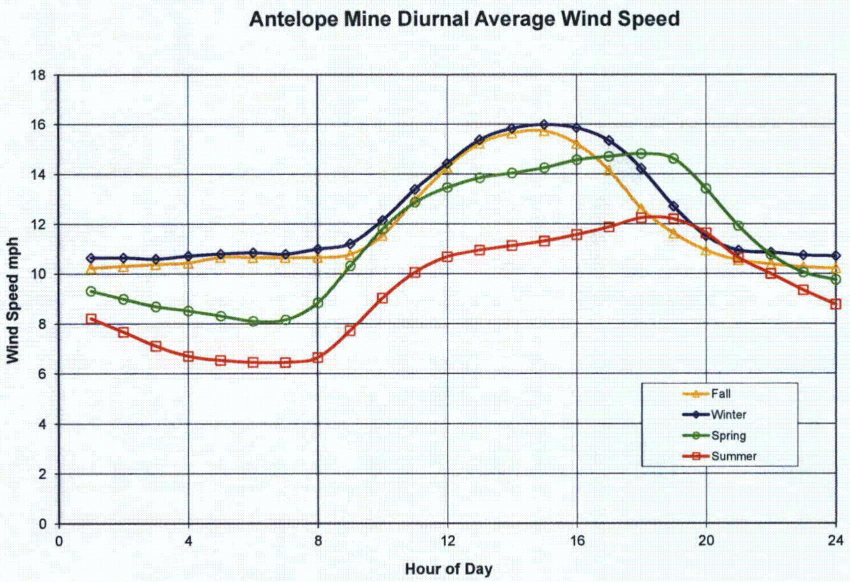
Figure 2.5-10 shows the 25-year wind rose for the Antelope Mine site. Predominant winds are generally from the west-southwest and westerly directions. Strong winds are also present from the southwest, as well as from the west-northwest to northerly quadrant.



Source: Inter-Mountain Labs, 2012, hourly data from 1987 through 2012.

Figure 2.5-10. Antelope Mine 25-Year Wind Rose

The winds in the region exhibit a diurnal pattern. **Figure 2.5-11** shows this pattern at Antelope Coal Mine for each season of the year. The largest diurnal variations are seen in the spring and summer seasons, with maximum wind speeds being reached in the late afternoon, which is an effect of solar heating. The highest overall wind speeds are seen in the fall and winter months.



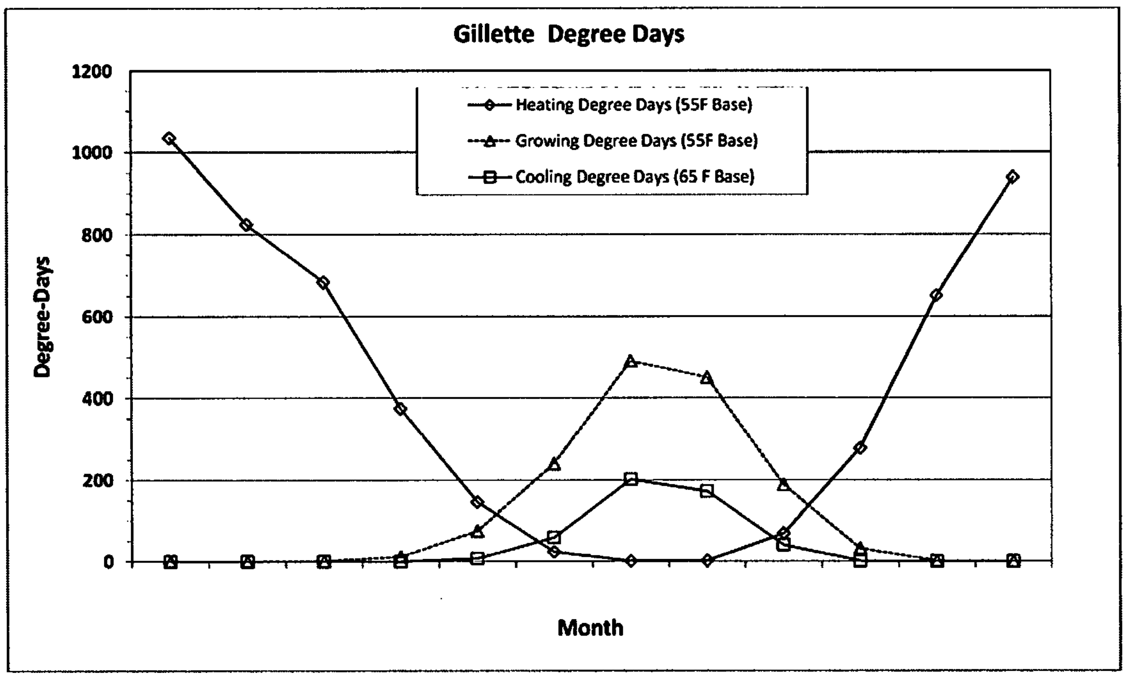
Source: National Climate Data Center, 2012, hourly data from 1986 through 2012.

Figure 2.5-11. Antelope Mine Diurnal Wind Speeds by Season.

Heating, Cooling and Growing Degree Days

Figure 2.5-12 summarizes the monthly cooling, heating, and growing degree days for Gillette. The heating and cooling degree days are included to show deviation of the average daily temperature from a predefined base temperature. In this case, 55° F has been selected as the base temperature for computation of heating and growing degree days. The base temperature for computing cooling degree days is 65° F. The number of heating degree days is computed by taking the average of the high and low temperature occurring that day and subtracting it from the base temperature. The calculation for growing and cooling degree days is the same, except that the base temperature is subtracted from the average of the high and low temperature for the day. Negative values are disregarded for both calculations.

As expected, the graphs of heating degree days and cooling degree days are inversely related and the growing and cooling degree days are directly related. The maximum number of heating degree days occurs in December and January, at roughly 1,000 degree days per month. This coincides with the months having the lowest minimum average temperatures. Conversely, July registers the most growing degree days with nearly 500, and the most cooling degree days at about 200. This also corresponds to July having the highest average temperature. The North Butte Remote Satellite area is expected to exhibit a greater number of heating degree days and lower number of cooling and growing degree days, as compared to Gillette, due to its higher elevation.



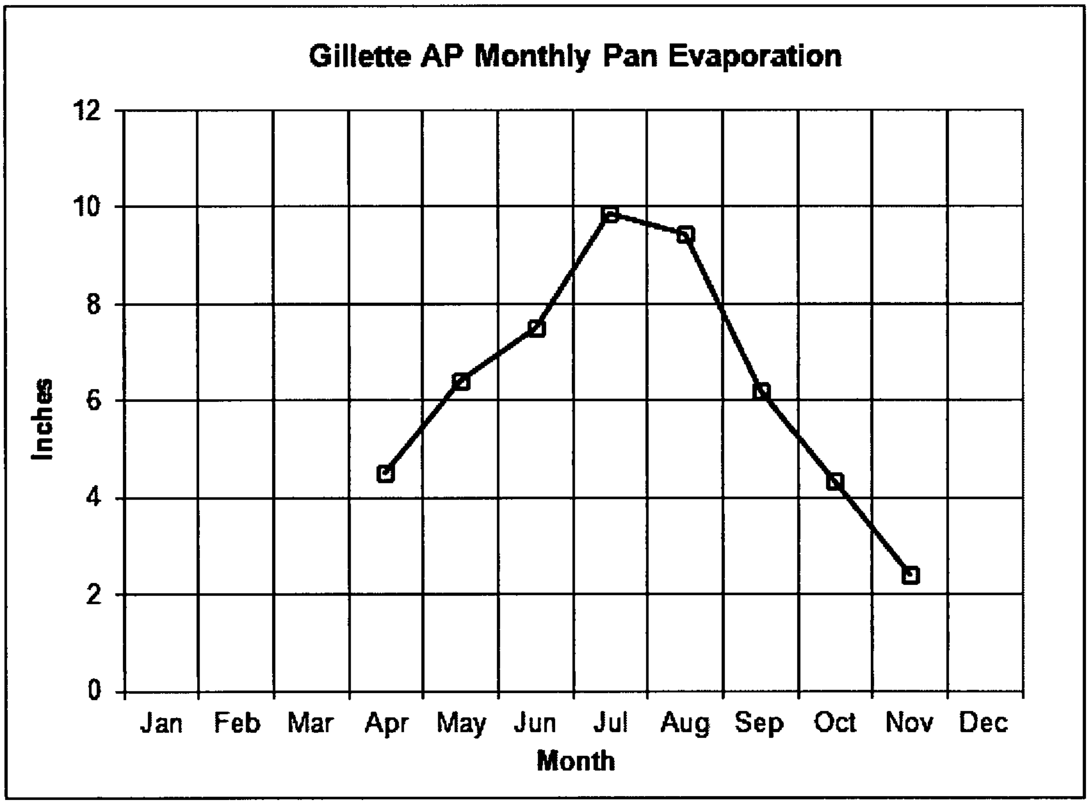
Source: High Plains Regional Climate Center, 2011, data from 1902 to 2010.

Figure 2.5-12. Gillette Airport Cooling, Heating, and Growing Degree Days.

Evapotranspiration

The region is characterized by high evaporative demand during much of the year. This demand is related to dry air (low dew points), warm daytime temperatures, and moderate to high wind speeds. The Gillette AP site, approximately 41 miles north-northeast of the North Butte project site, is the closest station with historical evaporation data. With an elevation of 4,354 feet and an average annual precipitation of 15.7 inches, this site is considered to have evaporation rates that are representative of the North Butte Remote Satellite area.

Figure 2.5-13 shows the monthly pan evaporation rates, measured in inches of water per month, at the Gillette AP site. Evaporation rates are higher in the summer, with an average of 9.9 inches in July. The lowest rates are seen in late fall and early spring. Evaporation was not measured at this site for December through March. The average evaporation at Gillette AP is approximately 51 inches per year.



Source: WRCC, data from 1925-2005.

Figure 2.5-13. Gillette AP Monthly Pan Evaporation.