Section 2.5.10:
Minntac Area

U.S. Steel’s Minntac Mine is the largest taconite mining operation on the Mesabi Iron Range. Located in the city of Mountain Iron, the Minntac operation lies prominently along the Laurentian Divide as one comes around the bend of U.S. Highway 53 from Eveleth into Virginia. Minntac actually straddles the Divide, with its pits and plant site to the south and its tailings basin to the north. Also located along the Divide in this area is Minnesota Power’s Taconite Ridge Wind Farm (Fig. 2.5.10-1), a plus to locating a PHES at this site.

Figure 2.5.10-1. Minntac Area site map (U.S. Steel Minnesota Ore Operations Minntac Mine and taconite processing operation).
PHES POTENTIAL

Massive stockpiles have been built up at Minntac along the Laurentian Divide over the 44 years since plant start-up in October, 1967 (Skillings, 1998). This, coupled with deep pockets within each of two large taconite pits, provide the following scenarios:

East Pit PHES Scenario: Constructed upper reservoir in stockpile to existing pit lower reservoir
West Pit PHES Scenario: Constructed upper reservoir in stockpile to existing pit lower reservoir

The Minntac Mine has the elevation differential to support several options for both the upper reservoir and lower reservoir of a PHES system. It should be understood that these designations have been made strictly from GIS coverages, with no notification made to or input received from U.S. Steel Corporation. The author has no knowledge regarding Minntac's present and future mining operations.

East Pit PHES Scenario: Constructed Upper Reservoir in Stockpile to Existing Pit Lower Reservoir
Head: 350+ feet

Figure 2.5.10-2. Minntac East Pit PHES Scenario.
Three potential upper reservoirs are depicted in Fig. 2.5.10-2. Two of these would be constructed within a rock stockpile while the third would be constructed in a surface/overburden stockpile. Stockpile elevations range from a minimum base elevation of 1,620 feet in the lowest of the rock stockpiles to elevations exceeding 1,800 feet in the large surface overburden stockpile. Three potential lower reservoirs are depicted. Two of these lie within the East Pit and the third is the Mountain Iron natural ore pit. Maximum water elevations of the lower reservoirs would be approximately 1,350 feet.

**West Pit PHES Scenario: Upper Reservoir in Stockpile to Existing Pit Lower Reservoir**

**Head: 350 Feet**

![Diagram of Minntac West Pit PHES Scenario](image)

*Figure 2.5.10-3. Minntac West Pit PHES Scenario.*

There are two stockpiles that could potentially host an upper reservoir in the Minntac West Pit. One consists of surface overburden, the other of rock. Base elevations for a constructed upper reservoir exceed 1,700 feet. Maximum water elevation for the proposed lower elevation would again be 1,350 feet. A major drawback to this particular scenario is the length of the penstock shown, which approximates two miles.

**PROS:** existing lower reservoirs; reservoirs reside within a permitted mining area; available construction materials from stockpiles and coarse tailings loadout; access to power transmission lines; road and rail access; access to Taconite Ridge Wind Farm.

**CONS:** current/future mining activity; constructing a reservoir in a stockpile; possible watershed issues with stockpiles that straddle the divide.
Figure 2.5.10-4. Minntac Area Base Map.
Figure 2.5.10-5. Minntac Area Hydro Map.
Figure 2.5.10-6. Minntac Area Elevation Contours Map.
Figure 2.5.10-7. Minntac Area USGS Elevation Contours Map.
Figure 2.5.10-8. Minntac Area Ownership Map.
Figure 2.5.10-9. Minntac Area Geologic Map.
The Alpena-Minorca Area is situated on the tip of the northern fold of the Biwabik Iron Formation. Located northeast of the City of Virginia, it is the site of the present-day ArcelorMittal Minorca Mine Inc. taconite operation.

Figure 2.5.11-1. Alpena-Minorca Area.

The plant site (Fig. 2.5.11-1) and tailings basin (not shown) reside on the north side of the Laurentian Divide, while the Minorca Pit lies on the south side. The Minorca Pit has been mined out for the most part. While some ore remains in the western part, the main body of the Minorca pit has been permitted for tailings disposal. Minorca Mine now obtains its ore from the Laurentian pit, located east of the City of Gilbert, and from the Lynx pit, located west of the City of Biwabik.
Minorca Mine was originally operated as two underground natural ore mines, making its first shipment in 1902 (Skillings, 1998). The earlier underground mine was located within the confines of the present-day Minorca taconite pit (Fig. 2.5.11-2). A second underground mine was opened one forty to the west of the original mine (south of the western lobe of the Minorca taconite pit). Natural ore operations, which subsequently included open pit mining, continued until 1953. In 1976, Minorca Mine was opened by Inland Steel Mining Co. as a taconite mine and processing facility.

![Alpena-Minorca area geologic map](image)

**Figure 2.5.11-2.** Natural ore mines in the Alpena-Minorca area.

Opened prior to the Minorca Mine, the Alpena Mine also began as an underground natural ore operation. The Alpena East Mine (Fig. 2.5.11-2), which lies directly to the west and south of the western lobe of the current Minorca taconite pit, shipped ore from 1900 until 1968 (Skillings, 1998). The Alpena West underground mine shipped ore from 1955-1960 (Skillings, 1998).

Subsequent open pit mining removed part of the underground workings of the Alpena East Mine. Open pit mining occurred in a north-south-trending fault zone that runs through the western portion of the Alpena East Mine (see Alpena-Minorca Area Geologic Map (Fig. 2.5.11-9)).
Alpena-Minorca PHES Potential

The fault zone noted in the previous paragraph plays into the potential for locating a PHES at this location. Uplift of the eastern side of the fault (and, hence, the iron-formation) relative to the western side generates significant head between mined areas located on either side of the fault zone. Note the elevation difference evident in Figure 2.5.11-3 between the Minorca taconite pit (perched on top of the block to the east) and the mined-out Alpena pit (seen as the water-filled reservoir at the base).

Scenario: Existing Pit Upper Reservoir to Existing Pit Lower Reservoir
Head: 350 Feet

The proposed Alpena-Minorca area PHES consists of two existing mine pits, one taconite, the other natural ore (Fig. 2.5.11-4). The upper reservoir is the western part of the Minorca Mine taconite pit. Future mining plans for this pit are unknown. The lower reservoir is a coalescence of three adjoining natural ore mine pits, the Alpena (north), Sauntry (east) and Enterprise (west) mine pits (Fig. 2.5.11-4).

The potential lower reservoir is denoted in two extents. One excludes the Enterprise pit, while the other includes it. ArcelorMittal maintains a pumping barge in the Enterprise pit, as can be seen in Figure 2.5.11-2. This site has been a source of processing water for the mine. If necessary, a coffer dam could be established at the saddle between the Enterprise and Sauntry pits, limiting the lower reservoir to the extent of the Alpena and Sauntry pits (Fig. 2.5.11-4).

This site would require construction of containment dikes in places around the upper reservoir. The Minorca Mine’s coarse tailings loadout sits directly to the north at the head of the haul road into the pit (Fig. 2.5.11-4). Coarse tailings are an excellent construction aggregate that is commonly used in dike construction at Mesabi Iron Range area taconite facilities.
**PROS:** 350-foot head; uses existing mine pits for both upper and lower reservoirs; upper reservoir on permitted mine land; on-site construction material (coarse taconite tailings); close proximity to transmission lines; substation at plant site; road access to upper and lower reservoirs via Minorca Mine entrance road; rail line into mine site.

**CONS:** potential for future mining in western portion of the Minorca pit (upper reservoir); Missabe Mountain reservoir directly south of proposed lower reservoir is City of Virginia's water source (containment issues); effect of old underground workings near site; Minorca Mine draws processing water from the Enterprise pit; impacts from blasting (past, present and future); unknown bathymetry of the lower reservoir; lower reservoir lies along the axis of a fault zone.

**DISCUSSION**

The Alpena-Minorca site has the advantage of an existing upper and lower basin. Elevation is at 1,600 feet along the southwestern rim of the Minorca pit (upper reservoir). Water elevation in the lower pit at the time of the aerial photos used (2009) is approximately 1,320 feet. The lowest elevation found on old pit maps for the lower pit is 1,040 feet. There appears to be sufficient depth to allow for lowering the water elevation in this pit. Bathymetry is needed to calculate the actual volume of water available in the
lower reservoir. Additional head could be gained by increasing the water elevation of the upper reservoir via construction of a perimeter dike within the upper pit.

Underground workings of the Alpena East and Alpena West mines are shown in Figure 2.5.11-2. The workings of the Alpena West mine, immediately north of the lower reservoir, lie sufficiently high in the bank to be above the water level of the lower reservoir. Underground workings of the Alpena East mine lie much higher in the ground, immediately south and southwest of the upper basin; they do not underlie the basin itself. Deeper underground workings between the two Alpena mines have been mined out via open pit. Placement of the penstocks can be made so as avoid the underground workings. Proposal by the facilities team (Lueker et al., this report) to use shaft and drift from upper to lower reservoir would eliminate underground mine workings concerns. It would, however, limit the head as it comes from the base of the upper reservoir.

ArcelorMittal’s use of the Enterprise pit for process water is the reason for the proposed coffer dam in the lower reservoir. This water usage may prove to be a significant inhibitor to PHES development at this site.
Figure 2.5.11-5. Alpena-Minorca Area Base Map.
Figure 2.5.11-6. Alpena-Minorca Area Hydro Map.
Figure 2.5.11-7. Alpena-Minorca Area Elevation Contours Map.
Figure 2.5.11-8. Alpena-Minorca Area Ownership Map.
Figure 2.5.11-9. Alpena-Minorca Area Geologic Map.
The Virginia Horn South Area is situated on the southern fold of the Biwabik Iron Formation. It encompasses the larger Mesabi Iron Range cities of Virginia, Eveleth, and Gilbert (Fig. 2.5.12-1). Extensive open pit mines, both taconite and natural ore, as well as large, deep underground natural ore mines, mark the trace of the fold.

Figure 2.5.12-1. Virginia Horn South Area site map.
The Virginia Horn South Area contains one of the more recently-developed mining features on the Mesabi Iron Range, ArcelorMittal’s Laurentian Mine. Located between the communities of Gilbert and McKinley, the Laurentian Mine was opened in 1991 by the former Inland Steel Mining Company as ore in the Minorca pit was running out. Ore from the Laurentian Mine is hauled approximately six miles by truck, up and over the Laurentian Divide, to the Minorca plant site for processing. Currently, ArcelorMittal is mining approximately 30% of its ore from the Laurentian pit. The remainder is mined from its Lynx pit, located west of the City of Biwabik, which opened in late 2007 (John Arola, MNDNR, 2011, pers. comm.).

Figure 2.5.12-2. Virginia Horn South Area PHES Scenario 1.
PHES POTENTIAL

Two potential PHES scenarios shown in Figure 2.5.12-1 will be presented in this section. The area shown as UTac (United Taconite) Area PHES contains multiple PHES scenarios that are covered in the section entitled UTac Area. The two scenarios to be discussed here are:

1. Constructed upper reservoir in stockpile to existing pit lower reservoir; and
2. Constructed upper reservoir to existing pit lower reservoir (after Barr Engineering, 2010).

Scenario 1: Constructed Upper Reservoir in Stockpile to Existing Pit Lower Reservoir
Head: 400+ Feet

Scenario 1 proposes to utilize the Laurentian Mine pit as the lower reservoir of a PHES system (Fig. 2.5.12-2). New LiDAR elevation data coming out this year will show the actual depth of the Laurentian pit. According to John Arola, MNDNR (pers. comm., 2011), the Laurentian pit is approximately 350-400 feet deep in the northeast corner. It could eventually go as deep as 600 feet. Water elevation in the proposed lower reservoir would be below 1,300 feet.

The upper reservoir would be constructed in the mixed rock and surface overburden stockpiles located to the northeast of the Laurentian Mine pit. These stockpiles reside up against the Laurentian Divide. The upper reservoir would lie to the south of the divide and, therefore, be in the same watershed as the lower reservoir. Proposed water elevation for the upper reservoir is 1,700 feet. An overland penstock would connect the upper and lower reservoirs.

Scenario 1 is based on mined-out status of the Laurentian pit. This could take an additional ten years (John Arola, MNDNR, pers. comm., 2011). According to Arola, economics have changed such that mining down-dip may be economically feasible, extending the life of the mine.

PROS: 400+ foot head; existing lower reservoir; permitted mine land; upper reservoir on Inland Steel (ArcelorMittal) and Oliver Iron Mining Company (U.S. Steel) lands; road access.

CONS: time factor for availability; time factor for reservoir to fill; past issues in the area with dewatering mine pits affecting local residents’ water; distance to electrical transmission lines; proposed upper reservoir encompasses some lands offered for metallic mineral leasing.

Scenario 2: Constructed Upper Reservoir to Existing Pit Lower Reservoir (after Barr Engineering, 2010)
Head: 350 Feet

Scenario 2, as proposed by Barr Engineering, would utilize the massive Missabe Mountain reservoir, located just east of the City of Virginia, as the lower reservoir of a PHES system (Fig. 2.5.12-3). The Missabe Mountain pit lake is formed from the former Sauntry, Columbia, Commodore, Missabe Mountain, Lone Jack, Shaw, Moose, and Roucheau open pit natural ore mines. Several underground natural ore mines were located in the immediate vicinity as well. Normal pool elevation for the lower reservoir would be 1,300 feet (Barr Engineering, 2010).

The upper reservoir would be formed by means of perimeter dikes to contain water at an elevation of 1,650 feet. The proposed upper reservoir lies to the east of the Missabe Mountain pit. A short overland
penstock would connect the upper reservoir to the lower reservoir, with a powerhouse residing at the edge of what was formerly the Lone Jack mine. The Norman underground mine underlies the proposed penstock path, with the Julia and Victoria underground mines residing below the proposed intake area.

Figure 2.5.12-3. Virginia Horn South Area PHES Scenario 2 (PHES features drawn after Barr Engineering, 2010).

**DISCUSSION**

There are several factors not encountered in other sites that impact this particular site. The City of Virginia obtains its drinking water from the Missabe Mountain pit, the proposed lower reservoir. United Taconite is going to be mining to the northeast of its current site in the southwest corner of the map in Figure 2.5.12-3. This mining may extend into the Rouchleau Pit, which is the southern end of the proposed lower reservoir, affecting water elevations. Another consequence of UTac’s mining to the
northeast is the need to move a major highway, U.S. Hwy 53. Some of the proposed realignments for the highway are shown in Figure 2.5.12-3. Several of these cross the proposed lower reservoir, although the likely realignment will go through the current UTac pit.

Underground mines were common throughout this area. The known extent of these mines are shown in Figure 2.5.12-3, as well as known mine shaft locations. Raising and lowering water elevations can affect the stability of these features and result in surface subsidence or collapse. Of particular note is the proposed location of the penstock overlying the underground Norman Mine. The Norman was mined from 32 to 334 feet below ground. A total of nearly 7,340,000 long tons of ore was shipped from this mine alone (Skillings, 1998).

A final factor to take into consideration for this scenario is the location of the St. Louis County landfill immediately east, and partially within, the proposed upper reservoir. There may be potential for serious environmental impacts related to this site.

**PROS:** 350-foot head; massive lower reservoir.

**CONS:** city water supply; underground mine workings and shafts; nearby landfill; future mining from the south; realignment of U.S. Hwy 53; distance from electrical transmission lines.
Figure 2.5.12-4. Virginia Horn South Area Base Map.