Mesaba Energy Project

Mesaba One and Mesaba Two

Plan for Carbon Capture and Sequestration

Public Version

Prepared by

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October 10, 2006 Revision 1

Executive Summary

Excelsior Energy Inc., the developer of the Mesaba Energy Project has prepared this plan to identify the opportunities for capture and sequestration of carbon dioxide ("CO_2") emissions from its integrated gasification combined-cycle ("IGCC") power stations. This carbon capture and sequestration plan ("CCS Plan") was prepared to provide a concrete option for the State of Minnesota to meet its obligations under future CO_2 regulations, which if promulgated, would affect coal-fired power plants, including the Mesaba Energy Project. We undertook the plan with the goal of providing the Minnesota Public Utilities Commission (the "Commission") with information about all options that available now and in the future with respect to carbon management through capture and geological sequestration from the Mesaba Project.

The decision to implement a carbon capture and sequestration ("CCS") program is one that the Commission must weigh from time to time, based upon the costs to ratepayers associated with CCS and the benefits to ratepayers associated with a CCS program. This Plan provides a framework within which the Commission can make such a decision. The costs to ratepayers of implementing CCS would include additional capital and operating costs, reduced output and plant efficiency and potential downtime to implement the system. The benefits would include (a) any revenues from enhanced oil recovery (EOR), and (b) the ability to cost-effectively comply with any form of legislation limiting or regulating carbon dioxide emissions as part of an initiative to stabilize atmospheric concentrations of greenhouse gases ("Carbon Constraints"), whether in the form of avoiding carbon taxes or the purchase of allowance credits, or the ability to reduce carbon emissions to levels specified on a fleetwide or statewide basis.

The first option for CCS presented by the Mesaba Project entails capture and sequestration carbon dioxide present in the syngas, which represents 30% of the total carbon dioxide emissions from the plant. Technologically, this option would entail the installation of amine scrubbers downstream of the acid gas removal system in the IGCC power stations to remove up to 85% of the CO_2 in the synthesis gas that fuels the plants, resulting in an overall CO_2 capture rate of 30% for the plant. This technology is available now to achieve 30% capture at a relatively low cost to ratepayers. This option could be implemented as early as 2014, following the commercial operation date for the first unit of the Mesaba Energy Project. Implementation of CCS prior to the availability of credits or carbon avoidance benefits would rely exclusively on revenues that may be available from EOR. Sequestration at EOR sites would have higher costs, due to the longer distances to the candidate oil fields, than would sequestration in saline formations closer to the plant site. Those additional costs would be weighed against the revenues that would accompany the supply of CO_2 for EOR. A decision to implement this form of CCS prior to the imposition of Carbon Constraints would have to weigh the likelihood that the base line emissions year would be established such that reductions implemented before that date would be given credit.

The second, longer-term option for CCS presented by the Mesaba Project would reduce CO_2 emissions by approximately 90%. This option could be implemented following the successful demonstration by the DOE's FutureGen of full capture from an IGCC plant. The costs of this option are significantly higher than the 30% capture approach using currently available technology. Significant ongoing research and development efforts sponsored by the Department

of Energy ("DOE") are expected to reduce these costs significantly and result in commercial offerings of these technologies. Given the fact that IGCC is a least-cost source of carbon reductions in the power sector, these deeper reductions are likely to be cost justified in the event Carbon Constraints are imposed that require any meaningful reduction in total greenhouse gas emissions. Implementation of 30% capture option would not preclude later decisions to increase capture levels to 90%.

In an EOR scenario, the captured carbon dioxide would be transported via pipeline to oil fields in North Dakota, southwestern Manitoba, and/or southeastern Saskatchewan. Once the CO_2 arrives at its destination, it would be sequestered underground, potentially in connection with enhanced oil recovery operations.

Alternatively, the saline formation scenario would entail transporting the CO_2 to a saline formation located much closer to the plant site, reducing the pipeline costs but also eliminating the revenues associated with the sale and beneficial use of the CO_2.

The economics of CCS look promising. The 30% capture option identified in the CCS Plan would enable CO_2 capture at a cost per ton below that of any other existing power plant in the state. IGCC plants' ability to economically capture CO_2, combined with the potential for revenues described above, have the potential to significantly decrease the cost of CCS.

Under this proposed Plan, Excelsior would commit to undertake capture, transportation and sequestration of carbon dioxide, upon a decision by, and at the direction of, the Commission, upon approval of a modification to the proposed power purchase agreement that would allow for Excelsior to be compensated at a reasonable cost of capital for the necessary capital investments, and to be made whole on the other costs associated with the CCS program. This commitment, together with Excelsior's ongoing work to refine the costs and technical means to implement CCS, will position the State to respond in a timely and economic fashion to carbon constraints.

I. Introduction

This ability to capture and sequester CO_2 is important because Carbon Constraints are likely to be implemented within the next ten years. As evidence of this, various proposals to regulate greenhouse gas emissions ("GHGs") have been introduced in the United States Congress, and various states have embarked upon their own GHG programs.

Identification of strategies to comply with likely Carbon Constraints is a critical element of protecting Minnesota's consumers and economy. Excelsior is working in conjunction with the Energy and Environmental Research Center ("EERC") as part of the Plains CO_2 Reduction Partnership ("PCOR") initiative to develop CO_2 management options for the Mesaba Energy Project based on evaluations of sequestration opportunities associated with regional geologic formations/features and nearby terrestrial features.[1]

[1] The EERC is part of the University of North Dakota and has been selected by the Department of Energy to develop a regional vision and strategy for dealing with carbon management in the Plains Region

What follows is Excelsior's CCS Plan for the first two of six IGCC units to be constructed over time on three state-authorized sites within the Taconite Tax Relief Area of Northeastern Minnesota. The proximity of the three sites with IGCC units, together with the potential opportunities for carbon sequestration identified by the EERC, affords the State of Minnesota the opportunity to carefully plan for and implement the most cost-effective and flexible response to carbon constraints.

II. Background: Mesaba Energy Project Phases I and II

The IGCC Power Station described in this document consists of Phase I and Phase II of the Mesaba Energy Project ("Mesaba One" and "Mesaba Two," respectively). Each phase is nominally rated at peak to deliver 606 megawatts ("MW") of electricity to the bus bar.

Excelsior has submitted the necessary regulatory petitions and preconstruction permit applications to support construction of Mesaba One and Mesaba Two. The key pending regulatory filings made in connection with the Mesaba Project include the following: On December 22, 2005, Excelsior submitted to the Commission a petition to approve a Power Purchase Agreement with Xcel Energy under Minn. Stat. § 216B.1693 and 1694. On June 16, 2006, Excelsior submitted a Joint Permit Application for a Large Electric Power Generating Plant Site Permit, a High Voltage Transmission Line Route Permit, and a Natural Gas Pipeline Route Permit to the Commission for Mesaba One and Mesaba Two. On June 28, 2006, Excelsior submitted applications for New Source Review Construction Authorization and National Pollutant Discharge Elimination System Permits to the Minnesota Pollution Control Agency for Mesaba One and Mesaba Two. On June 29, 2006, Excelsior submitted an application for a Water Appropriation Permit to the Minnesota Department of Natural Resources.

When operational, the Mesaba Energy Project will allow Minnesota and the nation to benefit from the environmental advantages that IGCC technology offers over conventional, solid fuel alternatives. Beyond its capability for achieving an emission profile unmatched by conventional coal combustion systems, IGCC is adaptable to capture significant amounts of carbon dioxide from the synthesis gas prior to its combustion. Mesaba One and Two will be configured to allow for the installation of additional equipment that can capture up to 30% of the potential carbon in its selected feedstock.

III. Regulatory Context for Carbon Capture and Sequestration

Excelsior's intent in proposing a framework for CCS is to commence a process to identify and define conditions for development of CCS when state or national considerations require GHG reductions, and/or when such reductions might otherwise become an economic choice for the ratepayers of Northern States Power Company under the PPA, in the context of Mesaba One and

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(including the Canadian Provinces of Alberta, Saskatchewan, and Manitoba, and the states of Montana, NE Wyoming, North Dakota, South Dakota, Nebraska, Minnesota, Wisconsin, Iowa, and Missouri). *See* PCOR Partnership Profile, http://www.undeerc.org/pcor/partnership.asp.

Mesaba Two. Excelsior's efforts will advance State decision makers' practical knowledge regarding the role IGCC and the Mesaba Energy Project can play in achieving actual reductions in the state's CO_2 emissions.

Several states are undertaking initiatives to reduce greenhouse gas emissions, most notably carbon dioxide, in isolated sectors of their economies.[2] To achieve significant reductions of such emissions, it is probable that future climate change initiatives will extend nationwide and to all sectors of the economy. The ability to physically reduce the volume of GHG emissions from Minnesota's economic activity will be a critical component to the State's economic health, whether the constraints require roll-backs from any one sector or sources, or whether the constraints take the form of a tax or a cap-and-trade system. The precise form that the carbon limits take is outside the scope of this CCS Plan, and in any event is not critical to the analysis of IGCC, which has the lowest cost of capture of any fossil fuel technology. In a carbon-managed economy, large sources of CO_2 emissions that can economically achieve significant GHG reductions will likely be the major source of CO_2 offsets for other economic sectors whose only meaningful alternative for achieving reductions may be the purchase of GHG offset credits. Because IGCC is the technology best suited to carbon capture of all the fossil technologies, it is a least-cost means to achieve actual reductions in GHG emissions, and will therefore very likely be able to achieve emission reductions at a cost below where credits will trade or where tax levels are established in order to signal sufficient reductions to meet the national program goals.

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[2] Connecticut, Delaware, Maine, New Hampshire, New Jersey, New York and Vermont have formed the Regional Greenhouse Gas Initiative ("RGGI") with the goal of creating a regional cap-and-trade program. The plan will begin addressing carbon dioxide emissions from power plants in the member states by capping 2009 carbon dioxide emissions at current levels. Beginning in 2015, RGGI states will begin reducing carbon dioxide emissions to achieve a 10% reduction by 2019. To facilitate the process, power plants will receive CO_2 emission allowances, which they may trade with other power plants. *See* Press Release, Regional Greenhouse Gas Initiative, States Reach Agreement on Proposed Rules for the Nation's First Cap-and-Trade Program to Address Climate Change (Aug. 15, 2006), *available at* http://www.rggi.org/docs/model_rule_release_8_15_06.pdf; Regional Greenhouse Gas Initiative, Model Rule (Aug. 15, 2006), *available at* http://www.rggi.org/docs/model_rule_8_15_06.pdf.

Similarly, California recently enacted legislation that calls for the development of regulations and market mechanisms that will reduce the state's greenhouse gas emissions by 25% by 2020. The law will impose mandatory caps beginning in 2012 and will incrementally tighten emission limits to reach the 2020 goals. *See* Press Release, Gov. Arnold Schwarzenegger, Gov. Schwarzenegger Signs Landmark Legislation to Reduce Greenhouse Gas Emissions (Sept. 27, 2006), *available at* http://gov.ca.gov/index.php?/press-release/4111/; California Global Warming Solutions Act of 2006, Assembly Bill No. 32, *available at* http://www.leginfo.ca.gov/pub/bill/asm/ab_0001-0050/ab_32_bill_20060927_chaptered.pdf.

In 2001, Massachusetts developed regulations that apply to power plants in the state. Under the regulations, CO_2 emissions may not exceed the historical actual emissions for the three-year period from 1997 to 1999, and CO_2 emissions may not exceed 1800 lbs/MWh. See Massachusetts Dept. of Environmental Protection, Governor Swift Unveils Nation's Toughest Power Plant Regulations, Inside DEP, April/May 2001, at 1, *available at* http://www.environmentalleague.org/Issues/Enforcement/DEPMay2001.pdf#search=%22Governor%20Swift%20air%20regulations%22; 310 Mass. Code Regs. 7.29 (2004), *available at* http://enviro.blr.com/display_reg.cfm/id/48436.

Mesaba One and Mesaba Two are therefore likely to be ideal sources of carbon offsets under such circumstances, and are likely to provide the State with a meaningful, cost-effective hedge in meeting any federally-imposed GHG reductions.

IV. Preliminary Plan Description and Analysis

There are two primary components of the CCS Plan. First, Excelsior identifies the most promising, commercially available CO_2 capture technology to install at the IGCC power station. As described later in this section, an amine scrubber process currently has the most potential for carbon capture at the Mesaba Project. Second, Excelsior develops engineering plans for different methods of sequestering the captured CO_2. Based upon studies to date, the CCS Plan suggests a staged development of CO_2 pipelines from its Iron Range plant sites to North Dakota oil fields and proximate locations. The pipelines would likely utilize existing railroad, pipeline, or transmission line rights of way.

A. CO_2 Capture

Several processes have been proposed for carbon capture in coal power plants, consisting primarily of scrubbing or membrane separation-based processes. In conventional coal plants, the carbon must be scrubbed from very large volumes of stack gases at low pressures and temperatures. The most mature and proven of these is amine scrubbing, which is similar to the process used by the Mesaba Energy Project to capture sulfur from the syngas. In this process, the amine solution first adsorbs carbon dioxide from the gas being treated, and then CO_2-enriched amine is regenerated, recycling the amine and producing a relatively pure stream of CO_2.

IGCC plants enable pre-combustion capture of CO_2, which provides the intrinsic advantages of treating an undiluted and pressurized gas stream. An additional advantage enjoyed by IGCC is that CO_2 captured from high-pressure syngas requires less compression before transport and/or storage.

The Mesaba Energy Project features a design that is adaptable to carbon capture, which enables relatively simple upgrades to be made in order to commence carbon capture. These upgrades entail installing a CO_2 amine scrubber downstream of the acid gas removal system and adding driers and compressors for captured CO_2. In this design, the CO_2 available for capture is limited by the proportion of carbon dioxide in the syngas, which varies for different fuels. Up to 30% of the potential CO_2 could be removed from the design subbituminous coal, while up to 20% could be removed from other design feedstocks.

Higher capture rates are not commercially available today, but will be demonstrated in the future. This is the primary objective of DOE's FutureGen project, which aims to capture at least 90% of the CO_2 from a non-commercial plant to begin operation in 2013. After such a demonstration of commercial viability, the Mesaba Energy Project could achieve 90% capture by adding a gas reheater and a water gas shift reactor upstream of the CO_2 amine scrubber. The shift reactor process converts CO to CO_2 by the following reaction:

$$CO + H_2O \rightarrow CO_2 + H_2$$

Nearly all of the carbon in the resulting syngas stream is in the form of CO_2, enabling the amine scrubber to remove at least 90% of the CO_2. However, at the current state of technology, this process would increase capital cost and reduce efficiency of the plant, making it more expensive for capturing CO_2 on a per ton basis than the 30% configuration. It should be noted that a plant that has implemented 30% capture would still be technically capable of being converted to capture 90% once the technology is demonstrated by DOE's FutureGen project.

Because the 90% approach has not yet been demonstrated and the 30% approach is the most mature and proven option, Excelsior concludes that the 30% approach is the most likely candidate for CCS in the near term. The 30% CO_2 capture configuration represents a cost-effective, commercially available option today for the Mesaba Project.

B. Economic Considerations Relating to Sequestration

The potential economic drivers for CCS by the Mesaba Energy Project include opportunities to supply the CO_2 to an oil field for sale and use in enhanced oil recovery ("EOR"), and the opportunity for financial benefits to ratepayers from reductions in the costs of complying with carbon limits imposed in the future. This CCS Plan contains information on economical sequestration opportunities within the oil fields located in closest proximity to the Mesaba IGCC power stations. Because CO_2 used for EOR is also sequestered, the Mesaba Energy Project would likely earn carbon credit revenues (or avoid costs in other carbon limit scenarios) once regulations limit CO_2 emissions, which would be in addition to the EOR revenues. Therefore, investments in pipeline infrastructure for EOR will provide additional value as a method of sequestration once a carbon credit market is established.

1. Enhanced Oil Recovery

Carbon dioxide has been proven to be very effective for secondary and tertiary oil recovery by both displacing and decreasing the viscosity of otherwise unrecoverable oil. Upon extraction of the oil, the EOR process easily removes pressurized CO_2 and recycles it by reinjecting into the pool. Economic benefits from EOR have been realized in at least two regions in North America. Kinder Morgan CO_2 has a CO_2 pipeline network of 1100 miles servicing the Permian Basin in western Texas and eastern New Mexico.[3] Similarly, the Dakota Gasification Project in the Northern Plains pipes CO_2 over 200 miles to the Weyburn oil field in southeastern Saskatchewan. The market for CO_2-based EOR is still available in oil fields across the country, so the Mesaba Energy Project, by virtue of its advanced stage of development, may be poised to exploit some of the most economical oil recovery operations available to the benefit of Minnesota ratepayers.

2. Carbon Credits or Other Economic Benefits of CCS

Carbon credits or other economic benefits derived from CCS under other forms of potential carbon regulation also represent a potential economic driver for the Mesaba CCS development,

[3] See Kinder Morgan CO_2, http://www.kindermorgan.com/about_us/about_us_kmp_co2.cfm.

with future regulation in the U.S. determining the final value of the Carbon Benefits generated by CCS undertaken by the Mesaba Energy Project.

D. CCS Approach

This CCS Plan analyzes the most promising initial approach for CCS from the Mesaba Energy Project under present circumstances, which would entail capture of 30% of the CO_2 generated by the power stations and would direct that captured CO_2 to EOR sites. This approach requires a longer pipeline than would direct sequestering of CO_2 in closer, non-EOR sites. Therefore, targeting EOR sites will require higher front-end costs than if Excelsior were to sequester carbon simply to meet carbon limits without providing CO_2 for EOR opportunities. EOR and future carbon credit markets may offset the higher costs associated with initially targeting EOR sequestration sites.

While the timetable for implementation of regulations governing the operation of a carbon-managed economy is unknown, Excelsior anticipates that it would have adequate time to implement the power station upgrades and construct a CO_2 pipeline.

Numerous in-depth studies exist describing the technological means to capture 90% of the carbon dioxide from an IGCC plant.[4] Because of the real-time research and development efforts with respect to 90% capture, and the expected reductions in costs of this option as the technologies are demonstrated, Excelsior has not attempted to quantify the costs nor describe the technological approach in detail in this phase of the plan.

V. Currently Available Regional Sequestration Studies and Experience with CO_2 Pipelines

A. Regional Sequestration Studies

The EERC has extensively characterized three major types of sinks for carbon sequestration that are within the appropriate geographic proximity of the Mesaba Energy Project. The options are geological sequestration in oil fields (for enhanced oil recovery or storage only) or saline formations, and terrestrial sequestration (primarily using wetlands). Terrestrial sites are not suited to accommodate direct injection of CO_2 because such sites rely on changing the existing physical configuration of large areas of the earth's surface, rather than accepting the direct input of CO_2 at a stationary point. This CCS Plan focuses on geological sequestration, to which IGCC is uniquely suited.

Oil fields have proven to be CO_2 sinks with sufficient storage capacity to accommodate CCS projects equivalent to the long-term output of all six phases of the Mesaba Energy Project. Fields in the Permian Basin in western Texas have sequestered CO_2 for decades at scales even larger than those addressed in this CCS Plan.

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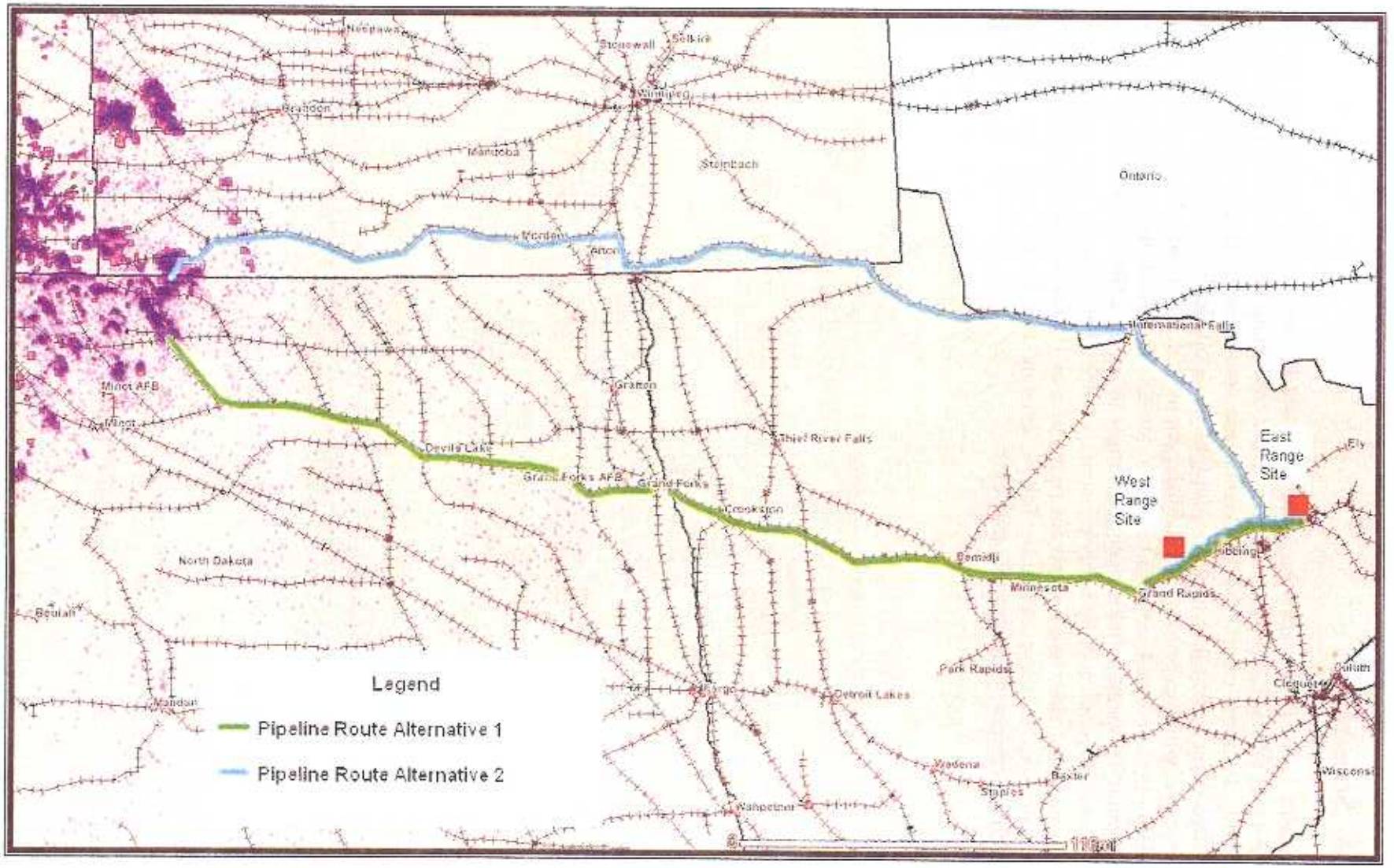
[4] For a summary of such studies, see the Oct. 10, 2006 testimony of Douglas H. Cortez, OAH Docket No. 12-2500-17260-2, MPUC Docket No. E-6472-/M-05-1993.

A. Scenario 1

For Scenario 1 and its alternatives, pipelines would be constructed between the three Mesaba Energy Project's Iron Range plant sites (each site containing two generating units) and a cluster of oil fields in north central North Dakota, the southwestern corner of Manitoba, and the southeastern corner of Saskatchewan. Many of these oil fields are either unitized or run by a single operator, which expedites the establishment of EOR in a field. (Unitization is a process by which field operators combine all oil and gas interests in a field into a single operation.) Non-unitized, multiple operator fields may take longer to set up EOR, so the readily available fields would be advantageous and the likely economic choice. For the main trunk pipeline connecting the plants and oil fields, two options for rights of way ("ROWs") are shown in Figure 1. The pipeline corridors in these scenarios follow existing rail ROWs only for the purpose of illustration – other potential corridors may exist.

Figure 1. Potential Pipeline Routes for the Mesaba Energy Project CO_2 Pipeline

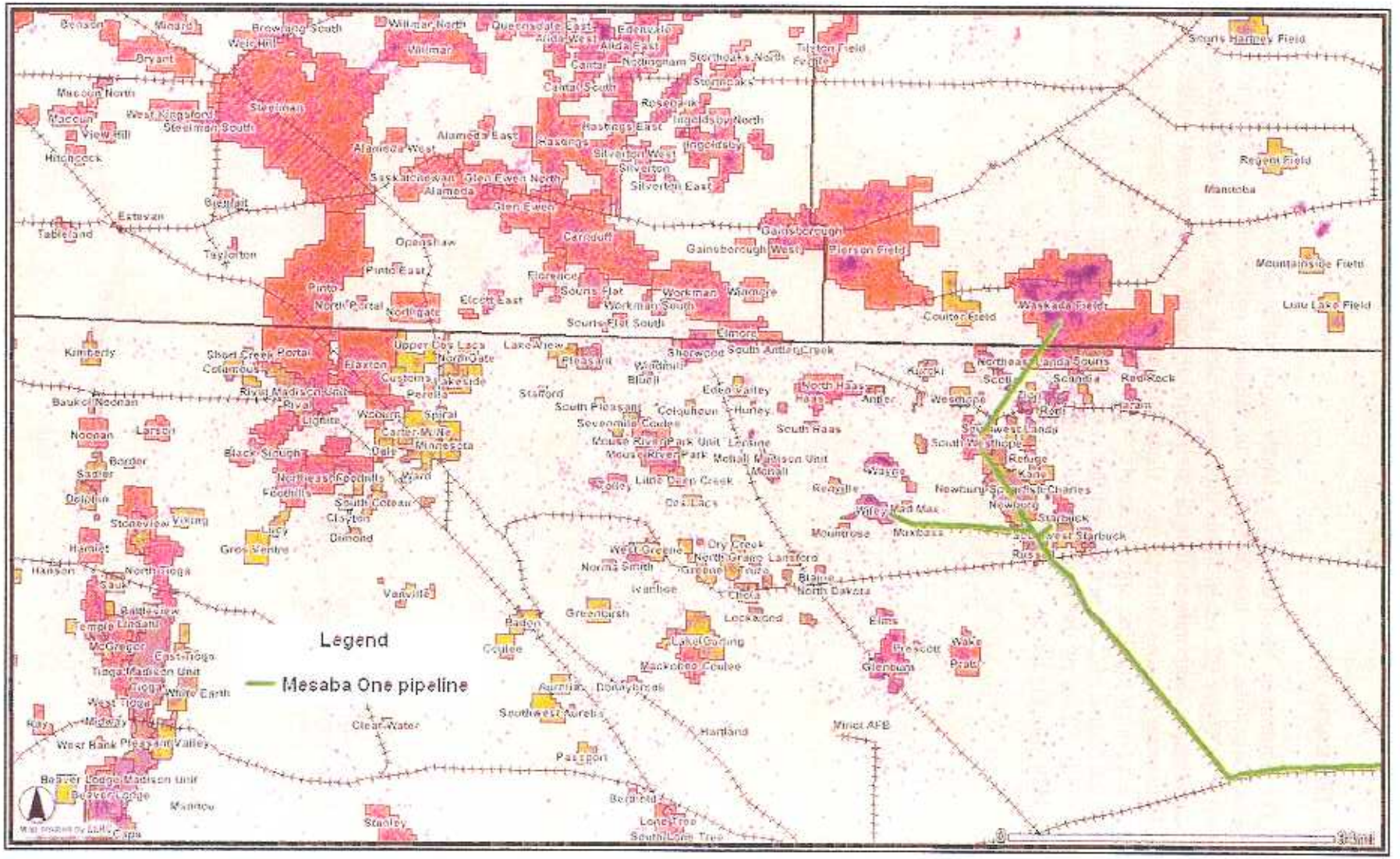


Source: EERC

B. Scenario 1A

For the CO_2 captured at Mesaba One, a cluster of oil fields in north-central North Dakota and southwestern Manitoba are targeted, with preliminary expectations that such fields could accommodate EOR for 22 years. This duration, which is used throughout the analysis of the various scenarios, corresponds to that of the financial model and does not reflect cessation of capture. Following existing railroad track (for purposes of illustration) from the preferred West Range site, a 12-inch pipeline approximately 405 miles long could reach the first proposed oil field. Over the course of 22 years, an additional 40 miles of pipeline would be needed to connect to nearby fields. Two of the fields are unitized. The pipeline network needed to serve this scenario is shown in Figure 2.

Figure 2. Western Terminus of CO_2 Pipeline Serving Mesaba One

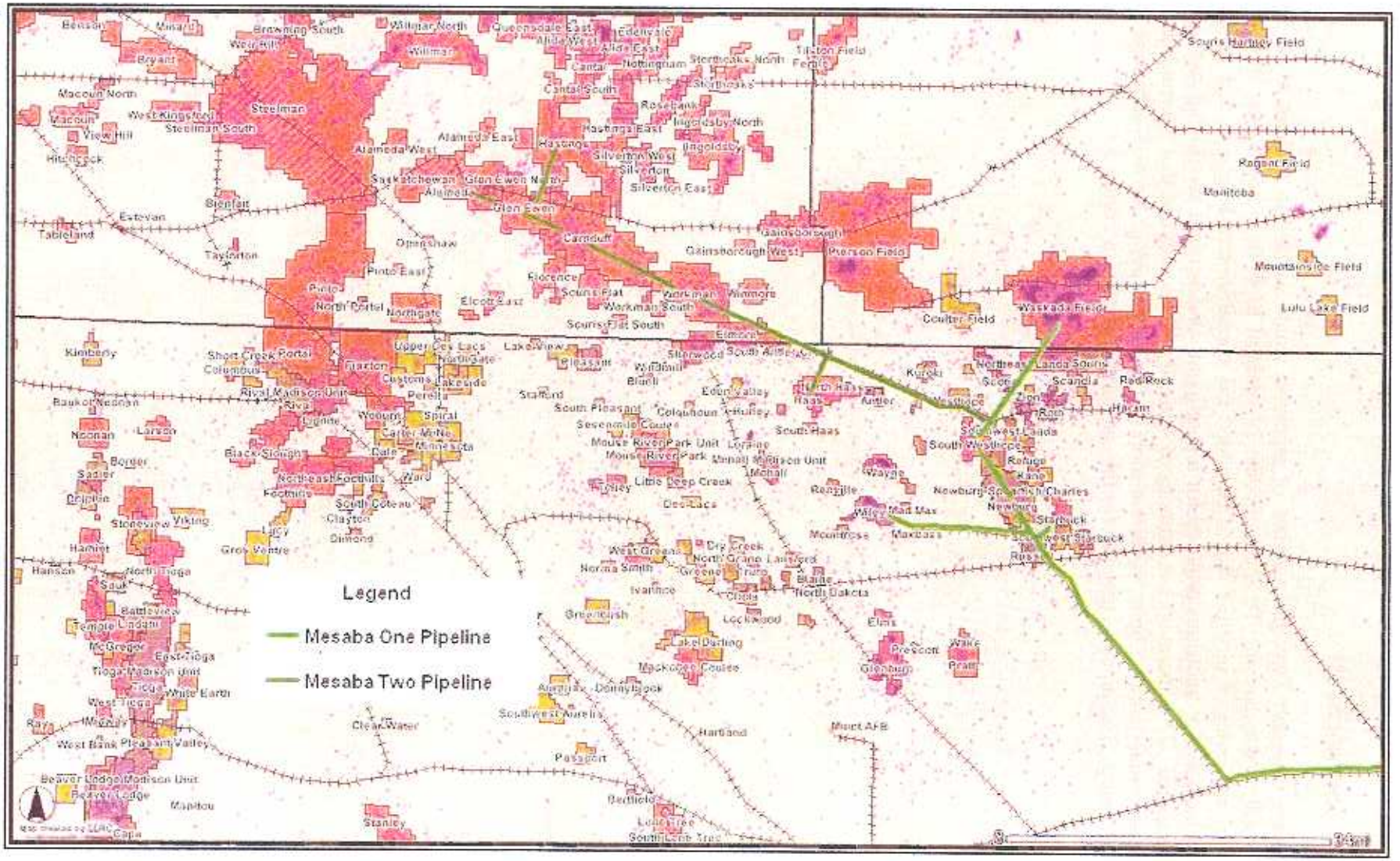


Source: EERC

C. Scenario 1B

For Mesaba One and Two, the network of pipelines would expand to a chain of oil fields in southeastern Saskatchewan. To accommodate 22 years of EOR from both units, approximately 120 additional miles of pipeline would be added for a total system length of 525 miles. This length is inclusive of additions required for a single unit as described above, and such additions could be staged. To illustrate the economies of scale, it will be assumed that the trunk pipeline is sized to accommodate two units, such that looping (i.e., duplicating) the 405 mile base pipeline is not necessary. The pipeline network for this scenario is shown in Figure 3.

Figure 3. Extension of Western Terminus of Mesaba One Pipeline to Accommodate Mesaba Two



Source: EERC