**Core Energy**

# Northern Niagaran Pinnacle Reef Trend (NNPRT) $CO_2$ Monitoring, Reporting, and Verification (MRV) Plan

September, 2018

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## Introduction

Core Energy LLC (Core Energy) operates an integrated carbon dioxide ($CO_2$) capture and enhanced oil recovery (EOR) facility in the Northern Niagaran Pinnacle Reef Trend (NNPRT) in Michigan. The Core Energy facility includes equipment to capture $CO_2$ from various sources, dedicated pipelines, a set of subsurface geologic reef formations, and equipment to process oil.

Core Energy joined the Midwest Regional Carbon Sequestration Partnership (MRCSP) in 2005 and has worked closely with the research team to advance the technical understanding of the reefs and the regional geology in the context of ongoing EOR operations. This research demonstrates that $CO_2$-EOR results in incidental $CO_2$ storage in the reefs at the end of the $CO_2$-EOR life cycle. Core Energy intends to inject $CO_2$ with a secondary purpose of establishing long-term containment of a measurable quantity of $CO_2$ in subsurface geological formations in the NNPRT for a term referred to as the "Specified Period."

The MRCSP regional geologic characterization indicates that there is potential capacity for hundreds of millions tonnes of $CO_2$ through ancillary $CO_2$ EOR storage in the NNPRT. This potential far exceeds the amount of $CO_2$ available for EOR and, ultimately, ancillary storage capacity. This means that Core Energy anticipates being limited by the amount of available $CO_2$ in the future rather than by the amount of economically viable $CO_2$ EOR opportunity. In addition, the nature of the reef geology, as described in Section 2, provides operational flexibility that is much like buffer storage capacity. As a result, Core Energy anticipates continuing its business practice of capturing as much $CO_2$ as it can while the Antrim Shale play is still active and storing it within the reef system to support its EOR operations. Since it began operations, Core Energy has developed an inventory of anthropogenic $CO_2$ that is in circulation within the existing reef structures. Calculation of this inventory of working $CO_2$ is discussed further in Section 2.

During the Specified Period, Core Energy will utilize the working inventory of $CO_2$ through capture at the Dover 36 Facility and combine it with new $CO_2$ captured through the Chester 10 Facility. Over time, the mass balance calculation of stored $CO_2$ will reflect the existing inventory of $CO_2$ plus the new $CO_2$, as discussed in Sections 2, 5, and 7. Core Energy plans to further expand the amount of $CO_2$ introduced to the field if new sources become available. This additional amount would also be reflected in the mass balance calculation of stored $CO_2$.

Core Energy developed this monitoring, reporting, and verification (MRV) plan in accordance with 40 CFR §98.440-449 (Subpart RR) to provide for the monitoring, reporting and verification of the quantity of $CO_2$ sequestered at the Core Energy facility during the Specified Period. This plan describes how $CO_2$ EOR and ancillary storage take place in the reefs and how Core Energy will apply the requirements in 40 CFR §98.440-449 (Subpart RR) to calculate the annual amount of $CO_2$ stored throughout the entire Core Energy $CO_2$ EOR facility

In accordance with Subpart RR, flow meters are used to quantify the mass of $CO_2$ received, injected, produced, contained in products, and lost through venting or leakage. If leakage is detected, the mass of leaked $CO_2$ will be quantified using three approaches. First, Core Energy follows the procedures in 40 CFR §98.230-238 (Subpart W) to quantify fugitive emissions, planned and unplanned releases of $CO_2$, and other surface releases from equipment. Second, Core uses orifice type flow meters installed at its Wet and Dry Vent locations to measure the mass of recycle gas that is vented. And finally, Core Energy's risk-based monitoring program uses surveillance techniques in the subsurface and above ground to detect $CO_2$ leaks from potential subsurface leakage pathways. The $CO_2$ mass data, including $CO_2$ mass at different points in the injection and production process, equipment leaks, and surface leaks, will be used in the mass balance equations included in 40 CFR §98.440-449 (Subpart RR) to calculate the mass of $CO_2$ stored on an annual and cumulative basis.

**This MRV plan contains 12 sections:**

- Section 1 contains general facility information.
- Section 2 presents the project description. This section describes the geologic setting, reservoir modeling of the reefs, the operational history in the area, and the Core Energy facility operations.
- Section 3 describes the monitoring area for the Core Energy facility.
- Section 4 presents the evaluation of potential pathways for $CO_2$ leakage to the surface and demonstrates that the potential for leakage through pathways other than the man-made well bores and surface equipment is minimal.
- Section 5 describes Core Energy's risk-based monitoring process.
- Section 6 describes the baselines against which monitoring results will be compared to assess whether changes indicate potential leaks.
- Section 7 describes Core Energy's approach to determining the mass of $CO_2$ stored using the mass balance equations in 40 CFR §98.440-449, Subpart RR of the Environmental Protection Agency's (EPA) Greenhouse Gas Reporting Program (GHGRP).
- Section 8 presents the schedule for implementing the MRV plan.
- Section 9 describes the quality assurance program to ensure data integrity.
- Section 10 describes Core Energy's record retention program.
- Section 11 contains References.
- Section 12 contains Appendices.

Technical Notes:

1. Unless otherwise stated, this document uses the term "tonnes" to indicate metric tons (MT).

2. All calculations and reporting will be done on a metric ton basis (1000 kgs to 1 MT). Anytime $CO_2$ numbers are reported on a volume basis, Core Energy will utilize a conversion factor of 0.019 million cubic feet (MMCF), or 19,000 cubic feet, of $CO_2$ per metric ton of $CO_2$. This translates to approximate conversion between weight basis to volume basis of $CO_2$ at 60° F, 1 atm (~1.87 kg/m$^3$ density).

## 1. Facility Information

i) Reporter number – 545462

ii) US Environmental Protection Agency (USEPA) (Region V) administers the Underground Injection Control (UIC) program for all classes of injection wells in Michigan. The Michigan Department of Environmental Quality (MDEQ) Oil, Gas and Minerals Division (OGMD) administers the statutes and rules subject to Part 615, Supervisor of Wells, of the Natural Resources and Environmental Protection Act, 1994, PA 451, as amended (NREPA). The injection wells operated by Core Energy are permitted as UIC Class II wells by US EPA and all wells (including production, injection and monitoring wells) are regulated by OGMD.

iii) As of April 2018, there are 36 active wells penetrating the Niagaran reefs operated by Core Energy and there are additional wells that have been plugged and abandoned. A summary of these wells is included in Appendix I. Table A-1 indicates the active wells and includes the unit (reef), processing facility, API and MDEQ permit numbers, well name, depth and status. Table A-2 lists all wells that penetrate the reefs and includes reef, permit number, well name, well number, completion depth and date, type, and a wireline log inventory. Changes to the well inventory will be included in annual reporting.

## 2. Project Description

Core Energy operates in the upper north portion of Michigan in what is known as the NNPRT. (Figure 1).

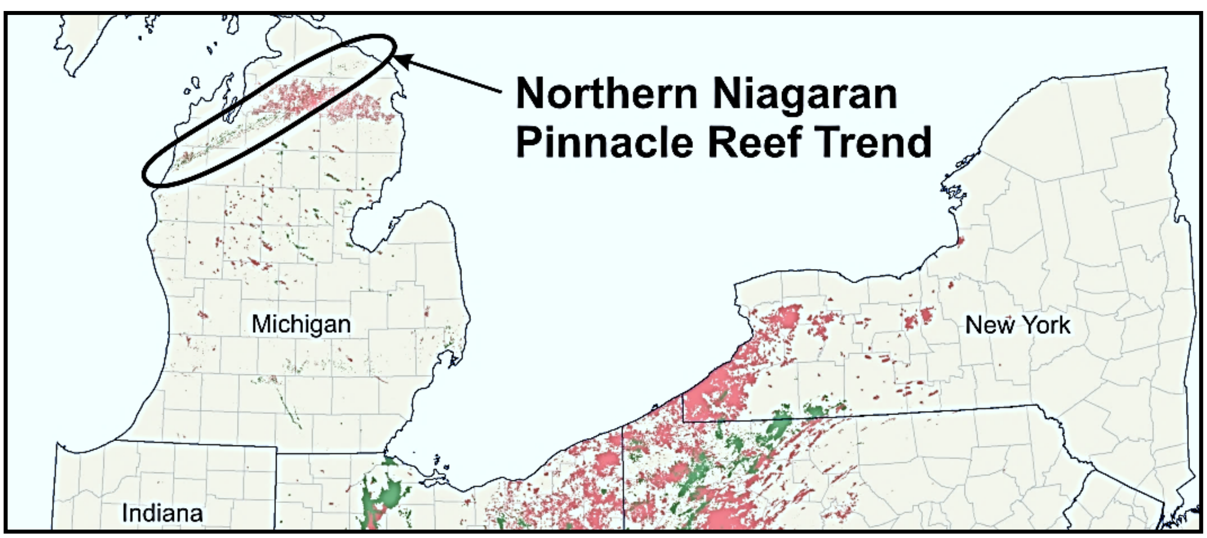



*Figure 1 - General location of Core Energy operations*

The NNPRT consists of closely spaced but highly-compartmentalized pinnacle reefs located, on average, about 6,000 feet below the ground surface (bgs) but can range from 3,000 to 8,000 feet (Most of the oil- and gas-producing reefs along the NNPRT are at depths of approximately 3500 to 5500 feet). This formation began as a series of coral reefs that formed millions of years ago in a setting similar to what we now observe in the Bahamas or Great Barrier Reef.

Since the reefs formed, sediments and other debris were deposited in layers around and above the reefs, forming hard structures that are excellent for containing the oil and gas that collected in them when the ocean receded and the corals died. It is estimated that in northern Michigan alone, such reefs could sequester several hundred million tonnes of $CO_2$.

Data was compiled for all reefs including data from ten cores and covering five Core Energy reefs: Bagley, Chester 16, Dover 33, Chester 2 and Chester 5. Core analyses included descriptions, photographs, porosity and permeability measurements, and advanced analyses in select cores. More than 40 additional Niagaran cores were collected in Otsego County with data available at the Michigan Geologic Repository for Research and Education (MGRRE).

Core Energy also collected 3D seismic data for nine reefs: Chester 16, Dover 33, Dover 35, Dover 36, Chester 2, Chester 5, Charlton 19, Charlton 30/31, and Charlton 6 (Figure 2). The data was used to identify the boundary of the reef edges and verify that there are no structural concerns in the area. Where 3D seismic data is not available, formation tops, thicknesses, and production are used along with nearby reefs to define the boundaries.

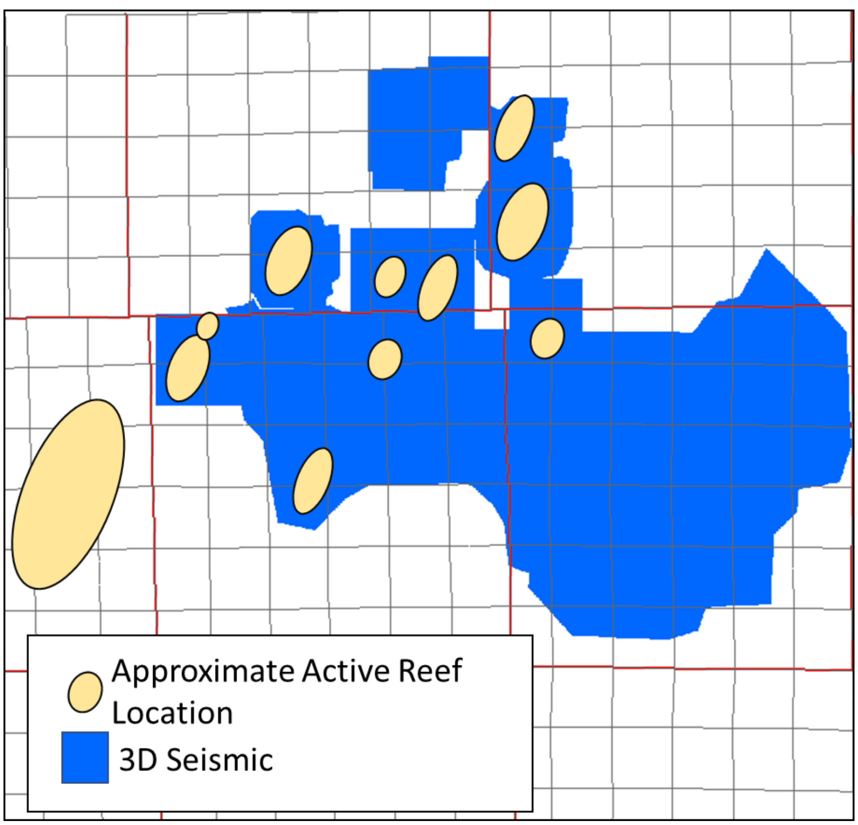
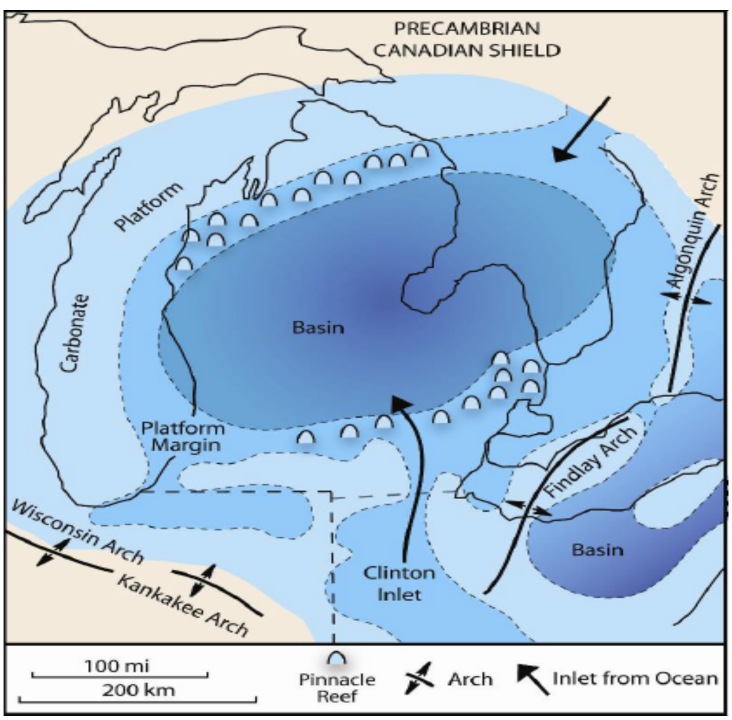



*Figure 2: Map of approximate active reef locations (yellow) and 3D seismic (blue).*

## 2.1 Geologic Setting

The NNPRT is part of an extensive paleo shallow shelf carbonate depositional system. The trend of pinnacle reefs forms a circular belt along the platform margin that rings the Michigan Basin (Figure 3). Most of the oil- and gas-producing reefs along the NNPRT are at depths of approximately 3500 to 5500 feet. While individual reef complexes are localized (averaging 50 to 400 acres in area), they may be up to 2000 acres in areal extent and 150 to 700 feet in vertical relief with the steeply dipping flanks. Reef height, pay thickness, burial depth, and reservoir pressure increase towards the basin center (Gill 1979). Currently, there are approximately 800 fields in the NNPRT and approximately 400 in the Southern Niagaran Pinnacle Reef Trend (SNPRT) of the Michigan Basin.

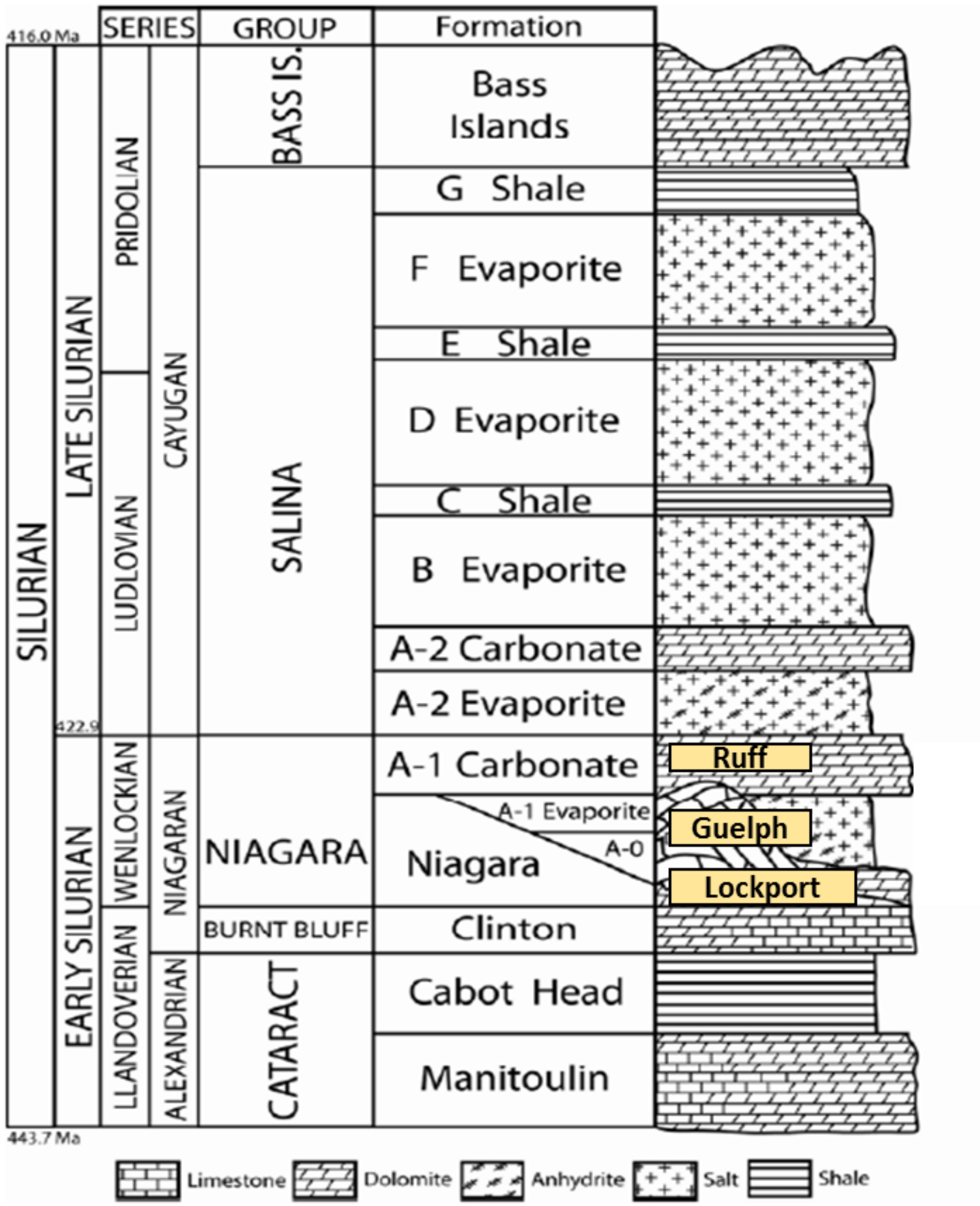
The NNPRT is generally divided in an updip direction into gas, oil, and water-saturated zones (Gill 1979). The reservoir facies primarily consist of porous and permeable dolomite and limestone. Some reefs are completely dolomitized, while others are essentially all limestone. Dolomitization of reefs increases as the reefs become shallower, and salt and anhydrite plugging of porosity occurs in the deeper reefs (Gill 1979). Effective porosity intervals for the reservoir range from only a few feet to several hundred feet from reef to reef. Porosity values extend to 35%, but typically average 3-12%; the best porosity and permeability are associated with dolomitized reef core and flank facies. The best reservoir rocks are characterized by well-developed inter-crystalline and vuggy porosity with average permeability values of 3 to 10 millidarcies Secondary porosity can significantly enhance permeability within the reservoir.




Ritter (2008), modified from Briggs and Briggs (1974)

*Figure 3: Carbonate platform and Basin setting during NNPRT development in Michigan.*

The reef facies developed within the Niagara Group and includes the Lockport and Guelph lithostratigraphic formations (Figure 4). The Lockport Formation is characterized by two types of crinoidal wackestones: dolomitized and low-porosity, undolomitized (Charbonneau 1990). The Lockport reaches a thickness of approximately 500 feet near the basin margins, but thins and has a more reddish color toward the center of the Basin (Huh 1973; Huh et al. 1977; Charbonneau 1990). The Lockport is frequently referred to as the "White Niagaran" but grades upward into a gray argillaceous, nodular crinoidal wackestone. The Guelph Formation contains the informal "Gray Niagaran" and the "Brown Niagaran". The Guelph "Brown Niagaran" consists of skeletal wackestones, packstones, grainstones, and boundstones/bindstones associated with the carbonate pinnacle reef buildups. It includes thin off-reef carbonate detrital/conglomerate lithofacies below the A-0 carbonate (Huh 1973). The Guelph Formation forms the core of the reservoir rocks associated with producing reefs.




Ritter (2008), modified from Cercone (1984).

*Figure 4.Generalized Stratigraphic Column for the Silurian Section noting Niagaran reefs.*

The seals for the Niagaran reefs consist of a series of evaporites and salt-plugged carbonates that encase the flanks of the reefs and form regional seals over the entire reef complex (see Figure 4). The A-1 and A-2 evaporites regionally transition from salt off the reefs to anhydrites over the tops of the reef. The A-1 evaporite generally thins or is not present over the tops of the reef but forms restricted seals along the flanks of the reefs. MRCSP studied five representative reefs in detail: Chester 16, Dover 33, Charlton 19, Bagley 11-14-23, and Chester 2. This study included acquiring a full suite of density and acoustic logs in order to characterize the rapid changes in the composition of the evaporites surrounding the reef flanks. These data enabled the MRCSP to understand and map reservoir porosity, seal integrity, and seismic response and are discussed below.

The A-1 carbonate belongs to the Ruff Formation and overlies the A-1 evaporite. It is a light-brown to tan, fine to medium crystalline, laminated, dolomitic mudstone and stromatolitic or microbial laminated boundstones, which may show truncation surfaces and rip-up clasts (Huh 1973; Gill 1973; Ritter 2008). Laminated, dolomitic mudstones occur in inter-reef deposits and on the reef; dolomitic microbial boundstone facies unconformably overlie the Brown Niagaran skeletal deposits (Gill 1973). The A-1 carbonate generally seals the flanks of the reefs, but some reservoir zones within the carbonate can be developed on the crests of the reefs.

Figure 5 illustrates the internal structure and geometry of reefs as well as their development cycle. This knowledge is important for predicting areas of best reservoir within the reef. The building of a Niagaran reef was initiated by carbonate mud-rich bioherm accumulation in warm, calm, shallow waters. The bioherm grew as sea level rose, following the prime conditions where biohermal organisms thrive (Stage 1). As sea level continued to rise, the reef core developed, dominated by corals and stromatoporoids. The wind direction during time of reef building was important because it created asymmetry within the reef (Rine 2015). The windward direction developed reef rubble where pieces of the reef core broke off and reduced in size by wave water impact. The leeward side developed a muddy detrital grain apron as fine-grained material sloughed off the reef. (Stage 2). When relative sea level stabilized, stromatolitic algal caps formed over top of the reef and created an intertidal, depositional environment. Next, as sea level fell within the Michigan Basin, the reef complex was exposed (Stage 3), and the living reef was killed. Evaporites such as salt and anhydrites were deposited along the flanks of the reefs and diagenesis occurred within the reef core. As post-Niagaran sea level rose and fell, layers of carbonates and evaporites were deposited over the reef complex (Stage 4).

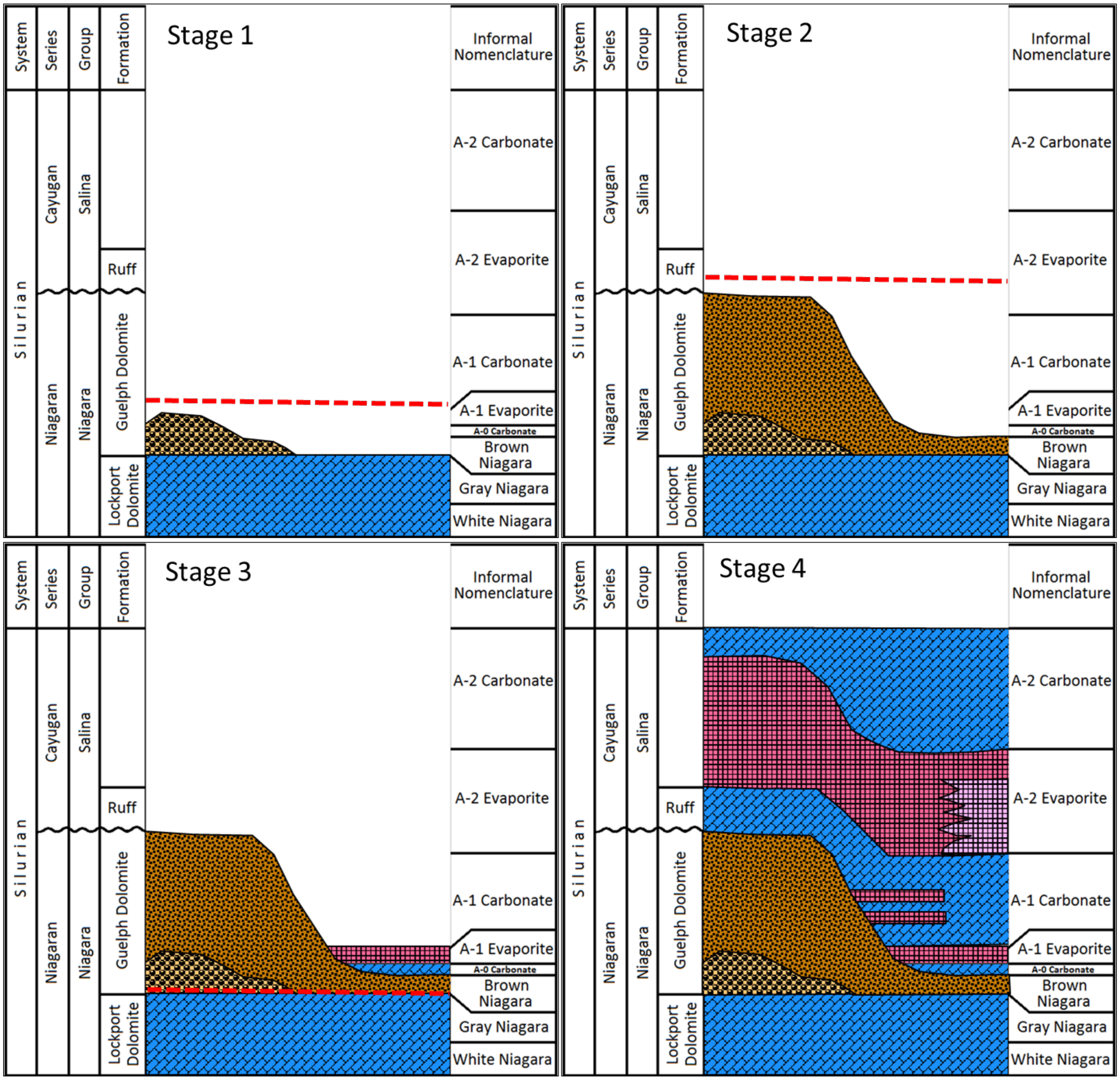



*Figure 5: Simplified diagrams of the stages of Niagaran reef development. Red dashed line denotes approximate sea level relative to reef growth.*

## 2.2 Reef Reservoir Characterization and Modeling

This subsection of the MRV plan describes the modeling that was developed to characterize the NNPRT reefs operated by Core Energy, Core Energy's understanding of the behavior of EOR operations in the reefs as indicated by the models, and the procedures going forward to use and or expand the modeling to determine which new reefs to include in operations as well as the operations plans for those reefs.

Core Energy worked with MRCSP to model six representative reef reservoirs. The key objectives of this modeling were to develop a detailed understanding of each modeled reef as well as the predictability of internal reef architecture. The modeling was successful in achieving both aims. Going forward, Core Energy does not plan to develop detailed models for each new reef but will draw on a set of transferable principles from existing modeling that can be applied in operations and improving $CO_2$ flood performance.

### 2.2.1 Model Development

MRCSP used Static Earth Models (SEMs) to integrate all available geologic and geophysical information into a single framework used to conceptualize $CO_2$ migration and retention in the subsurface (Figure 6). The SEMs also provide the basis for incorporating geologic information into dynamic models for the reservoirs. The building of SEMs was an iterative process with multiple stages of quality checks to develop an SEM most representative of geology and reservoir properties. To build SEMS and dynamic models, the following information was integrated by geologists and engineers:

- Reef geometry (seismic and/or production), well locations and construction, formation depth and thickness, and delineation of lithofacies
- Rock properties including porosity, permeability, and fluid saturations from core and wireline log data
- Fluid flow such as density and viscosity of fluids, relative permeability, capillary pressure, and fluid phase

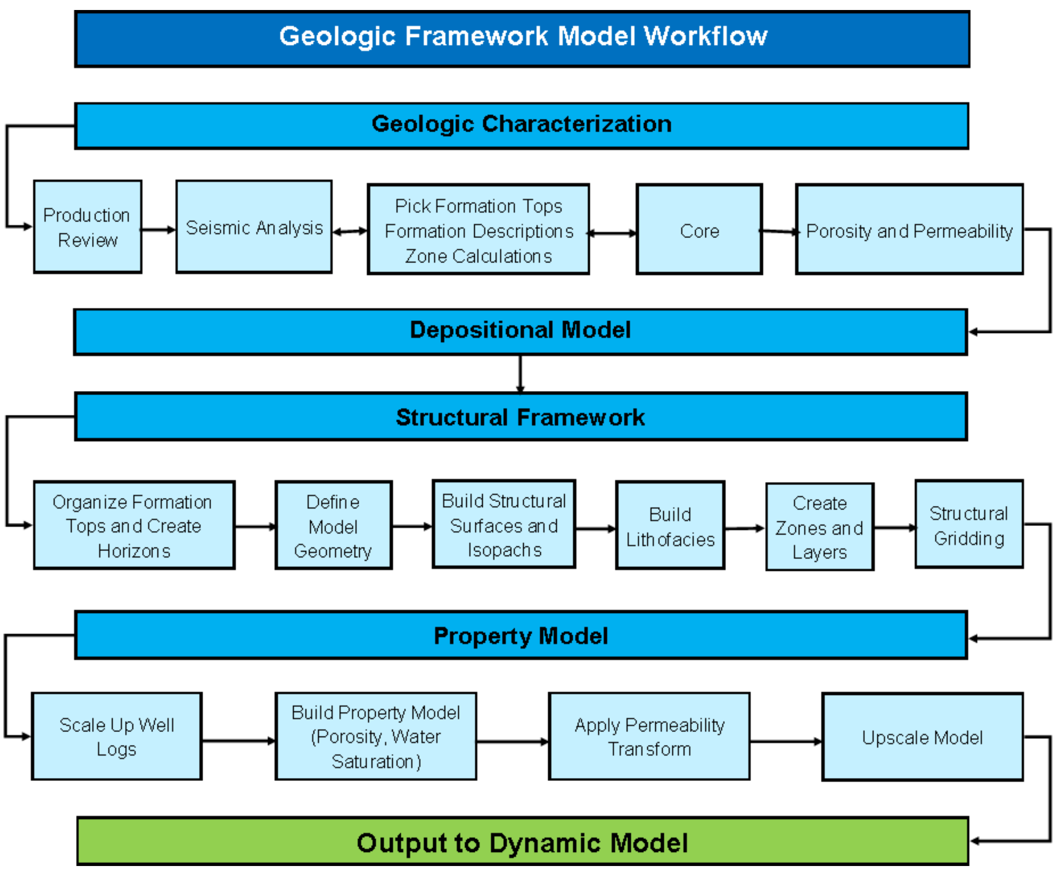



*Figure 6: Typical geologic characterization and modeling workflow for reefs.*

The modeling workflow began with geologic characterization of a reef which incorporated and integrated all information and data to develop a conceptual/depositional model. Figure 7 illustrates a 2D cross section through one such reef (Chester 16) with formations and reservoir flags. SEMs were then constructed using a conceptual geologic model, which allows for predictability of both vertical and horizontal lithofacies distributions by use of whole core and wireline log data. Figure 8 is an example 2D slice through a 3D SEM of Chester 16 (A) and Dover 33 (B) showing porosity distributions. Once SEMs were complete, they were outputted for dynamic modeling.

Dynamic modeling was used to history match with production records, simulate fluid flow and pressure changes, and assist with well design and $CO_2$-EOR flood configuration design.

Basic geologic characterization is used to define the reef, describe formations, and identify reservoir and caprocks. Advanced geologic characterization and modeling are typically used to aid in planning or when a reef does not perform as expected. While Core Energy does not do the same level of characterization and modeling for each reef, lessons learned from advanced modeling show the predictability of internal reef architecture. Core Energy combines the knowledge gained from modeling regarding $CO_2$ flows within reef architecture along with the feedback from material balance and pressure monitoring and response to develop operational plans for $CO_2$ EOR.

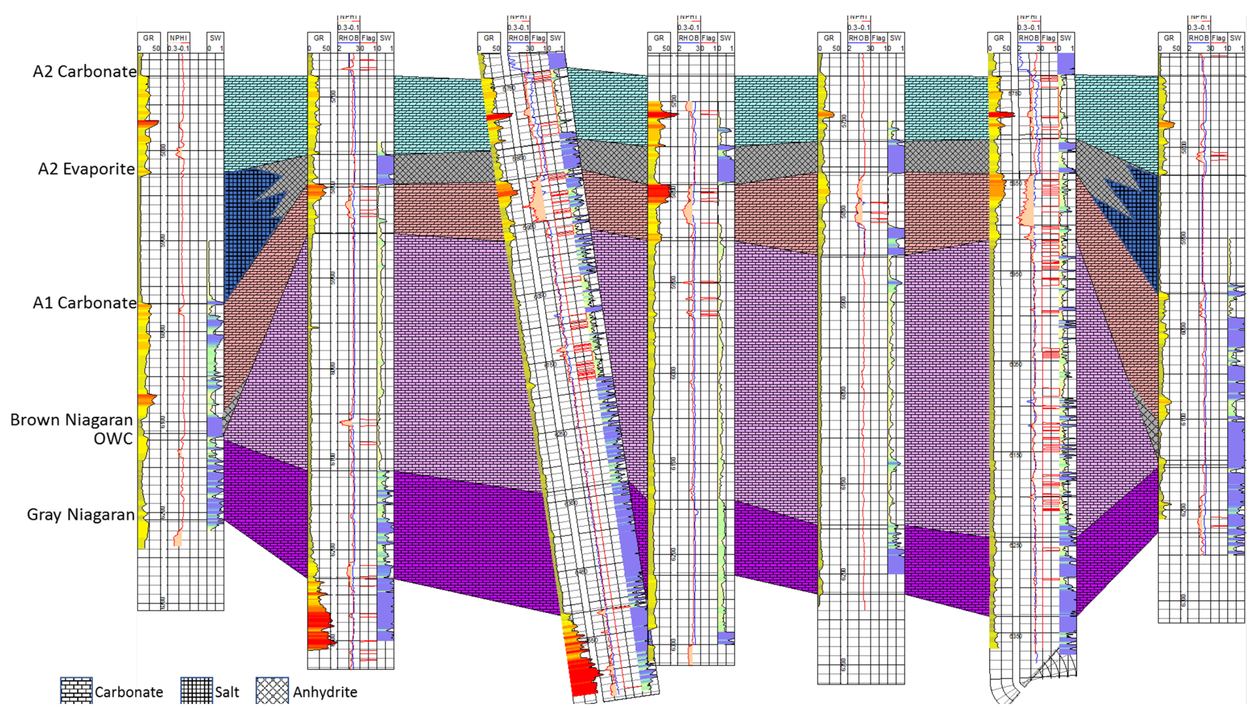


*Figure 7: Example 2D conceptual model and geologic characterization of a reef.*

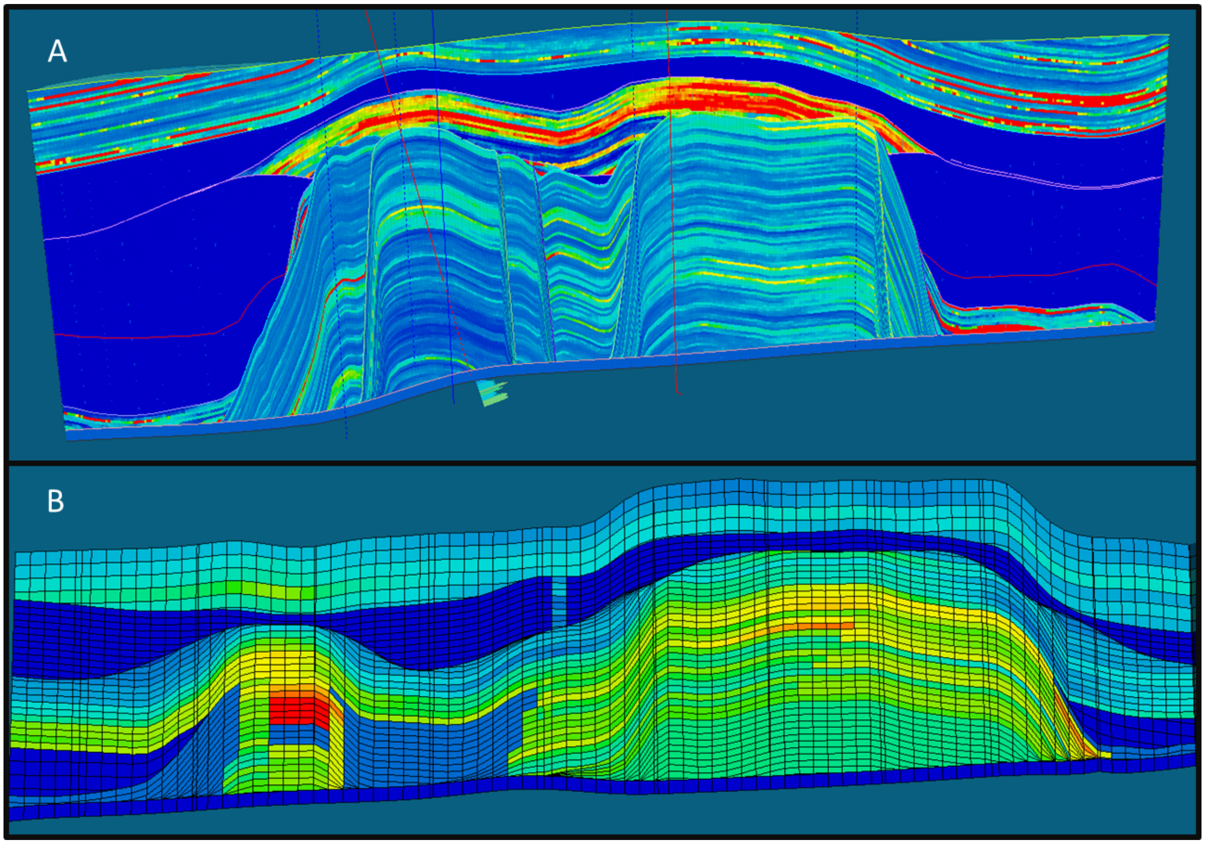


*Figure 8. Example slice through a 3D SEM showing porosity distribution through Chester 16 (A) and Dover 33 (B)*

Core Energy in collaboration with MRCSP has completed a significant amount of characterization and modeling on select reefs (Figure 9). To date, all 10 reefs have undergone basic geologic characterization to develop a 2D conceptual model of the reef. Five reefs have been developed into SEMs and taken into dynamic modeling. Even though the reefs have variable reservoir properties, there are predictable controls on reservoir performance such as amount of dolomitization, secondary porosity development, and salt plugging which can be identified through geologic characterization. For example, limestone reefs tend to have tighter porosity mid to lower reef with highest porosity and permeability in the upper reef and A1 Carbonate, as illustrated in Figure 8A with hotter colors for higher porosity. Dolomitized reefs tend to have more enhanced porosity throughout the reef due to secondary porosity development as illustrated in Figure 8B with hotter colors for higher porosity. The variability or heterogeneity in rock/facies type is related to a reef's location within the larger Michigan Basin geologic setting.

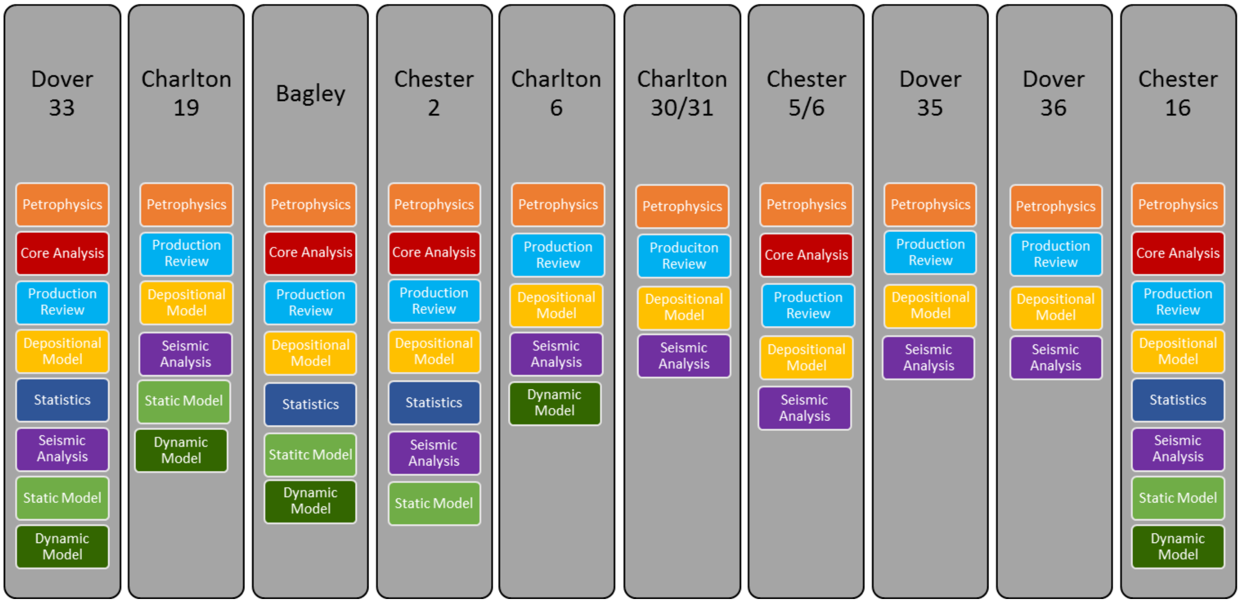



*Figure 9: Analyses completed to date by reef.*

### 2.2.2 Conceptual Understanding of $CO_2$ EOR in Reef Structures

The modeling and extensive history of oil and gas production in the NNPRT have demonstrated the varying degree of compartmentalization of the reefs and the efficiency of the overlying evaporites and carbonates as seals. The reefs act as a closed reservoir system, which provides excellent conditions for $CO_2$-EOR operations.

The discovery pressure in the oil-bearing NNPRT reefs averages about 3,000 (psi). Primary production utilized this pressure to flow oil to the surface. Secondary production, using water flooding, was attempted but not widely used. Tertiary production, using $CO_2$ EOR, was initiated in the late 1990's and expanded by Core Energy as it started operations in 2003.

Core Energy typically initiates $CO_2$ EOR in reefs that have undergone primary and in some cases after secondary production.  As $CO_2$ is injected into the reefs, it contacts the oil trapped in the pore space while it simultaneously increases the reservoir pressure. As contact and pressure increase, the $CO_2$ eventually becomes miscible with the oil which allows it to flow towards a designed production well. Figure 10 illustrates the $CO_2$ EOR process in a reef field for a $CO_2$ injection well and the associated production well.  Note that the source of $CO_2$ is from the gas producing zone indicated at the top of the column.

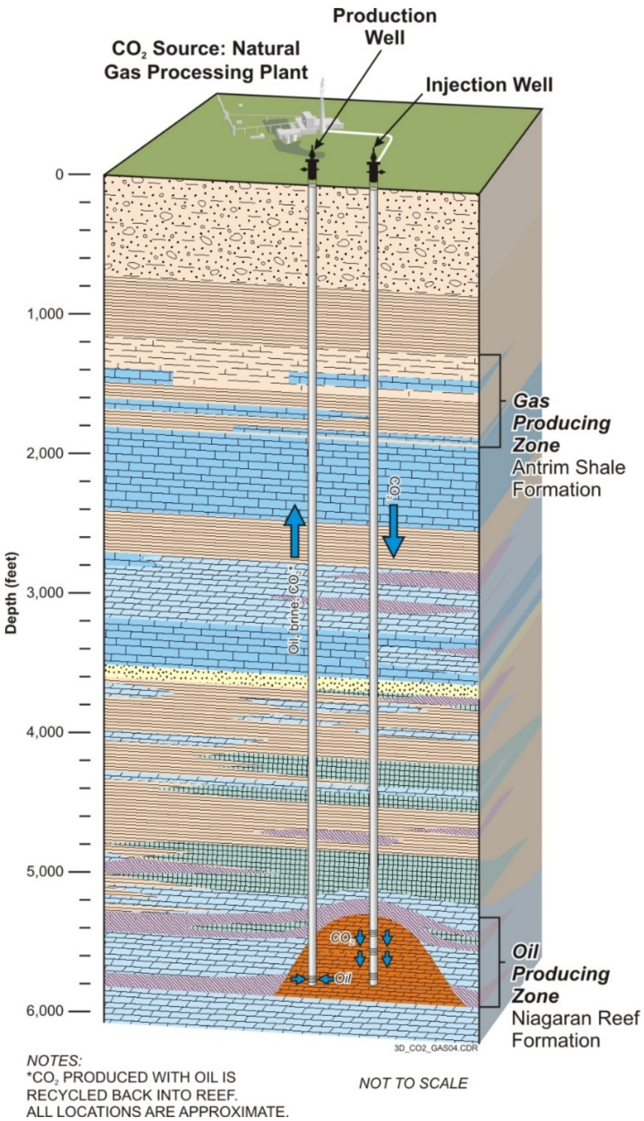
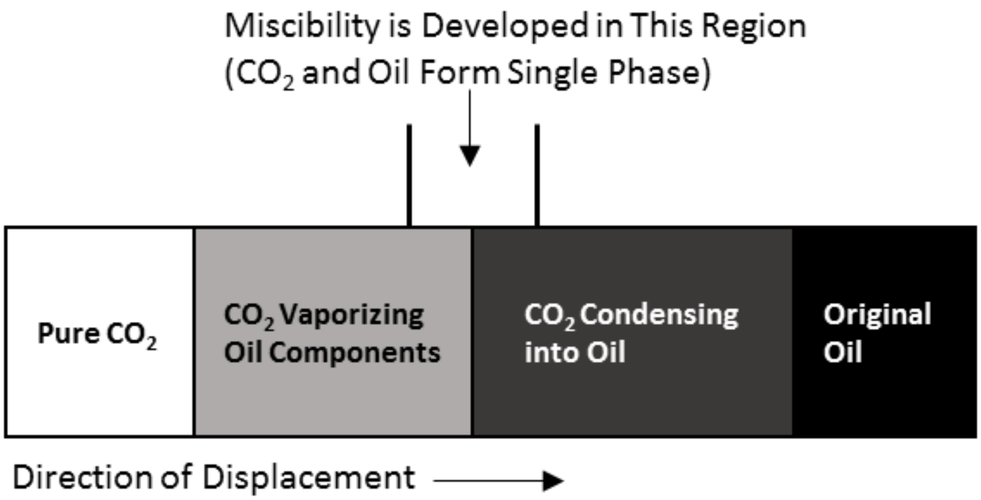



*Figure 10: Simplified diagram illustrating $CO_2$-EOR process in a reef.*

Figure 11 shows a graphic representation of how $CO_2$ and oil become miscible. At either end of the image are pure $CO_2$ and original oil. As the two come into contact and pressure increases, $CO_2$ vaporizes oil and also condenses into it, forming a single-phase fluid mixture of $CO_2$ and oil. This mixture of $CO_2$ and oil, along with formation brine present in some cases, is then produced from the well.




From Zick, 1986

*Figure 11: $CO_2$ Miscibility Diagram (SPE Monoraph 22)*

At the end of $CO_2$ EOR operations, when a project is no longer economically viable and in preparation for closure, Core Energy typically attempts to recover as much $CO_2$ as it can by producing fluids back through a CPF until such time the reservoir pressure has been reduced to a level whereby wells can no longer flow (approximately 500 psi or less). After the $CO_2$ recovery effort has been completed, the reservoir pressure has been depleted, and wells will no longer flow; it leaves the reef in a state whereby there is significant voided pore space.

The Core Energy facility has significant operational flexibility due to the modular nature of the reefs and the diversity of their development status. The Core Energy reefs are isolated from each other, and each goes through a phase development maturation process that ranges from new or "fill up", to operational, onto depleted.

New reefs are in the fill up stage in which the initial volume of $CO_2$ is being injected to raise reservoir pressure above the minimum miscibility pressure (~1190 psi MMP) of $CO_2$ in oil. Above this MMP, the $CO_2$ and oil become a single phase fluid and begin to flow to producer wells depending on the pressure gradient between the injection well and the producer wells. After the reef has been pressurized above the MMP (the fill-up phase), these reefs transition into the operational phase, which can last for many years.

Once a reef is determined to be operational, pipelines will be extended from the producing wells to a central processing facility, if they are not already in place. Based on the oil type and the temperature of the reservoirs, Core Energy found that conducting miscible $CO_2$ flooding is optimized at roughly 1,300 PSI.

Core has also tested the capacity to increase pressure above the optimal range and finds that while it has the headroom (available pore space) and ability to increase pressure to well above 1,300 psi, it does not have equipment that could raise pressure to levels near or above the fracture pressure.

When the bulk of economically available oil has been produced via EOR, the reef is considered depleted or nearing depletion. In depleted reefs, the economic return on $CO_2$ EOR is not as high as in the operational reefs. However, these reefs still have some oil left in place and can also effectively act as short-term storage for $CO_2$ in the system. When $CO_2$ EOR operations in a reef end, Core Energy typically recovers as much $CO_2$ as it can by producing fluids back through a CPF until such a time as the reservoir pressure has been reduced to a level whereby the wells can no longer flow (approximately 500 psi). The amount of $CO_2$ which remains in the reef below this pressure cannot be recovered and is stored under current conditions.

This development cycle for each reef, combined with operating multiple reefs at once, provides Core Energy with unique operational flexibility. At any time, the number of reefs and the diversity of their status enables Core to accept as much $CO_2$ as it can capture and then use it over time. This is especially important due to the depleting nature of their anthropogenic source of $CO_2$ (i.e. gas processing plants servicing the Antrim Shale production).

### 2.3 Operational History of the Core Energy Reefs

The NNPRT reefs, originally developed in the 1970-1980s, have undergone primary production and, in some cases, secondary recovery through water flood and other methods.  Oil operations largely subsided in the early 1990s and then picked up sporadically towards the end of the decade. Core Energy entered the play in 2003, taking over two operating reefs and slowly expanding into eight additional reefs.

#### 2.3.1 Core Energy EOR Reef Complex Development

Core Energy currently operates 10 active EOR reefs in Otsego County in northern Michigan. $CO_2$ EOR was initiated in each of these reefs at different times as indicated in Table 1. Figure 12 shows the location of each reef.

**Table 1: Active CO2-EOR reefs and date of initial flooding.**

| Reef | Date $CO_2$ Flooding Initiated |
|---|---|
| Dover 33 | 1996 |
| Dover 36 | 1997 |
| Dover 35 | 2004 |
| Charlton 30/31 | 2005 |
| Charlton 6 | 2006 |
| Chester 2 | 2009 |
| Chester 5 | 2011 |
| Charlton 19 | 2015 |
| Bagley 11-14-23 | 2015 |
| Chester 16 | 2017 |

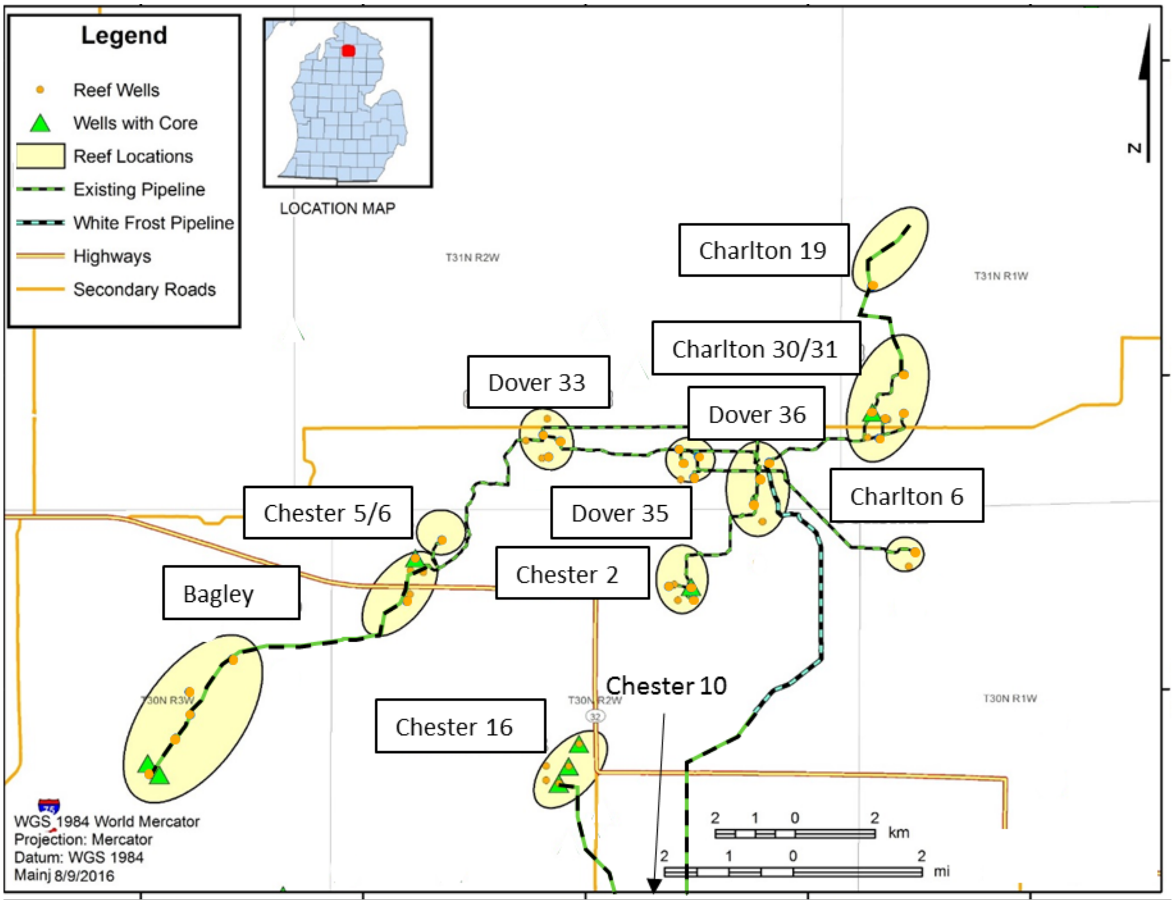



*Figure 12: Location of active reefs operated by Core Energy.*

## 2.3.2 $CO_2$ Production and Injection History

All of the active reefs have undergone primary production in the past. Core Energy maintains production records for all wells in the active reefs, including volumes of the following:

- oil produced,
- gas produced (commingled natural gas and $CO_2$)
- water produced
- water injected (if applicable), and
- $CO_2$ injected.

Core Energy worked with Battelle to develop a baseline accounting as of December 31, 2017 of the $CO_2$ that has been injected since 1996. Since 1996, 2.11 million tonnes of $CO_2$ has been injected into the Core Energy reefs.

Core Energy is starting its mass balance accounting for $CO_2$ at zero. This means that the amount of $CO_2$ already in the system will ultimately be reflected in the mass balance calculation of the amount stored. Over time, the total amount stored will be roughly equal to the sum of $CO_2$

from Chester 10 and the inventory of $CO_2$ produced through Dover 36 less any losses from equipment or subsurface leaks, which are expected to be minimal.

## 2.4 Description of CORE Energy $CO_2$-EOR and Ancillary Storage Project Facilities and the Injection Process

Core Energy operates an integrated facility that includes $CO_2$ capture, dedicated pipelines, injection and production wells, a central processing facility for fluids, and compressors. Figure 13 is a detailed flow chart with equipment names and meter numbers. The rest of this section will use Figure 13 to review the facilities and processes taking place at the Core Energy facility.

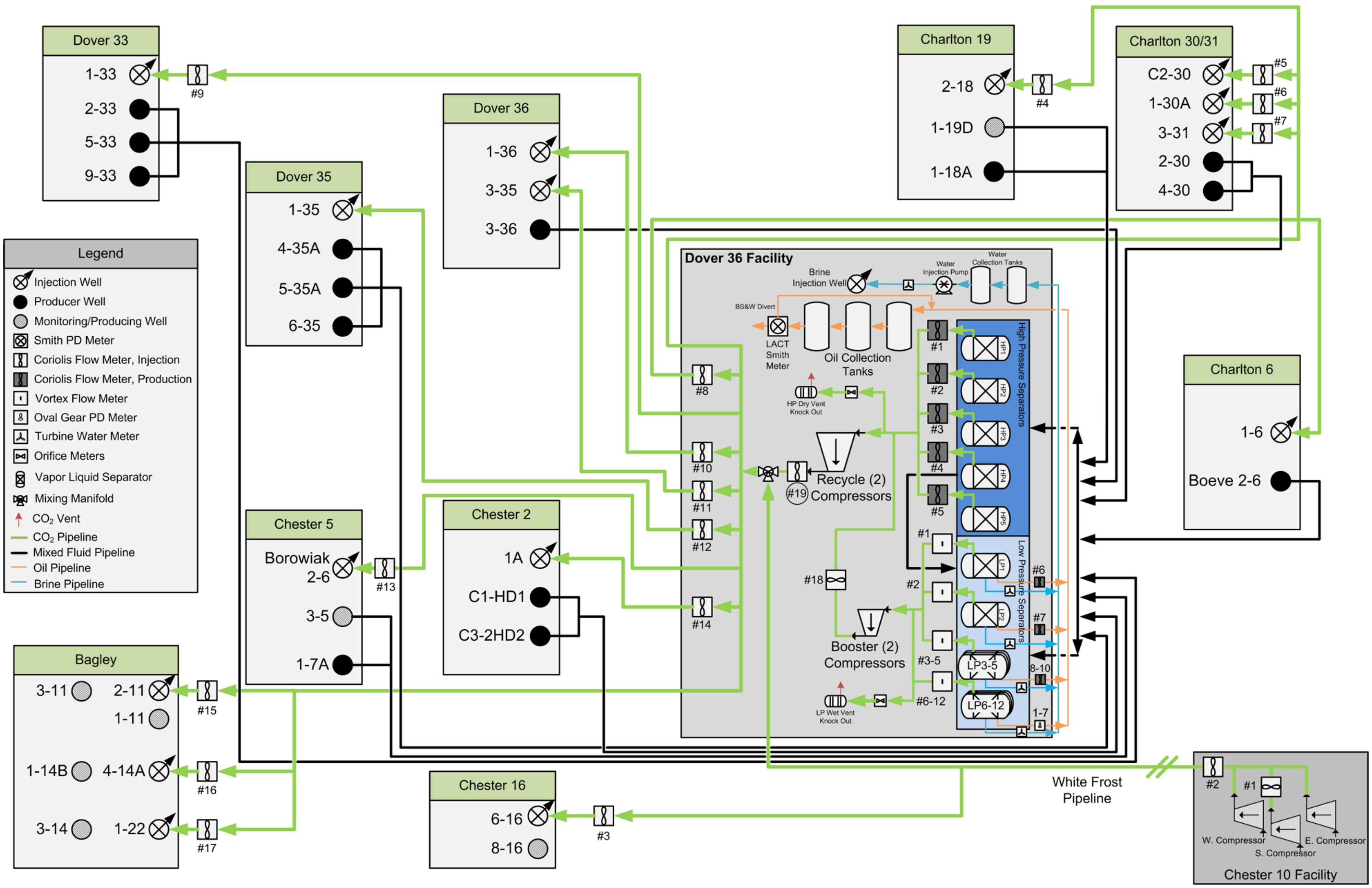



Figure 13 – Simplified Process Flow Diagram of Core Energy's EOR Facility

### 2.4.1 $CO_2$ Capture

Core Energy captures $CO_2$ at two locations:

- Chester 10 Facility (shown in bottom right corner of Figure 13): This facility captures $CO_2$ from a natural gas processing facility that treats gas produced from the Antrim Shale. Core Energy has the right to capture up to 100% of the $CO_2$ that would normally be vented from the natural gas plant. Core has made investments to expand capture operations over time and plans to make additional investments in the future. It currently captures between 300,000 to 350,000 tonnes of new $CO_2$ per year. Also, there is potential to capture an additional 100,000 tonnes per year, resulting in net potential 450,000 tonnes of new $CO_2$ per year. It is expected that the natural gas processing plant will continue operations for at least 10 to 20 years but continued operations depend on market conditions. Core currently has three compressor units at this facility, with the mass of all new $CO_2$ measured using Coriolis mass flow meter number 2 (Figure 13).

- Dover 36 Facility (large rectangular box in Figure 13): This facility is co-located along with the Dover 36 reef. This facility contains the main Recycle Compressor along with capture equipment which captures $CO_2$ from various high-pressure (HP) and low-pressure (LP) fluid separators that treat the fluids from the production wells. Core Energy currently captures ~300,000 tonnes of gas per year at the Dover 36 Facility. This gas consists of $CO_2$ (~95% by wt.) with small quantities of hydrocarbon gas which is recompressed and sent back to various EOR reefs. The mass of this gas is measured using Coriolis mass flow meter number 19.

### 2.4.2 $CO_2$ Distribution and Injection

Core Energy maintains about 80 miles of pipelines that are used to move $CO_2$, produced fluids, and oil. A diagram of the pipeline network and locations of 10 EOR reefs is shown in Appendix II.

A portion of $CO_2$ from the Chester 10 Facility delivered via the White Frost Pipeline can be withdrawn directly for injection into Chester 16 reef (measured using Coriolis mass flow meter number 3); the remainder of the $CO_2$ from Chester 10 flows to the Dover 36 Facility, where it mixes with $CO_2$ from the Recycle Compressor at the Mixing Manifold. From the Mixing Manifold, Core can re-arrange various piping and valves to direct $CO_2$ to any one of the reefs.

Dedicated Coriolis mass flow meters are attached to each injection well at the EOR reefs. Some of the meters are located at the Dover 36 Facility while others are located directly at the wellhead. These meters are numbered 3 through 17 (Figure 13) for the 15 injection wells at 10 EOR reefs. It is important to note that Core can change the operational configuration of wells whereby an injector well may become a producer or monitoring well, or a producer well may be converted to an injector well. If in future, a producer well is reconfigured to be an injector well, Core will install a Coriolis or other suitable flow meter to measure the quantity of $CO_2$ being injected into that well and will indicate such changes in the annual reporting.

### 2.4.3 Produced Fluids Handling and Processing

Table A-1 in Appendix I lists the active wells, of which 20 are "producers". These 20 wells are further indicated by status as a current producer (PR), a shut-in producer (SI-P) or an observation (OBS) well. Generally, at least one production well is located in each reef. For the new reefs, the production wells will be connected to pipelines for produced fluids once they start producing. For the other reefs, all produced fluids from the reefs flow directly to dedicated separators at central processing facilities.

Core Energy currently has a network of 5 HP separators and 12 LP separators at the Dover 36 Facility. Product streams from reefs that are producing oil under high pressure (> 340 psi) are first sent to an HP separator; product streams from reefs that are producing under low pressure (<340psi) are sent to one of the LP separators. The remaining liquid product stream (containing mostly oil and brine) from an HP separator is further sent to an LP separator for separation and stripping of any entrained gas. The produced gas that is separated in the HP separator is sent to the Recycle Compressor, while the gas separated from the LP separator is first sent to a Booster Compressor prior to being sent to the Recycle Compressor.

The produced gas which primarily consists of $CO_2$ (>95% by wt) is separated from the produced fluid and flows through a Coriolis mass flow meter at each of the HP separators before being sent to the Recycle Compressor (meters numbered 1 through 5). The bulk of the produced gas is captured in the HP separators (> 90% by wt). Meanwhile, the produced gas that is separated at the LP separator, flows through a Vortex type flow meter. The system of Coriolis mass flow meters (attached to the HP separators) and Vortex flow meters (attached to the LP separators) measures the mass of recycle gas produced from each operational reef. Additionally, one Coriolis mass flow meter (number 18) measures the mass of all recycle gas captured at the LP separators while another (number 19) measures the total quantity of produced gas that is produced by all operational EOR reefs.

Brine is separated by the LP separators. The collected brine is sent to a brine disposal well located onsite at the Dover 36 Facility.

Oil is gathered in collection tanks before flowing through a LACT meter for offsite sales. A small amount of $CO_2$ remains entrained in the oil after the $CO_2$ separation process, which bleeds off as the oil moves through the LP meters into a temporary storage/gathering tanks. Core hired an external engineering firm to conduct a survey in 2011 to determine the amount of $CO_2$ entrained in oil. This study indicates that the concentration of $CO_2$ entrained in oil is 0.7512% by weight. This translates into roughly 150 tons per year at current operations levels. Because the oil is blended in the gathering tank, Core Energy believes this factor applies uniformly to all oil.

While rare, operational outages periodically occur, which forces produced gas to be vented to the atmosphere. Core has orifice type flow meters installed at its Wet and Dry Vent locations to measure the mass of recycle gas that is vented. Looking back for the last 12 months (May 17 to April 18), a small volume of $CO_2$ was vented during eight (8) of those months (roughly 50 tons). The volume of $CO_2$ vented represents less 0.0174% of the produced volume.

### 2.4.4 Data Collection

The system of flow metering at the Dover 36 Facility is centrally tied to a Core Energy HMI computer system. Coriolis mass flow meters that are located at the reef-site locations (at injection wellheads) typically have data-loggers which collect and store injection data. The HMI system records continuous production and injection data files on a per-minute basis for each day of operations. Operators typically record totalizer readings from injection and production parameters at 9 AM each day for the previous operational day. Additionally, there are daily site visits to the wellsites where operators record well data (e.g., tubing pressure, casing pressures, and wellhead temperatures). Together, these data streams provide accurate accounting of all $CO_2$ being acquired (from the Chester 10 Facility), injected into EOR reefs, and recycled at the Dover 36 Facility.

The method used when estimating the volume of $CO_2$ "lost" due to an interruption in data collection or mechanical failure of a meter (equipment) is to use the most recent daily volume of $CO_2$ associated with the meter and calculate the proportionate volume of "lost" $CO_2$ based on the number of hours involved in the data gap or until the meter was repaired. Core Energy has well and facility data in three forms: 1) Paper copies (scanned to server), 2) Keyed in data from paper copies into database, and 3) Automated capture of limited set of data that was recently instrumented (Fall of 2016).

Subsequent sections of this Plan, Section 5.5 and Section 6, provide a more detailed explanation for how this data and other means will be used as baseline data for comparison to detect possible surface leakage.

### 2.4.5 Existing Wells

Core Energy operates 16 injection wells (1 of which is a shut-in injector) and 20 production/observation wells. These wells are listed in Appendix I.

Well status is discussed in Section 4.1.

Wells are configured as each EOR project is developed (see Table 1). Mechanical integrity for injection wells is monitored through daily readings of casing pressure, quarterly fill-up tests and mandatory mechanical integrity tests (MIT) every five years. All injection wells utilize a corrosion inhibited packer fluid in the annular space between the tubing string and casing, above the required isolation packer. Corrosion coupons are placed at various nodes in the system as a way to monitor metal loss.

Maps showing the locations of the wells in each reef are provided in Figure 12. In general, the basic open-hole geophysical logs (e.g. gamma ray, density, resistivity, neutron porosity, photoelectric) are available for most of the wells in the active reefs. A sonic log is available for approximately half of the wells. Cement-bond logs are sparingly available.

## 2.5 Core Energy Procedures for $CO_2$- EOR Facility Modification

Core Energy plans to continue routine business operations, which may include securing additional $CO_2$; modifying, adding, or closing wells; adding or closing reefs, and adding new facility equipment and pipelines.  These modifications represent a continuation of the basic integrated current configuration and MRV approach and not a material change that triggers a revised plan (see 40CFR Part 98.448(d). Therefore, Core Energy intends to indicate such changes in the annual monitoring report rather than submitting new MRV plans. The monitoring report would demonstrate how the change is a continuation of the existing EOR Facility and would also include any new site characterization, risk assessment, monitoring, and mass balance information as is already included for the existing EOR Facility. The existing provisions for the MRV would continue to apply. Each of these potential changes is discussed in more detail below.

### 2.5.1 New Sources of $CO_2$

Core Energy is considering the addition of new equipment to capture additional $CO_2$ from the adjacent natural gas processing plant through its Chester 10 Compression Facility. It is also exploring the potential to obtain additional $CO_2$ through nearby sources that are in development.

In the event new sources of $CO_2$ are added, the amount of $CO_2$ would be measured using flow meters and added to the reported amount of $CO_2$ received onsite as indicated in Section 7. Injected $CO_2$ from these sources would be measured using flow meters and added to the reported amount of $CO_2$ injected as indicated in Section 7.

### 2.5.2 Adding New Wells

In order to add any new injection wells, Core Energy would have to work with the US EPA (or if Michigan gains primacy for Class II, MDEQ/OGMD) to obtain the permits and from MDEQ/OGMD to obtain permits for any new production wells. Such wells would be sited, completed, and operated in the same manner as the existing wells, under the oversight of the US EPA and/or MDEQ. The existing modeling and learned transferable principles would be combined with reef characteristics to determine location and operational plans for such wells. Well numbers and information would be included in the annual statement.

### 2.5.3 Abandoning Existing Wells

Core Energy follows the UIC Class II requirements and/or the MDEQ/OGMD requirements for closing wells. Any wells closed within a reporting year would be noted in the annual statement.

### 2.5.4 Changing the status of Existing Wells

Core Energy may change the status of an existing well from producer to injector or vice versa. In such situations, Core Energy will work with US-EPA and/or MDEQ/OGMD to obtain the necessary permits and will indicate the status change in the annual statement.

### 2.5.5 Acquiring New Reefs

Core Energy is looking to expand into new reefs based on their potential development value, which is a reflection of past operational history and current ownership structures as well as other factors. Based on the modeling and history of reef development in the area, Core Energy does not anticipate that past operations will preclude any reef from being selected as an expansion candidate. As part of the permitting process, Core Energy will conduct a site characterization, determine the boundaries of the reef, and assess the Area of Review (AoR) of at least ¼ mile around the reef to determine if there are any old wellbores that need to be remediated or closed and whether there are any other impediments to the successful implementation of $CO_2$ EOR on that reef. All potential new reefs are located in the MMA as indicated in Section 3.2 and would be moved into the AMA as indicated in Section 3.1 if they are developed by Core Energy.

### 2.5.6 Abandoning Existing Reefs

Core Energy will follow the requirements for closing wells and will follow any contractual or permit requirements for abandoning a reef. Core Energy will prepare a closure report for any abandoned reefs that assesses the amount of $CO_2$ that will be incidentally stored in that reef after closure and serving as the foundation for removing that reef and the related $CO_2$ from the active MRV reporting program.

### 2.5.7 Adding New Facility Equipment

Core Energy may add new equipment that could have an impact on the mass balance. This might include additional compressors, processing equipment, and/or other equipment. These changes would be noted in the annual statement and $CO_2$ losses from this equipment would be calculated as in Section 7 and the results included in the mass balance.

### 2.5.8 Acquiring New Pipeline Routes

Core Energy may build additional pipelines to connect new wells to the Core Energy Facility or to connect fill up reefs to production facilities. These changes would be noted in the annual statement and $CO_2$ losses from this pipeline would be calculated as in Section 7 and the results included in the mass balance.

## 3. Delineation of the Monitoring Area

### 3.1 Active Monitoring Area

Due to the highly compartmentalized nature of the Niagaran reefs, the Active Monitoring Area (AMA) is defined by the boundary of the Unit Area of each individual reef/field as established in the Order by the Supervisor of Wells for the MDEQ authorizing each EOR project. The following factors are considered in defining the boundaries:

- $CO_2$ injected into a reef remains contained in the reef because of the efficient seals along the edges and overlying the reef

- The edge of the reef is typically defined using 3D seismic data. Where 3D seismic data is not available, reef edges are approximated using all wells surrounding and penetrating a reef, along with analog reef geometry.

- Stored $CO_2$ will remain within a reef and will not migrate over geologic time, as is demonstrated by the long history of oil and gas production occurring within a reef. Just as the oil and/or gas were trapped in and contained by the reef, the same would be true for the $CO_2$.

- Free-phase $CO_2$ is contained within the reefs and will remain there after injection ceases and wells are shut-in or closed

- MDEQ rules state that an operator must demonstrate that the reservoir is wholly contained in the Unit Area before an EOR project is authorized.

## 3.2 Maximum Monitoring Area

The maximum monitoring area (MMA) for the MRV Plan, based on the anticipated future of expansion to conduct $CO_2$ EOR operations in reefs within the NNPRT, extends geologically along the northern edge of the Michigan Basin. The NNPRT extends as a band of reefs from Lake Huron (Presque Isle County) to Lake Michigan (Manistee County), of which there are prospective CO2 EOR reefs in every labeled county shown in Figure 14. In accordance with § 98.448-449, the actual MMA will extend for ½ mile beyond the reefs. The red dashed line in Figure 14 encompasses the half mile buffer to the north and south of the reefs in the MMA.

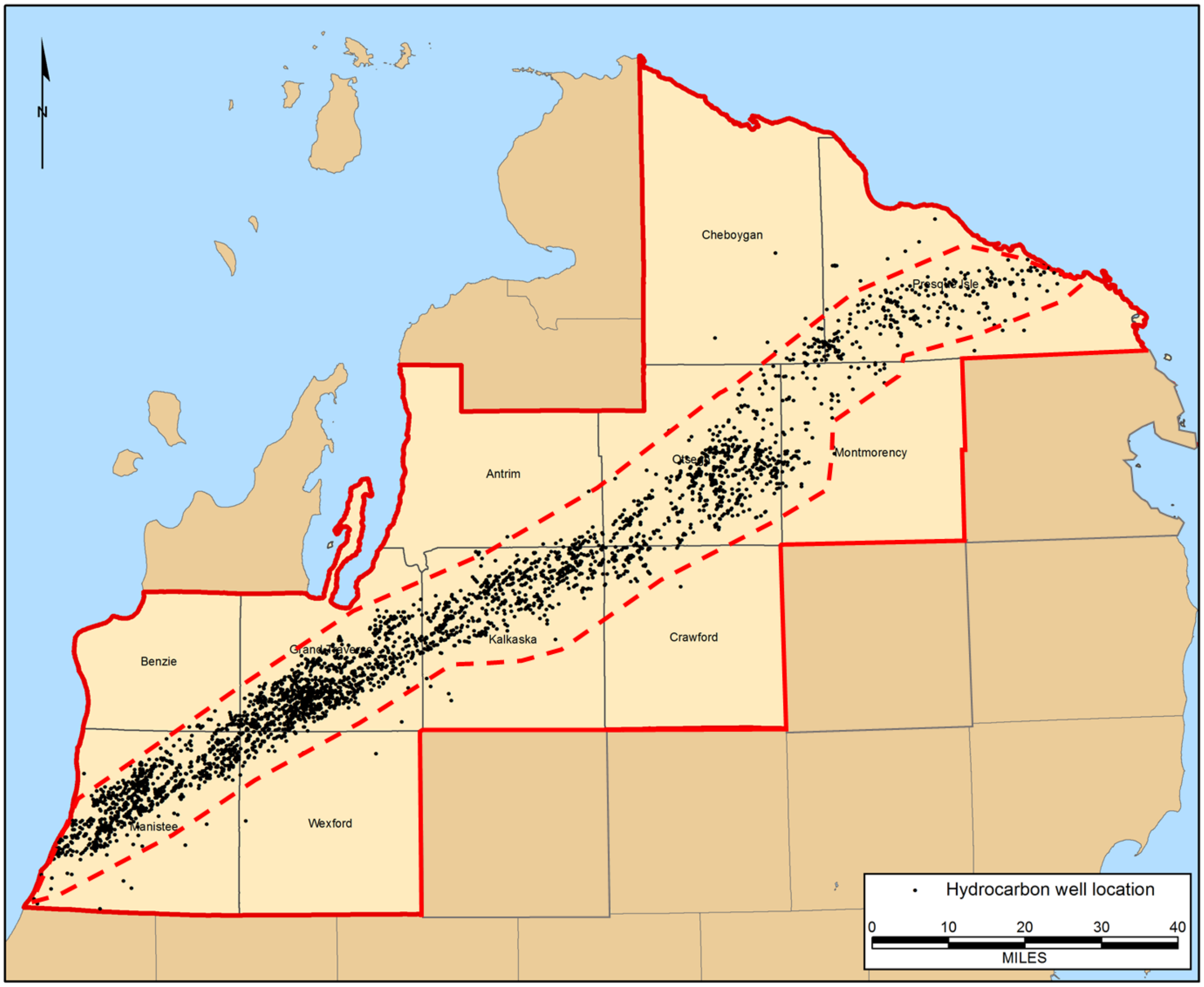



*Figure 14 Areal Extent of Maximum Monitoring Area includes the hydrocarbon bearing pinnacle reefs in the NNPRT*

The reefs that are currently undergoing $CO_2$ EOR in Otsego County and all of the reefs in the NNPRT that would be suitable $CO_2$ EOR targets in the future are found at the same place within Michigan's geological stratigraphic column. The reefs are always contained below the B-Salt and A2-Carbonate and above the White Niagaran (see Figure 15).

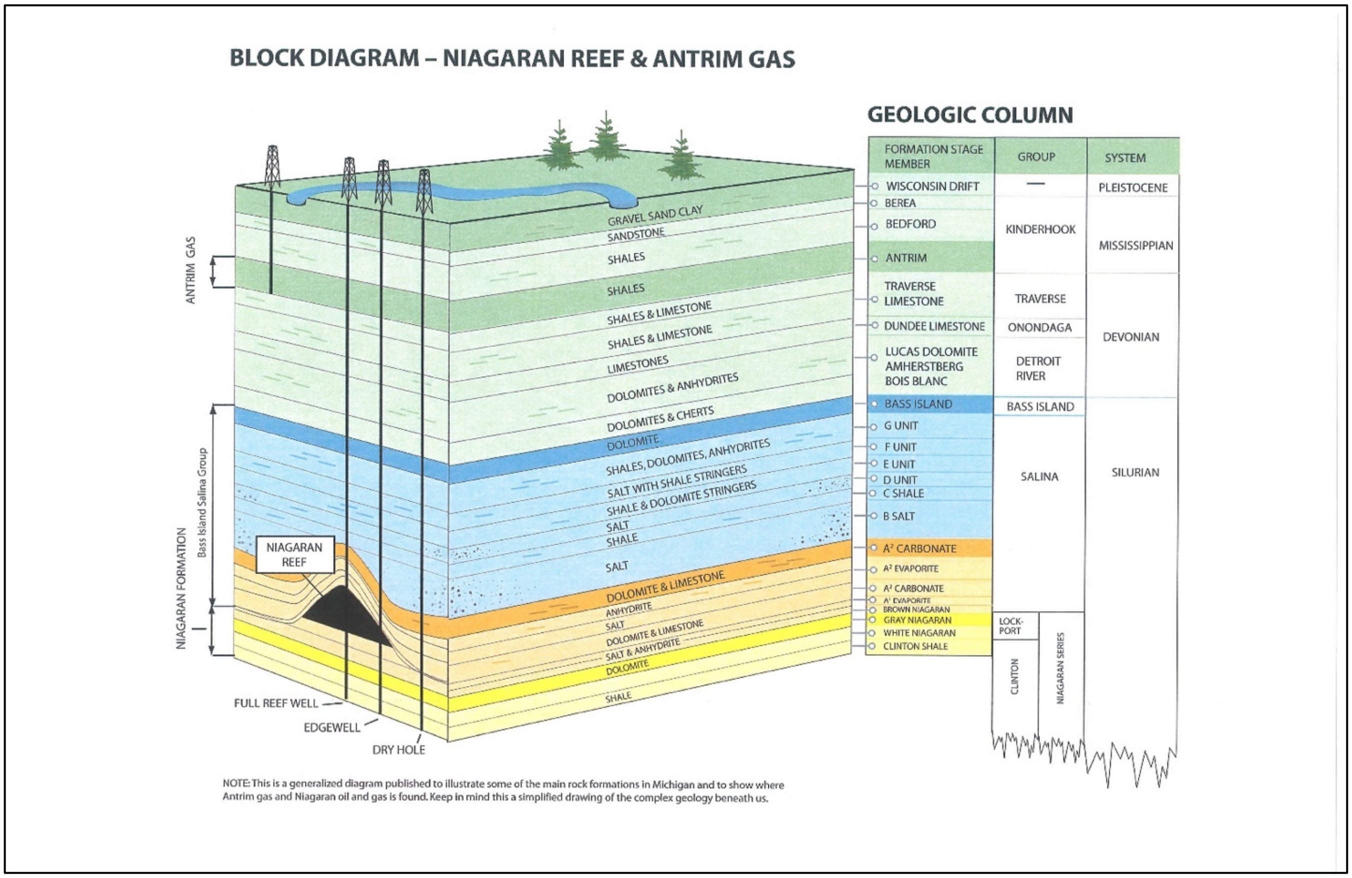



*Figure 15 Michigan Stratigraphic Column*

The potential risk of leakage is consistent from reef-to-reef in the MMA for several reasons. The hydrocarbon bearing reefs that Core Energy will develop are always found in the same geologic setting within the Michigan Basin. They are isolated, self-contained reservoirs, and the risk associated with leakage pathways are the same from reef-to-reef. Further, any reef added to Core Energy's EOR operations would first be screened for suitability for EOR operations and would then have to undergo the Michigan unitization process by MDEQ. New wells or well changes would go through the state (MDEQ) and federal (US EPA) permitting requirements.

## 3.3 Monitoring Timeframes

Core Energy's primary purpose for injecting $CO_2$ is to produce oil that would otherwise remain trapped in the reservoir and not, as in UIC Class VI, "specifically for the purpose of geologic storage."[1] During a Specified Period, Core Energy will have a subsidiary purpose of establishing the long-term containment of a measurable quantity of $CO_2$ in the reefs that it operates. The Specified Period will be shorter than the period of production from the Core Energy facility. At the conclusion of the Specified Period, Core Energy will submit a request for discontinuation of reporting. This request will be submitted when Core Energy can provide a demonstration that current monitoring and model(s) show that the cumulative mass of $CO_2$ reported as sequestered during the Specified Period is not expected to migrate in the future in a manner likely to result in

[1] EPA UIC Class VI rule, EPA 75 FR 77291, December 10, 2010, section 146.81(b).

surface leakage. It is expected that it will be possible to make this demonstration within three years after injection for the Specified Period ceases. The demonstration will rely on three principles: 1) the amount of $CO_2$ stored in properly abandoned reefs will be considered unlikely to migrate to the surface, 2) the continued process of fluid management during the years of $CO_2$ EOR operation after the Specified Period will contain injected fluids in the reefs, and 3) that the cumulative mass reported as sequestered during the Specified Period is a fraction of the theoretical storage capacity of the reefs in the field. *See* 40 C.F.R. § 98.441(b)(2)(ii).

## 4. Evaluation of Leakage Pathways

Knowledge gained through the long history of oil and gas production in the Niagaran reefs coupled with the regional geological characterization conducted by Battelle for the MRCSP were used to identify and assess potential pathways for leakage of $CO_2$ to the surface. The following potential pathways are reviewed:

- Existing wellbores
- Faults and fractures
- Natural and induced seismic activity
- Lateral migration outside of a reef
- Diffuse leakage through the seal
- Pipeline/surface equipment

### 4.1 Existing Wellbores

Wellbores that penetrate the reef constitute the most likely pathway for leakage, however this risk is assessed as very small because of the well construction specifications implemented by Core Energy. Wells are constructed with four strings of casing (i.e. conductor, surface, intermediate and total depth string), three of which are cemented in place; the surface casing is cemented all the way to the surface. Additionally, all wells have tubing strings run to near the permitted injection zones. Injection wells require a packer attached to the tubing string, located no more than 100 feet (30 m) above the permitted injection zone and mechanical integrity on injection wells must be established and maintained. Core Energy adheres to all regulatory requirements of the state and federal agencies charged with oversight as they relate to well drilling, completion and operation as means to maintain mechanical integrity and prevent wellbore leakage. Though previously drilled wells and plugged/abandoned wells may be thought to have a higher risk for leakage pathways than newly drilled wells, all wells within a defined AoR for a project are evaluated. All wells in northern Michigan have been ranked based on age, status, and depth (penetrating seal). It was concluded that wells which penetrated the seals were ranked with high integrity because they were more recent and adhered to regulatory requirements. Figure 16 shows all the well rankings in Otsego County (green is high integrity) and the number of wells which penetrate each reef.

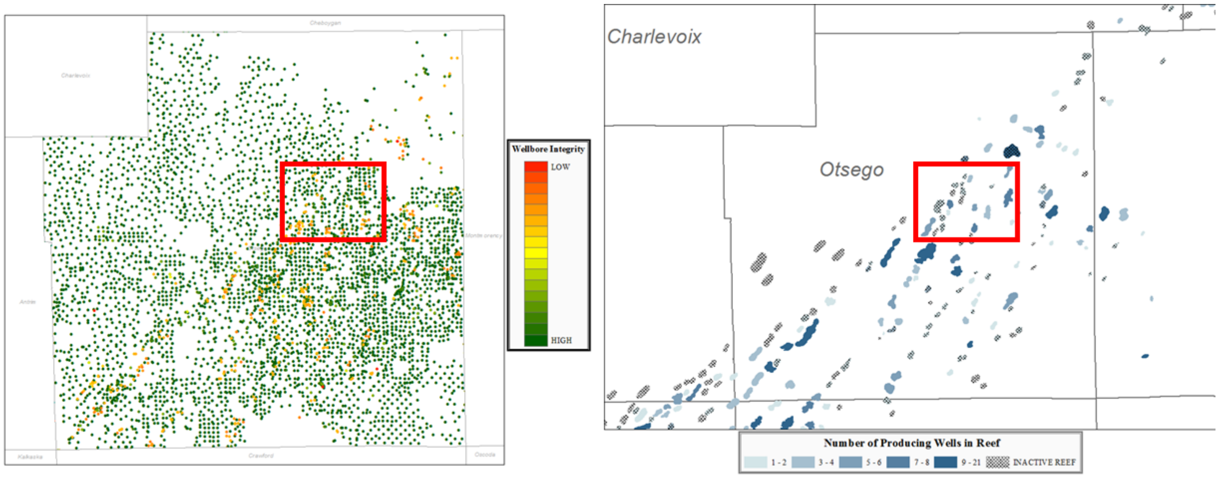



*Figure 16: Wellbore integrity ranking (left) of all wells in Otsego County showing dominantly high integrity and the number of wells which penetrate each reef (blue) showing few seal penetrations within the Core Energy reef area (red)*

MRCSP's systematic wellbore integrity evaluation in seven fields in the Michigan Basin which were actively being used for $CO_2$ EOR also included an assessment of cement plugs. In this study, cement plugs were analyzed and ranked based on depth, the number of plugs, thickness, and age. It was concluded that plugged wells which penetrated the reefs and nearby off reef locations had sufficient plug placement and thickness to prevent leakage.[2]

Leakage through wellbore cement was also researched in the NNPRT by analyzing several cement bond logs in the region. Cement was categorized based on the bond index. Cement with 80 to 100% bond was considered sufficient, 60 to 80% was intermediate, and less than 60% was not ideal. Wells which penetrated the reef were shown to have at least 50 feet of sufficient cement bond within the seal, which by industry standards is sufficient (Figure 17). Several wells were also tested for sustained casing pressure after being exposed to $CO_2$ and did not demonstrate any sustained casing pressure which would be caused by leakage through a cement annulus.

[2] Haagsma, A. , Weber, S. , Moody, M. , Sminchak, J. , Gerst, J. and Gupta, N. (2017), Comparative wellbore integrity evaluation across a complex of oil and gas fields within the Michigan Basin and implications for $CO_2$ storage. Greenhouse Gas Sci Technol, 7: 828-842. doi:10.1002/ghg.1620

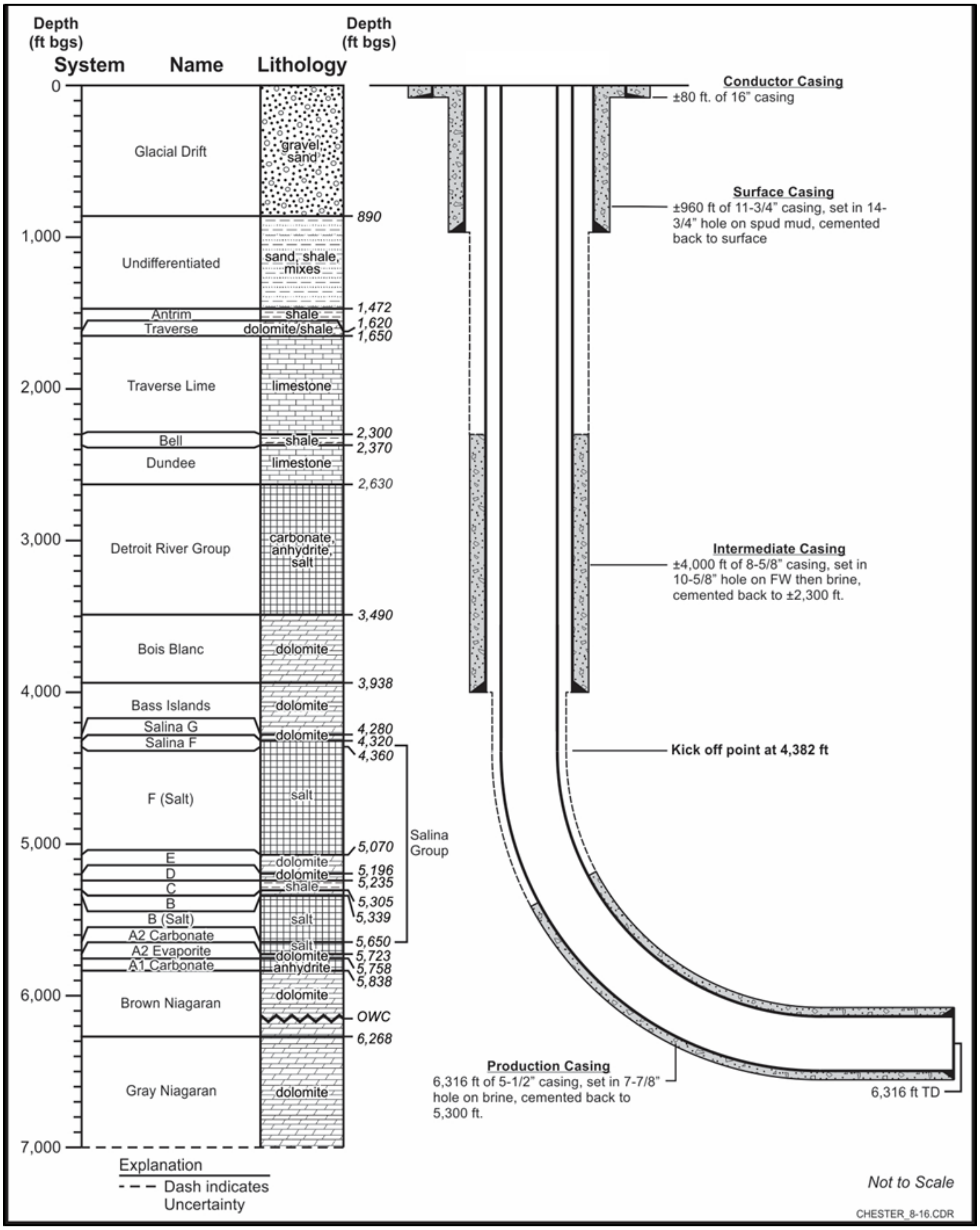



*Figure 17: Example of well construction for a Core Energy well showing intervals of cement over crucial formations.*

Overall, wellbore integrity studies and the oil and gas history demonstrate that while leakage through a wellbore is possible, the wells have been constructed ideally to prevent such leakage. Core Energy also conducts routine monitoring of active wellbores by performing bottom hole pressure measurements and wellhead inspections.

### 4.1.1 Future Wells

The highly-compartmentalized nature of the NNPRT reefs and the state requirements for drilling wells in active and new reefs will prevent new wells from posing a threat of leakage. As discussed in section 2.1, the structure of each reef ensures that they are separated from each other and that there is no fluid communication. This means that any well drilled in the MMA that does not intersect or pass through a reef, even if drilled to a depth deeper than that of the NNPRT reefs, is not a potential leakage pathway. Additionally, because reefs undergoing $CO_2$ EOR have to be unitized prior to commencing EOR operations, Core Energy controls all the pertinent rights that would preclude (or allow) for a well to be drilled within its unit, thus, no well could be drilled within the unit boundary of an active EOR project.

## 4.2 Faults and Fractures

Basement crustal features such as the Mid-Michigan Rift/geophysical anomaly and the Grenville Front (Figure 18) may affect formation thickness and the tectonic movement of Paleozoic structures in the sedimentary rock section. Many ancient faults and folds in the Paleozoic section are parallel or perpendicular to the basement features. There are fewer identified faults in the northern most counties of Michigan than there are in southern Michigan, making the NNPRT an ideal location for $CO_2$-EOR. The faults in northern Michigan are deeper features and do not influence the integrity of the caprocks for the reefs.

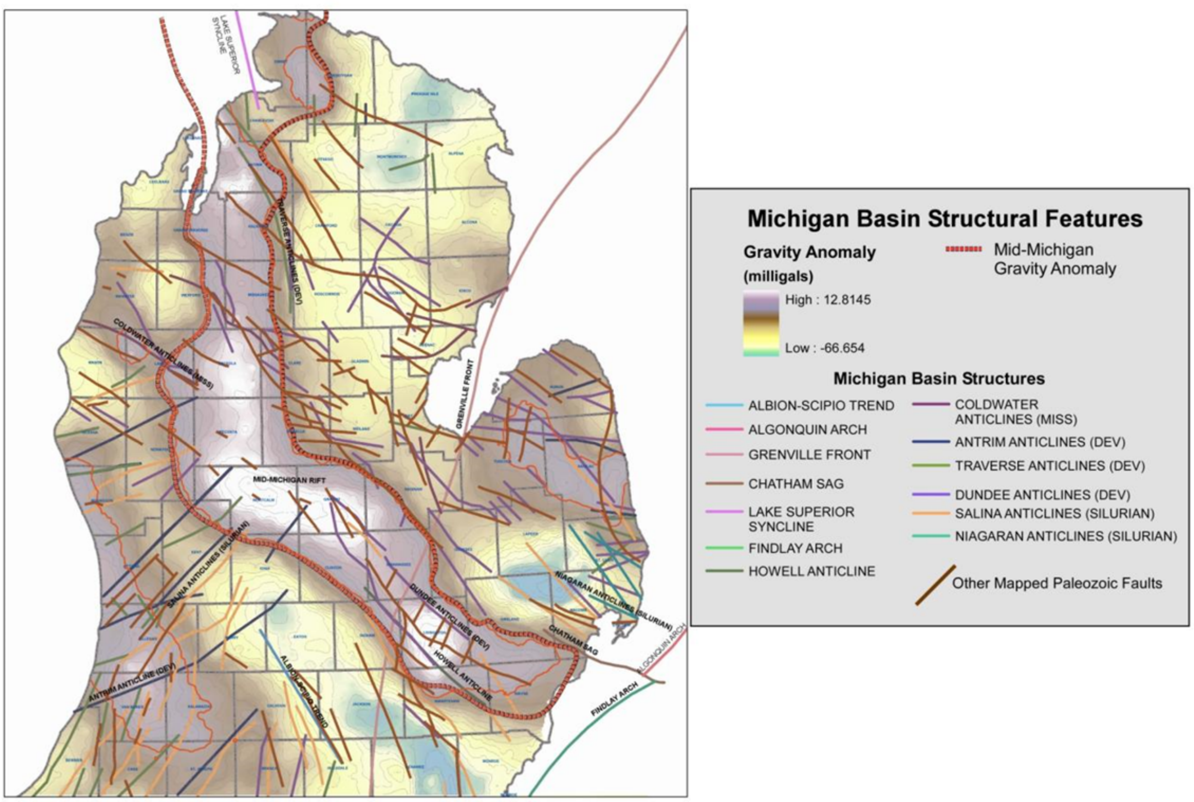



*Figure 18: Michigan Basin structural feature*

## 4.3 Natural and Induced Seismic Activity

Michigan Basin is structurally stable with few known faults. There are no recorded seismic events in northern Michigan and risk of seismic activity is low with a 0 to 4% chance of a seismic event in northern Michigan and no recorded seismic events (Figure 19A). Nearby 2D and 3D seismic data confirm there are no major structural features around the sites of interest (Figure 19B).

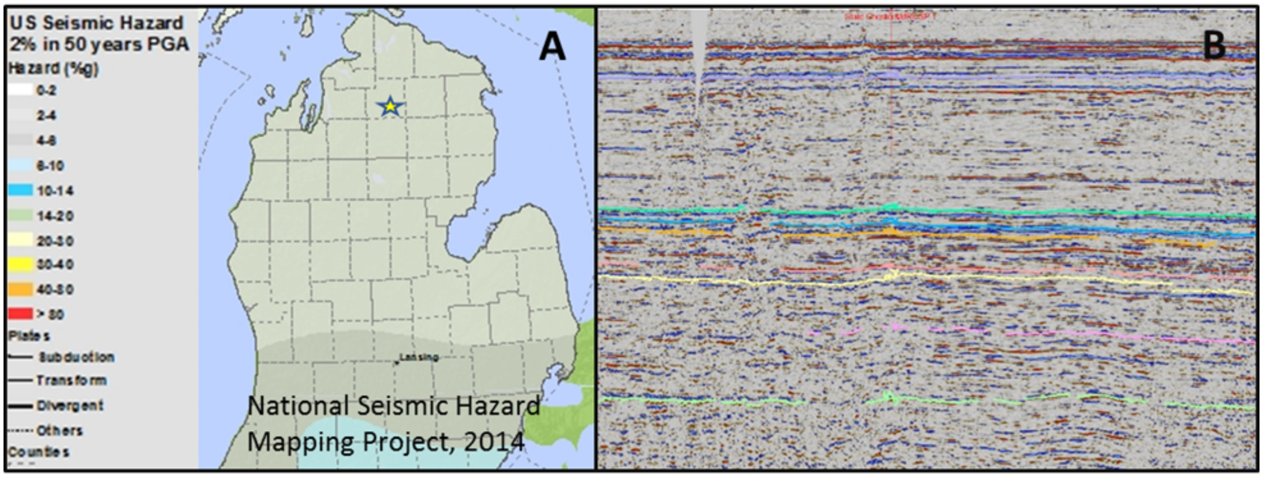



*Figure 19: US seismic hazard map (A) with example 2D seismic line (B) showing low risk for seismic activity and no major structural features.*

## 4.4 Lateral Migration Outside of a Reef

It is highly unlikely that injected $CO_2$ will migrate outside of the boundaries of a reef due to the following factors:

1) The containment provided by the inherent reef geology consisting of non-porous salts and evaporites along the flanks and overlying the reef structure. This containment is believed to effectively isolate the individual reefs resulting in closed reservoir dynamics observed over the course of MRCSP $CO_2$ injection (see section 2.1)

2) Operational procedures at Core Energy, which monitor injection and production volumes from well-managed wells.

3) Periodic material balance associated with the measured reservoir fluid amounts, which has helped correlate and reconfirm that no $CO_2$ has been lost to the surroundings from the reef thus far.

Containment is also validated by the numerical modeling exercises (both analytical and dynamic numerical models) undertaken for each of the reefs of interest aimed at investigating reef response and $CO_2$ migration over time.

### 4.5 Diffuse Leakage through the Seal

Diffuse leakage through the seal, overlying Salina group, is highly unlikely. The seal is composed of several hundred feet of salt, shale, and tight carbonate. Oil and gas production also confirms the successful trapping of fluids in the reefs over geologic time. Additional pressure monitoring and geomechanical modeling of the seals in several reefs confirmed the efficiency and integrity of the confining system.

The fracture gradient is 0.8 psi/ft which is approximately 4130 psi at a depth of 5162 ft (shallowest perforation in Core Energy reefs). The coordinating wellhead (surface) pressure equates to 1761 psi. The maximum pressure tubing can experience is 1400 psi, based on the pressure that can be delivered from the injection compressors. Thus, the fracture pressure is higher than can physically be realized within the well and there is no risk of fracturing the seals. Further, each $CO_2$ injection well is assigned a maximum surface injection pressure as a part of the US EPA permitting process, whose purpose is to ensure that the reservoir fracture pressure is not exceeded.

Additionally, geomechanical analyses were conducted using wireline logs and core tests for select reefs. Analytical techniques were used to estimate changes in minimum horizontal stress, $\sigma h$, caused by changes in pressure and temperature during $CO_2$ injection and to determine whether the stress state compromises the ability of reservoirs for safe and effective $CO_2$ storage. It was found that fracturing of the reservoir or caprock is not likely as long as the injection pressure is maintained below the UIC permit pressure limit.

### 4.6 Pipeline/surface equipment

Leakage through pipelines and surface equipment is a potential risk. Core Energy uses its routine maintenance and daily inspection procedures to minimize this risk. Further, it will deploy three approaches to calculate the amounts of $CO_2$ lost through pipelines and surface equipment: 1) following GHGRR Subpart W methods for estimating fugitive and vented emissions, 2) using direct metering to measure specific venting events as discussed in Section 2.4.3, and 3) in the event an extreme event were to occur, using engineering best practices to estimate a loss.

## 5. Monitoring

This section describes the general approach to monitoring at the Core Energy facility and indicates how data will be collected for this MRV plan.

### 5.1 General Monitoring Procedures

As part of its ongoing operations, Core Energy monitors and collects flow, pressure, and gas composition data from each reef in the central HMI computer system.

As indicated in Figure 13 Core Energy uses Coriolis mass flow meters for all measurements included in the mass balance (Section 7) and also uses Vortex flow meters for some operational monitoring. Fluid composition will be determined, at a minimum, quarterly, consistent with EPA

GHGRP's Subpart RR, section 98.447(a). All meter and composition data are documented, and records will be retained for the Specified Period. Quarterly composition analysis will be done at meter #2 at Chester 10 Facility for pure $CO_2$ gas and at meter #19 at Dover 36 Facility for combined recycle gas. If any other combined recycle gas processing facilities are added, as indicated in Section 2.5, similar Coriolis mass flow meters will be installed and quarterly composition analyses will be conducted. Such new meters would be included in the monitoring report and Section 7 calculations. If not done on a routine basis, Core will use initial baseline data or last available quarter composition analysis as continuation of reporting quarter, with justification as to why analysis was not done/deemed necessary. All composition analysis will be on % wt. basis of $CO_2$ in gas stream.

Core Energy has invested in Micro Motion Coriolis Mass Flow Meters throughout its operations. These meters are designed to retain calibration. The meters have no moving parts and a non-intrusive measuring sensor. As a result, there are no probes or detectors that come into direct contact with process fluids. The benefit of this design is that there are no bearings or rotors to wear, turbines to be deformed, electrodes to coat, or degradation of orifices to be concerned about. The manufacturer reports that "It has been our experience, and that of our customers, that Coriolis meters do not shift or lose their calibration during the life of the meter.

When calibration issues arise, the focus of the problem is normally traceable to the flowmeter installation or a characteristic of the process that was not previously taken into consideration." As a result, there are no prevailing industry standard(s) for meter calibration for these meters.

Core Energy observes trend data from the meters and has on occasion sent meters back to the company for recalibration but this does not occur routinely. This type of meter would have to be severely abused (serious mechanical damage, overheating beyond metal plasticity limits) to change calibration. These types of abuses do not happen during normal operations. Therefore, Core Energy considers this approach to be consistent with EPA GHGRP's Subpart RR, section 98.444(e)(3). These meters will be maintained, operated continually, and will feed data directly to the central HMI computer system. The meters meet the industry standard for meter accuracy and calibration frequency. The level of precision and accuracy for these meters currently satisfies the requirements for reporting in existing UIC permits.

Core Energy contracts with a third party firm that specializes in GHG Reporting Rule compliance to determine Core Energy's emissions using the Subpart W methodology. This results in an annual Subpart W report for Core Energy. Based on the results of this report to date, Core Energy does not meet the threshold for reporting its emissions to EPA through the EGRT system. Core Energy tracks its Subpart W emissions internally and will use these calculations, as specified the Subpart RR, for determining the mass of $CO_2$ stored.

### 5.2 $CO_2$ Received

Core Energy measures the volume of received $CO_2$ using Coriolis mass flow meters at the Chester 10 Facility and, as indicated in section 2.4.1,the Dover 36 Facility. As indicated in Section 2.5, any new recycle gas processing would be measured using Coriolis mass flow meters. No $CO_2$ is received in containers.

## 5.3 $CO_2$ Injected into the Subsurface

Injected $CO_2$ will be metered using the Coriolis mass flow meters dedicated to each injection well at a reef.

## 5.4 $CO_2$ Produced, Entrained in Products, and Recycled

For purposes of reporting under Subpart RR, Core energy will measure the mass of $CO_2$ produced through separators using  Coriolis mass flow meters #19.

For any new production facilities added, as indicated in Section 2.5, the mass of $CO_2$ produced would similarly be measured using Coriolis mass flow meters.

$CO_2$ is produced as entrained or dissolved $CO_2$ in produced oil. As the oil passes through low-pressure separation to a gathering tank, a small amount of $CO_2$ is released. Core Energy has determined the concentration of of $CO_2$ entrained in oil to be 0.7512% by weight (see Section 2.4.3).

## 5.5 $CO_2$ Emitted by Surface Leakage

Core Energy uses an event-driven process to assess, address, track, and if applicable quantify potential $CO_2$ leakage to the surface. Core Energy will reconcile the internal Subpart W report and results from any event-driven quantification to assure that surface leaks are not double counted.

The monitoring program for event-driven incidents has been designed to meet two objectives, in accordance with the leakage risk assessment in Section 4: 1) to detect problems before $CO_2$ leaks to the surface; and 2) to detect and quantify any leaks that do occur.  This section discusses how this monitoring will be conducted and used to quantify the volumes of $CO_2$ leaked to the surface.

### 5.5.1 Monitoring for potential Leakage from the Injection/Production Zone:

Core Energy routinely tracks and reports on a daily basis, the following surface data for all wells: Injection Rate (MCF), Production Rates (BO, BW, MCF), Tubing Pressure (psig), Casing Pressure (psig), Wellhead Temperatures (°F) and Runtime (Hours).  Where there is instrumentation, data are collected more frequently but in the oilfield it is normal and customary for data to be reduced to daily volumes and/or averages.  Core utilizes this data primarily for operational oversight and monitoring of EOR projects, but also intends to use this data to determine when further investigation of potential $CO_2$ leakage is warranted.

Core utilizes modeling, analog performance, operational practice, and historical project performance; bounded by permit conditions that take into account reservoir characteristics (e.g. injection pressure, injectant density, fracture gradient) to develop targeted daily/monthly injection rates, pressures and volumes. If injection rate or pressure significantly deviate from that which is targeted, it generates a flag and alerts operational personnel to investigate and resolve the matter. Operational and engineering personnel will collectively work to resolve these flagged events. Data flags and operational investigations do not mean that leakge of $CO_2$ has occurred, rather they are an indication that the injection rate and pressure are not conforming to the targeted values.  In most cases, the flagged events result in an easy fix (e.g. pressure gauge failure and subsequent replacement) and pose no threat of $CO_2$ leakage. However, in those rare cases whereby flagged events cannot be easily resolved, a more thorough and detailed investigation would be initiated, garnering wider Company or industry support as needed. Whenever any investigation identifies that $CO_2$ leakge has occurred, the volume of $CO_2$ that has escaped from the closed system will be quantified using operational and engineering judgement and included in the annual RR reporting.

Similarily, Core uses the collected data along with modeling, analogs and project performance to forecast produced volumes (i.e. oil, water, $CO_2$) and composition. If producing wells do not have individual separation vessels and meters, they are individually well tested at least quarterly (more frequently if overall project production or individual well pressure data warrant it). The production data is reviewed at least monthly and if there is a significant deviation from past performance or forecast, operational and engineering personnel investigate further. If the casue of the deviation cannot be understood and resolved quickly, a more thorough and detailed investigation would be initiated, garnering wider Company or industry support as needed. Whenever any investigation identifies that $CO_2$ leakge has occurred, the volume of $CO_2$ that has escaped from the closed system will be quantified using operational and engineering judgement and included in the annual RR reporting.

Again, because of the unique geology of the NNPRT, to date, there has never been a case whereby leakge was suspected to have occurred in the EOR flood zone. In the very rare event that $CO_2$ leakage may be suspected in the EOR flood zone, Core would deploy methods to quantify the volume of $CO_2$ involved. With respect to tracking reservoir pressure, episodic surveys are conducted, on a field-by-field or well-by-well basis to gather information about reservoir pressure and other parameters (e.g. kh, skin). Because of the heterogeneity of these carbonate pinnacle reefs, it is not feasible to let injection wells fall-off or producing wells build-up for periods long enough to reach static conditions, thus, the bottom hole pressure measured in an injection well can be very significantly higher than that measured in a producing well over the typical survey duration (e.g. 3 to 7 days). Therefore, over time, well pressure survey histories are developed for both injection and production wells, that yield general performance behavior and characteristics for each well (field). Then, if a survey is run and its results diverge from this survey history in a statistically significant way, it triggers a deeper evaluation to discern what may be taking place and causing the anomaly. For example if injection wells in a field, over time, yield similar pressure survey results and then suddenly a survey yields an anomalous and lower result, then further evaluation is done to discern what may be causing the change (e.g. net $CO_2$ in reservoir declined considerably since last survey and/or an injection well was shut-in or its injection rate reduced, then the measured pressure would be expected to be lower than previous surveys).

If leakage in the flood zone were detected, Core Energy would use an appropriate method to quantify the involved volume of $CO_2$. This might include use of material balance equations based on known injected quantities and monitored pressures in the injection zone to estimate the volume of $CO_2$ involved.

A subsurface leak might not lead to a surface leak. In the event of a subsurface leak, Core Energy would determine the appropriate approach for tracking subsurface leakage to determine and quantify leakage to the surface. To quantify leakage to the surface, Core Energy would estimate the relevant parameters (e.g., the rate, concentration, and duration of leakage) to quantify the leak volume. Depending on specific circumstances, these determinations may rely on engineering estimates.

### 5.5.2 Monitoring of Wellbores:

Core Energy monitors wells through continual pressure monitoring in the injection zone (as described in Section 5.1), monitoring of the annular pressure in wellheads, and routine maintenance and inspection. At any time, in the case of an injection well, where there is a loss of MIT, the well must be and is shut-in until such time the wellbore is repaired. Upon completion of the workover, a new MIT is performed under the oversight of the EPA. The results of the MIT along with workover information are supplied to the EPA and if all is in order, they issue a letter authorizing injection to be resumed. Under no circumstances is injection commenced until such time the letter is in hand.

Leaks from wellbores would be detected through the follow-up investigation of pressure anomalies and visual inspection.

Anomalies in injection zone pressure may not indicate a leak, as discussed above. However, if an investigation leads to a work order, field personnel would inspect the equipment in question and determine the nature of the problem. If it is a simple matter, the repair would be made and the volume of leaked $CO_2$ would be included in the internal Subpart W report for the Core Energy Facility. If more extensive repair were needed, Core Energy would determine the appropriate approach for quantifying leaked $CO_2$ using the relevant parameters (e.g., the rate, concentration, and duration of leakage).

Anomalies in annular pressure or other issues detected during routine maintenance inspections would be treated in the same way. Field personnel would inspect the equipment in question and determine the nature of the problem. For simple matters the repair would be made at the time of inspection and the volume of leaked $CO_2$ would be included in the internal Subpart W report for the Core Energy Facility. If more extensive repairs were needed, the well would be shut in until repairs could be completed and Core Energy would determine the appropriate approach for quantifying leaked $CO_2$ using the relevant parameters (e.g., the rate, concentration, and duration of leakage).

In the event $CO_2$ is lost during a repair, the most recent daily volume of $CO_2$ would be prorated against the number of hours that the failure caused $CO_2$ to leak from the system. It should be noted that when doing workovers, the wells are always “killed” by using appropriate density fluid and the wells are “dead” (no $CO_2$ flow), thus, leakage has not occurred during workovers to wells to date. In the rare and unlikely event surface leakage does occur during a workover, an estimate of the volume would be made using engineering and operational judgements.

### 5.6 Mass of $CO_2$ Emissions from Equipment Leaks and Vented Emissions of $CO_2$ from Surface Equipment Located Between the Injection Flow Meter and the Injection Wellhead

Core Energy evaluates and estimates leaks from equipment, the $CO_2$ content of produced oil, and vented $CO_2$, using the procedures in 40 CFR Part 98 Subpart W. Core Energy will use this method for reporting under Subpart RR.

### 5.7 Mass of $CO_2$ Emissions from Equipment Leaks and Vented Emissions of $CO_2$ from Surface Equipment Located Between the Production Flow Meter and the Production Wellhead

Core Energy evaluates and estimates leaks from equipment, the $CO_2$ content of produced oil, and vented $CO_2$, using the procedures in 40 CFR Part 98 Subpart W. It also measures $CO_2$ emissions from dry and wet vents attached to the separators. Both of these measurements will be included under Subpart RR.

### 5.8 Demonstration that Injected $CO_2$ is not expected to Migrate to the Surface

At the end of the Specified Period, Core Energy intends to cease injecting $CO_2$ for the ancillary purpose of establishing the long-term storage of $CO_2$ in the Core Energy Facility. After the end of the Specified Period, Core Energy anticipates that it will submit a request to discontinue monitoring and reporting. The request will demonstrate that the amount of $CO_2$ reported as stored "is not expected to migrate in the future in a manner likely to result in surface leakage"( §98.441).

At that time, Core Energy will be able to support its request with years of data collected during the Specified Period as well as two to three (or more, if needed) years of data collected after the end of the Specified Period. This demonstration will provide the information necessary for the EPA Administrator to approve the request to discontinue monitoring and reporting including:

i. An assessment of injection data for each reef indicating the total volume of injected and stored $CO_2$ as well as the actual surface injection pressures;
ii. An assessment of the $CO_2$ leakage detected, if any, including discussion of the estimated amount of $CO_2$ leaked and the distribution of emissions by leakage pathway; and
iii. An assessment of reservoir pressure that demonstrates the reservoir pressure in a reef is either too low to enable flow to the surface (i.e., reef has been blown down) or that the reservoir pressure is stable enough to demonstrate that the $CO_2$ is contained within the reef and not expected to migrate in a manner to create a potential leakage pathway.

## 6. Determination of Baselines for Monitoring $CO_2$ Surface Leakage

Core Energy will use the results from daily monitoring of field conditions and operational data, as well as routine testing and maintenance information to monitor for surface leakage.

As indicated in sections 2.4.4. and 5, Core Energy uses onsite management and an automatic data system to conduct it's EOR operations. Core Energy will use data from these efforts to identify and investigate variances from expected performance that could indicate $CO_2$ leakage. Below is a description of how this data will be used to determine when further investigation of potential $CO_2$ leakage is warranted.

- **Visual Inspections:** Operations personnel make daily rounds of the facilities and wells, providing a visual inspection of equipment used in the operations (e.g. vessels, piping, valves, wellheads). Making these rounds provide opportunity to identify issues early and address them proactively, which may preclude leaks from happening and/or minimize any $CO_2$ leakage. If an identified issue cannot be resolved by the person who first observes it, a work order will be generated to resolve the matter. Each event will be documented, include an estimate of the amount of $CO_2$ leaked and included in the annual RR reporting. Records for such events will be kept on file for a minimum of three years.

- **Injection Well Surveillance:** Core establishes target rates and pressures for all injection wells based on various parameters (e.g. $CO_2$ availability, field performance, delivery agreements, permit conditions). When a statistically significant deviation occurs that is outside of the established over or under range of the targeted values, it triggers further investigation to determine if the variance poses a leak threat. If investigation of an event identifies that a leak has occurred, those events will be documented, include an estimate of the amount of $CO_2$ leaked and included in the annual RR reporting. Records for such events will be kept on file for a minimum of three years.

- **Production Well Surveillance:** Core establishes a forecast for producing wells and projects, estimating the volumes of fluids (e.g. oil, $CO_2$, water) that are likely to be produced over a period of time. Evaluation of the produced volumes along with other data (e.g. pressure, composition) informs operational decisions for how to manage a project and aid in identifying possible issues that may involve $CO_2$ leakage. These evaluations can direct engineering and/or operational personnel to investigate matters further, which can lead to work orders being issued to work on wells and/or surface equipment involved in a $CO_2$ EOR project. If investigation of an event identifies that a leak has occurred, those events will be documented, include an estimate of the amount of $CO_2$ leaked and included in the annual RR reporting. Records for such events will be kept on file for a minimum of three years.

- **Mechanical Integrity Testing (MIT):** Each $CO_2$ injection well has a permit condition whereby mechanical integrity has to be established and maintained. This involves the regular monitoring of the tubing-casing annular pressure and conducting annular fill-up tests. Core operational personnel monitor the pressure and conduct the tests in accordance with the permit conditions. In the event a loss of mechanical integrity occurs, the injection well is immediately shut-in and an investigation is initiated to determine what caused the loss of mechanical integrity. If investigation of an event identifies that a leak has occurred, those events will be documented, include an estimate of the amount of $CO_2$ leaked and included in the annual RR reporting. Records for such events will be kept on file for a minimum of three years.

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## 7. Site Specific Considerations for the Mass Balance Equation

The Core Energy facility is small relative to many other EOR operations. It operates a current total of 15 injection, 14 production, and 7 monitoring/production wells located in 10 reefs. Core Energy also has 2.11 million metric tonnes of $CO_2$ inventory that will be reflected, over time, in the mass balance equation. Core Energy considers the following site specific conditions for using the equations in Subpart RR §98.443.

### 7.1. Mass of $CO_2$ Received

Core Energy will use equation RR-1 as indicated in Subpart RR §98.443 to calculate the mass of $CO_2$ received from the Chester 10 Facility and all recycle gas (currently from Dover 36 Facility but to include other new recycling facilities as indicated in Section 2.5.). In the annual monitoring report, Core Energy will track the current and cumulative volume of Dover 36 Facility $CO_2$ and indicate when it has reached 2,110,000 metric tonnes of working inventory; at that time, it will stop reporting the amount from Dover 36 under RR-1 / RR-3. In the future, any additional new sources of $CO_2$ will be added in the same manner.

$$\mathrm{CO}_{2T,r} = \sum_{p=1}^{4} (\mathrm{Q}_{r,p} - \mathrm{Sr,p}) * C_{CO_2,p,r} \qquad \text{Equation RR-1}$$

where:

$CO_{2T,r}$ = Net annual mass of $CO_2$ received through flow meter r (metric tons).

$Q_{r,p}$ = Quarterly mass flow through a receiving flow meter r in quarter p at standard conditions (metric tons).

$S_{r,p}$ = Quarterly mass flow (metric tons) through a receiving flow meter r that is redelivered to another facility without being injected into a site well in quarter p

$C_{CO_2,p,r}$ = Quarterly $CO_2$ concentration measurement in flow for flow meter r in quarter p (wt. percent $CO_2$, expressed as a decimal fraction).

p = Quarter of the year.

r = Receiving flow meters.

Core Energy will sum to total Mass of $CO_2$ Received using equation RR-3 in §98.443

$$CO_2 = \sum_{r=1}^{R} CO_{2T,r} \qquad \text{Equation RR-3}$$

where:

$CO_2$ = Total net annual mass of $CO_2$ received (metric tons).

$CO_{2T,r}$ = Net annual mass of $CO_2$ received (metric tons) as calculated in Equation RR-1 for flow meter r.

r = Receiving flow meter.

## 7.2 Mass of $CO_2$ Injected into the Subsurface

Core Energy will use equation RR-4 as indicated in Subpart RR §98.443 to calculate the mass of $CO_2$ injected into the subsurface at each of the ten reefs. Core proposes to use a method to calculate "$C_{CO2,p,u}$" that uses a weighted average concentration that reflects the different $CO_2$ concentrations in the different sources of $CO_2$ as explained below.

$$CO_{2,u} = \sum_{p=1}^{4} Q_{p,u} * C_{CO_2,p,u}$$

Equation RR-4

where:

$CO_{2,u}$ = Annual $CO_2$ mass injected (metric tons) as measured by flow meter u.

$Q_{p,u}$ = Quarterly mass flow rate measurement for flow meter u in quarter p (metric tons per quarter).

$C_{CO_2,p,u}$ = Quarterly $CO_2$ concentration average measurement in flow for all injection flow meters (wt. percent $CO_2$, expressed as a decimal fraction) as determined from Equation A below.

p = Quarter of the year.

u = Injection Flow meter.

For the weighted average concentration, $C_{CO_2}$, Equation A indicates the current calculation using $CO_2$ from Chester 10 Facility and Dover 36 Facility. If new facilities are added, the weighted concentration average would be modified to include them in the same manner.

Equation A

$$Concentration\ Average = \frac{Q_{p,CH10} * C_{CO_2,p,CH10} + Q_{p,D36} * C_{CO_2,p,D36}}{Q_{p,CH10} + Q_{p,D36}}$$

Where:

$Q_{p,CH10}$ = Quarterly mass flow rate measurement of pure $CO_2$ (from Chester 10 Facility at flow meter #2) in quarter p (metric tons per quarter).

$Q_{p,D36}$ = Quarterly mass flow rate measurement of recycle gas (from Dover 36 Facility at flow meter #19) in quarter p (metric tons per quarter).

$C_{CO_2,p,CH10}$ = Quarterly $CO_2$ concentration of pure $CO_2$ (from Chester 10 Facility at flow meter #2) in quarter p (wt. percent $CO_2$, expressed as a decimal fraction).

$C_{CO_2,p,D36}$ = Quarterly $CO_2$ concentration of recycle gas (from Dover 36 Facility at flow meter #19) in quarter p (wt. percent $CO_2$, expressed as a decimal fraction).

Core Energy will aggregate injection data using equation RR-6:

$$CO_{2i} = \sum_{u=1}^{U} CO_{2,u} \qquad \text{Equation RR-6}$$

where:
$CO_{2i}$ = Total annual $CO_2$ mass injected (metric tons) through all injection wells.
$CO_{2,u}$ = Annual $CO_2$ mass injected (metric tons) as measured by flow meter u.

## 7.3 Mass of $CO_2$ Produced

Core Energy uses Coriolis mass flow meters to measure $CO_2$ in produced fluids as follows.
If new production facilities are added, as indicated in Section 2.5, the same approach will be applied.

$$CO_{2,w} = \sum_{p=1}^{4} Q_{p,w} * C_{CO_2,p,w} \qquad \text{Equation RR-7}$$

Where:
$CO_{2,w}$ = Annual $CO_2$ mass produced (metric tons) through separator w.
$Q_{p,w}$ = Quarterly gas mass flow rate measurement for separator w in quarter p (metric tons).
$C_{CO_2,p,w}$ = Quarterly $CO_2$ concentration of recycle gas (currently at Dover 36 Facility flow meter #19) for separator w in quarter p (wt. percent $CO_2$, expressed as a decimal fraction).
p = Quarter of the year.
w = Separator.

Core will aggregate production data using equation RR-9 net of the mass of $CO_2$ entrained in oil as follows:

$$CO_{2P} = \sum_{w=1}^{W} CO_{2,w} + X \qquad \text{Equation RR-9}$$

Where:
$CO_{2p}$ = Total annual $CO_2$ mass produced (metric tons) through all separators in the reporting year.
$CO_{2,w}$ = Annual $CO_2$ mass produced (metric tons) through separator w in the reporting year.
w = Separator flow meter.
X= Mass of entrained $CO_2$ in oil in the reporting year measured utilizing commercial meters and electronic flow-measurement devices at each point of custody transfer. The mass of $CO_2$ will be calculated by multiplying the total volumetric rate by the $CO_2$ concentration.

## 7.4 Mass of $CO_2$ emitted by Surface Leakage

Core Energy will calculate and report the total annual Mass of $CO_2$ emitted by Surface Leakage using an approach that is tailored to specific leakage events. As described in Sections 4 and 5.1.5-5.1.7, Core Energy is prepared to address the potential for leakage in a variety of settings. Estimates of the amount of $CO_2$ leaked to the surface will likely depend on a number of site-specific factors including measurements, engineering estimates, and emission factors, depending on the source and nature of the leakage.

Core Energy's process for quantifying leakage will entail using best engineering principles or emission factors. While it is not possible to predict in advance the types of leaks that will occur, Core Energy describes some approaches for quantification in Section 5.1.5-5.1.7. In the event leakage to the surface occurs, Core Energy would quantify and report leakage amounts, and retain records that describe the methods used to estimate or measure the volume leaked as reported in the Annual Subpart RR Report. Further, Core Energy will reconcile the internal Subpart W report and results from any event-driven quantification to assure that surface leaks are not double counted.

Equation RR-10 in 48.433 will be used to calculate and report the Mass of $CO_2$ emitted by Surface Leakage:

$$CO_{2E} = \sum_{x=1}^{X} CO_{2,x} \qquad \text{Equation RR-10}$$

where:

$CO_{2E}$ = Total annual $CO_2$ mass emitted by surface leakage (metric tons) in the reporting year.

$CO_{2,x}$ = Annual $CO_2$ mass emitted (metric tons) at leakage pathway x in the reporting year.

x = Leakage pathway.

## 7.5 Mass of $CO_2$ sequestered in subsurface geologic formations.

Core Energy will use equation RR-11 to determine the mass of $CO_2$ that is incidentally stored each year.

$$CO_2 = CO_{2I} - CO_{2P} - CO_{2E} - CO_{2FI} - CO_{2FP} \qquad \text{Equation RR-11}$$

where:

$CO_2$ = Total annual $CO_2$ mass sequestered in subsurface geologic formations (metric tons) at the facility in the reporting year.

$CO_{2I}$ = Total annual $CO_2$ mass injected (metric tons) in the well or group of wells covered by this source category in the reporting year.

$CO_{2P}$ = Total annual $CO_2$ mass produced (metric tons) net of CO2 entrained in oil in the reporting year.

$CO_{2E}$ = Total annual $CO_2$ mass emitted (metric tons) by surface leakage in the reporting year.

$CO_{2FI}$ = Total annual $CO_2$ mass emitted (metric tons) from equipment leaks and vented emissions of $CO_2$ from equipment located on the surface, between the flow meter used to measure injection quantity and the injection wellhead in the reporting year, calculated as provided in subpart W.

$CO_{2FP}$ = Total annual $CO_2$ mass emitted (metric tons) from equipment leaks and vented emissions of CO2 from equipment located on the surface between the production wellhead and the flow meter used to measure production quantity in the reporting year, calculated as in Subpart W and including the metered $CO_2$ measurements at the wet and dry vents attached to the separators.

### 7.6 Cumulative mass of $CO_2$ reported as sequestered in subsurface geologic formations

Core Energy will sum up the total annual volumes obtained using equation RR-11 in 98.443 to calculate the Cumulative Mass of $CO_2$ Sequestered in Subsurface Geologic Formations.

## 8. Estimated Schedule for Implementation of MRV Plan

This plan will be effective as of January 1, 2018.

## 9. Quality Assurance Program

### 9.1 Monitoring

Core Energy will follow the requirements in 40 CFR part 98.444 as indicated in Sections 2, 5 and 7. As indicated in Section 5.1, Core Energy has invested in Micro Motion Coriolis Mass Flow Meters throughout its operations. These meters are designed to retain calibration. The meters have no moving parts and a non-intrusive measuring sensor. As a result, there are no probes or detectors that come into direct contact with process fluids. The benefit of this design is that there are no bearings or rotors to wear, turbines to be deformed, electrodes to coat, or degradation of orifices to be concerned about. The manufacturer reports that “It has been our experience, and that of our customers, that Coriolis meters do not shift or lose their calibration during the life of the meter. When calibration issues arise, the focus of the problem is normally traceable to the flow meter installation or a characteristic of the process that was not previously taken into consideration.” As a result, there are no prevailing industry standard(s) for meter calibration for these meters. Core Energy observes trend data from the meters and has on occasion sent meters back to the company for recalibration but this does not occur routinely. Core Energy considers this approach to be consistent with EPA GHGRP’s Subpart RR, section 98.444(e)(3). These meters will be maintained, operated continually, and will feed data directly to the central HMI computer system. The meters meet the industry standard for meter accuracy and calibration frequency. The level of precision and accuracy for these meters currently satisfies the requirements for reporting in existing UIC permits.

### 9.2 Procedures for estimating missing data.

In the event Core Energy is not able to collect data for the mass balance equations, it will follow the requirements in 40 CFR part 98.445 to provide missing data.

When estimating the volume of missing $CO_2$ data due to an interruption in data collection or mechanical failure of a meter (equipment) is to use the most recent daily volume of $CO_2$

associated with the meter and calculate the proportionate volume of “lost” $CO_2$ based on the number of hours involved in the data gap or until meter repaired.

### 9.3 MRV Plan Revisions

In the event there is a material change to the monitoring and/or operational parameters of the Core Energy $CO_2$ EOR operations that is not anticipated in this MRV plan, the MRV plan will be revised and submitted to the EPA Administrator within 180 days as required in §98.448(d).

## 10. Records Retention

Core Energy will maintain and submit records required under 40 CFR Part 98.3(g) and 40 CFR Part 98.447. Records will be maintained by Core Energy in electronic format at the Core Energy headquarters. In addition, Core Energy has well and facility data in three forms; A.) Paper copies (scanned to server), B.) Keyed in data from paper copies into database, and C.) Automated capture of limited set of data that was recently instrumented (Fall of 2016).

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# Appendix

## Appendix I: List of Wells

Table A-1. Core Energy Wells used for Monitoring and Accounting

| Unit | Facility | API Permit | DEQ Permit | Well Name | Well Type | Well Status |
|---|---|---|---|---|---|---|
| **Dover 33 EOR Unit** | Dover 36 CPF | 21-137-29565-00-00 | 29565 | Lawnichak & Myszkier 1-33 | Injection | INJ |
| **Dover 33 EOR Unit** | Dover 36 CPF | 21-137-00652-00-00 | 61209 | Lawnichak 9-33 | Oil | PR |
| **Dover 33 EOR Unit** | Dover 36 CPF | 21-137-51603-00-00 | 51603 | Lawnichak & Myszkier 5-33 HD1 | Oil | PR |
| **Dover 33 EOR Unit** | Dover 36 CPF | 21-137-50985-04-00 | 55942 | Lawnichak & Myszkier 2-33 HD4 | Oil | PR |
| **Bagley 11-14-23 EOR** | Dover 36 CPF | 21-137-39758-01-00 | 39866 | Wrubel 4-14A | Injection | INJ |
| **Bagley 11-14-23 EOR** | Dover 36 CPF | 21-137-30536-00-00 | 30536 | MBM 1-22 | Injection | INJ |
| **Bagley 11-14-23 EOR** | Dover 36 CPF | 21-137-38240-00-00 | 38240 | Daughters of Friel 2-11 | Injection | INJ |
| **Bagley 11-14-23 EOR** | Dover 36 CPF | 21-137-37794-00-00 | 37794 | Janik Mackowiac 1-11 | Oil | OBS |
| **Bagley 11-14-23 EOR** | Dover 36 CPF | 21-137-38286-00-00 | 38286 | Janik Stevens 3-11 | Oil | OBS |
| **Bagley 11-14-23 EOR** | Dover 36 CPF | 21-137-39748-00-00 | 39748 | Janik Strappazon 3-14 | Oil | OBS |
| **Bagley 11-14-23 EOR** | Dover 36 CPF | 21-137-38859-02-00 | 39897 | Glasser 1-14B | Oil | OBS |
| **Charlton 19 Unit (EOR)** | Dover 36 CPF | 21-137-42766-00-00 | 42766 | El Mac Hills 2-18 | Injection | INJ |
| **Charlton 19 Unit (EOR)** | Dover 36 CPF | 21-137-40911-04-00 | 57261 | El Mac Hills 1-19D | Oil | SI-P |
| **Charlton 19 Unit (EOR)** | Dover 36 CPF | 21-137-41801-01-00 | 61197 | El Mac Hills 1-18A | Oil | PR |
| **Charlton 30/31 EOR Unit** | Dover 36 CPF | 21-137-30203-00-00 | 30203 | State Charlton C2-30 | Injection | INJ |
| **Charlton 30/31 EOR Unit** | Dover 36 CPF | 21-137-59048-00-00 | 59048 | State Charlton & Larsen 3-31 | Injection | INJ |
| **Charlton 30/31 EOR Unit** | Dover 36 CPF | 21-137-29989-00-00 | 29989 | State Charlton 1-30A | Injection | INJ |
| **Charlton 30/31 EOR Unit** | Dover 36 CPF | 21-137-57916-00-00 | 57916 | State Charlton 4-30 | Oil | PR |
| **Charlton 30/31 EOR Unit** | Dover 36 CPF | 21-137-31287-00-00 | 31287 | State Charlton 2-30 | Oil | PR |
| **Charlton 6 EOR Unit** | Dover 36 CPF | 21-137-35209-00-00 | 35209 | Zeimet-Higgins & St Charlton 1-6 | Injection | INJ |
| **Charlton 6 EOR Unit** | Dover 36 CPF | 21-137-59086-00-00 | 59086 | State Charlton & Boeve 2-6 | Oil | PR |
| **Chester 2 EOR Unit** | Dover 36 CPF | 21-137-29430-00-00 | 29430 | Wolf, Carl 1A | Injection | INJ |
| **Chester 2 EOR Unit** | Dover 36 CPF | 21-137-29958-01-00 | 29958 | Wolf, Carl et al C1-HD1 | Oil | PR |

| | | | | | | |
|---|---|---|---|---|---|---|
| **Chester 2 EOR Unit** | Dover 36 CPF | 21-137-60596-01-00 | 60596 | Cargas 3-2 HD2 | Oil | PR |
| **Chester 5 EOR Unit** | Dover 36 CPF | 21-137-59237-00-00 | 59237 | Borowiak 2-6 | Injection | INJ |
| **Chester 5 EOR Unit** | Dover 36 CPF | 21-137-58926-00-00 | 58926 | Butler 3-5 | Injection | SI-I |
| **Chester 5 EOR Unit** | Dover 36 CPF | 21-137-29265-01-00 | 60833 | Piasecki 1-7A | Oil | PR |
| **Dover 35 EOR Unit** | Dover 36 CPF | 21-137-29236-00-00 | 29236 | Salling Hanson Trust 1-35 | Injection | INJ |
| **Dover 35 EOR Unit** | Dover 36 CPF | 21-137-37324-01-00 | 59238 | Pomarzynski et al 5-35A | Oil | SI-P |
| **Dover 35 EOR Unit** | Dover 36 CPF | 21-137-29947-01-00 | 29995 | Salling Hanson Trust 4-35A | Oil | PR |
| **Dover 35 EOR Unit** | Dover 36 CPF | 21-137-57787-00-00 | 57787 | Pomarzynski et al 6-35 | Oil | PR |
| **Dover 36 EOR Unit** | Dover 36 CPF | 21-137-29348-00-00 | 29348 | Kubacki State 3-35 | Injection | INJ |
| **Dover 36 EOR Unit** | Dover 36 CPF | 21-137-29235-00-00 | 29235 | Kubacki State 1-36 | Injection | INJ |
| **Dover 36 EOR Unit** | Dover 36 CPF | 21-137-52719-00-00 | 52719 | Dover State 36 Unit 3-36 | Oil | PR |
| **Chester 16 EOR Unit** | Dover 36 CPF | 21-137-61189-00-00 | 61189 | Chester 16 Unit 6-16 Pilot | Injection | INJ |
| **Chester 16 EOR Unit** | Dover 36 CPF | 21-137-61186-00-00 | 61186 | Chester 16 Unit 8-16 | Oil | OBS |

Table A-2. Summary of Niagaran Wells by Reef With Listing of Depth, Completion Date, and Wireline Log Inventory used for Geologic Characterization

Source: Michigan DEQ Oil and Gas Well Database
Note: CAL=CALIPER; GR=GAMMA RAY; NPHI=NEUTRON POROSITY; RHOB=DENSITY; PE=PHOTOELECTRIC; SON=SONIC; RES=RESISTIVITY; CBL=CEMENT BOND LOG; CBIL= circumferential borehole image log (acoustic image log); NEUTRON= neutron log reported in neutron units; PNC=Pulsed Neutron Capture log.
(a) Indicates currently active (not plugged/abandoned) producing well.
(b) Indicates currently active (not plugged/abandoned) injection well.
(c) Deviated well; total depth amsl will be determined after acquiring deviation survey.

| Reef | Well Permit No. | Well Name | Well No. | Total Depth, ft | | Date Completed | Wireline Logs |
|---|---|---|---|---|---|---|---|
| | | | | bgs | amsl | | |
| Bagley | 29074 | Yule King Tree | 1-15 | 6135 | -4815 | 1/14/1973 | CAL,GR,NPHI,RHOB,RES |
| | 29085 | Alan Gornick | 1-23 | 6177 | -4867 | 1/18/1973 | CAL,GR,NPHI,RHOB |
| | 29249 | Alan Gornick | 1-14 | 6165 | -4869 | 11/23/1973 | CAL,GR,NPHI,RHOB |
| | 30536[(a)] | MBM | 1-22 | 6013 | -4689 | 10/24/1975 | CAL,GR,NPHI,RHOB,RES |
| | 37794[(a)] | Janik & Mackowiac | 1-11 | 6326 | -5021 | 9/11/1984 | CAL,GR,NPHI,RHOB,RES,PNC |
| | 38240[(b)] | Daughters of Friel | 2-11 | 6250 | -4739 | 10/30/1984 | CAL,GR,NPHI,RHOB,RES |
| | 38286[(a)] | Janik & Stevens | 3-11 | 6045 | -4676 | 11/2/1984 | CAL,GR,NPHI,RHOB,RES |
| | 38859 | Glasser | 1-14A | 6115 | -4811 | 3/2/1986 | CAL,GR,NPHI,RES |
| | 38923 | Yule King Tree | 1-14 | 6024 | -4725 | 10/17/1985 | CAL,GR,NPHI,RES,PNC |

| Reef | Well Permit No. | Well Name | Well No. | Total Depth, ft | | Date Completed | Wireline Logs |
|---|---|---|---|---|---|---|---|
| | | | | bgs | amsl | | |
| | 39554 | Stevens and State Bagley | 1-22 | 6295 | -4975 | 1/13/1986 | CAL,GR,NPHI,RHOB,RES |
| | 39748[(a)] | Janik & Strappazon | 3-14 | 6000 | -4706 | 2/24/1986 | CAL,GR,NPHI,RHOB,RES |
| | 39758 | Wrubel | 4-14 | 6140 | (c) | 3/9/1986 | CAL,GR,NPHI,RHOB,RES |
| | 39850 | Glasser | 1-14A | 6367 | -4839 | 3/12/1986 | CAL,GR,NPHI,RHOB,RES |
| | 39866[(a)] | Wrubel | 4-14A | 6191 | -4822 | 4/21/1986 | CAL,GR,NPHI,RHOB,RES |
| | 39897[(a)] | Glasser | 1-14B | 6130 | -4752 | 5/7/1986 | CAL,GR,NPHI,RES,PNC |
| | 55307 | Stevens and State Bagley | 1-22A | 6270 | -4910 | 1/9/2003 | CAL,GR,NPHI,RHOB,RES |
| Charlton 6 | 28895 | Zeimet & Higgins | 1-6 | 6008 | -4724 | 6/21/1972 | CAL,GR,NPHI,RHOB,RES |
| | 35209[(b)] | Zeimet, Higgins & State Charlton | 1-6 | 5975 | -4745 | 12/10/1981 | CAL,GR,NPHI,RHOB,PE,RES |
| | 59086[(a)] | State Charlton & Boeve | 2-6 | 6202 | -4796 | 6/19/2008 | CAL,GR,NPHI,RHOB,RES,PE |
| Charlton 19 | 40911 | El Mac Hills | 1-19 | 5675 | -4552 | 3/9/1988 | CAL,GR,NPHI,RHOB,RES,SON |
| | 41801 | El Mac Hills | 1-18A | 5466 | -4341 | 2/24/1989 | CAL,GR,NPHI,RHOB,RES,PNC |
| | 42766[(b)] | El Mac Hills | 2-18 | 5555 | (c) | 2/5/1990 | CAL,GR,NPHI,RHOB,RES,PNC |
| | 54416 | El Mac Hills | 1-19A | 5433 | -4297 | 6/22/2001 | Not Logged |
| | 54582 | El Mac Hills | 1-19B | 5421 | (c) | 6/27/2001 | Not Logged |
| | 54583 | El Mac Hills | 1-19C | 5321 | -4246 | 7/1/2001 | Not Logged |
| | 57261[(a)] | El Mac Hills | 1-19D | 5495 | -4335 | 12/21/2005 | CAL,GR,NPHI,RHOB,RES,SON,PNC |
| Charlton 30-31 | 29073 | Salling Hanson et al | 1-31 | 5770 | -4645 | 1/9/1973 | CAL,GR,NPHI,RHOB,SON,RES |
| | 30195 | State Charlton "C" | 1-30 | 5679 | -4497 | 3/21/1975 | CAL,GR,NPHI,RHOB,RES |

| Reef | Well Permit No. | Well Name | Well No. | Total Depth, ft | | Date Completed | Wireline Logs |
|---|---|---|---|---|---|---|---|
| | | | | bgs | amsl | | |
| | 32605 | State Charlton "C" | 3-30 | 5746 | -4563 | 12/16/1978 | CAL,GR,NPHI,RHOB,RES |
| | 29989[b] | State Charlton | 1-30A | 5650 | -4582 | 12/24/1974 | CAL,GR,NPHI,SON,RES |
| | 30203[b] | State Charlton "C" | 2-30 | 6255 | -4588 | 4/22/1975 | CAL,GR,NPHI,RHOB,RES |
| | 31287[a] | State Charlton | 2-30 | 5660 | -4517 | 12/7/1976 | CAL,GR,NPHI,SON,RES |
| | 57916[a] | State Charlton | 4-30 | 5800 | -4599 | 11/30/2006 | CAL,GR,NPHI,RHOB,PE,RES |
| | 59048[b] | State Charlton & Larsen | 3-31 | 5800 | -4689 | 7/7/2008 | CAL,GR,NPHI,RHOB,PE,RES |
| Chester 2 | 28459 | Cargas, Perry J | 1 | 6005 | -4762 | 10/4/1971 | CAL,GR,NPHI,RHOB,SON,RES |
| | 28706 | Finnegan, Bernard et al | 1 | 6051 | -4818 | 1/6/1972 | CAL,GR,NPHI,RES |
| | 29677 | Wolf, Carl | 1-B | 5847 | -4568 | 6/27/1974 | CAL,GR,NPHI,RHOB,RES |
| | 31646 | Cargas, Perry J | 1-2A | 5990 | -4745 | 9/9/1977 | CAL,GR,NPHI,RHOB,RES |
| | 29430[b] | Wolf, Carl | 1-A | 5973 | -4710 | 12/2/1973 | CAL,GR,NPHI,RHOB,RES |
| | 29958[a] | Wolf, Carl et al "C" | 1 | 5806 | -4536 | 12/9/1974 | CAL,GR,NPHI,RHOB,RES |
| | 29958-01[a] | Wolf, Carl et al "C" | 1 HD1 | 6570 | -4509 | 10/9/2001 | CAL,GR,CBL |
| | 60596[a] | Cargas, Perry J | 3-2 HD-1 | 6962 | -4556 | 10/9/2012 | CAL,GR,NPHI,RHOB,RES,SON,PNC |
| Chester 5-6 | 29067 | Borowiak | 1-6 | 6022 | -4673 | 1/11/1973 | CAL,GR,NPHI,SON,RES |
| | 29234 | Borowiak | 1-5 | 5725 | -4409 | 4/13/1973 | CAL,GR,NPHI,SON,RES |
| | 29254 | Kosiara | 2-7 | 5750 | -4398 | 5/24/1973 | CAL,GR,SON,RES |
| | 29265 | Piasecki | 1-7 | 5770 | -4416 | 5/4/1973 | CAL,GR,NPHI,SON,RES,PNC |

| Reef | Well Permit No. | Well Name | Well No. | Total Depth, ft bgs | Total Depth, ft amsl | Date Completed | Wireline Logs |
|---|---|---|---|---|---|---|---|
| | 31515 | Piasecki, John State Chester | 1-7 | 5800 | -4462 | 6/1/1977 | CAL,GR,NPHI,RHOB,RES |
| | 32207 | Kosiara, Josephine | 2-7A | 5881 | (c) | 3/20/1978 | CAL,GR,NPHI,RHOB,RES |
| | 38424 | Gottloeb | 1-8 | 6080 | (c) | 11/21/1984 | CAL,GR,NPHI,RHOB,PE,RES |
| | 40169 | Nienaber | 2-5 | 5985 | -4633 | 12/16/1986 | CAL,GR,NPHI,RHOB,PE,RES |
| | 58926[b] | Butler | 3-5 | 5897 | -4585 | 5/1/2008 | CAL,GR,NPHI,RHOB,RES,CBIL,CRA |
| | 59237[b] | Borowiak | 2-6 | 6100 | -4751 | 7/25/2008 | CAL,GR,NPHI,RHOB,PE,RES,CBIL,CBL |
| Chester 16 | 28159 | Gaylord Mortgage | 1-16 | 6210 | -4873 | 1/4/1971 | CAL,GR,NPHI,RHOB,RES,SNP |
| | 28433 | Veraghen, Martin G | 4-21 | 6303 | -4972 | 8/13/1971 | CAL,GR,NPHI,RHOB,RES,SNP,SON |
| | 28511 | Gaylord Mortgage | 2-16 | 6250 | -4907 | 9/4/1971 | CAL,GR,NPHI,RES,SNP,SON |
| | 28743 | Veraghen & Rypkowski | 5-21 | 6350 | -5037 | 3/29/1972 | CAL,GR,NPHI,RES,SNP,SON |
| | 28796 | Gaylord Mortgage | 3-16 | 6222 | -4896 | 8/22/1972 | CAL,GR,NPHI,RES,SNP |
| | 28798 | Dreffs | 4-16 | 6265 | -4913 | 3/13/1972 | RES,SNP, SON |
| | 28918 | Veraghen & Dreffs | 6-21 | 6318 | -4995 | 7/20/1972 | CAL,GR,RES,SNP,SON |
| | 61186 | Chester | 8-16 | 6455 | -5020 | 2/26/2017 | CAL,GR,NPHI,RES,RHOB,SON |
| | 61189*** | Chester | 6-16 | 6697 | -5061 | 12/23/2016 | CAL,GR,NPHI,RES,RHOB,SON,PNC |
| Dover 33 | 29565[b] | Lawnichak & Myszkier | 1-33 | 5675 | -4528 | 5/20/1974 | CAL,GR,NPHI,RES,RHOB,SON,PNC |
| | 29781 | Lawnichak & Myszkier | 3-33 | 5625 | -4404 | 8/16/1974 | CAL,GR,NPHI,RES |
| | 29809 | Koblinski & Fisher | 1-28 | 5514 | -4397 | 8/22/1974 | CAL,GR,NPHI,RES,SNP |

| Reef | Well Permit No. | Well Name | Well No. | Total Depth, ft | | Date Completed | Wireline Logs |
|---|---|---|---|---|---|---|---|
| | | | | bgs | amsl | | |
| | 29840 | Kirt House | 2-28 | 5475 | -4290 | 8/7/1974 | CAL,GR,NPHI,RES,SON |
| | 30392 | Winter | 2-33 | 5840 | -4560 | 8/9/1975 | CAL,GR,NPHI,RES,SON |
| | 31108 | Amejka | 2-34 | 5886 | -4657 | 9/5/1976 | CAL,GR,NPHI,SON |
| | 31228 | Boughner State Dover | 3-28 | 5520 | -4401 | 7/23/1977 | CAL,GR,NPHI,SON |
| | 31303 | Thompson | 1-33 | 5690 | -4540 | 11/22/1976 | CAL,GR,NPHI,RES,RHOB |
| | 32298 | Boughner State Dover | 4-28 | 5505 | (c) | 7/7/1978 | CAL,GR,NPHI |
| | 33830 | Lawnichak & Myszkier | 5-33 | 5775 | -4565 | 7/28/1980 | CAL,GR,NPHI,RES,SON |
| | 33937 | Lawnichak & Myszkier | 5-33A | 5746 | -4536 | 8/4/1980 | CAL,GR,NPHI,RES,SON |
| | 35195 | Winter | 1-33 | 5740 | -4457 | 12/31/1982 | CAL,GR,NPHI,RES,RHOB |
| | 35584 | Lawnichak & Morey | 1-33 | 5703 | -4539 | 8/24/1982 | CAL,GR,NPHI,RHOB |
| | 50985 | Lawnichak & Myszkier | 2-33 | 5763 | -4597 | 11/22/1996 | CAL,GR,NPHI,RHOB,PNC |
| | 51601 | Lawnichak & Myszkier | 2-33 HD1 | 6990 | -4315 | 12/30/1996 | CAL,GR,TDT |
| | 51603 | Lawnichak & Myszkier | 5-33 HD1 | 6456 | -4354 | 2/2/1997 | CAL,GR,PNC |
| | 55479 | Lawnichak & Myszkier | 2-33 HD2 | 6138 | (c) | 8/21/2003 | Not Logged |
| | 55845 | Lawnichak & Myszkier | 2-33 HD3 | 7335 | -4368 | 9/23/2003 | Not Logged |
| | 55942 | Lawnichak & Myszkier | 2-33 HD4 | 7134 | -4348 | 12/29/2003 | Not Logged |
| | 61209 | Lawnichak | 9-33 | 6085 | -4677 | 12/3/2016 | CAL,GR,NPHI,RES,RHOB,SON |
| Dover | 29374 | Pomerzynski | 2-35 | 5760 | -4619 | 9/27/1973 | CAL,GR,NPHI,SON,RES |

| Reef | Well Permit No. | Well Name | Well No. | Total Depth, ft | | Date Completed | Wireline Logs |
|---|---|---|---|---|---|---|---|
| | | | | bgs | amsl | | |
| | 29947 | Salling Hanson Trust | 4-35 | 5564 | -4450 | 10/18/1974 | CAL,GR,SON |
| | 35941 | Tinsey | 1-35 | 5792 | (c) | 8/23/1982 | CAL,GR,NPHI,RHOB,PE,RES |
| | 37324 | Pomerzynski et al | 5-35 | 5715 | -4575 | 12/22/1983 | CAL,GR,NPHI,RHOB,PE,RES |
| | 37381 | Taskey & Saddler Estate | 1-35 | 5768 | -4615 | 2/14/1984 | CAL,GR,NPHI,RHOB,RES |
| | 29236[b] | Salling & Hanson | 1-35 | 5780 | -4656 | 5/25/1973 | CAL,GR,NPHI,SON,RES |
| | 29995[b] | Salling Hanson Trust | 4-35A | 5715 | -4504 | 11/4/1974 | CAL,GR,NPHI,SON,RES |
| | 57787[a] | "Pomarzynski" | 6-35 | 5950 | -4688 | 11/30/2006 | CAL,GR,NPHI,RHOB,PE,RES |
| | (59238)[a] | "Pomarzynski" | 5-35A | 5864 | -4437 | 8/24/2008 | CAL,GR,NPHI |
| Dover 36 | 29303 | Kubacki Cole | 2-36 | 5765 | -4592 | 6/14/1973 | CAL,GR,NPHI,SON,RES |
| | 29664 | Freese, Charles E III et al | 1-2 | 5830 | -4614 | 4/8/1974 | CAL,GR,NPHI,SON,RES |
| | 29235[b] | Kubacki & State Dover | 1-36 | 5835 | -4683 | 4/29/1973 | CAL,GR,NPHI,SON,RES |
| | 29348[b] | Kubacki State | 3-35 | 6431 | (c) | 7/6/1973 | CAL,GR,NPHI,SON,RES |
| | 52719[a] | Dover 36 Unit | 3-36 | 5700 | -4533 | 7/31/1998 | CAL,GR,NPHI,RHOB,PE,RES |

Source: Michigan DEQ Oil and Gas Well Database
Note: CAL=CALIPER; GR=GAMMA RAY; NPHI=NEUTRON POROSITY; RHOB=DENSITY; PE=PHOTOELECTRIC; SON=SONIC; RES=RESISTIVITY; CBL=CEMENT BOND LOG; CBIL= circumferential borehole image log (acoustic image log); NEUTRON= neutron log reported in neutron units; PNC=Pulsed Neutron Capture log.

(a) Indicates currently active (not plugged/abandoned) producing well.
(b) Indicates currently active (not plugged/abandoned) injection well.
(c) Deviated well; total depth amsl will be determined after acquiring deviation survey.

## Appendix II: Map of Core Energy pipelines