Carlson McCain

ENVIRONMENTAL • ENGINEERING • LAND SURVEYING

September 5, 2013

Mr. Ralph Smith
Wisconsin Department of Commerce
Environmental & Regulatory Services Division
Bureau of PECFA
P.O. Box 8044
Madison, Wisconsin 53708

Mr. Jamie Dunn – Hydrogeologist
Wisconsin Department of Natural Resources
Remediation and Redevelopment
810 West Maple Street
Spooner, Wisconsin 54801

RECEIVED
SEP 11 2013
Remediation & Redevelopment

Re: Remedial Action Report
Moose Junction Lounge
13195 South State Road 35
Dairyland, Wisconsin
BRRTS # 03-16-000301

Dear Mr. Dunn and Mr. Smith:

Please find enclosed a copy of the Remedial Action Report for Moose Junction Lounge (Site) located at 13195 South State Road 35 in Dairyland, Wisconsin. The Remedial Action Report serves to summarize the results of the in-situ chemical injection activities that were completed at the Site. Carlson McCain, Inc. (Carlson McCain) has prepared this report on behalf of the responsible party, Mr. Trent Sprague.

Site clean-up activities included injection of an in-situ chemical oxidation compound into the subsurface soils and shallow groundwater to facilitate chemical oxidation of residual petroleum soil and groundwater contamination. Two separate injection events were completed between October 2010 and November 2010. In addition, seven quarterly groundwater sampling events have been completed since the in-situ chemical injections. A groundwater monitoring report will be sent under separate cover that summarizes the groundwater monitoring results.

If you have any questions, or require additional information, please contact me at (763) 489-7900 (office).

Sincerely,

Carlson McCain, Inc.

FOR

Jeffrey M. Neisse
Staff Geologist

Cc: Mr. Trent Sprague (Responsible Party)

REMEDIAL ACTION REPORT

Moose Junction Lounge
13195 South State Rd 35
Dairyland, Wisconsin 54830
Commerce # 54830-9999-97-A
BRRTS # 03-16-000301
Project #2490-00

Prepared for:

Mr. Trent Sprague
2116 16 ½ Street
Rice Lake, Wisconsin 54868

Wisconsin Department of Natural Resources
Remediation and Redevelopment
Mr. Jamie Dunn
810 Maple Street
Spooner, Wisconsin 54801

September 5, 2013

Carlson McCain

248 Apollo Drive, Suite 100
Lino Lakes, MN 55014
Tel 763-489-7900
Fax 763-489-7959
www.carlsonmccain.com

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1.0 INTRODUCTION

On behalf of Mr. Trent Sprague, Carlson McCain, Inc. (Carlson McCain), has prepared this Remedial Action Report to summarize the environmental activities that have occurred at the Moose Junction Lounge (Site) between October 2010 and November 2010. ProSource Technologies, Inc. (ProSource) was initially retained by Mr. Trent Sprague to complete the work at the Site. On June 1, 2009, the environmental and engineering staff of ProSource initiated services under the name Carlson Professional Services, Inc. (Carlson) as part of a corporate restructuring. On June 1, 2011, Carlson merged with McCain Associates, Inc. and continues services under the name Carlson McCain, Inc.

The remedial and monitoring activities that occurred at the Site over the reporting period included: remedial action through injection of an in situ chemical treatment; post injection soil sampling; post injection groundwater monitoring; and annual reporting. The Site is located at 13195 South State Highway 35 in Dairyland, Wisconsin, in Douglas County, Wisconsin. The Site location is visually depicted on the attached Figure 1. A site plan overview is provided as Figure 2 (attached).

This Remedial Action Report is a deliverable required by the Wisconsin Department of Commerce, Bureau of PECFA. Carlson was selected as the least costly qualified bid during Round 57 to provide environmental services for the above referenced Site. Proposed Site clean-up activities included injection of an in-situ chemical oxidation compound into the subsurface soils and shallow groundwater to facilitate chemical oxidation of residual petroleum soil and groundwater contamination.

1.1 Background

The Site currently operates as a tavern, which formerly sold gasoline. Based on figures provided from previous reports, it appears the Site operated two underground storage tanks (USTs): one UST appears to have existed on the north side of the tavern, near the northeast corner of the Site building; and one UST existed on the south side of the tavern, near the southeast corner of the building. The Site also operated two dispenser islands and associated piping: one pump island existing near the east side of the tavern near State Highway 35; and one existing near the southeastern corner of the tavern, just east of a former UST. Soil and groundwater contamination were discovered at the Site in October 1990 during a Phase II Environmental Assessment performed for the Department of Transportation (DOT) on the State Highway 35 right-of-way.

1.2 Site Description

The Property is approximately 0.41 acres in size and is located at 13195 south State Highway 35 in Dairyland, Wisconsin. A majority of the Site and surrounding property uses are undeveloped wooded lots with a few rural residential properties existing to the south and west. The Site has relatively flat topography, with small ditches existing on either side of State Highway 35. The Site is located in the SE ¼ of the SE ¼ of Section 18, Township 44 North, Range 14 West in Douglas County, Wisconsin.

The Site is supplied potable water through a private well. The geology of the investigated area consists of variable layers of medium-grained sand, silty sand and silty clay (till). The till can range in thickness, generally several meters thick (Clayton, 1985). Bedrock in the area is depicted as middle Proterozoic Keweenawan volcanic rock and is reported at a depth ranging between 5 and 50 feet below ground surface (Wisconsin Geological and Natural History Survey, 2005). Soils encountered at the Site consist of silty sands and medium-grained sands. A "bedrock ridge" has been reported to be encountered during Site investigation activities at depths between 10 and 12 feet below ground surface (bgs). The water table is typically at depths between 1 and 3 feet bgs.

The regional groundwater flow direction is to the south. Hydraulic conductivity tests conducted in Site monitoring wells determined values ranging between $2.7x10^{-5}$ and $4.3x10^{-5}$ cm/sec, with a resultant groundwater flow velocity of 3.6 ft/yr. The Site and adjacent properties are supplied potable water through private potable water wells. The drinking water well at the Swenson residence, south of the Site, has been sampled periodically since 1992 and has identified concentrations of benzene above the WDNR Enforcement Standard (ES) of 5 µg/L. The on-site potable well serving the tavern has also been periodically sampled since 1992 and has not reported contaminant concentrations above WDNR ES except in October of 2011.

1.3 Purpose and Objectives

The purpose of the remedial action was to treat the residual soil and groundwater petroleum contamination remaining beneath the existing tavern property, in addition to the adjacent street right-of-way. To accomplish this, approximately 3,800-pounds of RegenOx™ was injected into the subsurface soils and shallow groundwater beneath the Site.

2.0 IN-SITU REMEDIATION PROCESS

The primary objective of the remedial action was to provide rapid mass reduction of contaminants within the source area and down-gradient plume margins through chemical treatment to address the residual soil and groundwater contamination. A discussion of the RegenOx™ oxidation process and remedial action plan and implementation is presented in the following sections.

2.1 RegenOx™ Oxidation Process

RegenOx™ is an advanced in-situ chemical oxidation technology designed to treat organic contaminants including petroleum hydrocarbons in the saturated and vadose zones. RegenOx™ produces a low temperature reaction that directly oxidizes contaminants while its catalytic complex generates a suite of highly charged, oxidative free radicals that are responsible for the rapid destruction of contaminants. By products produced by the oxidation include carbon dioxide and water. The direct oxidation formula is listed below:

$$C_2Cl_4 + 2\ Na_2CO_3 * 3\ H_2O_2 + 2\ H_2O \leftrightarrow CO_2 + 4\ NaCl + 4\ H_2O + 2\ H_2CO_3$$

The oxidation process occurs as the RegenOx™ activator complex binds and "coats" to the contaminant surface and the oxidizer then reacts to the activator to create a reaction that destroys the contaminant.

To create a 4.6% oxidant solution, 60 pounds of oxidant [Part A] and 60 pounds of activator [Part B] are combined with 140 gallons of water. The oxidant is first added to the 140 gallons of water and mixed until it is dissolved. The activator is then added to the solution immediately prior to injection. A pump is utilized to pump the solution through direct push probe soil borings to the desired depth. Sandy soils require less RegenOx™ solution and injection points can be spaced ten to fifteen feet apart on a grid pattern.

Although there was no planned discharge of RegenOx™ solution to the surface, sewers or water bodies, a Wastewater Discharge Permit was required to be completed and submitted to the Wisconsin Department of Natural Resources prior to initiating injection activities.

2.2 Remedial Action Plan

The remedial action included the implementation of an in-situ chemical injection to treat the residual soil and groundwater contamination remaining on the Site. Previous environmental investigation activities at the Site have defined a "target" area for the remedial injection generally surrounding monitoring well MW-2 (see Figure 3, attached).

The proposed treatment system was in-situ chemical injection RegenOx™. RegenOx™ is an advanced in-situ chemical oxidation technology that reduces petroleum contaminants through controlled chemical reactions. RegenOx™ directly oxidizes the petroleum hydrocarbons in high concentration

source areas in the saturated zone by using a solid alkaline oxidant complex (sodium percarbonate/catalytic formulation) and an activator complex (a composition of ferrous salt embedded in a micro-scaled catalyst gel).

A total of 5,400 pounds of RegenOx™ was planned to be injected into the Site's soil and shallow groundwater over two separate events. The injections were located within two areas and were spaced in a grid pattern for best possible Site coverage. Based on Site conditions, a total of 29 push probe borings were proposed within the areas for the scheduled injections. Each injection point had an estimated radius of influence of 10 to 15 feet. Due to very shallow groundwater conditions, lower than anticipated RegenOx volumes were used during the injection events. Site access and location of underground utilities, reduced the number of injection points advanced.

The anticipated flow rate of the injection material was eight gallons per minute (gpm) using a Geoprobe DP800 pump. The eight gpm injection rate was dependent on subsurface soil types and varied to some degree based on the hydraulic conductivity of the unit the RegenOx™ solution was being injected into. The total discharge of injection was 2,040 pounds RegenOx™ for the first injection event and 1,440 pounds RegenOx™ during the second event for a total of 3,480 pounds of RegenOx™ injected over the two injection events.

3.0 IN-SITU CHEMICAL INJECTION ACTIVITES

A total of two separate injection events occurred at the site: October 18-19, 2010 and November 8-9, 2010. Each event taking two days to complete. Carlson McCain personnel supervised the advancement and injection of the in-situ chemical treatment. The details of the in-situ chemical injections are summarized below.

3.1 RegenOx™ Preparation

RegenOx™ is divided into two parts: a Part A, which is the oxidant and a Part B, which is the Activator. Part A is a white powder that needs to be mixed with the appropriate amount of water until it is dissolved. Once dissolved, Part B is added to the mixture and mixed for another several minutes. Part B has a consistency of molasses. The solution percentage can be changed by adding more or less water as dictated by subsurface conditions. After both parts had been thoroughly mixed, the mixture was injected into the subsurface soil and groundwater using a pressure activated injection tool probe. This probe was attached at the end of the steel rods advanced by the geoprobe. The material was injected by a pump, which draws the mixture from the 55-gallon mixing barrels through tubing.

The rate of injection was approximately eight gallons per minute using a Geoprobe DP800 pump. Actual injection rates varied slightly depending on subsurface conditions, soil types and hydraulic conductivity. Prior to each injection boring, the RegenOx™ oxidant was added to the appropriate amount of water and mixed for five minutes with a power drill and paddle wheel until dissolved. After the oxidant was dissolved, the activator was added to make a 4.6 % solution. Regenesis, the company that produces RegenOx™, provided support and suggestions as to the proper percent solution to use based upon soil boring logs, groundwater analytical data and contaminant concentrations. Approximately 120 pounds of RegenOx™ and 140 gallons of water were injected into each injection point. Complete RegenOx™ instructions are provided as a reference and included in Appendix B. The Material Safety Data Sheets (MSDS) for the oxidant [Part A] and the activator {Part B] are included for reference in Appendix C.

3.2 Chemical Injection Events

The first injection event occurred from October 18-19, 2010. A total of 2,040 pounds of RegenOx™ and 2,380-gallons of water were injected into the subsurface soils and shallow groundwater over the 2 days. A total of 17 shallow injection points (5-12 feet bgs), in the area of MW-2 and within County Road M were advanced at the Site. Figure 3a – Injection Location Map (attached) displays the location of the injection points. A grid pattern was used to provide the best possible site coverage.

The second injection event occurred from November 8th and 9th, 2010. An additional 1,440 pounds of RegenOx™ and 1,680-gallons of water were injected into the subsurface soils and shallow groundwater over the 2 days. A total of 12 shallow injection points (5-12 feet bgs) were advanced at the Site. Figure 3b – Injection Location Map (attached) displays the location of the injection points for the second injection event.

3.3 Results

Groundwater samples were collected during seven quarterly monitoring events following the injection activities at the Site. The groundwater laboratory analytical data provided a basis to gauge the effectiveness of the RegenOx™ injections. Complete groundwater monitoring results are discussed in Groundwater Monitoring Report, dated September 5, 2013 which has been sent under separate cover.

4.0 CONCLUSIONS/RECOMMENDATION

The remedial action detailed in this report consisted of a two event in-situ chemical injection treatment that was completed; in an attempt to reduce the source area contaminant mass and decrease the potential for future leaching effects to groundwater and surface water. Post remedial action groundwater monitoring is detailed in the monitoring reports, dated September 5, 2013. Recommendations for continued monitoring and/or further remedial treatments will be outlined in separate correspondence.

5.0 CERTIFICATION

Carlson McCain has prepared this Remedial Action Report for the exclusive use of Mr. Trent Sprague, for the specific application to the property located at 13195 South State Highway 35 in Dairyland, Wisconsin. The services performed by Carlson McCain for this project have been conducted in a manner consistent with the level of skill and care ordinarily exercised by other members of the profession currently practicing in this area. No other warranty, expressed or implied, is made.

If you have any questions, or require additional information, please contact me at (763) 489-7900 (office).

Sincerely,

Carlson McCain, Inc.

Kelly Strut FOR

Jeffrey M. Neisse
Staff Geologist

Sincerely,

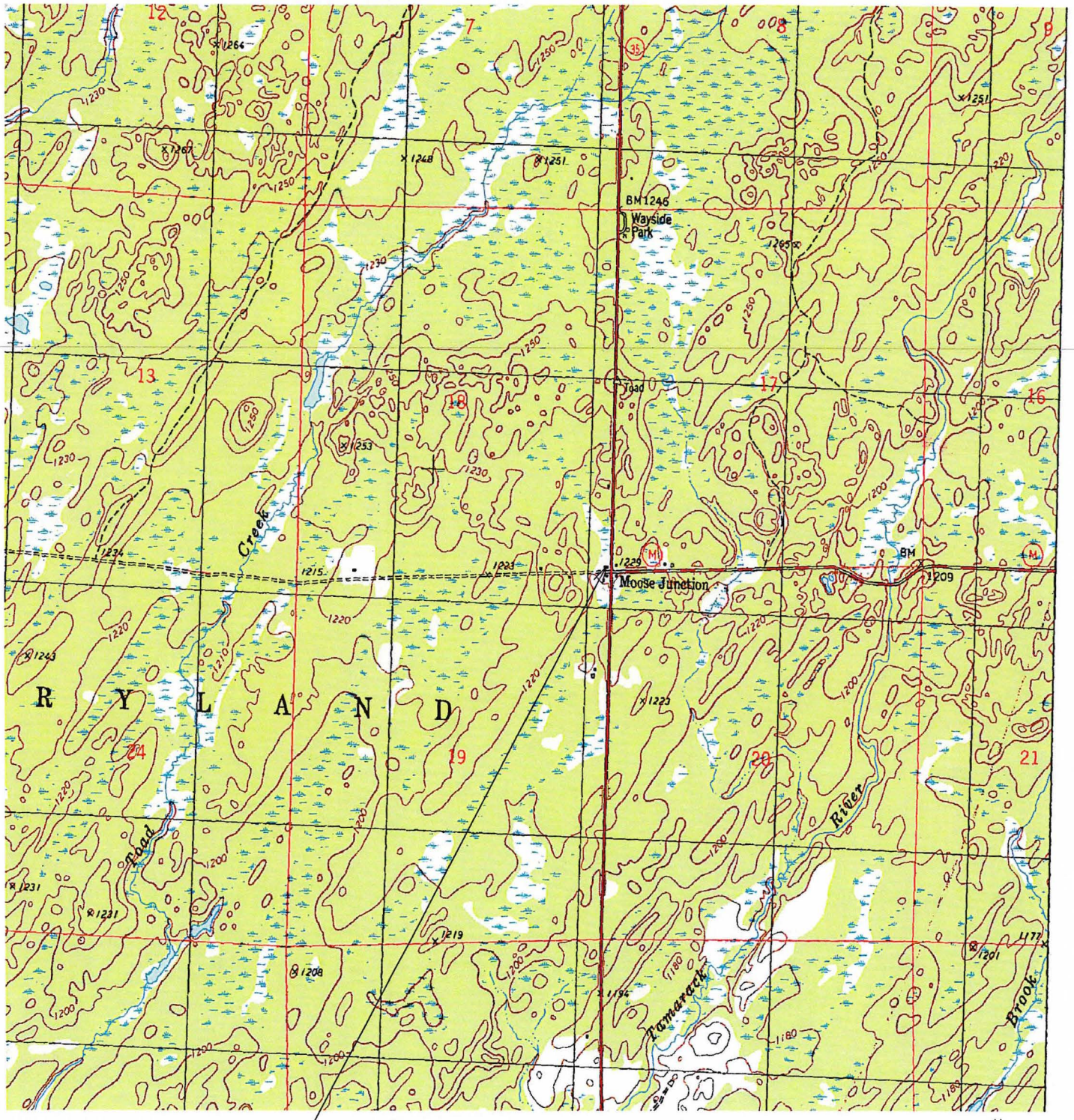
Carlson McCain, Inc.

Barbara A. Ryan, P.G.
Senior Project Manager

Cc: Mr. Trent Sprague

Table 1
RegenOx™ Quantities Injected
Moose Junction Lounge
Dairyland, Wisconsin
BRRTS# 03-16-000301 COMM# 54830-9999-97-A

Sampling Event	October 18-19, 2010	November 8-9, 2010	Totals
RegenOx™ Part A	1,020 pounds	720 pounds	1,740 pounds
RegenOx™ Part B	1,020 pounds	720 pounds	1,740 pounds
Water	2,380 gallons	1,680 gallons	4,060 gallons



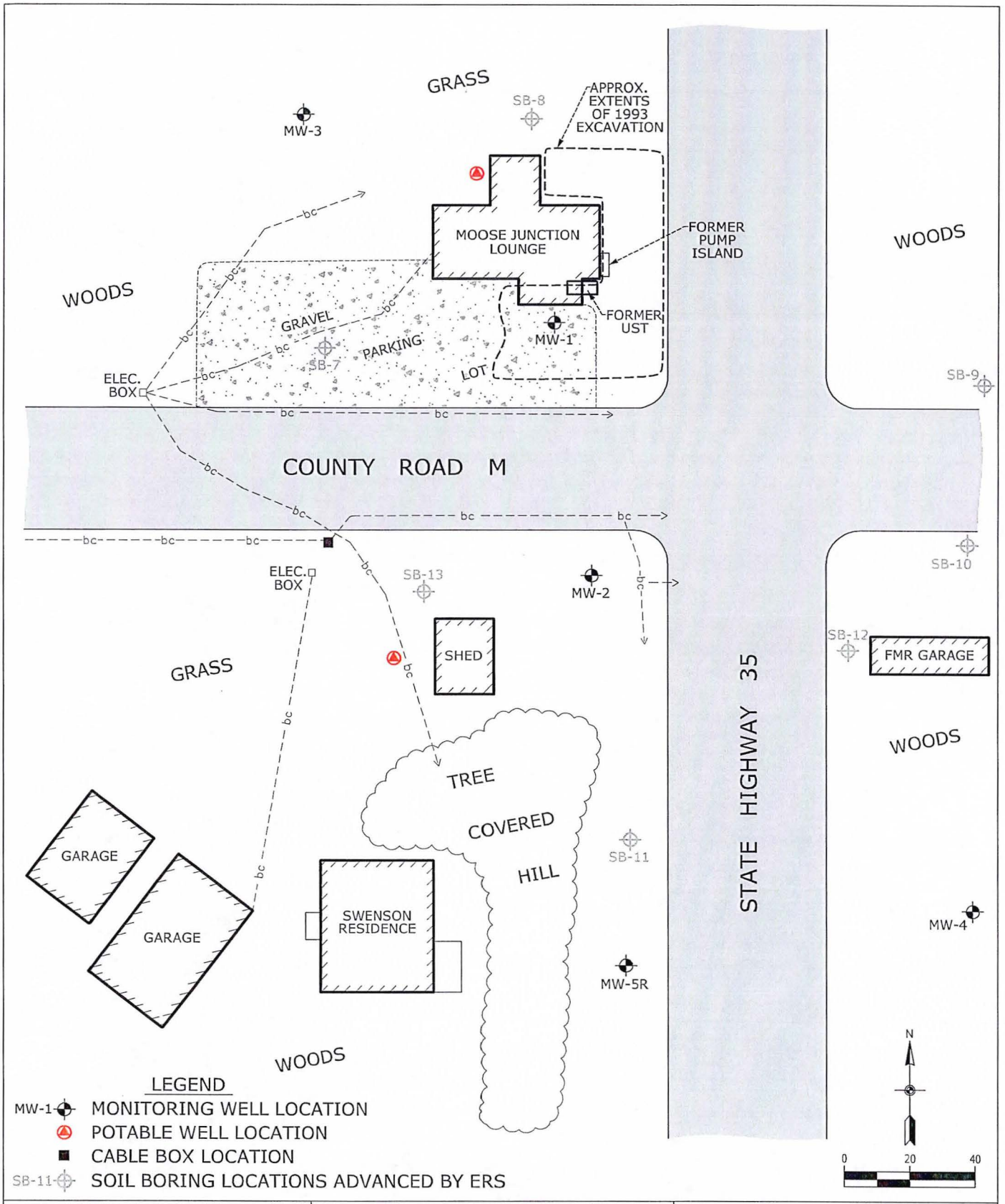
SOURCE: USGS MOOSE JUNCTION 7.5 MIN. QUADRANGLE

Carlson McCain
ENVIRONMENTAL • ENGINEERING • SURVEYING

ANNUAL MONITORING REPORT
Moose Junction Lounge
13195 Highway 35 South
Dairyland, Wisconsin
Carlson Project No.: 2490-00

FIGURE 1
SITE LOCATION MAP

F:\jobs\2481-2500\2490 - Moose Junction Lounge\CAD\AMR 2013\2490Fig.1.dwg 1/17/2013 1:52:42 PM CST

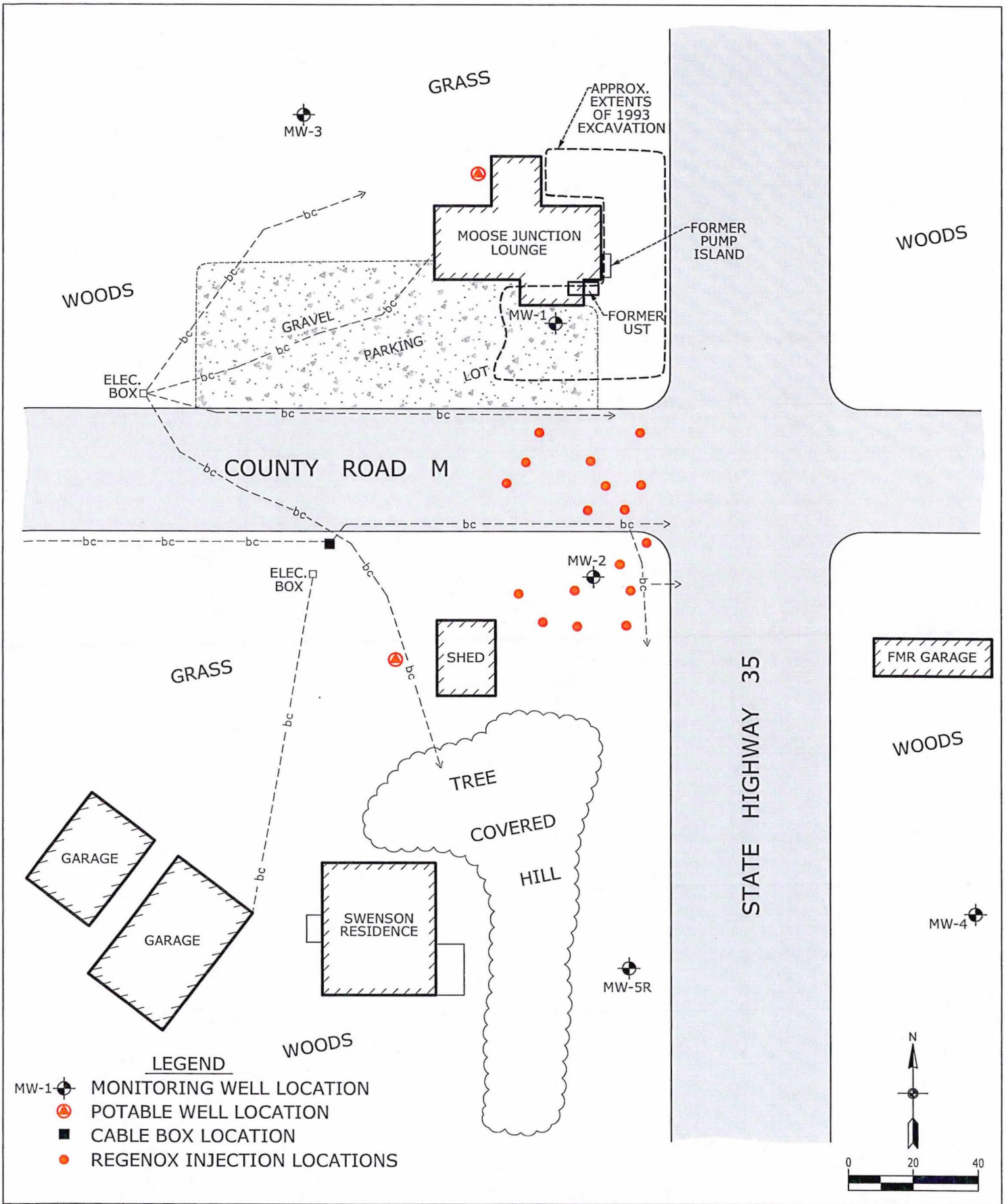


Carlson McCain
ENVIRONMENTAL • ENGINEERING • SURVEYING

INJECTION REPORT
Moose Junction Lounge
13195 Highway 35 South
Dairyland, Wisconsin
Carlson Project No.: 2490-00

FIGURE 2
SITE PLAN VIEW

F:\jobs\2481-2500\2490 - Moose Junction Lounge\CAD\InjectionRpt\2490Fig.2-3.dwg 6/5/2012 10:34:04 AM CDT



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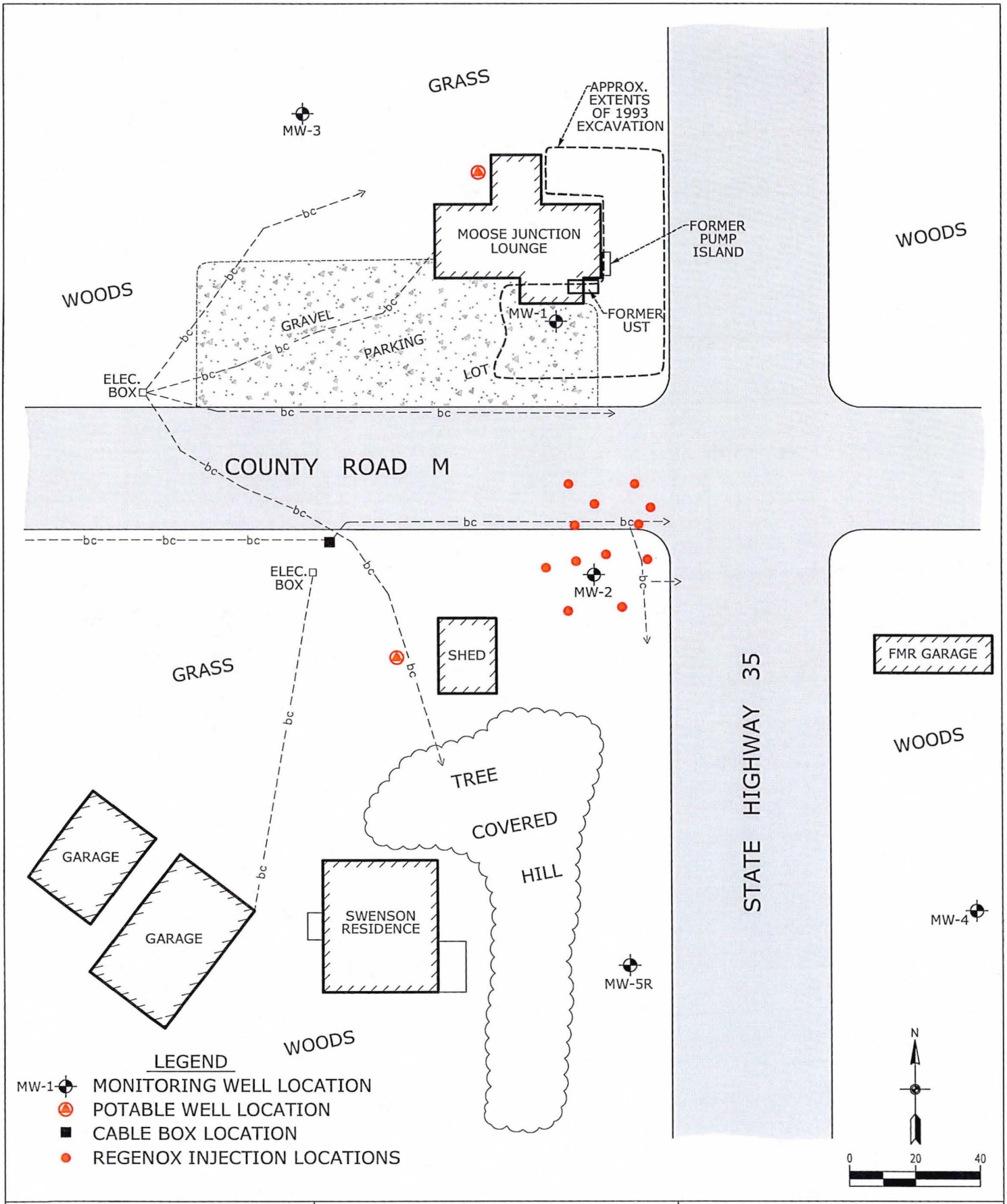
INJECTION REPORT
Moose Junction Lounge
13195 Highway 35 South
Dairyland, Wisconsin
Carlson Project No.: 2490-00

FIGURE 3a
INJECTION LOCATIONS
FIRST EVENT
10/18-10/19/2010

F:\jobs\2481-2500\2490 - Moose Junction Lounge\CAD\InjectionRpt 2013\2490Fig.2-3.dwg 1/17/2013 2:02:16 PM CST



Carlson McCain
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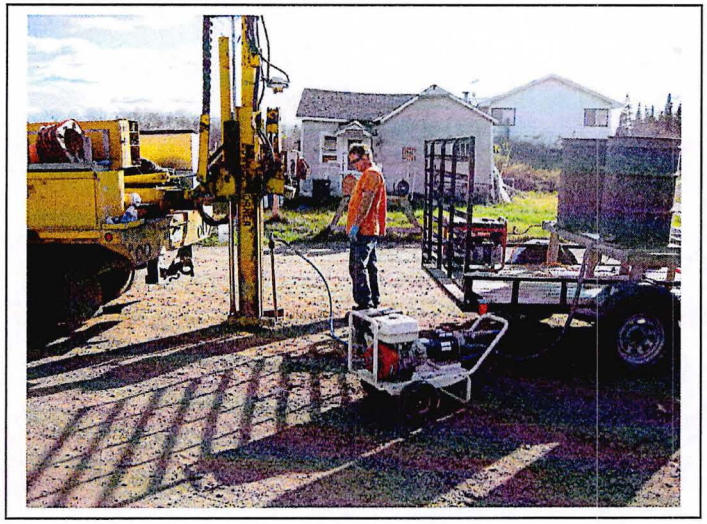
INJECTION REPORT
Moose Junction Lounge
13195 Highway 35 South
Dairyland, Wisconsin
Carlson Project No.: 2490-00

FIGURE 3b
INJECTION LOCATIONS
SECOND EVENT
11/08-11/09/2010

F:\jobs\2481-2500\2490 - Moose Junction Lounge\CAD\InjectionRpt 2013\2490Fig.2-3.dwg 1/17/2013 2:02:16 PM CST



Facing:	South	Photo 1
View of:	RegenOx™ Injection. October Event	

Facing:	East.	Photo 2
View of:	Mixing of RegenOx™. October Event	

Facing:	East.	Photo 3
View of:	RegenOx™ Injection. October Event	

Facing:	East	Photo 4
View of:	Injection Point Setup. October Event	

Facing:		Photo 5
View of:	RegenOx™ Injection point. November Event	

Facing:	North	Photo 6
View of:	RegenOx™ Injection point. November Event	

Facing:	Day lighting of injection	Photo 7
View of:	RegenOx™ Injection point. November Event	

		Photo 8
View of:	RegenOx™ Injection point. November Event	

RegenOx™

CHEMICAL OXIDATION REDEFINED...

RegenOx™ is an advanced in situ chemical oxidation technology designed to treat organic contaminants including high concentration source areas in the saturated and vadose zones*

PRODUCT FEATURES:

- Rapid and sustained oxidation of target compounds
- Easily applied with readily available equipment
- Destroys a broad range of contaminants
- More efficient than other solid oxidants
- Enhances subsequent bioremediation
- Avoids detrimental impacts to groundwater aquifers

RegenOx product application

HOW IT WORKS:

RegenOx maximizes in situ performance using a solid alkaline oxidant that employs a sodium percarbonate complex with a multi-part catalytic formula. The product is delivered as two parts that are combined and injected into the subsurface using common drilling or direct-push equipment. Once in the subsurface, the combined product produces an effective oxidation reaction comparable to that of Fenton's Reagent without a violent exothermic reaction. RegenOx safely, effectively and rapidly destroys a wide range of contaminants in both soil and groundwater (Table 1).

ACHIEVES RAPID OXIDATION VIA A NUMBER OF MECHANISMS:

RegenOx directly oxidizes contaminants while its unique catalytic complex generates a suite of highly charged, oxidative free radicals that are responsible for the rapid destruction of contaminants. The mechanisms by which RegenOx operates are:

- Surface- Mediated Oxidation: (see Figure 1 and description below)
- Direct Oxidation: $C_2Cl_4 + 2\ Na_2CO_3 \cdot 3\ H_2O_2 + 2\ H_2O \leftrightarrow CO_2 + 4\ NaCl + 4\ H_2O + 2\ H_2CO_3$
- Free Radical Oxidation:
  - -- Perhydroxyl Radical ($HO_2\cdot$)
  - -- Hydroxyl Radical ($OH\cdot$)
  - -- Superoxide Radical ($O_2\cdot$)

Figure 1. RegenOx™ Surface-Mediated Oxidation

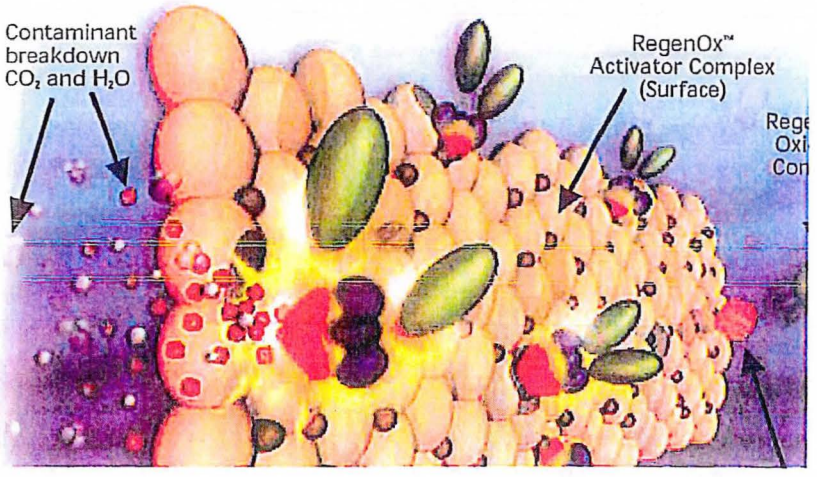


Figure 1. Surface-Mediated Oxidation is responsible for the majority of RegenOx contaminant destruction. This process takes place in two stages. First, the RegenOx activator complex coats the subsurface. Second, the oxidizer complex and contaminant react with the activator complex surface destroying the contaminant.

RegenOx™

From Mass Reduction to Bioremediation:

RegenOx™ is an effective and rapid contaminant mass reduction technology. A single injection will remove significant amounts of target contaminants from the subsurface. Strategies employing multiple Regenox injections coupled with follow-on accelerated bioremediation can be used to treat highly contaminated sites to regulatory closure. In fact, RegenOx was designed specifically to allow for a seamless transition to low-cost accelerated bioremediation using any of Regenesis controlled release compounds.

Significant Longevity:

RegenOx has been shown to destroy contaminants for periods of up to one month.

Product Application Made Safe and Easy:

RegenOx produces minimal heat and as with all oxidants proper health and safety procedures must be followed. The necessary safety guidance accompanies all shipments of RegenOx and additional resources are available on request. Through the use of readily available, highly mobile, direct-push equipment and an array of pumps, RegenOx has been designed to be as easy to install as other Regenesis products like ORC® and HRC®.

Effective on a Wide Range of Contaminants:

RegenOx has been rigorously tested in both the laboratory and the field on petroleum hydrocarbons (aliphatics and aromatics), gasoline oxygenates (e.g., MTBE and TAME), polyaromatic hydrocarbons (e.g., naphthalene and phenanthrene) and chlorinated hydrocarbons (e.g., PCE, TCE, TCA).

Oxidant Effectiveness vs. Contaminant Type:

Table 1

CONTAMINANT	RegenOx™	Fenton's Reagent	Permanganate	Persulfate	Activated Persulfate	Ozone
Petroleum Hydrocarbons	A	A	B	B	B	A
Benzene	A	A	D	B	B	A
MTBE	A	B	B	C	B	B
Phenols	A	A	B	C	B	A
Chlorinated Ethenes (PCE, TCE, DCE, VC)	A	A	A	B	A	A
Chlorinated Ethanes (TCA, DCA)	A	B	C	D	C	B
Polycyclic Aromatic Hydrocarbons (PAHs)	A	A	B	B	A	A
Polychlorinated Biphenyls (PCBs)	B	C	D	D	D	B
Explosives (RDX, HMX)	A	A	A	A	A	A

Based on laboratory kinetic data, thermodynamic calculations, and literature reports.

Oxidant Effectiveness Key:

A = Short half life, low free energy (most energetically favored), most complete
B = Intermediate half life, low free energy, intermediate degree of completion
C = Intermediate half life, intermediate free energy, low degree of completion

REGENESIS
Advanced Technologies for Groundwater Resources
1011 Calle Sombra / San Clemente / California 92673-6244

REGENESIS

RegenOx™

CHEMICAL OXIDATION REDEFINED

RegenOx™ *In Situ* Chemical Oxidation Application Instructions

Using Direct-Push Injection (Step-by-Step Procedures)

RegenOx™ is the new generation of chemical oxidation. RegenOx™ is a proprietary (patent-applied-for) *in situ* chemical oxidation process using a solid oxidant complex (sodium percarbonate/catalytic formulation) and an activator complex (a composition of ferrous salt embedded in a micro-scale catalyst gel). RegenOx™ with its catalytic system has very high activity, capable of treating a very broad range of soil and groundwater contaminants including both petroleum hydrocarbons and chlorinated solvents.

Instructions

1) Prior to the installation of RegenOx™, any surface or overhead impediments should be identified as well as the location of all underground structures. Underground structures include but are not limited to utility lines; tanks; distribution piping; sewers; drains; and landscape irrigation systems. The planned installation locations should be adjusted to account for all impediments and obstacles. These considerations should be part of the SSHP or HASP.

2) Pre-mark the installation locations, noting any points that may have different vertical application requirements or total depth.

3) Set up the direct push unit over each point and follow the manufacturer standard operating procedures (SOP) for the direct push equipment. Care should be taken to assure that probe holes remain in the vertical.

4) For most applications, Regenesis suggests using 1.5-inch O.D./0.625-inch I.D drive rods. However, some applications may require the use of 2.125-inch O.D./1.5-inch I.D. or larger drive rods.

5) Advance drive rods through the surface pavement, as necessary, following SOP.

6) Push the drive rod assembly with an expendable tip to the desired maximum depth. Regenesis suggests pre-counting the number of drive rods needed to reach depth prior to starting injection activities.

7) After the drive rods have been pushed to the desired depth, the rod assembly should be withdrawn three to six inches. Then the expendable tip can be dropped from the drive rods, following SOP. If an injection tool was used instead of an expendable tip, the application of material can take place without any preliminary withdrawal of the rods.

8) In some cases, introduction of a large column of air prior to RegenOx™ application may be problematic because the air can block water flow to the treatment area. This is particularly the case in deep injections (>50 ft) with large diameter rods (>1.5-inch O.D.). To prevent the injection of air into the aquifer during RegenOx™ application, as well as to prevent problems associated with heaving sands, fill the drive rods with water, or the RegenOx™ mixture prior dropping the expendable tip or exposing the injection tool.

9) The RegenOx™ percent of the oxidizer in solution should range between 3% to 5%. Although solutions up to 8% may be used, this will likely increase the difficulty of injection due to reactivity. Solutions with greater than 8% oxidizer in solution will result in excess reaction and flocculation prior to injection and are not typically recommended

Measure the appropriate quantity of RegenOx™ Oxidizer for one to four vertical foot of injection into a 55 gallon drum or mixing tank. The volume of water per injection location can be calculated from the following formula:

$$\frac{\text{RegenOx Oxidizer lbs/foot}}{(8.34\ \text{lbs/gal water})(\%\ \textit{RegenOx\_Oxidizer}\ \text{solids})}\left[1-(\%\ \textit{RegenOx\_Oxidizer}\ \text{solids})\right]$$

Tighter formations (clays and silts), and even some fine sand formations will likely require higher oxidant percentages since less volume can be injected per location. The following are guides to various RegenOx™ mixing ratios based on the above equation.

- to make a roughly 3% oxidant solution for every 10 lbs of oxidant and 10 lbs of activator (20 lbs total RegenOx™), use 38 gallons of water.
- to make a roughly 4% oxidant solution for every 10 lbs of oxidant and 10 lbs of activator (20 lbs total RegenOx™), use 28 gallons of water.
- to make a roughly 5% oxidant solution for every 10 lbs of oxidant and 10 lbs of activator (20 lbs total RegenOx™), use 22 gallons of water.

10) Pour the pre-measured quantity of RegenOx™ Oxidizer into the pre-measured volume of water to make the desired target % oxidant in solution. NOTE: always pour the Oxidizer into water, do not pour water into the Oxidizer. Mix the water and oxidant with a power drill and paint stirrer or other mechanical mixing device to ensure that the Oxidizer has dissolved in the water.

11) Pour the applicable quantity of the pre-mixed RegenOx™ Activator into the oxidant:water solution. Mix the Oxidant and Activator using a power drill paint stirrer or other mechanical mixing device for at least 5 minutes until a homogenous mixture is formed. After mixing the RegenOx™ mixture should be injected into the subsurface as soon as possible.

12) Do not mix more RegenOx™ material than will be used over roughly 1 to 4 feet of injection so as to minimize potential above ground reaction/flocculation prior to injection.

    Transfer the contents of the mixing tank to the pump using gravity feed or appropriate transfer pump. (See Section 9.2: Pump Selection) For some types of pumps, it may be desirable to perform a volume check prior to injecting RegenOx™

13) Connect the delivery hose to the pump outlet and the delivery sub-assembly. Circulate RegenOx™ though the hose and the delivery sub-assembly to displace air in the hose. NOTE: an appropriately sized pressure gauge should be placed between the pump outlet and the delivery sub-assembly in order to monitor application pump pressure and detect changes in aquifer backpressures during application.

14) Connect the sub-assembly to the drive rod. After confirming that all of the connections are secure, pump the RegenOx™ through the delivery system to displace the water/fluid in the rods.

15) Slowly withdraw the drive rods. Commonly RegenOx™ injection progress at 1-foot intervals. However, continuous injection while slowly withdrawing single lengths of drive rod (3 or 4 feet) is an acceptable option. The pre-determined volume of RegenOx™ should be pumped into the aquifer across the desired treatment interval.

16) Remove one section of the drive rod. The drive rod may contain some residual RegenOx™. Place the RegenOx™-filled rod in a clean, empty bucket and allow the RegenOx to drain. Eventually, the RegenOx™ should be returned to the RegenOx™ pump hopper for reuse.

17) Monitor for any indications of aquifer refusal. This is typically indicated by a spike in pressure as indicated or (in the case of shallow applications) RegenOx™ "surfacing" around the injection rods or previously installed injection points. At times backpressure caused by reaction off-gassing will impede the pumps delivery volume. This can be corrected by bleeding the pressure off using a pressure relief/bypass valve (placed inline between the pump discharge and the delivery sub-assembly) and then resume pumping. If aquifer acceptance appears to be low, as indicated by high back pressure, allow sufficient time for the aquifer to equilibrate prior to removing the drive rod.

18) Repeat steps 13 through 23 until treatment of the entire contaminated vertical zone has been achieved. It is recommended that the procedure extend to the top of the capillary fringe/smear zone, or to the top of the targeted treatment interval.

19) Install an appropriate seal, such as bentonite, above the RegenOx™ material through the entire vadose zone. Prior to emplacing the borehole seal, we recommend placing clean sand in the hole to the top of the RegenOx™ treatment zone (especially important in holes that stay open). Bentonite chips or granular bentonite should be placed immediately above the treatment zone, followed by a cement/bentonite grout to roughly 0.5 feet below ground surface. Quick-set concrete should then be used as a surface seal.

20) Remove and clean the drive rods as necessary.

21) Finish the borehole at the surface as appropriate (concrete or asphalt cap, as needed). We recommend a quick set concrete to provide a good surface seal with minimal set up time.

22) A proper borehole and surface seal assures that the RegenOx™ remains properly placed and prevents contaminant migration from the subsurface. Each borehole should be sealed immediately following RegenOx™ application to minimize RegenOx™ surfacing during the injection process. If RegenOx™ continues to "surface" up the direct push borehole, an appropriately sized (oversized) disposable drive tip or wood plug/stake can be used to plug the hole until the aquifer pressures equilibrates and the RegenOx™ stops surfacing. If wells are used for RegenOx™ injection the RegenOx™ injection wells and all nearby groundwater monitoring wells should be tightly capped to reduce potential for surfacing through nearby wells.

23) Periodically compare the pre- and post-injection volumes of RegenOx™ in the holding tank or pump hopper using the pre-marked volume levels. Volume level may not be present on all tanks or pump hoppers. In this case, volume level markings can be temporarily added using known amounts of water and a carpenter's grease pencil (Kiel crayon).

24) Move to the next probe point, repeating steps 8 through 29. We recommend that the next RegenOx™ injection point be as far a distance as possible within the treatment zone from the previous RegenOx™ injection point. This will further minimize RegenOx™ surfacing and short circuiting up an adjacent borehole. When possible, due to the high volumes of liquid being injected, working from the outside of the injection area towards the center will limit expansion of the plume.

Pump Selection

Regenesis has evaluated a number of pumps and many are capable of delivering RegenOx™ to the subsurface at a sufficient pressure and volumetric rate. However, even though a number of the evaluated pumps may be capable of delivering the RegenOx™ to the subsurface based on adequate pressures and delivery rates, each pump has its own set of practical issues that may make it more or less difficult to manage in a field setting.

In general, Regenesis strongly recommends using a pump with a pressure rating of 200 pounds per square inch (psi) in sandy soil settings, and 800 psi in silt, clay or weathered bedrock settings. Any pump under consideration should have a minimum delivery rate of 5 gallons per minute (gpm). A lower gpm rated pump may be used; however, they are not recommended due to the amount of time required to inject the volume of liquids typically associated with a RegenOx™ injection (i.e. 1,000 lbs of RegenOx™ [500 lbs Oxidant/500 lbs Activator] require roughly 1,100 gallons of water to make a 5% Oxidant solution).

Quite often diaphragm pumps are used for the delivery of chemical oxidants. Generally, these pumps operate pressures from 50-150 psi. Some of these pumps do not have the pressure head necessary to overcome the back pressure encountered in silt and clay lenses. In these cases the chemical oxidant thus ends up being delivered to the surrounding sands (the path of least resistance) and is not delivered to soil with residual adsorbed contamination. The use of a positive displacement pump such as a piston pump or a progressing cavity pump is may be superior because these pumps have the pressure necessary to overcome the resistance of low permeability soils. NOTE: be aware that application at pressures that are too high may over-consolidate the soil and minimize the direct contact of the oxidant. The key is to inject at a rate and pressure that maximizes the radius of influence without causing preferential flow. This can be achieved by injecting at the minimum pressure necessary to overcome the particular pressures associated with your site soil conditions.

Whether direct injection or wells are used, it is best to start by injecting RegenOx™ outside the contaminated area and spiral laterally inwards toward the source. Similarly, RegenOx™ should be applied starting vertically at the bottom elevation of contamination, through the layer of contamination, and a couple of feet above the layer of contamination. The reagents can be pushed out from the well bore with some water.

Pump Cleaning

For best results, flush all moving parts and hoses with clean water at the end of the day; flush the injection system with a mixture of water and biodegradable cleaner such as Simple Green.

For more information or technical assistance please call Regenesis at 949-366-8000

Regen OX – Part A (Oxidizer Complex)

Material Safety Data Sheet (MSDS)

Last Revised: October 1, 2007

Section 1 – Supplier Information and Material Identification

Supplier:

REGENESIS
1011 Calle Sombra
San Clemente, CA 92673
Telephone: 949.366.8000
Fax: 949.366.8090
E-mail: info@regenesis.com

Chemical Description:	A mixture of sodium percarbonate [$2Na_2CO_3 \cdot 3H_2O_2$], sodium carbonate [Na_2CO_3], sodium silicate and silica gel.
Chemical Family:	Inorganic Chemicals
Trade Name:	Regen Ox – Part A (Oxidizer Complex)
Product Use:	Used to remediate contaminated soil and groundwater (environmental applications)

Section 2 – Chemical Information/Other Designations

CAS No.	Chemical	Percentage
15630-89-4	Sodium Percarbonate	60 -100 %
5968-11-6	Sodium Carbonate Monohydrate	10 – 30 %
7699-11-6	Silicic Acid	< 1 %
63231-67-4	Silica Gel	< 1 %

Section 3 – Physical Data

Form:	Powder
Color:	White
Odor:	Odorless
Melting Point:	NA
Boiling Point:	NA

Section 3 – Physical Data (cont)

Flammability/Flash Point:	NA
Vapor Pressure:	NA
Bulk Density:	0.9 – 1.2 g/cm^3
Solubility:	Min 14.5g/100g water @ 20 °C
Viscosity:	NA
pH (3% solution):	≈ 10.5
Decomposition Temperature:	Self-accelerating decomposition with oxygen release starts at 50 °C.

Section 4 – Reactivity Data

Stability:	Stable under normal conditions
Conditions to Avoid/Incompatibility:	Acids, bases, salts of heavy metals, reducing agents, and flammable substances
Hazardous Decomposition Products:	Oxygen. Contamination with many substances will cause decomposition. The rate of decomposition increases with increasing temperature and may be very vigorous with rapid generation of oxygen and steam.

Section 5 – Regulations

TSCA Inventory Listed:	Yes

CERCLA Hazardous Substance (40 CFR Part 302)

Listed Substance:	*No*
Unlisted Substance:	*Yes*

SARA, Title III, Sections 313 (40 CFR Part 372) – Toxic Chemical Release Reporting: Community Right-To-Know

Extremely Hazardous Substance:	No
WHMIS Classification:	C, D2B
Canadian Domestic Substance List:	Appears

Section 6 – Protective Measures, Storage and Handling

Technical Protective Measures

Storage:	Oxidizer. Store in a cool, well ventilated area away from all sources of ignition and out of the direct sunlight. Store in a dry location away from heat and in temperatures less than 40 °C.
	Keep away from incompatible materials and keep lids tightly closed. Do not store in improperly labeled containers.
	Protect from moisture. Do not store near combustible materials. Keep containers well sealed.
	Store separately from reducing materials. Avoid contamination which may lead to decomposition.
Handling:	Avoid contact with eyes, skin and clothing. Use with adequate ventilation.
	Do not swallow. Avoid breathing vapors, mists or dust. Do not eat, drink or smoke in the work area.
	Label containers and keep them tightly closed when not in use.
	Wash hands thoroughly after handling.

Personal Protective Equipment (PPE)

Engineering Controls:	General room ventilation is required if used indoors. Local exhaust ventilation, process enclosures or other engineering controls may be needed to maintain airborne levels below recommended exposure limits. Avoid creating dust or mists. Maintain adequate ventilation at all times. Do not use in confined areas. Keep levels below recommended exposure limits. To determine actual exposure limits, monitoring should be performed on a routine basis.
Respiratory Protection:	For many conditions, no respiratory protection is necessary; however, in dusty or unknown conditions or when exposures exceed limit values a NIOSH approved respirator should be used.
Hand Protection:	Wear chemical resistant gloves (neoprene, rubber, or PVC).

Section 6 – Protective Measures, Storage and Handling (cont)

Eye Protection:	Wear chemical safety goggles. A full face shield may be worn in lieu of safety goggles.
Skin Protection:	Try to avoid skin contact with this product. Chemical resistant gloves (neoprene, PVC or rubber) and protective clothing should be worn during use.
Other:	Eye wash station.
Protection Against Fire & Explosion:	Product is non-explosive. In case of fire, evacuate all non-essential personnel, wear protective clothing and a self-contained breathing apparatus, stay upwind of fire, and use water to spray cool fire-exposed containers.

Section 7 – Hazards Identification

Potential Health Effects

Inhalation:	Causes irritation to the respiratory tract. Symptoms may include coughing, shortness of breath, and irritations to mucous membranes, nose and throat.
Eye Contact:	Causes irritation, redness and pain.
Skin Contact:	Causes slight irritation.
Ingestion:	May be harmful if swallowed (vomiting and diarrhea).

Section 8 – Measures in Case of Accidents and Fire

After Spillage/Leakage:	Eliminate all ignition sources. Evacuate unprotected personnel and never exceed any occupational exposure limit. Shovel or sweep spilt material into plastic bags or vented containers for disposal. Do not return spilled or contaminated material to the inventory.
Extinguishing Media:	Water

First Aid

Eye Contact:	Flush eyes with running water for at least 15 minutes with eyelids held open. Seek a specialist.
Inhalation:	Remove affected person to fresh air. Seek medical attention if the effects persist.
Ingestion:	If the individual is conscious and not convulsing, give two-four cups of water to dilute the chemical and seek medical attention immediately. **Do Not** induce vomiting.

Section 8 – Measures in Case of Accidents and Fire (cont)

Skin Contact:	Wash affected areas with soap and a mild detergent and large amounts of water.

Section 9 – Accidental Release Measures

Precautions:	
Cleanup Methods:	Shovel or sweep spilt material into plastic bags or vented containers for disposal. Do not return spilled or contaminated material to the inventory.

Section 10 – Information on Toxicology

Toxicity Data	
LD50 Oral (rat):	2,400 mg/kg
LD50 Dermal (rabbit):	Min 2,000 mg/kg
LD50 Inhalation (rat):	Min 4,580 mg/kg

Section 11 – Information on Ecology

Ecology Data	
Ecotoxicological Information:	NA

Section 12 – Disposal Considerations

Waste Disposal Method	
Waste Treatment:	Dispose of in an approved waste facility operated by an authorized contactor in compliance with local regulations.
Package (Pail) Treatment:	The empty and clean containers are to be recycled or disposed of in conformity with local regulations.

Section 13 – Shipping/Transport Information

D.O.T. Shipping Name:	Oxidizing Solid, N.O.S. [A mixture of sodium percarbonate [$2Na_2CO_3 \cdot 3H2O_2$], sodium carbonate [Na_2CO_3], sodium silicate and silica gel.]
UN Number:	1479
Hazard Class:	5.1
Labels:	5.1 (Oxidizer)
Packaging Group:	III

Section 14 – Other Information

HMIS® Rating	Health – 1 (slight)	Reactivity – 1 (slight)
	Flammability – 0 (none)	Lab PPE – goggles, gloves, and lab coat

HMIS® is a registered trademark of the National Painting and Coating Association.

Section 15 – Further Information

The information contained in this document is the best available to the supplier at the time of writing, but is provided without warranty of any kind. Some possible hazards have been determined by analogy to similar classes of material. The items in this document are subject to change and clarification as more information become available. This document is intended only as a guide to the appropriate precautionary handling of the material by a properly trained person. Individuals receiving this information must exercise their independent judgment in determining its appropriateness for a particular purpose.

Regen OX – Part B (Activator Complex)

Material Safety Data Sheet (MSDS)

Last Revised: November 7, 2005

Section 1 – Supplier Information and Material Identification

Supplier:

REGENESIS

1011 Calle Sombra
San Clemente, CA 92673
Telephone: 949.366.8000
Fax: 949.366.8090
E-mail: info@regenesis.com

Chemical Description:	A mixture of sodium silicate solution, silica gel and ferrous sulfate
Chemical Family:	Inorganic Chemicals
Trade Name:	Regen Ox – Part B (Activator Complex)
Product Use:	Used for environmental remediation of contaminated soils and groundwater

Section 2 – Chemical Information/Other Designations

CAS No.	Chemical
1344-09-8	Silicic Acid, Sodium Salt, Sodium Silicate
63231-67-4	Silica Gel
7720-78-7	Ferrous Sulfate
7732-18-5	Water

Section 3 – Physical Data

Form:	Liquid
Color:	Blue/Green
Odor:	Odorless
Melting Point:	NA
Boiling Point:	NA
Flammability/Flash Point:	NA
Vapor Pressure:	NA

Section 3 – Physical Data (cont)

Specific Gravity	1.39 g/cm^3
Solubility:	Miscible
Viscosity:	NA
pH (3% solution):	11
Hazardous Decomposition Products:	Oxides of carbon and silicon may be formed when heated to decomposition.

Section 4 – Reactivity Data

Stability:	Stable under normal conditions.
Conditions to Avoid:	None.
Incompatibility:	Avoid hydrogen fluoride, fluorine, oxygen difluoride, chlorine trifluoride, strong acids, strong bases, oxidizers, aluminum, fiberglass, copper, brass, zinc, and galvanized containers.

Section 5 – Regulations

TSCA Inventory Listed: Yes

CERCLA Hazardous Substance (40 CFR Part 302)

Listed Substance: *No*

Unlisted Substance: *Yes*

SARA, Title III, Sections 302/303 (40 CFR Part 355) – Emergency Planning and Notification

Extremely Hazardous Substance: No

SARA, Title III, Sections 311/312 (40 CFR Part 370) – Hazardous Chemical Reporting: Community Right-To-Know

Hazard Category: Acute

SARA, Title III, Sections 313 (40 CFR Part 372) – Toxic Chemical Release Reporting: Community Right-To-Know

Extremely Hazardous Substance: No

Section 6 – Protective Measures, Storage and Handling

Technical Protective Measures

Storage:	Keep in a tightly closed container (steel or plastic) and store in a cool, well ventilated area away from all incompatible materials (acids, reactive metals, and ammonium salts). Store in a dry location away from heat and in temperatures less than 24 °C. Do not store in aluminum, fiberglass, copper, brass, zinc or galvanized containers.
Handling:	Avoid contact with eyes, skin and clothing. Avoid breathing spray mist. Use with adequate ventilation. Do not use product if it is brownish-yellow in color.

Personal Protective Equipment (PPE)

Engineering Controls:	General room ventilation is required if used indoors. Local exhaust ventilation, process enclosures or other engineering controls may be needed to maintain airborne levels below recommended exposure limits. Safety shower and eyewash station should be within direct access.
Respiratory Protection:	Use NIOSH-approved dust and mist respirator where spray mist exists. Respirators should be used in accordance with 29 CFR 1910.134.
Hand Protection:	Wear chemical resistant gloves.
Eye Protection:	Wear chemical safety goggles. A full face shield may be worn in lieu of safety goggles.
Skin Protection:	Try to avoid skin contact with this product. Gloves and protective clothing should be worn during use.
Other:	
Protection Against Fire & Explosion:	Product is non-explosive and non-combustible.

Section 7 – Hazards Identification

Potential Health Effects	
Inhalation:	Causes irritation to the respiratory tract. Symptoms may include coughing, shortness of breath, and irritations to mucous membranes, nose and throat.
Eye Contact:	Causes irritation, redness and pain.
Skin Contact:	Causes irritation. Symptoms include redness, itching and pain.
Ingestion:	May cause irritation to mouth, esophagus, and stomach.

Section 8 – Measures in Case of Accidents and Fire

After Spillage/Leakage (small):	Mop up and neutralize liquid, then discharge to sewer in accordance with local, state and federal regulations.
After Spillage/Leakage (large):	Keep unnecessary personnel away; isolate hazard area and do not allow entrance into the affected area. Do not touch or walk through spilled material. Stop leak if possible without risking injury. Prevent runoff from entering into storm sewers and ditches that lead to natural waterways. Isolate the material if at all possible. Sand or earth may be used to contain the spill. If containment is not possible, neutralize the contaminated area and flush with large quantities of water.
Extinguishing Media:	Material is compatible with all extinguishing media.
Further Information:	
First Aid	
Eye Contact:	Flush eyes with running water for at least 15 minutes with eyelids held open. Seek a specialist.
Inhalation:	Remove affected person to fresh air. Give artificial respiration if individual is not breathing. If breathing is difficult, give oxygen. Seek medical attention if the effects persist.
Ingestion:	If the individual is conscious and not convulsing, give two-four cups of water to dilute the chemical and seek medical attention immediately. **DO NOT** induce vomiting.
Skin Contact:	Wash affected areas with soap and a mild detergent and large amounts of water. Remove contaminated clothing and shoes.

Section 9 – Accidental Release Measures

Precautions:	
PPE:	Wear chemical goggles, body-covering protective clothing, chemical resistant gloves, and rubber boots (see Section 6).
Environmental Hazards:	Sinks and mixes with water. High pH of this material may be harmful to aquatic life. Only water will evaporate from a spill of this material.
Cleanup Methods:	Pick-up and place in an appropriate container for reclamation or disposal. US regulations (CERCLA) require reporting spills and releases to soil, water and air in excess of reportable quantities.

Section 10 – Information on Toxicology

Toxicity Data	
Sodium Silicate:	When tested for primary eye irritation potential according to OECD Guidelines, Section 405, a similar sodium silicate solution produced corneal, iridal and conjunctival irritation. Some eye irritation was still present 14 days after treatment, although the average primary irritation score has declined from 29.7 after 1 day to 4.0 after 14 days. When tested for primary skin irritation potential, a similar sodium silicate solution produced irritation with a primary irritation index of 3 to abraded skin and 0 to intact skin. Human experience confirms that irritation occurs when sodium silicates get on clothes at the collar, cuffs, or other areas where abrasion may exist. The acute oral toxicity of this product has not been tested.
Ferrous Sulfate:	LD50 Oral (rat): 319 mg/kg not a suspected carcinogen.

Section 11 – Information on Ecology

Ecology Data

Ecotoxicological Information:	Based on 100% solid sodium silicate, a 96 hour median tolerance for fish of 2,320 mg/l; a 96 hour median tolerance for water fleas of 247 mg/L; a 96 hour median tolerance for snail eggs of 632 mg/L; and a 96 hour median tolerance for Amphipoda of 160 mg/L.

Section 12 – Disposal Considerations

Waste Disposal Method

Waste Treatment:	Neutralize and landfill solids in an approved waste facility operated by an authorized contactor in compliance with local regulations.
Package (Pail) Treatment:	The empty and clean containers are to be recycled or disposed of in conformity with local regulations.

Section 13 – Shipping/Transport Information

D.O.T.	This product is not regulated as a hazardous material so there are no restrictions.

Section 14 – Other Information

HMIS® Rating	Health – 2 (moderate)	Reactivity – 0 (none)
	Flammability – 0 (none)	Lab PPE – goggles, gloves, and lab coat
	Contact – 1 (slight)	

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Section 15 – Further Information

The information contained in this document is the best available to the supplier at the time of writing, but is provided without warranty of any kind. Some possible hazards have been determined by analogy to similar classes of material. The items in this document are subject to change and clarification as more information become available. This document is intended only as a guide to the appropriate precautionary handling of the material by a properly trained person. Individuals receiving this information must exercise their independent judgment in determining its appropriateness for a particular purpose.