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Letter of Transmittal

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To: Mr. John Feeney
Wisconsin Department of Natural Resources
4041 North Richards Street
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Milwaukee, WI 53212-0436

Date: 1/26/05
Project No.: 3084.28
Subject: Tecumseh Power Company
WDNR FID #~~24009170~~
BRRTS #02-46000751

Prepared By: Stacey A Koch, P.E. **Title** Project Manager

Signature: Stacey Koch

We are sending you: ☒ Copy of Letter

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1	1/26/05		Revised Letter to the 2004 Annual Status Report - Lactate Injection System

These items are transmitted as checked below:

☒ For your use

Remarks:

Enclosed is a revised letter for the 2004 Annual Status Report which was submitted to the WDNR on January 18, 2005. We have revised the schedule on page 8. Please replace the January 18, 2005, letter with the attached January 26, 2005, letter.

Please call me at 608-662-5405 if you have any questions.

cc: Kerry DeKeyser, Victor Menting – Tecumseh Power Company
Henry Handzel – DeWitt, Ross & Stevens
Alyssa Sellwood – RMT, Inc.

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January 26, 2005

Mr. John Feeney
Wisconsin Department of Natural Resources
4041 North Richards Street
P.O. Box 12436
Milwaukee, WI 53212-0436

Subject: 2004 Annual Status Report - Lactate Injection System
Tecumseh Power Company
Grafton, Wisconsin (WDNR FID #24009170, BRRTS #02-46000751)

Dear Mr. Feeney:

This letter documents the lactate injections and associated groundwater and soil monitoring that occurred in 2004 at the Tecumseh Power Company (Tecumseh) in Grafton, Wisconsin. This letter includes a discussion of the lactate injections and monitoring events, a summary of the groundwater monitoring and soil monitoring results, and conclusions and recommendations based on the monitoring results.

Background

RMT conducted a series of site investigations at Tecumseh between 1994 and 1996, and the results of the investigations are summarized in the Subsurface Investigation Report (RMT, 1997). In general, the results of the investigations indicated that the West Dock and Recycling Dock Areas at the Tecumseh facility were potential sources for trichloroethylene (TCE) and 1,1,1-trichloroethane (TCA) (Figure 1). Additional findings reported in the Subsurface Investigation Report and the Bioremediation Treatability Study Results (RMT, 1999) indicated that anaerobic biodegradation of the groundwater impacted with TCE and TCA is occurring in both areas, and could be accelerated using *in situ* enhanced bioremediation.

RMT selected to enhance the *in situ* bioremediation of TCE and TCA at Tecumseh through lactate injections. As described in the WDNR Publication RR-699, "Understanding Chlorinated Hydrocarbons" (WDNR, 2003), anaerobic biodegradation of TCE and TCA can occur by reductive dechlorination. In reductive dechlorination, TCE and similar chlorinated compounds are reduced by the replacement of a chlorine atom with a hydrogen atom. When lactate is introduced into the subsurface and is biodegraded, other volatile fatty acids (VFAs) are produced and degraded, and hydrogen is generated. The hydrogen produced in this reaction serves as the electron donor in the reductive dechlorination of TCE and similar chlorinated compounds. Consequently, the introduction of lactate into the subsurface can enhance the reductive dechlorination of TCE and TCA.

In October and November 2002, three injection wells and four infiltration trenches were constructed at Tecumseh for the purpose of *in situ* enhanced bioremediation of the groundwater and soil using

lactate injections. In addition, four monitoring wells (MW-23, MW-24, MW-25, and MW-26) were installed during that time for purposes of evaluating the lactate injection system. The details of the construction of the wells and trenches were described and submitted to the WDNR in a Construction Documentation Report (RMT, 2003). Monitoring well MW-24 was paved over when the parking lot near the Recycling Dock area was resurfaced in June 2003. Consequently, this well was replaced with MW-24R in November 2003, and the documentation of the construction of MW-24R was submitted to the WDNR in the 2003 Annual Status Report for the site (RMT, 2004). The locations of the wells and trenches are shown on Figure 1.

Following construction of the trenches and wells, RMT performed two lactate injections in the West Dock and Recycling Dock Areas in November 2002 and April 2003. The results of the groundwater and soil monitoring associated with those injections were summarized in the 2003 Annual Status Report. In general, the results indicated the lactate injections were enhancing the reductive dechlorination of TCE and TCA at the site. RMT recommended that the lactate injections continue; however, in order to optimize the performance of the lactate injections, RMT recommended that some modifications be made to the procedure. RMT recommended that the concentration of lactate in the Recycling Dock Area be reduced, while the concentration of the lactate in the West Dock Area be increased. These recommendations were generally carried out in the 2004 injections.

Site Activities

Lactate Injections

Two rounds of lactate injections were conducted at both the West Dock Area and the Recycling Dock Area in 2004. The lactate solution used for each injection is composed of sodium lactate, sodium sulfide, yeast extract, and sodium bicarbonate. In the Recycling Dock Area, the lactate solution is injected directly into the groundwater via three injection wells to target treatment of the groundwater; whereas, in the West Dock Area, the lactate solution is injected into the vadose zone via gravity infiltration trenches to target treatment of the unsaturated soil and groundwater. The injection procedure for each area is outlined in the Construction Documentation Report.

Recycling Dock Area

In 2004, the first injection occurred on January 21, over approximately a 12-hour period and the second injection occurred on April 21, over approximately a 24-hour period. During the January injection, the injection volume, rather than the concentration of lactate, was reduced from the volumes used in 2003. This was done in order to reduce the total time of the injection, and thus reduce the potential that the system would freeze. In the January injection, the target concentrations of sodium lactate, sodium sulfide, yeast extract, and sodium bicarbonate were 2,000 mg/L, 30 mg/L, 10 mg/L, and 37 mg/L, respectively; and the total injection volume was 8,108 gallons. During the April injection, the total volume was kept consistent with the 2003 injections; however, the concentration of

lactate was reduced from 2,000 mg/L to 1,500 mg/L, based on the recommendations made in the 2003 Annual Status Report. The total volume injected during the April injection was 18,626 gallons. The average flow rates for the three injection wells during each injection ranged from 3.8 to 4.4 gpm, and the average total flow rate during each injection was approximately 12 gpm.

West Dock Area

Each of the two injections in the West Dock Area occurred over approximately a 2-month time period. The first injection occurred during the period December 19, 2003, through February 13, 2004; and the second injection occurred during the period May 11, 2004, through July 1, 2004. During the first injection, the concentration of sodium lactate was increased from the concentration used in 2003. The target concentrations of sodium lactate, sodium sulfide, yeast extract, and sodium bicarbonate were 2,500 mg/L, 30 mg/L, 10 mg/L, and 37 mg/L, respectively. Based on an interim review of the monitoring data for the site following the first injection, it was determined that the concentration of sodium lactate should be further increased; therefore, the concentration of sodium lactate in the second injection was increased to approximately 4,000 mg/L. The total flow volumes recorded during the first and second injection were 61,338 and 64,327 gallons, respectively.

Groundwater Monitoring

The locations of the monitoring wells that are monitored by RMT (MW-8, M-8D, MW-23, MW-24R, MW-25, and MW-26) to assess the effectiveness of the *in situ* enhanced bioremediation system are shown on Figures 1 through 3. Monitoring wells MW-8 through MW-24 are used to evaluate the Recycling Dock Area (Figure 2), and monitoring wells MW-25 and MW-26 are used to evaluate the West Dock Area (Figure 3). RMT collected groundwater samples from each well on March 24, 2004, and August 11, 2004, following completion of the first and second round of injections, respectively.

Soil Monitoring

RMT and the Geoprobe® subcontractor, SGS, Inc., were on-site on March 23, 2004, and August 10, 2004, to collect two soil samples from the West Dock Area, following completion of the first and second injections, respectively. Numerous soil samples were collected in the West Dock Area in August 1995 during the Subsurface Investigation, the results of which are documented in the Subsurface Investigation Report. A cross section of the concentration of TCE in the soil in the West Dock Area, based on the 1995 soil data, is included on Figure 4. Two areas in the soil that contained high concentrations of TCE were targeted and sampled during the 2003 soil sampling event (GP-1 and GP-2). These same locations were targeted and sampled during the March 2004 and August 2004 sampling events. The locations of the two borings, GP-1 and GP-2, and the depths from which the soil samples were collected in each boring, are shown on Figure 3 and Figure 4, respectively.

Groundwater Analysis

The groundwater samples collected during the March and August 2004 sampling rounds were submitted to TriMatrix Laboratories, Inc., and laboratory-analyzed for volatile organic compounds (VOCs), VFAs, and chloride. The laboratory reports are included in Attachment A. In addition, the water level, pH, specific conductivity, temperature, oxidation-reduction potential, and dissolved oxygen concentration of the groundwater samples were measured in the field during each sampling round. The results of the VOC and chloride analyses are summarized in Table 1, and the results of the field parameter and VFA analyses are summarized in Table 2.

Recycling Dock Area

In general, the concentrations of TCE and TCA have been decreasing in the Recycling Dock Area since the lactate injections were initiated. The effects of the lactate injection system can be seen most dramatically in the concentration of TCA in the wells adjacent to, and directly downgradient from, the injection locations (MW-8 and MW-23). In MW-8, the concentration of TCA has shown a general decreasing trend since the startup of the lactate injection system (110 to 66 µg/L), while the concentration of its breakdown products, 1,1-dichloroethane (DCA) and chloroethane, have shown general increasing trends from 160 to 550 µg/L and from 2.3 to 1,000 µg/L, respectively. Downgradient, in MW-23, the concentration of DCA has decreased from 47,000 µg/L to 690 µg/L since the startup of the lactate injection system, while the concentration of its breakdown product, chloroethane, has increased from less than 420 µg/L to as high as 17,000 µg/L. During the most recent (August 2004) monitoring event, the concentration of chloroethane decreased to 7,900 µg/L. The decrease in the concentration of TCA in MW-8 and the decrease in the concentration of DCA in MW-23, marked by the general increase in the concentration of their respective breakdown products within each well, indicate that anaerobic biodegradation of the chlorinated solvents is occurring at an accelerated rate in the groundwater in the Recycling Dock Area.

The presence of residual VFAs in monitoring wells provides further support that conditions are supportive of anaerobic biodegradation in the Recycling Dock Area. As mentioned previously, VFAs are generated when lactate is biologically degraded. Hydrogen is also generated when lactate and subsequent VFAs are degraded. The hydrogen is believed to serve as the electron donor in reductive dechlorination. Acetic acid was detected in MW-8, MW-8D, and MW-23, at concentrations ranging from 15 to 450 mg/L. In addition, propionic acid was detected in MW-8, MW-8D, and MW-23 at concentrations ranging from 1.1 to 68 mg/L. In general, the highest concentrations of the VFAs were detected in upgradient wells MW-8D and MW-23, which are closer to the injection location. The residual VFAs that remain in the groundwater in the source area suggest that the lactate concentration and the frequency of injections are appropriate in the Recycling Dock Area.

Other geochemical parameters also suggest that conditions are supportive of reductive dechlorination in the Recycling Dock Area. The concentrations of dissolved oxygen are generally below 0.5 mg/L,

and the oxidation reduction potential is consistently below 50 mV (Table 2). Both of these conditions support reductive dechlorination as described in WDNR Publication PUB-RR-5184, *Quick Reference Guide to Natural Degradation of Chlorinated Solvents*. In addition, the high chloride concentrations in MW-8 and MW-23 indicate that reductive dechlorination is occurring at a high rate, because chlorine atoms are removed from the chlorinated organics by the microorganisms during reductive dechlorination, and this process contributes directly to the high concentration chlorine in the groundwater.

West Dock Area

A significant concentration of TCE was detected in the vadose zone in the West Dock Area during the site investigations. The gravity infiltration trenches in the West Dock Area were designed to flush the TCE from the vadose zone and to anaerobically degrade the TCE in the groundwater. Monitoring well MW-25 is within the source area of the TCE in the West Dock Area and is directly below the gravity infiltration trenches; whereas, MW-26 is downgradient from MW-25 and the source area.

During the 2003 monitoring events, the concentrations of TCE; cis-1,2-DCE; and vinyl chloride in source area well MW-25 increased from 260 µg/L to 8,500 µg/L, from 110 to 1,100 µg/L, and from 24 to 170 µg/L, respectively; whereas, in downgradient well MW-26, the concentration of TCE decreased from 950 mg/L to 140 µg/L, while the concentrations of cis-1,2-DCE and vinyl chloride increased from 2,400 to 6,500 µg/L and from 290 to 4,500 µg/L, respectively. For illustration purposes, the molar concentrations of TCE; cis-1,2-DCE; and vinyl chloride in MW-25 and MW-26 are shown on Figure 5. The pattern in the concentrations of TCE, DCE, and vinyl chloride described above, and shown on Figure 5, indicated that, in 2003, the gravity infiltration of lactate was flushing the high concentrations of TCE from the vadose zone, and that the lactate was enhancing the anaerobic biodegradation of the TCE in the groundwater.

During the 2004 monitoring events, the pattern in the concentration of TCE, DCE, and vinyl chloride was relatively consistent with that described for 2003, when compared with the background concentrations measured before the lactate injections were initiated. However, between the 2003 to 2004 sampling events, there has been a general decreasing trend in the concentration of TCE, DCE, and vinyl chloride in MW-25 and MW-26 (Figure 5). In MW-25, TCE, DCE and vinyl chloride decreased from 8,500 to 2,500 µg/L, from 1,100 to 290 µg/L, and from 170 to 37 µg/L, respectively; while in MW-26, DCE and vinyl chloride decreased from 6,500 to 2,900 µg/L and from 4,500 to 1,900 µg/L, respectively. This recent decreasing concentration trend may indicate that the rate of leaching of the TCE from the vadose zone in the West Dock Area has decreased, and that a stable to decreasing trend can be expected in concentrations in the groundwater as lower quantities of TCE continue to leach from the unsaturated soil and undergo anaerobic biodegradation in the groundwater.

Residual VFAs were not detected in the West Dock Area. Since the concentration pattern of TCE and its breakdown products suggests that reductive dechlorination of TCE is occurring as a result of the lactate injections, it can be assumed that the lactate is being biodegraded in the West Dock Area. The absence of VFAs from the 2004 monitoring event suggests that the concentration of lactate in the West Dock Area will need to be further increased for future injections in order to maintain a supply of electron donor for reductive dechlorination.

As in the Recycling Dock Area, other geochemical parameters suggest that conditions are supportive of reductive dechlorination in the West Dock Area. The concentrations of dissolved oxygen are generally below 1.0 mg/L and the oxidation reduction potential is consistently below 50 mV (Table 2). Both of these conditions support reductive dechlorination as described in WDNR Publication PUB-RR-5184, *Quick Reference Guide to Natural Degradation of Chlorinated Solvents*. In addition, the high chloride concentrations in MW-25 and MW-26 indicate that reductive dechlorination is occurring at a high rate, because chlorine atoms are removed from the chlorinated organics by the microorganisms during reductive dechlorination and this process contributes directly to the high concentration of chlorine in the groundwater.

Soil Analysis

West Dock Area

The soil samples collected in March and August of 2004 were submitted to EnChem, Inc., and laboratory-analyzed for VOCs. The laboratory reports are included in Attachment B, and the results are summarized in Table 3. As mentioned previously, the borings drilled in March and August of 2004 (GP-1 and GP-2) targeted the depth and location of two areas in the soil that had high concentrations of TCE according to data collected in 1995. As illustrated on Figures 3 and 4, the samples collected from GP-1 were in proximity to the sample collected in 1995 from SB7WD, and the samples collected from GP-2 were in proximity to the sample collected in 1995 from SB1WD. The results of the VOC analysis on the soil samples collected from SB1WD and SB7WD are also summarized in Table 3 for comparison purposes.

The concentration of TCE in the soil samples collected 6 feet below grade from borings GP-1 has decreased consistently since the startup the lactate injections. The concentration of TCE in the soil sample collected from SB7WD in 1995 was 8,100 µg/kg; whereas, the concentrations decreased to 720 and 340 µg/kg in the March and August 2004 sampling events, respectively. The concentration of TCE in the soil samples collected 11 feet below grade from boring GP-2 has decreased since 1995, but has shown a slight increasing trend in the 2004 monitoring events. The concentration of TCE in the soil sample collected from SB7WD in 1995 was 110,000 µg/kg; whereas, the concentrations were 21,000 and 31,000 µg/kg in the March and August 2004 sampling events, respectively. The increase between the March and August 2004 sampling events may be a result of TCE being leached from the shallower unsaturated soil, or may be due to heterogeneities in the soil causing different concentrations at

slightly different locations. In general, the concentrations are on the same order of magnitude and show an order of magnitude decrease in soil concentrations since 1995. The results of the soil analysis support the conclusion made in the analysis of the groundwater results, that the lactate injections through gravity infiltration are flushing the TCE from the vadose zone, and are performing as anticipated.

Conclusions and Recommendations

The results of the groundwater monitoring and soil sampling indicate that the lactate injection systems at Tecumseh are performing as expected in both the Recycling Dock and the West Dock Areas. In general, the concentrations of TCA and DCA have decreased in the Recycling Dock area, while the concentrations of their breakdown products have increased. In addition, residual VFAs degraded from the lactate are also present in this area. These patterns suggest that reductive dechlorination is occurring in the Recycling Dock Area, and that conditions supportive of reductive dechlorination remain between injections.

In the West Dock Area, the concentration of TCE has increased in the source area. Downgradient, the concentration of TCE has decreased, and the concentrations of its breakdown products have increased and subsequently decreased, since the startup of the lactate injection system. A recent decreasing trend in the concentrations of TCE, DCE, and vinyl chloride in the groundwater may suggest that the rate of leaching of the TCE from the vadose zone has decreased, and that stable to decreasing trends in the concentrations of TCE, DCE, and vinyl chloride can be expected as lower quantities of TCE continue to leach from the unsaturated soil and undergo anaerobic biodegradation in the groundwater. The concentrations of TCE in the soil also suggest the TCE is being leached from the vadose zone. The pattern in the concentrations of TCE in the groundwater and soil in the West Dock Area suggest that the lactate infiltration trenches are flushing the TCE from the vadose zone and that the TCE is undergoing anaerobic biological degradation in the groundwater. No residual VFAs were detected in the West Dock Area following the injections.

The nondetectable concentrations of VFAs in the West Dock Area suggest that modifications should be made to the lactate solution in this area. In general, a more concentrated solution of lactate is needed in the West Dock Area in order to maintain a supply of electron donor for reductive dechlorination and to optimize performance of the system.

The elevated concentration of vinyl chloride in MW-26 in the West Dock Area has shown a decreasing trend since November 2003 and is expected to continue to decrease as reductive dechlorination continues at the site. The addition of a more concentrated solution of lactate in the West Dock Area should provide the additional electron donor and nutrients necessary to accelerate the biological degradation of vinyl chloride. In addition, it is likely that vinyl chloride will degrade aerobically, once it is downgradient of the reducing area. Monitoring wells MW-9 and MW-9D will be closely

monitored (results to be obtained from Moraine Environmental, Inc's. semiannual groundwater monitoring of the site) to ensure that vinyl chloride does not migrate from the site.

RMT recommends that the lactate injections continue at Tecumseh; however, RMT recommends that the modifications described above be made to the lactate solution in the West Dock Area. The number and frequency of the injections, and the total amount of lactate injected should be similar to the number, frequency, and volume used in 2004. RMT recommends that two rounds of injections be performed in 2005. The first injection will be initiated by February 2005, and the second injection should be initiated by October 2005. For the upcoming sequence of injections, RMT will collect groundwater samples from the Recycling Dock and the West Dock Areas in August 2005 and February 2006, and two soil samples with a Geoprobe® from the West Dock Area in August 2005. A letter report documenting the site activities and the results of the groundwater and soil monitoring will be submitted to the WDNR in the spring of 2006.

Please feel free to contact Stacey Koch, at 608-662-5405, or Alyssa Sellwood, at 608-662-5480, if you have any questions.

Sincerely,

RMT, Inc.

Alyssa Sellwood
Staff Engineer

Stacey Koch

Stacey A. Koch, P.E.
Project Manager

Attachments: Tables
Figures
Attachment 1 - Groundwater Laboratory Reports
Attachment 2 - Soil Laboratory Reports

cc: Victor Menting - Tecumseh Power Company
Kerry DeKeyser - Tecumseh Power Company
Henry Handzel - DeWitt, Ross, and Stevens