State of Wisconsin
Department of Natural Resources
PO Box 7921, Madison WI 53707-7921
dnr.wi.gov

Technical Assistance, Environmental Liability Clarification or Post-Closure Modification Request

Form 4400-237 (R 12/18)

Notice: Use this form to request **a written response (on agency letterhead)** from the Department of Natural Resources (DNR) regarding technical assistance, a post-closure change to a site, a specialized agreement or liability clarification for Property with known or suspected environmental contamination. A fee will be required as is authorized by s. 292.55, Wis. Stats., and NR 749, Wis. Adm. Code., unless noted in the instructions below. Personal information collected will be used for administrative purposes and may be provided to requesters to the extent required by Wisconsin's Open Records law [ss. 19.31 - 19.39, Wis. Stats.].

Definitions

"Property" refers to the subject Property that is perceived to have been or has been impacted by the discharge of hazardous substances.

"Liability Clarification" refers to a written determination by the Department provided in response to a request made on this form. The response clarifies whether a person is or may become liable for the environmental contamination of a Property, as provided in s. 292.55, Wis. Stats.

"Technical Assistance" refers to the Department's assistance or comments on the planning and implementation of an environmental investigation or environmental cleanup on a Property in response to a request made on this form as provided in s. 292.55, Wis. Stats.

"Post-closure modification" refers to changes to Property boundaries and/or continuing obligations for Properties or sites that received closure letters for which continuing obligations have been applied or where contamination remains. Many, but not all, of these sites are included on the GIS Registry layer of RR Sites Map to provide public notice of residual contamination and continuing obligations.

Select the Correct Form

This from should be used to request the following from the DNR:

- Technical Assistance
- Liability Clarification
- Post-Closure Modifications
- Specialized Agreements (tax cancellation, negotiated agreements, etc.)

Do <u>not</u> use this form if one of the following applies:

- Request for an **off-site liability exemption or clarification** for Property that has been or is perceived to be contaminated by one or more hazardous substances that originated on another Property containing the source of the contamination. Use DNR's Off-Site Liability Exemption and Liability Clarification Application Form 4400-201.
- Submittal of an Environmental Assessment for the **Lender Liability Exemption**, s 292.21, Wis. Stats., **if no response or review by DNR is requested**. Use the Lender Liability Exemption Environmental Assessment Tracking Form 4400-196.
- Request for an **exemption to develop on a historic fill site** or licensed landfill. Use DNR's Form 4400-226 or 4400-226A.
- **Request for closure** for Property where the investigation and cleanup actions are completed. Use DNR's Case Closure - GIS Registry Form 4400-202.

All forms, publications and additional information are available on the internet at: dnr.wi.gov/topic/Brownfields/Pubs.html.

Instructions

1. Complete sections 1, 2, 6 and 7 for all requests. Be sure to provide adequate and complete information.
2. Select the type of assistance requested: Section 3 for technical assistance or post-closure modifications, Section 4 for a written determination or clarification of environmental liabilities; or Section 5 for a specialized agreement.
3. Include the fee payment that is listed in Section 3, 4, or 5, unless you are a "Voluntary Party" enrolled in the Voluntary Party Liability Exemption Program **and** the questions in Section 2 direct otherwise. Information on to whom and where to send the fee is found in Section 8 of this form.
4. Send the completed request, supporting materials and the fee to the appropriate DNR regional office where the Property is located. See the map on the last page of this form. A paper copy of the signed form and all reports and supporting materials shall be sent with an electronic copy of the form and supporting materials on a compact disk. For electronic document submittal requirements see: http://dnr.wi.gov/files/PDF/pubs/rr/RR690.pdf"

The time required for DNR's determination varies depending on the complexity of the site, and the clarity and completeness of the request and supporting documentation.

Section 1. Contact and Recipient Information

Requester Information

This is the person requesting technical assistance or a post-closure modification review, that his or her liability be clarified or a specialized agreement and is identified as the requester in Section 7. DNR will address its response letter to this person.

Last Name	First	MI	Organization/ Business Name
Schreiner	Evan		Wauleco, Inc.

Mailing Address	City	State	ZIP Code
1800 North Point Drive	Stevens Point	WI	54481

Phone # (include area code)	Fax # (include area code)	Email
(715) 346-8530	(715) 346-7842	Evan.Schreiner@Sentry.com

The requester listed above: (select all that apply)

- ☒ Is currently the owner
- ☐ Is considering selling the Property
- ☐ Is renting or leasing the Property
- ☐ Is considering acquiring the Property
- ☐ Is a lender with a mortgagee interest in the Property
- ☐ Other. Explain the status of the Property with respect to the applicant:

Contact Information (to be contacted with questions about this request) ☒ Select if same as requester

Contact Last Name	First	MI	Organization/ Business Name
Schreiner	Evan		Wauleco, Inc.

Mailing Address	City	State	ZIP Code
1800 North Point Drive	Stevens Point	WI	54481

Phone # (include area code)	Fax # (include area code)	Email
(715) 346-8530	(715) 346-7842	Evan.Schreiner@Sentry.com

Environmental Consultant (if applicable)

Contact Last Name	First	MI	Organization/ Business Name
Iverson	Bruce	A	TRC

Mailing Address	City	State	ZIP Code
708 Heartland Trail, Suite 3000	Madison	WI	53717

Phone # (include area code)	Fax # (include area code)	Email
(608) 826-3644	(608) 826-3941	biverson@trccompanies.com

Section 2. Property Information

Property Name	FID No. (if known)
Wauleco, Inc.	737079310

BRRTS No. (if known)	Parcel Identification Number
02-37-000006	291-2907-354-0972

Street Address	City	State	ZIP Code
125 Rosecrans Street	Wausau	WI	54402

County	Municipality where the Property is located	Property is composed of:	Property Size Acres
Marathon	◉ City ○ Town ○ Village of Wausau	◉ Single tax parcel ○ Multiple tax parcels	8

1. Is a response needed by a specific date? (e.g., Property closing date) Note: Most requests are completed within 60 days. Please plan accordingly.

◉ No ○ Yes

Date requested by: _____

Reason:

_____

2. Is the "Requester" enrolled as a Voluntary Party in the Voluntary Party Liability Exemption (VPLE) program?

◉ No. **Include the fee that is required for your request in Section 3, 4 or 5.**

○ Yes. **Do not include a separate fee.** This request will be billed separately through the VPLE Program.

Fill out the information in Section 3, 4 or 5 which corresponds with the type of request:
Section 3. Technical Assistance or Post-Closure Modifications;
Section 4. Liability Clarification; or Section 5. Specialized Agreement.

Section 3. Request for Technical Assistance or Post-Closure Modification

Select the type of technical assistance requested: [**Numbers in brackets are for WI DNR Use**]

☐ No Further Action Letter (NFA) (Immediate Actions) - NR 708.09, [183] - **Include a fee of $350.** Use for a written response to an immediate action after a discharge of a hazardous substance occurs. Generally, these are for a one-time spill event.

☐ Review of Site Investigation Work Plan - NR 716.09, [135] - **Include a fee of $700.**

☐ Review of Site Investigation Report - NR 716.15, [137] - **Include a fee of $1050.**

☐ Approval of a Site-Specific Soil Cleanup Standard - NR 720.10 or 12, [67] - **Include a fee of $1050.**

☐ Review of a Remedial Action Options Report - NR 722.13, [143] - **Include a fee of $1050.**

☐ Review of a Remedial Action Design Report - NR 724.09, [148] - **Include a fee of $1050.**

☐ Review of a Remedial Action Documentation Report - NR 724.15, [152] - **Include a fee of $350**

☐ Review of a Long-term Monitoring Plan - NR 724.17, [25] - **Include a fee of $425.**

☐ Review of an Operation and Maintenance Plan - NR 724.13, [192] - **Include a fee of $425.**

Other Technical Assistance - s. 292.55, Wis. Stats. [97] (For request to build on an abandoned landfill use Form 4400-226)

☐ Schedule a Technical Assistance Meeting - **Include a fee of $700.**

☐ Hazardous Waste Determination - **Include a fee of $700.**

☒ Other Technical Assistance - **Include a fee of $700.** Explain your request in an attachment.

Post-Closure Modifications - NR 727, [181]

☐ Post-Closure Modifications: Modification to Property boundaries and/or continuing obligations of a closed site or Property; sites may be on the GIS Registry. This also includes removal of a site or Property from the GIS Registry. **Include a fee of $1050, and:**

☐ Include a fee of $300 for sites with residual soil contamination; and

☐ Include a fee of $350 for sites with residual groundwater contamination, monitoring wells or for vapor intrusion continuing obligations.

Attach a description of the changes you are proposing, and documentation as to why the changes are needed (if the change to a Property, site or continuing obligation will result in revised maps, maintenance plans or photographs, those documents may be submitted later in the approval process, on a case-by-case basis).

Skip Sections 4 and 5 if the technical assistance you are requesting is listed above and complete Sections 6 and 7 of this form.

Section 4. Request for Liability Clarification

Select the type of liability clarification requested. Use the available space given or attach information, explanations, or specific questions that you need answered in DNR's reply. Complete Sections 6 and 7 of this form. **[Numbers in brackets are for DNR Use]**

☐ "Lender" liability exemption clarification - s. 292.21, Wis. Stats. [686]

❖ **Include a fee of $700.**

Provide the following documentation:

(1) ownership status of the real Property, and/or the personal Property and fixtures;

(2) an environmental assessment, in accordance with s. 292.21, Wis. Stats.;

(3) the date the environmental assessment was conducted by the lender;

(4) the date of the Property acquisition; for foreclosure actions, include a copy of the signed and dated court order confirming the sheriff's sale.

(5) documentation showing how the Property was acquired and the steps followed under the appropriate state statutes.

(6) a copy of the Property deed with the correct legal description; and,

(7) the Lender Liability Exemption Environmental Assessment Tracking Form (Form 4400-196).

(8) If no sampling was done, please provide reasoning as to why it was **not** conducted. Include this either in the accompanying environmental assessment or as an attachment to this form, and cite language in s. 292.21(1)(c)2.,h.-i., Wis. Stats.:

h. The collection and analysis of representative samples of soil or other materials in the ground that are suspected of being contaminated based on observations made during a visual inspection of the real Property or based on aerial photographs, or other information available to the lender, including stained or discolored soil or other materials in the ground and including soil or materials in the ground in areas with dead or distressed vegetation. The collection and analysis shall identify contaminants in the soil or other materials in the ground and shall quantify concentrations.

i. The collection and analysis of representative samples of unknown wastes or potentially hazardous substances found on the real Property and the determination of concentrations of hazardous waste and hazardous substances found in tanks, drums or other containers or in piles or lagoons on the real Property.

☐ "Representative" liability exemption clarification (e.g. trustees, receivers, etc.) - s. 292.21, Wis. Stats. [686]

❖ **Include a fee of $700.**

Provide the following documentation:

(1) ownership status of the Property;

(2) the date of Property acquisition by the representative;

(3) the means by which the Property was acquired;

(4) documentation that the representative has no beneficial interest in any entity that owns, possesses, or controls the Property;

(5) documentation that the representative has not caused any discharge of a hazardous substance on the Property; and

(6) a copy of the Property deed with the correct legal description.

☐ Clarification of local governmental unit (LGU) liability exemption at sites with: (select all that apply)

☐ hazardous substances spills - s. 292.11(9)(e), Wis. Stats. [649];

☐ Perceived environmental contamination - [649];

☐ hazardous waste - s. 292.24 (2), Wis. Stats. [649]; and/or

☐ solid waste - s. 292.23 (2), Wis. Stats. [649].

❖ **Include a fee of $700, a summary of the environmental liability clarification being requested, and the following:**

(1) clear supporting documentation showing the acquisition method used, and the steps followed under the appropriate state statute(s).

(2) current and proposed ownership status of the Property;

(3) date and means by which the Property was acquired by the LGU, where applicable;

(4) a map and the ¼, ¼ section location of the Property;

(5) summary of current uses of the Property;

(6) intended or potential use(s) of the Property;

(7) descriptions of other investigations that have taken place on the Property; and

(8) (for solid waste clarifications) a summary of the license history of the facility.

Section 4. Request for Liability Clarification (cont.)

☐ Lease liability clarification - s. 292.55, Wis. Stats. [646]

- ❖ **Include a fee of $700 for a single Property, or $1400 for multiple Properties and the information listed below:**

(1) a copy of the proposed lease;

(2) the name of the current owner of the Property and the person who will lease the Property;

(3) a description of the lease holder's association with any persons who have possession, control, or caused a discharge of a hazardous substance on the Property;

(4) map(s) showing the Property location and any suspected or known sources of contamination detected on the Property;

(5) a description of the intended use of the Property by the lease holder, with reference to the maps to indicate which areas will be used. Explain how the use will not interfere with any future investigation or cleanup at the Property; and

(6) all reports or investigations (e.g. Phase I and Phase II Environmental Assessments and/or Site Investigation Reports conducted under s. NR 716, Wis. Adm. Code) that identify areas of the Property where a discharge has occurred.

General or other environmental liability clarification - s. 292.55, Wis. Stats. [682] - Explain your request below.

- ❖ **Include a fee of $700 and an adequate summary of relevant environmental work to date.**

☐ No Action Required (NAR) - NR 716.05, [682]

- ❖ **Include a fee of $700.**

Use where an environmental discharge has or has not occurred, and applicant wants a DNR determination that no further assessment or clean-up work is required. Usually this is requested after a Phase I and Phase II environmental assessment has been conducted; the assessment reports should be submitted with this form. This is not a closure letter.

☐ Clarify the liability associated with a "closed" Property - s. 292.55, Wis. Stats. [682]

- ❖ **Include a fee of $700.**

- Include a copy of any closure documents if a state agency other than DNR approved the closure.

Use this space or attach additional sheets to provide necessary information, explanations or specific questions to be answered by the DNR.

Section 5. Request for a Specialized Agreement

Select the type of agreement needed. Include the appropriate draft agreements and supporting materials. Complete Sections 6 and 7 of this form. More information and model draft agreements are available at: dnr.wi.gov/topic/Brownfields/lgu.html#tabx4.

☐ Tax cancellation agreement - s. 75.105(2)(d), Wis. Stats. [654]

- ❖ **Include a fee of $700, and the information listed below:**

(1) Phase I and II Environmental Site Assessment Reports,

(2) a copy of the Property deed with the correct legal description.

☐ Agreement for assignment of tax foreclosure judgement - s.75.106, Wis. Stats. [666]

- ❖ **Include a fee of $700, and the information listed below:**

(1) Phase I and II Environmental Site Assessment Reports,

(2) a copy of the Property deed with the correct legal description.

☐ Negotiated agreement - Enforceable contract for non-emergency remediation - s. 292.11(7)(d) and (e), Wis. Stats. [630]

- ❖ **Include a fee of $1400, and the information listed below:**

(1) a draft schedule for remediation; and,

(2) the name, mailing address, phone and email for each party to the agreement.

Section 6. Other Information Submitted

Identify all materials that are included with this request.

Send both a paper copy of the signed form and all reports and supporting materials, and an electronic copy of the form and all reports, including Environmental Site Assessment Reports, and supporting materials on a compact disk.

Include one copy of any document from any state agency files that you want the Department to review as part of this request. The person submitting this request is responsible for contacting other state agencies to obtain appropriate reports or information.

- ☐ Phase I Environmental Site Assessment Report - Date: _____
- ☐ Phase II Environmental Site Assessment Report - Date: _____
- ☐ Legal Description of Property (required for all liability requests and specialized agreements)
- ☐ Map of the Property (required for all liability requests and specialized agreements)

Analytical results of the following sampled media: Select all that apply and include date of collection.

☐ Groundwater ☐ Soil ☐ Sediment ☐ Other medium - Describe: _____

Date of Collection: _____

- ☐ A copy of the closure letter and submittal materials
- ☐ Draft tax cancellation agreement
- ☐ Draft agreement for assignment of tax foreclosure judgment
- ☒ Other report(s) or information - Describe: Alternatives Array doc prior to RAOR submitted to Matt Thompson 5-31-19

For Property with newly identified discharges of hazardous substances only: Has a notification of a discharge of a hazardous substance been sent to the DNR as required by s. NR 706.05(1)(b), Wis. Adm. Code?

- ◉ Yes - Date (if known): _____
- ○ No

Note: The Notification for Hazardous Substance Discharge (non-emergency) form is available at: dnr.wi.gov/files/PDF/forms/4400/4400-225.pdf.

Section 7. Certification by the Person who completed this form

- ☒ I am the person submitting this request (requester)
- ☐ I prepared this request for: _____

Requester Name

I certify that I am familiar with the information submitted on this request, and that the information on and included with this request is true, accurate and complete to the best of my knowledge. I also certify I have the legal authority and the applicant's permission to make this request.

Eva J Schein — Signature

5/29/19 — Date Signed

Treasurer — Title

(715) 346-8530 — Telephone Number (include area code)

Section 8. DNR Contacts and Addresses for Request Submittals

Send or deliver one paper copy and one electronic copy on a compact disk of the completed request, supporting materials, and fee to the region where the property is located to the address below. Contact a DNR regional brownfields specialist with any questions about this form or a specific situation involving a contaminated property. For electronic document submittal requirements see: http://dnr.wi.gov/files/PDF/pubs/rr/RR690.pdf.

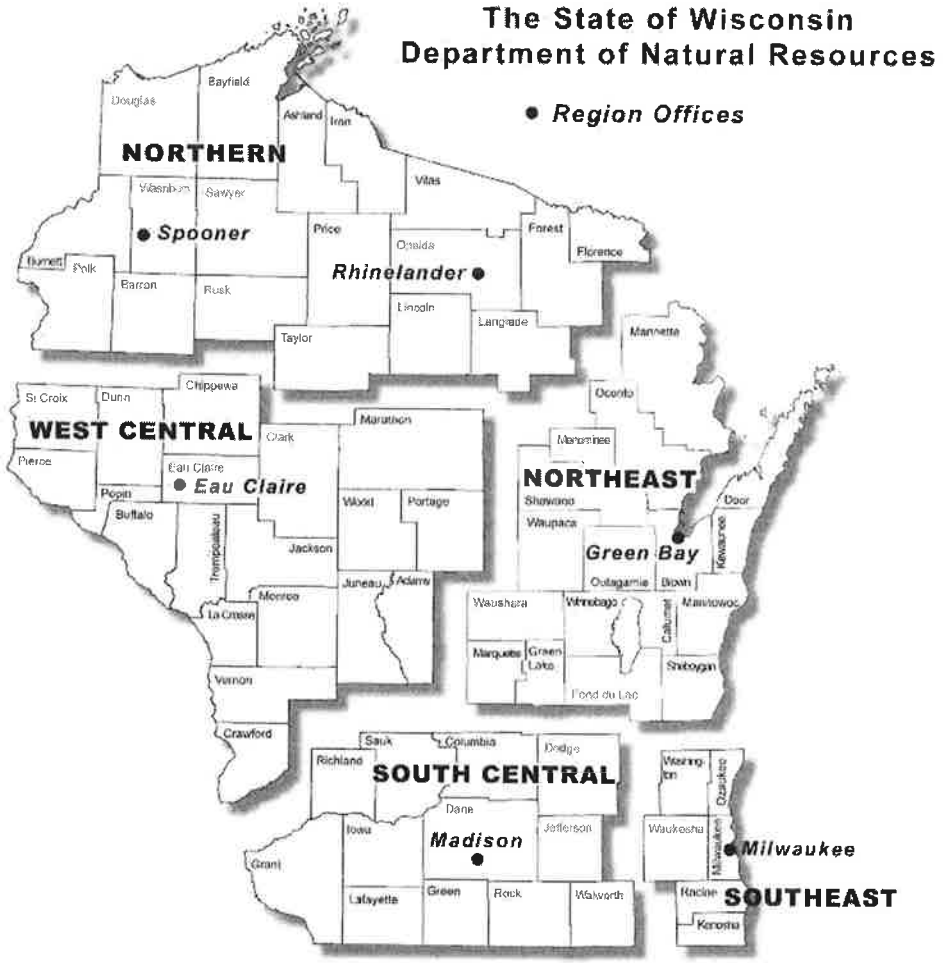
DNR NORTHERN REGION
Attn: RR Program Assistant
Department of Natural Resources
223 E Steinfest Rd Antigo, WI 54409

DNR NORTHEAST REGION
Attn: RR Program Assistant
Department of Natural Resources
2984 Shawano Avenue
Green Bay WI 54313

DNR SOUTH CENTRAL REGION
Attn: RR Program Assistant
Department of Natural Resources
3911 Fish Hatchery Road
Fitchburg WI 53711

DNR SOUTHEAST REGION
Attn: RR Program Assistant
Department of Natural Resources
2300 North Martin Luther King Drive
Milwaukee WI 53212

DNR WEST CENTRAL REGION
Attn: RR Program Assistant
Department of Natural Resources
1300 Clairemont Ave.
Eau Claire WI 54702



Note: These are the Remediation and Redevelopment Program's designated regions. Other DNR program regional boundaries may be different.

DNR Use Only			
Date Received	Date Assigned	BRRTS Activity Code	BRRTS No. (if used)
DNR Reviewer	Comments		
Fee Enclosed? ◯ Yes ◯ No	Fee Amount $	Date Additional Information Requested	Date Requested for DNR Response Letter
Date Approved	Final Determination		

Technical Assistance – Section 3/Other Technical Assistance
Wauleco Project Site
May 31, 2019

Wauleco requests WDNR technical review of the TRC document titled "Technical Memorandum – Development and Screening of Alternatives/List of Alternatives for Revised Groundwater RAOR" dated May 31, 2019, and an indication if there are additional alternatives the WDNR recommends being included in the revised Groundwater RAOR prior to Wauleco performing the detailed and comparative analysis.

P/7129/Focused_RAOR/Alt Array/Technical Assistance Attachment

From: WI DNR <no-reply@wisconsin.gov>
Sent: Monday, June 03, 2019 11:32 AM
To: Sheskey, Teresa
Subject: 0237000006 : Other

Dear Teresa Sheskey,

Your document has been successfully uploaded.

Please do not reply to this email.

Confirmation #: *9579524229*
BRRTS #: *0237000006*
Name: *Teresa Sheskey*
Company/Organization: *TRC Environmental Corporation*
Site Name: *WAULECO SNE CORP*
Fee Amount: *$700.00*

1. Please send your fee and a copy of your confirmation page to:

   DNR Service Center
   Attn: DEENA KINNEY
   1300 W CLAIREMONT AVE
   EAU CLAIRE WI - 54701

2. Please send a paper copy of your submittal to your assigned Project Manager. Please see the DNR Staff Directory to find your project manager's address.

A submittal is not considered complete until the fee (if applicable), paper and electronic copy of the document or report are received, per Wis. Admin. Code § NR 749.04 (1) and § NR 700.11 (3g) respectively.

For more information please see the Guidance for submitting Document to the Remediation and Redevelopment Program(RR-690)

If you have any questions, please contact:

DEENA KINNEY
deena.kinney@wisconsin.gov
715-839-2784

TRC Environmental Corporation
708 Heartland Trail, Suite 3000
Madison, WI 53717

Main 608.826.3600
Fax 608.826.3941

Technical Memorandum

To:	Matt Thompson Wisconsin Department of Natural Resources
From:	Ken Quinn and Bruce Iverson TRC Environmental Corporation
Subject:	Development and Screening of Alternatives/List of Alternatives for Revised Groundwater RAOR – Wauleco Site – BRRTS #02-37-000006
Date:	May 31, 2019
CC:	Evan Schreiner – Wauleco Dave Crass – Michael Best
Project No.:	189597.0008

Executive Summary

Wauleco, Inc. ("Wauleco") and TRC Environmental Corporation ("TRC") have reviewed numerous potential residual phase light nonaqueous-phase liquid (LNAPL) and groundwater remediation technologies and methods for the Wauleco site. Following a screening of potential remedial alternatives, four alternatives are proposed to be included in the detailed and comparative analysis phase of the revised Groundwater Remedial Action Options Report (Groundwater RAOR) to address on-site and off-site groundwater at the Wauleco Project Site, including the following:

1. On-site Pump and Treatment System
2. Chemical Oxidation of Portion of Residual Phase LNAPL
3. Enhanced Bioremediation
4. Permeable Treatment Walls (Property Boundary and Off-Site Walls)

The remedial alternatives identification, screening and development process described in this Technical Memorandum is based on the requirements of Chapter NR 722, Wis. Admin. Code as well as U.S. EPA guidance documents for similar projects. Prior to Wauleco performing the detailed and comparative analysis, Wauleco requests technical review by the WDNR and an indication if there are additional alternatives the WDNR recommends be included in the revised Groundwater RAOR.

1.0 Introduction

On behalf of Wauleco, this Technical Memorandum summarizes the identification and screening of technologies (Section 3), and the development and initial screening of remedial alternatives (Section 4) to be included in the revised Groundwater RAOR for the Wauleco Project Site. These technologies and alternatives are intended to address residual phase LNAPL and dissolved phase groundwater for on-site and off-site groundwater. The remedial alternatives identification, screening and development process described in this Technical Memorandum is based on the requirements of Chapter NR 722, Wis. Admin. Code as well as U.S. EPA guidance documents for similar projects.

Based on this process, the alternatives Wauleco proposes to carry forward to the detailed and comparative analysis phase of the NR 722 process in the revised Groundwater RAOR are listed in Section 5.0.

2.0 Background Information

After meeting with the WDNR Closure Committee in May of 2014 and at WDNR's request, Wauleco submitted an initial Groundwater RAOR dated September 2015 (2015 Groundwater RAOR). WDNR provided comments on the 2015 Groundwater RAOR by letter dated August 31, 2016. Follow-up technical meetings were held among WDNR, Wauleco, and TRC to discuss potential approaches to address groundwater at the Wauleco Project Site. Information discussed at these meetings included the Conceptual Site Model (CSM), with specific discussion regarding the following points:

- The WDNR agreed that mobile phase LNAPL has been addressed to the extent practicable. There is no further expectation that active mobile phase LNAPL recovery efforts continue. The WDNR's focus has moved on to the residual phase LNAPL and dissolved phase components.
- There is evidence of degradation of pentachlorophenol (PCP) in the residual phase LNAPL.
- There is evidence of natural attenuation of dissolved phase PCP in groundwater.
- Data collected during the Lake Wausau drawdown showed that even with widespread groundwater decline, no significant mobile LNAPL occurred. This data revealed that the residual phase LNAPL on and off the Wauleco Site has insufficient saturation to create mobile, recoverable LNAPL. See Attachment A.

Based on these meetings, TRC submitted Technical Memorandum – Development and Screening/List of Alternatives for Revised Groundwater RAOR dated November 15, 2017 (2017 Alternatives Array). WDNR responded to the 2017 Alternatives Array document by letter dated December 4, 2017.

Per NR 722.05 (5), the objective of the identification, evaluation and documentation of an appropriate set of remedial action options is to address each medium and migration exposure pathway. As discussed in Section 3.1, the medium for this Groundwater RAOR is on-site and

off-site groundwater. Based on the requirements of NR 722.05 and 07, the process used for the identification and evaluation of remedial action options is described in the following sections.

3.0 Identification and Screening of Technologies

The objective of the identification and screening of technologies process is to identify a manageable number of applicable LNAPL and groundwater remedial technologies which can then be assembled into groundwater remedial alternatives (see Section 5.0). This process consists of the following tasks:

- Identification of media of concern.
- Identification and screening of remedial technologies for:
  - LNAPL; and,
  - Groundwater
- Evaluation and selection of technologies/process options for:
  - LNAPL; and,
  - Groundwater

The following subsections provide a discussion of each of these tasks.

3.1 Identification of Media of Concern

The scope of the Groundwater RAOR is limited to groundwater. For the purposes of this Groundwater RAOR, the groundwater media includes the presence of residual phase LNAPL and dissolved phase PCP.

3.2 Identification and Screening of Remedial Technologies

The purpose of this task is to identify and screen a broad range of remedial technologies and process options applicable to each general response action and to eliminate those that cannot be implemented technically at the Wauleco Project Site. Remedial technologies are general categories of technologies. Process options are specific technologies or processes within each technology type. The identification and screening of remedial technologies was performed in consideration of:

- LNAPL; and
- Groundwater

3.2.1 LNAPL Identification and Screening of Remedial Technologies

The Interstate Technology Regulatory Council (ITRC) Technical/Regulatory Guidance document titled "Light Non-Aqueous Phase Liquid (LNAPL) Site Management: LCSM Evolution, Decision Process and Remedial Technologies," dated March 2018 (LNAPL Guidance) was considered for the identification of LNAPL remedial technologies. The LNAPL Guidance "provides a systematic framework to: develop a comprehensive LCSM…, establish appropriate LNAPL remedial goals…, select remedial technologies that will best achieve the LNAPL

remedial goals…." This process, as applied to the Wauleco site, is summarized in the document included in Attachment B.

3.2.2 Groundwater Identification and Screening of Remedial Technologies

Groundwater remedial technologies and process options are screened at this point based on their technical implementability. Remedial technologies and process options that are applicable are carried forward for further evaluation. Those not technically implementable are eliminated. This process is shown schematically on Table 1. As shown on Table 1, several remedial technologies were identified for each general response action and numerous process options were identified within each technology type. Table 1 also provides a description of each process option and includes the reason for carrying forward or screening out individual process options for groundwater.

3.3 Evaluation and Selection of Technologies/Process Options

Based on the technologies that were carried forward from Section 3.2, an evaluation and selection of remedial technologies was performed in consideration of:

- LNAPL; and,
- Groundwater

3.3.1 LNAPL Evaluation and Selection of Technologies/Process Options

The LNAPL Guidance was followed, in general, to evaluate and select LNAPL remedial technologies. The LNAPL Guidance contains 13 potentially applicable technologies. Three of these technologies combined what historically had been separate technologies (e.g., combining surfactant-enhanced subsurface remediation with water flooding and cosolvent flushing under enhanced LNAPL recovery). We separated these variations in technologies, for a total of 21 potentially applicable technologies that were considered in this process. This process is summarized in the document included in Attachment B.

The LNAPL Guidance[1] was discussed with WDNR during a June 13, 2017 meeting. Based on this discussion, the parties agreed that the following LNAPL remedial technologies warranted further consideration for the Wauleco Site:

- **In Situ Chemical Oxidation (ISCO)** – This technology is included in Alternative 2 discussed below in Section 4.0.
- **Surfactant Enhanced Subsurface Remediation (SESR)** – This technology is included in Alternative 7 discussed below in Section 4.0.
- **Enhanced Anaerobic Degradation** – This technology is included in Alternative 4 discussed below in Section 4.0.
- **Natural Source Zone Depletion (NSZD)** – This technology is included in Alternative 3 discussed below in Section 4.0.

[1] The parties discussed a draft of the 2018 LNAPL Guidance. No additional technologies were added to the final guidance.

3.3.2 Groundwater Evaluation and Selection of Technologies/Process Options

After the broad screening of groundwater technologies based solely on technical implementability was performed as described in Section 3.2.2, the remedial technologies considered to be technically implementable were analyzed in greater detail to select the process options that could represent each technology type. The purpose of this task is to select a limited number of promising process options for consideration in developing groundwater alternatives. Process options are evaluated considering:

- Effectiveness
- Implementability
- Cost

Effectiveness is the primary criterion used to screen process options at this point in the process. Effectiveness focuses on:

- The potential effectiveness of the process options in handling the estimated areas and volumes of the media of concern.
- The ability of the process options to meet the remediation goals identified in the remedial action objectives.
- The potential impacts to human health and the environment during the remedial action.
- The reliability of the process options with respect to the contaminants of concern and the site conditions.

Effectiveness is evaluated considering the relative effectiveness of a process option compared to the other process options in the same technology type. For example, the ability of the process option to meet the remedial action objective and the ability of the process option to adequately accommodate the relevant waste type and quantities compared to the other process options is critical for a process option to be retained.

Implementability focuses on the technical feasibility and availability of the technologies each process option would employ and the administrative feasibility of implementing the process option. Technical implementability considers a range of factors relevant to obtaining, installing and using a particular technology. Some remedial technologies are proven and readily available, while others are in the research and development stages. Insufficiently developed technologies are generally screened out. Site conditions must be compatible with the feasible range of a given technology's capabilities, considering for example, depth to bedrock, depth to groundwater, space requirements, ability of the technology to treat contaminants identified, etc. Administrative implementability considers a range of factors relevant to the testing; review; approval; availability of services, workers, and equipment; or permitting of a particular technology. Because technologies were screened based on their technical implementability in Section 3.2.2, this subsequent, more detailed evaluation of process options, places greater emphasis on the administrative aspects of implementability.

Cost is evaluated relative to construction (capital) costs and any long-term (operation and maintenance) costs required to operate and maintain the process option. Cost plays a limited role in the screening of process options at this stage. However, groundwater technologies that are grossly expensive but also equally or only marginally more effective than much lower cost technologies are eliminated from further consideration.

The process options are evaluated at this point based on their relative effectiveness, implementability and cost. This evaluation is documented on Table 2. Table 2 includes the evaluation of each process option carried forward from Table 1 for the above three criteria.

4.0 Development and Initial Screening of Alternatives

Based on LNAPL and groundwater technologies that were carried forward from the initial screening phase as discussed above in Section 3.0, remaining technologies were considered to assemble into alternatives.

This section discusses the development and screening of groundwater alternatives. The objective of developing alternatives is to assemble groundwater alternatives from the remaining remedial technologies carried through the initial screening. The groundwater alternatives assembled should protect human health and the environment and encompass a range of potentially appropriate remedial options.

The objective of subsequent alternative screening is to narrow the list of potential groundwater alternatives that will be evaluated in the detailed and comparative analysis phases of NR 722.07(3). This subsequent screening aids in streamlining the Groundwater RAOR process while retaining the most promising groundwater alternatives for more detailed consideration.

Following is a summary of the eight groundwater alternatives developed and an overview description of each alternative:

1. **Alternative 1: On-site Pump and Treatment System; Description** – This alternative involves continuing to operate the current pump and treatment system to provide a level of containment of groundwater from the Wauleco property (i.e., the majority of the mass of PCP in the plume) and reduce the groundwater flux downgradient of the site.
2. **Alternative 2: Chemical Oxidation of Portion of Residual Phase LNAPL; Description** – This alternative involves the removal of additional residual phase LNAPL off-site via chemical oxidation (chemox) to provide additional distance for natural attenuation (NA) to reduce contaminant concentrations at the eastern extent of residual phase LNAPL. Operation of the current pump and treatment system may be adjusted after the implementation of the chemox dependent upon the success of the alternative.
3. **Alternative 3: Natural Source Zone Depletion (NSZD) and Natural Attenuation (NA); Description** – This alternative is a combination of natural source zone depletion (NSZD) of the residual phase LNAPL and natural attenuation of dissolved constituents in

groundwater[2]. This NSZD and natural attenuation remedy would be implemented as a pilot study whereby groundwater quality would be assessed under non-pumping conditions. This assessment would include evaluations of the effectiveness of NSZD for the residual phase LNAPL and natural attenuation for the dissolved phase. While the pilot study is being implemented, the existing pump and treatment system would be maintained and periodically exercised, so that it can be restarted, if warranted.

4. **Alternative 4: Enhanced Bioremediation; Description** – This alternative involves the enhancement of the existing bioremediation of PCP through injection of amendments into the groundwater on the Wauleco property and at select off-site locations. This would consist of additional electron acceptors (e.g., nitrate-N) and nutrients (e.g., phosphorous). This may be accomplished through a combination of new injection wells, additional off-site extraction wells, and use of City water to deliver the amendments. The operation of the current on-site pump and treatment system may be adjusted depending on the success of this alternative.

5. **Alternative 5: Permeable Treatment Walls (Property Boundary and Off-Site Walls); Description** – This alternative involves implementation of treatment walls (biological or chemical) at the eastern portion of the Wauleco property boundary and off-site at the eastern extent of the dissolved phase. Groundwater that flows through the walls would be treated. The operation of the current on-site pump and treatment system may be adjusted after the walls are complete and depending on the success of this alternative.

6. **Alternative 6: Off-site Pump and Treatment System; Description** – This alternative involves removing residual phase LNAPL near the eastern extent of the dissolved phase via a groundwater pump and treatment system, to reduce the volume of the off-site residual phase LNAPL. The purpose of the off-site pump and treatment system would be to attempt to convert residual phase LNAPL to mobile phase LNAPL so it could be removed/recovered and to extract dissolved phase PCP from groundwater. The new groundwater extraction wells and conveyance piping/utilities would either be located within the City right-of-way or on private property (via access agreements). A new groundwater treatment system, in addition to the current groundwater treatment system, would likely be required to treat the additional quantity of extracted groundwater. Treated groundwater would either be discharged to the City's POTW system or discharged to the surface water via a WPDES Permit.

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[2] NSZD is distinctly different than natural attenuation. The USEPA defines natural attenuation (USEPA, 1999[2]) as "a variety of physical, chemical, or biological processes that, under favorable conditions, act without human intervention to reduce the mass, toxicity, mobility, volume, or concentration of contaminants in soil or groundwater." ITRC (2009[2]) defines NSZD as: "a combination of processes that reduce the mass of LNAPL in the subsurface." Natural attenuation depletes contaminants in soil or groundwater, whereas, NSZD reduces the mass of LNAPL. Therefore, NSZD is a source reduction process whereas natural attenuation is a migration control process. The combination of NSZD and natural attenuation can be effective in treating both the source and in migration pathways.

7. **Alternative 7: Off-site Horizontal Wells and Surfactant Flushing; Description** – This alternative involves removing off-site residual phase LNAPL by surfactant flushing between horizontal wells, to reduce the volume of residual phase LNAPL. Horizontal wells would be installed either in the City's right-of-way or under private property (via access agreements). A surfactant would be introduced to mobilize the residual phase LNAPL, which is currently immobile and present in an approximate 1 ft. thick zone at or above the water table. Additional horizontal wells would be pumped in an attempt to capture the mobilized emulsion of LNAPL/water/surfactant. A new groundwater treatment system would be needed to treat the complex emulsified mixture. Treated groundwater would either be discharged to the City's POTW system or discharged to the surface water via a WPDES Permit. Recovered LNAPL would be disposed at a licensed facility and the recovered surfactant recycled to the system.

8. **Alternative 8**: **Pressure Pulse Technology (PPT); Description** – This alternative is an advanced LNAPL recovery approach developed by the oil industry. The purpose of the PPT would be to enhance LNAPL source control/recovery by converting residual phase LNAPL to mobile phase LNAPL, where the mobile phase LNAPL could then be recovered by the existing groundwater pump and treatment system. This is accomplished by:

   — The PPT delivers its energy to deform the soil structure and overcome the surface tensions by injecting water under pressure into the zone of residual phase. A water flood on its own is a common practice in the oil and environmental remediation industries and has been successful in some cases in increasing LNAPL recovery.

   — The PPT method goes a step further and increases the force of the water flood by pulsing the water into the subsurface. The frequency and magnitude of pulsing have been shown to magnify the effect of the force of the water flood. In effect, the waves of water pressure become additive, so that the forces of multiple waves are added together. This has the effect of magnifying the temporary deformation of the soil structure and forcing globules of LNAPL together.

   The PPT would involve the installation of injection wells, potentially reinjecting treated effluent from the on-site pump and treatment system as the source of the water, while continuing to operate the on-site pump and treatment system.

An initial screening of these eight alternatives was performed based on the following criteria:

1. **Effectiveness:** In consideration of the following:
   a. Effectiveness in protecting human health and the environment; considering both:
      i. Short-term effectiveness: Construction and implementation periods.
      ii. Long-term effectiveness: Period after the remedial action is complete
   b. Effectiveness in the reduction of toxicity, mobility or volume that alternative will achieve

2. **Implementability:** In consideration of the following:
    a. ***Technical Feasibility:*** The ability to construct, reliably operate and meet technology-specific regulations for process options until a remedial action is complete. Also includes operation, maintenance, replacement and monitoring of technical components of the alternative.
    b. ***Administrative Feasibility:*** Ability to obtain approvals from other offices and agencies, the availability of treatment, storage and disposal services and capacity and the requirements for, and availability of, specific equipment and technical specialists.
3. **Cost:** In consideration of a relative cost comparison.

This initial screening process is documented in Table 3. Table 4 illustrates the symbolic ratings of each alternative. Based on this initial screening process, Alternatives 3 (Natural Source Zone Depletion (NSZD) and Natural Attenuation (NA), 6 (Off-Site Pump and Treatment System), 7 (Off-Site Horizontal Wells and Surfactant Flushing), and 8 (Pressure Pulse Technology) will not be carried forward in the revised Groundwater RAOR to the detailed analysis and comparative analysis phase. As described in Table 3, the main reasons Alternatives 3, 6, 7, and 8 were screened out and not carried forward are summarized as follows:

- **Alternative 3: Natural Source Zone Depletion (NSZD) and Natural Attenuation (NA)** – Objective of this alternative is a combination process to reduce the mass of LNAPL (i.e., NSZD), and natural attenuation of dissolved constituents to reduce their concentration in groundwater (i.e., NA).
    - ***Effectiveness*** – Based on on-going monitoring data for the Wauleco Site, the data supports that this alternative would be effective, as the data provides evidence that NSZD and NA are both occurring. This is consistent with the LNAPL Guidance that states "NSZD processes therefore play an important role in risk mitigation and the long-term stability of LNAPL bodies." (LNAPL Guidance Section 3.2.3).
    - ***Implementability and Cost*** – The process outlined in the LNAPL Guidance demonstrates that NSZD is cost effective, and an implementable technology at Wauleco. However, WDNR has recommended that Wauleco not include this technology in the Groundwater ROAR, at this time.
    - ***Cost*** – This alternative would be cost effective compared to other alternatives.
- **Alternative 6: Off-Site Pump and Treatment System** – Objective of this alternative is to reduce the volume of residual phase LNAPL off-site by reducing the groundwater elevation, converting residual phase to mobile phase LNAPL and collecting the mobile phase LNAPL.
    - ***Effectiveness*** – This alternative would not be effective, based on the Lake Wausau drawdown that has demonstrated that there is insufficient volume of residual phase LNAPL for collection via this method. See Attachment A.
    - ***Implementability and Cost*** – Difficult and costly due to the off-site conditions, but the primary reason for rejection is described in Effectiveness.

- **Alternative 7: Off-site Horizontal Wells and Surfactant Flushing** – Objective of this alternative is to reduce the volume of residual phase LNAPL off-site.
  - ***Effectiveness*** – Surfactant flushing of a thin zone of residual phase LNAPL at and possibly above the water table between horizontal wells is difficult to accomplish due to flow of the surfactant flush to occur primarily below the water table, with the majority of the surfactant not flowing through the lower permeability zone containing the LNAPL. (Note: The zone containing the residual phase LNAPL is lower permeability because of the partial saturation of this zone with two immiscible fluids—LNAPL and water). The LNAPL guidance reports that surfactant flushing "success rate is higher for very small areas. As the treatment area increases in size, the chance for success decreases." (LNAPL guidance, Table A-7.B.) The Wauleco residual phase LNAPL area is such that the chance for success is not high.
  - ***Implementability*** – Requires closely spaced injection and extraction points (i.e., 50 ft. or less), so it is impractical for off-Site implementation. Use of horizontal wells may reduce disruptions at the surface, but they still require access agreements from the City or private property owners prior to installing horizontal well(s). Access to private property in this setting would likely be difficult to secure. The presence of the sewer interceptor along the river presents another installation obstacle for the placement of a horizontal well to capture surfactant emulsion. Even if a horizontal well is not located under a private property, an access agreement is needed for surfactant injection that will move onto/beneath a private property. Surfactant enhanced mobilization of the residual phase LNAPL is not recommended because of the potential to mobilize residual phase LNAPL and the potential for discharge to surface water. In addition, given the volume of residual phase LNAPL and the difficulty in treating the surfactant/mineral spirits/PCP/water emulsion, the technical practicability to achieve PCP discharge standards is questionable or at a minimum, very difficult.
  - ***Cost*** – Very high cost for the volume of residual phase LNAPL potentially recovered.
- **Alternative 8: Pressure Pulse Technology; Description** – Objective of this alternative is to enhance LNAPL source control/recovery by converting residual phase LNAPL to mobile phase LNAPL, where the mobile phase LNAPL could then be recovered by the existing groundwater pump and treatment system.
  - ***Effectiveness*** – This alternative would not be effective, based on the results of a pilot test of this technology conducted at the Wauleco Project Site, which concluded that the PPT was not able to convert immobile residual phase LNAPL to mobile phase LNAPL because the pressure pulse dispersed too rapidly into the permeable aquifer. See Pressure Pulse Pilot Test Report dated May 22, 2006 (RMT).
  - ***Implementability and Cost*** – Difficult and costly due to the clogging of the injection well screen observed during the pilot test, but the primary reason for rejection is described in Effectiveness.

5.0 List of Alternatives to Carry Forward to the Detailed and Comparative Analysis of Alternatives

Based on the initial screening of alternatives discussed above in Section 4.0, the following four groundwater alternatives will be carried forward to the detailed and comparative analysis phases in the revised Groundwater RAOR:

1. Alternative 1: On-site Pump and Treatment System
2. Alternative 2: Chemical Oxidation of Portion of Residual Phase LNAPL
3. Alternative 4: Enhanced Bioremediation
4. Alternative 5: Permeable Treatment Walls (Property and River Walls)

6.0 Technical Review and Requested WDNR Response

Per NR 749, Wisc. Admin. Code, Wauleco is submitting a technical review fee for review of this Technical Memorandum. Wauleco requests a response from the WDNR if there are any other alternatives the WDNR recommends being included in the revised Groundwater RAOR, prior to Wauleco performing the detailed and comparative analysis.

List of Enclosures

- Table 1 – Identification and Screening of Groundwater Technologies and Process Options
- Table 2 – Evaluation of Groundwater Process Options
- Table 3 – Initial Screening of Alternatives
- Table 4 – Summary of Initial Screening of Alternatives
- Attachment A – Lake Wausau Drawdown
- Attachment B – LNAPL Site Management Evaluation

Tables

Table 1
Identification and Screening of Groundwater Technologies and Process Options
Wauleco, Inc.
May 31, 2019

Media	General Response Action	Remedial Technology Type	Process Option	Description	Applicability
Groundwater	Institutional controls	Deed Restrictions	Groundwater Use Restrictions	A municipal ordinance within the City that prohibits installation of new wells within the municipal water distribution system or listing on the WDNR GIS registry.	Permanently prevents use of groundwater in this area. Retain as part of potential options and GIS registry requirements if site is to be closed. City of Wausau already has an ordinance that prohibits the installation of private potable wells.
	Monitoring	Monitoring	Groundwater Monitoring	Long-term monitoring of groundwater wells to monitor degradation, dissipation, and migration of COCs in the groundwater.	Not applicable on its own, but would be a component of any remedy.
			Natural Attenuation Monitoring	Quantifying the rate of biodegradation and fate of constituents in groundwater to demonstrate that constituents will degrade before adversely affecting a receptor.	Potentially viable based on NA assessment and could be an essential component of an alternative.
	Gradient Controls	Containment	Slurry Wall	A slurry wall would be effective in reducing the pumping rate to maintain containment on the Site, but requires an extraction system to maintain gradient control.	Not viable due to the large area encompassed by the groundwater plume within the City and the number of utilities that would be present in the footprint of the slurry wall.
		Groundwater Recharge Elimination	Impermeable Surface Cap	Installation of an impermeable cap over the entire groundwater source area to prevent further recharge and migration of the plume.	Not viable. Residual phase LNAPL is present at the water table, so an impermeable surface cap would not be applicable.

Table 1
Identification and Screening of Groundwater Technologies and Process Options
Wauleco, Inc.
May 31, 2019

Media	General Response Action	Remedial Technology Type	Process Option	Description	Applicability
	Extraction and Ex-situ Treatment	Biological Treatment	Cometabolic Aerobic Biodegradation	Addition of specific compounds to feed bacteria that can cometabolize PCP into non-hazardous compounds.	No cometabolic aerobic biodegradation systems known to be effective with PCP.
			Anaerobic Biodegradation	Addition of specific compounds to enhance the anaerobic biodegradation of PCP in extracted groundwater.	Partially aerobic biological treatment shown to be more effective in existing treatment system than anaerobic biological treatment.
			Aerobic Treatment	Aerobic biotreatment of PCP in extracted groundwater.	This is the existing system's treatment method. This is technologically viable.
		Chemical Treatment	Chemical Oxidation	Addition of compounds that oxidize PCP present in extracted groundwater to non-hazardous compounds.	Potentially viable.
			Chemical Precipitation	Addition of chemicals to precipitate certain chemicals from extracted groundwater.	Not viable. Technology is most efficient for metals.
		Physical Treatment	Air Stripping	Mass transfer of VOCs from groundwater to the gaseous phase.	Not viable for PCP.
			Spray Evaporation	Dispersion of groundwater into tiny droplets with large surface area that facilitate the transfer of certain chemicals to the gaseous phase.	Not viable for PCP.
			Carbon Adsorption	Filtration of extracted groundwater through activated carbon filters which adsorb certain chemicals.	Viable treatment method, as shown by existing system polishing system.
			Discharge to POTW	Discharge of extracted groundwater to the local POTW for treatment	Not viable on its own. Historically shown not to be able to meet POTW discharge limits without pretreatment. Retained for possible treated discharge option.
			Ion Exchange	Removal of charged compounds from the groundwater.	Not viable. Non-charged chemicals are not amenable to this technology.
			Reverse Osmosis	Removal of chemicals from groundwater using microfiltration technology.	Potentially viable.

Table 1
Identification and Screening of Groundwater Technologies and Process Options
Wauleco, Inc.
May 31, 2019

Media	General Response Action	Remedial Technology Type	Process Option	Description	Applicability
	In-situ Treatment	Biological Treatment	Enhanced Biodegration	Injection of specific constituents (substrate, nutrients, oxygen, etc.) or bacteria into source area groundwater to feed bacteria that degrade PCP into non-hazardous compounds.	Potentially viable to enhance biodegradation of PCP in the dissolved phase and enhance PCP removal from LNAPL. Increasing degradation rate in groundwater would increase rate of dissolution from the mobile and residual phase sources. Primary limitation is due to the presence of large volumes of free and residual phase product.
		Chemical Treatment	Permeable Treatment Wall	Injection of compounds (e.g., chemical oxidation) into source area groundwater that oxidize PCP to non-hazardous compounds. Application can be areally or in a permeable treatment wall.	Permeable treatment wall potentially viable to treat groundwater migration away from source area as a continuous injection. Areal injection not viable due to the large area of LNAPL present.
			Passive Treatment Wall	Installation of permeable wall in the path of groundwater flow which treats groundwater as it passes through the wall. No known material to chemically treat PCP.	Not viable for PCP.
		Physical Treatment	Air sparging/soil vapor extraction	Injection of air into groundwater to transfer volatile chemicals to the gaseous phase and then the extraction of this air through separate wells in the unsaturated zone.	Not viable for PCP. Viable for removal of mineral spirits, which is not a COC.
			Electro-kinetic Extraction	Applying voltage difference across electrodes forces movement of water, dissolved constituents and non-aqueous liquids between electrodes	Typically applicable to sites with low hydraulic conductivity soils. Not applicable to Wauleco.
			Thermal Vapor Extraction	In-situ heating of groundwater to transfer chemicals to the gaseous phase and subsequent extraction of air containing these chemicals in separate wells.	Potentially viable. Although unlikely to be cost effective due to the high PCP volatilization temperature, soils' relatively high permeability increasing flow and high energy consumption/costs.
			Vacuum Vapor Extraction	Vacuum extraction of soil gas above the water table to remove volatile constituents vented from the groundwater.	Not viable for PCP.

Table 1
Identification and Screening of Groundwater Technologies and Process Options
Wauleco, Inc.
May 31, 2019

Media	General Response Action	Remedial Technology Type	Process Option	Description	Applicability
		LNAPL Removal	Pressure Pulse	Use of a water flood with pressure pulse to help force NAPL out of the soils. Used in combination with a groundwater extraction system.	Potentially viable.
			Surfactant Flushing	Injection and extraction of surfactants and polymers to remove product.	Potentially viable but extensive technical challenges to: • treat the surfactant/water/LNAPL emulsion prior to discharge, • install wells (horizontal). Administrative challenges for installation and operation are also significant.
			Thermal Vapor Extraction	Heated soil vapor extraction would remove product as well as dissolved phase PCP.	Potentially viable.
			Enhancing LNAPL Recovery	Product recovery while pumping groundwater to create cone of depression.	Lake Wausau drawdown demonstrates current system removed recoverable LNAPL, so this is not viable in the future.
			Chemical Oxidation	Injection of compounds into source area groundwater that oxidize product to non-hazardous compounds. This does not directly react with product. Rather it degrades constituents in groundwater increasing dissolution rate from product.	Potentially viable, however, due to volume of product, potential is low.
			Excavation	Excavation of residual phase LNAPL would require removal of overburden soil located above residual phase LNAPL.	Not considered viable in consideration of the depth to residual phase LNAPL, up to ≈30 feet below ground surface, and the sandy soils present. Both of these factors would represent significant technical implementability concerns.
		Phyto-remediation	Phyto-remediation	Planting and cultivating trees to utilize groundwater flow through an area, potentially containing groundwater, with removal of COCs through treatment in rhizosphere and volatilization.	Not viable due to depth to groundwater on source area.

Notes:

	Process Option not carried forward
	Process Option retained
POTW	Public Owned Treatment Work
COCs	Constituents of Concern
PCP	Pentachlorophenol

Table 2
Evaluation of Groundwater Process Options
Wauleco, Inc.
May 31, 2019

Media	General Response Action	Remedial Technology Type	Process Option	Effectiveness	Implementability	Cost
Groundwater	Institutional Controls	Deed Restrictions	Groundwater Use Restrictions	GIS registry is an effective institutional control.	The City of Wausau already has an ordinance that prohibits the installation of private potable wells.	Low to moderate cost.
	Monitoring	Monitoring	Groundwater Monitoring	Not effective on its own, but a component of any remedy.	Easy to implement for most applications.	Cost dependent on duration of remedy and complexity of required monitoring.
			Natural Attenuation Monitoring	NA is shown to be occurring and reducing PCP concentration in groundwater.	Already naturally occurring.	Low cost.
	Extraction and Ex-situ Treatment	Biological Treatment	Aerobic Treatment	(1). General for source area extraction and treatment: would be effective, but would require long term OM&M. This is the existing system and shown to be effective in containing groundwater on-site and treatment system has been effective in treating PCP.	Easy to implement. Long remediation duration likely, requiring major renovation to the old, existing system.	Moderate cost for short term operation. High capital cost for system renovation required if planned for long term OM&M. Moderate OM&M cost for long term.
		Chemical Treatment	Chemical Oxidation	See (1) in Aerobic Treatment. Treatment method not widely applied to PCP, but may be effective in meeting POTW standards.	Difficult to implement. Would require bench scale testing . Long remediation duration likely.	High capital cost, potentially lower long term OM&M cost than current system.
		Physical Treatment	Carbon Adsorption	See (1) in Aerobic Treatment. Treatment method regularly used for PCP, and would be effective in meeting POTW standards.	Moderate difficulty to implement. Would require special chemicals and treatment trains.	Moderate capital cost, high OM&M cost. Dependent on system pumping rate.
			Discharge to POTW	Not viable without pretreatment. Retained for potential discharge option.	Easy to implement.	Low cost.
			Reverse Osmosis	See (1) in Aerobic Treatment. Treatment method not widely applied to PCP, but may be effective in meeting POTW standards.	Difficult to implement. Would require bench scale testing. Long remediation duration likely.	High capital cost and moderate to high OM&M cost.

Table 2
Evaluation of Groundwater Process Options
Wauleco, Inc.
May 31, 2019

Media	General Response Action	Remedial Technology Type	Process Option	Effectiveness	Implementability	Cost
	In-situ Treatment	Biological Treatment	Enhanced Biodegration	Natural biodegradation is shown to be occurring, so enhancement would be effective. Would require shorter term operation than extraction and treatment.	Easy to implement, but may require bench scale testing . Shorter remediation duration than current pump and treatment system.	Moderate capital cost and low to moderate OM&M cost.
		Chemical Treatment	Permeable Treatment Wall	Systems shown to be effective with concentrations observed at Wauleco.	Difficult to implement. Is not subject to biotoxicity or heterogeneity of LNAPL distribution in source area.	Moderate to high capital costs and moderate OM&M costs for long term OM&M.
		Physical Treatment	Thermal Vapor Extraction	Effectiveness considered questionable based on the quantity of groundwater requiring treatment.	Difficult to implement due to the volume of product on-site and heterogeneity of LNAPL distribution.	High to very high capital costs using utility energy. Moderate to high cost with low cost heat.
		LNAPL Removal	Surfactant Flushing	May be effective in reducing residual phase LNAPL somewhat, but limited applications for PCP sites result in limited reliability for mobilizing LNAPL and for treatment of collected surfactant/LNAPL/water emulsion. Potential for migration of emulsion to river is a serious limitation.	Difficult to implement horizontal wells and treatment system, both technically and administratively.	High to very high capital and OM&M costs.
			Thermal Vapor Extraction	Effectiveness considered questionable based on the quantity of groundwater requiring treatment.	Difficult to implement due to the volume of product on site and heterogeneity of LNAPL distribution.	High to very high capital costs using utility energy. Moderate to high cost with low cost heat.
			Enhancing Product Recovery	It has been concluded that current groundwater system has recovered LNAPL to the extent practicable. The Lake Wausau drawdown results demonstrates that off-site LNAPL recovery would not be effective.	Uses existing treatment system in short term.	Moderate to high capital costs, low OM&M costs.
			Chemical Oxidation	No history of chemical oxidation for product removal on this scale, so reliability is not known. Typically used to treat dissolved phase PCP with excavation of residual phase LNAPL in smear zone prior to use. Excavation of smear zone at Wauleco is not practicable. Several years of injections would be required at a minimum.	Difficult to implement due to heterogeneity of LNAPL distribution and ability to obtain access agreements to install injection points off-site.	High to very high costs.

Notes:

	Process Option not carried forward
	Process Option retained
POTW	Public Owned Treatment Work
COCs	Constituents of Concern
PCP	Pentachlorophenol

Table 3
Initial Screening of Alternatives
Wauleco Project Site: Groundwater Remedial Action Options Report
Wausau, Wisconsin
May 31, 2019

INITIAL SCREENING CRITERIA EVALUATION CRITERIA	ALTERNATIVE 1 ON-SITE PUMP AND TREATMENT (P&T) SYSTEM	ALTERNATIVE 2 CHEMICAL OXIDATION OF PORTION OF RESIDUAL PHASE LNAPL	ALTERNATIVE 3 NATURAL SOURCE ZONE DEPLETION AND NATURAL ATTENUATION	ALTERNATIVE 4 ENHANCED BIOREMEDIATION (BIO)	ALTERNATIVE 5 PERMEABLE TREATMENT WALLS (PROPERTY AND OFF-SITE WALLS)	ALTERNATIVE 6 OFF-SITE PUMP AND TREATMENT SYSTEM	ALTERNATIVE 7 OFF-SITE HORIZONTAL WELLS AND SURFACTANT FLUSHING	ALTERNATIVE 8 PRESSURE PULSE TECHNOLOGY
	SYMBOLIC RATING	SYMBOLIC RATING	SYMBOLIC RATING	SYMBOLIC RATING	SYMBOLIC RATING	SYMBOLIC RATING	SYMBOLIC RATING	SYMBOLIC RATING
1. Effectiveness Evaluation								
Effectiveness in protecting human health and the environment; considering both: a. Short-term effectiveness: Construction and implementation periods. b. Long-term effectiveness: Period after the remedial action is complete	Continuation of an on-site pump and treat system at a rate to contain groundwater on the source area is effective in protecting human health and the environment in the short and long term in that the highest concentration PCP is captured and treated on-site, and off-site groundwater that discharges to the river would be protective of the environment based on the conclusion of the WDNR Water Quality Bureau [1]. This alternative would be protective in the short term and long term, as there are no receptors, other than groundwater that discharges to the river or, potentially, to a sewer interceptor. Groundwater that discharges to the river would be protective of the environment based on the conclusion of the WDNR Water Quality Bureau [1].	Removing residual phase LNAPL east of the site, by chemical oxidation (chemox), will provide additional distance for natural attenuation to reduce contaminant concentrations between the eastern extent of residual phase LNAPL and the river. In the short term there is risk that chemox could mobilize residual phase LNAPL (which is currently immobile) that could migrate and discharge to the river, thereby increasing risk to human health and the environment. Under current conditions, residual phase LNAPL is immobile, and dissolved phase constitutes that any discharge to the river would be protective based on the conclusions of the WDNR Water Quality Bureau.[(1)] Therefore, if implemented, this alternative may make conditions worse (i.e., greater risk to human health and the environment), than under current conditions. There could be short term impacts to human health, safety, and welfare during and shortly after the injection of oxidant downgradient of the Wauleco site, which is a residential area. Chemical oxidation, if implemented, could generate heat and off-gassing in this area resulting in a vapor intrusion risk, which under current conditions, there is no potentially complete vapor intrusion pathway. In the long term this alternative would further reduce the potential for human health or environmental risk due to reducing discharge of PCP to the river. However, long term risk is currently acceptable as described in Alternative 1.	This alternative relies on various processes to degrade the residual phase LNAPL, the source of dissolved phase PCP to groundwater, and degradation of PCP in groundwater. This alternative would be protective in the short term and long term, as there are no receptors, other than groundwater that discharges to the river or, potentially, to a sewer interceptor. Groundwater that discharges to the river would be protective of the environment based on the conclusion of the WDNR Water Quality Bureau [1]. In the short term, PCP in groundwater discharge would be expected to increase after discontinuing the current pump and treat remedy in the vicinity where residual phase LNAPL is present, but would still be protective of the environment based on the conclusion of the WDNR Water Quality Bureau [1]. In the long term, demonstrated natural source zone depletion of the residual phase LNAPL is expected to continue to reduce the recharge of dissolved phase PCP to groundwater, with further reduction of dissolved phase PCP discharge to the river. There is no additional risk of mobilization of residual phase LNAPL in the short or long term.	Injection of amendments to enhance the current natural attenuation of PCP in groundwater would be completed on-site and off-site, and potentially shutting down the pump and treatment system when PCP concentrations begin to decline. Amendment injections would continue after shutdown of the pump and treatment. This may create limited acceleration of residual phase LNAPL dissolution. There may be minor increased short term risks to human health, safety, and welfare during installation of the injection wells and potentially additional extraction wells, and during injections; but this is considered manageable though an appropriate Health & Safety (H&S) Plan and personnel protective equipment (PPE). In the long term this alternative would further reduce the potential for human health or environmental risk due to reducing discharge of PCP to the river. However, long term risk is currently acceptable as described in Alternative 1. The remaining residual phase LNAPL is expected to continue to be immobile. However, in the short and long term, amendment additions may mobilize some residual phase LNAPL, as dissolved phase, that may not be controlled.	The treatment walls would chemically treat groundwater as it passes through the walls. However, the property area wall would not reduce the concentration of PCP within the source area faster than natural dissolution of the residual phase to groundwater. The off-site wall would reduce constituent concentrations in groundwater prior to discharge. The remaining residual phase LNAPL is expected to continue to be immobile. However, there is a risk that oxidants injected in the property area wall may mobilize some residual phase LNAPL that would need to be treated at the off-site wall. If residual LNAPL is mobilized and not treated by the off-site wall, it could discharge, thereby increasing risk to human health and the environment. Under current conditions, residual phase LNAPL is immobile, and dissolved phase constituents that may discharge would be protective based on the conclusions of the WDNR Water Quality Bureau. [(1)] Therefore, if implemented, this alternative may make conditions worse (i.e., greater risk to human health and the environment), than under current conditions. This alternative would be protective in the short and long term for the same reasons as Alternative 1. Potential risks to the environment through mobilization of residual phase product would be controlled through monitoring and controls in the off-site treatment wall. However, there may be minor increased risks to human health, safety, and welfare during installation of the injection wells, and during injections; but this is considered manageable though an appropriate H&S Plan and PPE.	Installation/expansion of the pump and treat system to off-site locations to contain groundwater off-site would be no more effective in protecting human health and the environment in the short and long term than Alternative 1, as there are no receptors, other than groundwater that discharges to the river or, potentially, to a sanitary sewer interceptor. Groundwater that discharges is already protective of the environment based on the conclusion of the WDNR Water Quality Bureau [1]. No additional LNAPL would be collected from an off-site pump and treat system based on the limited volume of residual phase LNAPL present. This was demonstrated during the Lake Wausau drawdown, conducted by others, during September to November 2016 (refer to Attachment A).	Removing residual phase LNAPL off-site, by surfactant flushing between horizontal wells, is intended to reduce the volume of residual phase LNAPL off-site. The success rate is typically higher for very small areas and potential for success decreases for larger areas like Wauleco. In the short term there is risk that surfactants could mobilize residual phase LNAPL that could migrate and discharge, thereby increasing risk to human health and the environment. Under current conditions, residual phase LNAPL is immobile, and dissolved phase constituent that may discharge to the river would be protective based on the conclusions of the WDNR Water Quality Bureau.[(1)] Therefore, if implemented, this alternative may make conditions worse (i.e., greater risk to human health and the environment), than under current conditions. In the long term this alternative would further reduce the potential for human health or environmental risk due to reducing discharge of PCP. However, long term risk is currently acceptable as described in Alternative 1.	Pressure Pulse Technology (PPT) can be effective in mobilizing residual phase LNAPL for collection by extraction wells. PPT is intended to reduce the volume of residual phase LNAPL near the river, in both the short term and long term. Short term effectiveness would be similar to Alt. 7, in that mobilization of residual phase LNAPL near the river by this technology would have to be collected. Long term effectiveness is similar to Alt. 7, in that mobilization and recovery of residual phase LNAPL would reduce potential future risk, although long term risks is currently acceptable as described in Alternative 1.
Effectiveness in the reduction of toxicity, mobility, or volume that alternative will achieve	Toxicity reduction occurs through groundwater extraction and treatment. The pump and treatment system slowly reduces the mass/volume of residual phase LNAPL through dissolution of LNAPL into the groundwater. No mobile LNAPL is expected to be collected. The remaining residual phase LNAPL would continue to be immobile.	Chemox treatment would target residual phase LNAPL in an area east of the site for destruction. Therefore, a large mass/volume of residual phase LNAPL would be reduced. Continued natural attenuation would occur on and off the site. However, the removal of residual phase LNAPL in an area east of the site would allow biodegradation to reduce PCP concentrations, without dissolution of additional PCP from residual phase LNAPL. This reduces the volume, mobility and toxicity of the residual contaminants. However, the current conditions result in groundwater discharge to the river that would be protective of the environment based on the conclusion of the WDNR Water Quality Bureau [1]. This alternative has the potential to mobilize some residual phase LNAPL, thereby increasing its mobility and potential toxicity. This would be closely monitored.	The volume, toxicity, and mobility will continue to be reduced through degradation of the residual phase LNAPL and PCP in groundwater. In the short term, some additional migration of PCP in groundwater will occur, but within limits established to be protective of the environment based on the conclusion of the Water Quality Bureau[(1)]. In the short and long term the residual phase LNAPL would continue to be immobile.	The enhanced bio would treat groundwater beneath the residual phase LNAPL area, enhancing the shift of PCP from residual phase LNAPL to dissolved phase PCP in groundwater, thereby reducing the mass and volume of residual phase LNAPL. Existing PCP degradation in groundwater would be enhanced as groundwater flows towards the river, reducing the toxicity of constituents in groundwater. This alternative has the potential to mobilize some residual phase LNAPL as dissolved phase, thereby increasing its mobility and potential toxicity. This would be monitored.	Treatment walls would chemically treat groundwater. However, the property area wall would not reduce the concentration of PCP within the residual phase LNAPL on-site faster than natural processes. The off-site wall would reduce constituent concentrations in groundwater prior to discharge. The remaining residual phase LNAPL is expected to continue to be immobile. However, there is a risk that chemical oxidation may mobilize some residual phase LNAPL that would need to be treated at the off-site wall.	Same as Alternative 1, with increased toxicity reduction and mobility of dissolved phase PCP with increased extraction off-site. This alternative would not be effective in mobilizing residual phase LNAPL for collection. This is based on the results of the Lake Wausau drawdown during September to November 2016.	The volume of residual phase LNAPL off-site will be reduced, which will reduce the mobility and discharge of PCP to the river through natural attenuation with smaller continued source of PCP to off-site groundwater. The surfactant flushing of residual phase LNAPL will increase the mobility of residual phase LNAPL, which is currently immobile, that could migrate and discharge as LNAPL.	Implementation of this technology is theoretically feasible. However, a 2005 pilot study demonstrated that implementation of the PPT on the Wauleco property was not effective in mobilizing significant volumes of residual phase LNAPL.

Table 3
Initial Screening of Alternatives
Wauleco Project Site: Groundwater Remedial Action Options Report
Wausau, Wisconsin
May 31, 2019

INITIAL SCREENING CRITERIA EVALUATION CRITERIA	ALTERNATIVE 1 ON-SITE PUMP AND TREATMENT (P&T) SYSTEM	ALTERNATIVE 2 CHEMICAL OXIDATION OF PORTION OF RESIDUAL PHASE LNAPL	ALTERNATIVE 3 NATURAL SOURCE ZONE DEPLETION AND NATURAL ATTENUATION	ALTERNATIVE 4 ENHANCED BIOREMEDIATION (BIO)	ALTERNATIVE 5 PERMEABLE TREATMENT WALLS (PROPERTY AND OFF-SITE WALLS)	ALTERNATIVE 6 OFF-SITE PUMP AND TREATMENT SYSTEM	ALTERNATIVE 7 OFF-SITE HORIZONTAL WELLS AND SURFACTANT FLUSHING	ALTERNATIVE 8 PRESSURE PULSE TECHNOLOGY
	SYMBOLIC RATING	SYMBOLIC RATING	SYMBOLIC RATING	SYMBOLIC RATING	SYMBOLIC RATING	SYMBOLIC RATING	SYMBOLIC RATING	SYMBOLIC RATING
2. Implementability Evaluation								
a. Technical Feasibility: The ability to construct, reliably operate, and meet technology-specific regulations for process options until a remedial action is completes. Also includes operation, maintenance, replacement, and monitoring of technical components of alternative.	System relies on existing infrastructure for water treatment and discharge. Construction is either complete, or modifications are easy and reliable and can be modified further if necessary. OM&M is on-going and will provide feedback for system modifications if necessary.	The large volume of oxidant, injected on a tight spacing required to treat the residual phase LNAPL are the greatest limitations to its technical feasibility. Potential for mobilization of residual phase LNAPL, with potential for migration to the river, is difficult or impossible to predict and control. Requires construction of a large number of injection locations.	Demonstration of natural attenuation of LNAPL and PCP in groundwater has already been documented through routine monitoring of product and groundwater that has been conducted at Wauleco. The technology for documentation of Natural Source Zone Depletion is readily available to Wauleco and can be implemented and monitored.	Injection technology is readily available, and theoretically can be operated and monitored, on-site and in right-of-ways (R-O-W) off-site. Requires construction of off-site injection wells (approximately 4 to 6) and potentially additional extraction wells (4 to 6) with several rounds of amendment injections. If these injection wells are proposed for installation in the off-site R-O-W, there are currently several utilities present in the R-O-W that may prohibit the installation. In addition, a small building to house injection equipment may be needed at injection wells.	Injection technology is readily available, and theoretically can be operated and monitored, on-site and off-site. Requires construction of approximately 22 injection locations for the property wall, and approximately 28 off-site injection locations for the off-site wall. There are numerous utilities in the area of the off-site wall which will present constraints. In addition, injection of oxidants near the City interceptor may not be allowed by the City. There are also utilities in the area of the property wall.	Installing/extending extraction and transport systems off-site, along right-of-ways (R-O-W) is theoretically technically feasible, but practically may not be feasible based on the actual location of other off-site utilities also located in the R-O-W.	Construction of horizontal wells is theoretically feasible, but is limited by the presence of utilities. Although most utilities are expected to be shallower than the horizontal wells in the groundwater, the sewer interceptor off-site is at the same interval and would prevent placement of any horizontal wells in this area. Operational limitations are major, and include: 1). The difficulty of mobilizing a thin zone of residual phase LNAPL between widely spaced horizontal wells; 2). Treatment of PCP in solution of emulsified LNAPL, water, and surfactant; 3). Capturing 100% of the mobilized LNAPL so none of it migrates and discharges; and 4). The technical infeasibility of placing a horizontal well for downgradient capture, as a barrier to migration to the river, because it would be required in the vicinity of the existing sewer interceptor.	Additional improvements in the technology is needed for the Wauleco site for PPT to be successfully implemented. Therefore, the technology is not considered to be technically feasible, at the Wauleco Site, at this time.
b. Administrative Feasibility: Ability to obtain approvals from other offices and agencies, the availability of treatment, storage, and disposal services and capacity, and the requirements for, and availability of, specific equipment and technical specialists.	System relies on existing approvals for water treatment and discharge. System upgrade components are readily available.	Access to private property for implementation of closely spaced injection wells is a serious administrative limitation. Obtaining approval from off-site residential property owners to perform chemical injections on their property does not appear to be administratively feasible. Therefore, the administrative feasibility of Alternative 2 may be difficult. Potential for off-gassing also raises serious administrative feasibility concerns in this residential area.	Implementation of this alternative requires limited off-site, right-of-way access for additional monitoring points. The specific equipment and technical specialists are limited, but available to Wauleco. Based on WDNR comments on the 2017 Alternatives Array document, this alternative is not considered to be administratively feasible because the WDNR recommended that Wauleco not include this technology at this time.	Injection of bioaugmentation fluids requires City permission for use of municipal water for injection and installation of injection wells and potentially additional extraction wells at locations potentially in City R-O-W. Obtaining approval from the City for injection wells and potentially additional extraction wells in City R-O-W may be challenging due to space limitations and concerns for chemical injections. If the City does not grant approval to construct these structures in their R-O-W, then this alternative is not considered to be administratively feasible as obtaining approval from off-site residential property owners does not appear to be feasible. The specific equipment and technical specialists are limited, but available to Wauleco.	Off-site barrier chemox would require City permission for access in Riverside Park for installation and operation. Based on previous experience it is expected that the City will have significant concerns placing injection locations near utilities.	Extending extraction and transport systems off-site, along right-of-ways is expected to have limited administrative limitations. Obtaining approval from the City for work in the City R-O-W may be challenging due to space limitations. If the City does not grant approval to construct these structures in their R-O-W, then this alternative is not considered to be administratively feasible as obtaining approval from off-site residential property owners does not appear to be feasible.	Installation of horizontal wells in right-of-ways would require City permission for access. Based on previous experience it is expected that the City will have significant concerns placing horizontal wells and injection locations near utilities. Obtaining approval from the City for horizontal wells in City R-O-W may be challenging due to space limitations and concerns for chemical injections. If the City does not grant approval to construct these structures in their R-O-W, then this alternative is not considered to be administratively feasible as obtaining approval from off-site residential property owners does not appear to be administratively feasible.	Administrative feasibility is similar to Alt. 6, in that approval for injection and extraction wells and associated piping is needed from the City for work in the City R-O-W.
3. Cost Evaluation								
Relative cost comparison	Present net worth cost would be high, relative to other alternatives.	Present net worth cost would be high, relative to other alternatives.	Present net worth cost would be low, relative to other alternatives.	Present net worth cost would be medium, relative to other alternatives.	Present net worth cost would be medium, relative to other alternatives.	Present net worth cost would be high, relative to other alternatives.	Present net worth cost would be high, relative to other alternatives.	Present net worth cost would be high, relative to other alternatives.

Notes:

(1) Statement from the WDNR Water Quality Bureau regarding river discharge standard: "After consultations with WDNR legal staff and wastewater managers, the Bureau of Water Quality determined that no WPDES permit is required for the diffuse, non-point discharge of groundwater containing residual PCP because the Department "do not suspect that there is potential for exceedances of water quality standards."

- Green = Alternative meets the requirement of this criterion.
- Yellow = Alternative partially meets the requirement of this criterion.
- Red = Alternative does not meet the requirement of this criterion.

Table 4
Summary of Initial Screening of Alternatives
Wauleco Project Site: Groundwater Remedial Action Options Report
Wausau, Wisconsin
May 31, 2019

INITIAL SCREENING CRITERIA EVALUATION CRITERIA	ALTERNATIVE 1 ON-SITE PUMP AND TREATMENT (P&T) SYSTEM	ALTERNATIVE 2 CHEMICAL OXIDATION OF PORTION OF RESIDUAL PHASE PRODUCT	ALTERNATIVE 3 NATURAL SOURCE ZONE DEPLETION AND NATURAL ATTENUATION	ALTERNATIVE 4 ENHANCED BIOREMEDIATION (BIO)	ALTERNATIVE 5 PERMEABLE TREATMENT WALLS (PROPERTY AND RIVER WALLS)	ALTERNATIVE 6 OFF-SITE PUMP AND TREATMENT SYSTEM	ALTERNATIVE 7 OFF-SITE HORIZONTAL WELLS AND SURFACTANT FLUSHING	ALTERNATIVE 8 PRESSURE PULSE TECHNOLOGY
	SYMBOLIC RATING	SYMBOLIC RATING	SYMBOLIC RATING	SYMBOLIC RATING	SYMBOLIC RATING	SYMBOLIC RATING	SYMBOLIC RATING	SYMBOLIC RATING
1. Effectiveness Evaluation								
Effectiveness in protecting human health and the environment; considering both: a. Short-term effectiveness: Construction and implementation periods. b. Long-term effectiveness: Period after the remedial action is complete								
Effectiveness in the reduction of toxicity, mobility, or volume that alternative will achieve								
2. Implementability Evaluation								
a. Technical Feasibility:								
b. Administrative Feasibility:								
3. Cost Evaluation								
Relative cost comparison								

Notes:

Green = Alternative meets the requirement of this criterion.
Yellow = Alternative partially meets the requirement of this criterion.
Red = Alternative does not meet the requirement of this criterion.

Attachment A

Lake Wausau Drawdown

Lake Wausau Drawdown

Lake Wausau was drawn down in the fall of 2016 for Domtar dam repair work to be completed in Rothschild. Prior to this time, Lake Wausau has been maintained at a nearly constant stage for 60+ years. Wauleco performed groundwater monitoring in select monitoring wells during this drawdown period to determine if any residual phase LNAPL was converted to mobile LNAPL during the very uniform drawdown in the groundwater elevation expected throughout the zone of residual phase LNAPL. This was expected to be an effective test to determine whether any residual phase LNAPL would be mobilized.

Drawdown was begun on September 24 and reached a maximum drawdown in the lake of approximately 4.8 ft. Refilling the lake began November 15. Groundwater and LNAPL thickness was monitored at several wells and results are included in Table A. Monitoring began on September 8, prior to beginning drawdown and then twice per week between September 24 and December 9, 2016. An additional measurement of this program was made on December 20. Table A also presents a table of head changes compared to the groundwater elevations on July 9, 2016. These values illustrate the change from a pre-drawdown level. The change in head at each well is also shown on a graph imbedded on Table A.

The drawdown of Lake Wausau over nearly an eight week period, resulted in a uniform drawdown in groundwater elevations over an extended period of time. This would be even more effective in mobilizing residual phase LNAPL than an extraction system. Therefore, it was an effective test to determine whether any residual phase LNAPL would be mobilized, to create mobile, recoverable LNAPL.

Based on the monitoring of groundwater elevations and LNAPL thicknesses over this period, the Lake Wausau drawdown has demonstrated that there is insufficient volume of residual phase LNAPL to create mobile, recoverable LNAPL. Therefore, an off-site pump and treatment system to recover LNAPL would not be effective.

TABLE A

Groundwater Measurements During Lake Wausau Drawdown
Wauleco, Inc.
Wausau, Wisconsin

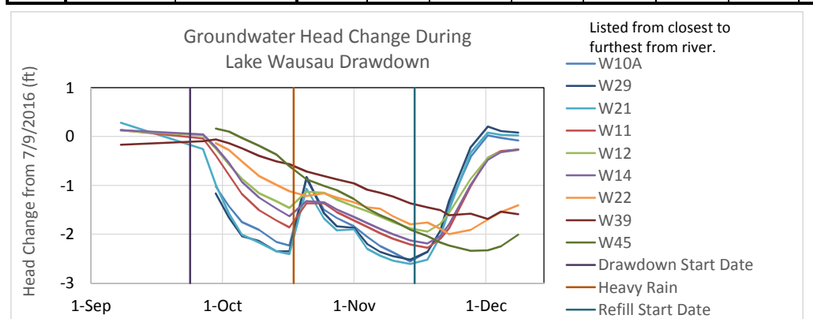
Well	Approximate Elev. Of Residual Phase Product		Groundwater Elevation																								
	Top Elev. (ft)	Bottom Elev. (ft)	7/19/2016	9/8/2016	9/24/2016	9/27/2016	9/30/2016	10/3/2016	10/6/2016	10/10/2016	10/14/2016	10/17/2016	10/21/2016	10/25/2016	10/28/2016	11/1/2016	11/4/2016	11/7/2016	11/10/2016	11/14/2016	11/18/2016	11/21/2016	11/23/2016	11/28/2016	12/2/2016	12/5/2016	12/9/2016
W10A	1161.1	1159.7	**1160.98**	-		-	**1159.95**	***1159.55***	***1159.23***	***1159.07***	***1158.82***	***1158.75***	**1160.11**	***1159.48***	***1159.31***	***1159.14***	***1158.93***	***1158.74***	***1158.61***	***1158.42***	***1158.62***	***1159.04***	***1159.57***	**1160.56**	**1161.00**	**1160.95**	**1160.90**
W11	None present	None present	1160.94	1161.07		1160.9	1160.55	1160.15	1159.76	1159.43	1159.22	1159.08	1159.57	1159.57	1159.39	1159.22	1159.09	1158.96	1158.85	1158.73	1158.66	1158.85	1159.06	1159.93	1160.5	1160.64	1160.67
W12	None present	None present	1160.58	1160.7		1160.6	1160.33	1160	1159.71	1159.42	1159.25	1159.12	1159.45	1159.43	1159.29	1159.15	1159.05	1158.94	1158.83	1158.7	1158.63	1158.79	1159.01	1159.71	1160.14	1160.26	1160.3
W14	None present	None present	1159.62	1159.75		1159.66	1159.4	1159.08	1158.69	1158.37	1158.14	1157.99	1158.3	1158.27	1158.12	1157.97	1157.85	1157.73	1157.62	1157.49	1157.43	1157.58	1157.82	1158.63	1159.14	1159.3	1159.35
W21	None present	None present	1160.78	1161.06		1160.52	1159.79	1159.2	1158.77	1158.61	1158.43	1158.37	1159.71	1159.1	1158.86	1158.88	1158.48	1158.34	1158.24	1158.17	1158.26	1158.73	1159.27	1160.45	1160.86	1160.81	1160.8
W22	1160.5	1159.5	1161.68	-		-	1161.54	1161.4	1161.17	1160.87	1160.69	1160.56	**1160.46**	1160.52	**1160.43**	**1160.33**	**1160.23**	**1160.2**	**1160.05**	**1159.88**	**1159.92**	**1159.79**	**1159.68**	**1159.77**	**1159.98**	**1160.13**	**1160.27**
W29	None present	None present	1160.81	-	Start Lake Wausau Drawdown	-	1159.64	1159.15	1158.77	1158.67	1158.46	1158.46	1159.98	1159.24	1158.97	1158.94	1158.61	1158.45	1158.36	1158.29	1158.45	1158.89	1159.49	1160.59	1161.01	1160.92	1160.89
W39	1160.3	1159.5	1162.76	1162.59		1162.66	1162.7	1162.62	1162.52	1162.36	1162.25	1162.19	1162.04	1161.95	1161.88	1161.8	1161.67	1161.61	1161.53	1161.39	1161.31	1161.25	1161.15	1161.18	1161.07	1161.22	1161.17
W45	1161	1156	1163.35	-		-	1163.51	1163.45	1163.32	1163.16	1162.98	1162.74	1162.47	1162.34	1162.25	1162.07	1161.88	1161.74	1161.63	1161.44	1161.31	1161.18	1161.12	1161.01	1161.02	1161.1	1161.34
W3A	1160.5	1159.2	1161.81							1160.95										**1159.93**							
W17	1160.5	1159.2	1162.05							1161.19										**1160.09**							
W18	None present	None present	1160.98							1159.06										1158.63							
W26	None present	None present	1160.98							1159.22										1158.65							
W40	1160	1159.6	1161.63							1160.72										1159.76[1]							

Lake Wausau Stage Notes: Oct. 4: 4.8 ft. drawdown in Lake Wausau.
Oct. 18: Large amount of rain north of Wausau resulted in 3-4 ft rise in river level.
Nov. 15: Refilling started at 2"/day, increasing to 6"/day by Nov. 19.

Bold = Groundwater elevation below top of residual phase product
Bold Italics = Groundwater elevation below bottom of residual phase product

Footnotes:
(1) Only apparent product thickness detected was at well W40 on 11/14/2016.

Well	Head Changes from July 9, 2016 Groundwater Elevations																										
W10A					-1.03	-1.43	-1.75	-1.91	-2.16	-2.23	-0.87	-1.5	-1.67	-1.84	-2.05	-2.24	-2.37	-2.56	-2.36	-1.94	-1.41	-0.42	0.02	-0.03	-0.08
W11			0.13		-0.04	-0.39	-0.79	-1.18	-1.51	-1.72	-1.86	-1.37	-1.37	-1.55	-1.72	-1.85	-1.98	-2.09	-2.21	-2.28	-2.09	-1.88	-1.01	-0.44	-0.3	-0.27
W12			0.12		0.02	-0.25	-0.58	-0.87	-1.16	-1.33	-1.46	-1.13	-1.15	-1.29	-1.43	-1.53	-1.64	-1.75	-1.88	-1.95	-1.79	-1.57	-0.87	-0.44	-0.32	-0.28
W14			0.13		0.04	-0.22	-0.54	-0.93	-1.25	-1.48	-1.63	-1.32	-1.35	-1.5	-1.65	-1.77	-1.89	-2	-2.13	-2.19	-2.04	-1.8	-0.99	-0.48	-0.32	-0.27
W21			0.28		-0.26	-0.99	-1.58	-2.01	-2.17	-2.35	-2.41	-1.07	-1.68	-1.92	-1.9	-2.3	-2.44	-2.54	-2.61	-2.52	-2.05	-1.51	-0.33	0.08	0.03	0.02
W22						-0.14	-0.28	-0.51	-0.81	-0.99	-1.12	-1.22	-1.16	-1.25	-1.35	-1.45	-1.48	-1.63	-1.8	-1.76	-1.89	-2	-1.91	-1.7	-1.55	-1.41
W29						-1.17	-1.66	-2.04	-2.14	-2.35	-2.35	-0.83	-1.57	-1.84	-1.87	-2.2	-2.36	-2.45	-2.52	-2.36	-1.92	-1.32	-0.22	0.2	0.11	0.08
W39			-0.17		-0.1	-0.06	-0.14	-0.24	-0.4	-0.51	-0.57	-0.72	-0.81	-0.88	-0.96	-1.09	-1.15	-1.23	-1.37	-1.45	-1.51	-1.61	-1.58	-1.69	-1.54	-1.59
W45						0.16	0.1	-0.03	-0.19	-0.37	-0.61	-0.88	-1.01	-1.1	-1.28	-1.47	-1.61	-1.72	-1.91	-2.04	-2.17	-2.23	-2.34	-2.33	-2.25	-2.01
W3A									-0.86										-1.88							
W17									-0.86										-1.96							
W18									-1.92										-2.35							
W26									-1.76										-2.33							
W40									-0.91										-1.87							



Prepared by: K. Quinn 3/24/2017
Checked by: T. Dushek 3/29/2017

Attachment B

LNAPL Site Management Evaluation

Attachment B
LNAPL Site Management Evaluation
Wauleco Project Site, Wausau, Wisconsin
May 31, 2019

This document presents the proposed light, nonaqueous-phase liquid (LNAPL) site management evaluation for the Wauleco Project Site. Mobile phase LNAPL has been addressed to the extent practicable at the Wauleco site. There is no further expectation that active mobile phase LNAPL/product recovery efforts continue. Rather, Wauleco and WDNR's focus has moved to the dissolved-phase component and the residual phase LNAPL that is a source of PCP to the dissolved phase. Consequently, this document focuses on residual phase LNAPL as a source to the groundwater dissolved-phase constituents of concern (i.e., PCP). This document is based on the approach presented in the Interstate Technology Regulatory Council (ITRC) Technical/Regulatory Guidance document titled "Light Non-Aqueous Phase Liquid (LNAPL) Site Management: LCSM Evolution, Decision Process, and Remedial Technologies." dated March 2018 (LNAPL Guidance) and presents a proposed remedial strategy consistent with that approach.

The LNAPL Guidance "provides a systematic framework to: develop a comprehensive LCSM…, establish appropriate LNAPL remedial goals…, select remedial technologies that will best achieve the LNAPL remedial goals…." The LNAPL Guidance recommends several fundamental steps in developing an appropriate LNAPL remedial strategy to move LNAPL sites toward an end point. These steps, outlined in Section 1 of the LNAPL Guidance are as follows:

1. Develop a comprehensive LNAPL Conceptual Site Model (LCSM).
2. Establish appropriate and achievable LNAPL remedial goals for the site.
3. Inform stakeholders of the applicability and capability of various LNAPL technologies.
4. Select remedial technologies that will best achieve the LNAPL remedial goals.
5. Develop an LNAPL remedial strategy designed to achieve the LNAPL remedial objectives.
6. Evaluate the implemented remedial technologies to measure progress toward an identified technology specific endpoint.

Prior to addressing these steps, this document summarizes background information specific to the Wauleco project site to provide necessary foundation for the development of an appropriate site-specific LNAPL remedial strategy.

Wauleco Background Information[1]

As presented and/or discussed with the WDNR previously, relevant background information associated with the Wauleco Site demonstrates that potential exposure pathways to receptors are, or can be, addressed. The media evaluated for the Wauleco site include the following:

1. **Direct Contact with Contaminated Soils on the Wauleco Property –** Residual soil contamination above the industrial direct contract residual contaminant level (RCL) can be addressed by a soil performance standard per NR 720 for the direct contact pathway by capping the contaminated soil with an appropriate barrier to limit exposure. The barrier will consist of: 1) an engineering control in the form of a cover, the final configuration of which is yet to be determined (in part because future redevelopment of the Site is not yet known), will be placed, at a minimum, over the former soil mound/former dip tank area. In the interim, the site is fenced, with limited access: a cover consisting of a geotextile fabric and 6-inches of gravel has been placed over the area of the former soil mound; and 2) the existing chip-seal paving will serve as a barrier for the remainder of the Site.
2. **Use of Contaminated Groundwater on or Downgradient of the Wauleco Property –** Based on the results of a well survey with the Department of Agriculture Trade and Consumer Protection, there are no known private or public wells within the extent of PCP in groundwater. In addition, the City of Wausau Municipal Code, Chapter 19.30 regulates the construction and use of private wells. This code would not allow a new well to be installed within the limits of the groundwater plume. Furthermore, there are no public wells located south of Bridge St., which is several thousand feet north of Wauleco. There are no groundwater users between the Wauleco property and the downgradient natural discharge to the Wisconsin River. In addition, the depth to groundwater is greater than 20 ft. below the buildings downgradient of the Site. None of these buildings are large enough to expect to have a foundation or other structure that extends to groundwater. Therefore, exposure to groundwater is an incomplete pathway.
3. **Vapor Intrusion –** An assessment of potential vapor intrusion risks was conducted by TRC (April 16, 2019 letter report to WDNR) that concluded there are no potentially complete vapor intrusion pathways associated with the Wauleco Site.
4. **Preferential Migration in Utility Corridors –** A May 31, 1990 Keystone Hydrogeologic Investigation Report included an assessment of utility corridors on and around the Site, including borings installed around sewers. They concluded the utility corridors were not preferential migration pathways.
5. **Sanitary Sewer Interceptor –** A City of Wausau sanitary sewer interceptor was identified as receiving PCP inflow from the groundwater on two occasions (1996 and 2019). During 1996 the sewer interceptor was videoed, showing very small inflows at some joints. These joints were sealed and subsequent sampling showed the sanitary sewer to not contain PCP.

[1] To assist in the development and understanding of a LNAPL Conceptual Site Model for the Site, this section provides background on the overall site Conceptual Site Model. As such, it presents information on media and pathways that are not the subject of the Groundwater RAOR, which is focused on immobile residual phase LNAPL and dissolved phase in groundwater.

During 2019, this migration pathway continues to be monitored and actions will be taken by the City, as appropriate.

6. **Groundwater Discharge to Surface Water -** Groundwater flow from the Site occurs to the east and discharges naturally to the Wisconsin River. Considering the concentrations and likely discharge point to be a "diffuse/non-point source" discharge, WDNR concluded that there is no potential for exceedance of surface water quality standards at the point of discharge.

With the foregoing background in mind and the focus on residual phase LNAPL as a source of PCP dissolving into groundwater, we address below the process outlined in the LNAPL Guidance in developing an appropriate LNAPL remedial strategy:

Step 1: Develop a Comprehensive LNAPL Conceptual Site Model

The LCSM relies on the extensive investigation and remedial activities performed at the Wauleco Project Site over the past nearly three decades, that includes 177 soil borings, 75 groundwater monitoring wells installed and monitored, 65 laser induce fluorescence borings and operation of a groundwater and LNAPL recovery system for nearly three decades. A Wauleco LCSM cross section is included as Figure 1. Additional information on the hydrogeological and LCSM for the Wauleco project site is included in Attachment 1.

As discussed in Section 4.1 of the LNAPL Guidance, ASTM identifies three tiers of data collection and analysis to develop LCSMs based on site complexity: Tier 1 – Relatively standard field and lab data, Tier 2 – Detailed vertical profiling and possible LNAPL recoverability pilot testing, and Tier 3 – Extensive data and numerical modeling. The LCSM is deemed adequate (in terms of level of detail) when the collection of additional information regarding the site/LNAPL will not enhance decision making associated with the LNAPL remedial objectives. Data collection at the Wauleco Project Site approximates Tier 2, utilizing a large number of groundwater monitoring wells and LIF points, both on and off site, and a long history of groundwater and LNAPL extraction.

As discussed in Section 5.2 of the LNAPL Guidance, LNAPL remedial objectives, remediation goals, and performance metrics are based on LNAPL concerns identified. As discussed above, because the WDNR concurs that mobile phase LNAPL has been addressed to the maximum extent practicable, and current and future receptors have been, or can be addressed at the point of regulatory closure, concerns are associated with the residual phase LNAPL and dissolved-phase components.

Site and LNAPL Conditions:

Based on the LCSM and geologic/hydrogeologic conditions described above and in Attachment 1, the Site and LNAPL conditions at the Wauleco Project Site are summarized as follows:

- Unsaturated Zone: Sand, and sand and gravel glacial outwash (C)
- Saturated Zone: Sand, and sand and gravel glacial outwash (C)

- Groundwater is Unconfined: the glacial outwash units extend from ground surface to well below the water table in most areas.
- Underlying the sand and gravel outwash is a clay deposit overlying bedrock, that limits the vertical extent of dissolved-phase constituents to the approximately 10 ft. thick saturated glacial outwash sand and gravel.
- Depth to groundwater is approximately 30 ft. bgs (well W8) west (i.e., upgradient) of the Wauleco Project Site, 25 to 28 ft. bgs on-Site, and 19 ft. bgs (well W10A) east (i.e., downgradient) of the Wauleco Project Site near the Wisconsin River. In the park north of W10A, depth to groundwater is about 10 ft. bgs.
- Natural groundwater flow is towards, and discharges to, the Wisconsin River located approximately 500 ft. to 900 ft. east of the Site.
- LNAPL is predominantly mineral spirits, that originally contained 85% mineral spirits, 10% inerts, and 5% PCP. The PCP concentration was shown to have declined to less than 1% (i.e., 0.77% and 0.05% in two samples of mobile phase LNAPL composited in 2016 and 2017). Therefore, the bulk LNAPL is light (HV, HS), but contains a semi-volatile, PCP. Additional field work is scheduled for the week of June 3, 2019 to further assess LNAPL characteristics.
- PCP is the principal constituent of concern.

Notes:
C= Coarse soils; sand to gravel
S= Saturated zone
HV, HS = High volatility, high solubility, light LNAPL with significant percentage of volatile soluble constituents

LNAPL Concern:

For the Wauleco Project Site, the LNAPL concern is: Residual immobile LNAPL is a continuing source to the dissolved-phase groundwater which discharges to surface water.

Step 2: Establish Appropriate and Achievable LNAPL Remedial Goals for the Site

As discussed in Section 5.2 of the LNAPL Guidance, once concerns are identified, LNAPL remedial goals and objectives are set to address the LNAPL concerns at the site, to the extent appropriate and achievable.

LNAPL Remedial Objective:

For the Wauleco Project Site, the primary LNAPL remedial objective is (per LNAPL remedial objectives presented in Table 5-1 of the LNAPL Guidance): Abate PCP concentrations in dissolved-phase from the residual phase LNAPL source to a concentration that meets surface water quality standards, for groundwater that discharges to surface water.

As discussed in Section 5.2 of the LNAPL Guidance, the LNAPL remedial objectives are stated as an LNAPL remediation goal to specify the condition or end point to be achieved by the technology group to satisfy the LNAPL remedial objective.

LNAPL Remediation Goals:

For the Wauleco Project Site, the primary LNAPL remediation goal is (per Table 5-1 of the LNAPL Guidance that lists example LNAPL remediation goals for example LNAPL remedial objectives): Achieve dissolved-phase PCP concentration in groundwater to meet surface water quality standards, for groundwater that discharges to surface water.

As discussed in Section 5.3 of the LNAPL Guidance, for each LNAPL remediation goal, one or more performance metrics are defined. Performance metrics are measurable characteristics that relate to the remedial progress of a technology in abating the concern.

Performance Metric:

For the Wauleco Project Site, the performance metric is (per performance metric examples presented in Table 5-2 of the LNAPL Guidance): PCP dissolved-phase plume is stable or decreasing. End Point: PCP dissolved-phase concentrations meet surface water quality standards, for groundwater that discharges to surface water.

Step 3: Inform Stakeholders of the Applicability and Capability of Various LNAPL Technologies

This Technical Memorandum, and a subsequent Groundwater RAOR, are intended to inform stakeholders of the applicability and capability of various LNAPL technologies.

Step 4: Select Remedial Technologies That Will Best Achieve the LNAPL Remedial Goals

Many LNAPL remedial technologies exist, each with unique applicability and capability. Ideally, the degree of LNAPL remediation is commensurate with that warranted to satisfy applicable risk or non-risk-based federal and state regulations and overall project objectives. The selected LNAPL remedial technology should align with the particular LNAPL remedial objective and LNAPL remediation goal. Section 6 of the LNAPL Guidance explains the technology selection process, which consists of a three-step screening process: Step 1. General Screening; Step 2. Refinement of the Remedy Selection LCSM; and, Step 3. Detailed Screening of Technologies.

Step 1 - General Screening:

As discussed in Sections 5 and 6.1 of the LNAPL Guidance, once the applicable remedial objective and remediation goals have been identified, then Step 1 - General Screening of the technologies listed in the LNAPL Guidance is conducted based on their conceptual potential to achieve the remedial objectives, given the site and LNAPL conditions. The LNAPL Guidance (refer to Section 6.2 of the LNAPL Guidance) provides that this screening should be

accomplished by identifying the technologies listed in Table 6.3 for those remedial objective, and LNAPL remediation goals, matching the footnoted conditions. However, the remediation objective included in Table 6.3 considers LNAPL in general, including both mobile phase and residual phase, whereas, immobile residual phase LNAPL is the LNAPL of concern at Wauleco. Technologies limited to mobile phase LNAPL will be screened out in Step 3, below. For the Wauleco Project Site, the Step 1 - General Screening is summarized as follows:

Step 1 - General Screening

LNAPL REMEDIAL OBJECTIVE	LNAPL REMEDIATION GOAL	TECHNOLOGY GROUP	EXAMPLE PERFORMANCE METRICS	LNAPL TECHNOLOGY AND LNAPL SITE CONDITIONS For conditions[1] F, C, U, S, HV, HS, technologies include:
Abate PCP concentrations in dissolved-phase from the residual phase LNAPL source to a concentration that meets surface water quality standards.	Achieve dissolved-phase PCP concentration in groundwater to meet surface water quality standards.	LNAPL Phase Change	PCP dissolved-phase concentrations meet surface water quality standards.	MPE - Multiphase Extraction
				Steam Injection
				Thermal Conduction Heating
				Electrical Resistance Heating
				AS/SVE – Air sparging/soil vapor extraction
				Biosparging/bioventing
				ISCO – In Situ Chemical Oxidation
				Enhanced Anaerobic biodegradation
				NSZD – Natural Source Zone Depletion
				Activated Carbon
				Phytotechnology
				Surfactant Enhanced Subsurface Remediation (SESR)[2]

Notes:

1. Conditions outlined in Table 6.3 of the LNAPL Guidance
   F = Fine-grained soils; clay to silt
   C= Coarse soils; sand to gravel
   U= Unsaturated zone
   S= Saturated zone
   HV, HS = High volatility, high solubility, light LNAPL with significant percentage of volatile soluble constituents
2. SESR included as a technology based on WDNR comments

Step 2 - Refinement of the Remedy Selection LCSM

As discussed in Section 6.2.2, Step 2 the initial LCSM should be reviewed to determine whether data for the questions described in Section 4.4 of the LNAPL Guidance is available. These questions and Wauleco data are as follows:

1. Where is the source mass: At Wauleco the source mass (i.e., the residual phase LNAPL) is present in reasonably homogenous permeable soils at and below the water table.

2. What is the nature of the source: The LNAPL consists of mineral spirits with PCP, originally at a concentration of 5%.
    a. This LNAPL is volatile and soluble and the PCP is not volatile but is soluble.
    b. Both the LNAPL and the PCP are biodegradable as illustrated in the Wauleco Annual Groundwater Monitoring Reports.
    c. Mobile vs. residual fractions – As described above, the LNAPL is in residual phase.
3. What is achievable for a given technology?
    a. Mobility Based Limit – As described above the practical limit of LNAPL recovery has already been achieved.
    b. Volatility Based Limit – Given that PCP is not volatile, technologies relying on volatility are not applicable.
    c. Solubility – Both the mineral spirits constituents and PCP are sufficiently soluble in groundwater for migration from the residual phase LNAPL into groundwater.
    d. Biodegradability Based Limit – PCP has been shown to be biodegradable through observations in the groundwater and through reduction of the PCP concentration in the recovered LNAPL.

Step 3 - Detailed Screening of Technologies

The technologies identified in Step 1 are carried forward to Step 3, utilizing the Wauleco LCSM, as further refined in Step 2, to further screen the technologies using the detailed screening tables included in Appendix A of the LNAPL Guidance. Tables referenced in the following comments are to tables in Appendix A of the LNAPL Guidance.

Step 3 – Detailed Screening of Technologies

LNAPL TECHNOLOGY	COMMENT
MPE - Multiphase Extraction	As described in Table A-5.A, this technology removes both vapor and LNAPL liquids from mobile phase LNAPL. At Wauleco, there is no mobile phase LNAPL, so that portion of the technology is not applicable to residual phase LNAPL. Removal of vapor will not remove PCP, as it is not volatile, so this portion of the technology is not applicable either. Therefore, this technology is not carried forward.
Steam Injection	As stated in Table A-9.A, steam injection is more effective in stratified LNAPL settings where a low permeability layer can help to control steam distribution. Even the approximate 10 ft. of saturation above the clay layer at Wauleco is much too thick and much too permeable for steam injection to be a feasible method for achieving the LNAPL composition changes desired. Therefore, this technology is not carried forward.
Thermal Conduction Heating	As stated in Table A-10.A, thermal conduction heating consists of applying heat and vacuum simultaneously to heat soil and mobilize and volatilize LNAPL and it is effective in less permeable soils. Given the permeability of the soils at Wauleco this is not an applicable technology and is not carried forward.
Electrical Resistance Heating	Same as for thermal conduction heating, with reference to Table A-11.A, and is not carried forward.
AS/SVE – Air sparging/soil vapor extraction	As described in Table A-13.A. AS/SVE utilizes the volatility to mobilize LNAPL constituents into the vapor phase for recovery via SVE. PCP is not volatile, so this technology is not applicable to Wauleco and is not carried forward.

Step 3 – Detailed Screening of Technologies

LNAPL TECHNOLOGY	COMMENT
Biosparging/bioventing	Biosparging/bioventing would be applicable for degrading the mineral spirits, however, as demonstrated in the above ground biological treatment system, operated at Wauleco, PCP is degraded in a mixed, but primarily anaerobic environment. Therefore, this aerobic biological treatment approach is not applicable and not carried forward.
ISCO – In Situ Chemical Oxidation	ISCO is applicable and carried forward.
Enhanced Anaerobic Biodegradation	Enhanced Anaerobic Biodegradation is applicable and carried forward.
NSZD – Natural Source Zone Depletion	NSZD is applicable and carried forward.
Activated Carbon	As described in Table A-18.A, this technology is applied as a permeable reactive barrier wall to adsorb and promote biodegradation of the contaminants in groundwater. Therefore, this technology is carried forward as a permeable reactive treatment wall.
Phytotechnology	As described in Table A-19.A, this technology can provide hydraulic control and assist with biodegradation in the root zone. However, groundwater migration rates and depth to groundwater are such that this technology is not applicable and is not carried forward.
Surfactant Enhanced Subsurface Remediation (SESR)	As described in Table A-7.A, this technology can satisfy the objective of LNAPL phase change and mobilization and is carried forward in this screening evaluation.

Summary:

In summary, based on the remedial technology screening and selection process described in the LNAPL Guidance, the following technologies are carried forward from this preliminary screening process.

- In Situ Chemical Oxidation (ISCO)
- Enhanced Anaerobic Degradation
- Natural Source Zone Depletion (NSZD)
- Activated Carbon (as a permeable treatment wall)
- Surfactant Enhanced Subsurface Remediation (SESR)

List of Attachments:

- Attachment 1 – Hydrogeological and LNAPL Conceptual Site Model Information for Wauleco Project Site
- Figure 1 – LCSM Cross Section
- Figure 2 – Areal Extent of Residual Phase LNAPL

Attachment 1
Hydrogeologic and LNAPL Conceptual Site Model Information for Wauleco Project Site

Hydrogeologic and LNAPL Conceptual Site Model:

The geologic/hydrogeologic conditions and LNAPL occurrence and behavior at the Wauleco Project Site are summarized as follows:

Hydrogeology

- Unsaturated Zone: Sand, and sand and gravel glacial outwash.
- Saturated Zone: Sand, and sand and gravel glacial outwash.
- Groundwater is Unconfined: the glacial outwash units extend from ground surface to well below the water table in most areas.
- Underlying the sand and gravel outwash is a clay deposit overlying bedrock, that limits the vertical extent of dissolved-phase constituents to the approximately 10 ft. thick saturated glacial outwash sand and gravel.
- Depth to groundwater is approximately 30 ft. bgs (well W8) west (i.e., upgradient) of the Wauleco Project Site, 25 to 28 ft. bgs on-Site, and 19 ft. bgs (well W10A) east (i.e., downgradient) of the Wauleco Project Site near the Wisconsin River. In the park north of W10A, depth to groundwater is about 10 ft. bgs.
- Natural groundwater flow is toward and discharges to the Wisconsin River/Lake Wausau located approximately 500 ft. to 900 ft. east of the Site.

LNAPL Properties

- LNAPL is predominantly mineral spirits, with 10% inerts, and 5% PCP. Therefore, the bulk LNAPL is light, but contains a semi-volatile, PCP.
- PCP is the principal constituent of concern based on its NR-140 ES (1 ug/L), and solubility in groundwater (14,000 ug/L 2016 EPA[2]).
- PCP concentration in LNAPL appears to have declined from 3.2% in 1986 (Keystone, 1986 Site Characterization Report, Sept. 1986) to <0.1% in September 2010 or <1% in 2018 based on waste LNAPL testing.
- Mineral spirits constituents are minor, secondary constituents of concern compared to PCP based on their higher NR-140 ES (i.e., Naphthalene – 100 ug/L, trimethylbenzenes, total – 480 ug/L, xylenes, total – 2,000 ug/L)
- Physical/hydraulic testing of soil and LNAPL in 1992 Keystone[3] indicate the following properties
    - Porosity – 26% to 31%

[2] 2016 EPA. Vapor Intrusion Screening Level Spreadsheet, chemical properties tab, from: https://www.epa.gov/vaporintrusion/vapor-intrusion-database

[3] 1992 Keystone. Addendum Report to Evaluation of Treatment System Alternatives for Product Removal.

- Minimum residual saturation in gas (Sog) 10% of porosity
- Minimum residual saturation in water (Sor) 14% to 17% of porosity
- Irreducible water saturation (Sm) 12% to 23% of porosity

LNAPL Distribution

- Mobile Phase LNAPL
  - The extent of mobile phase LNAPL has been reduced from an area of 302,000 ft^2 in 1997 to 4,000 ft^2 in 2013. This constitutes a 98.6% reduction in mobile phase LNAPL due to the enhanced LNAPL recovery system implemented between 1999 and 2011.
- Residual Phase LNAPL
  - The areal extent of Residual Phase LNAPL was determined via LIF (UVOST) and is presented in Figure 2.
  - Vertical distribution of residual phase LNAPL characterized by LIF, shows:
    - On-Site LIF responses:
      - A thickness of up to 6.0 ft on-Site in the vicinity of groundwater extraction wells.
      - A thickness of up to 2.1 ft. on-Site outside of the immediate influence of groundwater extraction wells.
      - On-Site mobile phase up to 40% of the reference emitter (%RE) in apparent saturated LNAPL at the water table, when saturated LNAPL existed in the 2003 LIF survey.
      - On-Site residual phase up to approximately 42% RE.
    - Off-Site LIF responses:
      - Thickness less than 1 ft.
      - Off-Site residual phase response up to 18% RE, but typically much less.
  - Additional testing is planned to be completed per the Residual Phase LNAPL – Soil Investigation Work Plan (dated April 2019) to help characterize the current physical and chemical characteristics of the residual phase LNAPL.

LNAPL Recovery Behavior

- Mobile phase LNAPL extraction clearly controlled by groundwater elevation, based on LNAPL recovery and groundwater elevation graphs.
- Enhanced LNAPL recovery, between January 1999 and March 2011, was effective in extracting the bulk of the 147,000 gallons of LNAPL recovered to date. Basic recovery method was LNAPL skimming with groundwater depression. Enhancements included:
  - Methods to maintain high LNAPL transmissivity:
    - Maintaining about 1 ft. of LNAPL in extraction wells, to maintain sufficient LNAPL thickness, under normal groundwater fluctuations;

        - Operating groundwater depression 100% of the time when LNAPL recovery was high, to maintain high LNAPL permeability, eliminating influx of water with even short term, small water level rises;
        - Redeveloping wells to remove fouling in LNAPL zone and to maintain groundwater production with limited well losses.
    - Focused pumping in zone of greatest LNAPL persistence, in the southeast of the Site (wells FP1 through FP4).
- Viability of off-Site LNAPL Recoverability via Large Area Drawdown Assessment
    - Lake Wausau Drawdown Study – Lake Wausau was drawn down for dam inspection/maintenance for the first time in more than 60 years, beginning on September 24, 2016 through November 15, 2016. Groundwater elevation and LNAPL thickness monitoring during this period showed:
        - 2.56 ft. (W10A) of drawdown in areas of residual phase LNAPL (more than could be achieved through remedial action pumping technologies)
        - Only one off-Site well (W40) showed a thin, 0.2 ft. accumulation of apparent mobile phase LNAPL, whereas several other wells showed no accumulation.
        - Only thin accumulations of LNAPL were observed at 5 on-Site wells (0.02 to 0.13 ft)
    - This assessment illustrates that the current residual phase LNAPL on and off the Wauleco Site has insufficient saturation to create mobile, recoverable LNAPL using existing remedial pumping/recovery technologies.

NA Assessment

- Degradation of PCP is effective in the above ground bioreactor, with a low DO environment, and is optimized through the introduction of nitrogen, phosphorous, and bacteria.
- Degradation in the above ground reactor is not via reductive dechlorination and exhibits no separate PCP degradation products except for inorganic chloride.
- Concentration-Distance graphs for a flow path outside the capture zone shows a concentration decline within a zone that is within the groundwater travel distance, indicating that there is natural attenuation occurring at a rate faster than possible with adsorption or dispersion, leaving only biodegradation as the only mechanism for natural attenuation.
- Several literature examples illustrate natural attenuation of PCP does occur. One such example (Bosso, 2014[4]) summarizes more than 30 studies that describe and document biodegradation of PCP. These studies show that there are numerous bacteria that degrade PCP, many demonstrating mineralization of PCP with chloride being the only measured decay product.
- Concentration-Time graphs for several well locations, outside of the capture zone, show distinct concentration declines in shorter distances than groundwater would flow in even 10 years, indicating biodegradation must be active as well.

[4] Boss, L. and Gennaro Cristinzio. 2014. A comprehensive overview of bacteria and fungi used for pentachlorophenol biodegradation. Rev. Environ Sci Biotechnol 13L387-427.