Pacific Northwest NATIONAL LABORATORY

CPCCo Central Plateau Cleanup Company

An Amentum-led Partnership with Fluor and Atkins

Hanford 200-PW-1 Operable Unit Soil Vapor Extraction Endpoint Evaluation

January 26, 2021

Christian Johnson and **Mark Byrnes**

Senior Development Engineer   Senior Project Manager

REMPLEX

CENTER FOR THE REMEDIATION OF COMPLEX SITES

@PNNL

U.S. DEPARTMENT OF ENERGY   BATTELLE

PNNL is operated by Battelle for the U.S. Department of Energy

PNNL-SA-159296

Pacific Northwest
NATIONAL LABORATORY

Seminar Overview

Objective: Discuss a performance analysis to determine the endpoint for a soil vapor extraction remedy at Hanford

Take-aways from today's seminar:

- Challenge: How to determine the endpoint for a soil vapor extraction (SVE) remedy? Does the system need optimization? Is a different technology required? Or can the system be terminated, while protecting human health and the environment?
- Approach: Apply guidance for vadose zone volatile organic compound sources—a structured process of evaluating data, estimating impacts, and using decision logic to arrive at an outcome.
- This work demonstrates a successful collaboration of Hanford contractors and Department of Energy/Richland Operations Office (DOE/RL) to provide a sound technical basis to the Environmental Protection Agency (EPA) for making remedial decisions, validating the approach of the guidance document.

REMPLEX
CENTER FOR THE REMEDIATION OF COMPLEX SITES
@PNNL

Pacific Northwest NATIONAL LABORATORY

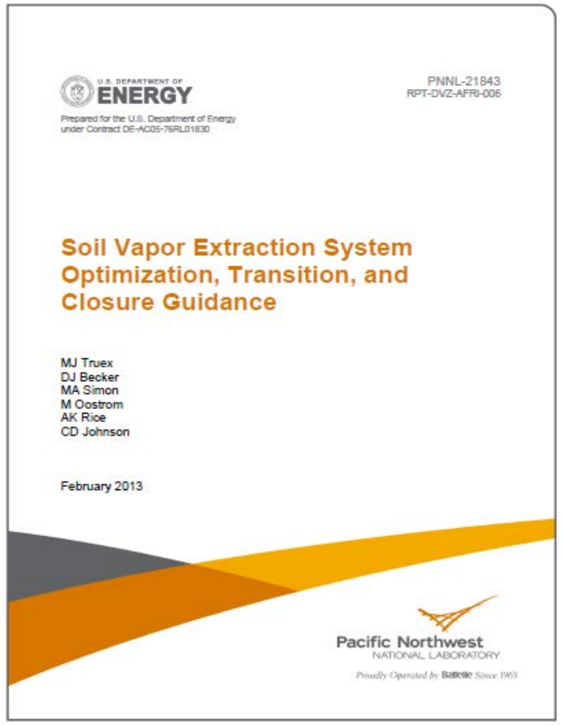
Outline of Discussion

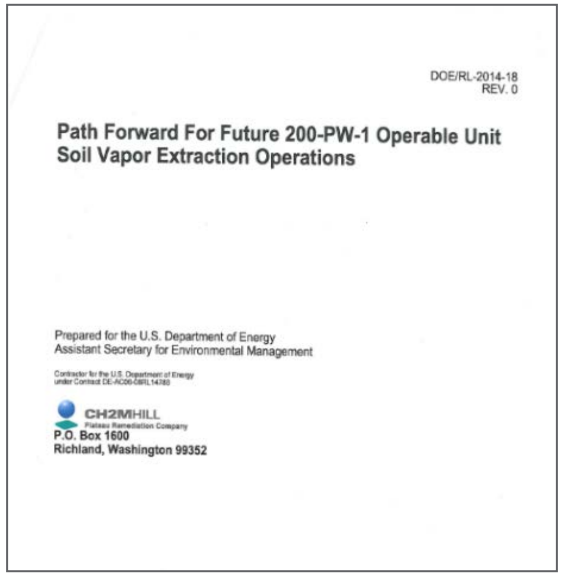
- SVE performance assessment guidance as context for 200-PW-1 OU
- Site background
- Operational history
- Data collection in support of performance assessment
- Conceptual model
- Regulatory context
- Estimated impacts of remaining contamination
- Performance assessment recommendations
- Outcome for the site remedy

REMPLEX CENTER FOR THE REMEDIATION OF COMPLEX SITES @PNNL

Soil Vapor Extraction (SVE) Closure Guidance & Path Forward

- 2013 guidance document on SVE and Vadose Zone Sources
  - *Soil Vapor Extraction System Optimization, Transition, and Closure Guidance* (PNNL-21843)
  - Co-authored by PNNL, U.S. Army Corps of Engineers, and EPA
  - Provides guidance on when is it appropriate to terminate, optimize, or transition SVE operations
- 2013 guidance was the basis for a 2014 "path forward" plan for the 200-PW-1 Operable Unit
  - *Path Forward For Future 200-PW-1 Operable Unit Soil Vapor Extraction Operations* (DOE/RL-2014-18)
  - EPA and DOE agreement on the approach and structure for assessing when to terminate SVE operations

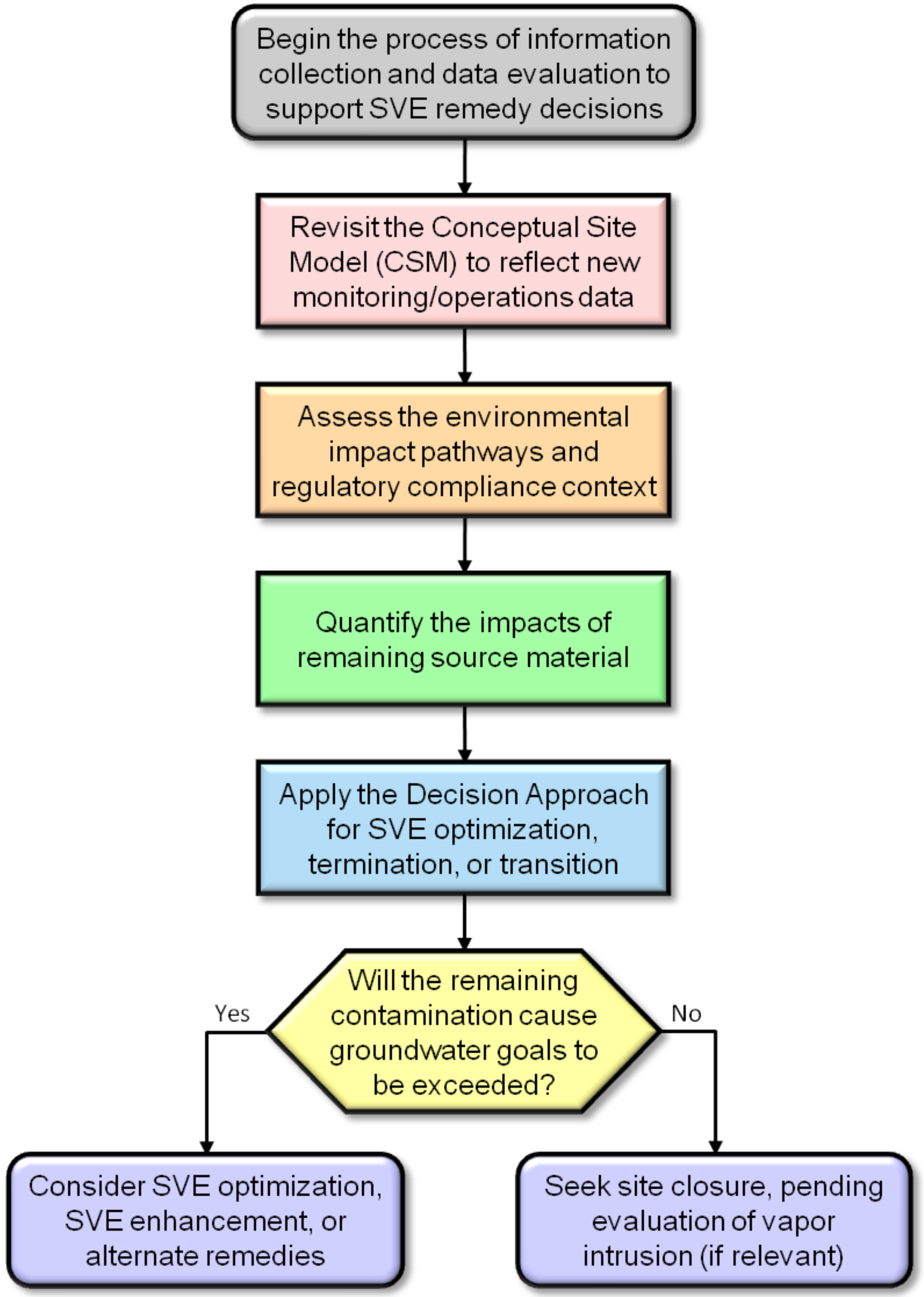

U.S. DEPARTMENT OF ENERGY
PNNL-21843
RPT-DVZ-AFRI-006
Prepared for the U.S. Department of Energy under Contract DE-AC05-76RL01830
Soil Vapor Extraction System Optimization, Transition, and Closure Guidance
MJ Truex
DJ Becker
MA Simon
M Oostrom
AK Rice
CD Johnson
February 2013
Pacific Northwest NATIONAL LABORATORY
Proudly Operated by Battelle Since 1965


DOE/RL-2014-18
REV. 0
Path Forward For Future 200-PW-1 Operable Unit Soil Vapor Extraction Operations
Prepared for the U.S. Department of Energy Assistant Secretary for Environmental Management
CH2MHILL Plateau Remediation Company
P.O. Box 1600
Richland, Washington 99352

REMPLEX
CENTER FOR THE REMEDIATION OF COMPLEX SITES
@PNNL

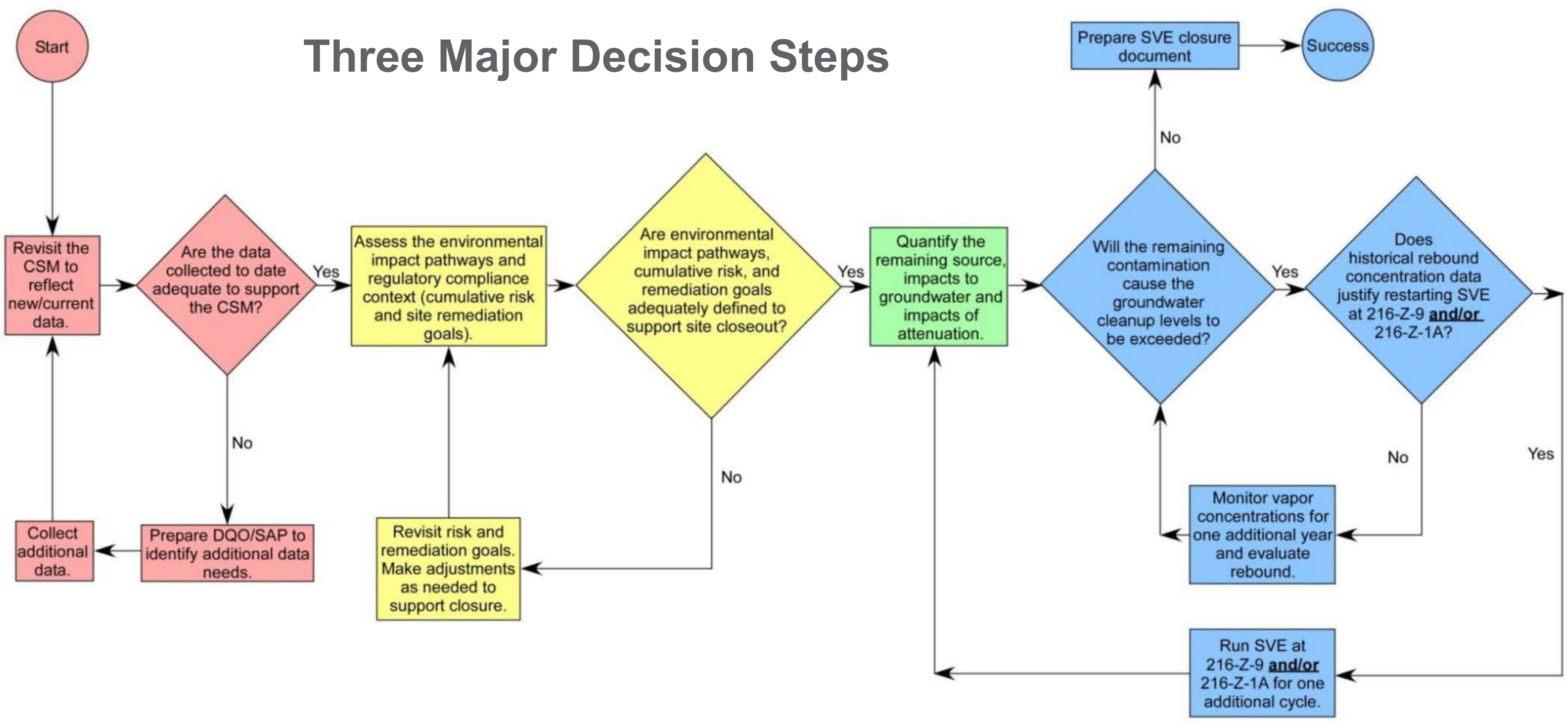
Performance Assessment Process

- Multi-step process to gather required information, assess the information, and make decisions about the remedy
- Revisit conceptual site model (CSM)
- Re-assess environmental pathways and regulatory context
- Quantify impacts of remaining vadose zone contamination
- Apply decision logic to determine if SVE should be terminated, optimized, or transitioned to another remediation technology



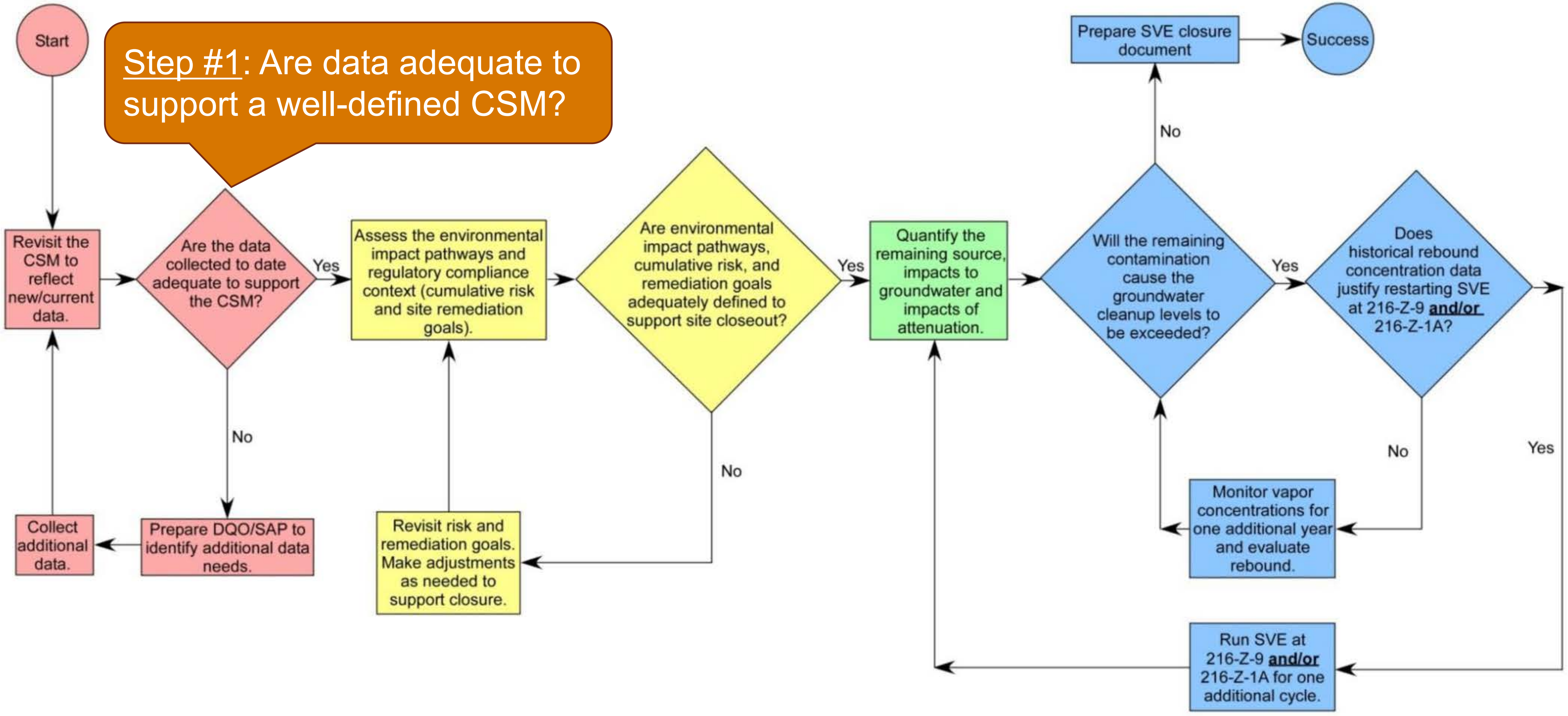
REMPLEX
CENTER FOR THE REMEDIATION OF COMPLEX SITES
@PNNL

Site Specific SVE Closure Assessment
PNNL-21843 Guidance and Path Forward



Site-Specific Flow Chart from the Path Forward Document (DOE/RL-2014-18)
Based on the Process in the SVE Guidance (PNNL-21843)

Site Specific SVE Closure Assessment
PNNL-21843 Guidance and Path Forward

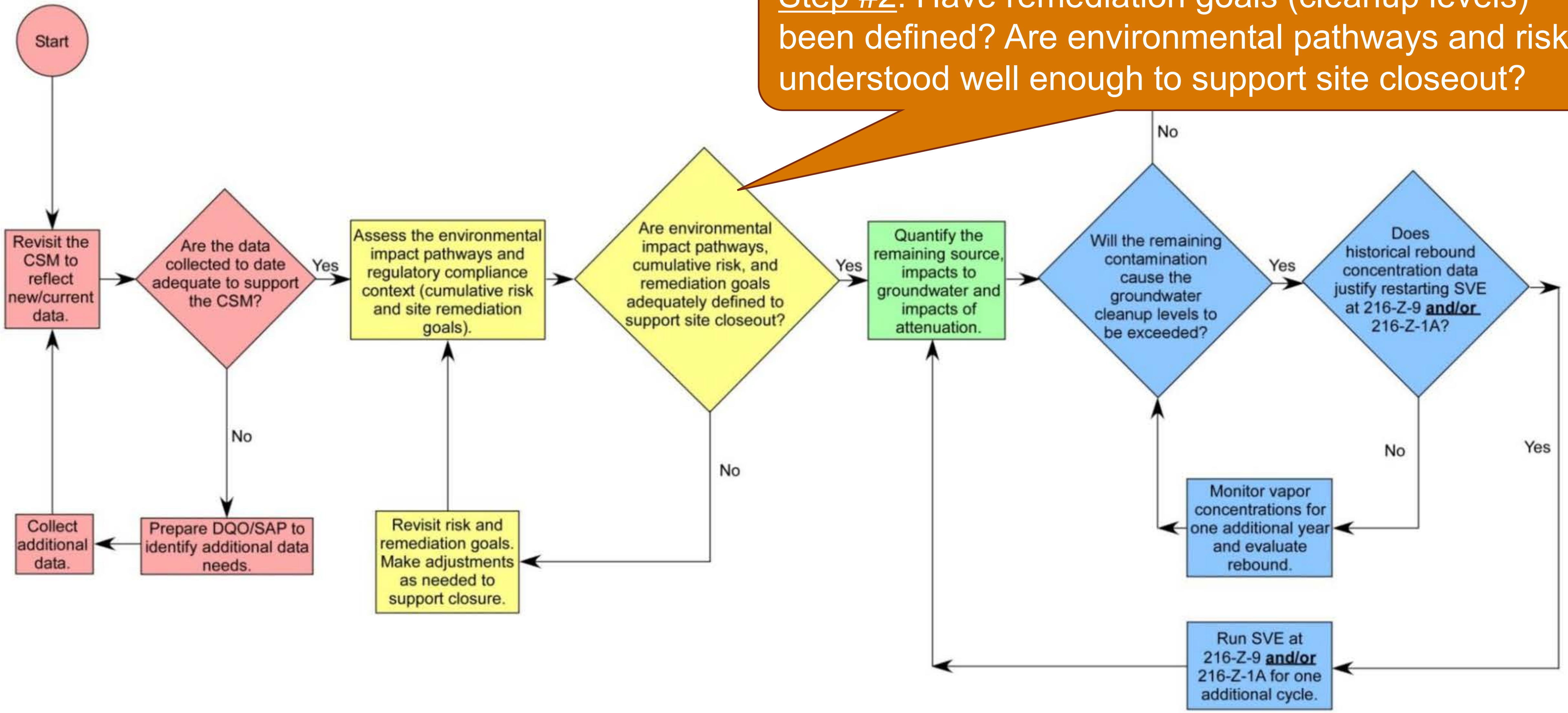


Site-Specific Flow Chart from the Path Forward Document (DOE/RL-2014-18)
Based on the Process in the SVE Guidance (PNNL-21843)

Site Specific SVE Closure Assessment

PNNL-21843 Guidance and Path Forward

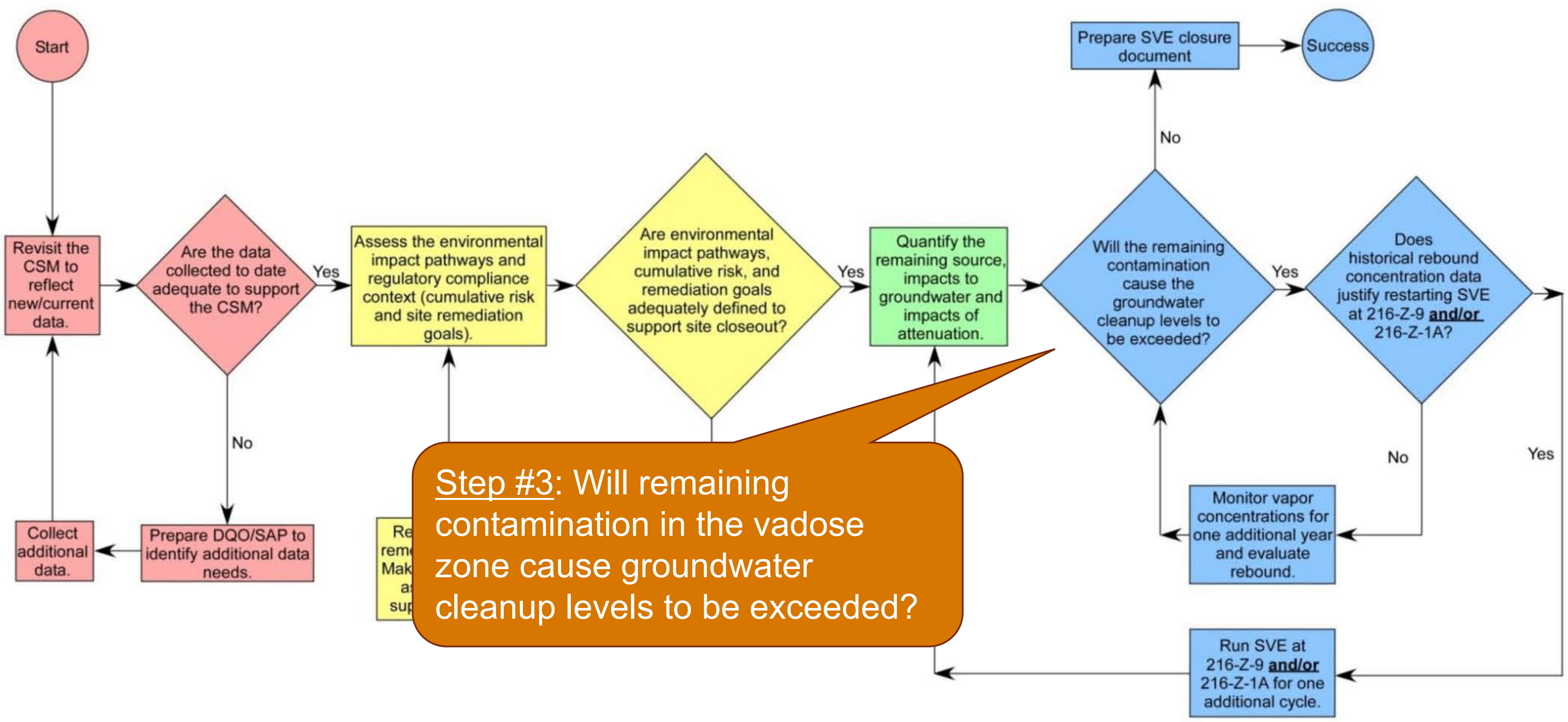
Step #2: Have remediation goals (cleanup levels) been defined? Are environmental pathways and risk understood well enough to support site closeout?



Site-Specific Flow Chart from the Path Forward Document (DOE/RL-2014-18)
Based on the Process in the SVE Guidance (PNNL-21843)

Site Specific SVE Closure Assessment

PNNL-21843 Guidance and Path Forward



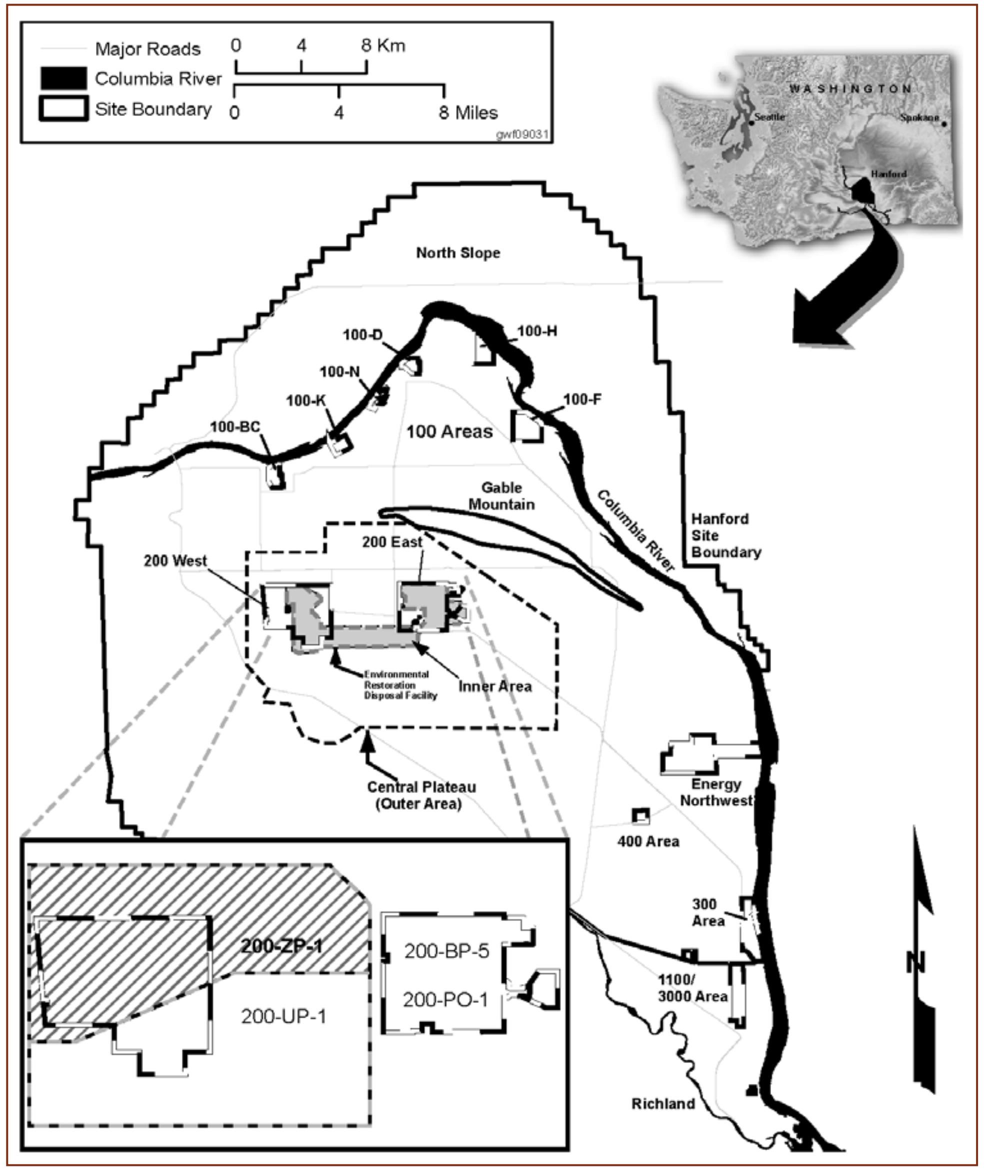
Site-Specific Flow Chart from the Path Forward Document (DOE/RL-2014-18)
Based on the Process in the SVE Guidance (PNNL-21843)

Site Background

The Hanford Site:

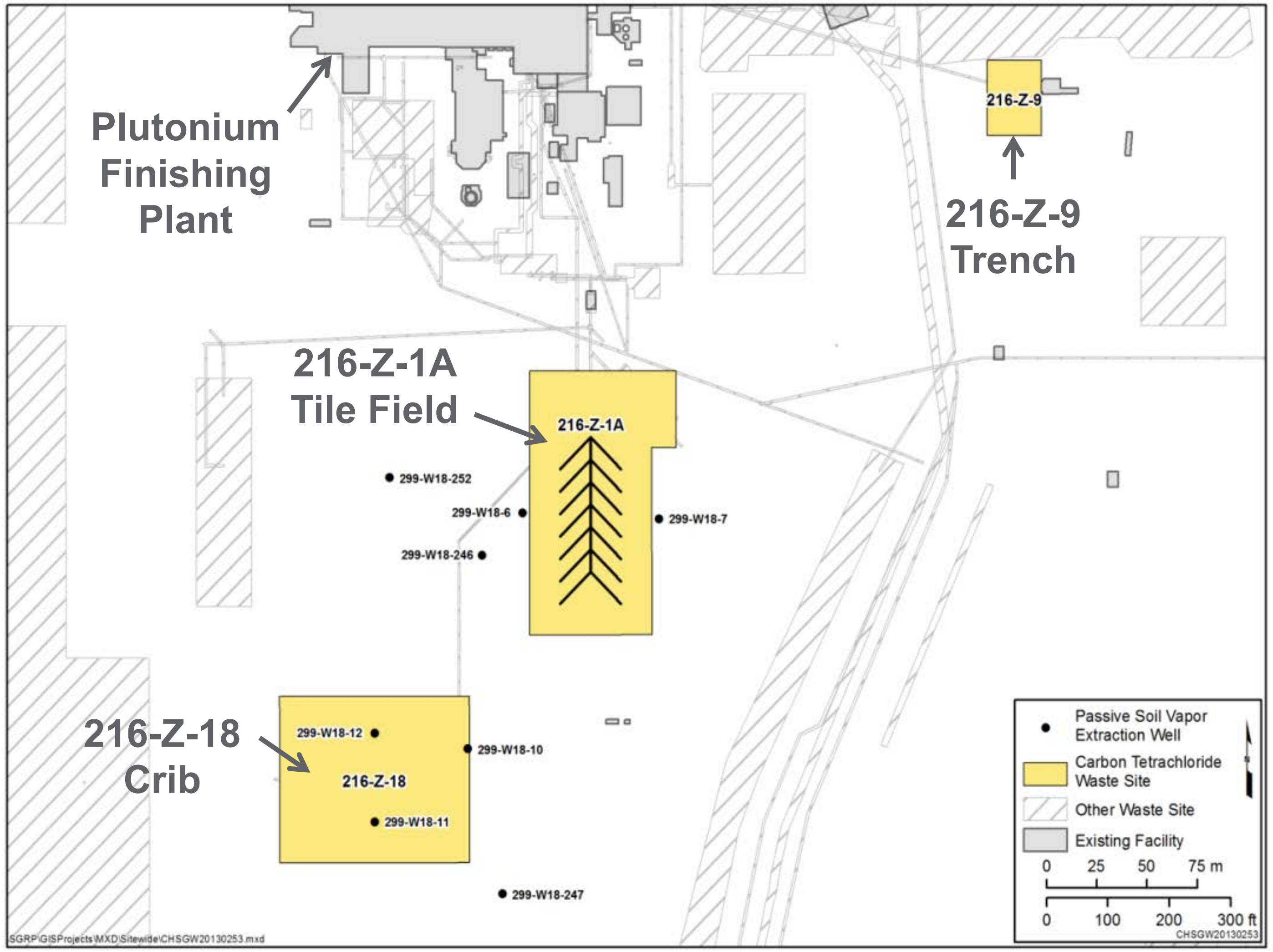
- 586-square-mile site in southeastern Washington State
- Borders the Columbia River
- 40 years of plutonium production, from the 1940s
- Had nine nuclear reactors and associated processing facilities
- World's largest environmental cleanup project

- The 200-PW-1 operable unit (OU) is located on the Central Plateau in the 200 West Area
  - Soil column received liquid waste from plutonium separation operations



200-PW-1 Operable Unit

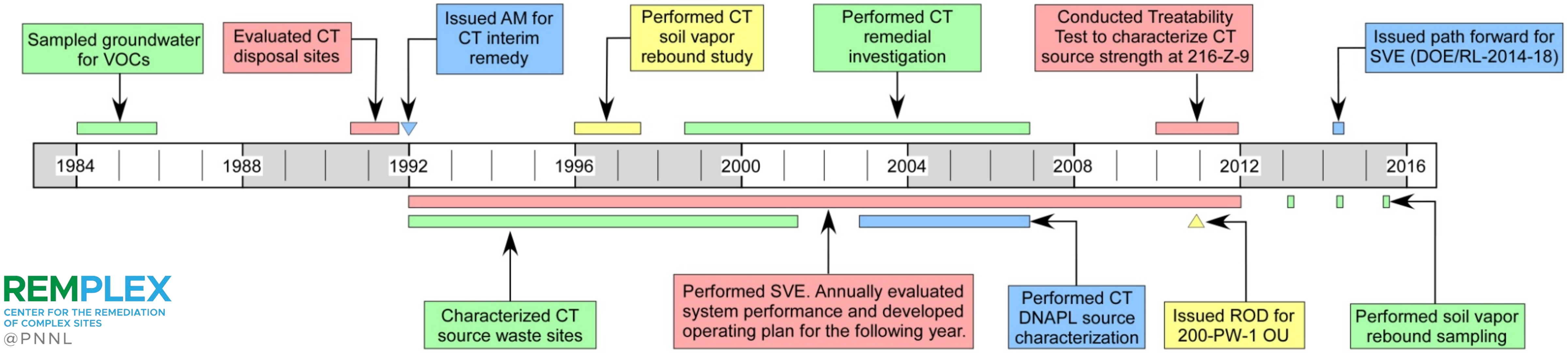
- Liquid waste disposal from 1955-1973
- Aqueous waste containing Carbon tetrachloride (CT)
- Three structures used for disposal
  - 216-Z-9 Trench
  - 216-Z-1A Tile Field
  - 216-Z-18 Crib
- SVE systems were used to recover CT from the vadose zone between 1992 and 2012



REMPLEX
CENTER FOR THE REMEDIATION OF COMPLEX SITES
@PNNL

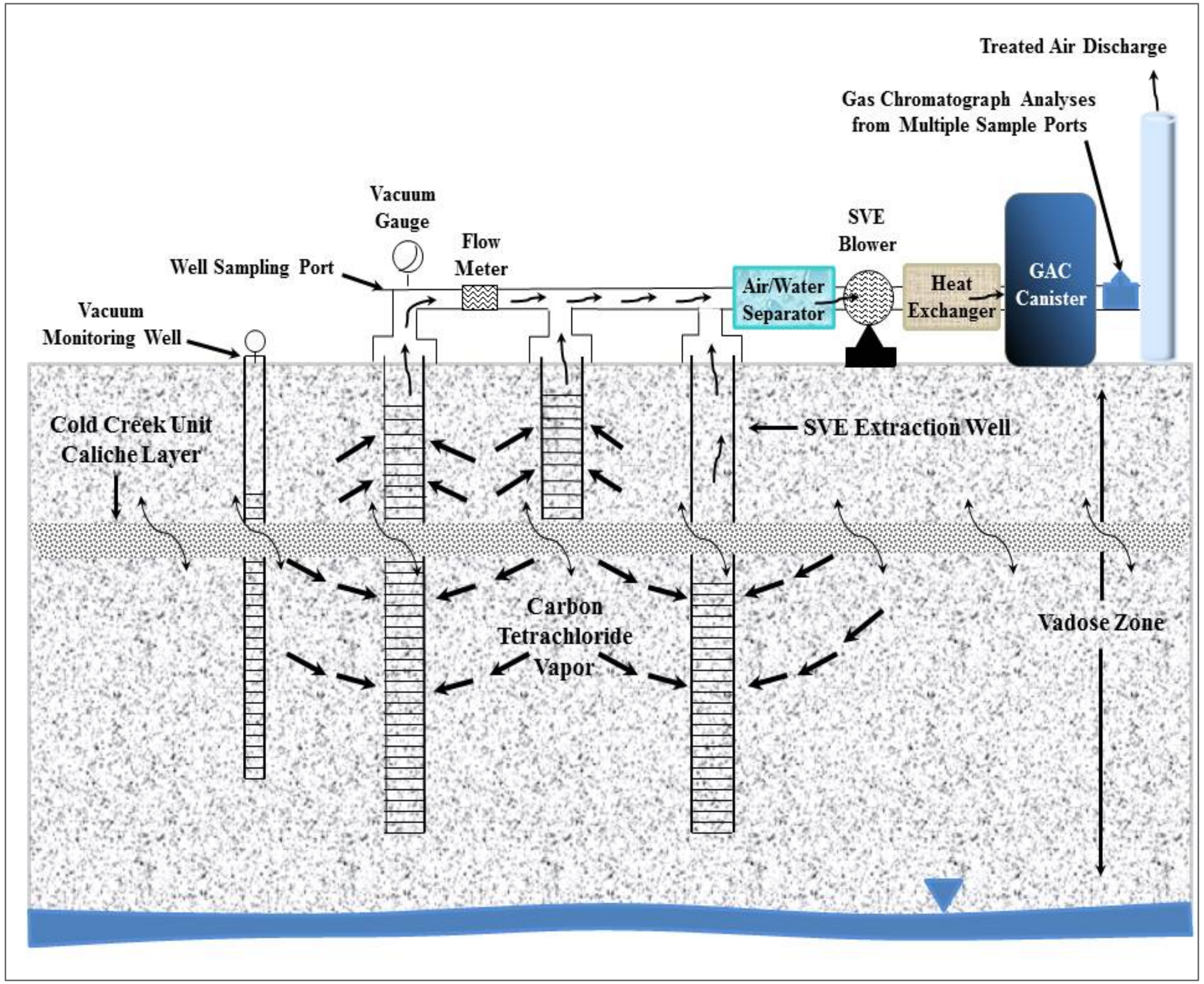
Site Remediation Timeline

- 1992: Action Memorandum was signed by EPA
  - Allowed SVE operations to start as part of an interim action
- 1992-2012: Active SVE operations were performed at all three waste sites
  - More emphasis in later years on the 216-Z-9 Trench and 216-Z-1A Tile Field
- 2000-2013: Passive SVE operations at 216-Z-1A Tile Field and 216-Z-18 Crib
- 2011: Finalized the 200-PW-1 OU Record of Decision (ROD)
  - SVE was selected as part of the final remedial action



Soil Vapor Extraction System Operation

- Vacuum extraction of vapor-phase CT from vadose zone
- Above and below the low permeability caliche layer (CCU)
- Aboveground capture of CT on granular activated carbon



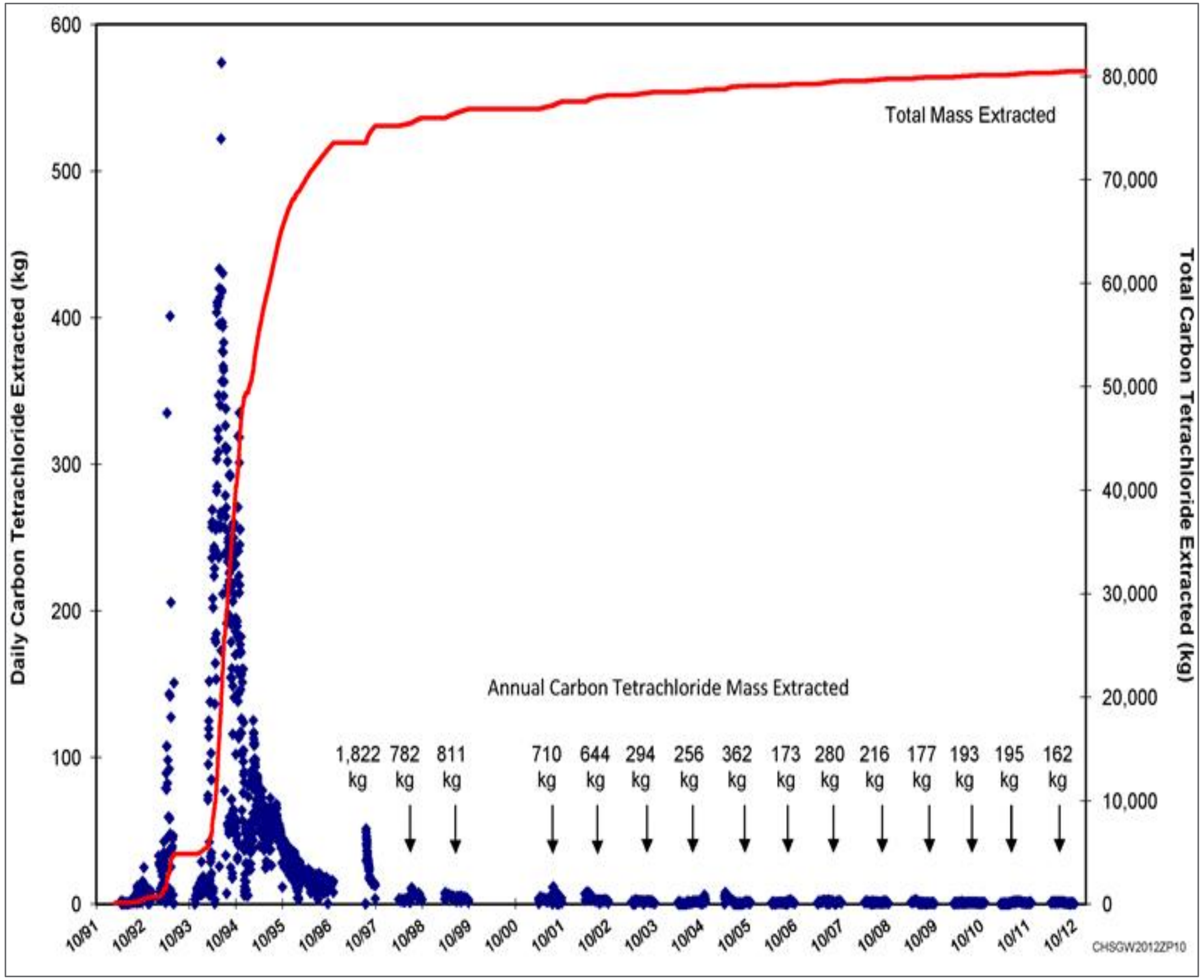
REMPLEX
CENTER FOR THE REMEDIATION OF COMPLEX SITES
@PNNL

Active SVE Operations

- 1992-1997: Three SVE systems (500 cfm, 1,000 cfm, and 1,500 cfm) were operated continuously throughout the year
  - During this period, 74,851 kg of CT were removed
- One-year rebound study performed in 1997
  - Subsequently, a single 500 cfm SVE unit was run 6 months out of the year from 1998-2008, alternating between sites
  - System was in standby mode the remainder of the year to allow vapor to rebound
- Between 2009 and 2012, two 500 cfm SVE units were operated for six to eight months out of the year

CT Removal from Active SVE Operations

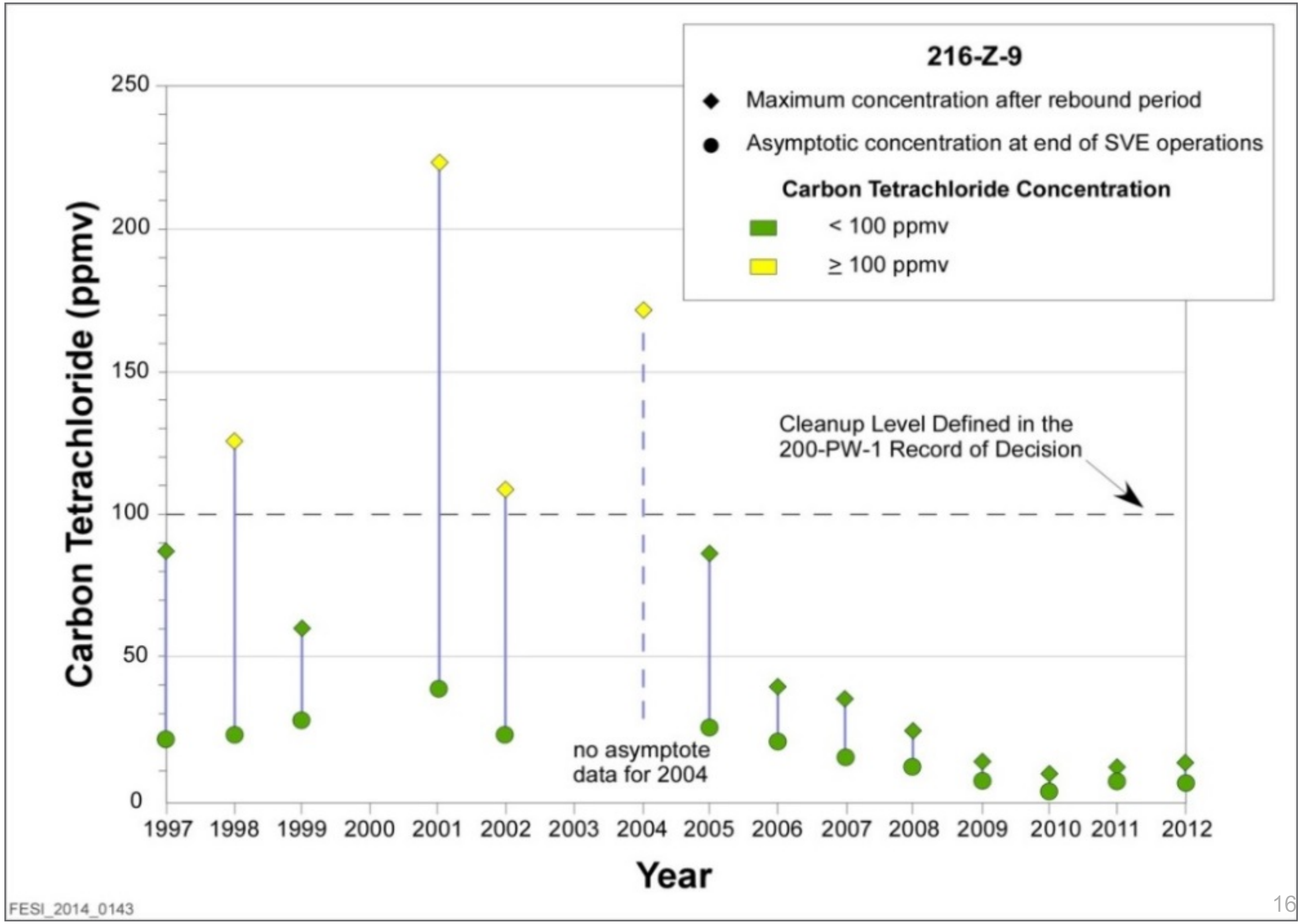
- 80,107 kg of CT mass was recovered through 2012
- 93% of this mass was recovered in the first six years of operations
- Diminishing returns as time went on



REMPLEX
CENTER FOR THE REMEDIATION OF COMPLEX SITES
@PNNL

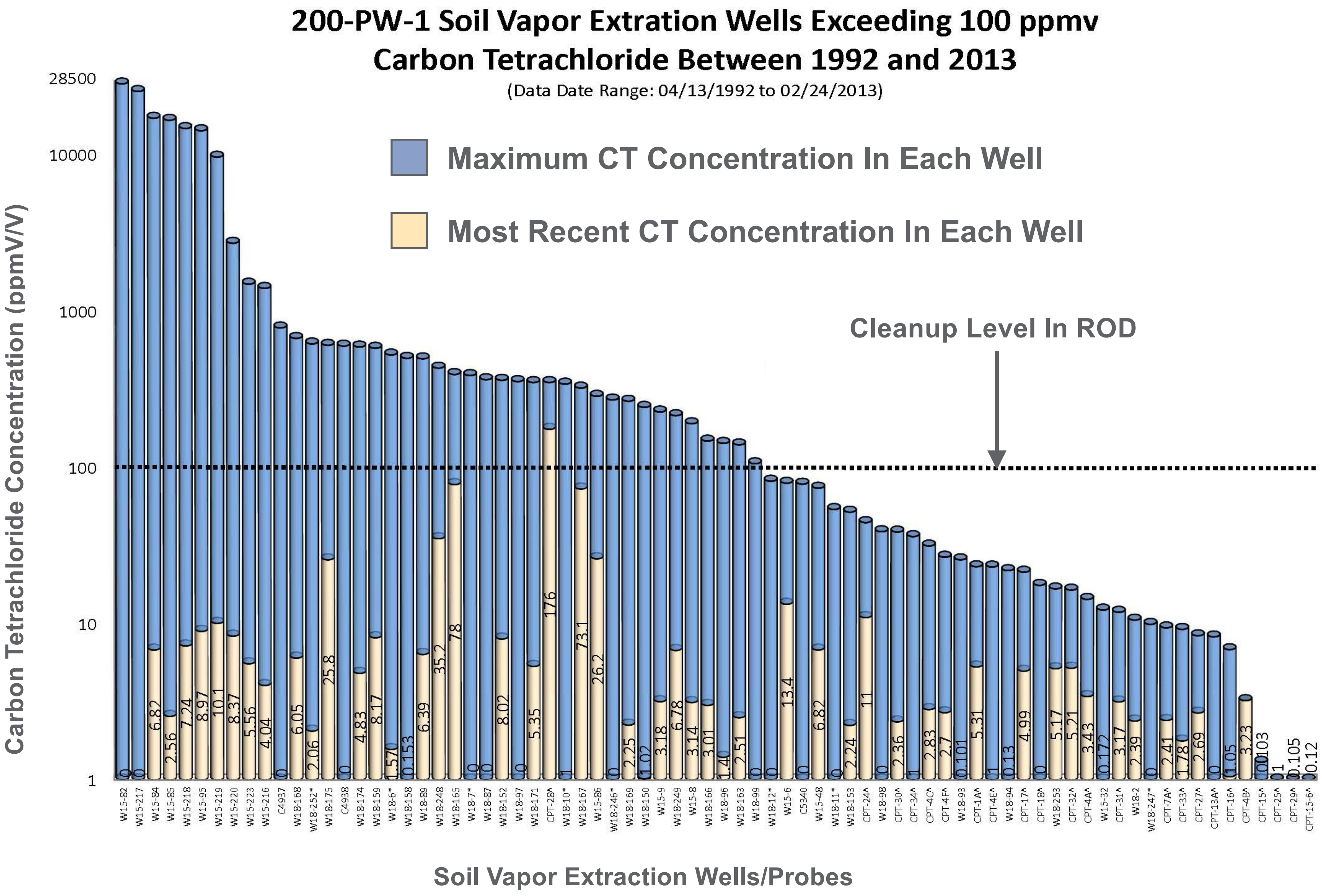
SVE Rebound Operations

- Illustration of the maximum CT concentration at the end of each operational cycle (green circles) and the concentration after a rebound period (yellow and green diamonds)
- Shows a steady decrease in rebound over time



CT Concentrations from 1992 to 2013

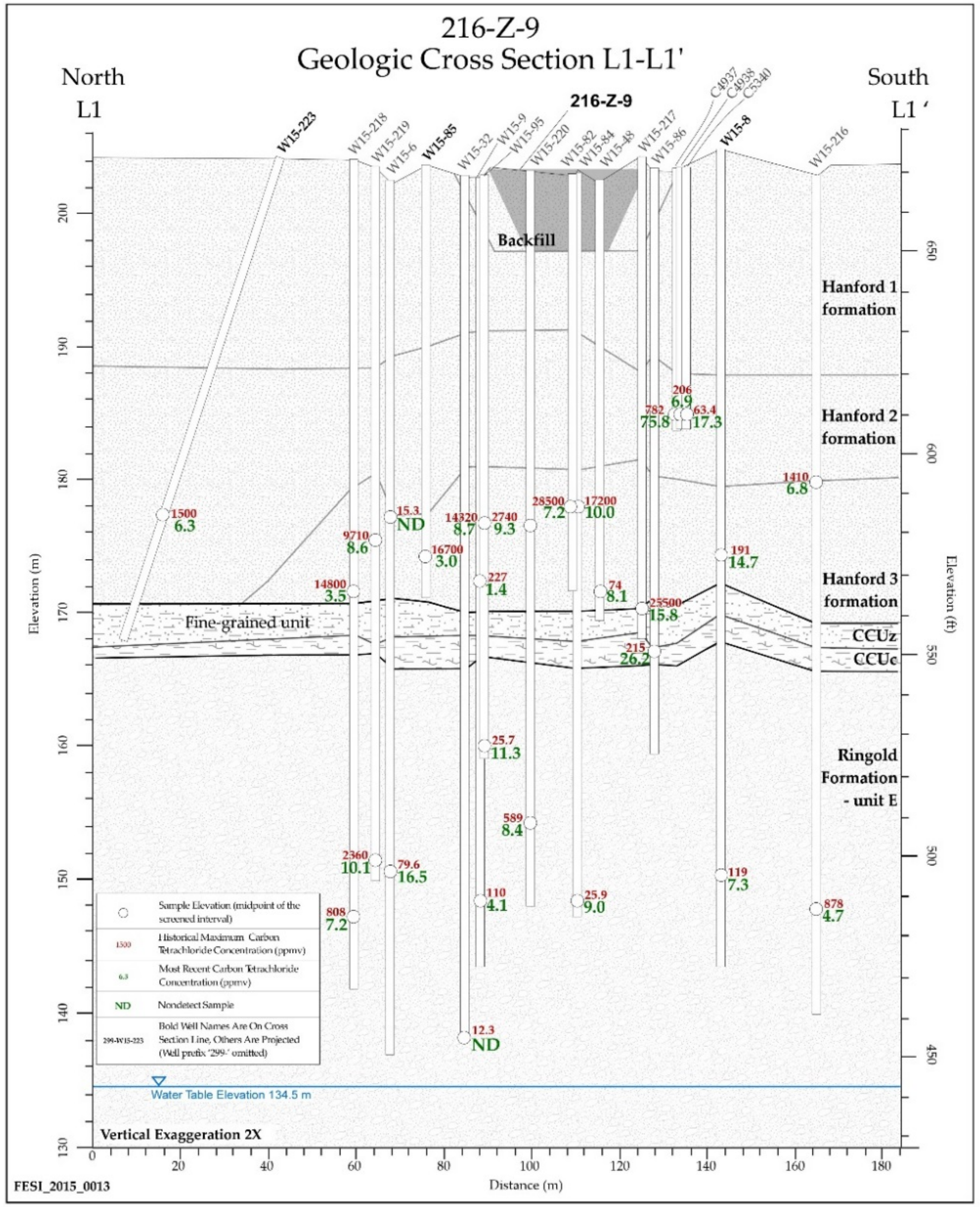
- Comparison of maximum and 2013 CT concentrations

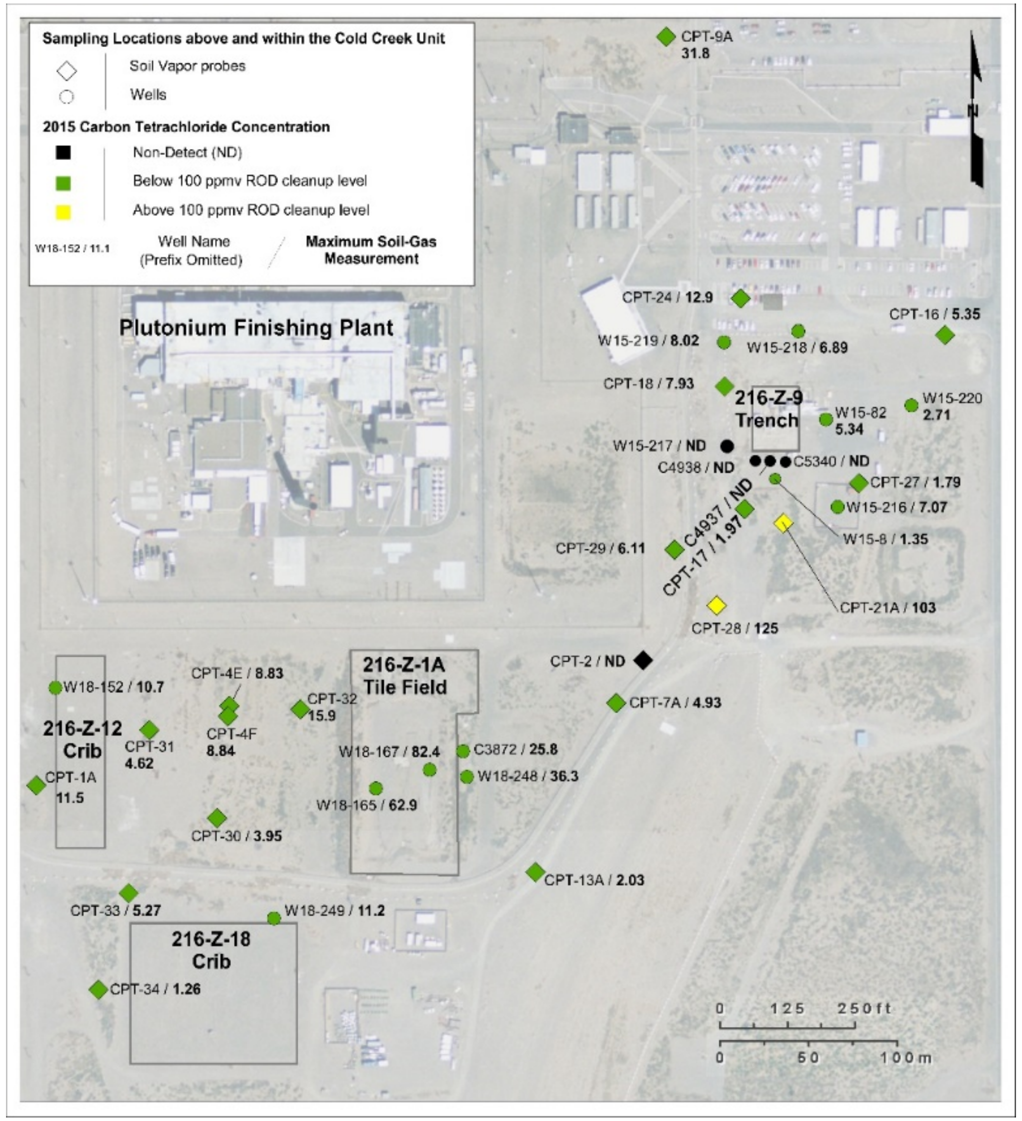


REMPLEX
CENTER FOR THE REMEDIATION OF COMPLEX SITES
@PNNL

"Recent" Soil Gas CT Concentrations

- CT concentrations measured during SVE operations have dropped dramatically both above and below the CCU

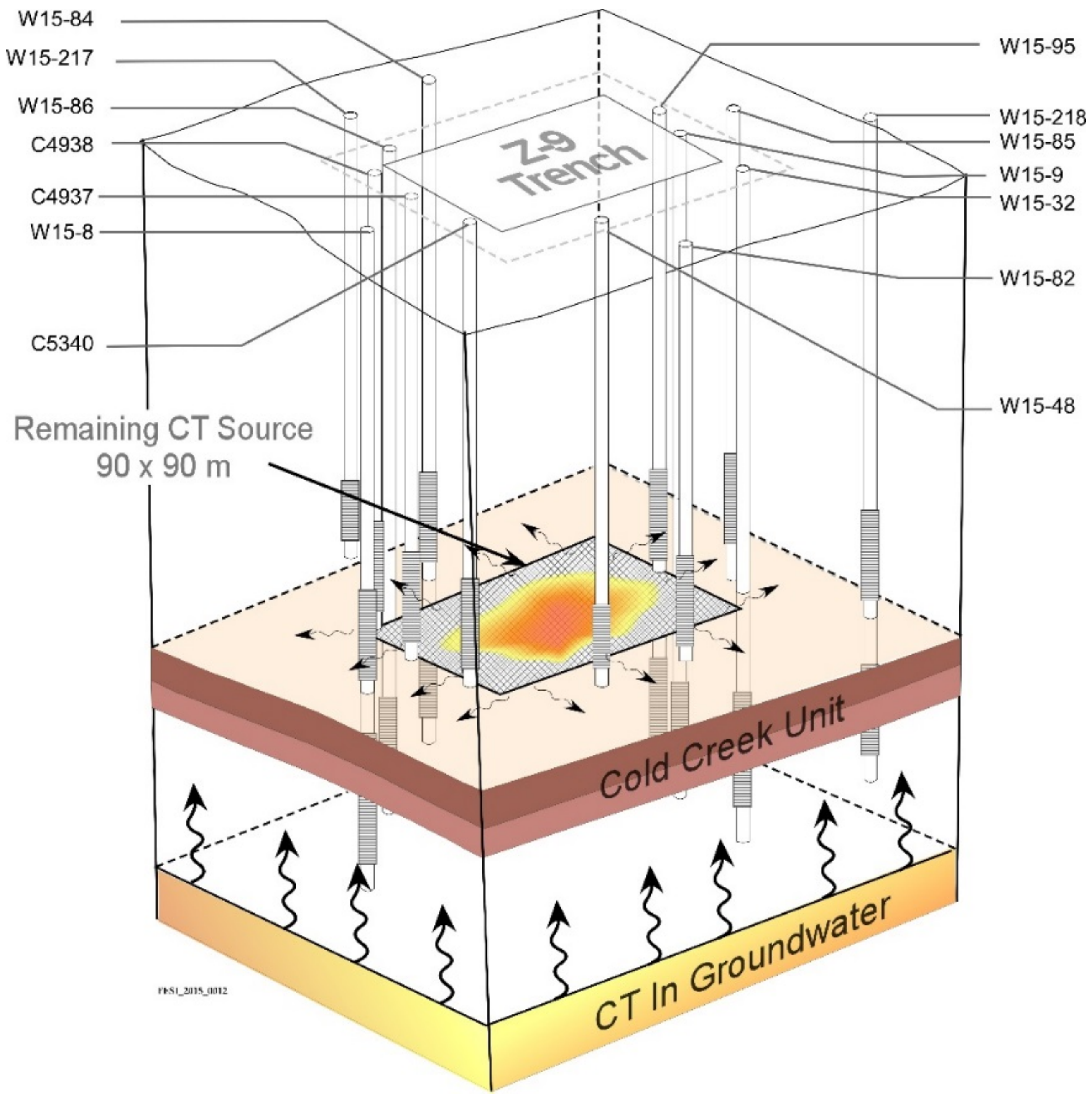




2015 Soil Gas CT Results

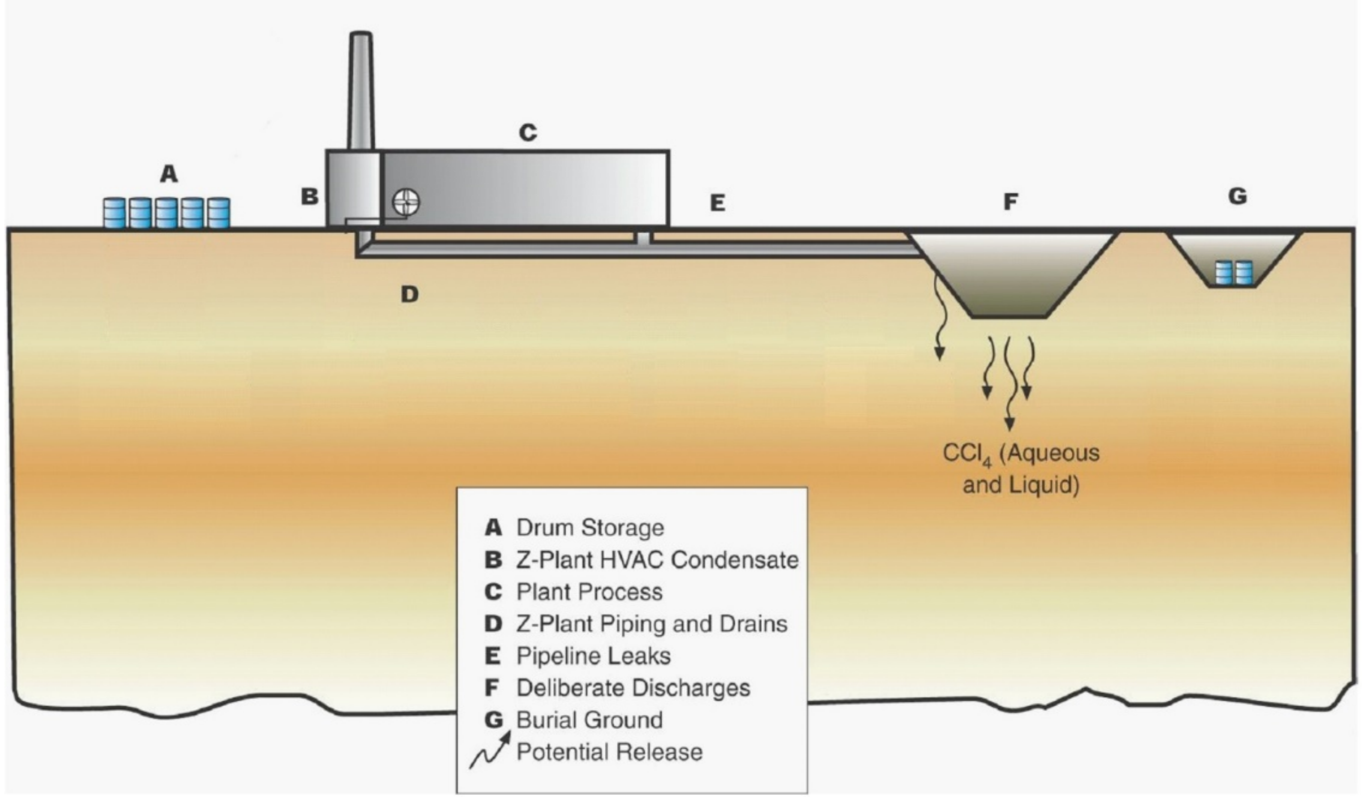
216-Z-9 Treatability Test

- In 2012, PNNL's 216-Z-9 Trench treatability test (PNNL-21326) concluded:
  - Remaining CT levels have no long-term adverse impact to groundwater
  - The only remaining source of CT is contained within the CCU



Extensive Site Investigations

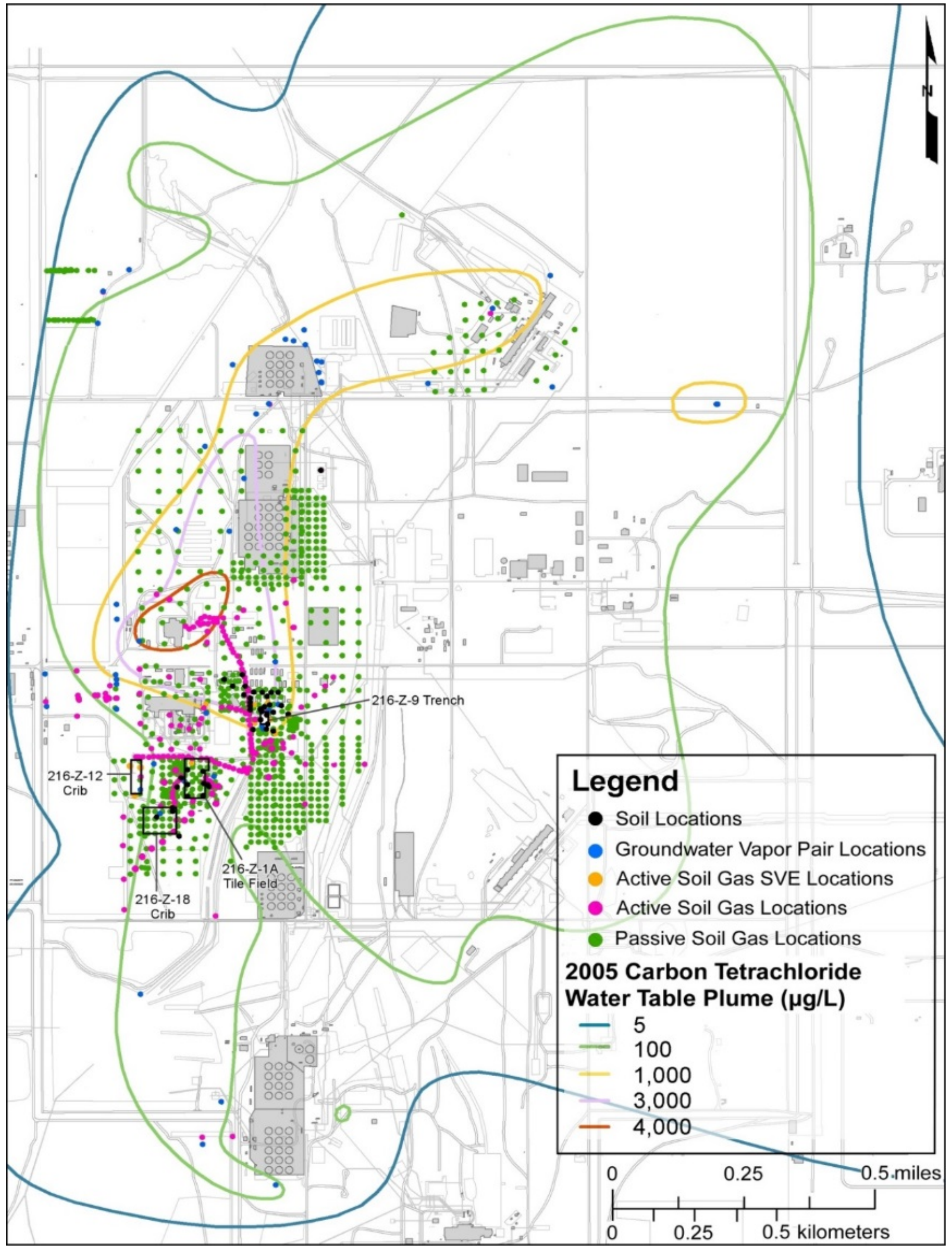
- Extensive recent characterization work
  - Assessed all potential contamination source areas overlying the groundwater CT contamination plume
  - Performed to support an accurate CSM
- Characterization activities included:
  - Widespread passive soil gas sampling
    - ✓ Encompassed all potential source areas
  - Active soil gas sampling
    - ✓ Focused on passive locations showing elevated readings
    - ✓ Also targeted features such as pipelines
  - Soil sampling at active soil gas locations having elevated readings



REMPLEX
CENTER FOR THE REMEDIATION OF COMPLEX SITES
@PNNL

200-PW-1 OU is Well-Characterized

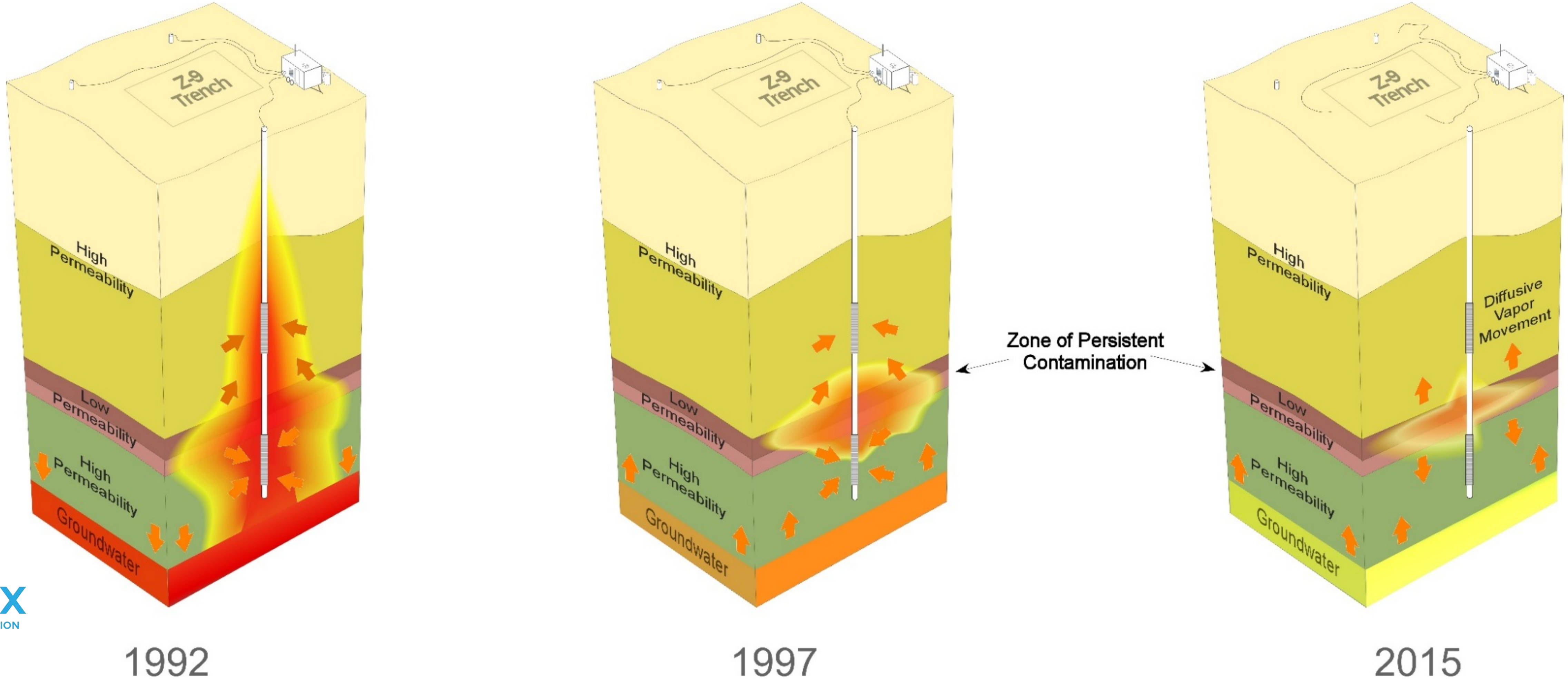
- RI/FS characterization activities concluded there are no other sources of CT besides the disposal sites:
  - 216-Z-9 Trench
  - 216-Z-1A Tile Field
  - 216-Z-18 Crib
- Remaining CT source is within CCU



REMPLEX
CENTER FOR THE REMEDIATION OF COMPLEX SITES
@PNNL

Evolving CT Conceptual Site Model

- Operational history and recent characterization information inform the CSM
- Aggressive SVE operations since 1992 resulted in CSM evolution over time



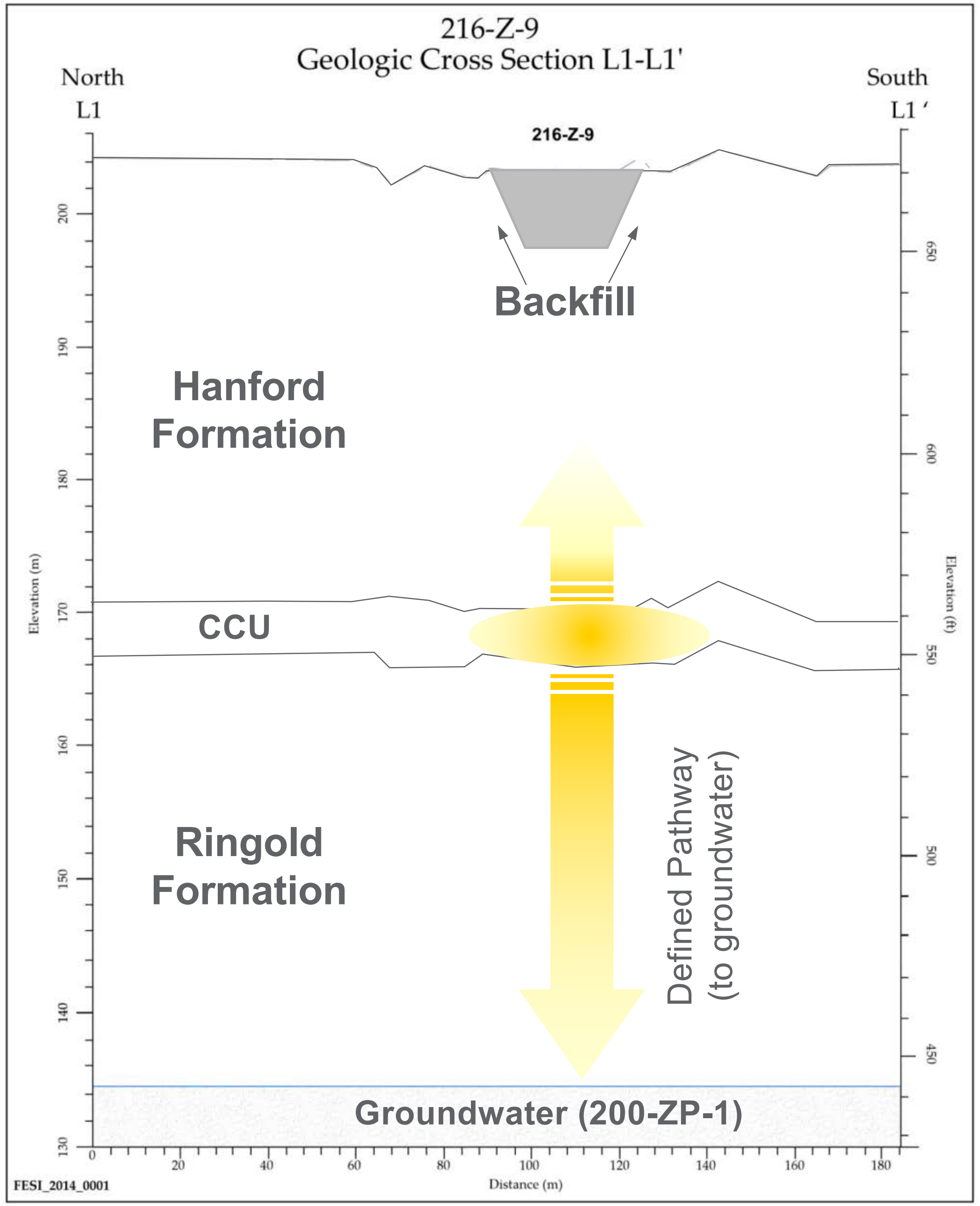
REMPLEX
CENTER FOR THE REMEDIATION OF COMPLEX SITES
@PNNL

Remediation Goals – 200-PW-1 ROD

- Identified two COCs for soil vapor: CT and methylene chloride (MC)
- Remedial Action Objective #3
  - Control source of potential groundwater contamination to protect beneficial use of groundwater
- Specified Final Soil Vapor Cleanup Levels: 100 ppmv for CT, 50 ppmv for MC
  - These cleanup levels "will be further refined and assessed to ensure they are protective of groundwater"
- Selected SVE as the final remedial action for soil vapor

Consider Environmental Pathways

- Environmental pathways and risk
  - Addressed in baseline risk assessment (DOE/RL-2007-27 feasibility study)
  - Groundwater defined as the only pathway
  - Risk is assessed as part of 200-ZP-1 OU groundwater remedy
- CT is the controlling factor for remediation
  - CT in the CCU is a continuing source
  - MC was not disposed
    - ✓ Present at low concentrations
    - ✓ Dispersed remnant of historical anaerobic degradation conditions
    - ✓ No continuing source of MC



REMPLEX
CENTER FOR THE REMEDIATION OF COMPLEX SITES
@PNNL

Estimated Impact to Groundwater

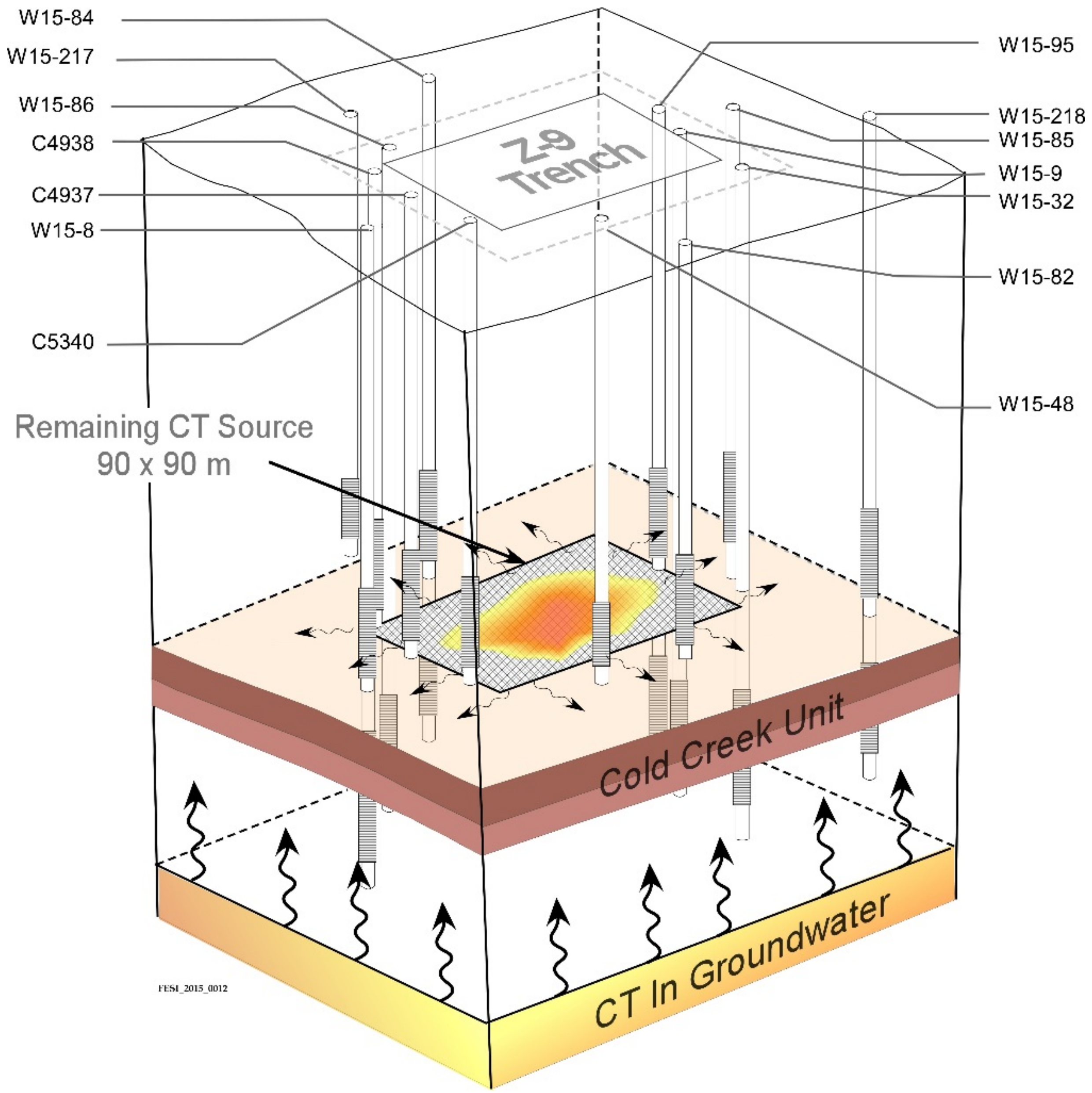
- PNNL's Soil Vapor Extraction Endstate Tool (SVEET) was used to calculate soil vapor impacts to groundwater
  - SVEET is a companion tool to the SVE Guidance (PNNL-21843)
  - Assumes underlying aquifer is clean and there are no CT sources in the groundwater
  - Assumes that vadose zone source remains constant over time
- Estimated groundwater impact for source based on current vadose zone CT concentrations
  - Impacts are consistent with 216-Z-9 Trench treatability test estimates (PNNL-21326)

Waste Site:	216-Z-9	216-Z-1A	216-Z-18
Source gas concentration (ppmv)	24.7	13.9	9.65
Estimated groundwater concentration (µg/L)	27	17	12
ppmv = parts per million by volume			

REMPLEX
CENTER FOR THE REMEDIATION OF COMPLEX SITES
@PNNL

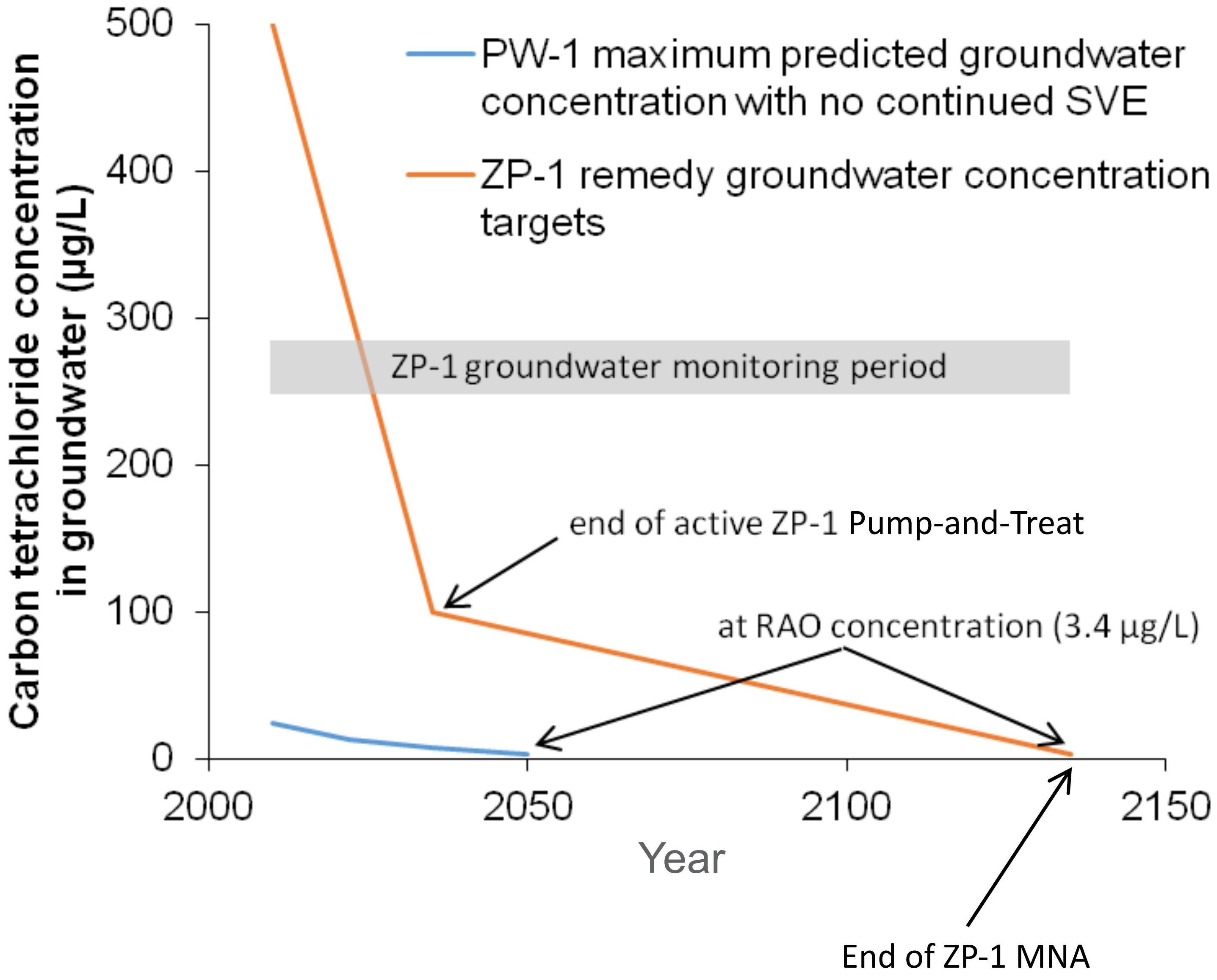
Actual Conditions – No Impact

- Groundwater contains > 300 µg/L of CT in this area
- At these groundwater CT concentrations there is not mass transfer into the groundwater
- Hence, the vadose zone contamination is not currently impacting groundwater CT concentrations



Impact In Context and Over Time

- Context: groundwater P&T + MNA (200-ZP-1 OU)
  - CT cleanup level: 3.4 µg/L
- Calculated the estimated impact over time
- By 2050
  - Remaining vadose zone CT will NOT cause groundwater concentration above 3.4 µg/L
- However, existing groundwater CT
  - Levels are not expected to drop below 3.4 µg/L until year 2135



REMPLEX
CENTER FOR THE REMEDIATION OF COMPLEX SITES
@PNNL

Protection of Groundwater

- Have estimated the impact of the vadose zone source on the groundwater
- These calculations constitute the refinement required by the 200-PW-1 OU ROD
  - Documented in the 216-Z-9 Treatability Test report (PNNL-21326)
- RAO 3 from the 200-PW-1 ROD is met
  - Source of potential groundwater contamination is controlled to protect groundwater

Conclusions of the Assessment

- SVE was very effective for vadose zone CT removal
  - Through 2012, a total of 80,107 kg of carbon tetrachloride was recovered
- The 200-PW-1 OU ROD defines the RAOs and remedy
  - Groundwater is the only exposure pathway
- The CSM is well-defined
  - There are no unknown sources
- Remaining vadose zone CT is not causing (and will not cause) groundwater cleanup levels to be exceeded
  - Calculated impact to clean groundwater is < 3.4 µg/L within 40 years
  - ROD RAO 3 is met
  - Risk/exposure is addressed with the existing 200-ZP-1 OU groundwater remedy

Recommendations and Outcome

- Discontinue soil vapor extraction
- Perform groundwater monitoring only (under 200-ZP-1 OU remedy)
  - Groundwater is the risk driver
- Prepare a Response Action Report to close out the SVE portion of the 200-PW-1 OU remedy
- EPA concurred with the assessment and recommendations
  - Signed off on the 2016 Response Action Report (DOE/RL-2014-48, Rev. 0) to indicate concurrence
- SVE system operations were subsequently terminated and the system was demobilized, ending a successful remedy after 20+ years

Impact and Broader Application

- This work demonstrates the utility of well-thought-out guidance to provide a structured approach for evaluating remediation performance and determining appropriate remedy endpoint
- This guidance and approach fit well with adaptive management of waste sites
  - A remedy should not be selected and operated in perpetuity
  - Rather, the remedy should adapt to changes over time and availability of new information
- The 200-PW-1 operable unit represents a complex site
  - Challenges from subsurface materials and concurrent remedies
- This evaluation resulted in cost savings, while maintaining protectiveness of human health and the environment
- This case study provides a template for endpoint evaluations at other sites

References

- DOE/RL-2013-18, 2013, *Hanford Site Environmental Report for Calendar Year 2012*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://msa.hanford.gov/files.cfm/DOE-RL-2013-18_Rev0_(9-20-13)_2012_complete_Report.pdf.
- DOE/RL. 2016. *Response Action Report for the 200-PW-1 Operable Unit Soil Vapor Extraction Remediation*. DOE/RL-2014-48, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, WA. Available at: https://pdw.hanford.gov/document/0074963H.
- EPA, 2011, *Record of Decision Hanford 200 Area Superfund Site: 200-CW-5 and 200-PW-1, 200-PW-3, and 200-PW-6 Operable Units*, U.S. Environmental Protection Agency, Region 10, Seattle, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0093644.
- Oostrom, M., M.J. Truex, A.K. Rice, C.D. Johnson, K.C. Carroll, D.J. Becker, and M.A. Simon. 2014. "Estimating the Impact of Vadose Zone Sources on Groundwater to Support Performance Assessment of Soil Vapor Extraction." *Ground Water Monitoring and Remediation.* 34(2):71-84.
- Smith, R.F. and R. Stanley, 1992, "Action Memorandum: Expedited Response Action Proposal for 200 West Area Carbon Tetrachloride Plume" (Letter No. 9200423 to R.D. Izatt, U.S. Department of Energy, Richland Operations Office), U.S. Environmental Protection Agency, Region 10, and Washington State Department of Ecology, Seattle, Washington, January 21. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D196088487.
- Truex, M.J., D.J. Becker, M.A. Simon, M. Oostrom, A.K. Rice, and C.D. Johnson. 2013. *Soil Vapor Extraction System Optimization, Transition, and Closure Guidance*. PNNL-21843, Pacific Northwest National Laboratory, Richland, WA. Available at: https://www.pnnl.gov/projects/remediation-performance-assessment/soil-vapor-extraction

Center for the Remediation of Complex Sites

REMPLEX
CENTER FOR THE REMEDIATION OF COMPLEX SITES
@PNNL

Technical Leadership
Independent technical resource with proven track record of supporting deployment of advanced technologies and alternative strategies

Multi-institutional Collaborations
Integration and leveraging across federal and private partnerships to facilitate solution development

Solution Development
Leverage existing capabilities spanning all TRLs to provide solutions in adaptive remediation and long-term stewardship that enable risk-based remediation

Thank you

Christian Johnson
cd_johnson@pnnl.gov

Mark Byrnes
Mark_E_Byrnes@rl.gov

remplex@pnnl.gov
www.pnnl.gov/projects/remplex

REMPLEX
CENTER FOR THE REMEDIATION OF COMPLEX SITES
@PNNL