Final
FORMER MARINE CORPS AIR STATION (MCAS) El Toro
100th Restoration Advisory Board (RAB) Meeting Minutes

Meeting Location: Irvine City Hall, Conference Training Center, Irvine California
Meeting Date/Time: 25 August 2010/6:30pm – 8:06pm
Minutes Prepared by: Matt Brookshire, CDM Federal Programs Corporation (CDM)

Attachment:

Presentation Slides: "Pilot Study: In Situ Bioremediation of Perchlorate- and Trichloroethylene (TCE)-Impacted Groundwater at IRP Sites 1 and 2."

WELCOME/INTRODUCTIONS/AGENDA REVIEW:

Mr. Jim Callian (Base Realignment and Closure [BRAC] Environmental Coordinator [BEC] and Navy RAB Co-Chair) welcomed everyone and introduced the RAB community Co-Chairman, Mr. Bob Woodings. Self-introductions by all those in attendance followed. A total of 30 attendees were present. Mr. Callian asked Ms. Marcia Rudolph (RAB member, Subcommittee Chair) to lead the Pledge of Allegiance.

ANNOUNCEMENTS/ REVIEW OF ACTION ITEMS

Mr. Callian began the meeting with the following announcements and discussion:

- Mr. Callian noted that tonight's RAB meeting is a special event, the 100th RAB meeting for MCAS El Toro. The RAB has been active for almost 20 years. After tonight's technical presentation there will be a recognition ceremony. After the RAB meeting is formally adjourned, the Orange County Great Park will give a special presentation about the activities associated with the re-use of MCAS El Toro; there will also be a cake cutting ceremony, refreshments, and photo opportunities.

- Mr. Callian reviewed the RAB meeting agenda; no changes to the agenda were suggested by the RAB. He announced one presentation would be presented at the meeting that will discuss the pilot study conducted at Installation Restoration Program (IRP) Site 1.

- Mr. Callian presented a series of slides listing dates and times for the upcoming quarterly RAB meetings. In addition, he presented slides listing key Navy and Regulatory Agency contacts, RAB points of contact, Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Administrative Record (AR) File and Information Repository (IR) locations and hours, and environmental and reuse/redevelopment websites.

- Mr. Callian reiterated the RAB's focus was on environmental issues and restoration and not on reuse. Mr. Callian then read an excerpt from the RAB Mission Statement.

- Mr. Callian reminded everyone to sign-in for tonight's RAB meeting.

APPROVAL OF 28 APRIL 2010 RAB MEETING MINUTES

Mr. Woodings opened the floor for discussion, questions, or corrections to the 28 April 2010 RAB meeting minutes. Mr. Woodings noted he had read the meeting minutes and had one comment on Page 2 where Ray Ouellette was recognized as a RAB member; Mr. Ouellette is not a RAB member. Mr. Woodings had no other comments or questions. No other comments, corrections, or questions were made and the 28 April 2010 meeting minutes were approved with the one correction of Mr. Ouellette not being a RAB member.

Mr. Callian recognized CDM as the Navy contractor who supports these RAB meetings and that they have gone over and above in preparation of the RAB meetings to ensure they run without a problem. Mr. Callian also notified the RAB that Tony Guiang who was with CDM and had been supporting the RAB meetings is now working directly with the Navy.

SUBCOMMITTEE MEETING REPORT

Ms. Rudolph began her subcommittee meeting report by noting that all three regulators were present for the meeting. Ms. Rudolph directed other RAB members to review Department of Toxic Substances Control (DTSC) comment letters to obtain information on what is going on regarding restoration activities. Ms. Rudolph noted that she asked a number of questions during the meeting and all were satisfactorily answered.

Ms. Rudolph stated that she had not been receiving United States Environmental Protection Agency (U.S. EPA) review comment letters. She asked if U.S. EPA was still commenting on the restoration activities. Mr. Callian stated that U.S. EPA is still providing comments to the Navy.

Ms. Rudolph stated that tonight's 100th RAB meeting was a momentous occasion. The RAB has been a real learning experience and that she very much appreciated the Navy's outreach to the community. She has been glad to be part of the RAB as an elected official of Lake Forest and the RAB has allowed her to report back to her constituents on activities at MCAS El Toro. Ms. Rudolph thanked the Navy, the DTSC, the U.S. EPA, and all the other regulators for their support through the years.

REGULATORY AGENCY UPDATE

Ms. Mary Aycock (U.S. EPA)

Ms. Aycock provided the following update to the RAB:

- The Record of Decision (ROD) for Anomaly Area 3 (AA 3) has been signed and was issued on 18 August 2010.

- U.S. EPA is currently reviewing Finding of Suitability for Transfer (FOST) #6 and is hoping to have the document finalized by the end of September 2010. Mr. Callian added that a FOST is the last document that certifies properties are suitable for transfer because remedies to protect human health and the environment are either in place or completed.

Mr. Quang Than (DTSC)

Mr. Than provided the following update to the RAB:

- FOST #5 has been completed since the last RAB meeting.
- DTSC is currently working with the Navy on FOST #6.

Mr. John Broderick (Regional Water Quality Control Board [RWQCB])

Mr. Broderick provided the following update to the RAB:

- Provided an update on the status of IRP Landfill Sites 3 and 5.
- The petroleum corrective action at the Fire Fighting Training Pit has been completed.
- Very few petroleum contaminated sites are remaining at MCAS El Toro to be remediated.

Mr. Callian stated that the ROD for AA 3 is the last landfill at MCAS El Toro that had been awaiting a ROD to be issued.

Mr. Callian recognized the Navy's contractors, including Crispin Wanyoike with AECOM Environmental Technical Services and Dhananjay Rawal and Mike Wolff with Enviro Compliance Solutions, Inc. (ECS) who were present at tonight's meeting.

PRESENTATION: PILOT STUDY: IN SITU BIOREMEDIATION OF PERCHLORATE- AND TRICHLOROETHYLENE (TCE)-IMPACTED GROUNDWATER AT IRP SITES 1 AND 2

Ms. Dunn began her presentation with a brief introduction and noted that Mr. Wolff from ECS would be giving the presentation with her. Ms. Dunn indicated that ECS was the Navy contractor for the pilot study. She reminded the audience that the Navy had given an earlier presentation of the pilot study to the RAB in December 2009 to explain what the Navy planned to do during the pilot study. The focus of the presentation was on the results from the pilot study and what the Navy plans to do with these results. A summary of the topics presented by Ms. Dunn and Mr. Wolff included:

- Ms. Dunn discussed the presentation overview (Slide 2) which included background, geologic setting, main objectives of the pilot study (direct injection and hydraulic fracturing), methodology and results, and the conclusions.
- Background of the site was presented (Slide 3). Because the map on the slide is difficult to read an 11 x 17 inch figure of the map is provided in the handout package. IRP Site 1 is a former explosive ordnance disposal (EOD) training range and is the source of the perchlorate-impacted groundwater. IRP Site 2 is a former landfill and is the source of the TCE-impacted groundwater. IRP Site 2 is also where the commingled TCE- and perchlorate-impacted groundwater is located.

- Mr. Wolff provided a summary of the geologic setting for both IRP Sites 1 and 2 (Slide 4). The geology at each site is different and the slide presents the two subsurface profiles. Mr. Wolff noted that during dry years at IRP Site 1 the perchlorate does not really go anywhere as it is located in the bedrock, but during wet years the perchlorate goes into the alluvium which is much more porous and can travel down to IRP Site 2. This perchlorate comes into contact with the TCE-impacted groundwater and the result is the commingled contamination.
- The main objectives of the pilot study were presented (Slide 5) by Ms. Dunn. The objective for IRP Site 1 was to evaluate the effectiveness of in situ bioremediation (ISB) for perchlorate-impacted groundwater using direct injection of EOS® (an emulsified oil substrate) and injection of EOS® following hydraulic fracturing. The objective for IRP Site 2 was to evaluate the effectiveness of ISB for application in a permeable reactive barrier (PRB) using direct inject of EOS® and injection of EHC® (zero-valent iron) during hydraulic fracturing. Data from the pilot study will then be incorporated into the Feasibility Study for evaluating full-scale remedial alternatives.
- The direct injection of EOS® at IRP Site 1 (Slide 6) was conducted by installing injection and monitoring well arrays, conducting a baseline monitoring event, injecting the EOS®, and monitoring geochemical changes at injection and monitoring wells for 6 months.
- Results of the direction injection of EOS® at IRP Site 1 were presented in Slides 7 and 8 by Mr. Wolff. The results discussed the reduction in perchlorate concentrations as well as the reduction of total organic carbon (TOC) concentrations. Perchlorate concentrations dropped quickly and remained low during the monitoring period. The effective radius of a single injection was at least 15 feet. Because EOS® is a carbon source the TOC concentrations increased at first and then began to reduce indicating the carbon was being used by the bacteria as the bacteria population increased. This indicates that were more bacteria available to reduce the perchlorate concentrations.
- The injection of EOS® after hydraulic fracturing at IRP Site 1 was discussed in the next slide (Slide 9) by Ms. Dunn. This included installing the hydraulic fracturing boreholes, installing a monitoring well array, and the conducting baseline monitoring. This was followed by performing the hydraulic fracturing, monitoring the extent and distribution of fractures using tiltmeter geophysics, and completing the fracture borings as an injection well. Then a known quantity of EOS® was injected, verification borings were installed, and the geochemical changes were monitoring for 6 months.
- The results of the injection of EOS® after hydraulic fracturing at IRP Site 1 were presented in Slide 10 by Mr. Wolff and discussed the perchlorate concentrations. The reduction in perchlorate concentrations was good, except for the well located 30 feet away from the injection point indicating that the radius of influence was not reaching this well location. There was some rebound and this indicates in a full-scale application that more than one injection will probably be needed.
- Ms. Dunn discussed the direct injection of EOS® at IRP Site 2 (Slide 11) was conducted by installing injection and monitoring well arrays, conducting a baseline monitoring event, injecting the EOS®, and monitoring geochemical changes at injection and monitoring wells for 6 months.

- Results of the direct injection of EOS® at IRP Site 2 were discussed in Slides 12, 13, and 14 by Mr. Wolff. Slide 12 presented the reduction of perchlorate concentrations. Reduction of the perchlorate concentrations were similar to the IRP Site 1 results with the exception of the upgradient well which showed a delayed reaction. Slide 13 presented the reduction of TCE concentrations. Slide 14 presented the TCE degradation pathway associated with the EOS® injection. It is important to understand that during the degradation of TCE you do not want to create toxic daughter products such as vinyl chloride, but rather have complete degradation to ethane.
- The injection of EHC® after hydraulic fracturing at IRP Site 2 was discussed in the next slide (Slide 15) by Ms. Dunn. This included installing two hydraulic fracturing boreholes, installing a monitoring well array, and the conducting baseline monitoring. This was followed by performing the hydraulic fracturing, injecting EHC® during the fracturing, and monitoring the extent and distribution of fractures using tiltmeter geophysics. Then geochemical changes were monitoring for 6 months.
- The results of the EHC® injection during hydraulic fracturing were presented in Slides 16 and 17 by Mr Wolff. The perchlorate concentrations results were presented in Slide 16 and the results of the TCE concentrations were presented in Slide 17. Having two injection points provides a more complex set of data to evaluate, but also allows for assessing if the two injections overlap with each other. The data indicates that the spacing used in this pilot study worked well.
- Ms. Dunn presented the IRP Site 1 conclusions (Slide 18) and IRP Site 2 conclusions (Slides 19 and 20). Both the EOS® and the EHC® are effective. At IRP Site 1 the radius of influence was larger using the injection following the hydraulic fracturing. At IRP Site 2 both techniques were very effective. The results of the pilot study will be used to complete the Feasibility Study.

Mr. Callian noted that during the hydraulic fracturing for IRP Sites 1 and 2 the Navy used very sensitive tiltmeters and used digital mapping to model the fractures in the subsurface.

Mr. Peter Hirsch (RAB Member) had a question regarding Slide #5; whether the second bullet was correct in identifying EOS®. Ms. Dunn stated the reference to EOS® was correct. EOS® could be direct injected; EHC® has a larger grain size and therefore could not be direct injected.

Mr. Hirsch asked for an explanation of how the two compounds, EOS® and EHC®, degrade the contaminants. Ms. Dunn stated that EHC® is a zero-valent iron compound containing both iron particles and carbon which stimulate the microbial population to degrade TCE. EOS® is a vegetable oil and is used to reduce oxygen levels and stimulate the microbial population to consume the vegetable oil and essentially trick the microbial population to also ingest the perchlorate.

Mr. Roy Herndon asked why if the concentrations are already very low as presented in Slide 12, why did the Navy select this site for the pilot study? Mr. Wolff stated this area is located where there is a mixture of contaminants; therefore, this area allows evaluating how the treatment would work for low concentrations of perchlorate and also for TCE. Ms. Dunn added this site is also located along the Station Boundary.

Mr. Hirsch asked a question regarding Slide #10; does the rebound in concentrations shown indicate that a source of the contaminant is still present. Mr. Wolff stated that we expected some amount of rebound and this allows the Navy to gauge how a full scale application would work. Mr. Callian stated that there was no source in the soil; the Navy conducted extensive soil sampling throughout IRP Site 1 and no remaining perchlorate source areas were identified.

Mr. Herndon asked if the Navy anticipates that vinyl chloride will further degrade over time. Mr. Wolff stated that they do expect the vinyl chloride to further degrade, but this is an indication that you would need multiple injections to completely degrade the vinyl chloride to concentrations below the drinking water standard.

Mr. Hirsch asked if the land is going to be leased to the Federal Bureau of Investigation (FBI), why is the Navy spending all this time and money to cleanup a site that the FBI may recontaminate with explosives. Mr. Callian stated that the source of the perchlorate was caused by jet-assisted take-off (JATO) bottles that are no longer used. Any future use of the site will have to follow all applicable regulations.

Mr. Herndon asked if the pilot study provided sufficient data to understand the effective radius of influence needed to clean the site. Mr. Wolff stated that the results did provide the necessary data for evaluation in the Feasibility Study.

OPEN QUESTIONS AND COMMENTS

Mr. Woodings asked if any of the wells are sited in the planned Alton Parkway roadway. Mr. Callian stated that there may be one or two but the Navy has coordinated with the County to relocate them when needed. Mr. Woodings asked if future activities required lane closure or other impedance and what is the Navy plan for this. Ms. Arnold stated that the Project Environmental Review Form (PERF) for the Alton Parkway project has been submitted and reviewed by the Navy. However, this Navy project is only in the feasibility study (FS) stage and the Navy is analyzing the feasibility of multiple alternatives for remediating the site.

Mr. Woodings noted he appreciated the color copies of the handouts and the acronym list at the end of the presentation.

Mr. Callian asked if the RAB had any topics they would like to consider for discussion at the next meeting. The following topics for discussion were requested:

- Mr. John Hills suggested the Well 78 replacement project as a topic for the next RAB meeting. Mr. Callian stated that Well 78 is associated with IRP Site 18.

- Mr. Hirsch suggested an update for IRP Sites 3 and 5.

Mr. Callian recognized Ms. Arnold for her 10 years of service to the RAB and for her mentoring.

100TH RAB CELEBRATION

Mr. Callian stated it was his pleasure to commemorate the progress of the restoration activities that have been completed at MCAS El Toro since it was placed on the National Priorities List

(NPL). The Navy, with community input, has transferred to the public sector more than 75 percent of MCAS El Toro. As part of this process, the RAB has been available for public review and comment on 24 CERCLA sites. At this time 22 of the 24 CERCLA sites have final RODs in place or remedial action underway. Community involvement in the CERCLA process is mandated by Congress. The Navy truly appreciates the RAB's input over the last 15 to 20 years.

Mr. Callian stated he wanted to take tonight to recognize all the RAB community members who have donated their valuable time to the RAB and accommodating the CERCLA process. In reviewing the attendance records over the last two years, there are several RAB members who have not missed more than two meetings without an excused absence and the Navy would like to specifically recognize these members. Mr. Callian invited Mr. Woodings, Ms. Rudolph, and Mr. Hirsch to come to the front to receive a certificate of appreciation from the Navy. Mr. Callian presented each of the three members with their certificates. Mr. Callian noted that Ms. Matheis (RAB Member) who is not present tonight will also be receiving a certificate of appreciation.

Ms. Arnold recognized the time commitment for the RAB members to participate in the CERCLA process. Ms. Arnold stated she had not been to a RAB meeting where Ms. Rudolph was not in attendance. She gave her heart-felt thanks to all the RAB members, the Agencies, and the Navy consultants who have supported this program.

Ms. Aycock also wanted to show U.S. EPA's appreciation to the RAB members and presented Mr. Woodings, Ms. Rudolph, and Mr. Hirsch with 35-Year U.S. EPA Commemorative Pins.

MEETING SUMMARY AND CLOSING

In closing, Mr. Callian stated that there would be photographs taken, cake cutting, other refreshments served, and then a presentation by the Orange County Great Park. The meeting officially adjourned at 8:06pm.

LIST OF HANDOUTS PROVIDED AT THE MEETING

- 25 August 2010 Former MCAS El Toro RAB Meeting Agenda and Upcoming RAB Meeting Schedule
- Where to Get More Information & Environmental Websites
- Presentation Slides: "Pilot Study: In Situ Bioremediation of Perchlorate- and Trichloroethylene (TCE)-Impacted Groundwater at IRP Sites 1 and 2."
- Former MCAS El Toro IRP Site Location Map
- Former MCAS El Toro RAB Mission Statement and Operating Procedures
- Former MCAS El Toro RAB Fact Sheet/Membership Application
- Former MCAS El Toro Mailing List Coupon

Copies of the meeting minutes and handouts provided at the 25 August 2010 RAB meeting are available at the IR for former MCAS El Toro located in the Government Publication Section of the Heritage Park Regional Library, Irvine, California. Library hours are 10 am to 9 pm Monday through Thursday; 10 am to 5 pm Friday and Saturday; and 12 pm to 5 pm on Sunday. The library may be reached at (949) 936-4040. In addition, copies of the meeting minutes and handouts are also available at the CERCLA AR maintained at Building 307 at former MCAS El Toro by Ms. Sue Rawal. Documents can be viewed by appointment; call Ms. Rawal at (949) 859-6014 between 9 am and 1 pm Monday through Thursday.

Final minutes from previous RAB meetings can be found on the internet at the Navy BRAC Program Management Office (PMO) website: www.bracpmo.navy.mil

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INTERNET SITES

Navy and Marine Corps Internet Access

BRAC PMO Web Site (includes RAB meeting minutes): http://www.bracpmo.navy.mil/

Department of Defense – Environmental Cleanup Home Page Web Site:

http://www.dtic.mil/envirodod/

U.S. EPA:

Homepage: www.epa.gov

Superfund information: www.epa.gov/superfund

National Center for Environmental Assessment: www.epa.gov/ncea

Federal Register Environmental Documents: www.epa.gov/federalregister

Cal/EPA:

Homepage: www.calepa.ca.gov

Department of Toxic Substances Control: www.dtsc.ca.gov

Department of Health Services, reorganized into the Department of Health Care Services and the Department of Public Health: www.dhs.ca.gov

Santa Ana Regional Water Quality Control Board: www.waterboards.ca.gov/santaana

Additional Websites: Reuse and Redevelopment

Orange County Great Park: www.ocgp.org

Great Park Conservancy: www.orangecountygreatpark.org

Pilot Study:
In Situ Bioremediation of Perchlorate- and Trichloroethylene (TCE)-Impacted Groundwater at IRP Sites 1 & 2

Former Marine Corps Air Station El Toro

Restoration Advisory Board Meeting

August 25, 2010

Presented by

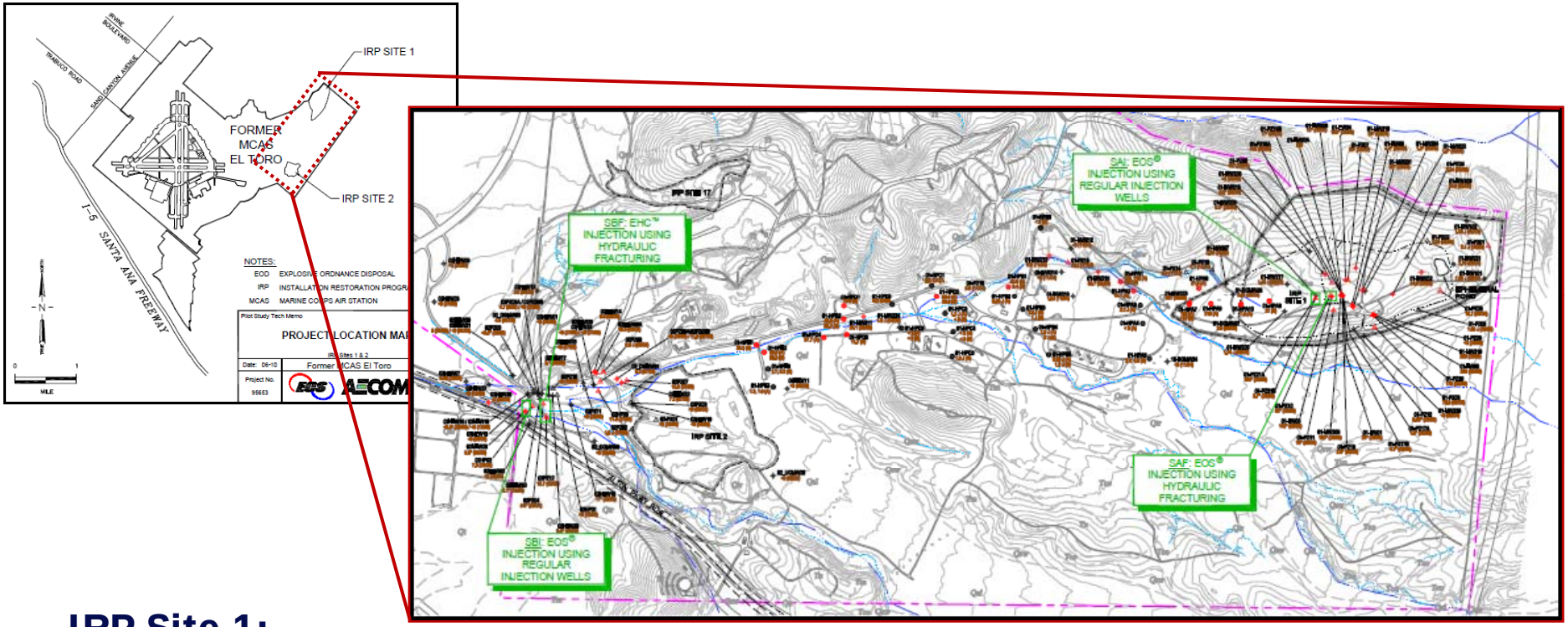
Jacqueline Dunn, PE, NAVFAC SW, Navy BRAC PMO West

Michael Wolff, PG, CEG, Enviro Compliance Solutions, Inc. (ECS)

Presentation Overview

- Background
- Geologic Setting
- Main Objectives
  - Direct Injection
  - Hydraulic Fracturing
- Methodology/Results:
  - Installation Restoration Program (IRP) Site 1
  - IRP Site 2
- Conclusions
- Acronyms

Background



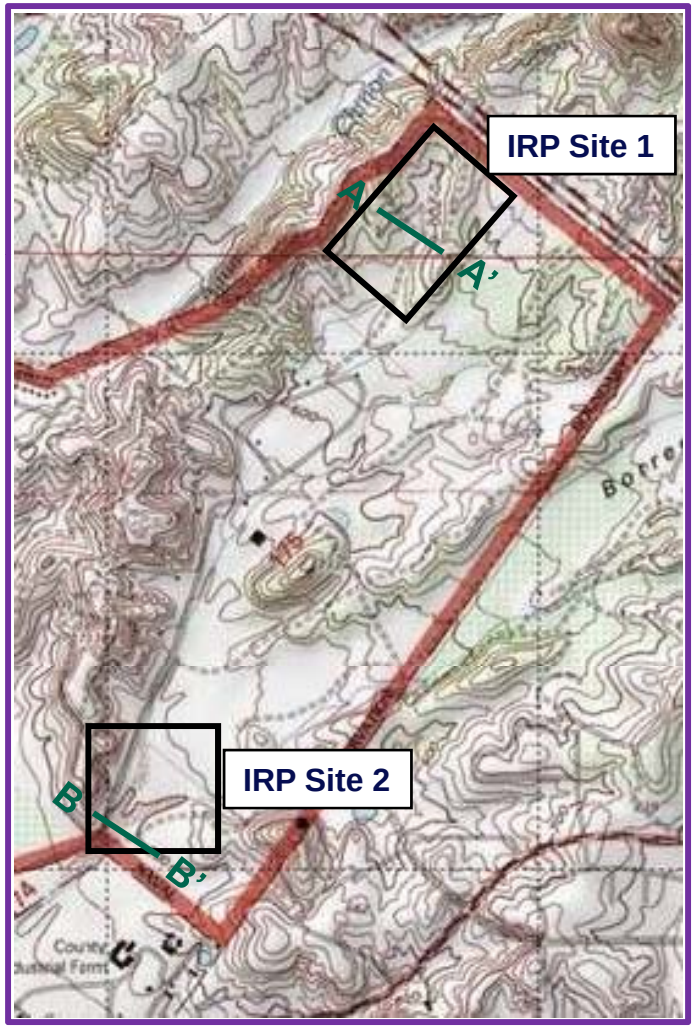
IRP Site 1:

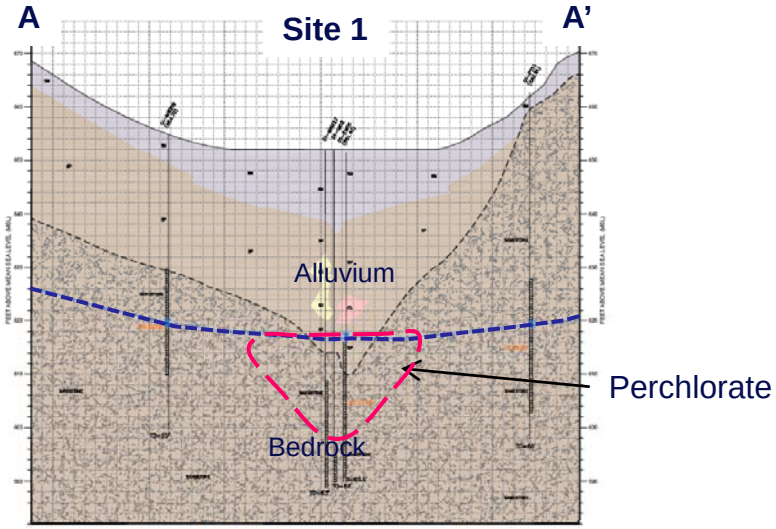
- ❑ **Former Explosive Ordnance Disposal (EOD) Training Range**
- ❑ **Source of perchlorate-impacted groundwater**

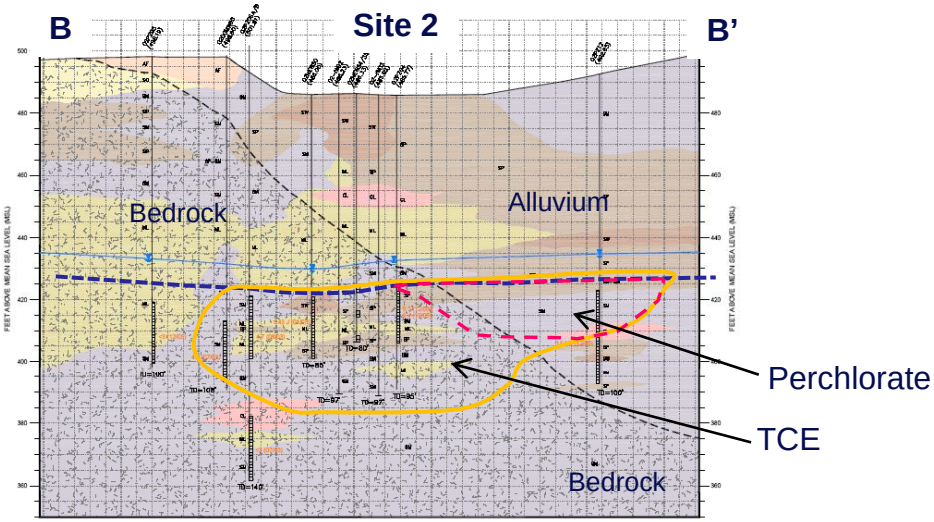
IRP Site 2:

- ❑ **Former landfill – closed and capped**
- ❑ **Source of TCE-impacted groundwater**
- ❑ **Commingled TCE- and perchlorate-impacted groundwater**

Geologic Setting







Main Objectives

- ***Site 1:*** **Evaluate the effectiveness of in situ bioremediation (ISB) for perchlorate-impacted groundwater at using:**
    1. **Direct injection of EOS®**
    2. **Injection of EOS® following hydraulic fracturing**

- ***Site 2:*** **Evaluate the effectiveness of ISB for application in a permeable reactive barrier (PRB) using:**
    1. **Direct injection of EOS®**
    2. **Injection of EHC® during hydraulic fracturing**

- ***Feasibility Study:*** **Gather site-specific performance data to establish parameters (substrate volume, ROI, timeframe, cost, etc.) for evaluating full-scale remedial alternatives**

IRP Site 1 Methodology
Part I: Direct Injection of EOS®

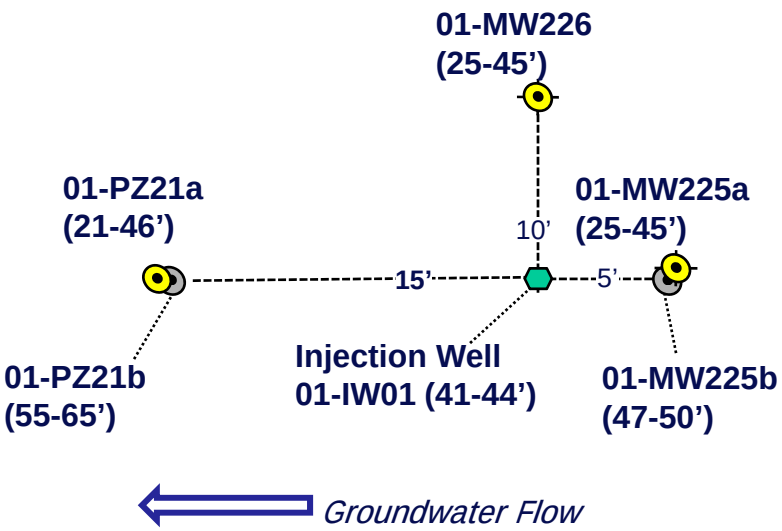
1. Install injection and monitoring well arrays.

2. Conduct baseline monitoring for perchlorate and target analytes

3. Inject known quantities of EOS® and tracers.

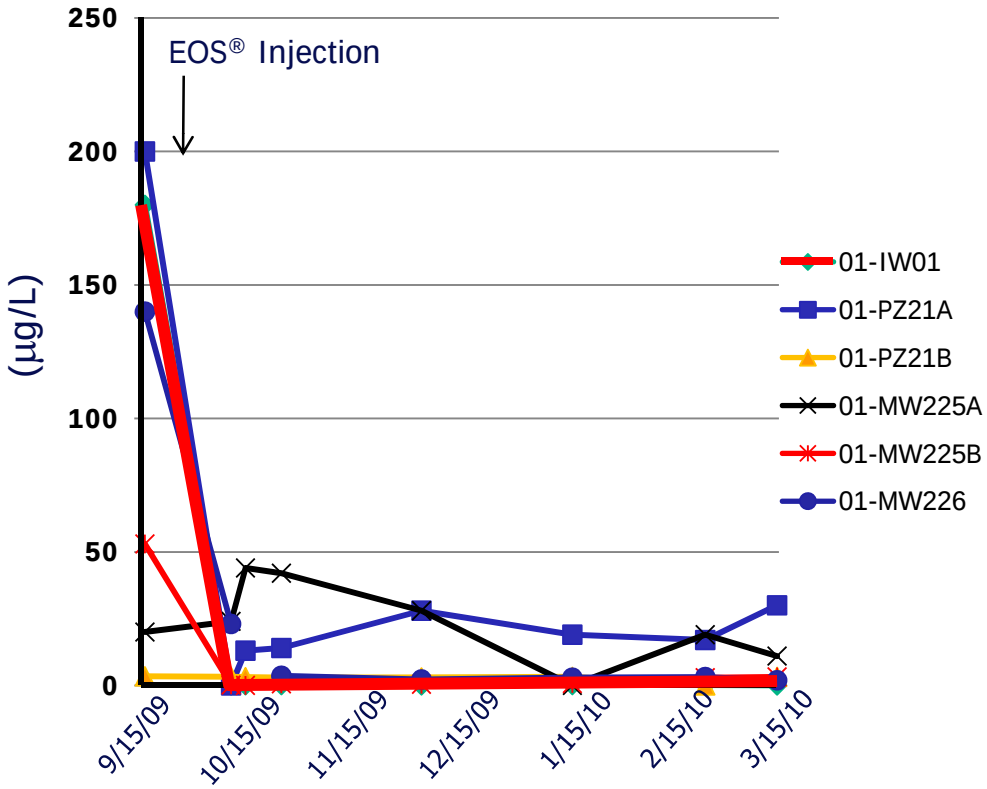
4. Monitor geochemical changes at injection and monitoring wells for 6 months

IRP Site 1 - Direct EOS® Injection

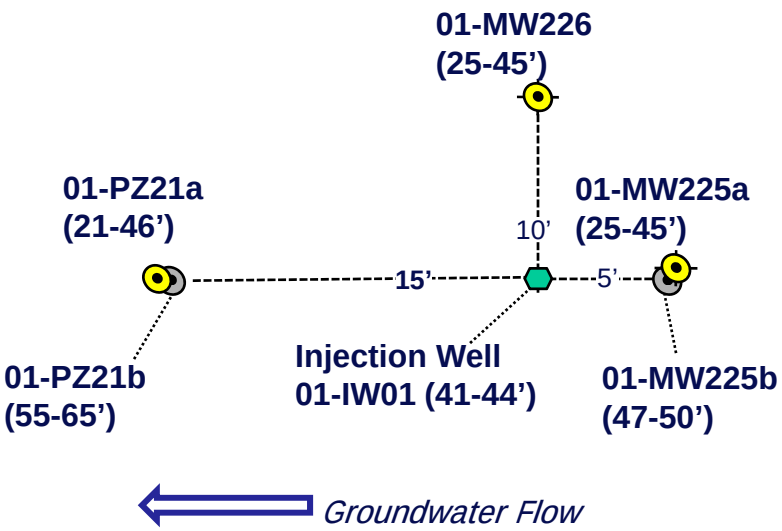


Plan View

Perchlorate

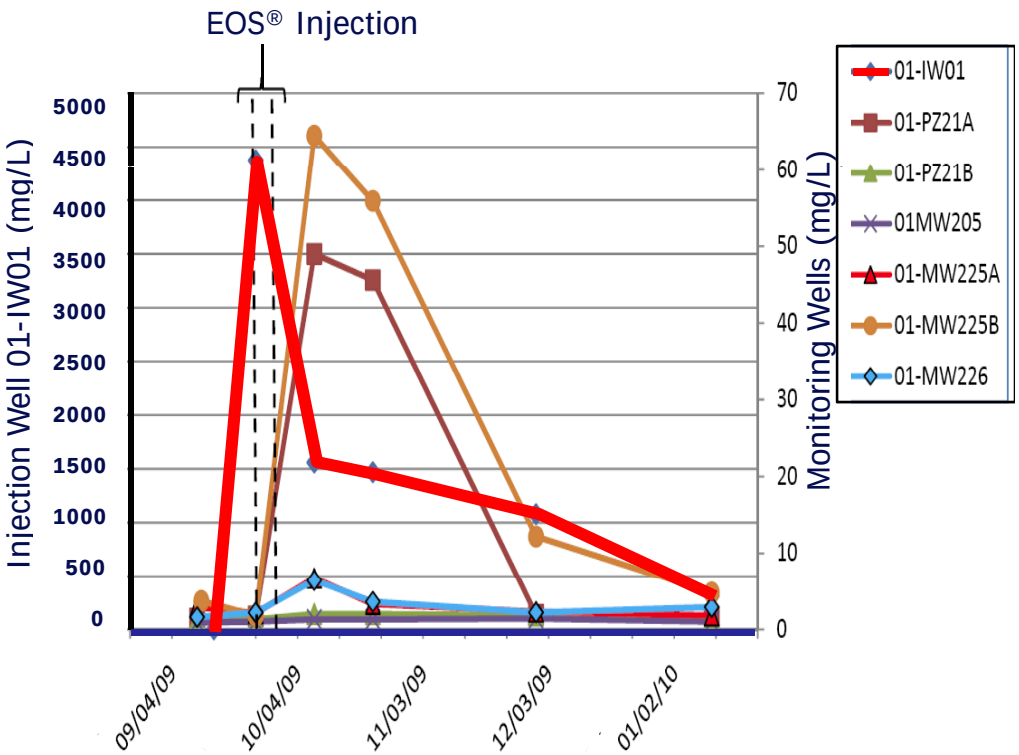


IRP Site 1 - Direct EOS® Injection



Plan View

Total Organic Carbon (TOC)



IRP Site 1 Methodology
Part II: EOS® Injection After Hydraulic Fracturing

1. Install hydraulic fracturing boring; install monitoring well array; conduct baseline monitoring for perchlorate and target analytes.

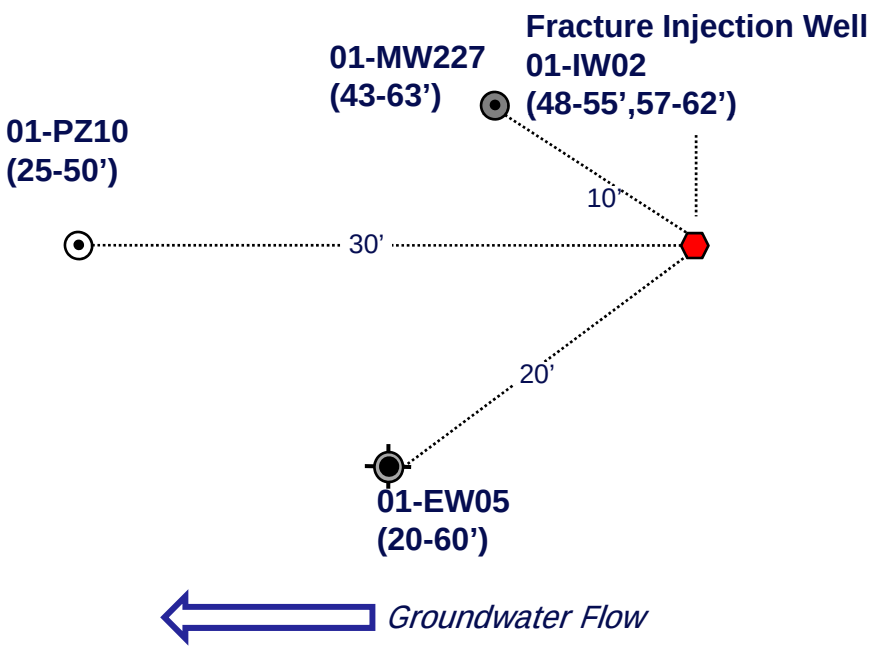
2. Perform hydraulic fracturing; monitor extent and distribution of fractures using tiltmeter geophysics; complete boring as injection well.

3. Inject known quantity of EOS® and tracers.

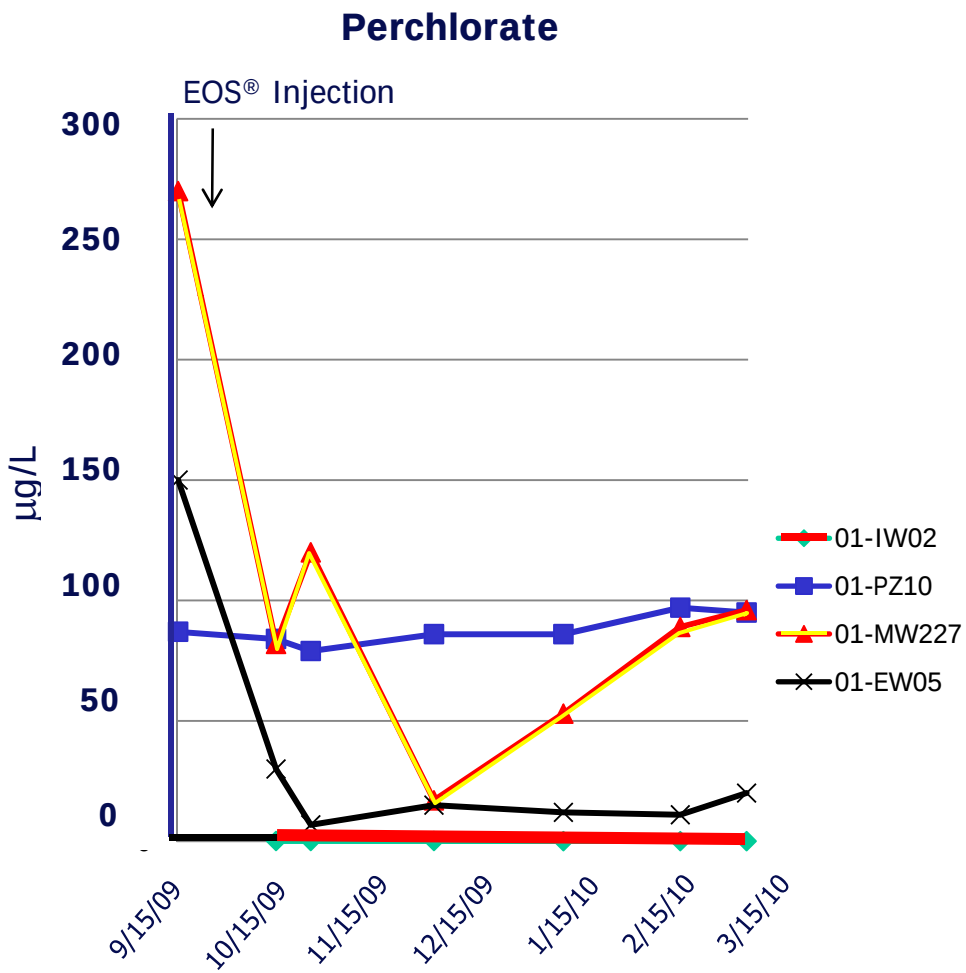
4. Install and sample verification borings.

5. Monitor geochemical changes at injection and monitoring wells for 6 months to determine effective ROI and evaluate rebound.

IRP Site 1 - EOS® Injection Following Hydraulic Fracturing



Plan View



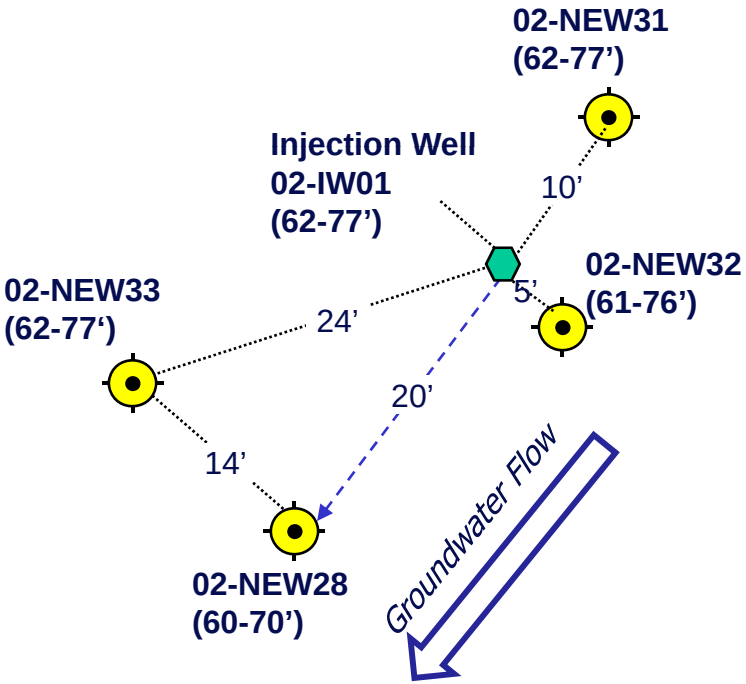
IRP Site 2 Methodology
Part I: Direct Injection of EOS®

1. Install and develop injection well and monitoring well array; analyze baseline samples for target analytes (TCE, perchlorate, TOC, DO, ORP, metabolic gases, general chemistry parameters, etc.).

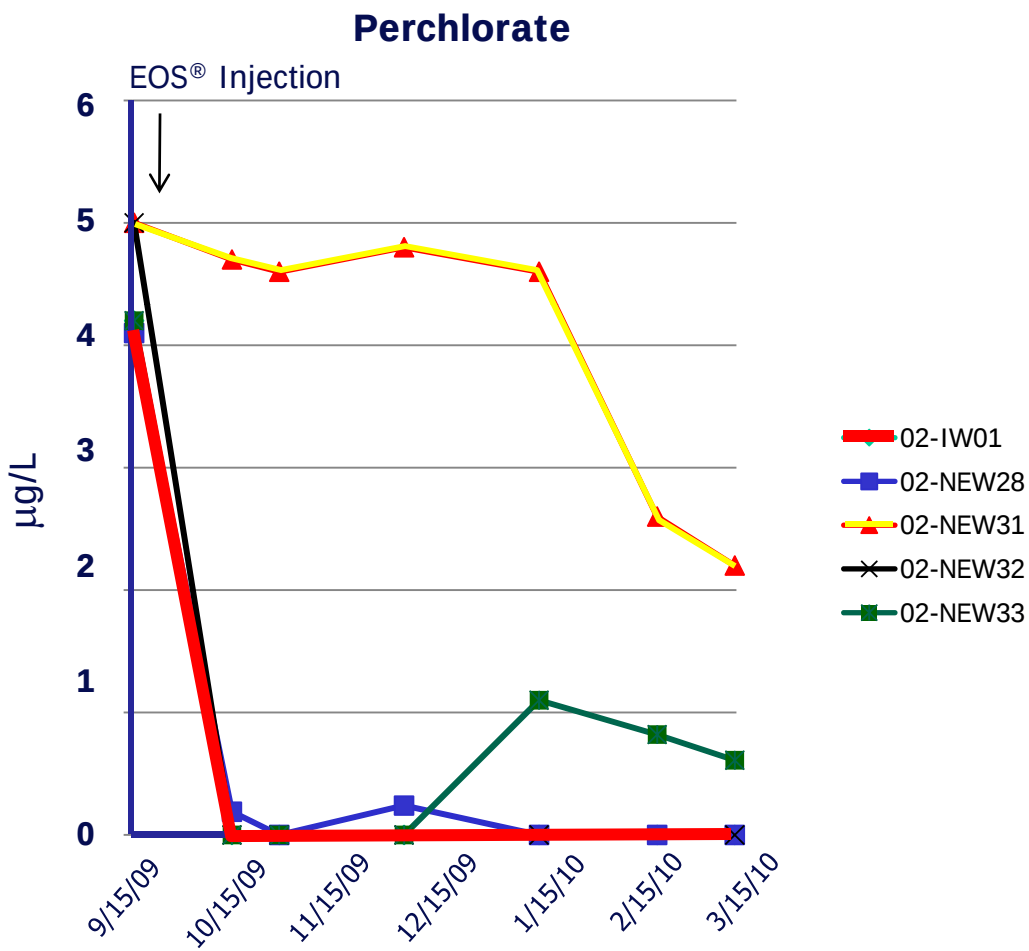
2. Inject known quantities of EOS® and tracers.

3. Monitor geochemical changes at injection and monitoring wells for 6 months to evaluate effective ROI and TCE/perchlorate rebound.

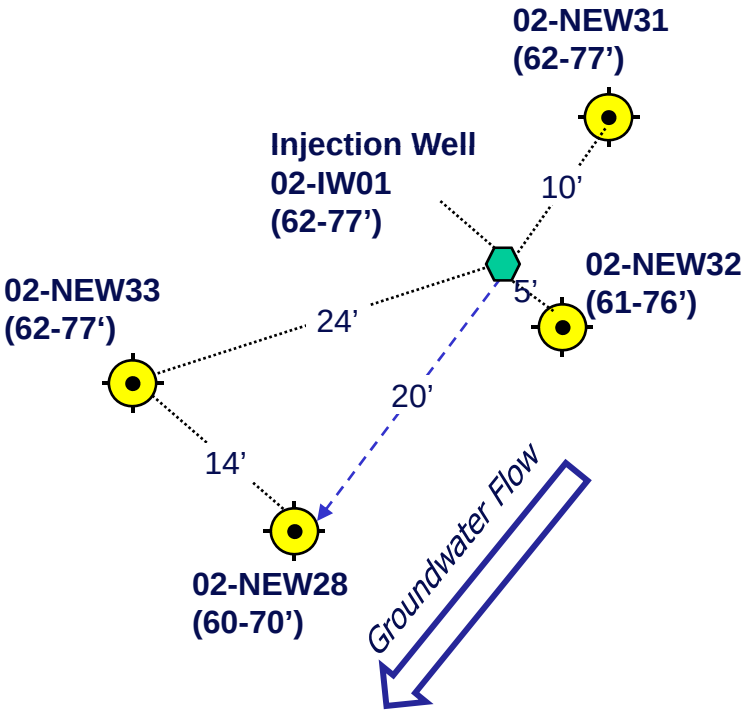
IRP Site 2 - Direct EOS® Injection



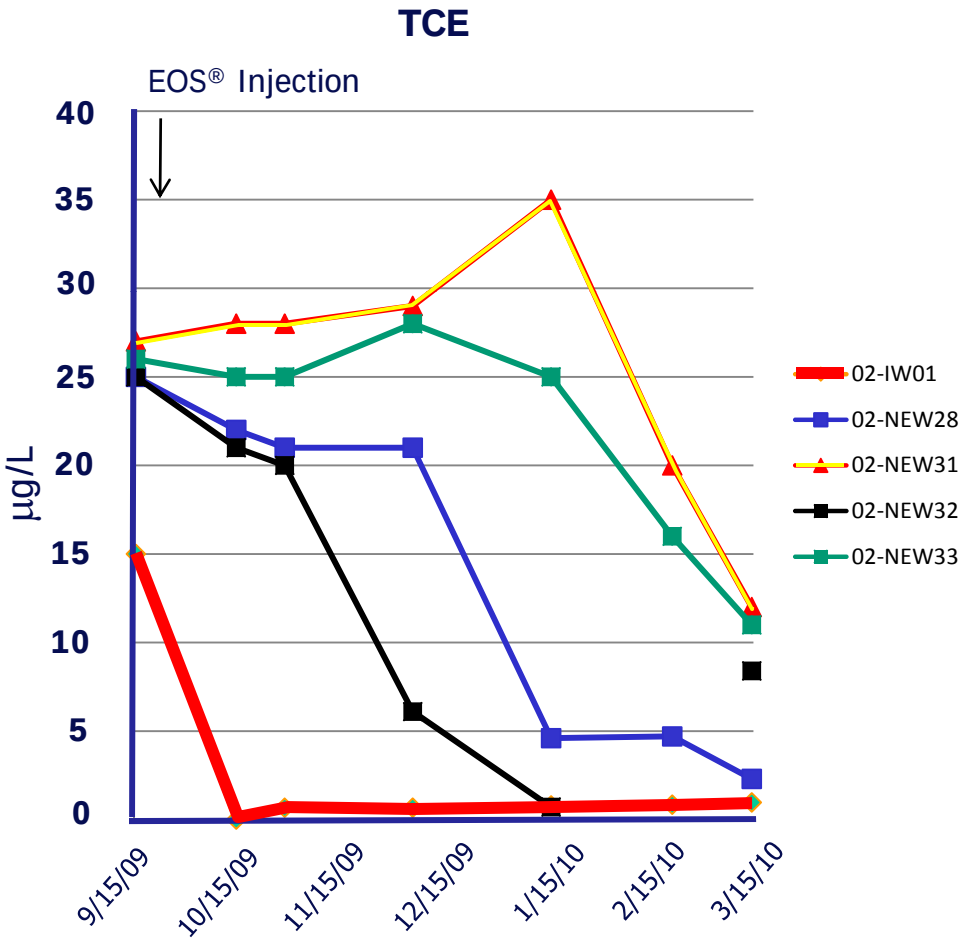
Plan View



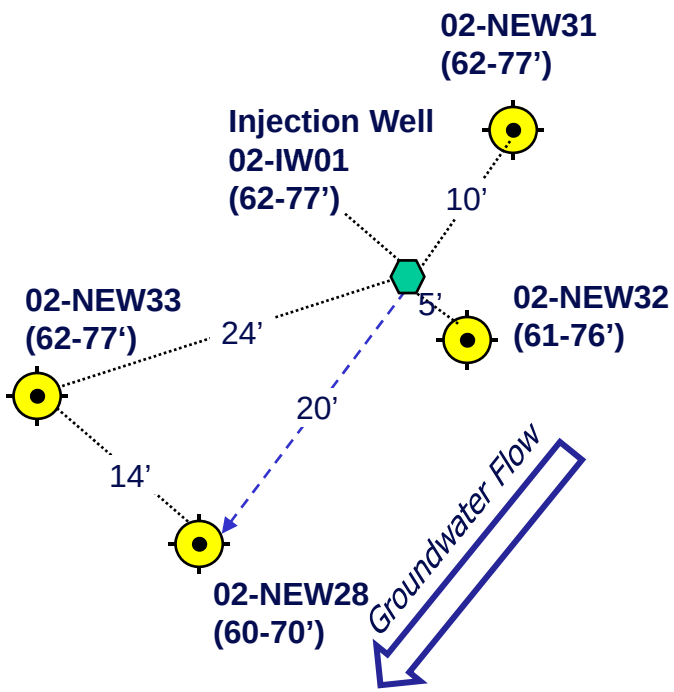
IRP Site 2 - Direct EOS® Injection



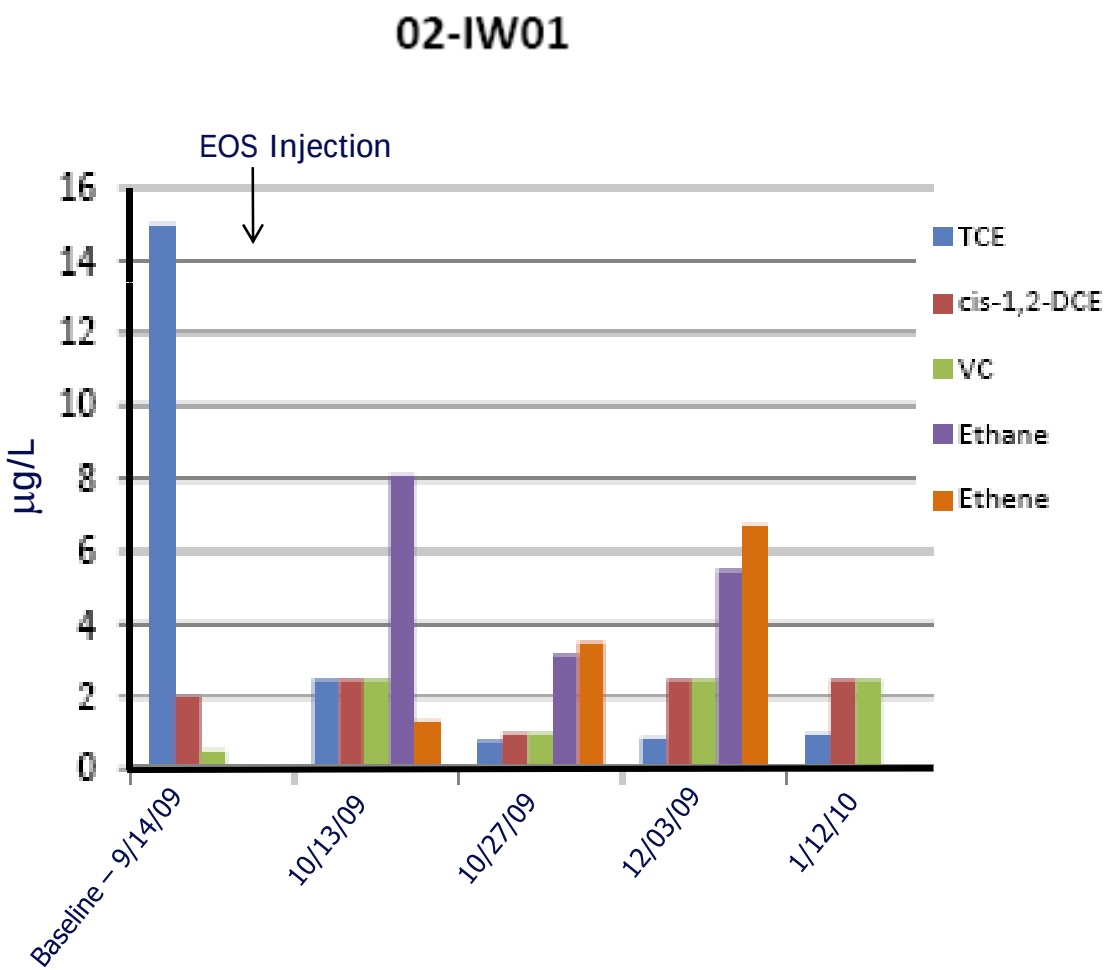
Plan View



IRP Site 2 - Direct EOS® Injection



Plan View

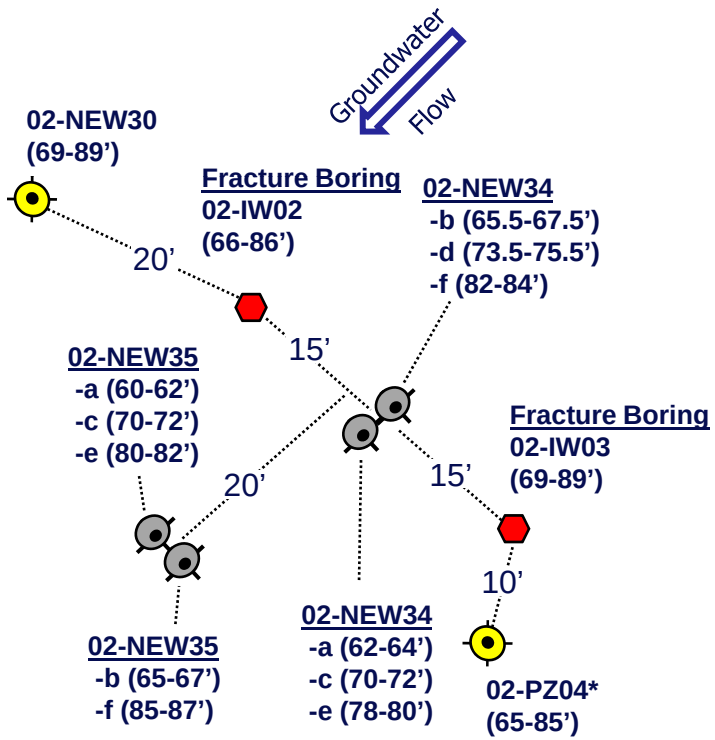


TCE degradation pathway completed
(TCE › cis DCE › VC › ethene > ethane)

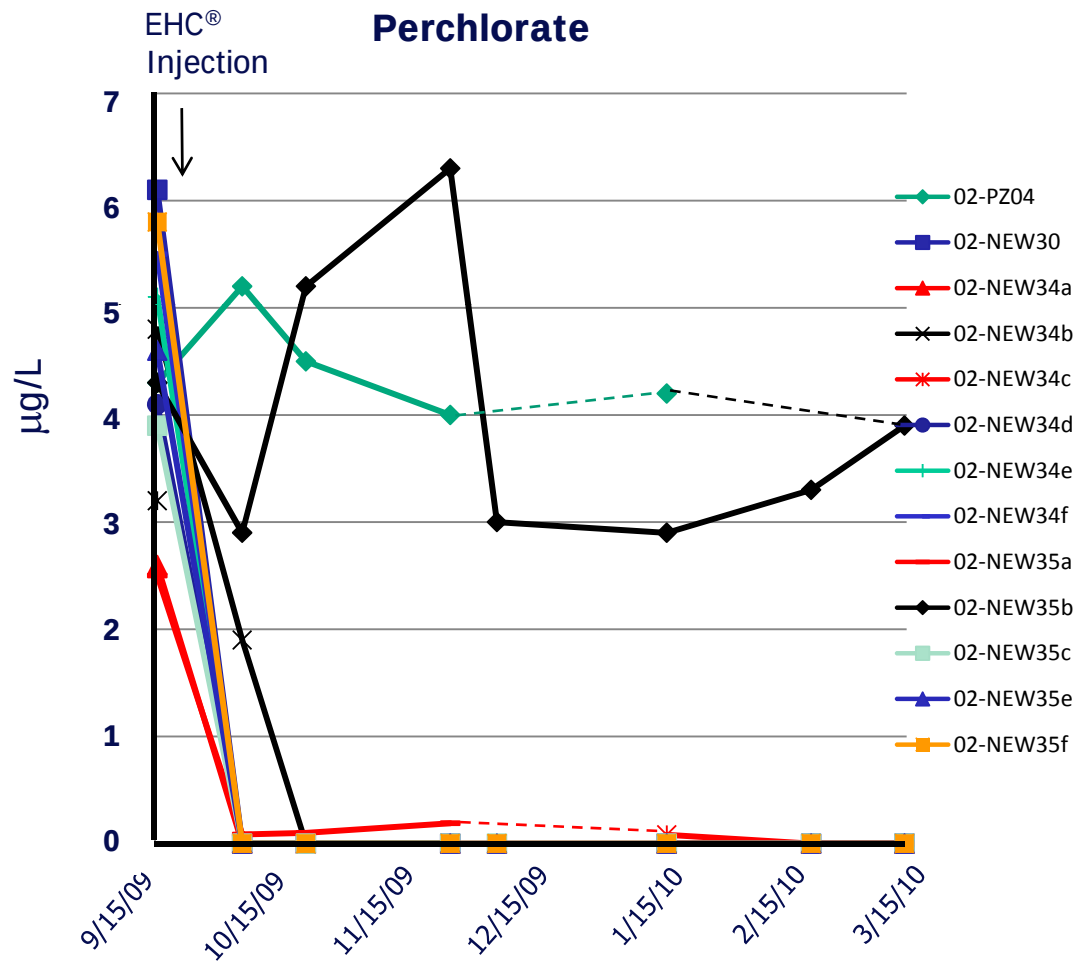
IRP Site 2 Methodology
Part II: EHC® Injection During Hydraulic Fracturing

1. Install two hydraulic fracture borings 30 ft. apart; install nested monitoring well array; conduct baseline monitoring for target analytes
2. Perform sequential hydraulic fracturing in two borings; inject known quantities of EHC® and tracers during fracturing
3. Monitor extent and distribution of fractures using tiltmeter geophysics
4. Monitor geochemical changes for 6 months to determine effective ROI for given substrate quantity, and evaluate TCE/perchlorate rebound

IRP Site 2 - EHC® Injection During Hydraulic Fracturing

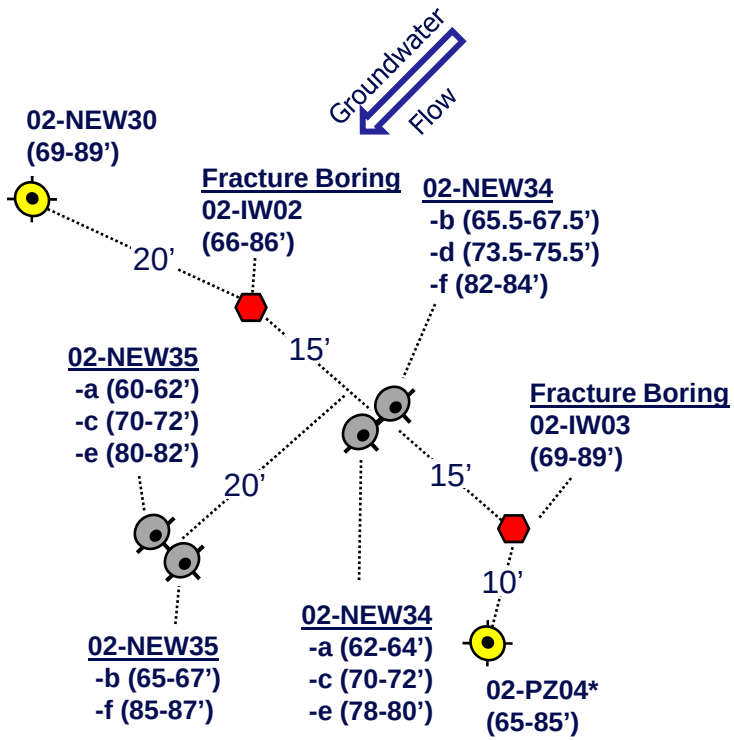


Plan View

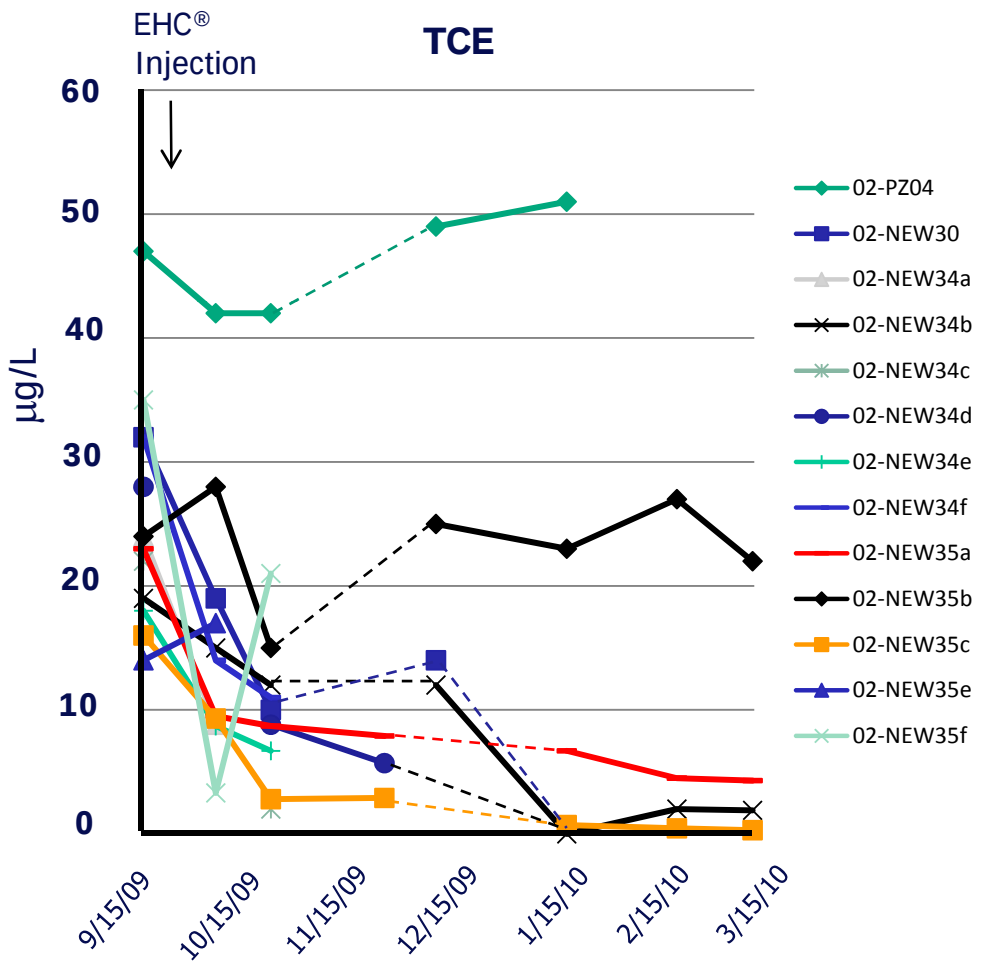


* Well destroyed

IRP Site 2 - EHC® Injection During Hydraulic Fracturing



Plan View



* Well destroyed

IRP Site 1 Conclusions

- ISB using EOS® : reduction of perchlorate concentrations within the area of injection
  - Could work in PRB or in grid pattern geometries.

- Radius of Influence (ROI): Hydraulic fracturing produces larger ROI than direct injection
  - ROI is highly asymmetric and is controlled by bedrock structure at this site.

- Direct injection of 1,600 gal. of 5% EOS® solution degraded perchlorate within an ROI > 15 ft.

- Injection of 1,600 gal. of 5% EOS® solution following hydraulic fracturing degraded perchlorate within an asymmetric ROI > 20 ft.

IRP Site 2 Conclusions

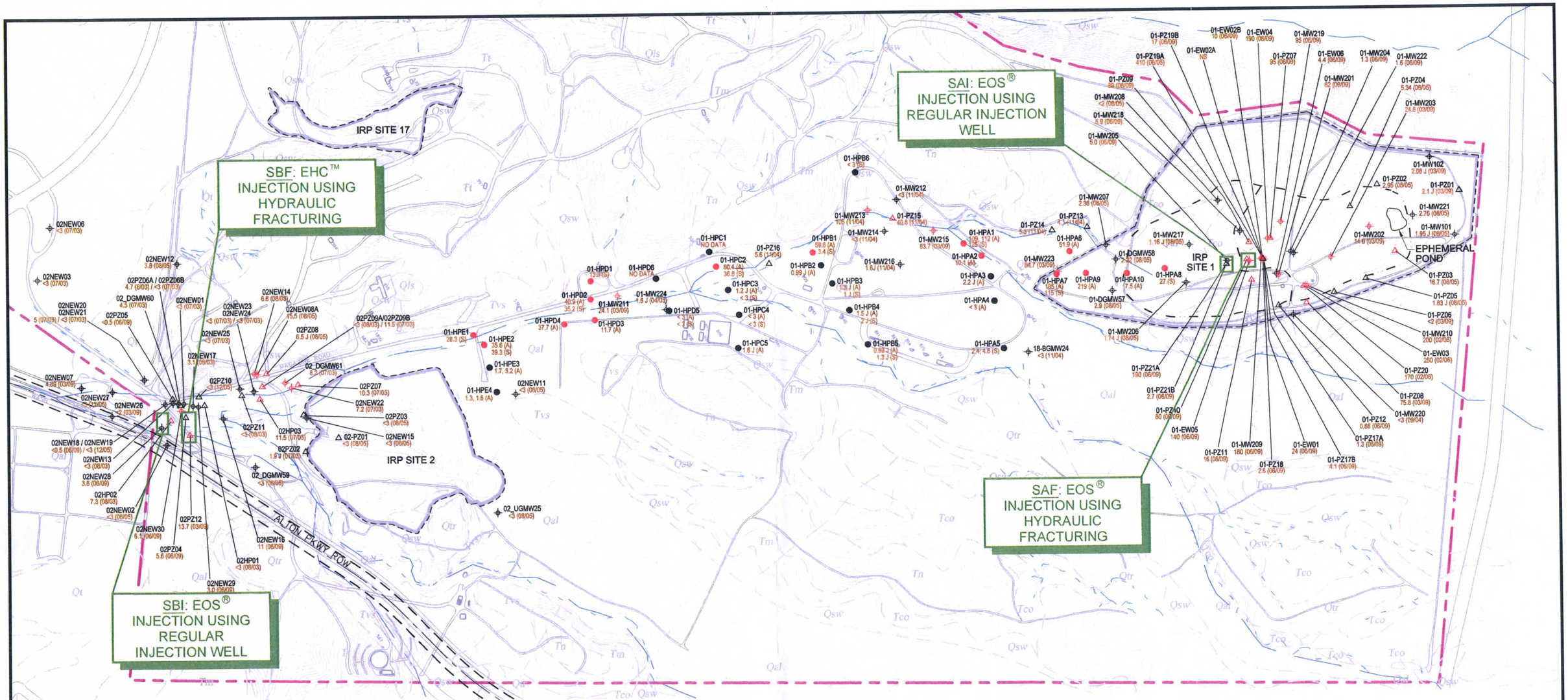
- EOS® and EHC® created reducing conditions that stimulated biodegradation of TCE and perchlorate.
- EOS® can be directly injected without hydraulic fracturing; however, multiple EOS® injections may be required to maintain highly-reducing conditions to complete the reductive dechlorination pathway for TCE.
- EHC® injection resulted in reduction of concentrations of TCE and perchlorate.
- EHC® is a solid containing ZVI; in low-permeability lithologies it must be injected through induced fractures (direct injection not feasible where pore-throat dimension < EHC grain size).

Site 2 Conclusions (cont.)

- Hydraulic fracturing produces larger ROI than does direct injection.
- Direct injection of 3,400 gal. of 5% EOS® in one injection well degraded TCE and perchlorate within an area with ROI up to 20 ft. downgradient.
- Hydraulic fracturing in two borings spaced at 30 ft., produced a highly interconnected fracture network.
- Injecting 10,000 lbs. of EHC® in two fracture borings spaced at 30 ft. effectively degraded perchlorate and TCE within an area with ROI up to 20ft. around each boring.
- A 30-ft. spacing is effective for PRB using injection of EHC® during hydraulic fracturing.

Acronyms

cis DCE	*cis* 1,2 dichloroethene
DO	Dissolved oxygen
EHC®	Proprietary amendment that utilizes ZVI to reduce redox potential (Eh) and cellulosic carbon (C) as a bacterial food source
EOS®	Proprietary amendment that utilizes emulsified oil substrate as a bacterial food source
FS	Feasibility Study
IRP	Installation Restoration Program
LEL	Lower Explosive Limit
MCAS	Marine Corps Air Station
MCL	Maximum Contaminant Level
µg/L	Micrograms per liter
mg/L	Milligrams per liter
ORP	Oxidation/reduction potential
PRB	Permeable reactive barrier
ROI	Radius of influence
TCE	Trichloroethene
TOC	Total organic carbon
VC	Vinyl chloride
ZVI	Zero valent iron



LEGEND:

01-HPE4 ●	HYDROPUNCH SAMPLING LOCATION (PERCHLORATE LESS THAN 6 µg/L)
01-HPA1 ●	HYDROPUNCH SAMPLING LOCATION (PERCHLORATE MORE THAN 6 µg/L)
1.6 J (A) / < 3 (S) / J	HYDROPUNCH PERCHLORATE CONCENTRATION (A INDICATES ALLUVIUM SAMPLE, S INDICATES WEATHERED BEDROCK SAMPLE, J INDICATES ESTIMATED VALUE)
01-MW206	4-INCH GROUNDWATER MONITORING WELL (PERCHLORATE LESS THAN 6 µg/L)
01-MW201	4-INCH GROUNDWATER MONITORING WELL (PERCHLORATE MORE THAN 6 µg/L)
01-PZ02 △	2-INCH PIEZOMETER (PERCHLORATE LESS THAN 6 µg/L)
01-PZ08 △	2-INCH PIEZOMETER (PERCHLORATE MORE THAN 6 µg/L)
	MCAS EL TORO BOUNDARY
	EOD RANGE BOUNDARY
	IRP SITE BOUNDARY (1, 2, AND 17)
	EPHEMERAL STREAM OR WASH (INTERPOLATED FROM TOPOGRAPHIC DATA)
	GEOLOGIC FAULT, DOTTED WHERE INFERRED
	EXISTING FENCE

DESCRIPTION OF MAP UNITS:

Qal	Flood Plain and Stream Channel Deposits (Holocene and Late Pleistocene)
Qsw	Sheetwash Deposits (Holocene to Middle Pleistocene)
Qtr	Trail Ridge Sands (Pleistocene)
Tn	Niguel Formation
Tco	Oso Member
Tm	Monterey Formation (Miocene)
Tt	Topanga Foundation (middle Miocene)
Tvs	Sespe and Vaqueros Formations

NOTES:

1. DATA SOURCE: STATIONWIDE GROUNDWATER MONITORING (TREVET 2010); PRE-BASELINE SAMPLING; PHASE II RI (EARTH TECH 2006b; & AQUIFER CHARACTERIZATION AND BENCH-SCALE TREATABILITY TESTING (ECS 2006)

<	LESS THAN
µg/L	MICROGRAMS PER LITER
EOD	EXPLOSIVE ORDNANCE DISPOSAL
IRP	INSTALLATION RESTORATION PROGRAM
MCAS	MARINE CORPS AIR STATION
RI	REMEDIAL INVESTIGATION

NORTH

0 350 700 FEET

SCALE: 1" = 700'

Pilot Study Tech Memo — Draft

PILOT STUDY AREAS

IRP Sites 1 & 2

Former MCAS El Toro

Date: 06-10

Project No. 95653

ECS AECOM

Figure 14

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