

Kyle Waggoner
Whiting Petroleum
56719 CR 127
New Raymer, CO 80742

March 19, 2019

Re: **Remedial Action/Pilot Test**
Whiting Petroleum
Terrace A Site
Weld County, Colorado

Dear Mr. Waggoner:

REMEDIAL ACTION & PILOT TESTING

Remington proposes to conduct a remedial injection and extraction near monitoring well MW-1 (See Figure 1). This remedial action is not intended to fully treat soil and groundwater to regulatory levels, however, the pilot test data will be used to determine the technical and economic feasibility of using injection, multiphase extraction, and/or soil vapor extraction (SVE) technologies to remediate the soil and groundwater hydrocarbon mass present near well MW-1.

Injection and Extraction Pilot Testing Goals

The goals of the pilot test are to determine the following:

- Estimate Radius of influence (ROI) from an injection point and extraction point.
- Injection pressure required to inject remedial material.
- Flow rate characteristics of the subsurface in terms of vertical/lateral permeability.
- Characteristics of the subsurface in terms of penetration rate.
- Total injectate volume required to establish a baseline ROI.
- Effectiveness of multiphase extraction and/or SVE to remove hydrocarbon mass from the vadose soil.

Injectate for Pilot Testing

Remington recommends using COGACTM as the solution for the injection pilot test. The formulation of COGACTM contains 80% activated carbon and 20% oxidant. This formulation of COGACTM effectively targets

dissolved phased hydrocarbons through insitu chemical oxidation which transitions to adsorption and bioremediation.

The COGAC™ material will be mixed with water at a 12% concentration. At this concentration one pound of COGAC™-Oxy will be mixed in one gallon of water so the number of gallons of injectate equal the pounds of remedial material used. The oxidant in the solution provides a tracer, increases dissolved oxygen (DO), and oxidation reduction potential (ORP), which can be detected in the adjacent monitoring well during and after the pilot test.

Injection Pilot Test Plan

The injection pilot test plan will consist of the following activities.

- Install In-Situ Aqua TROLL® 600 water quality meter and collecting groundwater quality data from monitoring well MW-1.
- Install injection pilot test points
- Perform injection pilot test injection

Multiphase Extraction and SVE Pilot Test Plan

The multiphase extraction and SVE pilot test plan will consist of the following activities.

- Install submersible pump in monitoring well MW-1.
- Install 4 soil vapor extraction test points
- Perform extraction pilot test on MW-1 and SVE points

Temporary SVE Wells

The pilot test plan will consist of installing four temporary 2-inch diameter SVE wells (SV-1, SV-2, SV-3 and SV-4) at approximately 10 foot spacing from monitoring well MW-1 as shown on Figure 1.

Each 2-inch diameter temporary SVE well shall be installed with 30 feet of 0.020 slot PVC screen. Screen shall be placed from 15 to 45 feet bgs. Solid blank PVC riser shall be installed from 15 feet to ground surface. Silica sand shall be placed from 12 to 45 feet bgs. Bentonite shall be used to seal the temporary monitoring wells from 12 to ground surface. Each SVE well shall be completed with PVC solid well riser extending between 2 to 3 feet above ground surface.

Groundwater Quality Monitoring

Prior to the injection event, an In-Situ Aqua TROLL® 600 water quality meter will be placed into monitoring well MW-1 to measure (data log) groundwater quality parameters (barometric pressure, conductivity, dissolved oxygen, pH, ORP, temperature and water level). Groundwater data logging will be performed before, during and will end 7-days after the injection pilot test.



Injection Point Installation

Four injection points will be installed approximately 8 feet from well MW-1 by direct push technologies and will collect continuous core soil to a depth of 65 feet below ground surface (bgs). If refusal is met utilizing direct push technologies the remainder of the boring will be completed utilizing solid stem augers. Field screening using a Photo-Ionization Detector (PID) will be completed every 1 to 2 feet from ground surface to the total depth of the boring. Field screening and soil characterization information will be used to identify depth(s) at which the competent (resistant to flow) layer(s) may be present. This information will be utilized during the injection event to maximize remedial material application and distribution.

Injection Pilot Testing

After the In-Situ Aqua TROLL® 600 water quality meter is installed and data logging has started, the injection pilot testing will be initiated. Up to 200 gallons of an 12% solution of COGAC™ will be mixed and injected. During the injection event, injection pressure, flow rate and total injectate volume will be recorded for evaluation/comparison to groundwater quality data collected from the In-Situ Aqua TROLL® 600 water quality meter during the injection pilot test.

Assuming that direct push technology is unable to penetrate to the total depth required at this site, the pilot test injection will be completed using an inflatable packer injection method. The temporary injection point will be installed by advancing solid stem auger to a depth of 65 feet bgs. After reaching this depth, solid stem augers will be extracted from the borehole. An inflatable packer will be installed to 60 feet for the first injection interval (60 to 65 feet), and 25% of the total injectate volume or 50 gallons will be injected. After completing this injection interval, the inflatable packer will be raised to 55 feet bgs and the 25% of the injectate volume will be injected at this interval. This process will be repeated twice for a total of 200 gallons.

A summary of the injection pilot test plan is listed in the table below.

Summary of Injection Pilot Test Plan		
Whiting Petroleum Terrace A Site		
Description	Units	Pilot Test Area
Total Number of Injection Points	#	4.0
% Solution COGAC	%	12%
Number of Feet per Injection Interval	Feet	5.0
Number of Injection Intervals	Intervals	4.0
Total Injection Interval (feet)	Feet	20.0
Injection Interval Range (feet bgs.)	Feet	45'-65'
Injectate Gallons per Foot	Gallons	10.0
Injectate Gallons per Interval	Gallons	50.0
Pounds per Interval	Pounds	50.0
Pounds per Injection Point	Pounds	200.0
Injectate Gallons per Point	Gallons	200.0
Total Gallons of Solution	Gallons	800.0
Total Pounds of COGAC	Pounds	800.0

Multiphase Extraction and SVE Pilot Test Plan

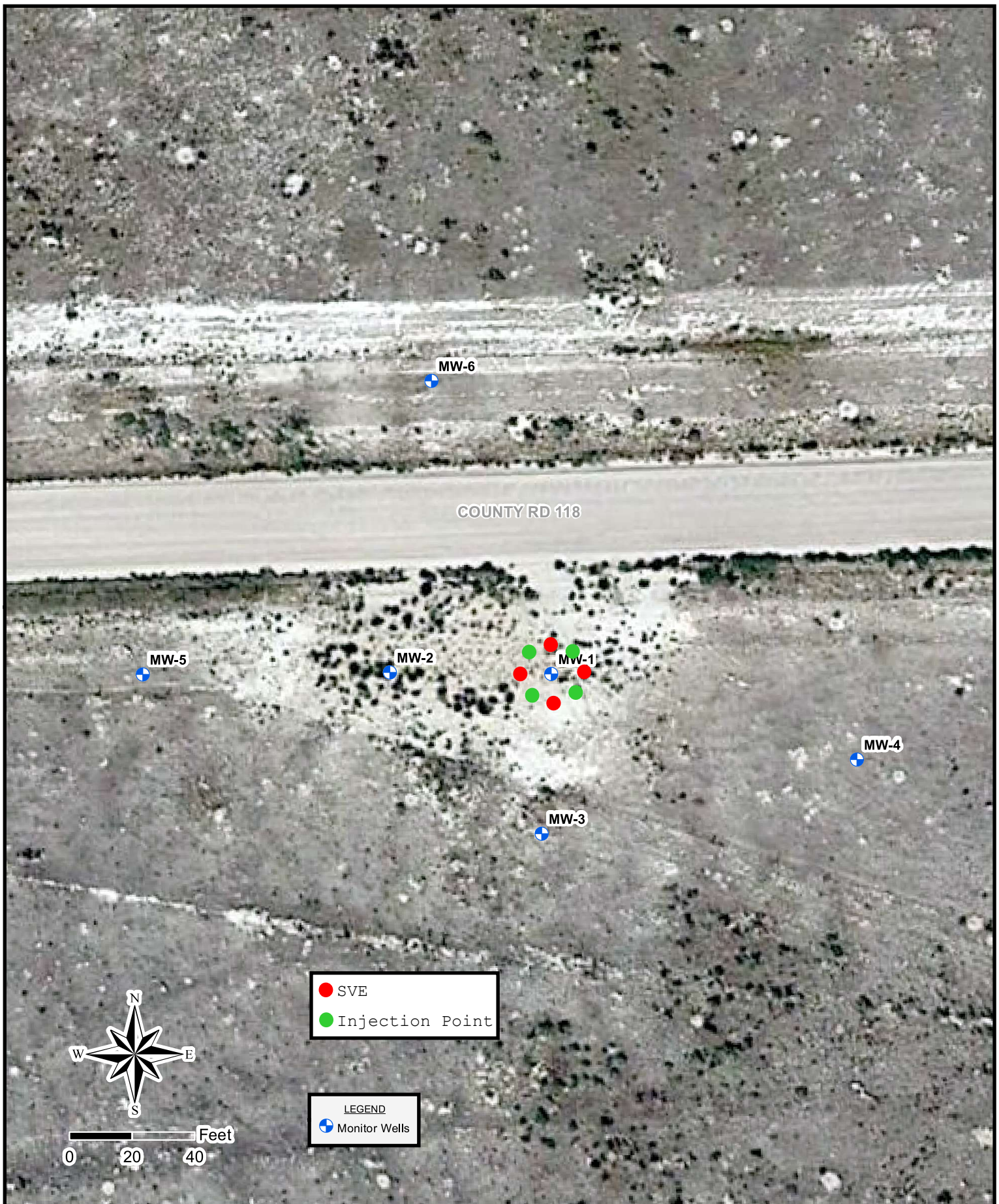
Multiphase Extraction

During the Injection testing activities, a submersible pump and well head vacuum will be utilized at well MW-1. This multiphase extraction will have a dual purpose: 1) to determine the effectiveness of multiphase extraction for hydrocarbon mass removal from impacted groundwater and the smear zone; and 2) to determine if the extraction has a positive impact on the injectate distribution. During the multiphase extraction the In-Situ Aqua TROLL® 600 will monitor groundwater parameters, while at the surface vapor concentration and pressure readings will be collected via a photo ionization detector (PID) and magnehelic gauges. Pressure readings will be collected from the SVE wells to determine ROI.

Soil Vapor Extraction

Following the injection and multiphase extraction testing, SVE pilot testing commence. A vacuum will be pulled from each point for a total of 2 hours. Pressure readings will be collected every 15 minutes from each SVE point and MW-1 and PID readings will be collected from the point under vacuum while the vacuum is being pulled. Additionally, laboratory analytical samples will be collected pre and post extraction via summa canister and submitted for analysis using EPA method TO-15 for TPH and BTEX.

FIGURE



Drafted: 7/3/2018
1 in = 40 ft
Drafted By: IJM

Whiting Oil and Gas Corporation
Terrace Pit
Weld County, CO
Figure 2 - Site Plan