



LT Environmental, Inc.

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Arvada, Colorado 80003
303.433.9788*

February 5, 2020

Mr. Jacob Evans
Environmental Coordinator - EHSR
Noble Energy, Inc.
2115 117th Avenue,
Greeley, Colorado 80631

**RE: Phytoremediation Plan
Gemini B #31-11, 12, 13, 14, 25
SESW Sec 31-T5N-R64W
Weld County, Colorado**

Dear Mr. Evans:

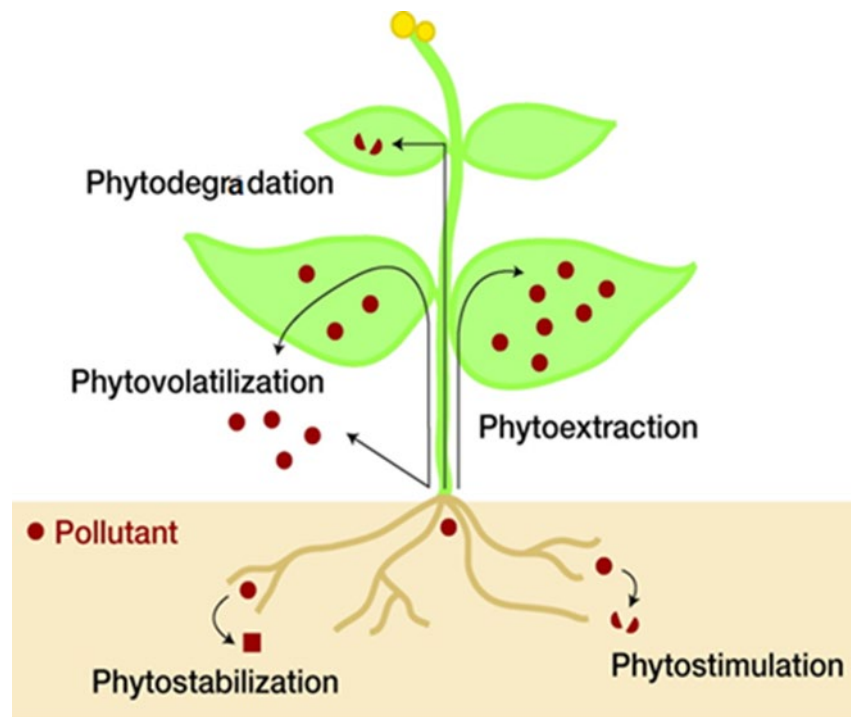
LT Environmental, Inc. (LTE) is pleased to present to Noble Energy, Inc. (Noble) this Phytoremediation Plan (Plan) for the former Gemini B #31-11, 12, 13, 14, 25 tank battery (Site). This Plan presents a brief background, the proposed additional remedial option, estimated costs, and schedule. The proposed additional remedial option is the implementation of phytoremediation technology to target a soil layer believed to be back-diffusing petroleum impacts into the groundwater and causing persistent elevated benzene and total xylenes concentrations. The Site Map is provided as Figure 1.

BACKGROUND

An unintentional release occurred along the produced water line running from the separator to the production tanks at the Site. In October 2018, December 2018, and January 2019, environmental assessments were conducted. Based on the results of the environmental assessments, excavation activities occurred in September and October 2019. Approximately 1,050 cubic yards of contaminated soil were excavated and disposed of at the Buffalo Ridge Landfill in Keenesburg, Colorado. The groundwater at the Site has been monitored on a quarterly basis since October 2018. For more historical information at the Site, refer to Colorado Oil and Gas Conservation Commission (COGCC) Remediation #12355.

PROPOSED REMEDIATION

To target the remaining impacted soil and groundwater, phytoremediation is proposed. Phytoremediation is an *in-situ* remediation technique that uses the physical and chemical processes of vegetation to remediate impacted sites. Phytoremediation is the use of plants and plant-associated microbes to remediate contaminants of concern (COCs). Plants are grown in the presence of contaminated soil and/or groundwater to enhance the decomposition or removal of organic contaminants. The plants can uptake the hydrocarbons (phytoextraction) and degrade the COCs into harmless byproducts (phytodegradation) or release them into the air through transpiration (phytovolatilization). In addition, plants improve the soil structure by increasing aeration and improving microbial growth (phytostimulation). This technique has long-term effectiveness and is relatively non-intrusive as compared to excavation.



Phytoremediation can be conducted with a variety of plant species, and the proposed Site-specific approach would use hybrid poplar cottonwood trees that are cottonless. The trees will be inoculated with endophytes (PD1). PD1 is a specialized endophytic strain of *Pseudomonas putida* that is beneficial on sites with petroleum hydrocarbons. PD1 are native endophytic bacteria, are gram negative, non-pathogenic, and non-virulent. They are safe for humans and safe for the environment. PD1 has been shown in laboratory and field studies to improve plant growth, tolerance, and degradation of contaminants. In natural systems, plants can use symbiosis with internal microorganisms, to adapt to environmental challenges, including pollutants. Plants in contaminated areas have a high number of endophytes, which are capable of degrading the

pollutant. The use of endophytes can increase nutrient acquisition, develop more extensive root systems, increase environmental stress tolerance, and increase contaminant degradation rates.

An approximately 12,000 square foot area has been selected for phytoremediation, which includes a 30-foot setback from the existing cottonwood tree. Based on the concentrations of impact and the groundwater levels at the Site, a tree spacing of approximately eight feet was selected. With the above parameters, a total of 170 trees is recommended.

Boreholes six inches in diameter will be drilled to approximately 5 feet below ground surface (bgs). Because the trees will not be planted directly into the groundwater, a drip irrigation system will be installed. A one-inch polyvinyl chloride irrigation line will be installed in each borehole to a depth of five feet bgs. This will help the tree roots to develop in the impacted zone, which in turn will draw hydrocarbons out of the impacted target zone at a faster rate than is currently occurring. The tree, which will not have roots or leaves at the time of planting, will be placed in the borehole, and the borehole will then be backfilled with the native soil and compost. A fence will be installed to protect the saplings.

Approximately 500 gallons of water per day will be needed for the drip irrigation system. The trees will need to be watered from spring until fall for the first two years. Following the first year, the watering frequency can be reduced. The watering can cease after the second year, except in drought conditions. LTE will make monthly visits during the spring, summer, and fall months to maintain the drip irrigation system and ensure it is operating properly.

Planting is recommended in early April 2020. LTE estimates that following tree installation, five years will be required for remediation as the tree roots will need to fully interact with the impacted clay layer and impacted groundwater. Groundwater monitoring will continue on a quarterly basis, and the analytical data will be used to assess performance of the phytoremediation approach. The trees will be inspected for growth and health each quarter during the groundwater monitoring event.

SCHEDULE

The borehole drilling can be conducted on a staggered schedule to the planting schedule to minimize the number of open boreholes. LTE can initiate phytoinstallation in April 2020. The Site will be monitored for a period of five years.

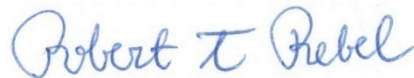
LTE appreciates the opportunity to provide this Plan to Noble. If you have any additional questions, please contact us at (303) 433-9788.

Sincerely,

LT ENVIRONMENTAL, INC.



Chris Roy
Senior Environmental Scientist



Rob Rebel, P.E.
Senior Engineer

Appendices:

Figure 1 – Site Map



IMAGE COURTESY OF GOOGLE EARTH 2016

LEGEND

- HYBRID POPLAR TREE (170)
- ⊗ APPROXIMATE MONITORING WELL
- ⊗ DESTROYED MONITORING WELL
- ⊗ APPROXIMATE RELEASE LOCATION
- ⊗ 30 FOOT RADIUS (EXISTING COTTONWOOD TREE)
- ⊗ EXCAVATION EXTENT
- ⊗ PROPOSED FENCE

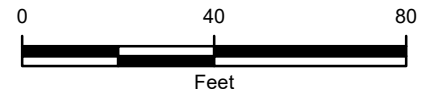


FIGURE 1
SITE MAP
 GEMINI B #31-11, 12, 13, 14, 25
 SESW SEC 31-T5N-R64W
 WELD COUNTY, COLORADO
 NOBLE ENERGY, INC.

