APPENDIX L

ADDITIONAL EXPERT ANALYSIS (KUEPER)

Dr. Bernard Kueper
11-22-22
Exhibit 2
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REMEDY SELECTION FOR CHLORIDES IN GROUNDWATER

August Levert, Jr., Family, LLC, et al. v. BP America Production Company
18th Judicial District Court, Division "A", Docket No. 078953
Grand River Oil and Gas Field
Section 15, Township 10 South, Range 11 East
Iberville Parish, Louisiana
LDNR OC Legacy Project No. 018-028-001

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Remedy Selection for Chlorides in Groundwater

The Levert Property (Site) is located in the Iberville Parish of Louisiana approximately 2.1 miles southwest of Jack Miller's Landing and can only be accessed by water through the Grand River/lntracoastal Waterway. The Site periodically floods, which additionally limits access. ICON Environmental Services, Inc. (ICON) conducted a subsurface investigation at the Site (ICON, 2022). The Iberville Parish School Board (IPSB) property is located west of, and adjacent to, the Site. Hydro-Environmental Technology, Inc. (HET) and ICON conducted subsurface investigations at the IPSB property (ICON, 2015; HET, 2016).

In general, the soils from ground surface to at least 60 ft below ground surface (bgs) primarily comprise clays and silts (HET, 2016). The Mississippi River Valley Aquifer occurs at depths greater than 100 ft bgs at the Site (HET, 2016). There are no drinking water wells within 1 mile of the Site. ICON (2022) drilled borings LT1 to LT6 at the Site to a maximum depth of approximately 28 ft bgs, which exhibited predominantly clay with an approximate 2 to 5 ft thick silt layer occurring at selected locations. The geology at the Site is consistent with the geology at the adjacent IPSB property. The groundwater at the IPSB property is classified as GW_{3NDW} (HET, 2017). Laboratory measured vertical hydraulic conductivities in clay ranged from 4.0×10^{-8} cm/s to 1.4×10^{-7} cm/s at the IPSB property (HET, 2016). Geometric mean horizontal hydraulic conductivities were derived from slug tests in monitoring wells screened across predominantly silty layers on the IPSB property, and ranged from 4.6×10^{-5} cm/s (HET, 2016) to 1.4×10^{-4} cm/s (ICON, 2022). Groundwater elevation contour maps prepared by ICON (2022) and HET (this Proposed Plan) indicate that the direction of the shallow groundwater flow is variable with a horizontal component of hydraulic gradient of approximately 0.005 or less. The shallow groundwater velocity at the Site is estimated to be approximately 2.4 ft/yr or less.

Laboratory measured chloride concentrations in groundwater at ICON monitoring wells LT1, LT2, LT3, LT4 and LT5 are provided in Table T3 of this Proposed Plan, and range from 120 mg/L (LT4) to 12,400 mg/L (LT1) at the Site. The chloride concentration in groundwater at monitoring well LT1 is associated with former operations on the IPSB property. The chloride concentration in groundwater at monitoring well LT2 (3640 mg/L) is associated with former operations at the adjacent pit on Site. The chloride concentration in groundwater at monitoring well LT3 (2600 mg/L) is associated with former operations at the adjacent pit on Site.

Criteria for selecting appropriate site-specific groundwater remedies are well-documented. In general, groundwater remedy selection can be evaluated based on (USEPA, 1990; USEPA, 1997):

- Overall protectiveness (human health and environment)
- Regulatory compliance
- Effectiveness (short-term and long-term)
- Reduction of toxicity, mobility or volume
- Implementability
- Cost

Cohen et al., (1997) and USEPA (1993) summarized contaminant and hydrogeologic characteristics that affect groundwater restoration at sites and provided a generalized remediation difficulty scale based on site use, chemical properties, contaminant distribution, geologic conditions, and groundwater flow parameters. Based on Cohen et al., (1997) and USEPA (1993), contaminant and hydrogeologic characteristics that are most difficult with respect to the remediation of chlorides in groundwater at the Site include: (i) low biotic/abiotic decay potential, (ii) low volatility, (iii) fine-grained soils (clay and silt), and (iv) low hydraulic conductivity ($< 10^{-4}$ cm/s).

ICON (2022) proposed a groundwater pump and treat (P&T) remedy at the Site to reduce chloride concentrations in groundwater to background concentrations by utilizing an extraction system comprising 40 pumping wells operating continuously for 51.8 years at a cost of approximately $26M. Due to the low hydraulic conductivity (4.6×10^{-5} cm/s to 1.4×10^{-4} cm/s), fine-grained soils (clay and silt) at the Site, P&T is not appropriate for remedy selection due to poor implementability and high cost. In addition, the ICON proposal of installation and operation of 40 extraction wells and associated infrastructure for over 50 years will be invasive and disruptive at the Site. Furthermore, P&T remedial time scales will be exacerbated by backdiffusion from clays and silts, and the associated concentration tailing (Kueper et al., 2014). In practice, P&T remedies are typically not considered feasible in clays and silts, with other remedial approaches being more appropriate. Ultimately, even if the proposed ICON P&T remedy (ICON, 2022) or a similar P&T remedy were implemented, it is unlikely that the P&T remediation would function as ICON predicts (ICON, 2022), and it is highly unlikely that a background chloride concentration would be achieved in the timeframe suggested by ICON (ICON, 2022).

Monitored natural attenuation (MNA) is proposed as an appropriate groundwater remediation strategy for the Site. MNA relies upon the natural assimilative capacity of the subsurface to passively reduce concentrations in groundwater over time (USEPA, 1999). MNA can be a fully compliant remedial strategy. MNA can meet the objective of reducing chloride concentrations in groundwater at the Site within a timeframe that is reasonable compared to P&T. Both MNA and P&T can lead to decreasing chloride concentrations in groundwater over time, with continued attenuation eventually approaching background conditions. However, given site-specific conditions, MNA has good implementability and is low cost, while P&T has poor implementability and is high cost. In addition, P&T is not substantially more reliable than MNA to achieve an ultimate return to background chloride conditions, especially given the characteristics of the shallow water-bearing zone being addressed and the fact that it has no current or future environmental or ecological effects. MNA is the preferred remedy for chloride concentrations in groundwater at the Site.

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