Colonial Pipeline Company

Sam McEwen
Director, Environmental

May 12, 2021

To: Michael Scott via e-mail

Re: **Colonial Pipeline SR 2448/Pipeline ROW**
Incident Number 95827
Huntersville, North Carolina

Dear Mr. Scott:

Enclosed is Colonial Pipeline Company's (Colonial or the Company) response to Items 1 and 6 of the May 5, 2021 Notice of Continuing Violation (NOCV).

Item 1

As requested by NCDEQ, Attachment 1 to this letter is a technical memorandum prepared by Colonial's modeling consultant, TRC Environmental Corporation, detailing Colonial's evaluation and selection of volume estimating models.

Colonial would like to correct any misimpression regarding its selection and use of the American Petroleum Institute's LNAPL (light non-aqueous phase liquid) Distribution and Recovery Model (LDRM) for estimating total product released to the environment. As described in Attachment 1, LDRM is a proven model for estimating volume of product present at a location. Given what was known about the site geology and LNAPL distribution at the time, the LDRM appeared to be an appropriate model. It was Colonial's understanding the NCDEQ was relying on the LDRM to evaluate the Huntersville release volume as well. As has been previously communicated to NCDEQ, the LDRM model estimated approximately 1.2 million gallons of total product released into the environment.

On April 14, 2021, Colonial received initial data from its Optical Image Profiling (OIP) work, and that data was provided to NCDEQ on April 15, 2021. The OIP data indicates that unique geologic and hydrogeologic conditions in the northern portion of the Site have resulted in LNAPL below the water table. This OIP data was collected subsequent to the LDRM model runs. The new data indicates that the model selection needs to be reevaluated to account for the LNAPL below the water table.

Based on TRC's evaluation of available methods for estimating released product volumes and Colonial's present understanding of Site conditions, Colonial believes that using the OIP data and site-specific hydrogeologic data in conjunction with 3-D visualization software would be a more appropriate method for estimating the total volume of product released to the environment. To perform this modeling, additional LNAPL saturation and geological data would need to be collected under static conditions in the northern portion of the Site. To collect the optimal number of representative samples throughout the vertical and horizontal extent of LNAPL, recovery wells and hydraulic controls would need to cease operation for a period of time, possibly for several weeks.

At this time, Colonial believes it would be most protective to postpone collection of the needed saturation and geologic information from the northern area. Additional data collection should occur only after capturing sufficient recoverable free product in order to minimize risks associated with potential migration. Before NCDEQ's requested May 28 deadline, Colonial would like to discuss the timing of these data collection efforts and model selection with NCDEQ, to ensure that we are responsive to NCDEQ's inquiries while also selecting the path forward that is most protective of human health and the environment. Colonial will

continue to evaluate methods for estimating release volume as it follows the science and deploys required resources to protect human health and the environment.

Colonial has been and continues to work on the conceptual site model (CSM). The estimated release volume is not needed to continue or complete the ongoing CSM efforts. In addition, corrective action planning and remediation technology selection will not be influenced by an updated release volume estimate.

Item 6

In response to Item 6 referenced in the May 5, 2021 NOCV, Attachment 2 to this letter a Gantt chart with explanatory text supporting the request for extension to August 31, 2021. As explained in Attachment 2, Colonial has identified ten discrete tasks to be completed to fully respond to NCDEQ's directive to provide a revised CSA. Several of those tasks involve collection of soil and groundwater samples and drilling of additional deep groundwater monitoring wells, as proposed to NCDEQ in the May 7, 2021 work plan. Colonial believes that this schedule is a reasonable sequence of the tasks needed to complete the items NCDEQ requested in the February 24, 2021 NOCV.

As always, Colonial's intent is to be responsive to NCDEQ's requests while continuing assessment and recovery efforts needed to protect human health and the environment. If you have any questions or concerns about today's submission, please do not hesitate to contact me.

Respectfully,

/s/ Sam McEwen

Sam McEwen
Director, Environmental

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Memorandum

To:	Sam McEwen Colonial Pipeline Company
From:	Chelsea Wenhardt, TRC Environmental Corporation (TRC)
Subject:	Model Evaluation Notice of Continuing Violation, N.C. Gen Stat. § 143-214.1, 15A NCAC 02L .0202 Colonial Pipeline, SR 2488/Pipeline ROW, Huntersville, NC Incident: 95827
Date:	May 12, 2021
CC:	Karen C. Saucier, PhD, TRC
Project No.:	327626.0004

The American Petroleum Institute (API) LNAPL (light nonaqueous phase liquid) Distribution and Recovery Model (LDRM) is a one-dimensional, scenario-based model that is primarily used to simulate performance of proven hydraulic technologies for recovering free product in ground water. LDRM is also capable of using parameters derived from capillary pressure curves in combination with fluid properties and apparent in-well LNAPL thickness to estimate the specific volume of LNAPL present at a point location. The model is limited to three soil layers, assumes that homogeneous hydrogeologic conditions are present, and that LNAPL is in vertical equilibrium with the water table (i.e. LNAPL is not floating on water as a uniform "pancake" with a high saturation percentage).

Previous volume estimates were derived based on use of the LDRM model and data collected between August and December 2020. Additional data collection and interpretation from February – April 2021 revealed that the hydrogeologic and geologic conditions in the northern portion of the Site are highly heterogenous and contain LNAPL mass that is trapped below the water table at potentially high saturations. These findings indicate the assumptions of homogeneity and vertical equilibrium are not accurate for the Huntersville release. Therefore, the LDRM would not be expected to produce a reliable estimate of LNAPL volume for this Site because it cannot account for the LNAPL mass trapped below the water table.

NCDEQ has directed Colonial to provide a revised estimate of the total product volume released to the environment at the Huntersville, NC site based on current information. The limitations observed in the LDRM modeling effort (referenced above) has prompted Colonial to evaluate other model options. Several model options have been identified to calculate these volumes, as described by Lenhard, *et al.,* (2017[1]). These model options include:

- The various models using the apparent LNAPL thicknesses in monitoring wells (*e.g.,* the pancake model),
- More advanced models that calculate the average mobile and residual LNAPL saturations (*e.g.,* the LDRM model[2]),
- Multi-phase flow and transport models (*e.g.,* Pruess and Battistelli, 2002[3] and Lenhard, *et al.,* 2017[1]), and

1 R.J. Lenhard, J.L. Rayner, G.B. Davis. 2017. practical tool for estimating subsurface LNAPL distributions and transmissivity using current and historical fluid levels in groundwater wells: Effects of entrapped and residual LNAPL. Journal of Contaminant Hydrology. 205 (2017)1-11

2 Charbeneau, R.J., 2007. LNAPL distribution and recovery model (LDRM). In: Volume 1: Distribution and Recovery of Petroleum Hydrocarbon Liquids in Porous Media. API Publ. No. 4760. American Petroleum Institute, Washington, D.C.

3 Pruess, K. and A. Battistelli. 2002. TMVOC, A Numerical Simulator for Three-Phase Non-isothermal Flows of Multicomponent Hydrocarbon Mixtures in Saturated-Unsaturated Heterogeneous Media. LBNL,-49375.

- Customized, site-specific models using 3-D visualization software (*e.g.,* Earth Vision and Earth Volumetric Studio) and a distribution of potential input parameters.

Table 1 presents a summary of the available models, inherent assumptions, limitations, and additional data requirements.

It is TRC's recommendation that using the OIP data and site-specific hydrogeologic data in conjunction with 3-D visualization software would be a more appropriate method for estimating the total volume of product released to the environment. As presented in the table, potentially viable options for estimating the volume of free product present in the subsurface requires additional data to be collected during static conditions, are subject to interpretation, will contain a high degree of uncertainty, and are labor intensive. Outside influence on the subsurface systems (i.e. free product recovery) must be suspended for data to be collected under static conditions and remain suspended while the data is being collected. As further explained in the table, application of alternative predictive modeling tools at this time would yield, at best, an estimated total volume of product range with a potentially high degree of uncertainty due to estimated input parameters and other data variables.

Table 1 – Summary of Model Evaluation

Model	Inherent Assumptions	Limitations	Additional Data Needs
"Pancake" Models	• LNAPL saturation is constant across the modeled area ○ i.e. no differentiation between mobile and residual phases • Apparent LNAPL thicknesses in monitoring wells are representative of LNAPL thicknesses in the formation.	• Apparent LNAPL thicknesses are not representative of thicknesses in the formation. • LNAPL that does not appear in a well are not accounted for • Model is not theoretically or practically accurate	None. Model not appropriate.
Vertical Equilibrium Models (*e.g.*, American Petroleum Institute LNAPL Distribution and Recovery Model)	• Up to three soil/geologic layers present • Homogeneous conditions of the porous media • Peak LNAPL saturation occurs above the water table • Apparent in-well LNAPL thickness is representative of the vertical LNAPL distribution in the vadose and saturated zones	• Cannot account for high saturations of LNAPL trapped beneath the water table • Volume estimates are based on a vertical slice at a point location • Limited ability to account for vertical heterogeneity • Accounting for horizontal heterogeneity is subject to user interpretation and limited by data density	None. Model not appropriate.

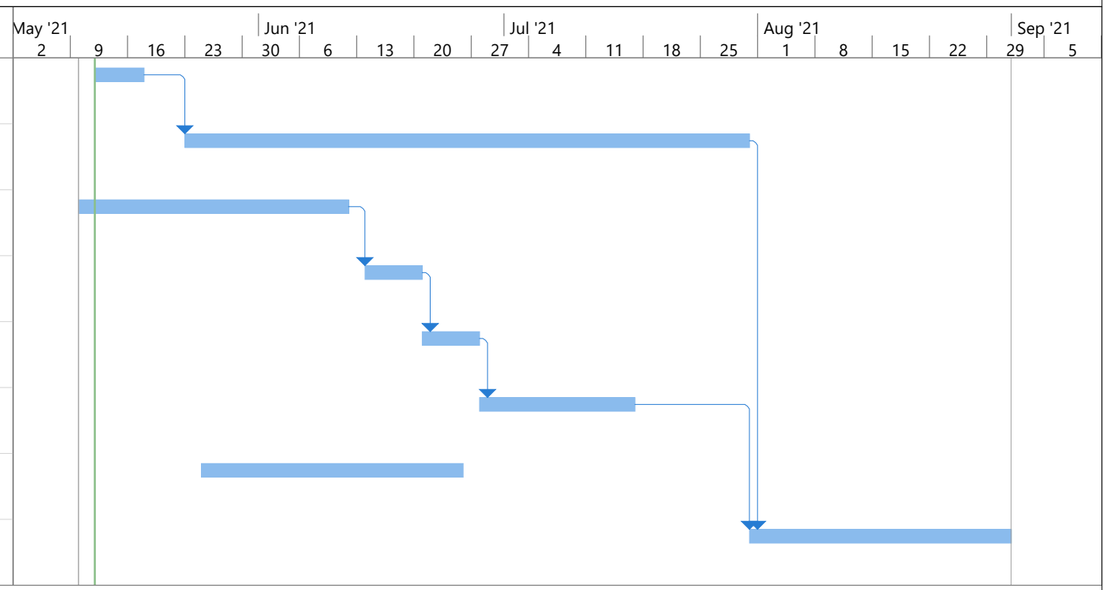
Multi-phase Flow and Transport Models (*e.g.*, Pruess and Battistelli, 2002 and Lenhard, *et al.*, 2017)	• Vertical equilibrium conditions are present
	  ○ Peak LNAPL saturation occurs above the water table
	• LNAPL conditions include residual LNAPL above the water table (S_{or}), residual LNAPL below the water table (S_{oe}), and free, mobile LNAPL (S_{of})
	• LNAPL release history, rainfall recharge, and groundwater elevation fluctuations are known.
	• The hydraulic and multiphase fluid flow properties of the soil, rock, and groundwater are known, so that groundwater/LNAPL migration simulations re-create the saturation path history.
		• The rate and volume of LNAPL released, timing and magnitude of potential fluid saturation path changes from precipitation and water table fluctuations are known
		• Volume estimates are based on a vertical slice at a point location dependent on the parameters such as release history and groundwater elevation changes.
		• Accounting for horizontal heterogeneity is subject to user interpretation and limited by data density
		• Time and labor intensive
			• The rate and volume of LNAPL released, timing and magnitude of potential fluid saturation path changes from precipitation and water table fluctuations are not known and will need to be estimated – creates a high degree of uncertainty
			• Static fluid level measurements – recovery system operation must be paused
			• Hydraulic properties of different geologic materials, especially in the northern portion of the Site
			  ○ Current data provided by one geotechnical boring

Table 1 – Summary of Model Evaluation

Model	Inherent Assumptions	Limitations	Additional Data Needs
Customized approach using 3-D Modeling Software (*e.g.*, Earth Visions, Earth Volumetric Studio, *etc.*)	• The distribution of LNAPL throughout the Site has been fully characterized through OIP investigation • The HPT probe estimates of permeability are representative of soil hydraulic properties and can be used to estimate multiphase fluid flow properties • Location and distribution of LNAPL is fully defined • Can analyze types of analytical and geophysical data in any environment (e.g. soil, ground water, surface water, air, noise, resistivity, *etc*.	• Current data allows for volumetric measurement of impacted area • Input parameters will need to be estimated which will result in a volume range with a high degree of uncertainty • Uncertainties in the fluid saturation properties of each geologic unit will result in uncertainties in the estimated LNAPL volume • Uncertainties in the observed fluid saturations will result in uncertainties in the estimated LNAPL volume • The distribution of LNAPL volume will be based on current observed conditions and the limitations associated with these observations (*e.g.*, ability of the OIP to detect LNAPL presence, estimates of water saturation, *etc.*)	• *In-situ* fluid saturation and hydraulic properties for the different geologic materials – requires numerous data points • Static fluid level measurements – recovery system operation must be paused •

SCHEDULE FOR COMPLETION OF ASSESSMENT RELATED MILESTONES - INCIDENT NUMBER 95827

ID	Task Name	Duration	Start	Finish
1	Complete Soil Vapor Extraction Pilot Test at North Study Area(1)	6 days	Wed 5/12/21	Mon 5/17/21
2	Complete Soil Delineation Sampling for VOCs and VPH(2)	69 days	Sun 5/23/21	Fri 7/30/21
3	Complete Deep Delineation Monitoring Well Drilling(3)	33 days	Mon 5/10/21	Fri 6/11/21
4	Complete Deep Delineation Monitoring Well Geophysical Logging(4)	7 days	Mon 6/14/21	Sun 6/20/21
5	Construct Deep Delineation Monitoring Wells(5)	7 days	Mon 6/21/21	Sun 6/27/21
6	Complete Deep Delineation Monitoring Well Sampling(6)	19 days	Mon 6/28/21	Fri 7/16/21
7	Updated Conceptual Site Model to NCDEQ(7)	32 days	Tue 5/25/21	Fri 6/25/21
8	Revised Comprehensive Site Assessment to NCDEQ(8)	32 days	Sat 7/31/21	Tue 8/31/21



Notes:

1 - The soil vapor extraction test is required to determine radius of influence for soil delineation sample spacing as detailed in the Soil and Groundwater Delineation Work Plan dated May 7, 2021 for NCDEQ Incident Number 95827.

2 - Soil samples collected for VOCs and VPH will be utilized for delineation purposes as detailed in the Soil and Groundwater Delineation Work Plan dated May 7, 2021 for NCDEQ Incident Number 95827. The timeframe stated for Task 2 includes laboratory analysis. Soil borings may be converted to soil vapor extraction points as a presumptive remedy during implementation of Task 2. Task 2 will pause for completion of Task 3 utilizing the same drill rig.

3 - Task 3 includes drilling of four additional bedrock monitoring wells as detailed in the Soil and Groundwater Delineation Work Plan dated May 7, 2021 for NCDEQ Incident Number 95827.

4 - Task 4 includes geophysical logging of four additional bedrock monitoring wells as detailed in the Soil and Groundwater Delineation Work Plan dated May 7, 2021 for NCDEQ Incident Number 95827.

5 - Wells will be completed with 2" PVC casings and screens as detailed in the Soil and Groundwater Delineation Work Plan dated May 7, 2021 for NCDEQ Incident Number 95827.

6 - Task 6 includes sampling and laboratory analysis of four additional bedrock monitoring wells as detailed in the Soil and Groundwater Delineation Work Plan dated May 7, 2021 for NCDEQ Incident Number 95827.

7 - In a letter dated May 5, 2021 NCDEQ made the following request: Please provide an updated Conceptual Site Model (CSM) based on current information for the Colonial Pipeline Company's petroleum release including receptors and incorporating all the available site information, including but not limited to, the resistivity survey, vapor intrusion investigation, air monitoring, noise monitoring, springs, boring logs, drilling information, optical image profiling (OIP) information, updated information on the free product volume estimation, vertical and horizontal extent of soil and groundwater contamination, geophysical logging information, hydraulic information, etc. A CSM is an iterative, 'living representation' of a site that summarizes and helps project teams visualize and understand available information. A CSM update will be provided by June 25, 2021 based on current information available at that time.

8 - Delineation of soil and groundwater impacts as detailed in the Soil and Groundwater Delineation Work Plan dated May 7, 2021 for NCDEQ Incident Number 95827, within the timeframes stated herein is predicated and upon favorable sampling results below NCDEQ Maximum Soil Contaminant Concentrations and 2L Groundwater Quality Standards.

This schedule is contingent upon receipt of access agreements, completion of clearing activities, and specialty contractor and equipment availability.

This schedule does not include any delays related to CPC operations or requirements, access related delays or adverse weather conditions.

If environmental conditions are encountered that preclude completion of soil and groundwater delineation within the anticipated time frames stated above, an updated schedule projecting completion of those activities will be provided to NCDEQ.

Abbreviations:

VOCs - Volatile organic compounds

VPH - Volatile petroleum hydrocarbons

TPH-GRO - Total petroleum hydrocarbons - gasoline range organics