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SITE CONVEYANCE NETWORK AND OUTFALL 002 PFAS MASS LOADING CALCULATION PROTOCOL

Chemours Fayetteville Works

Prepared for

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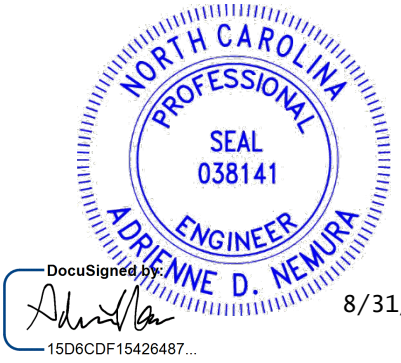

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CO	Consent Order
hr	hour
mL	milliliter
ng/L	nanograms per liter
PFAS	per- and polyfluoroalkyl substances

1 INTRODUCTION

Geosyntec Consultants of NC, PC (Geosyntec) has prepared this Protocol for establishing current mass loading from Outfall 002 to the Cape Fear River ("Outfall 002 Trendline") on behalf of The Chemours Company FC, LLC (Chemours) pursuant to the requirements of Paragraph 1(c)(ii) of the Addendum to Consent Order Paragraph 12 (CO Addendum). The objective of this document is to describe the sampling activities and calculation methods associated with per- and polyfluoroalkyl substances (PFAS) mass loading at Outfall 002.

The CO Addendum specifies that PFAS mass loading calculations use the PFAS compounds listed in Attachment C of the Consent Order (CO) (February 25, 2019). Table 1 lists the Attachment C PFAS compounds and the associated analytical methods. Specifically, this protocol describes how the PFAS loads reaching the river at Outfall 002 from the Site conveyance network are calculated by estimating the PFAS load in river water intake water and the PFAS load at Outfall 002. The remainder of this document is organized as follows:

- Section 2 – Outfall 002 and River Intake Sampling, which describes the background and protocols for sampling and flow measurements at Outfall 002; and
- Section 3 – PFAS Mass Loading Calculation Method, which describes the methods used to calculate loading using composite samples collected at Outfall 002.

2 OUTFALL 002 AND RIVER INTAKE SAMPLING

This section provides an overview of the types of sampling and flow measurements conducted at Outfall 002 and the River Intake.

2.1 Outfall 002 Sample Types

PFAS mass loading at Outfall 002 can be assessed by sampling the discharge at Outfall 002 using both 3.5-day composite samples and 24-hour (hr) composite samples as detailed below:

- 3.5-day composite samples: 3.5-day composite samples have been collected twice per week. Samples have been time-composited using an auto-sampler set to collect 350-mL aliquots every three hours. The location of the auto-sampler is shown in Figure 1.
- 24-hr composite samples: 24-hr composite samples have been collected as flow-weighted samples. Samples have been collected using an auto-sampler set to collect 150-mL aliquots for every 200,000 gallons of flow. The location of the autosampler is shown in Figure 1.

On a sample-specific basis, samples collected with different composite sample durations or grab samples may also be used to develop the PFAS mass load at Outfall 002.

2.2 River Intake Samples

The site draws water from the Cape Fear River which at the River Water intake already contains PFAS from upstream sources. This water, after use at the Site, is then discharged at Outfall 002. As part of the *Cape Fear River PFAS Mass Loading Calculation Protocol* (Geosyntec, 2020), the River Water Intake at Facility location will be sampled as a 24-hr composite sample once per month. The River Water Intake at the Facility location represents water drawn in by the facility through the intake piping.

2.3 Consent Order Addendum Sampling Requirements

The CO Addendum requirements for the PFAS sampling program at Outfall 002, as detailed in Paragraph 1(c)(i) of the CO Addendum, are as follows:

c. *Outfall 002 Trendline:*
   i. *Starting no later than August 31, 2020, Chemours shall, each week for at least twelve consecutive weeks, take a 24-hour composite sample from Outfall 002 and analyze for the PFAS listed in Attachment C to the Consent Order. Chemours shall also conduct 24-hour composite sampling within 24 hours of any rain event predicted two days before with at least a 70%*

likelihood to be of 1 inch or greater over a 24-hour period. Chemours shall record the flow through Outfall 002 for each sampling event.

To fulfill these requirements, 24-hr composite samples will be collected weekly for at least twelve weeks, in addition to within 24 hours of a rain event that meets the criteria specified in the CO Addendum. Samples will be sent to an approved external laboratory for analysis. The PFAS analyte list to be used (Table 1) includes all Consent Order Attachment C PFAS.

2.4 Flow Measurement Methods

The flow at Outfall 002 will be measured using a flowmeter to record flow readings from a 60-inch Parshall flume (Figure 1). Flow measurements will be translated into a flow per time unit, such as gallons per hour. If flow measurements are unable to be collected based on temporary equipment malfunction or other unforeseen circumstances, flow at Outfall 002 will be estimated for purposes of these calculations. For dry weather flow data gaps, dry weather flow measurements close in time to the data gap along with facility water usage records will be used to estimate dry weather flows at Outfall 002. If the data gaps in flow measurement occur during wet weather, the Site hydrologic model will be used to estimate stormwater flows at Outfall 002, and these estimates will be summed with an estimate of the dry weather flow for that same time period. For the purposes of these calculations, flows at the river intake are assumed to be equal to dry weather Outfall 002 flows.

3 PFAS MASS LOADING CALCULATION METHODOLOGY

This section presents the calculation methodology to estimate PFAS mass loading at Outfall 002. The mass loading at Outfall 002 is calculated using measured and estimated PFAS concentrations and measured flows at Outfall 002. The mass loading in river water at the intake is also calculated using measured and estimated PFAS concentrations, as well as measured flows, from river water at the intake. The mass loading in river water at the intake is then subtracted from the mass loading at Outfall 002 to determine the mass load reaching the river at Outfall 002 from the Site conveyance network.

The calculations presented here are suitable for evaluating the mass loads of any given set of selected PFAS. For the purposes of calculations and reporting for Paragraph 1 of the CO Addendum, the set of PFAS will be those listed in Attachment C of the Consent Order and listed here as Table 1.

3.1 Total Mass Load Calculation Methodology

This sub-section describes the methodology for calculating PFAS mass loading over a given time period. The mass loads over the given time intervals will be summed, as shown in Equation 1 below:

Equation 1: Total Mass Loading at Outfall 002

$$M_{OF002} = \sum_{n=1}^{N} m_{OF002,n} - m_{intake,n}$$

where,

- $M_{OF002} =$ is the total PFAS mass load at Outfall 002 for a given number of time periods "N", as mass per time, typically pounds per day, that originated from the Site conveyance network;
- $m_{OF002,n}$ = is the total PFAS mass load at Outfall 002 for a given time interval "n" (mass per time), calculated by summing (or subdividing) the appropriate values of $m_{OF002,j}$;
- $n =$ represents individual time intervals in a time period to assess mass loading at Outfall 002;
- $N =$ is the total number of time intervals in a time period to assess mass loading at Outfall 002; and
- $m_{intake,n}$ = is the total PFAS mass load in river water from the intake for a given time interval "n" (mass per time), calculated by summing (or subdividing) the appropriate values of $m_{intake,k}$.

3.2 Loading at Outfall 002

Measured and estimated concentrations, as well as measured flows at Outfall 002, are used to calculate mass loading at Outfall 002, as shown in Equation 2 below:

Equation 2: Outfall 002 Mass Loading

$$m_{OF002,\mathrm{j}} = C_{OF002,j} \times Q_{OF002,j} \times F$$
$$= \sum_{i=1}^{\mathrm{I}} c_{OF002,\mathrm{j,i}} \times Q_{OF002,\mathrm{j}} \times F$$

where,

m_{OF002} = is the total PFAS mass load at Outfall 002 as measured in mass for a given time interval, "j";

j = is time interval (represents either full 3.5-day composite period, portion of the 3.5-day composite period, 24-hr composite period, or time interval of data gap [i.e., no composite sample collection], described further in Section 3.4);

$C_{OF002,j}$ = is the measured or estimated total PFAS concentration at Outfall 002 for a given time interval, "j" (described further in Section 3.4);

$Q_{OF002,j}$ = is the total measured flow at Outfall 002 in a given time interval "j"; and

F = is a conversion factor (to convert from concentrations in ng/L multiplied by flow in gallons per time unit to load in pounds per time unit)

$c_{OF002,j,i}$ = is the measured or estimated concentration of the i^{th} PFAS compound based on samples collected from Outfall 002;

i = represents each of the PFAS compounds being evaluated; and

I = represents total number of PFAS compounds included in the summation of total PFAS concentrations.

3.3 Loading from River Water Intake

Measured and estimated concentrations, as well as measured flows from river water at the intake, are used to calculate mass loading in river water at the intake, as shown in Equation 3 below:

Equation 3: River Intake Mass Loading

$$m_{intake,\mathrm{k}} = C_{intake,k} \times Q_{intake,k} \times F$$
$$= \sum_{i=1}^{\mathrm{I}} c_{intake,k,i} \times Q_{intake,k} \times F$$

where,

$m_{intake,k}$ = is the total PFAS mass load in the river water at the intake as measured in mass for a given time interval, "k";

$k =$ is time interval for calculating the mass loading represents either the 24-hr composite period, or time interval of data gap [i.e., no composite sample collection], described further in Section 3.5);

$C_{intake,k}$ = is the measured or estimated total PFAS concentration in the river water at the intake for a given time interval, "k" (described further in Section 3.5);

$Q_{intake,k}$ = is the total measured flow at the intake in a given time interval "k";

F = is a conversion factor (to convert from concentrations in ng/L multiplied by flow in gallons per time unit to load in pounds per time unit);

$c_{intake,\mathrm{k,i}}$ = is the measured or estimated concentration of the i^{th} PFAS compound based on samples collected from the river water at the intake;

$i =$ represents each of the PFAS compounds being evaluated; and

$I =$ represents total number of PFAS compounds included in the summation of total PFAS concentrations.

3.4 Concentrations at Outfall 002

This section describes the methodology for estimating PFAS concentrations at Outfall 002 to be used in calculating mass loads. The methodology is also illustrated in Figure 2. The calculation methodology outlined here considers all collected samples in a given time period, including cases where samples are collected contemporaneously with each other (e.g. both 3.5-day and 24-hr composites) and cases where composite sample collection events do not occur successively (i.e., there could potentially be time gaps where a composite sample is not being collected).

Sample concentrations will be assigned to the corresponding time period over which the composite sample was collected (for both 3.5-day and 24-hr composite samples). If a composite sample collected over a shorter time interval (i.e., compositing period) is collected contemporaneously with a composite sample having a longer compositing period, the sample result representative of the shorter compositing period will be applied

for that compositing period. The sample result representative of the longer compositing period will be applied to that compositing period, except for the period of time covered by the shorter compositing period. In other words, sample results with shorter compositing periods will take precedence over those with longer compositing periods when sampled contemporaneously.

For example, if a 24-hr composite sample was collected during a time period where a 3.5 day composite was also collected, the concentration from the 24-hr sample will be applied to that 24-hr period, and the 3.5-day composite result will be applied to the appropriate period of time prior to and following the 24-hr composite time period (in other words, the 3.5-day composite result will not be applied during the time interval when the 24-hr composite sample was collected).

If there are data gaps (i.e., where neither a 3.5-day or 24-hr composite sample is collected during a period of time), the time period will be assessed for whether it is considered "wet" or "dry". Each time period with data gaps will be considered wet or dry based on the total precipitation depth measured in the preceding 72 hours, with "wet" defined as greater than 0.2 inches of precipitation in the preceding 72 hours (below this approximate rainfall threshold, minimal stormwater runoff generation is expected).

A 60-day rolling average wet or dry concentration will be applied to the time periods with data gaps based on the wet or dry designation. To calculate the 60-day rolling wet and dry concentrations, each composite sample result at Outfall 002 (both 3.5-day and 24-hr) will be assigned wet or dry based on the definition noted above (where samples with greater than 0.2 inches of precipitation in the preceding 72 hours, based on the end of the composite sample collection period, are considered wet). The 60-day rolling wet and dry average sample concentrations will be calculated based on the sample dates reported for each composite sample (which represent the end of the composite sample collection period), and each sample result in the rolling 60-day period will be counted as one result in the calculation of the average (i.e., weighted evenly), regardless of whether it is a 3.5-day, 24-hr, or other composite sample result.

3.5 Concentrations in Site River Water Intake

This section describes the methodology for estimating PFAS concentrations in river water at the intake to be used in calculating mass loads. The methodology is also illustrated in Figure 3. The calculation methodology outlined here considers all collected samples in a given time period (24-hr composites) and cases where composite sample collection events do not occur successively (i.e., there are time gaps where a composite sample is not being collected).

Sample concentrations will be assigned to the corresponding 24-hr time period over which the composite sample was collected. Where there are data gaps (i.e., where no 24-

hr composite sample is collected during a period of time), the 60-day rolling average river water intake sample concentrations will be calculated.

3.6 Potential Adjustments

The calculation methodologies described in this section have been outlined based on the present understanding of Site conditions. If conditions or methods change, modifications may need to be made to this protocol. Modifications to the calculation methodologies will be described in future submitted reports.

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TABLES

TABLE 1
PFAS ANALYTICAL METHODS AND ANALYTE LIST
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Analytical Method	Common Name	Chemical Name	CASN	Chemical Formula
Table 3+ Lab SOP	HFPO-DA*	Hexafluoropropylene oxide dimer acid	13252-13-6	C6HF11O3
	PEPA	Perfluoro-2-ethoxypropionic acid (Formerly Perfluoroethoxypropyl carboxylic acid)	267239-61-2	C5HF9O3
	PFECA-G	Perfluoro-4-isopropoxybutanoic acid	801212-59-9	C12H9F9O3S
	PFMOAA	Perfluoro-2-methoxyacetic acid	674-13-5	C3HF5O3
	PFO2HxA	Perfluoro-3,5-dioxahexanoic acid (Formerly Perfluoro(3,5-dioxahexanoic) acid)	39492-88-1	C4HF7O4
	PFO3OA	Perfluoro-3,5,7-trioxaoctanoic acid (Formerly Perfluoro(3,5,7-trioxaoctanoic) acid)	39492-89-2	C5HF9O5
	PFO4DA	Perfluoro-3,5,7,9-tetraoxadecanoic acid (Formerly Perfluoro(3,5,7,9-tetraoxadecanoic) acid)	39492-90-5	C6HF11O6
	PMPA	Perfluoro-2-methoxypropionic acid (Formerly 2,3,3,3-Tetrafluoro-2-(trifluoromethoxy)propanoic)	13140-29-9	C4HF7O3
	PFO5DA	Perfluoro-3,5,7,9,11-pentaoxadodecanoic acid	39492-91-6	C7HF13O7
	PS Acid (Formerly PFESA-BP1)	Ethanesulfonic acid, 2-[1-[difluoro[(1,2,2-trifluoroethenyl)oxy]methyl]-1,2,2,2-tetrafluoroethoxy]-1,1,2,2-tetrafluoro- (Formerly PFESA-BP)	29311-67-9	C7HF13O5S
	Hydro-PS Acid (Formerly PFESA-BP2)	Ethanesulfonic acid, 2-[1-[difluoro(1,2,2,2-tetrafluoroethoxy)methyl]-1,2,2,2-tetrafluoroethoxy]-1,1,2,2-tetrafluoro- (Formerly PFESA-BP2)	749836-20-2	C7H2F14O5S
	PFHpA*	Perfluoroheptanoic acid	375-85-9	C7HF13O2

Notes:

* - HFPO-DA and PFHpA are also analyzed by EPA Method 537 Mod.
EPA - Environmental Protection Agency
PFAS - Per- and Polyfluoroalkyl substances
SOP - Standard Operating Procedure

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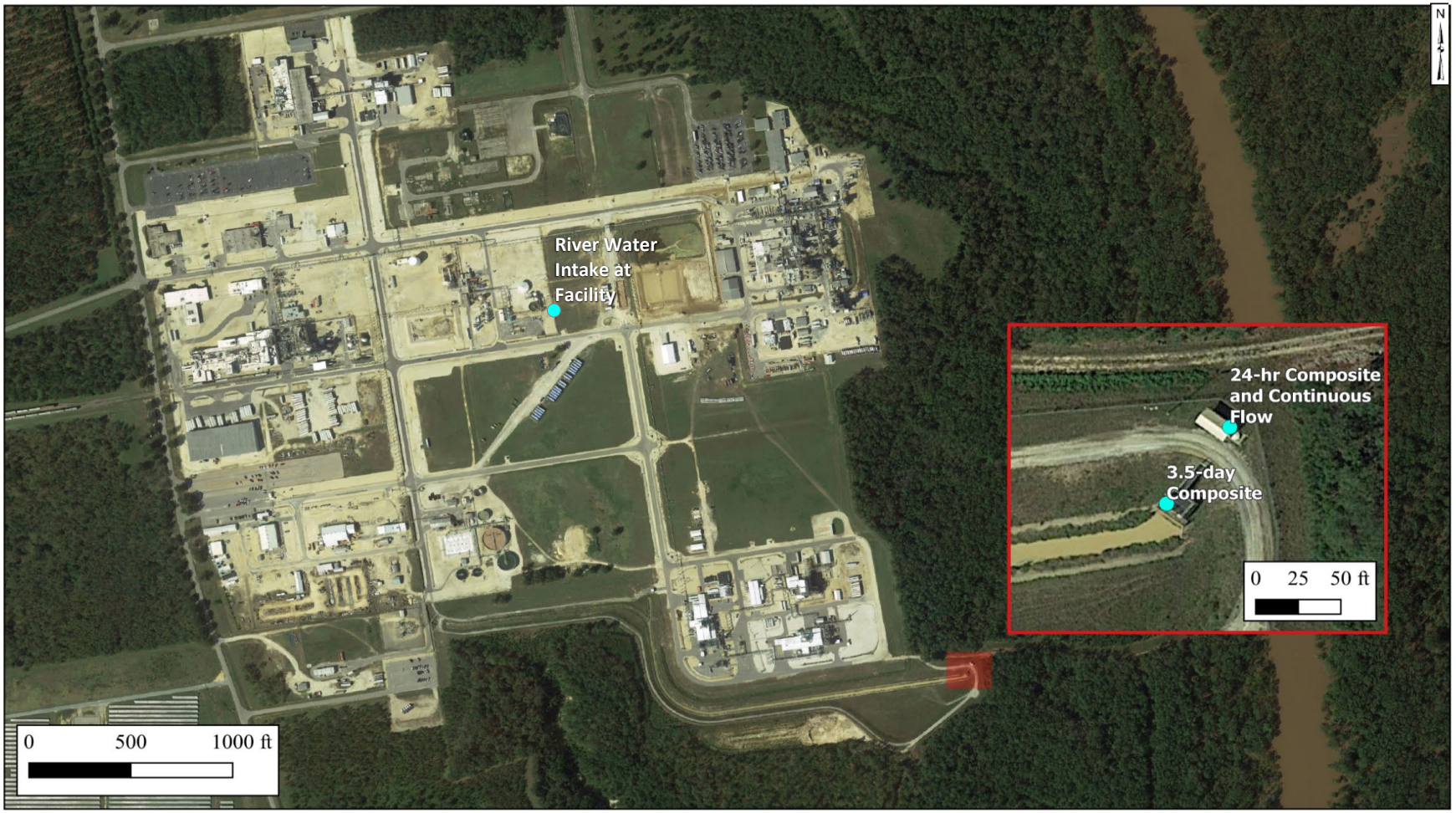
FIGURES



Legend

Sampling Location

Outfall 002 Sampling Locations
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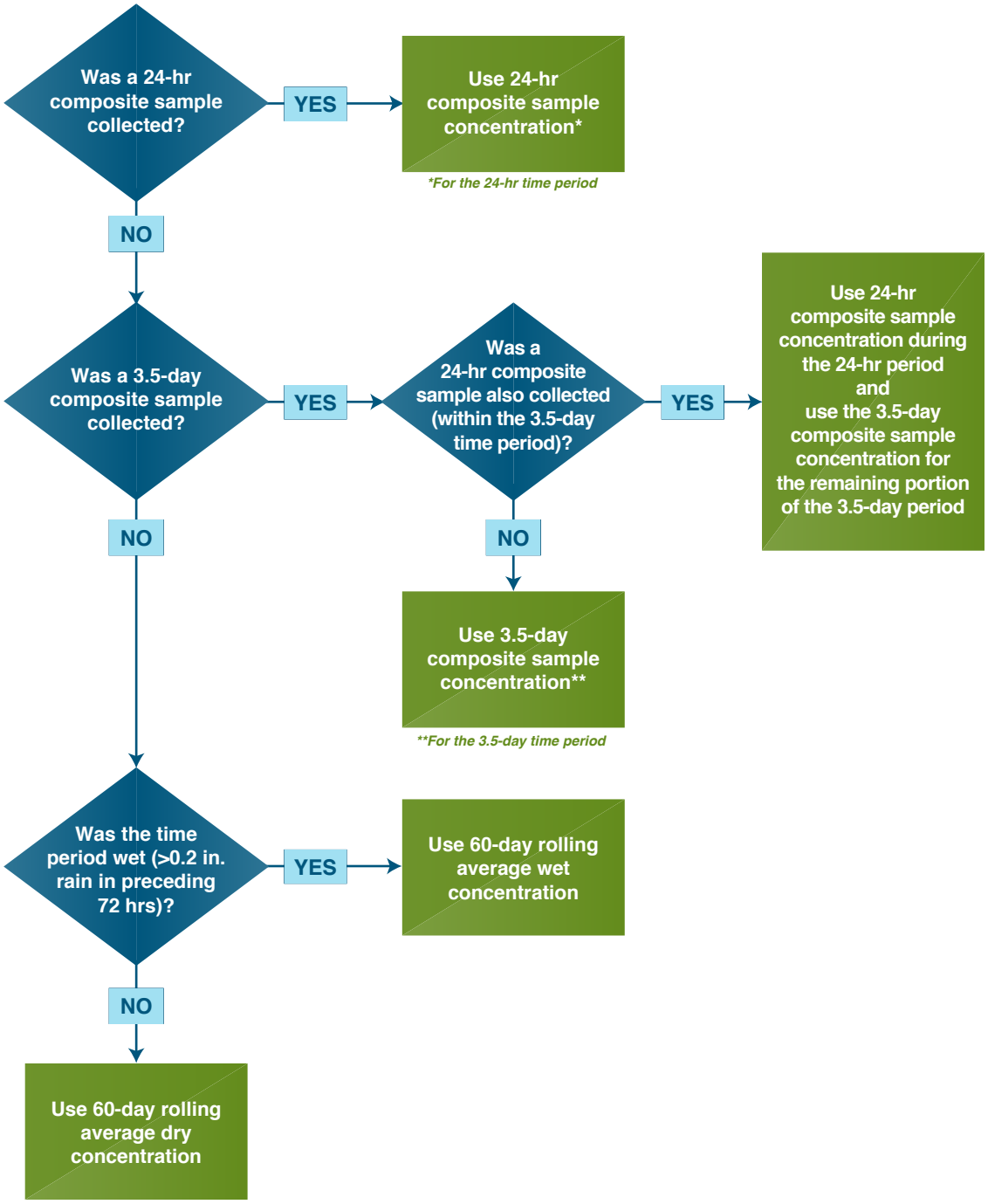
Figure

1



Flowchart for Determining the Concentration for Loading at Outfall 002

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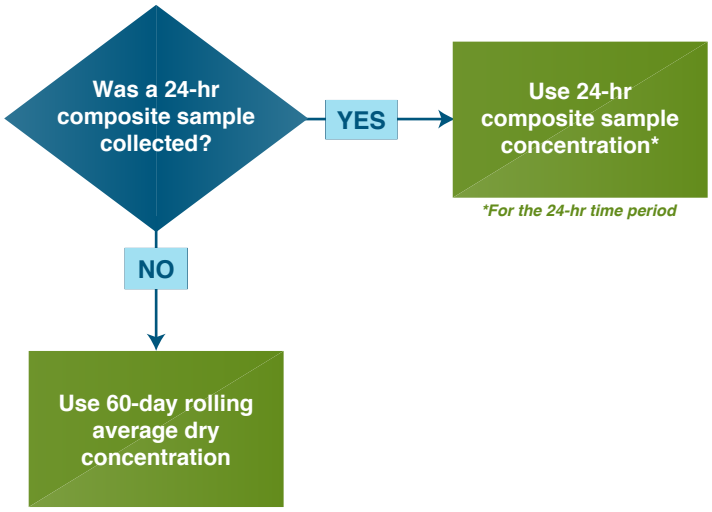
Figure 2

Illustrator/Flow Charts/OutfallProtocol_flowchart_Sec3.4.ai



Flowchart for Determining the Concentration for Loading at the River Water Intake

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Figure 3

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