



**Appendix H to Tab E**

**Additional Impacts Analysis  
Detailed Soils and Vegetation  
Carolinac Cement Company LLC | Castle Hayne Plant  
Castle Hayne, North Carolina**

**Additional Impact Analysis (AIA)  
Detailed Soils and Vegetation**

Carolinas Cement Company LLC  
Castle Hayne Plant

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## EXECUTIVE SUMMARY

This document provides a refined soils and vegetation analysis required as part of the Prevention of Significant Deterioration (PSD) permit application submittal for the proposed Carolinas Cement Company LLC (CCC) plant located near Castle Hayne, North Carolina. CCC is proposing the construction of a new Portland cement manufacturing plant. This document includes an Additional Impact Analysis (AIA), specifically the ecological impacts to soils and vegetation surrounding CCC.

Dispersion modeling was performed for pollutant emissions from the proposed new sources at CCC. These results were submitted under separate cover in a report dated February 25, 2011. The modeling results from the February report served as the basis for this demonstration by evaluating appropriate ecological screening threshold values. **Based upon this analysis it was determined that CCC would not have a significant impact on the soils and vegetation surrounding the proposed plant.**



SECTION 1

## PROJECT BACKGROUND AND ANALYSIS OVERVIEW

### 1.1 Introduction

CCC has submitted a revised air permit application to construct a modern 6000 ton per day (clinker) Portland cement manufacturing plant at the site of its existing cement terminal near Castle Hayne, North Carolina. A more detailed description of the project is presented in the Regulatory Analysis Report section (Tab A) of the application package. The project emissions triggered requirements under the PSD rules at 15A NCAC 02D.0530 for the following pollutants: PM<sub>10</sub>, PM<sub>2.5</sub>, sulfur dioxide (SO<sub>2</sub>), NO<sub>x</sub>, carbon monoxide (CO), and volatile organic compounds (VOC). The project emissions will also trigger requirements under 15A NCAC 2Q.0700 regarding toxic air pollutants (TAPs).

This document provides the methodologies that were followed in completing the additional impacts analysis (AIA) for soils and vegetation. The results of this analysis are also summarized within this report.

### 1.2 Soil and Vegetation Analysis Overview

Pursuant to 40 CFR 51.166(o), an applicant for a PSD permit is required to conduct an analysis of the impairment to soils and vegetation that may occur as a result of the proposed source. The applicant is not required to provide an analysis of impacts to vegetation having no "significant commercial or recreational value." Since developing its comprehensive 1980 guidance document entitled "A Screening Procedure for the Impacts of Air Pollution Sources on Plants, Soils, and Animals", the United States Environmental Protection Agency (EPA) has not issued significant guidance on the preferred approach for conducting a complete and accurate soils and vegetation analysis, with the exception of limited guidance provided in the *NSR Workshop Manual* and a few Environmental Appeals Board (EAB) decisions.

The *NSR Workshop Manual* recommends an evaluation of impacts on the soil and vegetation types found within the Class II Modeling Domain that was established for the modeled criteria pollutants within the Significant Impact Analysis (i.e., SIL Analysis). This provides a reasonable reference for establishing impact thresholds for the analysis beyond the secondary NAAQS (which are generally considered to be protective of most soils and vegetation).

For the purposes of this vegetation survey, the term "significant commercial value" is interpreted to mean plant species that are harvested for sale which include commodity crops (i.e., corn, soybeans, tobacco, wheat, etc.), hay, and forest products. The concept of "significant recreational value" for vegetation is much more ambiguous in a rural area dominated by agriculture and forestry than it would be in an area where recreation areas are more clearly defined. To simplify the analysis and to ensure the vegetation survey encompasses as many potentially sensitive species as possible, dominant plant species are evaluated within all areas of the designated impact area regardless of whether or not these areas are designated as parks or other public protected areas which offer "significant recreational value." Based on other recently performed AIAs accepted by the NCDAQ and other state regulatory agencies, potential impacts were evaluated on soils and vegetation from deposition [PM trace metals and volatile organic compounds (VOC)] in addition to direct phytotoxic effects of modeled criteria pollutants (i.e., CO, NO<sub>x</sub>, SO<sub>2</sub>, and PM). It should be noted that detailed deposition modeling was not required to be performed, instead a more conservative screening estimate of deposition was made, as applicable, based upon the modeled ambient concentrations. This screening methodology is presented in Section 4.4.

CCC is located near the border of New Hanover and Pender counties near Wilmington, North Carolina. Possible additional impacts were evaluated out to the extent of the currently established modeling domain, as presented in the Class II Air Dispersion Modeling Report submitted to the North Carolina Department of Environment and Natural Resources (DENR). When completing the AIA soils and vegetation inventory, an evaluation of the soils and vegetation within the entire modeling domain is required. To maintain consistency between the performed modeling analysis for the criteria pollutants and the NSR Workshop Manual, the study area was defined as the Class II modeling domain. It was also shown within the Class II modeling report that the largest SIA was 18.0 km, which suggests that modeling domain is sufficient for the determination of significant impacts of this facility.

The subsequent sections of this Soils and Vegetation AIA provide the following:

- 1) The characteristics of the land use, soils, and vegetation in the impact area,
- 2) The general soil and vegetation sensitivity to CO, NO<sub>x</sub>, SO<sub>2</sub>, PM, and VOC,
- 3) The observed thresholds below which adverse effects from these pollutants are expected to be negligible,
- 4) A summary of results of the soil and vegetation impact assessment.

Contaminants of Potential Ecological Concern (COPEC) deposition within the modeling domain from CCC will not affect any Class I Areas (federally protected national parks and wilderness areas), as it is completely located within the Class II Area. The Class I report dated January 30, 2009 discusses the possible effects of sulfate and nitrate deposition on the surrounding region. Therefore, no specific review of any Class I area will be provided in this document, although areas of state or regional interest will be



discussed in Section 2.2 (Vegetation Survey). The following sections present the PSD additional impacts analysis associated with the COPEC's from the CCC facility.

## SECTION 2 SOILS AND VEGETATION SURVEY

### 2.1 Soils Survey

Soils data, for the purposes of this project, were obtained from several sources in order to accurately describe the soil horizons, parent material, and chemistry that are found in the CCC modeling domain. The primary data resource was the U.S. Department of Agriculture (USDA) Natural Resources and Conservation Service (NRCS)<sup>1</sup>, which in cooperation with other state and local agencies, completed a survey of soils in New Hanover County, North Carolina, in 1977<sup>2</sup>, and in Pender County, North Carolina, in 1990<sup>3</sup>. Also, the Federal Geographic Data Committee (FGDC) Geologic Data Subcommittee (GDS) maintains up-to-date digital cartographic standards for geologic maps in the United States, which provides additional geologic data necessary for interpreting the soil series parent substrate material.<sup>4</sup> Additionally, geospatial soil data was obtained from the USDA Natural Resources Conservation Service, Soil Data Mart.<sup>5</sup>

For the CCC modeling domain, the majority of the soils' parent material consists of a mixture of eroded Cretaceous age (140 to 65 million years) sedimentary rocks<sup>6</sup> mixing with woody organic material (mucks), clayey and loamy marine deposits, loamy and sandy marine deposits, sandy and loamy alluvium, eolian sands, and/or sandy fluviomarine deposits.<sup>7</sup> Like the rest of the Southeastern Atlantic-coastal states, eastern North Carolina is dominated by the South Atlantic Coastal Plain and the Western Atlantic coastline. The coastal plain is bordered on the west by the mostly Paleozoic geology of the Piedmont plateau.<sup>8</sup> The South Atlantic Coastal Plain is a relatively flat landform with an average elevation of less than 300 feet above sea level, and extends 50 to 100 kilometers inland from the ocean.<sup>9</sup> Generally, the coastal plain is wet, including many brown and black water rivers, marshes, pocosins, and swamplands.<sup>10</sup>

Pender and New Hanover Counties are both located within the Atlantic Coast Flatwoods USDA major land resource area (MRLA) with approximately 70% of the land cover being forested.<sup>11</sup> This region is dominated by many broad shallow valleys that have widely meandering stream channels with slow moving water flow. Elevation ranges from 25 to 50 meters, with local relief of less than 10 meters, though some short steep slopes border the stream valleys. Stream valleys in this MRLA are shallow, narrow, and local relief is only a few meters. Wetness is a major land use problem as many of the soils require artificial

drainage before they can be used for agriculture, though in some areas sandy soils need irrigation during droughts.

Most of the soils in the region are deep, sandy-loams or silty-loams, with restricted drainage. Almost 50% of the soils in the modeling domain are considered hydric, which form under conditions of saturation, flooding, or ponding, long enough to develop anaerobic conditions in the upper soil horizons, and thus support wetlands. Otherwise, the most extensive soil group in the area is the Aquults, with a thermic temperature regime and an aquic moisture regime. These soils are deep, with a medium to fine texture. Soils that are aquic are poorly drained, and maintain a reducing moisture regime that is virtually free of dissolved oxygen because of saturation by water. In some poorly drained soils, drain tiles help to maintain the available water in the aquic soils at more optimal ranges for non-wetland plants and agriculture, thus allowing commercial agriculture to excel in the region. Some soils in the area have an udic moisture regime and are excessively well-drained.<sup>12</sup> Soil series dominant in the area include Goldsboro, Dorovan, Craven, Leon, Murville, Seagate, and Woodington.<sup>13</sup>

The region is important for the production of various agricultural crops and products, such as the commercial production of corn, soybeans, tobacco, peanuts, beets, and wheat, in addition to livestock (hogs and sheep) and pulpwood (farm woodlots) production.<sup>14,15</sup> The modeling domain for the CCC contains several soil series that the USDA considers Prime Farmland,<sup>16</sup> which identifies soils that are exceptionally suitable for high yielding agricultural production. These soils can be viewed in Appendix A, Table A-1.

Based on the analysis of the available data discussed above, the soil series in the modeling domain can be described as a nearly level coastal plain, dominated by many broad shallow valleys that have widely meandering stream channels with slow moving water flow, small lakes, pocosins, and wetlands. Soils are generally sandy-loams in the upper soil horizons (area that could be effected by any COPEC deposition and tillage). The majority of the soils in the study area are poorly drained (58.7%), with 49.8% of the soils considered hydric, while well-drained soils account for less than half (41.3%) of the overall area. Soils are acidic to circumneutral, with pH ranges from 3.2 to 9.0, with a weighted average soil pH of 4.6.<sup>17</sup> The cation exchange capacity (CEC) of the soil is the sum of the exchangeable cations that a soil can absorb at a specific pH,<sup>18</sup> and in this study area the CEC ranges from 0.0 – 84.5 meq/100g soil, with a weighted average of 14.3 meq/100g soil.<sup>19</sup> The base saturation percentage of the soil is the extent to which the absorption complex of a soil is saturated with alkali or alkaline earth cations (expressed as a percentage of the CEC)<sup>20</sup>, or saturation of deposited cations onto soil surfaces. Base saturation for the soils in the modeling domain was found to range from 0-100%, with a weighted average of 14.0%.<sup>21</sup>

Due to low pH, CEC, and base saturation levels, the soils in general throughout the modeling domain are somewhat chemically susceptible to acidification or eutrophication, due to the low buffering capacity of the soil. Acidification of the soil may be a concern due to the chemical qualities of soil in the modeling domain. However,

further discussion of soil acidification is addressed in Sections 3 and 4, specifically section 3.4.1, for Trace Metals. The facility expansion will not cause or contribute to any exceedance of PSD increments or NAAQS in the modeling domain and as a result, CCC will not cause the acidification of soils in the area. Detailed soil characteristics are provided in Appendix A, Table A-1. An ArcGIS map depicting the soil types for the modeling domain is provided in Appendix B, Drawing 002.

## 2.2 Vegetation Survey

### 2.2.1 Overview of Vegetation and Land Use

In order to describe the vegetation in the Class II modeling domain surrounding CCC, multiple sources of North Carolina land use data and natural communities' descriptions were applicable to creating a base map in ArcGIS (Appendix B, Drawing 001). Sources of data included first, aerial photographs, which were obtained from GoogleEarth imagery, allowing an initial evaluation of general natural communities and agricultural tenure.<sup>22</sup> Second, ArcGIS shape and raster files of land use data were obtained from the North Carolina Geographic Information Coordinating Council, which were uploaded and clipped to build base maps for analysis and area measurements.<sup>23</sup> Third, detailed descriptions of land use in North Carolina were reviewed in a corresponding NC OneMap support file,<sup>24</sup> which were then compared with the Schafale and Weakley publication, *Classification of Natural Communities of North Carolina*.<sup>25</sup> The descriptions of North Carolina natural communities' classifications found in this publication were utilized to describe the dominant vegetation of the modeling domain in respect to the land use shape files obtained from the NC OneMap. ArcGIS tools were then used to analyze the data via data tables, calculations, and statistics.

### 2.2.2 Agriculture and Forestry

The land use and vegetation in the modeling domain is dominated by Southern Yellow Pine woodlots (73.3% of the land use)<sup>26</sup>, specifically by Mesic Pine Flatwoods (woodlots and protected areas). Agriculture accounts for 11.9% of the modeling domain, specifically for the cultivation of Corn (*Zea mays* x.), Soybeans (*Glycine max* x.), Tobacco (*Nicotiana tabacum*), Peanuts (*Arachis hypogaea*), and Wheat (*Triticum aestivum*), with some oats, vegetable, poultry, and livestock (sheep and hogs) production as well.<sup>27</sup> According to the NC Geographic Information Coordinating Council, 3.2% of the domain is used for pasture/hay and 8.6% of county is in crop production, including corn, soybeans, tobacco, peanuts, potatoes, beets, wheat, and oats.<sup>28</sup>

### 2.2.3 Natural Communities Classifications

The CCC modeling domain is located in the U.S. EPA Level III Ecoregion of the Mid-Atlantic Coastal Plain, and more specifically in the Carolina Flatwoods, Swamps and Peatlands, and the Mid-Atlantic Floodplains and Low Terraces (Level IV Ecoregions)<sup>29</sup>.

Pre-Colonization natural communities supported a complex mixture of wet and mesic pine flatwoods and Pocosins, draining into Cypress-Gum bottomland/wetland, brown/black water rivers, estuaries and salt marsh, as well as maritime shrublands and forest, and inter-dune communities.<sup>30,31,32</sup> The current natural communities that are present in the modeling domain include Upper Beach and Dune Grass (0.2%), Maritime Shrub (0.3%), Salt Marsh and Maritime Wet Grassland (2.0%), Low Pocosin (0.26%), Nonriverine Wet Hardwood Forest (1.4%), Cypress Savanna (0.1%), Mesic Pine Flatwoods (73.3%), Wet Marl Forest (0.1%), Pine-Scrub Oak Sandhill (1.4%), Cypress-Gum Swamp (1.5%), and Water (5.9% - open ocean, estuaries (brackish), rivers, streams, lakes, and "other Waters of the United States"<sup>33</sup>).<sup>34</sup> The natural communities are discussed briefly below. They account for 86.3% of the land use in the modeling domain.

The Upper Beach and Dune Grass natural communities account for only 0.2% of the area, or 342 acres. Though relatively undisturbed community in the ecoregion, this was never a dominant community type in North Carolina as it is found only in a narrow band along the coast. Historic and recent human impacts to coastal barrier dunes have begun to be addressed as the importance of the dune communities to the protection of the coast has been recognized. Restoration efforts have included establishing native grasses and other species in disturbed dunes.<sup>35</sup> The Upper Beach and Dune Grass community in this ecoregion is dominated by coarse shifting or recently stabilized sands (Newhan soil series), which are excessively drained, and the vegetation is dominated by Sea oats (*Uniola paniculata*), Bitter Panicgrass (*Panicum amarum*), American Beachgrass (*Ammophila breviligulata*), and further inland by various species of Bluestem grass (*Andropogon spp.*).<sup>36</sup> Various other species of low-growing, woody shrubs such as Seacoast Marsh Elder (*Iva imbricata*) are found growing in stabilized sands. In addition, some areas become inundated occasionally by saltwater flooding during storms and are dominated by salt-tolerant species such as Saltmeadow Cordgrass (*Spartina patens*).

Often found adjacent to and inland from the Upper Beach and Dune Grass community, is the Maritime Shrub community, accounting for 0.3% of the area, or 640 acres. This natural community is dominated by dense evergreen shrubs and small trees. Due to its physiographic location, much of this community has been impacted by coastal development and climate change.<sup>37</sup> This community is dominated by Wax myrtle (*Myrica cerifera*), Yaupon Holly (*Ilex vomitoria*), Eastern Red Cedar (*Juniperus virginiana*), and Dwarf Live Oak (*Quercus minima*).<sup>38</sup> This community is found in extremely well-drained soils (also Newhan soil series) with no horizon development of stabilized sand dunes, dune swales, and sand flats protected from salt water flooding and the most extreme salt spray.

Salt Marsh and Maritime Wet Grassland accounts for 2.0% of the modeling domain, or 3,860 acres. Many of these areas are used for small boat docking, fishing, and shellfishing. Vegetation in this community is dominated by Sea Oats in drier areas, and Jamaica Swamp Sawgrass (*Cladium mariscus spp. Jamaicense*), Saltwort/Glasswort (*Salicornia bigelovii*), Needlegrass Rush (*Juncus roemerianus*), and Cordgrasses (*Spartina spp.*).<sup>39</sup> This natural community is a major contributor to coastal protection, occurring along the intertidal shore of estuaries and sounds where salinity ranges from near ocean

strength to near fresh in upriver marshes, and ranks among the most productive ecosystems on earth.<sup>40</sup>

Further inland, the natural communities diversify from many of the salt tolerant species of the coast and estuaries to a mixture of wet and mesic communities. One of the most unique natural communities of the Mid-Atlantic Coastal Plain is the Low Pocosins, or are peatlands (with peat deposits over 1 meter deep), which have formed on poorly drained interstream flats, bays, and swales.<sup>41</sup> Low Pocosins account for 0.3% of the modeling domain, or 515 acres, and are seasonally flooded or saturated, though often slightly higher in elevation than surrounding lands. The peat is deep and saturated enough that plant roots never reach mineral soil. This community consists of a dense shrub layer less than 1.5 meters tall dominated by Fetterbush *Lyonia (Lyonia lucida)*, Swamp Titi (*Cyrilla racemiflora*), Inkberry (*Ilex glabra*), and Laurel Greenbrier (*Smilax laurifolia*).<sup>42</sup> This community receives its nutrient input only from rainfall and thus plant species have adapted to an extremely acidic and nutrient poor environmental conditions.<sup>43</sup>

Typically on the margins of large Pocosins, poorly drained loamy or clayey soils, support a Palustrine seasonally saturated or flooded natural community known as the Nonriverine Wet Hardwood Forest. This community is distinguished by the combination of bottomland oak or mixed hardwood vegetation located on flats not flooded by rivers or tidal waters. Nonriverine Wet Hardwood Forest accounts for 1.4% of the study area, or 2,704 acres. This community is dominated by Swamp Chestnut Oak (*Quercus michauxii*), Laurel Oak (*Quercus laurifolia*), American Elm (*Ulmus americana*), Red Maple (*Acer rubrum*), and Swamp Tupelo (*Nyssa biflora*).<sup>44</sup> This natural community is easy to drain and rich soils make excellent farmland, so though once common in the area, very few of these communities remain intact and make this one of the most threatened community types on the Coastal Plain.<sup>45</sup> This community is not found present within the confines of the currently proposed CCC project.

Cypress Savannah is found on wetland soils with a clay hardpan, forming Palustrine, seasonally to temporarily flooded wetlands in Carolina bays and other clayey depressions.<sup>46</sup> Considered a rare community in North Carolina, only 0.1% of area, or 215 acres, were accountable for this natural community. With an open to sparse canopy dominated by Bald Cypress (*Taxodium distichum*), some other wetland trees and shrubs grow in minimal association. This community is dependent on a combination of flooding and fire to maintain an open savanna structure, for without flooding or fire young pines and hardwoods begin to invade many sites.<sup>47</sup>

The modeling domain is dominated by the Mesic Pine Flatwoods natural community, accounting for 73.3% of the study area, or 142,446 acres. This community is found in mesic, non-wetland sites, with either flat or rolling Coastal Plain sediments, which are neither excessively drained nor with a significant seasonal high water table, and dominated by a closed to open canopy of Longleaf Pine (*Pinus palustris*) or Loblolly Pine (*Pinus taeda*), and in some cases of Slash Pine (*Pinus elliotii*).<sup>48</sup> This community has been cleared in some areas for agriculture, but is mostly utilized for large, privately owned woodlots and pulpwood production.<sup>49</sup>

The modeling domain contains a very rare natural community, Wet Marl Forest, which is presently known to exist in only southern Pender County, on a marl outcrop area.<sup>50</sup> The only known example of such a community in North Carolina is in Rocky Point Marl Forest, located in Southern Pender County, and it is not known to exist on the current CCC property.<sup>51</sup> Flat or gently sloped poorly drained uplands with marl or limestone near the surface, retain wet, seasonal to intermittently flooded soils that exhibit relatively high base saturation levels. This closed canopy forest of mesic and wetland hardwoods accounts for 0.1% , or 87 acres, of the study area, and is dominated by many species of oaks such as Shumard's Oak (*Quercus shumardii*), White Oak (*Quercu alba*), Swamp White Oak (*Quercus michauxii*), and others in conjunction with hickories (*Carya myristiciformis*, *C. aquatic*, *C. aquatica*, *C. cordiformis*, and others), Red Mulberry (*Morus rubra*), Carolina Basswood (*Tilia americana* var. *caroliniana*), American Elm (*Ulmus Americana*), Sweetgum (*Liquidambar styraciflua*), and a diverse understory of mesic small trees, shrubs, herbs, and vines.<sup>52</sup>

The Pine-Scrub Oak Sandhill is found on sites with generally rolling to more steeply sloping sandy Coastal Plain sediments with a clay layer near the surface, exhibiting dry to xeric moisture regimes. This open canopy community is found on about 1.4%, or 2,736 acres, and is dominated by Longleaf Pine (*Pinus palustris*), Turkey Oak (*Quercus marilandica*), Black Oak (*Quercus marilandica*), and other oak species (*Quercus spp.*).<sup>53</sup> The understory is often moderately sparse, though at times it can be rather dense. This community naturally experience frequent low intensity surface fires which keeps the understory sparse and stimulates herbaceous growth.<sup>54</sup>

The final natural community found within the modeling domain of the CCC facility is the Cypress-Gum Swamp. This community is typically classified into two subtypes, Blackwater Subtype and Brownwater Subtype, though they are presented here as one group as remote analysis of available data does to differentiate between the two subtypes.<sup>55</sup> Cypress-Gum Swamp communities account for 1.5% of the study area (2,892 acres) and are found in backswamps, sloughs, swales, and on floodplains of blackwater and brownwater rivers. The hydrology is palustrine, with seasonal to semipermanent flooding, and the water tends to be very acidic, low in mineral sediment and nutrients.<sup>56</sup> Cypress-Gum Swamps are dominated by Swamp Tupelo (*Nyssa biflora*), Blackgum (*Nyssa sylvatica*), Pond Cypress (*Taxodium ascendens*), and Bald Cypress (*Taxodium distichum*).<sup>57</sup> The environmental factors mentioned above enable very slow growth in trees, and therefore community recovery from logging activities can be slow.<sup>58</sup>

#### 2.2.4 Summary of Natural Communities

By describing the basic matrix of the plant communities of the modeling domain, both agricultural and natural, more efficient analysis of gap dynamics, ecosystem functionality, and possible impacts to various change agents such as urbanization, development, and/or the increase of COPEC's can be analyzed in respect to the proposed CCC project. The natural communities can be viewed in tabular format in Appendix A, Table A-2, and geospatially depicted in Appendix B, Drawing 001. About three-quarters (73.3%) of the land use in the study area are found in Pine Flatwoods as

protected areas or private woodlots.<sup>59</sup> For this Additional Impacts Analysis (AIA), assessing the increase of COPECs in the impact area is important for ecological parameters due to the high presence of wetlands (49.8% of the county)<sup>60,61</sup> and other sensitive or rare communities in the area, and also from a commercial (recreational, fisheries, agricultural and agro forestry) perspective as well. It can be difficult to predict ecological or agricultural impacts due to air emissions based on data and conclusions available in peer-reviewed literature because of significant variations in experimental designs.<sup>62</sup>

For the purposes of this project, threshold values (TRVs) for assessing COPEC impacts were obtained first from EPA sources. Where data was absent for particular COPECs, additional literature review was completed in order to determine critical TRVs. The EPA maintains a high level of screening of peer-reviewed literature in developing these ecological screening levels (Eco-SSL's)<sup>63</sup> and establishing TRVs<sup>64,65</sup> for COPECs. Many COPECs do not have federal Eco-SSL's or TRVs, and thus a review of other sources of TRVs for secondary receptors (vegetation, plants, animals, water, etc) is necessary. Other sources of data include but are not limited to the EPA Supplemental Guidance to RAGS: Region 4 Bulletins for Ecological Risk Assessment<sup>66</sup>, EPA Region 5 Ecological Screening Levels<sup>67</sup>, EPA Screening Level Ecological Risk Assessment Protocol for Hazardous Waste Combustion Facilities<sup>68</sup>, EPA's secondary NAAQS standards (not human-health based)<sup>69</sup>, peer-reviewed literature in scientific journals and publications, World Health Organization's standards<sup>70</sup>, or other international/multi-national organizations.<sup>71</sup> It is important to note that many of these TRVs are guidance levels and are not based on any regulatory standards.

## SECTION 3

# SOIL AND VEGETATION SENSITIVITY TO EXPOSURE

The following sections provide an evaluation of potential adverse effects to soils and vegetation from direct and indirect exposure to the NO<sub>x</sub>, SO<sub>2</sub>, CO, PM, and VOC emissions from CCC. These evaluations reference threshold exposure levels that define the lowest air, deposited soil, or plant tissue concentrations at which either acute or chronic exposure damage has been recorded in the referenced technical literature. The screening thresholds established are expected to be protective of even the most sensitive soils and vegetation in the modeling domain and are presented in Table 1.

By describing the basic matrix of both agricultural and natural plant communities in the modeling domain, a more detailed analysis of possible impacts from the CCC project's PSD triggering pollutant emissions was conducted. Specifically, during the course of the literature review conducted to establish soils and vegetation screening thresholds for potential adverse impacts, the available literature was searched for toxicological studies of the species known to exist within the impact area (refer to Tables A-3 to A-4 of Appendix A) with a primary focus on wetlands, pine flatwoods, and corn. As the scope of the vegetation survey was not limited to only species with "commercial or recreational value", Table A-5 of Appendix A and Drawing 001 of Appendix B show the locations of all natural areas, water bodies, state park, preserves, and other recreation areas within the modeling domain that may have specific recreational and commercial value, and therefore, may contain plant species of specific interest for the vegetation analysis.

TABLE 1 | ECOLOGICAL SCREENING THRESHOLDS

| Pollutant                   | Acute Ecological Screening Threshold |                   |      |     | Chronic Ecological Screening Threshold |                   |      |     |
|-----------------------------|--------------------------------------|-------------------|------|-----|--|-------------------|------|-----|
|                             | Value                                | Units             | Avg. | Ref | Value                                  | Units             | Avg. | Ref |
| NO <sub>2</sub>             |                                      | NA                |      |     | 100                                    | µg/m <sup>3</sup> | Ann. | 1   |
| SO <sub>2</sub>             | 1300                                 | µg/m <sup>3</sup> | 3-hr | 1   |  | NA                |      |     |
| CO                          | 10,000                               | µg/m <sup>3</sup> | 8-hr | 2   |  | NA                |      |     |
| PM Trace Metals             |                                      |                   |      |     |  |                   |      |     |
| Trace Metals: Chromium      |                                      | NA                |      |     | 200                                    | µg/kg soil        | Ann. | 3   |
| VOC Constituents of Concern |                                      | NA                |      |     | 18                                     | µg/kg plant       | Ann. | 3   |
| Benzene                     |                                      | NA                |      |     | 255                                    | µg/kg soil        | Ann. | 3   |

<sup>1</sup> U.S.EPA, 2011. Policy Assessment for the Review of the Secondary National Ambient Air Quality Standards for Oxides of Nitrogen and Oxides of Sulfur. US EPA Office of Air Quality Planning and Standards. EPA-452/R-11-004a, January 14, 2011.

<sup>2</sup> U.S.EPA: Office of Air Quality Planning and Standards - Assessment for the Review of the Carbon Monoxide National Ambient Air Quality Standards, EPA 452/R-10-007, October 2010.

<sup>3</sup> U.S. EPA Office of Solid Waste and Emergency Response, Screening Level Ecological Risk Assessment Protocol for Hazardous Waste Combustion Facilities, EPA-530-D-99-001A, August 1999.

### 3.1 Direct NO<sub>x</sub> Exposure

Nitrogen is an essential plant nutrient, which is a key component in plant proteins and chlorophyll that has been recognized by science and agricultural communities for over 200 years. Gaseous NO<sub>x</sub> enters plant leaves through the stomata, which open at sunrise and close in darkness, although drought conditions, higher temperatures, and low concentrations of atmospheric CO<sub>2</sub> can also cause the stomata to open during the night.<sup>72</sup> Sufficient ambient concentrations of nitrogen oxide (NO) and nitrogen dioxide (NO<sub>2</sub>) (which are collectively referred to as NO<sub>x</sub>) can have phytotoxic effects on plants through decreased photosynthesis and induced visible foliar injury. However, the functional relationship between ambient concentrations of NO<sub>x</sub> and a specific plant response, such as foliar injury, reduction in rates of photosynthesis, or reduced growth, is a complex process that relies on a number of internal and external factors specific to the plant species studied.

In the recently completed review of the secondary NO<sub>2</sub> NAAQS, EPA concluded that existing ambient NO<sub>x</sub> concentrations are rarely high enough to cause phytotoxic effects to vegetation.<sup>73</sup> Nevertheless, the 2010 Integrated Science Assessment (ISA) for the NO<sub>2</sub> NAAQS review includes a complete and thorough review of experimental studies on the topic of adverse impacts from NO<sub>x</sub> exposure on many types of vegetation. Based on this literature review, EPA concluded that "very little new research has been done" on the phytotoxic effects of NO<sub>x</sub> to alter the conclusions in the 1993 Air Quality Criteria Document (AQCD). Additionally, in the January 14, 2011, U.S. EPA Policy Assessment for the Review of the Secondary National Ambient Air Quality Standards for Oxides of Nitrogen and Oxides of Sulfur, it is indicated that the current NAAQS secondary standards are sufficient for the protection of vegetation from direct damage associated with exposure to gaseous NO<sub>x</sub>.<sup>74</sup>

The 1993 AQCD included results from various experimental studies for various species found in the modeling domain, including Loblolly Pine, Sweetgum, Corn, and Soybeans. Loblolly Pine and Sweetgum both showed no injury due to NO<sub>2</sub> concentrations of 100 ppb (6 hr/day for 28 days). Though this species is not dominant in the modeling domain, it is present and it is listed here due to its similar growth habit of several of the dominant pine species that were not reviewed in the AQCD document. Corn showed no injury due to NO<sub>2</sub> concentrations ranging from 100 to 1,000 ppb at 24-hour exposures, for two weeks. Soybeans showed no response to NO<sub>2</sub> concentrations of 100 to 400 ppb at varying time intervals from two weeks to two months. The relationship of exposure response of vegetation to various NO<sub>x</sub> concentrations over time is shown in Figure 1 below.



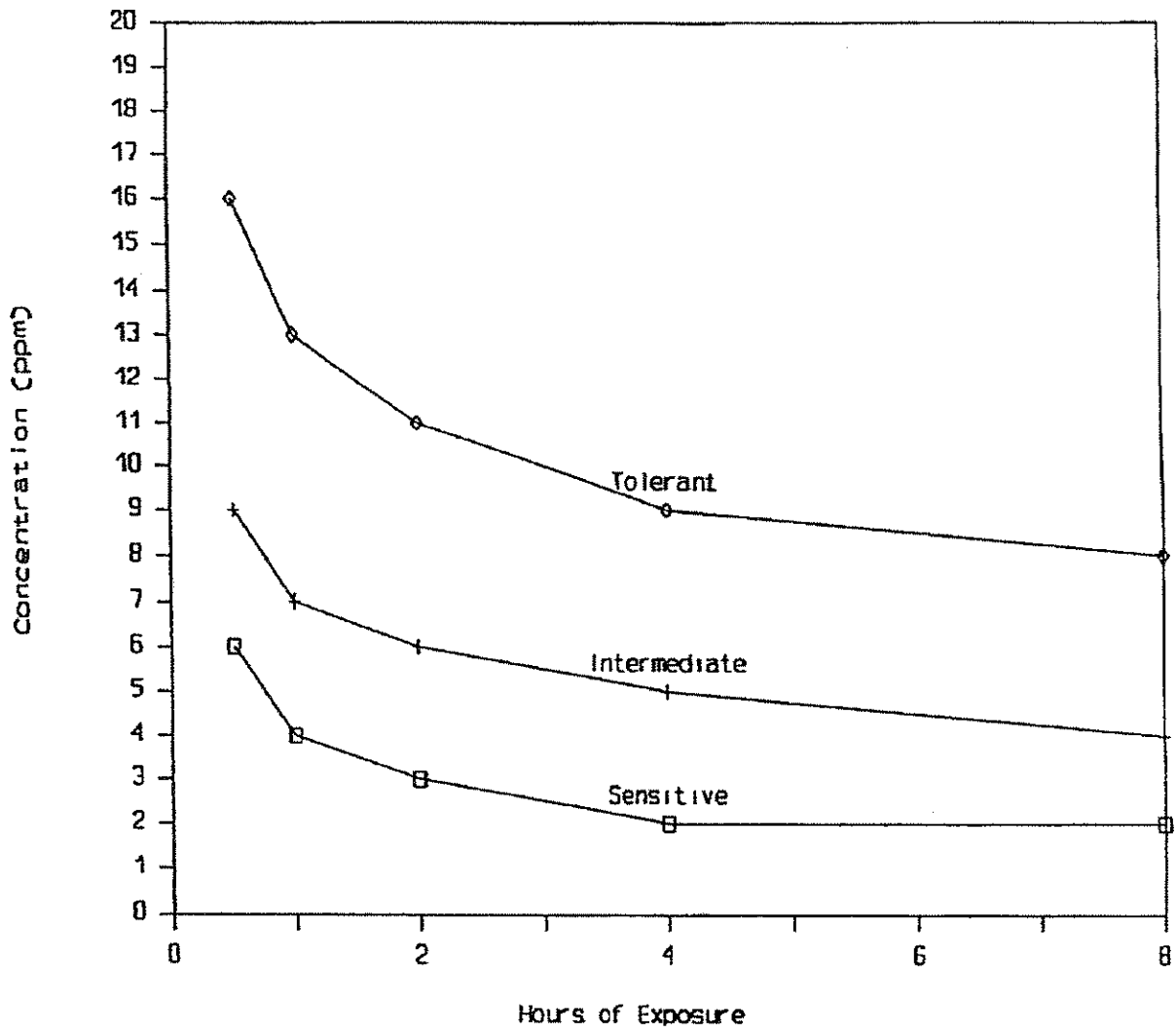


Figure 1 | Exposure Response Curve for Foliar Injury from Direct NO<sub>x</sub> Exposure

It is reasonable to expect based on the results of the chronic exposure studies that plants would not exhibit any adverse response to NO<sub>2</sub> concentrations below 100 ppb, and in fact, the exposure-response curve suggests NO<sub>2</sub> concentrations up to 600 ppb would be protective.<sup>75</sup> Based on all of the experimental evidence reviewed, as well as the recently published U.S.EPA 2011 Policy Assessment for the Review of the Secondary National Ambient Air Quality Standards for Oxides of Nitrogen and Oxides of Sulfur, the current NAAQS secondary standard provides a protective screening threshold for injury to sensitive plants from NO<sub>x</sub>. Thus, an annual screening threshold for chronic exposure was used based on the current secondary NO<sub>2</sub> NAAQS standard of 53 ppb (100 µg/m<sup>3</sup>), which is far below any site-specific screening thresholds that would be established based on the peer-reviewed literature.

### 3.2 Direct SO<sub>2</sub> Exposure

Sulfur is an essential plant nutrient that has been recognized by science and agricultural communities for over 200 years.<sup>76</sup> Intermediary metabolism requires sulfur, and it is a constituent of many organic compounds (amino acids and proteins in plant tissues).<sup>77</sup> The most common form of sulfur uptake is as sulfate (SO<sub>4</sub><sup>2-</sup>) from the soil through the roots, although uptake of sulfate through direct deposition to foliage and uptake of SO<sub>2</sub> through foliage from the atmosphere are other significant pathways. SO<sub>2</sub> is absorbed into plant foliage via diffusion through the stomata.<sup>78,79</sup> Therefore, plants generally show a higher degree of resistance to SO<sub>2</sub> at night and they become more sensitive with increasing irradiance, similar to the NO<sub>x</sub> exposure pathways discussed previously.<sup>80</sup> Acute and chronic symptomology of SO<sub>2</sub> exposure to vegetation is intensified by increased temperatures, increased relative humidity (from 35 to 75 percent), and increased available soil water capacity.<sup>81,82</sup> Soil fertilization via nitrogen in the form of nitrate (NO<sub>3</sub><sup>-</sup>) increases SO<sub>2</sub> tolerance of plants, although the ammonium ion (NH<sub>4</sub><sup>+</sup>) in fertilizers may exhibit competing adverse effects.<sup>83</sup>

Visible injury response of various plants in field conditions is commonly the response to a mixture of high concentration acute and low concentration chronic SO<sub>2</sub> exposures, and variable environmental conditions. The use of defined SO<sub>2</sub> concentration thresholds for visible injury can be difficult, despite the overwhelming amount of related research over the past 100 years. Foliar SO<sub>2</sub> injury in dicotyledonous plants appears initially as dull, dark-green water soaked appearance, forming into marginal and interveinal bifacial necrosis.<sup>84</sup> Specifically, acute SO<sub>2</sub> injury on leaves of soybean is typically seen as a whitish-tan interveinal necrosis.<sup>85</sup> Dicots that are common in the impact area and are relatively sensitive to SO<sub>2</sub>, include Soybeans, Wheat, Beets, Oats, and American Elm (*Ulmus americana*). Chronic foliar injury in monocots is commonly seen as interveinal and marginal chlorosis (rapid inhibition of chlorophyll formation), extending from the lead tip downward toward the lead base.<sup>86,87</sup> Acute foliar injury in monocots is commonly seen as reddish-brown tip necrosis, that, depending on the duration of repeated exposure to SO<sub>2</sub>, can lead to distinct banding patterns in the necrotic area (corn) and premature dropping of older needles in species of pine.<sup>88</sup> Monocots in the impact area



for CCC, which are considered sensitive to SO<sub>2</sub>, include Corn (*Zea mays* ssp. *indurata*) and various sedges and grasses. In general, injury caused by SO<sub>2</sub> exposure ranges from tissue damage from acute exposure, to yield reduction, growth inhibition, and severe tissue damage or loss from chronic exposure.

Currently, SO<sub>2</sub> is the only criteria pollutant with a secondary NAAQS distinct from the primary standard which was specifically established based on welfare effects including acute foliar injury resulting from exposure to SO<sub>2</sub> in the ambient air. The current secondary SO<sub>2</sub> NAAQS, 0.50 ppm (1,300 µg/m<sup>3</sup>) on a 3-hr average basis, was promulgated in 1970. The last AQCD for ecological effects of SO<sub>2</sub> was completed in 2008. According to the recent ISA developed for the SO<sub>2</sub> NAAQS review, "controlled experiments and field observations supported retaining this secondary standard," and the limited research on acute foliar damage that has been conducted since the 1982 AQCD was developed provides "no clear evidence of acute foliar injury below the level of the current standard".<sup>89</sup>

Therefore, relying on information presented in the most recent AQCD developed for SO<sub>2</sub>, as well as the U.S.EPA 2011 Policy Assessment for the Review of the Secondary National Ambient Air Quality Standards for Oxides of Nitrogen and Oxides of Sulfur, it is indicated that the current NAAQS secondary standard is sufficient for the protection of vegetation from direct damage associated with exposure to gaseous SO<sub>x</sub>.<sup>90</sup> An acute screening threshold was used for injury to sensitive plants from SO<sub>2</sub> emissions of 1300 µg/m<sup>3</sup> on a 3-hour average basis, based on the existing secondary NAAQS standard.

### 3.3 Direct CO Exposure

Concentrations of CO are not typically detrimental to vegetation, and have not been found to produce detrimental effects on plants at concentrations below 114,500 µg/m<sup>3</sup> for exposures from 1 to 3 weeks, nor has it been shown that CO is absorbed by plants via transpiration and root uptake.<sup>91</sup> Microorganisms in the soil appear to be a major sink for CO.

On April 30, 1971, EPA promulgated identical primary and secondary NAAQS for CO set at 9 ppm (10,000 µg/m<sup>3</sup>) on an 8-hour average basis and 35 ppm (40,000 µg/m<sup>3</sup>) on a 1-hr average basis (36 FR 8186). After a reexamination of the scientific data upon which the CO NAAQS was based, EPA announced its final decision on September 13, 1985 to revoke the secondary standard for CO, due to a lack of evidence of direct effects on public welfare at ambient concentrations. Subsequent scientific reviews of data available on the welfare effects of CO including effects on soils and vegetation in 1991, 2000, and 2009 have not altered EPA's previous decision to not impose a secondary NAAQS for CO. In October of 2010, U.S.EPA conducted a policy assessment on CO NAAQS primary and secondary standards and continued to uphold this decision.<sup>92</sup> Based on this recent action, an acute screening threshold for potential adverse impacts

to vegetation from CO exposure of 10,000  $\mu\text{g}/\text{m}^3$  on an 8-hour average basis was utilized. No chronic effects from CO exposure were documented in the literature.

### 3.4 Direct and Indirect PM Exposure

PM is not a single pollutant, but instead is composed of a heterogeneous, largely inert, mix of compounds with differing particle size, mechanisms of formation, and chemical composition. PM can enter the foliage of vegetation through the stomata if the particle size is small enough ( $\text{PM}_{2.5}$ ).<sup>93</sup> For coarse particles ( $\text{PM}_{10}$ ) that are water soluble, or have some water soluble components and/or react with chemicals in the soil, plant uptake of ions from the leaf or through the roots does occur.<sup>94</sup> Indirect entry through roots may cause chronic effects because of changes in soil chemistry.<sup>95</sup> Detrimental effects of PM on vegetation (phytotoxicity) have been demonstrated in areas that are in the immediate vicinity of some types of stationary industrial sources. The most imposing effect of PM deposition on vegetation is a physical smothering of the leaf surface, reducing light transmission (decreased photosynthesis) and possible closure and clogging of stomata (decreased transpiration), both of which can cause reduced productivity, inhibited growth, or ultimately death.

Exposure to a given concentration of airborne PM and the resulting mass of deposited material may lead to widely varying phytotoxic effects depending on the particle size and chemical composition of the PM species in the ambient air. In the most recent AQCD for PM conducted in 2004, EPA recognized this fact when it stated "effects of particulate deposition on individual plants or ecosystems are difficult to characterize because of the complex interactions among biological, physicochemical, and climatic factors."<sup>96</sup> A subsequent staff paper issued by U.S. EPA concerning the PM NAAQS review process also acknowledged the difficulty in assessing adverse effects on soils and vegetation from PM air pollution when evaluated as a single class by stating the following:<sup>97</sup>

*"Because PM size classes do not necessarily have specific differential relevance for vegetation or ecosystem effects (Whitby, 1978; EPA, 1996a), it is the opinion of the staff that an ecologically relevant indicator for PM should be based on one or more chemical species found in ambient PM."*

The chemical species found in PM specifically evaluated in the AQCD include trace metals and semivolatile organic compounds (which can deposit and cause phytotoxic effects). The following sections establish screening thresholds for each of these chemical species found in PM which exhibit ecological toxicity and can be used as indicators to assess potential adverse impacts from CCC's PM emissions.

#### Trace Metals

PM emissions from the proposed sources at the CCC are expected to contain the following trace metals with documented ecological toxicity: antimony, arsenic,



beryllium, cadmium, chromium IV (bioavailable), chromium IV (soluble), cobalt, lead, manganese, mercury, nickel, and selenium.<sup>98</sup> Deposited heavy metals tend to accumulate in soil layers just below the level where root activity occurs.<sup>99</sup> Although some trace metals are essential for vegetative growth, they can be toxic to plants when accumulated in large quantities through both direct uptake from foliage and indirect uptake from soils through root systems.<sup>100</sup> As shown in Table A-3 of Appendix A, a complete inventory of plant and soil toxicity data was compiled for the emitted metallic compounds found in PM based on the U.S. EPA *Screening Level Ecological Risk Assessment Protocol* (SLERAP) toxicity reference values (TRVs) and the U.S. EPA Office of Solid Waste and Emergency Response (OSWER) Ecological Soil Screening Levels (Eco-SSLs).

In order to determine which of these chemical species to evaluate quantitatively in the air dispersion modeling analysis for comparison against the screening threshold, a toxicity-weighted emissions score was calculated for each metallic compound by dividing the annual potential emissions in tons per year (tpy) by the lowest of the plant and soil TRVs or Eco-SSLs in  $\mu\text{g}/\text{kg}$ . The resulting individual pollutant scores for plant and soil toxicity were then expressed as a percentage of the total score for all metallic compounds to determine the compound that is most likely to cause the highest offsite impacts on plants and soils. To determine which pollutant is expected to have the highest cumulative impact on plants and soils, the percentages of the total emission score for plant and soil toxicity were averaged. Based on this analysis, modeling impacts of chromium (Chromium VI) were evaluated, both soluble and bioavailable, in order to evaluate potential ecological impacts from the CCC's PM emissions (refer to Table A-3 of Appendix A). This toxicity-weighted emissions scoring approach is identical to the procedure used to select chemicals of potential ecological concern (COPECs) in multiple ecological Screening Analyses and AIA's for other PSD applicants.<sup>101</sup>

Chromium is both an essential nutrient and a carcinogen, yet the essentiality and carcinogenicity of chromium depend on its chemical form. Oxidation state and solubility (trivalent chromium compounds are less toxic than those of hexavalent chromium ( $\text{Cr}^{\text{VI}}$ )) are particularly important in determining the biological effects of chromium compounds. For this reason, total chromium measurements are of little value in assessing its nutritional benefits or its toxicological hazards.<sup>102</sup> According to the NCDENR's *Update Guidelines for Implementing Acceptable Ambient Levels (AALs) for Chromium (VI) Compounds*, the primary form of Cr (VI) present in combustion processes is a soluble chromate compound under NC TAP rules, chromic acid ( $\text{CrO}_3$ ), which is not considered a marine pollutant by the US EPA.<sup>103</sup> In addition, Chromium(VI)-contaminated soil can support a viable anaerobic bacterial community (such as those found in wetlands); however, Cr(VI) alters the soil composition, which could affect the soil biodegradation potential.<sup>104</sup> However, with decreasing pH in acid media such as the soils in and near the CCC facility,  $\text{Cr}^{\text{VI}}$  compounds are transposed to soluble sodium chromate. Soluble  $\text{Cr}^{\text{VI}}$  compounds dissolve under lower pH soil conditions.<sup>105</sup>

Since the TRVs for chromium are the lowest thresholds from among the TRVs and Eco-SSLs listed in Table A-3 of Appendix A, a chronic screening threshold for potential adverse

impacts to soils from total chromium exposure of 200 µg/kg over the lifetime of the CCC's operations were utilized. To evaluate adverse effects on vegetation from total chromium exposure, a chronic screening threshold of 18 µg/kg over the lifetime of the CCC's operations based on the plant TRV was utilized. No acute ecological screening thresholds for metallic compound deposition were found in the literature review, and therefore, only chronic impacts were evaluated.

### 3.5 Direct and Indirect VOC Exposure

VOC in the atmosphere is partitioned between the gas and particle phases, depending on the liquid-phase vapor pressure of the organic compounds at the ambient temperatures, the surface area per unit volume of air of PM in the atmosphere available for adsorption, and the nature of the particles and of the chemical being adsorbed. Trace low vapor pressure semivolatile organics such as certain polycyclic organic matter (POM) and polynuclear aromatic hydrocarbons (PAH) are more likely to adsorb onto particles, while more commonly emitted VOC compounds such formaldehyde and benzene remain in the gas phase. These particle-phase semivolatile organic compounds may enter plants indirectly by uptake through the roots or directly by deposition onto the cuticles and stomata.<sup>106</sup> The dominant exposure pathway depends on the chemical and physical properties of the pollutant, (i.e., lipophilicity, water solubility, vapor pressure and Henry's law constant), environmental conditions such as ambient temperature and soil organic content, and the plant species which influences the available surface area for deposition and the lipids available for accumulation.<sup>107</sup>

Concentrations of VOC, when evaluated as a class of pollutant, are not typically directly detrimental to vegetation or soils (with the exception of ethylene), and have not been found to produce detrimental effects on plants, until VOCs and NO<sub>x</sub> react in sunlight to form atmospheric ozone (O<sub>3</sub>).<sup>108 109 110</sup> Most compounds found within VOC tend to be highly reactive with short atmospheric residence times that prevent persistent exposure to vegetation and the possibility for phytotoxic effects, and therefore, almost no literature is available on the direct effects of VOC emissions on plants.<sup>111</sup>

Similar to PM, concentrations of VOC when evaluated as a class of pollutant are not typically directly detrimental to vegetation or soils (with the exception of ethylene), and they have not been found to produce detrimental effects on plants until VOCs and NO<sub>x</sub> react in sunlight to form atmospheric ozone (O<sub>3</sub>).<sup>112 113 114</sup> Most compounds found within VOC tend to be highly reactive with short atmospheric residence times that prevent persistent exposure to vegetation and the possibility for phytotoxic effects, and therefore, very little literature is available on the direct effects of VOC emissions on plants.<sup>115</sup> Ecological screening levels for soil contamination for selected VOC compounds are, however available, and as shown in Table A-4 of Appendix A, the available EPA Supplemental Guidance to RAGS: Region 4 Bulletins for Ecological Risk Assessment<sup>116</sup> and EPA Region 5 Ecological Screening Levels (ESL) for emitted VOCs were used to determine which compound to evaluate quantitatively in the modeling portion of this analysis.<sup>117</sup>



The same toxicity-weighted emissions scoring approach applied to metals and PAHs was applied to these VOC compounds. Based on this analysis, benzene is expected to produce the highest offsite soil impacts.

Absorption of benzene through leaf stomata or cell walls can cause death in plants and roots and damage to the leaves of many agricultural crops.<sup>118</sup> Benzene is carried via the atmosphere. When it comes into contact with soil, benzene will usually breakdown quickly. It can be mobile in soil, however, and may contaminate groundwater.<sup>119</sup>

Benzene is expected to produce the highest offsite soil and vegetation impacts. Therefore, a chronic screening threshold for potential adverse impacts to soils from benzene exposure of 255 µg/kg over the lifetime of the CCC's operations was utilized. No acute ecological screening thresholds for benzene deposition were found in the literature review, and therefore, CCC only evaluated chronic impacts.

SECTION 4

## RESULTS OF SOIL AND VEGETATION IMPACT ANALYSIS

### 4.1 Direct NO<sub>2</sub> Exposure

In order to assess compliance with the acute screening threshold for direct NO<sub>2</sub> exposure [53 ppb (100 µg/m<sup>3</sup>) on an annual average basis], the Highest First High (H1H) modeled concentrations from CCC sources only was used. As shown in Table 3, **CCC remains below the established acute ecological screening threshold values. As such, no further ecological analysis were performed and no adverse impacts to soils and vegetation from direct NO<sub>2</sub> exposure are expected.**

TABLE 2 | NO<sub>2</sub> SOIL AND VEGETATION IMPACT ANALYSIS

| Pollutant       | Averaging Period | Modeled Result <sup>1</sup><br>(µg/m <sup>3</sup> ) | Acute Ecological Screening Threshold<br>(µg/m <sup>3</sup> ) | Chronic Ecological Screening Threshold<br>(µg/m <sup>3</sup> ) |
|-----------------|------------------|---|--|--|
| NO <sub>2</sub> | Annual           | 0.8   | NA   | 100  |

<sup>1</sup> Based on H1H modeled concentrations.

### 4.2 Direct SO<sub>2</sub> Exposure

In order to assess compliance with the acute screening thresholds for direct SO<sub>2</sub> exposure (1300 µg/m<sup>3</sup> on a 3-hr average basis), the H1H modeled concentration from the 3-hr averaging period for CCC sources only was used. As shown in Table 4, **CCC remains below the established screening threshold values. As such, no further impact analysis were performed and no adverse impacts to soils and vegetation from direct SO<sub>2</sub> exposure are expected.**

TABLE 3 | SO<sub>2</sub> SOIL AND VEGETATION IMPACT ANALYSIS

| Pollutant       | Averaging Period | Modeled Result <sup>1</sup><br>(µg/m <sup>3</sup> ) | Acute Ecological Screening Threshold<br>(µg/m <sup>3</sup> ) | Chronic Ecological Screening Threshold<br>(µg/m <sup>3</sup> ) |
|-----------------|------------------|---|--|--|
| SO <sub>2</sub> | 3-hour           | 9.1   | 1,300  | NA   |

<sup>1</sup> Based on H1H modeled concentrations.

### 4.3 Direct CO Exposure

In order to assess compliance with the acute screening threshold for direct CO exposure (10,000 µg/m<sup>3</sup> on an 8-hour average basis), the H1H 8-hr modeled concentration for CCC sources only were relied upon. As shown in Table 5, **CCC's 8-hr average impacts are less than the acute screening threshold, and therefore, no adverse impacts to soils and vegetation from direct CO exposure are expected.**

TABLE 4 | CO SOIL AND VEGETATION IMPACT ANALYSIS

| Pollutant | Averaging Period | Modeled Result <sup>1</sup><br>(µg/m <sup>3</sup> ) | Acute Ecological Screening Threshold<br>(µg/m <sup>3</sup> ) | Chronic Ecological Screening Threshold<br>(µg/m <sup>3</sup> ) |
|-----------|------------------|---|--|--|
| CO        | 8-hour           | 28  | 10,000   | NA   |

<sup>1</sup> Based on H1H modeled concentrations.

### 4.4 Direct and Indirect Chromium Exposure

Particle-phase deposition modeling for chromium was performed to determine the maximum offsite annual average deposition rate. This maximum deposition rate from among the five-years modeled was then used to calculate the maximum accumulated soil and plant tissue concentrations at the end of the facility's useful life. The same modeling parameters presented within the January 2011 modeling report were used with the exception of the deposition parameters. Dry and wet particle phase deposition modeling for chromium was conducted using the "Method 2" approach in AERMOD. As recommended in the *AERMOD User's Guide*, the recommended mass fraction of

chromium emissions in the fine mode (55 percent) and mass-mean aerodynamic particle diameter (1.2  $\mu\text{m}$ ) were used, as presented in Appendix B of the draft ANL report.

In order to compare these maximum modeled deposition rates with the ecological screening values established, the procedure outlined in EPA's guidance document "A Screening Procedure for Impacts on Air Pollution Sources on Plants, Soils, and Animals" was used. Based upon this screening methodology the following equations were used to derive the deposited concentration on soils:

$$DC = \frac{W_{dep}}{W_{soil}}$$

Where:

- DC = deposited concentration ( $\mu\text{g}/\text{kg}$  soil),
- $W_{dep}$  = weight deposited ( $\mu\text{g}$ ), and
- $W_{soil}$  = weight of soil (kg).

To derive the weighted deposited ( $W_{dep}$ ) the following equation was used:

$$W_{dep} = (DR)(A_{dep})(N)$$

Where:

- DR = maximum annual average deposition rate from the source ( $\mu\text{g}/\text{m}^2/\text{yr}$ ),
- $A_{dep}$  = deposition area (1  $\text{m}^2$ ), and
- N = expected lifetime of the source (years).

To derive the weight of the local soil ( $W_{soil}$ ), the following equation was used:

$$W_{soil} = (A_{dep})(d)(\rho_{soil})$$

Where:

- d = depth of soil through which the deposited material is distributed (cm), and
- $\rho_{soil}$  = bulk density of soil ( $\text{g}/\text{cm}^3$ ).

Based upon site-specific conditions it was determined that the depth through which the deposited material is distributed (d) is 4.5 cm, the bulk density of soil ( $\rho_{soil}$ ) is 1.27  $\text{g}/\text{cm}^3$ . Given the long expected lifetime of this source (N), a conservative value of 100 years

was selected. As a conservative approach the H1H modeled value for total chromium deposition was used.

To derive the concentration in plant tissue, the following equation was used:

$$TC = (DC)(CR)$$

Where:

- TC = tissue concentration ( $\mu\text{g}/\text{kg}$  plant),
- DC = deposited soil concentration ( $\mu\text{g}/\text{kg}$  soil), and
- CR = concentration ratio.

Table 3.6 in EPA's guidance "A Screening Procedure for Impacts on Air Pollution Sources on Plants, Soils, and Animals" provides the required plant-to-soil concentration ratios. Based upon this table, for chromium a ratio of 0.02 is recommended.

The results of the chromium soil and plant tissue concentration calculations are provided in Table A-6, Appendix A based upon the deposition modeling performed and the methodology described above. As shown in Table 6, **the highest deposited chromium concentrations modeled for CCC are below the chronic ecological screening threshold, and therefore, no adverse impacts to soils and vegetation from chromium exposure are expected.**

TABLE 5 | CHROMIUM SOIL AND VEGETATION IMPACT ANALYSIS

| Pollutant      | Averaging Period | Highest Deposited Concentration ( $\mu\text{g}/\text{kg}$ ) | Acute Ecological Screening Threshold ( $\mu\text{g}/\text{kg}$ ) | Chronic Ecological Screening Threshold ( $\mu\text{g}/\text{kg}$ ) |
|----------------|------------------|---|--|--|
| Total Chromium | Annual (soil)    | 96.8  | NA   | 200  |
|                | Annual (plant)   | 1.94  | NA   | 18   |

#### 4.5 Direct and Indirect Benzene Exposure

Gas-phase deposition modeling for benzene was performed to determine the maximum offsite annual average deposition rate. These results were used to calculate the

maximum accumulated soil concentration at the end of the CCC's useful life (100 years). This methodology is consistent with the procedure outlined previously for chromium. Given the volatile nature of benzene, it is expected that deposited amounts will not remain or accumulate within the soils as this methodology assumes, as such this will present a most conservative approach. The same modeling parameters presented within the January 2011 modeling report were used with the exception of the deposition parameters used for benzene. The following pollutant specific source parameters required for benzene gas deposition modeling taken from Appendix C and D of the ANL report were used: 1) diffusivity in air, 0.08962 cm<sup>2</sup>/s, 2) diffusivity in water, 1.040 × 10<sup>-5</sup> cm<sup>2</sup>/s, 3) cuticular resistance, 2.51 × 10<sup>4</sup> s/cm, and 4) Henry's law constant, 5.57 × 10<sup>2</sup> Pa × m<sup>3</sup>/mol.

As there are no vegetation screening values only soil concentrations were determined. The results of the benzene gas-phase deposition modeling are provided in Table 7. Table A-7, Appendix A provides a detailed summary of the modeling results and concentration derivation. As shown in Table 7, **the highest deposited benzene concentrations modeled for CCC are below the chronic ecological screening threshold, and therefore, no adverse impacts to soils and vegetation from benzene exposure are expected.**

TABLE 6 | BENZENE SOIL IMPACT ANALYSIS

| Pollutant | Averaging Period | Highest Deposited Concentration (µg/kg soil) | Acute Ecological Screening Threshold (µg/kg soil) | Chronic Ecological Screening Threshold (µg/kg soil) |
|-----------|------------------|--|---|---|
| Benzene   | Annual           | 2.95   | NA  | 255   |

APPENDIX A  
TABLES

**APPENDIX B  
DRAWINGS AND FIGURES**

APPENDIX C  
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