# 1240: Jimblebar Greenhouse Gas Emissions (Land clearing)

## Subject: Greenhouse Gas Emissions – Land Clearing

Date: 27 July 2023

BHP operates the Jimblebar iron ore mining operations located 40km east of Newman in the Pilbara region of Western Australia. BHP proposes to continue mining operations at Jimblebar through to 2060, with land clearing activities ceasing from 2046.

BHP has identified that 3,558 hectares (ha) of ground disturbance (native vegetation clearing) is required to continue supporting the Jimblebar mining operations. This is comprised of 1,674 ha for existing ongoing operations, as well as an additional 1,884 ha for the proposed Jimblebar East extension to mining operations (the Proposal).

BHP commissioned Environmental Technologies & Analytics Pty Ltd (ETA) to estimate the Greenhous Gas (GHG) emissions associated with this clearing of vegetation at the Jimblebar iron ore mining operations.

This memorandum details the methodology and estimated GHG emissions associated with clearing of vegetation for the Proposal.

Please do not hesitate to contact the undersigned should you have any queries.

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# Contents

# Figures



# Tables

# 1 Introduction

BHP operates the Jimblebar iron ore mining operations located 40km east of Newman in the Pilbara region of Western Australia. BHP proposes to continue mining operations at Jimblebar through to 2060, with land clearing activities ceasing from 2046. Greenhouse Gas (GHG) emissions associated with clearing of vegetation for the mining operations at Jimblebar have been estimated.

Emissions have been estimated using the Full Carbon Accounting Model (FullCAM). The FullCAM model (Richards, 2001), was developed as part of the National Carbon Accounting System (NCAS). It provides fully integrated estimates of carbon pools in forest and agricultural systems. It also accounts for anthropogenic contributions that lead to changes in emissions due to the release of sequestered carbon into the atmosphere.

The FullCAM model was developed and is used in Australia's National Greenhouse Accounts for land use, land use change and forestry sectors. Within the context of estimating GHG emissions for the Project, the use of the FullCAM model offers the following benefits:

- comprehensive carbon accounting and projection capacity for land-based activities
- consistent, scientifically rigorous, and transparent model platform that allows for ongoing improvements in fundamental input data and model calibration
- consistency with land sector[1] reporting within Australia's National Inventory System GHG emissions inventory data for purposes of evaluating Project contribution, noting that clearing emissions are not reportable under the National Greenhouse and Energy Reporting System (NGERS) and so methods for emissions estimation are not prescribed
- commonly adopted for Environmental Impact Assessment (EIA) of resources sector projects throughout Australia.

The scope of work involved configuring the FullCAM model to estimate GHG emissions from clearing of vegetation over the proposed life of mine, based on the currently available indicative clearing schedule provided by BHP.

This memorandum details the methodology and estimated GHG emissions associated with clearing of vegetation for the Project.

## 1.1 Project overview

The Jimblebar mining operation is located in the eastern Pilbara region, approximately 40 km east of the town of Newman. The dominant land use is pastoral and iron ore mining operations, including BHP's existing mining operations at the Jimblebar and Newman hubs.

BHP proposes to continue operations at Jimblebar to 2060, with land clearing activities ceasing from 2046.,. The continuation of Jimblebar's operations will involve above and below water table mining at Jimblebar East (JB East) and other associated activities (the Proposal).

[1] Australia reports GHG emissions and carbon sequestration from land use change and forestry for deforestation, afforestation and reforestation, forest management (commercial timber), cropland and grazing land management and revegetation (DCCEEW, 2023).

The Jimblebar Hub is a significant amendment to consolidate Approved Proposals for individual mines (Jimblebar (MS1126), Orebody 31 (MS1021) and Orebody 18 (MS439 as amended by MS1012)) into the Amended Proposal for the Jimblebar Hub.

New components of the Proposal include (but are not limited to) the following key activities and elements:

- above and below water table mining at Jimblebar East
- increase in mine dewatering at Jimblebar
- new overburden storage areas (OSAs) north of Jimblebar East
- new haul roads and creek crossings (Jimblebar Creek)
- processing plant and conveyor at Jimblebar East
- new beneficiation plant and in-pit tailings storage facilities (TSF) .

Consistent with the hub approach proposed for the Strategic Proposal, the Proposal will use existing infrastructure including processing at the Jimblebar Hub.

The Proposal is located within and adjacent to the Approved Proposals (Jimblebar, Orebody 31 and Orebody 18) within the Jimblebar Hub. The Proposal also includes the amalgamation of the Approved Proposals for the Jimblebar (JB), Orebody 31 (OB31) and Orebody 18 (OB18) mines.

# 2 Study Approach

Vegetation is a natural carbon sink, wherein plants capture carbon dioxide from the atmosphere for use in photosynthesis. During its life cycle, carbon is stored in:

- aboveground biomass – stems, branches, bark, leaves
- belowground biomass – coarse roots, fine roots
- soil.

The conversion of land use leading to the elimination of any type of vegetation results in the release of sequestered carbon to the atmosphere. The assessment of potential GHG emissions from land clearing due to a development needs to consider:

- emissions due to breakdown of forest debris
- loss of carbon sink (carbon that could have been sequestered in the future if the vegetation was not cleared)
- emissions due to changes in soil carbon.

In order to determine the impact of the Project, GHG emissions attributed to land clearing were estimated using the FullCAM model. Greenhouse gas emissions for each year of mine operations were estimated for two cases. The 'baseline' case refers to a case wherein no anthropogenic clearing was assumed within the development footprint. The 'progressive clearing' case refers to a case that follows the proposed clearing schedule of the existing and proposed mine operations, discussed in Section 3.2.3.

Greenhouse gas emissions attributed to land clearing are defined as the difference between the 'progressive clearing' case and the 'baseline' case, (i.e., loss of carbon equates to total $CO_2$ emissions released to atmosphere as a result of Project clearing).

Sequestration from revegetation associated with mine rehabilitation is not included. This is conservative (over-estimates emissions) and is consistent with the approach used for other EIAs.

# 3 FullCAM

## 3.1 Operational scenarios

Operational scenarios considered in the assessment include:

- **Scenario 1: Existing only**
  - Business as usual, based on actual clearing schedule projected for current mine development
  - JB, OB18, OB31
- **Scenario 2: Existing and proposed**
  - JB, OB18, OB31 + JB East
- **Scenario 3: Proposed only**
  - JB East only, proposed additional clearing in isolation

As discussed in Section 2, GHG emissions for each year of the mining operations were estimated for 'baseline' and 'progressive clearing' cases. GHG emissions for each operational scenario assessed are defined as the difference between the two cases (i.e., loss of carbon equates to total $CO_2$ emissions released to atmosphere as a result of anthropogenic land clearing).

## 3.2 Model configuration

The FullCAM model incorporates access to a spatial and temporal database of vegetation native to Australia. These include plant growth profiles, debris breakdown percentages, sensitivity to temperature and weather, biomass, initial profiles, biomass, productivity etc. In addition to these, the database also includes information on soil and climate.

FullCAM can be used to determine estimates of carbon stock change and greenhouse gas emissions due to a number of potential events that can affect the density of vegetation in an area. These include planting, thinning, forest fire, treatment, chopper roller, and termite change. These events can be periodically or intermittently scheduled for a time period.

Parameters used in estimating the amount of carbon stored by vegetation and then released due to land clearing are summarised in Table 3-1. Data on climate, vegetation, and soil parameters were downloaded from the FullCAM database. Default values were used, consistent with the recommendations in the FullCAM manual (DISER, 2020). Monthly climate and weather profiles were based on monthly average values from 1970 to 2018, included in the FullCAM database.

FullCAM was configured to simulate carbon pools from 1 January 2023 until 31 December 2060. The period initialises using a full year without clearing for all operational scenarios (2023) and extends the simulation period to end of 2060, 15 years after the final proposed clearing event in 2046. This was done in order to simulate ongoing effects of debris breakdown and soil decomposition. Results are presented from 2024 to 2060.

FullCAM does not have the capability to simulate the impact of future climate and weather for projecting emissions over the estimated life of mine.  Notwithstanding, FullCAM is the model used for developing Australia's emissions projections, currently provided out to 2030 (DCCEEW, 2022).

**Table 3-1 Input data used in FullCAM configuration**

| Parameter | | Units | Scenario 1 | Scenario 2 | Scenario 3 |
|---|---|---|---|---|---|
| Cleared areas | | | Existing only | Existing + Proposed | Proposed only |
| Period of operations | | year | 2024 - 2045 | 2024 - 2046 | 2025 - 2046 |
| Location | | latitude<br>longitude | -23.3642°<br>120.1492° | | |
| | | Region | East Pilbara, WA | | |
| Simulation Period | | Start | 1 Jan 2023 | | |
| | | End | 31 Dec 2060 | | |
| Vegetation type [2] | | - | *Acacia Forest and Woodlands* | | |
| Maximum aboveground biomass [2] | | tonnes of dry matter (tdm)/ha | 6.6981 | | |
| Clay content in soil [2] | | % | 11.8707 | | |
| Clearing rate | | - | Table 3-3 | | |
| Spatial data averaged over | | ha | 1,674 | 3,558 | 1,884 |
| Climate (site) Monthly profile basis | rainfall [3] | - | average (1970 – 2018) | | |
| | open-pan evaporation [3] | | | | |
| | temperature [3] | | | | |
| | forest productivity [3] | | | | |

**Notes**:
1. Simulation based on area to be cleared (Table 3-3), rather than total area within Project footprint.
2. Sourced from FullCAM database.

### 3.2.1 Location

The FullCAM database includes spatial information for numerous bio-geographic factors that affects the calculation of the amount of carbon sequestered at a site, including vegetation characteristics, rainfall, temperature, soil type and evaporation rates.

The FullCAM model was configured for the Jimblebar mine site, approximately located in the centre of the Jimblebar development envelope. Two alternative sites were also modelled, as shown in Figure 3-1. Aside from the locations, all settings and parameters are assumed consistent.

The FullCAM database shows a slight difference in the maximum aboveground biomass and clay content in soil for the different locations. These differences are summarised in Table 3-2, which also shows the statistics for the mass of carbon calculated onsite, aboveground and belowground components.

Notwithstanding the differences between the nominated sites and the alternative locations, carbon content is shown to be relatively similar. Subsequent analysis of greenhouse gas emissions and carbon content estimates have been based on the location representing the centre of the mine sites.

**Table 3-2 Model parameters and output summary for the locations used in the sensitivity studies**

| Parameter | | Units | Location | Alt 1 | Alt 2 |
|---|---|---|---|---|---|
| Location | | latitude<br>longitude | -23.3642°<br>120.1492° | -23.3762°<br>120.0670° | -23.3807°<br>120.2434° |
| Maximum aboveground biomass | | tdm/ha | 6.6981 | 6.38908 | 5.05102 |
| Clay content in soil | | % | 11.8707 | 14.5959 | 12.142 |
| C mass onsite | Max | tonnes Carbon tC/ha | 18.6 | 17.9 | 17.0 |
| | Average | | 17.7 | 16.9 | 15.3 |
| | 2060 | | 17.2 | 16.4 | 14.5 |
| C mass aboveground | Max | tC/ha | 6.1 | 5.9 | 5.3 |
| | Average | | 5.4 | 5.2 | 4.3 |
| | 2060 | | 5.2 | 4.9 | 4.0 |
| C mass belowground | Max | tC/ha | 12.5 | 12.1 | 11.7 |
| | Average | | 12.3 | 11.7 | 11.0 |
| | 2060 | | 12.0 | 11.4 | 10.5 |

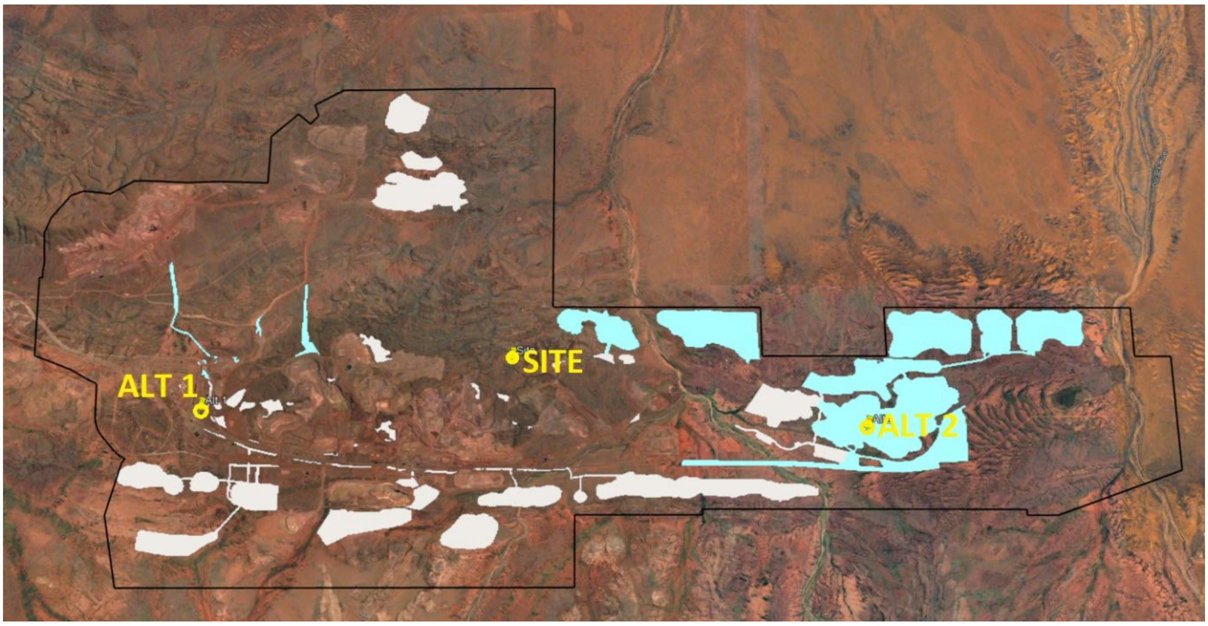


**Figure 3-1 Location of points used in sensitivity study**

### 3.2.2 Vegetation type

The FullCAM database identifies *Acacia Forest and Woodland* as the dominant vegetation types for the Jimblebar mine sites. Growth and other properties required by the FullCAM model were downloaded from the database, which include:

- growth profiles
- plant parts – stems, branches, bark, leaves, roots (coarse and fine)
  - carbon percentages
  - turnover
  - standing dead properties
  - atmospheric percentage of breakdown
  - debris composition
- stem density
- soil properties
- initial conditions.

### 3.2.3 Clearing events

The indicative clearing schedule provided by BHP is detailed in Table 3-3 and shown in Figure 3-2. FullCAM was configured to assign clearing to occur on the first day of each year (1 January). Carbon sink and greenhouse estimates are simulated on a yearly basis and presented as a value at the end of each year (31 December). Rate of clearing used for each scenario is presented in Table 3-3.

While the FullCAM model allows for recovery of the different plant components, the clearing events were configured to assume 100% loss, as detailed in Table 3-4. Biomass-based age adjustment was enabled during the thinning events.

**Table 3-3 Progressive forest clearing rates (ha)**

| Year | Existing | Proposed | Scenario 1 (Existing) | Scenario 2 (Existing + Proposed) | Scenario 3 (Proposed) |
|---|---|---|---|---|---|
| 2024 | 35.5 | 0.0 | 35.5 | 35.5 | 0.0 |
| 2025 | 133 | 4.7 | 133.0 | 137.7 | 4.7 |
| 2026 | 97.5 | 199.8 | 97.5 | 297.3 | 199.8 |
| 2027 | 55.4 | 204.6 | 55.4 | 260.0 | 204.6 |
| 2028 | 34.5 | 221.6 | 34.5 | 256.1 | 221.6 |
| 2029 | 137.3 | 117.6 | 137.3 | 254.9 | 117.6 |
| 2030 | 194.9 | 206.4 | 194.9 | 401.3 | 206.4 |
| 2031 | 91.1 | 99 | 91.1 | 190.1 | 99.0 |
| 2032 | 38.1 | 0.0 | 38.1 | 38.1 | 0.0 |
| 2033 | 115.4 | 30 | 115.4 | 145.4 | 30.0 |
| 2034 | 184.8 | 0.0 | 184.8 | 184.8 | 0.0 |
| 2035 | 111.5 | 147.6 | 111.5 | 259.1 | 147.6 |
| 2036 | 34.5 | 36.7 | 34.5 | 71.2 | 36.7 |
| 2037 | 3.6 | 56.4 | 3.6 | 60.0 | 56.4 |
| 2038 | 22.3 | 21.7 | 22.3 | 44.0 | 21.7 |
| 2039 | 150.9 | 0.0 | 150.9 | 150.9 | 0.0 |
| 2040 | 63.1 | 16.9 | 63.1 | 80.0 | 16.9 |
| 2041 | 39.9 | 0.0 | 39.9 | 39.9 | 0.0 |
| 2042 | 27.3 | 0.0 | 27.3 | 27.3 | 0.0 |
| 2043 | 40.4 | 0.0 | 40.4 | 40.4 | 0.0 |
| 2044 | 0.0 | 245.2 | 0.0 | 245.2 | 245.2 |
| 2045 | 63.2 | 110.6 | 63.2 | 173.8 | 110.6 |
| 2046 | 0.0 | 165.2 | 0.0 | 165.2 | 165.2 |
| 2047 – 2060 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **Total** | **1674.2** | **1884.0** | **1674.2** | **3558.2** | **1884.0** |

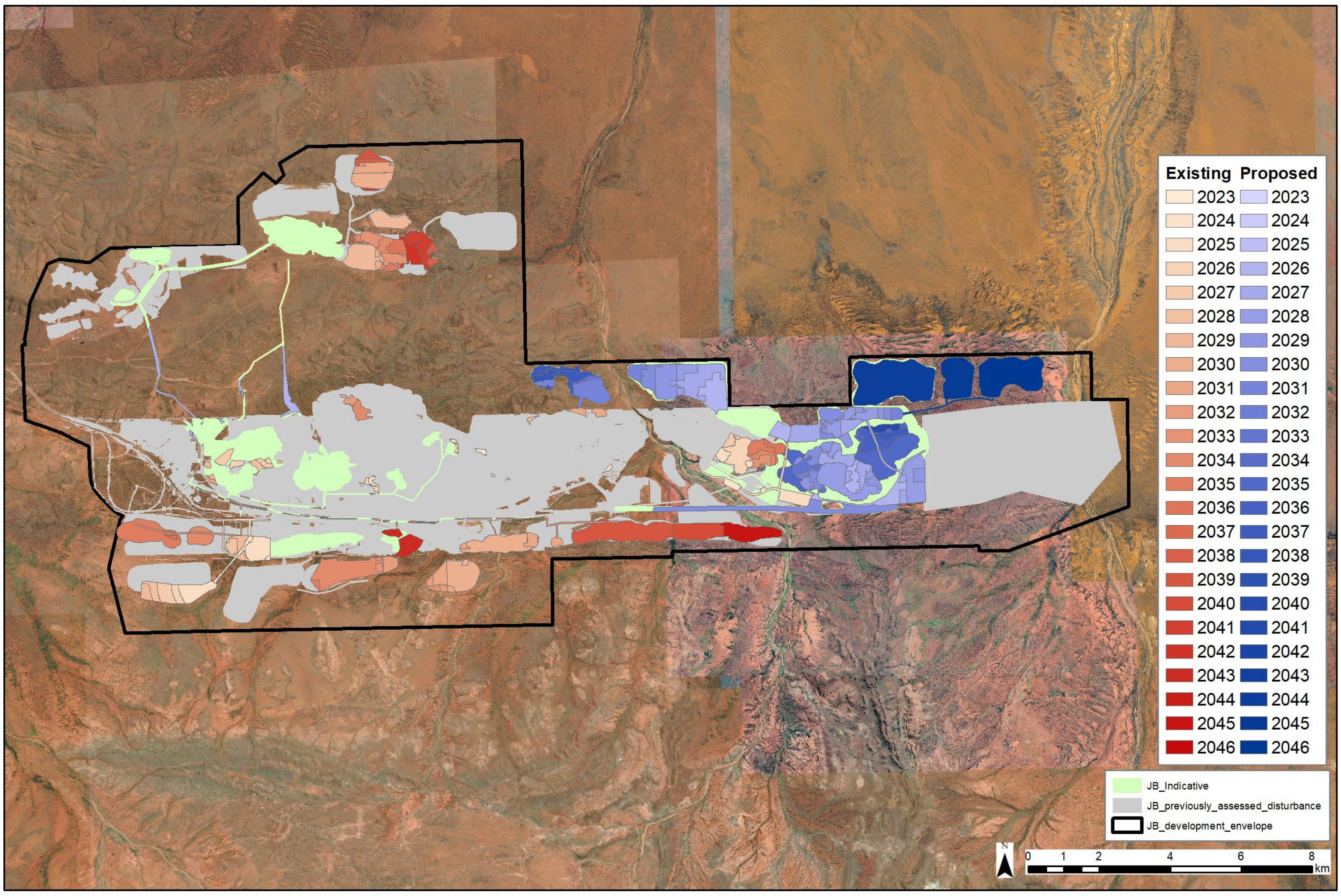


**Figure 3-2 Location of clearing areas for existing and proposed operations**

**Table 3-4 Destination percentages of thinning components**

| Parameter | Rate of conversion (%) | To |
|---|---|---|
| Stems | 100% | deadwood |
| Branches | 100% | deadwood |
| Bark | 100% | deadwood |
| Coarse roots | 100% | coarse dead roots |
| Fine roots | 100% | fine dead roots |

### 3.2.4 Initial soil carbon

Preliminary simulation of the modelled location indicated the default initial soil carbon levels were at a much higher level than the balance of plant growth, decay, turnover and decomposition would support, exaggerating soil carbon loss over the simulated period. This is a known limitation of the FullCAM model's soil carbon calibration for more remote areas where limited data is available (*Pers. comm*. T Liersch, Senior Analyst Land Sector Carbon Modelling, DISER. 25 March 2021).

Upon advice of the Department of Climate Change, Energy, the Environment and Water (DCCEEW) (formerly Department of Industry, Science, Energy and Resources (DISER)), the initial soil conditions were modified, specifically for the humidified organic matter (HUM) and resistant plant matter (RPM) components. An extended 200-year simulation was used for the model to reach 'steady state' soil carbon levels, that were in turn used as the initial soil conditions for the simulated period.

The default and revised initial soil carbon levels are presented in Table 3-5.

**Table 3-5 Default and revised initial carbon content in soil**

| Scenario | RPM (tC/ha) | HUM (tC/ha) |
|---|---|---|
| Default (all scenarios) | 3.17118 | 16.0502 |
| Revised (all scenarios) | 1.8784 | 3.0572 |

## 3.3 Model output

### 3.3.1 Carbon pools

Carbon mass of the above ground and below ground plant components, debris, and forest soil for the 'baseline' cases are detailed in Table 3-6, Table 3-7 and Table 3-8 for Scenario 1, Scenario 2, and Scenario 3, respectively. Carbon mass pools for the 'progressive clearing' cases are detailed in Table 3-9, Table 3-10 and Table 3-11 for Scenario 1, Scenario 2, and Scenario 3, respectively.

**Table 3-6 Carbon pools (tC) for Scenario 1 – baseline case**

| Year | Above ground | | | | | Below ground | | | | Total carbon sink | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | plant components | | | | debris | plant components | | debris | forest soil | tC | t $CO_2$ -e |
| | stems | branches | bark | leaves | | coarse roots | fine roots | | | | |
| 2024 | 2,409 | 1,779 | 675 | 626 | 4,466 | 2,323 | 661 | 1,734 | 16,261 | 30,934 | 113,346 |
| 2025 | 2,409 | 1,779 | 675 | 626 | 4,355 | 2,323 | 661 | 1,713 | 16,270 | 30,812 | 112,900 |
| 2026 | 2,409 | 1,779 | 675 | 626 | 4,255 | 2,323 | 661 | 1,696 | 16,272 | 30,697 | 112,478 |
| 2027 | 2,409 | 1,779 | 675 | 626 | 4,163 | 2,323 | 661 | 1,682 | 16,269 | 30,588 | 112,078 |
| 2028 | 2,409 | 1,779 | 675 | 626 | 4,079 | 2,323 | 661 | 1,665 | 16,262 | 30,480 | 111,683 |
| 2029 | 2,409 | 1,779 | 675 | 626 | 4,002 | 2,323 | 661 | 1,655 | 16,251 | 30,382 | 111,325 |
| 2030 | 2,409 | 1,779 | 675 | 626 | 3,933 | 2,323 | 661 | 1,646 | 16,237 | 30,290 | 110,986 |
| 2031 | 2,409 | 1,779 | 675 | 626 | 3,869 | 2,323 | 661 | 1,639 | 16,220 | 30,202 | 110,664 |
| 2032 | 2,409 | 1,779 | 675 | 626 | 3,810 | 2,323 | 661 | 1,629 | 16,202 | 30,115 | 110,344 |
| 2033 | 2,409 | 1,779 | 675 | 626 | 3,757 | 2,323 | 661 | 1,624 | 16,181 | 30,036 | 110,055 |
| 2034 | 2,409 | 1,779 | 675 | 626 | 3,708 | 2,323 | 661 | 1,619 | 16,160 | 29,961 | 109,781 |
| 2035 | 2,409 | 1,779 | 675 | 626 | 3,663 | 2,323 | 661 | 1,616 | 16,137 | 29,890 | 109,520 |
| 2036 | 2,409 | 1,779 | 675 | 626 | 3,621 | 2,323 | 661 | 1,609 | 16,115 | 29,818 | 109,258 |
| 2037 | 2,409 | 1,779 | 675 | 626 | 3,583 | 2,323 | 661 | 1,606 | 16,091 | 29,754 | 109,022 |
| 2038 | 2,409 | 1,779 | 675 | 626 | 3,548 | 2,323 | 661 | 1,604 | 16,066 | 29,692 | 108,797 |
| 2039 | 2,409 | 1,779 | 675 | 626 | 3,516 | 2,323 | 661 | 1,602 | 16,042 | 29,634 | 108,582 |
| 2040 | 2,409 | 1,779 | 675 | 626 | 3,485 | 2,323 | 661 | 1,597 | 16,018 | 29,574 | 108,363 |
| 2041 | 2,409 | 1,779 | 675 | 626 | 3,458 | 2,323 | 661 | 1,596 | 15,993 | 29,520 | 108,166 |
| 2042 | 2,409 | 1,779 | 675 | 626 | 3,433 | 2,323 | 661 | 1,595 | 15,968 | 29,469 | 107,979 |
| 2043 | 2,409 | 1,779 | 675 | 626 | 3,409 | 2,323 | 661 | 1,594 | 15,943 | 29,420 | 107,799 |
| 2044 | 2,409 | 1,779 | 675 | 626 | 3,387 | 2,323 | 661 | 1,590 | 15,919 | 29,369 | 107,613 |
| 2045 | 2,409 | 1,779 | 675 | 626 | 3,367 | 2,323 | 661 | 1,589 | 15,894 | 29,324 | 107,448 |
| 2046 | 2,409 | 1,779 | 675 | 626 | 3,349 | 2,323 | 661 | 1,589 | 15,870 | 29,281 | 107,289 |
| 2047 | 2,409 | 1,779 | 675 | 626 | 3,332 | 2,323 | 661 | 1,588 | 15,845 | 29,239 | 107,136 |
| 2048 | 2,409 | 1,779 | 675 | 626 | 3,315 | 2,323 | 661 | 1,585 | 15,822 | 29,195 | 106,976 |
| 2049 | 2,409 | 1,779 | 675 | 626 | 3,301 | 2,323 | 661 | 1,584 | 15,798 | 29,157 | 106,834 |
| 2050 | 2,409 | 1,779 | 675 | 626 | 3,287 | 2,323 | 661 | 1,584 | 15,774 | 29,119 | 106,698 |
| 2051 | 2,409 | 1,779 | 675 | 626 | 3,275 | 2,323 | 661 | 1,584 | 15,751 | 29,083 | 106,566 |
| 2052 | 2,409 | 1,779 | 675 | 626 | 3,263 | 2,323 | 661 | 1,581 | 15,728 | 29,045 | 106,426 |
| 2053 | 2,409 | 1,779 | 675 | 626 | 3,252 | 2,323 | 661 | 1,580 | 15,706 | 29,012 | 106,303 |
| 2054 | 2,409 | 1,779 | 675 | 626 | 3,242 | 2,323 | 661 | 1,580 | 15,683 | 28,979 | 106,184 |
| 2055 | 2,409 | 1,779 | 675 | 626 | 3,233 | 2,323 | 661 | 1,580 | 15,661 | 28,948 | 106,069 |
| 2056 | 2,409 | 1,779 | 675 | 626 | 3,223 | 2,323 | 661 | 1,577 | 15,640 | 28,914 | 105,946 |
| 2057 | 2,409 | 1,779 | 675 | 626 | 3,216 | 2,323 | 661 | 1,577 | 15,618 | 28,885 | 105,838 |
| 2058 | 2,409 | 1,779 | 675 | 626 | 3,208 | 2,323 | 661 | 1,577 | 15,597 | 28,856 | 105,733 |
| 2059 | 2,409 | 1,779 | 675 | 626 | 3,201 | 2,323 | 661 | 1,577 | 15,576 | 28,828 | 105,631 |
| 2060 | 2,409 | 1,779 | 675 | 626 | 3,194 | 2,323 | 661 | 1,574 | 15,556 | 28,798 | 105,521 |

**Table 3-7 Carbon pools (tC) for Scenario 2 – baseline case**

| Year | Above ground | | | | | Below ground | | | | Total carbon sink | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | plant components | | | | debris | plant components | | debris | forest soil | tC | t $CO_2$ -e |
| | stems | branches | bark | leaves | | coarse roots | fine roots | | | | |
| 2024 | 5,121 | 3,782 | 1,434 | 1,331 | 9,492 | 4,938 | 1,405 | 3,685 | 34,561 | 65,748 | 240,911 |
| 2025 | 5,121 | 3,782 | 1,434 | 1,331 | 9,257 | 4,938 | 1,405 | 3,642 | 34,581 | 65,490 | 239,964 |
| 2026 | 5,121 | 3,782 | 1,434 | 1,331 | 9,043 | 4,938 | 1,405 | 3,605 | 34,586 | 65,245 | 239,066 |
| 2027 | 5,121 | 3,782 | 1,434 | 1,331 | 8,849 | 4,938 | 1,405 | 3,574 | 34,580 | 65,013 | 238,216 |
| 2028 | 5,121 | 3,782 | 1,434 | 1,331 | 8,669 | 4,938 | 1,405 | 3,540 | 34,564 | 64,784 | 237,377 |
| 2029 | 5,121 | 3,782 | 1,434 | 1,331 | 8,507 | 4,938 | 1,405 | 3,518 | 34,540 | 64,576 | 236,615 |
| 2030 | 5,121 | 3,782 | 1,434 | 1,331 | 8,359 | 4,938 | 1,405 | 3,499 | 34,510 | 64,379 | 235,894 |
| 2031 | 5,121 | 3,782 | 1,434 | 1,331 | 8,224 | 4,938 | 1,405 | 3,484 | 34,475 | 64,193 | 235,211 |
| 2032 | 5,121 | 3,782 | 1,434 | 1,331 | 8,098 | 4,938 | 1,405 | 3,463 | 34,436 | 64,007 | 234,531 |
| 2033 | 5,121 | 3,782 | 1,434 | 1,331 | 7,985 | 4,938 | 1,405 | 3,451 | 34,393 | 63,839 | 233,917 |
| 2034 | 5,121 | 3,782 | 1,434 | 1,331 | 7,881 | 4,938 | 1,405 | 3,442 | 34,347 | 63,680 | 233,334 |
| 2035 | 5,121 | 3,782 | 1,434 | 1,331 | 7,785 | 4,938 | 1,405 | 3,434 | 34,299 | 63,529 | 232,780 |
| 2036 | 5,121 | 3,782 | 1,434 | 1,331 | 7,696 | 4,938 | 1,405 | 3,420 | 34,251 | 63,377 | 232,221 |
| 2037 | 5,121 | 3,782 | 1,434 | 1,331 | 7,615 | 4,938 | 1,405 | 3,414 | 34,200 | 63,240 | 231,720 |
| 2038 | 5,121 | 3,782 | 1,434 | 1,331 | 7,541 | 4,938 | 1,405 | 3,410 | 34,148 | 63,109 | 231,241 |
| 2039 | 5,121 | 3,782 | 1,434 | 1,331 | 7,472 | 4,938 | 1,405 | 3,406 | 34,096 | 62,985 | 230,785 |
| 2040 | 5,121 | 3,782 | 1,434 | 1,331 | 7,407 | 4,938 | 1,405 | 3,395 | 34,044 | 62,858 | 230,319 |
| 2041 | 5,121 | 3,782 | 1,434 | 1,331 | 7,349 | 4,938 | 1,405 | 3,392 | 33,992 | 62,744 | 229,902 |
| 2042 | 5,121 | 3,782 | 1,434 | 1,331 | 7,296 | 4,938 | 1,405 | 3,390 | 33,939 | 62,635 | 229,503 |
| 2043 | 5,121 | 3,782 | 1,434 | 1,331 | 7,246 | 4,938 | 1,405 | 3,388 | 33,886 | 62,531 | 229,121 |
| 2044 | 5,121 | 3,782 | 1,434 | 1,331 | 7,199 | 4,938 | 1,405 | 3,379 | 33,834 | 62,423 | 228,726 |
| 2045 | 5,121 | 3,782 | 1,434 | 1,331 | 7,157 | 4,938 | 1,405 | 3,378 | 33,782 | 62,327 | 228,374 |
| 2046 | 5,121 | 3,782 | 1,434 | 1,331 | 7,118 | 4,938 | 1,405 | 3,376 | 33,730 | 62,235 | 228,037 |
| 2047 | 5,121 | 3,782 | 1,434 | 1,331 | 7,081 | 4,938 | 1,405 | 3,375 | 33,678 | 62,146 | 227,712 |
| 2048 | 5,121 | 3,782 | 1,434 | 1,331 | 7,046 | 4,938 | 1,405 | 3,368 | 33,628 | 62,053 | 227,371 |
| 2049 | 5,121 | 3,782 | 1,434 | 1,331 | 7,016 | 4,938 | 1,405 | 3,367 | 33,577 | 61,971 | 227,070 |
| 2050 | 5,121 | 3,782 | 1,434 | 1,331 | 6,987 | 4,938 | 1,405 | 3,367 | 33,527 | 61,892 | 226,780 |
| 2051 | 5,121 | 3,782 | 1,434 | 1,331 | 6,960 | 4,938 | 1,405 | 3,366 | 33,478 | 61,815 | 226,500 |
| 2052 | 5,121 | 3,782 | 1,434 | 1,331 | 6,934 | 4,938 | 1,405 | 3,359 | 33,430 | 61,734 | 226,203 |
| 2053 | 5,121 | 3,782 | 1,434 | 1,331 | 6,912 | 4,938 | 1,405 | 3,359 | 33,382 | 61,663 | 225,942 |
| 2054 | 5,121 | 3,782 | 1,434 | 1,331 | 6,890 | 4,938 | 1,405 | 3,359 | 33,334 | 61,594 | 225,689 |
| 2055 | 5,121 | 3,782 | 1,434 | 1,331 | 6,871 | 4,938 | 1,405 | 3,358 | 33,287 | 61,527 | 225,445 |
| 2056 | 5,121 | 3,782 | 1,434 | 1,331 | 6,851 | 4,938 | 1,405 | 3,352 | 33,241 | 61,456 | 225,182 |
| 2057 | 5,121 | 3,782 | 1,434 | 1,331 | 6,835 | 4,938 | 1,405 | 3,352 | 33,196 | 61,393 | 224,952 |
| 2058 | 5,121 | 3,782 | 1,434 | 1,331 | 6,819 | 4,938 | 1,405 | 3,352 | 33,151 | 61,332 | 224,730 |
| 2059 | 5,121 | 3,782 | 1,434 | 1,331 | 6,804 | 4,938 | 1,405 | 3,352 | 33,106 | 61,273 | 224,514 |
| 2060 | 5,121 | 3,782 | 1,434 | 1,331 | 6,790 | 4,938 | 1,405 | 3,346 | 33,063 | 61,209 | 224,279 |

**Table 3-8 Carbon pools (tC) for Scenario 3 – baseline case**

| Year | Above ground | | | | | Below ground | | | | Total carbon sink | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | plant components | | | | debris | plant components | | debris | forest soil | tC | t $CO_2$ -e |
| | stems | branches | bark | leaves | | coarse roots | fine roots | | | | |
| 2024 | 2,712 | 2,003 | 759 | 705 | 5,026 | 2,615 | 744 | 1,951 | 18,300 | 34,814 | 127,565 |
| 2025 | 2,712 | 2,003 | 759 | 705 | 4,902 | 2,615 | 744 | 1,928 | 18,311 | 34,678 | 127,064 |
| 2026 | 2,712 | 2,003 | 759 | 705 | 4,788 | 2,615 | 744 | 1,909 | 18,314 | 34,548 | 126,588 |
| 2027 | 2,712 | 2,003 | 759 | 705 | 4,685 | 2,615 | 744 | 1,892 | 18,310 | 34,425 | 126,138 |
| 2028 | 2,712 | 2,003 | 759 | 705 | 4,590 | 2,615 | 744 | 1,874 | 18,302 | 34,304 | 125,694 |
| 2029 | 2,712 | 2,003 | 759 | 705 | 4,505 | 2,615 | 744 | 1,863 | 18,290 | 34,194 | 125,290 |
| 2030 | 2,712 | 2,003 | 759 | 705 | 4,426 | 2,615 | 744 | 1,853 | 18,273 | 34,089 | 124,909 |
| 2031 | 2,712 | 2,003 | 759 | 705 | 4,355 | 2,615 | 744 | 1,845 | 18,255 | 33,991 | 124,547 |
| 2032 | 2,712 | 2,003 | 759 | 705 | 4,288 | 2,615 | 744 | 1,834 | 18,234 | 33,892 | 124,187 |
| 2033 | 2,712 | 2,003 | 759 | 705 | 4,228 | 2,615 | 744 | 1,828 | 18,211 | 33,804 | 123,862 |
| 2034 | 2,712 | 2,003 | 759 | 705 | 4,173 | 2,615 | 744 | 1,823 | 18,187 | 33,719 | 123,553 |
| 2035 | 2,712 | 2,003 | 759 | 705 | 4,122 | 2,615 | 744 | 1,818 | 18,162 | 33,639 | 123,259 |
| 2036 | 2,712 | 2,003 | 759 | 705 | 4,075 | 2,615 | 744 | 1,811 | 18,136 | 33,559 | 122,964 |
| 2037 | 2,712 | 2,003 | 759 | 705 | 4,032 | 2,615 | 744 | 1,808 | 18,109 | 33,486 | 122,698 |
| 2038 | 2,712 | 2,003 | 759 | 705 | 3,993 | 2,615 | 744 | 1,805 | 18,082 | 33,417 | 122,445 |
| 2039 | 2,712 | 2,003 | 759 | 705 | 3,957 | 2,615 | 744 | 1,803 | 18,054 | 33,351 | 122,203 |
| 2040 | 2,712 | 2,003 | 759 | 705 | 3,922 | 2,615 | 744 | 1,798 | 18,027 | 33,284 | 121,956 |
| 2041 | 2,712 | 2,003 | 759 | 705 | 3,892 | 2,615 | 744 | 1,796 | 17,999 | 33,224 | 121,736 |
| 2042 | 2,712 | 2,003 | 759 | 705 | 3,863 | 2,615 | 744 | 1,795 | 17,971 | 33,166 | 121,525 |
| 2043 | 2,712 | 2,003 | 759 | 705 | 3,837 | 2,615 | 744 | 1,794 | 17,943 | 33,111 | 121,322 |
| 2044 | 2,712 | 2,003 | 759 | 705 | 3,812 | 2,615 | 744 | 1,789 | 17,916 | 33,054 | 121,113 |
| 2045 | 2,712 | 2,003 | 759 | 705 | 3,789 | 2,615 | 744 | 1,789 | 17,888 | 33,003 | 120,927 |
| 2046 | 2,712 | 2,003 | 759 | 705 | 3,769 | 2,615 | 744 | 1,788 | 17,860 | 32,954 | 120,748 |
| 2047 | 2,712 | 2,003 | 759 | 705 | 3,750 | 2,615 | 744 | 1,787 | 17,833 | 32,907 | 120,576 |
| 2048 | 2,712 | 2,003 | 759 | 705 | 3,731 | 2,615 | 744 | 1,783 | 17,806 | 32,858 | 120,396 |
| 2049 | 2,712 | 2,003 | 759 | 705 | 3,715 | 2,615 | 744 | 1,783 | 17,780 | 32,814 | 120,236 |
| 2050 | 2,712 | 2,003 | 759 | 705 | 3,700 | 2,615 | 744 | 1,783 | 17,753 | 32,772 | 120,083 |
| 2051 | 2,712 | 2,003 | 759 | 705 | 3,686 | 2,615 | 744 | 1,782 | 17,727 | 32,732 | 119,934 |
| 2052 | 2,712 | 2,003 | 759 | 705 | 3,672 | 2,615 | 744 | 1,779 | 17,701 | 32,689 | 119,777 |
| 2053 | 2,712 | 2,003 | 759 | 705 | 3,660 | 2,615 | 744 | 1,779 | 17,676 | 32,651 | 119,639 |
| 2054 | 2,712 | 2,003 | 759 | 705 | 3,649 | 2,615 | 744 | 1,778 | 17,651 | 32,615 | 119,505 |
| 2055 | 2,712 | 2,003 | 759 | 705 | 3,638 | 2,615 | 744 | 1,778 | 17,626 | 32,579 | 119,375 |
| 2056 | 2,712 | 2,003 | 759 | 705 | 3,628 | 2,615 | 744 | 1,775 | 17,602 | 32,541 | 119,236 |
| 2057 | 2,712 | 2,003 | 759 | 705 | 3,619 | 2,615 | 744 | 1,775 | 17,577 | 32,508 | 119,115 |
| 2058 | 2,712 | 2,003 | 759 | 705 | 3,611 | 2,615 | 744 | 1,775 | 17,554 | 32,476 | 118,997 |
| 2059 | 2,712 | 2,003 | 759 | 705 | 3,603 | 2,615 | 744 | 1,775 | 17,530 | 32,445 | 118,883 |
| 2060 | 2,712 | 2,003 | 759 | 705 | 3,595 | 2,615 | 744 | 1,772 | 17,507 | 32,411 | 118,758 |

**Table 3-9 Carbon pools (tC) for Scenario 1 – progressive forest clearing case**

| Year | Above ground | | | | | Below ground | | | | Total carbon sink | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | plant components | | | | debris | plant components | | debris | forest soil | tC | t $CO_2$ -e |
| | stems | branches | bark | leaves | | coarse roots | fine roots | | | | |
| 2024 | 2,408 | 1,779 | 674 | 626 | 4,468 | 2,322 | 661 | 1,734 | 16,261 | 30,933 | 113,343 |
| 2025 | 2,393 | 1,767 | 670 | 622 | 4,387 | 2,308 | 656 | 1,724 | 16,271 | 30,798 | 112,847 |
| 2026 | 2,385 | 1,761 | 668 | 620 | 4,298 | 2,300 | 654 | 1,709 | 16,273 | 30,668 | 112,371 |
| 2027 | 2,382 | 1,759 | 667 | 619 | 4,205 | 2,297 | 653 | 1,691 | 16,270 | 30,545 | 111,923 |
| 2028 | 2,381 | 1,759 | 667 | 619 | 4,117 | 2,296 | 653 | 1,672 | 16,262 | 30,426 | 111,485 |
| 2029 | 2,365 | 1,747 | 662 | 615 | 4,066 | 2,281 | 649 | 1,668 | 16,251 | 30,304 | 111,037 |
| 2030 | 2,333 | 1,723 | 653 | 607 | 4,049 | 2,250 | 640 | 1,674 | 16,236 | 30,166 | 110,533 |
| 2031 | 2,326 | 1,718 | 651 | 605 | 3,982 | 2,243 | 638 | 1,659 | 16,218 | 30,042 | 110,078 |
| 2032 | 2,325 | 1,717 | 651 | 605 | 3,908 | 2,242 | 638 | 1,639 | 16,197 | 29,922 | 109,639 |
| 2033 | 2,314 | 1,709 | 648 | 602 | 3,861 | 2,231 | 635 | 1,631 | 16,175 | 29,805 | 109,209 |
| 2034 | 2,286 | 1,688 | 640 | 594 | 3,849 | 2,204 | 627 | 1,634 | 16,151 | 29,674 | 108,730 |
| 2035 | 2,276 | 1,681 | 637 | 592 | 3,801 | 2,194 | 624 | 1,622 | 16,125 | 29,552 | 108,282 |
| 2036 | 2,275 | 1,680 | 637 | 591 | 3,737 | 2,194 | 624 | 1,602 | 16,097 | 29,436 | 107,857 |
| 2037 | 2,275 | 1,680 | 637 | 591 | 3,677 | 2,194 | 624 | 1,586 | 16,068 | 29,331 | 107,474 |
| 2038 | 2,274 | 1,680 | 637 | 591 | 3,622 | 2,193 | 624 | 1,574 | 16,038 | 29,233 | 107,113 |
| 2039 | 2,256 | 1,666 | 632 | 587 | 3,607 | 2,175 | 619 | 1,575 | 16,008 | 29,124 | 106,716 |
| 2040 | 2,253 | 1,664 | 631 | 586 | 3,561 | 2,172 | 618 | 1,561 | 15,977 | 29,022 | 106,340 |
| 2041 | 2,251 | 1,663 | 630 | 585 | 3,515 | 2,171 | 618 | 1,550 | 15,946 | 28,929 | 106,000 |
| 2042 | 2,251 | 1,662 | 630 | 585 | 3,471 | 2,170 | 617 | 1,540 | 15,914 | 28,842 | 105,680 |
| 2043 | 2,250 | 1,661 | 630 | 585 | 3,432 | 2,169 | 617 | 1,532 | 15,882 | 28,758 | 105,374 |
| 2044 | 2,250 | 1,661 | 630 | 585 | 3,393 | 2,169 | 617 | 1,522 | 15,850 | 28,676 | 105,074 |
| 2045 | 2,246 | 1,659 | 629 | 584 | 3,364 | 2,166 | 616 | 1,517 | 15,818 | 28,599 | 104,792 |
| 2046 | 2,246 | 1,659 | 629 | 584 | 3,330 | 2,166 | 616 | 1,511 | 15,786 | 28,528 | 104,530 |
| 2047 | 2,246 | 1,659 | 629 | 584 | 3,299 | 2,166 | 616 | 1,506 | 15,754 | 28,460 | 104,281 |
| 2048 | 2,246 | 1,659 | 629 | 584 | 3,269 | 2,166 | 616 | 1,499 | 15,723 | 28,392 | 104,032 |
| 2049 | 2,246 | 1,659 | 629 | 584 | 3,243 | 2,166 | 616 | 1,495 | 15,692 | 28,331 | 103,808 |
| 2050 | 2,246 | 1,659 | 629 | 584 | 3,218 | 2,166 | 616 | 1,492 | 15,662 | 28,272 | 103,594 |
| 2051 | 2,246 | 1,659 | 629 | 584 | 3,195 | 2,166 | 616 | 1,490 | 15,631 | 28,217 | 103,390 |
| 2052 | 2,246 | 1,659 | 629 | 584 | 3,173 | 2,166 | 616 | 1,485 | 15,602 | 28,160 | 103,184 |
| 2053 | 2,246 | 1,659 | 629 | 584 | 3,154 | 2,166 | 616 | 1,483 | 15,572 | 28,110 | 102,998 |
| 2054 | 2,246 | 1,659 | 629 | 584 | 3,136 | 2,166 | 616 | 1,481 | 15,544 | 28,061 | 102,821 |
| 2055 | 2,246 | 1,659 | 629 | 584 | 3,119 | 2,166 | 616 | 1,480 | 15,515 | 28,015 | 102,650 |
| 2056 | 2,246 | 1,659 | 629 | 584 | 3,103 | 2,166 | 616 | 1,476 | 15,488 | 27,967 | 102,476 |
| 2057 | 2,246 | 1,659 | 629 | 584 | 3,089 | 2,166 | 616 | 1,475 | 15,460 | 27,925 | 102,319 |
| 2058 | 2,246 | 1,659 | 629 | 584 | 3,075 | 2,166 | 616 | 1,474 | 15,433 | 27,884 | 102,169 |
| 2059 | 2,246 | 1,659 | 629 | 584 | 3,063 | 2,166 | 616 | 1,474 | 15,407 | 27,844 | 102,025 |
| 2060 | 2,246 | 1,659 | 629 | 584 | 3,051 | 2,166 | 616 | 1,470 | 15,381 | 27,803 | 101,875 |

**Table 3-10 Carbon pools (tC) for Scenario 2 – progressive forest clearing case**

| Year | Above ground | | | | | Below ground | | | | Total carbon sink | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | plant components | | | | debris | plant components | | debris | forest soil | tC | t $CO_2$ -e |
| | stems | branches | bark | leaves | | coarse roots | fine roots | | | | |
| 2024 | 5,119 | 3,781 | 1,433 | 1,331 | 9,495 | 4,937 | 1,404 | 3,686 | 34,561 | 65,747 | 240,907 |
| 2025 | 5,100 | 3,767 | 1,428 | 1,326 | 9,296 | 4,918 | 1,399 | 3,655 | 34,582 | 65,471 | 239,896 |
| 2026 | 5,073 | 3,747 | 1,420 | 1,319 | 9,130 | 4,892 | 1,392 | 3,632 | 34,588 | 65,193 | 238,877 |
| 2027 | 5,056 | 3,734 | 1,416 | 1,315 | 8,957 | 4,876 | 1,387 | 3,603 | 34,581 | 64,925 | 237,894 |
| 2028 | 5,041 | 3,723 | 1,412 | 1,311 | 8,791 | 4,861 | 1,383 | 3,568 | 34,565 | 64,655 | 236,906 |
| 2029 | 5,012 | 3,701 | 1,403 | 1,303 | 8,669 | 4,833 | 1,375 | 3,553 | 34,541 | 64,390 | 235,933 |
| 2030 | 4,946 | 3,653 | 1,385 | 1,286 | 8,626 | 4,769 | 1,357 | 3,562 | 34,510 | 64,093 | 234,845 |
| 2031 | 4,932 | 3,642 | 1,381 | 1,282 | 8,480 | 4,755 | 1,353 | 3,528 | 34,471 | 63,824 | 233,859 |
| 2032 | 4,930 | 3,641 | 1,380 | 1,282 | 8,318 | 4,754 | 1,352 | 3,482 | 34,426 | 63,566 | 232,915 |
| 2033 | 4,915 | 3,630 | 1,376 | 1,278 | 8,199 | 4,739 | 1,348 | 3,458 | 34,377 | 63,320 | 232,014 |
| 2034 | 4,880 | 3,604 | 1,366 | 1,269 | 8,127 | 4,705 | 1,338 | 3,450 | 34,325 | 63,064 | 231,074 |
| 2035 | 4,856 | 3,586 | 1,360 | 1,262 | 8,035 | 4,682 | 1,332 | 3,432 | 34,270 | 62,814 | 230,160 |
| 2036 | 4,854 | 3,585 | 1,359 | 1,262 | 7,904 | 4,680 | 1,331 | 3,392 | 34,211 | 62,578 | 229,293 |
| 2037 | 4,853 | 3,584 | 1,359 | 1,262 | 7,782 | 4,680 | 1,331 | 3,364 | 34,149 | 62,364 | 228,510 |
| 2038 | 4,852 | 3,584 | 1,359 | 1,262 | 7,671 | 4,679 | 1,331 | 3,340 | 34,086 | 62,162 | 227,771 |
| 2039 | 4,829 | 3,567 | 1,352 | 1,256 | 7,611 | 4,657 | 1,325 | 3,335 | 34,022 | 61,953 | 227,003 |
| 2040 | 4,824 | 3,563 | 1,351 | 1,254 | 7,516 | 4,652 | 1,323 | 3,309 | 33,958 | 61,751 | 226,264 |
| 2041 | 4,823 | 3,562 | 1,350 | 1,254 | 7,424 | 4,651 | 1,323 | 3,290 | 33,892 | 61,569 | 225,596 |
| 2042 | 4,822 | 3,561 | 1,350 | 1,254 | 7,338 | 4,650 | 1,323 | 3,273 | 33,825 | 61,396 | 224,965 |
| 2043 | 4,820 | 3,560 | 1,350 | 1,253 | 7,260 | 4,648 | 1,322 | 3,260 | 33,759 | 61,232 | 224,364 |
| 2044 | 4,808 | 3,551 | 1,346 | 1,250 | 7,206 | 4,637 | 1,319 | 3,249 | 33,693 | 61,059 | 223,730 |
| 2045 | 4,799 | 3,544 | 1,344 | 1,248 | 7,151 | 4,628 | 1,316 | 3,242 | 33,627 | 60,899 | 223,143 |
| 2046 | 4,794 | 3,540 | 1,342 | 1,246 | 7,093 | 4,622 | 1,315 | 3,233 | 33,561 | 60,746 | 222,581 |
| 2047 | 4,794 | 3,540 | 1,342 | 1,246 | 7,027 | 4,622 | 1,315 | 3,220 | 33,495 | 60,602 | 222,054 |
| 2048 | 4,794 | 3,540 | 1,342 | 1,246 | 6,965 | 4,622 | 1,315 | 3,204 | 33,430 | 60,458 | 221,528 |
| 2049 | 4,794 | 3,540 | 1,342 | 1,246 | 6,909 | 4,622 | 1,315 | 3,195 | 33,366 | 60,329 | 221,054 |
| 2050 | 4,794 | 3,540 | 1,342 | 1,246 | 6,857 | 4,622 | 1,315 | 3,188 | 33,302 | 60,206 | 220,604 |
| 2051 | 4,794 | 3,540 | 1,342 | 1,246 | 6,809 | 4,622 | 1,315 | 3,182 | 33,239 | 60,089 | 220,174 |
| 2052 | 4,794 | 3,540 | 1,342 | 1,246 | 6,763 | 4,622 | 1,315 | 3,171 | 33,177 | 59,970 | 219,738 |
| 2053 | 4,794 | 3,540 | 1,342 | 1,246 | 6,722 | 4,622 | 1,315 | 3,166 | 33,115 | 59,863 | 219,347 |
| 2054 | 4,794 | 3,540 | 1,342 | 1,246 | 6,684 | 4,622 | 1,315 | 3,163 | 33,055 | 59,761 | 218,973 |
| 2055 | 4,794 | 3,540 | 1,342 | 1,246 | 6,649 | 4,622 | 1,315 | 3,159 | 32,996 | 59,663 | 218,615 |
| 2056 | 4,794 | 3,540 | 1,342 | 1,246 | 6,615 | 4,622 | 1,315 | 3,151 | 32,937 | 59,563 | 218,247 |
| 2057 | 4,794 | 3,540 | 1,342 | 1,246 | 6,585 | 4,622 | 1,315 | 3,149 | 32,880 | 59,473 | 217,917 |
| 2058 | 4,794 | 3,540 | 1,342 | 1,246 | 6,557 | 4,622 | 1,315 | 3,147 | 32,824 | 59,387 | 217,601 |
| 2059 | 4,794 | 3,540 | 1,342 | 1,246 | 6,531 | 4,622 | 1,315 | 3,145 | 32,768 | 59,304 | 217,297 |
| 2060 | 4,794 | 3,540 | 1,342 | 1,246 | 6,505 | 4,622 | 1,315 | 3,139 | 32,714 | 59,217 | 216,980 |

**Table 3-11 Carbon pools (tC) for Scenario 3 – progressive forest clearing case**

| Year | Above ground | | | | | Below ground | | | | Total carbon sink | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | plant components | | | | debris | plant components | | debris | forest soil | tC | t $CO_2$ -e |
| | stems | branches | bark | leaves | | coarse roots | fine roots | | | | |
| 2024 | 2,711 | 2,002 | 759 | 705 | 5,027 | 2,614 | 744 | 1,951 | 18,300 | 34,814 | 127,564 |
| 2025 | 2,707 | 1,999 | 758 | 704 | 4,910 | 2,611 | 743 | 1,931 | 18,311 | 34,674 | 127,049 |
| 2026 | 2,688 | 1,985 | 753 | 699 | 4,832 | 2,592 | 737 | 1,923 | 18,315 | 34,525 | 126,506 |
| 2027 | 2,674 | 1,975 | 749 | 695 | 4,751 | 2,578 | 733 | 1,912 | 18,312 | 34,379 | 125,971 |
| 2028 | 2,660 | 1,965 | 745 | 692 | 4,674 | 2,565 | 730 | 1,896 | 18,303 | 34,229 | 125,422 |
| 2029 | 2,646 | 1,955 | 741 | 688 | 4,603 | 2,552 | 726 | 1,885 | 18,290 | 34,086 | 124,896 |
| 2030 | 2,613 | 1,930 | 732 | 679 | 4,576 | 2,519 | 717 | 1,887 | 18,274 | 33,927 | 124,312 |
| 2031 | 2,605 | 1,924 | 729 | 677 | 4,498 | 2,512 | 715 | 1,868 | 18,253 | 33,782 | 123,782 |
| 2032 | 2,605 | 1,924 | 729 | 677 | 4,410 | 2,512 | 715 | 1,843 | 18,229 | 33,644 | 123,276 |
| 2033 | 2,601 | 1,921 | 728 | 676 | 4,338 | 2,508 | 713 | 1,828 | 18,202 | 33,515 | 122,804 |
| 2034 | 2,594 | 1,916 | 726 | 674 | 4,277 | 2,501 | 711 | 1,816 | 18,174 | 33,390 | 122,345 |
| 2035 | 2,580 | 1,905 | 722 | 671 | 4,234 | 2,488 | 708 | 1,810 | 18,145 | 33,262 | 121,878 |
| 2036 | 2,579 | 1,905 | 722 | 671 | 4,167 | 2,487 | 707 | 1,791 | 18,114 | 33,142 | 121,436 |
| 2037 | 2,578 | 1,904 | 722 | 670 | 4,106 | 2,486 | 707 | 1,778 | 18,081 | 33,032 | 121,035 |
| 2038 | 2,578 | 1,904 | 722 | 670 | 4,049 | 2,486 | 707 | 1,766 | 18,048 | 32,929 | 120,658 |
| 2039 | 2,573 | 1,900 | 720 | 669 | 4,004 | 2,481 | 706 | 1,760 | 18,014 | 32,828 | 120,288 |
| 2040 | 2,572 | 1,899 | 720 | 669 | 3,956 | 2,480 | 705 | 1,748 | 17,980 | 32,729 | 119,924 |
| 2041 | 2,571 | 1,899 | 720 | 669 | 3,909 | 2,480 | 705 | 1,740 | 17,946 | 32,639 | 119,596 |
| 2042 | 2,571 | 1,899 | 720 | 669 | 3,867 | 2,479 | 705 | 1,733 | 17,911 | 32,555 | 119,285 |
| 2043 | 2,571 | 1,899 | 720 | 668 | 3,827 | 2,479 | 705 | 1,727 | 17,877 | 32,474 | 118,990 |
| 2044 | 2,559 | 1,890 | 716 | 665 | 3,813 | 2,467 | 702 | 1,727 | 17,843 | 32,383 | 118,657 |
| 2045 | 2,553 | 1,885 | 715 | 664 | 3,788 | 2,462 | 700 | 1,725 | 17,809 | 32,300 | 118,351 |
| 2046 | 2,547 | 1,881 | 713 | 662 | 3,763 | 2,456 | 699 | 1,721 | 17,775 | 32,218 | 118,051 |
| 2047 | 2,547 | 1,881 | 713 | 662 | 3,728 | 2,456 | 699 | 1,714 | 17,741 | 32,142 | 117,773 |
| 2048 | 2,547 | 1,881 | 713 | 662 | 3,695 | 2,456 | 699 | 1,705 | 17,707 | 32,067 | 117,496 |
| 2049 | 2,547 | 1,881 | 713 | 662 | 3,666 | 2,456 | 699 | 1,700 | 17,674 | 31,998 | 117,247 |
| 2050 | 2,547 | 1,881 | 713 | 662 | 3,639 | 2,456 | 699 | 1,696 | 17,640 | 31,934 | 117,010 |
| 2051 | 2,547 | 1,881 | 713 | 662 | 3,614 | 2,456 | 699 | 1,692 | 17,607 | 31,872 | 116,784 |
| 2052 | 2,547 | 1,881 | 713 | 662 | 3,590 | 2,456 | 699 | 1,686 | 17,575 | 31,810 | 116,555 |
| 2053 | 2,547 | 1,881 | 713 | 662 | 3,568 | 2,456 | 699 | 1,684 | 17,543 | 31,753 | 116,349 |
| 2054 | 2,547 | 1,881 | 713 | 662 | 3,548 | 2,456 | 699 | 1,681 | 17,511 | 31,700 | 116,152 |
| 2055 | 2,547 | 1,881 | 713 | 662 | 3,530 | 2,456 | 699 | 1,680 | 17,480 | 31,648 | 115,964 |
| 2056 | 2,547 | 1,881 | 713 | 662 | 3,512 | 2,456 | 699 | 1,675 | 17,450 | 31,596 | 115,771 |
| 2057 | 2,547 | 1,881 | 713 | 662 | 3,496 | 2,456 | 699 | 1,674 | 17,420 | 31,548 | 115,598 |
| 2058 | 2,547 | 1,881 | 713 | 662 | 3,481 | 2,456 | 699 | 1,673 | 17,390 | 31,503 | 115,432 |
| 2059 | 2,547 | 1,881 | 713 | 662 | 3,468 | 2,456 | 699 | 1,672 | 17,361 | 31,459 | 115,272 |
| 2060 | 2,547 | 1,881 | 713 | 662 | 3,454 | 2,456 | 699 | 1,668 | 17,333 | 31,414 | 115,106 |

### 3.3.2 Future sequestration losses

To indicate the carbon that could have been sequestered at the Project site in the future if the vegetation was not cleared (loss of carbon sink), the changes over time in the carbon pools simulated by FullCAM for the 'baseline' scenario were analysed. The changes in carbon pools for each of the scenarios are presented in Figure **3-3**.

The declining total carbon pool is driven by predicted soil carbon loss in the absence of commensurate increase in above and below ground plant components, presumably because the vegetation is assumed within the model to have reached full maturity.

To what extent the total carbon pool actually declines at the Project site over time is uncertain, however the FullCAM simulated result does suggest that the loss in future sequestration potential, if vegetation was not cleared at the Project site, is not expected to be overly significant.

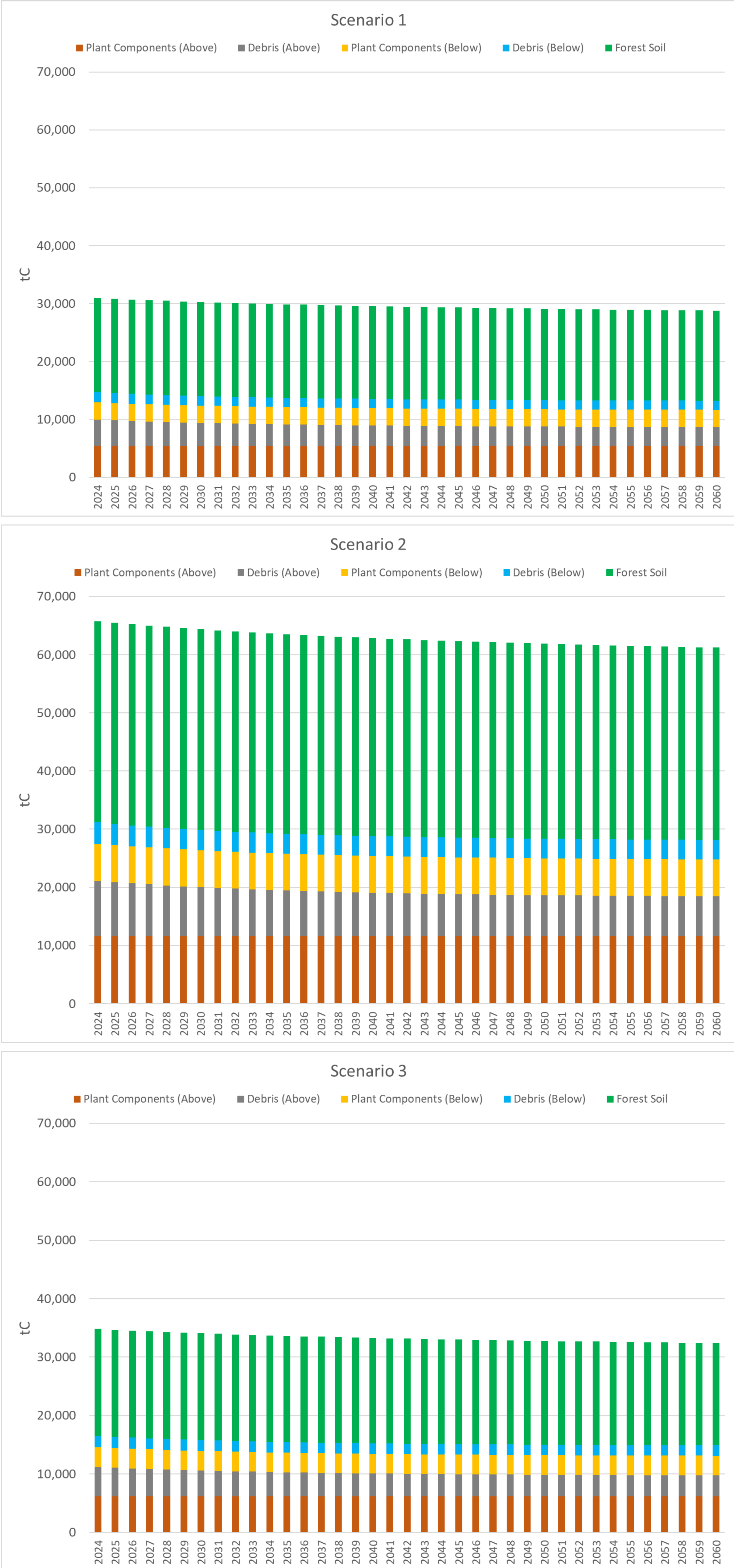


**Figure 3-3 Change in carbon pools – baseline case**

### 3.3.3 Disturbance of topsoil

An apparent limitation of FullCAM when applied to mining as the land-use changes, is that it is limited to events that affect the density of vegetation in an area (refer to Section 3.1), but does not consider soil carbon loss associated with topsoil removal and stockpiling. Theoretically, it is possible for the disturbance of topsoil to promote an increase in the rate of decomposition of soil organic carbon that is released to atmosphere as $CO_2$. However, considering the generally low soil organic carbon in Western Australian soils by global standards (DAF, 2013), and the concurrent process of return of organic matter to soil from cleared vegetation decay within the topsoil stockpiles, it is reasonable to assume a neutral effect on soil carbon at the Project site in relation to the disturbance of topsoil.

This is based on our understanding that cleared vegetation will be retained at the Project site within topsoil stockpiles, and will not be burnt, disposed to landfill or otherwise removed from the Project site.

## 3.4 Greenhouse gas emissions

FullCAM was used to estimate greenhouse emissions resulting from progressive clearing. Greenhouse gas emissions occur due to direct release of carbon to the atmosphere or the subsequent migration of carbon content from plant components to debris to forest soil, which are also eventually released into the atmosphere. While these processes occur naturally in the life cycle of forests, the clearing of trees are expected to result in an increase in the volume of forest material breakdown and the succeeding soil decomposition. The mass of carbon sequestered to existing vegetation is also calculated.

Sequestration from revegetation associated with mine rehabilitation is not included. This is conservative (over-estimates emissions) and is consistent with the approach used for other EIAs.

Table 3-12 shows a summary of greenhouse gas attributed to progressive land clearing for the three operational scenarios assessed. These are calculated as the difference of the carbon pools between the relevant 'progressive clearing' case (Table 3-9 to Table 3-11) and the 'baseline' case (Table 3-6 to Table 3-8). Loss in carbon mass and greenhouse gas emissions for each year of simulation is shown in Table 3-13 to Table 3-15, and provides details on the contribution of the plant components, debris, and forest soil during the life of mine and the following years. The rate of emissions is comparable to the rate of clearing.

Table 3-13 to Table 3-15 show that the carbon content of debris and forest soil during the' baseline' cases are lower than the 'progressive clearing' cases for some years, leading to a reduction in carbon and greenhouse gas emissions as a result of clearing. This could be attributed to the significant increase in the volume of plant components being migrated to forest litter to soil, resulting in an increase in the carbon mass.

Greenhouse gas emissions attributable to operations of the three scenarios are summarised in Table 3-12.

**Table 3-12 Carbon pools (tC) and Greenhouse Gas emissions from progressive clearing**

| Period | Parameter | Units | Scenario 1 | Scenario 2 | Scenario 3 |
|---|---|---|---|---|---|
| | Area cleared | ha | 1,674 | 3,558 | 1,884 |
| 2024 – 2060 (All Years) | Total Carbon loss | tC | 995 | 1,992 | 997 |
| | Total GHG emissions | t $CO_2$ -e | 3,646 | 7,299 | 3,653 |
| | Average GHG emissions | t $CO_2$ -e / ha | 2.18 | 2.05 | 1.94 |

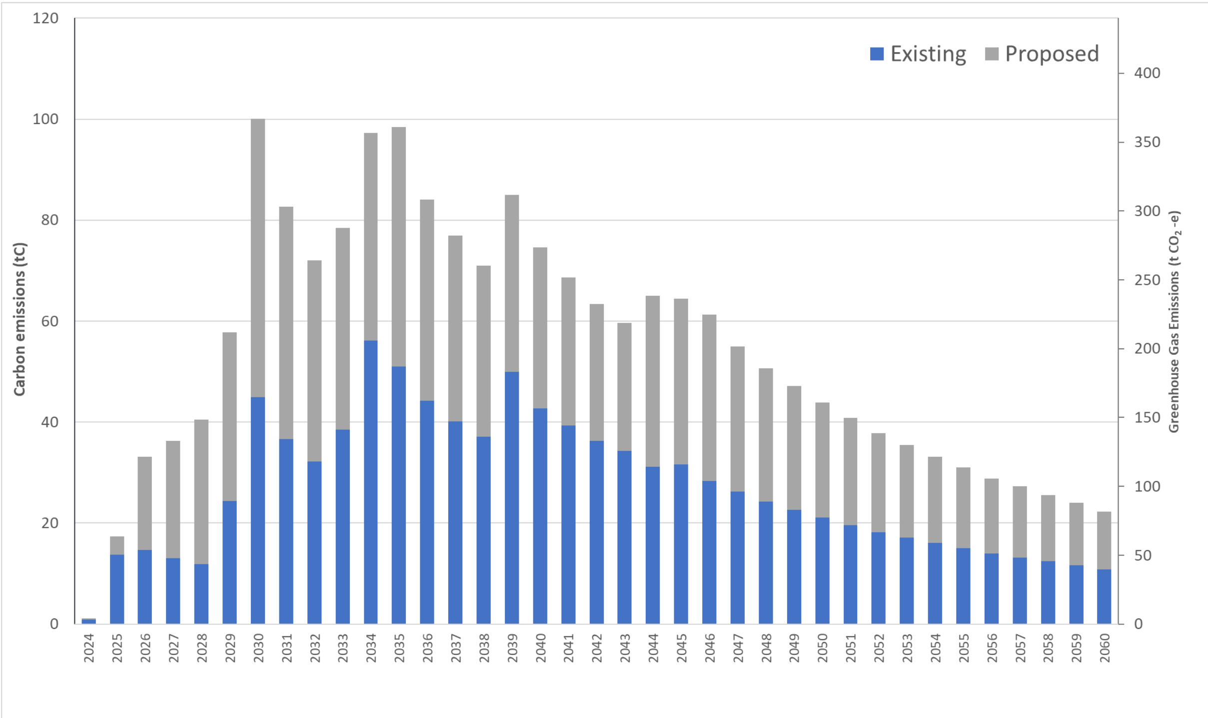


**Figure 3-4 Estimated carbon (tC) and greenhouse gas (t $CO_2$ -e) emissions due to progressive land clearing**

**Table 3-13 Loss of carbon (tC) in biomass attributed to progressive forest clearing of Scenario 1**

| Year | plant components | | | | | | debris breakdown | | soil decomposition | Total Loss of Carbon | | | Area cleared |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | stems | branches | bark | leaves | coarse roots | fine roots | above ground | below ground | | tC | t $CO_2$ -e | t $CO_2$ -e / ha | ha |
| 2024 | 1 | 1 | 0 | 0 | 1 | 0 | -2 | -1 | 0 | 1 | 3 | 0.10 | 35.50 |
| 2025 | 15 | 11 | 4 | 4 | 15 | 4 | -29 | -10 | -1 | 14 | 50 | 0.38 | 133.00 |
| 2026 | 8 | 6 | 2 | 2 | 8 | 2 | -12 | -2 | 0 | 15 | 54 | 0.55 | 97.50 |
| 2027 | 3 | 2 | 1 | 1 | 3 | 1 | 1 | 3 | 0 | 13 | 48 | 0.86 | 55.40 |
| 2028 | 1 | 1 | 0 | 0 | 1 | 0 | 4 | 4 | 1 | 12 | 43 | 1.26 | 34.50 |
| 2029 | 16 | 12 | 4 | 4 | 15 | 4 | -25 | -7 | 0 | 24 | 89 | 0.65 | 137.30 |
| 2030 | 32 | 24 | 9 | 8 | 31 | 9 | -53 | -15 | 0 | 45 | 165 | 0.84 | 194.90 |
| 2031 | 7 | 5 | 2 | 2 | 7 | 2 | 3 | 8 | 2 | 37 | 134 | 1.48 | 91.10 |
| 2032 | 1 | 1 | 0 | 0 | 1 | 0 | 15 | 11 | 2 | 32 | 118 | 3.10 | 38.10 |
| 2033 | 11 | 8 | 3 | 3 | 11 | 3 | -6 | 3 | 2 | 39 | 141 | 1.22 | 115.40 |
| 2034 | 28 | 21 | 8 | 7 | 27 | 8 | -37 | -8 | 2 | 56 | 206 | 1.11 | 184.80 |
| 2035 | 10 | 7 | 3 | 3 | 10 | 3 | 3 | 8 | 4 | 51 | 187 | 1.68 | 111.50 |
| 2036 | 1 | 1 | 0 | 0 | 1 | 0 | 22 | 14 | 5 | 44 | 162 | 4.69 | 34.50 |
| 2037 | 0 | 0 | 0 | 0 | 0 | 0 | 22 | 13 | 5 | 40 | 147 | 40.81 | 3.60 |
| 2038 | 0 | 0 | 0 | 0 | 0 | 0 | 19 | 10 | 6 | 37 | 136 | 6.09 | 22.30 |
| 2039 | 18 | 14 | 5 | 5 | 18 | 5 | -17 | -3 | 5 | 50 | 183 | 1.21 | 150.90 |
| 2040 | 3 | 2 | 1 | 1 | 3 | 1 | 16 | 9 | 6 | 43 | 156 | 2.48 | 63.10 |
| 2041 | 1 | 1 | 0 | 0 | 1 | 0 | 18 | 10 | 7 | 39 | 144 | 3.61 | 39.90 |
| 2042 | 1 | 0 | 0 | 0 | 1 | 0 | 18 | 9 | 7 | 36 | 133 | 4.86 | 27.30 |
| 2043 | 1 | 1 | 0 | 0 | 1 | 0 | 16 | 7 | 7 | 34 | 126 | 3.11 | 40.40 |
| 2044 | 0 | 0 | 0 | 0 | 0 | 0 | 17 | 7 | 7 | 31 | 114 | 0.00 | 0.00 |
| 2045 | 3 | 2 | 1 | 1 | 3 | 1 | 10 | 4 | 7 | 32 | 116 | 1.84 | 63.20 |
| 2046 | 0 | 0 | 0 | 0 | 0 | 0 | 15 | 6 | 7 | 28 | 104 | 0.00 | 0.00 |
| 2047 | 0 | 0 | 0 | 0 | 0 | 0 | 14 | 5 | 7 | 26 | 96 | 0.00 | 0.00 |
| 2048 | 0 | 0 | 0 | 0 | 0 | 0 | 13 | 4 | 7 | 24 | 89 | 0.00 | 0.00 |
| 2049 | 0 | 0 | 0 | 0 | 0 | 0 | 12 | 3 | 7 | 23 | 83 | 0.00 | 0.00 |
| 2050 | 0 | 0 | 0 | 0 | 0 | 0 | 11 | 3 | 7 | 21 | 77 | 0.00 | 0.00 |
| 2051 | 0 | 0 | 0 | 0 | 0 | 0 | 10 | 2 | 7 | 20 | 72 | 0.00 | 0.00 |
| 2052 | 0 | 0 | 0 | 0 | 0 | 0 | 10 | 2 | 7 | 18 | 67 | 0.00 | 0.00 |
| 2053 | 0 | 0 | 0 | 0 | 0 | 0 | 9 | 2 | 7 | 17 | 63 | 0.00 | 0.00 |
| 2054 | 0 | 0 | 0 | 0 | 0 | 0 | 8 | 1 | 6 | 16 | 59 | 0.00 | 0.00 |
| 2055 | 0 | 0 | 0 | 0 | 0 | 0 | 8 | 1 | 6 | 15 | 55 | 0.00 | 0.00 |
| 2056 | 0 | 0 | 0 | 0 | 0 | 0 | 7 | 1 | 6 | 14 | 51 | 0.00 | 0.00 |
| 2057 | 0 | 0 | 0 | 0 | 0 | 0 | 6 | 1 | 6 | 13 | 48 | 0.00 | 0.00 |
| 2058 | 0 | 0 | 0 | 0 | 0 | 0 | 6 | 1 | 6 | 12 | 46 | 0.00 | 0.00 |
| 2059 | 0 | 0 | 0 | 0 | 0 | 0 | 6 | 1 | 6 | 12 | 43 | 0.00 | 0.00 |
| 2060 | 0 | 0 | 0 | 0 | 0 | 0 | 5 | 0 | 5 | 11 | 40 | 0.00 | 0.00 |
| **All Years** | **163** | **120** | **46** | **42** | **157** | **45** | **144** | **104** | **175** | **995** | **3,646** | **81.93 (sum)<br>2.18 (average)** | **1,674** |

**Table 3-14 Loss of carbon (tC) in biomass attributed to progressive forest clearing of Scenario 2**

| Year | plant components | | | | | | debris breakdown | | soil decomposition | Total Loss of Carbon | | | Area cleared |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | stems | branches | bark | leaves | coarse roots | fine roots | above ground | below ground | | tC | t $CO_2$ -e | t $CO_2$ -e / ha | ha |
| 2024 | 1 | 1 | 0 | 0 | -3 | 1 | 0 | -1 | 0 | 1 | 4 | 0.00 | 35.50 |
| 2025 | 19 | 14 | 5 | 5 | -37 | 19 | 5 | -13 | -1 | 17 | 64 | 0.00 | 137.70 |
| 2026 | 27 | 20 | 8 | 7 | -47 | 26 | 7 | -14 | -1 | 33 | 121 | 0.00 | 297.30 |
| 2027 | 17 | 13 | 5 | 4 | -21 | 16 | 5 | -2 | 0 | 36 | 133 | 0.00 | 260.00 |
| 2028 | 15 | 11 | 4 | 4 | -14 | 14 | 4 | 1 | 1 | 40 | 148 | 0.00 | 256.10 |
| 2029 | 30 | 22 | 8 | 8 | -40 | 29 | 8 | -7 | 1 | 58 | 212 | 0.00 | 254.90 |
| 2030 | 66 | 49 | 18 | 17 | -104 | 63 | 18 | -27 | 0 | 100 | 367 | 0.00 | 401.30 |
| 2031 | 14 | 11 | 4 | 4 | 10 | 14 | 4 | 18 | 4 | 83 | 303 | 0.01 | 190.10 |
| 2032 | 2 | 1 | 0 | 0 | 36 | 1 | 0 | 25 | 6 | 72 | 264 | 0.06 | 38.10 |
| 2033 | 15 | 11 | 4 | 4 | 6 | 15 | 4 | 12 | 6 | 78 | 287 | 0.02 | 145.40 |
| 2034 | 35 | 26 | 10 | 9 | -32 | 34 | 10 | -1 | 6 | 97 | 356 | 0.01 | 184.80 |
| 2035 | 24 | 18 | 7 | 6 | -4 | 23 | 7 | 10 | 8 | 98 | 361 | 0.01 | 259.10 |
| 2036 | 2 | 1 | 1 | 1 | 41 | 2 | 1 | 25 | 10 | 84 | 308 | 0.07 | 71.20 |
| 2037 | 1 | 1 | 0 | 0 | 41 | 1 | 0 | 23 | 11 | 77 | 282 | 0.09 | 60.00 |
| 2038 | 1 | 1 | 0 | 0 | 37 | 1 | 0 | 19 | 12 | 71 | 260 | 0.13 | 44.00 |
| 2039 | 23 | 17 | 6 | 6 | -9 | 22 | 6 | 1 | 11 | 85 | 311 | 0.04 | 150.90 |
| 2040 | 5 | 3 | 1 | 1 | 30 | 4 | 1 | 16 | 13 | 75 | 273 | 0.08 | 80.00 |
| 2041 | 2 | 1 | 0 | 0 | 34 | 2 | 0 | 16 | 13 | 69 | 251 | 0.17 | 39.90 |
| 2042 | 1 | 1 | 0 | 0 | 33 | 1 | 0 | 14 | 14 | 63 | 232 | 0.26 | 27.30 |
| 2043 | 2 | 1 | 0 | 0 | 29 | 2 | 0 | 11 | 14 | 60 | 219 | 0.18 | 40.40 |
| 2044 | 12 | 9 | 3 | 3 | 6 | 12 | 3 | 2 | 14 | 65 | 238 | 0.03 | 245.20 |
| 2045 | 9 | 7 | 3 | 2 | 13 | 9 | 3 | 5 | 14 | 64 | 236 | 0.04 | 173.80 |
| 2046 | 5 | 4 | 2 | 1 | 20 | 5 | 2 | 8 | 14 | 61 | 225 | 0.05 | 165.20 |
| 2047 | 0 | 0 | 0 | 0 | 30 | 0 | 0 | 11 | 14 | 55 | 201 | 0.00 | 0.00 |
| 2048 | 0 | 0 | 0 | 0 | 27 | 0 | 0 | 9 | 14 | 51 | 186 | 0.00 | 0.00 |
| 2049 | 0 | 0 | 0 | 0 | 25 | 0 | 0 | 8 | 14 | 47 | 173 | 0.00 | 0.00 |
| 2050 | 0 | 0 | 0 | 0 | 23 | 0 | 0 | 7 | 14 | 44 | 161 | 0.00 | 0.00 |
| 2051 | 0 | 0 | 0 | 0 | 21 | 0 | 0 | 6 | 14 | 41 | 150 | 0.00 | 0.00 |
| 2052 | 0 | 0 | 0 | 0 | 20 | 0 | 0 | 4 | 14 | 38 | 138 | 0.00 | 0.00 |
| 2053 | 0 | 0 | 0 | 0 | 18 | 0 | 0 | 4 | 13 | 36 | 130 | 0.00 | 0.00 |
| 2054 | 0 | 0 | 0 | 0 | 17 | 0 | 0 | 3 | 13 | 33 | 122 | 0.00 | 0.00 |
| 2055 | 0 | 0 | 0 | 0 | 16 | 0 | 0 | 3 | 13 | 31 | 114 | 0.00 | 0.00 |
| 2056 | 0 | 0 | 0 | 0 | 14 | 0 | 0 | 2 | 12 | 29 | 105 | 0.00 | 0.00 |
| 2057 | 0 | 0 | 0 | 0 | 13 | 0 | 0 | 2 | 12 | 27 | 100 | 0.00 | 0.00 |
| 2058 | 0 | 0 | 0 | 0 | 12 | 0 | 0 | 2 | 11 | 26 | 94 | 0.00 | 0.00 |
| 2059 | 0 | 0 | 0 | 0 | 12 | 0 | 0 | 1 | 11 | 24 | 88 | 0.00 | 0.00 |
| 2060 | 0 | 0 | 0 | 0 | 11 | 0 | 0 | 1 | 11 | 22 | 82 | 0.00 | 0.00 |
| **All Years** | **327** | **242** | **92** | **85** | **285** | **316** | **90** | **207** | **349** | **1,992** | **7,299** | **61.97 (sum) 2.05(average)** | **3,558** |

**Table 3-15 Loss of carbon (tC) in biomass attributed to progressive forest clearing of Scenario 3**

| Year | plant components | | | | | | debris breakdown | | soil decomposition | Total Loss of Carbon | | | Area cleared |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | stems | branches | bark | leaves | coarse roots | fine roots | above ground | below ground | | tC | t $CO_2$ -e | t $CO_2$ -e / ha | ha |
| 2024 | 0 | 0 | 0 | 0 | 0 | 0 | -1 | 0 | 0 | 0 | 1 | 0.00 | 0.00 |
| 2025 | 4 | 3 | 1 | 1 | 4 | 1 | -8 | -3 | 0 | 4 | 13 | 2.85 | 4.70 |
| 2026 | 19 | 14 | 5 | 5 | 18 | 5 | -36 | -12 | -1 | 18 | 68 | 0.34 | 199.80 |
| 2027 | 14 | 11 | 4 | 4 | 14 | 4 | -22 | -5 | 0 | 23 | 85 | 0.42 | 204.60 |
| 2028 | 14 | 10 | 4 | 4 | 13 | 4 | -18 | -2 | 0 | 29 | 105 | 0.47 | 221.60 |
| 2029 | 14 | 10 | 4 | 4 | 13 | 4 | -15 | 0 | 1 | 33 | 122 | 1.04 | 117.60 |
| 2030 | 34 | 25 | 9 | 9 | 32 | 9 | -51 | -12 | 0 | 55 | 202 | 0.98 | 206.40 |
| 2031 | 7 | 6 | 2 | 2 | 7 | 2 | 7 | 11 | 2 | 46 | 169 | 1.70 | 99.00 |
| 2032 | 0 | 0 | 0 | 0 | 0 | 0 | 21 | 14 | 3 | 40 | 146 | 0.00 | 0.00 |
| 2033 | 4 | 3 | 1 | 1 | 4 | 1 | 11 | 10 | 4 | 40 | 146 | 4.88 | 30.00 |
| 2034 | 7 | 5 | 2 | 2 | 7 | 2 | 6 | 7 | 4 | 41 | 151 | 0.00 | 0.00 |
| 2035 | 14 | 10 | 4 | 4 | 13 | 4 | -7 | 2 | 4 | 47 | 174 | 1.18 | 147.60 |
| 2036 | 1 | 1 | 0 | 0 | 1 | 0 | 20 | 11 | 5 | 40 | 146 | 3.98 | 36.70 |
| 2037 | 1 | 1 | 0 | 0 | 1 | 0 | 19 | 10 | 6 | 37 | 135 | 2.39 | 56.40 |
| 2038 | 0 | 0 | 0 | 0 | 0 | 0 | 18 | 9 | 6 | 34 | 124 | 5.73 | 21.70 |
| 2039 | 5 | 3 | 1 | 1 | 4 | 1 | 8 | 5 | 6 | 35 | 129 | 0.00 | 0.00 |
| 2040 | 1 | 1 | 0 | 0 | 1 | 0 | 14 | 6 | 6 | 32 | 117 | 6.92 | 16.90 |
| 2041 | 0 | 0 | 0 | 0 | 0 | 0 | 15 | 6 | 7 | 29 | 108 | 0.00 | 0.00 |
| 2042 | 0 | 0 | 0 | 0 | 0 | 0 | 14 | 6 | 7 | 27 | 99 | 0.00 | 0.00 |
| 2043 | 0 | 0 | 0 | 0 | 0 | 0 | 13 | 5 | 7 | 25 | 93 | 0.00 | 0.00 |
| 2044 | 12 | 9 | 3 | 3 | 12 | 3 | -11 | -4 | 6 | 34 | 124 | 0.51 | 245.20 |
| 2045 | 6 | 5 | 2 | 2 | 6 | 2 | 3 | 2 | 6 | 33 | 120 | 1.08 | 110.60 |
| 2046 | 5 | 4 | 2 | 1 | 5 | 2 | 5 | 3 | 7 | 33 | 121 | 0.73 | 165.20 |
| 2047 | 0 | 0 | 0 | 0 | 0 | 0 | 15 | 6 | 7 | 29 | 105 | 0.00 | 0.00 |
| 2048 | 0 | 0 | 0 | 0 | 0 | 0 | 14 | 5 | 7 | 26 | 97 | 0.00 | 0.00 |
| 2049 | 0 | 0 | 0 | 0 | 0 | 0 | 13 | 5 | 7 | 25 | 90 | 0.00 | 0.00 |
| 2050 | 0 | 0 | 0 | 0 | 0 | 0 | 12 | 4 | 7 | 23 | 84 | 0.00 | 0.00 |
| 2051 | 0 | 0 | 0 | 0 | 0 | 0 | 11 | 3 | 7 | 21 | 78 | 0.00 | 0.00 |
| 2052 | 0 | 0 | 0 | 0 | 0 | 0 | 10 | 3 | 7 | 20 | 72 | 0.00 | 0.00 |
| 2053 | 0 | 0 | 0 | 0 | 0 | 0 | 9 | 2 | 7 | 18 | 67 | 0.00 | 0.00 |
| 2054 | 0 | 0 | 0 | 0 | 0 | 0 | 9 | 2 | 6 | 17 | 63 | 0.00 | 0.00 |
| 2055 | 0 | 0 | 0 | 0 | 0 | 0 | 8 | 2 | 6 | 16 | 59 | 0.00 | 0.00 |
| 2056 | 0 | 0 | 0 | 0 | 0 | 0 | 7 | 1 | 6 | 15 | 54 | 0.00 | 0.00 |
| 2057 | 0 | 0 | 0 | 0 | 0 | 0 | 7 | 1 | 6 | 14 | 51 | 0.00 | 0.00 |
| 2058 | 0 | 0 | 0 | 0 | 0 | 0 | 6 | 1 | 6 | 13 | 48 | 0.00 | 0.00 |
| 2059 | 0 | 0 | 0 | 0 | 0 | 0 | 6 | 1 | 6 | 12 | 45 | 0.00 | 0.00 |
| 2060 | 0 | 0 | 0 | 0 | 0 | 0 | 5 | 1 | 5 | 11 | 42 | 0.00 | 0.00 |
| **All Years** | **164** | **121** | **46** | **43** | **158** | **45** | **141** | **103** | **174** | **997** | **3,653** | **35.19 (sum)<br>1.94 (average)** | **1,884** |

## 3.5 Source contribution

The contribution of the plant components, debris, and soil to the total carbon and greenhouse gas emissions is summarised in Table 3-16. Plant components are shown to be the main source of greenhouse gases, contributing approximately 40% from above ground plant components and 22% from below ground plant components. Above ground and below ground debris contribute 12% and 11%, respectively. Soil decomposition contributes 16% of the total greenhouse gas emissions.

The contribution of the sources for the operations of the three scenarios are shown in Figure 3-5, showing that the source contribution is generally consistent for the operational scenarios assessed.

**Table 3-16 Source contribution for operations of the scenarios (2024 – 2060)**

| Parameter | | Scenario 1 | Scenario 2 | Scenario 3 |
|---|---|---|---|---|
| plant components | stems | 18% | 18% | 16% |
| | branches | 13% | 13% | 12% |
| | bark | 5% | 5% | 5% |
| | leaves | 5% | 5% | 4% |
| | coarse roots | 17% | 17% | 16% |
| | fine roots | 5% | 5% | 5% |
| debris | above ground | 12% | 11% | 14% |
| | below ground | 11% | 11% | 10% |
| soil | decomposition | 15% | 15% | 17% |

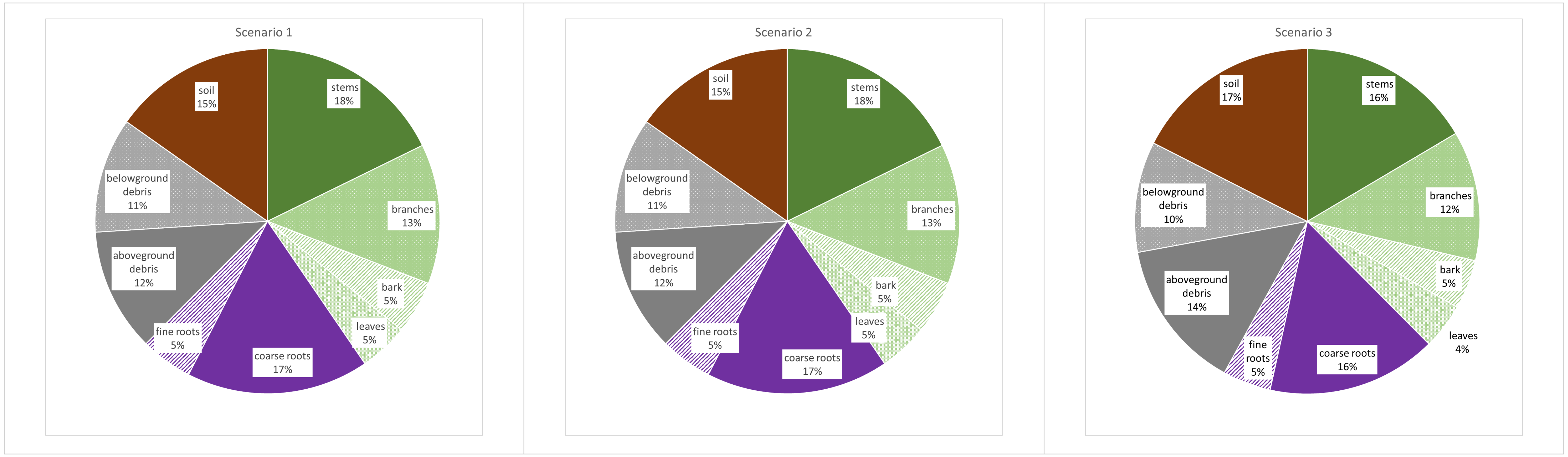


**Figure 3-5 Contribution (%) of plant components, debris, and soil to greenhouse gas emissions (2024 - 2060)**

# 4 Alternative approach

Road traffic and transport authorities in Australia and New Zealand have formed a Transport Authorities Greenhouse Group (TAGG). A key action of the TAGG is to develop a common methodology for the estimation, reporting and minimisation of GHG emissions associated with road construction, operation and maintenance (TAGG, 2013).

The methodology developed by the TAGG offers an alternative approach for estimating GHG emissions from vegetation clearing. Although developed for clearing during road construction, the approach has also been adopted for EIA more generally. It should be noted that the method uses a much more conservative estimation approach, assuming that all carbon pools are entirely lost as emissions of $CO_2$ at the time of clearing. In so doing, the method does not take into account the various decomposition rates of the different biomass components. Furthermore, sequestration from re-vegetation and existing vegetation are not accounted for.

GHG emissions are estimated based on an emission factor dependent on vegetation type and an assumed potential maximum biomass class. The methodology is considered a conservative estimation approach, in that it takes into account the carbon that exists in the vegetation at the time of clearing and carbon that could have been sequestered in the future if the vegetation was not cleared. The key assumptions are:

- all carbon pools (i.e., woody, non-woody, debris and soil) are removed
- all carbon removed is converted to $CO_2$ and released to the atmosphere
- sequestration from revegetation of a site is not included.

Emissions are estimated based on the total cleared area and an emission factor of 113 t $CO_2$-e/ha, based on an assumption of Class G vegetation (open shrubland) and a potential maximum biomass class range of 0-50 tdm/ha.

A comparison of the greenhouse gas emissions estimated using FullCAM and the TAGG (2013) methodology is presented in Table 4-1.

**Table 4-1 Comparison of estimated greenhouse gas emissions (t $CO_2$-e) using different methods**

| Time Period | FullCAM | TAGG |
|---|---|---|
| Scenario 1 | 3,646 | 189,162 |
| Scenario 2 | 6,898 | 402,054 |
| Scenario 3 | 3,653 | 212,892 |

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