# NETL Life Cycle Inventory Data
# Process Documentation File

**Process Name:** Gravel Road, 12 Inch Deep Roadbed, Construction

**Reference Flow:** 1 m of Gravel Road, 12 Inch Deep Roadbed

**Brief Description:** This unit process models the air emissions and materials requirements associated with the construction of a gravel road for heavy equipment, to be used on site at the wind farm.

## Section I: Meta Data

**Geographical Coverage:** US **Region:** N/A

**Year Data Best Represents:** 2010

**Process Type:** Installation Process (IP)

**Process Scope:** Gate-to-Gate Process (GG)

**Allocation Applied:** No

**Completeness:** Individual Relevant Flows Captured

**Flows Aggregated in Data Set:**

☒ Process ☒ Energy Use ☐ Energy P&D ☐ Material P&D

**Relevant Output Flows Included in Data Set:**

| | | | |
|---|---|---|---|
| Releases to Air: | ☒ Greenhouse Gases | ☒ Criteria Air Pollutants | ☐ Other |
| Releases to Water: | ☐ Inorganic Emissions | ☐ Organic Emissions | ☐ Other |
| Water Usage: | ☐ Water Consumption | ☐ Water Demand (throughput) | |
| Releases to Soil: | ☐ Inorganic Releases | ☐ Organic Releases | ☐ Other |

**Adjustable Process Parameters:**

| | |
|---|---|
| RoadArea | *Area (length x width) of road installed per meter of road length, in meters* |

**Tracked Input Flows:**

| | |
|---|---|
| Diesel [Intermediate Product] | *Amount of diesel used for installation of gravel road, for grading and other construction equipment* |
| Inert Rock [Non-Renewable Resource] | *Amount of gravel used during installation of gravel road* |

**Tracked Output Flows:**

| | |
|---|---|
| Gravel Road, 12 Inch Deep Roadbed [Construction] | *Construction of one (linear) meter of gravel road* |

## Section II: Process Description

### Associated Documentation

This unit process is composed of this document and the data sheet (DS) *DS_Stage3_C_Gravel_Road _2010.01.xls*, which provides additional details regarding relevant calculations, data quality, and references.

### Goal and Scope

The scope of this unit process covers the materials required for the construction of a (linear) meter of gravel road, used on site at a wind farm or other industrial site, to facilitate the use of large/heavy transport trucks and other heavy duty vehicles. The road is assumed to be constructed entirely of gravel. Installation of the road on site is presumed to require conventional diesel fuel for the use of grading and other construction equipment. The process is based on the reference flow of 1 meter of gravel road, as described below and shown in **Figure 1**.

This unit process is used under Life Cycle (LC) Stage #3 to support construction and operations of the wind farm; however, this unit process could also be applied to any facility wherein a similar gravel road would be required. As modeled, it is combined with other relevant equipment for LC Stage #3 in a separate construction assembly process, DF_Stage3_C_Assembly_Wind_Farm_Construction_2010.01.doc. The assembly process quantifies the amount of gravel road needed under LC Stage #3 to produce 1 MWh of electricity.

### Boundary and Description

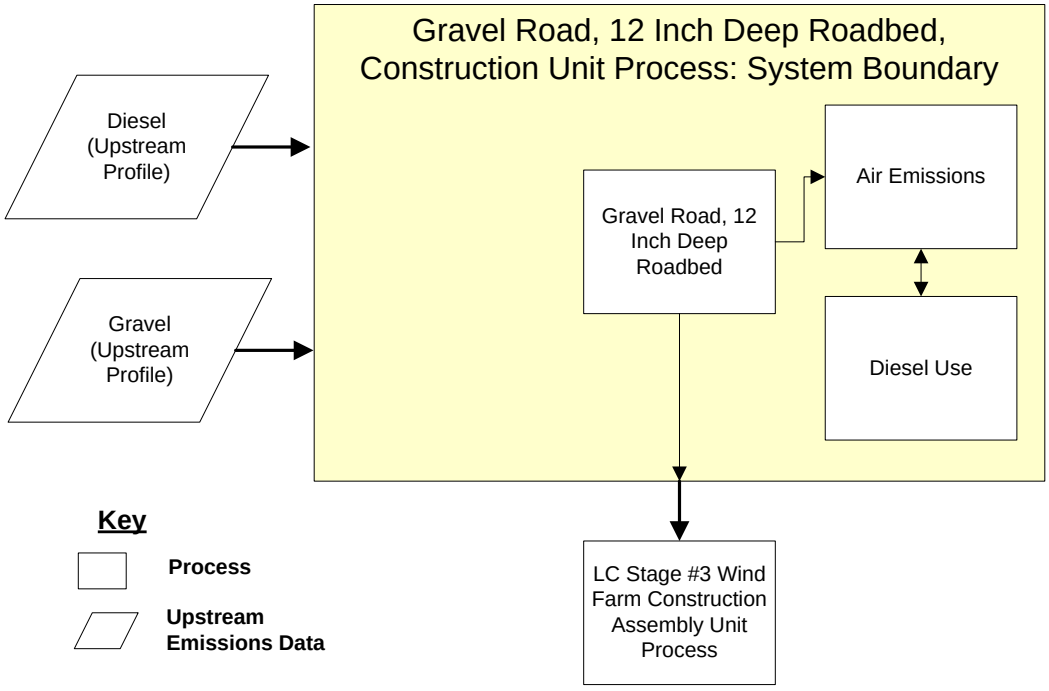
The total weight for a one meter length of gravel road, having a thickness of 1.0 ft and a default width of 5.0m, was estimated to be approximately 2,320 kg (5,115 lbs). This value is based on the a gravel mass of 1,522 kg per cubic meter (95 lbs/ft$^3$), taken from Simetric (2009). Carbon dioxide emissions were estimated based on three data sources for the construction of forest access roads, and two life cycle analyses of sustainable or green roads (Loeffler et al. 2008, Chappat and Bial 2003, and University of Washington 2010). Resulting average carbon dioxide emissions were 0.467 kg $CO_2$/m$^2$. The amount of diesel required for road construction was estimated by back-calculating the mass of diesel that would need to be combusted in order to account for this $CO_2$ emission rate. Nitrous oxide, methane, ammonia, and non-methane volatile organic carbon (NMVOC) emissions were then calculated based on USEPA emissions standards for stationary and non-road diesel emissions. Emissions

estimates for nitrogen oxides (NOx), carbon monoxide, sulfur dioxide, and particulate matter (PM10) were generated using URBEMIS air emissions software (Rimpo and Associates 2009), a standardized air emissions model used widely in California for the calculation of air emissions in support of various construction activities.

**Figure 1** provides an overview of the boundary of this unit process. Upstream emissions from the production of raw materials used for the construction of the tanker railcar (e.g., gravel and diesel) are calculated outside of the boundary of this unit process, based on profiles found elsewhere, such as the GaBi model. As shown in Figure 1 and discussed above, the gravel road constructed in this unit process is incorporated into an assembly process for wind farm construction, which occurs under LC Stage #3.

**Table 1** summarizes the relevant properties and assumptions used to calculate the amount of diesel and gravel contained in a 1 meter of gravel road, and the airborne emissions that would result. **Table 2** provides a summary of modeled input and output flows. Additional detail regarding input and output flows, including calculation methods, is contained in the associated DS.

**Figure 1: Unit Process Scope and Boundary**



## Table 1: Properties of Gravel Road and Materials

| Material Composition and Weights | | |
|---|---|---|
| Item | Value | Reference |
| Width of Gravel Road, m (ft) | 5.0 (16.4) | NETL Engineering Judgment |
| Depth of Gravel Road, m (ft) | 0.30 (1.0) | WTIC 2002 |
| Mass of gravel per meter of road, based on a 5m road width, kg (lbs) | 1,522 (3,355) | Simetric 2009 |
| Diesel use per meter of road, based on a 5m road width, kg (lbs) | 0.741 (1.63) | Rimpo Assoc. 2009 |

## Table 2: Unit Process Input and Output Flows

| Flow Name | Value | Units (Per Reference Flow) |
|---|---|---|
| Inputs | | |
| Diesel [Intermediate Product] | 0.741 | kg |
| Inert rock [Non renewable resources] | 2319.5 | kg |
| Outputs | | |
| Gravel Road, 12 Inch Deep Roadbed [Construction] | 1.00 | meter |
| Carbon dioxide [Inorganic emissions to air] | 2.33E+00 | kg |
| Methane [Organic emissions to air (group VOC)] | 3.33E-04 | kg |
| Nitrous oxide (laughing gas) [Inorganic emissions to air] | 5.93E-05 | kg |
| Nitrogen oxides [Inorganic emissions to air] | 2.95E-01 | kg |
| Sulphur dioxide [Inorganic emissions to air] | 3.36E-04 | kg |
| Carbon monoxide [Inorganic emissions to air] | 1.01E-01 | kg |
| NMVOC (unspecified) [Group NMVOC to air] | 4.92E-04 | kg |
| Dust (unspecified) [Particles to air] | 5.17E-01 | kg |
| Ammonia [Inorganic emissions to air] | 9.67E-05 | kg |

* **Bold face** clarifies that the value shown *does not* include upstream environmental flows. Upstream environmental flows must be added during the modeling process using information obtained elsewhere, such as GaBi modeling software, as shown in Figure 1.

## Embedded Unit Processes

None.

## References

Chappat 2003 — Chappat, M. 2003. Sustainable Development: *The Environmental Road of the Future, Life Cycle Analysis.* http://www.colas.com/FRONT/COLAS/upload/com/pdf/route-future-english.pdf (Accessed September 16, 2010)

| | |
|---|---|
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| Hoffman 2009 | Hoffman Transportation. 2009. *2008 Polar Alum. Double Conical DOT 407 Single Compartment*. Penton Media, Inc. http://www.trucker.com/TrailerDetail.aspx?TrailerID=187032&CompanyID=30429 (Accessed December 18, 2009). |
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## Section III: Document Control Information

**Date Created:** October 27, 2010

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