# The Deltalok™ GHG Analysis

# Introduction

The Deltalok™ System is a unique ecological engineered methodology developed to provide a permanent green solution for retaining walls, erosion control, slope stability and streambank protection. This patented system uses proven mechanically stabilized earth (MSE) and bag work technologies and offers 3D mechanically interlocked soft permanent structural strength. As an alternative to concrete walls, Deltalok System offers a natural solution using various vegetation options such as:

- hydroseeding (grass),
- live native planting (ferns, rose bush etc),
- live stacking (such as willow branches), and
- brush layering (vines etc).

It is the only system that can perform in both the soft armoured and hard structured applications. The Deltalok System offers the strength of stone and concrete with the natural beauty and environmental benefits of a grassy bank, a field of flowers or even a forest scape.

The two components of the system are:

- Deltalok geotextile (GTX) non-woven bags which is filled with growing material.
- Deltalok interlocking unit made of 100% recycled polypropylene, however the calculations in this report did not take into account the use of recycled material.

Over time, permanent naturalized structures built with Deltalok become even stronger as plant and tree root systems grow throughout.

# Greenhouse Gas Environmental Benefits

The Deltalok System has a number of GHG environmental benefits compared to traditional concrete walls, either poured concrete or engineered retaining wall blocks.

## Deltalok System (named the ‘Project’)

a) Manufacture of Deltalok materials.
b) Transportation to site and Installation of Deltalok system
c) Biological capture of Carbon in plant materials

## Traditional Concrete Retaining Walls (named the ‘Baseline’)

a) Manufacture of Concrete retaining wall materials.
b) Manufacture of adhesives (optional)
c) Transportation to site and Installation of retaining wall.

# Identifying GHG Sources, Sinks and Reservoirs (SSR) Relevant for the Project (Deltalok System)

<u>Selection and Establishment of Criteria and Procedures</u>

A review of applicable good practice guidance for criteria and procedures to identify SSRs relevant to the project included:

- WRI/WBCSD GHG Protocol for Projects, December 2005

A seven step procedure, similar to the one described below, was utilized to ensure all relevant sources, sinks and reservoirs associated with the project are identified:

1. Identify (potential) SSRs for the system that are controlled or owned by the project proponent. Focus on the primary project activities (i.e. the direct SSR or SSRs that aims to provide the main effect(s) on GHGs).
2. Identify (potential) SSRs that are physically related to the direct project. Trace products, materials and energy inputs/outputs upstream to origins in natural resources and downstream along life cycle.

3. Identify (potential) SSRs that are economically affected by the project. Consider the economic and social consequences of the project (compared to the baseline), look for activities, market affects, and social changes that result from or are associated with the project activity.
4. For each identified SSR determine parameters required to estimate or measure GHGs. This includes materials and energy inputs/outputs, and information on activities, products and services for the SSR.
5. Select SSR scale by aggregating or disaggregating identified potential SSRs. The number of SSRs defined and the degree of detail required is a function of the analysis at hand. This is guided by availability of data, management of data collection, and assurance of accurate GHG quantification. As a rule of thumb, more detailed (disaggregated) SSRs are appropriate where it is known that the project system differs from the baseline system, where more specific quantification is necessary, or where data are readily available. Aggregated SSRs are sufficient where the project and baseline systems are identical.
6. Determine the function(s) (products, goods and services) provided by the system of SSRs. The whole system of SSRs may perform one or more functions, plus individual SSRs may have specific functions.
7. Confirm that all SSRs are identified; that each is classified appropriately as owned, related or affected; that all GHG inputs and outputs for each SSR are identified; and that the sequence of SSRs for the system is correct. Repeat previous steps as necessary.

Application of Procedure

By following the above steps, a diagram (shown in Figure 1) was generated, showing all the project SSRs.

The SSRs were classified as onsite SSRs during project operation, upstream SSRs during project operation, downstream SSRs during project operation, upstream SSRs before project and downstream SSRs after project. A summary of the identified SSRs is presented in Table 1.

Figure 1: Identified Project (Deltalok System) SSRs

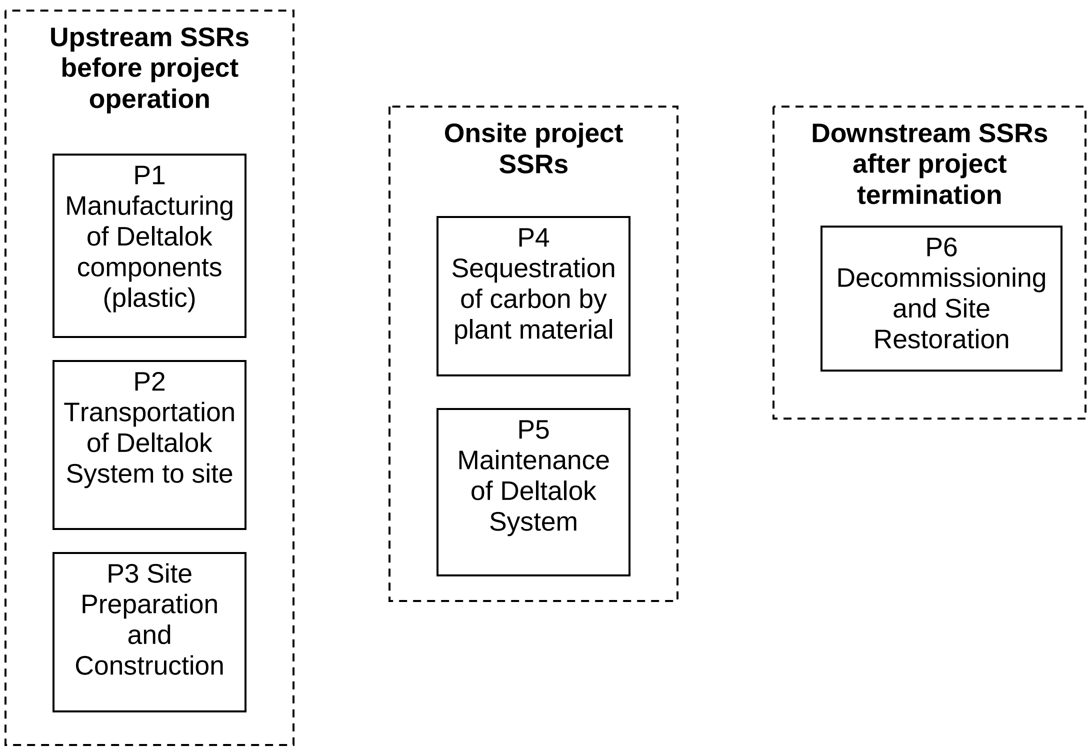

Table 1: Identified Project (Deltalok Systems) SSRs

| **Upstream SSRs before project operation** | | |
|---|---|---|
| SSR Name | Controlled / Related / Affected | Description |
| P1 Manufacturing of Deltalok components (plastic) | Related | Includes all activities involving the production of the polypropylene plastic material in the Deltalok components. GHG emissions arise from the combustion of fossil fuels required for raw material acquisition and manufacture. GHG emissions are also generated during the transportation of the raw materials to the manufacturing plant or facility. |
| P2 Transportation of Deltalok System to site | Related | GHG emissions result from the combustion of fuels during transportation of Deltalok components to the project site |
| P3 Site Preparation and Construction | Related | Includes the use of machinery (backhoe, compactor) for system installation and site preparation. |
| **Onsite Project SSRs** | | |
| P4 Sequestration of carbon by plant material | Related | Includes the amount of carbon sequestered (removed) by vegetation growth on the Deltalok System facial area. |
| P5 Maintenance of Deltalok System | Related | Emission from maintenance activities of the Deltalok System, if any. |
| **Downstream SSRs after project termination** | | |
| P6 Decommissioning and Site Restoration | Related | Includes all activities associated with the decommissioning & site restoration, if any. |

# Determining the Baseline Scenario

The Baseline is the most appropriate and best estimate of a reference case for which the Project (Deltalok System) can be compared to. The Baseline scenario covers the same time period as the Project.   In this case, because the analysis was to compare the Deltalok System against traditional concrete walls, concrete walls will be used as the Baseline Scenario.

# Identifying GHG Sources, Sinks and Reservoirs (SSR) for the Baseline Scenario (Concrete Walls)

A procedure similar to the one employed for the project was utilized for identification of SSRs for the baseline scenario. The following diagram Figure 2 illustrates the SSRs associated with the Baseline scenario. A summary of all these SSRs is presented in Table 2.

Figure 2: Identified Baseline (Concrete wall) SSRs

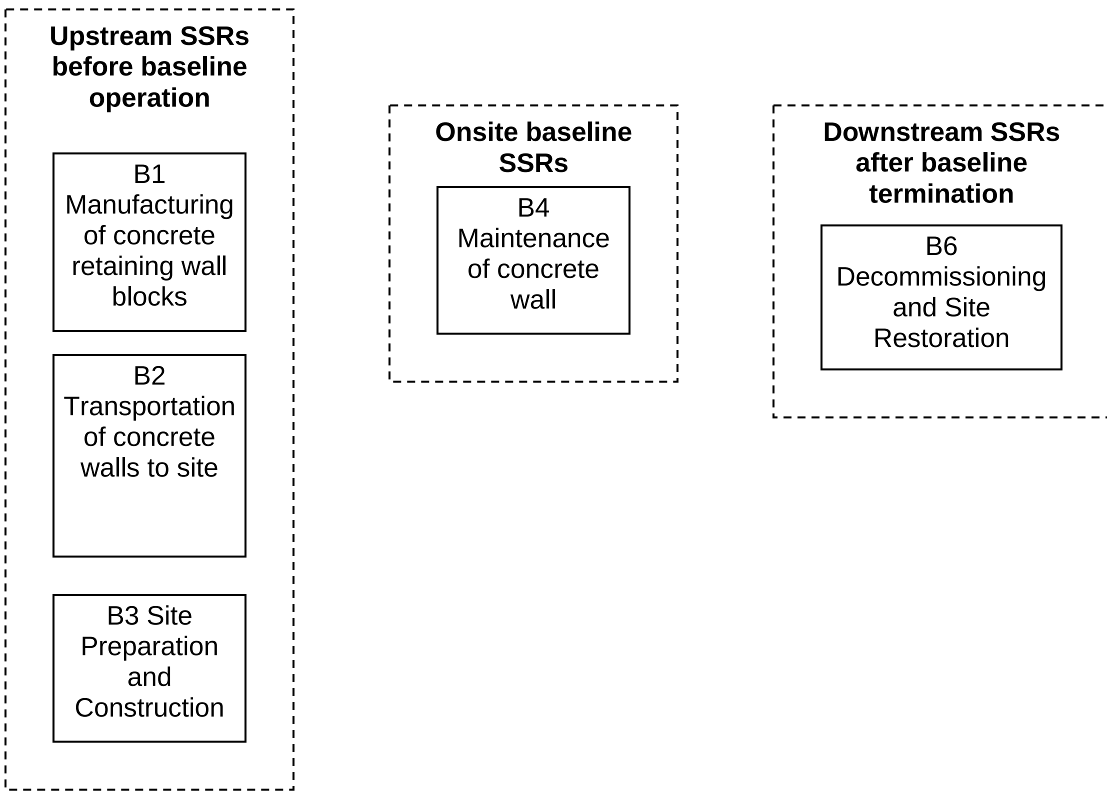

Table 2: Identified Baseline (Concrete walls) SSRs

| **Upstream SSRs before baseline operation** | | |
|---|---|---|
| SSR Name | Controlled / Related / Affected | Description |
| B1 Manufacturing of concrete walls | Related | Includes all activities involving the production of the concrete walls. GHG emissions arise from the combustion of fossil fuels required for raw material acquisition and manufacture. GHG emissions are also generated during the manufacture of cement used as input into the manufacture of concrete. It also includes transportation of the raw materials to the manufacturing plant or facility. |
| B2 Transportation of concrete walls to site | Related | GHG emissions result from the combustion of fuels during transportation of concrete walls to the project site |
| B3 Site Preparation and Construction | Related | Includes the use of heavy machinery (bull dozers, augers, loaders etc…) for system installation and site preparation. |
| **Onsite baseline SSRs** | | |
| B4 Maintenance of concrete walls | Related | Emissions from maintenance activities for the concrete walls. |
| **Downstream SSRs after baseline termination** | | |
| B5 Decommissioning and Site Restoration | Related | Includes all activities associated with the decommissioning & site restoration, if any. |

# Selecting Relevant GHG Sources, Sinks and Reservoirs for Monitoring or Estimation of GHG Emissions and Removals

Criteria and procedures for relevance of SSRs

Good practice guidance for the selection of relevant GHG SSRs for monitoring or estimating is very limited. Therefore the following procedure was developed and is justified based on the GHG quantification principles specified in ISO 14064-2 (relevance, conservativeness).

The procedure, illustrated in Figure 5, was applied to assess in sequence each identified SSR determined to be relevant for the project and the selected baseline scenario to determine whether the GHG SSRs will be monitored or estimated.  In cases where a SSR is selected for estimation rather than monitoring the rational for that decision will be justified. This approach allows the quantification to be faster and cheaper without compromising the credibility of the quantification of GHG emission reductions.

Application of criteria and procedures

Table 3 lists all SSRs excluded from quantification for the project and baseline and the explanation why.

Figure 5: Procedure for selection of SSRs relevant for GHG quantification

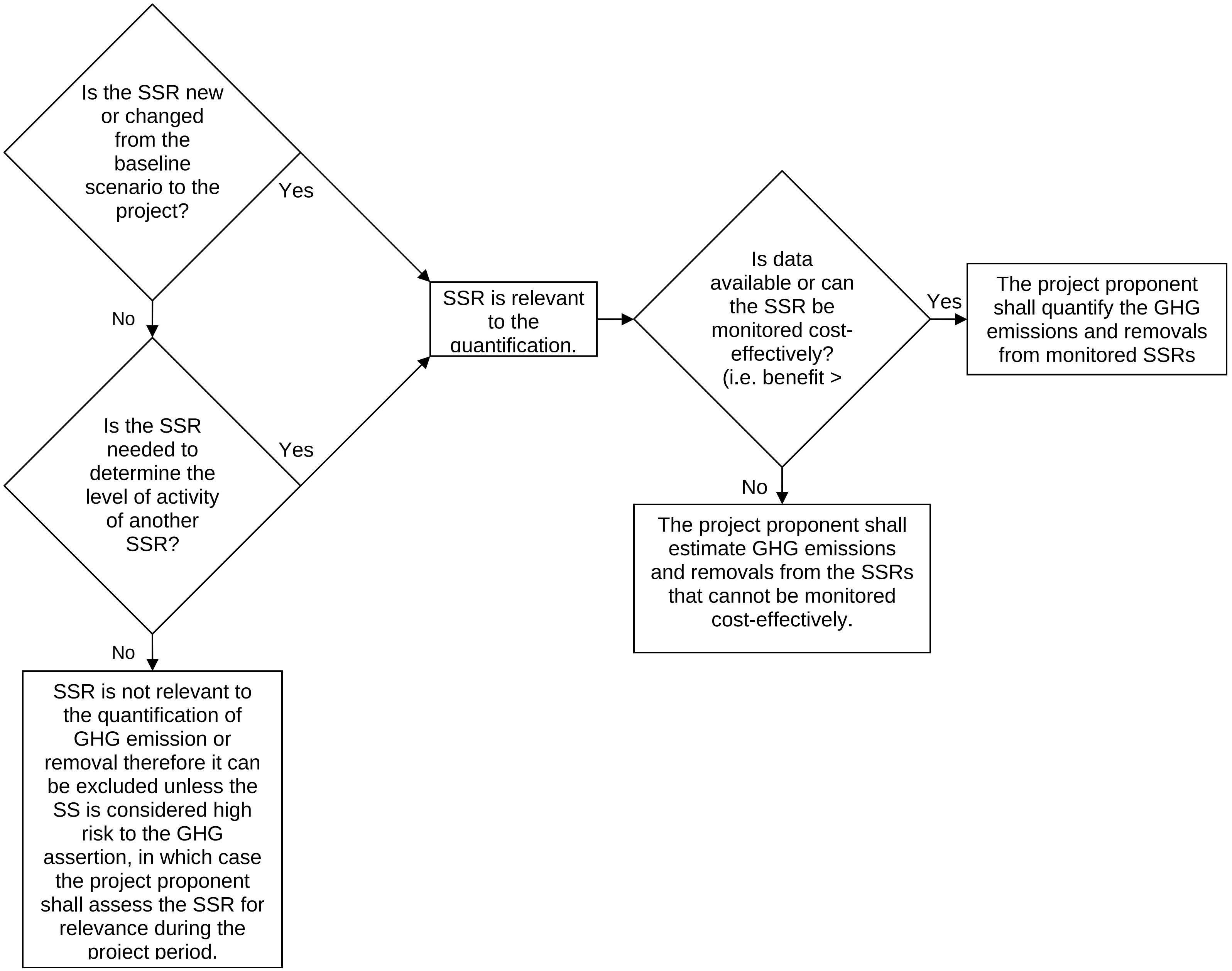

Table 3: Selection of relevant project SSRs for quantification

| SSR Name | Monitored/Estimated | Explanation |
|---|---|---|
| B3 and P3 Site Preparation and Construction | Not relevant | There is likely more heavy equipment used in the installation of concrete walls due to the fact that it is very heavy to move large amounts by hand. To be conservative, these SSRs will not be quantified. |
| P5 Maintenance of Deltalok System and B4 Maintenance of concrete wall | Not relevant | Very little maintenance of either system is required. Such maintenance would include repairs to the wall over time. There would be larger GHG emissions associated with the concrete retaining wall, due to its higher energy requirements. To be conservative, these SSRs will not be quantified. |
| P6 and B5 Decommissioning and Site Restoration | Not relevant | Since both of these systems are designed to be permanent, there are no GHG calculations necessary.. |

# Quantifying GHG Emissions

GHG quantification procedure

GHG emissions were quantified by taking the product of the activity level and an emission factor for the specific activity associated with the SSR. All of the emissions are calculated on a per square meter of retaining wall area :

$$E_i = ALxEF_i \qquad (1)$$

Where $E_i$ is the emission of greenhouse gas i ($CO_2$, $CH_4$ and $N_2O$), $AL$ is the activity level associated with each SSR and $EF_i$ is the emission factor associated with the SSR.

Activity levels were obtained from contractors or manufacturers (i.e. amount of plastic used in Deltalok System), or were estimated using professional engineering judgment. The emission factors were derived or obtained from published sources (i.e. Environment Canada). Emissions were calculated for each greenhouse gas emitted and converted to total $CO_2$ equivalent utilizing the appropriate global warming potentials as shown below.

$$E_{CO_2 equivalent} = E_i x GWP_i$$

Where $GWP_i$ is the global warming potential of greenhouse gas i. Table 4 provides the global warming potentials for each greenhouse gas accounted for in this report.

Table 4: Global Warming Potentials (GWPs)

| Types of GHG Emissions | GWP |
|---|---|
| $CO_2$ | 1 |
| $CH_4$ | 21 |
| $N_2O$ | 310 |

# Quantifying GHG Emissions from the Project (Deltalok System)

**Upstream SSRs before project operation**

P1 Manufacturing of Deltalok components (non-recycled polypropylene)

Parameters required for estimating the total emissions associated with the production of polypropylene are:

a) kg of polypropylene required for each m2 of Deltalok retaining wall
   0.92 kg of polypropylene plastic is needed per m2 of retaining wall area. This includes both the GTX bags and the interlocking connectors. This information was supplied by Deltalok Inc.

b) Polypropylene production emission factors. The emission factors for the manufacture of polypropylene were supplied by the Canadian Raw Material Database at the University of Waterloo.

P2 Transportation of Deltalok components to project site

The emissions associated with transportation of Deltalok System were estimated by taking a transportation emission factor of 0.072 kg CO2e/t-km (taken from the GHG Protocol mobile combustion tool) and multiplying by the average distance to the site and the mass of polypropylene needed per m2 of wall area.

To be conservative, the distance travelled for the Deltalok System was 200 km, compared to 100 km for the Baseline (concrete wall).

**Onsite Project SSRs**

P4 Sequestration of carbon by plant material

After the Deltalok wall is constructed, plant material is installed on the face of the wall. This may consist of seeds (hydroseeding), live stacking (willows etc) and live planting (native species such as ferns, vines etc). The sequestration of carbon consists of a number of components:

Table 5: Components of carbon sequestration

| Live Biomass | | | Dead Biomass | | |
|---|---|---|---|---|---|
| Trees | Herbaceous | Roots | Fine | Coarse | Soil |

The Deltalok System allows vegetation to grow on the face of the wall.  This plant material will start sequestering carbon as is starts growing.  It will increase the amount of carbon in both the living biomass and eventually in the soil as it decays.  Emission factors published by IPCC can estimate the amount of carbon sequestration for various plant types in various climatic and growing zones.  The amount of carbon sequestered by plant material will vary from year to year depending on the growing conditions.  Therefore, some kind of temporal averaging is often used.

During the initial seeding and planting stage, fertilizer may be used to accelerate the growth cycle.  The application of fertilizer will often released GHGs, primarily $N_2O$.  The type of fertilizer and method of application can influence these releases.

Some carbon stock factors are shown below:

Table 6: Carbon stock factors for naturally regenerated forests (tonnes C / ha)

| | | | | |
|---|---|---|---|---|
| Temperate | | | | |
| | Coniferous | Broadleaf | Mixed | |
| | 52 | 58 | 49 | |
| Boreal | Mixed | Coniferous | Forest-Tundra | Pine |
| | 12 | 10 | 4 | 50 |

Using an example case study from the GHG Protocol, a hybrid poplar plantation forest has a maximum annual carbon sequestration of 8.83 t C / ha, This translates into .00883 kg $CO_2$ / m2 [8.83 t C / ha x 1000 kg / t / (10,000 m2 / ha) = 0.00883 kg C / m2].

Typically, the type of plant material that can be supported by the Deltalok System has a much lower carbon sequestration rate.  Hence, a very conservative estimate of 10% of this value will be used in the calculations, or .000883 kg C / m2.  This is then multiplied by 44/12, (the ratio of the molecular weight of carbon dioxide [$CO_2$] to the molecular weight of carbon).  Thus, the $CO_2$ sequestration is estimated at 0.00324 kg $CO_2$ / m2.

# Quantifying GHG Emissions from the Baseline (Concrete Wall)

The only SSRs that will be quantified for the baseline (concrete wall) are the upstream manufacture and transportation of the concrete walls. All other SSRs were not relevant since there was no change between the project (Deltalok System) and the baseline (Concrete Wall).

B1 Manufacturing of concrete walls

Parameters required for estimating the total emissions associated with the production of concrete walls are:

c) kg of concrete required for each m2 of retaining wall. A conservative assumption was made that concrete walls are typically 200 mm in depth. Hence, using the density of concrete, approximately 460 kg of concrete are needed per m2 of wall area.

d) Cement production emission factors. The emission factors for the manufacture of cement were taken from the Canadian Cement Industry 2008 Sustainability Report. This emission factor does not include indirect electricity GHG emissions nor does it include emissions associated with transportation of materials to the cement plant.

B2 Transportation of concrete walls to project site

The emissions associated with transportation of concrete walls were estimated by taking a transportation emission factor of 0.072 kg CO2e/t-km (taken from the GHG Protocol mobile combustion tool) and multiplying by the average distance to the site and the mass of concrete needed per m2 of wall area.

To be conservative, the distance travelled for the concrete walls was 100 km, compared to 200 km for the Deltalok System.

# Quantifying GHG Emission Reductions

Total emission reductions achieved from implementation of the project (Deltalok System) was quantified by taking the difference between total emissions generated by the project (Deltalok System) and total emissions generated by the baseline (concrete wall). The results, in terms of kg CO2e/m2 area are shown below:

Table 7: GHG emissions reduction estimates (Baseline – Project GHG emissions)

| **System** | | |
|---|---|---|
| CO2 | kg CO2e/m2 area | 71.30 |
| CH4 | kg CO2e/m2 area | -0.54 |
| N2O | kg CO2e/m2 area | 0.00 |
| **Total GHGs** | **kg CO2e/m2 area** | **70.76** |

# Appendices

## Emissions Sources and Other References

1) Intergovernmental Panel on Climate Change 1997, Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories Reporting Instructions – global warming potential values (http://www.ipcc-nggip.iges.or.jp/public/gl/invs1.html)

2) Canadian Raw Materials Database – emission factors for the manufacture of polypropylene plastic. (http://crmd.uwaterloo.ca/eng.html)

3) WRI-WBCSD GHG Protocol Initiative – co2-mobile.xls calculation tool for emission factors for transportation. (http://www.ghgprotocol.org/downloads/calcs/co2-mobile.xls)

4) WRI-WBCSD GHG Protocol Initiative – The Land Use, Land Use Change and Forestry Guidance for GHG Project Accounting for emission factors for carbon sequestration by plants (http://www.ghgprotocol.org/files/lulucf-final.pdf)

5) Canadian Cement Industry 2008 Sustainability Report – emission factors for the manufacture of cement. (http://www.cement.ca/images/stories/Canadian%20Cement%20Industry%202008%20Sustainability%20Report.pdf)

Deltalok installation photos

Bag filling Closing

Deltalok®

Installing Bags & Geogrid

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