BEAM*2022 Biosolids Management GHG Calculator

Nicholas Leblanc, Englobe
Bobbie Thoman, NOCO
NEBRA Carbon Trading Committee

Canadian Residuals & Biosolids Conference
September 19th, 2022
Niagra-on-the-Lake, ON

Biosolids GHGs
formulas to mitigate climate change

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- US States: Maine, Vermont, New Hampshire, Massachusetts, Rhode Island, Connecticut
- Canadian Provinces: Quebec, Nova Scotia, New Brunswick, Newfoundland & Labrador, Prince Edward Island

- **Mission**: to cooperatively promote sustainable diversion, recycling and beneficial use of biosolids and residuals from the municipal and industrial sectors

- Committees Include:
- Research
- Residuals
- Reg-Leg
- ***Carbon & Nutrient Trading***

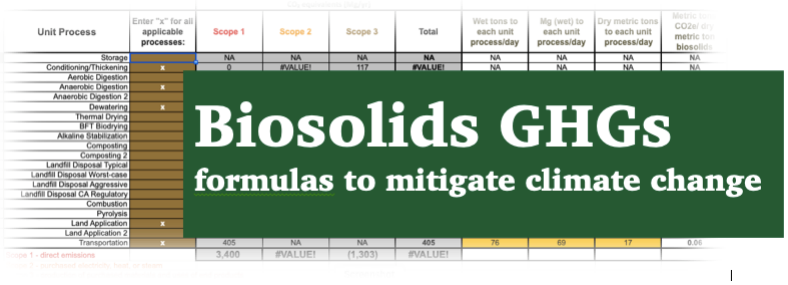
Why did NEBRA take on BEAM*2022?

- Help address the challenges of inventorying GHGs including:
  - Inconsistent use of methodologies – BEAM is a consistent, widely used model for biosolids management
  - Unavailable or unreliable emissions factors - BEAM*2022 provides peer-reviewed updates of default emissions factors and assumptions, making for reliable estimates of GHG emissions from biosolids management.
- Updates to BEAM needed to reflect current emissions factors, default values and references
- Additional modules developed by practitioners for new unit processes (e.g., pyrolysis) needed to be incorporated

BEAM*2022 and the new *www.BiosolidsGHGs.org* are made possible...

What is the Biosolids Emissions Assessment Model (BEAM?)

- Excel spreadsheet
- Calculates net GHG emissions and sinks for different biosolids treatment and end use options
  - Does not address all WRRF, utility emissions – just for solids
- Estimates Scopes 1, 2, 3 & biogenic CO_2 emissions
- Uses detailed emissions factors from published literature
  - As specific as possible to different biosolids materials
- Original published in 2010, 2011, from project by Canadian Council fo Ministers of the Environment (CCME).



Original BEAM purpose
(from CCME User Guide, 2009)

The model can be used to:

- **estimate a program's GHG emissions**, including establishing a baseline
- **compare different biosolids management scenarios**
- estimate **impacts from changes** in biosolids management
- understand the **factors that have the greatest impact** on GHG emissions

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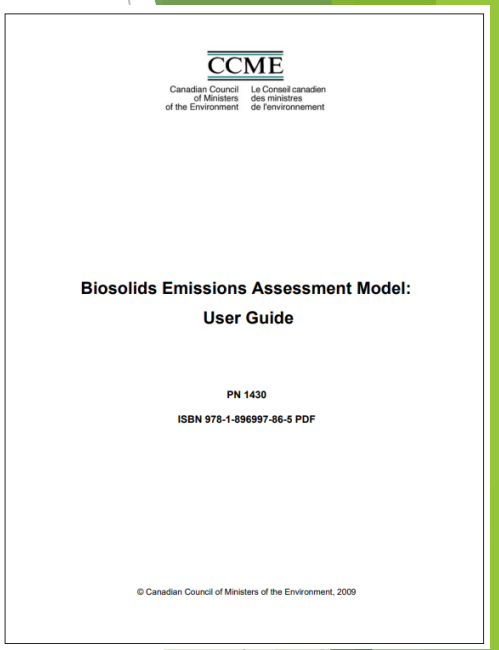
BEAM – Background & History

- 2008 - 2009: BEAM created under contract from Canadian Council of Ministers of the Environment (CCME) by
  - Sylvis (Mike van Ham, Mark Teshima, John Lavery); with assistance from:
    - Sally Brown (Univ. of WA)
    - Andrew Carpenter (Northern Tilth)
    - Ned Beecher (NEBRA)
- 2009: BEAM 1.0 & User Guide published by CCME
- Oct. 2010: BEAM 1.1, paper, & supplemental material by Brown et al. in *Env. Sci. & Tech.*
- 2011: CCME publishes BEAM 1.1
- 2021: CCME allows updates but is no longer formally involved
- 2021: Effort to update BEAM merged with Northwest Biosolids online GHG calculator project


CCME

Canadian Council of Ministers of the Environment | Le Conseil canadien des ministres de l'environnement

Biosolids Emissions Assessment Model: User Guide

PN 1430

ISBN 978-1-896997-86-5 PDF

© Canadian Council of Ministers of the Environment, 2009

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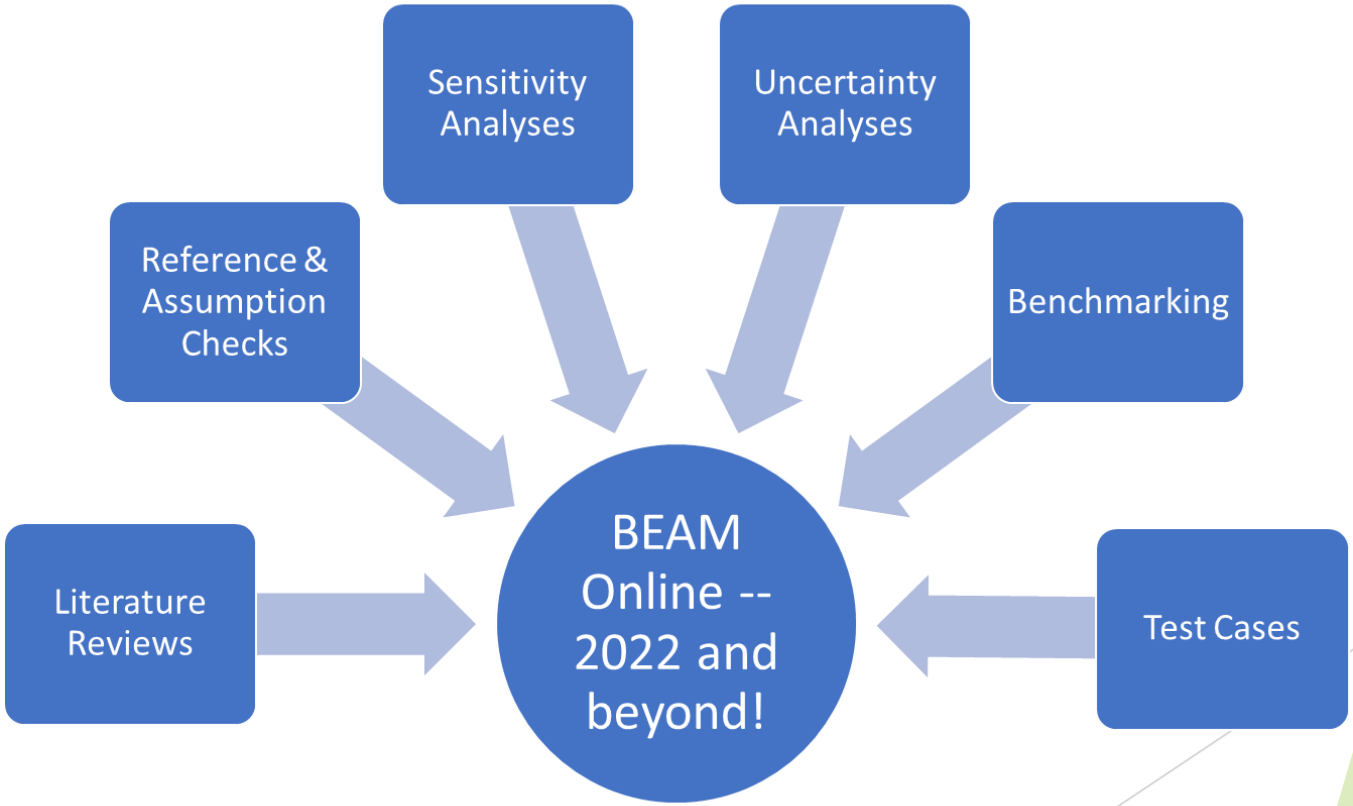
BEAM*2022 Review Process

- Annual reviews by the Science Review Team (SRT)
  - Annual updates to BEAM (e.g. BEAM*2023)
- Modules for new technologies typically developed as part of a project



The Reviewers – thanks!

- 2022 Science Review Team (all PhDs)
  - Sally Brown (University of Washingon)
  - John Willis (Brown & Caldwell)
  - Emma Shen (Jacobs)
  - Céline Vaneeckhaute (Université Laval)
  - Mike Badzmierowski (Virginia Tech/ Oregon Department of Agriculture)

BEAM*2022 Updates Include:

- Up to **10 scenarios** can be compared side by side
- More options for unit processes
- Key factors and calculations have been reviewed and updated based on more-recent published literature
- Updated user guide
- Default values and suggested ranges included
- List of changes from prior versions

Goal: Available by end of September 2022

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High Priority Topics for SRT Review for BEAM*2022

- Anaerobic digestion process details (%VSR, SRT)
- Carbon sequestration of land applied biosolids
- Fugitive CH_4 from biogas combustion (engines, flares)
- Electricity & heat efficiency from internal combustion engines
- Fertilizer offsets
- N_2O from combustion & land application

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High Priority Topics for SRT Review for BEAM in 2023

- Fertilizer offsets (GHG emissions from commercial fertilizer production)
- N_2O from combustion
- N_2O and methane from land application
- Fugitive CH_4 emissions from Anaerobic Digestion
- Carbon sequestration values

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BEAM*2022 Screenshot

WRRF Characteristics	
Amount of Wastewater Treated (MGD)	NA
Amount of Wastewater Treated (m^3/day)	NA
Population served by Wastewater Treatment Plant	NA
Annual Production of de-watered Biosolids (wet tons)	30,000
Location (from e-Grid)	Northeast US
Weighted GHG Emissions for Power Generation by Province (g/kWh)	368
GWP time horizon (years)	100

CO_2eq Totals (Mg/year)	*Scenario 1* *AD land ap*	*Scenario 2* *Land Ap Dry*	*Scenario 3* *Land Ap Biochar*	*Scenario 4* *ASP Compost*	*Scenario 5* *Windrow comp.*	*Scenario 6* *Incineration*	*Scenario 7* *Typical LF*	*Scenario 8* *Aggressive LF*	*Scenario 9* *Agg. LF RR AD*	*Scenario 10* *Mix of Options*
Unit Process	Land application of anaerobically digested, de-watered biosolids	Land Application of Anaerobically Digested, Dried Biosolids	Land Application of Pyrolyzed Biosolids after BioDrying (BFT Technology)	Composted Biosolids using ASP	Composted Biosolids using turned windrows	Biosolids combusted in fluidized bed incinerator	Biosolids landfilled in "Typical US Landfill" based on WARM parameters	Biosolids landfilled in landfill using aggressive capping and gas capture strategies	Aggressive LF of AD Solids using rail transport	Many options using anaerobically digested solids
Conditioning/Thickening	82	82	82	82	82	82	82	82	82	82
Anaerobic Digestion	-1,250	-1,250	-1,250	NA	NA	NA	NA	NA	NA	-1,250
De-watering	185	185	185	324	324	324	324	324	185	185
Thermal Drying	NA	2,560	NA	NA	NA	NA	NA	NA	NA	NA
BFT BioDrying	NA	NA	220	NA	NA	NA	NA	NA	NA	NA
Composting	NA	NA	NA	-3,964	-3,663	NA	NA	NA	NA	-661
Landfill Disposal - Typical	NA	NA	NA	NA	NA	NA	14,199	NA	NA	2,108
Landfill Disposal - Worst Case	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Landfill Disposal - Aggressive	NA	NA	NA	NA	NA	NA	NA	9,673	2,089	NA
Landfill Disposal - CA Regulatory	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Combustion	NA	NA	NA	NA	NA	2,259	NA	NA	NA	1,852
Pyrolysis	NA	NA	159	NA	NA	NA	NA	NA	NA	NA
Land Application	-1,914	-3,465	-1,987	NA	NA	NA	NA	NA	NA	-945
Transportation	439	122	55	702	702	2	702	702	139	445
TOTALS	-2,458	-1,767	-2,536	-2,856	-2,554	2,667	15,307	10,781	2,495	1,816
Wet Tons	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000
Wet Mg	27,223	27,223	27,223	27,223	27,223	27,223	27,223	27,223	27,223	27,223
Dry Mg	6,806	6,806	6,806	6,806	6,806	6,806	6,806	6,806	6,806	6,806
CO_2eq/Dry Mg	-0.36	-0.26	-0.37	-0.42	-0.38	0.39	2.25	1.58	0.37	0.27

Emissions by Gas Type (Mg/year)	*Scenario 1* *AD land ap*	*Scenario 2* *Land Ap Dry*	*Scenario 3* *Land Ap Biochar*	*Scenario 4* *ASP Compost*	*Scenario 5* *Windrow comp.*	*Scenario 6* *Incineration*	*Scenario 7* *Typical LF*	*Scenario 8* *Aggressive LF*	*Scenario 9* *Agg. LF RR AD*	*Scenario 10* *Mix of Options*
	Total	Total	Total	Total	Total	Total	Total	Total	Total	Total
CO_2	-4,081	-1,861	-2,636	-3,967	-4,089	-747	-944	-1,443	-2,398	-3,777
CH_4 (CO_2eq)	230.7	94	94	0	424	8	13,735	9,707	3,458	2,998
N_2O (CO_2eq)	1,392.2	0	5	1,111	1,111	3,406	2,517	2,517	1,435	2,595
Biogenic CO_2	2,523	2,523	4,857	0	0	9,410	1,132	1,576	561	4,329

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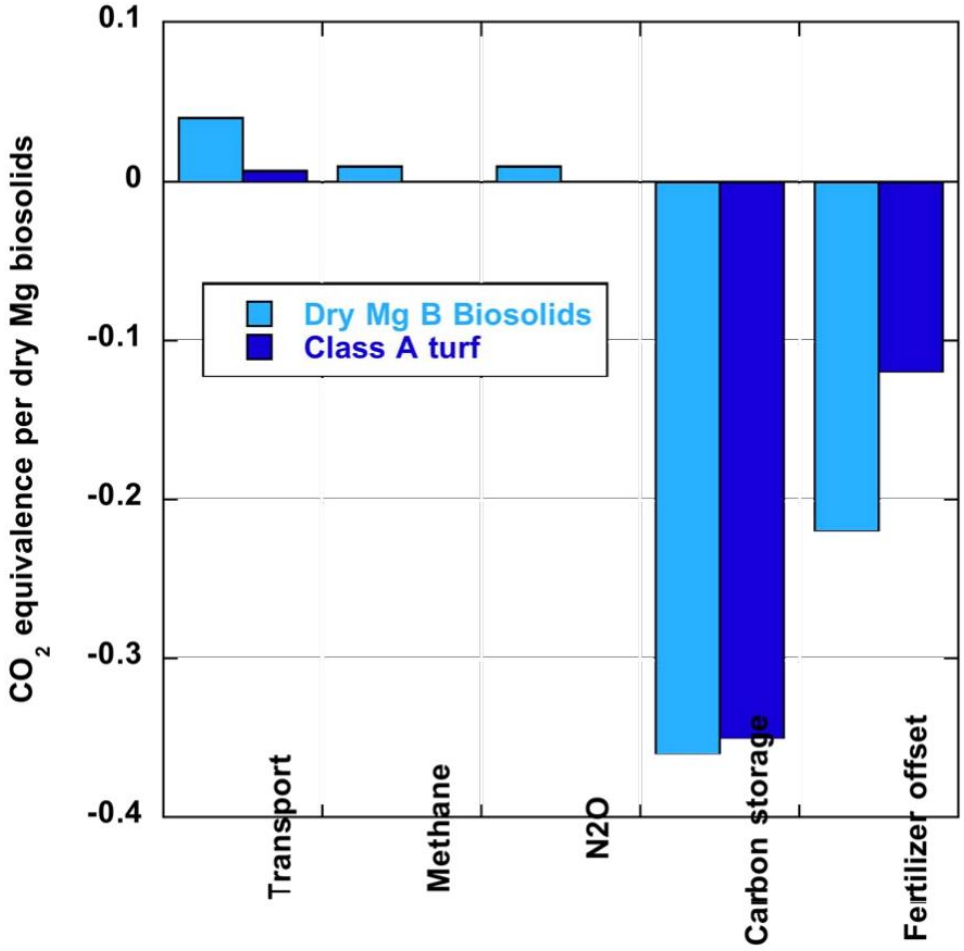
Examples of Using BEAM Over the Past Decade

Chicago MWRD: Comparing Management Options



Brown & Tian; 2010. https://mwrd.org/sites/default/files/documents/M&RSeminar_07-30-2010-Seminar-Brown_Tian_MWRD_CO2.pdf

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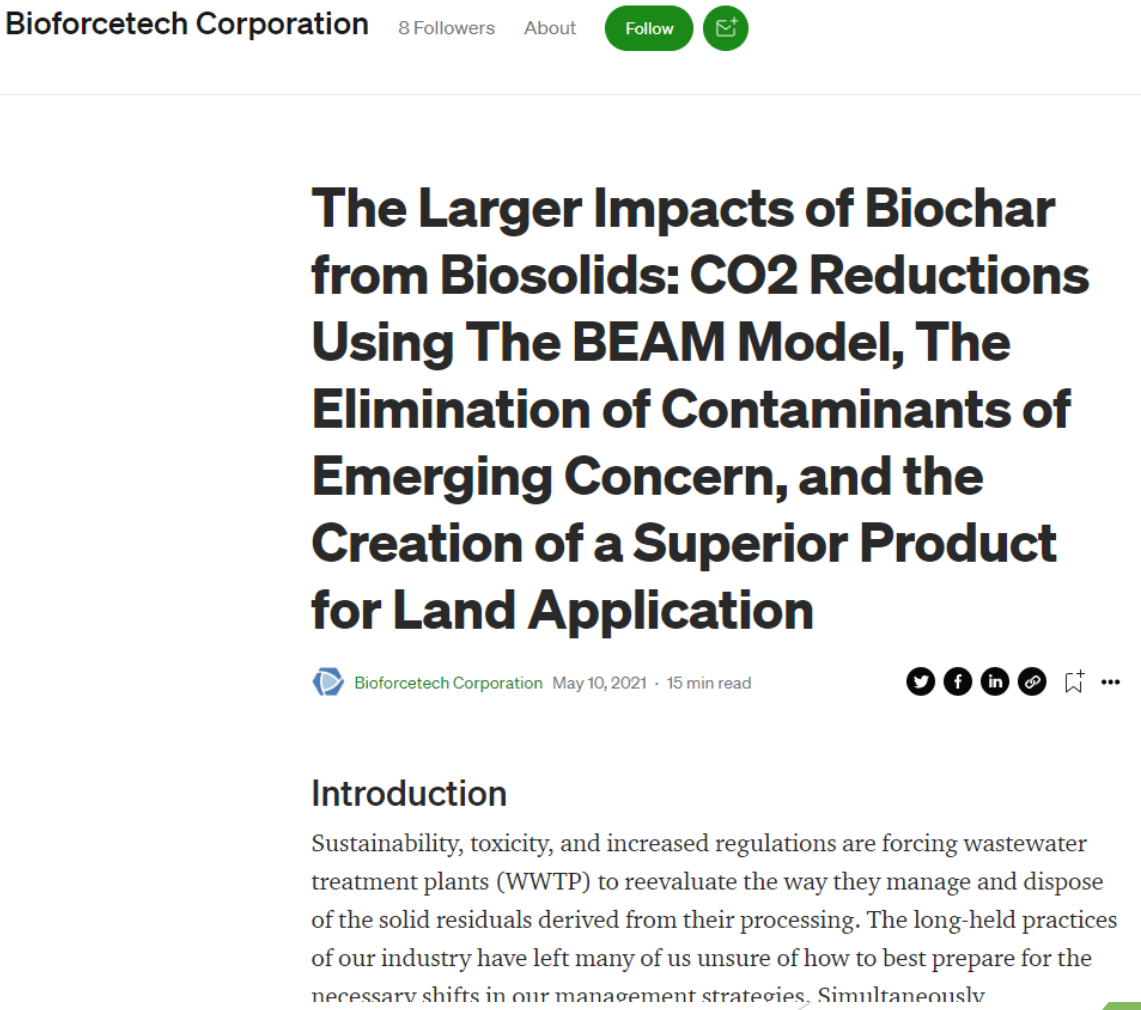
Australia: Referenced Carbon Sequestration Factor

Vendor: Technology-Specific Emissions Factors



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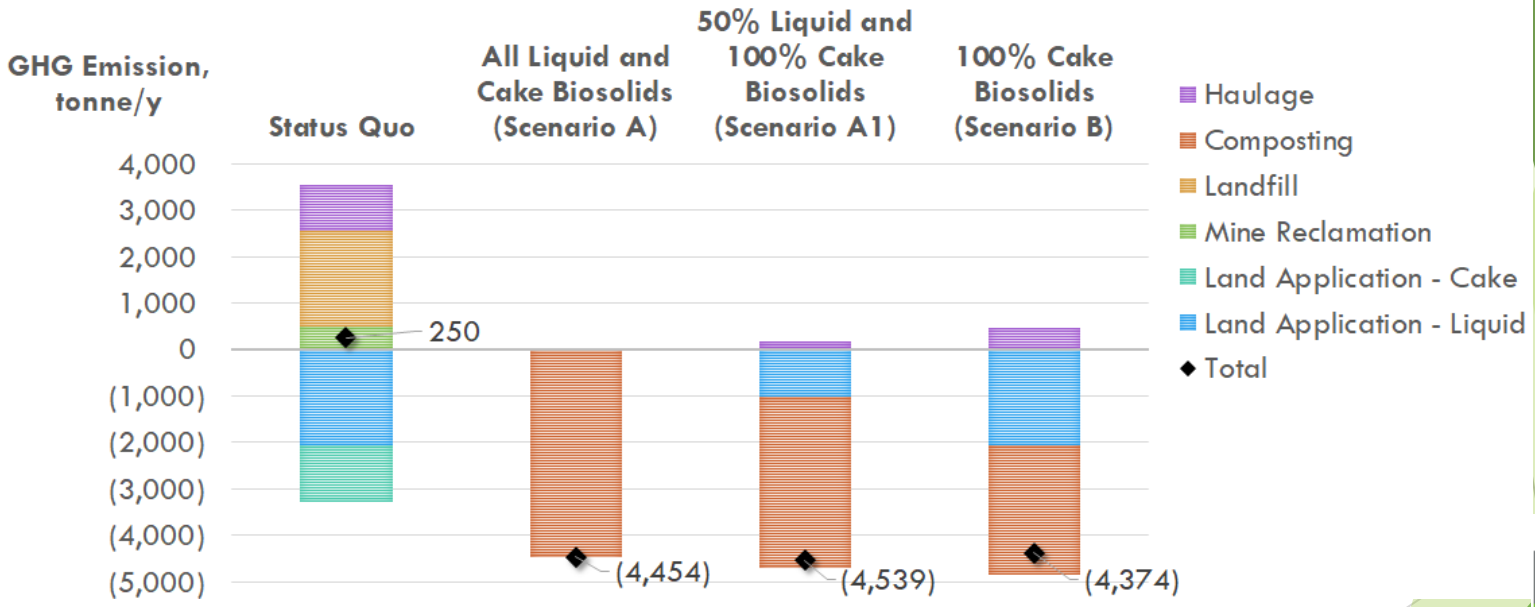
Halton Region, Ontario: Biosolids Composting Feasibility Study

- Demonstrating GHG benefits of composting over status quo to assist decision making



Reference: Proceedings from WEFTEC 2019, paper presentation by T.O. Williams. E. Shen, D. Ross, P. Morden, D. Iamarino – see https://www.accesswater.org/?id=-328435&fromsearch=true#iosfirsthighlight

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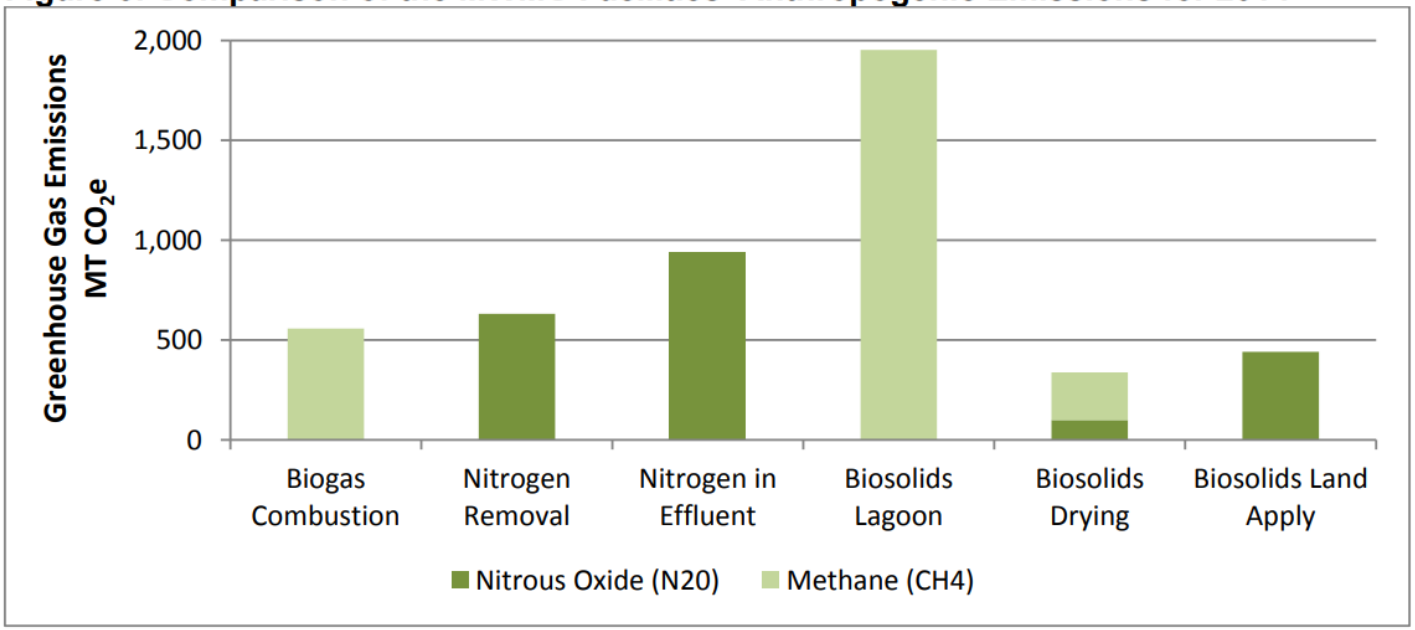
Eugene & Springfield, OR: Part of Modeling Full WRRF Inventory

Figure 6: Comparison of the MWMC Facilities' Anthropogenic Emissions for 2014



Eugene & Springfield, OR: https://www.eugene-or.gov/DocumentCenter/View/30521/2015-MWMC-GHG-Inventory?bidId

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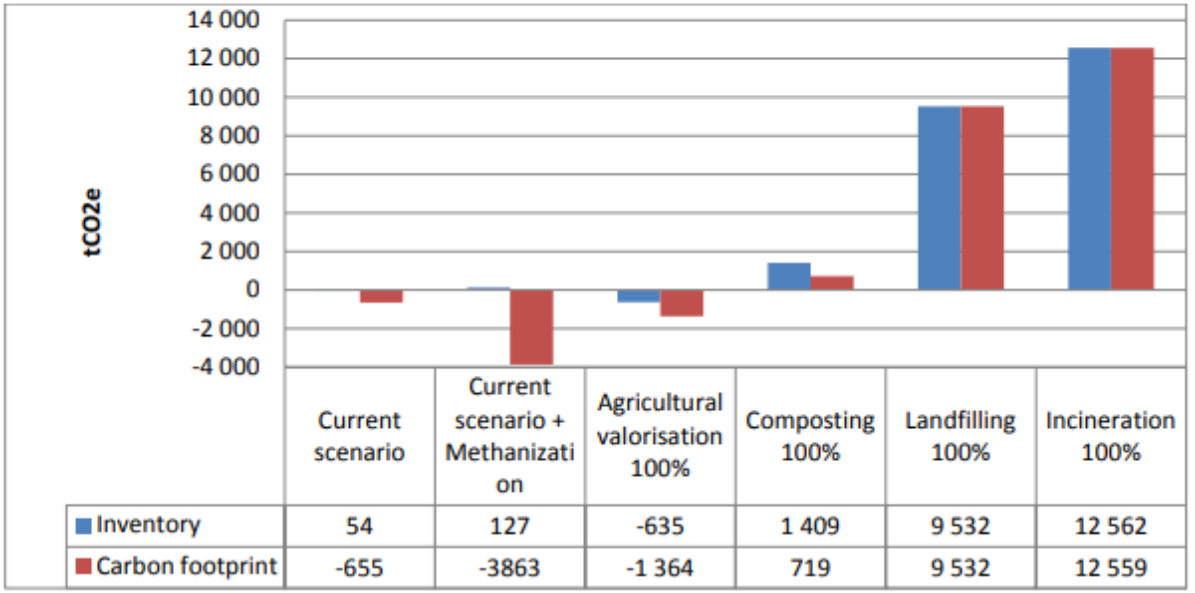
Québec: Baseline & Comparing Alternatives

Table 1. Summary of emissions for the current scenario

Agricultural valorisation (65%)	tCO_2e	Composting (35%)	tCO_2e
1-Process direct emissions			
Transportation	80	Transportation	41
Machinery	31	Machinery	88
CH_4 emissions	67	CH_4 emissions	221
N_2O emissions	47	N_2O emissions	360
Sequestration	-599	Sequestration	-287
2- Indirect emissions linked to energy use			
Electricity consumption	0	Electricity concumption	5
3- Other indirect emissions			
N replacement	-393	N replacement	-193
P replacement	-81	P replacement	-42
Total (1 + 2)	**54**		
Total (1 + 2 + 3)	**-655**		

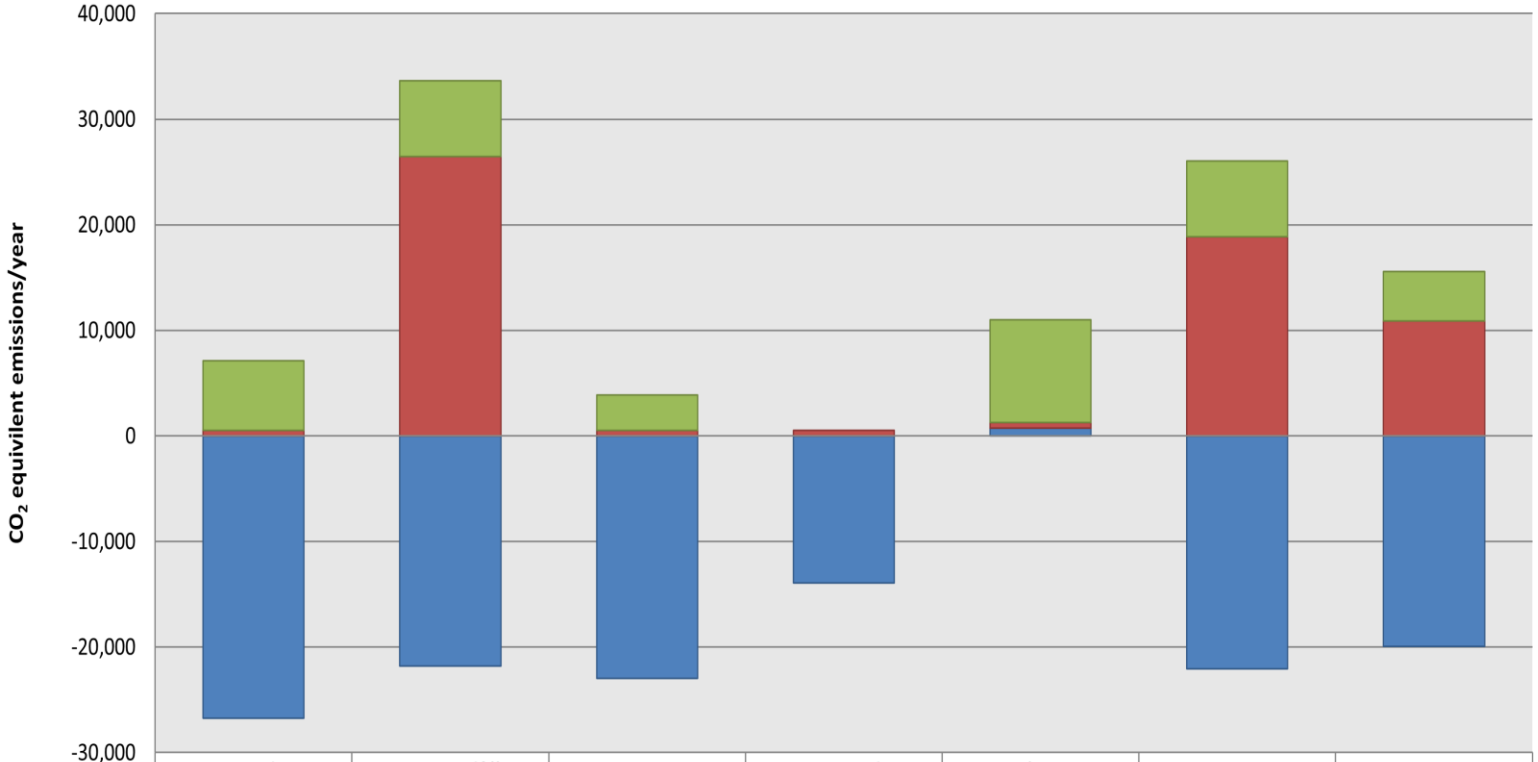
Figure 2. Comparison of annual emissions for five different scenarios of biosolids management for the city of Saguenay.



	Current scenario	Current scenario + Methanization	Agricultural valorisation 100%	Composting 100%	Landfilling 100%	Incineration 100%
Inventory	54	127	-635	1 409	9 532	12 562
Carbon footprint	-655	-3863	-1 364	719	9 532	12 559

Saguenay, Villaneuve & Dessurealt; 2011: https://www.environnement.gouv.qc.ca/matieres/articles/Municipal-biosolids.pdf

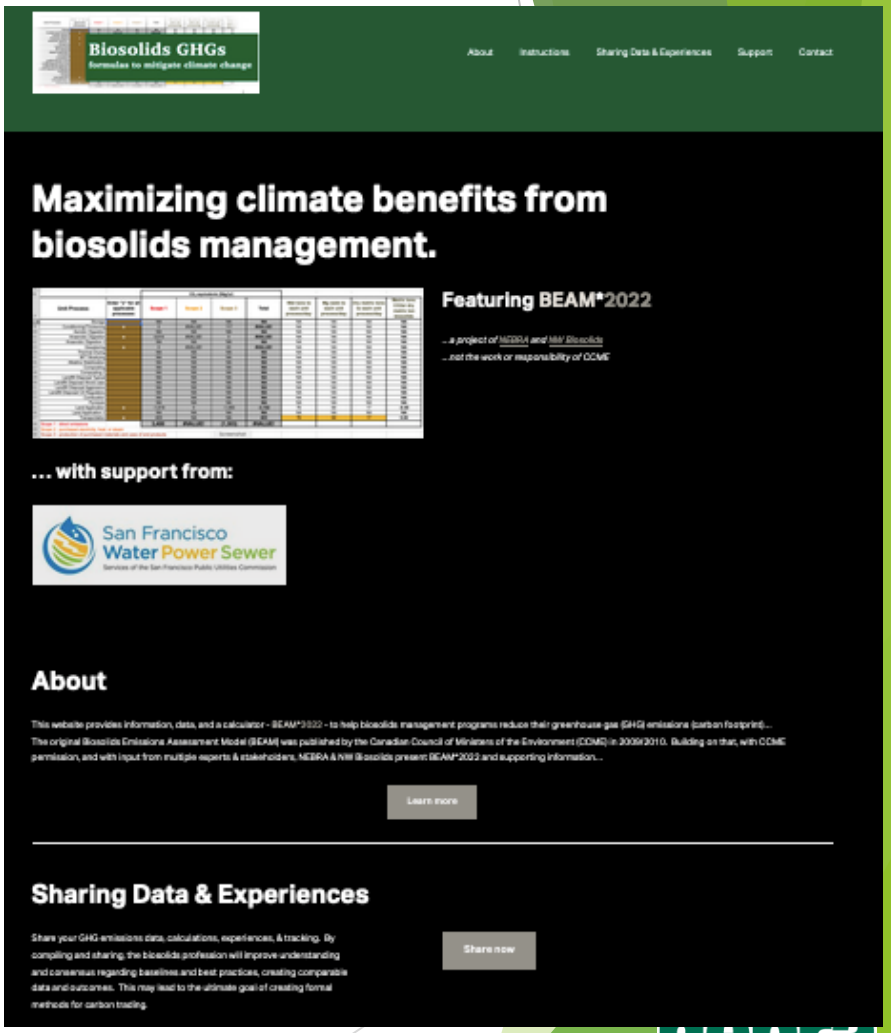
Example of BEAM*2022 Output:
Comparing Biosolids Management Options for a Large WRRF



	AD Land Ap	Typ Landfill	Composting	Drying Land Ap	Combustion	Aggressive LF	Composite
N2O (CO2eq)	6,573	7,171	3,334	0	9,702	7,171	4,658
CH4 (CO2eq)	533	26,469	533	533	558	18,863	10,890
CO2	-26,742	-21,804	-22,981	-13,940	716	-22,070	-19,915

New Website: BiosolidsGHGs.org

- Spreadsheet available for download
  - Sliding scale recommended donation to support ongoing annual reviews & website hosting
- Supporting documents & links
  - Resources for utilities on GHG emissions & calculations
  - Standard protocols
- Space for sharing:
  - results
  - tips
  - uses of data



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Future?

- BEAM*2022 becomes the consensus method for calculating GHG emissions from biosolids management
- A resource hub with crowd-sourced supporting information & examples
- Respected source for biosolids-specific emissions/reductions/sequestration factors
- Eventually helping develop protocols and working with registrars to allow for marketable carbon offsets

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NEBRA Membership

- Biosolids/residuals managers from Quebec, Atlantic Provinces – you need NEBRA!
- **NEBRA needs more Canadians!**
- Carbon-Trading Committee
- Your input welcome & needed.

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Questions?