# Greenhouse Gas (GHG) Emissions from Wastewater Treatment and Biosolids Management

**Ned Beecher**

**North East Biosolids and Residuals Association**

**NH Joint Water & Watershed Conference**

**November 20, 2009**

**Concord, NH**

Photo: *BioCycle*

# Presentation Outline

- Quick overview of wastewater treatment and biosolids management
- What are the potential greenhouse gas (GHG) emissions from these processes?
- Mitigating GHG emissions
  - Energy efficiency
  - Optimize processes to keep them aerobic
  - Offset fossil fuel use by extracting energy from biosolids.
  - Sequester captured carbon (C).

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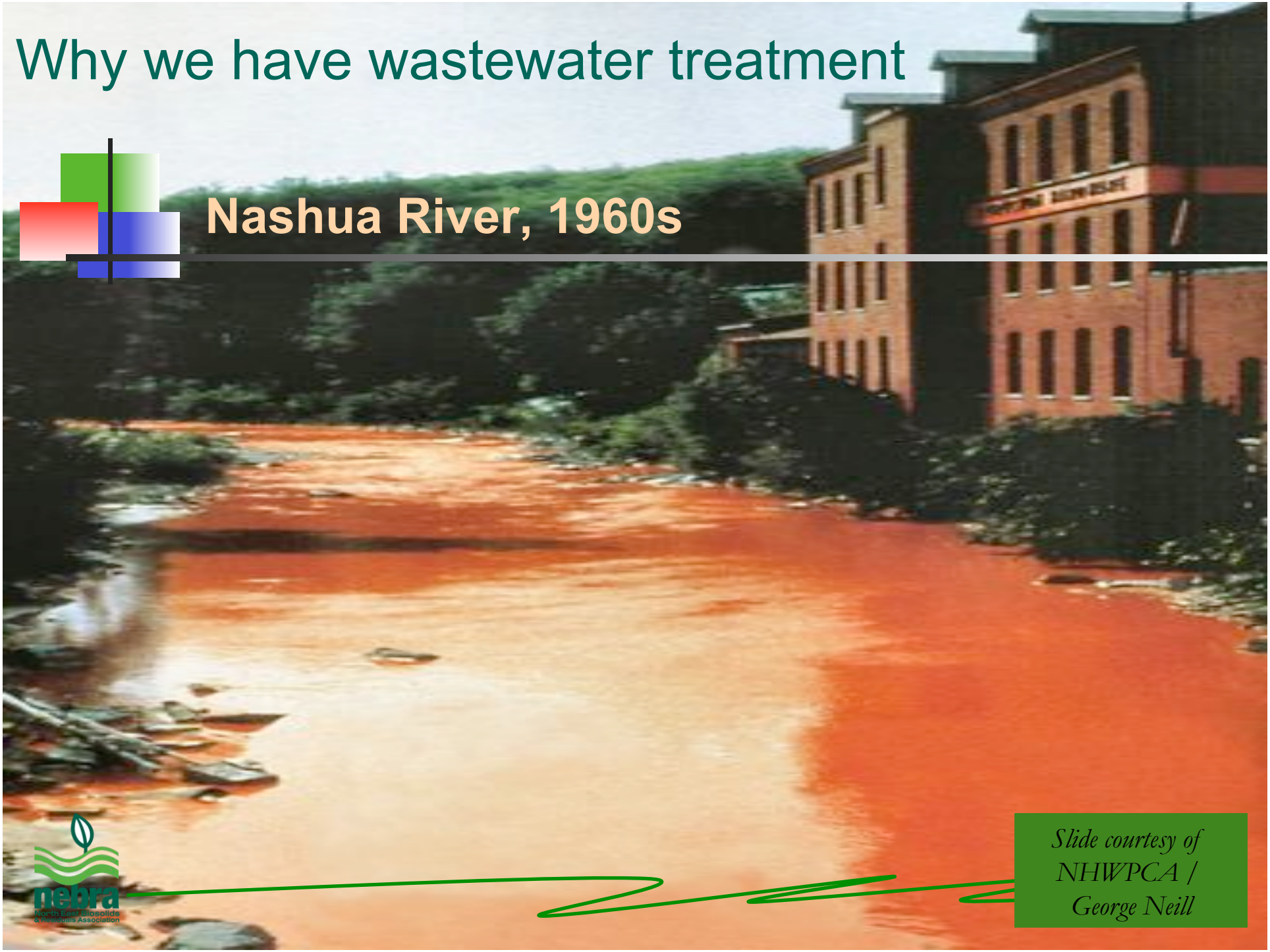
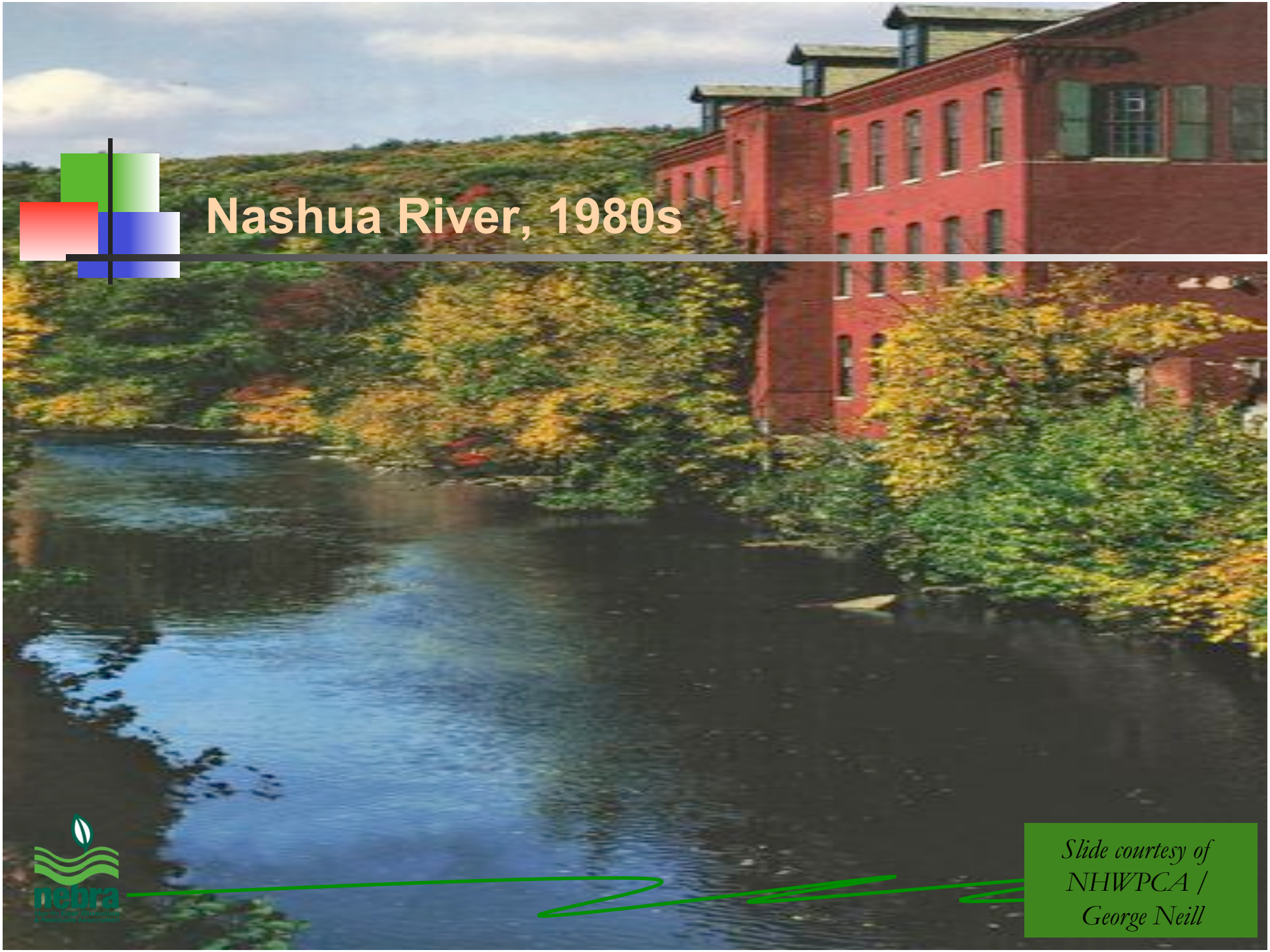
# Why we have wastewater treatment



# Nashua River, 1980s



*Slide courtesy of NHWPCA / George Neill*

# Manchester, NH – state's largest WWTP

*Slide courtesy of NHWPCA / George Neill*

# Biological treatment is the norm.

microorganisms

air is bubbled through the wastewater to help microorganisms thrive; pH and temperature are also controlled

Middlebury, Vermont

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# Solids are separated out in clarifiers.

Keene, NH

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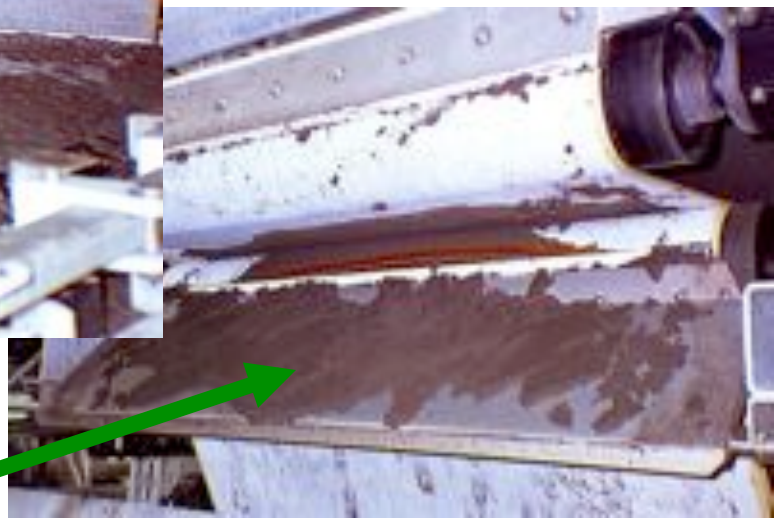
# Solids are treated, dewatered…
# …and must be managed…



…creating
biosolids

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## Wastewater treatment uses energy.

## Biosolids can provide energy and offset greenhouse gas emissions.

**biosolids**: plural noun: organic matter recycled from sewage, especially for use in agriculture

*--New Oxford Dictionary of English, 1998*

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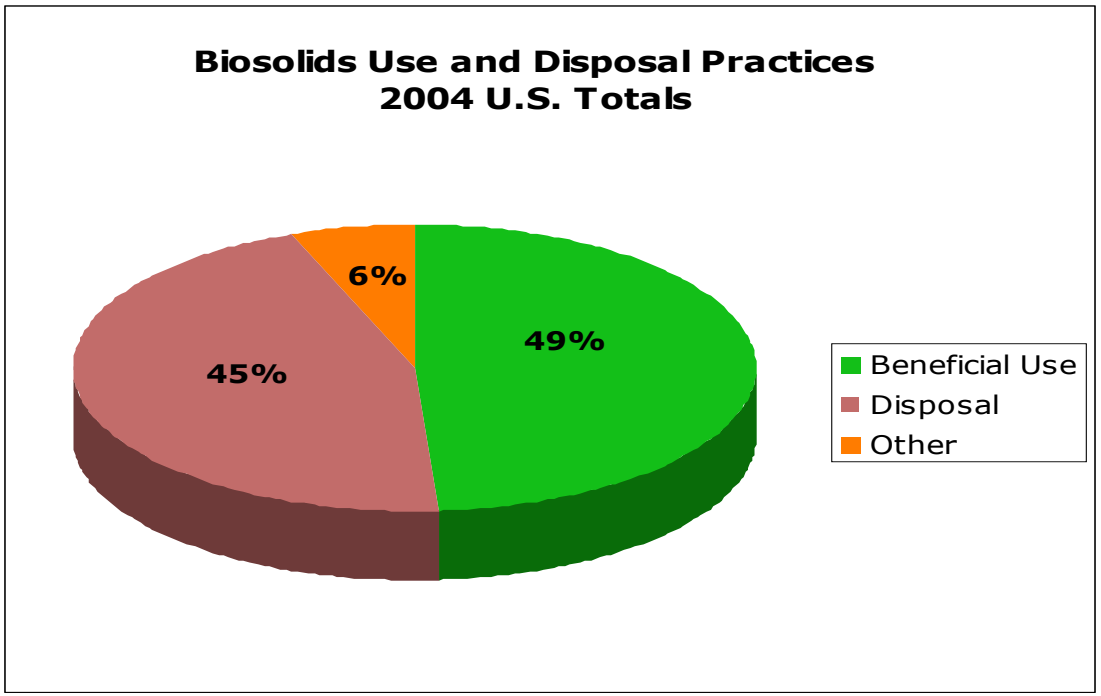
# What happens with U. S. biosolids?

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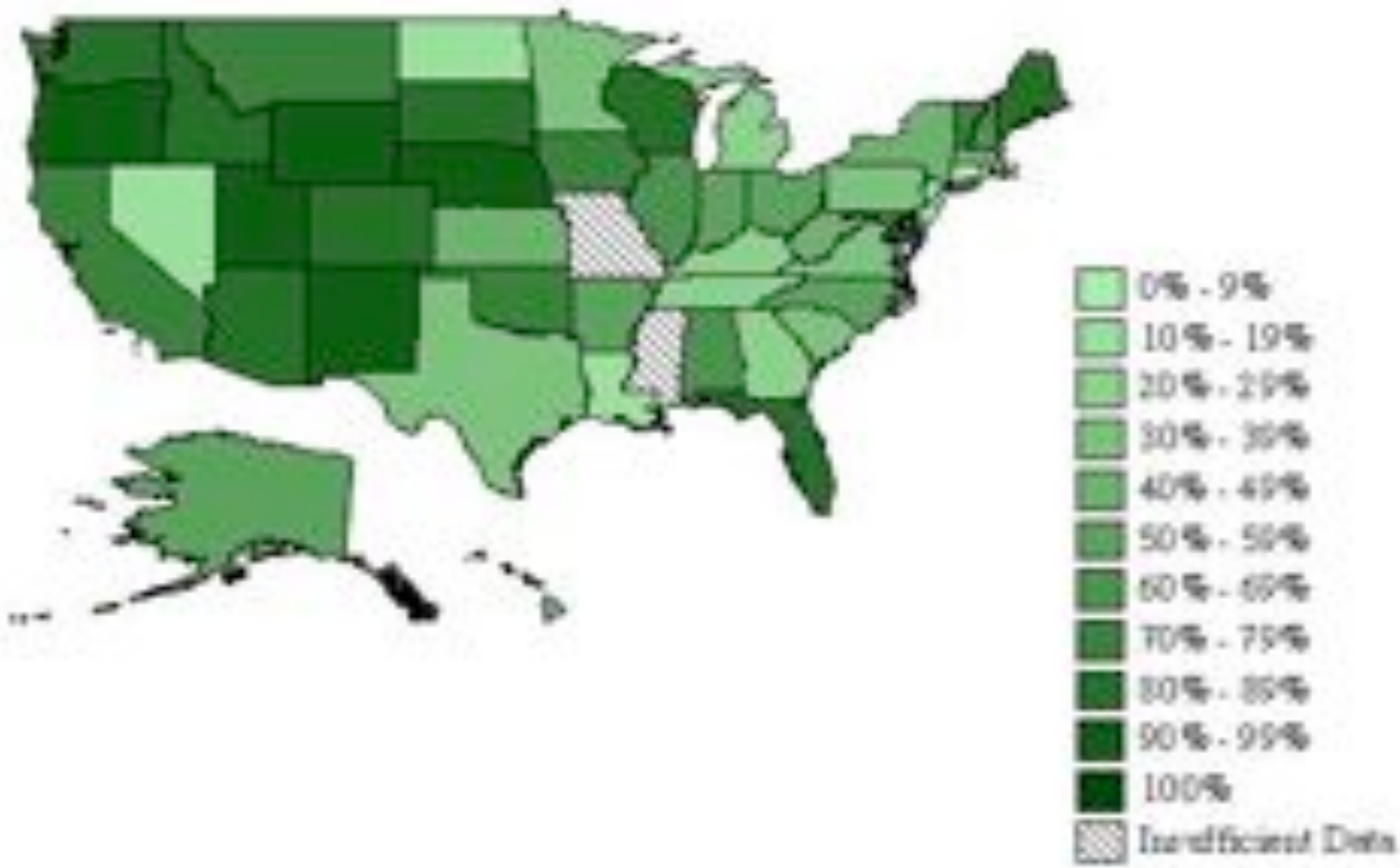
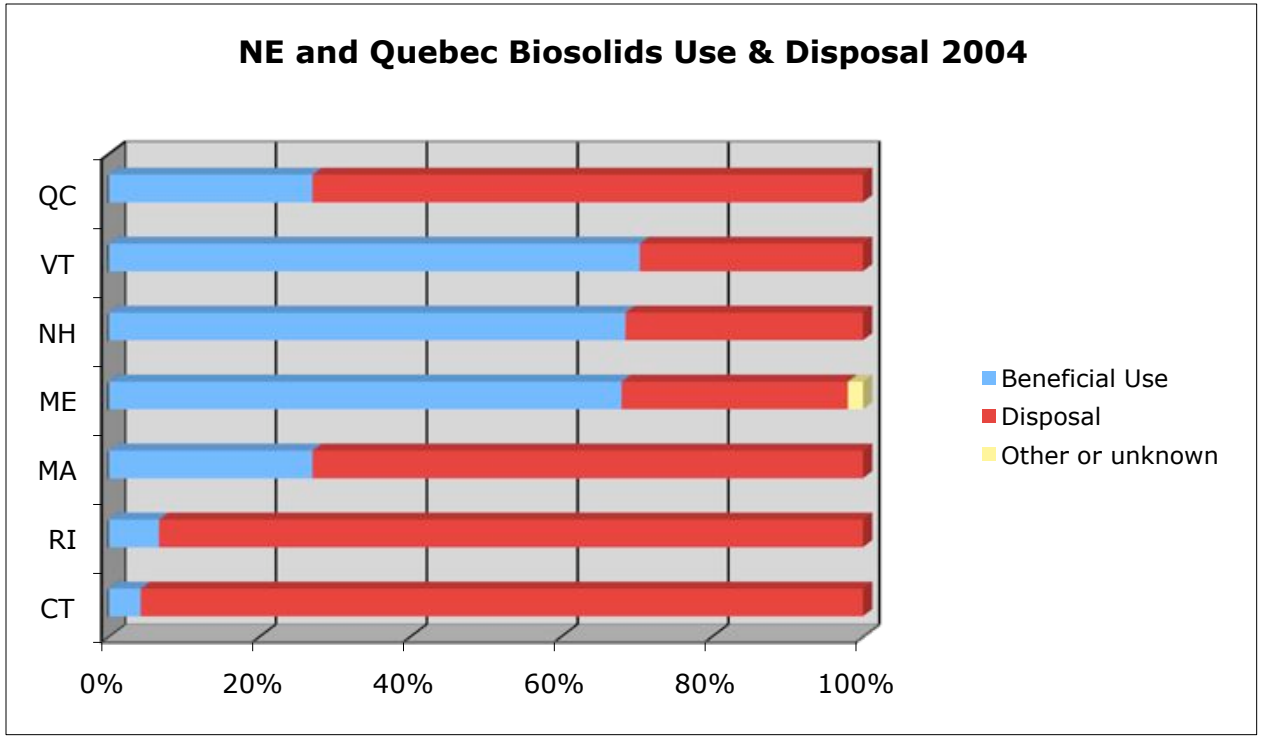
# Percent Biosolids Beneficially Used by State, 2004



# New England & Quebec

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# Land application (41% of U. S. biosolids)

NH farm sites

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# It's effective…

The darker green areas of these grass hay fields have been fertilized with bulk Class B biosolids.

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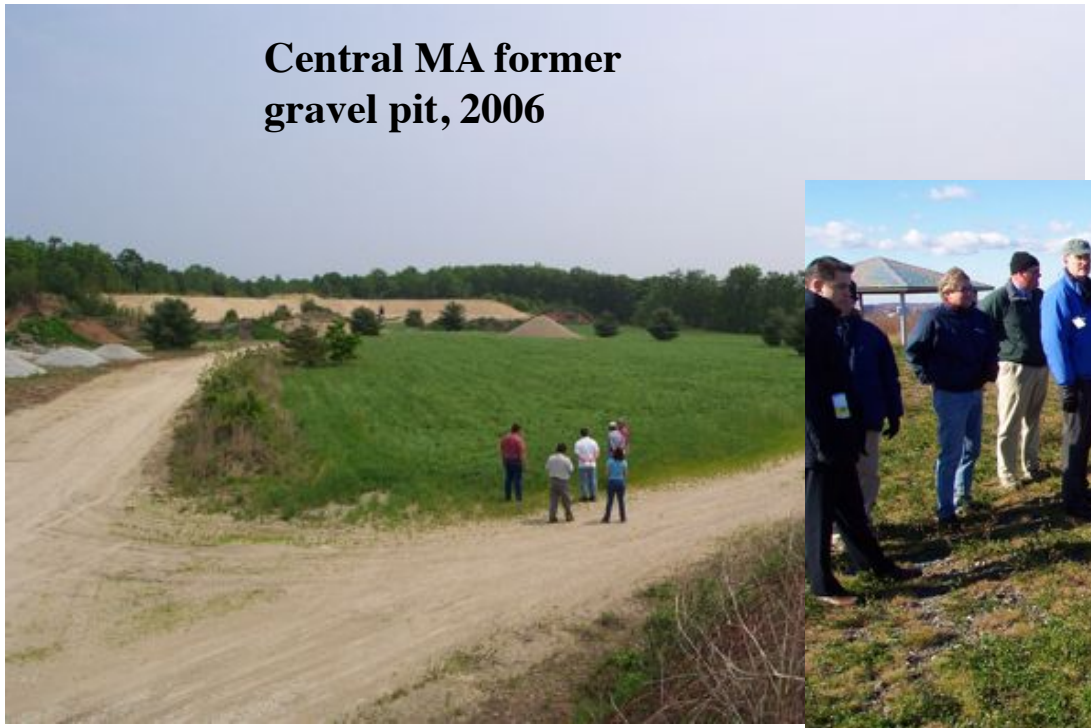
# Land reclamation (3% of U.S. biosolids)



**Central MA former gravel pit, 2006**

**Boston Harbor Islands, 2004**

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# It's effective…

a NH gravel pit 2 years after reclamation

1 year after reclamation

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# Composting

**Merrimack**

# It's effective in horticulture & landscaping…

The Great Lawn in New York's Central Park is growing on Merrimack, NH biosolids compost.


Biosolids compost for wildflowers along a NH interstate highway.

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# Dried biosolids

GLSD, Massachusetts (includes wastewater from Salem); Boston also makes dried biosolids pellets

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# Dried biosolids are effective…

Castle Island, South Boston

...some are used right close to home…

The Esplanade along the Charles River is fertilized with Bay State Fertilizer.

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# Biosolids can provide energy
## (but incineration is not the efficient way)

Biosolids pellets are burned in cement kiln,
(Wikipedia photo)

Minnesota (photo courtesy
Metropolitan Council)

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# Biosolids can provide energy
## (digestion is efficient)

Nashua:

- Anaerobic digester reduces biosolids volume and cost by > 50%.
- Costs for biosolids use reduced by ~ $1 million /yr.
- Electricity produced from burning biogas saves the plant an estimated $10,000 / month.
- Greenhouse gas benefits…

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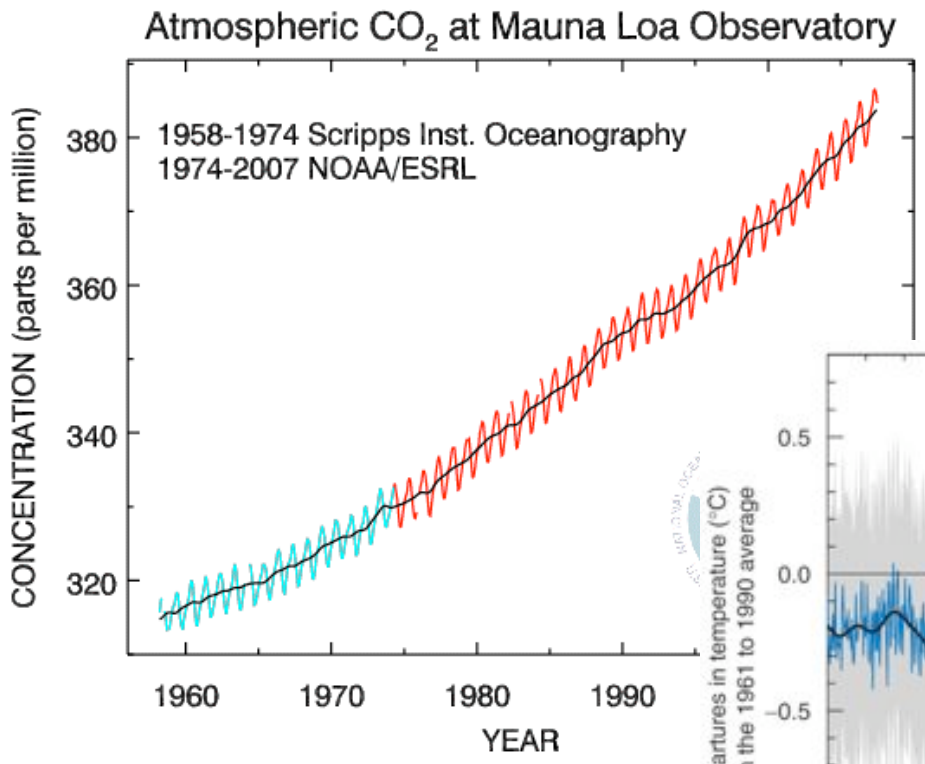
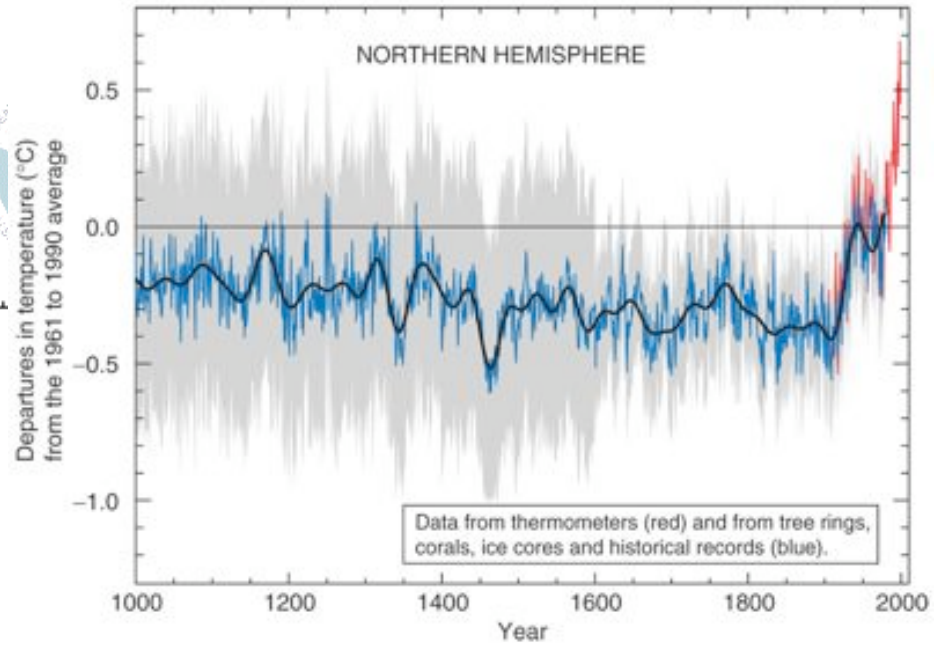
# Talking of greenhouse gases…

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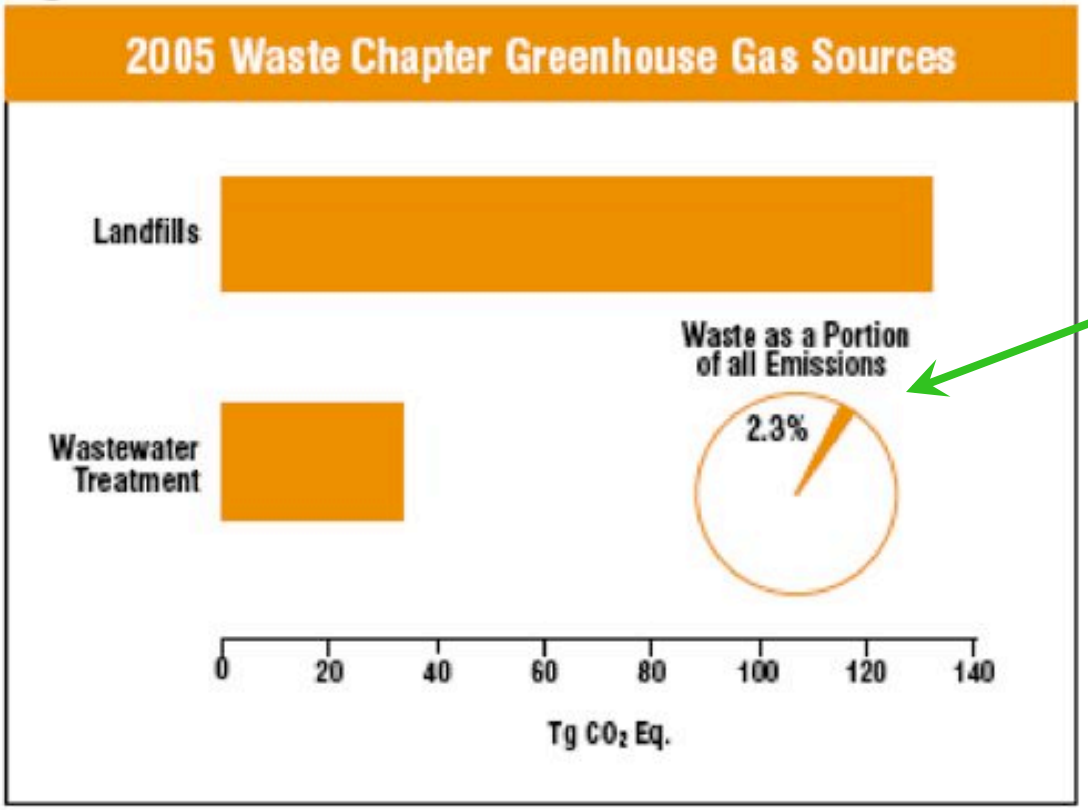
# Waste management = small %

(wastewater treatment = even smaller %)

Figure 8-1




2.3% of all emissions; wastewater treatment = 1/4 of that

EPA, 2007

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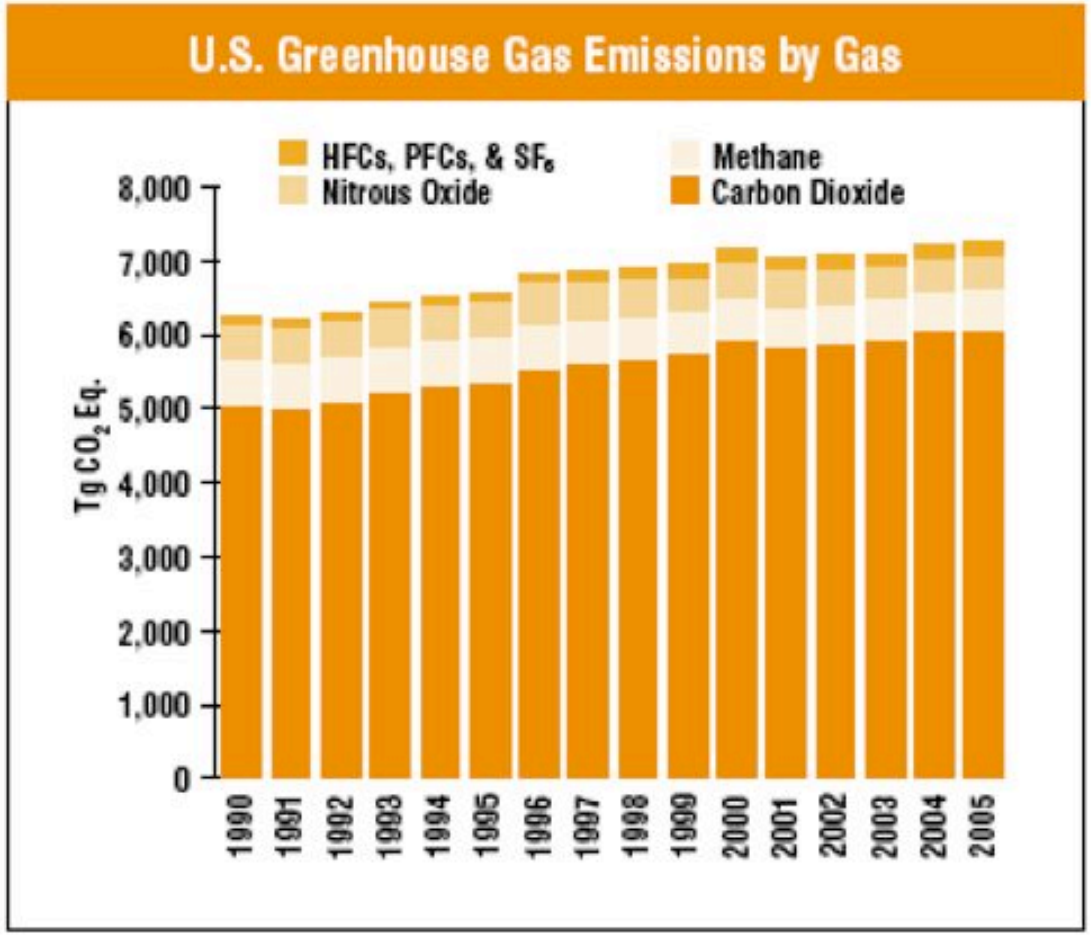
# $CO_2$ (mostly from energy use) is most notable GHG

**Figure ES-1**




EPA, 2007: *Inventory of U. S. Greenhouse Gas Emissions and Sinks: 1990-2005*

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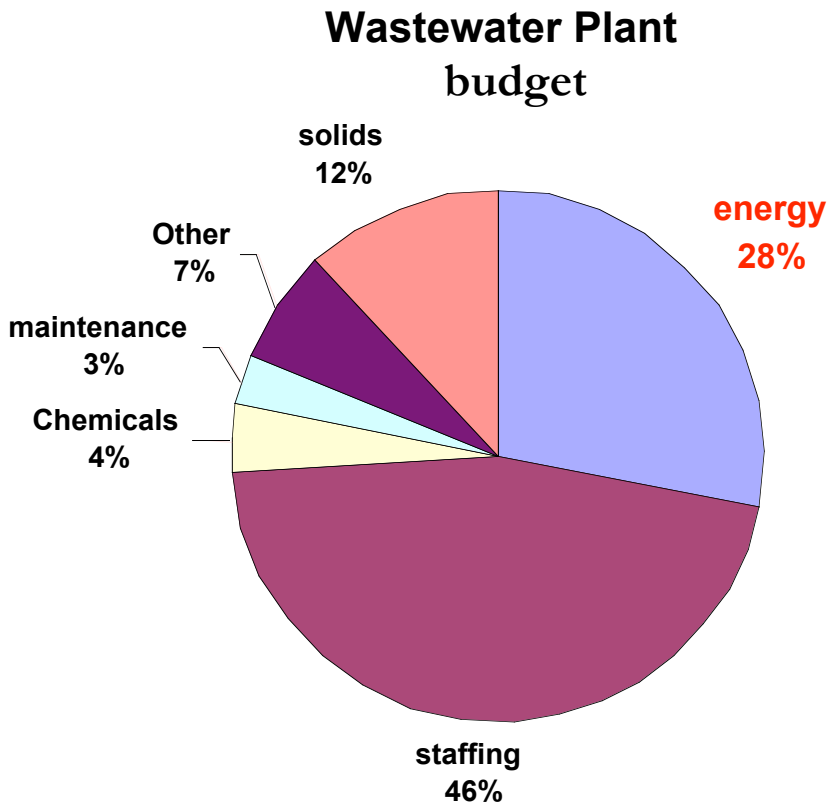
# WWTPs use lots of energy (= CO2 emissions)

- Wastewater treatment uses 3% of electricity in U. S. (EPA)
- In any city, this percentage is higher – up to 20%
- Lots of room for more energy efficiency and reducing CO2 emissions (current focus)

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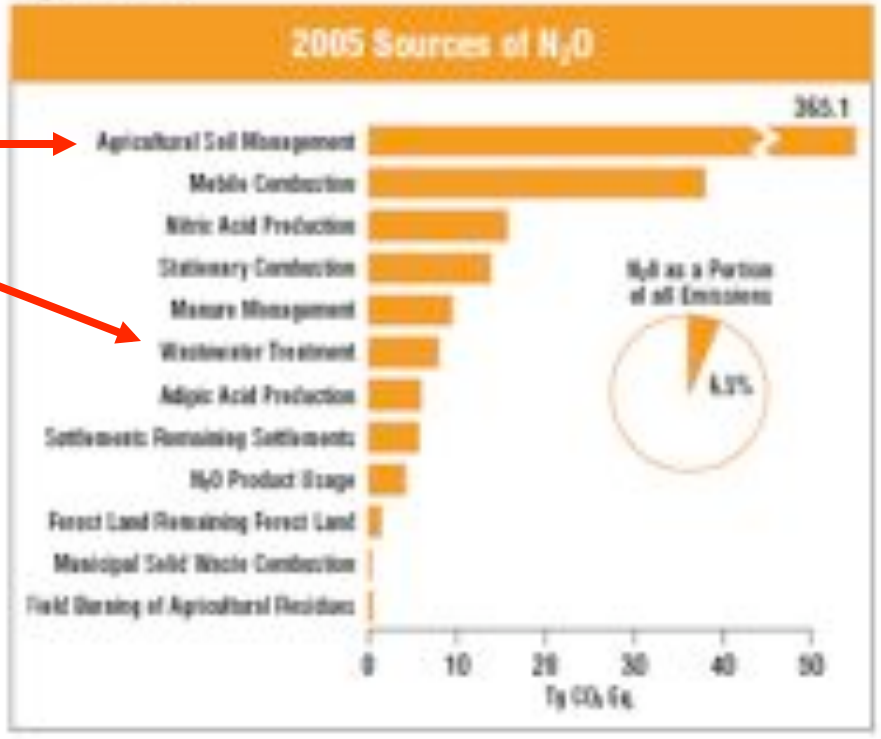
# BUT… CH4 and N2O are also BIG for WWTPs

**Figure ES-8**


**Figure ES-9**




EPA, 2007: http://www.epa.gov/climatechange/emissions/downloads06/07ES.pdf

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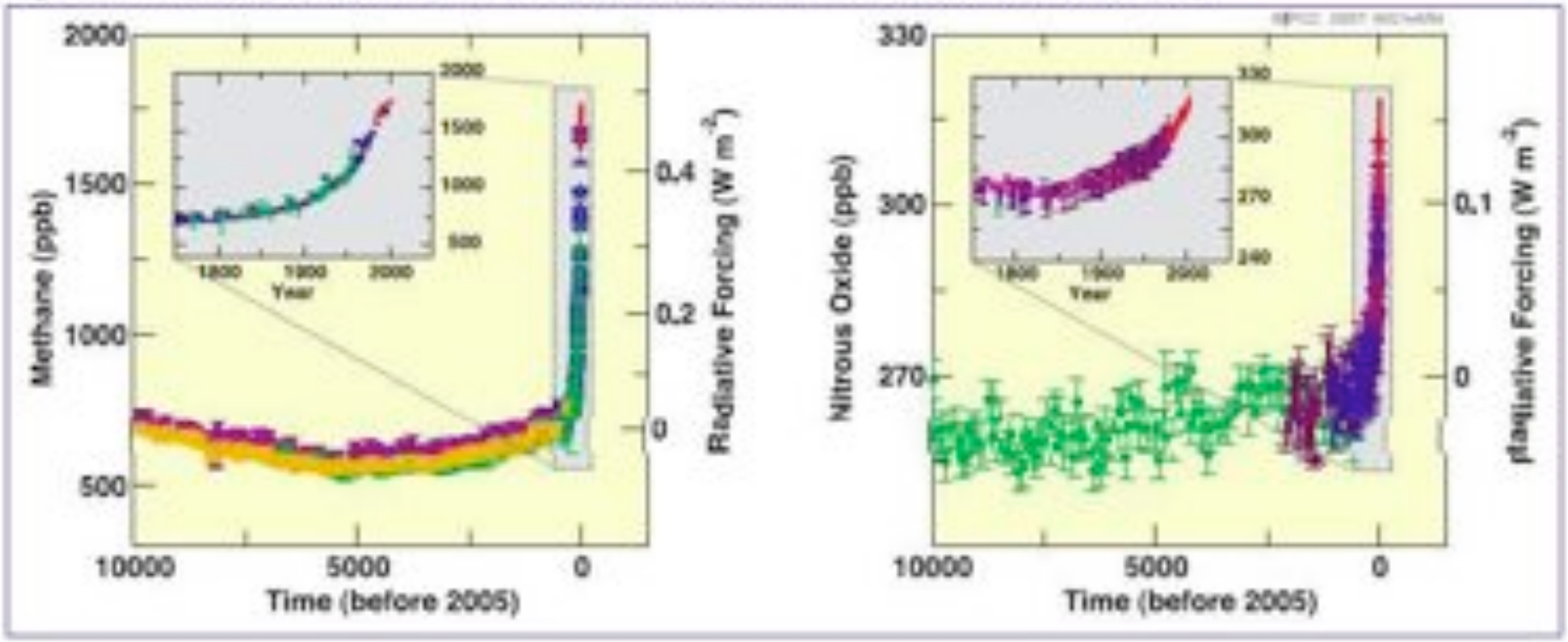
# $CH_4$ & $N_2O$

Figure 2 Atmospheric Methane and Nitrous Oxide Concentrations (IPCC, 2007)

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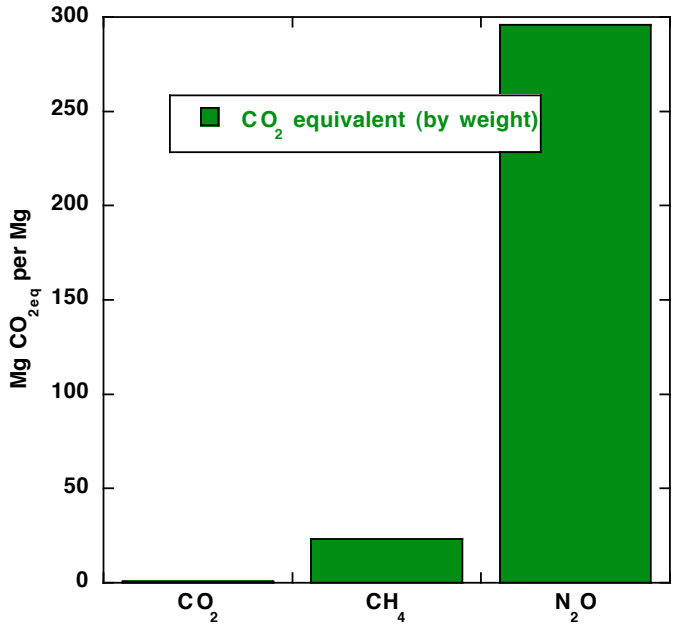
# Global Warming Potential (GWP)

- $CO_2 = 1$
- $CH_4 = 21\ CO_2e$ (or 25 per latest IPCC 4th assessment)
- $N_2O = 310\ CO_2e$ (or 296 per latest IPCC)
- But over < 100 years, methane has higher GWP: ~ $72\ CO_2e$
- Curbing these emissions now can provide "bridge" to low-C energy

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# Potential GHGs from on-site (septic) systems

- EPA estimates 75% of CH4 from wastewater treatment comes from septic systems (anaerobic tanks)
  - Questionable assumption; scant research
  - Does covering soil oxidize CH4?
  - Water Environment Research Foundation current study
- Most NH septage goes to WWTPs
  - Adds to solids - and GHG - production there
  - Some land applied (minimal GHG losses)

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# Potential GHG emissions from WWTPs & biosolids

- Debits:
  - $CO_2$ from fossil fuel & electricity use
    - Direct & indirect (e.g. in polymers, lime)
  - $CH_4$ from anaerobic wastewater or biosolids
  - $N_2O$ from near-anaerobic materials & combustion
- Credits (all are from how biosolids are managed):
  - Energy from biosolids
  - Offsetting fertilizer, peat, and lime use
  - Sequestering C

**Remember…any $CH_4$ or $N_2O$ are especially significant!**

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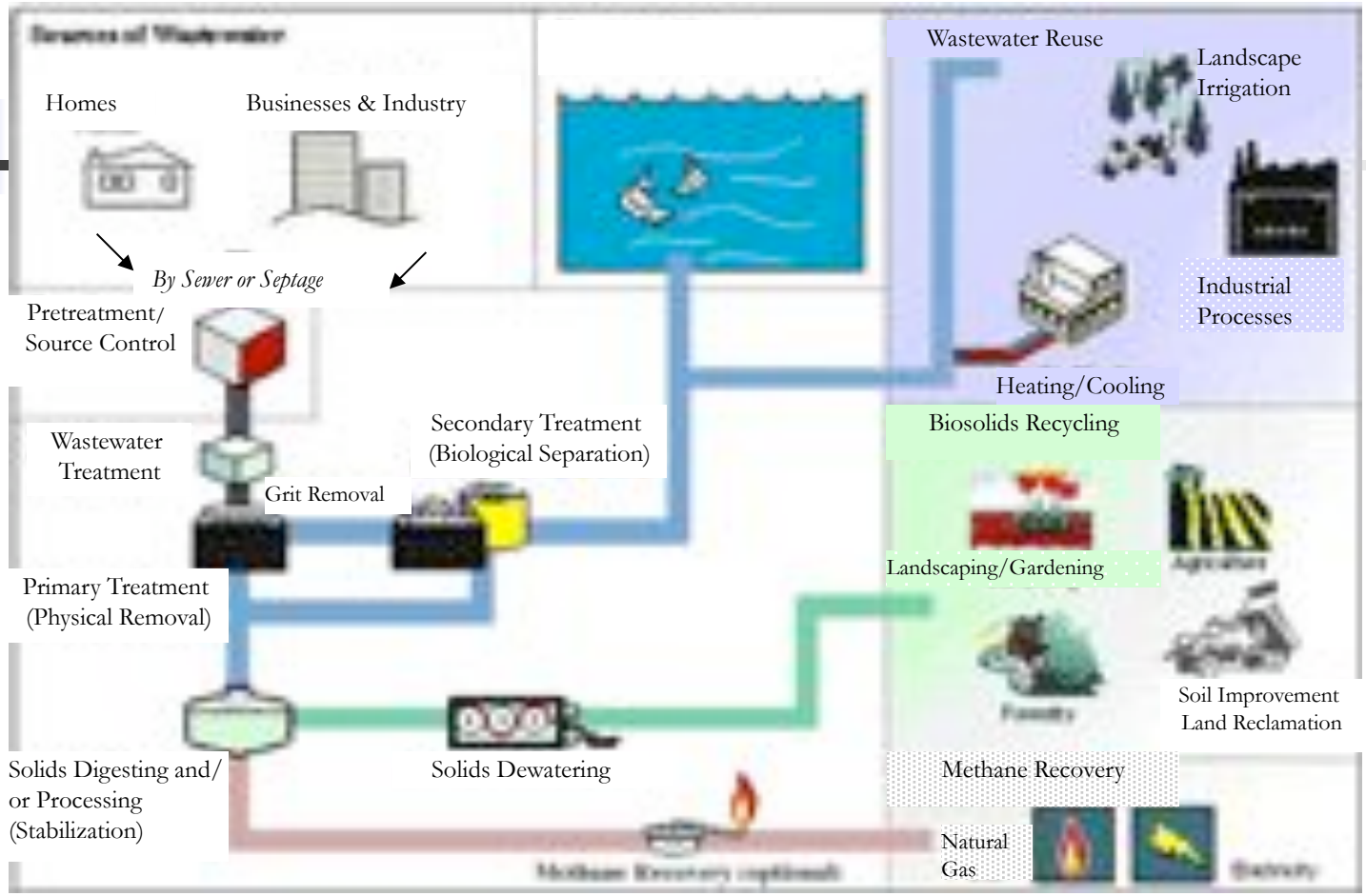
# Typical Wastewater Treatment Plant




*Source: Northwest Biosolids Management Association*

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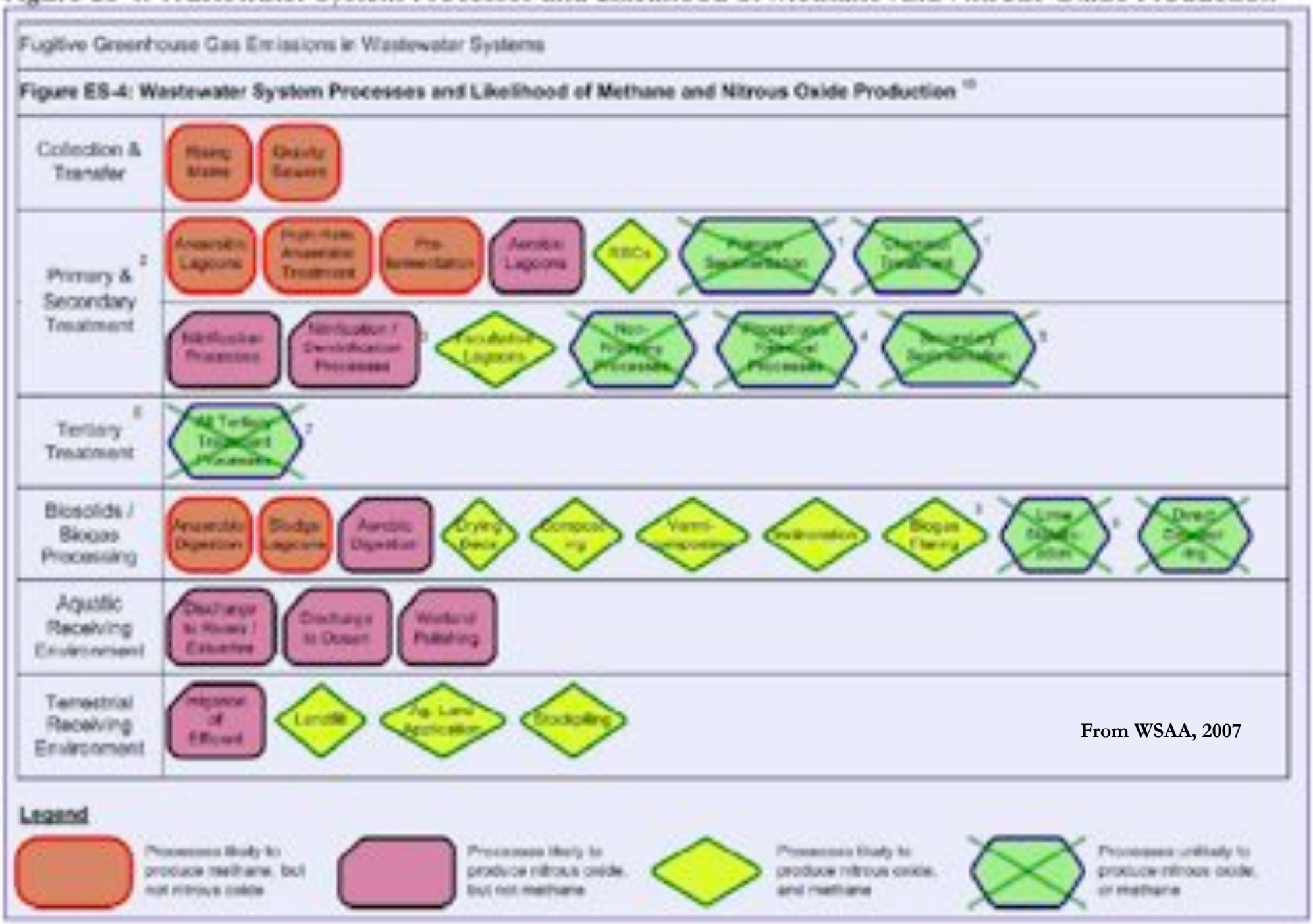
## Figure ES-4: Wastewater System Processes and Likelihood of Methane And Nitrous Oxide Production




From WSAA, 2007

# Mitigating GHGs at WWTPs

1. Energy efficiency (VSD pumps, fine-bubble, etc.)
2. Optimize processes to keep them aerobic (assess & avoid $CH_4$ & $N_2O$ losses).
3. Offset fossil fuel use by extracting energy from biosolids.
4. Sequester captured carbon (C).

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# Portfolio Manager

## www.energystar.gov/benchmark

- EPA energy benchmarking system
- Now has module for WWTPs
- Compares a WWTP to similar plants
- Tracks energy efficiency improvements

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# Extracting energy: Nashua is a leader!

(digestion is most efficient)

**Nashua**:

- Anaerobic digester reduces biosolids volume and cost by > 50%.
- Costs for biosolids use reduced by ~ $1 million /yr.
- Electricity produced from burning biogas saves the plant an estimated $10,000 / month.
- Greenhouse gas benefits…

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# Sequestering C = less $CO_2$ in atmosphere

- "Soils can contain as much as or more carbon than living vegetation. For example, 97 percent of the 335 billion tons (304 billion metric tonnes) of carbon stored in grassland ecosystems is held in the soil" (Amthor et al, Oak Ridge National Lab, 1998, as quoted at http://www.sustainablesites.org).

- "Some cultivated soils have lost one-half to two-thirds of the original SOC* pool ….The soil C sequestration is a truly win–win strategy. It restores degraded soils, enhances biomass production, purifies surface and ground waters, and reduces the rate of enrichment of atmospheric $CO_2$ by offsetting emissions due to fossil fuel" (R. Lal, Ohio State, 2004).

*soil organic carbon

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# Biosolids, manures, & compost have “C” for soils…

- Compost food waste
- Compost yard trimmings
- Manures / biosolids

Return them to soils!

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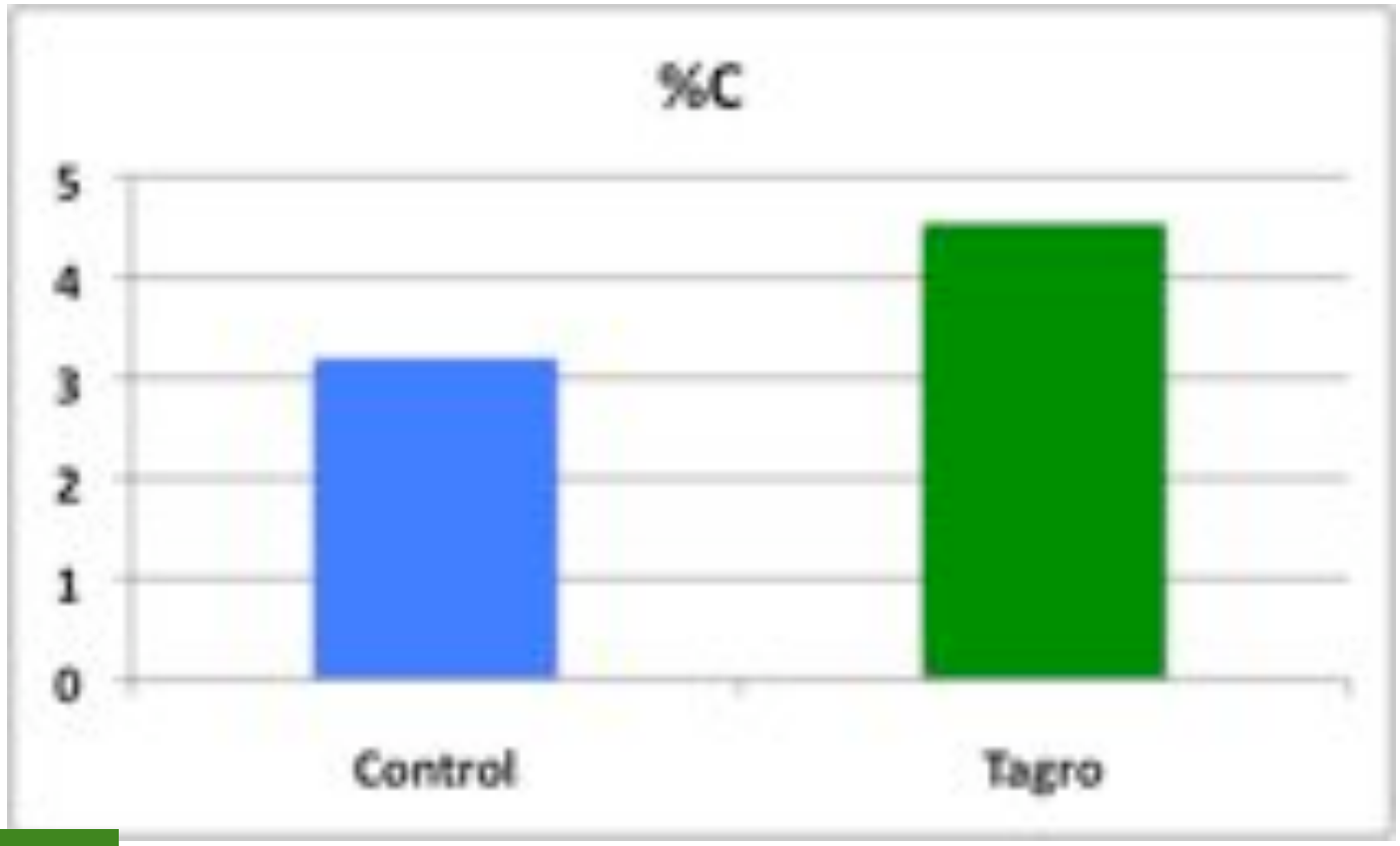
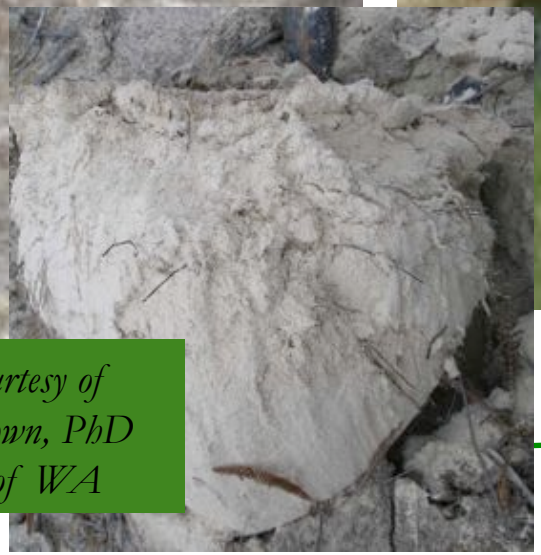
# Soil C after 10 years of gardening




*Slide courtesy of Sally Brown, PhD Univ. of WA*

# Soil C after site reclamation

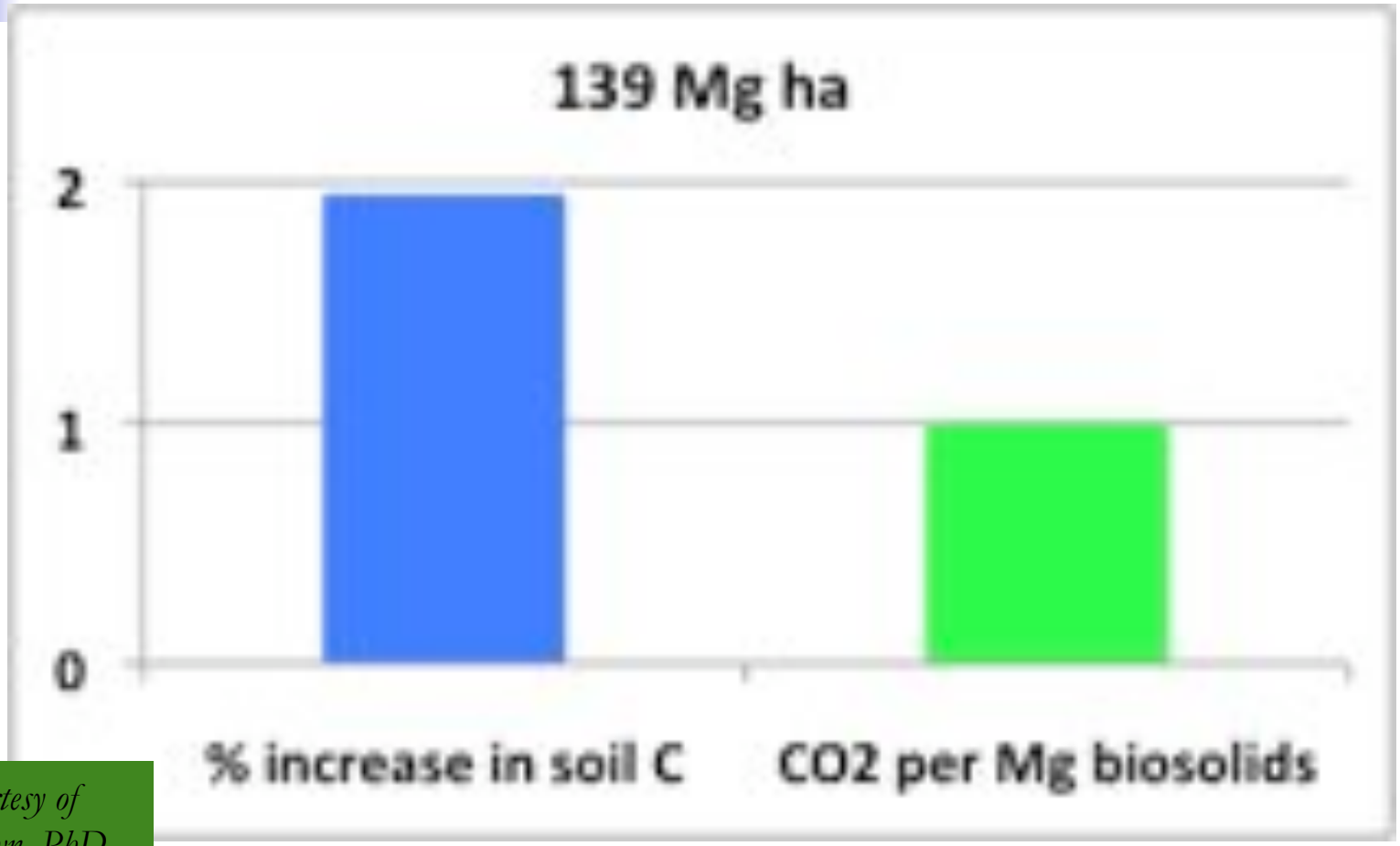
## Highland Valley Copper, BC





*Slide courtesy of Sally Brown, PhD Univ. of WA*

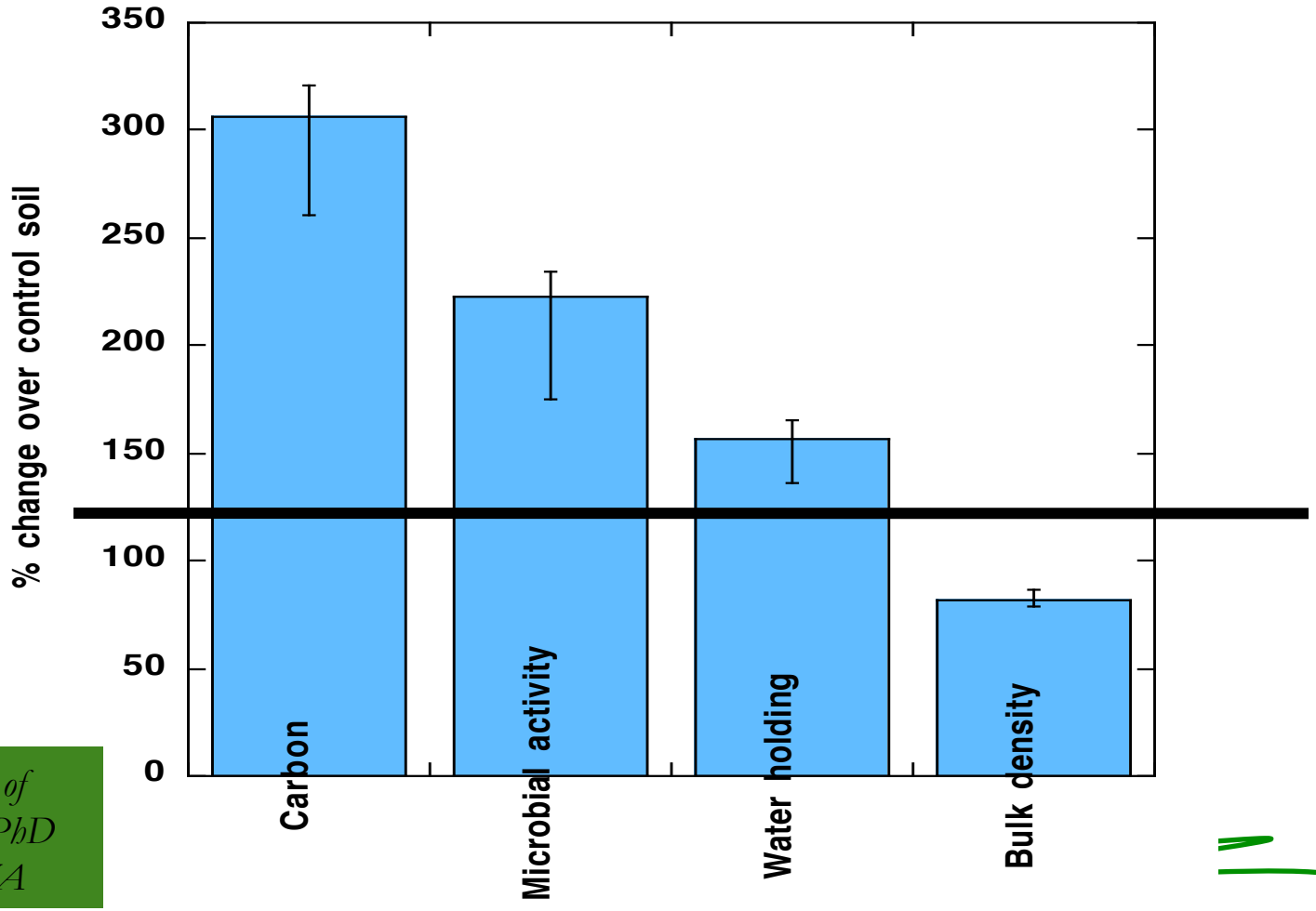
# Highland Valley, BC after 6-8 years




*Slide courtesy of Sally Brown, PhD Univ. of WA*

# Benefits of applying biosolids, etc. to soils

(Univ. of WA study: across all sites)




*Slide courtesy of Sally Brown, PhD Univ. of WA*

greenhouse gas

# Other ^benefits of biosolids *use*…

- Replacing chemical fertilizers
  - ~ 4 kg $CO_2$ / kg N (Recycled Organics Unit, 2006)
  - ~ 2 kg $CO_2$ / kg P (Recycled Organics Unit, 2006)
- Improved soil tilth / workability = less fuel for working soil
- Improved water holding capacity & infiltration (less runoff)

(Not to mention replacing peat….and irrigation needs… and….)

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# Life Cycle Analysis of solids options

## Adapted from Murray et al., 2008

| Treatment | End use | Total economic cost | GWE* Mg CO2 | |
|---|---|---|---|---|
| Dewatering | landfill | $26,000,000 | 380 | |
| Lime stabilization | land application | $35,000,000 | 15,000 | |
| Anaerobic (no lime) | land application | $31,000,000 | – 11,000 | #1 |
| Anaer (no lime) + heat | cement | $50,000,000 | – 4,100 | #1 alt |
| FBC incineration (gas) | brick/cement | $190,000,000 | 65,000 | |

*Economic cost* data are reported for a 20 year time horizon with 6% discount rate and include environmental externalities.

*GWE = global warming effect

alt means if land application is not an option

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# NEBRA Study (2008):
## Biosolids Management Options at Merrimack, NH

Report available at www.nebiosolids.org

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# Results

| Operation | kWh equivalent / dry ton solids | CO2 Equivalent Emissions (Mg / year) |
|---|---|---|
| CURRENT COMPOSTING | 735 | 1529 |
| UPGRADED COMPOSTING | 568 | 1094 |
| LANDFILLING AT ROCHESTER, NH | 261 | 3,754 |

(Energy use does not necessarily equate with GHG emissions.)

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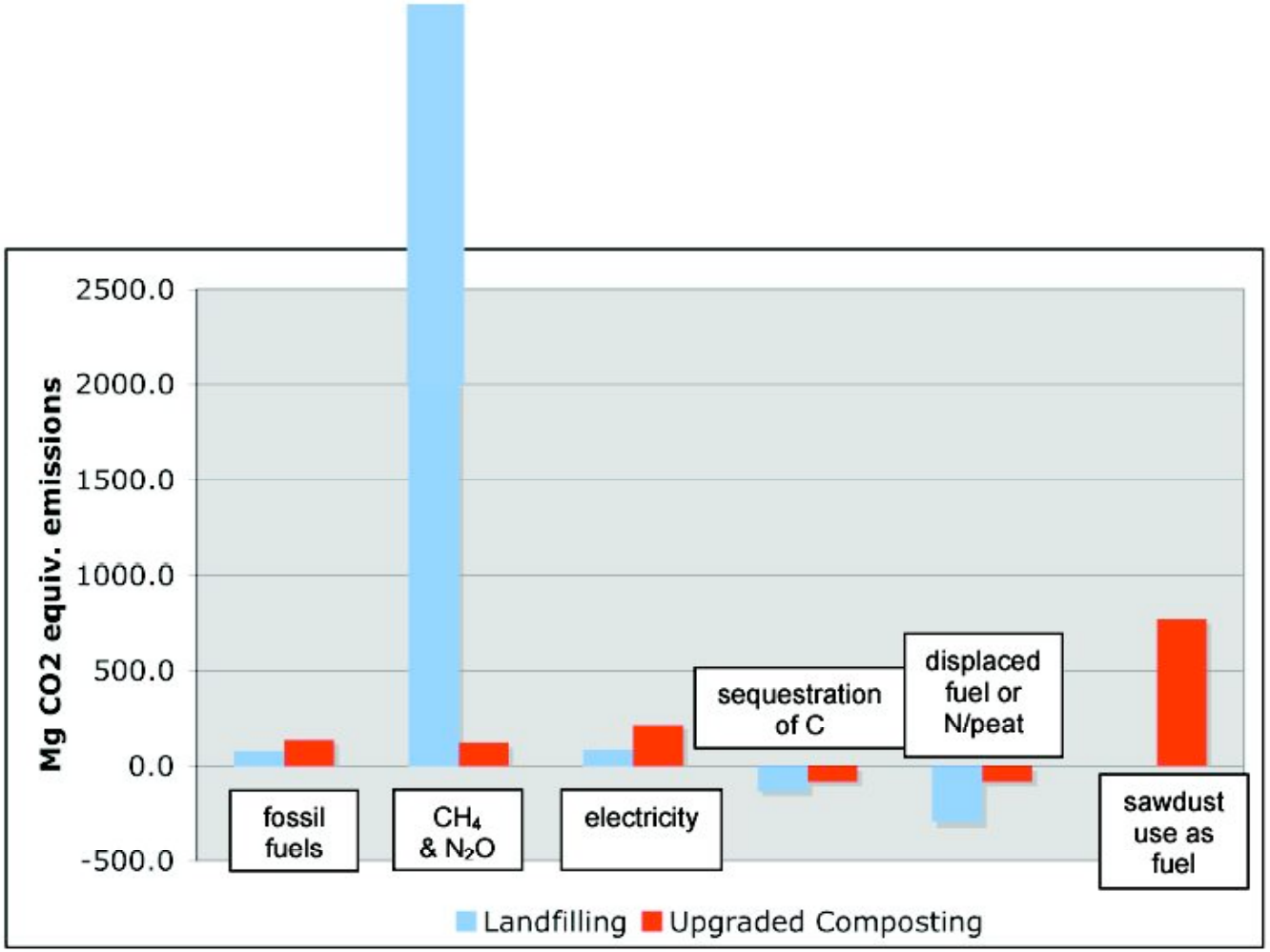
# Results: $CO_2e$ emissions

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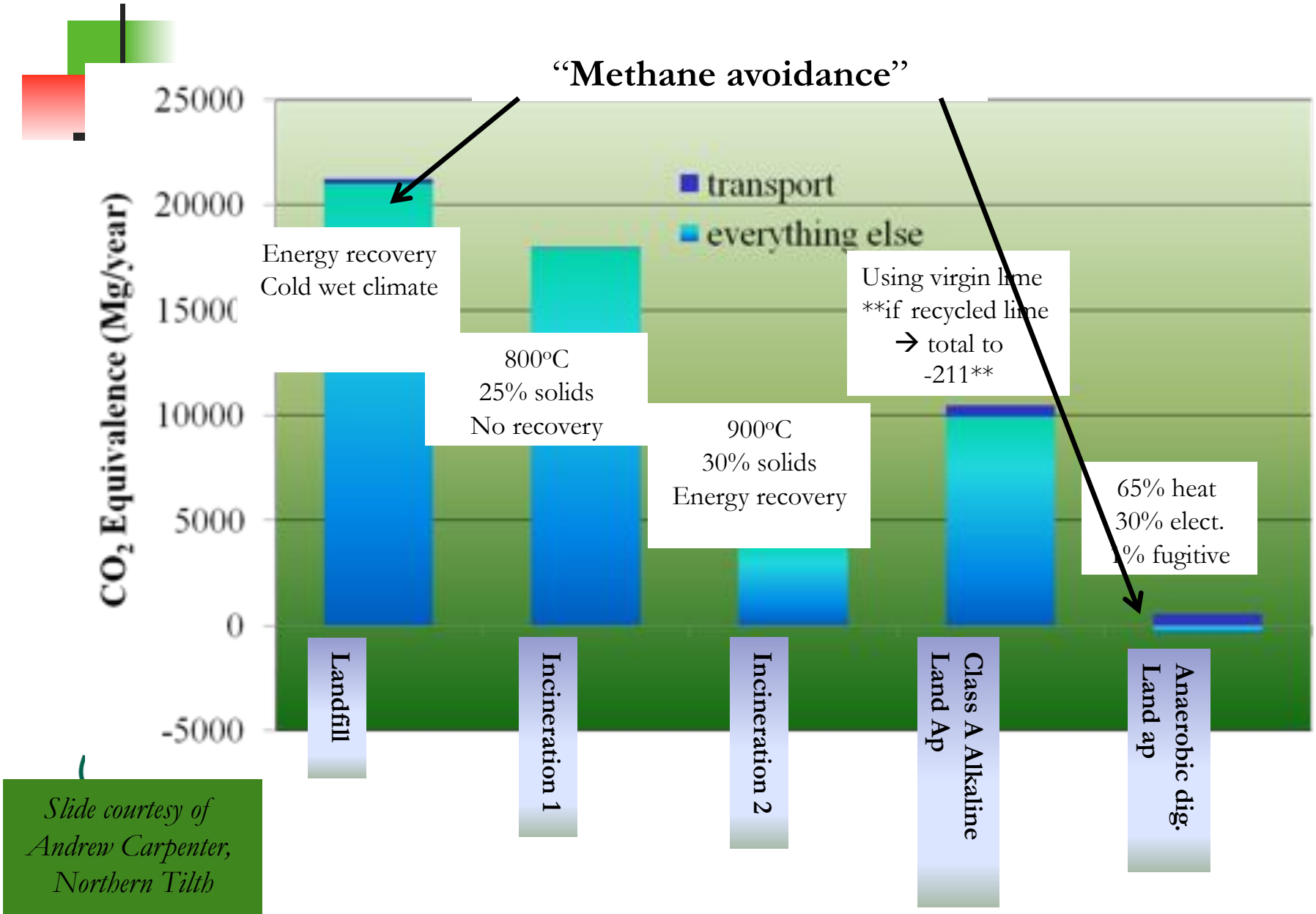
# BEAM: Comparing biosolids management scenarios

(each scenario includes thickening, de-watering and transport)




*Slide courtesy of Andrew Carpenter, Northern Tilth*

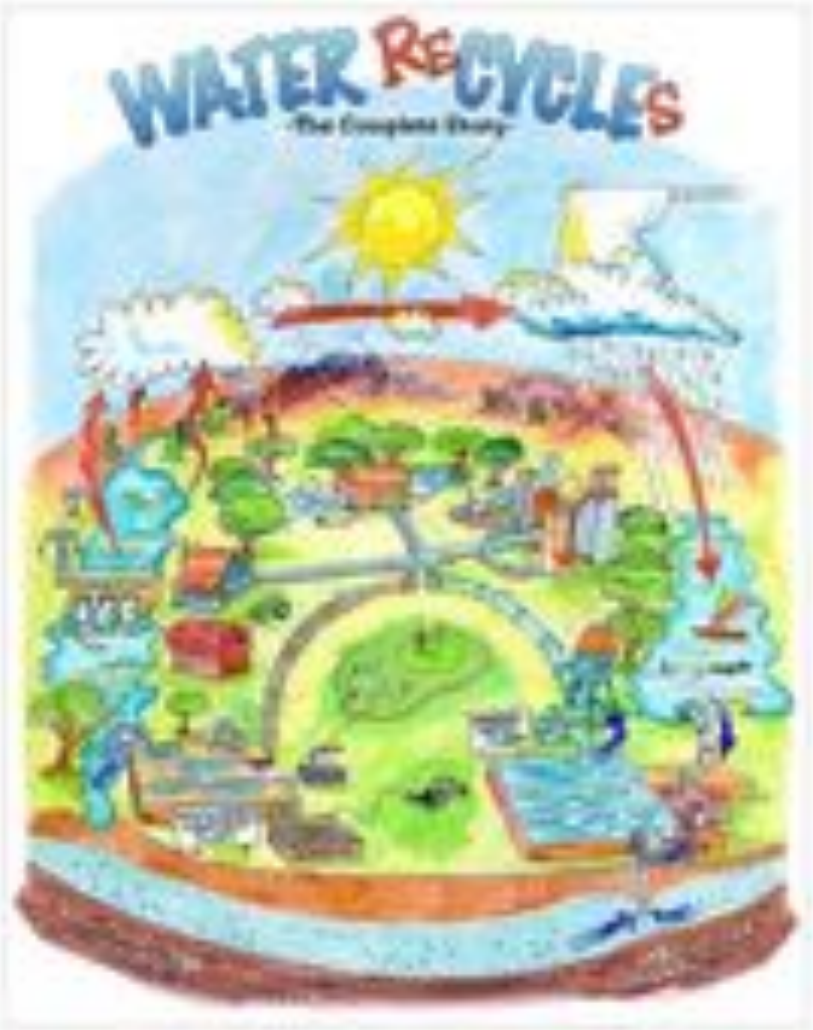
**Thanks** for… your invitation your attention, & your comments.

ned.beecher@nebiosolids.org
603-323-7654

**Presentation available at:**

www.nebiosolids.org

**Under "Resources and Links," choose greenhouse gas page.**

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**Sewage sludge must be managed**. There are 3 options; all present some risks. When trying to set **policy** on a complex matter like what to do with sewage sludge, it helps to look at what major expert **scientific reviews** found.

In 1996, the nation's premier scientific body, the National Academy of Sciences (NAS), reviewed biosolids recycling and concluded:

**"In summary, society produces large volumes of treated municipal wastewater and sewage sludge that must be either disposed of or reused. While no disposal or reuse option can guarantee complete safety, the use of these materials in the production of crops for human consumption, when practiced in accordance with existing federal guidelines and regulations, present negligible risk to the consumer, to crop production, and to the environment."**

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# An NAS 2002 review found:

"There is no documented scientific evidence that the Part 503 rule has failed to protect public health. However, additional scientific work is needed to reduce persistent uncertainty about the potential for adverse human health effects from exposure to biosolids. There have been anecdotal allegations of disease, and many scientific advances have occurred since the Part 503 rule was promulgated. To assure the public and to protect public health, there is a critical need to update the scientific basis of the rule to (1) ensure that the chemical and pathogen standards are supported by current scientific data and risk-assessment methods, (2) demonstrate effective enforcement of the Part 503 rule, and (3) validate the effectiveness of biosolids management practices."

**This research is ongoing; no findings of great risk. The risks being studied are far lower than addressed risks such as cholera, heavy metals, dioxins…**

***Benefits of biosolids use on land are well documented.***

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