



California Landfill Methane Inventory Model

A Process-Based Annual Inventory Model for Site-Specific Landfill Methane Emissions
Inclusive of Seasonal Methane Oxidation

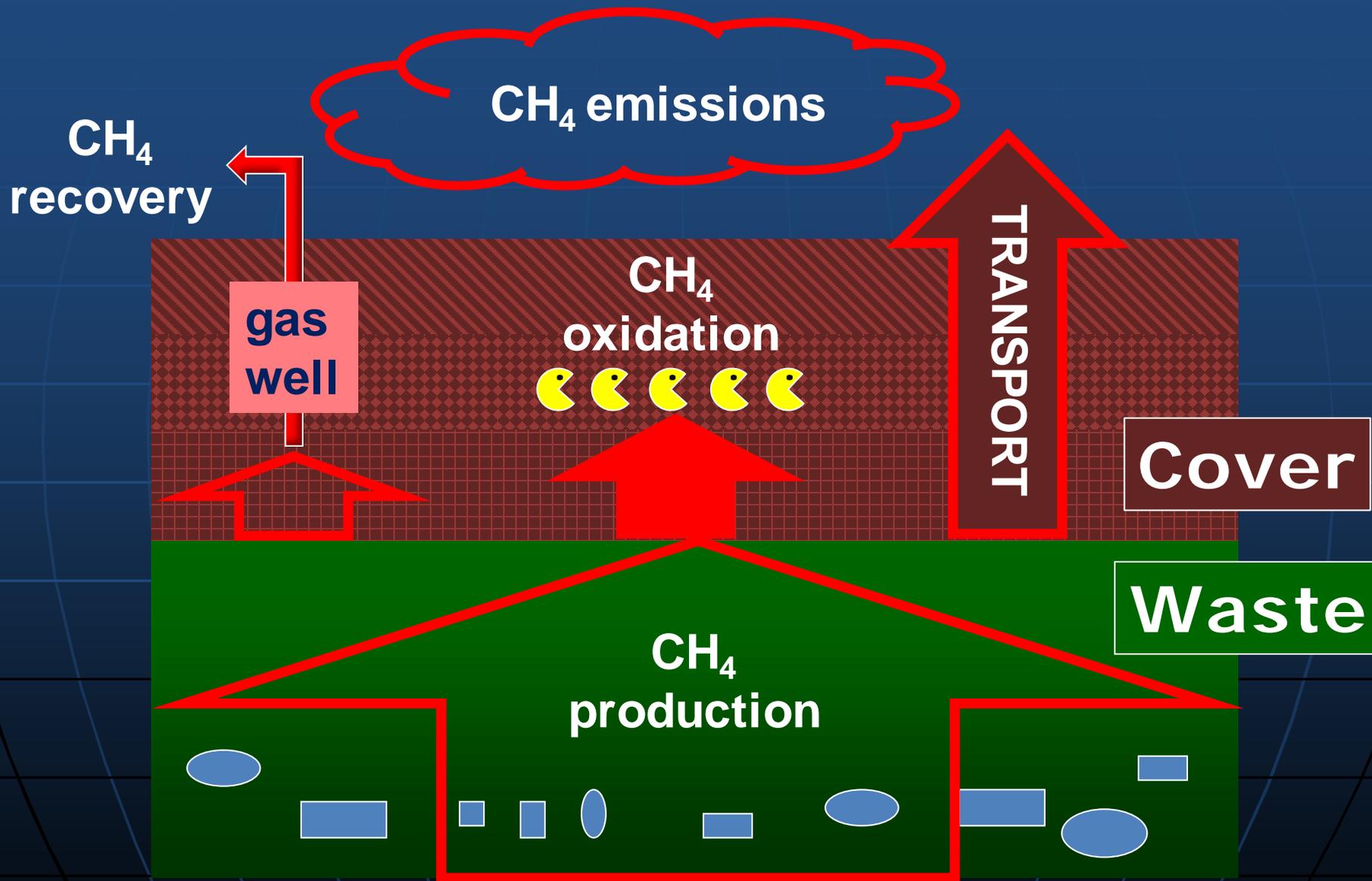
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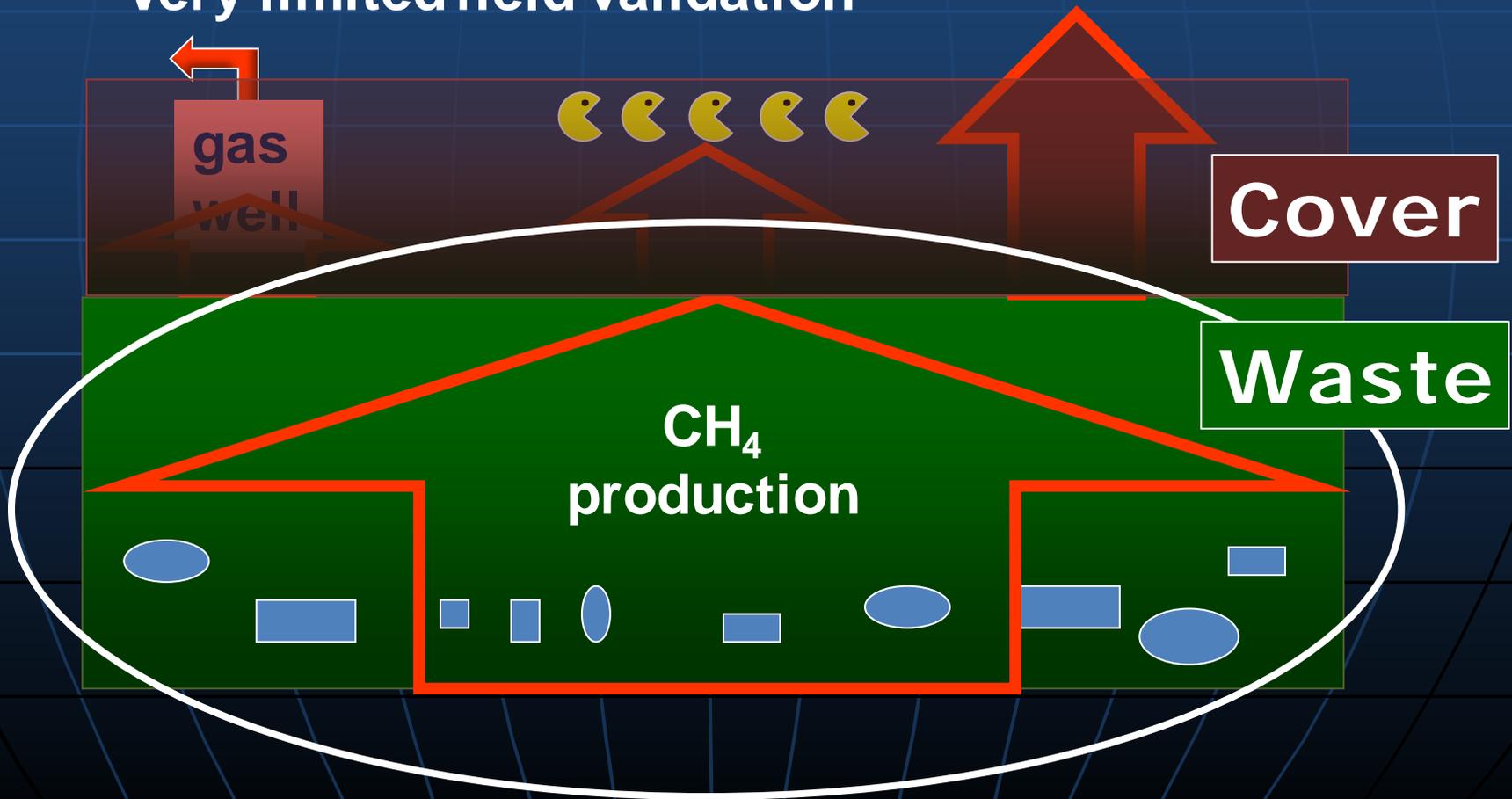
LMOP Conference, January 17-19, 2012

What Controls Landfill Methane Emissions?



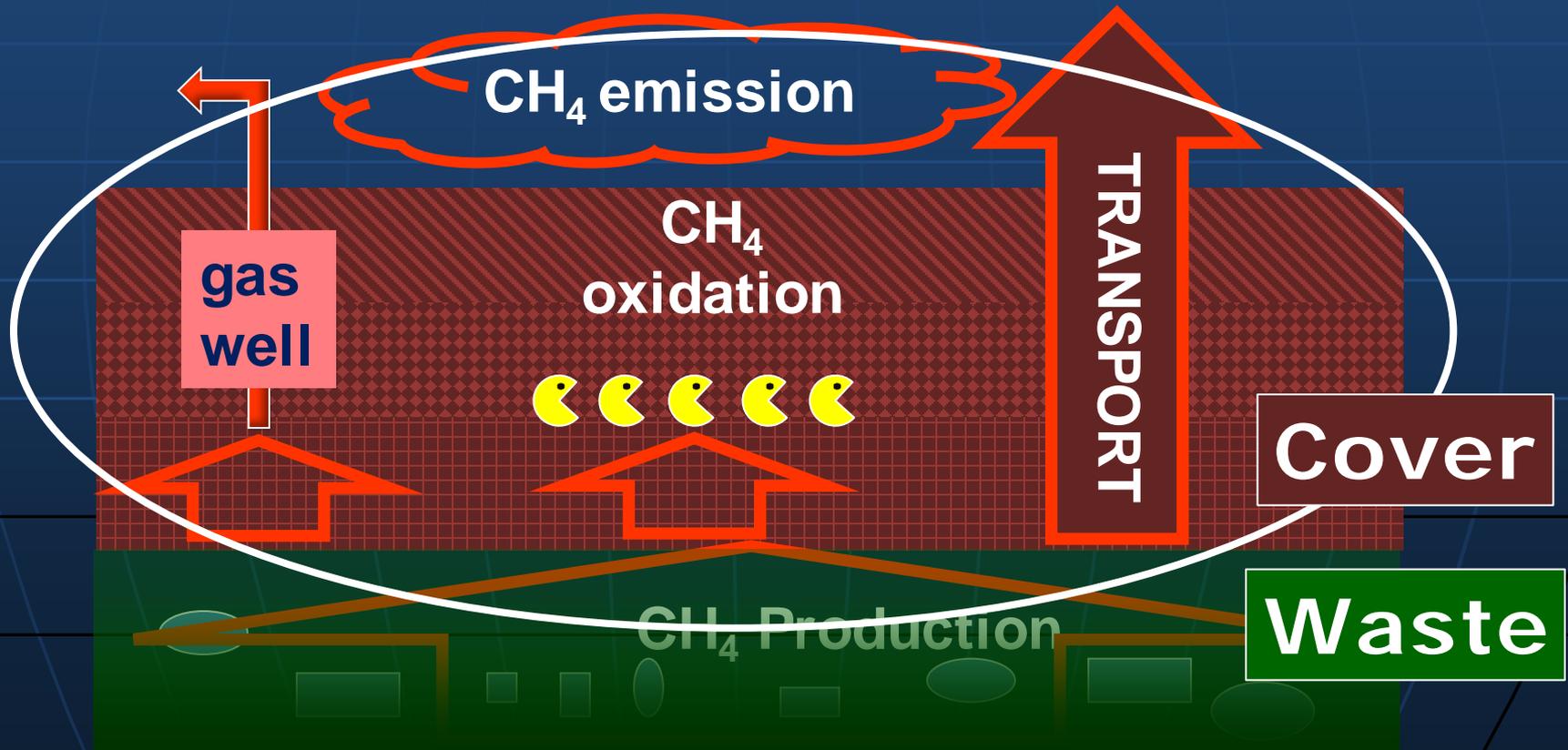
Most inventory methods:

- Focus on methane generation
- High uncertainty
- No accounting for diffusion, oxidation, or transport
- Very limited field validation



CALMIM model includes:

- Reduced diffusion due to engineered gas extraction
- Effect of cover on gas transport and oxidation
- Seasonal moisture and temperature effects on transport and methane oxidation



CALMIM Model Overview

(1) User defined physical characteristics for each cover type

(2) Environment and weather

(3) Soil temperature and moisture (1-D)

(4) CH₄ Emission/Oxidation Model

Annual Methane Emission Estimate for Site

Lab studies

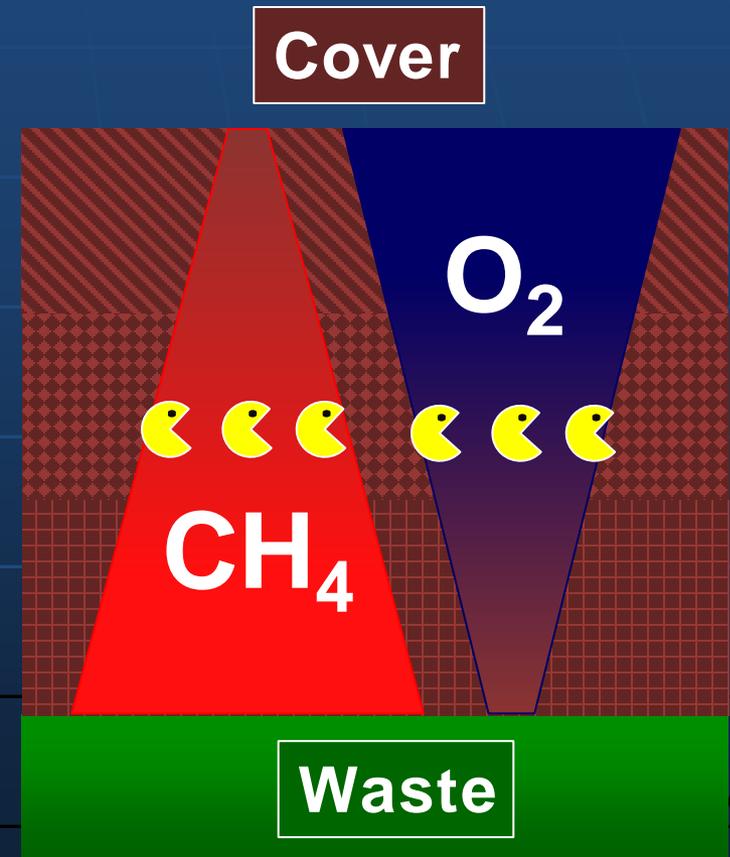
Field validation



(4) CH₄ Emission/Oxidation Model

1-D diffusional transport of methane and oxygen...

- Cover materials retard diffusion
- Diffusion driven by concentration gradient
- Methane oxidation scaled to soil temperature & moisture (laboratory incubations)
- User can choose between conservative default values or site-specific values based on field data



CALMIM Cover Input Screen

CALMIM - Version 5.0

Menu

GrandLandes25Adefault5.0 GrandLandes25Bdefault5.0

Cover Details:

Cover Type: Daily Intermediate Final Custom

Coverage % 50%

Cover Properties:

Organic Matter Low High

Gas Recovery 0 25 50 75 100 100%

Vegetation Present 0 25 50 75 100 100%

Cover Editor:

Layer Editor - Currently editing Layer # 4

Select a pre-defined final cover ->

Geomembrane (HDPE)

Depth:

Default Covers:

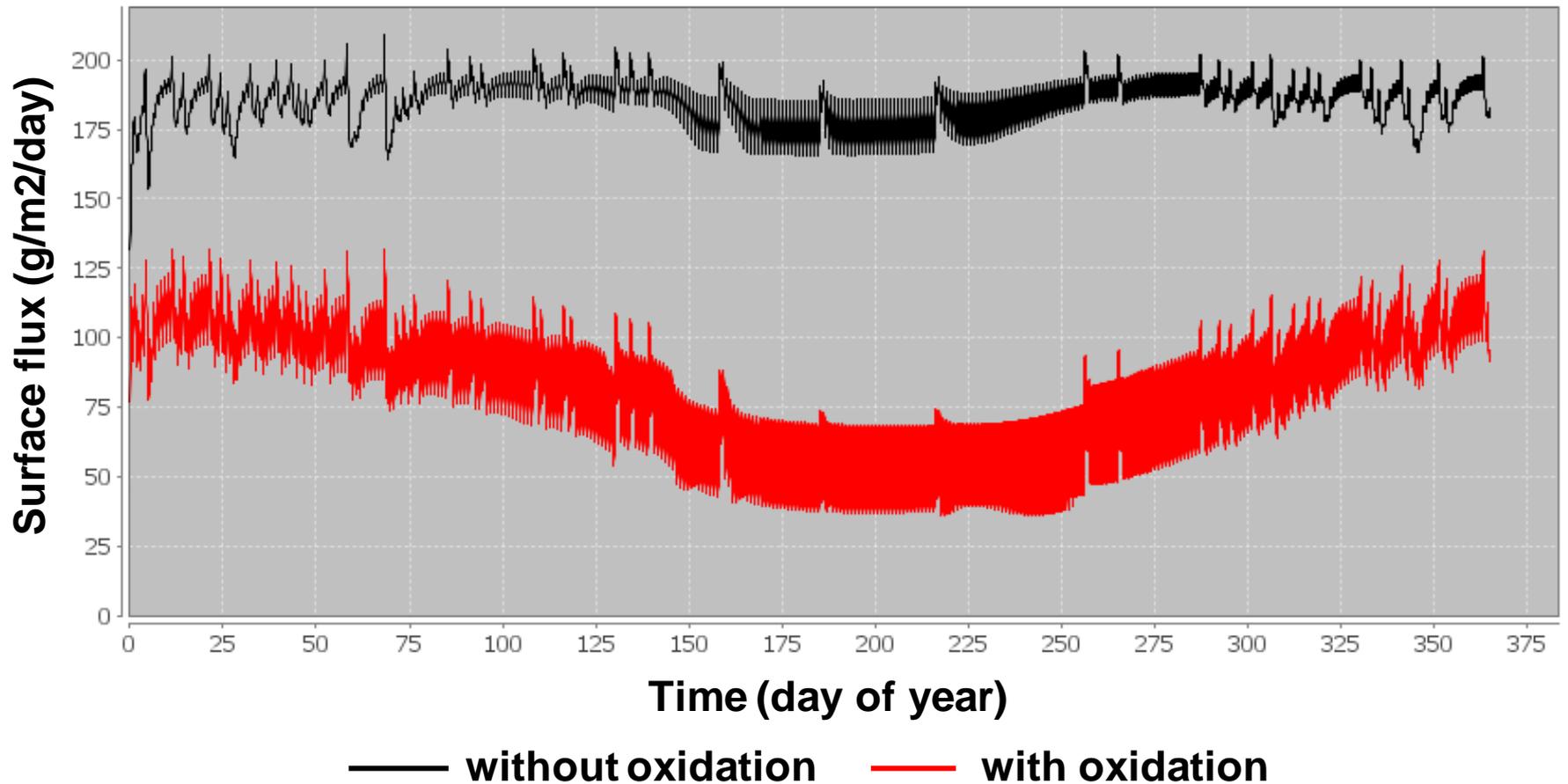
Layer(1 = surface)	Cover Material	Thickness(in/cm)
1	LOAM	12
2	CLAY	28
3	Geotextile (woven)	1
4	Geomembrane (HDPE)	1
5	Geotextile (woven)	1

100% of site covered

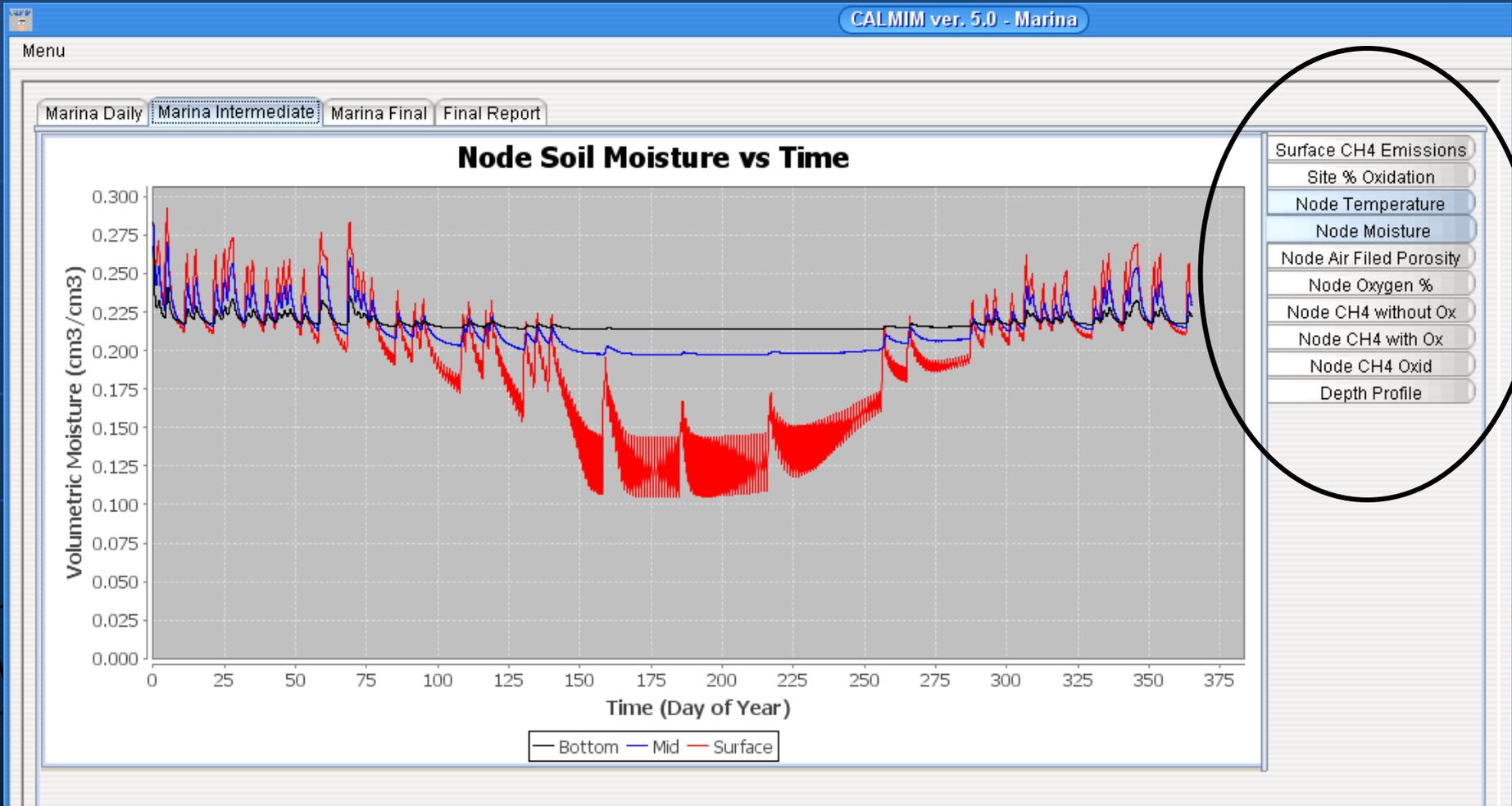
Back Site Properties Cover Properties Weather Simulation Next

Example of CALMIM output: Methane emissions over annual cycle:

Surface Methane Emissions (with and without oxidation) vs Time



Additional charts show other parameters:



CALMIM: Supporting Laboratory and Field Validation

Oxidation Model Development

- Methane oxidation based on laboratory incubation studies



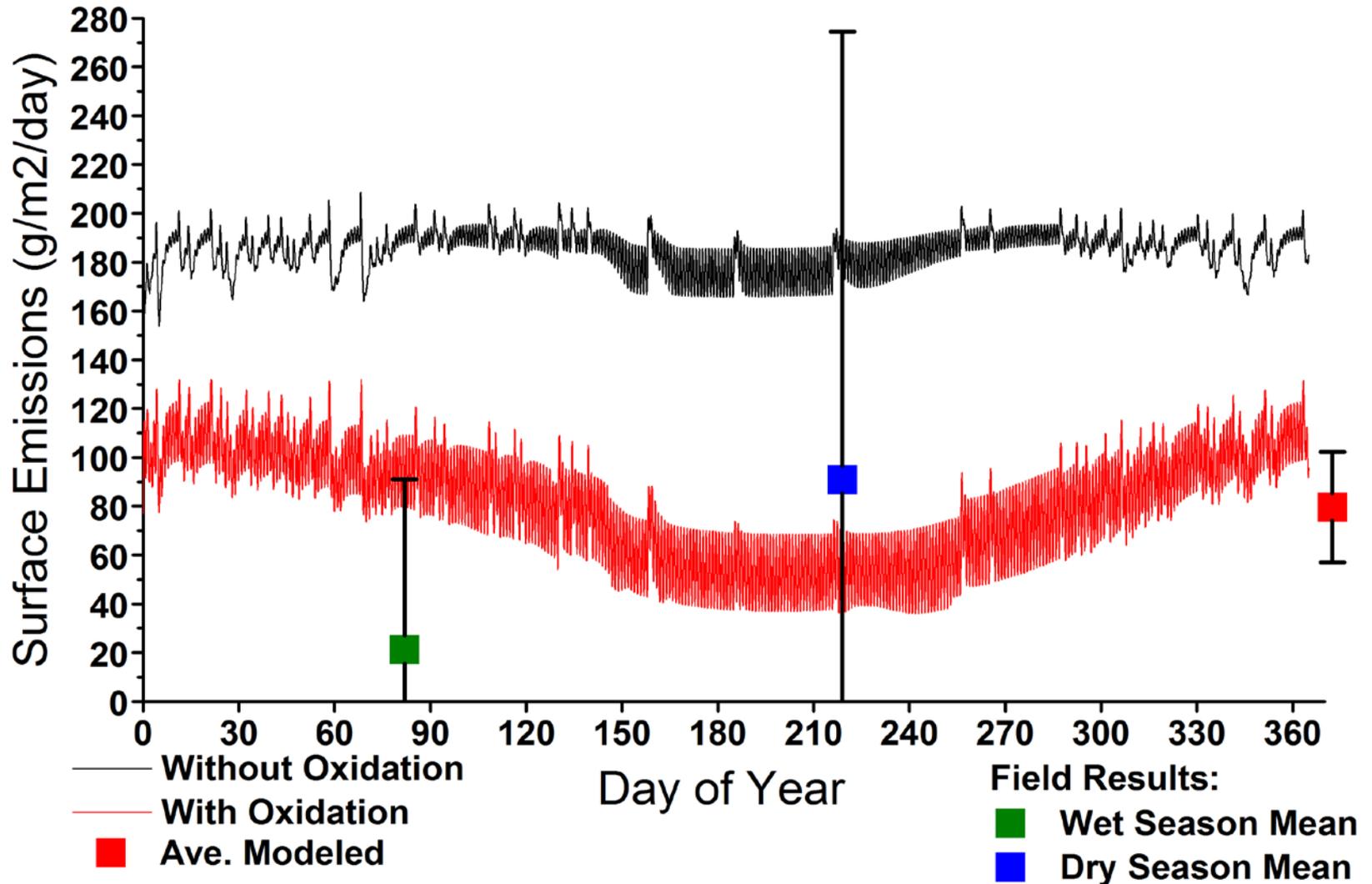
Model Validation

- Field measurement of methane emissions using static closed chambers
- Field measurements of methane oxidation using stable carbon isotope method
- Field Measurement of weather and soil microclimate data



Marina Field Validation:

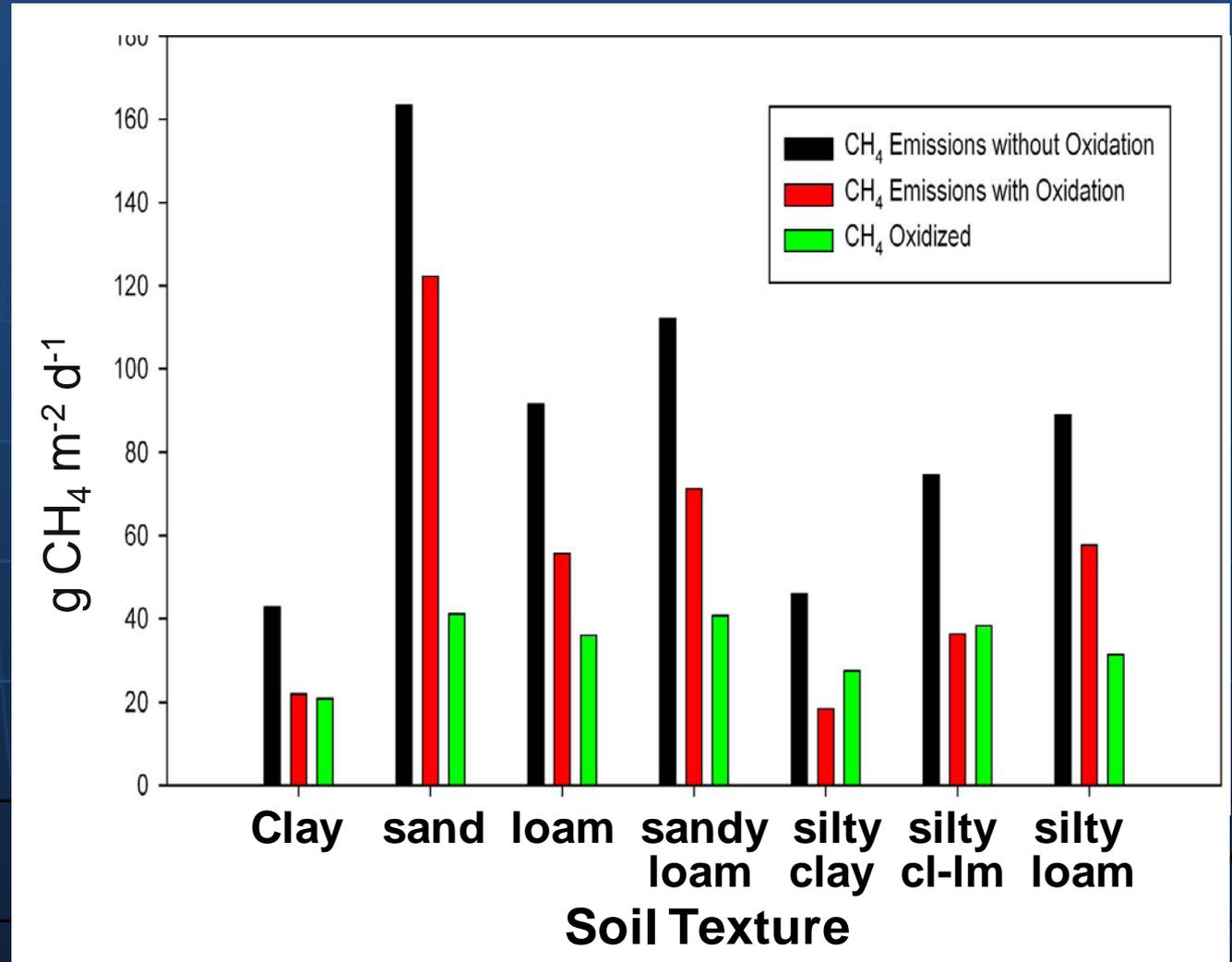
CALMIM Model: Marina - Intermediate Cover



Using CALMIM for “What-if” modeling

Investigate the effect of:

- Soil Texture
- Cover thickness
- Gas recovery on or off
- Irrigation



In summary: CALMIM...

Does:

- Comply with IPCC Tier III
- Model 1-D diffusion, transport, and oxidation
- Include site specific cover properties and seasonal factors
- Include extensive field validation
- Allow use of conservative defaults or custom data

Does Not:

- Include a methane generation model
- Consider gaseous transport mechanisms other than diffusion
- Address emissions from cracks and fissures
- Use compacted soil physical properties

For further information:

To download CALMIM Model and User Manual:

<http://www.ars.usda.gov/services/software/download.htm?softwareid=300>

Journal articles:

- Spokas, K., Bogner J., and Chanton, J., A Process-Based Inventory Model for Landfill CH₄ Emissions Inclusive of Soil Microclimate and Seasonal Methane Oxidation, *J. Geophysical Research-Biogeosciences*, 116, G04017, doi:10.1029/2011JG001741 (2011)
- Bogner, J., Spokas, K., and Chanton, J., Seasonal Greenhouse Gas Emissions (methane, carbon dioxide, nitrous oxide) from Engineered Landfills: Daily, Intermediate, and Final California Landfill Cover Soils, *J. Environ. Quality* 40:1010-1020 (2011).
- Spokas, K., and Bogner, J., Limits and dynamics of methane oxidation in landfill cover soils, *Waste Management* 31:823-832 (2011).

Thanks for your attention!

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