Methane Emissions from Farm Dams

A simple overview for WA extension staff, Natural Resource Management groups and growers.

Dams are critical water-storage infrastructure for Western Australian (WA) farms, supplying water for livestock, crop spraying, and non-potable domestic use. WA growers are aware of the challenges in managing dams to ensure water security. In recent years, including the summers of 2018-20 and 2024-25, many dams have run dry or been reduced to very low water levels. During these hot, dry summers, when water levels drop, the risk of algal blooms and poor water quality rises sharply. Declining water quality can impact livestock health and reduce the effectiveness of spray programs, with flow-on effects for farm productivity.

What's less widely known is that research from eastern Australia and internationally has shown that small, constructed water bodies such as farm dams can be surprisingly significant sources of greenhouse gas (GHG) emissions, often contributing disproportionately compared to larger reservoirs (Ollivier et al., 2019). Studies indicate that dams receiving large inputs of organic matter (e.g., animal faeces, crop stubble) are typically net emitters of GHG. In contrast, dams where these inputs are managed through measures such as restricting direct stock access, using vegetation buffers, and installing silt traps can reduce emissions or even sequester carbon. These practices also deliver co-benefits, including improved water quality and enhanced livestock productivity.

Why This Matters for Your Farm

- **Improved water security and quality:** Farm dams with a well-designed, high-performing catchment have greater water volume and better quality water, supporting spray efficacy, livestock health and productivity.

This project received funding from the Australian Government's Future Drought Fund

- Future market requirements: While farm dam emissions are counted in the National Greenhouse Gas Inventories, they are not yet a routine part of on-farm GHG accounting. However, they may be incorporated into farm accounting or sustainability accreditation standards for livestock and grain markets in the future.
- New income opportunities: As carbon and nature-repair markets mature, landholders may be able to earn income by transforming farm dams from GHG emitters.

1. Processes of Methane Production in Farm Dams

While a farm dam can be a source and sink of gases like carbon dioxide (CO_2) and nitrous oxide (N_2O), we focus here on methane (CH_4) as a key GHG for emissions reduction in the agricultural sector. For example, in 2022, Australia signed the Global Methane Pledge (an ambition to reduce methane emissions by 30% by 2030) to help secure continued access to international markets for the livestock and dairy industry. Methane can be up to 34 times more potent as a GHG than CO_2 (Beaulieu et al., 2019).

Methane emissions from dams may make up around 5-10% of a farm's total carbon footprint. Improving dam management has broader benefits for water quality and productivity. Here, we outline the primary drivers of methane emissions from water bodies, with a focus on the Western Australian production environment. With the development of nature-positive initiatives and the potential for financial rewards to farmers through biodiversity or carbon credits, the aim is to provide industry and extension staff with a knowledge base to contextualise research findings from other regions.

Methane production in farm dams is a biological process driven by microorganisms called methanogens. These microbes thrive in oxygen free environments, which can occur in the sediments at the bottom of some farm dams.

Organic Matter Accumulation: Farm dams are collection points for water runoff, which can result in high nutrient loads, such as nitrogen (N) and phosphorus (P), from fertilisers and livestock faeces. These nutrients can fuel the growth of aquatic plants and algae. An example of excess algae is the toxic blue-green algal blooms that can occur during the summer in WA farm dams when water temperatures are at their highest. Dead plants, algae, stubble and faeces, sink to the bottom of the dam, and over time, this leads to the accumulation of organic matter.

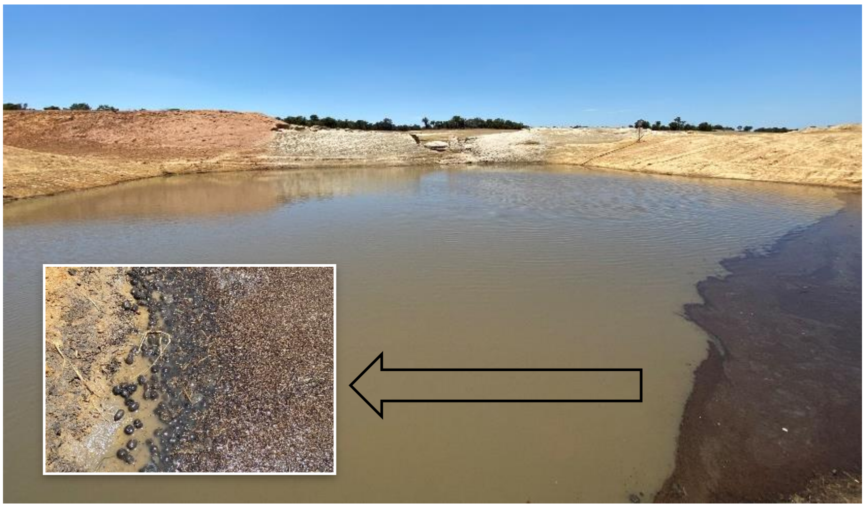


Figure 1. An example of sheep faeces floating on the surface of a dam after a large summer storm.

Organic Matter Decomposition: Microbes break down large pieces of organic material at the bottom of the dam into smaller fragments, consuming oxygen, thereby reducing dissolved oxygen (DO) levels there. As oxygen levels decline, specialised microbes that thrive in low-oxygen environments take over the decomposition process. Methanogens are among these microbes; they utilise the byproducts of the breakdown of previous material, such as carbon dioxide, hydrogen, and acetate, and convert them into CH_4 through a process called methanogenesis.

Methanogens use redox reactions, which involve the transfer of electrons, to fuel their metabolism. Two key pathways they use are:

$CO_2 + 4H_2 \rightarrow CH_4 + 2H_2O$ (Carbon dioxide + Hydrogen → Methane + Water)

$CH_3COOH \rightarrow CH_4 + CO_2$ (Acetate → Methane + Carbon dioxide)

(Conrad, 2005)

2. What Drives Methane (CH_4) Emissions from Farm Dams?

Several environmental and physical factors influence the amount of methane produced and released from farm dams.

Organic Matter Availability: Runoff from surrounding land, crop residues, faeces, and fertilisers all contribute to the build-up of organic matter in dams. This material fuels microbial activity that produces methane.

Nutrient Levels: High levels of nitrogen (N) and phosphorus (P), often from fertilisers and livestock faeces, promote algal and microbial growth. When algae die and settle to the bottom, they contribute to further accumulation of organic matter.

Temperature: Warm temperatures promote microbial activity and accelerate chemical reactions. It also causes water to stratify, forming layers that resist mixing. This creates oxygen-poor conditions at the bottom, which are ideal for methanogens. Methanogen activity typically increases with temperature.

Water Level: The water level in the dam determines the hydrostatic pressure on the bottom sediments. Lower water levels reduce pressure, which encourages the formation of methane bubbles. It also means there is less distance for methane to travel to the surface, reducing the likelihood that it is oxidised in the water column. High water levels increase pressure, suppressing bubble formation and allowing more time for methane to break down before reaching the surface. This is one reason you see farm dams bubbling more in summer when water levels are lower.

Changes in dam water levels can affect the release of carbon from wet and dry sediments. Research generally shows that drying sediments increases CO_2 emissions, while reducing CH_4 production (Marcé et al., 2019). However, results can vary. Some studies show that both CO_2 and CH_4 increase as wet sediments initially dry, but when sediments are re-wetted, CO_2 emissions increase again, but CH_4 levels can remain unchanged (Paranaíba et al., 2020).

Dam Size: Small farm dams often have a high surface-to-volume ratio, which increases the potential for gas exchange with the atmosphere. Several studies from

New South Wales and Victoria found that smaller dams (less than 1,000 m^2) tend to emit more methane than larger ones (1,000-100,000 m^2). This is mainly due to their higher sediment-to-water ratio (Webb et al., 2023).

Amount of Oxygen Dissolved in the Water: As methane is produced in low-oxygen environments, any condition that reduces oxygen levels increases the likelihood of methane production. For example, warm water holds less DO, and the breakdown of organic matter further consumes oxygen. Conversely, a significant influx of freshwater can enhance water mixing and increase oxygen levels, thereby helping to suppress methane emissions. Work in Victoria showed that farm dams with higher DO have lower methane emissions (Malerba et al., 2022).

Seasonal Variability: Due to fluctuations in temperature and water levels, methane emissions from farm dams can vary substantially across seasons. Research in Victorian farm dams showed that there was 12 times more CH_4 release from farm dams in summer (412 $KgCH_4$ ha^{-1} y^{-1}) than in winter (33 $KgCH_4$ ha^{-1} y^{-1}) (Odebiri et al., 2024).

Surrounding Land Use: Land use surrounding the farm dam influences inputs to the dam. Studies of Australian farm dams have shown that CH4 emissions can be up to 250% higher in areas with livestock (Ollivier et al., 2019). However, other studies in different production systems, such as those in Canada, have shown high emissions from crop sites compared to pastures (Webb et al., 2019).

3. How is methane released from the dam?

Methane can move from the dam water into the atmosphere in two main ways: ebullition and diffusion.

Ebullition refers to the release of methane as visible bubbles that rise to the surface. This process is often episodic, occurring when gas pressure builds up in the sediment or when the sediment is physically disturbed. If you have observed extensive bubbling on the surface of your dam, especially toward the end of summer, you may be witnessing the release of methane from the dam sediments into the atmosphere.

Diffusion, by contrast, is a slower and less visible process. Methane dissolved in the water gradually moves upward through the water column and escapes into the atmosphere. Unlike ebullition, diffusion tends to be more consistent across time.

Research from farm dams in Victoria has shown that bubbling is the primary mechanism for methane release, accounting for over 90% of total emissions (Odebiri et al., 2024). This pattern was also observed in Queensland dams, where bubbling was also identified as the dominant emission pathway (Grinham et al., 2018). Bubbling tends to increase with rising water temperatures and is more prevalent in shallow (>5m) areas of lakes and dams (Deemer & Holgerson, 2021; DelSontro et al., 2016).

Studies of other agricultural water bodies, such as ditches in China, have found that diffusion was the dominant methane-emission process in medium-sized ditches, primarily driven by nutrient inputs. But that bubbling was the more dominant process in larger ditches influenced by water temperature, depth, and hydrological conditions (Niu et al., 2024)

In Western Australia, the spatial and seasonal patterns of methane emissions from farm dams, including both bubbling and diffusion, remain largely unknown. However, the generally small size of dams and the dry, warm summer that drives considerable variation in water level suggest that ebullition is likely a key emission pathway.

4. CH4 production in WA farms? Salinity & Water Clarity

While methane dynamics in Western Australian farm dams haven't been widely studied, research in other regions and our understanding of the unique characteristics of WA's farm dams can hold clues to potential emission patterns.

Salinity and CH_4 Emissions.

The replacement of deep-rooted native vegetation with shallow-rooted crops and pastures across Western Australia's ancient landscape has led to rising water tables and the mobilisation of salt. As a result, some farm water supplies in the region can exhibit higher salinity levels than those typically found in the eastern states, where most farm dam methane research has been conducted.

Salinity can influence methane production in aquatic systems by shaping the microbial communities that inhabit them. Research mostly from North America has shown that higher water conductivity (a measure of salinity) is often linked to lower methane emissions in small water bodies (Soued et al., 2024). However, sulphate is the primary driver of salinity in those dams.

Sulphate plays a key role in limiting methane production in dam sediments. As oxygen levels decline, microbes switch to alternative electron acceptors, such as sulphate, to break down organic matter (Conrad, 2005). Sulphate-reducing bacteria compete with methanogens for shared fuels, such as hydrogen, and typically outcompete them because their process is more energy-efficient. Methanogenesis is the least energy-efficient process in the redox chain. This suppresses methane production, and, in some cases, sulphate can even facilitate methane removal through the anaerobic oxidation of methane (AOM), in which methane is degraded before it is released to the atmosphere. The presence of metal oxides (e.g iron, manganese) can also break down CH_4.

In Western Australia, chloride from marine sources is often the dominant salt. Unlike sulphate, chloride doesn't fuel the same microbial competition, but it can still indirectly suppress methane production. High chloride levels can stress methanogens and shift microbial communities, slowing down the breakdown of organic matter and reducing methane emissions.

Water Clarity (Turbidity) and CH_4 Emissions.

Many Western Australian growers are familiar with milky or muddy farm dams, particularly in areas with dispersive clay soils, which are widespread across the state. These conditions contribute to high turbidity, in which suspended particles obscure the water and reduce clarity. Water clarity can also be reduced by organic matter, phytoplankton, and tannins. While there is no simple correlation between measured turbidity and methane production, the source of turbidity is important.

Low water clarity, caused by fine clay particles, reduces light penetration, limiting photosynthesis in aquatic plants and algae and, in turn, lowering oxygen levels in the water, creating low-oxygen conditions for methanogenesis. However, it may also reduce the amount of organic matter available for methane production.

When turbidity is caused by fine organic particles or elevated chlorophyll a, methane emissions tend to increase, particularly in phosphorus-rich waters. For example, a 2019 Nature Communications study warned that rising eutrophication (excess nutrients) driven by climate change and population growth will significantly amplify methane emissions from lakes and impoundments throughout the 21st century (Beaulieu et al., 2019).

5. Dam Management Options

While farm dam methane emissions may represent a relatively small part of a farm's overall carbon budget, water quality and security are critical priorities for Western Australian farmers, especially in an increasingly dry climate. Many of the key drivers of methane emissions, such as high nutrient levels, elevated water temperatures, and shallow water depths, also contribute to poor water quality and reduced water security.

Managing dams in hotter, drier climates often entails warmer water temperatures and lower levels, which can concentrate nutrients and organic matter. Fortunately, several practical strategies can help address both methane emissions and water quality concerns:

Improving Nutrient Management

Adopting farming practices that improve fertiliser efficiency, such as precision application or timing fertiliser use to match crop needs, can help retain nutrients in the soil and reduce nutrient concentrations in runoff entering dams. This not only lowers methane producing substrates but also improves water quality.

For example, in Ollivier et al. (2018), a 25% increase in nitrate concentration was observed to double the CO_2 equivalent carbon flux per m^2 of a farm dam.

Ensuring Your Dam Has a Silt Trap

Dams, without a silt trap to intercept sediment runoff and potentially filter organic matter between the catchments and the dam will accumulate silt over time, reducing their storage capacity. The Department of Primary Industries and Regional Development (DPIRD) recommends that all farm dams be fitted with silt traps. Installing a silt trap captures nutrients and organic material, such as livestock faeces, after storms, preventing their entry into the dam and thereby reducing turbidity and methane-producing substrates. Silt traps are easier to clean regularly than the dam itself, making them a cost-effective solution for maintaining water quality and storage efficiency.

See DPIRD resource on desilting dams

(https://www.dpird.wa.gov.au/environment-and-sustainability/water/dams/desilting-dry-dams/)

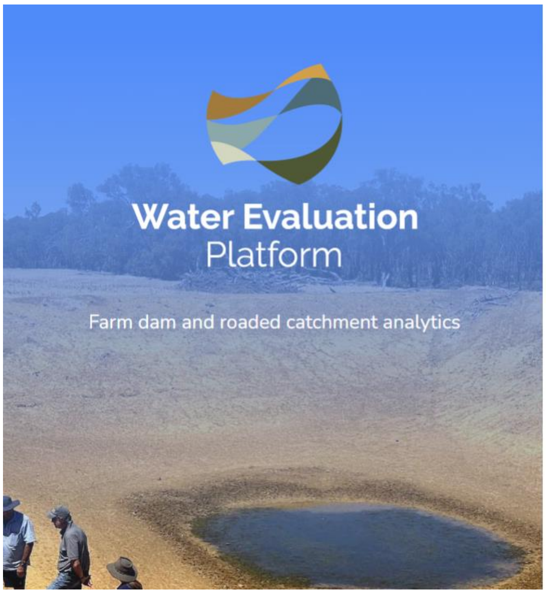
A dam without silt traps will require periodic cleaning to restore storage capacity. Removing accumulated organic matter during cleaning may temporarily reduce methane emissions by eliminating the substrates for methanogenic microbes. However, managing nutrient and organic inputs in future inflows is essential to maintain water quality and minimise future emissions. While direct methane emissions from the dam may be reduced following cleaning. Scooping out the sediment and spreading it across the surrounding paddock, or piling it up, will generally oxidise the material, potentially increasing overall GHG (CO_2 and N_2O) (Marcé et al., 2019), though this has not been quantified in WA.

Figure 2: Looking upslope at a silt trap that has captured sheep faeces from a storm event.

Key Dams

Larger farm dams tend to maintain higher water levels than smaller ones, making them more reliable under climate change (Malerba et al., 2022). Deeper dams also increase water residence time, stabilise temperatures, and dilute nutrient-rich inflows.

Consider transitioning to fewer, larger, strategically located key dams with sufficiently large, reliable catchment areas to maintain optimal water levels year-round. Web tools such as the Water Evaluation Platform (WEP) can help assess dam reliability and whether the catchment is sized to fill the dam sufficiently for the specified climate. WEP also allows you to determine the impact of different catchment surface types, such as roaded and high-performing engineered surfaces.



The WaterSmart Dams project is a collaborative initiative to improve the resilience and performance of farm dams in Western Australia. Detailed findings from the Water Smart Dams projects can be found in the Evaporation Technical Report and the Surface Water Technical Report

(https://docs.waterevaluationplatform.app/technical-reports.html)

Enhancing Existing Dams

An 'enhanced' dam is a term developed by the Sustainable Farms team at ANU. It refers to a dam that is actively managed to protect water quality by excluding or managing livestock access and using vegetation to filter runoff before it enters the dam.

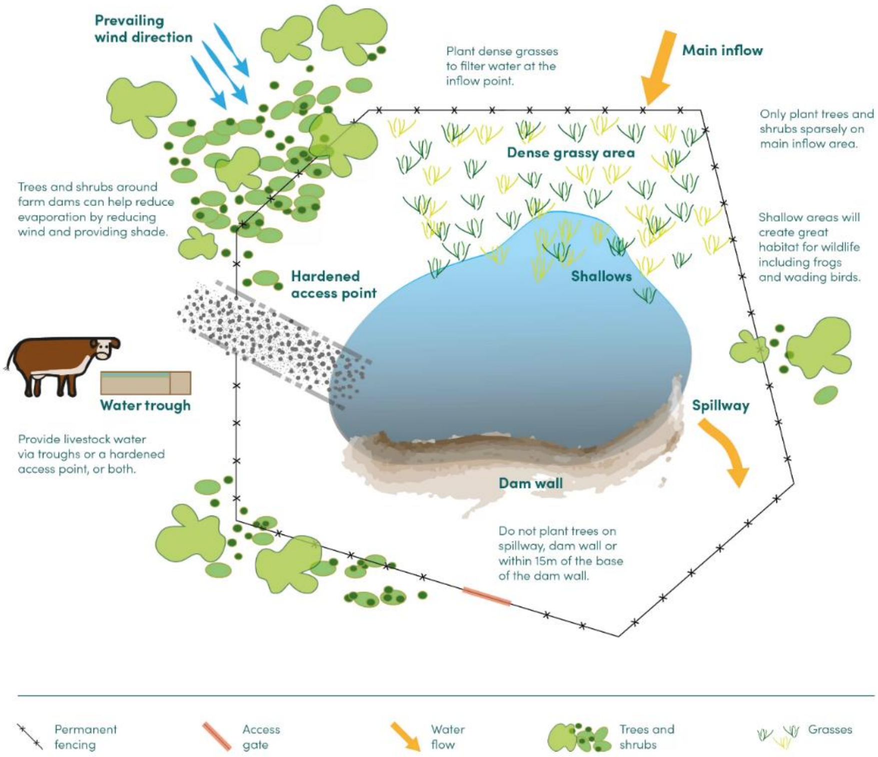


Figure 3: Features of an enhanced farm dam (Source ANU- https://www.sustainablefarms.org.au/on-the-farm/farm-dams/

Key elements of an enhanced dam can include fencing, revegetation, hardened livestock access points, and off-dam watering systems, such as troughs. Studies by ANU and RMIT have shown that these enhancements can significantly reduce levels of phosphorus, nitrogen, turbidity and E. coli. Improved water quality can lead to enhanced animal production through livestock weight gain (Dobes et al., 2021). If the dam water is being used in spray programs, it can also lead to increased product efficacy (Centre for Water and Spatial Science, 2025).

Studies in eastern Australia have documented that fenced dams have 56-92% lower methane emissions than unfenced dams (Malerba et al., 2022; Odebiri et al., 2024).

See the ANU Sustainable Farms Enhancing Farm Dam guide for more information.

(https://www.sustainablefarms.org.au/wp-content/uploads/2023/05/Enhancing-Farm-Dams-guide.pdf)

Research on managing irrigation dams for carbon benefits in the Riverina, NSW, suggests that establishing floating aquatic vegetation could help reduce methane emissions by processing dissolved nutrients and trapping methane bubbles before they reach the atmosphere (Webb et al., 2023). While floating vegetation shows promise for improving water quality and lowering emissions, the authors note its practical feasibility remains challenging and requires further research. This may also reduce dam evaporation, but this has not been quantified.

See Managing irrigation dams for carbon benefits.

(https://irec.org.au/wp-content/uploads/Managing-Irrigation-Dams-for-Carbon-Benefits-Dr-Jackie-Webb.pdf)

To develop effective management strategies for farm dams in WA, greenhouse gas emissions must be monitored across a broad range of sites to understand key pathways and the biological, hydrological, and physical interactions that drive their spatial and temporal variability.

A pilot study, supported by the South-West WA Drought Resilience Adoption and Innovation Hub through the Australian Government's Future Drought Fund, began this process at two dams, focusing on building local capacity and refining methods. These learnings provide a strong foundation for future research and inform the design of larger-scale studies. The report "Preliminary Investigation of Methane Emissions from Farm Dams in Western Australia" is available by request to the Centre for Water and Spatial Science or the Grower Group Alliance.

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