# GOOGONG DAM ACTIONS FOR CLEAN WATER PLAN UPDATE 2025

## 2025 ACWA PLAN UPDATE

Icon Water

## Contents

# 1. EXECUTIVE SUMMARY

Erosion in key Googong catchment zones remains a high and preventable risk to drinking water quality. Without targeted intervention, sediment will continue to enter Googong Reservoir, threatening water quality, increasing treatment costs, and undermining public confidence in the ACT region's water supply.

Since 2018, mixed progress has been observed across the catchment, with some sites showing signs of natural stabilisation while major erosion hotspots persist (see Table 1). The primary drivers of sediment delivery remain legacy land use, climate variability, and poor riparian management. Proven, low-cost measures such as fencing, revegetation, and small-scale stabilisation works have the potential to substantially reduce sediment loads.

**Table 1.** *Summary of 2025 ACWA Management zone sites*

| Site | 2018 risk | 2025 risk | Risk trend | Key drivers | Priority actions |
|---|---|---|---|---|---|
| **MZ5 – G2**<br>Burra Creek | Very High 🔴 | High 🔴 | Improved slightly | - Steep terrain<br>- Poor riparian cover<br>- Stock access | - Fencing<br>- Riparian planting<br>- Low-cost stabilisation works |
| **MZ6 - G9**<br>Googong Foreshore | High 🔴 | Moderate 🟠 | Improved | - Visitor pressure<br>- Gullies in north<br>- Compaction | - Gully stabilisation<br>- Tin Hut Pond sediment management |
| New site for G2 | | | | | |
| **MZ7- G2**<br>London Bridge Tributary Gully | N/A | High 🔴 | New hotspot | - Road culvert runoff<br>- Dispersive soils<br>- Poor groundcover | - Head cut stabilisation<br>- Reshaping<br>- Revegetation |

Action is urgent as the two management zones assessed in G2 are still delivering fine sediment directly into Burra Creek, one of the main inflows to Googong Reservoir. The other management zone, G9, has shown recovery in its southern section, however active gullies in the north remain hydrologically connected to the reservoir. These risks are being amplified by climate variability, particularly during wet-on-dry rainfall events that accelerate erosion and sediment transport.

The top priorities for action are to control erosion at the source by stabilising gullies, repairing fencing, and re-establishing native riparian buffers; to protect and maintain sediment retention structures, particularly at Tin Hut Pond; and to strengthen coordination between Icon Water, ACT Parks and Conservation, Queanbeyan-Palerang Regional Council (QPRC), NSW Local Land Services (LLC), and landholders to deliver joint works. Early, strategic investment in these measures is a cost-effective safeguard for water quality, infrastructure longevity, and public health. This 2025 ACWA Plan provides a clear, evidence-based framework to guide these efforts and ensure Googong Reservoir remains a reliable drinking water source for decades to come.

# 2. INTRODUCTION

## 2.1 Background

The existing 2018 Actions for Clean Water Plan (ACWA) was developed to identify and manage erosion risks across the Googong catchment. This area includes the Queanbeyan River and Burra Creek systems above Googong Dam, which are essential to maintaining water quality for one of the ACT's key drinking water supplies. The plan prioritised 12 management zones, each with targeted actions for erosion control, land management, and source water protection.

The 2025 ACWA update (this document) builds on this foundation by re-assessing zones G2 and G9, which were originally classified as very high to high risk.

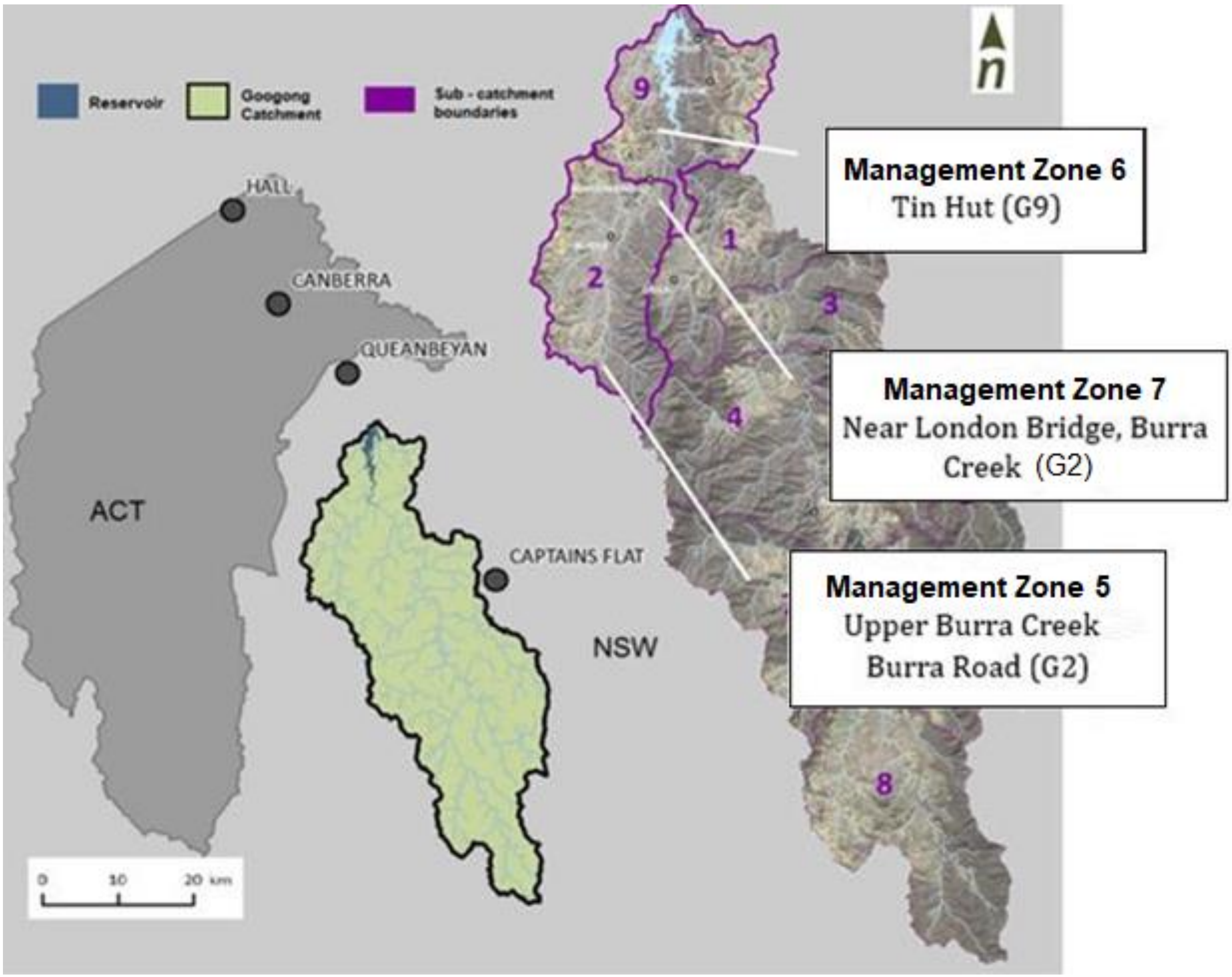


**Figure 1.** *Location map of the Googong catchment and corresponding sub catchments, Management Zones highlighted - G2 (Burra Creek) and G9 (Googong Foreshore).*

Field inspections conducted in April 2025 (see Table 2) confirmed that all sites assessed in G2 and G9 continue to exhibit active erosion and sediment transport pathways. These zones have been prioritised due to severe gully degradation and direct hydrological connectivity to Burra Creek, reinforcing the importance of responsive risk assessment frameworks. Management Zone 7 (G2) was not assessed in 2018 but has been included in this assessment due to its proximity to Googong reservoir.

**Table 2.** *Summary of sites assessed in 2018 and results*

| Subcatchment | Area (km²) | Main waterway | Location description | Hillslope erosion | Channel erosion | Gully erosion | Risk (LxCxT) | Risk rating |
|---|---|---|---|---|---|---|---|---|
| **G2 Management Zone 5** | 99 | Burra Creek | Upstream near Burra Rd & Captain Robertson Dr | High 🔴 | Mod-High 🟠 | Moderate 🟠 | 48 | Very High 🔴 |
| **G9 Management Zone 6** | 90 | Queanbeyan River | Tributaries near 'The Hut' entering Googong Reservoir | High 🔴 | Low-Mod 🟠 | Moderate 🔴 | 36 | High 🔴 |

Note: The management zones identified in the 2018 ACWA Plan are designated for targeted reassessment due to their ratings of 'High' to 'Very High.' Management Zone 7 was not assessed in 2018 but has been included in this assessment.

### Purpose of the 2025 Update

This update refocuses stakeholder attention on key sediment sources and prioritises remediation within the Googong catchment. Without targeted intervention, erosion in high-risk zones is likely to intensify under variable climatic conditions, particularly after wet-on-dry events.

To make priorities clear and progress easier to track, a traffic-light system has been applied across this plan:

- high to very high priority 🔴
- moderate priority 🟠
- low priority 🟢

This includes colour-coded site summaries, action tables, and a catchment-wide map highlighting sub-catchments from high (red) to low (green) erosion risk.

### Key findings from the 2018 ACWA Plan

The 2018 ACWA Plan provided the first structured erosion risk assessment across the catchment. Several findings remain highly relevant: areas G2 and G9 were identified as ongoing erosion hotspots due to steep slopes and channel incision. Despite these risks, little on-ground intervention has occurred. Field observations in 2018 highlighted clear sediment transport pathways into Burra Creek and Queanbeyan River, reinforcing the link between land condition and Googong Reservoir water quality. The plan also identified natural regeneration opportunities in lower-risk riparian zones and emphasised the need for adaptive management in the face of shifting land use and rainfall trends.

### Evolving risks and ongoing priorities

Since 2018, sediment risks have changed due to continued land-use pressures, climate variability, and limited remediation activity. The number of sites assessed as part of this reassessment are much fewer but remain priority areas due to their proximity to key inflows and their ongoing contribution of fine sediment. They represent the best opportunity for targeted erosion control, riparian buffer strengthening, and landholder engagement, particularly in the upper Burra Creek sub catchment, where natural erosion and human activity intersect.

## 2.2 Supporting assessments

### Catchment condition and erosion drivers

A report by Alluvium 2024 (see appendix), prepared for Icon Water's 2021-2024 Catchment Sanitary Survey, reinforces the original ACWA findings. While 61 per cent of the Googong catchment is bushland (which modelling highlights as erosion-prone due its steep areas), the primary sediment source is agricultural land (32 per cent of the catchment), particularly along degraded, grazed streambanks. Field inspections confirm that poorly vegetated grazing corridors contribute most to sediment loads (see Figure 3).

Sub catchments G2, G9 remain actively eroding with strong sediment connectivity to Burra Creek. Figure 3 shows an example of severe gully erosion, where the lack of fencing has allowed stock access, accelerated sediment mobilisation and threatens downstream water quality.

### Reservoir water quality modelling and source-pathway linkages

The Googong Reservoir Water Quality Modelling Report (Icon Water, 2025) provides critical evidence of the links between sediment inflows and in-reservoir processes. It shows that the sediment loads from Burra Creek and the Queanbeyan River directly influence stratification, nutrient cycling, and cyanobacterial risk, especially during warmer months. These impacts are most evident near inflow zones represented in G2 and G9. The report confirms that land use change, rainfall variability, and reservoir operations significantly influence water quality.

### Additional risk indicators from source water assessments

The 2022 Water Quality Status Review (Icon Water, 2024) found that higher levels of nutrients, turbidity, and occasional pathogen detections were more likely after rainfall, particularly in areas where the land is disturbed, for example with unsealed roads or where livestock have access to waterways. This highlights the need to align ACWA actions with areas experiencing active erosion.

### Supporting infrastructure and monitoring

Icon Water uses several measures to protect and monitor water quality in Googong Reservoir:

- Land and community programs help reduce pollution from the catchment through land management and public engagement.
- Two mixing units (destratification systems) push oxygen-rich surface water into deeper layers. However, the pipes (called draft tubes) only reach 5 metres deep — not enough to fully mix the reservoir or prevent low oxygen near the bottom. Extending them to 15 metres could improve deep water quality.
- Certified lab testing supports decisions on which depth to draw water from using the multi-level intake tower, especially during inflow events.
- Online monitoring is limited, with buoys placed away from the intake tower, reducing water quality visibility at the point of water extraction.

The modelling report recommends upgrading river and creek monitoring stations to include full water quality testing, improving intake visibility, and installing early warning systems to better manage risks.

**Figure 2.** *Comparison of Burra Creek inflows to Googong Reservoir between 2018 and 2025.*
(Left) In 2018, the tributary of Burra Creek and the Queanbeyan River within the Googong Foreshores, with low water levels and visible sediment impacts. (Right) By 2023, following several wet years, modest improvements in riparian vegetation and water clarity were observed upstream of the confluence — suggesting some localised sediment buffering.

**Figure 3.** *Severe gully erosion in Upper Burra Creek (2025)*
Characteristics include deep incision, collapsing vertical banks, and a near-total absence of riparian vegetation. The lack of fencing has allowed unrestricted stock access, compounding erosion and sediment mobilisation. This site poses a serious and ongoing risk to downstream water quality and highlights the urgent need for stabilisation and landholder support.

# 3. ACTIONS FOR CLEAN WATER ASSESSMENT 2025

## 3.1 Management Zone 5 - Burra Creek Sub catchment (G2).

### Location and significance

MZ5 is located along the upper reach of Burra Creek, upstream of Captain Robertson Drive near Burra (see Figure 4). The zone includes steep reserve lands and adjacent grazing paddocks that drain directly into Burra Creek, one of the key inflows to Googong Reservoir. It was ranked as a Very High risk in 2018 due to its steep terrain, limited groundcover, and highly dispersive soils.

### Field observations

Field inspections in April 2025 confirmed ongoing gully expansion and undercutting, especially where subdivision and vegetation clearance have exposed vulnerable soils. While some minor groundcover recovery has occurred, active gullies remain largely untreated. Without intervention, these processes will worsen, particularly during alternating wet–dry cycles, increasing sediment input to the reservoir.

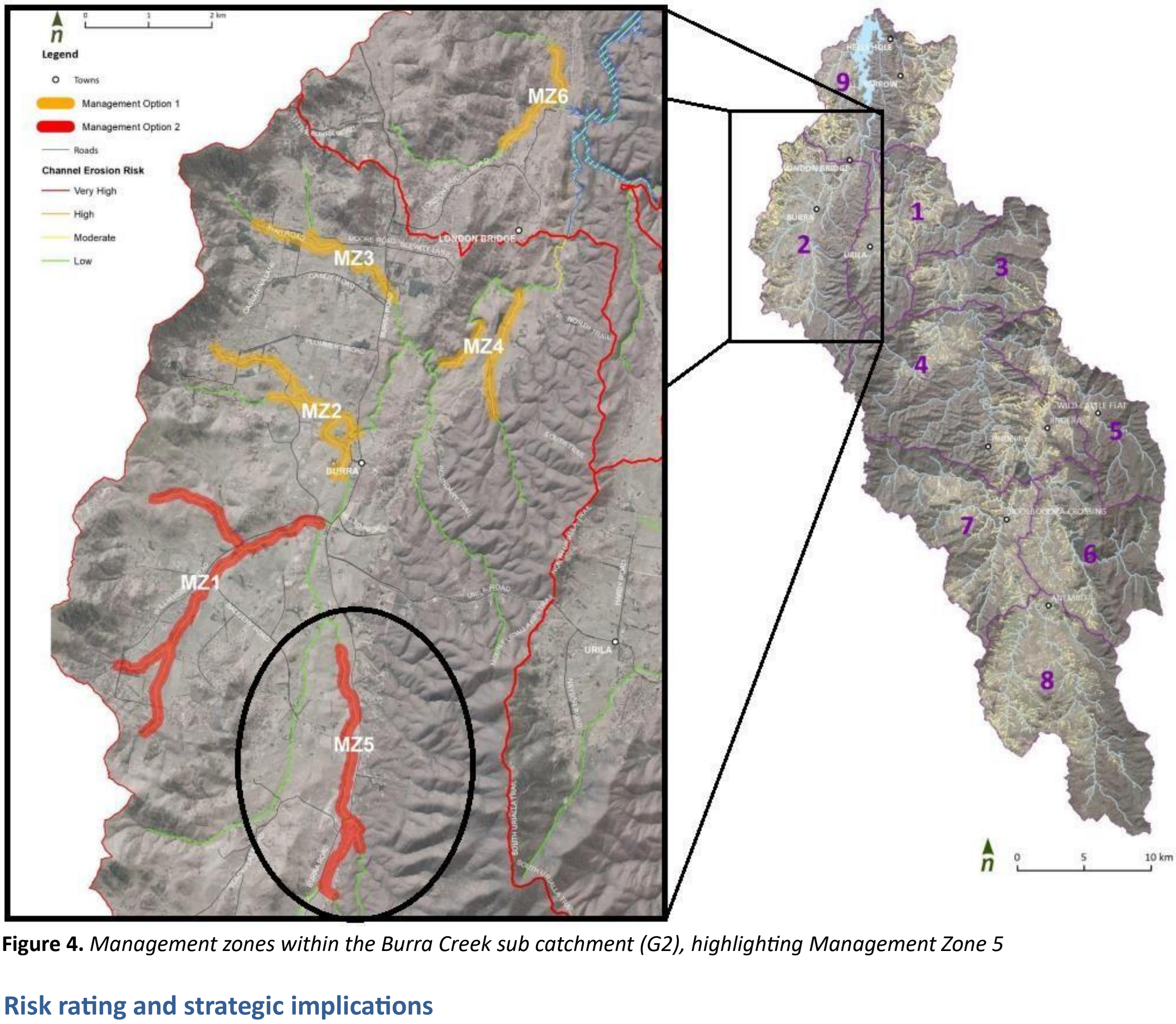


**Figure 4.** *Management zones within the Burra Creek sub catchment (G2), highlighting Management Zone 5*

### Risk rating and strategic implications

Although some signs of aggradation have reduced the erosion trajectory rating from 4 to 3, the risk remains High (see Table 3). Much of the site spans both Crown and private land, requiring close collaboration with Queanbeyan Palerang Regional Council (QPRC), Local Land Services (LLS), and landholders. Its proximity to newly established dwellings and community makes it a strong candidate for local community-assisted erosion control.

**Table 3.** *Management Zone 5 Erosion risk comparison 2018 vs 2025*

| Aspect | 2018 assessment | 2025 update |
|---|---|---|
| **Likelihood** | Likely (4) | Likely (4) |
| **Consequence** | Moderate (3) | Moderate (3) |
| **Trajectory** | Degradation and widening (4) | Widening and aggradation (3) |
| **Overall risk** | Very high (Score 48) | High (36) |

### Current erosion processes

Active erosion persists in steep gullies and sloped paddocks, especially where vegetation is sparse. Sheet and rill erosion are evident in disturbed areas, and several access points lack sufficient buffering. Contributing factors include dispersive soils, storm-driven runoff, and animal disturbance (e.g., wombats). Figures 5–10 show active erosion features, fencing failures, and partial natural recovery.

**Figure 5.** *Tall vertical bank collapse, fencing at risk (left); overhanging bank, tunnel initiation, undercutting, potential tunnel erosion (right)*

**Figure 6.** *Collapsing meander near paddock and active head cut (left); lateral erosion, slumping and gully initiation showing red dispersible soils (right)*

**Figure 7.** *Deep scour pool and near-vertical wall showing hydraulic scour (left); incised gully with returning tussocks (right)*

**Figure 8.** *Moderate bank, rill and surface erosion (left); subsurface tunnel collapses due to wombats (right)*

**Figure 9.** *Grass/tussock cover in previous gully (left); fenced buffer with regrowth (right)*

**Figure 10.** *Dense tussocks in gully, self-armouring channel (left); sparse but emerging gully vegetation and early-stage recovery (right)*

## Summary and recommendations

Despite signs of natural recovery, erosion hotspots remain. Early intervention using low-cost, stabilisation-focused actions could prevent costly future remediation. A collaborative approach will be essential. These interventions are listed in Table 4, and outline practical treatments, delivery partners, timeframes, and relative priority to support source water protection and land stability.

**Table 4.** *Summary of recommended management actions for erosion control in Management Zone 5.*

| Action area | Description | Delivery partners | Timeframe | Priority |
|---|---|---|---|---|
| **Fencing & stock exclusion** | Repair or realign fencing along actively eroding banks. Work with landholders and QPRC to reinforce stock exclusion in priority areas. | - QPRC<br>- LSS<br>- Landholders | Short term (0–1 yr) | High 🔴 |
| **Riparian planting** | Replant exposed gully heads and banks with native grasses and sedges. Partner with local groups to support revegetation and phased weed control. | - QPRC<br>- Greening<br>- Australia<br>- Landcare | Short–long term (1–5 yrs) | High 🔴 |
| **Coordination & engagement** | Strengthen collaboration with QPRC and LLS to clarify responsibilities and plan erosion control works across interface areas. | - Icon Water<br>- QPRC<br>- LLS | Ongoing | Moderate 🟠 |
| **Erosion control measures** | Trial low-cost treatments (e.g. brush layering, coir matting, small flow diversions) in high-risk but accessible sites. Avoid major earthworks. | - QPRC<br>- Contractors | Short–medium term (1–3 yrs) | Moderate 🟠 |
| **Monitoring & adaptive management** | Establish photo points, monitor seasonal changes, track fence movement as a proxy for channel migration, and map wombat activity. | - Icon Water<br>- QPRC | Ongoing | Moderate 🟠 |

## 3.2 Management Zone 6 – Googong Foreshore Subcatchment (G9)

### Location and significance

Management Zone 6 (see Figure 11) spans the western slopes near Tin Hut within the Googong Foreshores and is managed by ACT Parks and Conservation Service (PCS). It includes ephemeral tributaries that drain into Tin Hut Bird Hide Pond (a sediment pond) before reaching Googong Reservoir. It is a highly visited public area with several access roads and recreational areas.

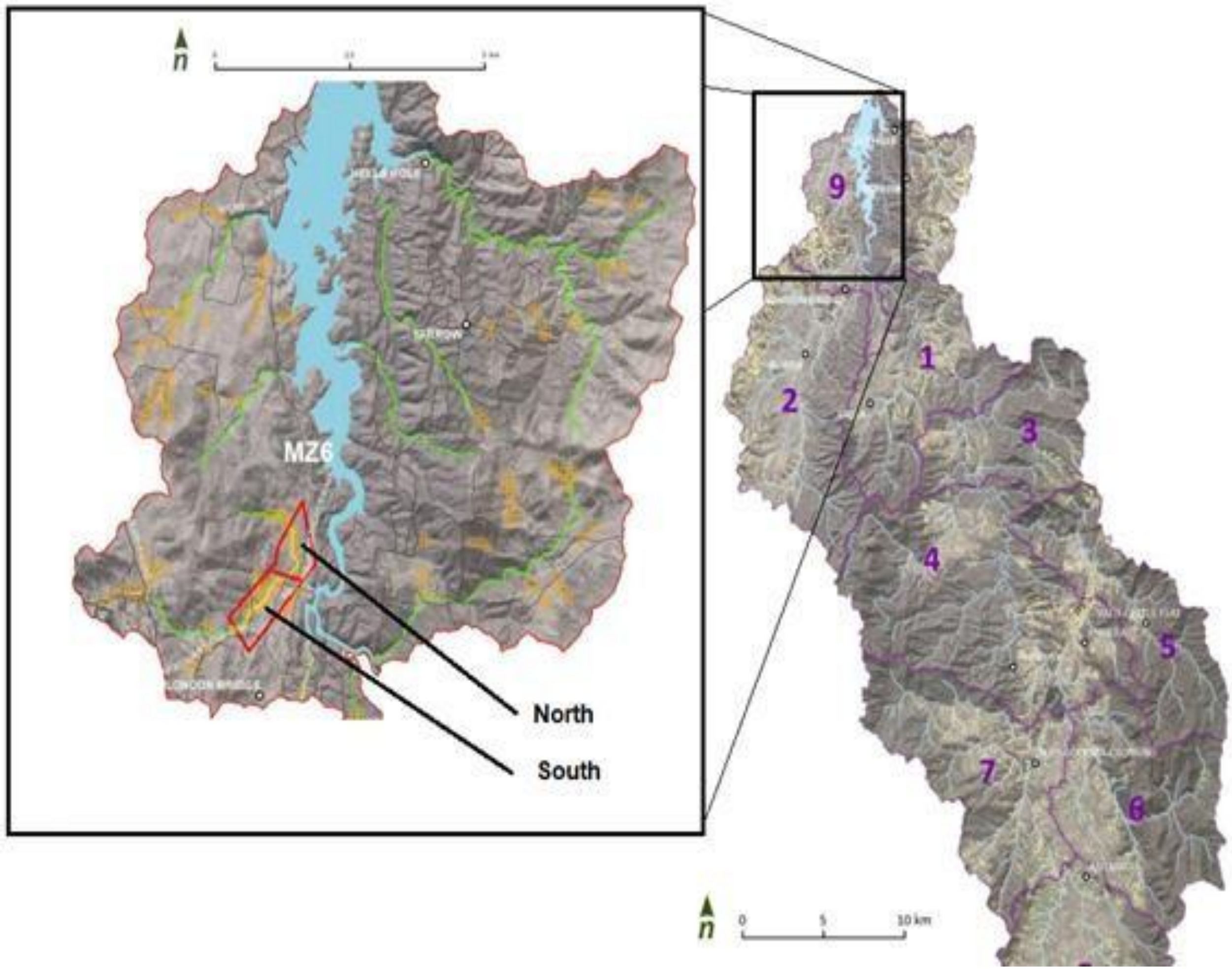


**Figure 11.** *Management zones within the Googong Foreshores subcatchment (G9), highlighting Management Zone 6*

### Field observations

The 2025 inspection found that some previously active erosion has stabilised, aided by some track closures, revegetation, and land management. However, gullies in the northern reaches remain unstable. Disused roads and compacted surfaces continue to mobilise sediment, especially during storms.

### Risk rating and strategic implications

While the overall risk score has improved from High (36) to Moderate (27) (see Table 5), sediment risks remain due to ongoing visitor pressure and the site's erosion-prone landscape. It continues to warrant priority attention, particularly given recreational use and the comparatively weaker oversight of activities in southern Googong Foreshores relative to the north of the reserve.

**Table 5.** *Updated erosion risk comparison for Management Zone 6 (G9)*

| Aspect | 2018 Assessment | 2025 Update |
|---|---|---|
| **Likelihood** | Likely (4) 🔴 | Likely (4) 🔴 |
| **Consequence** | Moderate (3) 🟠 | Moderate (3) 🟠 |
| **Trajectory** | Widening and aggradation (3) 🟠 | Partially stabilised (2) 🟢 |
| **Overall risk** | High (36) 🔴 | Moderate (27) 🟠 |

### Current erosion processes

The northern tributary shows active head cuts, gully incision, and undercutting exacerbated by sparse vegetation and wombat activity. In contrast, the southern area near Tin Hut shows vegetative recovery, sediment deposition, and reduced channel energy. Overall, MZ6 displays a clear spatial contrast with active erosion in the north versus general stabilisation in the south, highlighting the need for site-specific management tailored to each area's erosion drivers. Figures 12-17 below illustrate a mix of erosion features, faunal disturbance, and early recovery.

**Figure 12.** *Active headwall collapse and gully deepening (left); bank undercutting and lateral widening (right)*

**Figure 13.** *Active bank slumping and vertical gully walls (left); channel incision and faunal instability (right)*

**Figure 14.** *Sediment deposition at Tin Hut Pond (left); early-stage rocky-based vegetation cover and stability (right)*

**Figure 15.** *Incised channel with exposed bedrock and active bank erosion (left); signs of vegetation recovery and flow dissipation (right)*

**Figure 16.** *Localised sediment deposition and fauna disturbance (left); vegetation establishment in a receding channel zone at Tim Hut bird pond (right)*

**Figure 17.** *Deeply incised channel with faunal burrowing (left); bank collapse and highly dispersive soils (right)*

### Summary and recommendations

The northern gullies require targeted stabilisation and ongoing monitoring. The sediment pond's capacity and integrity should be structurally assessed, and sediment removal considered. G9's mixed erosion profile warrants site-specific management and coordination across PCS, QPRC, and community groups. Given its moderate risk and signs of recovery, G9 is well suited to low-cost, practical works, alongside continued feral animal management to reduce disturbance and targeted bank stabilisation through strategic plantings (see Table 6). Ongoing classification of this management zone, coupled with monitoring of implemented works and support from Icon Water, PCS, and landholders, will be essential to consolidating gains and addressing these erosion hotspots.

**Table 6.** *Management Zone 6 targeted management actions to help reduce sediment risk*

| Action | Description | Responsibility/ delivery partner | Timeframe | Indicative priority |
|---|---|---|---|---|
| **Fencing & stock exclusion** | Realign or reinforce fencing where gully expansion has breached boundaries, particularly in the northern reach. | - QPRC<br>- Landholders<br>- PCS | Short-term | High 🔴 |
| **Riparian planting** | Target native sedge and tussock planting at gully heads, exposed banks, and erosion-prone slopes. Support revegetation in recovering areas and manage invasive weeds. | - QPRC<br>- LLS<br>- Greening Australia<br>- Community | Short–long Term | High 🔴 |
| **Tin Hut function assessment** | Assess the structural integrity and sediment storage capacity of Tin Hut dam. Consider sediment removal to increase holding capacity and reduce downstream sediment load. | - PCS (Lead)<br>- Icon Water (Support) | Short–long Term | High 🔴 |
| **Erosion control measures** | Trial low-cost interventions (e.g. brush layering, matting, minor flow dispersal structures) in actively eroding gullies in the northern reach. Avoid major works. | - PCS<br>- LSS<br>- Landholders | Short–medium term | High 🔴 |
| **Pest management** | Map and monitor wombat burrows contributing to erosion. Trial exclusion or stabilisation approaches in high-risk zones. | - PCS<br>- LLS<br>- Landholders | Ongoing | Moderate 🟠 |

| | | | | |
|---|---|---|---|---|
| **Monitoring** | Establish photo points and conduct seasonal inspections to track vegetation, erosion progression, and post-storm changes. | - Icon Water<br>- PCS<br>- QPRC | Ongoing | Moderate 🟠 |
| **Cross-agency coordination** | Align erosion management activities across G9 by engaging QPRC, PCS Rangers, and LLS, especially where erosion affects infrastructure and access. | - Icon Water<br>- PCS<br>- QPRC<br>- LLS | Ongoing | Moderate 🟠 |

## 3.3 Management Zone 7 - London Bridge Tributary Gully (G2)

### Location and significance

Management Zone 7 (MZ7) is a newly identified gully system on the true right bank of Burra Creek, roughly 200–250 m downstream of London Bridge Homestead (see Figure 18). Although small in area, it drains directly into Burra Creek and poses a clear sediment delivery risk to Googong Reservoir. It is not directly connected to a defined drainage line, however the gully functions as a preferential flow path during rainfall events, capturing and channelling surface water across an open, sloped paddock.

### Field observations

MZ7 shows clear signs of active erosion (see Figure 19), driven by concentrated stormwater runoff from a road culvert. This has caused deep gully incision, upslope head-cut migration (exceeding 1.5 m in height), and vertical walls composed of dispersive soils. The gully floor is poorly vegetated and shows active scouring and sediment transport. Widening and lateral erosion are occurring where minor surface flow lines intersect with grazing and bare soils.

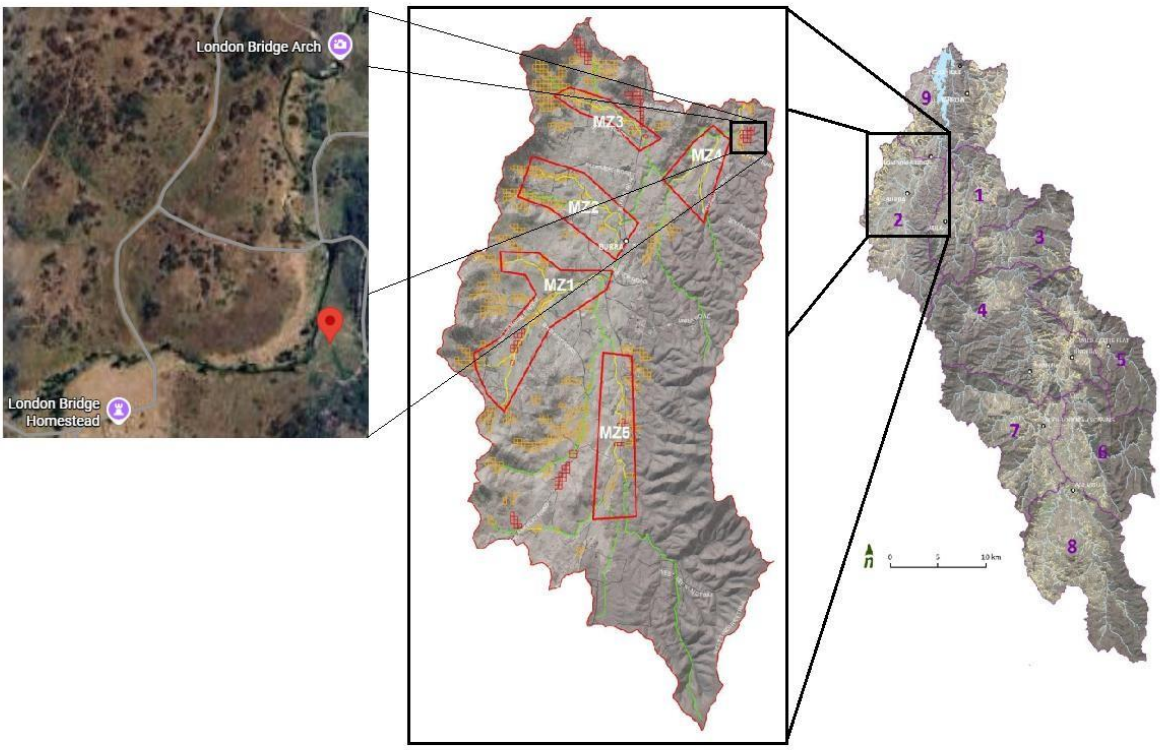


**Figure 18.** *A series of aerial maps showing location and field images near Management Zone 7 (MZ7), G2 .*
The red pin marks the approximate location just downstream of London Bridge Homestead along Burra Creek.


**Figure 19.** *Aerial view of the MZ7 (G9) erosion site on the true right bank of Burra Creek.* Image shows active gully incision extending from the roadside toward the creek (parts of the lower gully are obscured by blackberry cover). The site drains directly into Burra Creek, posing a sediment risk to Googong Reservoir.

Downstream, the gully enters a blackberry-filled drainage depression that obscures visibility and may conceal further instability. Scattered poplars and woody debris offer minimal hydraulic resistance, and overall groundcover remains patchy. Given the site's proximity to Burra Creek and lack of control measures, sediment delivery risk to Googong Reservoir is high, highlighting the need for early stabilisation works.

### Risk rating and strategic implications

Ongoing erosion contributed to the site's high-risk score of 40, a clear water quality risk (see Table 7). Intervention should prioritise stabilising head cuts, reshaping gullies, diverting channels, and revegetating banks. Traffic and fauna management are also recommended to reduce further disturbance.

**Table 7.** *Risk profile for Management Zone 7 (G2).*

| Risk criteria | Assessment | Rating |
|---|---|---|
| **Likelihood** | Active head cutting and steep gully walls indicate ongoing erosion with direct hydrological connection to Burra Creek | Likely (4) 🔴 |
| **Consequence** | Potential for significant sediment loading to Googong Reservoir and associated treatment challenges | Major (4) 🔴 |
| **Trajectory without intervention** | Without action, gully expansion and sediment output are expected to increase under climatic variability | Worsening (2.5) 🟠 |
| **Overall risk rating** | | High (40) 🔴 |

## Current erosion processes

MZ7 remains actively unstable, with steep incised gully walls, dispersive subsoils, and sparse vegetation contributing to frequent slumping and sediment mobilisation (see Figures 20-21).

**Figure 20.** *Gully erosion at G2*
Photos show steep, actively incising walls and sparse vegetation. Exposed dispersive soils and a lack of stabilising groundcover highlight ongoing sediment risks to Burra Creek.

**Figure 21.** *Downstream view of G2*
Photos show eroding banks, exposed dispersive subsoils, and minimal recovery. Visible sediment layers and fallen timber indicate recent instability and ongoing sediment transport to Burra Creek.

Head cuts and tension cracks observed in 2025 indicate ongoing upslope migration and lateral expansion, exacerbated by runoff from adjacent roads. The gully floor is poorly vegetated and shows signs of scouring and concentrated flow. Blackberry thickets downstream obscure visibility and may conceal further erosion. With direct drainage into Burra Creek and limited buffering, the site poses an ongoing sediment risk to Googong Reservoir, especially during storm events.

## Summary and recommendations

Strategic intervention is urgently required to halt further gully erosion and protect the integrity of Burra Creek. Recommended treatments include low-impact structural measures, erosion control matting, and targeted revegetation. A detailed assessment of flow paths is needed to identify opportunities for redirecting water away from the gully and into surrounding grasslands. Collaborative implementation with community partners, such as the Googong community or local Landcare groups, will be essential to support long-term restoration efforts (refer to Table 8).

Actions focus on stabilising head cuts, reshaping unstable banks, revegetation, and managing fauna impacts. Delivery will rely on collaboration between PCS, Icon Water, and local partners, aligned with ACWA Plan objectives for source water protection.

**Table 8.** *Proposed erosion control actions for the Management Zone 7 (G2).*

| Action | Description | Responsibility/ delivery partner | Timeframe | Indicative priority |
|---|---|---|---|---|
| **Gully head stabilisation** | Construct small rock checks, drop structures, or use geotextile matting to reduce headward erosion – especially around the road culvert | - PCS<br>- Icon Water | Short term (0–1 yr) | High 🔴 |
| **Bank reshaping and stabilisation** | Safely re-profile gully sidewalls and apply jute mesh or mulch to minimise active slumping | - PCS<br>- Icon Water | Short–medium term (1–2 yrs) | Moderate 🟠 |
| **Targeted revegetation** | Establish native sedges, grasses, and mid-storey shrubs to stabilise slopes and improve groundcover | - PCS<br>- Icon Water<br>- Local Landcare or community group<br>- Township | Medium term (1–3 yrs) | High 🔴 |
| **Fauna access management** | Install low-profile fencing or barriers to reduce disturbance from wildlife and encourage regrowth | PCS | Medium term (1–2 yrs) | Moderate 🟠 |
| **Monitoring & adaptive management** | Establish fixed photo points and assess site condition annually to inform future interventions | PCS | Ongoing | Moderate 🟠 |

# 4. PROTECTING SOURCE WATER THROUGH INTEGRATED CATCHMENT ACTION

Icon Water's commitment to safeguarding the ACT and surrounding region's drinking water supply is supported by a broad suite of scientific, operational, and collaborative programs. These initiatives aim to reduce sediment inflows, detect emerging threats, and foster strong partnerships across jurisdictions.

This section summarises Icon Water's key activities and studies contributing to erosion control and catchment monitoring, all of which help underpin a secure, clean water future.

## 4.1 Source Water Protection Strategy

Icon Water's Source Water Protection Strategy (2024) is a unifying framework to guide proactive management of raw water quality. Anchored in three pillars, monitoring and surveillance, risk management, and stakeholder engagement. It supports programs such as catchment sanitary surveys, source water quality improvement plans, and ecological monitoring. These efforts ensure alignment with the Australian Drinking Water Guidelines (ADWG) and a strong preventive approach to managing source water risks.

## 4.2 Actions for clean water and field monitoring

The Actions for Clean Water (ACWA) Plan drives field-based identification and mitigation of erosion risks across the Googong Catchment. This 2025 update leveraged light detection and ranging (LiDAR) data, photo monitoring, and rapid on-ground inspections to evaluate active erosion zones. These assessments inform low-impact interventions like coir logs, targeted revegetation, and track redirection, all of which interrupt sediment transport pathways to Googong Reservoir.

## 4.3 Reservoir modelling and sediment inflows

The Googong Reservoir Water Quality Modelling Report (2025) was developed in response to strategic concerns raised in the Water Quality Status Review (2023), which identified gaps in hazard recognition, regulatory compliance, and operational resilience at Googong WTP. The modelling confirmed that sudden, high rainfall events are strongly linked to elevated suspended sediment concentrations in the reservoir. These findings support the sediment source mapping in the ACWA Plan and reinforce the need for upstream erosion control. The outcomes also provide a predictive framework to guide flow monitoring and improve sediment risk management under varying climatic and operational scenarios.

## 4.4 Carp monitoring and aquatic health

Icon Water partners with consultants and researchers on biannual fish monitoring surveys, with eDNA trials underway in Burra Creek and Queanbeyan River tributaries. Invasive species like carp disturb streambeds and contribute to turbidity, especially in degraded or low-flow environments. These programs complement aquatic health assessments under the Murrumbidgee Ecological Monitoring Program (MEMP) and the Below Dams Monitoring Program, which monitor ecosystem responses and inform water quality protection strategies.

## 4.5 Collaboration and future directions

Surveys of ACT drinking water catchments and broader stakeholder engagement efforts, including Upper Murrumbidgee Catchment Network (UMCN), Waterwatch participation and cross-border coordination, strengthen Icon Water's integrated catchment approach. Strategic partnerships with NSW Government agencies, Queanbeyan Palerang Regional Council (QPRC), Local Land Services (LLS), and rural landholders are critical to delivering erosion control outcomes at scale. Future directions include improving rainfall-triggered inspections, refining photographic benchmarks, and activating community-led stewardship under Icon Water's Source Water Protection Strategy.

# 5. CONCLUSION AND CALL TO ACTION

Sediment risks in the Googong Catchment remain active. The management zones identified in this report continue to deliver fine sediment directly into Googong Dam, particularly under short-cycle wet–dry climate patterns.

This has significant implications such as reduced source water quality, greater complexity and costs associated with water treatment, and potentially a lower-quality water product delivered to the community. MZ5 (Burra Creek, Figure 22) and MP7 (London Bridge Tributary) both retain high-risk ratings, while MZ6 (Googong Foreshore) has improved to moderate risk but still requires targeted works in its northern gullies.

Reducing these risks is achievable through targeted, immediate action (see Table 9), focused on the most vulnerable areas, ensuring effective protection of water quality and long-term catchment resilience.

**Immediate priorities**

1. Stabilise low cost active gullies, repair or realign fencing, and re-establish native riparian buffers to break sediment pathways
2. Assess the structural integrity and capacity of Tin Hut Pond and other retention assets, removing sediment where necessary to maintain function.
3. Align efforts between Icon Water, PCS, QPRC, LLS, and landholders to deliver joint works, share monitoring data, and leverage funding.
4. Continue targeted pest management to reduce burrowing and bank instability.
5. Use native sedges, tussocks, and shrubs to reinforce vulnerable banks and improve resilience to high-flow events.

**Figure 22.** *Severe streambank erosion along a small rural section of Burra Creek (G2)*
Likely within an actively grazed area, this image highlights the extent to which riparian zones in this reach have been poorly managed or left unprotected, resulting in significant degradation of bank structure and loss of riparian health.

**Why urgent action is needed**

- Without early intervention, wet-on-dry rainfall events will accelerate erosion, increase treatment costs and reduce reservoir resilience.
- Current natural stabilisation trends in parts of G9 can be locked in with low-cost works before erosion reactivates.
- These measures support Icon Water's Source Water Protection Strategy, NSW and ACT sediment reduction targets, and Murray-Darling Basin Authority catchment health objectives.

A targeted, coordinated, and sustained program of works guided by this report and prioritisation system will deliver measurable water quality benefits, reduce operational costs, and protect Googong Reservoirs a secure drinking water source for decades to come.

**Table 9.** *Priority actions for agency and stakeholder collaboration*

| Priority status | Priority actions |
|---|---|
| 🔴 High | Stabilise erosion at source: Implement targeted gully and bank stabilisation works in MZ5 and MZ7 (G2), including fencing repairs, stock exclusion, and re-establishment of native riparian vegetation. |
| | Sediment retention maintenance: Assess and maintain key sediment retention structures (e.g., Tin Hut Pond), removing accumulated material where necessary to preserve capacity and function. |
| 🟠 Moderate | Cross-agency coordination: Strengthen partnerships between Icon Water, PCS, QPRC, LLS, and landholders to align erosion control programs, pool resources, and co-invest in priority works. |
| | Feral animal management: Continue targeted control of wombats and other pest species to reduce burrowing and bank destabilisation in sensitive zones. |
| | Bank stabilisation through revegetation: Use native sedges, tussocks, and shrubs to reinforce vulnerable banks and enhance resilience to high-flow events. |
| | Track rehabilitation and flow redirection: Redirect or close compacted access tracks in high-risk areas to reduce concentrated runoff and sediment delivery. |
| 🟢 Low | Monitoring and adaptive management: Maintain fixed photo points, conduct rainfall-triggered inspections, and update erosion risk ratings using the traffic-light system to measure progress and guide future investment. |

The Australian Drinking Water Guidelines (ADWG) identify source water protection as the first and most critical barrier for safe drinking water. In the Googong Catchment, uncontrolled erosion is currently compromising this barrier – elevating turbidity, increasing treatment costs, and potentially eroding public confidence in the water supply.

# 6. APPENDIX: AN INTEGRATED CATCHMENT ASSESSMENT

**Sediment Risk, Rainfall Variability (2018–2024), and Land Use Comparison Across the Googong Foreshores and Outer Zones**

**This report has been prepared by Alluvium Consulting Australia Pty Ltd**

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**Approved: A Sims**
**Version: 1.0**
**Date issued: 20th September 2024**

## Introduction

Googong Reservoir is part of the water supply infrastructure in the Australian Capital Territory (ACT). It forms a major component of a network of other dams, reservoirs, treatment plants and pump stations managed by Icon Water. The reservoir represents 43 per cent of Canberra's water supply storage capacity.

Sediment transport to, and accumulation in, water storages used in the potable water supply system imposes costs on Icon Water as the manager and operator of the system. These costs result from increased water treatment of inflows with high sediment and nutrient concentrations and declining storage capacity as the dam fills with sediment. Sediment entering dams also enhances algal and weed growth, leading to loss of fish stock, increased methane production and reduced recreational value for the local community. The geomorphic and hydrologic processes that drive the increased sediment and nutrient delivery collectively pose substantial impacts on the operational and financial risk profile of the operation of Googong Reservoir.

Icon Water engaged Alluvium Consulting Australia (Alluvium) in 2018 to develop an Actions for Clean Water (ACWA) Plan to establish a baseline understanding of the sources and quantum of the sediment loads entering the Queanbeyan River and Burra Creek upstream of the Googong Reservoir, and to prioritise sites for interventions that reduce sediment delivery. This project report summarises a preliminary desktop analysis that will be used to inform the update to the ACWA Plan, and to guide future efforts to limit sediment and nutrient inputs to the Googong Reservoir. The updated ACWA plan will be used to direct efforts to stabilise and remediate sites over time, based on a prioritisation of risk to water quality in the receiving environment.

### Project aims and objectives

This preliminary analysis is desktop-based and has the following objectives:

- Map and quantify the proportion of sub-catchments within the Googong Reservoir catchment that are classified as agricultural land and pristine bushland.
- Analyse the potential for each land use type to contribute to sediment to Googong Reservoir.
- Undertake the analysis described in points 1 and 2 above for the inner and outer catchment zones of the Googong Reservoir (where inner and outer zones are as defined by Icon Water in relevant management plans).

- Analyse rainfall patterns within the Googong Catchment using available data.

### Catchment context

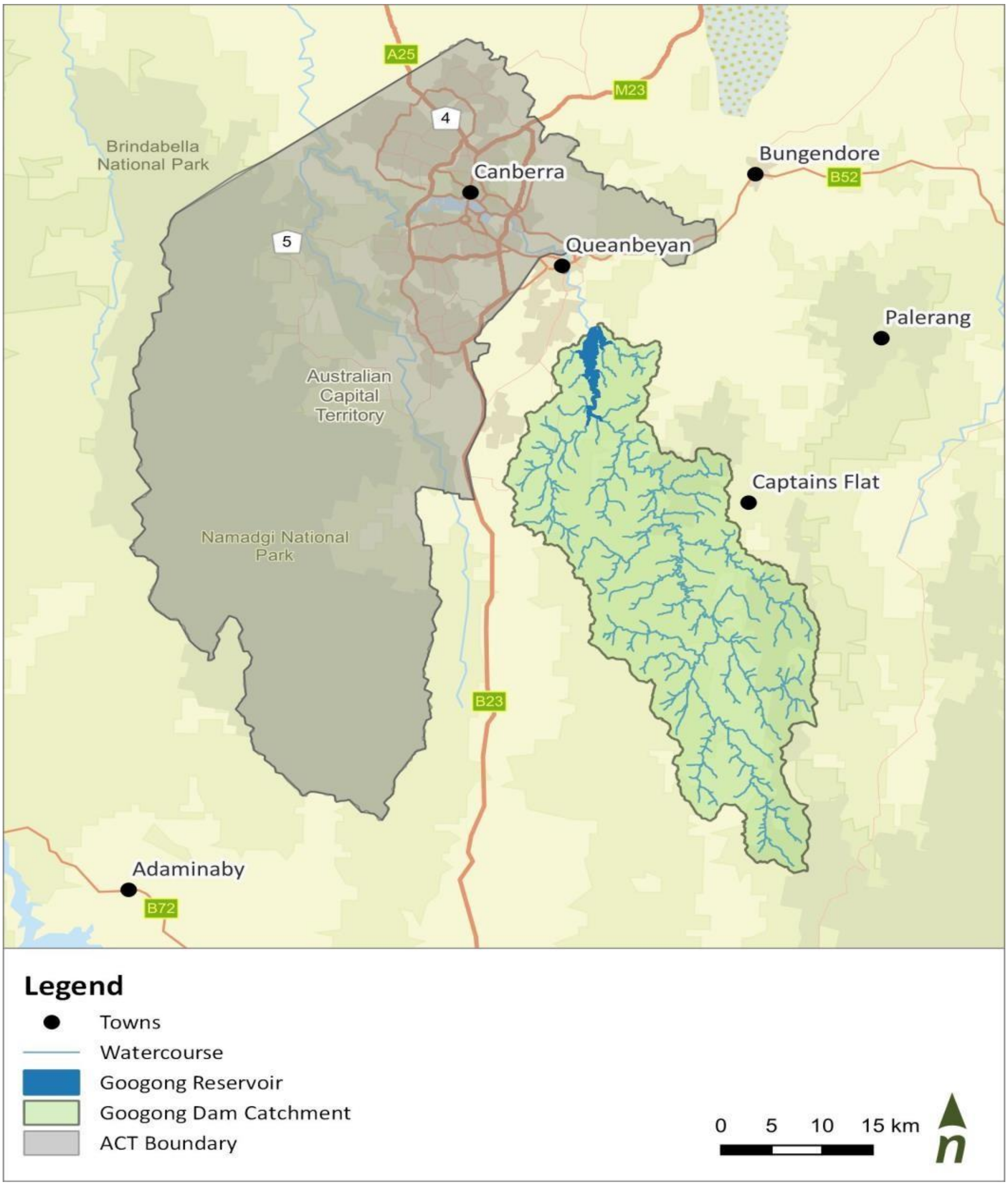


**Figure 1.** *Catchment location*

The Googong catchment is in New South Wales, to the south-east of Canberra and is part of the larger Queanbeyan River catchment. Googong Reservoir was completed in 1978 and upon closure formed the Googong Reservoir. The catchment area to the Dam is 875 km2, extending approximately 70 km south from the Dam to Gourock National Park (Figure 1). The catchment is bounded by the Tinderry Range in the west and south and the Gourock Range to the east.

The Queanbeyan River, with its headwaters rising in the Gourock Range in the south of the catchment, drains most of the catchment into Googong Reservoir. It flows south to north through the centre of the catchment and is fed by several tributaries that drain the ranges to the east and west. The main tributaries of the Queanbeyan River include Burra, Urialla, Tinderry, Ballinafad, Groggy, Woolpack, Sherlock, Lyons, Towney's and Mile Creeks. Burra Creek, which flows in a northerly direction drains the north-west of the catchment and several small waterways drain directly to Googong Reservoir.

## Methods

### *Agricultural vs bushland dynamics*

#### Land use analysis

Understanding the land use types throughout the Googong Catchment is important in determining the potential for sediment delivery to local waterways and ultimately the reservoir, as different erosion processes are typically associated with different land use types (for example, debris flows in steep forested catchments versus gullying in lowland agricultural land). As a result of accelerated in-stream erosion and gully development, grazed areas often generate and deliver greater volumes of sediment per hectare than Nature Conservation areas. This general trend is subject to significant local scale variability, driven by topography, the distribution of rainfall and the destabilising impacts of disturbance vents, such as fires and floods. It is also important to understand the land use types as they will directly affect the feasibility and eventual implementation of management actions aimed at reducing sediment loads delivered to downstream waterways.

For the purposes of this analysis, the Googong Catchment was divided into the nine subcatchments identified in the Googong Dam Actions for Clean Water Plan (Alluvium, 2018) (see Figure).

The percentage of land in the Googong Catchment covered by various land use types was delineated using the following spatial data layers:

- NSW Land use 2017 v1.5 (NSW DCCEEW, 2023)
- NSW State Vegetation Type – Extant Plant Community Type (NSW DCCEEW, 2022)
- Environmental Planning Instrument - Land Zoning (NSW DPHI, 2024)
- Google Satellite aerial imagery (various years)

The datasets were cross-checked against each other and the following land use types delineated: Agricultural; Bushland; Forestry; Other (residential without agriculture); Major waterbody; Googong protected foreshore. Once the land use types were delineated, a comparison of the composition of agricultural land and pristine bushland areas within the nine subcatchments was undertaken

### *Sediment and contaminant delivery potential*

The purpose of this assessment was to compare sediment delivery potential from each of the land use types within each subcatchment, to quantify the potential for these areas to contribute to sediment delivery.

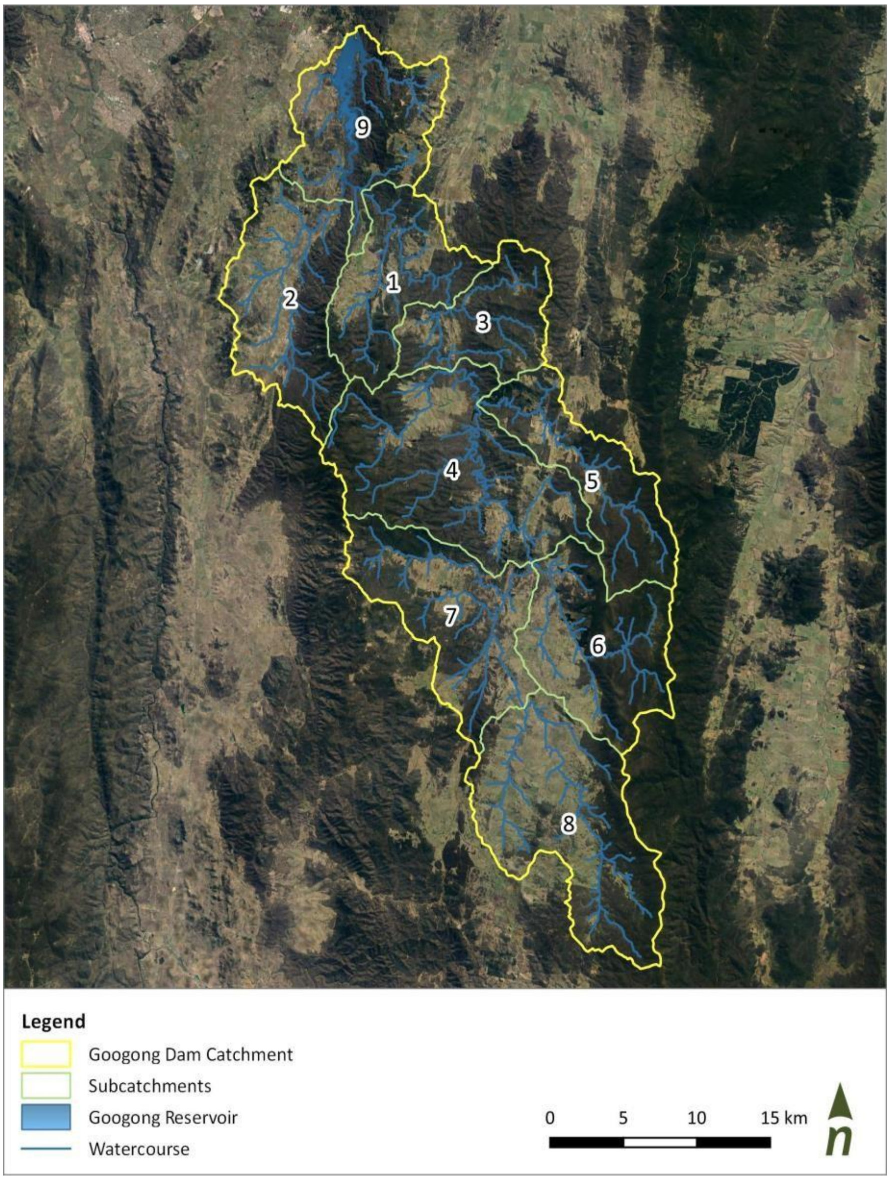


**Figure 2.** *Googong subcatchments*

Sediment and pathogen delivery potential was determined using hillslope erosion modelling, which relies on the Revised Universal Soil Loss Equation (RUSLE) to predict the volume of sediment produced per hectare per year. The RUSLE determines mean annual soil erosion as a product of six parameters including rainfall erosivity, soil erodibility, slope length, slope steepness, cover management and erosion control practice. By mapping the spatial distribution of the parameters, the location of likely hillslope erosion and sediment generation within a catchment can be estimated.

The sediment yield predicted by the RUSLE modelling is an over-estimate of the annual volume of sediment supplied to the Googong Reservoir because not all sediment generated by erosion is delivered to the channel network within a year. Instead, much of the sediment generated is stored lower on the hillslope or other temporary stores such as fans, terraces or on floodplains. To correct for this factor, we used the methods of Fu et al (2010) who assessed the delivery of sediments from unsealed roads in forested catchments, showing that the distance from the source of sediment to the stream was a useful proxy for the sediment delivery ratio. Based on this research and similar studies, it was assumed that for sediment generated within 10m, 30m and greater than 30m of a waterway, 100 per cent, 35 per cent and 10 per cent, respectively, of generated sediment would enter the waterway and be delivered to the Googong Reservoir.

Two years of modelled (RUSLE) erosion data were used to represent the variation in predicted erosion depending on observed rainfall. These were:

- 2019, representing a 'dry' year (i.e. low rainfall); and
- 2021, representing a 'wet' year (i.e. high rainfall).

For both the wet and dry year cases, the potential for each of the nine subcatchments to contribute to sediment to Googong Reservoir was calculated, along with the average sediment delivery potential of each land use type within each subcatchment.

**Inner catchment analysis**

The inner Googong catchment as defined by Icon Water (2024), and the main streams entering the reservoir is shown in Figure 3. The red line depicts the boundary of the Googong Foreshores, which is a protected management zone under the Googong Foreshores Land and Conservation Management Plan (2020).

Firstly, a comparison of the inner and outer catchment areas was undertaken, which compared the proportions of land use types between the two zones. Secondly, analysis of sediment and contaminant delivery potential (using the same methods described above) as undertaken for the inner catchment, in which the potential for the subcatchments of each mainstream entering the Googong Reservoir to contribute to sediment runoff was quantified and mapped.

Lastly, a qualitative assessment of the sediment buffering potential of the section of waterways that cross the inner catchment, and their respective subcatchments, was undertaken by considering the following attributes:

- Channel grade (using 2020 LiDAR data) – On average, steeper channels will have higher stream power and will more easily transport fine sediments. Conversely, flatter channels will have lower fine sediment transport capacity and therefore higher sediment buffering capacity.
- Channel confinement/geomorphology (using 2020 LiDAR data) – More confined channels will have higher stream power, in which fine sediments will be transported more easily. Conversely, less confined channels or those with floodplains will have lower fine sediment transport capacity, and therefore higher sediment buffering capacity.
- Catchment and riparian vegetation density – Vegetation can help slow down flow, which reduces stream power and promotes sediment deposition, hence raising sediment buffering capacity.
- Land use type – Different erosion processes are typically associated with different land use types (e.g. debris flows in forested catchments versus gullying in lowland agricultural land). Generally, grazing areas will supply more sediment than nature reserves and hence have a lower sediment buffering capacity.

This data was compared at each of the main streams to help build a preliminary understanding of the buffering potential of the inner catchment to safeguard the water quality.

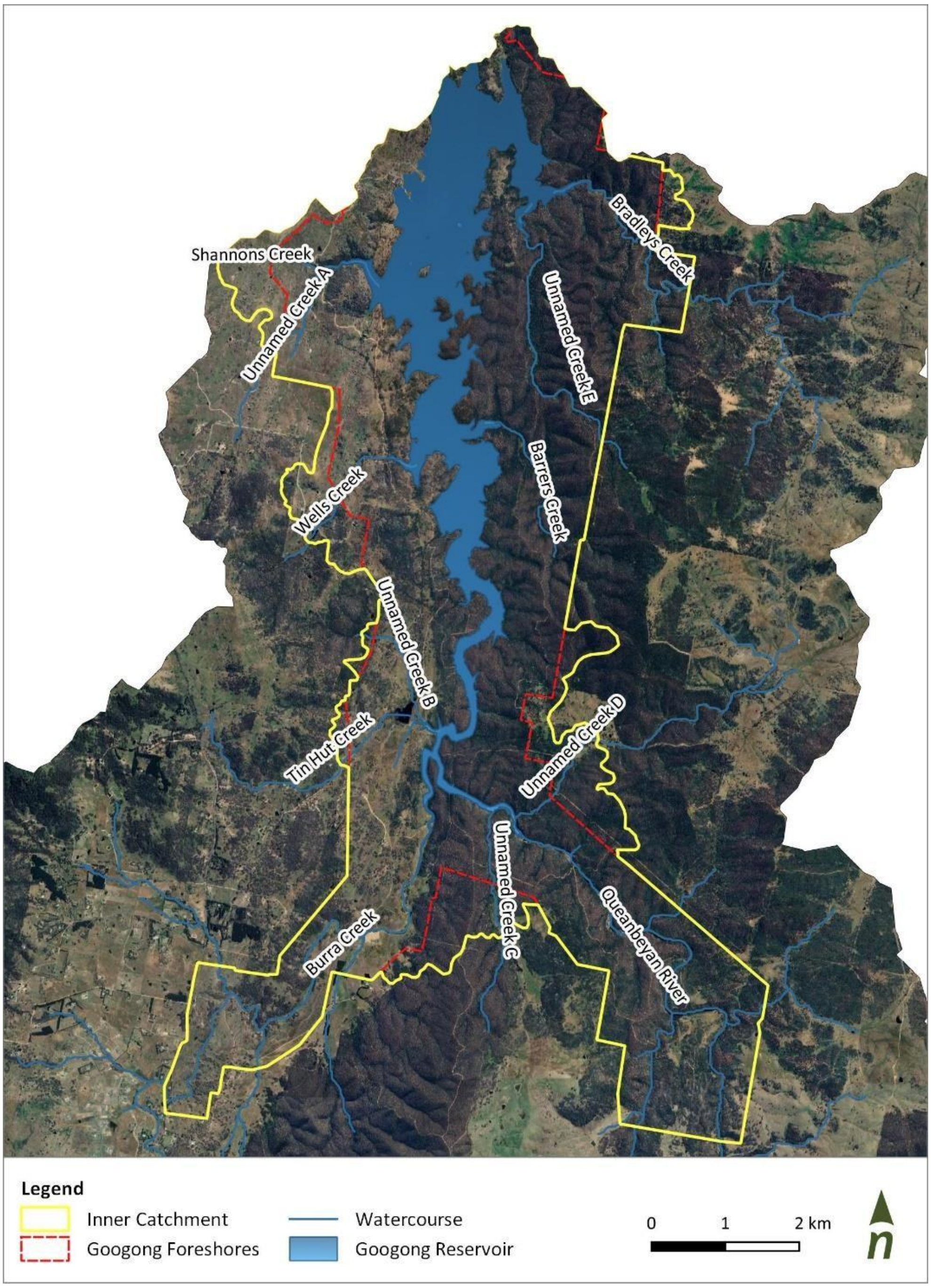


**Figure 3**. *Inner catchment and main streams entering the Googong Reservoir*

## *Rainfall dynamics*

Rainfall pattern analysis was undertaken using rainfall data from two sites in the Googong Catchment: Burra River at Burra Road (station ID 410774) and Queanbeyan River at Tinderry (station ID 570965) for the period 1990-2024 (see Figure 4).

A twelve-monthly SPI (Standardised Precipitation Index) was generated to characterise 'wet' and 'dry' years. SPI is an index to characterise droughts (e.g. meteorological, agricultural, and hydrological) on any timescale (e.g., three, six, nine and 12 months, these are monthly averages but with different moving averages. Hence, SPI12 means that monthly SPI is calculated based on a 12-month moving average). For a given station, the SPI is calculated by normalising precipitation after it has been fitted to a probability density function (a gamma distribution). The SPI at a longer timescale (12 months) can be related to streamflow, reservoir storage, and groundwater. Because the SPI is a normalised index, and wetter and drier climates can be represented in the same way, it is effective in determining wet periods and dry periods, and it can be used to compare precipitation anomalies for any geographic location.

SPI values are used to define wet and dry years/periods and drought intensity. Negative values of SPI specify less than median precipitation, and positive values specify greater than median precipitation. A dry year/period or drought event occurs any time the SPI is negative (SPI < 0), and a wet year occurs when the SPI value is positive (SPI > 0). For each month, a monthly SPI (twelve-monthly SPI12) was calculated from 1990 to 2024 and then averaged monthly data for each year to characterise if that year is a wet and dry year. Python programming language and python packaged was used to calculate SPI and characterise and plot wet and dry years.

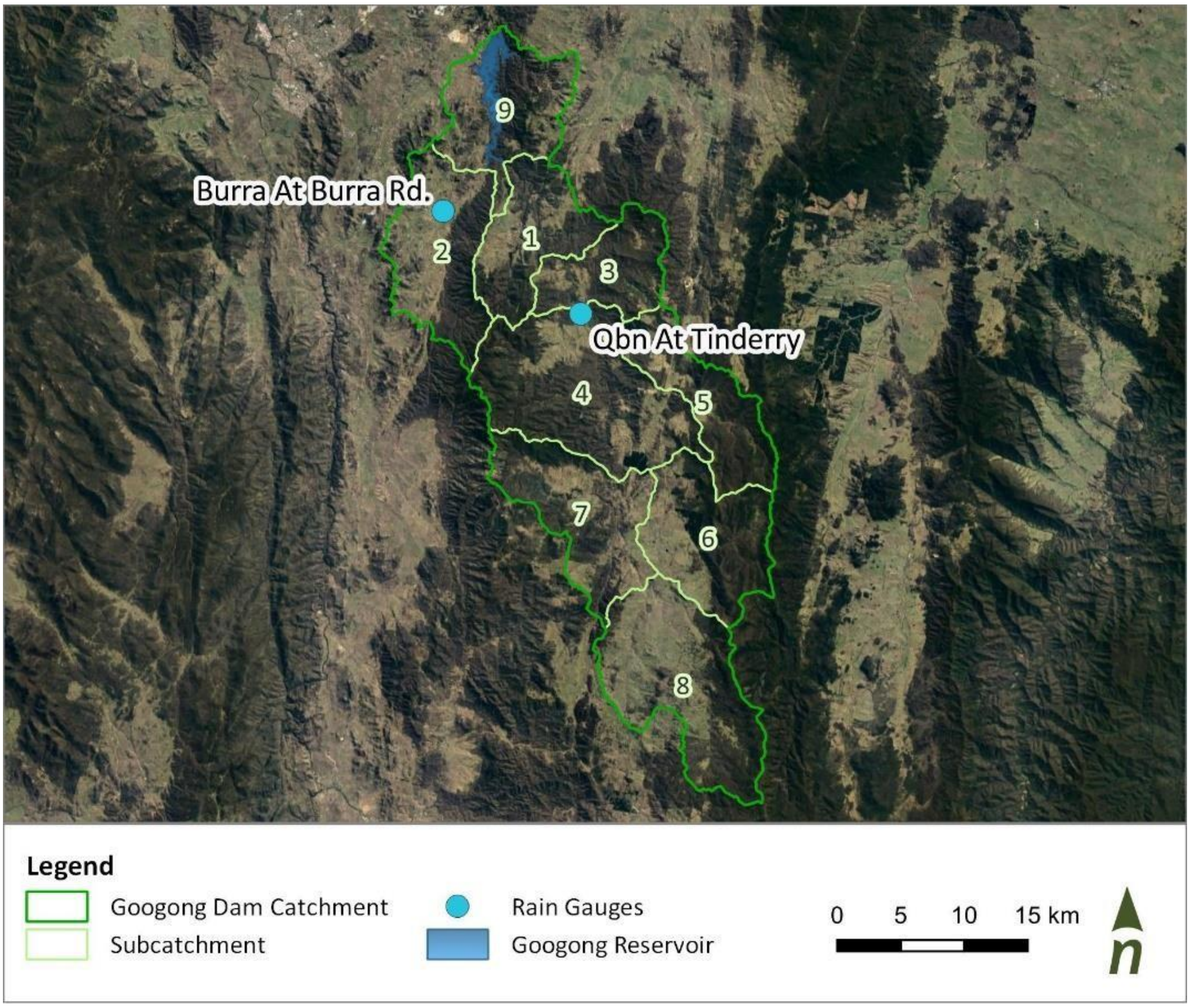


**Figure 4**. *Rain gauge locations*

The SPI calculation was also applied to weekly total rainfall data, tagging each week as either ‘wet’, ‘dry’ or ‘normal’. The purpose of the weekly SPI calculation is to identify instances where prolonged dry periods are interrupted by high rainfall events, and the average gap between weeks classified as dry and weeks classified as wet. This event-scale analysis is relevant to sediment delivery because prolonged dry periods lead to drier soils and a greater proportion of runoff during the subsequent high rainfall events converted to runoff, enhancing sediment delivery.

# Results and analysis

## *Agricultural vs bushland dynamics*

### Land use analysis

Within the whole Googong Catchment, bushland is the dominant land use type, covering 61 per cent of the area. Agricultural land is the next largest, covering 32 per cent, followed by forestry at three per cent, major waterbodies at two per cent, residential land without agriculture at one per cent, and protected foreshore land not covered by bush at one per cent.

It is important to note that 43 per cent of the overall catchment is mapped as 'Grazing Modified Pastures' in the NSW Land Use 2017 dataset (NSW DCCEEW, 2023). Through cross-checking with aerial imagery and the NSW State Vegetation Type dataset (NSW DCCEEW, 2022), these areas were divided into agricultural and bushland by estimating the level and impact of grazing in each area (e.g. an area of dense vegetation which did not have evidence of cattle tracks or dams was classified as bushland).

Table 1 shows the percentage of land use delineated within each subcatchment. Subcatchments 2, 8 and 7 have the highest proportions of agricultural land respectively, and subcatchments 3, 5 and 4 have the highest proportions of bushland respectively.

**Table 1.** *Percentages of land use types in each subcatchment*

| Sub-catchment | Area (ha) | Agriculture | Bushland | Protected foreshore | Waterbody | Forestry | Other (residential w/o agriculture) |
|---|---|---|---|---|---|---|---|
| 1 | 7,510 | 32% | 67% | 0.0% | 1.0% | 0.4% | 0.0% |
| 2 | 9,928 | 54% | 41% | 0.0% | 1.6% | 0.2% | 3.5% |
| 3 | 6,035 | 16% | 83% | 0.0% | 0.5% | 0.0% | 0.0% |
| 4 | 15,587 | 20% | 76% | 0.0% | 0.9% | 2.8% | 0.0% |
| 5 | 7,489 | 12% | 80% | 0.0% | 0.0% | 7.6% | 0.0% |
| 6 | 9,624 | 29% | 55% | 0.0% | 0.0% | 15.4% | 0.0% |
| 7 | 10,112 | 35% | 63% | 0.0% | 1.1% | 0.3% | 0.0% |
| 8 | 13,680 | 51% | 46% | 0.0% | 0.3% | 2.5% | 0.0% |
| 9 | 9,141 | 31% | 43% | 13.3% | 8.8% | 0.1% | 3.5% |

A map of the results is shown in Figure 5.

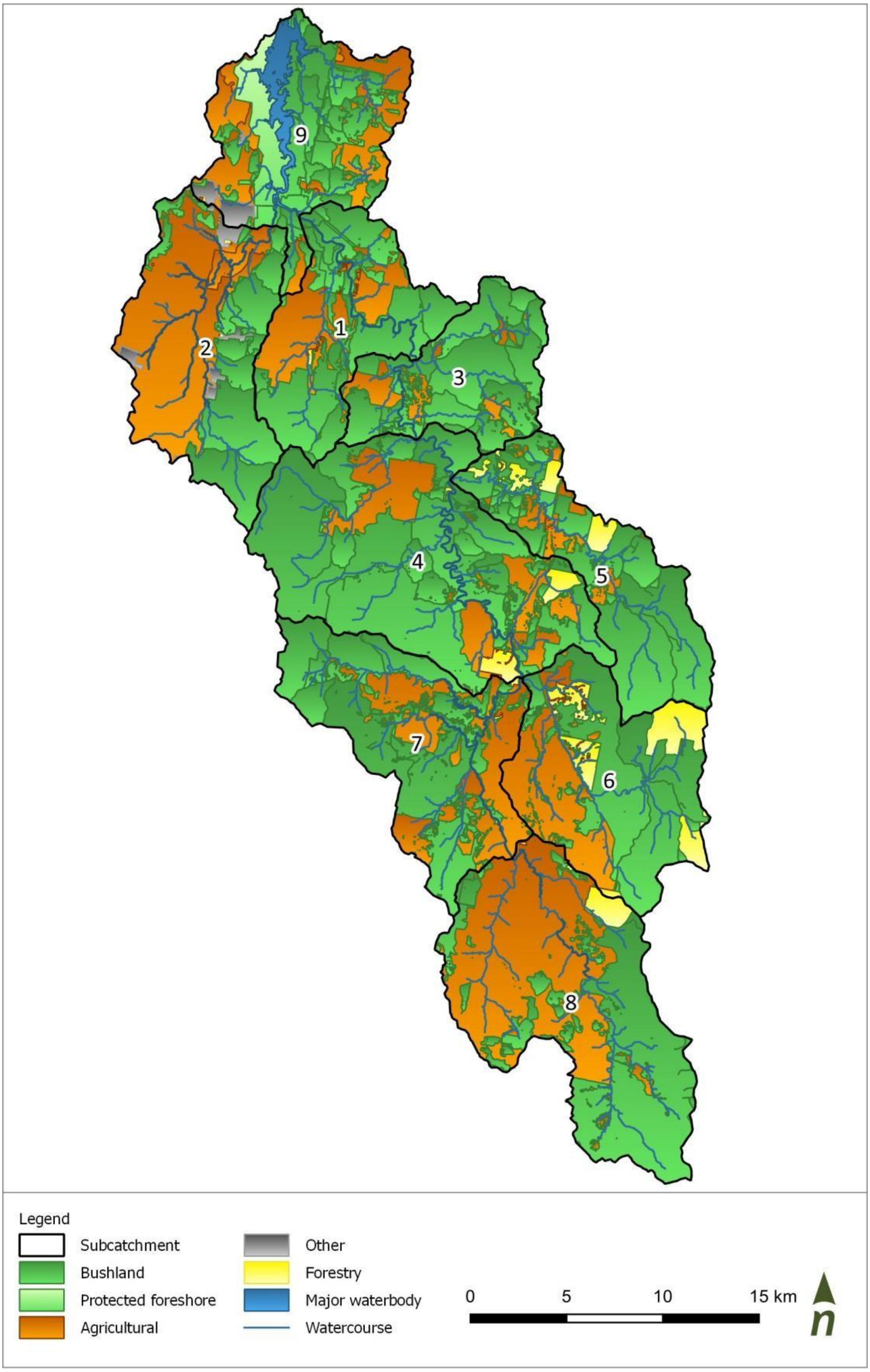


**Figure 5**. *Land use in the Googong Catchment*

### *Sediment and contaminant delivery potential*

The potential sediment delivery to waterways across the catchment (at a 2m grid resolution) for both a 'wet' year and a 'dry' year was calculated in tonnes per hectare per year (t/ha/y) and is shown below in Figure 6. In 2019 (i.e. the dry year), the volumes ranged from 0.000002 to 5.34 t/ha/y, with an average of 0.08 and a median of 0.04 t/ha/y. In 2021 (i.e. the wet year), the volumes ranged from 0.000007 to 18.07 t/ha/y, with an average of 0.27 and a median of 0.15 t/ha/y. It is unsurprising that the predicted sediment yield for the wet year is significantly higher than the dry year, given that rainfall erosivity is one of the parameters of the RUSLE modelling.

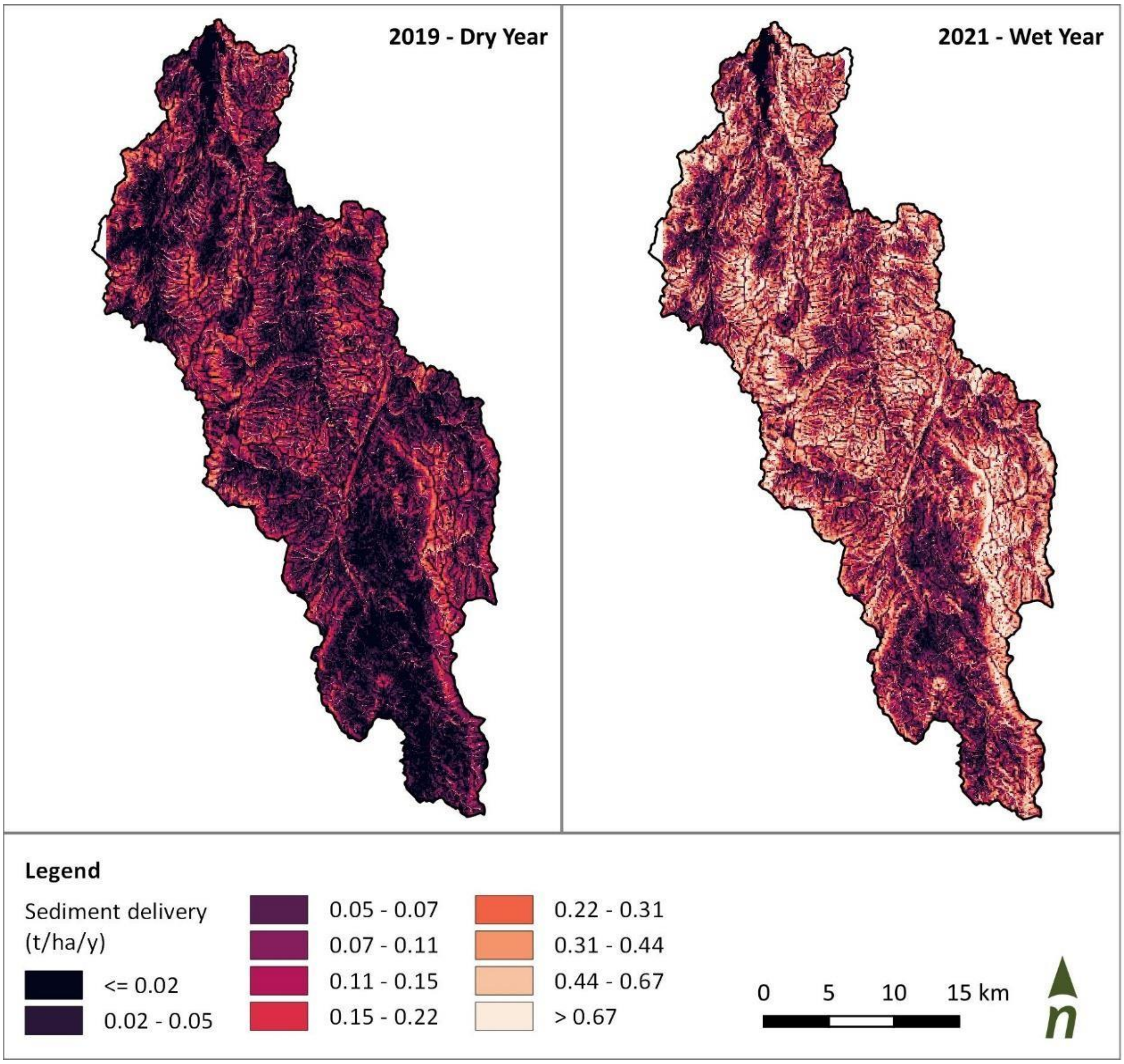


**Figure 6.** *Potential sediment delivery across the Googong Catchment in wet and dry years*

Recall that the hillslope erosion estimates have been adjusted to account for hillslope-waterway connectivity, so the values presented in the following maps and tables are estimates of the average volume of sediment delivered (not the total sediment generated, which is much greater). Sediment delivery modelling results were averaged across each subcatchment to visualise which subcatchments have the greatest potential to contribute sediment to the Googong Reservoir. Figure 7 shows a 'heat map' of the subcatchment average sediment delivery potential for both a wet and dry year. In the wet year, subcatchments 6 and 5 present the greatest average sediment and contaminant delivery potential (at 0.35 and 0.34 t/ha/y respectively), followed by subcatchments 3 and 4 (both at 0.29 t/ha/y). In both the wet and dry years, subcatchment 8 presents the lowest average sediment and contaminant delivery potential.

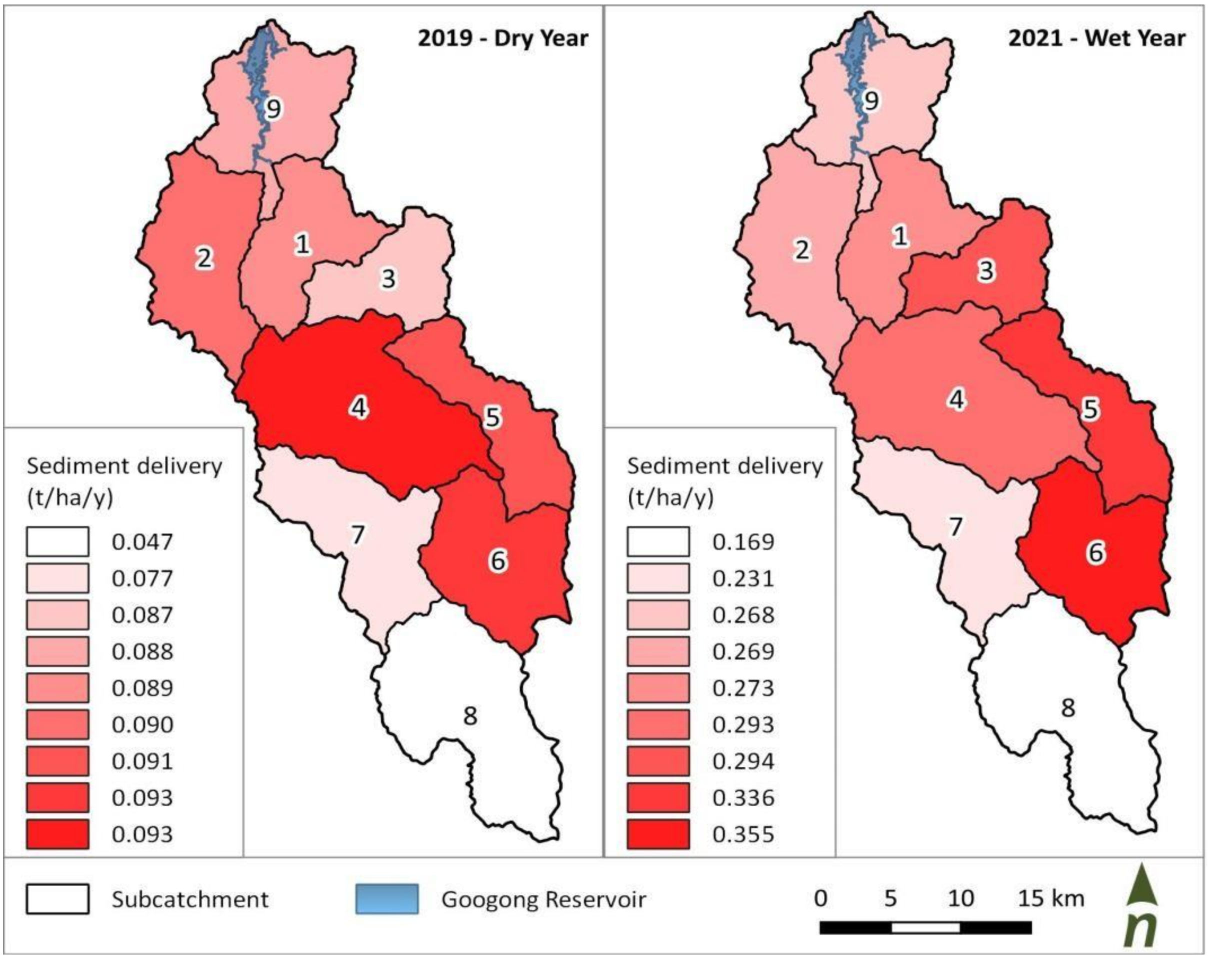


**Figure 7.** *Subcatchment average potential sediment delivery volumes in wet and dry years*

The potential for each land use type to contribute to sediment runoff was also analysed. Table 2 shows the average sediment delivery potential of each land use type within each subcatchment and is presented in descending order from highest to lowest 2021 (i.e. wet year) volume. Surprisingly, the highest yielding areas within Googong Catchment are bushland and forestry, with agricultural land only falling into the mid to bottom range of average delivery volumes. Bushland in subcatchment 6 appears to be the highest potential contributor to sediment runoff in a wet year, and the second highest contributor in a dry year (behind forestry in subcatchment 2). Bushland in the downstream subcatchments 2 and 9, along with forestry in subcatchments 2 and 5, are among the highest potential contributing areas to sediment and contaminant delivery.

These somewhat counterintuitive results are likely due to the slope parameters (i.e. slope length and steepness) of the RUSLE model dominating the results. This can result in higher erosion values for the areas of land with bigger, steeper slopes (i.e. bushland). On face value, the results suggest that flatter areas with lower vegetation (largely agricultural plains) will deliver less sediment compared to steeper hillslopes. However, though gentle hillslopes within agricultural areas may produce less sediment, the low relief agricultural catchments often produce significantly more sediment at the outlet. While no data on sediment yield is available at the outlet of any of the waterways that drain to the Googong

Reservoir, we suspect that the lack of hillslope and riparian vegetation within agricultural catchments will lead to:

- higher runoff
- a greater instance of gully formation
- greater connectivity between hillslope sediment sources (or gullies) and waterways
- higher peak flows in waterways, which leads to higher stream power and a greater erosion potential.

While our analysis does account for hillslope-waterway connectivity at a high level, the influence of accelerated gullying and bed and bank erosion in agricultural waterways is not captured. This type of in-channel erosion is often the primary driver of increased sediment yield at the catchment outlet.

**Table 2.** *Average sediment delivery potential of each land use type within each subcatchment*

| Subcatchment | Catchment | Land use type | 2021 mean (t/ha/y) | 2019 mean (t/ha/y) |
|---|---|---|---|---|
| 6 | Outer | Bushland | 0.508 | 0.132 |
| 5 | Outer | Forestry | 0.452 | 0.123 |
| 2 | Outer | Bushland | 0.370 | 0.114 |
| 2 | Inner | Forestry | 0.366 | 0.141 |
| 9 | Inner | Bushland | 0.354 | 0.104 |
| 9 | Outer | Bushland | 0.345 | 0.113 |
| 5 | Outer | Bushland | 0.343 | 0.092 |
| 3 | Outer | Forestry | 0.328 | 0.101 |
| 4 | Outer | Bushland | 0.327 | 0.102 |
| 1 | Inner | Bushland | 0.322 | 0.104 |
| 3 | Outer | Bushland | 0.308 | 0.091 |
| 1 | Outer | Bushland | 0.304 | 0.096 |
| 7 | Outer | Bushland | 0.278 | 0.091 |
| 6 | Outer | Forestry | 0.265 | 0.065 |
| 9 | Outer | Other | 0.261 | 0.083 |
| 9 | Outer | Agricultural | 0.253 | 0.094 |
| 8 | Outer | Forestry | 0.249 | 0.069 |
| 9 | Inner | Other | 0.247 | 0.082 |
| 8 | Outer | Bushland | 0.241 | 0.060 |
| 9 | Inner | Agricultural | 0.219 | 0.079 |
| 4 | Outer | Forestry | 0.217 | 0.063 |
| 2 | Inner | Bushland | 0.215 | 0.068 |
| 5 | Outer | Agricultural | 0.214 | 0.068 |

| Subcatchment | Catchment | Land use type | 2021 mean (t/ha/y) | 2019 mean (t/ha/y) |
|---|---|---|---|---|
| 3 | Outer | Agricultural | 0.212 | 0.065 |
| 2 | Outer | Agricultural | 0.205 | 0.074 |
| 9 | Outer | Forestry | 0.201 | 0.058 |
| 7 | Outer | Forestry | 0.195 | 0.063 |
| 1 | Outer | Agricultural | 0.178 | 0.063 |
| 9 | Inner | Protected foreshore | 0.176 | 0.058 |
| 4 | Outer | Agricultural | 0.159 | 0.056 |
| 2 | Outer | Other | 0.155 | 0.053 |
| 1 | Outer | Forestry | 0.154 | 0.061 |
| 2 | Outer | Forestry | 0.152 | 0.055 |
| 9 | Inner | Protected foreshore | 0.148 | 0.053 |
| 1 | Inner | Agricultural | 0.146 | 0.051 |
| 2 | Inner | Agricultural | 0.142 | 0.051 |
| 7 | Outer | Agricultural | 0.131 | 0.047 |
| 6 | Outer | Agricultural | 0.111 | 0.033 |
| 8 | Outer | Agricultural | 0.099 | 0.033 |

### *Inner catchment analysis*

### Land use analysis

Figure 8 shows the land use types within the inner catchment and Table 3 presents a comparison of land use between the inner and outer Googong Catchments. Bushland and protected foreshore form the largest proportion of the inner catchment (70%) with agricultural land covering only 13%. In comparison, bushland forms a much larger portion of the outer catchment (34%).

### Sediment and contaminant delivery potential

The potential for the subcatchments of each of the major waterways that enter Googong Reservoir to contribute to sediment delivery was also calculated. Figure 9 displays the average sediment delivery potential of each stream subcatchment, and shows that Bradleys Creek, Barrers Creek and Wells Creek have the highest potential sediment yields according to the RUSLE modelling. The figure indicates that typically flatter areas with lower vegetation (largely agricultural plains) will have lower sediment generation compared to steeper hillslopes (which are largely bushland areas). As discussed earlier, this is because the RUSLE model was likely dominated by the slope parameter and does not consider the connection between hillslope/floodplain and waterways or and erosion/gullying within waterways.

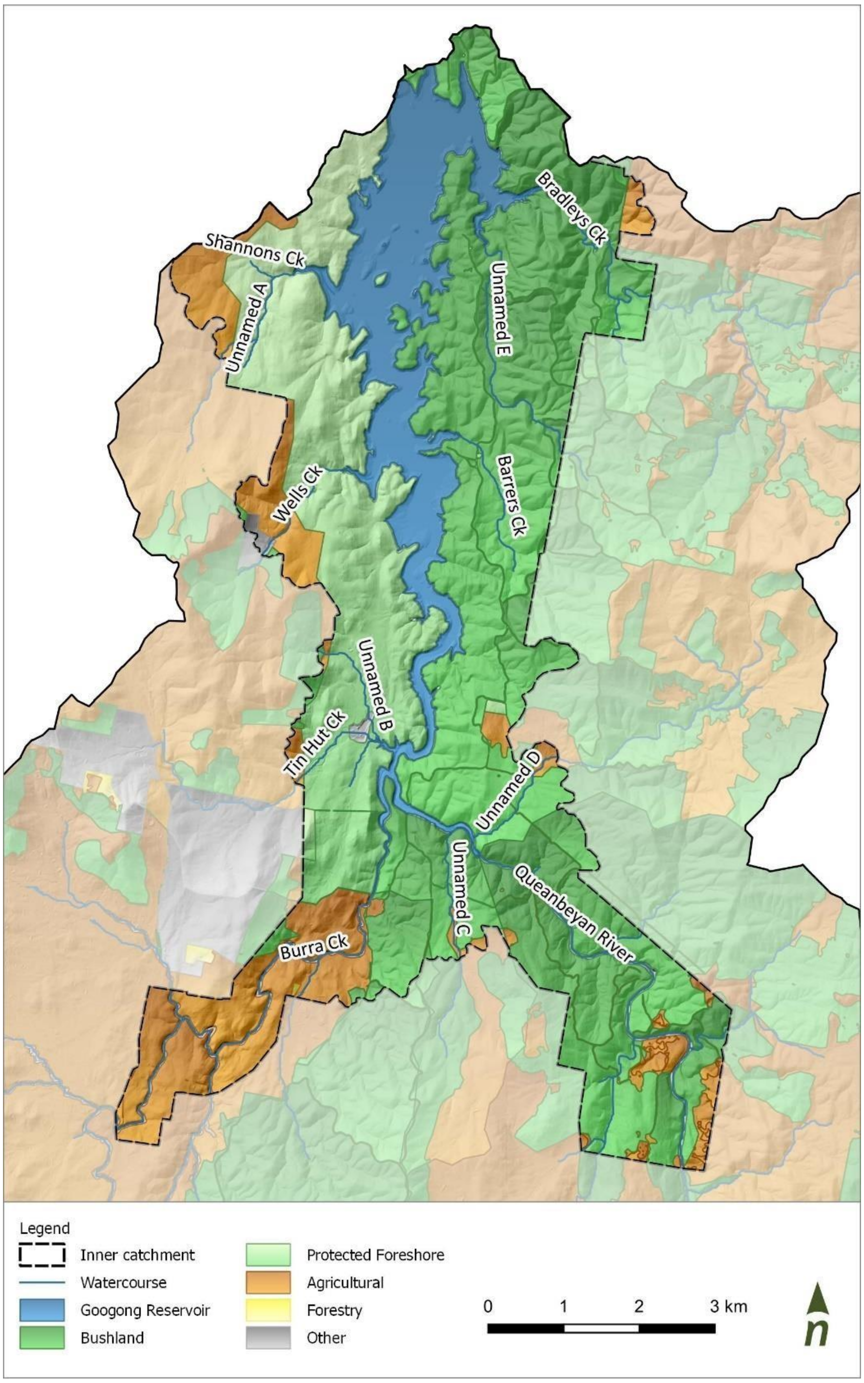


**Figure 8.** *Land use in the inner Googong Catchment*

**Table 3.** *Land use types in inner vs outer catchment*

| Subcatchment | Area (ha) | Agriculture | Bushland | Protected foreshore | Waterbody | Forestry | Other (residential w/o agriculture) |
|---|---|---|---|---|---|---|---|
| Inner | 5,506 | 13% | 48% | 22% | 16% | 0.0% | 0.2% |
| Outer | 83,599 | 34% | 61% | 0.0% | 0.6% | 3.5% | 0.8% |

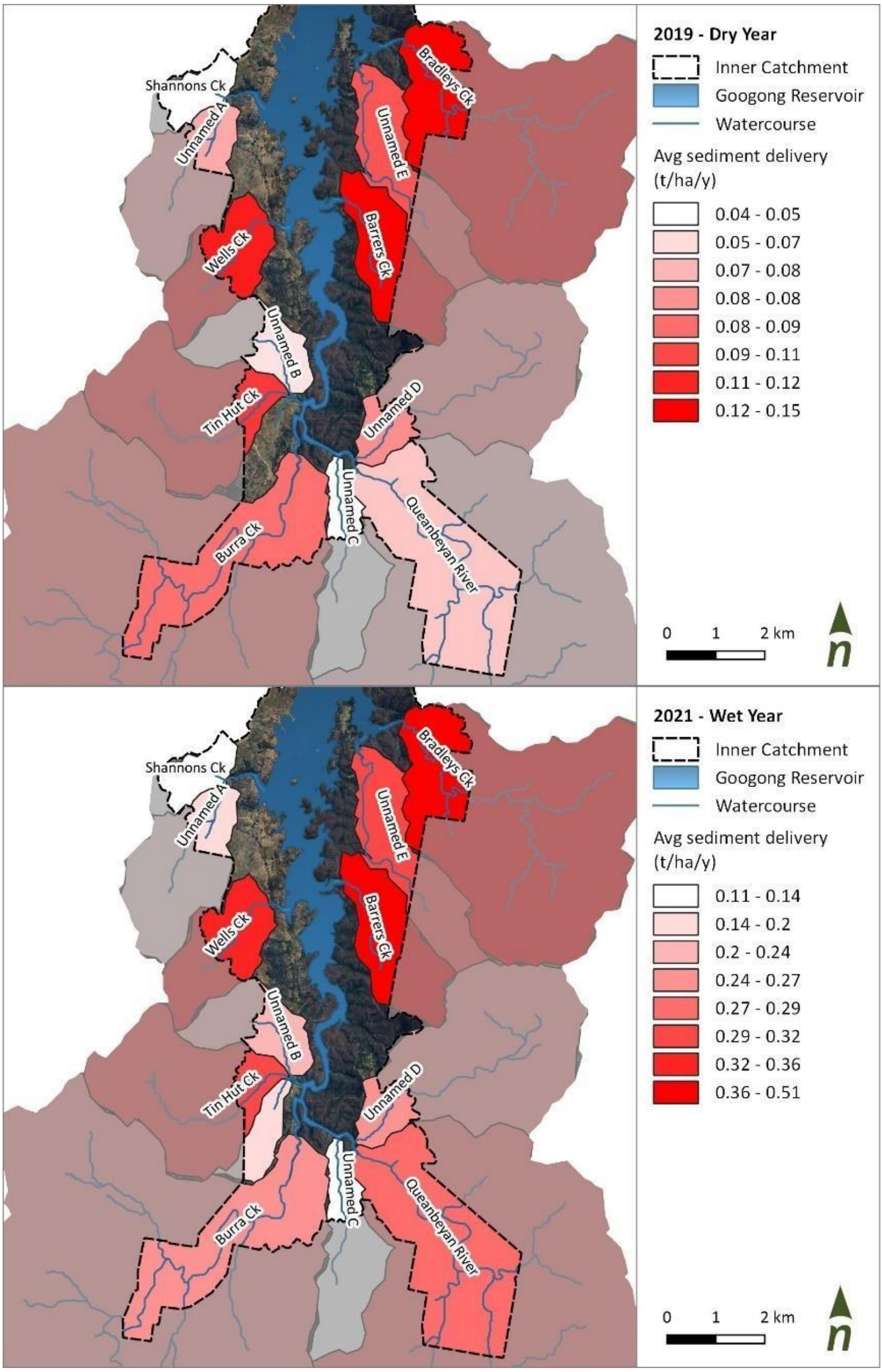


**Figure 9.** *Average potential sediment delivery of subcatchments of main streams entering Googong Reservoir*

## Buffering potential of the inner catchment

Figure 10 shows the results of the qualitative assessment of the inner catchment's sediment buffering potential. Buffering potential refers to the potential to intercept sediment derived from the upper catchment and lock that sediment into storage, typically using vegetation. This requires adequate space for such vegetation to grow, usually within natural deposition points, such as floodplains or low gradient reaches of the waterway. Table 4 provides a summary of the analysis undertaken, and a short discussion on the buffering potential of the lower reaches of waterways entering the Googong Reservoir and their respective subcatchments.

The inner zones of Bradleys Creek, Unnamed Creek A, Unnamed Creek D, Barrers Creek and Unnamed Creek E subcatchments have the lowest sediment buffering potential (i.e. the weakest sediment buffers) of the twelve streams assessment. Comparatively, the inner zones of Tin Hut Creek and Unnamed Creek B subcatchments have the highest sediment buffering potential due to the presence of Tin Hut Dam.

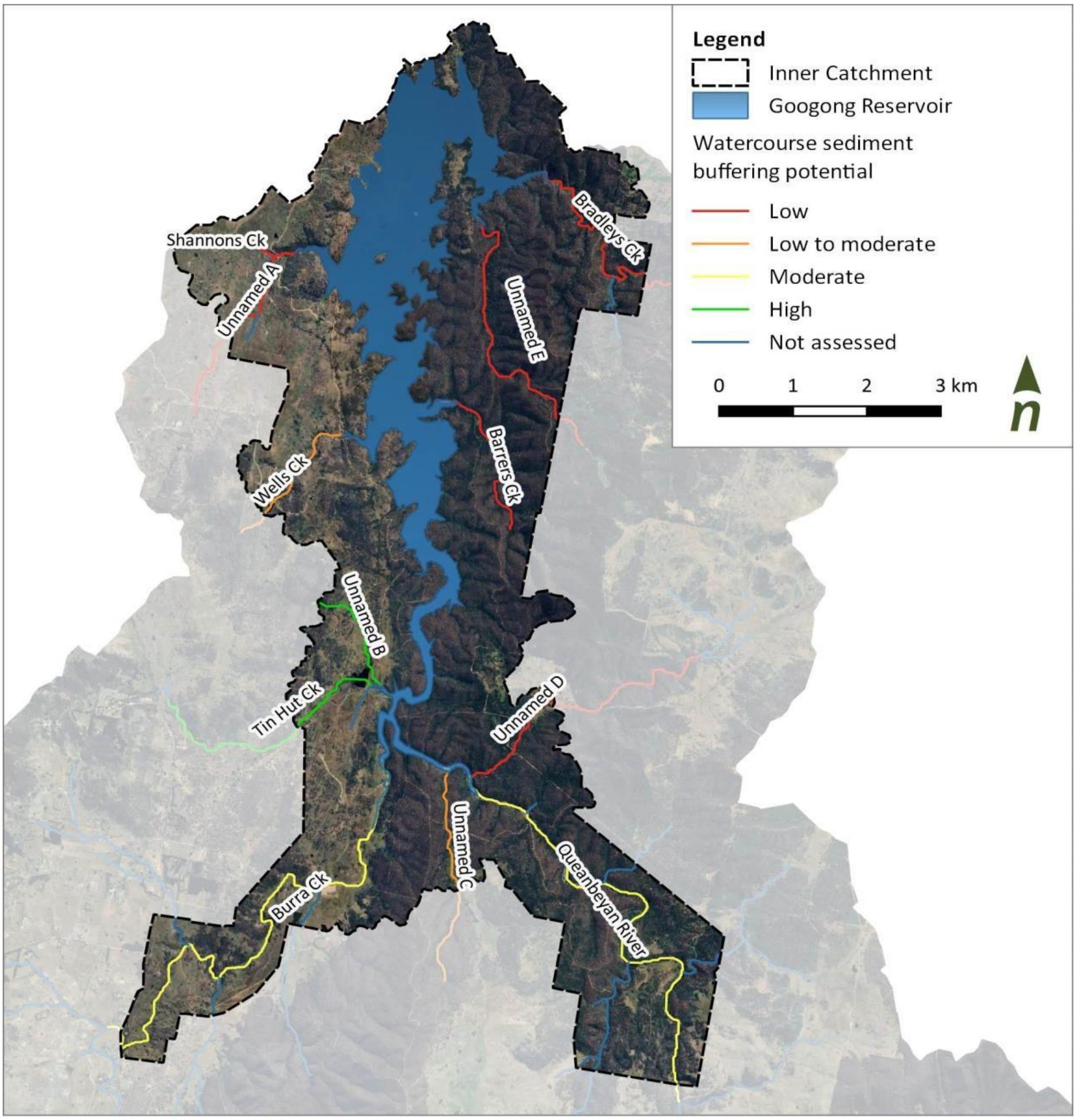


**Figure 10.** *Sediment buffering potential of main streams entering the Googong Reservoir*

**Table 4.** *Sediment buffering potential of the main streams in the inner Googong Catchment*

| Stream | Subcatchment area ($km^2$) | Length (m) | Channel grade | Confinement | Inner zone vegetation | Discussion |
|---|---|---|---|---|---|---|
| Shannons Creek | 1.61 | 1,283 | 6% | Mostly confined | Largely sparse though denser at outlet | Sparsely vegetated. Upstream half of catchment is agricultural land, and downstream half is protected foreshore. Steep bedrock gorge channel with evidence of gullying/headcuts in places.<br>Inner zone has low to moderate sediment buffering potential upstream of the bedrock gorge, and low sediment buffering potential within lower reach confined by bedrock. |
| Unnamed Creek A | 5.42 | 3,269 | 4% | Mostly confined | Largely sparse though denser at outlet | Sparsely vegetated, mostly agricultural catchment, though downstream third is protected foreshore. Bedrock gorge channel with evidence of gullying/headcuts in places.<br>Inner zone has low sediment buffering potential. |
| Wells Creek | 3.93 | 2,275 | 5% | Mostly confined | Light to moderate, denser in riparian zone | Moderately vegetated. Upstream half of catchment is mix of agricultural and bushland, and downstream half is protected foreshore. Steep bedrock gorge channel with evidence of gullying/headcuts.<br>Inner zone has low to moderate sediment buffering potential. |
| Unnamed Creek B | 2.92 | 1,756 | 3% | Inner zone floodplain, outer zone mostly confined | Light in downstream floodplain, denser in upper catchment | Upstream half of catchment is moderately vegetated agricultural land, and downstream half is lightly vegetated protected foreshore floodplain.<br>Inner zone has higher sediment buffering potential given Tin Hut Dam. |
| Tin Hut Creek | 8.1 | 1,832 | 2% | Inner zone floodplain, outer zone mostly confined | Light in downstream floodplain, moderately dense in upper catchment | Mostly moderately vegetated mixed landuse catchment (including residential, agricultural and bushland), though downstream portion is lightly vegetated protected foreshore floodplain.<br>Inner zone has higher sediment buffering potential given Tin Hut Dam. |
| Burra Creek | 99.5 | 6,316 | 1% | Inner zone partly confined with occasional floodplains | Mostly light to moderate in catchment, with stretches of no riparian veg | Mostly moderately vegetated agricultural catchment with zones of dense bushland and protected foreshore downstream. Flatter channel gradient.<br>Inner zone has moderate sediment buffering potential. |

| Stream | Subcatchment area (km$^2$) | Length (m) | Channel grade | Confinement | Inner zone vegetation | Discussion |
|---|---|---|---|---|---|---|
| Unnamed Creek C | 4 | 1,938 | 5% | Confined with occasional floodplain pockets | Mostly dense, sparse in upstream floodplain | Half densely vegetated bushland, and half lightly vegetated agricultural catchment. Steep bedrock gorge channel in downstream portion with dense vegetation.<br>Inner zone has low to moderate sediment buffering potential. |
| Queanbeyan River | 700.5 | 6,704 | 0.4% | Inner zone mostly confined, outer zone mixed | Mostly dense, lighter in upstream floodplain pockets | Very large mixed land use catchment, though inner catchment is largely densely vegetated bushland with pockets of lightly vegetated agricultural land upstream. Downstream is a confined valley setting with flatter channel gradient and dense vegetation.<br>Inner zone has moderate sediment buffering potential. |
| Unnamed Creek D | 11.6 | 1,813 | 5% | Confined with occasional floodplain pockets | Mostly dense, sparse in upstream floodplain pockets | Mixed landuse catchment (agricultural and bushland), though inner catchment is densely vegetated bushland with small pockets of agricultural land upstream. Steep bedrock gorge channel in downstream.<br>Inner zone has low sediment buffering potential. |
| Barrers Creek | 4.2 | 2,604 | 3% | Mostly confined | Dense | Densely vegetated bushland catchment. Bedrock gorge channel.<br>Inner zone has low sediment buffering potential. |
| Unnamed Creek E | 4.6 | 4,495 | 5% | Mostly confined | Dense | Densely vegetated, mostly bushland catchment with small pockets of agricultural land upstream. Steep bedrock gorge channel.<br>Inner zone has low sediment buffering potential. |
| Bradleys Creek | 19.3 | 3,804 | 2% | Mostly confined | Largely dense, though lighter in some pockets of riparian zone | Upstream half of catchment is mostly lightly vegetated agricultural land, and downstream half is densely vegetated bushland. Bedrock gorge channel.<br>Inner zone has low sediment buffering potential. |

### *Rainfall dynamics*

The outputs of the rainfall pattern analysis undertaken at Burra River at Burra Road (Station 570951) and Queanbeyan River at Tinderry (Station 570965) are presented in the following sections. In the graphs, the x-axes denote the year, and y-axes denote the SPI index values.

**Annual statistics**

Annual rainfall totals vary considerably year to year, spanning a range between 300-950 mm/yr (see Figure 11), with big drops evident in drought years (e.g. 2007, 2020). Both stations show similar trends, indicating relative consistency in annual rainfall patterns spatially across the Googong Catchment. At Burra River at Burra Road (Station 570951), the long-term mean annual rainfall is 654.7 mm, the minimum is 302.6 mm (in 2007), and the maximum is 966.4 mm (in 2022). At Queanbeyan River at Tinderry (Station 570965), the long-term mean is slightly lower at 644.4 mm, the minimum is lower at 244.0 mm (in 1983), and the maximum is higher at 1,140.9 mm (in 1989).

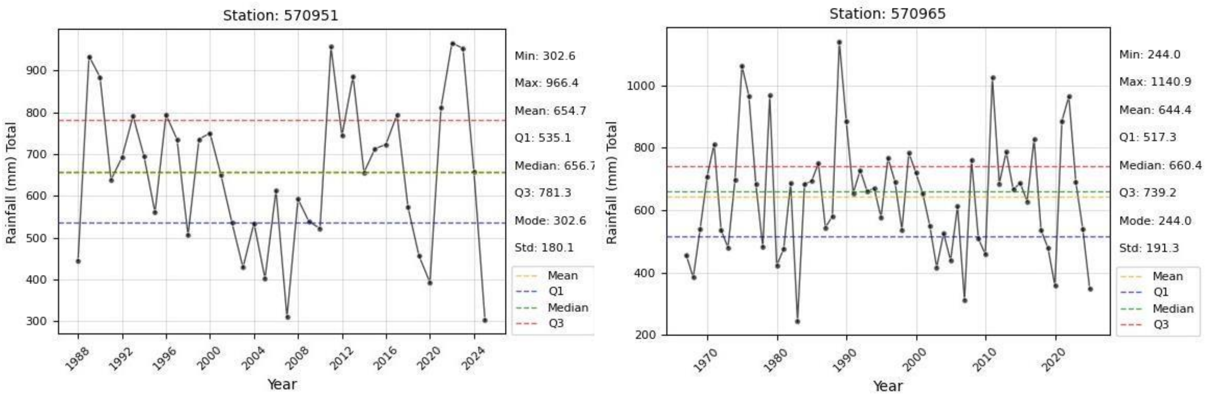


**Figure 11.** *Annual rainfall statistics*

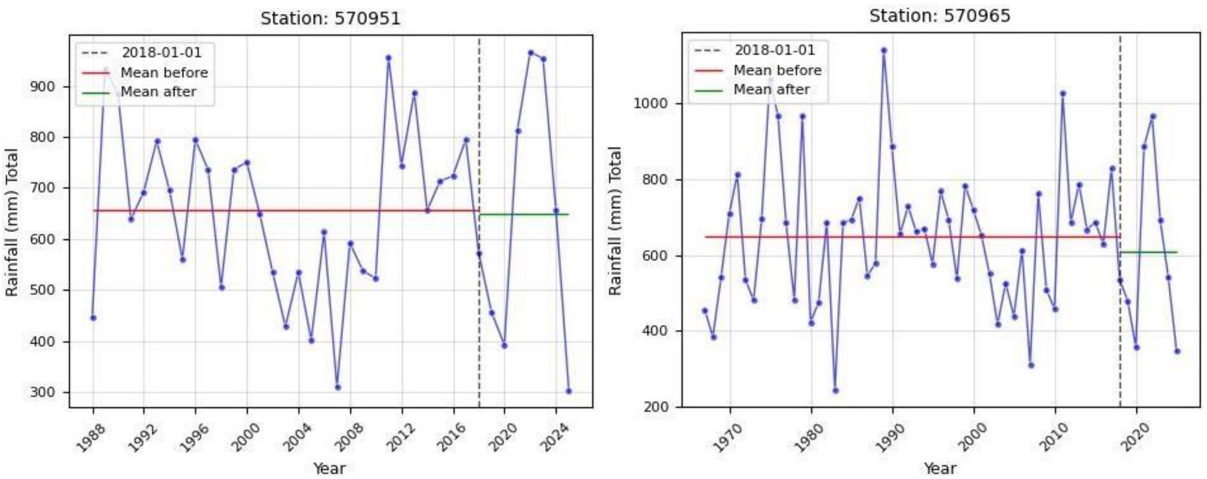


**Figure 12.** *Pre- and post-2018 comparison of annual rainfall statistics*

Comparing the annual rainfall averages pre- and post-2018 (Figure 12), there has been little change. Burra River at Burra Road (Station 570951) has shown a minor decrease in mean rainfall from 656 mm to 649 mm and Queanbeyan River at Tinderry (Station 570965) has similarly shown a minor decrease from 649 mm to 609 mm. This further indicates that annual rainfall patterns have not changed significantly since 2018 (i.e. the development of the ACWA Plan). Perhaps more relevant is the sharp increase in mean annual rainfall between 2020 and 2021 – the largest year on-year increase of any two-year period since 1988 for the Burra Road station, and one of the largest for Queanbeyan River at Tinderry.

**Monthly statistics**

The monthly rainfall statistics show greater variation in rainfall month to month (see Figure 13), as expected. Both stations have a similar trend in monthly totals and variability, indicating relative consistency in monthly rainfall spatially across the Googong Catchment. At Burra River at Burra Road (Station 570951), the long-term mean monthly rainfall is 55.4 mm and the maximum is 261.4 mm. At Queanbeyan River at Tinderry (Station 570965), the long-term mean is 54.6 mm and the maximum is 265.5 mm.

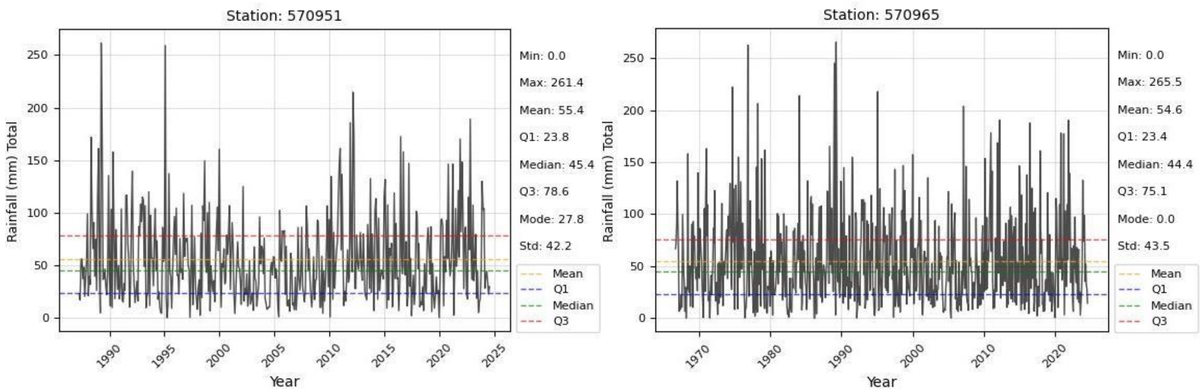


**Figure 13.** *Monthly rainfall statistics*

Like the annual results, pre- and post-2018 averages show little discernible difference (see Figure 14). Burra River at Burra Road (Station 570951) has shown a minor increase in mean rainfall from 55 mm to 57 mm, and Queanbeyan River at Tinderry (Station 570965) has shown a minor decrease from 55 mm to 54 mm. This further indicates that rainfall patterns have not changed significantly since 2018 (i.e. the development of the ACWA Plan). The sharp increase in rainfall totals between 2020 and 2021 seen in Figure 12 is mirrored by the monthly results, with 2021-2023 being part of a rise and then decline in monthly totals (annotated in red in Figure 14).

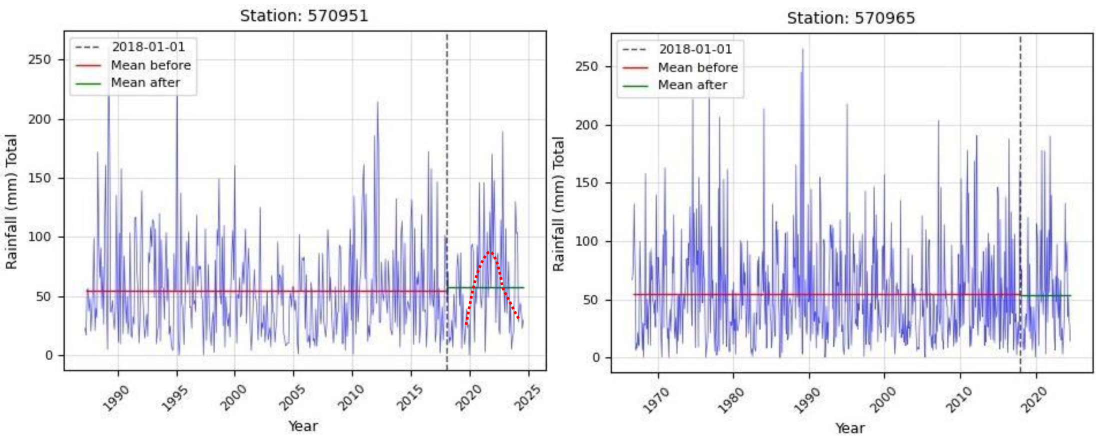


**Figure 14.** *Pre- and post-2018 comparison of monthly rainfall statistics*

### Spell events

The calculated SPI values were used to define wet and dry periods and drought intensity for both stations, with the results shown in Figure 15. Both stations display similar results, except for a few years, indicating relative similar patterns in spell events spatially across the Googong Catchment. The graphs indicate that big swings between dry and wet periods (such as the swing that occurred between 2020 and 2021) have historically occurred in the catchment and are likely to occur in the future.

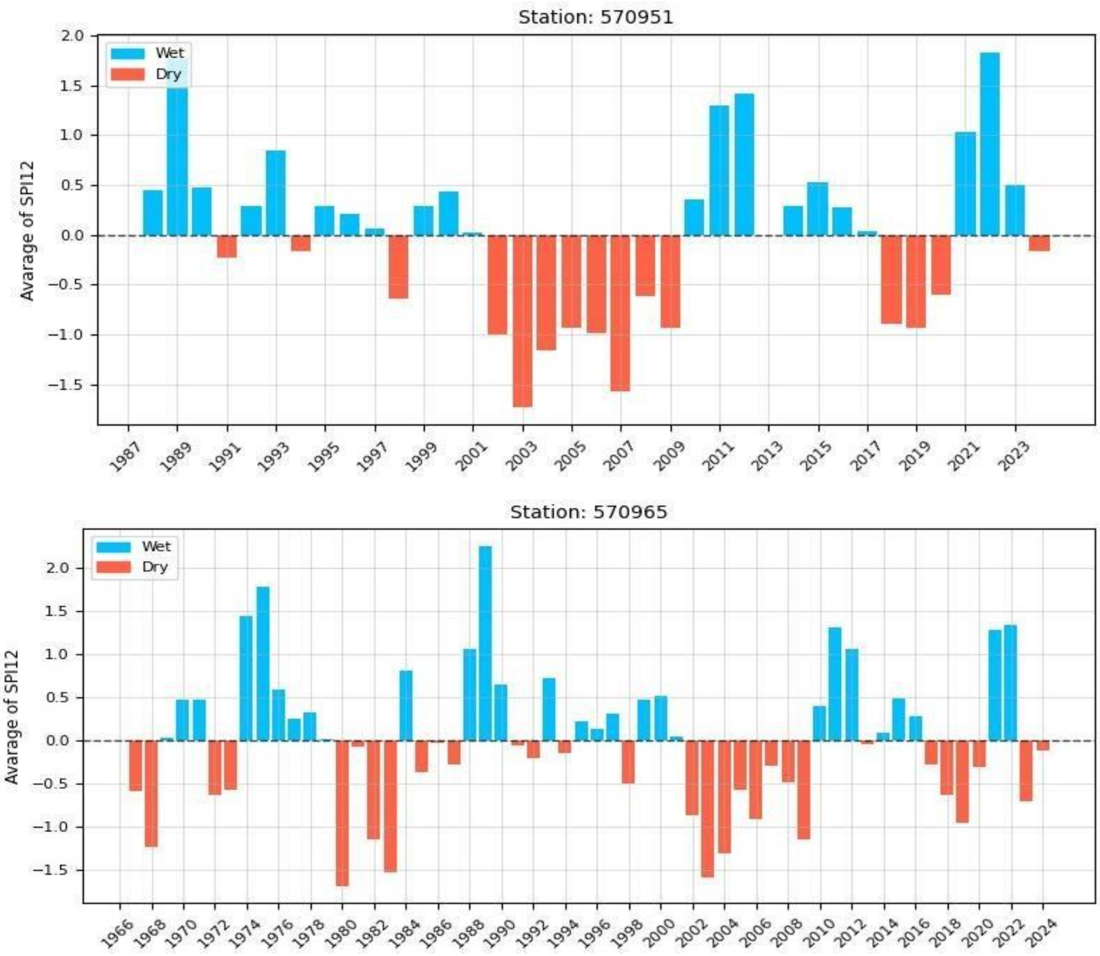


**Figure 15.** *Spell events (wet and dry periods)*

The shift from dry to wet conditions is of concern to catchment managers due to the potential for these wet-on-dry events to deliver larger volumes of fine sediment to Googong Reservoir than a wet-on-wet event might. To assess the average gap between a prolonged dry period and a wet period, we tagged weekly rainfall totals as wet, dry, or normal. The results of this analysis, separated by season, are shown in Figure 16. While the number of days between a dry and wet period is generally large (with normal conditions between the two, buffering any wet-on-dry type events), both stations have instances of this gap being 7 (one week), corresponding to a wet-on-dry rainfall event. Identifying the individual events and their characteristics is beyond the scope of this study, but the analysis points to the highly variable rainfall and the fact that such events can occur any time of year (not just in summer).

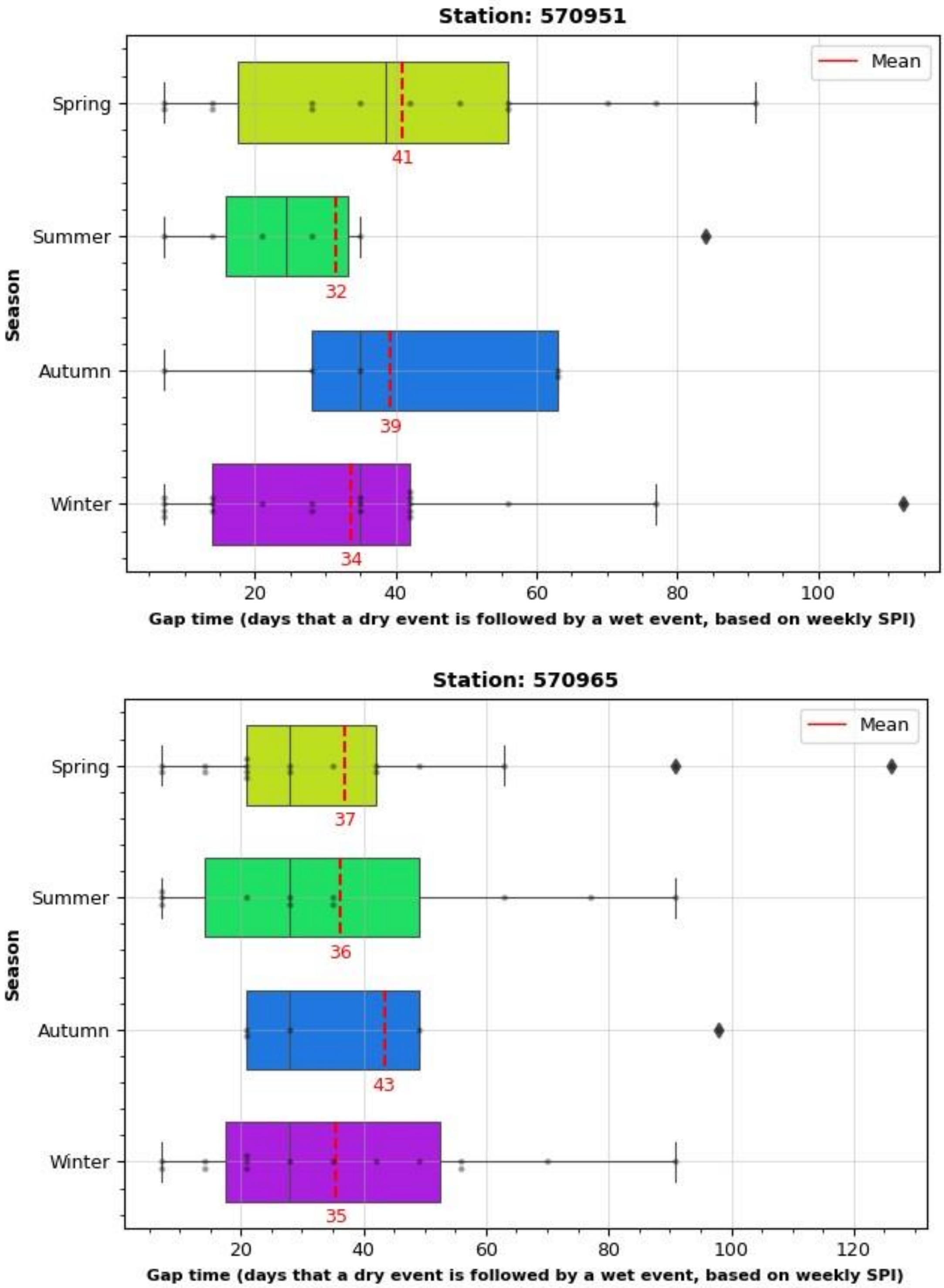


**Figure 16.** *Box plot showing the distribution of the gaps between dry and wet events, where an event is a weekly rainfall total.*

## Discussion and conclusions

The land use results show that bushland is the dominant land use type, covering 61 per cent of the Googong Catchment, with agricultural land the next largest, covering 32 per cent. Of the agricultural land, subcatchments 2, 8 and 7 have the highest proportions respectively. Sediment and contaminant delivery potential was also calculated across the Googong Catchment for both a dry year (2019) and a wet year (2021), with the results indicating that subcatchments 6 and 5 present the greatest average delivery potential respectively. Looking at the potential for each land use type to contribute to sediment runoff, surprisingly, the highest yielding areas within Googong Catchment are bushland and forestry, with agricultural land only falling into the mid to bottom range of average volumes. Bushland in subcatchment 6 appears to be the highest potential contributor to sediment runoff in a wet year, and the second highest contributor in a dry year.

As noted in this report, this is likely due to the slope parameters of the RUSLE model dominating the results, resulting in higher erosion/sediment yield values for the areas of land with bigger, steeper slopes (largely bushland) and lower values for flatter areas (largely agricultural plains). However, though agricultural areas may produce less erosion within the catchment, there tends to be more erosion and gullying in waterways within agricultural catchments, generating significant volumes of sediment, which the RUSLE does not consider. Therefore, Icon Water may be more effective in directing efforts to manage erosion in these waterways, rather than the bushland hillslope catchments. The high RUSLE values for bushland areas speak to their potential to yield high sediment loads following bushfire and intense rainfall. Fuel load and fire suppression/management is the primary tool to manage sediment loads from the steep, bushland areas to the east of Googong Reservoir.

The inner catchment analysis shows that there is significantly less agricultural land in the inner catchment compared to the outer catchment (13 per cent versus 34 per cent). The inner catchment is dominated by bushland and protected foreshore land. There is also no forestry in the inner catchment, compared to the outer catchment which has three per cent of land covered by forestry. The sediment and contaminant delivery potential of main streams entering the Googong Reservoir (including their subcatchments) was also calculated, with results showing that Bradleys Creek, Barrers Creek and Wells Creek have the highest potential sediment generation in their catchments. Moreover, qualitative analysis of the sediment buffering potential of these streams indicated that the level of confinement in the lower reaches limits their sediment buffering potential – fine sediment delivered to the inner zone portion of these reaches is likely to be quickly transported to Googong Reservoir. Several of these subcatchments do have the potential to buffer sediment further upstream through land management, but the overall impact of such interventions is likely to be small compared to the strategy of controlling erosion hotspots. Preventing sediment from being eroded in the first place is usually much more cost-effective than trying to intercept material already in transit.

The rainfall analysis indicates that there is great variation in rainfall between months and between years, with big drops evident in drought years. Moreover, large swings between dry and wet periods (such as the swing that occurred between 2020 and 2021) have historically occurred in the catchment and are likely to occur in the future. When looking at rainfall patterns since 2018 (i.e. the development of the ACWA Plan), monthly and annual fluctuations are well within the range that is seen in the pre-2018 records, and the average values have remained relatively consistent. This indicates that while sharp changes in rainfall from year to year occur, the post-2018 period is not wetter overall than the preceding period.

In summary, the preliminary desktop analyses presented in this report provide a general context for discussions surrounding the update of the 2018 ACWA Plan. However, proactive actions to manage the risk of erosion and sediment to water quality in the Googong Catchment should focus on the identified active waterway sites and recommended remediation efforts in the 2018 Plan.

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