Greater Sydney Harbour Coastal Management Program – Stage 2

Expert Workshop Summary

October 2022

SYDNEY COASTAL COUNCILS GROUP

Three Seeds

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Traditional Owners

The authors wish to acknowledge the *Eora, Dharug and Kuring-gai peoples* and as the traditional custodians of Greater Sydney Harbour catchment.

Document Management

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Disclaimer

Acknowledgments

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We extend our gratitude to the Sydney Institute of Marine Science (SIMS), Waverley Council, Blacktown City Council and City of Sydney for hosting the workshop series.

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Cover image

Sydney Harbour (Source: Destination NSW).

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Executive Summary

Sydney Harbour is one of the world's great harbours and is a public asset of national and heritage significance. However, this iconic waterway is threatened by urban development and associated pressures, with climate change exacerbating risks and consequences. Co-ordinated and consistent leadership delivering integrated catchment management is required to sustain and improve waterway health of Sydney Harbour and its tributaries.

All twenty councils in the Greater Sydney Harbour (GSH) catchment are contributing to the Coastal Management Program (CMP), to set a long-term strategy for coordinated management of coastal and estuarine areas. The GSHCMP seeks to improve and sustain waterway health through improved coordination, consistency, and leadership, aligned with the objectives of the *Coastal Management Act 2016*.

Four expert workshops were designed and delivered in August and September 2022, to support Stage 2 of GSHCMP This report documents the presentation, discussion and consensus that emerged from these workshops.

The three themes of the workshops were water quality monitoring, climate change and sea level rise, and catchment initiatives.

The workshops were attended by:

- 71 attendees
- 36 different agencies and organisations
- Heard 28 different expert presentations and speakers
- Contributed 540 hours to the process.

Specifically, the workshops resulted in support for:

1. The **proposition for a permanent whole-of-catchment core monitoring program for GHS** that responds to First Nations culture of caring for Country and the concept of one health – recognizing the interconnections between people and planet. The proposition was for a collaborative and coordinated monitoring program to protect Sydney Harbour's iconic status through robust, data-informed policy, planning and management decisions by State and local governments on behalf of current and future communities. A core monitoring program should focus on identified 'bare-bones' indicators across estuary and catchment that enables data-informed decision making, supported by complementary monitoring programs and modelling tools. The monitoring program needs to address ecosystem health and community uses with appropriate spatial and temporal coverage. Coordinated data management and reporting is required to provide all stakeholders with access to relevant, publicly available data for informed decision.
2. **An integrated whole of estuary / coastal zone assessment of climate change, sea level rise, and flooding**. Local government representatives were clear also that there is a need for consistent guidance and support to set consistent planning rules for all affected properties, people and assets across the whole catchment and coastal zone of Greater Sydney Harbour.
3. **More evidence-based approach to delivering structural and non-structural works in the catchment**, acknowledging that council capacity, available physical space, and a strong community engagement model is also critical to reducing pollution and runoff from urban catchments. This may take the form of a framework to deliver effective catchment initiatives recognising the variable nature of land uses, previous urban development, condition of waterways, and capacity of councils to design and maintain infrastructure.

Recurring themes (key messages) from the expert workshop series were:

1. **A 'whole of catchment approach' is valued and supported by individual councils**. There was clear acknowledgement that a collaborative model was the most efficient and effective way to address several issues raised by experts, and there was unanimous support for a whole of catchment approach to address these problems.
2. **Climate change is an immediate and significant threat to the health of the people and the ecology of the harbour** across all areas and jurisdictions. While specific impacts vary considerably across the harbour, there is a clear view that we need to act now, act fast, and work together to apply a consistent response across jurisdictions.
3. There is a genuine desire to ensure governance and funding issues are resolved for the long-term, so the **values of the harbour are protected for future generations**.
4. **There is genuine interest and concern for equity - that all residents of Sydney could benefit from a healthy harbour**, not just those with water views and harbour frontages.
5. **There is a significant amount of good quality scientific analysis that has completed for the harbour**. However, there are **barriers to sharing information** and ensuring all relevant stakeholders are using it effectively.
6. **Storing and publishing data for use by all stakeholders is critical for evidence-based decision making**. Several past studies were limited in access to data, and all future endeavours should be made to ensure that all data is open and accessible.
7. The **expert workshops demonstrated the value of coming together** as a network of professionals and agencies with a shared interest in improving the management of Greater Sydney Harbour and its catchment. They provided opportunities to hear from experts in different fields, debate ideas, and understand the application of contemporary methods and results of latest research to Sydney Harbour.

3

Themes to the workshops: water quality, climate change, and catchment initiatives.

71

experts, presenters, and participants

36

Organisations represented

540

Hours contribution across all expert workshops by all participants

28

Specific presentations and expert opinions

1 Introduction

1.1 Greater Sydney Harbour and its Catchment

Sydney Harbour is one of the world's great harbours and is a public asset of national and heritage significance. However, this iconic waterway is threatened by existing urban development and associated legacy pressures, with climate change exacerbating risks and consequences. Co-ordinated and consistent leadership delivering integrated catchment management is required to sustain and improve waterway health of Sydney Harbour and its tributaries.

Figure 1. Sydney Harbour (Source: Tim Richie)

The catchment and region itself are quite diverse, from the eastern suburbs, inner west, to the Hills district and the western suburbs. This geographic diversity probably exacerbates the fact that people across the region have differing views on the issue, knowledge of the latest science, and the priorities.

This workshop aligned with objectives of the Greater Sydney Commission (Clause 25), Marine Estate Management Strategy (Objective 1), and the Greater Sydney Water Strategy. It is part of a series of expert workshops seeking to identify and collate evidence to guide the development of the GSHCMP in relation to water quality monitoring, climate change impacts on stormwater and associated assets, and stormwater-related catchment initiatives.

1.2 Greater Sydney Harbour Coastal Management Program

All twenty-one councils in the Greater Sydney Harbour (GSH) catchment are contributing to the Coastal Management Program (CMP), to set a long-term strategy for coordinated management of coastal and estuarine areas. The GSHCMP seeks to improve and sustain waterway health through improved coordination, consistency, and leadership, aligned with the objectives of the *Coastal Management Act 2016*.

Preparation of the GSCCMP is guided by the Project Management Committee and delivered through the Sydney Coastal Councils Group (SCCG) in collaboration with the Parramatta River Catchment Group (PRCG).

Funding contributions from the 20 Councils in the catchment and from the NSW Coastal and Estuary Grants Program are gratefully acknowledged.

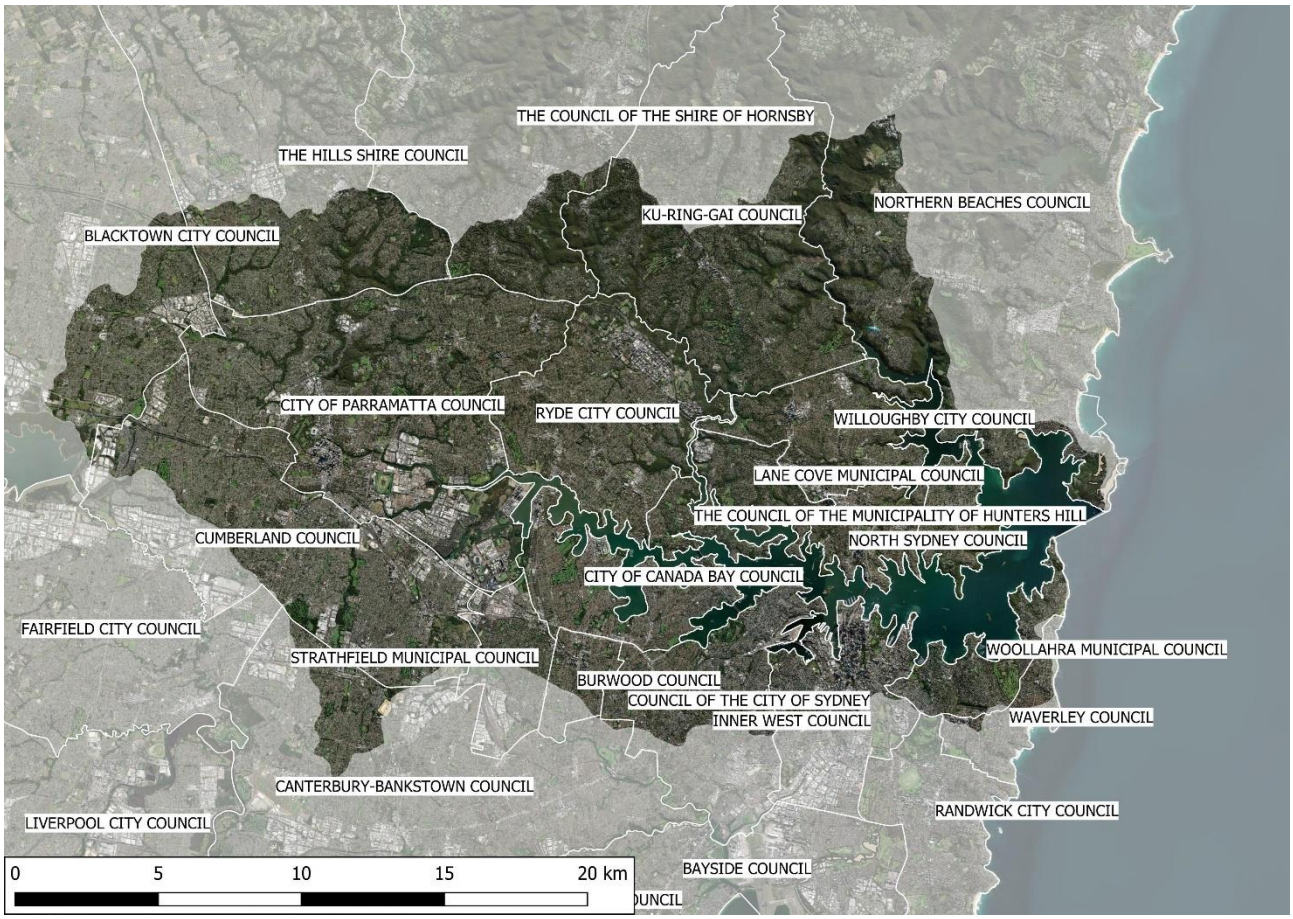


Figure 2. Sydney Harbour catchment and local government areas (Source: Wave Consulting and DPIE data)

The vision for Greater Sydney Harbour is:

> *To improve and sustain waterway health through improved coordination, consistency, and leadership.*

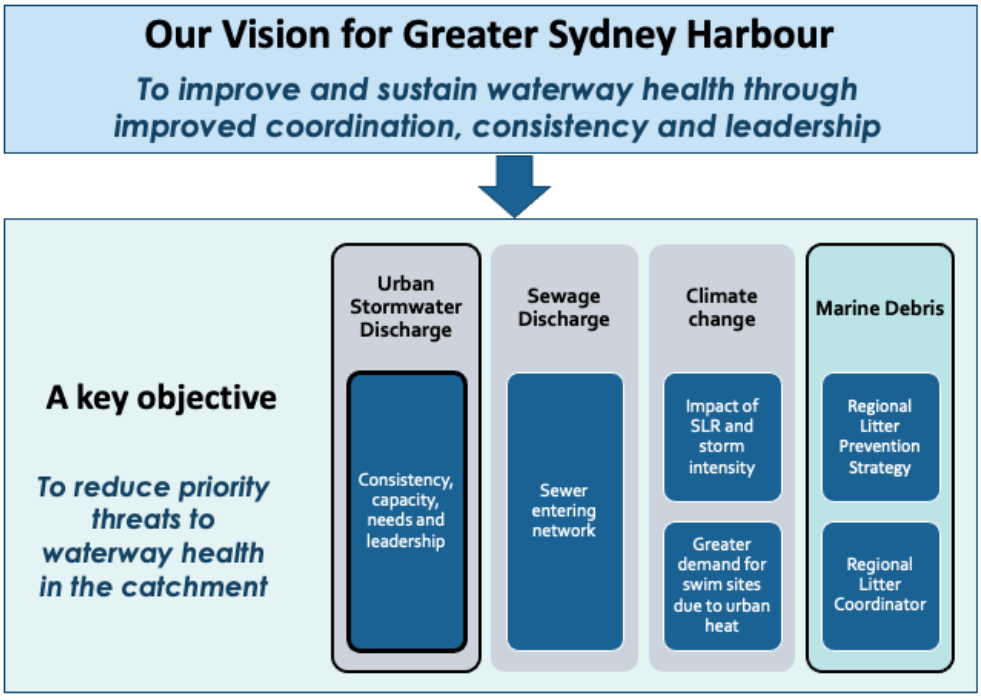


Figure 3. Greater Sydney Harbour vision and objectives (Bruce Thom, GSHCMP Project Steering Committee)

Organisations operating at the State, catchment and council scale have responsibilities that impact the waterway health of Greater Sydney Harbour.

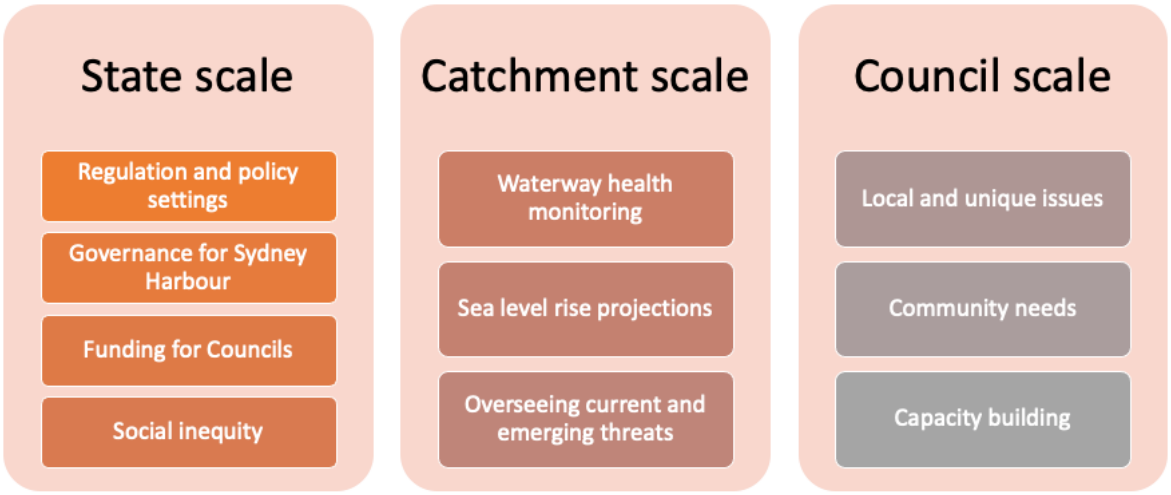


Figure 4. Responsibilities at different scales (Bruce Thom, GSHCMP Project Steering Committee)

Preparing and implementing a CMP involves five stages (Figure 3). The GSHCMP - Stage 1 study identified stormwater as the greatest threat to the health of the harbour (BMT 2018).

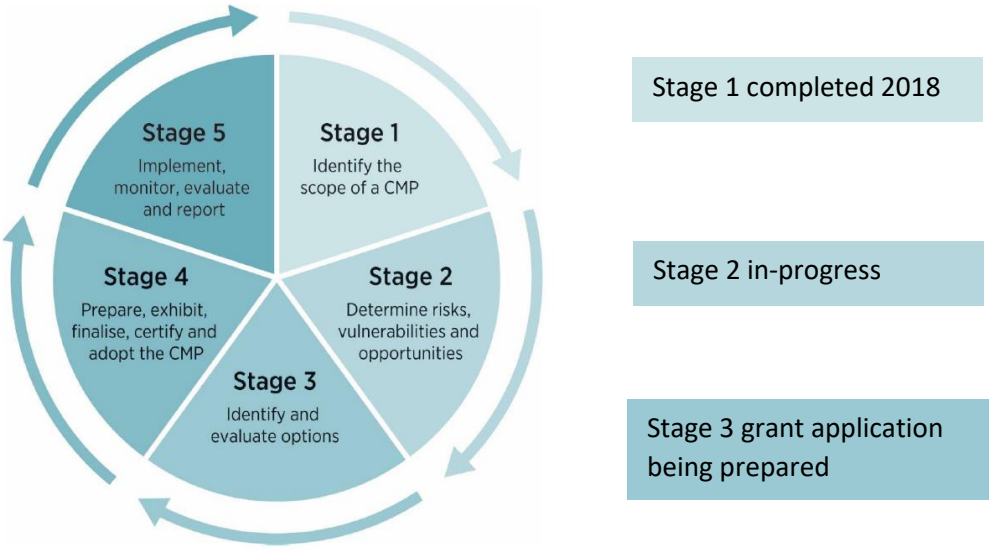


Figure 5. Stages in preparing and implementing a CMP (adapted from Our future on the coast, OEH 2018)

GSHCMP - Stage 2 (currently underway) involves three studies to identify, analyse and evaluate risks, vulnerabilities and opportunities associated with waterway health in the Greater Sydney Harbour catchment, with a particular focus on stormwater.

Study 1 – Collate information on current management activities by councils and agencies on waterway health.

Study 2 – Identify and prioritise council needs with regards to stormwater management

Study 3 – Identify effective and suitable governance and funding options that will assist local and state government organisations to work together more efficiently and to increase investment in natural resource management for the improved health of the waterways of the Greater Sydney Harbour.

In addition to these three studies, a series of expert workshops with GSHCMP stakeholders were undertaken to support and inform the Stage 2 Assessment.

1.3 GSHCMP - Stage 2 Expert Workshops

Outputs from the expert workshops, and the implications for the GSHCMP is the focus of this report (Wave 2022). The central thread and purpose of these workshops were to:

- Consult experts and gather the evidence across the themes of water quality monitoring, climate change, sea level rise, and catchment initiatives.
- Create a compelling case for change based on the evidence

The following organisations contributed to the expert workshop series as presenters, panellists and participants:

Governance group

- Greater Sydney Harbour Coastal Management Program (GSHCMP) Project Steering Committee
- Sydney Coastal Councils Group (SCCG)
- Parramatta River Catchment Group (PRCG)

State Government

- NSW Coastal Council
- NSW Department of Planning and Environment (DPE)
- NSW Environment Protection Authority (EPA)
- Transport for NSW
- Sydney Water

Local Government

- Blacktown City Council
- City of Parramatta
- City of Sydney
- Hornsby Shire Council
- Hunters Hill Council
- Inner West Council
- Ku-ring-gai Council
- Lane Cove Council
- Mosman Council
- North Sydney Council
- Northern Beaches Council
- Ryde Council
- Waverley Council
- Willoughby Council
- Woollahra Council

Academic Institutions

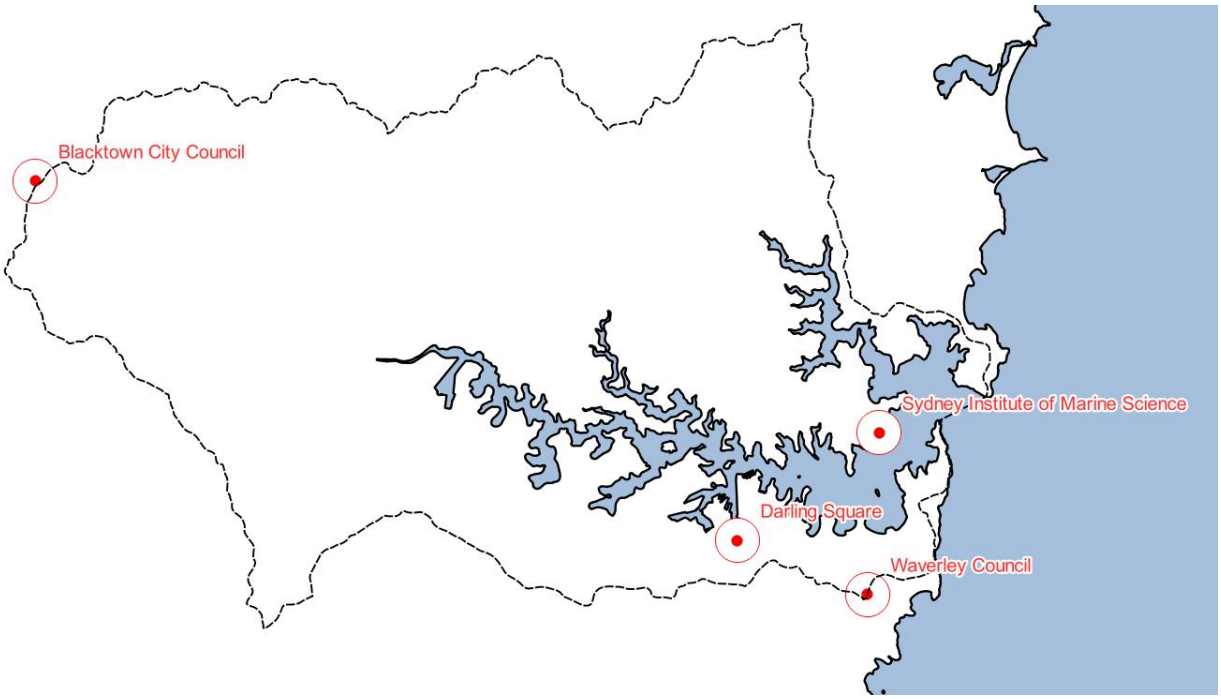
- Manly Hydraulics Laboratory (MHL)
- Melbourne University
- Sydney Institute of Marine Science (SIMS)
- University of Technology Sydney (UTS)
- University of NSW (UNSW)

Industry

- AusDiagnostics
- Baird
- BMT
- Civille (GSHCMP - Stage 2, Study 1 and Study 2 consultant)
- Mosaic Insights
- Optimal Stormwater
- Stormwater Shepherds
- Three Seeds Agency (expert workshop facilitator)
- Wave Consulting (expert workshop consultant).

1.4 Workshops

Four expert workshops were delivered in August and September 2022 (see locations of the workshop below).



1.5 Report Purpose and Structure

The purpose of this report is to document the outcomes of the GSHCMP expert workshop series to inform:

- GSHCMP – Stage 2 studies (particularly Study 2)
- GSHCMP Project Management Committee advice to government.

The report includes:

- Executive Summary
- Introduction
- Water Quality Monitoring
- Climate Change, Sea-Level Rise and Assessing Vulnerabilities
- Catchment Initiatives
- Implications for GSHCMP
- References
- Appendix (workshop agendas and participants).

2 Water Quality Monitoring Workshop

The workshop was held at the Sydney Institute of Marine Science (Chowder Bay / Mosman) on 16th August 2022 and attended by 36 presenters and participants.

2.1 Purpose

The purpose of the Water Quality Monitoring workshop was:

> *To co-create a compelling proposition for a permanent whole-of-catchment core monitoring program for Greater Sydney Harbour that supports waterway health now and into the future.*

2.2 Context

The GSHCMP seeks to improve and sustain waterway health through improved coordination, consistency, and leadership. The GSHCMP – Stage 1 study (BMT 2018) and subsequent investigations by SCCG identified challenges associated with current water quality monitoring, including inefficiencies and inconsistencies and the absence of a whole-of-catchment program linking pollutant fluxes from source to sink. As a result, it is not currently possible to identify whether waterway health is improving, declining, or staying the same, or under what conditions Harbour waters (including those of the Parramatta River) are swimmable now and into the future.

A key problem identified in Study 1, and in more recent analysis of water quality monitoring programs was that there were twenty-six unique water quality monitoring programs, including Council's freshwater monitoring, which are not coordinated in a way that to better the health of the harbour.

"It is almost impossible to remediate all of the existing contaminants in Sydney Harbour.

But we must avoid disturbing the sediments, and use a core monitoring program to manage pollution events and disturbances if they occur"

Graeme Batley, CSIRO.

2.3 Outputs

Toward a permanent whole-of-catchment core monitoring program

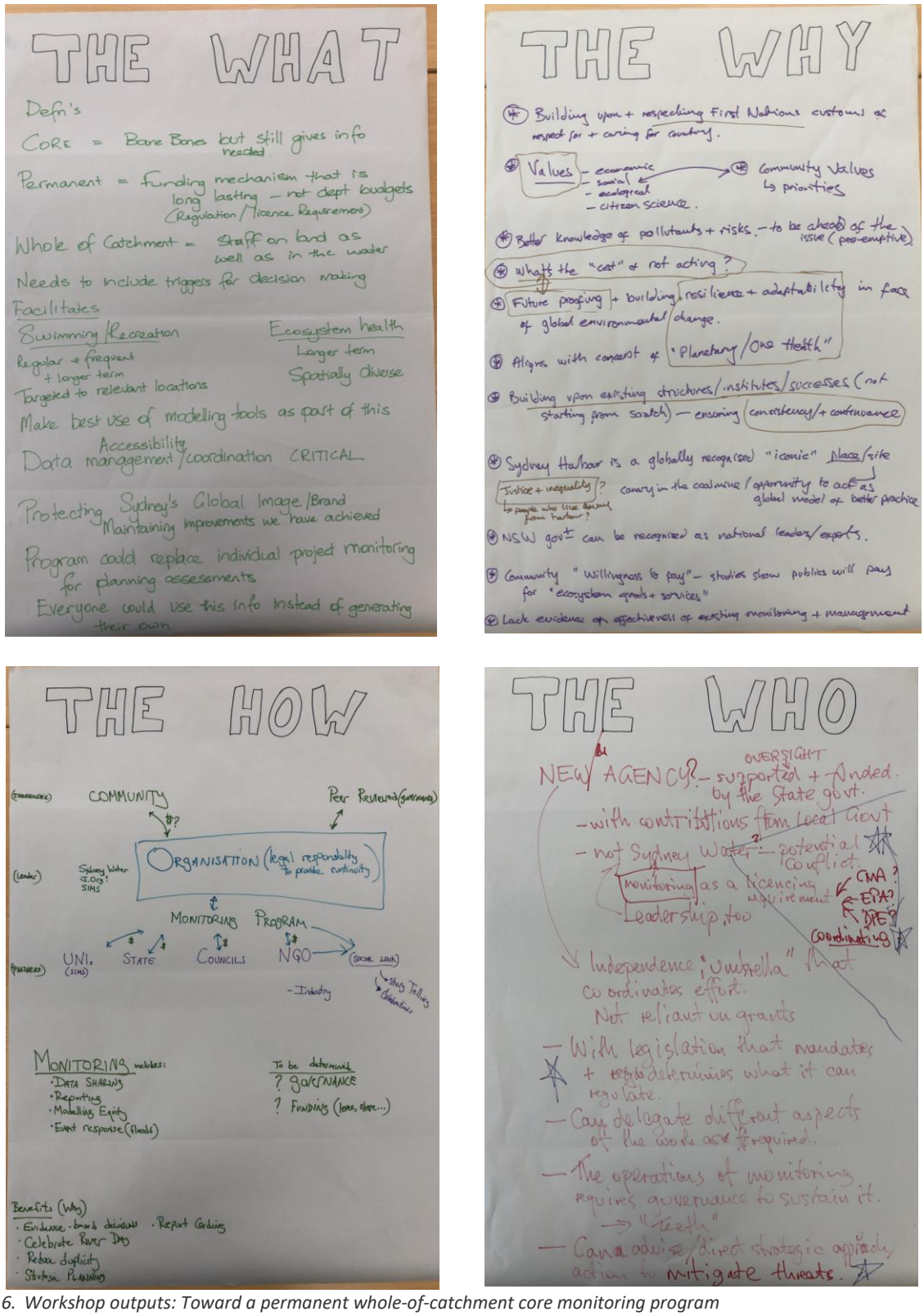


Figure 6. Workshop outputs: Toward a permanent whole-of-catchment core monitoring program


An key consideration is...
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2.4 Key Messages

The Sydney Harbour catchment and estuary are iconic places of national and international significance, and monitoring needs to reflect the significant social, environmental and economic values of this place. To points below summarise the key outcomes and messages from this workshop:

- The inefficiencies and duplication associated with currently delivering 26 existing water quality monitoring programs.
- Acknowledgement of the fact that there is an overarching responsibility for the management of Greater Sydney Harbour and its catchment.
- Acknowledgement of the fact there is no management plan for Sydney Harbour, and that the ownership of Sydney Harbour bed rests with the Minister for Transport, who focuses predominantly on transport related issues, and is not responsible for the management of the Harbour.
- There are differing views as to the lead agency of a whole of catchment core monitoring program, with pros and cons discussed as to creating a new agency or using the skills and capacity of existing agencies.
- There are a multitude of issues and history of contamination in the GSH, and it is most likely that it cannot ever be cost effectively remediated, but that doesn't prevent a more coordinated and smart monitoring program.
- Monitoring must take account of the fact that water quality varies significantly with depth, so monitoring must account for and be designed to sample at different depths in the water column, in line with the purpose of the monitoring program
- There is a real need to consider open access of data, as all modelling is constrained by the lack of empirical data and data to verify model runs.
- There is a real opportunity to use this move towards a whole of catchment core monitoring program to rewrite how we engage with the public on these issues, and present data that matters to the community, similar to the New Zealand Land, Air, Water Aotearoa program, and the existing NSW EPA Beachwatch program.
- There was real momentum and passion to work together to support a permanent whole-of-catchment core monitoring program.

2.5 Synthesis

Sydney Harbour is one of the world's great harbours and is of State and National significance. However, our iconic waterway is threatened by past and current activities within the catchment, with climate change exacerbating risks and consequences. Currently, there are numerous separate water quality monitoring programs across the Greater Sydney Harbour catchment – all with different objectives, responsible authorities, spatial and temporal scales, and data management processes. Much of this data is not publicly available.

The proposition for a *permanent whole-of-catchment core monitoring program for Greater Sydney Harbour* responds to First Nations culture of caring for Country and the concept of one health – recognizing the interconnections between people and planet. A collaborative and coordinated monitoring program are required to protect Sydney Harbour's iconic status through robust, data-informed policy, planning and management decisions by State and local governments on behalf of current and future communities. Participants unanimously supported this proposition.

A core monitoring program should focus on identified 'bare-bones' indicators across estuary and catchment that enables data-informed decision making, supported by complementary monitoring programs and modelling tools. Bare bones refers to typical parameters that a basic water quality monitoring program would traditionally include. The monitoring program needs to address ecosystem health and community uses with appropriate spatial and temporal coverage. Coordinated data management and reporting is required to provide all stakeholders with access to relevant, publicly available data for informed decision.

A collaborative governance model and sustainable funding mechanisms is required to support co-investment and shared responsibility. The lead organisation (to be determined) must have authority and responsibility to direct and coordinate monitoring activities of universities, State Government departments and agencies, local government (via a catchment management authority or coordinating group), industry and community organisations. It should build on existing structures and previous initiatives, providing consistency and continuity. There was a view by the experts involved in this discussion that the state agencies usually have the most expertise and capacity (if funded) but are not considered to be 'independent' in the true sense of the word, so a new agency may be preferred.

The integrated program will lay primary responsibility on councils to monitor their catchments, state agencies to monitor the harbour waterway. GSHCMP aims to improve the water monitoring program via better coordination, consistency, and leadership of the two entities and their roles.

Sydney Harbour is iconic. We need to better understand current and future threats to waterway health in order to protect this environmental, cultural and economic asset.

3 Climate Change Workshop #1

The workshop was held at Waverly Council (Bondi Junction) on 2nd September 2022 and attended by 30 presenters and participants. It was the first of two climate change workshops, the first being largely represented by State Government, researchers and consultants and the second dominated by councils in the catchment. The second workshop is documented in Section 4 below.

3.1 Purpose

The purpose of the first Climate Change workshop was:

> *To identify practical climate risk assessment methods, using latest state-of-knowledge, for consistent application across Greater Sydney Harbour catchment, with a focus on sea level rise.*

3.2 Context

Recorded sea level measurements at the main tidal gauge in Sydney Harbour (referred to by NSW Maritime Services Board as "Fort Denison 1 & 2") show an average rise of 2 (±1) mm / year in the mean sea level, consistent with forecasts that climate change will result in increases to sea level. IPCC forecasts for 2100 indicate sea level rise will continue to impact the harbour and foreshore. How sea level rise is modelled, and how climate change risks and mitigation strategies are assessed across the affected foreshore councils within the catchment is an important consideration for the development of the GSHCMP. While some work has already been completed on the issue of forecasting sea level rises along Australia's coast, and the impact of this rise on property inundation (in particular the national assessment in 2008 by Department of Climate Change), more advanced methods are now available and increase our understanding of these forecasts and impacts.

Sea level rise also has a significant impact on flood within the tidal zoner and upstream, as the tail water conditions will continually change.

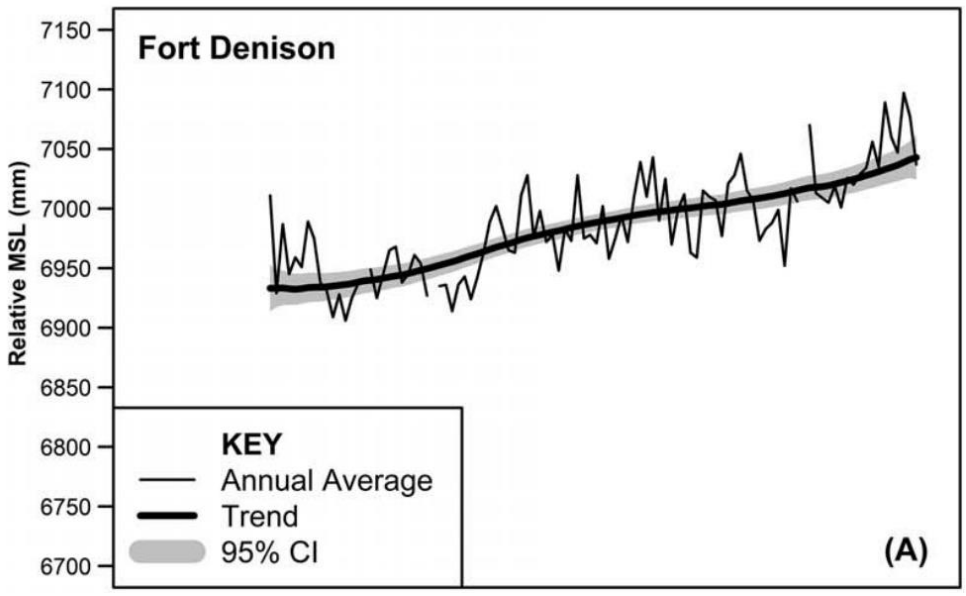
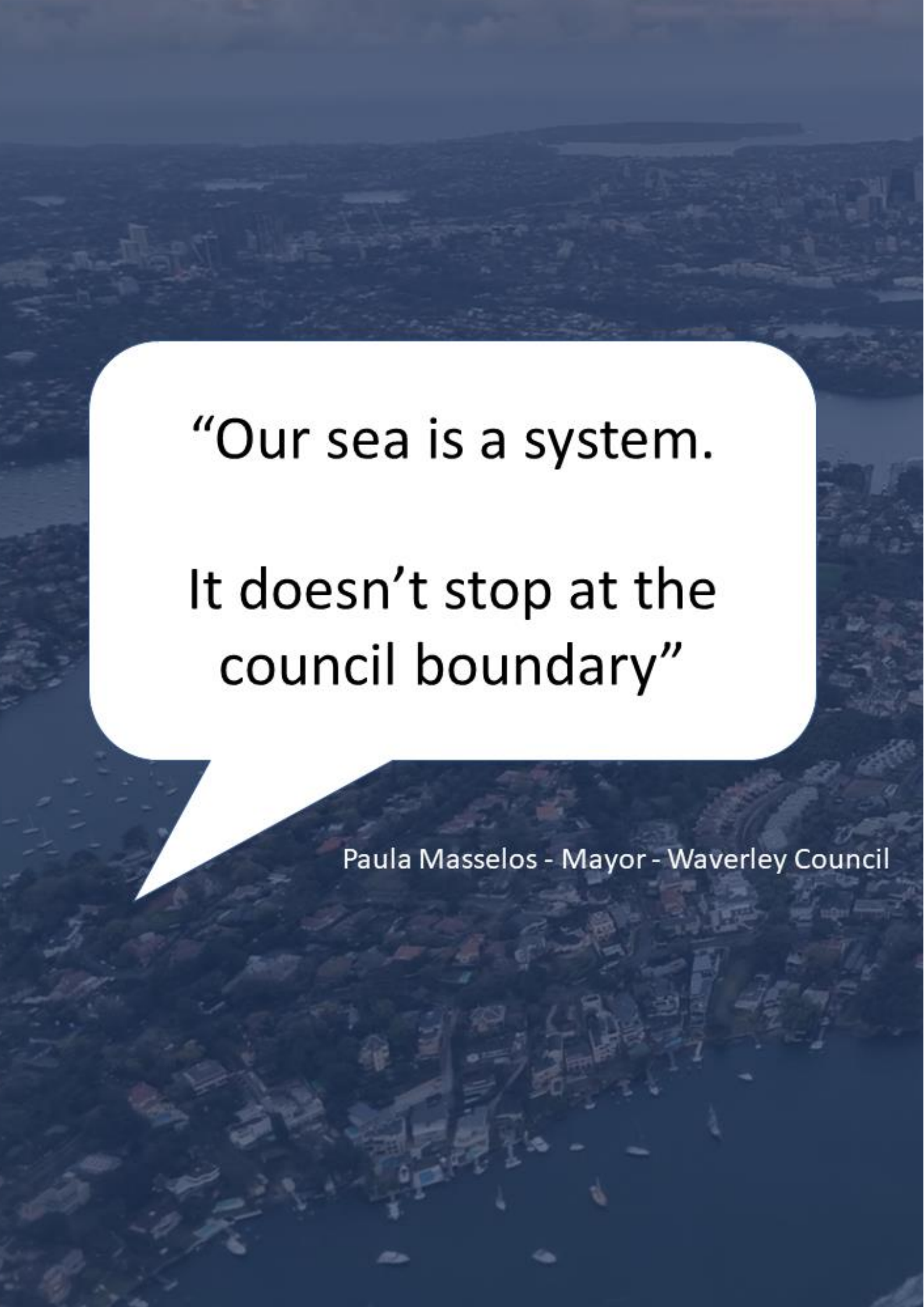


Figure 7. Watson, 2020. . Updated Mean Sea-Level Analysis: Australia (Figure 5). . Journal of Coastal Research, 36(5), 915–931. Coconut Creek (Florida), ISSN 0749-0208.

3.3 Outputs

This workshop focused on sharing the latest science and was used to inform a subsequent workshop with local councils on the issue of climate change, sea level rise and flooding risks. As a result, there was no time allocated to group discussion and no 'workshop materials' generated.


“Our sea is a system.
It doesn’t stop at the council boundary”
Paula Masselos - Mayor - Waverley Council

3.4 Key Messages

There was agreement that sea level rise is happening, is complex to model within Sydney Harbour, and that modelling of sea level rise and associated anomalies (and increase in the low tide level) will have profound impacts on Sydney Harbour. Some other key outcomes and messages from this workshop are outlined below.

Sea level rise

- Fort Denison tidal gauge is one of the longest running records in the southern hemisphere
- Sea level rise is accelerating, based on records at Fort Denison.
- The 1974 tidal event was an extreme anomaly (a frequency analysis suggests it is in the order of a 1 in 1400-year event), but with climate change will not be an extreme anomaly but an event with the probability of happening one in two years.
- At this point sea level rises are all but locked into 2050 timeframe, independent of RCP pathways.
- There is uncertainty around how extreme water levels will vary with sea level rises.
- Greater Sydney Harbour is a long river estuary where tidal propagation is dominated by friction and where sea level rise will result in decreased friction. However, sea level rise will change tidal range by only 10-15 cm in the Upper Greater Sydney Harbour estuary.
- Sea level rise will impact sedimentation, flushing, residence time, and a variety of other factors which must be accounted for in the Greater Sydney Harbour ecological response model.
- Concept of 'drainage window' was discussed, whereby sea level rise will decrease the time to drain upstream estuarine flood plains.
- The impacts of sea level rise on estuaries are an order of magnitude greater that on open coastal environments.
- Sydney Water's stormwater assets face a higher burden for triggering investment with respect to sea level rise than wastewater assets.
- Sydney Water using XDi analysis to quantify costs implications however not all asset types are included, and cumulative impacts were not assessed. Sea level rise greatly increases the complexity of asset management.

Catchment modelling

- There are only two active hydrological monitoring stations in the Sydney Harbour catchment, both upstream of Parramatta. Other stations have been discontinued, so the verification of hydrological models in the Sydney region is limited by this lack of catchment monitoring.
- Flood modelling is now more sophisticated than using the Rationale Method, but more sophisticated models don't necessarily result in better predictions of capacity and risk to property and life, again relating to the fact that there is limited verification data available to confirm engineering hydrological and hydraulic models, which highlights the inherent uncertainty in flood modelling.
- A precautionary approach is appropriate when considering how best to manage drainage, as there are several uncertainties in forecasting flooding already.
- We need publicly funded research to be made public, all presenters were clear that the publishing of data is critical to making informed policy decisions in the public interest.
- We need all sea level rise forecasts and vulnerability assessments to be made public.

Estuary processes

- Modelling of the sea level rise is complex in estuaries, and a 'bathtub' model is inadequate for this assessment of risk, for this high-profile urban environment.
- The Office of Environment and Heritage (OEH) conducted a valuable tidal inundation assessment. However, it did not consider anomalies and is not appropriate for assessing asset risk or undertaking strategic planning. This work will likely be updated following providing expected new funding is made available.

- Sea level rise can be dampened or amplified in estuary environments, depending on the bathymetry and the shape of the banks and tributaries. Future assessments should take this into account when embarking on new coastal inundation assessments.
- Modelling of the estuary itself is very complex, and modelling that aims to predict the mixing or stratification of the estuary in Sydney Harbour, and the impact on water quality from the stratification, is a function of the bathymetry, and the neap and spring tide set up, with spring tides enabling far more mixing in the estuary that the neap tides.
- New DELFT flexible mesh hydro-dynamic model of Greater Sydney Harbour is 5-10% more accurate and 500-600% more efficient than previous D3D model, and nearing completion. This model can be used to look at how water overtops and inundates foreshore.

Vulnerability

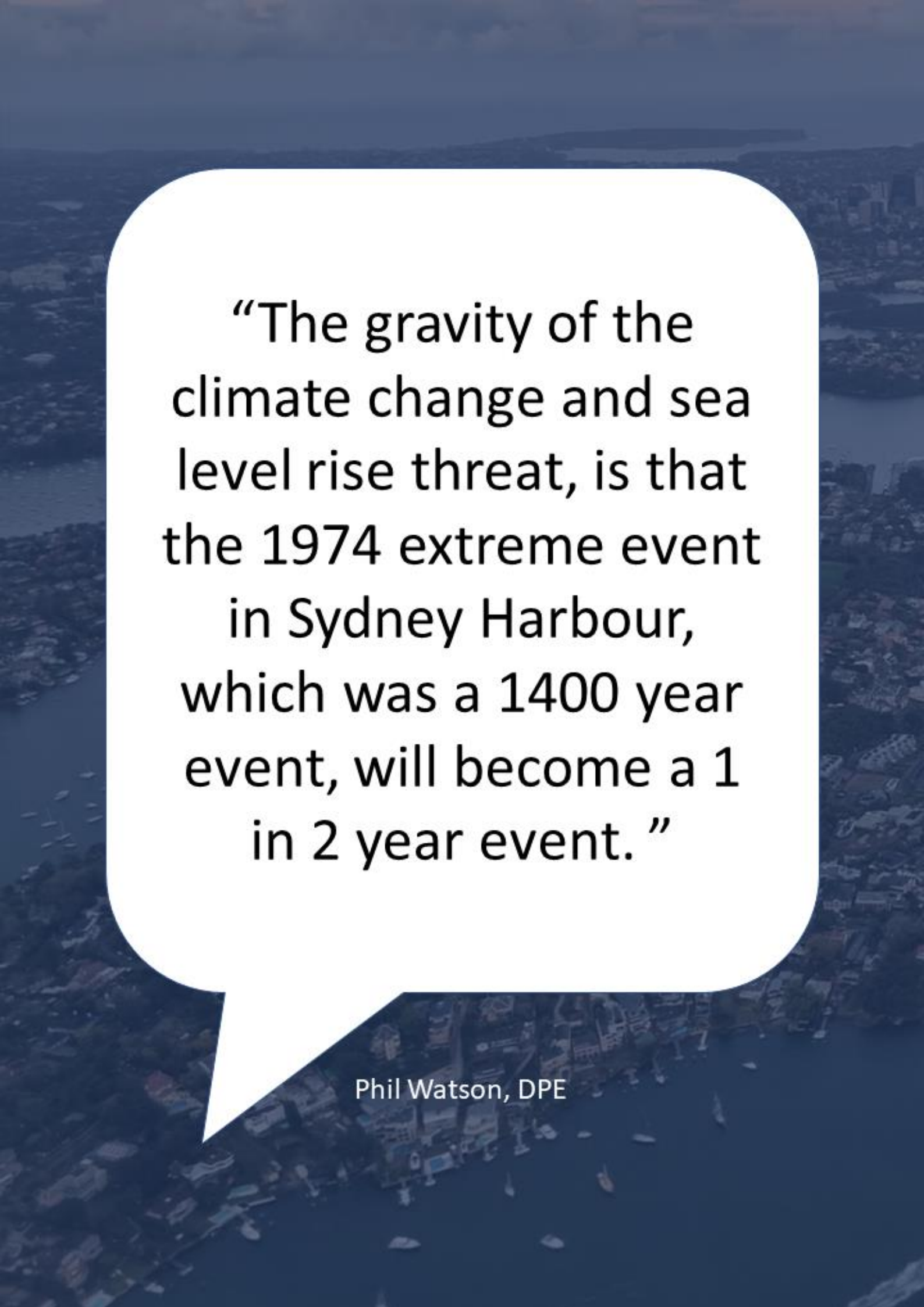
- Risk assessments should integrate sea level rise, anomalies, and catchment flooding to best estimate and understand the risk and vulnerability within the harbour.
- A study of sea level rise along the Eastern Beaches indicates a real risk of damage to property and infrastructure
- In 2018 modelling was completed to determine the scale of the impact of sea level rise across NSW. The estimate was that between 40,000 and 62,000 properties are at risk of sea level rise, when considering a RCP of 4.5 and 8.5.
- Sydney Water have already started to consider the impact of climate change on assets, and have adopted a RCP 4.5 trajectory and risk assessment profile as a base case for assessing assets. Already several assets (e.g., pumping stations) have resulted in a business case being accepted and capital works delivered to move assets and reduce the risk of flooding and sea level rise.
- There is agreement that all councils are seeking a state-led inundation mapping, guidance to consistently assess vulnerability and frameworks for adaptation planning & management.
- The development of the GSHCMP is an opportunity to set a consistent approach for foreshore councils with SLR risk, that enables the risk to be translated into asset management and strategic planning documents.
- Councils will be considering SLR impact on natural assets as well as private assets.
- Although exposure of Woollahra Council assets to inundation was identified, it was difficult to draw conclusions and develop specific action plans for the council (suggesting more work of risk assessment needs is required).
- Waves generated by marine craft a more significant risk then wind generated waves.

3.5 Synthesis

This session focused on knowledge sharing and limited time was available for discussion of presentations. However, there was a general consensus that there is sufficient knowledge and information about the impacts of climate change, sea-level rise and flooding on Greater Sydney Harbour and its catchment to act now. There was interest in supporting local government to access and understand the latest research and analysis to inform evidence-based and consistent decision-making.

Some of the points that did emerge from the discussion time available included:

- Local councils need State led inundation mapping, guidance to consistently assess vulnerability, and frameworks for adaptation and planning management.
- There's an opportunity for the CMP to set a consistent approach for foreshore Councils with SLR risk.
- Inundation risk needs to be translated into asset management and strategic planning.
- Sea level rise impacts on natural assets need to be considered.
- Sea level rise information needs to be made transparent.


“The gravity of the climate change and sea level rise threat, is that the 1974 extreme event in Sydney Harbour, which was a 1400 year event, will become a 1 in 2 year event.”
Phil Watson, DPE

4 Climate Change workshop #2

4.1 Purpose

The purpose of the second Climate Change workshop was:

> *To explore how the Coastal Management Program can support local government responses to community and infrastructure risks associated with climate change based on the latest state-of-knowledge on sea-level rise and flooding.*

4.2 Context

Recorded sea level measurements at Fort Denison 1 & 2 in Sydney Harbour show an average rise of 0.75 mm/year. IPCC forecasts for 2100 indicate sea level rise will continue to impact the harbour and foreshore. How sea level rise is modelled, and how climate change risks and mitigation strategies are assessed across the 21 councils within the catchment is an important consideration for the development of the GSHCMP.

An earlier GSHCMP workshop (Future directions for catchment management, 12 July 2022) provided an opportunity for councils and Sydney Water to share their perspectives on what the CMP needs to address to achieve the GSHCMP vision of *improving and sustaining waterway health through improved coordination, consistency, and leadership*, SLR and to present their expectations from the CMP. This workshop on "*climate change, sea level rise and flooding"* will build on the outcomes of the earlier workshop and hear from climate change experts to inform how councils respond to the risk and assess vulnerability.

The *climate change, sea level rise and flooding* workshop is an opportunity to consider climate change and sea level rise predictions and the methods available to understand community and infrastructure vulnerability in Greater Sydney Harbour. It is part of a series of expert workshops seeking to identify and collate evidence to guide the development of the GSHCMP in relation to water quality monitoring, climate change impacts on stormwater and associated assets, and stormwater-related catchment initiatives.

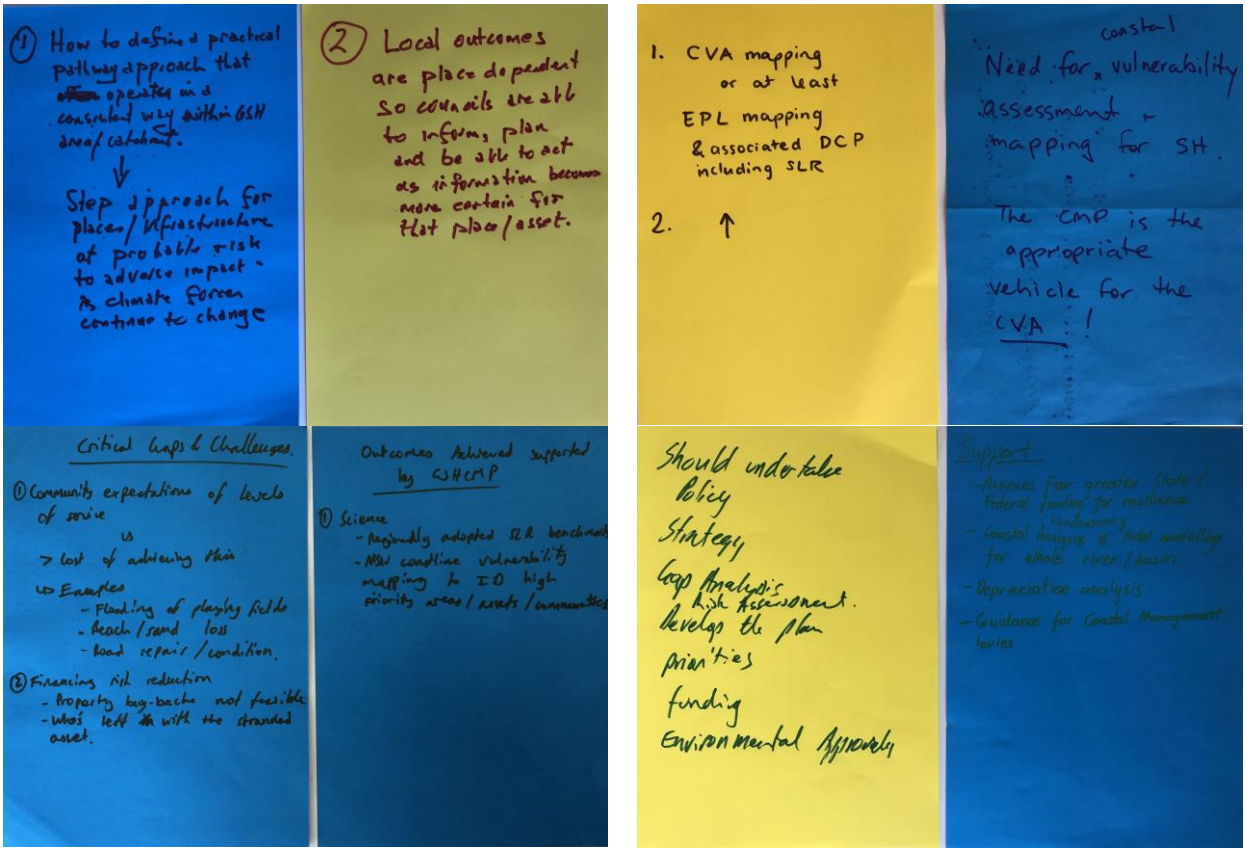
From a council perspective, earlier investigations through the GSHCMP Stage 2 process revealed that:

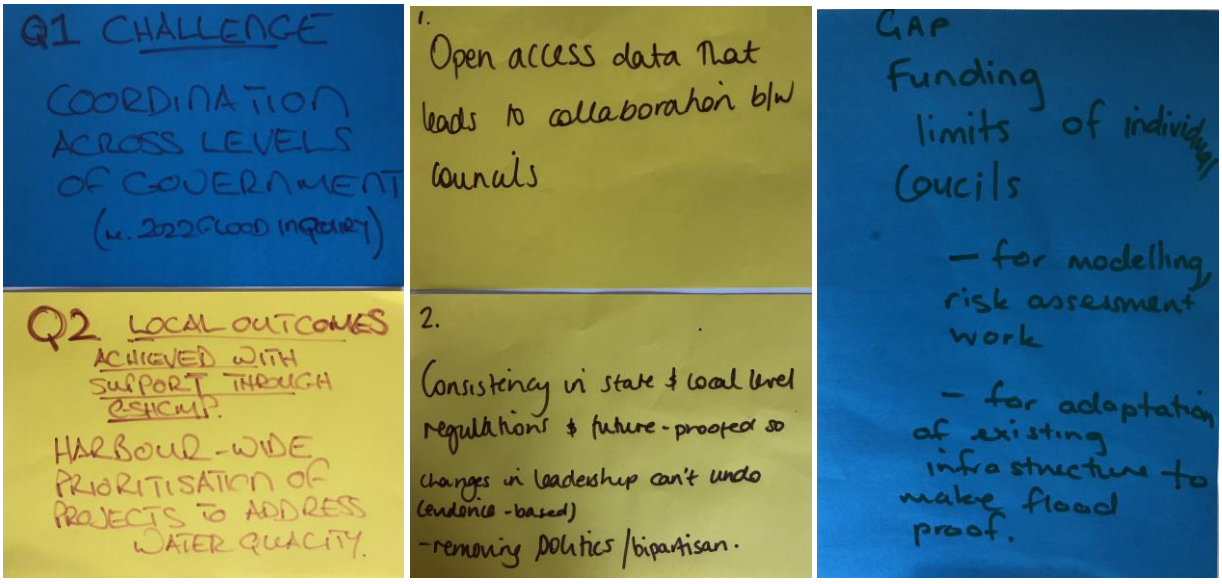
- 12 foreshore councils are impacted by sea level rise around the whole Greater Sydney harbour but have different levels of exposure to coastal inundation.
- Some of the 12 councils have undertaken basic risk assessments of sea level rise (e.g., the Northern Beaches Council, City of Sydney and Woollahra Municipal Council).
- Councils preferred to see the Sydney Coastal Councils Group (or other regional / state agency) take a lead and approach this as a whole of coast issue and are seeking a coordinated and consistent approach through the CMP.
- Councils are concerned about both the impacts to private property and public assets from sea level rise.

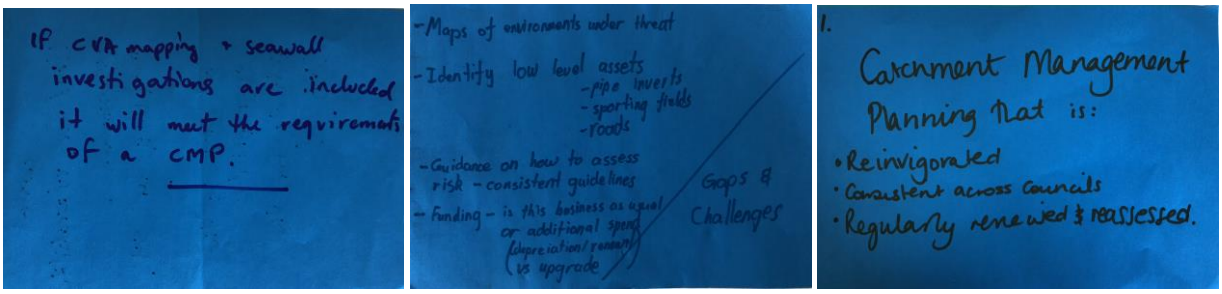

"We have an opportunity to use the Sydney Harbour Coastal Management Plan as a new model for our whole region and state"
Paula Masselos - Mayor - Waverley Council

4.3 Outputs

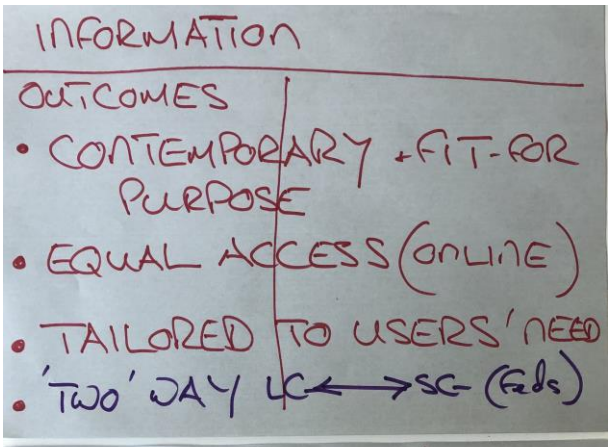
Critical challenges and gaps related to climate change, sea-level rise and flooding

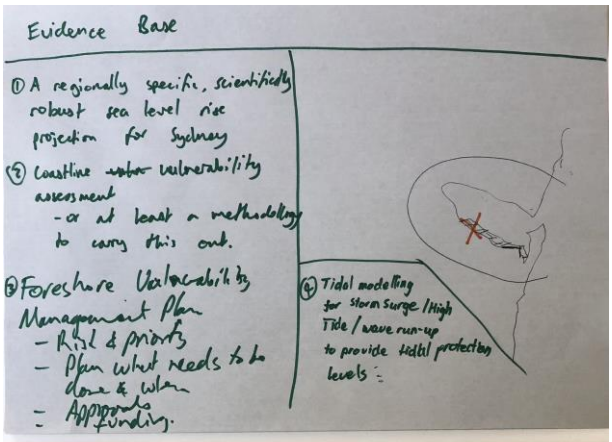


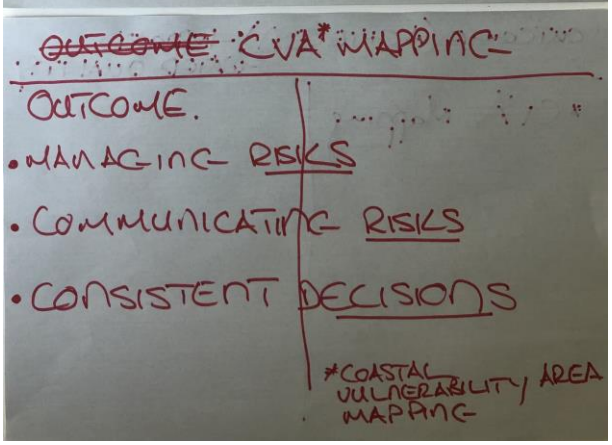


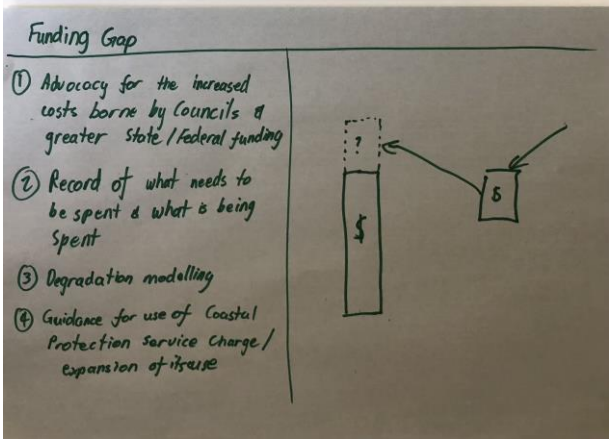


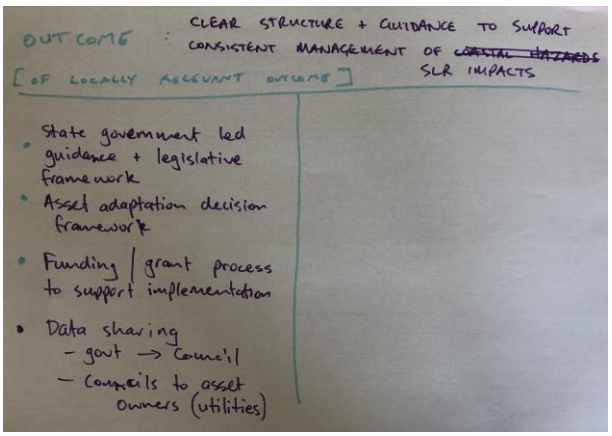
Locally relevant outcomes related to climate change, sea-level rise and flooding that could be achieved with the support of the GSHCMP.

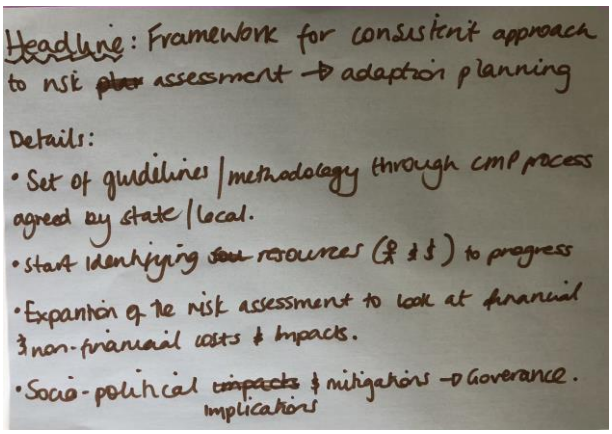

INFORMATION
OUTCOMES
• CONTEMPORARY + FIT-FOR PURPOSE
• EQUAL ACCESS (ONLINE)
• TAILORED TO USERS' NEED
• 'TWO' WAY LG ↔ SG (Feds)

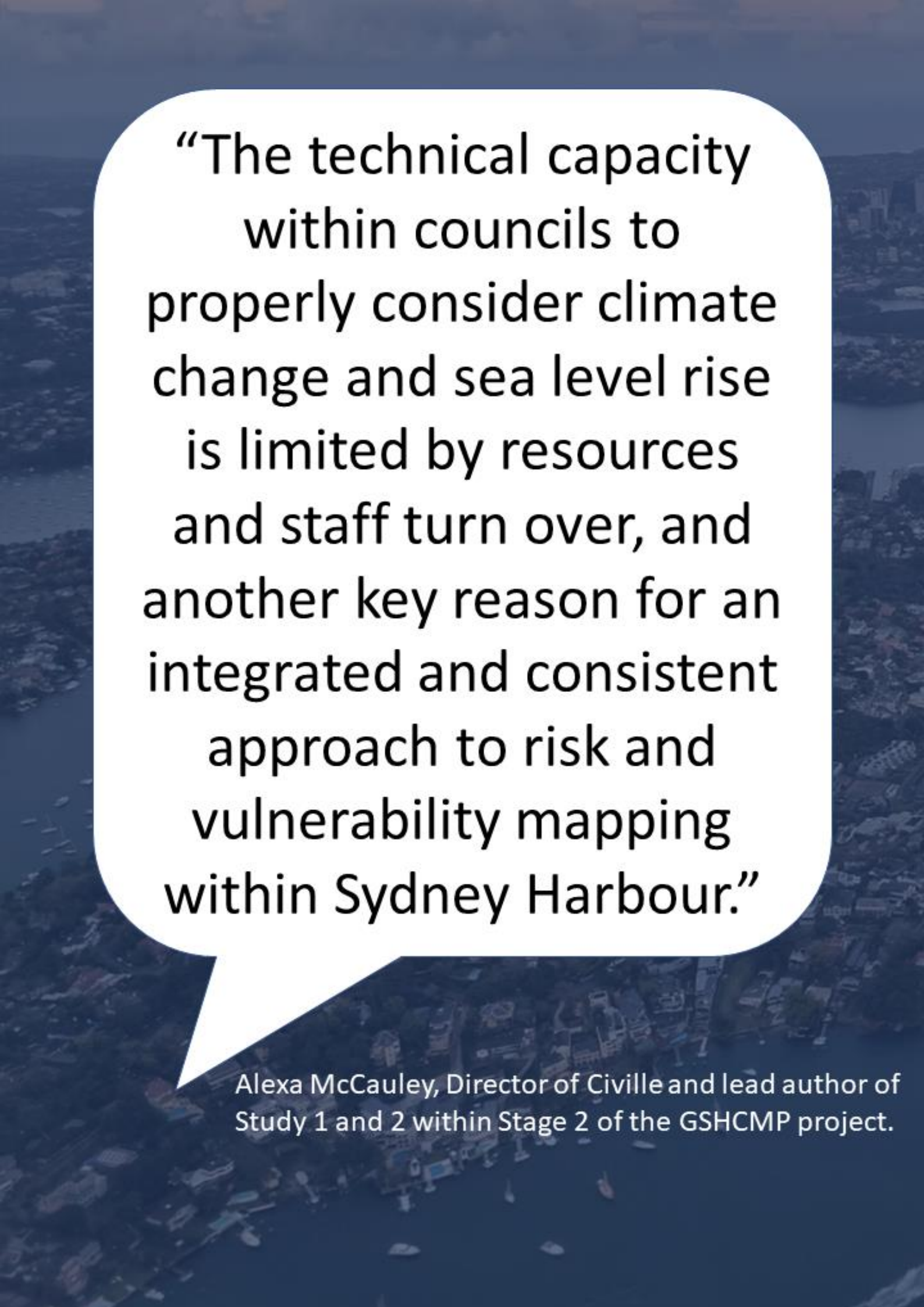

Evidence Base
① A regionally specific, scientifically robust sea level rise projection for Sydney
② Coastline wide vulnerability assessment - or at least a methodology to carry this out.
③ Foreshore Vulnerability Management Plan
- Risk & priority
- Plan what needs to be done & when
- Approvals funding.
④ Tidal modelling for storm surge / High Tide / wave run-up to provide tidal protection levels


~~OUTCOME~~ CVA* MAPPING
OUTCOME.
• MANAGING RISKS
• COMMUNICATING RISKS
• CONSISTENT DECISIONS
*COASTAL VULNERABILITY AREA MAPPING


Funding Gap
① Advocacy for the increased costs borne by Councils & greater State / Federal funding
② Record of what needs to be spent & what is being spent
③ Degradation modelling
④ Guidance for use of Coastal Protection Service Charge / expansion of its use
?
$
$


OUTCOME : CLEAR STRUCTURE + GUIDANCE TO SUPPORT CONSISTENT MANAGEMENT OF ~~COASTAL HAZARDS~~ SLR IMPACTS
[OF LOCALLY RELEVANT OUTCOME]
• State government led guidance + legislative framework
• Asset adaptation decision framework
• Funding / grant process to support implementation
• Data sharing
- govt → Council
- Councils to asset owners (utilities)


Headline: Framework for consistent approach to risk ~~plan~~ assessment → adaption planning
Details:
• Set of guidelines / methodology through CMP process agreed by state / local.
• Start identifying ~~sea~~ resources (£ & $) to progress
• Expansion of the risk assessment to look at financial & non-financial costs & impacts.
• Socio-political ~~impacts~~ & mitigations → Governance.
implications



Alexa McCauley, Director of Civille and lead author of Study 1 and 2 within Stage 2 of the GSHCMP project.

4.4 Key Messages

There was agreement that climate change is happening, is complex to model within Sydney Harbour, and a and consistent approach is needed by all councils in addressing this risk and understanding vulnerability.

Some other key outcomes and messages from this workshop including:

- NARCliM (NSW Australian Regional Climate Modelling) is a family of regional climate modelling projects that include robust climate projections for research, impact assessment, and planning.
- NARCliM data is a NSW specific process and data source that downscales Global Climate Models to NSW areas, for several parameters, in particular rainfall and temperature.
- There is a large amount of scientific rigour that is invested into to forecasting climate change impacts in the NSW region.
- Sydney Harbour will soon have a 4 km grid resolution for several scenarios and parameters
- DPE are committed to publishing and supplying these forecast grid datasets, at a range of Shared Socioeconomic Pathways
- Tidal issues are impacting coastal zones, buildings, streets and bridges right now
- Tidal anomalies will pose a significant threat and a collaborative council approach is most suitable to understand this risk
- There is no flood warning system for Sydney Harbour because it is a flash flood scenario, and the Bureau of Meteorology does not provide flood warnings for flash floods. The link to coastal inundation and SLR has not been identified. Some councils have in house systems to forecast the risk of flooding.
- There are decisions being made today regarding future development that will be difficult to manage, and particularly difficult for communities to be warned and respond to in real time, due the nature of the risks and impact in foreshore areas with flash flood catchments above them.
- Dynamic adaptive policy pathways (DAPP) are a potentially useful tool for testing adaptation responses to future coastal inundation. Predicting exactly when certain SLR will occur is not as important as testing SLR scenarios now. This method has been examined by Bundaberg Council.

4.5 Synthesis

Significant challenges for local government in relation to climate change, sea-level rise relate to:

- **Consistent and coordinated assessment of risk and vulnerability**
    - Access to up-to-date and locally relevant information (e.g., sea-level rise (SLR), climate vulnerability assessments (CVA), flood planning level (FPL), estuarine planning level (EPL)).
    - Coordination regarding how assessments information stated above are generated and processed.
    - Absence of a detailed and whole of estuary approach to sea-level rise inundation mapping (led by State Government) and risk assessment (led by local governments)
    - A lack of coordination across different levels of government (as identified in the 2022 NSW Flood Inquiry)
    - Availability of comprehensive and consistent guidance on assessing risks and vulnerabilities
    - Inconsistent approach when obtaining information on infrastructure and assets, which is likely to be impacted by sea-level rise and flooding.
- **Access to funding**
    - Access to funding to undertake risk and vulnerability assessments
    - Access to funding for adaptation of existing infrastructure and assets.
- **Community expectations and local government capacity**
    - Community expectations of levels of service and costs associated with achieving this
    - Managing stranded assets on public and private land.

The GSHCMP could investigate the following from catchment planning and management outcomes:

- accessible, fit-for-purpose information (based on State and local government data) to support risk assessment and adaptation planning
- a framework for consistent risk assessment and adaptation planning (guidelines/methodology co-developed by State and local government)
- quantification of the additional resources required the enable councils to address climate risks and vulnerability.

Workshop participants supported coastal vulnerability area (CVA) mapping being undertaken through the GSHCMP to identify and apply consistent approaches for assessing, communicating and managing risks.

5 Catchment Initiatives Workshop

The workshop was held at Blacktown City Council (Blacktown) on 5th September 2022 and attended by 24 presenters and participants.

5.1 Purpose

The purpose of the Catchment Initiatives workshop was:

> *To share knowledge and insights on catchment initiatives aimed at improving waterway health as a basis for more effective and consistent catchment planning for Greater Sydney Harbour.*

5.2 Context

The GSHCMP seeks to improve and sustain waterway health through improved coordination, consistency, and leadership. The GSHCMP – Stage 1 study (2018) identified stormwater as the greatest threat to the health of the harbour, echoing the findings of the Sydney Harbour Water Quality Improvement Plan (2015).

The ecological integrity of Greater Sydney Harbour underpins multiple social, environmental and economic benefits provided by this iconic waterway. Catchment initiatives that reduce the volume, frequency and pollutant load of stormwater discharges into the harbour are critical to improving and sustaining waterway health.

The health of Sydney Harbour is also a key issue that impacts on the opportunity for people across the whole city, particularly in the west of the city, to have access to swim in estuaries, waterways, beaches, and pools and remain cool on hot days, that will increase with climate change.

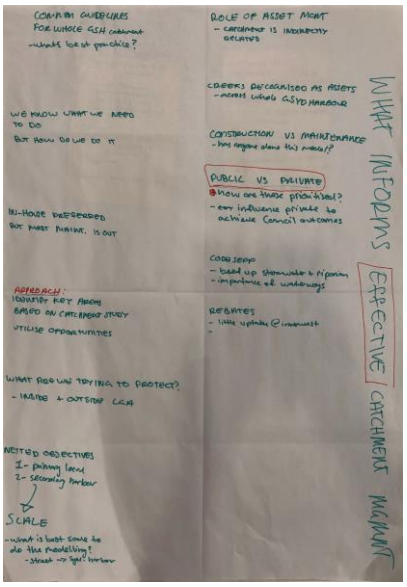
This *catchment initiatives* workshop provides a platform to share the latest knowledge and insights on catchment initiatives aimed at improving waterway health in Greater Sydney Harbour. Participants included experts from academia, government and industry across urban planning and design, and catchment and waterway management.

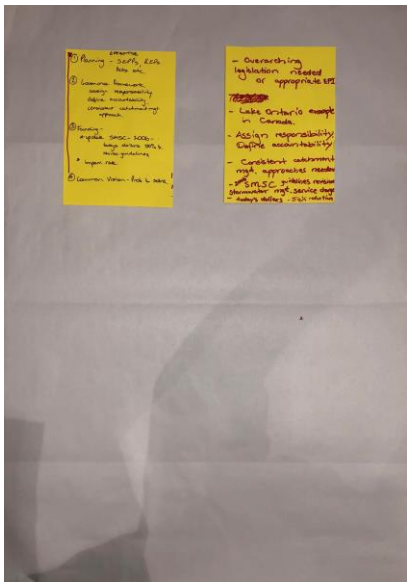
The delivery of catchment initiatives (structural and non-structural) should always be seen in the context of the current condition of the catchment, and values and assets that the community want protected, and the catchment management frameworks that will first set the strategic direction and need for catchment initiatives.

5.3 Outputs

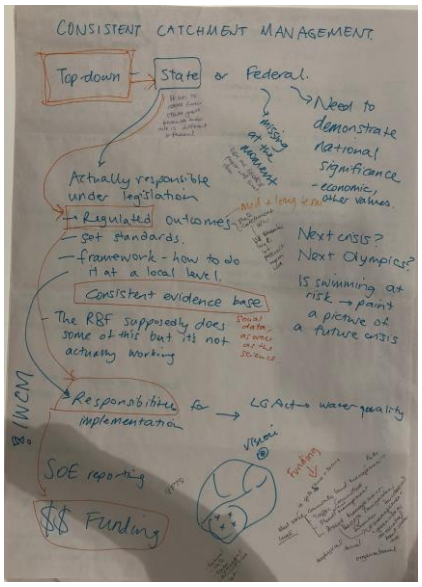
There were two key questions posed in this workshop, and the outputs below capture the results from the discussion based around effective and consistent planning, as the key solutions to the aim of the GSHCMP.

Toward more **effective** catchment planning





Toward more **consistent** catchment planning



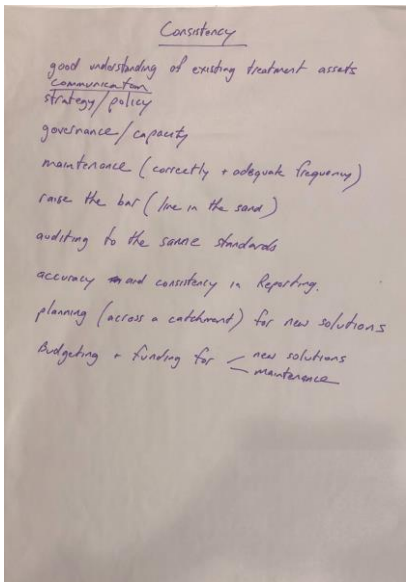
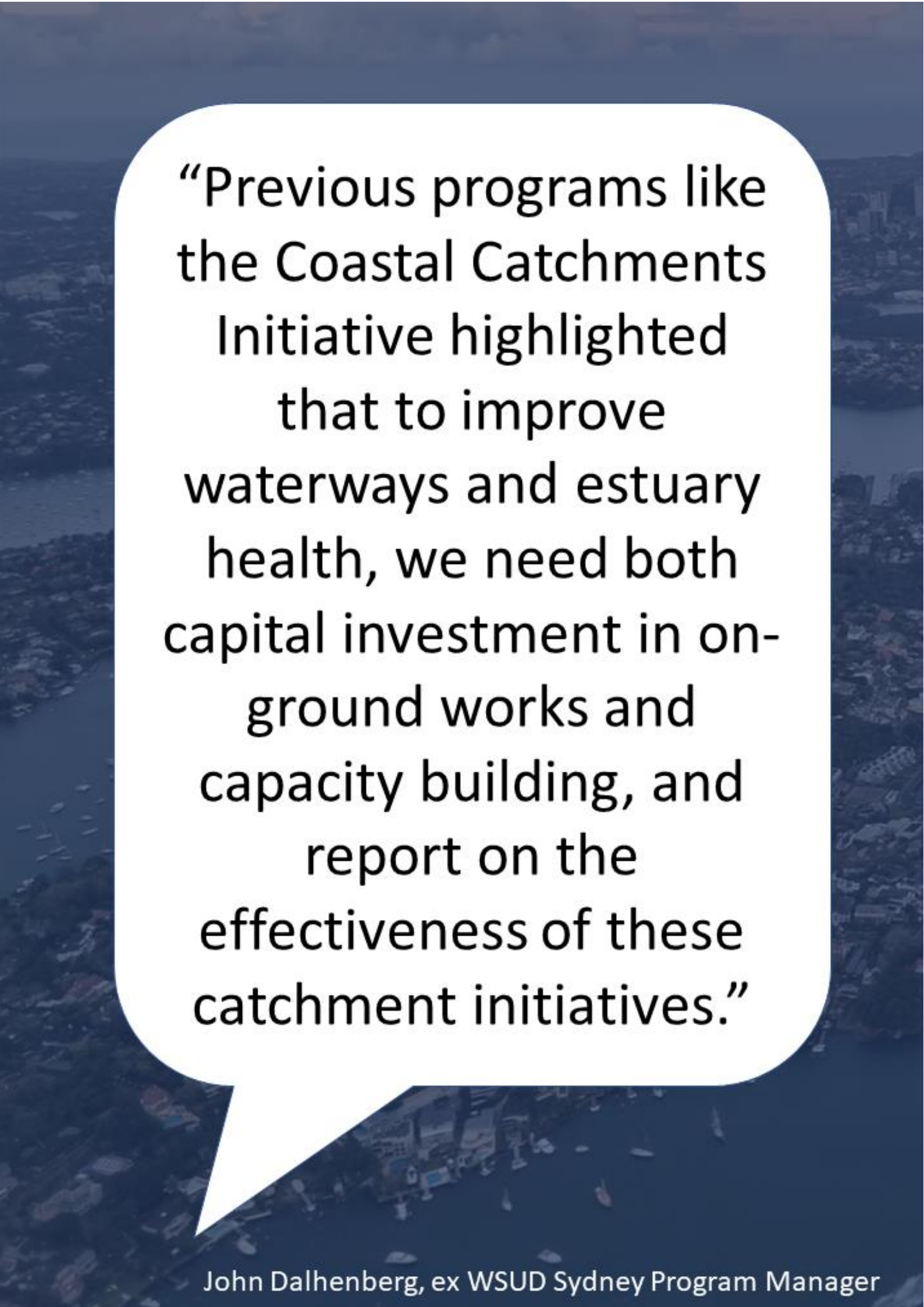


Figure 8. Workshop outputs: Toward more effective and consistent catchment planning


“Previous programs like the Coastal Catchments Initiative highlighted that to improve waterways and estuary health, we need both capital investment in on-ground works and capacity building, and report on the effectiveness of these catchment initiatives.”
John Dalhenberg, ex WSUD Sydney Program Manager

5.4 Key Messages

There was **widespread support for a more evidence-based approach to delivering structural and non-structural works in the catchment**, acknowledging that council capacity, available physical space, and a strong community engagement model is also critical to reducing pollution and runoff from urban catchments.

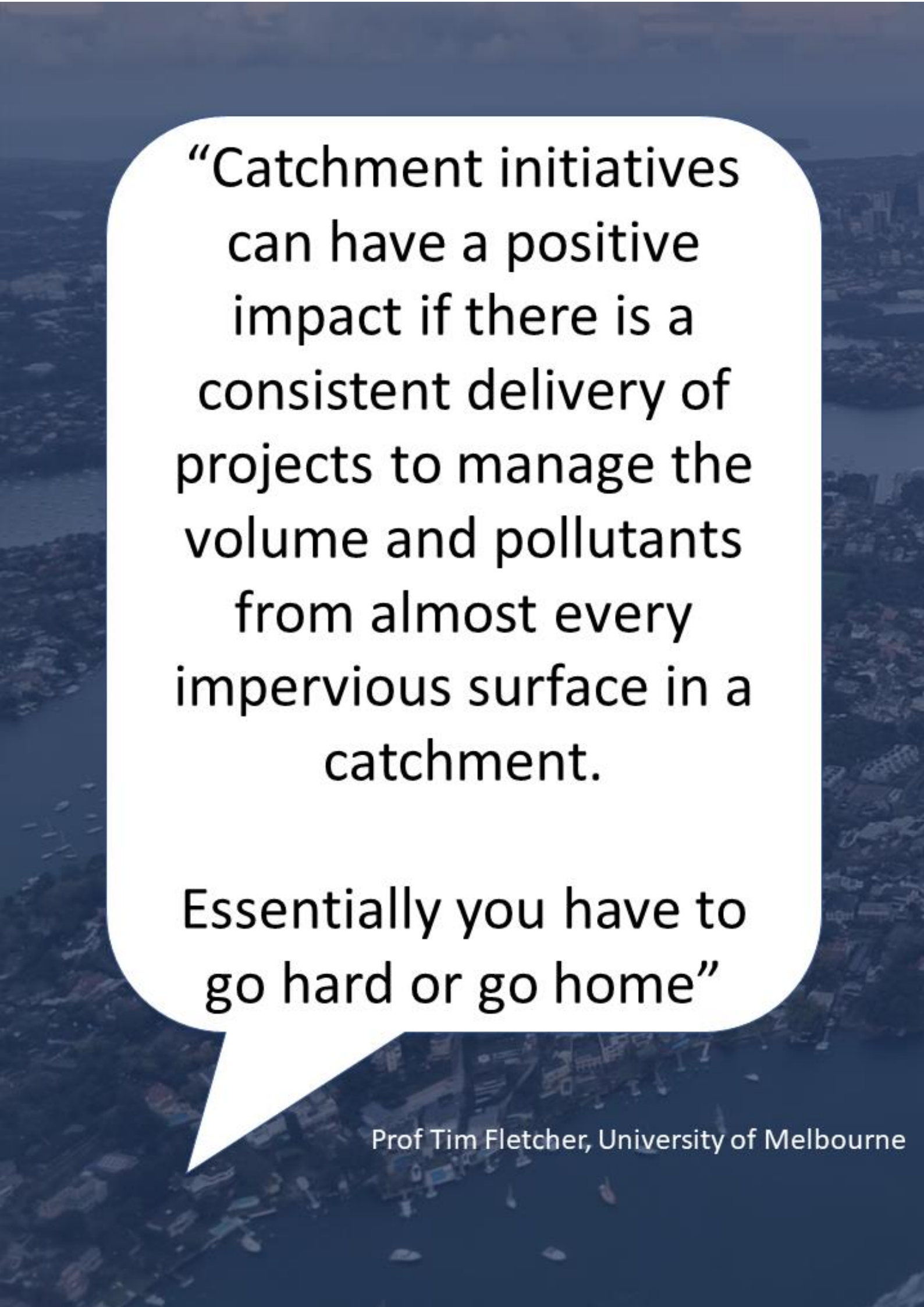
Some other key outcomes and messages from this workshop were as follows:

- There is a long history to trialling different catchment management approaches in Sydney, and future plans should review these to ensure lessons learnt are taken into account by the CMP.
- Parramatta River Catchment Group are trialling a new collaboration model that puts swimming and social uses at the heart of the vision for the river and provides a structure for all councils to be working together towards this shared vision.
- There is universal acknowledgement that urban development and directly connected impervious surfaces fundamentally changes the hydrology and ecology of downstream waterways, bays, harbours and beaches.
- There are very few examples around the world that have been able to monitor at a sub-catchment and catchment level the impact and effectiveness of catchment initiatives and the link with improved hydrology and ecology.
- Changes to baseflow are very hard to detect as they only change by a few millimetres in the channel, and other debris and water leaks in the catchment.
- There are various initiatives that can be applied to a catchment, both to mitigate new developments and mitigate existing developments. Water sensitive urban design initiatives such as
    - Bioretention systems
    - Rainwater tanks
    - Infiltration systems
    - Swales
    - Gross pollutant traps
- Several councils have tried many different initiatives to reduce the load of stormwater pollution and including different catchment models and engagement activities to create more awareness and increase local action.
- Communities in Marrickville have responded well to these initiatives.
- There are always difficulties in then maintaining the infrastructure that is delivered
- Minimal funding can still make a big difference.
- WSUD business cases should highlight the multiple benefits relevant to today's situation, such as flood or drought prevention, rather than emphasising the risks.
- The transition to WSUD cities requires community engagement and a diversity of asset owners – since public space is limited.
- WQIP modelling showed large pollutant reductions can be achieved.
- The importance of generating a high accuracy water balance when analysing catchments, reflecting the multiple elements to consider in catchment management (drivers, impacts, outputs, indicators, scale); as well as the community uniqueness of each catchment.
- SCMs are more present at a site scale than catchment due to expense, time and organisational commitment, as well as potential benefit decline further downstream.
- Monitoring is expensive and time-consuming and requires multi-year commitment. Funding monitoring and compliance is notoriously difficult.
- The cost-effectiveness of WSUD needs to be understood at multiple scales
- Council capacity for IUWM can be easily lost through staff turnover, organisational restructures and amalgamations.

5.5 Synthesis

Considerations in moving toward more effective and consistent catchment planning and management for Greater Sydney Harbour include:

- **shared vision and consistent practice**
- **policy and regulation** (SEPPs, REPs, Acts, etc.; overarching legislation is required)
- **planning** (guidance on best-practice catchment planning and management; understanding priority areas (sub-catchments) for investment; understanding the contribution of catchment management on public and private land)
- **governance** (framework assigning responsibilities and accountabilities)
- **funding**(review stormwater management service charge (SMSC) to reflect current situation; unchanged since 2006)
- **implementation** (appropriate maintenance of stormwater management assets.


"Catchment initiatives can have a positive impact if there is a consistent delivery of projects to manage the volume and pollutants from almost every impervious surface in a catchment.
Essentially you have to go hard or go home"
Prof Tim Fletcher, University of Melbourne

6 Recurring themes and implications for the CMP

While the workshops covered discrete technical areas and issues relevant to Stage 2 of the GSHCMP process (a review of risks and opportunities), there were several ideas and proposals that were raised by experts across all workshops.

This chapter highlights several of the reoccurring themes that were observed in these expert workshops, and then describes some implications for the next stages of the CMP, noting other workshop participants and agencies may have other views as to the implications from the content and discussion within these expert workshops.

Recurring themes across the expert workshop series (relevant to the next stages of the Coastal Management Program) were as follows:

1. **A 'whole of catchment approach' is valued and supported by individual councils**. There was clear acknowledgement that a collaborative model was the most efficient and effective way to address several issues raised by experts, and there was unanimous support for a whole of catchment approach to address these problems.
2. **Climate change is an immediate and significant threat to the health of the people and the ecology of the harbour** across all areas and jurisdictions. While specific impacts vary considerably across the harbour, there is a clear view that we need to act now, act fast, and work together to apply a consistent response across jurisdictions.
3. There is a genuine desire to ensure governance and funding issues are resolved for the long-term, so the **values of the harbour were protected for future generations**.
4. **There is genuine interest and concern for equity - that all residents of Sydney could benefit from a healthy harbour**, not just those with water views and harbour frontages.
5. **There is significant amount of good quality scientific analysis that has completed for the harbour**. However, there are **barriers to sharing information** and ensuring all relevant stakeholders are using it effectively.
6. **Storing and publishing data for use by all stakeholders is critical for evidence-based decision making**. Several past studies were limited in access to data, and all future endeavours should be made to ensure that all data is open and accessible.
7. The **expert workshops demonstrated the value of coming together** as a network of professionals and agencies with a shared interest in improving the management of Greater Sydney Harbour and its catchment. They provided opportunities to hear from experts in different fields, debate ideas, and understand the application of contemporary methods and results of latest research to Sydney Harbour.

The upcoming stages of the CMP are:

- Stage 3 (identify and evaluate options), and
- Stage 4 (prepare, exhibit, finalise, certify and adopt CMP), and
- Stage 5 (implement monitor, evaluate and report).

Experts that attended and contributed to these workshops have discussed all of these issues that are due to be considered in these upcoming stages (options, adoption and monitoring in particular).

What is apparent from the expert workshops is there is a desire to look at options, collaboration models and monitoring from a collaboration perspective, and with a whole of catchment and a systems thinking approach. What councils are often seeking is leadership and more open and transparent modelling and data access to support policy and strategic planning.

There was a sense too that there is a strong case for change, and that the change needs to happen immediately. There are millions to billions of dollars at stake across both public and private properties, with

significant implications for how assets are design, managed, and the costs of not adapting to climate change and not working towards a healthier Sydney Harbour.

There was a growing appreciation for the link between catchments, catchment management and the impact on the health of the harbour, both from a social and ecological perspective, which reinforced a need for the CMP to

The next stages of the CMP need to consider how best to develop a structure and framework that supports councils in taking a systematic and evidence-based approach and sets up a catchment and estuary monitoring framework to ensure the right data is collected and reported for all users and community.

Study 1 highlighted the impact of stormwater on the estuary and harbour, and in the expert workshops it was reinforced that there most of the pollution is accumulating in the tidal zone where the rivers and the estuary meet. The discussion in the workshops often converged on the need for a whole of catchment approach to catchment interventions and an understanding of the health of the estuary and monitoring methods.

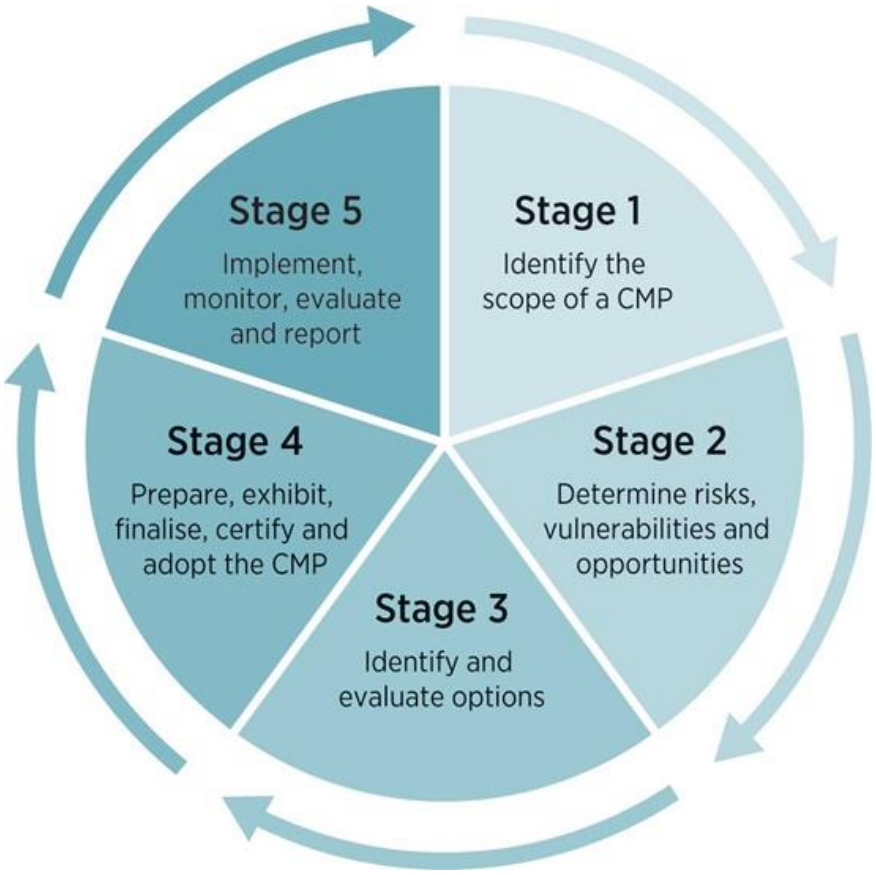


Figure 9. Stages for the CMP

7 Appendix A. Workshop agendas and participants

7.1 Water quality monitoring workshop - agenda

WATER QUALITY MONITORING
Expert Workshop Agenda

9:15	Tea & coffee on arrival
9:30	Welcome and workshop outline Ross Allen, Three Seeds Agency & Rob Catchlove, Wave Consulting Context, problem and purpose Bruce Thom, GSHCMP Project Management Committee
9:50	Three perspectives: water quality science and monitoring Graeme Batley, CSIRO; Angus Ferguson, DPE; Colin Beasley, Sydney Water Facilitated group session Other perspectives and insights on water quality monitoring
10:55	Break (~15min)
11:10	Panel discussion: legacy and existing contaminants of concern David Taylor, Baird; Ian Wright, Western Sydney University *Insights and implications*
11:50	Panel discussion: emerging contaminants of concern Stuart Khan, University of NSW; Maurizio Labbate, AusDiagnostics / University of Technology Sydney; Mary Rayner, Stormwater Shepherds *Insights and implications*
12:30	Lunch Break (~40min)
1:10	Opportunities for future agency collaboration in establishing best-practice WQ monitoring William Glamore, SIMS
1:25	Facilitated group session Toward a permanent whole-of-catchment core monitoring program Break (~10min) Group presentations Shaping a compelling proposition
2:50	Next steps and completion Bruce Thom, GSHCMP Project Management Committee
3:00	Close

7.2 Water quality monitoring workshop – participants

- Aaron Wright (DPE)
- Alexa McAuley (Civille)
- Ana Terrazas (SCCG)
- Angus Ferguson (DPE)
- Anissa Lawrence (Tierramar)
- Bruce Thom (SCCG)
- Cheryl Tang (DPIE)
- Colin Beasley (Sydney Water)
- Colin Johnson (DPE)
- Cynthia Chan (SCCG)
- Dale Dominey Howes (University of Sydney)
- David Gough (DPE)
- David Taylor (Baird)
- Erin Sellers (SCCG)
- Georgia O'Hara (Sydney Water)
- Graeme Batley (CSIRO - Aquatic Contaminants Group)
- Ian Wright (Western Sydney University)
- Jud Agius (DPE)
- Katherine Dafforn (Macquarie University)
- Katrina Wall (NSW Health)
- Kishen Lachireddy (NSW Health)
- Leanne Niblock (Sydney Water)
- Lyndall Pickering (Sydney Water)
- Mary Rayner (Stormwater Shepherds)
- Maurizio Labbate (AusDiagnostics)
- Merran Griffith (Sydney Water)
- Michelle Blewitt (AUSMAP)
- Nell Graham (PRCG)
- Nerida Taylor (Sydney Water)
- Pei Tillman (Sydney Water)
- Peter Freewater (DPE - Water Floodplains & Coast)
- Rob Catchlove (Wave Consulting)
- Ross Allen (Three Seeds Agency)
- Sarah Joyce (SCCG)
- Stuart Khan (UNSW)
- William Glamore (UNSW)

7.3 Climate change, sea-level rise and assessing vulnerability workshop - agenda

CLIMATE CHANGE AND SEA LEVEL RISE AND ASESSING VULNERABILTY
Expert Workshop Agenda

9:15	Tea & coffee on arrival
9:30	Welcome and workshop outline Ross Allen (Three Seeds Agency) & Rob Catchlove (Wave Consulting) Paula Masselos (Mayor - Waverley Council) Context, problem and purpose Bruce Thom, GSHCMP Project Management Committee
9:50	• Climate change and the Sydney region — Giovanni Di Virgilio (DPE) – did not present due to IT issues • Water level records for the Harbour: past, present, and future — Phil Watson (DPE) • Rainfall, runoff, and catchment flows — James Ball (UTS)
10:55	Break (~15min)
11:10	• Climate change and estuary processes-an introduction — Will Glamore (SIMS) • Eastern Beaches: Regional Sea Level Rise Hazard Assessment — Geoff Withycombe and Alex Waterhouse (BMT) Questions / clarifications
11:50	• Modelling hydrodynamics of Sydney Harbour (Part 1) — Xiao Hua Wang (UNSW) & Shiv Rao (DPE) • Modelling hydrodynamics of Sydney Harbour (Part 2) — David Taylor (Baird) • Modelling hydrodynamics of Sydney Harbour (Part 3) — Brad Morris (DPE) Questions / clarifications
12:30	Lunch Break (~40min)
1:00	• Assessing risk associated with climate change: the Sydney Water approach — Lyndall Pickering (Sydney Water) Facilitated group session • Small-group discussion - what are the practical methods for assessing risk of inundation under climate change conditions? • Summary — Will Glamore (SIMS) Group presentations • Practical approaches for consistent application of climate change methods
1:50	Next steps and completion Sarah Joyce (GSHCMP Project Manager)
2:00	Close

7.4 Climate change, sea-level rise and assessing vulnerability workshop – participant

- Alex Waterhouse (BMT)
- Ana Terrazas (SCCG)
- Peter Freewater (DPE - Water Floodplains & Coast)
- Cynthia Chan (SCCG)
- Alexa McAuley (Civille)
- Brad Morris (DPE)
- Bronson McPherson (UNSW / MHL)
- Bruce Thom (SCCG)
- Danial Khojasteh (UNSW)
- David Taylor (Baird)
- Daylan Cameron (DPE)
- Debbi Millener (DPE)
- Erin Sellers (SCCG)
- Fiona Coe (DPE)
- Geoff Withycombe (BMT)
- Giovanni Di Virgilio (DPE)
- James Ball (UTS)
- John Hudson (NSW Coastal Council)
- Kate Waddington (UNSW)
- Lyndall Pickering (Sydney Water)
- Martin Fitzhenry (DPE)
- Nell Graham (PRCG)
- Phil Watson (DPE)
- Pramod Janardhannan (Sydney Water)
- Priom Rahman (DPE)
- Rob Catchlove (Wave)
- Ross Allen (Wave)
- Sam McGuiness (Waverley)
- Sarah Joyce (SCCG)
- Shivanesh Rao (DPE)
- Suzanne Dunford (Waverley)
- Xiao Hua Wang (UNSW)
- William Glamore (UNSW / SIMS)

7.5 Catchment initiatives workshop - agenda

CATCHMENT INITIATIVES

Expert Workshop Agenda

9:15	Registration
9:30	Welcome and workshop outline Ross Allen, Three Seeds Agency & Rob Catchlove, Wave Consulting Context and invitation Bruce Thom, GSHCMP Project Management Committee
9:50	Catchment management and WSUD in Sydney: a brief history John Dahlenburg, Victorian EPA (and ex WSUD Sydney) Catchment initiatives and swimming in the Parramatta River: the PCRG journey Nell Graham, Parramatta River Catchment Group
10:40	Break (~10min)
10:50	The effectiveness of catchment initiatives: national and international evidence Prof Tim Fletcher, University of Melbourne - facilitated discussion Catchment initiatives in Blacktown: what we have tried, what we know (and what we do not know) Craig Bush, Blacktown City Council
12:00	Lunch Break (~40min)
12:40	Additional local government perspectives on reducing stormwater pollution - what works? (panel discussion) Jan Orton, Mosaic Insights (ex. Marrickville Council), Sophia Findlay, Ku-ring-gai Council, Peter Coad, Hornsby Shire Council
1:25	Toward more effective and consistent catchment planning and management for Greater Sydney Harbour - facilitated group work - insights and reflections
2:15	Next steps and completion Bruce Thom, GSHCMP Project Management Committee
2:30	Close

7.6 Catchment initiatives workshop - participants

- Adrian Smit (City of Sydney)
- Alexa McAuley (Civille)
- Ana Terrazas (SCCG)
- Andrew Thomas (Stormwater NSW)
- Bruce Thom (SCCG)
- Camila Drieberg (Blacktown City Council)
- Craig Bush (Blacktown City Council)
- Cynthia Chan (SCCG)
- Daylan Cameron (DPE - Water Floodplains & Coast)
- Erin Sellers (SCCG)
- Jan Orton (Mosaic Insights)
- Jocelyn Dela-Cruz (DPE)
- John Dahlenburg (Victorian EPA)
- Lyndall Pickering (Sydney Water)
- Mary Rayner (Stormwater Shepherds)
- Micaela Hopkins (Woollahra Council)
- Murray Powell (Optimal Stormwater)
- Nell Graham (PRCG)
- Peter Coad (Hornsby Shire Council)
- Peter Freewater (DPE - Water Floodplains & Coast)
- Rob Catchlove (Wave)
- Rod Kerr (Sydney Water)
- Ross Allen (Wave)
- Sarah Joyce (SCCG)
- Sophia Findlay (Ku-ring-gai Council)
- Tim Fletcher (Melbourne University)

8 Appendix B. Selected presentation slides

8.1 Water quality workshop presentations

Extracts from workshop presentations are included below to provide a snapshot of some of the information shared. They do not cover all topics presented. Presenters and panellists included:

- Graeme Batley, CSIRO
- Angus Ferguson, DPE
- Colin Beasley, Sydney Water
- Prof Stuart Khan, UNSW
- Dr Ian Wright, Western Sydney University
- David Taylor, Baird
- Maurizio Labbate, AusDiagonstics / University of Technology Sydney
- Mary Rayner, Stormwater Shepherds

8.1.1 Improving Contaminant Management

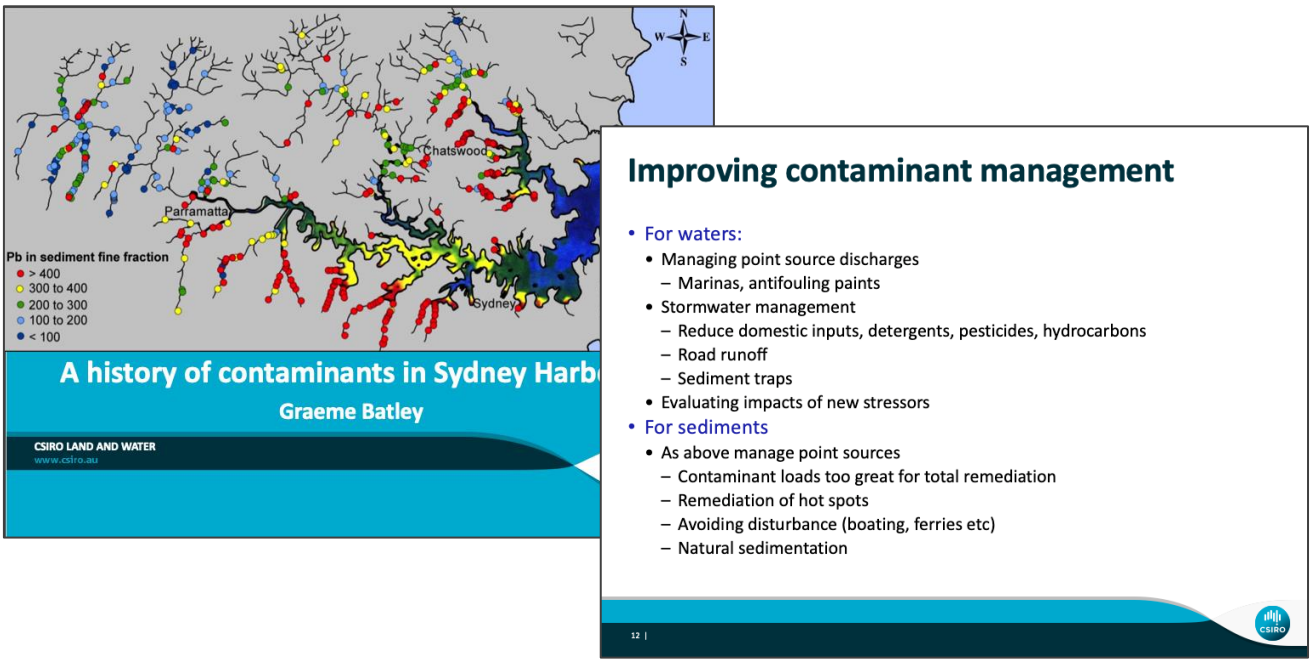


Figure 10. A history of contaminants in Sydney Harbour (Graeme Batley, CSIRO)

8.1.2 WestInvest Proposal – Waterway Health Sentinel Program

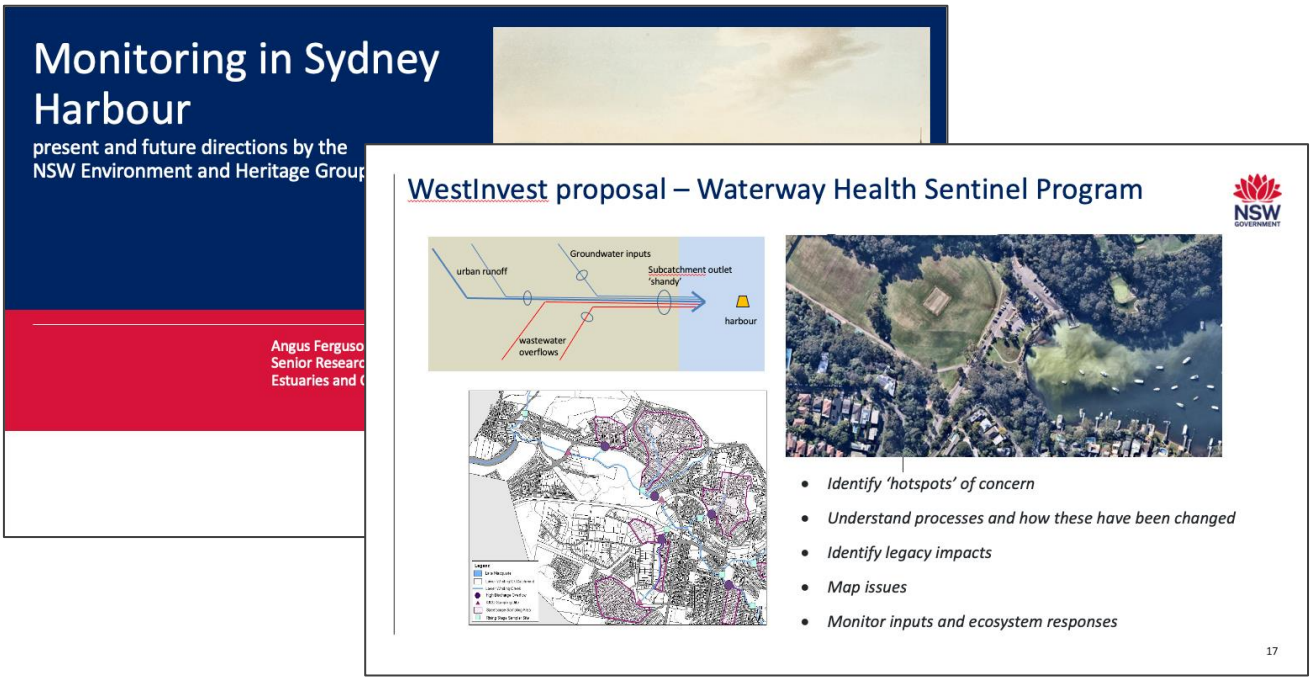


Figure 11. Monitoring in Sydney Harbour (Angus Ferguson, DPE)

8.1.3 Wet Weather Overflow Monitoring (WWOM) Program, Sydney Water

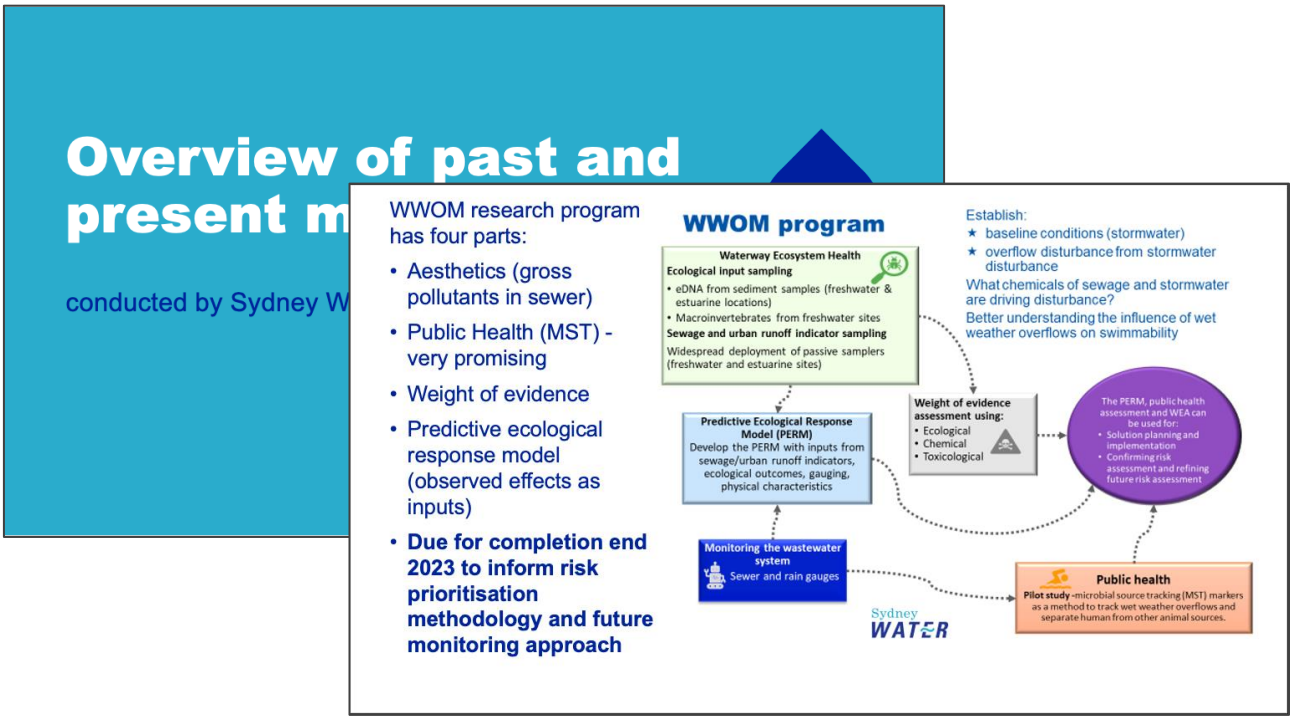


Figure 12. Overview of past and present monitoring (Colin Beasley, Sydney Water)

8.2 Climate change workshop #1 presentations

Extracts from workshop presentations are included below to provide a snapshot of some of the information shared. They do not cover all topics presented. Presenters and panellists included:

- Graeme Batley, CSIRO
- Paula Masselos (Mayor - Waverley Council)
- Bruce Thom, GSHCMP Project Management Committee

- Phil Watson (DPE)
- James Ball (UTS)
- Will Glamore (SIMS)
- Geoff Withycombe and Alex Waterhouse (BMT)
- Xiao Hua Wang (UNSW) & Shiv Rao (DPE)
- David Taylor (Baird)
- Brad Morris (DPE)
- Lyndall Pickering (Sydney Water)

Tidal Inundation Vulnerability, Sydney Harbour

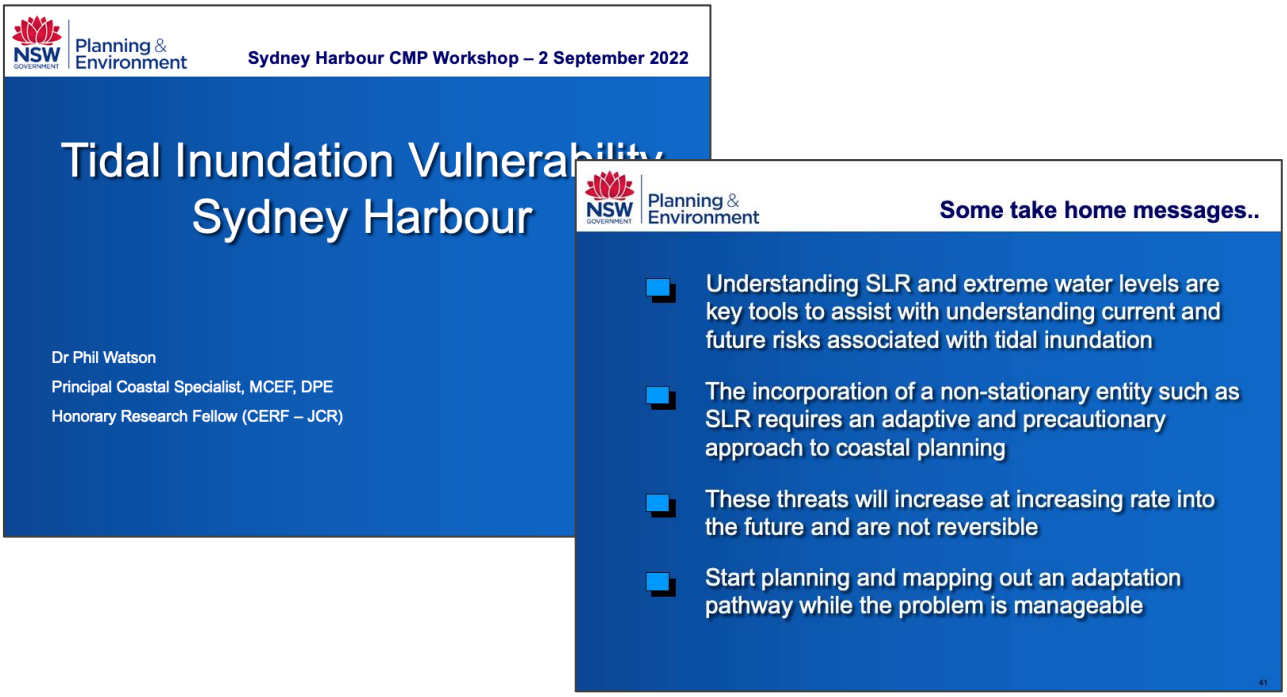


Figure 13. Tidal Inundation Vulnerability, Sydney Harbour (Phil Watson, DPE)

Catchment Runoff and Estuarine Receiving Waters

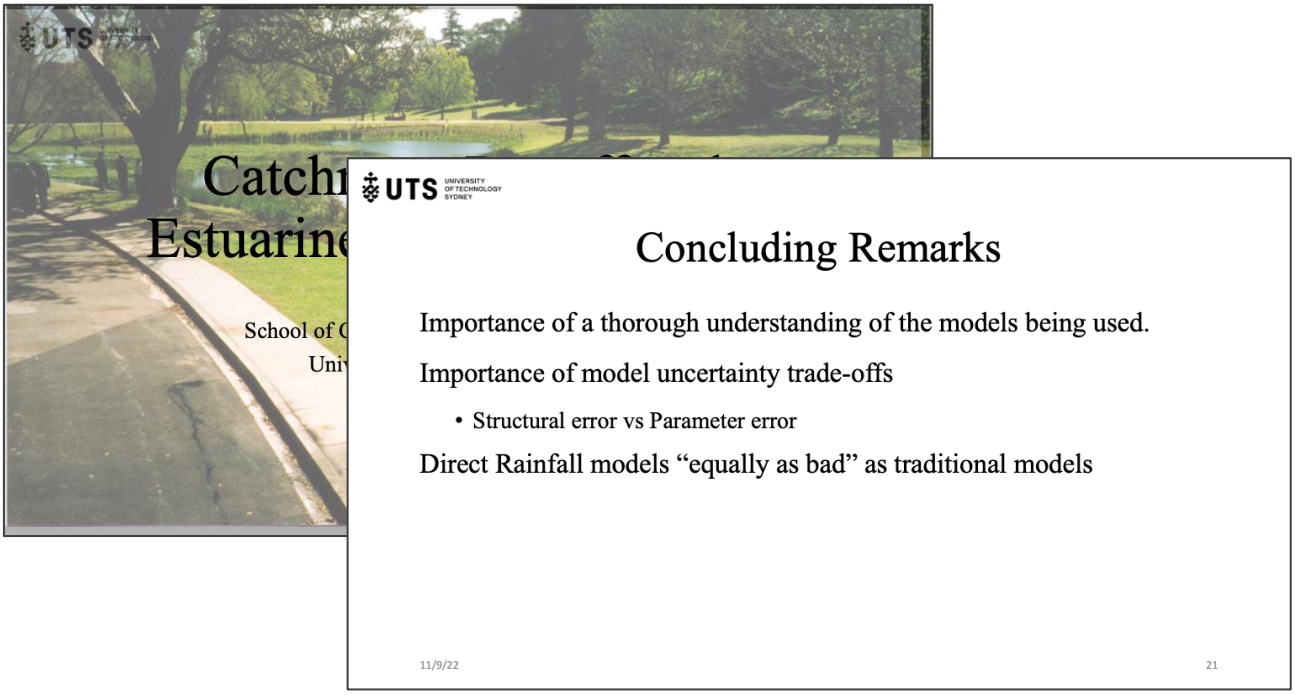


Figure 14. Catchment Runoff and Estuarine Receiving Waters (James Ball, UTS)

8.2.1 The Future of our Estuaries

Figure 15. The Future of Our Estuaries (Will Glamore, UNSW)

8.2.2 Hydrodynamics, Climate Change and Modelling

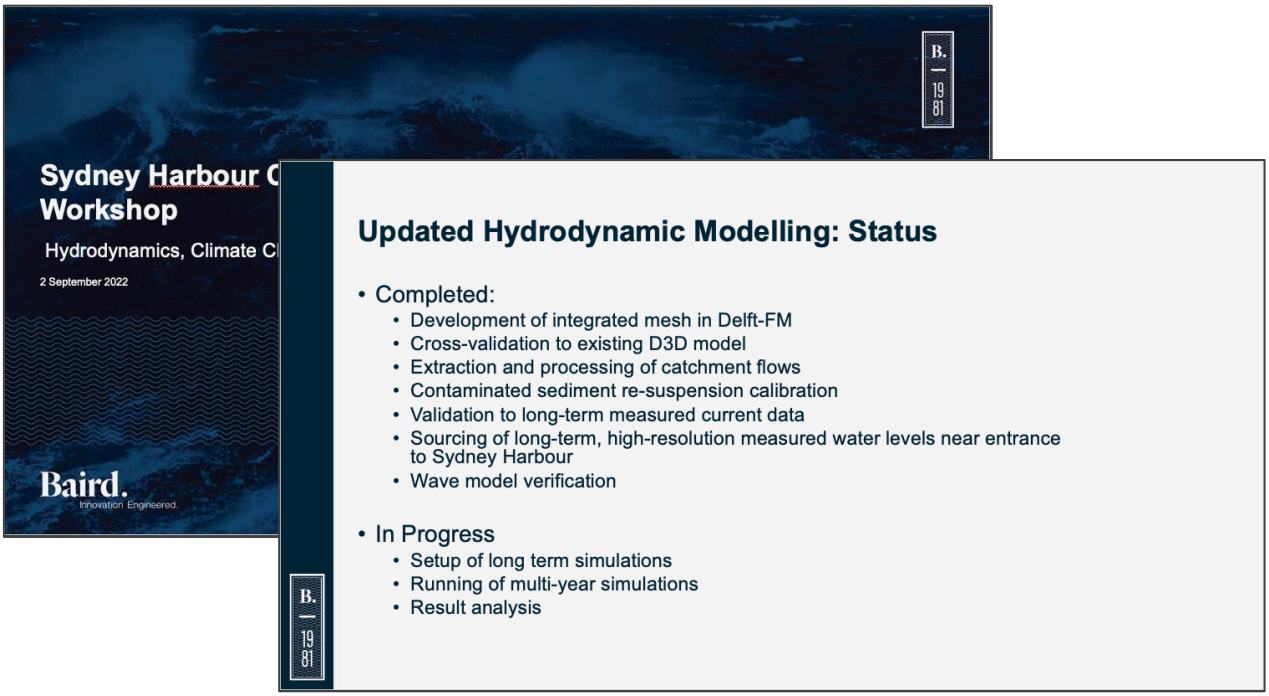


Figure 16. Hydrodynamics, Climate Change and Modelling (David Taylor, Baird)

8.2.3 Exposure to Sea Level Rise in New South Wales Estuaries

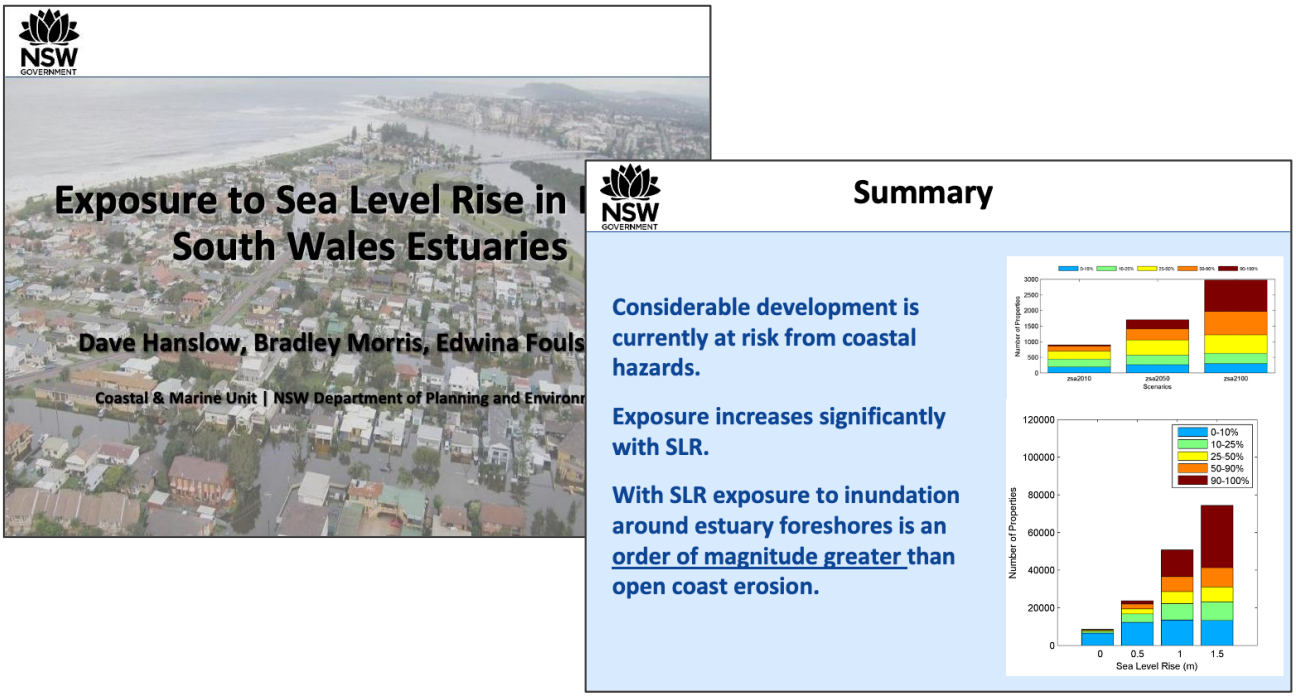


Figure 17. Exposure to Sea Level Rise in New South Wales Estuaries (Bradley Morris, DPE)

8.2.4 Sydney Water's Climate Change Adaptation Position and its Application

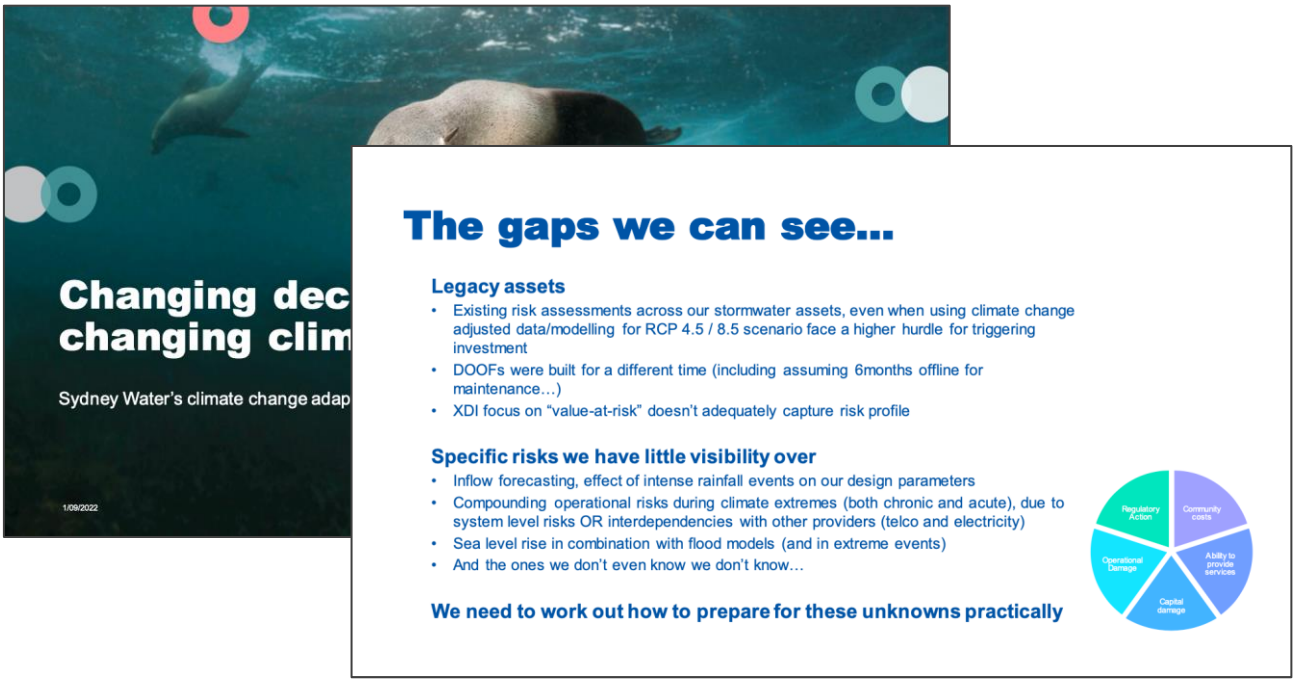


Figure 18. Sydney Water's Climate Change Adaptation Position and its Application (Lyndall Pickering, Sydney Water)

8.3 Climate change workshop #2 presentations

Extracts from workshop presentations are included below to provide a snapshot of some of the information shared. They do not cover all topics presented. Presenters and panellists included:

- Bruce Thom, Chair, GSHCMP Project Management Committee
- Alexa McAuley, Civille
- Rob Catchlove, Wave Consulting
- Giovanni Di Virgilio, DPE

- Bruce Thom on behalf of Phil Watson, DPE
- Fiona Coe, DPE

8.3.1 Council consultation and views on climate change and sea level rise

Figure 19. Council consultation and views on climate change and sea level rise (Alexa McAuley, Civille)

8.3.2 Climate change science and NARCLIM modelling

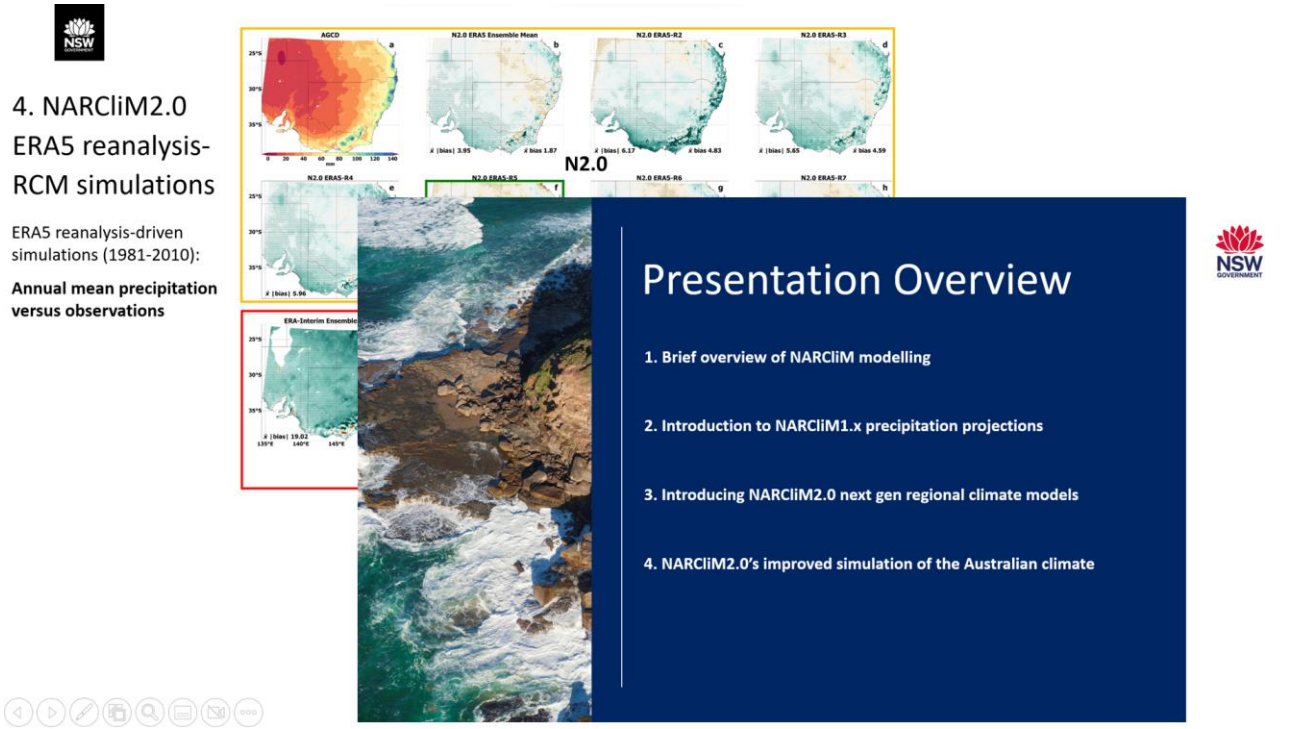


Figure 20. Climate change science and NARCLIM modelling (Giovanni Di Virgilio, DPE)

8.3.3 Flood warnings and risks

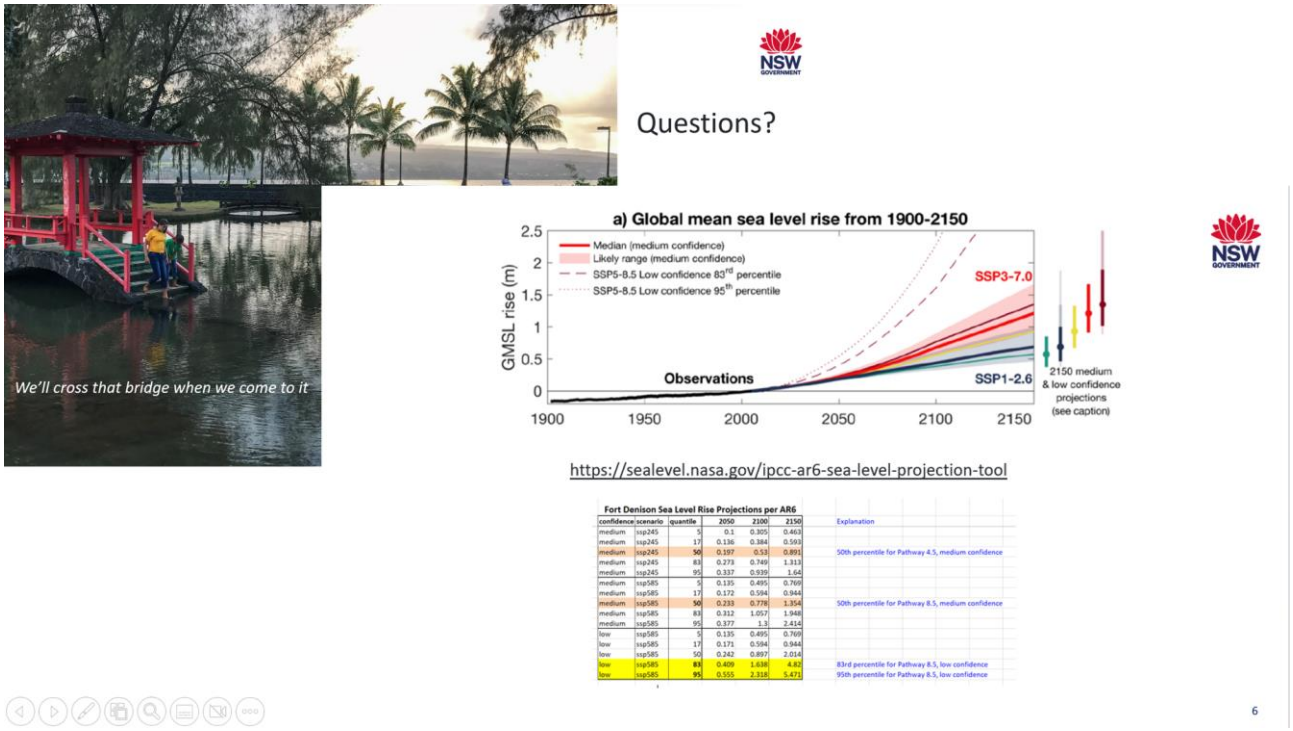


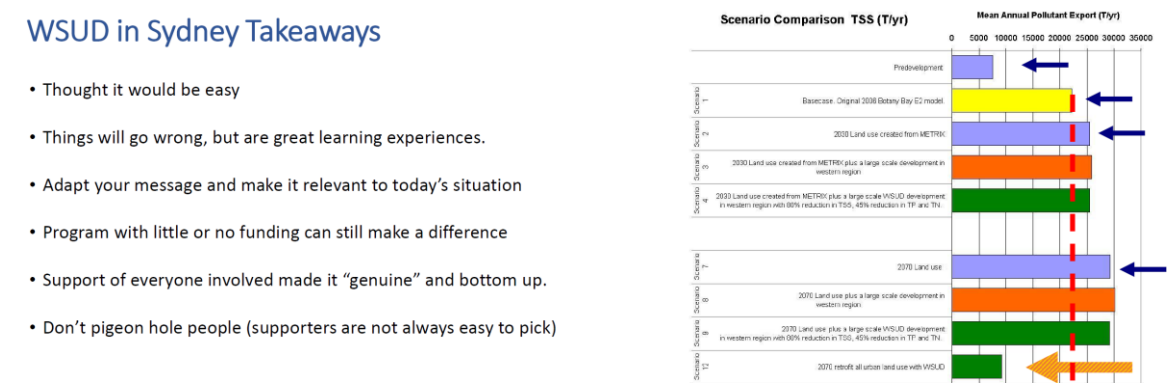
Figure 21. Flood warnings and risks (Fiona Coe, DPE)

8.4 Catchment initiatives workshop presentations

Extracts from workshop presentations are included below to provide a snapshot of some of the information shared. They do not cover all topics presented. Presenters and panellists included:

- Bruce Thom, GSHCMP Project Management Committee
- John Dahlenburg, Victorian EPA (and ex WSUD Sydney)
- Nell Graham, Parramatta River Catchment Group
- Prof Tim Fletcher, University of Melbourne
- Camila Drieberg and Craig Bush, Blacktown City Council
- Jan Orton, Mosaic Insights (ex. Marrickville Council)
- Sophia Findlay, Ku-ring-gai Council
- Peter Coad, Hornsby Shire Council

8.4.1 Catchment Management & WSUD in Sydney: a brief history



Water Quality Improvement Grants

- **14 Projects funded in total**
  - Combined value of projects about $4 Million,
  - 240 hectares of Catchment treated,
  - 9 different councils and one Trust,
  - Experiential learning/capacity building component of all projects.

Takeaways

- Go for more than you expect.
- If you can try and get some on gound tangible outcomes (not just reports and research). Better still combine the research into on ground outcomes.
- If giving grants, build in a capacity building component even if it's sold as risk mitigation.
- Still some potential for WSUD to be incorporated into developed urban areas by using flood infrastructure.
- Not making publicly funded research, data or reports available should be a criminal offence.

8.4.2 Parramatta River Catchment Group

PRCG history and current members

- History
  - In 1989 Upper Parramatta River Catchment Trust (UPRCT) formed
  - 2005 stormwater management charge introduced
  - UPRCT and the CMA dissolved
  - 2008 PRCG formed to protect/restore Parramatta F
  - 2015 Lake Parramatta re-opened for swimming
  - 2018 launch of the PRCG masterplan
- There are currently 10 council members, 3 state governi several community groups and universities

Financial members

Non-fina

What we did differently

1. Community Engagement

- Swimming identified as the community value
- Involved and asked the community at each phase of planning
- Prioritised water quality monitoring for recreational health

2. Collaboration

- Followed the Risk-Based Framework
- Involved stakeholders in decision making – utilising a senior executive Reference Group

3. Governance

- Identified the need for a state agency to take the lead – Sydney Water
- Identified key roles & responsibilities

8.4.3 Blacktown City Council

What we have tried?

- Numerous scales for all different scenarios
  - Small
    - isolated GPT's (Little Creek etc.)
    - Carpark bioretention systems
  - Medium
    - Stormwater harvesting schemes (Angus Creek)
    - Creek restoration projects (Pearce/Troubadour Reserve on Lalor Creek)
    - Combined assets or systems (GPT into bioretention)
      - Parts of Bungarribee – small GPT with central island bioretention system
  - Large scale
    - Blacktown Showground
    - End of pipe systems (growth centres)
      - The Ponds - Multiple GPT's and large bioretenti

Blacktown City Council

What we know? Imperviousness matters

- Once a catchment has an imperviousness of greater than 5% the onset of irreversible degradation occurs. A return to natural, pre-development conditions is mostly impossible without significant funding and long-term timeframes (i.e. greater than 20 years).
- The Urban Watershed Restoration Manual (Centre for Watershed Protection 2004) to classify catchments based on their imperviousness as either:

	Total Impervious Surface		
Creek Management Action	10 -25%	25-40%	40-60%
Prevent and manage litter	Achievable	Achievable	May be achievable
Improve riparian vegetation condition	Achievable	Achievable	May be achievable
	Achievable	Achievable	May be achievable
	Achievable	May be achievable	May be achievable
	Achievable	Achievable	May be achievable
	May be achievable	May be achievable	Not achievable

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What we don't know?

1) Is there an offset scheme that actually works?
   - Offset schemes are hard to get correct and to show real value for money
   - Normally projects take years to build = lost time = lost performance
   - Private WSUD can be managed appropriately if you invest the time and money into the establishment and ongoing operation of a compliance program

2) the true performance of in-situ interventions
   - We are relying a lot on lab results or small scale systems
   - Need improved catchment or runoff water quality (MUSIC inputs) > potential less pollution from new cars and other impacts
   - Better understand on the impacts on lack of maintenance on asset performance and asset lifespan = better cost/benefit of increased maintenance budgets

3) How management actions that occur now impact waterway health in the long term
   - Ensure the management options we use now are future proof as much as possible (e.g. climate change)

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