Demonstrating Climate Change Adaptation of Interconnected Water Infrastructure.

2012

Synthesis Report
Part 2 - User Guide

SYDNEY COASTAL COUNCILS GROUP

NSW GOVERNMENT Office of Environment & Heritage

Sydney WATER

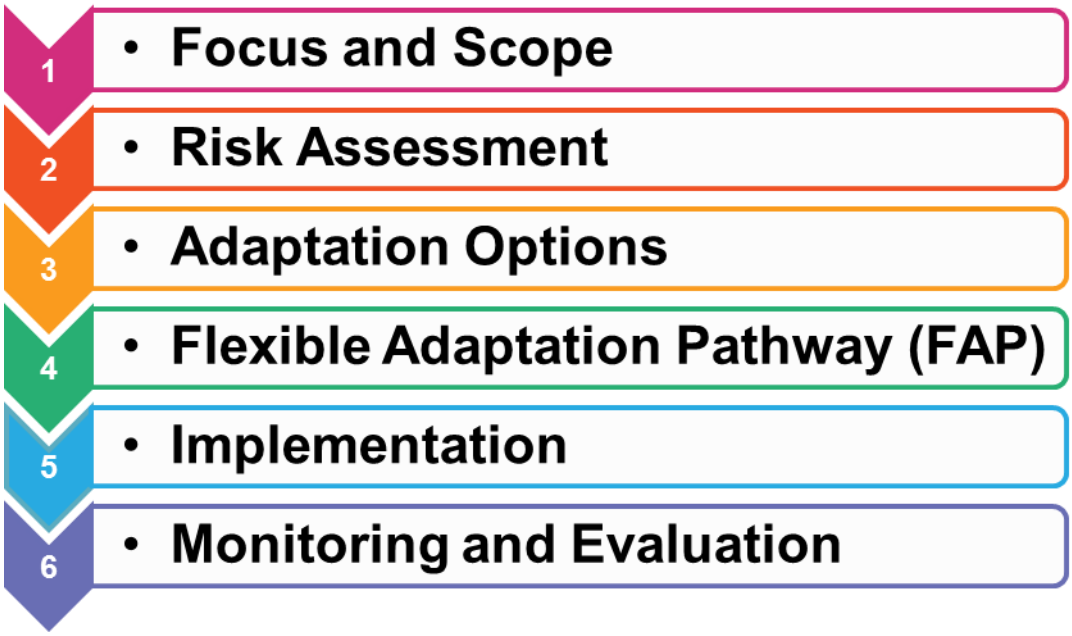
Coastal Adaptation Decision Pathways Project **(CAP)**

Contents

Introduction

This part of the Synthesis Report is a User Guide for climate change adaptation of interconnected water infrastructure. The User Guide has been developed based on the learnings of the case studies completed in this study in Part 4. The User Guide supports an interactive PDF (iPDF) which can be found in Part 3.

Each of the sections in this report guide the project team through a six stage framework.



The User Guide provides straight forward practical advice to aid decision making related to climate change adaptation of interconnected water infrastructure. The framework is intended to apply to 'a project' which may relate to a part of or the entire climate change adaptation problem facing decision makers. The framework can help the project team break the complex climate change problem into parts and progress through each of the stages, even where there is incomplete data and information. A key aspect of this six step framework is its iterative nature allowing the project team to return to previous stages and broaden or refine the project depending on information available. The ultimate aim of the framework is for decision makers to have an understanding of the whole of the problem, the range of adaptation options available, key decision making points and the way new information or increased certainty over time may influence these decisions.

Who should use this framework?

The User Guide is applicable across a broad range of situations:

- Where decision makers have no existing strategies and limited or no understanding of the implications of climate change on their assets, environment or community.
- Where decision makers have already undertaken significant work, have an in depth understanding of climate change problems and may have already implemented adaptation options. For these decision makers, the guide will build

upon the work already done, encourage decision makers to revisit the problem to potentially broaden the scope of their focus and identify gaps in their knowledge.

The guide will also encourage decision makers to establish monitoring and evaluation regimes to fill gaps and ensure that any adaptation options implemented are effective and efficient.

This framework can be applied by infrastructure managers, asset owners and council officers when considering climate change adaptation. Ideally the framework will be applied by a project team comprising the following stakeholders:

- Engineering officers and asset managers responsible for maintenance programs and upgrades.
- Land use planners who are responsible for ensuring land use planning is supported by appropriate infrastructure provisions.
- General managers and finance managers who are responsible for investment decisions in relation to infrastructure assets.
- Environmental or sustainability officers who are responsible for commissioning or overseeing technical assessments of climate change vulnerability, impacts and associated adaptation options.
- External stakeholders including managers of interconnected infrastructure.

How to use this framework?

This User Guide provides an overview of the six stages, with step by step guidance including:

- The inputs including information, data and resources required before starting.
- The relevant tools and approaches and when they should be applied.
- Who should be involved and when.
- The outputs that should be produced at each stage.
- A checklist to make sure that the project is ready to proceed to the next stage.
- Tips and ‘watch-its’ represented by the following icons.

This icon represents a key finding from the case studies undertaken as part of this study. Use these learnings to inform and guide the project.

This icon represents a ‘watch-it’ or warning which was identified during the case study. Use these lessons learnt to help avoid making common mistakes during the process.

This icon represents a point in the framework where the project team may need to review or return to previous stages based on new information which is now available.

This icon represents a link to information in the iPDF. Look at this section in the iPDF for more detailed guidance, examples or a template to use to assist this step of the framework.

This icon signifies that monitoring and evaluation is required. This icon appears across all stages and then all monitoring and evaluation requirements are combined in Stage 6.

Adaptation Resource Centre

This User Guide complements the Adaptation Resource Centre, an interactive PDF (iPDF), an easy to use support feature that contains templates, checklists and guidance to assist in applying the framework. The iPDF can be found in Part 3 of this document.

Refer to Table 1 for a brief overview of the framework, which also mirrors the Adaptation Resource Centre structure and content.

Table 1 Overview of Adaptation Resource Centre

Stage	Overview	Inputs	Tools	Outputs	Evaluation
1. Focus and Scope	Step 1 – Identify project aims and desired outcomes Step 2 – Develop project plan Step 3 – Identify scope and dependency Step 4 – Invite others to participate Step 5 – Review climate variables and climate events Step 6 – Review climate change projections Step 7 – Define problem Step 8 – Gather data identified	Organisational drivers Potential stakeholders Project team structure Previous climate change studies Potential assets, areas and impacts Ownership and responsibility of assets/services Possible climate change parameter(s) Existing plans, policies, strategies, studies Relevant legislative requirements	Stakeholder Identification Plan Impact Screening Matrix Kick-off Workshop Agenda	Agreed aim and desired outcome for project Project plan Asset register Register of relevant stakeholders Completed impact screening matrix Agreed climate change projections Definition of problem Data and information repository	Checklist
2. Risk Assessment	Step 1 – Review data and information Step 2 – Identify suitable risk assessment approach Step 3 – Identify attitudes to risk and risk thresholds Step 4 – Identify current likelihood of climate events Step 5 – Identify future likelihood of event(s) occurring with climate change Step 6 – Identify method to evaluate consequences Step 7 – Evaluate consequences Step 8 – Evaluate risk Step 9 – Compare risk against risk thresholds	Asset data and information Legal and corporate requirements Social context and community expectations Climate change projections	Climate Change Risk Assessment Techniques Publicly Available Calculators Guidance to Estimate Intangible Health Impacts of Flooding	Understanding of data Agreed risk assessment approach Description of risk thresholds, understanding of how risk attitudes may change over time, and process for monitoring changes Description of current likelihood Description of future likelihood Agreed method to evaluate different consequences Evaluation of consequences for range of events Quantified or qualified overall risk Comparison of risk level with risk thresholds over projection period, and where it is exceeded	Checklist
3. Adaptation Options	Step 1 – Identify potential adaptation options Step 2 – Identify ‘real options’ Step 3 – Check for maladaptation Step 4 – Identify barriers and adaptive capacity building options Step 5 – Refine adaptation options Step 6 – Evaluate effectiveness of options Step 7 – Nominate efficiency evaluation criteria Step 8 – Evaluate efficiency of options Step 9 – Test efficiency and effectiveness under multiple climate change scenarios	Technical knowledge and expertise Community expectations Stakeholder views and capacity Barriers to adaptation Capital costs Operational costs Lost opportunity costs Effectiveness of various options Understanding of risk thresholds	Adaptation Options Real Options Climate Change Risk Assessment Techniques	Broad list of adaptation options Understanding of how options could be staged to improve flexibility Refined list of adaptation options which excludes maladaptation List of barriers, potential strategies to overcome them, and adaptive capacity building adaptation options Detail for options relating to timing, size and extent Level of risk reduction, comparison with risk threshold and bundled options Set of criteria to evaluate efficiency Ranking of each option by efficiency Performance under different climate change scenarios	Checklist
4. Flexible Adaptation Pathway (FAP)	Step 1 – Identify and evaluate ‘no regrets’ options to implement now Step 2 – Review complementarity of other options Step 3 – Identify trigger points for options to implement later Step 4 – Prepare Flexible Adaptation Pathway (FAP) Step 5 – Undertake scenario testing	Opinions of relevant stakeholders Adaptation options and barriers (outputs of Adaptation Options stage) Timing, thresholds and trigger points Pre-work – feasibility studies, planning approval, business case approval, etc. Lead in and run-up time for adaptation options	No regrets options Flexible adaptation example Simplified Flexible Adaptation Pathway example Climate Change Risk Assessment Techniques	List of ‘no regrets’ options and risk reduction potential List of potential adaptation pathways List of options to be implemented at some point in time, trigger points and considerations for decision makers Visual representation of FAP Understanding of how FAP will be implemented, and opportunities to improve FAP	Checklist
5. Implementation	Step 1 – Review Flexible Adaptation Pathway (FAP) Step 2 – Agree governance for works Step 3 – Prepare business case (if required) Step 4 – Identify funding opportunities Step 5 – Implement adaptation option	Outputs from Flexible Adaptation Pathway stage Governance structures Potential funding requirements	Agenda for project governance plan Business case guidelines Community and Stakeholder Engagement Plan template Details of funding mechanisms and models	Stakeholder agreement on implementation task Project governance plan Completed and approved business case Agreement on how funding will be obtained Actual deliverable	Checklist
6. Monitoring and Evaluation	Step 1 – Monitor to define problem Step 2 – Monitor risk attitudes and risk thresholds Step 3 – Monitor climate change projections Step 4 – Monitor social, physical and economic factors Step 5 – Monitor and evaluate adaptation options	Initial objectives and scope Climate change projections Risk attitudes Community expectations Baseline data Stakeholder actions	SCCG Environmental Monitoring Results Based Management (RBM) Logical Framework Matrix	Monitoring and evaluation program to define problem Monitoring and evaluation program for risk threshold over time Monitoring and evaluation program for climate change projections Monitoring and evaluation program for social, physical and economic factors Monitoring and evaluation program for adaptation options	Checklist

Stage 1: Focus and Scope

The aim of Focus and Scope, the first stage in developing a Flexible Adaptation Pathway, is to establish an accurate definition of the problem and the desired outcomes.

This stage need not consider whether data is available or even whether a specific problem exists but should focus more on stakeholder collaboration and reaching agreement on a starting point.

For water infrastructure managers who have already progressed some way in developing an adaptation strategy, this stage requires consideration of how the focus and scope may be expanded. This may include consideration of additional issues of interconnected asset management, ownership, supporting infrastructure or additional climate change parameters.

The case study approach found that this stage in the process can take longer than expected. However, defining a clear scope and engaging the relevant stakeholders early in the assessment process will allow the assessment process to run smoothly and effectively.

Step 1 – Identify project aims and desired outcomes

Identify a core project team that will lead the delivery of the climate change assessment. The project team needs to establish clear guidance on the project delivery and expectations for meeting the project aims before commencing.

Consider who should be on the project team. The project team should include representatives from across the organisation(s) with a range of roles.

It is important in the first instance to look at the reasons behind undertaking this project. The questions the project team should ask include:

- What does the organisation want to achieve from the development and implementation of a Flexible Adaptation Pathway?
- What are the relevant legislative requirements that may require the organisation(s) to address climate change adaptation?
- Has the organisation(s) prepared a climate change adaptation strategy or completed any previous studies that can be built upon? What are the gaps in previous studies?
- Does the organisation currently have any plans, policies, programs, etc. that could affect this project?
- What are the possible risks to the project?

The ***output*** of this step is an agreed aim and desired outcome for the project that responds to any existing strategies, studies or legislative requirements.

Step 2 – Develop project plan

Develop and agree on a project plan that includes the following:

- Identified project steering group.
- Program of activities and tasks.
- Budget.
- Governance structure nominating project roles and responsibilities.
- Deliverables and responsibilities.
- Risk management strategies for risks identified in Step 1.
- Mechanisms for procurement.
- Mechanisms for change management.
- Occupational Health and Safety (OH&S) requirements and responsibilities.

The ***output*** of this step is a project plan which identifies funding, resources and project ownership.

Step 3 – Identify scope and dependency

In this step the project team will clearly define the infrastructure to be included in the scope of this assessment. As part of this process the team should:

- Define the geographical scope of the project.
- List all main assets and systems of concern including:
    - Water infrastructure assets owned, operated or maintained by the team's organisation(s).
    - Properties serviced or protected by the asset.
    - Other infrastructure serviced or protected by the asset.
    - Other infrastructure servicing the asset such as telecommunications, electricity, access roads.
    - Local environmental and community assets.
- Search for information about the assets including location, material, age, costs, condition, function within the system, maintenance requirements, performance indicators.
- Define who is responsible for the assets.
- Investigate if there is a history of climate impacts on the assets.

The ***output*** of this step is an asset register.

Step 4 – Invite others to participate

Once scope and dependency have been defined the project team should begin to identify stakeholders and interested parties.

Use the 'Stakeholder Identification Plan' in the iPDF.

Where appropriate these stakeholders should be kept involved in the planning of the project (workshops, comments, etc.) to foster their engagement.

Now that other stakeholders have been engaged in the project, it may be valuable to review the scope of the project again and capture inputs from stakeholders.

The ***output*** of this step is a register of relevant stakeholders.

Step 5 – Review climate variables and climate events

The next step is to review which climate variables and events the assets are likely to be sensitive to. For example, is the asset sensitive to sea level rise, or increased temperature?

A climate variable refers to the measurable component of climate such as temperature, rainfall or sea level. A climate event refers to a point in time where a certain quantity of the climate variable is reached such as a 1 in 100 year ARI flood event or an extreme heat day.

Organise a workshop with the project team to explore a wide range of potential variables. Use historical events as a starting point, i.e. what has the infrastructure been sensitive to in the past. Also consider climate variables which are not an issue but could result in impacts in the future.

If the problem is complex, try narrowing the scope of the assessment to a single variable to make it more manageable. It is always possible to come back and assess other variables to recognise that there are likely to be a range of potential complex and interrelated issues to be managed.

Use the 'Impact Screening Matrix' in the iPDF to help with the prioritisation.

The ***output*** of this step is an impact screening matrix linking climate variables and climate events with potential consequences (direct and indirect) for assets.

Step 6 – Review climate change projections

As a project team decide which climate change projections, climate change projection periods and event frequencies to use. Key considerations are:

- Will the scope include a number of climate change scenarios or will these be limited to a worst case scenario, or government agreed projections?

Note that the greater the range of projections considered, the more robust the final outcome will be. The number of projections will also be limited by time and budget.

Climate change projection reference sources can be found in the iPDF.

- What time scales are relevant to the assets or planning systems?

To assist in this stage consider the long term planning timeframes of the organisation(s).

Referring back to the aims of the project may help to identify which timescales and climate change projections are important to the project.

Often impacts of the current 1 in 100 year ARI event are well understood as these are used to set local flood zones and coastal hazard zones. However, for climate change adaptation the impacts during ALL events including the less intense but more frequent events (such as the 1 in 20 year ARI events) are important.

Considering just the 1 in 100 year ARI event may be a good way to start the project and to understand the order of magnitude of the potential impact. Smaller more frequent events (such as 1 in 20 year ARI) could be added to the scope later.

The ***output*** of this step is an agreed set of climate change projections.

Step 7 – Define problem

Problem definition is an important step in this first stage. Using the information gathered in Step 1 to Step 5, consider holding a problem definition workshop and inviting the identified stakeholders.

An example ‘Kick-off Workshop Agenda’ can be found in the iPDF.

The aim of this workshop is to:

- Confirm the drivers for the project.
- Identify any additional stakeholders.
- Review the asset register and impact screening matrix and possible ‘problems’ that could be investigated.
- Develop a clear picture of what information is available to the study.

Ask the following questions:

- Is there already a problem?

- What are the biggest risks of not undertaking any adaptation strategies?
- Is there a critical component to the system?
- What problem could be tackled now given the data we already have?
- What gaps were there in previous studies and how can these be filled?

Depending on the scale of the scope, this stage may take two or more workshops to reach a firm resolution. Getting the right people in the room at this stage is fundamental to understanding what climate change variables are likely to impact the asset.

Some problems may be important but excluded at this stage due to lack of data, or lack of resources. If this is the case, consider establishing a monitoring program to collect this data so the problem can be addressed in a future iteration of the framework.

The ***output*** of this step is a definition of the problem and a list of data and information to be gathered.

Step 8 – Gather data identified

Gather the data and information identified in the workshop and review its suitability and completeness. Identify gaps and uncertainties and acknowledge that these need to be addressed.

This step may take some time!

The ***output*** of this step is a data and information repository.

Evaluation

Evaluation and monitoring are key to the success of the project. Before proceeding to the next stage take time to review the outputs from this stage and ask the following questions.

Evaluation	Checkbox
Have aims and objectives been defined?	
Has a project plan been developed (including project management structure, project outline, timeline, budget, communications plan, etc.)?	
Have a clear set of assets and asset properties been developed?	
Have relevant stakeholders been engaged?	
Have project ownership and responsibilities been defined?	
Have funding and resources needed to undertake the project been identified?	
Has the project been defined in terms of the climate change variables and the direct and indirect consequences?	

If the checklist above is not successfully completed, spending more time now defining the project will assist in later stages. Once this checklist has been completed, move to Stage 2 – Risk Assessment.

Stage 2: Risk Assessment

This stage requires the project team to establish the risk represented by climate change to the assets identified. This may be either qualitative risk, quantitative risk or a risk expressed in economic terms.

The objectives of this stage are to develop an understanding of:

- The value of the assets in terms of direct value of water assets to managers, value of the service to users and the broader social, environmental and economic value of the assets.
- The projections of the relevant climate change variables and the associated uncertainty.
- The likelihood of climate change events occurring.
- The consequences of the impacts over time.
- The overall risk to the interconnected water infrastructure system as a result of climate change.

Step 1 – Review data and information

The aim of the data and information review step is to establish the quantitative and qualitative information available to feed into the risk assessment.

Convene the project team and review the data and information collected in Stage 1 with the objective to:

- Agree upon which data and information sets to consider within the project.
- Agree upon site specific climate change projections to be adopted.
- Develop a relationship between the climate variables and the extent of the consequences to the asset system.
- Develop an understanding of the current frequency of the event and current extent of the consequences.

Data to look for includes:

- Spatial mapping of asset location and condition.
- Mapping of the consequences of the event (such as coastal hazard mapping or flood studies).
- Previous reports relating to the existing problems which may quantify the frequency and/or consequences of existing events.
- Monitoring data which may link existing climate events with consequences.
- Reports relating to climate change.

The ***output*** of this step is an understanding of the data and information in terms of its:

- Completeness.
- Relevance.
- Quantitative and/or qualitative nature.

Step 2 – Identify suitable risk assessment approach

Review the available risk assessment approaches questioning:

- Which approaches best suit the desired outcomes?
- Which approaches best suit the data and other information that has been gathered?
- Which approaches best suit the time and resources allocated to the project?

The range of applicable risk assessment approaches are outlined in the 'Climate Change Risk Assessment Techniques' document in the iPDF.

In most situations, the data review will have revealed gaps that could potentially rule out quantitative assessments. Where data is incomplete, consider:

- Using proxy data or estimates that may suffice until more detailed data is collected.
- Qualitative or semi-qualitative approaches.

Identify whether the project team's organisation(s) has its own existing risk matrices.

Qualitative or semi-quantitative risk matrices are commonly used by organisations to address all types of corporate risk. Use of existing matrices allows climate change risks to be compared with other risks.

Consider multi-criteria analysis especially where it is difficult to value the potential consequences in monetary terms.

Where a number of climate change projections are to be considered the use of decision trees, Monte-Carlo analysis or Bayesian techniques may be appropriate. Refer to Part 5 – Background Information for more details on these techniques.

The ***output*** of this step is an agreed risk assessment approach.

Step 3 – Identify attitudes to risk and risk thresholds

Convene the project team or stakeholders to define attitudes to risk. Consider the following:

- What are the current risk types and risk levels that water infrastructure managers and users are exposed to?
- What current risk levels is the infrastructure manager required to provide by law or organisational policy?

- What risk types and risk levels should be avoided at all costs?
- What level of risk would be acceptable if the costs to maintain the risk level were too high?

Express the risk attitude in terms of a risk threshold as quantitatively as possible.

- What consequences are not acceptable at what level of likelihood? For example:
    - 100% of properties in an area must be protected from damages during a 1 in 20 year ARI flooding event.
    - 50% of properties in an area must be protected from damages during a 1 in 100 year ARI flooding event.
    - Failure of individual components of the wastewater infrastructure system is acceptable for a 1 in 5 year ARI storm event, but failure of the entire system is only acceptable for a 1 in 50 year ARI event.

Consider how these attitudes could change over time including:

- How would an actual intense climate event change attitudes?
- What are the influential community values informing this risk attitude and how might they change over time?

What social or environmental values impact attitude to risk? How can they be measured and monitored over time?

Understanding attitudes to risk is an essential activity in alerting stakeholders to existing problems. Often climate related risks are difficult for stakeholders to understand as the event has never been experienced. However, expressing the event in terms of its risk and comparing this to the attitudes to risk of the stakeholders can be a call to action.

The ***outputs*** of this step are:

- A quantitative or qualitative description of risk thresholds depending on the risk assessment approach adopted.
- An understanding of how risk attitudes may change over time should also be achieved.
- A process for monitoring how these changes may affect the risk threshold.

Step 4 – Identify current likelihood of climate events

The scope of this step will depend upon the risk assessment approach adopted.

If a qualitative approach is adopted such as a risk matrix:

- Convene the stakeholders and relevant engineering and climate change specialists.
- Estimate the likelihood of the event occurring based on current and historic climate data.

If a quantitative approach is adopted:

- Identify the current frequency and intensity of climate events (sometimes called a probability density function). If this is unknown, a consultant may be engaged to produce this data.

The ***outputs*** of this step are either:

- A qualitative description of current likelihood.
- A quantitative description of current likelihood (including a probability density function if a range of events are being considered).

Step 5 – Identify future likelihood of event(s) occurring with climate change

The scope of this step will also depend upon the risk assessment approach adopted.

If a qualitative approach is adopted such as a risk matrix:

- Consider convening the stakeholders as well as a wide range of specialists including relevant engineering and climate change specialists. This could be done at the same workshop as Step 4.
- Estimate the likelihood of the event(s) occurring over the assessment period with climate change.
- Consider how different climate change projections may alter the results of the risk assessment.

Change projections are generally provided as ranges instead of likelihood. As a minimum the qualitative assessment should consider the entire range of plausible climate change projections. Climate change projection reference sources are provided in the iPDF.

If a quantitative approach is adopted:

- Identify how the current frequency and intensity of climate events (sometimes called a probability density function) will change with climate change over the projection period.
- Carry out a sensitivity analysis as a simple method to understand how dependent the risk assessment is on climate change projections.

For detailed cost benefit assessment likelihood must be evaluated for each year across the projection period. It is often simpler to estimate likelihood for 5 to 10 year increments and then to interpolate for in between years.

Consider how the likelihood would change under more extreme or less extreme climate change scenarios.

Assigning probability to climate change scenarios can be problematic. There are a number of techniques available to assist stakeholders to consider the impact of a worse than expected or better than expected outcome provided. However, many of the techniques require specialist software and skills. Consider engaging a specialist consultant with both knowledge of climate change and water infrastructure to undertake this task.

An explanation of specialist techniques for risk assessment is provided in the 'Climate Change Risk Assessment Techniques' document in the iPDF.

The ***outputs*** of this step are either:

- A qualitative description of likelihood over the projection period.
- A quantitative description of likelihood (including a probability density function if a range of events are being considered) for each year over the projection period.

Step 6 – Identify method to evaluate consequences

The method for evaluation of consequences depends upon the risk assessment approach to be adopted and the outcomes desired from the project. Consider the following consequences:

- Direct damages to water infrastructure assets.
- Direct damages to infrastructure servicing the water infrastructure asset.
- Costs to users.
- Direct damages to private properties and other infrastructure.
- Direct damages to environmental or community assets and human health.
- Indirect damages such as loss in productivity.

If a simple qualitative approach is adopted:

- Involve stakeholders to estimate the extent of consequences based on their understanding of the assets, the community and the local environment.

If a quantitative economic approach is adopted consider the widest range of consequences which could be quantified.

- For direct damage to water infrastructure assets consider using existing maintenance and replacement rates.

Damage to private property, can also be estimated using publicly available calculators. A link to 'Publicly Available Calculators' is provided in the iPDF.

- For costs to the users of the service consider:

- Conducting surveys to understand the value of the service to the community it supplies in terms of a willingness to pay.
- Operating licence/customer contracts to understand the cost of the service to the community for the service delivery.
- Customer service agreement.

Willingness to pay surveys require the use of a specialist in socio-economics. However, a simpler method may be to adopt the compensation rates that the infrastructure manager is required to pay the user for a loss of service.

Willingness to pay will allow the inclusions of community views in the benefits assessment. However, completing this may add significant time and cost to the assessment.

- For indirect damages to other assets, consult with other infrastructure managers to understand how they value disruptions and damages in terms of:
  - Loss of productivity from reduced access to facilities.
  - Flow on effects to transport and energy infrastructure.
- For indirect social and environmental impacts consider:
  - Conducting surveys to understand the value of the service to the community it supplies in terms of a willingness to pay.
  - Using proxy data to represent environmental and social values such as evidence of how much a community spends on an environment (in terms of maintenance, volunteer hours, etc.) or how much a community spends on their health.
  - Using qualitative assessments and multi-criteria analysis where economic data is not available or not appropriate to assess social and environmental values.

Note that expenditure on health or environmental assets is often an underestimate of what a community or individual would be willing to pay to prevent the consequence occurring at all.

The UK has produced guidance on estimating the intangible human health impacts of flooding. Refer to the iPDF for a link to 'Guidance to Estimate Intangible Health Impacts of Flooding'. Where there are significant health risks identified and cost benefit analysis is to be undertaken a health economist may need to be engaged.

The ***output*** of this step is an agreed method to evaluate the different consequences identified.

Step 7 – Evaluate consequences

Evaluate the consequences of the event(s) under the current climate and for climate change projections across the assessment period.

If a simple qualitative approach is adopted:

- Involve stakeholders to estimate the extent of consequences based on their understanding of the assets, the community and the local environment.

For detailed cost benefit analysis:

- Evaluate the consequences for each given event for different levels of climate change.

This can potentially result in hundreds of different scenarios at which point the assessment can get out of hand. It may be worthwhile revisiting the Focus and Scope stage at this point if resources are not available to cope with this amount of data.

For detailed cost benefit assessment, consequences must be evaluated for the full range of events that occur across the projection period. It is often simpler to estimate damages for a low, medium and high event to establish a relationship between the event intensity and cost of the consequences.

The ***output*** of this step is an evaluation of the consequences for the range of events which occur over the projection period.

Step 8 – Evaluate risk

Combine the likelihood and consequence values determined in Step 5 and Step 7 to establish overall risk.

For qualitative assessments:

- Use a risk matrix which allows likelihood and consequence to be matched to give an overall risk rating.

For quantitative assessments:

- Multiply the likelihood by the consequence for every given year over the assessment period.
- Sum the risks for all years within the assessment period.
- For detailed cost benefit analysis use a discount factor to express the overall risk in present dollar terms.

Comparing the risk in the current year to the risk at the end of the projection period can provide insights on the extent of the problem.

Discounting is a standard method to add and compare costs and benefits that occur at different points in time. However, there is some debate about the appropriate discount factor to adopt in economic analysis of climate change adaptation. Consider using 7% as a first pass which is the rate adopted within standard economic appraisals of infrastructure projects by the NSW Treasury and Infrastructure Australia. Also consider using a lower rate for sensitivity testing especially where there are environmental and social consequences.

The ***output*** of this step is a quantified or qualified overall risk that the event(s) represent over the projection period. Detailed quantitative assessments will also map how this risk changes over time.

Step 9 – Compare risk against risk thresholds

Compare the risk identified in Step 7 to the risk thresholds identified in Step 2, asking:

- Is the overall risk unacceptable?
- Does the current risk exceed the risk thresholds?
- If not, at what point in time does the risk exceed the thresholds?

If the risk does exceed thresholds at some point in time, then progress to the next stage to identify options to reduce this risk.

Otherwise, check whether more extreme projections of climate change within the plausible range would change this outcome.

- How does the trigger point change with different projections of climate change?

The trigger point represents the point in time where the actual risk exceeds the risk threshold.

If there is some chance that risk levels exceed thresholds under more extreme climate change projections, establish a monitoring program to to review climate change projections as they are updated and the potential implications on risk.

The assessment may show that the climate variable selected is not a significant issue for the asset. In this case, return to Stage 1 and select another climate variable for investigation.

The ***outputs*** of this step are:

- A comparison of the risk level with the risk thresholds over the projection period.
- An understanding of the point in time where the risk thresholds are exceeded.

Evaluation

Evaluation and monitoring are key to the success of the project. Before proceeding to the next stage take time to review the outputs from this stage and ask the following questions.

Evaluation	Checkbox
Has a risk assessment approach been agreed?	
Have stakeholder risk attitudes been assessed and risk thresholds agreed?	
Does the project team understand the likelihood of the current event(s)? Has this been quantified or qualified in a form appropriate to the risk assessment approach?	
Does the project team understand how likelihood of event(s) will change over the projection period? Has this been quantified or qualified in a form appropriate to the risk assessment approach?	
Have the range of consequences and an agreed method to evaluate these been identified?	
Have consequences been evaluated for the full range of event(s) over the projection period? Have these been quantified or qualified in a form appropriate to the risk assessment approach?	
Has the overall risk been evaluated over the projection period? Has the risk been quantified or qualified in a form appropriate to the risk assessment approach?	
Has the risk been compared to the risk threshold and trigger points identified?	
Has the risk been considered under more extreme and less extreme scenarios of climate change?	

If the checklist above is not successfully completed, spend some more time gathering all available data to undertake a thorough risk assessment. This process will assist when moving onto Stage 3 – Adaptation Options.

Stage 3: Adaptation Options

This stage requires stakeholders to identify potential adaptation options, the associated potential costs and benefits, and risk reduction potential.

The objectives of this stage are to:

- Develop a list of potential adaptation options.
- Evaluate the effectiveness of each option in terms of risk reduction potential.
- Evaluate and rank the options according to relative efficiency.
- Develop an understanding of the efficiency and effectiveness of options over the range of plausible climate change projections.

Step 1 – Identify potential adaptation options

Convene the project team or consider holding a stakeholder workshop to collectively brainstorm ideas. To the extent possible involve technical, managerial, business and environmental specialists.

Consider a wide range of options and 'types' of options to mitigate the identified risks using the following categories as prompts:

- Avoid – New assets are located to avoid the event (e.g. a new development is not permitted within a coastal hazard zone).
- Defend/Protect – Defend against the event and/or protect against the consequences (e.g. floor levels are raised or assets are reinforced).
- Accommodate – Accept the event and its associated consequences. Insurance may also be a category to accommodate.
- Retreat – Existing assets are relocated to avoid the event.

An example list of potential 'Adaptation Options' is provided in the iPDF as a prompt.

The ***output*** of this step is a broad list of potential adaptation options.

Step 2 – Identify 'real options'

Real options allow assets to be incorporated with flexibility to adapt to future changes, rather than be 'fitted for' the projected change. Real options are able to be ramped up or ramped down in the future depending on the climate changes that occur.

During the same workshop as Step 1 the project team should consider whether any of the options could be broken into stages to allow the size or extent of the option to be adjusted depending on the extent of climate change that actually occurs.

A description and examples of 'Real Options' is presented in the iPDF.

The ***output*** of this step is an understanding of how the options could be staged to improve flexibility.

Step 3 – Check for maladaptation

During the same workshop as Step 1 and Step 2, the project team should review the broad list of options and check whether any have the potential to result in maladaptation.

Consider whether any of the following apply:

- Over engineering or design in excess of acceptable risk thresholds.
- Unnecessary early adaptation to impacts that do not eventuate.
- Options which do not complement or take into account the concurrent adaptation options being developed by other stakeholders.
- Options which reduce the incentive for individual stakeholders (e.g. providing government backed insurance to property owners in flood prone areas).
- Options which result in displacement of vulnerability (e.g. damages/value transferred from one stakeholder to another).
- Options which protect against conservative estimates of climate change and lock out flexibility to adapt to more extreme estimates.

Eliminate or refine options which have the potential to result in maladaptation.

Review the adaptation options being considered by other stakeholders. Are there opportunities to work collaboratively to fairly distribute both costs and benefits? Working together can improve the cost effectiveness of adaptation.

If maladaptation options are identified, review these in the context of real options in Step 2 to determine whether there is a way of staging the options or including greater flexibility.

The ***output*** of this step is a refined list of adaptation options excluding any options which result in maladaptation.

Step 4 – Identify barriers and adaptive capacity building options

For each of the adaptation options, review the potential barriers that may exist to their implementation. This should be undertaken in the same workshop or project team meeting as Step 1 to Step 3.

When working through the five case studies some common barriers and themes emerged. These offered a useful starting point when considering barriers in the context of interconnected water infrastructure. The most common barriers identified throughout the workshops were related to governance and in particular allocation of the shared responsibility for funding and maintaining adaptation options.

The project team should consider the following potential barriers:

- Ownership & Governance.
    - Fragmented infrastructure ownership (jurisdictionally).
    - Inadequate governance.
    - Lack of clarity on roles/responsibilities.
    - Lack of collaboration (siloed working).
    - No clear leaders/champions.
- Legislation & Regulation.
    - Inadequate planning legislation/controls.
    - Lack of clarity and consistency in policy.
    - Long planning approval lead-times.
    - Out of date legislation.
- Funding.
    - High costs of adaptation.
    - Limited available budget.
    - Limited access to funding.
    - Mismatch in cost ownership and broader benefit.
- Communication.
    - Poor communication across authorities.
    - Poor internal communication.
- Community Engagement.
    - Lack of community interest and acceptance.
    - Unrealistic community expectations.
- Knowledge & Capability.
    - Inadequate knowledge sharing.
    - Limited technical depth of knowledge.
    - Limited knowledge of new technology.

- Physical/technical barriers.
    - Limited space.
    - Other assets and external constraints.

This list is a prompt only. Consider additional barriers that may be context specific.

For each of the barriers, the team now need to identify options to overcome these barriers. Determine which of these may be described as adaptive capacity building options.

Finding ways to overcome certain barriers can often constitute an adaptation option in itself, helping to build 'Adaptive Capacity'. For example, in a number of the case studies barriers were identified around the lack of community interest and acceptance of climate change adaptation strategies. Holding community education sessions on climate change is one option to overcoming this barrier and this is considered to be a 'no regrets' option that helps to build adaptive capacity.

Add adaptive capacity building options to the list of adaptation options.

The ***outputs*** of this step are:

- A list of barriers and potential strategies to overcome barriers for each option.
- A list of adaptive capacity building adaptation options.

Step 5 – Refine adaptation options

Refine the options in terms of timing of implementation and size and extent. Consider:

- How big or extensive does the option need to be to reduce the risk level to the acceptable risk threshold?
- Can two or more options be combined to provide a greater level of risk reduction (bundled option) and flexibility?
- Can the option(s) be timed to be implemented at the end of the life of existing assets or during programmed maintenance or upgrades?
- Can the option(s) be staged as per Step 2?

Consider adding different combinations of the same option in terms of timing, size and extent to the list.

There may be many potential permutations of the same option. Detailed analysis of each option may be time and cost prohibitive. Remember that at this stage the objective is to prioritise rather than undertake detailed design and reduce the number of options accordingly. The detail needs to reflect the level of detail required by the risk assessment approach.

The ***output*** of this step is additional detail for each option relating to timing, size and extent to assist in further analysis.

Step 6 – Evaluate effectiveness of options

Effectiveness of each option is measured in terms of the extent of risk reduction able to be achieved.

Evaluate each of the options in terms of their ability to reduce risk in line with the risk assessment approach adopted in Stage 2.

- Determine how each adaptation option reduces the likelihood of the event over the projection period.
- Determine how each adaptation option reduces the consequences of the event over the projection period.
- Determine how each adaptation option reduces the overall risk level over the projection period.

If a qualitative risk assessment approach is adopted, involve stakeholders and relevant specialists to form a professional judgement of the level of risk reduction and residual risk.

If a detailed quantitative risk assessment approach is adopted, consider engaging engineering specialists to undertake the analysis.

Compare the level of residual risk with the risk thresholds identified in Stage 2.

- Does the option adequately reduce the level of risk?
- Which options could be combined (bundled options) to reduce the level of risk to an acceptable level?

The ***outputs*** of this step are:

- An estimate of the level of risk reduction achieved by each option.
- A comparison of the level of risk reduction with risk thresholds.
- Bundled options.

Step 7 – Nominate efficiency evaluation criteria

Efficiency is measured in terms of how quickly, cheaply or easily options can achieve risk reduction avoiding environmental or social consequences.

The efficiency criteria will ultimately become part of the monitoring program. Key metrics should be identified which will be measured into the future.

Identify which criteria the efficiency of the option is to be evaluated against considering:

- Is economic performance the only criteria?
- What economic parameters are important? (e.g. net present value, benefit cost ratio, internal rate of return, payback period).

It is helpful for later stages to include a review now of the economic or financial criteria that are used by those allocating funding. This may be internal financial managers or external funding providers including the Independent Pricing and Regulatory Tribunal (IPART).

- Are other criteria important in terms of discerning between options? If so, consider using multi-criteria analysis and identifying relevant metrics for additional criteria.

An example of a possible multi-criteria analysis framework is provided in the 'Climate Change Risk Assessment Techniques' document in the iPDF.

Environmental and social criteria are likely to be very important to stakeholders. If environmental and social consequences have been adequately valued in monetary terms, they will form part of the economic performance and there will be no need to include additional environmental and social criteria. However, it is far more likely that these consequences have not been monetised and therefore may need to be considered separately.

The ***output*** of this step is a set of criteria to evaluate efficiency.

Step 8 – Evaluate efficiency of options

Collate information relating to each adaptation option to evaluate against the criteria nominated in Step 7. For qualitative analysis this may be undertaken by relevant specialists using professional judgement. For detailed economic analysis, develop a detailed discounted cash flow model incorporating the following data:

- Capital cost of the option.
- Ongoing maintenance cost of the option.
- Year of implementation of the option.
- Economic benefits of reduction in consequences and likelihood as identified in Step 6.
- Any additional indirect costs that arise as a result of option (such as lost opportunity costs)

This is known as a cost benefit analysis.

A lost opportunity cost is the value that would have otherwise been derived if the option was not implemented. This may include rental income or council rates that may have otherwise been received for property if a retreat option was not implemented.

More information on approaches that can be adopted to evaluate different adaptation options is provided in the 'Climate Change Risk Assessment Techniques' document in the iPDF.

Compare the efficiency of each option against the criteria and rank options accordingly.

Consider revisiting the size and/or year of implementation of the option to optimise efficiency.

The ***outputs*** of this step are:

- An evaluation of the efficiency of each option.
- A ranking of options for overall efficiency.

Step 9 – Test efficiency and effectiveness under multiple climate change scenarios

Compare the relative efficiency of options under a range of plausible projections of climate change, asking:

- Which options are efficient and effective for the entire range of plausible climate change projections?
- Which options are efficient and effective for only the more extreme ranges of climate change?
- Which options are efficient and effective for only the less extreme ranges of climate change?

The ***output*** of this step is an understanding of the relative performance of options under different climate change scenarios.

Evaluation

Evaluation and monitoring are key to the success of the project. Before proceeding to the next stage take time to review the outputs from this stage and ask the following questions.

Evaluation	Checkbox
Has a range of adaptation options been considered?	
Have 'real options' been considered?	
Has the potential for maladaptation been considered?	
Have potential barriers to adaptation been identified?	
Have ways to overcome barriers been identified? Have these been considered as adaptive capacity building options?	
Have options been described in adequate detail including size, extent and timing in line with the risk assessment approach?	
Has the effectiveness of each option been evaluated and compared against risk thresholds?	
Have criteria to measure efficiency been defined?	
Has each option been evaluated against the efficiency criteria and ranked accordingly?	
Has the efficiency of each option been tested under a range of plausible climate change scenarios?	

If the checklist above is not successfully completed, spend some more time investigating alternative feasible adaptation options and any barriers to these prior to moving to Stage 4 – Flexible Adaptation Pathway (FAP).

Stage 4: Flexible Adaptation Pathway (FAP)

This stage requires the project team to consider the relative merits of the adaptation options and to develop a pathway of actions and trigger points.

The objectives of this stage are to develop:

- An understanding of which options are complementary and which options are non-complementary.
- Recommendations for adaptation options to be implemented now.
- Recommendations for adaptation options to be implemented at some point in the future.
- Recommendations for adaptation options to be implemented only if certain climate changes occur.
- A series of trigger points where any one option is to be implemented to avoid risks exceeding risk thresholds.

Step 1 – Identify and evaluate 'no regrets' options to implement now

For each of these options identify:

- Which are effective and efficient under all plausible projections of climate change.

Options which achieve positive outcomes under all plausible projections of climate change are known as 'no regrets' options.

Determine the risk reduction potential achieved over the projection period by the 'no regrets' options.

Compare the risk reduction potential to risk threshold:

- Do the 'no regrets' options ensure that risk remains below the thresholds for the entire projection period?
- If not, have the options delayed the trigger point?

The trigger point represents the point in time where the actual risk exceeds the risk threshold. Implementation of the selected option must take place at the trigger point in order to avoid this exceedance. A decision must occur before the trigger point to ensure that there is enough time and space to plan and implement an option prior to the risk threshold being exceeded.

A description and examples of 'No regrets options' is presented in the iPDF.

The ***outputs*** of this step are:

- A list of 'no regrets' options to be implemented as soon as possible.
- An understanding of the risk reduction potential of the 'no regrets' options with respect to risk thresholds.

Step 2 – Review complementarity of other options

For each of these options determine:

- Which options are complementary and would not represent maladaptation if implemented together?
- Which options are non-complementary and would result in maladaptation if implemented together?

Non-complementary options will generally be options that are only appropriate under differing scales of climate change. Either one or the other and not both the options would ultimately be implemented depending on what climate change occurs. However, options that are appropriate for the same scale of climate change may also be non-complementary if they perform the same or conflicting purposes.

Bundle together a number of possible combinations of complementary options which represent potential pathways, and:

- Assess overall efficiency and effectiveness and review/modify as required for integration with other options.
- Review timing and responsibilities.
- Identify trigger points.

The ***output*** of this step is a list of potential adaptation pathways.

Step 3 – Identify trigger points for options to implement later

Within each of the pathways developed in Step 2, identify:

- Options which are effective and efficient under all plausible projections of climate change.
- Options which are effective and efficient under only the lower range of all plausible projections of climate change.
- Options which are effective and efficient under the higher range of all plausible projections of climate change.
- Options which are medium or long term options.

Review the risk assessment and identify the points at which the risk threshold is exceeded for the range of plausible climate change projections (the trigger points). For the range of plausible climate change projections, identify the earliest possible trigger point which should be expressed as a date or year. Work backwards from this date to include time for feasibility studies, funding applications, approvals to determine when a decision is to be made.

When the trigger point approaches, decision makers will then need to re-evaluate the option and decide whether to implement, delay or eliminate the option.

The ***outputs*** of this step are:

- A list of options to be potentially implemented at some point in time.
- A series of trigger points.
- Considerations for decision makers when the trigger point approaches.

Step 4 – Prepare Flexible Adaptation Pathway (FAP)

Combine the options and decisions points to map out a FAP. The FAP should combine all preceding analysis to:

- Describe the range of potential adaptation pathways.
- Identify the risk reduction potential of each pathway over time.
- Nominate where decisions occur and where pathways diverge.
- Identify a series of questions which decision makers will need to ask as trigger points approach, including:
    - Has the climate change projection been realised?
    - Is now the optimum time to implement the option?
    - If the option is implemented now, does this eliminate a future option that could be potentially more effective?

The trigger point will initially be based on current information, but there is the potential for the decision to be brought forward or delayed where new projections of climate change are released that either increase or reduce the range of plausible change. The monitoring program should ensure that any new projections are incorporated within the FAP.

Refer to the 'Flexible adaptation for the Thames Barrier' and 'Simplified Flexible Adaptation Pathway' in the iPDF for examples of what an FAP might look like.

The ***output*** of this step is a visual representation of a Flexible Adaptation Pathway.

Step 5 – Undertake scenario testing

Convene the project team and stakeholders and undertake scenario testing of the FAP under different scenarios of climate change.

Develop several scenarios of climate change projections for relevant climate variables and events. Scenarios should represent both conservative and more extreme scenarios within the range of plausible climate change projections.

Run each scenario by discussing the most appropriate decision at each trigger point and the outcomes of the decision.

Consider the following:

- How does each scenario affect the timing of the trigger points?
- How do the different scenarios affect the decisions that are made?
- Is the risk level reduced to below the risk thresholds for all scenarios?

Review the outcomes of the scenario testing and identify opportunities to improve the FAP.

More information on techniques which can assist in developing the Flexible Adaptation Pathway are provided in the 'Climate Change Risk Assessment Techniques' document in the iPDF.

The ***outputs*** of this step are:

- An understanding of how the Flexible Adaptation Pathway will be implemented over time.
- Opportunities to improve the Flexible Adaptation Pathway.

Evaluation

Evaluation and monitoring are key to the success of the project. Before proceeding to the next stage take time to review the outputs from this stage and ask the following questions.

Evaluation	Checkbox
Have 'no regrets' options been identified?	
Has the potential of 'no regrets' options to reduce risk levels been evaluated?	
Have other options been categorised in terms of their effectiveness and efficiency under a reduced range of climate change projections?	
Have other options been categorised in terms of whether they are complementary or non-complementary?	
Have trigger points for each option been identified?	
Has a Flexible Adaptation Pathway been developed and represented visually?	
Has scenario testing been undertaken?	

If the checklist above is not successfully completed, review Stage 3 – Adaptation Options in order to help produce an alternative FAP, as otherwise it is not possible to progress to the next part of the framework. Once this checklist has been completed, move to Stage 5 – Implementation.

Stage 5: Implementation

This stage is where stakeholders will implement actions from the Flexible Adaptation Pathway. The actions may include policy changes, studies to provide more information or design and construction of engineering solutions. Where the adaptation pathway includes the construction or replacement of infrastructure, this stage will also identify the business model for the construction, ownership and operation/maintenance for the assets involved.

The objectives of this stage are to develop:

- An agreement on the adaptation pathway including what should be implemented now.
- An agreement on governance for the implementation works.
- A business case for funding of the implementation works.
- Approved funding for the works.
- An implementation program to show durations for tasks and responsibilities.
- The completed project deliverable, this may include a new approved policy document, upgrade to infrastructure or construction of new infrastructure.

Implementing options can be accompanied by significant policy and project management risks. This is particularly the case if the option is technically or managerially complex, has not achieved consensus amongst stakeholder groups, or involves significant financial expenditure. Engaging stakeholders throughout the planning process may help to reduce this risk.

Step 1 – Review Flexible Adaptation Pathway (FAP)

Review the Flexible Adaptation Pathway developed in Stage 4 and recognise that time may have elapsed from the development of the Flexible Adaptation Pathway.

Convene a project team meeting to discuss and confirm the following:

- Agree the Flexible Adaptation Pathway is still relevant.
- Review the Flexible Adaptation Pathway timetable and agree which actions are required to be implemented now.

If significant time has elapsed between Stage 4 and Stage 5 it will be necessary to review climate change projections and to understand the potential implications of any changes on the Flexible Adaptation Pathway.

The ***output*** of this step is stakeholder agreement on the implementation task, e.g. writing of a stakeholder policy document, upgrade to infrastructure or construction of new infrastructure.

Step 2 – Agree governance for the works

Governance is one of the most critical aspects of implementing a Flexible Adaptation Pathway and was identified by the case studies as the most common barrier. If a Flexible Adaptation Pathway is to be implemented successfully it must be supported by an effective governance structure. This step therefore requires the development of a project governance plan. The plan should be developed via workshops with the project delivery team and should:

- Set an agreed vision and set of project objectives.
- Agree on who has overall responsibility for implementation, processes to ensure works are done as planned, and the agreed dispute resolution mechanisms.
- Encourage shared responsibility for action.
- Assign clear accountability for decision making.
- Provide sufficient authority for implementation, particularly across jurisdictional boundaries.
- Allow flexibility in decision making and does not hinder a particular course of action being taken.
- Provide details of key stakeholder groups affected, identifying a contact person for each group and who in the project team is responsible for engagement with them.

During this step it is also necessary to ask:

- Do the existing organisations have the capacity, skills, authority and resources required to implement the project?
- If additional resources, skills or capacity are needed who will provide these?

Refer to the iPDF for an ‘Agenda for Project Governance Plan’.

In some cases the creation of a new governing body may be required, particularly where responsibility for the affected assets spans across jurisdictional boundaries and asset management organisations. In other cases existing bodies and networks which already operate successfully could be used more effectively rather than reinventing the wheel and creating a new body.

Upgrading or building new infrastructure requires engineering design and construction services. The need for external consultants and contractors should be identified in the governance plan as well who in the project team will be contractually and financially responsible for engaging them.

The ***output*** of this step is a project governance plan which outlines:

- Core project implementation team and responsibilities.
- Project stakeholders and details of how they will be engaged during the project.

Step 3 – Prepare business case (if required)

Depending on the nature of the adaptation project to be implemented a business case may be required. The business case requirement is likely to be triggered by the size and risk of the project, the threshold for which will be determined by the infrastructure owner's policy or NSW Treasury guidelines.

The business case is a structured blueprint for how the project will address a service need or opportunity. It must make the case for funding; containing a logical argument that clearly demonstrates that the proposed project is necessary now, and will provide benefits which outweigh the economic costs of the proposal over its life. It must also demonstrate that the organisation responsible for its delivery has the capacity to implement the project and realise the intended service benefits.

During this step it will be necessary to:

- Determine the requirement for a business case based on size and risk of the project.
- Agree on the framework to be followed and the likely approval authority.
- Complete the business case.
- Submit the business case for approval of funding.

Refer to the 'Guidelines for Capital Business Cases' link in the iPDF for more details on business case frameworks.

Cost benefit data and information from Stage 3, in Step 7 to Step 9, can be used to support the economic and financial analysis that will be required as part of the business case.

The ***output*** of this step is a completed and approved business case.

Step 4 – Identify funding opportunities

Funding is frequently cited as a significant barrier to adaptation implementation. This step requires the stakeholders and beneficiaries of the adaptation option(s) to engage in a meaningful discussion on opportunities to fund the project.

The challenge of funding adaptation can in part be overcome by collaborating on adaptation implementation through effective governance structures. A coordinated approach allows infrastructure managers to share and reduce costs through more efficient implementation.

Funding mechanisms will vary depending on the option and stakeholders. Refer to the iPDF for more details on different 'Funding for adaptation'.

Many funding mechanisms ultimately place the cost of adaptation back on the user, e.g. water or council rates and taxes. This highlights the importance of community engagement and knowledge building to raise awareness of climate change risk so that users understand the need for the expenditure.

The ***output*** of this step is an agreement on how the funding will be obtained and how the different stakeholders will contribute financially to the implementation of the option.

Step 5 – Implement adaptation option

This step refers to the actual implementation of the adaptation option and could include the following:

- Preparation of a new policy or changes to an existing policy document.
- Preparation of a strategic assessment.
- Concept design.
- Detailed design.
- Tender of works.
- Construction activities.

Individual stakeholders will have their own project management procedures which will need to be followed during this step to comply with organisational policies and the tasks involved.

Prior to commencing the work the implementation team should prepare a list of deliverables which can be reviewed and monitored during the project.

Where collaborating with others, the implementation team should remember to allow time for both internal and external stakeholders to complete their necessary reviews and checks.

Depending on the tasks and complexity this step may take significant time and this is especially important if construction work is included. The implementation team will need to be aware of this and to plan for changes within the team, in external stakeholders and possibly even policy during this time.

The ***output*** of this step is the actual deliverable and it is likely that there will be many smaller outputs within the task. Typical deliverables could include:

- Draft/final strategic plans.
- Concept design/detailed design drawings.
- Tender documentation.
- Physical construction works.
- As constructed documentation.

Evaluation

Evaluation and monitoring are key to the success of the project. Before proceeding to the next stage take time to review the outputs from this stage and ask the following questions.

Evaluation	Checkbox
Have there been any significant changes since the Flexible Adaptation Pathway was developed?	
Are stakeholders in agreement about what is being implemented?	
Has project governance been agreed?	
Can the project be delivered via existing organisations, or is a new body required?	
Has the business case been completed and approved?	
Has the funding mechanism for the option been agreed?	
Has funding for the implementation of the option been secured?	
Have the deliverables been agreed?	
Have all the deliverables been met?	
Have monitoring requirements been identified?	

If the checklist above is not successfully completed, identify what further information is required to fill the gaps and successfully complete the business case and achieve approval. Once this checklist has been completed, move to Stage 6 – Monitoring and Evaluation to check all processes are in place.

Stage 6: Monitoring and Evaluation

This stage requires the implementation of an ongoing monitoring and evaluation program. The outcome of this stage is to:

- Identify when and how the risk assessment, evaluation of adaptation options and ultimately the Flexible Adaptation Pathway needs to be adjusted to respond to:
    - Changes in climate.
    - Revised climate change projections.
    - Changes in the social, physical and economic factors that influence risk rating and thresholds.
- Monitor implementation for compliance and operation.
- Monitor the effectiveness and efficiency of options already implemented.

It is important that monitoring and evaluation does not just occur at the end of the framework. It is an ongoing component of all other stages and is critical to accurately assess the risk level and therefore extent of adaptation required.

Monitoring icons have been distributed across this User Guide at critical points within the framework and are summarised in Stage 6.

Revisit all previous stages to establish the monitoring and evaluation requirements that have been identified.

Through the following steps, the project team should prepare a monitoring and evaluation program. In the preparation of each program, consider the eight key components of a monitoring and evaluation plan:

1. The aims and objectives of the monitoring and evaluation. (Why?)
2. The variable(s) or indicators to be monitored. (What to monitor?)
3. The monitoring methods. (How?)
4. The frequency of monitoring and duration of the monitoring period. (When?)
5. Responsibilities and resource allocation for monitoring. (Who does the monitoring and are they adequately resourced?)
6. The analysis and evaluation to outputs. (What to evaluate?)
7. The analysis and evaluation methods. (How to evaluate?)
8. The frequency of evaluation and duration of the evaluation period. (When to evaluate?)

Refer to the iPDF for information on how to design and implement monitoring programs.

Step 1 – Monitor to define problem

Review Stage 1 Focus and Scope to identify requirements for monitoring. Typically this will include environmental data or climate data to assist in defining the problem. It may not be required for all projects where adequate data is already publicly available.

Prepare a monitoring and evaluation program considering each of the eight key components.

Note that this monitoring may be undertaken to inform a project, while another project, with better data is progressed through to Stage 2.

The ***output*** of this step is a monitoring and evaluation program to define the problem.

Step 2 – Monitor risk attitudes and risk thresholds

In Stage 2, the project team identified risk thresholds. In this stage, the project team must identify:

- What are the factors that influence risk attitudes?
- How can these be monitored over time?
- How do these factors change the risk thresholds identified?

Prepare a monitoring and evaluation program considering each of the eight key components.

Consider how the evaluation will feed into and update:

- The risk assessment.
- The evaluation of adaptation options.
- The Flexible Adaptation Pathway.

If risk thresholds are lowered there may be a reduced need to act, whereas if risk thresholds increase action may need to be brought forward or increased in scale.

The ***output*** of this step is a monitoring and evaluation program for risk thresholds over time.

Step 3 – Monitor climate change projections

Monitor and evaluate changes in climate and revisions of climate change projections. Changes to the projections are typically publicly available and will be undertaken by the Intergovernmental Panel on Climate Change (IPCC) at the global level, and by state and federal governments in their applicability to local conditions.

Prepare a monitoring and evaluation program considering each of the eight key components.

Consider how the evaluation will feed into and update:

- The risk assessment.
- The evaluation of adaptation options.
- The Flexible Adaptation Pathway.

The ***output*** of this step is a monitoring and evaluation program for climate change projections.

Step 4 – Monitor social, physical and economic factors

Monitor and evaluate the other social, physical and economic factors which affect the effectiveness of the adaptation strategy.

A range of physical, social and environmental factors may affect the adaptation options. These may include the following:

- Development within a catchment and corresponding changes in elevation, flood surfaces and dwelling density.
- Upgrades or deterioration in infrastructure upstream or downstream undertaken by other water infrastructure providers.
- The quality of the environmental or social assets being protected.

The iPDF provides a link to the 'SCCG Environmental Monitoring' site. This site is a user oriented resource for the design and implementation of environmental monitoring programs.

Prepare a monitoring and evaluation program for the relevant factors considering each of the eight key components.

Consider how the evaluation will feed into and update:

- The risk assessment.
- The evaluation of adaptation options.
- The Flexible Adaptation Pathway.

The ***output*** of this step is a monitoring and evaluation program for social, physical and economic factors.

Step 5 – Monitor and evaluate adaptation options

Prior to implementing options consider how the following will be monitored:

- Whether the option has represented an efficient use of funding and other resources.
- Whether the option represents an effective outcome in terms of reducing risk or actual consequences.
- Also consider whether the option has resulted in displacement of damages or other equity impacts.

Consider approaches which require structured consideration and consistent monitoring and reporting of adaptation option outcomes, outputs and impacts against quantitative and qualitative indicators.

Evaluation of adaptation is a relatively new field. Approaches developed by international development agencies including Results Based Management and the Logical Framework Approach may be applicable. Guidance on both these methods is provided in the 'Results Based Management (RBM) Framework Adaptation to Climate Change' and 'Logical Framework Matrix' documents in the iPDF.

Prepare a monitoring and evaluation program for the relevant factors considering each of the eight key components.

Consider how the evaluation will feed into and update:

- The Flexible Adaptation Pathway.

The ***output*** of this step is a monitoring and evaluation program for the adaptation options.

Evaluation

Ongoing monitoring and evaluation following implementation of adaptation options is a fundamental component of a successful adaptation pathway. Before completing this stage take time to review the outputs from this stage and ask the following questions.

Evaluation	**Checkbox**
Has the framework been reviewed to identify all monitoring and evaluation requirements?	
Have the associated monitoring and evaluation programs been established?	

If the checklist above is not successfully completed, identify what further information is required to complete the stage. Once this checklist has been completed, the entire framework should be revisited commencing again at Stage 1 to identify a new or expanded focus and scope building upon the work already undertaken.