SA Water

Technical Standard

TS101 Safety In Design

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Government of South Australia

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Only the current revision of this Standard should be used which is available for download from the SA Water website.

Significant/Major Changes Incorporated in This Edition

Major review of the Standard to incorporate the use of standard templates and forms while outlining the requirements of the SiD Process. The identification of a Design Lead and the allocation of responsibly parties at each stage for the SiD requirements.

Document Controls

Revision History

Revision	Date	Author	Comments
1.0	23.03.15	L Donisthorpe	Issued for Use
1.1	03.03.18	L Haigh	Update and re-numbered to align technical standards and other SA Water documentation.
2.0	20.01.20	L Haigh	Major update of process steps and inclusion of supporting documentation.

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Role	Signature and Date
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Role	Name	Revision	Review Date
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Mgr Engineering, Capital Design	Carl Franz	1.1	14.03.2018
SiD Working Group	SiD Working Group Members	2.0	14.11.19

Contents

List of figures

No table of figures entries found.

List of tables

No table of figures entries found.

1 Introduction

SA Water is responsible for operation and maintenance of an extensive amount of engineering infrastructure.

This standard has been developed to assist in the safe design, modification, maintenance, construction, and management of this infrastructure.

Safety in Design is defined as

" the integration of hazard identification and control measures early in the design process to eliminate or, if this is not reasonably practicable, minimise risk to health and safety throughout the life of the structure being design"

Adapted from the Code of practice safe design of structures

1.1 Purpose

This Technical Standard specifies the minimum mandatory requirements of SA Water Safety in Design process.

This Standard specifies the process and minimum requirements that SA Water considers necessary to ensure that:

- SA Water delivers on its key corporate value of "Putting Safety Above All Else"
- SA Water meets its WHS legislative obligations as a "person conducting a business or undertaking" (PCBU) under the WHS legislation.
- Consideration of WHS Legislative requirements for PCBU, Designer, manufacturer, supplier.

This Standard is to allow key stakeholders to collectively identify and reduce health and safety risks associated with the design of assets for whole of life, including construction, installation, commissioning, operation, maintenance, repair, demolition and recycling.

1.2 Glossary

The following glossary items are used in this document:

Term	Description
CHAZOP	Control System Hazards & Operability Study - A HAZOP study specifically on Control Systems
CPMM	SA Water's "Corporate Project Management Methodology" system – a system used to manage and control capital project delivery.
HAZID	A guideword process to review preliminary hazards associated with a project
HAZOP	Hazard & Operability Study - A series of hazard studies at various stages throughout the design process with a focus on the process operation and what occurs when operating outside of design intent.
PCBU	A Person Conducting a Business or Undertaking – SA Water, including contractors SA Water engage to operate, maintain or construct infrastructure for SA Water
RIVER	SA Water SharePoint® based document management system
SA Water	South Australian Water Corporation
SFAIRP	So Far As Is Reasonably Practicable
SiD	Safety in Design
TG	SA Water Technical Guideline

TS	SA Water Technical Standard

1.3 References

1.3.1 Australian and International

The following table identifies Australian and International standards and other similar documents referenced in this document:

Number	Title
	Work Health and Safety Act 2012 (SA) Revision 1.07.2017
	Work Health and Safety Regulations 2012 (SA) Revision 1.07.2017
	Code of Practice "Safe Design of Structures", Safe Work Australia Revision 2018
	How to manage health and safety risks code of practice
ISBN 978-1-74361-065-7	How to determine what is reasonably practicable to meet a health and safety duty
IEC 31010:2019	Risk management – Risk assessment techniques

1.3.2 SA Water documents

The following table identifies the standards, documents and/or articles that are referenced in this document:

Number	Title
TG 110	Safety in Design Guideline
SAWT-ENG-0004	Safety in Design Hazard Register template
SAWT-ENG-0006	SA Water SiD Impact Assessment Template
SAWT-ENG-0002	Safety in Design Plan Template
SAWT-ENG-0003	Safety in Design Report Template
SAWL-ENG-0005	SiD Prompt List
SAWT-ENG-0001	Safety in Design Hazard Identification Workshop Template
SAWF-ENG-0007	Safety in Design Assessment Template (short)
SAWG-RM-0001	SA Water Corporate Risk Management Methodology
SAWL-ENG-004	SiD Facilitator Register

1.4 Definitions

For the purpose of this document, the following terms and definitions apply. The definitions below are intended to provide a practical description of terms for the purposes of the SA Water SiD process and related documents.

Where definitions included here also have definitions in legally binding documents (e.g. legislation, regulations, standards etc.) the legally binding definition(s) shall take precedence

from a contractual and/or legal perspective.

Term	Description
Asset	Structure, facility, plant, operating system / equipment.
Concept Design	The initial level of design undertaken to identify and address the major and/or critical elements of the asset being designed.
Design	The development of ideas & concepts to a suitable level of detail and production of documentation that can be used to construct or modify items or assets. The WHS Act defines design as follows: "*Design*, in relation to plant, a substance or a structure, includes- a) design of part of the plant, substance or structure; and b) redesign or modify a design."
Designer	A designer is a person who effects design, produces designs or undertakes design activities as defined in the WHS Act and Regulations.
Design Lead	The person identified as responsible for the SiD process. They will have experience in line with the scale, scope and complexity of the package of work to be carried out. Eg. Connection and extensions – Customer Technical Services co-ordinator Small designs –Designer /Project Manager Larger projects – Senior Designer, Principal Designer, Design Manager, Head Designer
Detailed Design	The level of design undertaken to develop a concept design to a level of detail necessary to allow construction, modification or installation of the work.
Ergonomics	The scientific discipline concerned with the understanding of the interactions among humans and other elements of a system, and the profession that applies theory, principles, data and methods to design in order to optimise human well-being and overall system performance.
Guideword/s	Prompt/s to assist brainstorming processes / stimulate discussion.
Hazard	A situation or thing that has the potential to harm.
Lifecycle	All phases in the life of an asset. The specific phases present in an assets lifecycle will depend upon the type of asset but may include design, development, manufacture, construction, assembly, import, supply, distribution, sale, hire, lease, storage, transport, installation, erection, commissioning, use or operation, consumption, maintenance, servicing, cleaning, adjustment, inspection, repair, modification, refurbishment, renovation, recycling, resale, decommissioning, dismantling, demolition, discontinuance, disposal.

Term	Description
Project	Any engineering development work (including creation, expansion or modification to assets) for which an expenditure proposal is required.
Project Manager	An appropriately qualified person who has been given the responsibility to manage an asset design or modification on behalf of the client. The Project Manager may delegate these activities however remain responsible. I.e. Mr Bigg on behalf of Mrs Strong.
Reasonably Practicable	Subdivision 2 section 18 of the WHS Act 2012 SA – What is reasonably practicable. Additional guidance is available in the Safe Work Australia publication How to determine what is reasonably practicable to meet a Health and Safety duty
Residual Risk	Residual risk is the risk remaining after risk treatment.
Risk	Risk is the effect of uncertainty on objectives. Risk is often expressed in terms of the consequences of the event and the likelihood of its occurrence.
Risk Assessment	Risk assessment is the overall process of risk identification, risk analysis and risk evaluation.
Risk Control	Taking action to eliminate health and safety risks so far as is reasonably practicable and, if that is not possible, minimising the risks so far as is reasonably practicable. Eliminating a hazard will also eliminate any risks associated with that hazard.
Safe Design	Safe design means the integration of control measures early in the design process to eliminate or, if this is not reasonably practicable, to minimise risks to health and safety throughout the life of the structure being designed.
SiD Facilitator	A person trained or experienced person who will lead Safety in Design Review workshops.
SiD Hazard Register	Register of hazards, and means to address them, per hierarchy of controls.
WHS Act	Work Health and Safety Act 2012 (SA) Revision 1.07.2017
WHS Reg.	Work Health and Safety Regulations 2012 (SA) Revision 1.07.2017

2 Scope

2.1 General

This Technical Standard specifies the minimum mandatory requirements of SA Water Safety in Design process to eliminate hazards and where this is not reasonably practicable to minimise so far as is reasonably practicable the risk to health and safety of workers and those in the vicinity of the design.

This Standard is applicable to all design projects including those delivered in the capital or operations space. It is applicable for infrastructure designed, constructed, modified, decommissioned or demolished by or for SA Water (e.g. design activities performed by operations, design activities carried out for an external party etc.) and applies to project delivery either internal or external to SA Water and infrastructure including structures, plant and equipment, permanent, temporary, fixed or mobile.

Figure 1: Typical life cycle of an asset

There is a duty of care for anyone involved in any of the phases of the lifecycle of an asset with regard to whole of life safety and Safety in Design.

SA Water personnel, contractors, subcontractors, developers and their employees who perform work on behalf of SA Water shall comply with the requirements of this Standard.

Compliance with this Standard (and other SA Water Safety in Design (SiD) documents) will not, in itself, ensure compliance with WHS legislation or SA Water corporate WHS objectives. It is the designer's responsibility to ensure that designs comply with the WHS legislation.

2.2 Small designs

For designs that meet the following criteria the SiD Short Form process can be used.

- The design has been assessed as low risk

  And

- is single discipline

  Or

- has OPEX value under $10,000.

The short form is to be completed by the Design Lead documenting the lessons learned and known hazards, stake holder's consultation, communication and co-operations, the activities being carried out to ensure a safe design SFAIRP and transfer of information to the relevant parties.

Independent of the delivery method there is a requirement to carry out the SiD process and ensure the design is free of hazards SFAIRP for whole of life.

2.3 Common designs

The SiD process is equally applicable to designs resulting from programs of work outputs. Programs typically have some commonality to group them as a program. In these circumstances a SiD impact assessment can be carried out at the program level, identifying the approach to Safe Design for the program. Where commonalities apply e.g. standard

design to apply across different sites or group of works to apply to one site. The SiD process can be carried out for the common element then for the repeated component/s apply the findings and review by difference. Note findings of any subsequent reviews need to be feedback to the program level and into outputs currently in progress and review. The decision-making process of any variations needs to be recorded. A specific safety report is required for each output.

An important aspect of the program level approach to SiD is how lessons learned are to be captures and fed back into the program works.

Where designs are one off and don't contain the common element the complete SiD process is to be followed for that design.

2.4 Benefits

In addition to increased safety, Safety in Design delivers benefits including;

- improved usability
- improved efficiency
- reduced rework
- prevention of injury and disease
- benefits to customers
- reduced redesign and retrofitting
- increased designer reputation and credibility
- reduced costs
- promotes innovation

3 SiD Key Principles Overview

3.1 Design for whole of life

The most effective time to eliminate hazards or minimise risk is early in the design phase of an asset.

The activities in different phases of an asset lifecycle will have different interfaces and therefore different hazards. Identification of the hazards during early design gives greatest scope to design out these hazards. Where it is not reasonably practicable to eliminate the hazard, controls are to be used to reduce the risk SFAIRP.

Consideration is to be given to all phases of an asset's life cycle including but not limited to construction, commissioning, testing, operation, maintenance, future uses or upgrades, refurbishing, decommissioning, mothballing, dismantling and reuse, recycling and disposal.

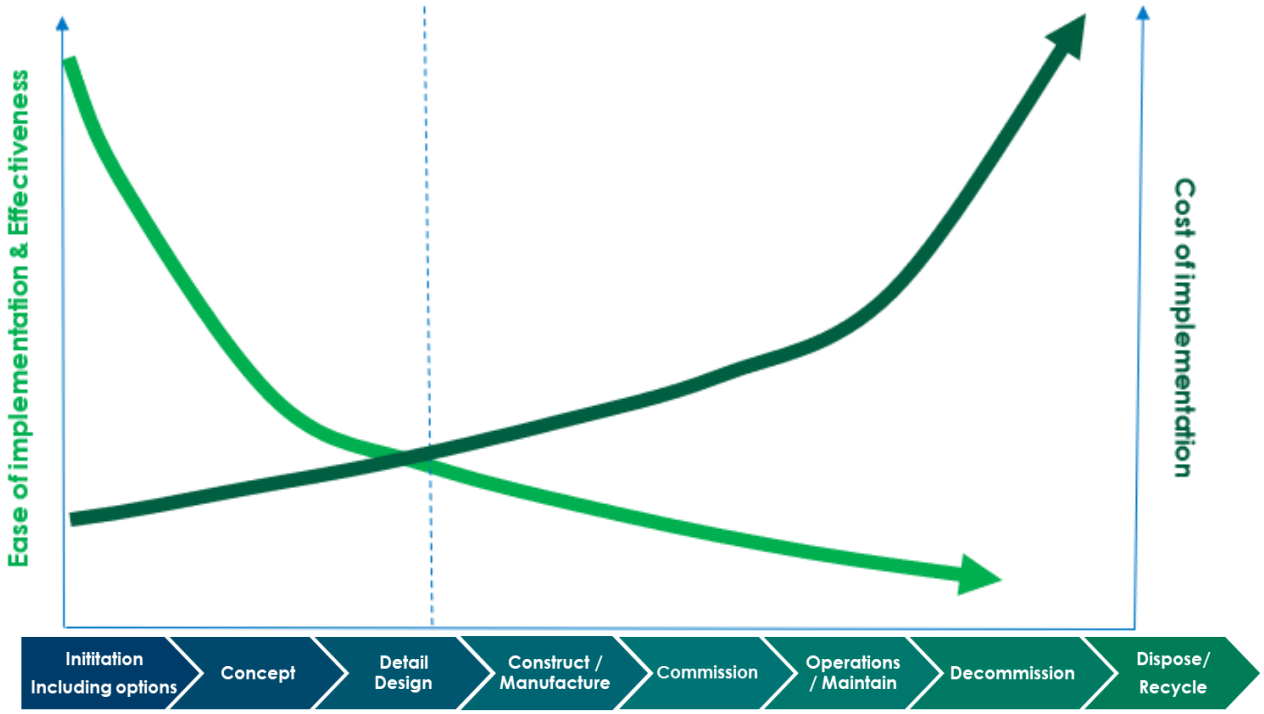

Figure 2: Impact on engagement early in the cycle on effectiveness and cost

3.2 Consultation communication and co-operation

The consultation, communication and co-operation with stakeholders to identify and eliminate hazards contributes to the development of a safer asset for whole of life. The legislative requirement for consultation with Stakeholders includes user groups as well as constructors, sub-contractors and other duty holders. Through early engagement of stakeholders their experience and knowledge can be drawn upon to identify hazards and produce informed decision on how best to effectively eliminate hazards and reduce risks SFAIRP.

Consultation, communication and co-operation also aids in the identification of hazards introduced or as a result of different groups activities or simultaneous works

There are several duty holders who have a role in consultation, communication and co-operation. These include and are not limited to;

- PCBUs
- Designers, manufacturers, importers and suppliers of plant, substances or structures
- Officers

- Workers
- Subject matter experts and others.

The WHS legislation requires Duty Holders to work together to identify and eliminate hazards.

Clear lines of communication for SiD matters shall be established (and recorded in the SiD impact assessment and plan) by the designer to ensure that this information is transferred at the appropriate time and decisions which have been made by the responsible parties are documented and communicated.

The duty for consultation, communication and co-operation is also important in the construction phase where different PCBUs maybe working in the vicinity and may introduce hazards not known to other PCBUs.

3.3 Information transfer

Information relating to identified hazards, lessons learned, control measures, action taken or required to control risks, are to be recorded and transferred through all phases to those involved in later stages of the lifecycle. Communicating this information makes other duty holders aware of residual risks and minimise the likelihood of safety features incorporated into a design being altered or removed by those engaged in subsequent work.

When requesting design work providing designers with information relating to the hazards and risks of the site and vicinity where the works are to be carried out commences the information transfer flow. The design information relating to SiD is to be transferred from one phase to the next.

Transfer of information between parties is one of the duties of designer as stated in the WHS Act Section 22.

3.4 Knowledge and capability

In addition to core design capabilities relevant to the designer's role, a designer is required to have:

- knowledge of work health and safety legislation, codes of practice and other regulatory requirements
- an understanding of the intended purpose/s of the structure
- knowledge of hazard identification and risk management processes
- knowledge of technical design standards
- an appreciation of construction methods and their impact on the design, and
- the ability to source and apply relevant data on human dimensions, capacities and behaviours.

Many design projects are too large and complex to be fully understood by one person. Various persons with specific skills and expertise may need to be included in the design team or consulted during the design process to fill any knowledge gaps, for example ergonomists, engineers and occupational hygienists.

3.5 Risk management approach

The only level of safety risk that is considered acceptable to SA Water is one which satisfies the so SFAIRP principle in accordance with Section 18 of the WHS Act.

The SiD process is not intended to reduce safety risks to a particular risk level but rather one which satisfies the So Far As Is Reasonably Practicable (SFAIRP) principles and requirements of the WHS Legislation.

There are three broad sources of hazards

- Hazards relating to the design
- Hazard relating to the way the design is used
- Hazards relating to the environment where the design will be used

Where it is not reasonably practicable to eliminate the hazard the risk therefore is to me minimised SFAIRP.

Figure 3: Risk management approach

Image from safe work NSW A risk management approach to work-related stress: Tip sheet 2

The elimination of the hazard is always the most effective control. Where it is not reasonably practicable to eliminate the hazard the method of controls will be determined by reference to the hierarchy of controls below:

- elimination of the hazard, removal of the hazard removes the risks.
- substitution of the hazard with less hazardous plant, process or substance

- reduction of the risk through isolation (separate the hazard from the person)
- reduction of the risk through engineering controls (e.g. automation, guarding, design and ventilation)
- reduction of the risk through administrative controls (e.g. training, instruction, supervision and systems of work)
- reduction of the risk through personal protective equipment (PPE). The use of PPE is a last resort.

Where reasonably practicable SA Water require hazard control measures to be "above the line" This philosophy minimises reliance on human behaviours to reduce exposure to hazards through the use of administrative controls and PPE. Administrative controls & PPE can be used to support control measures further above the pyramid.

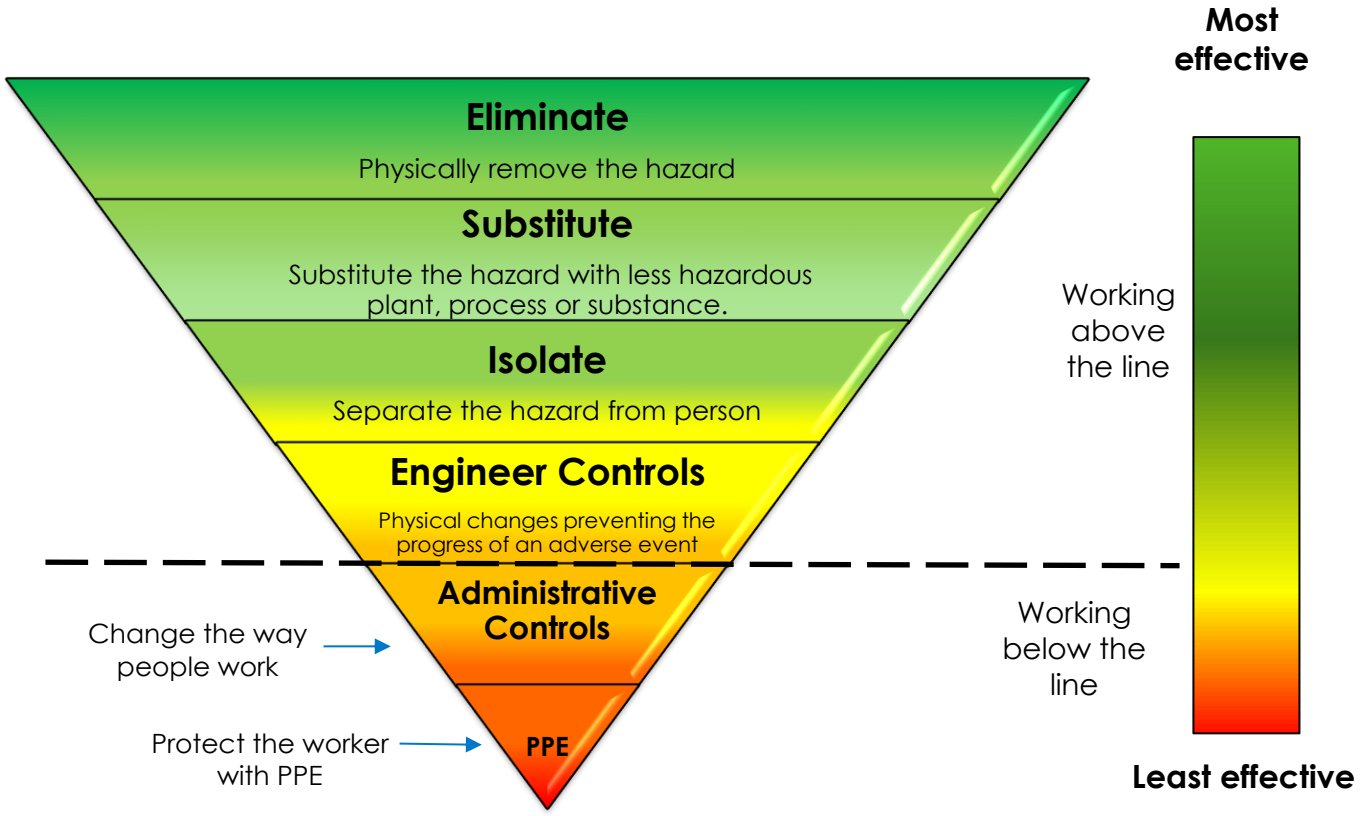

Figure 4: Hierarchy of Controls

3.6 Reasonably Practicable

" **reasonably practicable**, in relation to a duty to ensure health and safety, means that which is, or was at a particular time, reasonably able to be done in relation to ensuring health and safety, taking into account and weighing up all relevant matters including—

(a) the likelihood of the hazard or the risk concerned occurring; and
(b) the degree of harm that might result from the hazard or the risk; and
(c) what the person concerned knows, or ought reasonably to know, about—
  (i) the hazard or the risk; and
  (ii) ways of eliminating or minimising the risk; and
(d) the availability and suitability of ways to eliminate or minimise the risk; and

(e) after assessing the extent of the risk and the available ways of eliminating or minimising the risk, the cost associated with available ways of eliminating or minimising the risk, including whether the cost is grossly disproportionate to the risk. "

Source: South Australia Work Health and Safety Act 2012

When considering the benefits against the cost of implementation they can be broken into three categories. These are;

"Just do it" – when it is inexpensive/easy and provides safety benefit. This also applies to low risk hazards where control measures can be further improved.

"Further analysis required" additional analysis is required to make judgement. This can be carried out through a combination of tools and methods including so far as is reasonably practicable assessment, multi criteria analysis, fault tree analysis, whole of life cost benefit analysis may be required before making a decision. The decision process is to be recorded along with the outcome.

"Check for gross disproportionality- The safety benefit throughout the life of the asset does not justify the cost/complexity of implementation of the nominated control. Alternative controls, using the hierarchy of controls to minimise the risk SFAIRP need to be identified and implemented. The decision process is to be recorded along with the outcome.

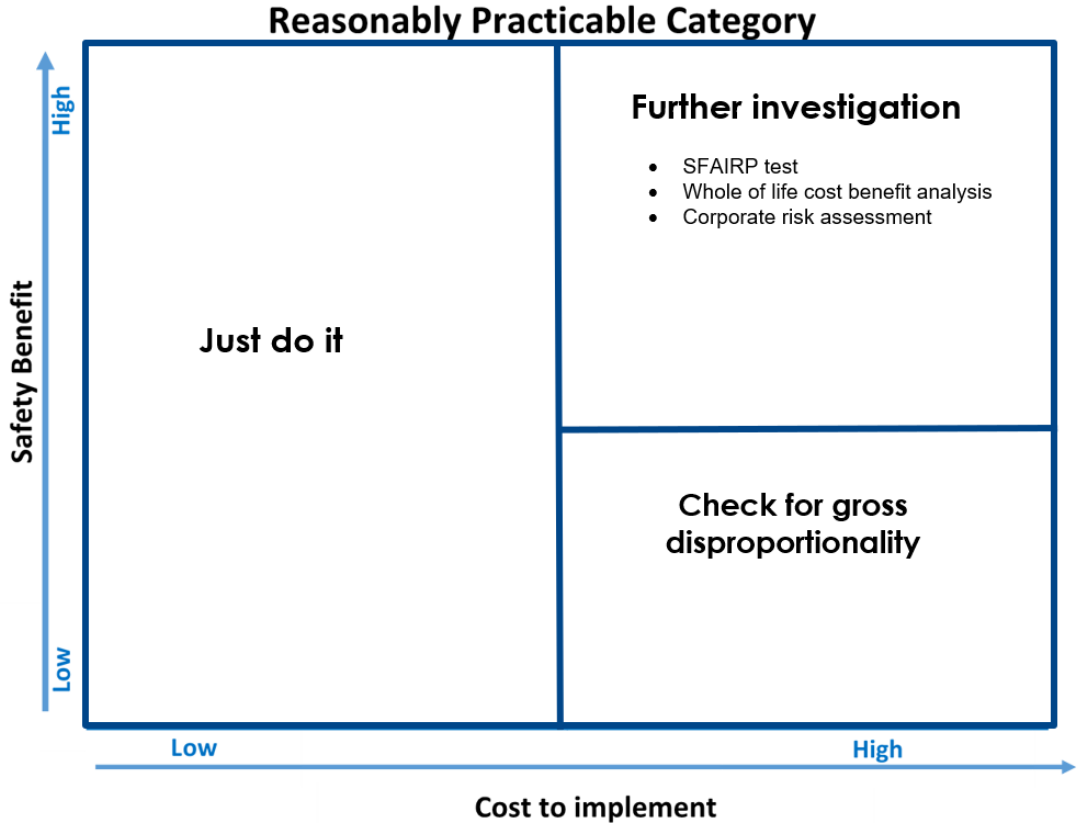

Figure 5: Reasonably practicable category

4 Safety in Design Process

4.1 General

The following are parts of project delivery related to this Standard and the related sections (in brackets) of the SA Water CPMM system:

- Project Brief – CPMM Initiate Phase (Project Brief)
- Options Development & Evaluation – CPMM Develop Phase (Options)
- Concept Design – CPMM Develop Phase (Develop Concept Design)
- Detailed Design – CPMM Deliver Phase (Detailed Design)
- Construction – CPMM Deliver Phase (Build)
- Project Operational Handover – CPMM Deliver Phase (Commission)

Figure 6: Typical life cycle of an asset

This section provides an overview of the activities to be undertaken to deliver a safe asset SFAIRP through safe design. SiD activities are sequential and commence in the Identification phase and are built on through options, design and life of asset. In the event the SiD Process has not been activated it is the duty of the designer to bring it to the current level. Including any activities that should have occurred prior to the given point.

In the event a phase of design is expedited the expedited phase SiD activities are still required to occur at the earliest time. The approach is to be noted in the design SiD Impact Assessment and SiD Plan.

A SiD impact assessment, is to be completed at the initial stage of the concept phase with the establishment of a SiD Hazard Register if it hasn't been created prior.

The SiD Hazard Register along with the safety report for the phase is to be carried through the project as a live document updated with new hazards and control methods through the project cycle and asset life cycle.

Where a design meets the requirements in section 2.2 the SiD Short Form is to be completed at the initiation stage of the concept phase to establish the approach to SiD.

The following process has been developed, to not only be more likely to deliver a safe design SFAIRP, but also to address requirements of the WHS Legislation in South Australia. Where projects or designs are applied outside the state of South Australia different legislative requirements may be required and should be reviewed. Contact SiD support for further information.

4.1.1 Programs of work

Programs of work generally follow the same structure as a project however there is a level of commonality that result in the outputs being delivered through the program process. The SiD Process applies equally to programs of work with the SiD impact assessment playing a pivotal role in identifying the approach to the development of a safe design and other legislative requirements.

Section 2.3 Common designs details more considerations for programs of work.

4.1.2 Operational single discipline designs

A SiD Short form can be used where

- The design is low risk

  And

- Single Discipline or OPEX value under $10,000.

4.2 Preliminary hazard identification and of lessons learned transfer.

(Asset Sponsor)

Preliminary Hazard Identification (HAZID) and identification of lessons learned shall be undertaken during the initiation process prior to concept design phase. A list of preliminary hazard and lessons learned sources can be found in Appendix A.

A HAZID workshop may be the best means to succinctly identify and record hazards and A-typical features for consideration of the designer/s.

Any hazards identified during this stage of the project shall be carried forward to the Options and Concept design phase where they shall be addressed in more detail. Instances that have known effective control measures can also be recorded.

4.3 Options considerations

(Designer)

Options analysis considerations for safety are to be included in options considerations and recorded in the options report.

4.4 Identification of Design Lead

(Project Manager and design team)

At the commencement of any phase (concept, detail design, program initiation, construction) a Design Lead is allocated and is accountable for ensuring the SiD Process and associated activities are carried out. The Design Lead will be agreed upon by the design group prior to commencing the SiD process. The Design Lead is typically the most senior designer and may be the Project Engineer, Design Manager. For smaller more simple designs the Engineer or in some cases where the Project Manager is also the designer the Project Manager will take on this role. The role holder will depend on the scale, scope and complexity, to be the most senior designer.

For programs of work a program level Design Lead is identified and then the deliverable level Design Lead is identified documenting the role and responsibilities in relation to Safety in Design in a program of work in the SiD Plan (4.6)

4.5 SiD Impact Assessment

(Design Lead)

At the commencement of concept design the identification of activities that will contribute to SiD will occur through the completion of the SiD Impact assessment, SAWT-ENG-0006.

The SiD Impact Assessment records the applicable considerations and activities that will contribute toward whole of life safe design for the given designs scope, scale and complexity. The SiD impact assessments identified what activities sit under the "SiD Umbrella"

A summary of some of the available tools, techniques and guidance on when they are to be applied for the identification of hazards, risk assessment and risk control is in Appendix B. This is to be referred to when completing the SiD Impact Assessment, SAWF-ENG-001.

Sign off and confirmation of available funding for the SiD activities occurs by the Design Lead, PM, Asset Sponsor and other relevant parities as identified.

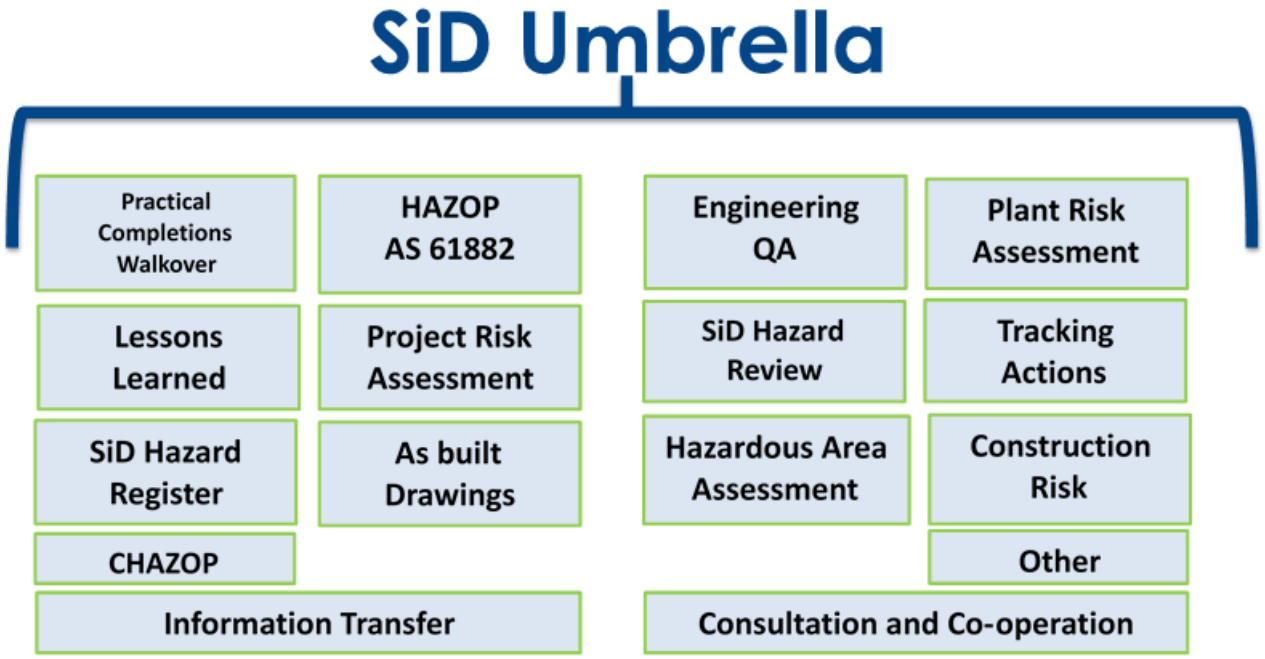

Figure 7: SiD Umbrella

4.6 SiD Plan

(Design Lead)

Having identified the SiD activities in the SID Impact Assessment a plan is to be developed using SiD Plan Template SAWT-ENG-0002. Where a design plan exists the SiD plan can be included as a subsection of the Design Management Plan.

Where a program approach is being taken a program level SID impact Assessment and SiD plan is to be developed.

4.7 SiD Meeting

(Design Lead)

The communication of the agreed approach and activities contributing to a safe design is to take place with the design and project team during a minuted meeting at kick off.

The SiD Impact Assessment and SiD Plan is distributed and discussed. The team members are responsible for familiarising themselves with the content.

Subsequent project meetings are to include SiD agenda items to raise:

- major scope changes or design changes that will require revisiting the SiD Impact assessment
- track identified hazards and how they are being controlled
- monitor progress of action items relating to Safe Design.

4.8 SiD Hazard Review 1 – SiD1 operations and maintenance

(Design Lead)

SiD1 hazard identification review workshop draws upon participants experience to identify and eliminate SFAIRP hazards associated with the interfaces of the design over whole of life including construction, commissioning, operations and maintenance, shutdown, future works, decommissioning demolition recycle disposal etc.

Through reviewing the tasks/activities, to be carried out during the life phases, the hazards can be identified and eliminated. Where it is not reasonably practicable to eliminate a hazard, using the hierarchy of control the risk is to be minimised SFAIRP.

Any WHS issues and hazards identified during the project initiation and options stage that have not been eliminated shall be reviewed at the SiD1 hazard review and shall be expanded to a higher level of detail, if necessary, in order to thoroughly identify all hazards that may occur throughout the life of the asset.

The Design Lead is responsible for organising the SiD hazard reviews, engaging an independent SiD facilitator, a scribe and use SAWT-ENG-0004 SA Water SiD Hazard Register template.

The critical design review in concept phase must occur prior to SiD1 review taking place. Appendix C SiD Hazard Review details more information relating to requirements for SiD Hazard Review Workshops

Attendees must include the following stakeholders;

- Project PM,
- Design Lead and discipline Engineers
- SA Water/AllWater Operations
- SA Water / AllWater maintenance and service providers,
- Technical Experts where required

The following are to be invited and strongly recommended their attendance;

- Asset Planner/ Project Sponsor
- Constructor/ commissioning
- WHS
- Owners Engineer

A SiD1 review cannot go ahead without participation from operations, maintainers and project team.

The facilitator shall lead a systematic “brainstorming” process to reduce the likelihood of overlooking any hazards within the design. SAWT-ENG-0001 SiD Hazard Review Workshop Introduction Template is to be used at the beginning of the workshop to align participants understanding of the workshop scope, project overview, interfaces and the workshop process.

For large or complex designs multiple SiD review workshops may be needed to address different packages of deliverables, nodes or portions / disciplines of the design.

SiD2 review takes place following the first design review in the detail design (or equivalent) phase with SiD Hazard Register actions and changes closed out prior to issue for construction.

4.9 Other safety in design activities

(Design Lead)

Other safety in design activities identified in the SiD impact assessment and plan are to be carried out as soon as the level of design is sufficient to complete the activity. Appropriate stakeholders are to be identified and engaged.

Specific designs will require additional SiD activities and the appropriate departments and subject matter experts are to be consulted when identifying applicable activities. When designing plant containing chemical dosing systems, biogas, safety critical systems, security or other speciality areas there are specific requirements consult relevant business partner. As a minimum carry out a HAZOP, CHAZOP and review of chemical licensing and hazardous area requirements.

A control System hazard review (CHAZOP or equivalent) is to occur on any control system, local or connected to SCADA following the HAZOP and the development of the process logic unit (PLU) functional descriptions.

Further information on other safety in design activities and when they must occur is in 6Appendix B Common Hazard and Risk Management tools, techniques and guidance of use

4.10 SiD Hazard Review 2 – SiD2 construction and commissioning

(Design Lead)

SiD2 review takes place following completion of the first design review in the detail design (or equivalent) phase. SiD2 is to be timed that the design has captured applicable changes as a result of the design review.

The process of SiD2 is the same as SiD1 with a focus on the interface hazards during construction and commissioning. The object being again to identify any engineering safeguards or features that can be incorporated into the design to eliminate hazards and minimise risk to construction and commission personnel.

The SiD Hazard register is to be tracked updated and monitored throughout the design. The SiD Hazard Register will be used to feed into the construction risk register and operational risks.

4.11 SiD Audit

(Project Manager)

Section 7.0 of the SiD Impact Assessment form, SiD Audit, is completed to identify the status of the SiD activities identified to produce a Safe Design (SFAIRP), confirm they are completed and closed out. This will include a review of the SiD Hazard Register and other actions (e.g. HAZOP) for the design phase are closed out. This activity is carried out by the Project Manager or where the Project Manager is also the Design Lead a peer Project Manager, prior to the completion of the SiD Report.

4.12 SiD Report

(Design Lead)

The SiD Report is to be completed following final design review, completion of the SiD Audit and prior to issue for construction. It is the responsibility of the Design Lead to complete the SiD report with the current updated SID Hazard Register an important component of the report where controls SFAIRP have been applied and the status of any residual hazards noted. The SiD Report Template SAWT-ENG-0003 is to be used for SA Water SiD reports.

Where stage wise approach to design and construction is applied, each stage will need to have a safety report associated with the packages. This can be a document that is built on as the construction progresses however prior to construction each stage must have a safety report issued to SA Water and others who give the design effect such as constructors and design approvers.

4.13 SiD Report handover and distribution

(Design Lead and Project Manager)

The Design Lead hands over the SiD report to the PM. The PM conveys the SiD Report and other relevant information to the PM Construction, Operations, Maintenance and other that will be giving effect to the design as identified in the SiD Plan. From this point the PM is responsible for tracking of identified hazards and the management of residual risks.

The SiD Report is an important document in the development of the construction management plan and the construction risk assessment.

4.14 SiD Hazard Review 3 (SiD3) - Safety in Design validation and verification

(Design Lead)

SiD3 is the verification and validation that the items on the SiD Hazard Register have been incorporated into the design as actioned. Where operational, maintenance or other residual hazards and corresponding control strategies have been incorporated as part handover, these are to be documented in the appropriate work instructions and O & M Manuals.

SiD3 will be performed following project construction and prior to operational handover to ensure that the completed asset is safe to operate and maintain SFAIRP. This can be achieved by incorporation into the PC Safety Walk.

Depending on the size and complexity of the design, a post construction design review could be performed by a small team with;

- knowledge of the final design and the operating and maintenance requirements of the design
- A thorough understanding of the function of the completed asset.

Any new hazards are so far as is reasonably practicable eliminated or the risk reduced. Updates are to be made to the SiD Hazard register.

4.15 Capturing lessons learned and continuous improvement

(Project Manager)

Capturing of lessons learned will be through the project Lessons Learned process. This is to reflect both positive and opportunities for improvement of the project.

A SiD Review and the SiD Hazard Register shall be reviewed following construction (SiD3) to identify safety related design issues that were addressed, and improvements made as part of the SiD process with the view to incorporate these improvements into future project designs, common or standard designs and SA Water technical standards.

This information is to be transferred as part of the lessons learnt sessions conducted during the finalisation phase of the project and shall be documented in the lessons learnt report.

Where a design is part of a program of works relevant lessons shall be communicated to the design team as documented in the Program Level SiD Plan.

The safety issues identified as part of this review shall also be communicated by the project manager via the lessons learned report for the project which shall be distributed to the following:

- SA Water's Senior Manager Asset Management for incorporating into project briefs for new or modified assets
- SA Water's Senior Manager Engineering Services for incorporation into the design of new projects, technical specifications and standards.

4.16 Changes and Change Management

(Design Lead and Project Manager)

Any changes made to the design or operation outside of design specifications, are to be managed such that there is systematic identification of the impact of the change, identification of hazards and control of the hazards using the SFAIRP principle.

This is applicable at any phase of an asset life cycle. The SiD Principles are to be applied to all changes and may require revisiting or initiating SiD activities to fully identify and control hazards.

4.17 Live hazard tracking

(Asset Manager)

The SiD process applies for whole of life of an asset. The live tracking of hazards is an integrated component of the construction, commissioning and operations through to decommissioning, demolition, recycling and disposal.

Where an atypical hazard is newly identified (at any time in the whole of life) the hazard is to be entered into the SiD Hazard register and hierarchy of control employed to ensure the interface is safe so far as is reasonably practicable. Where the hazard is identified in any phase following hand over the hazard is to be entered into SAAM.

Where deviation from design, including change of use or work methods are applied, the duty holder for that task or phase needs to establish if the change presents new hazards as per 4.16 changes and change management.

Any design shortcomings identified during the operation and maintenance of an asset which affect the safe operation or maintenance of that asset shall be recorded in SAAM and communicated by operations staff at any time to the following:

- SA Water's respective Asset Manager for incorporating into project briefs for new or modified assets
- SA Water's Senior Manager Engineering Services for incorporation into the design of new projects and technical specifications, standard and guideline reviews and updates.

4.18 SiD process overview with typical design process

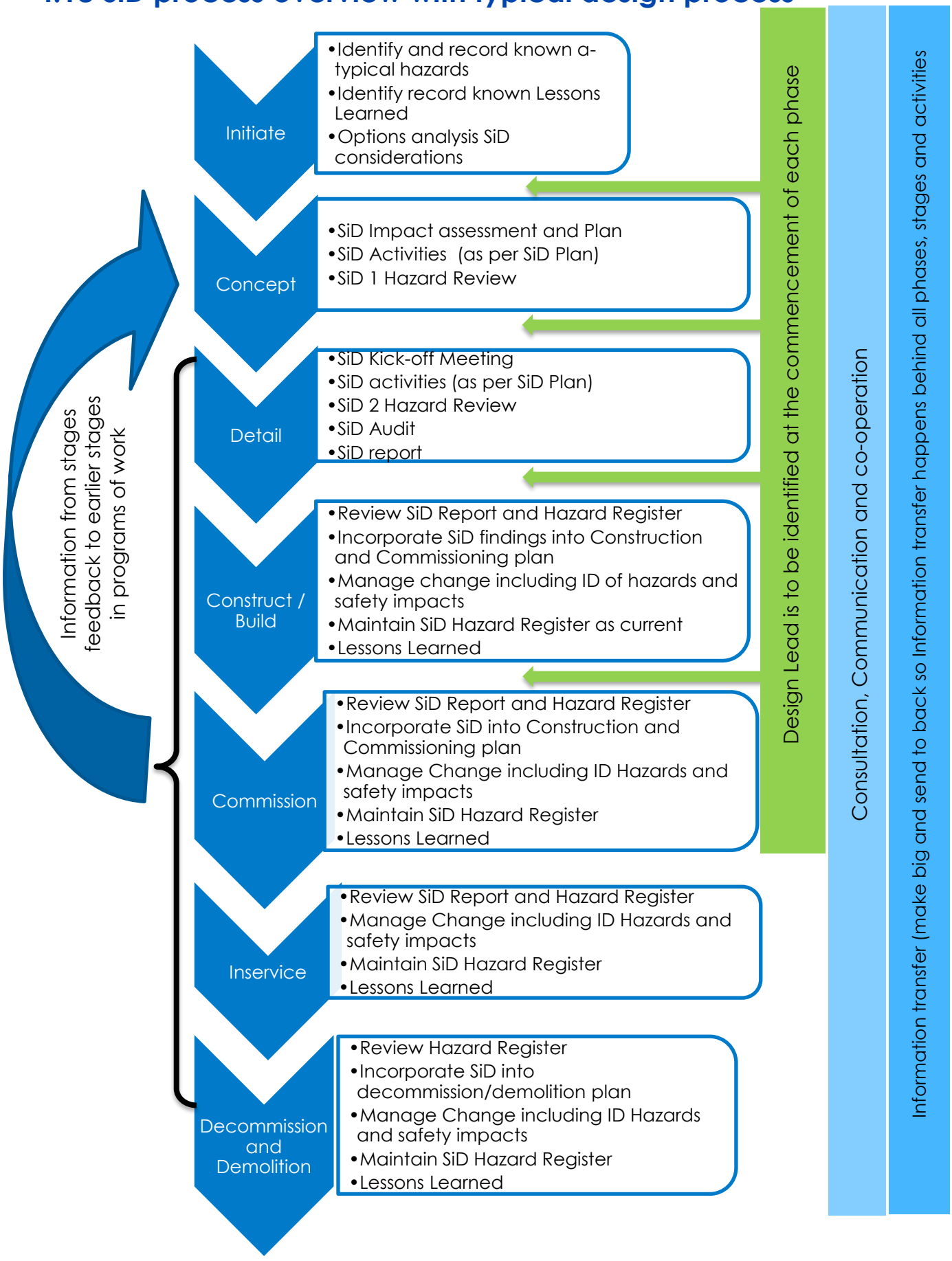

Figure 8: High level SiD process

5 Documentation and Records

5.1 General

SiD records may include (but are not limited to):

- SiD Hazard Register
- options analysis
- risk assessments, including risk ratings and actions
- risk reduction/control methods considered in the SFAIRP process
- reasons for selection of any risk reduction/control method (i.e. document the SFAIRP decision process)
- SiD delivery methodology
- options investigations and findings
- SiD meeting minutes
- SiD and safety changes identified in the lessons learnt process (refer to clause 4.15 Capturing lessons learned and continuous improvement).
- Change management reviews

All SiD records shall be maintained in accordance with this clause.

Requirements apply to records created by or on behalf of SA Water as well as documents returned to SA Water from partner or third-party designer.

5.2 Design carried out by designers external to SA Water

All designs carried out by external parties as a minimum shall comply with this Standard and the requirements of the WHS Legislation.

5.3 Safety in Design templates

The following templates are provided by SA Water for use in support of the SiD process;

Number	Title
SAWT-ENG-0004	Safety in Design Hazard Register template
SAWT-ENG-0006	SA Water SiD Impact Assessment Template
SAWT-ENG-0002	Safety in Design Plan Template
SAWT-ENG-0003	Safety in Design Report Template
SAWT-ENG-0001	Safety in Design Hazard Identification Workshop Template
SAWF-ENG-0007	Safety in Design Assessment Template (short)

5.4 Record format

The SA Water templates are available and are to be used where applicable.

Native version of the files are to be saved and transferred to the next phase of design. Due to the live whole of life nature of Safety in Design the documents are not to be transferred as PDFs.

5.5 Identification of SiD Hazard Register records

All SiD Hazard documents shall be identified using the following naming convention.

“xxx – SiDZZZZZ - yyy”.

Where:

- xxx = Maximo Asset ID number
- yyy = project number and site/project name
- zzz = Description of document

Examples:

- MA3235 – SiD Hazard Register – C4857 Marabel PS
- MA3235 – SiD Impact Assessment – C4857 Marabel PS
- MA3235 – SiD Plan – C4857 Marabel PS
- MA3235 – SiD HAZOP – C4857 Marabel PS
- MA3235 – SiD Report – C4857 Marabel PS

For designs where the Maximo ID is yet to be determined the XXXX can be used until known.

5.6 Location of records

SiD records for all SA Water assets shall be filed, at each milestone, in SA Water's SharePoint® filing system "RIVER" in the Safety In Design workspace.

Access is via http://river.sawater.sa.gov.au/workspaces/wsr/ws0099 or SA Water River > Workspaces > Workspace Register > Safety in Deign. Under Libraries on the left side of the page select Workspace documents and add documents using the "add document" function.

At handover practical completions the SiD documents (in native format) shall be included in the O&M Manual Appendix G WHS.

5.7 Documents modified external to SA Water

An additional version of the SiD Hazard Register shall be produced whenever the SiD Hazard Register document is developed or reviewed by parties external to SA Water. Details of who has custody of the live version of the document is to be recorded on the document prior to it being checkout.

At each design milestone the current, updated SiD documents is to be issued and uploaded into river.

This is required to allow SA Water to record the status of the SiD documents issued to the 3rd party designer for review and the status of modified documents returned to SA Water by the 3rd party designer. The SiD documents returned to SA Water supersedes the document issued for development by the 3rd party designer.

The SA Water Project Manager for each contract shall be responsible for management of these documents in accordance with the SA Water CPMM system, with assistance from SiD support in Engineering Services as required.

5.8 Documents modified internal to SA Water

The current version of the SiD documents shall be used as the basis for all SiD Reviews undertaken and modified by SA Water for that asset.

6 Standard update and reviews

Where opportunities for efficiencies and innovation in the SiD process, tools, application of the SiD process or interfaces between business groups have been identified please contact the document owner.

This document will be reviewed within 24 months of issue.

Appendix A Information sources for identifying hazards

Consider the following Sources of Lessons Learned

• OLDM Checklist • Incident Information (SAAM / IMS other) For changes to existing designs: reported (of that design) • Operational Issues Register • Similar designs or design changes • Talk to O&M (field) staff and Asset Owner • Environment and Heritage • Internal Design/Construction standards • Ergonomic assessments Internal Safety Bulletins • Design guidelines • Safe Work SA Bulletins / Safety Alerts • State regulators Bulletins / Safety Alerts • Bulletins / Safety Alerts from other utilities • Bulletins / Safety Alerts from industry • Industry Forums • Technical Networks • Supplier Notifications	• Site visit • Existing drawings of the 'standard' or "common" design • Previous works / Lessons Learned database (CPMM, Engineering Other) • Observations from stores, e.g. material compliance issues • What other water or service network organisations are doing for this type of design • Suppliers' history • Client's Design / Construction Manuals • Manufacturers' histories: product changes • Lessons learned with respect to land usage: site clearance lessons, landowners lessons, lessons from trying to build on another person's land

Appendix B Common Hazard and Risk Management tools, techniques and guidance of use

IEC 31030 is a good source for further information on the tools and techniques available for identification of hazards and analysis of risk and controls.

Method/tool	Description of tool
Hazard Identification (HAZID)	The HAZID review shall identify hazards that may exist or occur during all or specific phases of the project or may influence the preferred option selected. Identifying and understanding these risks at the earliest possible time in the project lifecycle will make it easier to eliminate or control them in further stages of the design process. All hazards identified during this HAZID process shall be documented and carried into the SiD Reviews that will be undertaken during all future stages of the project development including design, construction, operations and demolition phases. It is a requirement for SA Water to provide to designers (either internal or other) the reasonably known hazards and lessons learned applicable to the design. Safety in Design Hazard Review Workshop Hazard identification shall be undertaken during development of the project brief and/or options investigations/analysis or at the earliest opportunity.
Risk Assessment	A systematic process of evaluating the potential risks that may be involved in a projected activity or undertaking. A given risk ranking does not indicate if a hazard has been reduced so far as is reasonably practicable. (risk is two of the considerations in determining if something is reasonably practicable in relation to WHS) however, can be used as one of the tools to analyse the whole of life cost benefit analysis or as a comparison. Risk management "helps decision makers make informed choices, prioritize actions and distinguish among alternative courses of action." (ISO 31000:2009).
Hazard and Operability study **(HAZOP)**	The purpose of HAZOPs is to systematically evaluate each part of a system to identify any hazards or obstacles to operability that could arise, particularly through deviations from the design intent. The consequences of deviations are identified and where necessary appropriate corrective actions initiated. As per AS IEC 61882:2017. HAZOPS must occur for designs involving the creation or modification of operational or chemical processes. E.g. water, sewage and wastewater treatment plants, chemical injection / dosing systems/processes and other systems. HAZOPs will be based on mature diagrams/process and instrumentation drawings (P&IDs) that have undergone design review and on proposed operating strategies/procedures.
Control Hazard and Operability Study (CHAZOP)	The purpose of CHAZOP is to find possible causes of process upset due to control system failure. Similar to a HAZOP the output of this study is a detailed list of all possible consequences of control system failure, optionally including assessment of the frequencies and severities of the outcomes and further actions where required.

Method/tool	Description of tool
	A systematic review of the system is carried out following the HAZOP study principles. The review is to cover the hardware and configuration including instrumentation as well as any control logic or PLUs (process logic units). Where there are multiple systems or critical systems involved CHAZOP study is to occur. When instrumentation is used a review of the instrument and control logic is to take place. CHAZOP is to come after a HAZOP study in the project timeline. HAZOPS must occur for designs involving the creation or modification of operational or chemical processes. E.g. water, sewage and wastewater treatment plants, chemical injection / dosing systems/processes and other systems.
Ergonomic and Human Factors Assessments	Ergonomic and Human Factors Assessment examines the 'fit' between people and their work. It puts people first, taking account of their capabilities and limitations. Ergonomics aims to make sure that tasks, equipment, information and the environment fit the worker Where there is a common design established or where the design will be repeated an ergonomic review is to occur during detail design when activities and interfaces are understood.
Major Hazard Facility	Specific duties are placed on operators of Major Hazard Facilities to manage the risk of a major incident. Specific duties under the WHS Regulations including but not limited to the development of a Safety Case and •identification of all major incidents that could occur. •identification of major incident hazards. •preparation of a safety assessment Identification of changes to chemical/reagent manifest should occur in the concept phase and understanding of impact and requirements is to occur. Reagent and chemicals relating to a new design should not be considered in isolation. See WHS Regulations Division 2, 535—A major hazard facility must be licensed, for further details.
Chemical licensing	Where chemicals are incorporated in a design or changes made to existing chemical dosing or storage system a review of the licensing requirements is to occur. Contact SA Water Environmental Management Officer for further information or assistance in determining requirements. Changed or new licences can take up to 6 months to process including applications / notification to SafeWork SA. This should occur as soon in the process as possible to identify any additional requirements.
Bow Tie Analysis	A diagrammatic way of describing and analysing the pathways of a risk/event from hazards to outcomes with the ability to review controls. The event represents the knot in the bow tie, the left side of the bow represents the causes and indicates prevention and escalation controls. The right side of the

Method/tool	Description of tool
	bow(event) represents the consequences and indicates the mitigation and recovery controls. The focus on the bow0tie is on the barriers between the causes and the risks and the risk and the consequences. This method is used to analyse risk, analyse controls or describe risk. Often used in Safety Cases. Method can be applied to assess existing controls or identify required controls to an event throughout the life of an asset
Hazardous area review/report	Refer to SA Water Technical Standard Hazardous Areas TS0376 for Hazardous Area Requirement's. Where it is suspected a hazardous area may be present a hazardous area review is to be instigated. Identification of hazard area is to occur at the earliest opportunity either in initiation or early concept phase. Applying the hierarchy of controls the most effective manner to manage hazardous zones is eliminating through design the hazardous area where reasonably practicable.
Event Tree	Event tree analysis can be used qualitatively or quantitatively to help analyse potential scenarios and sequence of events following an initiating event, and to explore how potential outcomes are affected by various controls. It can be applied at any level of an organisation and to any time of initiating event.
Fault Tree Analysis	An undesirable state is defined, and the fault tree shows graphically the logical relationship between the particular system failure (undesirable state) and all its contributing causes. The fault tree process aids in determining all possible ways in which the undesirable event can occur.
Failure mode effect analysis **(FMEA)** **Failure mode effect and criticality analysis** **(FMECA)**	FMEA (Failure Mode and Effect Analysis) is a technique which identifies failure modes and mechanisms, and their effects. There are several types of FMEA: Design (or product) FMEA which is used for components and products, System FMEA which is used for systems, Process FMEA which is used for manufacturing and assembly processes, Service FMEA and Software FMEA. FMEA may be followed by a criticality analysis which defines the significance of each failure mode, qualitatively, semi-qualitatively, or quantitatively (FMECA). The criticality analysis may be based on the probability that the failure mode will result in system failure, or the level of risk associated with the failure mode, or a risk priority. FMEA should be used when required to understand the impact of component failure. from AS IEC60812
Human Reliability Analysis **(HRA)**	The concept of Human Reliability Analysis (HRA) reflects an understanding that people and systems are not error-proof, and that improved reliability requires an understanding of error problems, leading to improved mitigation strategies. Essentially, HRA aims to quantify the likelihood of human error for a given task. These methods allow to identify weak areas and implement targeted, data-driven interventions that will ultimately reduce accident and injury rates. HRA are used for elimination of historical events or to identify reoccurring trends in human performance and system deficiencies.

Method/tool	Description of tool
	Process can be used at any phase of the life cycle with greatest benefits when changes can be incorporated into the design phase.
Layer of Protection Analysis (LOPA)	Layers of Protection Analysis (LOPA) Allows controls and their effectiveness to be evaluated. Layer of Protection can provide a more detailed, semi-quantitative assessment of the risks and layers of protection associated with hazard scenarios. LOPA allows the safety review team an opportunity to discover weaknesses and strengths in the safety systems used to protect employees, the plant, and the public. LOPA is a means to identify the scenarios that present the most significant risk and determine if the consequences could be reduced by the application of inherently safer design principles. LOPA can also be used to identify the need for safety instrumented systems (SIS) or other protection layers to improve process safety. LOPA occurs in the detail design phase and is a semi-quantitative process.

Appendix C SiD Hazard Review Workshop

C1 SiD Hazard Review Workshop

The Design Lead is responsible for the SiD Hazard Review Workshops and documenting the outcomes.

The SA Water SiD Hazard Register is to be used for the capture SiD Hazard Reviews.

The outcomes shall include details of attendees, methodology, guidewords used, hazards identified, eliminated, control measures implemented, and findings documented.

Where a SiD Hazard Register exists for the project, group of assets or asset the existing document is to be built onto, updated and maintained.

For large or complex designs multiple SiD review workshops may be needed to address different nodes or packages of deliverables or portions / disciplines of the design. When a design is divided into packages for review the interfaces between the packages must be identified and reviewed.

C1.1 Workshop Structure

A SID workshop for a given design can span between 4 hours through to three days or more depending on the scope, scale and complexity of the design.

The order of priority for assessing safety of interfaces during the life of the asset is;

- SiD 1 focusses on operation and maintenance for the lifetime of the asset(s) as well as future works, decommissioning and disposal.
- SiD 2 focusses on construction and commissioning.

Hazards from any lifecycle phase should be identified and managed as soon picked up. If a construction hazard is known during SiD 1 it should be noted and control measures identified where applicable. It is not required to be left until SiD 2 review.

Consideration should be given to the most efficient way to structure the workshop; one which is tailored to the needs of the project. SiD Hazard Reviews can be split into discipline-specific sessions if required, to delve specifically into the discipline-specific interfaces.

A Systematic approach is to occur with the identification of Hazards at the interfaces. For each section/group of the design a process similar to the below is to occur which corresponds with the SiD Hazard Register.

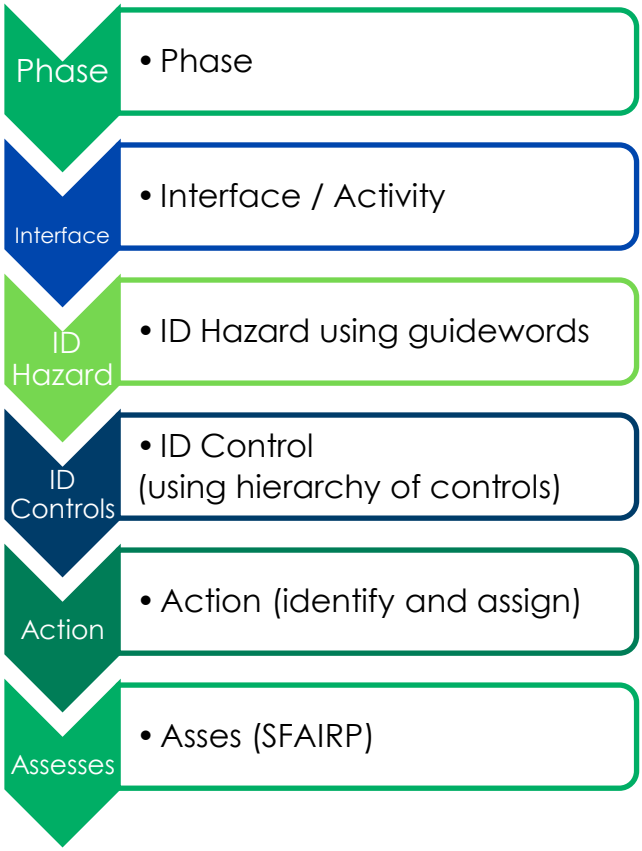

Figure 9 SiD hazard review workshop process

C1.2 Workshop Facilitator

The facilitator will impact the success of SiD Reviews by facilitating the experience and expertise of the study team to critically evaluate the design. Therefore, the selection of a trained or experienced facilitator is important.

For SiD Reviews s undertaken by SA Water, completion of the SA Water SiD facilitator training course is considered suitable training. A register of SiD Facilitators can be found on the SiD BMS page.

The facilitator should encourage workshop participants to identify the activities and interfaces, the hazards associated with these interfaces and constructively challenge the design to eliminate the hazards so far as is reasonably practicable and where elimination is not practicable reduce the hazards applying the hierarchy of controls.

For best results a SiD facilitator shall be selected and engaged at least 2 weeks prior to the SiD Hazard Review workshop.

The facilitator shall have knowledge of SA Water's SiD Review process (as per this document). They can be a SA Water employee or an external resource and must be independent and impartial of the project to prevent influence.

In a timely manner prior to the workshop, the facilitator will need to be provided with;

- the SiD Hazard Register including actions
- information regarding the project scope including atypical hazards
- workshop scope
- list of activities or tasks (interfaces) for the different phases and disciplines.
- the designs related to the project
- information regarding workshop participants (number, disciplines and responsibilities)
- location and timing of the workshop
- Between the Design Lead and SiD Facilitator it is to be agreed who provides any required printed materials for the day.

C1.3 Workshop Scribe

A workshop Scribe also needs to be assigned. The Scribe should be proficient in the use of Microsoft Excel, familiar with the SiD Hazard Register and a fast typist.

It is beneficial to use a Scribe who has a basic knowledge of engineering terminology and process. The scribe will allow the facilitator to focus on getting the best outcome from the participants.

It is the Design Leads Responsibility to organise the scribe.

C1.4 Workshop Participants

The minimum mandatory participants for SiD Reviews include are included in 4.8 and 4.10 above.

In addition to the minimum mandatory participants for a SiD Review, the following specialist are also required;

FOR SiD REVIEW 1 WORKSHOPS (O&M): Representatives of those who will interface with the new or modified asset(s) shall attend. These are primarily operations, maintenance and networks, but could include: other utility owners, road users and the general public.

FOR SiD REVIEW 2 WORKSHOPS (Construction & Commissioning): Constructors who understand the construction methods that will be used for each discipline shall attend. If a construction organisation has not been assigned, the Design Lead, in consultation with the SA Water Design Manager (DM) and or PM, shall organise for current, representative construction staff to participate.

FOR SiD REVIEW 3 (Post Construction & Pre-operation): The post construction SiD review is to be performed by a team (2 or more) that have detailed understanding of the existing SiD Hazard Register, knowledge of final design, operating and maintenance requirements of the project, and a thorough understanding of the completed asset(s) function.

Participants should be given three (3) weeks' notice of the workshop time, date and venue where possible.

The workshop is to be scheduled at a time when the mandatory participants can participate.

To minimise cost and maximise efficiency for larger SiD Reviews, the discipline-specific staff (i.e. any SMEs and specialist detail designers) should be invited only to the sessions that they need to attend. However, there must also be cross-discipline consultation for inter-disciplinary interfaces. The 'safest' approach is to ensure that all discipline SMEs attend all sessions. Another approach may be to have discipline SMEs 'on-call' to join the workshop whenever relevant interfaces are discussed.

Appendix D SiD Review Guidewords

SiD Review Hazard GUIDEWORDS

HAZARD	PROMPTS	
SIZE / SHAPE	Too large Too small Too long Too short	Too wide Too narrow Dimensions wrong
HEIGHTS / DEPTHS	Working at heights Fall / Dropping Scaffolding (shape, space to fit) Confined space	Access / egress Empty / Zero
POSITION / LOCATION	Too high Too low Too far Clearances (live equipment)	Misaligned Wrong position Other than
ERGONOMICS	Posture / manual handling RSI / discomfort / fatigue / stress Effect on PPE Visibility (lighting sightlines)	Slips, trips, falls Obstacles
MOVEMENT / DIRECTION	High speed Low speed High flow Low flow No movement Stability Compression Physical damage	Friction / slip Rotation Upwards / Downwards Reverse Impact personnel Expansion / Tension Rollover Vibration
LOAD / FORCE	High / excess / overload Low insufficient Additional loads (construction)	Dynamics Temporary Weakness
ENERGY	Provisions for Isolation Low / high energy Temperature high/low Bypass / divert Tension / compression Radiation - Electromagnetic, Radiofrequency / microwave	Potential / kinetic Induced voltage Inertia / moment Air Empty
TIMING	Too late Too early Too short	Too long Incorrect sequence Extended delays
EGRESS / ACCESS	Provisions for access No. of exit points Emergency egress and access, size Obstructions, lighting	External impacts Maintenance People and equipment Movements Entry / exit points
MAINTENANCE / REPAIR	Posture / Manual handling Isolation Washdown/clean up Size / Width Access / egress Heights / dropped	Objects weight Discomfort / stress / PPE Visibility / slips / trips Rotating equipment Other
ENVIRONMENTAL CONDITIONS	Extreme weather Temperature Ground Noise	Water Hazardous areas
EXTERNAL / VICINITY INTERFACES	Members of the Public Traffic Adjacent property Power / services	External fire / plans Day / night / weekend Wildlife

TOXICITY / CONTAMINATION	Lead / asbestos Handling Precautions Ventilation Hazardous Materials Corrosion	Dust Biological Ingress Sediment/solids Impurities Material specifications
FIRE / EXPLOSION	Combustible or flammable materials Prevention / detection Fire protection	Emergency procedures Hazardous area
ENVIRONMENTAL IMPACT	Vapor / dust Effluent / noise Seepage/ spill Waste Containment	Temperature Light Hazardous chemical or contaminants Flora and fauna
UTILITIES & SERVICES	Lighting Air / water Fuel / electricity Gas (O_2, N_2 LPG, Cl other)	Communications Waste Recycled
COMMISSION, STARTUP & SHOWDOWN	Requirements Isolations / pathways Sequence	First fills Testing Measurement & recording
SAFETY EQUIPMENT	Personnel protection Safety showers Barriers / guards	Controls &instrumentation Tools
SEQUENCING	Too early Too late Too short Too long Automated / Manual	Black start Interlocks Before After Incorrect sequence
NATURAL HAZARDS	Earthquake Flooding Ice Thunderstorm Lightning	High winds Fire Ambient temperature Rain / Sun
INSPECTION / TESTING	Isolation Access Eliminating	Purging Sampling Measuring
DEMOLITION	Ease Space / access	Issues Documentation
DOCUMENTATION	Operations Maintenance Inspection / testing	Sequence Emergency Records / Reports
QUALITY CONTROL	Inspection / testing Quality assurance	Change of composition
CONSTRUCTION EQUIPMENT	Sequence Laydown areas	Timing / access Simultaneous works