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AUSTRALIAN NATURAL HAZARDS EXPOSURE INFORMATION FRAMEWORK

Guidelines for national consistency and comprehensive information

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EXECUTIVE SUMMARY

Bushfires and Natural Hazards are features of the Australian climate and landscape and will continue to pose a threat (Council of Australian Governments (COAG), 2011). These hazards can have profound personal, social, economic and environmental impacts. The impacts of these disasters demand efforts in planning, preparation, response and recovery to improve community resilience. Disaster management is a collective responsibility of all levels of government, society and businesses and of individuals. For disaster resilience, emergency management planning should consider risk and risk treatments across built, economic, social and environmental assets (COAG, 2011). Exposure 'what is at risk' information is fundamental for assessing risk from natural hazards, and therefore, nationally consistent information is required for evidence-based prioritising and targeting interventions. To address this, consistent methodologies and frameworks are required to enable information sharing and accurate interpretation.

In natural hazards and disaster decision-making, exposure information is a key component and comprises information on people, buildings, infrastructure (transport, energy, communications and water), businesses, hazardous substances, primary and major industries. This report is the outcome of research funded by the Bushfire and Natural Hazards Cooperative Research Centre (CRC) to develop an *Australian Natural Hazards Exposure Information Framework* (ANHEF). The framework is aimed at supporting the development of nationally consistent exposure information systems to enable decision-making in disaster management to be evidence-based. The framework does not emphasise exposure information inventory and access technologies as the technology is advancing quite rapidly and the research aimed to implement this framework with existing information systems. This research has reviewed the current literature and material from information providers, engaged end-users and researchers to determine future requirements, and conducted a gap analysis in availability of required information.

The literature review helped to understand the relevant practices and trends at international, national, regional and local levels. In particular, the review highlights the exposure data requirements to enable researchers to develop

models for better impact analysis. The review has considered significant sources including the Foundation Spatial Data Framework (FSDF), Global Exposure Database for the Global Earthquake Model) HAZUS (United States national consistent methodology to estimate losses from natural hazards) Framework, Hyogo Framework, Sendai Framework and other Australian exposure information frameworks. The review also collates the information requirements needed by decision-makers for response and strategic policy initiatives.

The project conducted an on-line survey of existing exposure information capabilities in Australia to assess existing data and information capabilities for disaster response and recovery. The survey identified significant gaps in the existing data availability and models to translate the raw data into meaningful information for evidenced-based disaster risk response, recovery and reduction decision-making. Overall, a lack of national consistency in existing data and information capabilities is a limiting factor in evidence-based decision-making.

The project also conducted a Stakeholder Engagement Workshop to identify the exposure information needs of researchers and other end-users in Australia. The workshop provided an opportunity for 36 participants, representing decision-makers, emergency managers, planners, researchers, asset managers and the insurance sector, to outline their future requirements. The workshop assisted in understanding how this framework aligns with broader framework objectives of the National Emergency Risk Assessment Guidelines. The research considered Geoscience Australia's (GA) previous exposure workshop reports, and stakeholder engagement has continued with the researchers and subject matter experts. Recommendations have been developed to prepare a standardised, nationally consistent and scalable natural hazards exposure information framework for Australia.

The collective views of data managers, researchers and end-users have formed the basis for exposure information requirements to develop a consistent, standardised exposure information framework that will support vulnerability assessments for disaster risk reduction and socio-economic impact analysis.

The framework presents the exposure elements required to develop information systems to support various phases of disaster risk reduction from a variety of natural hazards at different levels of governance. The document outlines a

generic framework to underpin the abovementioned diverse utilisation and is focused on end-user requirements. Information on particular exposure elements is critical for some end-users and may not be of interest for others. To reduce complexity, the framework categorises the information provision into three levels depending on user requirements such as policy and planning, response and recovery, and research and analysis. ANHEF levels and their aims, description and boundaries are outlined in Chapter 2.

The fundamental information and common elements that underpin the entire exposure framework, such as spatial enablement, land-use categorisation, insurance status and metadata are outlined in Chapter 3.

Buildings are vulnerable from the impact of natural hazards and malevolent acts. The exposure elements of buildings considered are usage, type, structural system, number of storeys, size, age, attachments, replacement value and contents value. End-user and researcher building exposure element requirements, existing data sources and suggestions for the models to derive the information are outlined in Chapter 4.

Infrastructure is the lifeline support for communities, the economy and disaster response. The infrastructure sectors considered are transportation, energy, communication, urban water supply, waste management and hazardous substances. Infrastructure assets are vulnerable to the impact of natural hazards and malevolent acts and also their own failure. The infrastructure sectors exposure element requirements of end-user and researchers, existing data sources and suggestions are outlined in Chapter 5.

Information on heavy industries exposed to natural hazards is critical to the economy and safety of workers. Major industries, particularly the manufacturing sector, are considered within the scope of this exposure component. An industrial site has many unique elements that are at risk and contribute to the value chain of the economy. For major industries, the exposure element requirements of end-users, researchers and the insurance industry, existing data sources and suggestions are outlined in Chapter 6.

The primary industries sector includes agriculture, fishing, forestry and mining. The types of natural hazards or the climatic conditions and factors that impact on this sector in Australia include drought, water security, soil fertility, weeds,

global warming and biosecurity. End-user, researcher and primary industries exposure element requirements, existing data sources and suggestions are outlined in the Chapter 7.

Australian communities are varied in their composition and in their level of exposure to disaster risk (COAG, 2011). Factors that can influence disaster management and resilience include remoteness, population density, mobility, socio-economic status, age profile and communication skills. The population exposure elements requirements of end-users and researchers, existing data sources and suggestions are outlined in Chapter 8.

The business exposure information framework consists of business definition and activities information that is deemed necessary for disaster management. The framework identifies information requirements on business exposure that address issues of business continuity, disruption, resilience and recovery in disaster management. The framework has identified different elements of business and economics exposure for different economic activity levels such as micro and macro-economic levels, through an extensive literature review and subject area expert and stakeholders consultations. The business and broad economics information requirements and list of data custodians are outlined in Chapter 9.

The reliability assessment framework for the exposure information provides knowledge on the data available for end-user decision-making. The exposure information systems source the data from sources with varied resolutions, quality, standards, aggregation, disaggregation, statistical approximations and estimations. The reliability assessment framework primarily adopts the ISO standards data quality evaluation procedure as well as data provenance framework. The reliability assessment attributes are outlined in Chapter 10.

The ANHEF with its comprehensive list of exposure information requirements and existing information sources, State Emergency Services can improve their exposure database capabilities and risk assessment models in disaster response. The improved databases will strengthen operational capabilities in the longer term. These capabilities provide the authorities with situational awareness and support research on impact analysis to assist both tactical and strategic disaster management from multiple hazards.

END-USER STATEMENT

Mark Edwards, *Geoscience Australia, Canberra, ACT*

Emergency services are continuously striving to improve capabilities to strengthen and build disaster resilient communities across Australia. However, each disaster reveals new challenges to our understanding of the increasing exposure and impacts on government, industry and the community as a whole. Reliable and consistent information on natural hazard exposure is important for disaster management and decision making. Completion of the Natural Hazard Exposure Information Framework represents the first attempt at developing a national consistent framework for exposure information, identifying the complex exposure data requirements that are important for enabling a better understanding of vulnerability to natural disasters.

In developing the Natural Hazard Exposure Information Framework, a diverse range of stakeholders and known data custodians were consulted to prepare a holistic view of information requirements. Based on a three-tier structure of user types, the framework describes a comprehensive list of features and exposure elements related to buildings, utilities, infrastructure, population, businesses and primary industries. The framework also catalogues existing sources of information to enable the identification of gaps in current capabilities. To encourage better awareness and knowledge about the reliability of exposure information, guidelines have been included for creating a simplified approach to understanding whether data is fit-for-purpose as well as providing feedback on data performance.

To demonstrate the benefit of applying the exposure information framework, a research utilisation project is currently being undertaken to develop an online information platform to enable the discovery and the access to a broader range of exposure information on a national scale.

This report will serve as a central reference for understanding exposure elements and implementation of the framework in the future will enable organisations to develop robust, reliable, consistent and sustainable exposure information capabilities to assist governments and industry to make evidence based decisions for community safety.

1 INTRODUCTION

Natural disasters in Australia continue to highlight their disastrous impact on various assets and communities. Assets exposed to natural hazards can be categorised into ten major sectors. However, there is no comprehensive information system available in Australia that provides fundamental and consistent information about exposure components and elements of all ten sectors, which include buildings, people, transport, energy, communication, water, hazardous substances, major industries, primary industries, people and businesses, to natural hazards. The absence of a robust and quantitative evidence base is impeding the development and implementation of strategies for disaster management policy and planning. The present study is to develop a Australian Natural Hazards Exposure Information Framework (ANHEF) that links strongly with the National Strategy for Disaster Resilience (COAG, 2011). COAG (2011) states that 'Disaster resilience is the collective responsibility of all sectors of society, including all levels of government, business, the non-government sector and individuals". If all these sectors work together with a united focus and a shared sense of responsibility to improve disaster resilience, they will be far more effective than the individual efforts of any one sector'.

Consistent and reliable information on natural hazard exposure is crucial for disaster risk mitigation and evidence-based decision-making. Exposure is referred to as the elements that have been, or could be, subject to the impact of natural hazards within an area (Middelmann et al., 2007, p. 1). The elements that are at risk include buildings, assets, population, economic activities, services, utilities and infrastructure (Emergency Management Australia (EMA), 2004, p. 48). Describing these elements in a nationally consistent exposure information framework will provide a reliable base to inform decision-making for natural hazard risk reduction. Currently, there are few such capabilities in Australia to provide exposure information; examples include Geoscience Australia's (GA) National Exposure Information System (NEXIS) and a database developed by the Emergency Information Coordination Unit (EICU) in New South Wales. NEXIS was developed with the aim of supporting GA's risk and impact analysis projects and of providing advice for climate change adaptation policy development. It is not comprehensive enough to underpin

the entire spectrum of decision-making for disaster risk reduction. To manage disasters effectively and efficiently, there is a compelling requirement to develop a nationally consistent framework for collection, collation and provision of exposure information for researchers and decision-makers.

1.1 SCOPE OF THE REPORT

This research conducted to develop an Australian Natural Hazards Exposure Information Framework (ANHEF) was funded by the Bushfire and Natural Hazards CRC (BNHCRC). The scope of the report was to prepare an exposure information framework through review of existing literature and reports and international best practice, in collaboration with researchers, end-users and international experts. The report covers the information needs on exposure of ten sectors and proposes national standards for attribution of exposure components and elements and a reliability assessment framework. The research has reviewed the current literature and information providers, engaged end-users and researchers to determine future requirements, and conducted an information gap analysis to inform suggestions.

The literature review assisted in understanding the relevant practices and future trends at international, national, regional and local levels. In particular, the review highlighted the exposure data requirements to enable researchers to develop models for better impact analysis. The review considered significant literature including the Global Exposure Database for the Global Earthquake Model, HAZUS, the Hyogo and Sendai Framework for action and other Australian exposure information frameworks. Please refer to Nadimpalli et al. (2014) for a detailed literature review. The review also contributes to collating the requirements for information of decision-makers for response and strategic policy initiatives.

The research conducted through on-line survey to review the existing exposure information capabilities in Australia to ascertain existing data and information capabilities for Disaster Risk Reduction (DRR). The survey identified significant gaps in the existing data provisions and translation of information for evidence-based disaster risk response, recovery and reduction decision-making. An overall lack of national consistency in existing data and information capabilities is a limiting factor in decision-making.

The Stakeholder Engagement Workshop was conducted to identify the exposure information needs of researchers and end-users in Australia. The workshop provided an opportunity for 36 participants representing decision-makers, emergency managers, urban and regional planners, researchers, infrastructure asset managers and the insurance sector to outline their future requirements. Mind-maps developed and presented at the workshop enabled overlapping concepts and data elements in the ten sectors' disaster exposure information to be observed. The workshop helped in understanding how to align the framework with the broader objectives of the National Emergency Risk Assessment Guidelines (NERAG).

Further, GA's previous exposure workshop reports were also considered in this review. Stakeholder engagement has continued independently with the researchers and subject matter experts. Recommendations were drawn to develop a standardised, nationally consistent and scalable natural hazards exposure information framework for Australia to support vulnerability analysis and assessments for DRR and socio-economic impact.

The ANHEF report will provide a structure for development of exposure information systems around ten sectors: buildings, transport, energy, communication, water, primary industries, large industries, hazardous substances, population and business. The problems identified by COAG (2011) and the BNHCRC under the research priority themes of: Data and Knowledge, Disaster Resilience, Decision Support and Resource Assessment, Emergency Management Practice, and Risk Mitigation Policy and Planning are addressed in the report.

The framework is also scoped to provide guidance for the development of exposure information systems to support researchers and end-users. The framework will provide a reference for researchers' and users' investment priorities. Typically, exposure information is not available as an off-the-shelf product and rigorous modelling is required to integrate data and develop extraction, translation and provision tools.

2 ANHEF END-USER REQUIREMENT LEVELS

Allowing and enabling data generally to be available and used widely would provide enormous benefits, but there are risks involved. Public release of aggregated data on government regulatory activities, for example, may pose a risk, albeit very low, of adverse consequences (Productivity Commission, 2017).

The framework has defined the buildings, infrastructure (transport, energy, communication, water and waste management), industries, primary industries, population and business sectors as exposure components. Further the components are defined into exposure elements. For example, the exposure elements of the buildings are usage, form, structure system, external wall type, roof materials, etc. To gain a national consistency for the information, a set of attributes for each exposure element is proposed. For example, there a set of twenty one external wall types represent the large Australian building stock.

The present framework is a simple and clear way of presenting for all exposure components and elements for researchers and end users. The elements required to develop information systems to support various phases of DRR from a variety of natural hazards at different levels of governance. The report outlines a generic framework that is focused on end-user requirements and underpins better utilisation. Information on some exposure elements is critical for some end-users and may not be of interest for others. For example, floor height of buildings is significant information to assess flood vulnerability but is not normally used for earthquake risk assessment. Some researchers may require building floor height information with centimetre accuracy while qualitative information is good enough for others. To reduce complexity, the framework categorises elements into three levels depending on user information requirements. The levels are defined with a user perspective rather than being driven by the input datasets.

2.1 ANHEF LEVEL 1 DATA DESCRIPTION

ANHEF Level 1 recommends the data useful for situational awareness to develop policy and planning for Commonwealth and State or Territory Governments. The data is required to be aggregated for a defined geographic

area with a combination of the necessary exposure information for buildings, population, business and infrastructure. For example, a combination of building elements such as building type, wall type and roof type, together with the household income profile of people in a given geographic area would be aggregated and made available.

The exposure information available at this level includes derivatives of some of the Australian Statistical Geographic Standard (ASGS) data such as those from Statistical Area 2 (SA2) or larger (SA3 and SA4), State or Territory, Australia, Greater Capital City Statistical Areas (GCCSA), Urban Centres, sections of States, Indigenous Areas, Indigenous Regions and Remoteness Areas. Information derived from non-ASGS geographic areas for this level may include Local Government Areas (LGAs), Postal Areas (POAs), Electorate Boundaries, suburbs and localities, natural resource management regions, Australian drainage divisions and tourism regions. Further, the exposure information systems have to be able to be aggregated to 5 × 5-km or larger grid cells. The infrastructure assets with line geometry for elements such as roads may need to be aggregated in terms of their length or other relevant units of measurement in a defined area.

2.2 ANHEF LEVEL 2 DATA DESCRIPTION

ANHEF Level 2 recommends the data for situational awareness for response and recovery planning for State, Territory and local governments, researchers and the insurance sector. The data would be aggregated for a defined geographic area, with more detailed exposure classifications for buildings, population, business and infrastructure.

The exposure information available at this level includes some of that found in ASGS Statistical Area 1 (SA1), Australian Bureau of Statistics (ABS) Mesh Blocks and Indigenous locations. Categories of information from non-ASGS geographic areas considered for this level include Destination Zones, large buildings and 1 × 1-km or smaller grid cells. The infrastructure assets with line geometry such as roads may need to be aggregated in terms of their length or other relevant units of measurement in a defined area.

The privacy of the information available at this level is critical and needs to be maintained as per the Australian Privacy Principles guidelines (Privacy Act,

1988). The exposure information systems to be enabled for buildings and population numbers of a given classification for a defined area and provide aggregated information. The infrastructure assets with classifications at a more detailed level can be aggregated for a defined area to contain the information within commercial-in-confidence data restrictions.

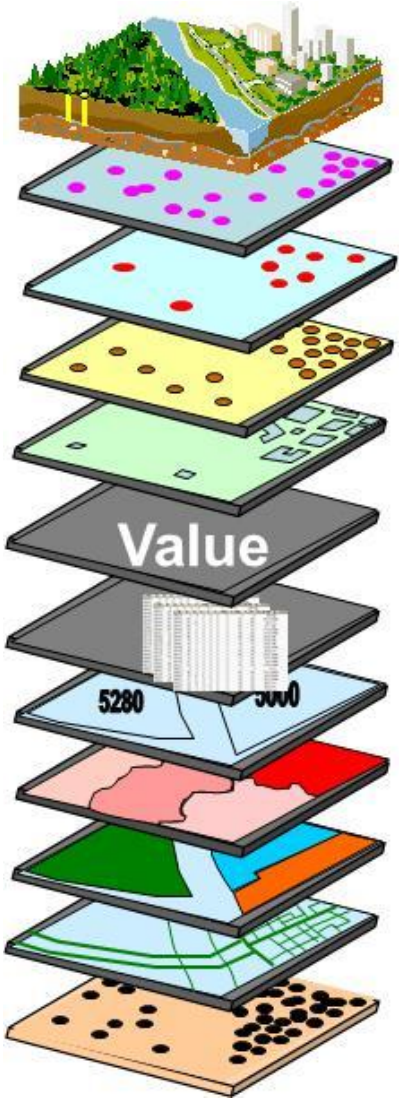
2.3 ANHEF LEVEL 3 DATA DESCRIPTION

ANHEF Level 3 recommends the data useful for research and analysis at the asset or building level, which may be needed to provide more detailed advice for decision-makers. The data sourced for this level must be authoritative, reliable and mapped at the asset or single-building level. This could include attributions such as structural, occupancy and economic variables. The information available at this level supports highly advanced modelling capabilities such as 3D blast and plume models. Further modelling may be required to translate data into 3D geometry suitable for analysis of buildings in central business districts (CBDs). Further, the data may be augmented to support analysis of the spatio-temporal dynamics of people and business activity.

Privacy of the information at this level, as well as its security classification, may require that its access be restricted to nationally significant projects and emergency response activities.

3 FUNDAMENTAL INFORMATION

3.1 LOCATION



Spatial location is a common reference for exposure data inventory, analysis and dissemination. It provides information about where the asset is physically located using a spatial referencing system such as geographic coordinates. Location is a fundamental element for exposure data and provides perspective for decision-making. Exposure information requirements are not in a defined spatial domain; many other subject matter attributes need to be integrated. Therefore, spatialisation of non-spatial data features is critical for the of benefit decision-makers. Once features are attributed a location, the exposure information system can aggregate information of assets for any given geographic area such as disaster footprint or impact zones. Some datasets are available at an aggregated level only (e.g. residential population data from the census) and the exposure information system may need to be able to disaggregate data and distribute its statistical information.

It is well documented by the United Nations Inter-Agency Secretariat of the International Strategy for Disaster Reduction (UNISDR, 2005) that there is a need for disaster risk assessments in the space of urban planning, and management human settlements in disaster-prone areas, in particular highly populated areas and rapidly developing urban settlements. The issues of informal or non-permanent housing and the location of housing in high-risk areas have been raised as priorities, and exposure information systems need to quantify these highly vulnerable elements of the built environment.

There is also an identified need to develop building vulnerability models for different housing locations and types (Stewart and Li, 2009; Henderson and Ginger, 2007) for different wind speed zones, flood categories and earthquake-prone areas. For example, risk analysis for a specific region will require an accurate and detailed probabilistic wind field model capable of considering topographic, terrain roughness and shielding effects. Location information of the assets will enable the alignment of building standards in those areas for the vulnerability model development.

Geocoded addressing is the primary source of data to provide a location once the asset has an address. Geocoded addressing is the process of associating an address with coordinates such as a latitude and longitude to enable it to be readily mapped and related to other spatial data. There are several administrative boundaries from governance and statistical perspectives. These include existing geographic areas such as national, State and local government areas within Australia. The ABS has defined Statistical Areas (SAs), such as SA1 through to SA4 and Mesh Blocks.

Exposure elements required for exposure data collection, collation and provision to users may include:

1. Latitude (degrees decimal or degrees–minutes–seconds)
2. Longitude (degrees decimal or degrees–minutes–seconds)
3. Address (unit number, street number, street name, suburb, state and postcode)
4. Geometry
    a. Point (e.g. address)
    b. Line
    c. Polygon (e.g. building footprint)

Existing Capabilities

Several information systems capture and manage the spatial data required to spatialise exposure information. The significant spatial data sources, custodians and products are summarised in the following table.

Agency	Product Description	Web Link
Public Sector Mapping Agency (PSMA)	Geocoded National Address File (GNAF) that locates addresses in a defined geographic location	https://data.gov.au/dataset/geocoded-national-address-file-g-naf
	Geoscape provides a digital representation of roof outline for urban areas. Additional building features such as zoning, solar panels, adjacent swimming pools, roof materials, and linkages with address, cadastre and other geospatial foundations will be added in the future	https://www.psma.com.au/blog/news/geoscape-has-arrived http://www.navigate.com.au/navigate/geoscape-r1-released
	CadLite (Cadaster) provides spatial representation and information about legal land parcels across Australia. This dataset is a graphical index of digital cadastral boundaries	https://www.psma.com.au/products/cadlite
Geoscience Australia	NEXIS used the GNAF, rural buildings survey database and many other sources to define buildings locations across Australia. The data is available for public use at an aggregated level	http://www.ga.gov.au/scientific-topics/hazards/risk-impact/nexis
	Foundational Spatial Data Framework provides metadata and spatial data discoverability	http://www.fsdf.org.au
LANDGATE, (WA)	Locate – WA spatial data portal	https://maps.slip.wa.gov.au/landgate/locate/
Tasmania	Land Information System (TheLIST) is spatial information portal of state government Department of Primary Industries, Parks, Water and Environment (DPIPWE) maintains the system.	https://www.thelist.tas.gov.au/app/content/home
South Australia Open Data Portal	SA is the South Australian Government's Open Data Portal. The portal is managed by the Department of the Premier and Cabinet, Office for ICT and Digital Transformation	https://data.sa.gov.au/data/dataset/residential-dwellings http://www.environment.sa.gov.au/Science/Information_data
Dept. Natural Resource Management (DNRM), Queensland	Spatial – gives the public access to view and download geospatial data and information	https://www.business.qld.gov.au/running-business/support-assistance/mapping-data-imagery/data/qspatial
ACT Planning (ACTPLA)	ACTMAPi – provides online block and section maps of Canberra and the ACT, planning, surveying and development information	http://www.actmapi.act.gov.au/
Finance, Services and Innovation (NSW)	NSW Cadastre is web service of Digital Cadastral Database (DCDB) to provide access to a state wide integrated database and a component of the foundation spatial datasets	http://spatialservices.finance.nsw.gov.au/mapping_and_imagery/lpi_web_services
EICU (NSW)	Emergency Information Coordination Unit maintains and provides detailed exposure information for emergency response in NSW	Exclusively for emergency management authorities
Local Government Jurisdictions	Only some major local governments have spatial data provisions online	

Gaps and Suggestions

There is no asset-level location information available for researchers and decision-makers across the nation. Spatial location of both tangible and non-

tangible assets is critical in deriving exposure information for a given area. The location of buildings, infrastructure, population and business assets and their exposure parameters are not available in a central database.

Some state jurisdictions such as Tasmania, South Australia, ACT and the Northern Territory have building location information captured for most of their building stock. NSW and Queensland have no state-level building locations database available, although some limited information about properties can be drawn from their cadastre system.

Geoscape, from PSMA, has a roof outline database for major cities but rural properties are not covered. Some major local governments, like the City of Sydney Council, have authenticated and authoritative data on the location of the assets in their jurisdiction. Many small local governments do not have sufficient resources to collect and maintain location information at the asset level.

3.2 LAND USE

Land-use and land-management practices have a profound impact on natural resources (water, soil, nutrients, plants and animals), agricultural production and the built environment. Information about land use and management is useful for agriculture audits, biosecurity, monitoring and evaluation of impacts on natural resources from disasters. This information is also required for assessing land degradation, drought and sedimentation from natural hazards. The availability of consistent and reliable spatial information regarding land use is critical for sustainable natural resource management at various levels of governments, and for regional, industry and community groups and land managers. Australia has well-defined land use plans prepared by local governments.

The Australian Land-Use and Management (ALUM) Classification system provides a nationally consistent method to collect and present land use information for a wide range of users across Australia. There are some gaps in the land-use classes at a local level.

The framework recommends adoption of the ALUM classification; more details are available at

http://www.agriculture.gov.au/abares/aclump/Documents/ALUM_Classification_V7_May_2010_summary.pdf

http://www.agriculture.gov.au/abares/aclump/Documents/ALUM_Classification_V7_May_2010_detailed.pdf

Existing Capabilities

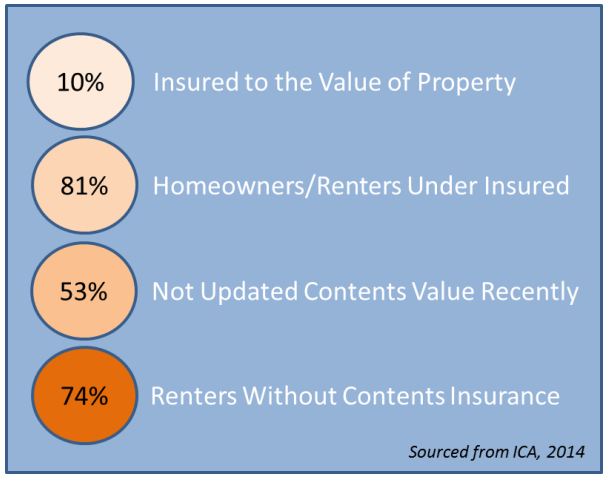
Agency	Product Description	Web Link
Agriculture and Water Resources (ABARES)	Australia Land-Use Map – national scale and catchment scale: the ALUM Classification system	http://www.agriculture.gov.au/abares/aclump/land-use/data-download
ACT Planning (ACTPLA)	ACTMAPi – provides land-use information on block and section maps of ACT	http://www.actmapi.act.gov.au
DNRM, QLD	QLUMP – maintains 'current and historic' land-use data	https://www.qld.gov.au/environment/land/vegetation/mapping/qlump-datasets/
Department of Infrastructure and Planning, Northern Territory	Natural Resource (NR) Maps Northern Territory (NT) is a web mapping tool to discover, research and map natural and cultural research data	https://nt.gov.au/environment/environment-data-maps/natural-resource-maps-nt
Department of Environment, Land, Water and Planning, Land, VIC	VicMap – authoritative spatial data: land management, location decisions, marketing, planning, procurement, mapping and more	http://services.land.vic.gov.au/landchannel/content/productCatalogue
PSMA	The cadastre spatial data distributed through PSMA has land-use information that is sourced from many local and state governments	

Gaps and Suggestions

The land-use plans and other information are available for decision-makers at ANHEF Level 1. Level 2 requires the data at catchment scale. The cadastre datasets do not provide land-use information mapped in accordance with the ALUM Classification but cadastral information can be used to derive land-use indicators to inform exposure information.

3.3 INSURANCE STATUS

Disaster-affected communities face a huge task in rebuilding assets and businesses and supporting people. The vast majority (81%) of homeowners / renters are exposed to significant financial loss because their insurance does not cover them to resume the same standard of living in the event of a crisis (Insurance Council of Australia, 2014).



Insurance payments are significant financial contributors to rebuilding and resilience efforts. An appropriate level of insurance cover improves the resilience of households, businesses, asset managers and governments after a disaster.

Under the National Disaster Relief and Recovery Arrangements (NDRRA), State and Territory Governments are required to have adequate capital or insurance to fund the replacement or restoration of essential public infrastructure.

Many insurance companies do not automatically provide cover for flood (Flood Insurance Guide, 2012). The Federal Government announced the Natural Disaster Insurance Review (NDIR) in 2011 into the availability and affordability of insurance for floods. A key outcome of this review is the Government's support for homes exposed to high flood risk through a Flood Insurance Pool.

The insurance status information requirement applies to all ten sectors of exposure information, i.e. buildings, transport, energy, communication, water, primary industries, large industries, hazardous, population and business assets. Hence, it is considered in the fundamental category of exposure data.

Insurance is available for the following:

1. People
    a. Life insurance
    b. Income protection insurance

    c. Health insurance
    d. Travel insurance

2. Householders
    a. Buildings insurance
    b. Contents insurance
    c. Car insurance
3. Business
    a. Workers' compensation
    b. Professional indemnity insurance
    c. Liability insurance
    d. Business continuity
4. Government
    a. State-owned assets
    b. Flood cover insurance
    c. Malevolent cover insurance
    d. Compulsory third party motor
    e. Public liability insurance
5. Insurance companies
    a. Re-insurance

For the ANHEF the following information at the asset level on insurance status is also useful in assessing resilience:

1. Insurance cover status
    a. No insurance
    b. Under-insured
    c. Optimum
    d. Comprehensive

Existing Capabilities

The Insurance Council of Australia (ICA) is the representative body of the general insurance industry in Australia. Insurance Council members, both insurers and reinsurers, are a significant part of the Australian financial services system. ICA has several projects assisting the insurance sector in Australia and has many relevant datasets to improve exposure information. Insurance companies such as Insurance Group of Australia (IAG) have insurance portfolio data but this is commercial-in-confidence and not available in the public domain. Re-insurance companies, such as AIR Worldwide, have developed exposure information systems using their proprietary data for internal use, which is thus not in available for public use. The following table provides a snapshot of exposure information.

Agency	Product Description	Web Link
Insurance Council of Australia	General Insurance Statistics	http://www.insurancecouncil.com.au/industry-statistics-data/GI-statistics
	DataGlobe	http://www.icadataglobe.com/
	Property Resilience and Exposure Program – PREP	http://www.insurancecouncil.com.au/affordability
Insurance Group of Australia, GE Insurance, AON Re, RMS, etc.	Portfolio data is not in the public domain	
Comcover	Commonwealth Assets – not available in the public domain	http://www.finance.gov.au/comcover/insurance/
Victoria Managed Insurance Authority	Data is not available in the public domain	https://www.vmia.vic.gov.au/
Understand Insurance	Knowledge of insurance schemes, claims, providers, etc.	http://understandinsurance.com.au/
State-owned insurance authorities hold their own portfolio data		

Gaps and Suggestions

Data on insurance status for people is always linked with privacy concerns and is difficult to collate. Even though this information is highly important for assessing people's resilience to disasters, the information is not accessible to researchers and policy-makers.

Comparing insurance portfolio data and the replacement value of buildings estimates from NEXIS would provide an overview of the assets' insurance status for a defined geographic area. A replacement value estimate of infrastructure assets is not available in the public domain from the relevant sector.

Asset managers including government organisations may have an estimated value of their assets. The Victoria Managed Insurance Authority provides risk and insurance services to the Victorian Government. However, the value of assets information is not in the public domain.

The ICA or similar authority need to take the initiative to collect and provide aggregated insurance portfolio data or sample data for exposure information capabilities so that the insurance status of people and assets and any consequences can be extrapolated.

3.4 METADATA

Metadata is often called 'data about data'. The development of metadata standards improves the quality, relevance, consistency and availability of data. Metadata consists of the data definitions and standards.

The exposure framework has identified the following minimum metadata attributes required to understand input data:

1. Keywords
2. Geometry
3. Feature type
4. Definition
5. Data source
6. Spatial accuracy
7. Attribute reliability
8. Attribute source
9. Attribute accuracy
10. Data currency
11. Maintenance cycle
12. Revision date
13. Limitations
14. Restrictions
15. Contacts

Existing Capabilities

Metadata for buildings, population, business and infrastructure data is collected and maintained by various government and non-government

organisations for diverse purposes. The standards, definitions and provision of access vary significantly. A number of standard classifications exist for industry, business and geographical areas that are widely accepted. However, standards have not been developed for exposure data elements.

Foundation Spatial Data Framework (FSDF) has released a spatial data discoverability tool, http://www.fsdf.org.au, for end-users. This enables end-users to assess the status, provenance and custodians of the required spatial data.

Gaps and Suggestions

The need for consistency of meaning is vital to facilitate information sharing among primary and secondary users of the data. Exposure data attribute definitions and standards, data dictionaries and a reliability assessment framework need to be developed at a detailed level for framework utilisation or implementation. Much of the work involved in establishing a data collection is in the development of metadata standards to ensure comparability and consistency. The present project will prepare these standards in consultation with data custodians, data providers, standards developers, subject matter experts and end-users in its next phase. This will enable the future exposure information systems to be transparent and consistent. The project is further developing a data reliability framework in its next phase and will provide guidelines for metadata standards.

4 BUILDING EXPOSURE INFORMATION

Buildings can be vulnerable to the extreme forces produced by natural hazards. Details of building components and elements including usage, type, structural system, foundation type, internal frame, external walls, façade, roof, height, size, age, architectural features and finishes and replacement value are required to analyse and assess likely impact and risk from natural hazards. These building components are considered further as exposure elements and discussed below. Further, these elements are defined to standard attribute level in framework. The purpose of defining the buildings' exposure attributes is to enable researchers to group them into a set of classes to which vulnerability models can be assigned. Damage and loss prediction models can then be developed for all representative building types. Building exposure information also underpins disaster mitigation and urban planning.

4.1 BUILDING USAGE

Building usage is defined as the purpose for which the building is presently used, such as residential, commercial, light industrial or institutional. Building usage, or occupancy, is important in understanding the exposure profile. Buildings may be constructed for a specific usage or their usage may vary with time, and building attributes may vary depending on usage.

Building usage information is important for disaster prevention, preparedness, response and recovery (PPRR) decision-making and impact assessment. It also supports estimation of the time–space population exposure to disasters, such as daytime population, night-time population and the population demographic or disability composition content of the building. This information is required by end-users for tactical response and planning for all natural hazards. Researchers need this information for analysis to derive meaningful information for other unknown variables and also for sustainable urban planning. After consultation with several end-users and researchers, a comprehensive list of building usage attributes is proposed in the following table.

Component	Element	Attribute
Usage	Residential	Single Dwelling
		Multiple Dwelling
		Temporary Lodging, Dormitory

	Commercial	Office
		Retail
		Shopping Mall Complex
		Restaurants & Cafes
		Cinemas
		Parking
		Automotive Dealerships
		Data Centres
		Service station
		Hotels
	Light Industrial	Manufacturing
		Services
	Educational Facilities	Kindergartens
		Pre-Schools
		Primary Schools
		Secondary Schools
		Special Schools
		Tertiary Institutions
		Technical Colleges
		Community College
		Research Laboratories
	Health & Welfare Facilities	Health Centres
		Medical Centres
		Dental Clinics
		Hospitals
		Psychiatric Facilities
		Dental Hospitals
		Respite Centres
		Hospices
		Nursing Homes
		Aged-Care facilities
		Childcare Centres
		Disability Support Services
		Veterinary Services
	Emergency Services	Police Stations
		Water Police Facilities
		Fire Stations
		Marine Fire Stations
		State Emergency Service Depots
		Ambulance Stations

		Aviation Fire & Rescue Stations
		Marine Rescue or Coast Guard Stations
		Surf Life Saving Clubs
		Aero-Medical and Rescue Facilities
	Government Buildings	Parliament Buildings or Council Chambers
		Government Houses – Accommodation
		Customer Service Centres
		Administration Centres
		Law Courts
		Field Operations Depots
		Scientific and Research Laboratories
		Correctional and Detention Facilities
		Australian Defence Force Barracks, Bases and Facilities
		Archive and Storage Facilities
		Transport Facilities
	Community Facilities	Community Centres
		Service Clubs
		Ethnic Society Clubs
		Sporting Clubs
		Exhibition Centres
		Arts Centres
		Places of Worship
		Cemeteries or Crematoria
		Public Libraries
	Recreational Facilities	Outdoor Stadiums
		Indoor Stadiums
		Outdoor Sports Centres
		Indoor Sports Centres
		Amateur Sports Grounds
		Race Tracks
		Shooting Ranges
		Sporting Clubs
		Aquatic Sports Centres
		Amusement Parks
		Parks and Gardens
	Mixed Use – Primary	
	Mixed Use – Secondary	
	Mixed Use – Tertiary	

Existing Capabilities

There is no information system in Australia that provides building usage information across the nation and is not consistent as proposed exposure elements and attributes. The following table provides a snapshot of currently available sources of building usage data.

Agency	Product Description	Web Link
Geoscience Australia	NEXIS – Geoscience Australia has sourced building usage information from various sources and incorporated it into the exposure database	http://www.ga.gov.au/scientific-topics/hazards/risk-impact/nexis
ABS	ASGS Mesh Blocks are the smallest geographical area and broadly reflect land-use categories such as residential, commercial, education	http://www.abs.gov.au/websitedbs/censushome.nsf/home/datapacks
PSMA	GNAF has an address database that provides some details about the usage of buildings or assets. This information is not complete for the entire set of address records	https://data.gov.au/dataset/geocoded-national-address-file-g-naf
	CadLite (Cadaster) provides land-use categories of land parcels across Australia	https://www.psma.com.au/products/cadlite
Department of Health and Ageing	MyHospitals Database	http://www.myhospitals.gov.au/about-the-data/overview
Department of Education	MySchools Database has list of schools and their locations	https://www.myschool.edu.au/
LANDGATE (WA)	Valuer General's Database provides building usage data for WA. This data may not be available on the website	https://maps.slip.wa.gov.au/landgate/locate/
DPIPWE (TAS)	Land Information System (TheLIST) has the building usage information for Tasmania	https://www.thelist.tas.gov.au/app/content/home
DPTI (SA)	Buildings database is available from the department. It is not a standard product available on the website	http://www.saplanningportal.sa.gov.au/
ACT Planning (ACTPLA)	ACTMAPi – provides information on the use of land parcels in ACT	http://www.actmapi.act.gov.au/
Finance, Services and Innovation (NSW)	NSW Cadastre is web service of DCDB	http://spatialservices.finance.nsw.gov.au/mapping_and_imagery/lpi_web_services
EICU (NSW)	EICU maintains and provides detailed exposure information for emergency response in NSW	Exclusively for emergency management authorities
Local Government Jurisdictions	Only some major local governments have spatial data provisions online	

Gaps and Suggestions

ABS Mesh blocks provide a reasonable level of urban land-use information but this is not comprehensive enough for informing risk and impact analysis for DRR.

NEXIS provides aggregated building usage information at the SA1 level and counts of residential and light-industrial buildings. The information in NEXIS is reasonably reliable for buildings in urban areas, but there are gaps in the information for rural areas of some states and some categories of buildings. Further investment is required to develop an exposure database for all buildings.

Tasmania, South Australia and the ACT have building usage information captured for most of their building stock. The Northern Territory has good building footprint data but has limited information on building usage. NSW and Queensland have no state-level building usage databases available, although some limited information can be drawn from their cadastre system and properties database. This can be used as a sample and is useful for extrapolation for the entire building stock. MySchools, MyHospitals and other datasets provide comprehensive information for public assets, but limited information is available for privately owned facilities.

The Census of Land Use and Employment (CLUE) provides comprehensive information about land use and employment, but it is only available for Melbourne City

Mixed-use buildings are defined as any urban or suburban building that blends a combination of residential, commercial, cultural, institutional or industrial uses. There is no single source of data to provide information on building usage for mixed-use buildings. This gap creates a bias in the existing information systems.

There is no exposure information source that provides reliable information at ANHEF level 3 except for the City of Melbourne and Sydney CBD.

4.2 BUILDING FORM

Every building is different depending on its functionality, look, size, materials and design. Houses can be built in a large variety of configurations. A basic

division is between free-standing or single-family houses and various forms of attached or multi-user dwellings. Both may vary greatly in scale and amount of accommodation provided.

Building form has a major influence on every individual, as it provides the homes in which we live, the places in which most of us work and play, and our schools and hospitals, which are all exposed and vulnerable to natural hazards. There is an identified need for building form information to develop building vulnerability models for different construction techniques (and materials), age profiles, code specifications, compliance and enforcement, changes in exposure categories (e.g. effect of increased urbanisation) (Stewart and Li, 2009; Henderson and Ginger, 2007). The ABS defines only a few building forms for residential dwellings.

Building form information is required by end-users for tactical response and planning for all natural hazards. Researchers need this information to understand the current building stock to derive meaningful information for vulnerability assessment and also for sustainable urban planning.

The framework suggests the list of building forms outlined in the following table to cover all building stock in Australia.

Component	Element	Attribute
Building Form	Building Form	Separate Houses
		Semi-Detached Houses
		Low-Rise Apartments
		Medium-Rise Apartments
		High-Rise Apartments
		Shopping Mall Complexes
		Warehouses
		Light-Industrial Buildings
		Parking Structures
		Monuments, Heritage Buildings
		Heavy-Industrial Structures
		Complex Buildings

However, the standard commercial or institutional building forms could also include the many buildings representing a single institution such as universities, schools, hospitals and sports precincts, or one building containing many

institutions, as are normally found in the CBD locations where a multi-storey building houses multiple institutions.

Existing Capabilities

Residential building forms or types are collected regularly through the census but this is not for all types of buildings. Valuer General Offices of various states collect this information for taxation purposes at the building level but the terminology does not follow a standard and is not consistent nationwide. Some commercial data vendors also collect data for city buildings but this is not available in the public domain. The following table provides a snapshot of currently available sources of building forms data.

Agency	Product Description	Web Link
Geoscience Australia	NEXIS – Geoscience Australia has sourced building form information from various sources	http://www.ga.gov.au/scientific-topics/hazards/risk-impact/nexis
ABS	Housing and population census collects data about Separate Houses, Semi-Detached, Apartment Buildings with 2 or 3 or 4+ storeys. It provides aggregated building form information for SA1	http://www.abs.gov.au/websitedbs/censushome.nsf/home/datapacks
LANDGATE (WA)	Valuer General's Database provides building form data for WA. This data may not be available on the website	https://maps.slip.wa.gov.au/landgate/locate/
DPIPWE (TAS)	Land Information System (TheLIST) has the building form information for Tasmania	https://www.thelist.tas.gov.au/app/content/home
DPTI (SA)	Buildings database is available from the department. It is not a standard product available on the website	http://www.saplanningportal.sa.gov.au/
EICU (NSW)	EICU maintains and provides detailed exposure information for emergency response in NSW	Exclusively for emergency management authorities
Local Government Jurisdictions	Only some major local governments have spatial data provisions online	

Gaps and Suggestions

No single dataset provides the information across the nation classified by the Australian building forms outlined in the ANHEF. Some information is available from large councils and where surveyed by particular research projects.

There is a significant gap in providing building form information at the national, state and small-area level that can be bridged using ABS Census of Population and Housing information.

More information and knowledge about building usage and forms can be accessed at https://en.wikipedia.org/wiki/List_of_building_types

4.3 NUMBER OF STOREYS ABOVE GROUND

Number of storeys above ground dictates the height of the building if this is not known from any other data. The number of storeys can be used to determine the building's total floor area or the size of the building for estimation of replacement value and number of people in the building, etc.

Existing Capabilities

The number of storeys data is collected as part of the housing and population census for residential buildings only. Valuer General Offices of various states collect this information for taxation purposes at the building level but the terminology used is not consistent nationwide. Some commercial data vendors also collect the data for city buildings but this is not available in the public domain. The following table provides a snapshot of currently available sources of the number of storeys data.

Agency	Product Description	Web Link
Geoscience Australia	NEXIS – Geoscience Australia has sourced number of storeys information from various sources	http://www.ga.gov.au/scientific-topics/hazards/risk-impact/nexis
	CBD Survey – GA conducted an engineering survey of city buildings in collaboration with other partners	Not available as a product
ABS	Housing and population census collects the data about Separate Houses, Semi-Detached, Apartment Buildings with 2 or 3 or 4+ storeys. It provides aggregated building form information for SA1	http://www.abs.gov.au/websitedbs/censushome.nsf/home/datapacks
LANDGATE (WA)	Valuer General's Database provides the building number of storeys data for WA. This data may not be available on the website	https://maps.slip.wa.gov.au/landgate/locate/
DPIPWE (TAS)	Land Information System (TheLIST) has the building number of storeys for Tasmania	https://www.thelist.tas.gov.au/app/content/home
DPTI (SA)	Buildings database is available from the department. It is not a standard product available on the website	http://www.saplanningportal.sa.gov.au/
EICU (NSW)	EICU maintains and provides detailed	Exclusively for emergency management authorities

	exposure information for emergency response in NSW	
Corelogic	Cityscope – provides detailed information on commercial properties for all major CBDs. Licensing restrictions	https://www.corelogic.com.au/products/cityscope
Private Data Custodians	RP Data, Australian Property Monitors, banks, mortgage companies, etc., have this data Commercial-in-confidence	
Local Government Jurisdictions	Only some major local governments have spatial data provisions online	

Gaps and Suggestions

There are no datasets that provide the number of storeys consistently across the nation in Australia.

The ABS Census provides information on the number of buildings with numbers of storeys for residential buildings that can be aggregated at national, state, ASGS SA2 and SA1 geographic areas. The number of storeys in ABS is classified as 2, 3 and 4 or more storeys.

Geoscience Australia collected number of storeys through engineering survey in CBD area of major cities. The data is not available as a product in the public domain. This is aggregated into 2, 3 and 4+ storeys for residential buildings (following the ABS classification), into 1–3, 4–7, 8–35 and 36+ storeys for commercial buildings and into 1 and 2+ storeys for industrial buildings. Institutional building classification has not been defined. NEXIS provides information on the number of buildings with number of storeys for residential buildings aggregated at the national, state, and ASGS SA 2 and SA1 geographic areas.

Both these datasets derive the information from different sources and processes. Some states such as Tasmania and South Australia have this information at individual building level and other states have no information on number of storeys.

Geoscience Australia and the Attorney General's Department have conducted exposure surveys of the CBD areas of major cities in Australia and collected information on the number of storeys for CBD buildings. Commercial datasets like Cityscope have number of storeys data covering major city centres but the data is available under commercial licensing conditions.

4.4 NUMBER OF BASEMENT LEVELS

The information on number of basement levels determines the building's total floor area for estimation of replacement value, building population, number of car parks, etc. In general, basements are constructed in multi-storey high-rise buildings. A single-level basement is very common in 1-4-storey apartments and commercial buildings for car parking. Multi-level basements are generally found in city buildings. This information is critical to determine flood impact on inundated floor area.

Existing Capabilities

Data on the number of basements is collected by some large councils, such as the City of Sydney. The following table provides a snapshot of currently available sources of the number of basements data.

Agency	Product Description	Web Link
Geoscience Australia	CBD Survey – GA conducted engineering survey of city buildings in collaboration with other partners	Not available as a product
LANDGATE (WA)	Valuer Generals Database provides the building basement data for WA. This data may not be available on the website	https://maps.slip.wa.gov.au/landgate/locate/
EICU (NSW)	Emergency Information Coordination Unit maintains and provides detailed exposure information for the emergency response in NSW	Exclusively for emergency management authorities
Corelogic	Cityscope – provides detailed information on commercial properties for all major CBDs Licensing restrictions	https://www.corelogic.com.au/products/cityscope
Private Data Custodians	RP Data, Australian Property Monitors, banks, mortgage companies, etc., have this data Commercial-in-confidence	
Local Government Jurisdictions	Only some major local governments such as the City of Sydney, Melbourne City Council, have this data available	

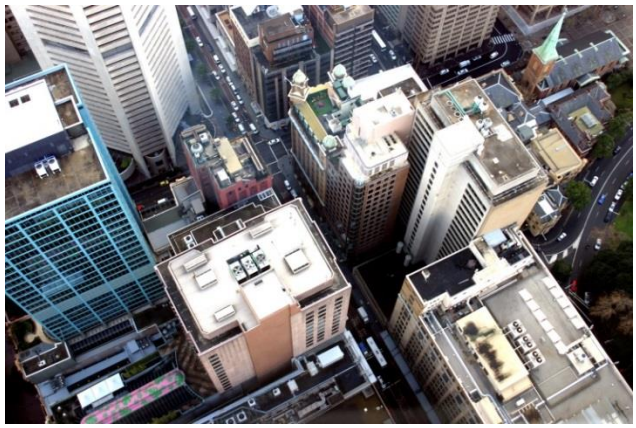
Gaps and Suggestions

There is no centralised database providing this information for researchers. Cityscope provides this data for major city centres but applies commercial licensing conditions on its use. Number of basements data is available with

building plan approval authorities in local councils. Some of this information can be derived using expert knowledge.

4.5 BUILDING HEIGHT

If the number of storeys is not known, building height can be used to determine the building's total floor area for estimation of replacement value, building population, etc.



Gaps and Suggestions

There is no centralised database providing this information for researchers. The building height can be derived using raw LiDAR data. Geoscape from PSMA are likely to incorporating in the future.

4.6 STOREY HEIGHT

Storey height is used in flood impact analyses to determine the portion of wall height inundated. It is used to estimate building height if not known from other sources.

Gaps and Suggestions

There is no centralised database providing this information for researchers. This can be derived once the building height and number of storeys are known. Year built data can provide the floor height information for the ground and upper levels.

4.7 GROUND-FLOOR STOREY HEIGHT

This is used in flood impact analyses to determine the portion of wall height inundated.

Gaps and Suggestions

There is no centralised database providing this information for researchers.

4.8 GROUND FLOOR HEIGHT ABOVE EXTERNAL GROUND

Ground floor height above external ground is used in flood impact analyses to determine which buildings have over-floor inundation.

Gaps and Suggestions

There is no centralised database providing this information for researchers. GA completed the floor height data for some areas as part of the post disaster survey and flood impact studies in parts of Sydney.

4.9 FOOTPRINT AREA

Building footprint is useful to determine building total floor area for estimation of replacement value, building population, etc.

Existing Capabilities

Building roof print data is provided by PSMA in its new product Geoscape. Building footprint data is available in PSMA Cadastre as another layer for some parts of Australia. Many local councils have building footprint data, which is also available on Google Maps.

Gaps and Suggestions

There is no centralised database providing this information for researchers.

4.10 STRUCTURAL SYSTEMS

A building's structural system is a combination of several components that act together to resist the loads imposed on it. Information about the structural system is central to assessing the structural vulnerability of a building from various hazards.

The structural system of the building will affect its replacement cost. As an example, with other aspects being equal, a building constructed using a

braced steel frame will have a different cost to a similar building built using reinforced masonry.

Numerous classifications of structural systems have been prepared, each tailored to the specific use for which it was created. Typically, no one classification is suitable for all Australian building types. The classification presented below may serve as a starting point from which researchers may develop project-specific classifications.

Steel Structures	Concrete Structures	Timber Structures	Masonry Structures
Special moment-resisting frames	Special moment-resisting frames	Shear walls	Close-spaced reinforced masonry
Intermediate moment-resisting frames	Intermediate moment-resisting frames	Braced frames	Wide-spaced reinforced masonry
Ordinary moment-resisting frames	Ordinary moment-resisting frames	Moment frames	Unreinforced masonry – solid masonry
Moderately ductile concentrically braced frames	Ductile coupled walls	Domestic residential timber frame with masonry veneer	Unreinforced masonry – cavity masonry
Limited ductile concentrically braced frames	Ductile partially coupled walls	Domestic residential timber frame with light cladding	
Fully ductile eccentrically braced frames	Ductile shear walls		
Steel portal frame	Limited ductile shear walls		
Steel light frame	Ordinary Moment Resisting Frame in combination with limited ductile shear walls		
	Precast concrete frame with concrete shear walls		
	Tilt-up panel construction		

Existing Capabilities

The structural system of buildings is highly technical and no data custodian collects that level of information in Australia. The building approval authorities

collect this information but do not provide as a service. The following table provides a snapshot of currently available sources of structural systems data.

Agency	Product Description	Web Link
Geoscience Australia	NEXIS – Geoscience Australia has sourced number of stories information from various sources	http://www.ga.gov.au/scientific-topics/hazards/risk-impact/nexis
	CBD Survey – GA conducted engineering survey of city buildings in collaboration with other partners	Not available as a product
ABS	Housing and population census collects the data about wall type, roof type, etc., aggregated to SA1 level	http://www.abs.gov.au/websitedbs/censushome.nsf/home/datapacks
EICU (NSW)	EICU maintains and provides detailed exposure information for emergency response in NSW	Exclusively for emergency management authorities
Corelogic	Cityscope – provides detailed information on commercial properties for all major CBDs Licensing restrictions	https://www.corelogic.com.au/products/cityscope
Private Data Custodians	RP Data, Australian Property Monitors, Banks, Mortgage companies, etc., have this data	

Gaps and Suggestions

There is no centralised database providing this information for researchers and no data custodian collects and maintains a comprehensive level of structure type data for all buildings across Australia. Structural engineers can develop a model to derive the system information from other building parameters such as year of construction, height and size.

4.11 FOUNDATION TYPE

The foundation of the building is part of the structural system and it is important information for the assessment of earthquake vulnerability. Some building taxonomies include foundation type in their list of attributes. To date, no Australian building taxonomy has included foundation type; however, it could be used in earthquake impact assessment to determine a building's vulnerability to earthquake in the event of liquefaction of the supporting soil. The proposed attribute values are:

1. Piled foundations
2. Spread footings (pad and strip foundations)
3. Raft foundations

Gaps and Suggestions

There is no centralised database providing this information for researchers. Data may be available with planning approval authorities of local councils. The available data may not be in an easily accessible, suitable format. Some of this information can be derived using expert knowledge.

4.12 SITE SOIL CLASS

The site soil class can be used for assessment of earthquake impact. The proposed classification is that presented in Australian Standard AS1170.4 (2007).

Class Ae – Strong Rock

Class Be – Rock

Class Ce – Shallow soil

Class De – Deep or soft soil

Class Ee – Very soft soil

Gaps and Suggestions

Local councils collect this information in their planning approvals at the local scale. There is no centralised database providing this information for researchers.

4.13 EXTERNAL WALL TYPE

External walls provide a barrier against the elements and may support the roof and any upper storeys. The analysis of some hazards may require recording of external wall type at a higher resolution than a single attribute for the entire building. After consultation with several end-users and researchers, a comprehensive list of building external wall type attributes is proposed in the following table.

Component	Element	Attribute
External Wall	External Wall	Cavity and Solid Masonry, load-bearing
		Cavity and Solid Masonry, non-load-bearing
		Veneer Masonry
		Timber
		Metal Sheeting
		Fibre Cement

		Mudbrick or Rammed Earth, load-bearing
		Mudbrick or Rammed Earth, non-load-bearing
		Synthetic
		Curtain Wall
		Double facade
		Planar Wall
		Foyer Wall
		Shop Front
		Balcony
		Composite
		Terracotta
		Copper
		Precast Panel load-bearing
		Precast Panel non-load-bearing
		Insitu Concrete

Existing Capabilities

External wall-type data is collected as part of the housing and population census for residential buildings only. Valuer General Offices of various states collect this information for taxation purposes at the building level but the terminology used is not consistent across all states and local governments. Some commercial data vendors also collect the data for city buildings but it is not available in the public domain. The following table provides a snapshot of currently available sources of external wall type data.

Agency	Product Description	Web Link
Geoscience Australia	NEXIS – sourced wall type information from various sources. The data is estimated using statistical extrapolation in the absence of authoritative sources	http://www.ga.gov.au/scientific-topics/hazards/risk-impact/nexis
ABS	Housing and population census collects the data about four wall types. It provides aggregated wall type data for SA1 and SA2	http://www.abs.gov.au/websitedbs/censushome.nsf/home/datapacks
LANDGATE (WA)	Valuer General's Database provides wall type data for WA. This data may not be available on the website	https://maps.slip.wa.gov.au/landgate/locate/
DPIPWE (TAS)	Land Information System (TheLIST) has wall type data for Tasmania	https://www.thelist.tas.gov.au/app/content/home
DPTI (SA)	Buildings database is available from the department. It is not a standard product available on the website	http://www.saplanningportal.sa.gov.au/
EICU (NSW)	EICU maintains and provides detailed exposure information for emergency response in NSW	Exclusively for emergency management authorities

Gaps and Suggestions

There are no standard external wall types defined in Australia and the external wall-type data is not collected using one standard approach. The 2011 census provides external wall-type data aggregated to the SA2 geographic area level and that has only four wall types. GA NEXIS has collated the external wall-type data for residential buildings using the best available data source. NEXIS sourced this data from State governments who maintained building data. For the rest of the country, a desktop survey was conducted and extrapolated statistically for the entire building stock in those areas. National consistency for wall type classes is missing to collect and maintain the data.

4.14 BUILDING ROOF SHAPE

The shape, pitch (angle of slopes) and materials used for a roof depend on the snow, rainfall and wind it is likely to be subjected to as well as the architectural character of the building. The shape of the roof and its attributes are defined as follows:

Component	Element	Attribute
Roof Shape	Roof Shape	Gabled
		Flat
		Hip
		Clerestory
		Arched
		Sawtooth
		Curved
		Domed
		Skillion
		Mansard
		Mixed

Gaps and Suggestions

There is no information available in the public domain about building roof shape. This information can be derived using Lidar raw data and spatial model development is required.

4.15 BUILDING ROOF MATERIAL

Like building roof shape, roof material is also determined by the climate, environment, availability of building materials and architectural character of

the building. The NEXIS Framework, GEM Building Taxonomy v 2.0 (2012) and HAZUS Inventory Framework provide a significant list of building roof materials. The proposed attributes are listed below.

Component	Element	Attribute
Roof Material	Roof Material	Tile
		Metal sheeting
		Concrete
		Fibre Cement
		Imitation Tile
		Synthetic
		Glass
		Fabric

Existing Capabilities

Roof type data is collected as part of the housing and population census for residential buildings only. Valuer General Offices of various states collect this information for taxation purposes at the building level but the terminology used is not consistent across all the States and local governments. Some commercial data vendors also collect the data for city buildings but it is not available in the public domain. The following table provides a snapshot of currently available sources of the roof type data.

Agency	Product Description	Web Link
Geoscience Australia	NEXIS – Geoscience Australia has sourced roof type information from various sources and incorporated. The data is estimated using statistical extrapolation in the absence of authoritative sources	http://www.ga.gov.au/scientific-topics/hazards/risk-impact/nexis
ABS	Housing and population census collects the data about four roof types. It provides aggregated wall type data for SA2	http://www.abs.gov.au/websitedbs/censushome.nsf/home/datapacks
LANDGATE (WA)	Valuer Generals Database provides the roof type data for WA. This data may not be available on the website	https://maps.slip.wa.gov.au/landgate/locate/
DPIPWE (TAS)	Land Information System (TheLIST) has the roof type data for Tasmania	https://www.thelist.tas.gov.au/app/content/home
DPTI (SA)	Buildings database is available from the department. It is not a standard product available on the website	http://www.saplanningportal.sa.gov.au/
EICU (NSW)	EICU maintains and provides detailed exposure information for emergency response in NSW	Exclusively for emergency management authorities

Gaps and Suggestions

There are no standard roof types (materials) defined in Australia and the roof-type data is not collected using one standard approach. The 2011 census provides roof-type data aggregated to the SA2 geographic area level and that has only four roof types. GA NEXIS has collated roof type data for residential buildings using the best available data source. State governments such as Tasmania and South Australia have this data; however, it needs to be mapped to a standard list of roof materials. For the rest of the country, a desktop survey was conducted and extrapolated statistically for the entire building stock in those areas. National consistency in roof-type classes is needed to collect and maintain the data.

4.16 BUILDING ORIENTATION

Orientation is the positioning of a building in relation to seasonal variations in sunlight as well as prevailing wind patterns. Orientation data can be used to assess a building's energy efficiency. It can also be used as an input into detailed assessments of a building's vulnerability to bushfire and wind.

Gaps and Suggestions

There is no centralised database in Australia that collects, maintains and provides building orientation information.

4.17 FLOOR TYPE

The choice of material for floor construction is affected by factors such as structural strength, cost, durability and noise insulation. Floors are load-bearing horizontal interior surfaces that transmit vertical loads to columns and walls and distribute lateral loads to the lateral load-resisting system. The floor type is important for assessing direct loss from floods and also affects how a building responds to earthquakes. After consulting with several end-users and researchers, a comprehensive list of building roof material attributes is proposed in the following table.

Component	Element	Attribute
Floor Type	Floor Type	Solid Timber
		Manufactured Timber (Particle Board)
		Prestressed In Situ Concrete Flat Slabs
		Prestressed In Situ Concrete Beams and Slabs

		Reinforced In Situ Concrete Flat Slabs
		Reinforced In Situ Concrete Beams and Slabs
		Precast Concrete Without In Situ Topping
		Precast Concrete With In Situ Topping
		Composite Steel and Concrete
		Other

Gaps and Suggestions

There is no centralised database that collects, maintains and provides building floor type data in Australia.

4.18 BUILDING APPURTENANCES

Appurtenances do not form part of the building structure. However, they can influence loss as they may be vulnerable to earthquake and wind hazards. Furthermore, in some instances, they can form a sizeable fraction of a building's replacement cost, for example, a tall masonry spire attached to a town hall. Appurtenances include such elements as towers, spires, steeples, balconies, awnings, signage, solar panels, air conditioning units and other rooftop equipment.

Gaps and Suggestions

These features are not currently captured by any dataset to provide for risk and impact analysis from natural hazards.

4.19 YEAR BUILT

Year built provides information on building standards, technologies, materials, components, construction practices and style. It can be used to

inform the assignation of vulnerability models as construction standards and methods have changed over time. It can also be used as a proxy to determine if certain building materials, perhaps dangerous, are likely to be encountered in a particular building.

The year built information is required by end-users for tactical response and planning for all natural hazards and also to understand the risks to emergency rescue teams.

Year built information has been identified as an attribute for inclusion in the Global Earthquake Model to assess the building vulnerability.

Existing Capabilities

NEXIS collates construction year at the building level using several datasets. Data can be sourced from actual age from local source data, cadastral parcel release date as a surrogate for building age or median suburb age derived from actual age data. NEXIS contains information on the number of residential buildings built: pre- and including 1980, and post 1981. About 1.5% of buildings have no data and are declared as 'unknown'. The information is aggregated at national, state, ASGS SA2 and SA1 levels. NEXIS also contains other age classifications.

Gaps and Suggestions

NEXIS has obtained and also derived the year built or period information for buildings from various sources. It is reasonably reliable for ANHEF Level 1 users. This information may be available from local planning authorities and can be sourced through proper data-sharing arrangements for more recent years. Exact year of construction may not be available for heritage and old buildings but they can be grouped into a period, such as pre-First World War.

4.20 YEAR OF RETROFIT

During their lifetime, buildings can be refurbished. While such work is being undertaken, the opportunity is sometimes taken to upgrade the building's structure, or retrofit, to bring the building into alignment or partial alignment with modern standards. An example would be upgrading roof structure tie-down when replacing a house's roofing. Such work clearly decreases a

building's vulnerability. Recording the year of retrofit enables a more accurate assignation of a vulnerability model for a retrofitted building.

Gaps and Suggestions

There is no centralised database that collects, maintains and provides building retrofit date data in Australia.

4.21 BUILDING POSITION WITHIN A BLOCK

Building position within a block is particularly important for buildings on large land parcels in rural or regional areas. On large farms, the address may refer to the location of the farm gate or letter box rather than to the building itself. The vulnerability of a building, or the hazard magnitude to which it is exposed, may be affected by its position on the land parcel. For example, a rural land parcel may have significant relief and a building sited on the high part of the land parcel may not be affected by flood although the lower parts are.

For semi-detached buildings on a block, this information provides the location of the shared wall on one side in case of the corner buildings, and two shared walls in the case of a building in the middle of row housing.

Gaps and Suggestions

This information is not publicly available. Building footprint data is available with some local governments, covering their jurisdictions.

4.22 BUILDING SIZE

Building size information is an important requirement to estimate the social aspects such as household income, possible size of the population, replacement value, contents value and energy consumption of the building. This is particularly needed to strengthen disaster preparedness for effective response at all levels of government. Building size helps the authorities to estimate the maximum number of persons in a residential building, student and teacher numbers in a school building, hospital beds and staff in a hospital building and number of seats in a restaurant, for example, that the building can accommodate. Some risk assessment projects require highly detailed exposure information inside the building reflecting floor space and different usage.

Building size information is required by the end-users for tactical response and planning for all natural hazards. The researchers need this information to estimate replacement value to derive meaningful information for vulnerability assessment. Building size includes the information listed below.

Component	Element	Attribute
Size and Capacity	Land Size	
	Gross Floor Area	
	Building Lettable Area	
	Number of Dwellings	
	Extensions	
	Number of Bedrooms	
	Number of Toilets	
	Number Car Parks	
	Size of Garage	
	Annex building	

Existing Capabilities

The building size or total floor area data is collected by planning approvals organisations and maintained by Valuer General Offices in various states for taxation purposes at the building level. Some commercial data vendors also collect the data for city buildings but it is not available in the public domain. GA NEXIS collects the data from various sources and derives it using statistical models where the data is not available from authoritative sources. The following table provides a snapshot of currently available sources of building size data.

Agency	Product Description	Web Link
Geoscience Australia	NEXIS – Geoscience Australia has estimated building size using statistical analysis	http://www.ga.gov.au/scientific-topics/hazards/risk-impact/nexis
LANDGATE (WA)	Valuer General's Database provides building size data for WA. This data may not be available on the website	https://maps.slip.wa.gov.au/landgate/locate/
DPIPWE (TAS)	Land Information System (TheLIST) has building size for Tasmania	https://www.thelist.tas.gov.au/app/content/home
DPTI (SA)	Buildings database is available from the department. It is not a standard product available on the website	http://www.saplanningportal.sa.gov.au/
EICU (NSW)	EICU, NSW maintains and provides detailed exposure information for emergency response	Exclusively for emergency management authorities
Corelogic	Cityscope – provides detailed information on commercial properties for all major CBDs Licensing restrictions	https://www.corelogic.com.au/products/cityscope
Private Data Custodians	RP Data, Australian Property Monitors, Banks, Mortgage companies, etc., have this data	
Local Government Jurisdictions	Only some major local governments have spatial data provisions online	

Gaps and Suggestions

There is no single and centralised dataset available for the whole of Australia.

4.23 BUILDING EMERGENCY EXITS

Every building is different in terms of functionality, look, size, materials and design. Information about emergency exits is important for building evacuation and tactical response planning for sudden-onset events.

Exits are usually strategically located (e.g. in a stairwell, hallway) with outward-opening doors with crash bars and with exit signs leading to them. Their name reflects their normal use; however, an emergency exit can also be a main doorway in or out. A fire escape is a particular kind of emergency exit mounted to the outside of a building.

Having this information readily available with exposure information enables emergency response to be more effective.

In Australia, the standard emergency exit types include:

Component	Element	Attribute
Emergency Exit	Signage	
	Evacuation Floors	
	Evacuation Lifts	
	Evacuation Stairwells	
	Evacuation Plan	
	Code Regulations	

Gaps and Suggestions

There is no centralised database that provides emergency exit information about buildings, or other facilities such as tunnels and industrial facilities. The information is available with planning authorities and may not be available in a digital format.

4.24 BUILDING UTILITY SERVICES CONNECTIONS

Knowledge of the locations of electricity, gas, water and communication network connections to buildings and industrial facilities is used in emergency response. In an emergency, continuing supply of these utilities could add further risk to the people in it and also affect rescue operations. These services in multiple-occupancy dwellings pose a complex set of challenges. In an emergency, early engagement with Utility Connection Providers (UCPs) is crucial to shut off supplies.

For exposure information purposes, the following information on building utility services connections is considered important:

Component	Element	Attribute
Utility Connections	Location of Gas Meter	
	Location of Electricity Mains	
	Location of Solar Power Mains	
	Location of Water Mains	
	Location of Hydrants	
	Location of communication point	

Gaps and Suggestions

There is no centralised database that provides the location of utility connections or mains for buildings and facilities. The information is available with utility service providers and the planning authorities at the building level. Having this information with exposure information would enable emergency response to be more effective.

4.25 BUILDING REPLACEMENT VALUE

The replacement value estimation methodology is largely adopted from Wehner (2013). In order to estimate the impact of natural hazards, it is

necessary to estimate the building replacement cost at the level of individual buildings. The replacement cost relates to the building fabric; that is, structure, finishes, walls, building services, etc. Publicly available references can be used to estimate the construction cost for different building types and usages. A more detailed estimate can be sourced through consultation with a quantity surveyor.

Quantity surveyors would usually break the building down into its constituent components and calculate the cost of each component to calculate an accurate replacement value for a building. Based on industry knowledge and data derived from past projects, each component would be evaluated, the individual values summed up and builder's overheads added to produce a final replacement value.

The value of a building varies with its geographic location: values progressively increase with distance from the larger cities, where resources are in close proximity.

It is suggested that many of the variables influencing replacement values be taken into account in the selection of the replacement rate. These variables include the following:

1. Urban and Rural

Distance from the main town centres is an important variable in estimating construction rates. Urban areas have better availability of materials and resources for building construction than rural areas.

2. Usage of Building

The usage for which a building is built will affect its replacement value. Thus, all other aspects being equal, a building built for residential apartments will have a different replacement value to a similar building built for hospital use. It is proposed that, where possible, the data supplied for rates reflect this.

3. Building Structure

The structural system used for a building will affect its replacement value. As an example, all other aspects being equal, a building constructed using a braced steel frame will have a different value to a similar building built using reinforced

concrete. It is proposed that, where possible, the data supplied for rates reflect this.

4. Size of Building

The size of a building will affect its replacement value with larger buildings of similar height attracting a lower rate than multiple buildings of smaller size owing to economies of scale. Taller buildings of similar footprint will attract higher rates than lower buildings. It is proposed that where possible, the data supplied for rates reflect this.

5. Type of Building

Within a given usage, the structural system, size and form or nature of a building will affect its replacement rate. For example, a single-storey brick veneer slab-on-grade residential building could be a free-standing building, a terrace house, a duplex or a townhouse. Each of these would have slightly different replacement rates. It is proposed that, where possible, the data supplied for rates reflect this.

6. Quality of Building

Within a given usage, structural system and size of building, the quality of finish can affect the replacement rate. The difference in residential reconstruction rates can vary by a factor of more than 2 between a basic standard of finish and a prestige standard of finish.

7. Site Topography

The local topography will affect the replacement cost of a building. In general, it is more expensive to build on steeply sloping or hilly than flat terrain. It is proposed that this be reflected in the data in two ways. Firstly, using different rates for different regions will tend to reflect regional differences in topography, and, secondly, providing a range of rates for each building type will reflect variations that may be encountered.

8. Site Ground Conditions

The local ground conditions will affect the replacement value of a building. In general, it is more expensive to build on sites underlain by deep, soft soils than sites with strong materials at shallow depths.

9. Demolition and Debris Removal Costs

In the event of a natural hazard, prior to rebuilding the damaged building, rubble must be removed from the site and disposed of. This is a cost to the reconstruction project, although clearly, in a new-build situation the cost does not exist. Demolition and disposal cost should be included.

10. Builder's Preliminaries

The charge levied by builders for their overheads and profit is a cost to the reconstruction project and hence should be included in the data provided for the reconstruction rate.

11. Rate Variations from the Date for which Data are Available

The cost of reconstruction for a given building in any one location will vary from year to year owing to inflation, local demand and other factors. Typically, the construction rate will not be able to be revised on a yearly basis. To account for annual variations in rates by year, it is proposed that yearly building price indices be prepared.

12. Design, Documentation, Authority, Taxes and Legal Fees Associated with Reconstruction

Though they are a fraction of the replacement value, it is required to consider these variables in estimating construction rates. It is normal quantity surveyor practice to exclude these fees in their estimate of the building construction rates.

Often, after a natural disaster, demand to repair or reconstruct buildings exceeds the capacity of the local building industry, leading to a post-disaster demand surge and higher prices. The magnitude of such a demand surge depends on factors such as the intensity and geographical extent of damage, people's decisions about whether to rebuild or relocate, the ability of the local building industry to obtain resources from neighbouring regions and government control on prices. In view of the uncertainty over the magnitude of a post-disaster demand surge, ANHEF plans to add demand multipliers that would be part of further special-purpose modelling explicit to the situation and nature or type of hazard. However, this demand multiplier is not considered in this more generic exposure framework.

Existing Capabilities

GA sourced building construction cost factors for some building types from quantity surveyors. These construction rates are applied to estimate the building replacement values in its NEXIS database. NEXIS provides the replacement value of the buildings aggregated to a known geographic area.

Rawlinson's Construction Handbook (2016) provides construction rates for buildings with a variety of usages, sizes and structural systems.

Gaps and Suggestions

GA NEXIS has implemented a methodology outlined above to estimate building replacement values. Estimation of the floor area or total built-up area is statistically driven by NEXIS. There is no dataset that provides the size of buildings accurately and that leads to low reliability of the data at the building level.

The reconstruction rate for heritage buildings to reinstate original appearance and materials is highly complex. Reconstruction rates are usually variable owing to the differing requirements on how faithfully the reconstruction is required to reinstate the original. Hence, it is not included in the framework.

Likewise, iconic or special buildings such as the Sydney Opera House are unique and do not lend themselves to generalisation, and so are not included in the framework.

4.26 CONTENTS VALUE

The contents value in buildings varies substantially depending on their usage and in the case of residential buildings, on household socio-economic status. The contents of a building include furniture, household goods, cars, equipment, goods in warehouses, memorabilia, outdoor equipment, and additional fittings. Contents replacement value may be estimated as a percentage of building replacement value and, for

residential properties, by a multiplier to account for household wealth or household income category:

CV = f(RV, HI)

where CV – contents value,

RV – replacement value,

HI – household income.

Home contents are the most commonly held household asset, with almost every household reporting items of value for insurance. According to the ABS, the average value of a household's home contents (e.g. clothing, jewellery, hobby collections, furniture, appliances, paintings, art works) was $61,000 in 2009–10.

Most households (90%) held some equity in their private vehicles. Net worth was $18,000, on average in 2009–10.

For large industries and businesses, insurance underwriters evaluate the exposure of value of assets and contents.

Existing Capabilities

GA NEXIS contains information on building contents value for residential buildings. It is derived using a statistical approximation using dwelling structure value and household income as variables. Total contents value ($) for all residential buildings is aggregated to a defined geographic area. Contents value is calculated as a proportion of the replacement cost and adjusted for the gross income classes.

The insurance portfolios of various insurance companies have information on contents insured. The insurance portfolios provide a reasonable estimate of contents value but some households are generally underinsured.

Underwriters such as Lloyds of London and Arch Underwriters estimate the exposure value of contents for medium to large industries.

Gaps and Suggestions

There is no standard process to estimate the contents value of buildings owing to variations in factors that influence people's spending behaviours and market

values. The contents value data available from insurance companies and underwriters is confidential for their property portfolio and thus not available in the public domain.

A good strategy would be to develop algorithms to estimate building content values using a sample of insurance portfolio data and applying them to the building stock across Australia.

5 INFRASTRUCTURE EXPOSURE FRAMEWORK

The literature review in Nadimpalli et al. (2014) identified the need to collect data describing infrastructure sectors, and to maintain and update information on attributes required to predict the consequences of infrastructure failures for multi-hazard planning and policy modelling for PPRR. This framework identifies the following broad components of the infrastructure sector that possess critical exposure risk:

1. Transport sector
2. Energy sector
3. Communications sector
4. Urban water supply and sanitation sector
5. Waste management sector
6. Hazardous substance sector

5.1 TRANSPORT SECTOR

Natural disasters in the form of extreme weather, climatic conditions and earthquakes have significant and wide-ranging impacts on the transport sector. The transport sector is the lifeline of modern-day logistics; its failure can lead to hazardous consequences. In the USA, the Humphrey (2008) identified that:

'Climate change will affect transportation primarily through increases in several types of weather and climate extremes, such as very hot days; intense precipitation events; intense hurricanes; drought; and rising sea levels, coupled with storm surges and land subsidence. The impacts will vary by mode of transportation and region of the country, but they will be widespread and costly in both human and economic terms and will require significant changes in the planning, design, construction, operation, and maintenance of transportation systems.'

Consequently, protecting and managing the transport sector during natural hazards is critical for disaster management, response and recovery actions. This drives the need for information collection, organise, store and manage

information on infrastructure networks of the transport sector. It is also important to maintain and update information on the different attributes required to predict the consequences of infrastructure failures.

The transportation system is divided into infrastructure, vehicles and operations in the framework for four modes of transport, viz. air, rail, road and water. Transport infrastructure consists of the fixed installations including roads, railways, airways, waterways, and terminals such as airports, railways stations, bus stations, warehouse, fuelling stations and seaports.

Facilities linked with the transport system include fixed assets or infrastructure such as terminals, toll plazas and parking lots. Terminals may be used both for interchange of passengers and cargo and for maintenance. Terminals such as airports, ports and stations are locations where passengers and freight can be transferred from one vehicle or mode of transport to another. For passenger transport, terminals integrate different modes to allow riders to take advantage of each mode's advantages. For instance, airport rail links connect airports to city centres and suburbs. The terminals for automobiles are parking lots, while buses and coaches can operate from simple stops. For freight, terminals act as trans-shipment points, though some cargo is transported directly from the point of production to the point of use.

5.1.1 Roadways

The road transport system consists of highways, bridges, tunnels and associated road equipment. Roads, bridges and tunnels are represented as lines and the terminals that are associated facilities such as bus stops and traffic controls are represented as points.

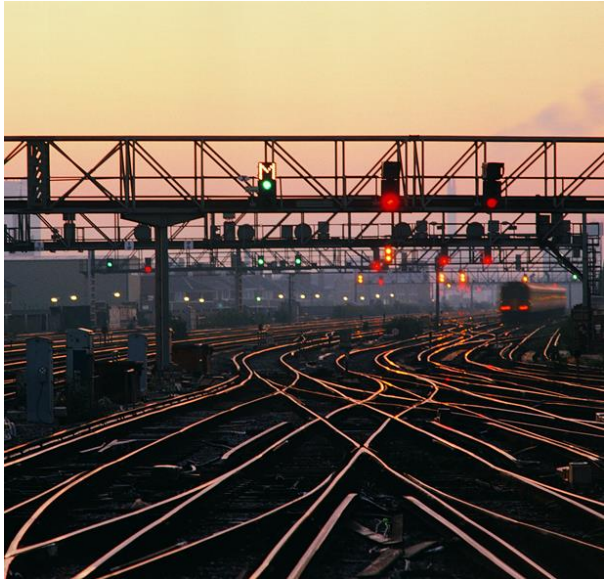
Roads information is required by the end-users to plan and respond evacuation during emergency for all natural hazards. The researchers need this information

to estimate direct and indirect losses, which is critical for recovery and community resilience.

After consultations with several end-users and researchers, a comprehensive list of roadway attributes are proposed in the following table.

Component	Element	Attribute
Roadway	Name	
	Ownership	
	Type	Freeways, Motorways
		Highways
		Secondary Roads
		Local Collector Roads
		Streets
	Private or Restricted Roads	
	Number of Lanes	
	Construction Material	
	Carrying Capacity	
	Capacity Utilisation	
	Year Upgraded	
	Lane Width	
	Shoulder Width	
	Grade, Condition	
	Carriageway Division	
	Bicycle Paths, Footpaths	
	Reconstruction Cost	

5.1.2 Railways



The rail transport system consists of railway lines and associated infrastructure. There are two modes of rail transport in Australia: trams (light rail) and trains. Light rail is mainly used as an urban public transport system, whereas train is for public (urban and rural) and goods transport. Railway lines and tracks buckle with earthquakes and heat waves, and are washed out by floods and storm surges. The transport service disruptions and response costs

from heatwaves in Melbourne in 2009 were estimated at $800 million (Steffen et al., 2014).

Railway lines information is required by the end-users and researchers to estimate direct and indirect losses. Different components of the rail transport network exposed to natural hazards are listed in the following table.

Component	Element	Attribute
Railway	Ownership	
	Railway Lines	Gauge (broad, metre, light)
		Usage (urban, rural, goods)
		Control Facilities
		Rail Gates, Intersections
		Train, Tram
		Metropolitan Networks
	Condition	Elevated, Ground
		Sleepers
		Electrification
	Carrying Capacity	
	Capacity Utilisation	
	Reconstruction Cost	
	Year Built	
	Year Upgraded	

5.1.3 Waterways

Water transport operates by means of a watercraft such as boats, ships or ferries over sea, ocean, lake, canal or river. Waterways are a significant mode of transport for urban commuters in Sydney, Brisbane and Perth, tourism on the Murray River and ferries at sea to Tasmania from mainland. Waterways network information required for disaster management is listed in the following table.

Component	Element	Attribute
Waterway	Channel Width	
	Channel Depth	
	Channel Purpose	
	Harbours, Wharves	
	Ferry Networks	

5.1.4 Bridges, Culverts and Aqueducts

Bridges are considered transport infrastructure as they overcome obstacles and provide passage for road and rail networks, pedestrians and pipelines; their design varies according to their purpose and the nature of the terrain.

A culvert is infrastructure that allows water to flow under a road, railroad, trail, or similar obstruction. Culverts may be made from pipes, reinforced concrete or other material. An aqueduct carries water over an obstacle.

Information on bridges, culverts and aqueducts is required by researchers to develop vulnerability models, particularly for earthquakes, floods, storm surge and tsunami risk assessment. It is also required to estimate direct and indirect losses, which is important for recovery and community resilience. The end-users need it for preparation for evacuation during emergency for all natural hazards. Bridge, culvert and aqueduct structures data required for disaster management is listed in the following table.

Component	Element	Attribute
Bridges	Forms	Bridges
		Aqueduct
		Culverts
	Ownership	
	Length	
	Width	
	Depth (Deck and Beams)	
	Type	Beam
		Truss
		Cantilever
		Tied Arch
		Suspension
		Cable Stayed
		Double-Decked
		Movable

		Multiple Levels
	Structure Type	Tension
		Compression
		Bending
		Torsion
		Shear
	Design	Conventional
		Standards
	Number of Spans	
	Length of Maximum Span	
	Span Continuity	
	Skewness of the Bridge	
	Materials	
	Purpose	Road over Rail
		Rail over Road
		Road over Water
		Rail over Water
		Water over Road
		Pedestrian Bridges
	Carrying Capacity	
	Capacity Utilisation	
	Flow Capacity under Bridge	
	Year Built	
	Year Upgraded	
	Retrofit Details	
	Pier Walls	
	Single, Multi-Column Bents	
	Abutment Type	
	Reconstruction Cost	

5.1.5 Tunnels

A tunnel may be for foot or vehicular traffic under a road, rail, or canal. The central portions of rapid transit networks are often in tunnels. Tunnels are used as aqueducts to supply water for consumption or

for hydroelectric stations or as sewers, as well as connecting buildings for the convenient passage of people and equipment. Utility tunnels are used for routing steam, chilled water, electrical power or telecommunication cables. Secret tunnels exist for military purposes or for civilian use, and special tunnels such as wildlife crossings are built to allow wildlife to cross human-made barriers safely. The impact of natural hazards on tunnels varies depending on the types, structure and extent of their use.

Information on tunnels is required by researchers to develop vulnerability models, particularly for earthquake hazard and any other sudden-onset events for emergency response. It is also required to estimate direct and indirect losses, which is critical for recovery and community resilience, and associated equipment information is also required to assess risk. The tunnels data required for disaster management is listed in the following table.

Component	Element	Attribute
Tunnels	Ownership	
	Usage	
	Length	
	Width	
	Type	Single Level
		Multiple levels
	Structure Type	
	Shape	
	Materials	
	Purpose	
	Equipment	
	Year Built	
	Year Upgraded	
	Carrying Capacity	
	Capacity Utilisation	
	Reconstruction Cost	

5.1.6 Airports

As well as being transportation terminals for air travel, airports have many associated facilities consisting of landing areas and runways, control towers, aircraft, helicopters, hangars, maintenance

workshops, customs, immigration, etc. The impacts of natural hazards on airports depend on equipment and other assets as they are complex and expensive infrastructure. Airports consider in the framework ranges from landing grounds (for rural and agriculture purposes) to domestic and large international airports. The airport information required for disaster management is listed in the following table.

Component	Element	Attribute
Airport	Functional Type	Rural Landing Ground
		Small Domestic
		Large Domestic
		International
		Military
		Cargo and Freight
		Defunct Airports
	Landing Grounds	Runway Length
		Runway Width
		Runway Material
	Air Traffic Control	Tower
		Systems
	Weather Station	
	Air Safety Facility	
	Airport Security	
	Fuel Depot	
	Hotels	
	Lounges	
	Terminals, Gates	Number
		Type
	Customs Offices	
	Immigration Offices	
	Hangars	
	Ownership	Public
		Private
		Partnership
	Establishment Year	
	Carrying Capacity	
	Capacity Utilisation	
	Activity	
	Traffic Pattern	
	Reconstruction Cost	

5.1.7 Sea Ports

Sea ports are a transportation terminal for maritime travel or a junction of road or rail with waterways, and dock ships, people and cargo transport operations. Ports need to handle a variety of traffic, storage and support facilities. They are economically critical and some are strategically significant for military operations. Thus, the impact of natural disasters on sea ports carries strategic importance for the country, and varies with the size and extent of their use. The ports assets information required for disaster management is listed in the following table.

Component	Element	Attribute
Sea Ports	Port Name	
	Port Type	Cargo
		Cruise
		Fishing
	Berthing Structures	Piers
		Wharves
		Jetties
		Bulkheads
		Docks
		Column or Pile
		Lamella Berth
	Platform Type	Gravity Wall
		Sheet Pile
		Relieving Structure
		Kerbs
		Pavements
	Protection Barriers	Bollards
		Handrails, Guardrails
		Crane Rails
		Breakwater
		Revetment
		Seawalls
	Port Superstructures	Administrative Buildings

		Warehouses
		Storage Sheds
		Terminals
	Ownership	Public
		Private
		Partnership
	Carrying Capacity	
	Capacity Utilisation	
	Year Established	
	Year Upgraded	
	Replacement Cost	
	Depth of Water	
	Connections	Road and Rail Infrastructure
	Corrosion Protection	
	Facilities	

5.1.8 Public Transport Facilities

Public transport facilities support the transport system and shared passenger services. The facilities comprise bus stations, railway stations, traffic control rooms and signalling systems, trucking terminals and terminals. Transport terminals may be used both for interchange of passengers and cargo and for maintenance. Passenger transport may be public, where operators provide scheduled services, or private. Thus, to study the impact of natural disasters on public transport facilities, this framework has identified the need to include information on different types and components of their infrastructure listed in the following table.

Component	Element	Attribute
Public Transport Facilities	Terminals	
	Interchanges, Hubs	
	Bus Stops	
	Railway Stations	

	Railway Yards, Depots	
	Control Rooms	
	Harbours	

5.1.9 Multimodal Transport Facilities

Multimodal transport is transportation performed with a combination of at least two different means of transport (by rail, sea and road), an integrated transport chain where the strength of each alternative is utilised. Multimodal transportation has trans-shipment terminals that allow efficient cargo handling for short- and long-distance freight. In general, trucks are used to cover short distances from the source and to the recipient of the freight, and long-distance haulage is by rail, air or ship. Freight transport has become focused on containerisation, although bulk transport is used for large volumes of commodities. Trailer shipment is generally considered multimodal transport. Transport plays an important part in economic growth and globalisation. The framework suggests the following information on the exposure elements of multi-modal transport hubs assets for disaster management.

Component	Element	Attribute
Multimodal Facilities	Transport Connections	
	Number of Containers	
	Type of Containers	
	Type of Cranes	
	Container Stackers	
	Trucks	
	Barges	
	Ships	
	Planes	
	Control Rooms	
	Capacity	
	Value	

5.1.10 Transport Vehicles

Vehicles travelling on different types of transport networks may include automobiles, bicycles, buses, trains, trucks, helicopters, watercraft and aircraft. The way these vehicles are operated in their respective transport infrastructure varies significantly. In the transport industry, operations and ownership of vehicles can be either public or private. The type and number of vehicles at a particular location varies with the time of the day and events. This requires development of a transport model to estimate the number and type of vehicles at a given time.

According to ABS Motor Vehicle Census 2016, the Australian motor vehicle fleet had 18.4 million registered vehicles, with a growth rate of 2.1 percent in 2015-16.

The impact of natural disasters on transport vehicles has significant importance in disaster management, response and recovery. The number, type and value of the following vehicles by mode of transport for inclusion in the framework are suggested in the table below.

Component	Element	Attribute
Vehicles	Aircrafts	Number and Type
	Helicopters	Number and Type
	Cargo Flights	Number and Type
	Buses	Number and Type
	Trucks	Number and Type
	Cars	Number and Type
	Motorcycles	Number and Type
	Trains	Number and Type
	Cargo Trains	Number and Type
	Trams	Number and Type
	Boats	Number and Type
	Ferries	Number and Type
	Ships	Number and Type

5.1.11 Transport Functions

Apart from relocation of travellers and cargo, transport sector functions also include the strategic and tactical relocation of armed forces during warfare, or civilian or emergency equipment mobility. Natural disasters have significant negative consequences on the transport sector as it is the lifeline of disaster management, response and recovery process. Thus, the following are some of

the broad categories of transport sector functions that are proposed for the framework.

Component	Element	Attribute
Functions	Schedule Services	
	Bus, Train Routes	
	Commuting Patterns	
	Logistics, Freight Patterns	
	Dependencies	
	Economic Capacity	
	Physical Capacity	

In addition to capturing and storing inherent spatial location information (geometry) for each transport infrastructure asset (spatial features), data tables and attributes should be structured to represent the above information in an accessible and transparent manner.

Existing Capabilities

Transportation is one of the critical sectors for the national economy. It is quite diverse and underpins several value-chain activities. There is plenty of segregated data available on the transport sector. However, its availability depends on the role of authoritative and regulatory organisations across Commonwealth, State or local jurisdictions. Information is also maintained by private companies. The following table provides a snapshot of available data sources for the transport sector.

Agency	Product Description	Web Link
	ROAD	
Geoscience Australia	National Roads – spatial data on roads	http://services.ga.gov.au/site_7/rest/services/Topographic_Base_Map_WM/MapServer/281
	Exposure Reports – provides aggregated information on roads	Email: nexis@ga.gov.au
PSMA	Roads database	http://www.psma.com.au/?product=transport-topography
Road Transport Authorities, NSW	NSW RTA – Roads	http://www.rms.nsw.gov.au/business-industry/heavy-vehicles/index.html
	NSW Spatial Services	https://six.nsw.gov.au/
	EICU – for emergency services	
Department of Transport and Main Roads (DTMR), Queensland	DTMR – higher-mass-limits maps	http://www.tmr.qld.gov.au/Travel-and-transport
	DNRM - Roads Database	
South Australia	Roads Database	https://data.sa.gov.au/data/dataset/roads

Tasmania	The List – Infrastructure	https://www.thelist.tas.gov.au/app/content/data/index#
NT	NT Road Report	http://www.ntlis.nt.gov.au/roadreport/
	Road Centrelines	http://www.ntlis.nt.gov.au/metadata/export_data?type=html&metadata_id=2DBCB7711FF306B6E040CD9B0F274EFE
Victoria	Data.VIC	https://www.data.vic.gov.au/data/group/transport
WA	Landgate-SLIP	https://catalogue.data.wa.gov.au/dataset/ntwk-iris-road-network
	Main Roads	https://www.mainroads.wa.gov.au/
Office of Spatial Management	Public Domain Data	http://www.openstreetmap.org
RAIL		
Geoscience Australia	National Rail Network	http://www.ga.gov.au/corporate_data/79566/Railways2014_WEB.pdf
Dept of Infrastructure	A wide range of rail information	http://www.infrastructure.gov.au/rail/
Bureau of Infrastructure, Transport and Regional Economics (BITRE	Rail freight performance indicators	https://bitre.gov.au/publications/2010/files/arfpi_2007_08.pdf
PSMA	Rail Network	http://www.psma.com.au/?product=transport-topography
ARTC	Australian Rail Track Corporation	http://www.artc.com.au/Content.aspx?p=37
Interstate Freight Operators	Aurizon Bulk Freight	http://www.aurizon.com.au/ourservices/bulk-freight
	Pacific National	http://asciano.com.au/pacific-national
	SCT Logistics	http://www.sctlogistics.com.au/
	Queensland Rail	http://www.queenslandrail.com.au/
	Patrick Rail	http://asciano.com.au/patrick
	Freightlink	http://www.freightlinks.com.au
	South Spur	http://www.southspurrail.tripod.com/ssr
	Tasmanian Railway Network	http://www.railtasmania.com/lines/
	Pilbara Rail Company	http://www.pilbararailways.com.au/
Regional Passenger Operators	V/Line	http://www.vline.com.au/
	TransWA	http://www.transwa.wa.gov.au/
	Great Southern Railways	http://www.greatsouthernrail.com.au/
	Country Link	http://www.greatsouthernrail.com.au/
Australian Rail Maps	Major Railway Lines and Rail Services	http://www.railmaps.com.au/austrail.htm
Metropolitan Rail Operators	Major Metro Rail	http://www.sydneytrains.info/stations/network_map
	Sydney	http://www.transport.nsw.gov.au/railcorp
	Melbourne	http://ptv.vic.gov.au/getting-around/stations-and-stops/metropolitan-trains/
	Adelaide	http://www.adelaidemetro.com.au/Timetables-Maps/
	Perth	http://www.transperth.wa.gov.au/Timetables
	Brisbane	https://www.queenslandrail.com.au/forcustomers/stationsmaps
OSM	Public Domain Data Source	http://www.openstreetmap.org

STRUCTURES		
Dept of Infrastructure	List of Australia's major road corridors and distribution hubs	http://investment.infrastructure.gov.au/publications/reports/
BITRE	Road freight capacity figures	http://bitre.gov.au/publications/publications.aspx?query=s:'freight'&link-search=true
State Governments	Vic Roads Height Clearance under Structures for Permit Vehicles	https://www.vicroads.vic.gov.au/.../heavyvehiclesheightclearanceunderstr
	WA Landgate	http://www.landgate.wa.gov.au/corporate.nsf/web/Topographic+Data
	WA Main Roads	https://www.mainroads.wa.gov.au/UsingRoads/HeavyVehicles/Pages/HeavyVehiclesHome.aspx
	ACT Bridge Weight Limits	http://www.tams.act.gov.au/roads-transport/Road_Infrastucture_and_Maintenance/bridges
Public-sourced	Major Australian bridges with construction information	http://en.wikipedia.org/wiki/List_of_bridges
	Road Rail Bridges	http://en.wikipedia.org/wiki/List_of_road-rail_bridges
	Low Bridges	https://www.gps-data-team.info/poi/australia/safety/Low_Bridges_au.html
Australian Tunnelling Society	ATS – 224 Existing Tunnels and 47 Current Projects in Australia	http://www.ats.org.au/index.php/resources/tunnelling-databases
VEHICLES & FUNCTIONS		
ABS	Motor Vehicle Census 2016 –downloaded from ABS datacubes	http://www.abs.gov.au/AUSSTATS/abs@.nsf/Lookup/9309.0Main+Features131%20Jan%202016?OpenDocument
Transport Authorities	Interchanges and Depots – Melbourne	http://www.metlinkmelbourne.com.au/timetables
	Interchanges and Depots – Brisbane	http://translink.com.au/travel-information/network-information/maps
	Interchanges and Depots – Canberra	http://www.action.act.gov.au/rider_Info/maps
	Interchanges and Depots – Adelaide	https://www.adelaidemetro.com.au/Timetables-Maps/
	Interchanges and Depots – Darwin	https://nt.gov.au/driving/public-transport-cycling/public-bus-timetables-maps-darwin
	Interchanges and Depots – Perth	MPT operators
	Interchanges and Depots – Hobart	http://www.metrotas.com.au/timetables/
	Interchanges and Depots – Sydney	http://www.sydneybuses.info/routes
Ferry and Shipping Operators	Sydney Ferries	http://www.transportnsw.info/#ferry-status-updates-item-tab
	NSW Maritime	http://www.rms.nsw.gov.au/maritime/index.html
	Brisbane	http://translink.com.au
	Melbourne	http://www.williamstownferries.com.au/
MARITIME		
Geoscience Australia	Australian Mines Atlas – List of Ports	http://www.australianminesatlas.gov.au/mapping/files/ports.xls
Ports Australia	Map of Australian Ports	http://www.portsaustralia.com.au/members_list/map.htm
	Imports and Exports	http://www.portsaustralia.com.au/aus-ports-industry/trade-statistics/
BITRE	Shipping Information	http://bitre.gov.au/statistics/maritime/index.aspx
	Australian Container Ports Study	https://bitre.gov.au/publications/2014/cr_001.aspx
State Governments	NSW Maritime	http://www.rms.nsw.gov.au/maritime/using-

		waterways/index.html
	QLD Transport	http://www.tmr.qld.gov.au/business-industry/Transport-sectors/Ports.aspx
	WA Transport	http://www.transport.wa.gov.au/imarine/sea-freight-and-ports.asp
	Tasmania Ports	http://www.tasports.com.au/
	Victoria Transport	http://economicdevelopment.vic.gov.au/transport/ports http://www1.transport.vic.gov.au/VTSP/homepage.html
	NT Lands and Planning	http://www.transport.nt.gov.au/public/mandorah-ferry
	SA Transport	http://www.sa.gov.au/topics/transport-travel-and-motoring/boating-and-marine
State Port Corporations	Flinders Ports	http://www.flindersports.com.au/portfacilities1.html
	North Queensland Bulk Ports Corporation (NQBP)	http://www.nqbp.com.au/
Major Port Operators – Individual port authorities have detailed information	Gladstone	http://gpcl.com.au/big6/SitePages/maps.aspx
	Esperance	http://www.esperanceport.com.au/map-port.asp
	Eden	http://edenport.com.au/port_facilities_and_services
	Brisbane	https://www.portbris.com.au/property-planning
	Geelong	http://www.geelongport.com.au/generalinfo_pl.html http://www.geelongport.com.au/downloads.html
	Sydney	http://www.sydneyports.com.au/trade_services/trade_information
AIR		
Air Services Australia	Control Tower and Runway Information	http://www.airservicesaustralia.com/about/our-facilities/
BITRE	Australian Domestic Aviation Activity Annual Publications	http://bitre.gov.au/publications/ongoing/domestic_airline_activity-annual_publications.aspx
	Air Transport Service Trends in Regional Australia	http://bitre.gov.au/publications/2012/files/report_130.pdf
Major Airport Operators – maps, facilities, master plans, capacities and other information for Australian capital city airports	Sydney	http://www.sydneyairport.com.au/corporate/master-plan/master-plan-downloads.aspx
	Melbourne	http://www.melbourneairport.com.au/About-Melbourne-Airport/Corporate-Information/Facts-Figures.html http://www.melbourneairport.com.au/About-Melbourne-Airport/Corporate-Information/Annual-Reports.html
	Brisbane	http://bne.com.au/corporate/current-publications
	Perth	http://www.perthairport.com.au/master-plan.aspx
	Adelaide	http://www.adelaideairport.com.au/corporate/community/adelaide-airport-master-plan/
	Canberra	http://www.canberraairport.com.au/corporate/planning-environment/masterplan/
	Hobart	http://hobartairport.com.au/corporate/environment-planning/master-plan/
	Darwin	http://www.ntairports.com.au/media-centre/darwin-international-airport-2010-master-plan-approved
Regional Airport Operators –	Gold Coast	http://www.goldcoastairport.com.au/
	Cairns	http://www.cairnsairport.com.au/

websites contain most required information	Townsville	http://www.townsvilleairport.com.au/
	Newcastle	http://www.newcastleairport.com.au/
	Launceston	http://www.launcestonairport.com.au/
	Mackay	http://www.mackayairport.com.au/
	Sunshine Coast	http://www.sunshinecoastairport.com.au/
Air Freight Stats	Airport-Sponsored Air Freight Data	http://www.airfreightstats.com/

Gaps and Suggestions

Some of the data on road, rail, airport and sea port transport infrastructure is available in the public domain. GA and state jurisdictions maintain location-only information about transport infrastructure and facilities. The data provided by these agencies is not comprehensive enough for decision-making and has limited coverage. GA is able to provide the length of transport infrastructure such as various types of roads and the number of associated facilities.

Road Transport Authorities of various states maintain data on transport operations and vehicles. This data is not in the public domain, though these agencies provide the data for research purposes, but not consistently across the nation.

BITRE provides data about transport activities such as freight and other value-chain information. BITRE holds subjective information and knowledge about the transport system and its sensitivities that would be useful to assess the impacts of natural hazards. BITRE collects a great deal of raw data that will be useful for impact analysis of the transport value-chain and consequences of hazard events.

However, there is no centralised database to collect, collate, maintain and disseminate transport exposure information other than the location of assets for emergency service authorities. The agencies holding the data needs to be engaged and make agreements with them to release the data to derive exposure information. Further work is required to implement the framework, develop the database and make the information available under creative commons licensing agreements. Legislation may be required for the above agencies to disclose the information.

5.2 ENERGY SECTOR

Modern society relies heavily on large amounts of fuel, and the energy industry is a crucial part of the infrastructure and economy. Thus, it is identified as a critical life-line of the nation. The energy infrastructure sector consists of the industries involved in the production and distribution of liquid fuels, gas and electricity.

In recent years, the devastating impact of natural disasters on the energy sector has been documented (Bucci et al., 2013; Vivoda, 2011) in the literature. For example, damage from natural disasters such as Hurricanes Sandy, Katrina, Isabel and Irene in the USA led to power outages ranging from hours to weeks before full restoration. The electricity sector is not the only one affected; there was severe damage to the petroleum and gas industry from hurricanes in the Gulf of Mexico and during the 2011 earthquakes in Japan. Therefore, it is important to understand the issues and operational challenges of the energy sector during natural disasters, and to improve the resilience of energy infrastructure by identifying gaps and areas for planning to prepare, respond and recover from natural disasters. A primary requirement for these initiatives is to develop a database of the energy sector that details each component of the sector.

The energy industry comprises primarily liquid fuels, gas and electricity. The liquid fuels industry includes petroleum wells, exploration, production, refineries, transportation and end-user sales at service stations. The gas industry includes natural gas and coal seam gas extraction, manufacturing, distribution and sales. The electrical industry includes power generation, distribution and sales.

5.2.1 Petroleum Wells

Petroleum wells are used for exploration and production of crude oil or gas. Exploration collects information about hydrocarbon deposits such as oil and gas beneath the Earth's surface. Companies

drill several exploration wells to estimate prospective hydrocarbon deposits. These wells are very expensive and are high-risk operations. Sometimes, they blow out, posing huge risks to communities and the environment.

For the purpose of natural disasters exposure information, the following details of the assets are suggested as exposure elements.

Component	Element	Attribute
Petroleum Wells	Location	Onshore
		Offshore
	Ownership	Public
		Private
		Partnership
	Well Status	Exploration
		Drilling
		Production
		Abandoned or Dead
	Depth	
	Storage Capacity	
	Platform	
	Value	$10 million
		$10–100 million
		$100 million
	Year Built	
	Year Upgraded	

5.2.2 Petroleum Refineries

A petroleum refinery is the manufacturing plant where crude oil is processed and refined into petroleum products such as petrol, diesel, kerosene, liquefied natural gas and asphalt base. Petroleum refineries are very large industrial complexes. They have extensive pipework running throughout carrying large volumes of chemicals and usually have crude storage tanks and product storage depots. Exposure information

of the different types and components of petroleum refineries are listed in the following table.

Component	Element	Attribute
Petroleum Refineries	Products	Light Distillates
		Middle Distillates
		Heavy Distillates
	Ownership	Public
		Private
		Partnership
	Processing Units	
	Processing Capacity	
	Associated Facilities	
	Storage Capacity	Crude
		Products
		Waste
	Shipping	
	Air Pollutant Monitors	
	Electricity Power Plants	
	Carrying Costs	
	Value	
	Year Built	
	Year Upgraded	

5.2.3 Petroleum Terminals

Petroleum terminals or oil depots are industrial facilities for the storage of oil and other petrochemical products that are processed and ready for the transport. These typically have tankage and pumping facilities for mobile tankers and pipelines. Import and export terminals have the facilities to handle marine cargo tankers. These storage facilities should also be treated as hazardous substances storage facilities. Small terminals are also used as distribution terminals for urban delivery. For the exposure information framework, the different types and components of petroleum terminals are listed in the following table.

Component	Element	Attribute
Petroleum Terminals	Ownership	Public
		Private
		Partnership
	Position	Underground
		Overground

	Vicinity	Refinery
		Seaport
		Airports
		Urban Gateways
	Substances Stored	
	Auxiliary Facilities	
	Total Capacity	
	Capacity Utilisation	
	Fuel Turnover	
	Year Built	
	Blending Facility	
	Reconstruction Cost	

5.2.4 Petroleum Transmission

Petroleum, liquid fuels and crude oil are transported by road, rail or pipeline between wells, refineries, terminals or other end-outlets. For the exposure information framework, the different types and components of the petroleum transmission process are listed in the following table.

Component	Element	Attribute
Petroleum Transmission	Pipeline Type	
	Pipeline Size	
	Pipeline Construction Material	
	Pipeline Capacity	
	Pipeline Year Built	
	Pipeline Year Upgraded	
	Pipeline Replacement Value	
	Pipeline Rebuilding Timeframe	
	Oil Cargo Ship Material	
	Oil Cargo Ship Capacity	
	Oil Cargo Ship Vessel Value	
	Ship–Ship Transfer	
	Tanker Truck	
	Rail Tanker	

5.2.5 Gas Processing

Liquid petroleum gas (LPG), liquid natural gas (LNG), bio-LPG, coal seam gas (CSG) and industrial gas are by-products of fossil fuel or available from natural sources. Gas is produced during petroleum (crude oil) refining or extracted as natural gas from the ground. All these products are used essentially the same way for cooking, heating and motor fuel but Their composition and calorific values are different. LPG is mostly transported and sold in cylinders whereas LNG is delivered in pipelines for domestic use. Industrial gases are specifically manufactured for use in industry. In the exposure framework, all these products are considered as gas.

There are three LNG projects operating on the North West Shelf and Pluto from the Carnarvon Basin in Western Australia and Darwin LNG in Northern Territory from the Bonepart Basin. An LNG facility at Curtis Island will turn CSG into LNG to export. The CSG is transported through pipelines from gas fields in Queensland. For the exposure information framework, the different components of the gas processing sector are listed in the following table.

Component	Element	Attribute
Gas Processing	Ownership	Public
		Private
		Partnership
	Products	LPG
		LNG
		CSG
		Industrial Gas
	Processing Units	
	Processing Capacity	
	Associated Facilities	
	Storage Capacity	Crude
		Products
		Waste
	Liquefaction Plants	

	Shipping Facility	
	Electricity Power Plants	
	Carrying Costs	
	Year Built	
	Reconstruction Cost	

5.2.6 Gas Transmission

Gas is compressed and transported by road, rail or pipeline from a gas processing facility to the end-user. Crude oil and gas are also transferred through pipelines to processing plants. For the exposure information framework, the different types and components of the gas transmission process are listed in the following table.

Component	Element	Attribute
Gas Transmission	Ownership	Public
		Private
		Partnership
	Pipeline Type	
	Pipeline Size	
	Pipeline Construction Material	
	Pipeline Capacity	
	Pipeline Year Built	
	Pipeline Year Upgraded	
	Pipeline Replacement Value	
	Pipeline Rebuilding Timeframe	
	Oil Cargo Ship Material	
	Oil Cargo Ship Capacity	
	Oil Cargo Ship Vessel Value	
	Ship–Ship Transfer	
	Tanker Trucks	
	Rail Tanker	
	Retail Cylinders	

5.2.7 Gas Storage

In a refinery or gas plant, LPG is stored in pressure vessels that are either cylindrical and horizontal, or spherical. In order to transport it, LPG is placed under modest pressure to form a liquid, which can then be stored and transported in LPG cylinders.

LNG is transported through pipelines from its source or a refinery to city gateways, and further distributed through pipelines for domestic use in many urban areas in Australia. LNG terminals are purpose-built ports used exclusively to export or import LNG. For the exposure information framework, the different types and components of the gas storage process are listed in the following table.

Component	Element	Attribute
Gas Storage	Ownership	Public
		Private
		Partnership
	Storage Tank – External Wall Type	
	Storage Tank – Internal Wall Type	
	Storage Tank – Capacity	
	Storage Tank – Compression Ratio	
	Cylinder Storage	Number and Size
	Cylinder Fill Facility	
	Auxiliary Facilities	Reliquefaction
		Blending
	Total Capacity	
	Capacity Utilisation	
	Fuel Turnover	
	Year Built	
	Reconstruction Cost	

5.2.8 Petrol Service Stations

Petroleum service stations are the customer end contact points of the petrol distribution chain and are retail stores that sell fuel and lubricants for

automobiles, usually with other ancillary businesses such as selling motor vehicle accessories or parts; food, drinks and other convenience goods; trailer hire; service or washing of motor vehicles; and installation of motor vehicle accessories or parts. For the exposure information framework, the different types and components of petrol service stations are listed in the following table.

Component	Element	Attribute
Petrol Service Stations	Ownership	Public
		Private
		Partnership
	Site Category	Super Sites
		Primary Sites
		Neighbourhood Sites
		Marginal Sites
	Tank Construction Material	Steel
		Fibre Glass
		Others
	Tank Year Built, Replaced	
	Number of Pumps	
	Auxiliary Facilities	Convenience Store
		Fast Food Outlets
		Carwash
		Workshop
	Capital Value	
	Fuel Turnover	
	Rebuild Timeframe	
	Reconstruction Cost	

5.2.9 Electricity Generation

Electricity generation is the process of converting sources of energy into electric power. Electricity is most often generated at a power station using electromagnetic induction to convert chemical energy stored in fossil fuels, gravitational energy of flowing water, or thermal energy released by nuclear fission into electric energy. Renewable

options such as using heat concentrators or thermal panels to harvest sunlight, or wind turbines to convert kinetic energy of wind into electric energy are becoming increasingly prevalent. For the exposure information framework, the different types and components of the electricity generation process are listed in the following table.

Component	Element	Attribute
Electricity Generation	Ownership	Public
		Private
		Partnership
	Generation Type	Coal Thermal
		Combined Cycle
		Gas Thermal
		Diesel Engines
		Hydroelectric
		Nuclear
		Wind
		Solar
		Geothermal
		Others
	Generation Capacity	
	Storage Type	
	Storage Capacity	
	Material Stackers	
	Conveyor Type	
	Conveyor Length	
	Boilers	
	Demineralisation Plants	Plant Redundancy
		Water Source
	Generators	Type
		Numbers
		Capacities
	Step-up Transformers	
	Cooling Towers	Type
		Numbers
	Cooling Tower Height	
	Cooling Tower Size	
	Chimneys	
	Water Supply	
	Switch Yard	

	Auxiliary Facilities	
	Generation Role	Baseload
		Peak
	Year Built	
	Rebuild Timeframe	
	Reconstruction Cost	

5.2.10 Electricity Transmission

Electric power transmission is the bulk transfer of electrical energy from electricity generation plants to substations located near demand centres. Transmission lines are interconnected and form transmission networks. The combined transmission and distribution network is known as the power grid.

Most transmission lines are high-voltage three-phase or single-phase (railway electrification systems). High-voltage direct-current (HVDC) technology is used for greater efficiency at long distances, in submarine power cables, and in the interchange of power between grids. HVDC links are also used to stabilise and control problems in large power distribution networks where sudden new loads or blackouts in one part of a network can otherwise result in synchronisation problems and cascading failures. For the exposure information framework, the different types and components of the electricity transmission process are listed in the following table.

Component	Element	Attribute
Electricity Transmission	Ownership	Public
		Private
		Partnership
	Transmission Lines	Overhead
		Underground
	Insulation	
	Voltage Capacity	High-voltage AC

		High-voltage DC
		Subtransmission
		Single-Phase
	Carrying Capacity	
	Year Built	
	Reconstruction Cost	

5.2.11 Electricity Transmission Towers

Transmission towers are the main support for overhead transmission lines. They carry heavy transmission conductors at a safe height from the ground. Transmission towers are vulnerable to natural hazards and lead to direct and indirect losses on the economy and communities in the event of their failure.

For the exposure information framework, the different types and components of electricity transmission towers are listed in the following table.

Component	Element	Attribute
Electricity Transmission Towers	Ownership	Public
		Private
		Partnership
	Year Built or Upgraded	
	Tower Foundation	
	Site Topography Class	
	Height of Tower (Peak)	
	Height of Tower (Cage)	
	Height of Tower (Body)	
	Width of Tower (Cross-arm)	
	Number of Circuits	
	Type of Conductors	
	Tower Types	Suspension
		Strainer
		Dead-end
		Termination Crossing Tower
	Tower Design	

	Tower Materials	
	Reconstruction Cost	

5.2.12 Electricity Transmission and Distribution Poles

Transmission poles are the main support for the overhead low-voltage electricity distribution lines, transformers, street lights and other cables. For the exposure information framework, the different types and components of electricity transmission poles are listed in the following table.

Component	Element	Attribute
Electricity Distribution Poles	Pole Type	
	Pole Usage	
	Pole Materials	
	Pole Height	
	Power Equipment	
	Pole Route	
	Reconstruction Cost	

5.2.13 Electricity Substations

Electricity substations and switching facilities are where electricity transmission lines are connected and switched, and voltage is changed by transformers for consumption. They range from the very large to the very small. For the exposure information framework, the different types and components of electricity substations are listed in the following table.

Component	Element	Attribute
Electricity Substations	Ownership	Public
		Private
		Partnership
	Substation Types	Transmission

		Distribution
		Collector
		Converter
		Switching
	Usage	National Grid
		Sealing End
		Intermediate
		Distribution
	Voltage	
	Design	Indoor
		Outdoor
	Seismic Design	Yes
		No
	Height	
	Equipment List	Capacitive Voltage Transformer
		Current Transformer
		Disconnect Switch
		Power Circuit Breaker Single-phase
		Power Circuit Breaker Three-phase with Current Transformer
		Power Transformer
		Control Building with Equipment
		Bus
	Total Capacity	
	Population Distribution Coverage	
	Year Built or Upgraded	
	Reconstruction Cost	

Existing Capabilities

GA has the spatial location of several energy infrastructure assets in Australia. The infrastructure data collected, collated and provided by GA includes power stations, substations, transmission towers, transmission lines, gas pipelines, refineries, fuel terminals, depots and petrol stations, but these datasets are not comprehensive enough to provide exposure information.

Several other organisations or private companies hold the data and release it through reports. The following table provides a comprehensive list of information sources for the energy sector.

Agency	Product Description	Web Link
ELECTRICITY		
Australian Energy Market Operator (AEMO)	Lists power stations and capacities for each National Electricity Market (NEM) state	http://www.aemo.com.au/Electricity/Data
	List of non-scheduled power stations, including energy source and capacity for the NEM	http://www.aemo.com.au/Electricity/Data
	Numerous diagrams of electricity and gas infrastructure	http://www.aemo.com.au/Electricity/Data http://www.aemo.com.au/Gas/Market-Data
Powerlink	QLD network map	https://www.powerlink.com.au/Network/
Transgrid	Relevant NSW network maps	https://www.transgrid.com.au/what-we-do/our-network/Pages/default.aspx
EICU, NSW	EISL Data – restricted access	http://www.lpi.nsw.gov.au/about_lpi/eicu
Australian Energy Regulator	SP AusNet transmission determination	https://www.aer.gov.au/networks-pipelines/determinations-access-arrangements/ausnet-services-sp-ausnet-determination-2014-17
Essential Services Commission	Distribution-level data but some links to transmission	http://www.esc.vic.gov.au/Accessibility
Electra-Net	State wide network map (SA)	http://www.electranet.com.au/network/network-maps-and-statistics/
	Metropolitan network map (SA)	http://www.electranet.com.au/network/network-maps-and-statistics/
Western Power	Network map (WA)	http://www.westernpower.com.au/corporate-information-network-data.html
PAWA	Power and Water (NT)	http://www.powerwater.com.au/
Transend	Statewide network map	http://www.tasnetworks.com.au/our-network
GAS		
Relevant information sources	Further Research is required from the below organisation – Australian Consumer Competition Commission Australian Energy Regulator Australian Energy Market Commission Independent Pricing and Regulatory Tribunal of NSW Economic Regulation Authority of WA	http://www.accc.gov.au/about-us/
Federal Government	Several policy-related documents	http://www.environment.gov.au
State Governments	NSW	http://www.planning.nsw.gov.au
	WA	http://www.energy.wa.gov.au
	QLD	http://www.coordinatorgeneral.qld.gov.au http://www.nrw.qld.gov.au http://www.energy.qld.gov.au
	VIC	http://www.invest.vic.gov.au http://www.dse.vic.gov.au
	Northern Territory	http://www.nt.gov.au http://www.ntgas.com.au/
	South Australia	http://www.pir.sa.gov.au http://www.infrastructure.sa.gov.au/

	ACT	http://www.actewagl.com.au/
SEA Gas	Transmission – Pipelines & Services	http://www.seagas.com.au/
APA Group	Pipelines	https://www.apa.com.au/pipeline-corridors/ https://www.apa.com.au/related-sites/
Goldfields Gas	Pipelines	https://www.erawa.com.au/gas/gas-access/goldfields-gas-pipeline
Dampier Bunbury	Pipeline	http://www.dbp.net.au/
ELGAS	Storage	http://www.elgas.com.au/
PETROLEUM		
GA	PEDIN-Petroleum Well Data	Petroleum and Greenhouse Gas Advice Group
Dept of Industry	Resources	https://industry.gov.au/resource/upstreampetroleum/Pages/default.aspx
Oil & Gas	Oil and Gas Infrastructure Portal	http://www.oilandgasinfrastructure.com/home/oilandgasoceania/australia
ABARES	Energy	http://www.abareconomics.com/research/energy/
Alinta Energy	Energy	https://alintaenergy.com.au/nsw/energy-products
Origin Energy	Energy	http://www.originenergy.com.au/files/
Arrow Energy	Energy	http://www.arrowenergy.com.au/
Santos		http://www.santos.com/
BHP Billiton		http://www.bhpbilliton.com/ http://www.bhpbilliton.com/investors/reports/2015-annual-reporting-suite
Chemlink	LPG Bottle Suppliers	http://www.chemlink.com.au/
Petroleum Exploration Society of Australia		https://www.pesa.com.au/technical-library/
Micro LNG		http://www.microlng.com/index.html
Australian Petroleum Production & Exploration Association		https://www.appea.com.au/industry-in-depth/technical-information/ https://www.appea.com.au/industry-in-depth/industry-statistics/
OIL	OIL Online	https://www.oilonline.com/news
AWE Company		http://www.awexplore.com/irm/content/home.html
GA	Petrol Stations	https://data.gov.au/dataset/national-petrol-stations-database
	Pipelines	National Geographic Information Branch GPInfo Pipelines dataset
Pipeliner	Australia Map	http://pipeliner.com.au/pipeline_map_of_australia/

Gaps and Suggestions

Some of the energy infrastructure like liquid fuels and electricity assets and facilities locations data is available from GA, spatial data providers of state jurisdictions and the industry. Sometimes the data is released in the form of

annual reports. The data provided by these agencies often has limited coverage and cannot be used to make decisions on DRR.

The exposure information about these facilities is held by the service providers and private companies. The information is partly available in their reports but there is no provision for these companies to provide the data, and some is considered commercial-in-confidence.

There is no centralised database to collect, collate, maintain and disseminate energy sector exposure information other than the location data for emergency service authorities. This framework identifies that the agencies holding the data could be engaged to release it for the development of the National Disaster Management Database. Further strategies are to be prepared to implement the framework, develop the database and deliver information under creative commons licensing agreements. There may be a requirement for legislation to facilitate the data being disclosed by private companies.

5.3 COMMUNICATIONS SECTOR

Communications infrastructure considers telephone, mobile and internet services, the national broadband network, international submarine cables, broadcasting (mass communication) and postal services. Australia's national security, community safety, economic prosperity and social wellbeing increasingly rely on telecommunications networks. This sector supports businesses, individuals and the public sector to do their business efficiently and is critical in emergency management. Proper disaster continuity planning is essential to ensure continued delivery of vital messages to communities during emergency situations and it is important to have information on the location of communication assets at a particular location.

5.3.1 Telephone Exchanges

Technology in the telecommunications sector is changing rapidly from analogue to digital. Telephone exchanges are the hubs located as central facilities that connect landline telephones through

cabling networks. Typically, a single building is used to house the equipment of potentially several telephone exchanges, each serving a specific geographical exchange area. Some of the important exposure information requirements for telephone exchanges are listed in the following table.

Component	Element	Attribute
Telephone Exchanges	Ownership	Public
		Private
		Partnership
	Area of Coverage	
	Services Offered	Mobile Voice
		Mobile Broadband
		Copper Landline
		xDSL
		Broadband
		Satellite Link
	Customers per Service	Mobile Voice
		Mobile Broadband
		Copper Landline
		xDSL
		Broadband
	Backup Power Duration	
	Backup Power Type	Diesel Generator
		Battery
		Other
	Year Built	
	Rebuild Timeframe	
	Reconstruction Cost	

5.3.2 Telephone Cable Network

The telephone network consists of a collection of cables connecting all end-users with a telephone exchange. The cables may be copper or fibre and overhead or underground. There may be cables for direct connection between exchanges. Some of the important exposure information requirements for the telephone cable network are listed in the following table.

Component	Element	Attribute
Telephone Cable Network	Ownership	Public
		Private
		Partnership
	Telephone line	
	Switch Nodes	
	Materials	Copper
		Fibre
	Year Built	
	Rebuild Timeframe	
	Reconstruction Cost	

5.3.3 Communication Towers

Communication towers are the main support for transmission antennae. They hold heavy transmission conductors at a sufficient, safe height from the ground. Natural disasters can have significant impact on communication towers and lead to severe impacts on communities and the economy. Some of the exposure information requirements for communication towers are listed in the following table.

Component	Element	Attribute
Communication Towers	Ownership	Public
		Private
		Partnership
	Tower Foundation	
	Site Topography	
	Tower Purpose	
	Height of Tower (Peak)	
	Tower Design	
	Tower Materials	
	Year Built	
	Rebuilding Timeframe	
	Reconstruction Cost	

5.3.4 Submarine Cables

Submarine cables laid on the sea bed between land-based stations carry telecommunication signals across stretches of ocean. As of 2006, 99% of international communication traffic was through submarine cables. The total carrying capacity of these cables is in terabits per second (BPS) while satellites offer 1 GBPS. Construction of these cables is very expensive and they are vital for the national economy. Hence, it is important to store and manage information on submarine cables for disaster management purposes. Some of the exposure information requirements are listed in the following table.

Component	Element	Attribute
Submarine Cables	Ownership	Public
		Private
		Partnership
	Submarine Cable Networks	
	Cable Landing Stations	
	Frequency or Bandwidth	
	Cable Type	
	Cable Capacity	
	Offshore Destinations	
	Year Built	
	Rebuilding Timeframe	
	Reconstruction Cost	

5.3.5 Broadcasting

Broadcasting is the distribution of audio and video content to a wide audience through mass communications media using the electromagnetic spectrum (radio waves). The methods used for broadcasting electronic media to the general public include radio, television, cable broadcasting, satellite broadcasting, webcasting and datacasting. With the emergence of the internet, social media is also quite popular in broadcasting information. Some of the exposure information requirements are listed in the following table.

Component	Element	Attribute
Broadcasting	Type	
	Ownership	Public
		Private
		Partnership
	Purpose	Community
		Commercial
		Private (Hospital, Campus)
		Digital
		Satellite
		Internet
		SMS Services
	Site Name	
	TV Station	
	Radio station	
	Studio Facilities	
	Coverage Area	
	Frequency	AM
		FM
	Equipment	
	Cable Networks	
	Rebuilding Timeframe	
	Reconstruction Cost	

5.3.6 Satellite Earth Stations

A ground or earth station is a terrestrial radio station designed for extraplanetary telecommunication with spacecraft, or reception of radio waves from an astronomical radio source. Earth stations communicate with spacecraft by transmitting and receiving radio waves in the super-high-frequency or extremely high-frequency bands. When a ground station successfully transmits radio waves to a spacecraft (or vice versa), it establishes a telecommunications link. A principal telecommunications device of the ground station is the parabolic antenna. Some of exposure information requirements are listed in the following table.

Component	Element	Attribute
Satellite Earth Stations	Ownership	Public
		Private
		Partnership
	Type of Antenna	
	Number of Antennas	
	Size of Antenna	
	Capacity	
	Equipment	
	Construction Material	
	Year Built	
	Rebuilding Timeframe	
	Reconstruction Cost	

5.3.7 Postal and Courier

With the emergence of digital telecommunications, the postal services are less critical in DRR. Courier services will be delayed by natural disasters and can be resumed once communities and businesses are back on track. The following facilities are considered as exposure elements in this category.

Component	Element	Attribute
Postal and Courier	Ownership	Public
		Private
		Partnership
	Mail Sorting Centres	
	Delivery Vehicles	

In addition to capturing and storing inherent spatial location information (geometry) for each communication infrastructure asset (spatial feature), data tables and attributes should be structured to best represent the above information.

Existing Capabilities

The Australian Communications and Media Authority (ACMA) provides comprehensive information on communications infrastructure, operations and regulations in Australia. The data needs to be cleaned and customised for end-users purposes. GA has collected the data from ACMA and through other sources and provides the spatial location of several infrastructure assets in Australia, but these datasets are not comprehensive enough to provide exposure information for DRR research and response.

There are several other organisations or private companies that hold this data but it is commercial-in-confidence or restricted owing to security reasons. The following table provides a comprehensive list of information sources for the communications sector available in the public domain.

Agency	Product Description	Web Link
TELECOMMUNICATIONS		
Telstra	Huge amount of operational information including key site locations and MPLS technology	http://telstrawholesale.com.au/products/product-roadmap/prod-roadmap.htm https://www.telstra.com.au/business-enterprise
Optus	Information about major terrestrial and satellite infrastructure	http://www.optus.com.au
ACMA	Submarine cable protection zones	http://www.acma.gov.au/
Alcatel	Global submarine cable map	https://www.alcatel-lucent.com/solutions/submarine-networks http://submarine-cable-map-2015.telegeography.com/
Operators	Each of the cable operators has annual reports	http://www.southerncrosscables.com/home/network/overviewandmap
General	Submarine cables	http://en.wikipedia.org/wiki/List_of_international_submarine_communications_cables
	Global submarine cable landing stations	http://www.kidorf.com/DBLandings.php

	Telephone exchange locations	http://whirlpool.net.au/wiki/Australian_Exchange_Guide
	ADSL2 exchanges	http://www.adsl2exchanges.com.au/
NBNCO	National broadband network information	http://www.nbnco.com.au/learn-about-the-nbn.html
RFNSA	National mobile phone tower information	http://www.rfnsa.com.au/nsa/index.cgi
BROADCAST		
GA	Towers Database	http://www.ga.gov.au/mapspecs/topographic/v6/appendixA_files/Culture.html#Culture Vertical Obstruction Point
FSDF		http://link.fsdf.org.au/dataset/4524
ACMA	RADCOM database	http://web.acma.gov.au/pls/radcom/register_search.main_page
	List of licensed radio and TV broadcasting transmitters	http://www.acma.gov.au/Citizen/Consumer-info/Broadcasting-in-my-area/Lists-of-broadcasters/licensed-broadcaster-listings-broadcasters-list-i-acma
Operators	ABC lists all broadcast services and their transmission towers	http://www2b.abc.net.au/reception/frequencyfinder/asp/results.asp
	SBS annual report and website list all radio and TV services and transmitters	http://www.sbs.com.au/shows/aboutus/tablistings/detail/i/2/article/4952/Annual-Reports http://www.sbs.com.au/blog/119042/Enjoying-the
	All commercial radio frequencies	http://www.commercialradio.com.au/find-a-station
POSTAL		
Australia Post	Locations of mail sorting and distribution centres	http://auspost.com.au/pol/app/locate

Gaps and Suggestions

Some of the data on communication sector infrastructure assets and facilities locations is available with ACMA and GA. The data provided by these agencies is not comprehensive enough to make decisions for DRR and has limited attribute coverage. GA NEXIS summarises and provides the number of assets aggregated for a given area for disaster management authorities.

The exposure information about these facilities is held by the service providers and private companies. Some of the information is available in their reports but there is no requirement for the companies to disclose the data. Some of the data is considered commercial-in-confidence and is also constrained by security classifications.

There is no centralised database to collect, collate, maintain and disseminate communication sector exposure information other than spatial location for emergency service authorities. Further strategies are to be prepared to implement the framework, develop the database and provide information under creative commons licensing agreements. Legislation may be required for the companies to disclose the information.

5.4 URBAN WATER SUPPLY AND SANITATION SECTOR

Urban water supply and sanitation is the provision of water by public utilities and commercial agencies for domestic and industrial use, usually via a system of pumps and pipes. Irrigation for agriculture is not covered in this section.

Provision of a clean water supply with high standards of sanitation is the most important public health concern. Damage and disruption of water supply and sanitation infrastructure following major catastrophes including earthquakes, floods and human threats poses a very high risk of public health hazards with escalating epidemics of life-threatening waterborne diseases.

Collating, storing and maintaining spatial location information (geometry) for each water infrastructure asset (spatial features) is an important requirement for disaster management, response and recovery.

5.4.1 Potable Water Catchments

Water supply systems get water from a variety of sources after appropriate treatment, including surface water (lakes and rivers), the sea through desalination, and groundwater (aquifers). Treated water then either flows by gravity or is pumped to reservoirs, which can be elevated, such as water towers, or on the ground. For the exposure information framework, the different types and components of the potable water catchment process are listed in the following table.

Component	Element	Attribute
Catchment	Area	
	Dams	Foundation
		Length
		Type
		Spillway Type
		Construction Material
		Year Built
		Replacement Value
		Height

		Storage Capacity
		Rebuilding Timeframe
	Ground-Water Well	Well Depth
		Well Type
		Well Capacity
		Storage Capacity
		Year Built
		Replacement Value
		Rebuilding Timeframe
	Criticality	
	Equipment	Pumping
		Repair Timeframe
	Storage Tanks and Reservoirs	

5.4.2 Potable Water Treatment

Water treatment is the removal of contaminants from water collected from catchments or desalination to produce drinking water that is pure enough for the most critical of its intended uses. Substances that are removed during the process of drinking water treatment include suspended solids, bacteria, algae, viruses, fungi, minerals such as iron, manganese and sulfur, and other chemical pollutants such as fertilisers. Measures taken to ensure water quality not only relate to the treatment of the water, but to its conveyance and distribution after treatment as well. For the exposure information framework, different types and components of the potable water treatment process are listed in the following table.

Component	Element	Attribute
Treatment	Ownership	Public
		Private
		Partnership
	Processing Capacity	

	Tank Volume	
	Tank Usage	
	Tank Storage	
	Tank Flocculation	
	Tank Sedimentation	
	Tank Foundation	
	Tank Material	
	Tank Anchorage	
	Tank Seismic Design Level	
	Tank Height-to-Diameter Ratio	
	Tank Roof	
	Tank Year Built or Upgraded	
	Tank Rebuild Timeframe	
	Inlet Control Building	
	Screen House	
	Clarifier	
	Filter Building	
	Disinfection Plant	
	Chemical Tanks	
	Desalination Plant	
	Outlet Building	
	Elevated Pipes	
	SCADA System	
	Backup Electric Power	
	Plant Reconstruction Cost	

5.4.3 Wastewater Treatment Plants

Wastewater treatment is the process of removing contaminants from wastewater, primarily from household and industrial sewage. It includes physical, chemical and biological processes to remove these contaminants and produce environmentally safe treated wastewater. A by-product of waste water treatment is usually a semi-solid waste or slurry called sewage sludge that has to undergo further treatment before being suitable for disposal or land

application. The sewer system also carries industrial effluent to wastewater treatment plants that has usually received pretreatment at the generators to reduce pollutant load.

The treated water is called grey water and it is permitted to be used for gardening or flushing toilets. For the exposure information framework, the different types and components of wastewater treatment plants are listed in the following table.

Component	Element	Attribute
Wastewater Treatment	Ownership	Public
		Private
		Partnership
	Processing Capacity	
	Storage Tank Size	
	Storage Tank Foundation	
	Storage Tank Construction	
	Grit Chamber Size	
	Grit Chamber Foundation	
	Grit Chamber Construction	
	Grit Chamber Type	Horizontal
		Aerated
		Vortex
	Aeration Tank Size	
	Aeration Tank Foundation	
	Aeration Tank Construction	
	Sludge Tank Size	
	Sludge Tank Foundation	
	Sludge Tank Construction	
	Sludge Removal Pumps	
	Dissolved Air Flotation Tank Size	
	Dissolved Air Flotation Tank Foundation	
	Dissolved Air Flotation Tank Construction	
	Secondary Treatment Equipment	Filter Beds
		Rotating Biological Contactors
		Activate Sludge System
		Surface-Aerated Basins
	Tertiary Treatment Equipment Filters	Sand
		Activated Carbon
	Tertiary Treatment Equipment Disinfection	Chemical

		Ozone Production
		Ultraviolet Radiation
	Tertiary Treatment Equipment Biological Nutrient Removal Tanks	
	SCADA System	
	Control Building	
	Backup Electric Power	
	Repair Timeframe	
	Reconstruction Cost	

5.4.4 Water Transmission Networks

Water is transmitted through pipelines from dams to a storage reservoir and then into the distribution networks. Water supply is based on gravity, or pumping facilities are provided to pressurise the water for high-rise buildings.

Once water is used, wastewater is typically discharged into a sewer system and treated in a wastewater treatment plant before being discharged into a river, lake or the sea, or reused for landscaping, irrigation or industrial use. Wastewater can be treated close to where the sewage is created or alternatively, sewage can be collected and transported by a network of pipes and pump stations to a municipal treatment plant. For the exposure information framework, the different types and components of the water transmission network are listed in the following table.

Component	Element	Attribute
Water Transmission	Ownership	Public
		Private
		Partnership
	Reticulation Area	
	Reticulation Type	Potable
		Storm Water
		Waste Water

		Recycled Water
		Multiple
	Pumping Stations	
	Pipe Bridge Type	
	Pipe Bridge Spans	
	Pipe Bridge Pier Height	
	Pipe Network	
	Pipe Size and Diameter	
	Pipe Material	
	Filtering	
	Connectors	
	Year Built or Upgraded	
	Repair Timeframe	
	Reconstruction Cost	

Existing Capabilities

Data is available for water supply catchments, dams and natural networks via the Australian Hydrological Geospatial Fabric (the Geofabric) managed by the Bureau of Meteorology (BOM) with assistance from GA, the Australian National University (ANU), CSIRO and the States and Territories. This data covers rural water supply for agriculture or catchment but not the urban water infrastructure or supply.

The availability of water sector data in the public domain is very limited, and little if any relevant urban water sector data is readily available from reports, websites and such. However, certain data sourced from water services corporations may be available by agreement for distribution in the public domain in some processed or aggregated form. The custodians of some of the public domain datasets are listed in the following table.

Agency	Product Description	Web Link
Water		
GA and BOM	Geofabric	http://www.bom.gov.au/water/npr/index.shtml
ANCOLD	Australian National Committee on Large Dams	http://www.ancold.org.au/
ACTEW	Water Supply & Recycle in ACT	https://www.iconwater.com.au/
Sydney Water	Spatial Data	http://www.waternsw.com.au/water-quality/catchment
	Dam Capacities	http://www.waternsw.com.au/supply/dam-levels/greater-sydneys-dam-levels
	Catchment Boundaries Weirs, Filtration, Recycle, Desalination	http://www.waternsw.com.au/supply/Greater-Sydney/system

	Contacts	http://www.waternsw.com.au/about/contact
Hunter Water	Dam Capacity, Water Supply, Wastewater Systems, Recycling, Storm Water	http://www.hunterwater.com.au/Water-and-Sewer/Water--Sewer.aspx
NSW Environment	Catchment Management Authority	http://www.hunterwater.com.au/Water-and-Sewer/Water--Sewer.aspx
EICU	Water Utilities	
QLD Urban Utilities	Water Utilities	http://www.urbanutilities.com.au/
SEQ Water	Dam Capacity, Water Supply, Wastewater Systems, Recycling, Storm Water	http://www.seqwater.com.au/water-supply
SUN Water	Dam Capacity, Water Supply, Wastewater Systems, Recycling, Storm Water	http://www.sunwater.com.au/
Melbourne Water	Dam Capacity, Water Supply, Wastewater Systems, Recycling, Storm Water	http://www.melbournewater.com.au/waterdata/Pages/waterdata.aspx
Victoria Councils	Barwon Water Central Highlands Water City West Water Coliban Water East Gippsland Water GWNWater Gippsland Water Goulburn Valley Water Lower Murray Water North East Water South East Water South Gippsland Water Wannon Water Western Water Westernport Water Yarra Valley Water	
Water Corp., WA		https://www.watercorporation.com.au/water-supply-and-services/rainfall-and-dams
SA Water		https://www.sawater.com.au/community-and-environment/our-water-and-sewerage-systems
TasWater		http://www.taswater.com.au/Community---Environment
Power and Water Corp	Northern Territory Utilities	https://www.powerwater.com.au/networks_and_infrastructure/water_services

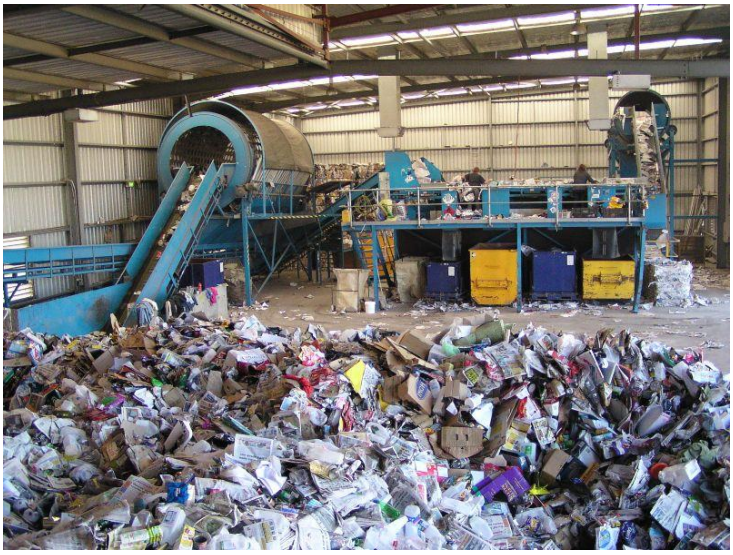
Gaps and Suggestions

Information on the location of urban water supply and wastewater infrastructure data is held by the respective utilities or companies. The data provided by the water supply agencies is not comprehensive enough to make decisions for DRR and has limited coverage as there are no centralised databases. The information available on the websites and in the reports is very

limited and there is no provision for comprehensive exposure data from these companies. Some of the data is considered commercial-in-confidence.

Strategies need to be prepared to implement the framework, develop the database and deliver information under creative commons licensing agreements. Legislation may be required for the private companies to disclose the information.

5.5 WASTE MANAGEMENT SECTOR



The waste management sector consists of collection, transport, treatment and disposal of waste, and includes prevention of waste production and reuse and recycling of waste. Waste materials generated include urban (residential, commercial and institutional), agricultural, healthcare, hazardous wastes and sewage.

Waste is considered as exposure to natural hazards and poses a risk to communities and the environment. Waste materials exposed to floods, storm surges or other natural hazards and mixed with the water can be highly dangerous to human health, the environment and its aesthetics.

The waste management infrastructure component of the framework suggests assets categories as follows:

1. Collection centres
2. Transfer stations
3. Collection trucks
4. Incineration plants
5. Recycling plants
6. Landfills
7. Waste type
8. Energy recovery facility

9. Reconstruction cost

NB: Water sewerage facilities are covered as part of water sector infrastructure.

Existing Capabilities

Waste Management Association of Australia (WMAA) is the peak waste industry body and most waste management businesses are members of this association. WMAA conducts surveys of landfill facilities and their activities regularly. A small amount of waste management sector data is publicly available. Each State and Territory government website lists (partially) landfills, waste transfer and reprocessing sites. Most of the specific information, including hazardous waste sites, is held at the State or Local Government level or with industry bodies. All known sources of waste management site information are listed in the following table.

Agency	Product Description	Web Link
SOLID WASTE		
Dept of Environment	National Waste Reporting 2013	http://www.environment.gov.au/resource/national-waste-reporting-downloads
WMAA	WMAA landfill survey for GA	http://www.impactenviro.com.au/waste2013/wmaa.html
CSIRO	Waste Database	http://www.greenfinder.com.au/Recycling-and-Waste/Australian-Waste-Database
State Governments	Environmental Protection Agencies of States and Territories	http://www.tams.act.gov.au http://www.ntepa.nt.gov.au/ http://epa.tas.gov.au/epa/ http://www.epa.vic.gov.au http://www.der.wa.gov.au/
Local Governments	Landfill facilities, e.g. Swan Hill	http://www.swanhill.vic.gov.au/environment-and-waste/waste-and-recycling/
HAZARDOUS WASTE SITES		
SEWPaC	Hazardous Waste Act and relevant data	https://www.environment.gov.au/protection/hazardous-waste
CSIRO	Australian Waste Database	http://www.greenfinder.com.au/Recycling-and-Waste/Australian-Waste-Database
Asbestos Safety and Eradication Agency	National Asbestos Exposure Register	https://asbestossafety.gov.au/national-asbestos-exposure-register

Gaps and Suggestions

GA has collected and collated waste management sites information from WMAA, the Environmental Protection Agencies of various jurisdictions and the Department of Environment. The exposure elements need to be added to the existing datasets to provide consistent information.

5.6 HAZARDOUS SUBSTANCES

Hazardous material facilities contain substances that can pose significant hazards because of their toxicity, radioactivity, flammability, explosiveness or reactivity. Casualties or property damage can occur from a small number or even single hazardous materials release induced by natural hazards. Extremely hazardous substances (EHSs) can be released accidentally as a result of chemical spills, industrial explosions, fires or accidents involving railroad cars and trucks transporting them. Workers and residents in communities surrounding industrial facilities where EHSs are manufactured, used or stored, and in communities along railways and highways are potentially at risk of being exposed to liquid spill and airborne EHSs during accidental releases. The consequences vary greatly according to the type and quantity of substance released, meteorological conditions and the timeliness and effectiveness of emergency response.

For example, in the Bhopal disaster of 1984, approximately 2,000 residents living near a chemical plant were killed and 20,000 more suffered irreversible damage to their eyes and lungs following accidental release of methyl isocyanate. The toll was particularly high because the community had little idea what chemicals were being used at the plant, how dangerous they might be, or what steps to take in an emergency. This tragedy served to focus international attention on the need for governments to identify hazardous substances and to assist local communities in planning how to deal with emergency exposures.

Information on hazardous substances is critical for the safety of emergency workers and managers when responding to disasters. There may be simple acts that can save lives and the future health of people. For example, in the Bhopal disaster, instructions to breathe through a wet cloth and head in an opposite

direction to the wind could have saved many lives. Comprehensive information on substances, impacts and mitigation strategies would enable authorities to reduce the risk to the communities significantly.

In terms of DRR, hazardous substances are considered as elements at risk from natural hazards. Exposure information capabilities are needed to collect, collate, maintain and provide data for disaster management. The exposure elements information listed in the following table is critical for DRR for all levels of governance.

Component	Element	Attribute
Hazardous Substance	Facility Location	
	Facility Name	
	Facility Structure	
	Facility Usage	Manufacturing
		Storage
		Transportation
		Emission in Air, Water, Underground.
		Treatment Plants
		Retail
		Asbestos Materials
		Others
	List of Substances	
	Substance Physical Characteristics	
	Substance Chemical Characteristics	
	Airborne Concentration Thresholds	
	Pictogram Codes	
	Pictogram Images	
	Hazard Statement Codes	
	Hazard Statements	
	Hazard Character	Explosive
		Radioactive
		Flammable
		Oxidising
		Gases under Pressure
		Corrosive
		Acute Toxicity
		Health Hazard
		Chronic Health Hazard
		Environmental

	Severity of Toxicity	Acute Lethal
		Non-lethal
	Symptoms when Exposed	
	Critical Support	
Hazardous Equipment	Hazardous Equipment	

Existing Capabilities

Safe Work Australia has developed the 'Hazardous Substances Information System' (HSIS), which provides information on hazardous substances and classifications. HSIS provides searchable access to two datasets, one for hazardous substances and the other for exposure threshold standards information. HSIS also provides access to consolidated lists of all substances included in the hazardous substances dataset. The HSIS database consists of information about chemical substance name, Chemical Abstract Service (CAS) Registry number, United Nations (UN) number, classification based on atmospheric contamination, labelling on products, risk and safety phrases, health hazard category, concentration cut-off levels and chemical substance mixture classification.

Regulatory and registration services in various state jurisdictions, such as the Department of Justice, collect some data about the chemical substances handled by industry. Some of the chemical substances stored above thresholds quantities also reported to the regulatory authorities.

The Commonwealth Department of Environment has developed a National Pollutants Inventory (NPI) database to support environmental planning and management for government and industry. This also provides up-to-date information on chemical substance emissions and transfers from industrial facilities to the community. Australian industrial facilities are mandated to disclose defined thresholds for 93 NPI substances, and to estimate and report emissions and transfers of NPI substances in waste to their State or Territory environment agency. The State and Territory environment agencies review all NPI reports for completeness and forward the data to the Federal Government. The data is then maintained and provided through the NPI website.

Insurance underwriters collect and process data on chemical substance manufacturing and storage capacities to evaluate the risk and exposure of

business or industries. Normally the information is in the form of reports and not released publicly.

Gaps and Suggestions

The NPI provides data on the location, airborne emissions and characteristics of hazardous materials for environmental protection decision-making by industry and governments.

The HSIS provides knowledge and information on chemical substances.

GA and other agencies from state jurisdictions maintain location (only) information about facilities. The data provided by these agencies is not comprehensive enough to use in making decisions and has limited coverage.

There is no centralised database to collect, collate, maintain and disseminate hazardous substances data to the emergency service authorities. The framework proposes that the agencies mentioned above develop a database and align this with capabilities like NEXIS at GA. Further strategies should be prepared to implement the framework, develop the database and provide information under creative commons licensing agreements. Legislation may be required for the facilities to disclose the information to the above agencies.

6 MAJOR INDUSTRIES

Information on industries is critical for the economy and the safety of workers exposed to natural hazards. The scope of this exposure component considers major industries, particularly in the manufacturing sector. In Australia, the major manufacturing sectors are metal products, building materials, automobiles, timber, food processing, textiles, pharmaceuticals and chemicals. An industrial facility has many unique elements that are at risk, pose risk and contribute to the value chain of the economy.

For exposure information purposes, there is a need to collect, collate, maintain and provide information on manufacturing industries for disaster management. The exposure elements and attributes listed in the following table are required for DRR at all levels of governance.

Component	Element	Attribute
Major Industry	Name	
	Industry Structure	
	Industry Usage	
	Total Floor Area	
	Ownership	Public
		Private
		Partnership
	Number of Buildings	
List of Facilities	Facilities - Buildings	
	Facilities - Workshops	
	Facilities - Engine Rooms	
	Facilities - Wharves	
	Facilities - Control Rooms	
	Facilities - Administration Offices	

	Facilities - Ancillary	
	Year Built	
	Building Materials	Combustible
		Non-Combustible
	Equipment - Maintenance Status	
	Equipment - Gas Compressors	
	Equipment - Steam Generators	
	Equipment - Coolers	
	Equipment - Boilers	
	Equipment - Power	
	Equipment - IT Systems	
	Equipment - Mobile Equipment	
	Storage Warehouse	Raw Materials
		Processing Materials
		Product Materials
		Capacity
	Working Hours	
	Waste Management	
	Liability Issues	Pollution
		Internal Hazards
	Special Hazards	
	Plant Layout	
	Firefighting Capability	Sprinkler systems
		Emergency Response Teams
		Evacuation Facilities
	Security	
	Critical Equipment	
	Interdependency	
	Production Capacity	
	Onsite Parking	
	Reconstruction Cost	

Existing Capabilities

Insurance underwriters collect and process manufacturing and storage capacity information to evaluate the risk and exposure of businesses or industries. Normally, the information is in the form of reports and not released publicly.

Gaps and Suggestions

There is no centralised database or data processing capability to collect, collate, maintain and disseminate exposure information relating to large industry sites. Further strategies will need to be put into place to implement the framework, develop the database and deliver information under creative commons licensing agreements. Legislation may be required for the facilities to disclose the information to the data provision agencies.

7 PRIMARY INDUSTRIES SECTOR

The primary industries sector includes agriculture, fishing, forestry and mining. The types of natural hazards, climatic conditions and factors that impact on this sector in Australia include drought, water security, soil fertility, weeds, global warming and biosecurity. CSIRO, the Federal Government agency for scientific research in Australia, has forecast that climate change will cause decreased precipitation over much of Australia and that this will exacerbate existing challenges and quality issues for agriculture (Preston and Jones, 2006).

Australia's primary industries produce a large variety of products for export and domestic consumption and earn $155 billion a year, for a 12% share of GDP. Australian farmers and graziers own 135,997 farms, employ over 325,300 people and cover 61% of Australia's landmass. The Australian Bureau of Agricultural and Resource Economics and Sciences (ABARES) forecasts agricultural exports to be worth $38 billion in 2014–15, which comprises 58% of Australia's food production. The agriculture sector comprises crops, horticulture, viticulture, dairy, meat, fisheries, wool and seaweed.

The gross production value of Australian commercial fisheries was $2.4 billion in 2013 (ABARES, 2013a). This comprises of a variety of fish products from wild catch (gross value of $1.4 billion) and aquaculture (gross value of $1 billion). Tasmania produces the greatest amount of aquaculture products, followed by South Australia.

Australia's native forests occur in a broad range of geographic landscapes and climatic environments, and contain a wide array of mostly endemic species combining to form unique and complex ecosystems. Australia's native forests provide a range of wood and non-wood products consumed by Australians and used for export. The forests are significant in providing clean water; protecting soil; providing opportunities for recreation, tourism, scientific and educational pursuits; and support cultural, heritage and aesthetic values.

7.1 AGRICULTURE – CROP FARMING

Crops refer to harvests from a range of cultivated agricultural plants such as cereals, pulses, vegetables, fruits and oil seeds. Australia's main crops include wheat, corn, vegetables, fruits, cotton, sugarcane, barley, and canola. Various exposure elements and associated assets of crops farming are listed in the following table.

Component	Element	Attribute
Crop Farming	Farm Size	
	Crop Type	
	Crop Calendar	
	Crop Value	
	Farmhouse	
	Equipment	
	Storage Size	
	Processing Plant	

7.2 AGRICULTURE – HORTICULTURE FARMING

Australia's horticulture industry comprises fruits, vegetables, nuts, flowers, turf and nursery products. It comprises mainly small-scale family farms; however, there is a growing trend towards medium- to larger-scale operations. From an exposure framework perspective, floriculture (flower farming) and viticulture (vineyards) are also considered in this category. Information about the exposure elements and associated assets for the different types and components of horticulture farming that need to be collated and managed are listed in the following table.

Component	Element	Attribute
Horticulture Farming	Farm Size	
	Plantation Type	
	Number of Plants	
	Age of Plants	
	Yield Pattern	
	Equipment	
	Storage Size	
	Processing Plant	
	Farm Value	

7.3 AGRICULTURE – DAIRY FARMING

Dairy farming concerns the long-term production of milk, which is processed (either on the farm or at a dairy plant) to manufacture dairy products. Australian dairy is a $13 billion industry (Dairy Australia, 2015). A range of high-quality consumer products including fresh milks, custards, butter, yogurts, varieties of cheese and milk powder are produced in Australia. Australia's 6700 dairy farmers produce around 9.5 billion litres of milk a year. The Australian dairy industry directly employs 43,000 Australians on farms and in factories, while more than 100,000 Australians are indirectly employed in related service industries. The industry is very sensitive to natural hazards such as drought, and dependant on other sectors like water, energy and fodder supply. Various exposure elements and associated assets relevant to dairy farming are listed in the following table.

Component	Element	Attribute
Dairy Farming	Farm Size	
	Animals Type	
	Number of Animals	
	Age Mix of Animals	
	Dominant Breed	
	Sub-dominant Breed	

	Equipment	
	Ancillary Buildings	
	Products	
	Farm Value	

7.4 AGRICULTURE – ANIMAL FARMING

Animal farming concerns primarily keeping livestock such as cattle, pigs, sheep, horses and chickens for meat, eggs and other by-products. This includes breeding programs in controlled environments with high levels of investment. Animal farming is sensitive to natural hazards and to the consequences of failures of infrastructure utilities. For the exposure information framework, information on the different types and components of animal farming that needs to be collated and managed includes:

Component	Element	Attribute
Animal Farming	Farm Size	
	Animal Types	
	Farming Types	Free-range
		Caged
		Indoors
	Number of Animals	
	Age Mix of Animals	
	Dominant Breeds	
	Sub-dominant Breeds	
	Equipment	
	Ancillary Buildings	
	Products	
	Farm Value	

7.5 FISHERIES – WILD CATCH

Commercial fishing undertaken in the sea, lakes and rivers constitutes wild-catch fisheries. Marine fisheries production is largely influenced by bathymetry (sea floor topography), reefs, estuaries, ocean currents, ocean temperature, salinity and habitats. Global warming, acidification, massive runoff of nutrients and sediments from agriculture land has direct impacts on the productivity of fishing. Natural hazards such as floods, cyclones, tsunamis and storm surge impact fishing industry harvest. Various exposure elements and associated assets relating to wild fisheries are listed in the following table.

Component	Element	Attribute
Fisheries – Wild Catch	Fishing Zones	
	Fishing Restrictions	
	Endangered Species	
	Port Location	
	Number of Trawlers	
	Size of Nets	
	Total Capacity	
	Storage Capacity	
	Processing Plants	

7.6 AGRICULTURE – AQUACULTURE

Aquaculture involves cultivating freshwater and saltwater populations under controlled conditions. Aquaculture includes the farming of fish, shrimp, oyster, seaweed, and ornamental fish. The farming of fish is the most common form of aquaculture and involves growing fish commercially in tanks, ponds, or ocean enclosures. Shrimp farming is more sensitive to climate variations, salinity and pollution.

Oysters are grown in brackish water estuaries, mainly for human consumption and also for pearl production. Various exposure elements and assets associated with fish farming are listed in the following table.

Component	Element	Attribute
Aquaculture Farming	Farm Size	
	Fish Type	
	Fishing Stock	
	Products Pattern	
	Equipment	
	Processing plants	
	Ancillary Buildings	
	Farm Value	

7.7 FORESTRY

Australia has a total of 125 million ha of forest (16% of Australia's land surface) and 98% of this is native forest. Australia has about 3% of the world's forest area, and globally, is the country with the seventh largest forest area. Native forests are categorised in Australia's National Forest Inventory into eight national forest types named after their key genus or structural form: Acacia, Callitris, Casuarina, Eucalypt, Mangrove, Melaleuca, Rainforest, and Others (ABARES, 2013b). Industrial plantations are grown on a commercial scale for wood production and sandalwood plantations for other products; non-commercial planted forests include agroforestry plantations and plantations within reserve systems. Various exposure elements and associated assets of the forest sector are listed in the following table.

Component	Element	Attribute
Forest	Forest Area	
	Status	
	Forest Structure	
	Dominant Species	
	Sub-dominant Species	
	Ownership	
	Products	Hardwood
		Softwood
		Veneer Logs
		Pulp Logs
		Oils

7.8 MINING

Mining is the extraction of valuable and other geological materials from the earth. The process of mining from exploration and prospectivity of an ore body through extraction of minerals to finally returning the land to its natural state consists of several distinct steps. Mining techniques can be divided into two common excavation types: surface and underground. Modern commercial mining uses heavy equipment to explore, develop sites, remove overburden, excavate, process the ore and carry out reclamation after the mine is closed. Mineral processing is considered as a heavy industry. Safety has long been a concern in the mining business, especially in underground extraction owing to natural hazards. Concentration of methane and other contaminants underground can be hazardous for the workers, and may be considered part of the hazardous substance exposure of mine workers.

Mining is a significant primary industry and contributor to the Australian economy. Disruptions in mining activity due to natural hazards will have a major impact on the economy and employment in Australia. Various exposure elements and associated assets of the mining sector are listed in the following table.

Component	Element	Attribute
Mining	Mine Area	
	Operating Status	
	Operating Type	Surface
		Underground
	Commodities	
	Ownership	
	Equipment	
	Production Capacity	
	Value	

Existing Capabilities

Primary industries exposure information is provided by many organisations for different purposes. The more authoritative sources of this information are outlined and summarised in the table below.

ABS conducts an agriculture census every five years. The agricultural census provides a detailed picture of what is happening in the Australian agricultural sector at the regional level. It provides vital information on agricultural production, water and land-management practices throughout Australia and allows a detailed understanding of the contribution that agriculture makes to the national economy. The ABS Agricultural Census provides estimates for a range of agricultural commodity items including land use, industry structure, broadacre crops, horticultural production and livestock. The data is presented for Statistical Area 4 (SA4), Statistical Divisions, Statistical Local Areas, the Murray–Darling Basin and Natural Resource Management (NRM) regions. The information gathered through the Agricultural Census can help influence decisions that shape the future of Australia.

ABARES conducts farm surveys annually to provide a broad range of information on the current and historical economic performance of farm business units in the rural sector. The main surveys are the Australian agricultural and grazing industries survey (AAGIS) and Australian dairy industry survey (ADIS). These two surveys cover detailed financial, physical and socioeconomic information for the broad acre and dairy sectors, which contain around 68% of Australian farm business units. The information gathered is presented in the publication 'Australian Farm Surveys Results' as well as in a range of industry publications such as 'Australian Grains', 'Australian Lamb', 'Australian Beef' and 'Australian Dairy'.

Australia's National Forest Inventory (NFI) represents by State, Territory and Australian government agencies involved in forest information management. The NFI collects, compiles, analyses and manages forest data, and the public communication of forest information.

The NPI is a program of the NFI. Data on Australia's industrial plantations is collected through an annual survey of growers, grower representatives and State and Territory agencies. The survey records the total commercially

managed plantation estate each year, and the area of commercially managed plantations newly established on land that had not previously been used for plantations.

Dairy Australia is the national services body for dairy farmers and the industry. Dairy Australia conducts research and development (R&D) throughout the dairy supply chain, identifying the opportunities and information to advice farmers. Dairy Australia has a large amount of research information about farms and product development that is useful to include in the exposure information.

The Fisheries Research and Development Corporation (FRDC) undertakes research to assist in the management of fisheries and aquaculture resources for ongoing sustainability, in particular directed at research that has a benefit for the three sectors of the fishing industry: commercial (wild-catch and aquaculture), recreational and Indigenous.

Resource & Energy Media maintains the Mining Oil Gas portal website, which provides data on Mine Sites of Atlas which is an easy-to-use, highly informative reference, providing a comprehensive overview of every operating mine site in the country. This includes site history, location details and production performance figures.

The primary industries data sources and custodians are listed in the following table.

Agency	Product Description	Web Link
ABS	Agriculture Census – 5 years	http://www.abs.gov.au/ausstats/abs@.nsf/Lookup/7101.0main+features2Dec%202012
ABARES	Farm Surveys	http://www.agriculture.gov.au/abares/surveys http://www.agriculture.gov.au/abares/aclump/Pages/land-use/data-download.aspx http://data.daff.gov.au/anrdl/metadata_files/pb_luausg9abll20150415_11a.xml
	National Forest Inventory (NFI)	http://www.agriculture.gov.au/abares/forestsaustralia/forest-data-maps-and-tools
	National Plantation Inventory (NPI)	http://www.agriculture.gov.au/abares/forestsaustralia/plantation-inventory-and-statistics1
Dairy Australia	Dairy Research	http://www.dairyaustralia.com.au/Markets-and-statistics.aspx
FRDC	Fisheries Research	http://frdc.com.au/Pages/home.aspx http://frdc.com.au/research/Documents/Final_reports/2009-214-DLD.pdf
Geoscience Australia	Mines Atlas	http://www.australianminesatlas.gov.au/?site=atlas
Mineral Council of Australia	Location & Policy	http://www.minerals.org.au

Mining Australia	Mine Map	https://www.australianmining.com.au/mine-map/
RSC Mining & Mineral Exploration	Resource Intelligence	http://intel.rscmme.com/#
Mines Australia	Mines Directory	https://en.wikipedia.org/wiki/List_of_mines_in_Australia
State Governments		Primary Industries Departments in various state jurisdictions have plenty of information.

Gaps and Suggestions

There is plenty of data on primary industries available for exploration, prospectivity, products, business operations, etc. However, the information is not prepared as exposure data for analysis and decision-making for DRR. This framework identifies the need to develop a centralised and consistent database with the data items defined above for risk assessment from natural hazards and infrastructure system failures.

8 POPULATION EXPOSURE

Collating and managing information on the level of population exposure to natural disasters in Australia is an important aspect of disaster management. Population exposure to natural hazards has been demonstrated in the past to be disastrous not only in densely populated countries like the Philippines and Japan, and in Honduras and Nicaragua (during Hurricane Mitch in 1998) but also in the USA during Hurricanes Sandy and Katrina. Australian communities are varied in their composition and in their level of exposure to disaster risk. For the exposure framework, the factors that influence the level of population vulnerability to natural hazards can broadly be classified as follows:

1. Remoteness status
2. Demographic composition
3. Socio-economic status
4. Labour force status
5. Health
6. Spatio-temporal population
7. Risk perception
8. Evacuation response
9. Social capital

8.1 POPULATION REMOTENESS STATUS

It is well known that the Australian population is diverse in composition and quite dispersed in spatial distribution and therefore widely varies in its level of exposure to disaster risk (COAG, 2011). Most of Australia's population is

concentrated in two widely separated coastal regions – the south-east and east, and the south-west. The population within these regions is concentrated in urban centres, particularly the capital cities (ABS, 2012). The distribution of the remote population is a significant factor that can influence disaster resilience and disaster management initiatives and policy (COAG, 2011) because of their level of access to infrastructure and services including health care and fire brigades. The proportion of the population living in each of the ASGS-classified Remoteness Areas (broad geographical areas sharing common characteristics of remoteness) varies considerably across the States and Territories (ABS, 2008).

This framework identifies that population ratios and population distribution at the national, state and small-area (SA2) level across the ASGS Remoteness Structures available from the ABS (ABS, 2011b) would be useful for end-users. The Remoteness Structure divides each State and Territory into several regions on the basis of their relative access to services. There are six classes of Remoteness Access in the Remoteness Structures: Major Cities of Australia, Inner Regional Australia, Outer Regional Australia, Remote Australia, Very Remote Australia and Migratory (ABS, 2011c). A further refinement is in designating the remoteness areas with a focus on community safety is required for emergency response and operational activities.

8.2 DEMOGRAPHIC COMPOSITION

The changing demographic landscape around the world, such as population growth; age, gender and ethnic composition; population distribution; migration and urbanisation is one of the important factors that have increased population exposure to hazards. Consequently, demographic composition has been identified as an important component of population exposure, risk assessment and vulnerability modelling for disaster management. Important components of this demographic composition include:

1. Number of people
2. Population age profile
3. Population density
4. Gender composition
5. Migration
6. Indigenous and ethnic composition
7. Household composition

8.2.1 Number of People

Information about the number of people exposed to natural hazards is essential during the rescue planning process. ABS conducts a population and dwelling census regularly and collects the data on census night. The information is provided aggregated to ASGSs. These areas do not necessarily match disaster-impacted areas, and moreover the information represents the population on census night.

The framework suggests the aggregated information be disaggregated and populated to buildings to enable the exposure information systems to re-aggregate the population count for any defined disaster-affected area.

GA NEXIS has developed a model to incorporate several relevant datasets and is able to provide the number of people in a given area to Australian Crisis Coordination Centres. This applies strictly to the residential population and the number of people exposed at any given time is discussed separately in the following sections of the framework.

8.2.2 Population Age Profile

This framework identifies the importance of information on population age composition, i.e. the number of people in different age categories, which can broadly be classified as children (0–4, 5–14 years), working age (15–64 years) and aged (65 years plus). Australia, like the other OECD (Organisation for Economic Co-operation and Development) partners, is characterised by a rapidly aging population with a low birth rate and high life expectancy. The number of Australians aged 65 years and over is projected to outnumber children aged 0–14 years by 2018. By 2056, nearly one in four Australians is projected to be aged 65 years and over (Kinfu et al., 2015). This population ageing presents a number of challenges to society in terms of their long-term health and care needs as they are more likely to be living with long-term health conditions, less mobile, living in single-person or group households. This significantly increases the exposure and vulnerability of the population to natural disasters. Along with information on the aged, information on infant, baby and children numbers is equally perceived as important for disaster response and recovery purposes.

8.2.3 Population Density

Not only population size but density (number of people living per square kilometre) is important indicators of population exposure to natural disasters (COAG, 2011). Rising population density primarily in relation to urbanisation and coastal developments poses a particular risk in natural disasters as the physical structure of urban settings and congestion not only result in exposing a greater numbers of individuals to natural disasters but, within an ecological context, also create conditions conducive for more man-made secondary disasters and for greater exposure. Environmental exploitation such as deforestation, destruction of mangroves or expanding the coastal zone to areas that were once occupied by water increase the likelihood of disasters (Donner and Rodriguez, 2008). It is also believed that areas of high population density – particularly urban areas – are more likely to effect to changes in meteorological conditions and increasing likelihood of severe storms such as tornadoes (Donner and Rodriguez, 2008).

This framework identifies that information on the number of people per square kilometre along with the absolute population count per area at national, state and small-area (SA2) level would be useful for the end-users.

8.2.4 Gender Composition

In including human behaviour in modelling population exposure to natural hazards, gender composition is an important component of the demographics that may influence population evacuation decisions. It is important to study human evacuation responses to disasters, as Bateman and Edwards (2002) have observed that, in general, women have greater objective and more realistic perceptions of risk. It is also essential for response and recovery to have information on the number of evacuees by age and gender to determine the type of support and care needed in the immediate aftermath of a disaster (Gender Equality Bureau, 2014; Delaney & Shrader, 2000). The number of pregnant women and women with babies is also important. Biological and physiological differences based on gender are unlikely to explain large-scale gender differences in mortality rates. Social norms and role behaviours, however, provide some explanation, but what is likely to matter most is the everyday socioeconomic status of women.

This framework identifies that information on population gender composition at national, state and small-area (SA1) level would be useful for the end-users and that this is available from the ABS Census.

8.2.5 Migration

Migration is an important aspect of population dynamics that determines the size, density and distribution of population in an area; the post-disaster impact on migration to and from an area is well documented and is the subject of ongoing research. Following COAG (2011,) this framework identifies that it is equally important to document the information on migration to and from an area before a disaster strikes. The Australian Emergency Management Institute (AEMI, 2011) identified that in Australia, internal migration increases the pressures on local communities, governments and environments (McLennan & Birch 2005, pp 101–108). It leads to a population that is more dispersed, and less well connected to its local community and formal and informal support structures. AEMI (2011) also noted that Indigenous Australians living in rural and remote areas may regularly move between different communities and family groups and may not see themselves as belonging to a geographically defined location.

International immigration patterns and processes can also significantly affect population response to disasters. Naik et al., (2007) in their study on the Indian Ocean Tsunami found migrants, both regular and irregular, face increased vulnerability at times of natural disaster. Although the composition of international migration is not as relevant in an Australian context for natural disaster response and recovery as elsewhere, it is important to identify the recent (post 2006) international immigration settlement patterns in regions. Owing to a lack of current information and knowledge about Australian practices, the migrants may miss out on rescue and recovery assistance and support.

This framework identifies that the following information at the national, state and small-area level would be useful for end-users:

1. Proportion of households with one or more residents having a different address one year ago

2. Proportion of households with one or more residents having a different address five years ago
3. Residents new to Australia – proportion of population having arrived in Australia after 2006.

8.2.6 Indigenous and Ethnic Composition

It has been identified that natural disasters affect people unequally (AEMI, 2011). Apart from inequalities in exposure based on geographical situation and sensitivity to risk based on age, gender, migrant status and population density, inequalities in access to resources, individual capabilities, and available opportunities systematically disadvantage certain groups of people and make them more vulnerable to the impact of natural disasters. For that reason, information on the Indigenous and ethnic composition of the population in Australia at different ANHEF levels is considered important for the exposure framework. It is recognised that in Australia, Indigenous people fare less well than the non-Indigenous population in most indicators of social disadvantage such as in education, health, employment and income. Also, it has been observed that they are less likely to access resources and services and harness opportunities meant for them. Hence, when faced with disasters, they are more vulnerable. Equally important are information requirements on the ethnic composition of the population, for example the non-English speaking population or population for which English is a second language (AEMI, 2011). These people are at risk of social exclusion and are more vulnerable to natural disasters owing to their restricted communication capabilities.

This framework identifies that the following information at national, state and small-area (SA2) level would be useful for end-users:

1. Proportion of the population who do not speak English
2. Proportion of Indigenous population.

8.2.7 Household Composition

Household composition is an indicator of household exposure and vulnerability to natural disasters. Information such as whether the household is composed of a family with dependent children, older people, adults only, single parent, single person or people with disabilities living in supported accommodation is important for disaster response, recovery and policy-making initiatives. This

information can also be a source of strength and resilience to aid recovery as large families and extended families can support each other, pool resources and assist the very old and young (AEMI, 2011).

This framework identifies that the following information at national, state and small-area (SA2) level would be useful for end-users:

1. Number or proportion of couple families with children
2. Number or proportion of couple families with no children
3. Number or proportion of group households
4. Number or proportion of other families
5. Number or proportion of single-parent families
6. Number or proportion of single-person households

8.3 SOCIO-ECONOMIC STATUS

Recent natural disasters like Hurricane Katrina (2005) and the Indian Ocean Tsunami (2004) highlighted the differential impact of disasters on socio-economically disadvantaged communities (Donner and Rodriguez, 2008; Martine and Guzman, 2002). Masozeraa et al. (2007) found that pre-existing socio-economic conditions played a significant role in the ability of particular economic classes to respond immediately to the disaster and to cope with the aftermath of Hurricane Katrina (also see Nix-Stevenson, 2013). Fothergill and Peek (2004) in their literature review of a wide range of studies on poverty and disaster in the USA over a period of 20 years found people of different socioeconomic statuses perceive, prepare for and respond to natural hazard risks differently. They suggested low-income populations are differentially impacted, both physically and psychologically, and disaster effects vary by social class even during the periods of emergency response, recovery and reconstruction.

Fothergill and Peek (2004) found that the poor in the United States are more vulnerable to natural disasters owing to their place and type of residence, building construction, and social exclusion. Fussell et al. (2010) in their study on return migration to New Orleans after Hurricane Katrina found that black residents lived in areas that experienced greater flooding and hence suffered more severe housing damage and returned to the city at a much slower pace

than white residents irrespective of socioeconomic status and demographic characteristics.

This framework identifies that the following information at national, state and small-area (SA2) level would be useful for end-users:

1. Household income
2. Household dwelling tenure status
3. Population insurance coverage
4. Labour force status.

8.3.1 Household Income

This framework affirms that information on different household income classes at different ANHEF geographic levels is important for disaster response, recovery and resilience. In this space, NEXIS (GA) contains information on the percentage of residential dwellings with low ($1–$599), middle ($600–$1999) or high (greater than $2000) gross household income per week derived from the ABS Population and Housing Census 2011. The lower threshold level is determined by calculating half the national median, as per the OECD definition of low income. The highest level represents the top 30% of households.

The following information at national, state and small-area (SA2) level would be useful for end-users. The framework proposes the household income categories as follows, as used in NEXIS.

1. For each dwelling type (Chapter 4), a percentage is required to calculate if that dwelling has a Nil, Low, Medium or High gross household weekly income as a proportion of all dwellings of that type. In 2011, the national median was $1234/week, which gives a low income measure of $617/week. This has been adjusted to $600 because it is the nearest available category in the Census data. High income is set to $2000/week, as this category reflects the top deciles nationally (NEXIS, GA).
2. An alternative measure is equivalised household income. This is the total household income adjusted to reflect the requirement of a larger household to have a higher level of income to achieve the same standard of living as a smaller household. The percentage of residential dwellings with Nil, Low, Middle or High equivalised income (ABS, 2006) for each dwelling type (Chapter 4) is required.

8.3.2 Household Dwelling Tenure Status

Information on the percentage of residential dwellings by tenure – owned, rented privately, rented publicly or other tenure type – has been identified as important for natural disaster response and recovery purposes in Australia (Nadimpalli et al., 2007). It is accepted that people who rent do so because they are either transient or do not have the financial resources for home ownership (Williams et al., 2009; Cutter et al., 2003). They often lack access to information about financial aid during recovery. In the most extreme cases, renters lack sufficient shelter options when lodging becomes uninhabitable or too costly to afford.

The following information has been identified as available at the national, state and small-area level for end-users:

1. Number or proportion of owner-occupied dwellings – owned outright or owned with a mortgage
2. Number or proportion of privately rented dwellings – rented from real estate agents or directly from owner
3. Number or proportion of rented public housing – rented from a State or Territory housing authority or rented from a co-operative, community or church group
4. Number or proportion of other tenure type dwellings – occupied rent-free, occupied under a life tenure system and all other tenure types.

8.3.3 Population Insurance Coverage

In line with this thinking, population insurance coverage is perceived as an important requirement for this framework as it provides much-needed security for building repair and replacement values after a natural disaster. Refer to Section 3.3 for a detailed explanation on user requirements of this component.

8.3.4 Labour Force Status

Information on the labour force status of the population in an area, such as employed full time or part time, unemployed and not in the labour force, is important as an indicator of social vulnerability (Cutter et al., 2003). Also, information on labour force status, like household income, in an area can indicate unequal access to resources and opportunities that leaves some people more vulnerable than others to natural disasters. Employment and

unemployment information is also important input data for post-disaster economic productivity loss estimation.

The following information at different ANHEF levels would be useful for end-users.

1. Proportion employed
2. Proportion unemployed
3. Proportion not in the labour force.

8.4 POPULATION HEALTH

The World Health Organisation (WHO, 2015b) identified that poor health in the population before a disaster makes people more vulnerable. It is essential to understand a priori the existing disease patterns in localities and to identify risks and the vulnerability of the population. The US Institute of Medicine (IOM, 2015) recommends integrating health considerations into recovery decision-making through the National Disaster Recovery Framework (NDRF). This puts population health at the forefront of disaster risk management, including PPRR.

The ANHF suggests three main aspects of population health to include:

1. Physical health status
2. Mental health status
3. Disability status.

8.4.1 Physical Health

Health-informed decision-making through the availability of data is critical for intermediate to long-term response, recovery and preparedness for disasters. IOM (2015) notes that a Community Health Needs Assessment (CHNA) has become a critical part of natural disaster impact assessment and planning in the USA. IOM (2015) identified some of public health indicators that can provide input to community health improvement and impact assessment planning before and after disasters. These indicators include:

1. Early childhood development
2. Data analysis, including use of geographic information systems
3. Social network analysis
4. Public health and health care economics
5. Clinical chronic and acute disease states

6. Epidemiology
7. Policy and legislative actions
8. Health education
9. Preventive medicine
10. Public health- and health care-related legal issues
11. Ethical issues
12. Lead poisoning
13. Continuous quality improvement
14. Oral health
15. Vital statistics
16. Immunisations, and
17. Special-needs populations.

While it is increasingly recognised that collecting and maintaining baseline data on the community health status is an essential component of disaster management, there is no such coordinated system available to provide information across Australia. Thus, this framework identifies the need to include community health status or community health indicators into disaster information systems.

For information on the individual-level health status or health profile of the Australian population, it is recommended to use the scores on the Short Form 36 Questionnaire (SF-36), a widely used multi-dimensional measure of health-related quality of life. The SF-36 is a multi-purpose, short-form health survey with only 36 questions (Månsdotter et al., 2008; Walters, 2004; Ware and Kosinski, 2001). It produces an 8-scale profile of functional health and well-being scores, as well as psychometrically based physical and mental health summary measures and a preference-based health utility index. It is a generic measure, as opposed to one that targets a specific age, disease or treatment group. The SF-36 has proved useful in surveys of general and specific populations, comparing the relative burden of diseases. It has been translated in more than 50 countries as part of the International Quality of Life Assessment (IQOLA) Projects and been subjected to studies of reliability and validity (Health Survey Update, 2015). Australian data for the SF-36 Health Survey is available from Household Income and Labour Dynamics in Australia Surveys (HILDA) and the ABS National Health Survey.

It is equally important to input information on the following:

1. Vital statistics
2. Early childhood development
3. Immunisation
4. Life expectancy
5. Epidemiology
6. Morbidity
7. Existing disease patterns in the community
8. Identified risk and vulnerabilities in the disease patterns
9. Quality of life.

8.4.2 Mental Health

There is wide-ranging literature on associations between respondents' natural disaster experiences and their mental health. Natural disasters cause unprecedented havoc, destroying people's life and property. Consequently, they exert tremendous impact on people's mental and physical wellbeing.

The prevailing mental health status of the population is also an indicator of existing social vulnerability and exposure to risk. WHO identifies mental well-being as a fundamental component of health. Good mental health enables people to realise their potential, cope with the normal stresses of life, work productively, and contribute to their communities (WHO, 2015) so it is an important component of disaster vulnerability. Mental disorders frequently lead individuals and families into poverty and homelessness, and increase their marginalisation and vulnerability. As such, persons with mental disorders often live in vulnerable situations and are excluded and marginalised from society. Therefore, this framework identifies information about the prevailing mental health status of the population as an important input requirement for disaster information systems.

Similarly to the physical health status of the population, for information on the individual-level mental health status or mental health profile of the population, it would be ideal to use scores from the Short Form 36 Questionnaire (SF-36) mental health summary or Kessler Psychological Distress Scale (K-10) measures. Data obtained using these measures are available from the HILDA Survey and ABS.

8.4.3 Disability

Persons with a disability are more vulnerable to disasters. Individuals with disabilities are disproportionately affected in disaster, emergency, and conflict situations owing to inaccessible evacuation, response and recovery efforts. The World Bank Disability and Development Team (2006) established that evaluation and monitoring of the inclusion of vulnerable groups in disaster preparedness should be part of planning. Also, since disasters happen locally, disability-inclusive planning processes should start locally, developing a bottom–up approach. The fundamental requirements in disaster planning should ensure: equal access to shelter facilities, equal access to evacuation or transportation, and equal access to disaster clean-up (World Bank Disability and Development Team, 2006). The post-2015 DRR strategy highlights 'It is imperative that persons with disabilities are explicitly represented as a group and that their perspectives and concerns are reflected in the Hyogo Framework for Action 2 (HFA2)'. The Sendai Framework for Disaster Risk Reduction 2015–2030 is in agreement with this.

In Australia, just under one in five people (4.2 million people or 18.5% of Australians) reported having a disability in 2012. For those people with a disability, 3.7 million (88%) had a specific limitation or restriction that meant they were limited in the core activities of self-care, mobility or communication, or restricted in schooling or employment (ABS, 2012).

The following information at national, state and small-area (SA2) level would be useful for the end-users.

1. Number or proportion of population with some kind of disability
2. Number or proportion of population with core activity need for assistance.

8.5 SPATIOTEMPORAL POPULATION

Another crucial aspect of population vulnerability to natural disasters is the space and time dependence of the population exposure to the hazard. This is critical to model the dynamics of high-resolution time-dependent population distribution data for disaster management. Policy decisions are significantly influenced by the number of impacted people, which in turn is dependent on the time of hazard occurrence (Bhaduri et al., 2007). Freire et al. (2013) in

assessing the tsunami hazard considered the time dependence of population exposure to hazard in a large urban area. They modelled population density in high spatial and temporal detail following a top–down approach to disaggregate data from official statistics. The resulting population distribution surfaces were integrated with a tsunami hazard map to estimate potential human exposure. Additionally, the population's speed of evacuation was modelled and analysed in night-time and day-time periods to investigate whether there were significant differences and what consequences these might have for emergency management.

Bhaduri et al. (2007) utilised the increasing availability of national geospatial datasets including high-resolution imagery such as the LandScan USA model to implement an innovative spatial data modelling approach. This included integration of multiple high-resolution indicator datasets, such as land cover, roads, cultural landmarks, educational institutions and business activity locations, combined with human intelligence thought analyst intervention, which allowed efficient resolution enhancement in both spatial and temporal dimensions. Such development to incorporate activity-based temporal information is needed to design and develop a nationally consistent model not only for night-time or residential population distribution, but also for the mobility and dynamics of different demographic groups in Australia.

For disaster management purposes, it would be ideal to have information on the spatiotemporal distribution of the population such as the daytime and night-time spatial distribution of population and transit population. ABS Census information on the location of work and ABS National Regional Profile (NRP) information on existing businesses in an area could be used as a starting point.

It is equally important to obtain a floating and tourist population census for natural hazard planning, recovery and response, particularly in important tourist destinations. In these locations, a significant proportion of the population is floating population or tourists. GAR-UNISDR (2013) identified that 6 of the top 10 countries in the world with the greatest proportion of assets at risk of cyclone wind damage are tourist small islands. While tourism investment and planning in such areas come with high levels of disaster risk, they also have large potential benefits from investment in disaster risk management, which needs to be factored into exposure information modelling. Therefore, this framework

identifies a floating and tourist population census on small islands and coastal cities in Australia as an important information requirement for communities in the exposure framework.

End-users require information on the number or proportion of floating, tourist and spatio-temporal distribution of the population at national, state and small-area level.

8.6 ACCESS TO TRANSPORTATION

Access to transportation has been identified as an important factor determining pre- and post-disaster ability to respond and evacuate (Cutter et al., 2010; Tierney, 2009). It is also an important determinant of disaster resilience as it can determine people's ability to move and evacuate freely and immediately, and return and resume their normal function without time lag in case of short-term displacement. Mode of transportation and establishing transportation standards for evacuation was found to be important in Hurricane Katrina when households with elderly and disabled family members and people with pets decided to stay instead of responding to the evacuation requirement (Tierney, 2009). In remote and regional Australia, household access to motor vehicles would possibly be the most important transportation option available for immediate disaster response and evacuation requirement.

This framework identifies that information on household access to motor vehicles would be useful for end-users for disaster evacuation response and resilience decision-making.

8.7 RISK PERCEPTION

Risk perception is the understanding of the likelihood and consequences of a hazard and is a key component in determining household and public preparedness and response to disasters (Boon, 2014; Bradford et al., 2012, Miceli et al., 2008; Slovic 2000), and is one of the four key themes in GA's household resilience framework (Canterford et al., unpublised). There have been many disasters where the public has not responded as expected, despite warnings, because the community's risk perception has not been appropriate (Bradfield et al., 2012). Assessing whether households are aware of the hazard potential is

not sufficient as many households greatly underestimate the potential impact or damage from an understood risk (Botzen et al., 2015).

Risk perception is influenced by several situational and personal factors (Bradfield et al., 2012). Situational factors include location in relation to the hazard, previous hazard experience, and socio-economic and demographic characteristics (Tierney, 1994) and can also be influenced by neighbourhoods (Boon, 2014). Personal characteristics mainly comprise an individual's psychological profile and include behavioural and emotional responses. Personal characteristics are difficult to measure, but even the relationship between situational characteristics and risk perception is not clear. Awareness derived from previous disaster experience, for example, diminishes over time (Bradfield et al., 2012) and can work against appropriate risk perception if the unfolding event has different circumstances, extent or hazards than previous events. Construction of structural mitigation measures also impacts on the awareness of the risk (Birkland et al., 2003; Bradfield et al., 2012).

The following information can help inform risk perception:

1. Previous hazard experience
2. Length of time since last hazard (by type)

8.8 EVACUATION RESPONSE

Human behaviour is an important determinant of population exposure to hazards, so information on people's evacuation response and speed after they hear hazard warnings is essential (Dash and Gladwin, 2007). As Dash and Gladwin (2007) acknowledged, accurate and geographically focused predictions of evacuation rates including clearance times, shelter usage and potential casualty rates, are needed by emergency managers. Information on shadow or spontaneous evacuators is equally important, such as those not at greatest objective risk but who panic and rush to evacuate (Dash and Gladwin, 2007).

The following information at national, state and small-area level would be useful for end-users.

1. Population evacuation speed after they hear a hazard warning

2. Geographically focused predictions of evacuation rates, clearance times, shelter usage and potential casualty rates

8.9 SOCIAL CAPITAL

The important role of social capital in natural disaster management has been well documented (Aldrich, 2012; Tierney, 2014; UNISDR, 2005). Individual and community resilience is an essential component of the risk reduction, response and recovery process. Social groups and community participation play a significant role in this process (Tierney, 2014; UNISDR, 2005). The Hyogo Framework (UNISDR, 2005) identified the significance of community participation in DRR and recommended the adoption of specific policies to promote networking, the strategic management of volunteer resources, the attribution of roles and responsibilities, and the delegation and provision of the necessary authority and resources. It is also identified that in the aftermath of natural disasters, it is not only the existing social community institutions and network organisations in that area that play a crucial role to bring together resilient communities, but also emerging new social networks and groups who create settings for adaptive resilience (Tierney, 2014). Aldrich (2012) examined the post-disaster responses of four distinct communities (Tokyo after the 1923 earthquake, Kobe after the 1995 earthquake, Tamil Nadu after the 2004 Indian Ocean Tsunami, and New Orleans post-Katrina) and found that those with robust social networks were better able to coordinate recovery. The role of social capital in disaster management and efficient reconstruction is further heightened through timely access to and dissemination of information and financial and physical assistance. Communities with an abundance of social capital were able to minimise the migration of people and valuable resources out of the area.

Geoscience Australia sees social capital as one of the four themes driving household resilience (Canterford et al., unpublished). In Australian policy, the National Strategy for Disaster Resilience does not explicitly identify social capital as a factor that influences resilience; however, it does identify several activities that are closely related (Australian Red Cross, 2013). These activities are related to the concepts of networks and partnerships between individuals, communities and governments. Until recently, there have been no practical guidelines for social capital and disasters. Wood et al., (2013) provided an

applied framework for social capital to build resilient communities expressed as fundamentals of social capital for disaster resilience. Attempts to quantify social capital have been conducted by the Australian Institute of Family Studies (2001), the ABS (2004) and spatially by the Bureau of Transport and Regional Economics (2005).

End-users require the following information at the national, state and small-area level.

1. Existing network organisations, community groups, volunteer groups
2. Population internet access

Existing Capabilities on Population Exposure

Detailed information on existing capabilities in Australia on population exposure to natural disasters is presented in the following table.

Agency	Product Description	Web Link
REMOTENESS STATUS		
ABS	Census of Population and Housing at National, State and Small-Area SA2 level	http://www.abs.gov.au/websitedbs/censushome.nsf/home/tablebuilder
DEMOGRAPHIC COMPOSITION		
ABS	Population Age Profile	http://www.abs.gov.au/websitedbs/censushome.nsf/home/tablebuilder
	Population Density	
	Gender Composition	
	Migration Status	
	Indigenous and Ethnic Composition	
	Household Composition	
SOCIO-ECONOMIC STATUS		
ABS	Household Income	http://www.abs.gov.au/websitedbs/censushome.nsf/home/tablebuilder
	Household Dwelling Tenure Status	
GA	NEXIS – Household Income Status	http://www.ga.gov.au/metadata-gateway/metadata/record/gcat_82219
Australian Urban Research Infrastructure Network	Income Support	http://data.aurin.org.au/dataset/ua-phidu-phidu-sa2-incomesupport-sa2
LABOUR FORCE STATUS		
ABS	Population and Housing Census	http://www.abs.gov.au/websitedbs/censushome.nsf/home/tablebuilder
POPULATION HEALTH		
ABS	Physical Health	http://www.abs.gov.au/ausstats/abs@.nsf/ViewContent?readform&view=productsbyCatalogue&Action=Expand&Num=3.3
	Life Expectancy at National and State Level	
	National Health Survey 2012	http://www.abs.gov.au/AUSSTATS/abs@.nsf/DetailsPage/4364.0.55

		.0012011-12?OpenDocument
	Disability, Ageing and Carers Australia Surveys	http://www.abs.gov.au/ausstats/abs@.nsf/mf/4430.0
AIHW	Australian Institute of Health and Welfare – Vital Statistics at National and State Level	http://www.aihw.gov.au/data/
	Hospital-Level Morbidity Information in Australia	
Torrens University Australia	Public Health Information Development Unit (PHIDU) data	http://phidu.torrens.edu.au/social-health-atlases/data
	Estimated Population – Obese by Gender	
	Alcohol Consumption and Smoking Risk Status	
	Self-Reported Health and Estimates of Long-Term Health Condition	
	Subjective Wellbeing	
Australian Early Develop. Census (AEDC)	Early Childhood Development Indicators data	https://www.aedc.gov.au/
Community Indicators Victoria (CIV)	Information on Immunisation Status of Children in Victoria	http://www.communityindicators.net.au/
	Life Expectancy at Small-Area Level	
	Risk Alcohol Consumption and Smoking Status	
	Self-Reported Health at Small-Area Level	
	Subjective Wellbeing	
Melbourne Institute	Household Income and Labour Dynamics in Australia (HILDA) Surveys	https://www.melbourneinstitute.com/hilda/
	Mental Health	
AURIN	Estimates of Australia-wide Subjective Wellbeing at SA2 LEVEL	http://data.aurin.org.au/dataset/uc-natsem-natsem-natsem-tb3-lifesat-in-3-groups-geometry-sa2
	National Survey of Mental Health and Wellbeing	http://www.abs.gov.au/ausstats/abs@.nsf/Products/4327.0~2007~Main+Features~Survey+products?OpenDocument
	Estimates of Chronic Disease	http://data.aurin.org.au/dataset/ua-phidu-phidu-sa2-chronicdisease-modelledestimate-sa2
	Disability Status	http://data.aurin.org.au/dataset/ua-phidu-phidu-sa2-disability-sa2
	Medical Benefits System (MBS) and Pharmaceutical Benefits System (PBS) Recipients	http://data.aurin.org.au/dataset/uc-natsem-natsem-natsem-tb5-3-mbs-and-pbs-geometry-sa2
AMBIENT POPULATION		
ABS	Census of Population and Housing – Location of Work	http://www.abs.gov.au/websitedbs/censushome.nsf/home/tablebuilder
	Number or Proportion of People Working Nearby or Far Away in the City	
	National Regional Profile (NRP) – Existing Businesses in the Area	http://www.abs.gov.au/ausstats/abs@.nsf/mf/1379.0.55.001
	Number Or Proportion of Floating and Tourist Population	http://www.abs.gov.au/websitedbs/censushome.nsf/home/tablebuilder
AURIN	Number of Businesses by Size of Turnover and the Industry Sector	http://data.aurin.org.au/dataset/vic-govt-dsdbi-dsdbi-sa2-ia-2011-turnover-industry-sa2
City of Melbourne	Census of Land Use and Employment (CLUE) – Temporal Distribution of Pedestrians	https://www.melbourne.vic.gov.au/AboutMelbourne/Statistics/CityEconomy/Pages/CLUE.aspx
ACCESS TO MOTOR VEHICLES		
ABS	Population and Housing Census – Population or	http://www.abs.gov.au/websitedbs/censushome.nsf/home/tablebu

	Household Access to a Motor Vehicle	ilder
SOCIAL CAPITAL		
AURIN	Volunteering 2011	http://data.aurin.org.au/dataset/uc-natsem-natsem-natsem-tb5-7-social-indicators-volunteering-geometry-sa2
ABS	Population and Housing Census – Population Internet Access	http://www.abs.gov.au/websitedbs/censushome.nsf/home/tablebuilder

Gaps and Suggestions

Largely, there is no data gap in information on population remoteness status, demographic composition, socioeconomic status, labour force status, population health and disability in Australia. This information can be sourced and estimated from ABS Census of Population Housing or other ABS publications.

However, there are a few data gaps such as information on population insurance coverage against fire and natural disasters, which are not openly available. This information can potentially be sourced from the Insurance Council of Australia or individual insurance companies.

For population physical health status, there is a significant data gap in Australia. To date, there is no integrated and standardised database available for all of Australia at the State and community level to provide information on a comprehensive set of population and public health indicators.

For population mental health status, there is no census-level information available for the population in Australia. The HILDA surveys and the National Survey of Mental Health and Wellbeing do not contain information at the small-area (SA2) level. However, potentially, microsimulation modelling techniques could be used to obtain SF36 Mental Health Summary Measures at small-area level using the Census 2011 and the surveys.

For population disability status, there is no data gap in Australia in information on people with a core activity need for assistance, and it can be estimated from the latest 2011 Census. There is no census-level information available on people with disability in general, and Disability, Ageing and Carers Australia Survey does not produce information at the small-area (SA2) level. However, potentially, microsimulation modelling techniques could be used to obtain disability estimates at the small-area level using the Census 2011 and Disability, Ageing and Carers Survey 2012.

There is no database providing information on the ambient and spatiotemporal distribution of population to researchers for the whole of Australia or major cities and small towns in Australia. This area needs to be further researched and population temporal dynamics need to be modelled to generate the data.

Similarly, in obtaining information on population evacuation response and speed, human risk perception needs to be modelled and synthetic estimates need to be generated at the small-area level.

Likewise, there is a gap in sources of information on existing network organisations, community groups and volunteer groups. This has to be compiled from a range of sources including local council registers.

9 BUSINESS EXPOSURE

In presenting the business exposure information framework, the first step is to define concepts such as business and economic activity.

What is a Business?

The ABS defines a business as 'a legal entity engaging in productive activity and/or other forms of economic activity in the market sector. Such entities accumulate assets on their own account and/or hold assets on behalf of others, and may incur liabilities. Excluded are the economic activities of individuals (except where individuals engage in productive activity either as sole traders or in partnership) and entities mainly engaged in hobby activities'.

What is Economic Activity?

Economic activity is defined as 'actions that involve the production, distribution and consumption of goods and services at all levels within a society. Gross domestic product or GDP is one way of assessing economic activity, and the degree of current economic activity and forecasts for its future level can significantly impact business activity and profits, as well as inflation and interest rates' (BusinessDictionary, 2017: http://www.businessdictionary.com/ on 28 June 2017).

ANHEF identifies and presents different components of business and economics activity exposure information requirements for disaster management. The business and economic activity exposure elements have been broadly classified into micro and macro-economic levels for information standardisation and easier interpretability. Also, irrespective of whether the business exposure element is a requirement at the micro- or macro-economic level, there are certain elements that are identified in this framework as information requirement at a fundamental level that are generic to both.

All the information needs to be spatially enabled, which means the location of the business needs to be captured. The location may be represented as a point or polygon. In business exposure information, the location of corporate offices and also operational sites needs to be recorded to reduce the complexity for decision makers. The spatial enablement and foundational information is

presented in detail in the milestone report 'Built Environment Exposure Information Framework' (Nadimpalli and Mohanty, 2015), while the present report presents the framework for micro and macro-economic activity levels.

Microeconomics focuses on small segments of the economy and studies the decision-making process and economic problems of individuals in an economy with respect to how they use scarce means or resources at their disposal to satisfying their unlimited needs. On the other hand, macroeconomics looks at the larger picture and is the study of the economy as a whole. Microeconomics is the study of an individual, household, business firm or individual industry with respect to how they use and divide their given scarce means among the possible alternative uses and ends in order to maximise their gain or well-being. Microeconomics studies and analyses of individual behaviour with respect to issues like production, consumption, distribution and price determination. Business Type

There is evidence suggesting that the business type or the industry classification to which a business belongs has an influence on their level of disaster preparedness; for example, Dalhamer and D'Souza (1995) found businesses in the finance, insurance and real estate sector were generally better prepared than businesses in other sectors of the economy. This relationship may be due to certain mandates and regulations required for the industry. For example, loss-reduction requirements are relatively strong for businesses in the finance, insurance and real estate sectors. Generally speaking, there are few outright mandates governing business disaster mitigation, preparedness, response and recovery.

Most industry classifications in Australia use the Australian and New Zealand Standard Industrial Classification (ANZSIC) 2006 (1292.0) (ABS, 2006b) that was jointly devised by the ABS and Statistics NZ. This classification is a hierarchical classification with four levels, namely:

1. Divisions (the broadest level)
2. Subdivisions
3. Groups, and
4. Classes (the finest level).

At the 'Division' level, the main purpose is to provide a limited number of categories that provide a broad overall picture of the economy and are suitable for the publication of summary tables in official statistics. The Subdivision, Group and Class levels provide increasingly detailed dissections of these categories for the compilation of more specific and detailed statistics. The numbering system adopted in the ANZSIC is alphanumeric and has a hierarchical structure (see example below), where the leading alpha character denotes the industry division. The ANZSIC Subdivision, Group and Class levels are denoted by numeric codes.

Where an individual business entity can be classified by more than one ANZSIC code, the ANZSIC identifier must reflect the primary (or most significant) industry that best describes the individual business entity's main economic activity.

In total, there are 19 divisions, 86 sub-divisions, 195 groups and 506 classes specified under ANZSIC:

Level Example

Division C Manufacturing

Subdivision 11 Food Product Manufacturing

Group 111 Meat and Meat Product Manufacturing

Class 1111 Meat Processing

9.1.1 Industry Division

The main purpose of the industry division level is to provide a limited number of categories that give a broad overall picture of the economy. There are 19 divisions within ANZSIC06, each identified by an alphabetical letter, that is, 'A' for Agriculture, Forestry and Fishing, 'B' for Mining, 'C' for Manufacturing, etc.

9.1.2 Industry Subdivision

This is the broadest category within an industry division of ANZSIC and is recognised by a two-digit code, e.g. Industry Subdivision 39 for Motor Vehicle and Motor Vehicle Parts Retailing. Industry subdivisions are built up from industry groups which, in turn, are built up from industry classes.

9.1.3 Industry Group

This is the intermediate level within an industry division of ANZSIC and is recognised by a three-digit code, e.g. Industry Group 391 for Motor Vehicle Retailing. It gives more detail than the industry subdivision and is created in a way that keeps industry classes together.

9.1.4 Industry Class

At the industry class level, the activities of businesses are narrowly defined and recognised by a four digit code, e.g. Industry Class 3911 for Car Retailing.

In the example above, the Manufacturing Division is denoted by the alpha character C. The 'Food Product Manufacturing' Subdivision is represented by the numeric code 11. The 'Meat and Meat Product Manufacturing' Group is represented by the numeric code 111, and the 'Meat Processing' Class is represented by the numeric code 1111.

ANHEF This framework identifies that the business exposure elements required for exposure data collection, collation and provision may include the above four standard ANZSIC classifications.

Existing Capabilities

Information on industry classifications is available through a range of data sources (ABS, Australian Business Register, Company360, IBISWorld).

Gaps and Suggestions

There is currently no consistency in the industry classification adopted by the data sources. For example, the ABS Count of Business Entry and Exit, the Australian Business Register and state-based WorkCover all utilise ANZSIC codes; however, Company360 uses the Standard Industrial Classification (SIC) codes. Further, the information may not be publicly available at the local-area level.

9.2 BUSINESS ORGANISATION

9.2.1 Business Structure

Different legal requirements apply to the various business structures. The business structure may also affect the type and amount of government assistance available following a disaster.

The four main business structures commonly used by small businesses in Australia are:

1. Sole trader: an individual trading on their own
2. Partnership: an association of people or entities running a business together, but not as a company
3. Trust: an entity that holds property or income for the benefit of others
4. Company: a legal entity separate from its shareholders.

Existing Capabilities and Gaps in Data Requirements

Information on business structure can be obtained from the Australian Business Register. Access to the information is limited to individual searches through the web interface.

9.2.2 Type of Legal Organisation

The Type of Legal Organisation (TOLO) classification is applied to business entities and subdivides them into classes on the basis of their legal organisation. This classification provides structures for presenting information on the characteristics of businesses in Australia and for analysis employing units.

Statistical units are businesses, government entities, households or other entities about which statistics are compiled. They are defined in a consistent way to enable users of ABS statistics to make valid comparisons of information compiled from different statistical sources and to enable composite pictures of the economy to be drawn.

The basic statistical unit that is classified by a sector is the institutional unit. An institutional unit is one that is able to:

- own or exchange goods and assets in its own right
- make economic decisions and engage in economic activities for which it is held directly responsible and accountable at law
- enter into contracts and incur liabilities on its own behalf, and
- compile a complete set of accounts, including a statement of financial position.

In some instances, it is statistically advantageous to recognise as separate institutional units some entities that do not meet the above criteria. Although these do not exist as separate institutional units from their owners, and therefore are not institutional units in their own right, where they operate autonomously and keep a full set of accounts, notional institutional units are created to enable their separate collection.

There are four types of institutional units:

1. Corporations
2. Government units
3. Non-profit institutions, and
4. Households.

Corporations

A corporation is 'a legal entity, created for the purpose of producing goods and services for the market, that may be a source of profit or other financial gain to its owner(s); it is collectively owned by shareholders who have the authority to appoint directors responsible for its general management' (ABS, 2008a).

Corporations are typically:

- created by processes of law that establish their existence as independent from their shareholders, including other institutional units (i.e. other corporations, household unincorporated enterprises, government units and non-profit institutions that may own shares or other equity in the corporations
- created for the purpose of market production
- owned by shareholders who receive a distribution of profits in proportion to their shareholdings, and
- fully accountable at law for their actions, obligations and contracts and are liable to pay taxes (i.e. they are a legal entity).

The company structure of corporations enables profits to be distributed to their shareholders. Examples of corporations are proprietary companies, limited liability companies and no-liability companies.

Some incorporated entities are prohibited from distributing profits to their shareholders or members. Most companies limited by guarantee and all incorporated associations fall into this category. These types of institutional units are NPIs and are discussed later in this chapter.

Government Units

Government units are 'legal entities established by political processes that have legislative, judicial or executive authority over other institutional units within a given area' (ABS, 2008a).

The principal functions of government units are:

- to provide goods and services to individuals or the community at large
- to redistribute income and wealth, and
- to engage in non-market production.

The majority of government units are readily identifiable as their operations are mainly financed from taxation and they redistribute income by means of transfers (e.g. subsidies, grants, welfare payments) or engage in other forms of non-market production, such as the provision of government services (e.g. defence, education, health services, economic advice) free of charge or at nominal prices.

To qualify as a separate legal entity, a government unit must:

- have funds of its own, raised by taxing other institutional units or received as transfers from other government units
- have authority to disburse some, or all, of such funds in the pursuit of its policy objectives, and
- have authority to borrow funds on its own account.

Units that do not meet all of these criteria are treated as part of a larger government unit, i.e. the collective legal entity comprising all government units included in the public accounts. Included in this collective legal entity are

departments and agencies operating from the public accounts of the parent government.

Non-Profit Institutions

Non-profit institutions are defined as 'legal or social entities created for the purpose of producing goods and services whose status does not permit them to be a source of income, profit or other financial gain for the units that establish, control or finance them' (OECD, 2003).

NPIs must have an enabling instrument that includes a clause that prohibits the NPI from distributing income, profit or other financial gain to its establishing, controlling or financing unit. This includes benefitting from the sale of assets in the event of the dissolution of the unit.

The productive activities of NPIs may generate either surpluses or deficits but any surpluses they make cannot be appropriated by the establishing, controlling or financing institutional unit. For this reason, they are frequently exempted from various kinds of taxes.

The main characteristics of NPIs are that they:

- are created by processes of law that establish the NPI's separate existence from the units that establish, finance, control or manage them
- have purpose statements set out in articles of association
- are associations with members who have equal voting rights and limited liability with respect to the NPI's operations
- cannot distribute profits to members (the term 'non-profit institution' reflects the embargo on distribution of financial gains and is not intended to imply that NPIs cannot make a profit), and
- are self-governing, with their direction usually vested in a group of officers, an executive committee or a similar body elected by a majority of members.

A unit that is 'self-governing' is in charge of its own destiny. It is able to 'dissolve itself, set and change its by-laws and alter its mission or internal structure without having to secure permission from any other authority than the normal registration officials' (United Nations, 2003).

Households

A household is 'a group of persons who share the same living accommodation, who pool some, or all, of their income and wealth and who consume certain types of goods and services collectively, mainly housing and food' (ABS, 2008a).

Individual members of households are not treated as institutional units because many assets are owned (and liabilities incurred) jointly by two or more members of a household. Income can be pooled, and expenditure decisions are often made for the household as a whole. As a result, the household as a whole, including all individual members, is considered to be an institutional unit.

Where an unincorporated enterprise is entirely owned by a household, it is treated as an integral part of that household. Some members of households engage in market production through unincorporated enterprises such as sole proprietorships, partnerships and trusts.

Partnerships can comprise partners belonging to different households.

The liability of the owners of unincorporated businesses is unlimited. As a result, these businesses are treated as household units since all the assets of the household, including the dwelling itself, are at risk if the enterprise goes bankrupt. The institutional unit of each household involved in the partnership therefore represents the individual members of the household as well as the share of the unincorporated partnership owned by each household.

The ANHEF recommends that identifying businesses as a TOLO will enable users of the database to make valid comparisons of information compiled from different statistical sources. It will enable identification of the business as legally able to receive certain type of subsidies.

Existing Capabilities and Gaps in Data Requirements

Information on TOLO for businesses can be obtained from the ABS Counts of Australian Businesses Including Entries and Exits (CABEE) (ABS, 2014d).

The statistical information is only available at the national level.

9.2.3 Business Name

A business name is a name or title under which a person or entity conducts a business. In Australia, all businesses must register a business name unless they fall within one of the following exemptions:

- if the business is operating as an individual and the operating name is the same as the individual's first name and surname
- if the business is in a partnership and the operating name is the same as all of the partners' names, or
- if the business is an already registered Australian company and the business operating name is the same as the company's name
- franchise or brand name

The recorded business name should be the full name and not be an acronym. The business name is recorded to enable matching with other local datasets and to assist in the local delivery of programs or further data collection. THE ANHEF This framework identifies that business name is an important information requirement for disaster management.

Existing Capabilities and Gaps in Data Requirements

Comprehensive information regarding business names is available through the Australian Business Register. Access to data including the individual business name is limited to individual searches through the web interface.

9.2.4 Business Age

Research outcomes on the relationship between business age and post-disaster recovery have been contradictory. Despite older businesses being expected to be more likely to recover from disasters as they are more established and have more resources upon which to draw in responding to a disaster, a study on the impacts of Hurricane Andrew showed otherwise (Webb et al., 1999). The vulnerability of older businesses may have been due to older businesses having more plant and stock to lose and therefore taking longer to fully recover from the hurricane.

It is likely that the age of a business will be an important consideration among other data to determine likely models of impact and recovery.

Existing Capabilities and Gaps in Data Requirements

Some limited datasets such as The Census of Land Use and Employment (CLUE) in Melbourne have commenced the collection of data about how long a business has been operating at a location. Publicly listed companies provide information on the commencement of the current business structure. The Australian Business Register also provides information on when the current trading name was entered into the system; however, the information is limited to individual searches through the web interface. None of these data sources have been found to provide consistent information on the age of businesses.

9.3 BUSINESS SIZE

Studies have identified that the size and financial conditions of businesses are an important predictor of recovery (Dahlhamer and Reshaur, 1996; Dahlhamer and D'Souza, 1998; Dahlhamer and Tierney, 1998). Larger firms have been found to be more likely to recover than smaller ones. Larger firms are generally in much sounder financial condition and more likely to engage in disaster preparedness activities.

There are a variety of definitions for business size in Australia, with both number of employees and turnover regularly being used.

9.3.1 Employees

The ABS defines an employed person as including all persons aged 15 years and over who, during the reference week: worked for one hour or more for pay, profit, commission or payment in kind in a job or business, or on a farm (comprising employees, employers and own account workers); or worked for one hour or more without pay in a family business or on a farm (i.e. contributing family workers); or were employees who had a job but were not at work and were away from work for fewer than four weeks up to the end of the reference week; or away from work for more than four weeks up to the end of the reference week and received pay for some or all of the four week period to the end of the reference week; or away from work as a standard work or shift arrangement; or on strike or locked out; or on workers' compensation and expected to return to their job; or were employers or own account workers, who had a job, business or farm, but were not at work.

Based on number of employees, business size is determined as:

1. Sole trader (no employees)
2. Small (<20 employees)
3. Medium (20–200 employees), and
4. Large (>200 employees).

The ABS defines a small business as employing less than 20 people. Categories of small businesses include:

- non-employing businesses – sole proprietorships and partnerships without employees;
- micro-businesses – businesses employing less than five people, including non-employing businesses;
- other small businesses – businesses employing 5 or more people, but less than 20 people;

Other businesses are classified as:

- medium businesses – businesses employing 20 or more people, but less than 200 people; and
- large businesses – businesses employing 200 or more people.

Existing Capabilities and Gaps in Data Requirements

CLUE in Melbourne as well as the City of Sydney Floor Space and Employment survey (FES) have detailed information on number of employees but this level of detail is not publicly available.

WorkCover Authorities in each State also maintain employee numbers for businesses but this information is not publicly available. Territory governments do not maintain this information.

CABEE (ABS, 2014d) provides the counts of businesses based on employment size. The information is available at the SA2 level.

There is currently no comprehensive data on the number of employees in Australian businesses although a number of datasets available for local level.

9.3.2 Turnover or Revenue

The business turnover or revenue refers to the value of total sales generated by a business from the provision of goods and services for a given accounting period without paying attention to expenses or any liabilities the company may have. This may include income derived by the business of any entity wholly or partly owned by the business.

The City of Melbourne surveys of business impacts from the 2014 heatwave indicated that businesses with a lower turnover typically suffered larger a decline in sales over this period. Although the mean decline in sales in turnover across all businesses was 9.7%, the 95 businesses that responded with less than $500,000 in annual turnover reported an average sales decline of 17.3% (City of Melbourne, 2014).

Based on turnover, the business size can be defined as

1. Small (<2 million)
2. Medium (2–20 million)
3. Large (>20 million)

Existing Capabilities and Gaps in Data Requirements

Information is available on the annual turnover of publicly listed companies through the Australian Stock Exchange (ASX) and other business monitoring.

The Australian Tax Office (ATO) and state-based WorkCover authorities also maintain information on turnover obtained through annual Business Activity Statements but this data may not be publicly available.

9.3.3 Assets

Under the Australian Accounting Standards, assets are divided into current and non-current. Further, they are classified as tangible and non-tangible.

Tangible assets that have a physical form include both fixed assets, such as machinery, buildings and land, and current assets, such as inventory.

Non-tangible assets are non-physical assets such as patents, trademarks, copyrights, goodwill and brand recognition.

Current assets are those that are expected to be realised within 12 months from the reporting date or within one operating cycle, whichever is the shorter. Current assets include:

- Cash and cash equivalents: cash and cash equivalents can be split into restricted (allocated for a specific purpose) and unrestricted funds and if in a negative position, may be referred to as a bank overdraft.
- Cash includes cash at bank and cash on hand, e.g. petty cash, cash floats and undeposited funds. Cash equivalents are highly liquid investments that are readily convertible to known amounts of cash and that are subject to an insignificant risk of change in value.
- Trade and other receivables: the amount of receivables still owing by customers (debtors) to the organisation at the end of the operating cycle that is expected to be collected in the next 12 months.
- Inventory: items held for sale or expected to be consumed in the process of delivery of services in the next 12 months. Includes fundraising stock, trading stock, publications for sale and emergency response stocks. Inventories may be purchased or received by way of donation.
- Assets held for sale: other current assets that are not inventory items but may be due to be sold in the next 12 months.
- Other financial assets: includes investments, deposits and bonds for services and non-cash exchanged credits, which are expected to be redeemed in the next 12 months.

Non-current assets are those that are not expected to be realised within 12 months from the reporting date or within one operating cycle, whichever is the shorter. Non-current assets include:

- Trade and other receivables: the amount of receivables still owing by customers (debtors) to the organisation at the end of the operating cycle that is not expected to be collected in the next 12 months.
- Other financial assets: includes long-term investments, deposits and bonds for services and non-cash exchanged credits that are not expected to be redeemed in the next 12 months.

- Property, plant and equipment: tangible items that are held for use in the production or supply of goods or services, for rental to others, or for administrative purposes and are expected to have a life beyond the next 12 months. Includes freehold and leasehold land (the land is shown at either cost or at its revalued amount), buildings and building improvements. Includes value of movable plant and equipment owned or leased recorded at cost. In the case of donated assets, these are recorded at the time of acquisition at fair value.
- Intangibles: this amount represents intangibles purchased (not internally generated) e.g. goodwill, distribution rights, intellectual property, licences, patents, trademarks.

Fixed Assets

Damage modelling and recovery timeframe prediction require an estimate of the capital in the form of buildings and assets that may be damaged or destroyed in an area. Although some data may be available from when buildings are first completed or insurance details, this information is likely to be out of date and incomplete.

One of the main reasons for providing data on fixed capital by framework is to measure the community impact of damage or loss of fixed assets. Furthermore, it assists in evaluating the impacts of loss or damage on employees. It could help in estimating the damage or loss associated with the fixed capital for the industry and sub-sectors, and also enable data users to measure the impact of loss of fixed assets to the whole economy. Last but not least, users could estimate the effect the loss or damage of fixed capital to the private or public sector.

The fixed assets of businesses include buildings (chapter 4) and infrastructure (chapter 5) covered in other sections of the report.

The following list provides some ideas of the data that may be useful in regard to fixed capital:

- Value of fixed capital of whole industry
- Value of fixed capital of each sub-sector
- Value of fixed capital of each business

- Interdependency of fixed assets
- Ownership of fixed capital
- Role of fixed assets in recovery of business
- Impact of loss or damage of fixed assets on business continuity
- What hazards affect fixed capital
- Location of fixed capital
- Insured value (including contents)
- Effect of loss or damage of fixed capital on turnover and revenue
- Critical outage period

Existing Capabilities and Gaps in Data Requirements

Information on assets is available or publicly listed through business annual reports where detailed financial analysis has been undertaken, such as those for large businesses listed on websites such as Company360.

Some information on capital assets obtained within the past 12 months is recorded in the ATO's Business Activity Statements and ASX reports, but this information is unlikely to be publicly available.

9.3.4 Ownership of Premises

Firms that owned their business property, as opposed to leasing it, have been found to be more likely to engage in preparedness activities (Dahlhamer and Reshaur, 1996; Dahlhamer and S'Souza, 1998). Businesses that rent space typically have fewer options with respect to the loss-reduction measures they can undertake. They cannot, for example, decide to make their buildings more flood, wind, or seismically resistant through structural upgrades (although they can take steps to protect inventory and equipment). Instead of being able to act independently, renters are often subject to the mitigation choices made by building owners.

Existing Capabilities and Gaps in Data Requirements

There is limited data available on the ownership of business premises. It is possible that this information could be derived from local government records.

9.3.5 Liabilities

Knowledge about the liabilities of a business is critical in understanding the overall financial position of the business. Governmental and non-governmental assistance for businesses may be provided in the form of loans, and therefore this will add to the pre-existing burden of liabilities faced by the business.

According to The Australian Accounting Standards Board 'a liability of an entity is a present economic burden for which the entity is obligated'. Typically, liabilities only include obligations that are considered legally enforceable.

Current liabilities are those that are due to be settled within 12 months from the reporting date, or within one operating cycle, whichever is the shorter, or the entity does not have an unconditional right to defer settlement for at least 12 months from the reporting date.

Current liabilities include:

- Trade and other payables: this item shows the total payable owing to creditors at the end of the operating cycle within the next 12 months (not including bank loans).
- Borrowings: all loans owed by the organisation to banks and other sources that are payable within the next 12 months.
- Current tax liabilities: amount of taxes payable to taxation authorities for Goods and Services Tax, Pay As You Go tax, Income Tax, Fringe Benefits Tax and Australian Business Number withholding tax.
- Other financial liabilities: includes other amounts payable to external parties due and payable within the next 12 months.
- Provisions: liabilities of uncertain timing or amount. Can include provisions for employee entitlements like annual leave and provisions for maintenance.
- Other: other current liabilities not specifically included in previous accounts.

Non-current liabilities are any liabilities that are not defined as current. Non-current liabilities typically include:

- Borrowings: all loans owed by the organisation to banks and other sources that are not payable within the next 12 months.
- Other financial liabilities: includes other amounts payable to external parties that are not payable within the next 12 months.
- Provisions: liabilities of uncertain timing or amount that is not payable within the next 12 months. Can include provisions for employee entitlements like long-service leave.
- Other: other non-current liabilities which are not specifically included in previous accounts.

Existing Capabilities and Gaps in Data Requirement

Information on liabilities is available for publicly listed companies through their annual report or for large businesses where detailed financial analysis has been undertaken, such as those businesses listed on websites like Company360. Data is not available for smaller business in regard to liabilities.

9.3.6 Coverage

Business coverage refers to the multinational, national or local nature of the business.

A multinational corporation is an enterprise operating in several countries but managed from one (home) country. Generally, any company or group that derives a quarter of its revenue from operations outside of its home country is considered a multinational corporation. There are four categories of multinational corporations: (1) a multinational, decentralised corporation with strong home country presence; (2) a global, centralised corporation that acquires cost advantage through centralised production wherever cheaper resources are available; (3) an international company that builds on the parent corporation's technology or R&D; or (4) a transnational enterprise that combines the previous three approaches.

A local business is a company that provides goods or services to a local population. Though most often used when referring to a locally owned business, the term may also be used to describe a franchise or corporate branch operating within a local area.

This information is important for disaster management; while a disaster in a local area can affect all three types of business equally, the recovery and resilience response will vary significantly. The multinational- and national-level businesses are expected to be more prepared and well placed with respect to contingency actions. They can mobilise resources easily and quickly. Also, they can temporarily transfer the operation of the locally affected unit to some other neighbouring locality where they also operate with minimum effect on their turnover.

Existing Capabilities and Gaps in Data Requirements

Information on the multinational, national or local nature of businesses can be obtained from the Australian Business Register. Access to the information is limited to individual searches through the web interface.

9.4 BUSINESS OPERATIONS

9.4.1 Multi-Location or Single Location

The Australian Business Registry (ABR) defines business locations as the permanent physical premises operated by a business or organisation. This is covered as a Foundational Information requirement in the milestone report 'Built Environment Exposure Information Framework' (Nadimpalli and Mohanty, 2015). However, the ABR reports it is equally important to provide additional business locations on all premises operated by the business or organisation, except in cases where there is a risk to the safety of individuals as a result of disclosure, e.g. women's refuge centres. For each location, the business needs to provide: the street address, the business activity details and the phone and email contacts. The definition of what and which premises are considered to be a business location are very clearly specified in the ABR.

For disaster response and recovery purposes, the information on single location, multi-location, individual home or mobile situation of the business are considered important information requirements. The following are the ABR-identified categories:

1. If a business operates from an individual's home, the home is considered a business location, for example, an internet-based business managed

from an individual home address or a tradesman who keeps their records and garages a business vehicle at home.

2. If a business operates a shopfront and a warehouse at different premises, the premises are considered as separate business locations.
3. Adjoining premises used for related activities, or premises used for multiple activities by the same business or organisation should be considered as one business location.
4. If a business is mobile, the permanent base for its operations is considered a business location, for example, a courier business that does its accounting from a commercial office.
5. If a business has no permanent base for its operations, the business office, home address, or home port in the case of maritime vessels, can be considered as a business location.

Existing Capabilities and Gaps in Data Requirements

Information on the multiple, single or mobile location of businesses can be obtained from the ABR. Access to the information is limited to individual searches through the web interface.

9.4.2 Operational Hours and Shift Operations

Business hours are the hours in which business is commonly conducted. Typical business hours may vary widely by industry type, state and local area. The purpose of maintaining common informal standards for business hours is to allow workers to communicate with each other more easily and to find a convenient divide between work life and home life. However, in the manufacturing sector, it may be mandatory to maintain common operational hours because of the interdependencies between workers of different skills to produce output.

In Australia, the hours between 9 am and 5 pm (the traditional '9 to 5') are typically considered to be standard business hours. However, as already mentioned, this may vary between industries in different states, also depending on whether it is a weekday, weekend or public holiday.

This framework identifies that the operational or trading hours at the individual business level is important information for disaster management as it provides information on whether the business is in operation or not at the time of disaster. Also, if the business operates different shifts, then it makes sense to obtain information on the number and type of employees on different shifts. This is crucial to assess the impact of a disaster on business.

Existing Capabilities and Gaps in Data Requirements

Generally, it is possible to acquire information on business operational hours by classifying a business into an industry sector or state or using legislation mandatory to the particular industry in the particular state. However, there is no individual-level access to such information, business shift operational hours and operational hours at a local-area level if there is any variation in the standard.

9.4.3 Business Track Record

A business' track record gives some indication of the long-term trend of the business. A range of studies have found that those businesses that have been struggling for many years recover considerably more slowly compared with businesses that have performed well.

Existing Capabilities and Gaps in Data Requirements

Business track record can be deduced from longitudinal tax data or other financial information. This data may be available through ATO's Business Activity Statements or publicly reported information.

9.4.4 Cash Flow

Cash flow is typically defined as the difference between cash or cash-like equivalents at the start of a period and that available at the end of a period. This includes all income and expenditure related to business operations.

Cash flow is a critical factor in business survival and is likely to be significantly impacted by disaster, likely through a loss of trade, loss of utilities, inability to obtain stock, or reduced workforce

Government policy may aim to ease cash flow through the use of low-interest loans and so information regarding cash flow is useful in assessing policy outcomes.

Existing Capabilities and Gaps in Data Requirements

Although some information regarding cash flow would be available for publicly listed companies, it is unlikely that there would be information on cash flow at the local level.

9.4.5 Cash Reserves

A reserve is essentially any amount of money specifically set aside by the governing body for future purposes. Any reserve established by the organisation (such as a capital profits reserve, building maintenance reserve, IT reserve) is included as part of the cash reserve.

Cash reserves are seen as critical for assisting a business to quickly respond to circumstances arising from a disaster. Adequate cash reserves enable a business to undertake mitigation and repair activities, cover temporary shortfalls in income and act as required without having to wait for insurance adjustment or organising loans.

Reserves should include any restatements of assets as recorded by an asset revaluation reserve, which is generated when an organisation decides to revalue certain non-current assets such as land and buildings.

Reserves may also include retained earnings, which represent the accumulated surpluses or deficits of the organisation over the years it has been operating.

Existing Capabilities and Gaps in Data Requirements

Cash and cash equivalent reserves are reported as part of the business current assets within their balance sheet. It is likely that this information is only available for publicly listed companies through their annual report or for large businesses where detailed financial analysis has been undertaken, such as those businesses listed on websites like Company360.

Data is not available for smaller business in regard to cash reserves.

9.5 SPACE USE

9.5.1 Office Space Use, Operational and Other

Information detailing the impact of a disaster on buildings and geographic areas is complemented by details on the use of that space. Detailed information on space utilisation can assist in determining whether there are disproportionate impacts on certain spaces and to help in modelling the specific impacts of the disaster.

An example might be the significant loss of manufacturing space in one event compared with the loss of retail and office space in another.

CLUE for Melbourne provides the classifications listed in the following table for the use of space within a building (City of Melbourne, 2012).

Space Use Code	Description	Relates to How Parts of Floors are Used by Individual Businesses
A	Office	Conduct of clerical, white-collar work. Professional services such as law, accounting, etc., are usually coded here
B1	Retail – Shop	The general retail sale of a wide range of goods or services in an enclosed structure
B2	Retail – Stall	The general retail sale of a wide range of goods or services from a structure that may be relocatable or not self-enclosed (e.g. flower stall, new kiosk, key cutter). These must be a separate establishment and not part of a larger business
B3	Retail – Showroom	Space used for the display of goods for sale, excluding cars. Does not include exhibition space (Y)
B4	Retail – Cars	Space used for the display of cars for sale
C	Wholesale	Wholesaling involves the purchase and resale of goods or services to another organisation. Wholesalers are involved in minimal sales directly to the public
D1	Manufacturing	Manufacturing involves the physical or chemical transformation of materials or components into new products. In the CLUE areas, space used for manufacturing is largely occupied establishments involved in jewellery making or scientific equipment making
D2	Workshop, Studio	This space use will most likely be encountered in design studios (e.g. architectural, graphics, advertising) or in workshops undertaking such activities as repairs (e.g. watchmaking, appliances, cars)
E	Equipment Installation	Salon exclusively used to house bulky plant and equipment such as printing plant, mainframe computers, air conditioning systems, electricity substations
F	Transport	Space used to conduct freight or passenger transport (e.g. railway stations, bus, tram, coach depots)
G	Storage	Space used to store goods, either as a business (e.g. furniture storage, grain storage) or in the course of conducting other business (e.g. file storage)
H	Education, Research	Space used for the conduct of training, educational, or research activities (e.g. schools, colleges, research laboratories). Space will be used as classrooms, training rooms or laboratories for training purposes
I	Hospital, Clinic	Space used for the conduct of medical or surgical treatment. Characterised by consulting rooms and medical wards. Laboratories used in conduct of commercial activities (e.g. pathology laboratories) are included here. Commonly located in office-type space

J1	Entertainment, Recreation – Indoor	Space used for a range of indoor entertainment and recreational pursuits (e.g. restaurants, cinemas, theatres, clubs, taverns, brothels, bowling alleys, gymnasiums)
J2	Park, Reserve	Public open space set aside as parks or reserves
J3	Sports & Recreation – Outdoor	Outdoor sports facilities
J4	Square, Promenade	Public open space with paved or other hard surface
K1	Community Use	Public libraries, jails and public toilets
L1	House, Townhouse	Detached, semi-detached, townhouse or terrace-style residential accommodation
L2	Residential Apartment	Medium- to high-density residential accommodation
L3	Commercial Accommodation	Short- to medium-term commercial accommodation, including hotels. Hostels, backpacker hotels, private hotels, boarding houses and serviced accommodation
L4	Institutional Accommodation	Accommodation providing various lengths of stay but usually provided as community services, e.g. shelters, supported accommodation, correctional facilities
L5	Student Accommodation	Medium- to long-term accommodation for students; may have shared facilities or be self-contained (does not include student apartments, which are coded as L2 Residential Apartment)
M1	Parking – Private Covered	Covered parking devoted to residential or commercial establishments, not for hire or lease to the public
M2	Parking – Private Uncovered	Open-air parking devoted to residential or commercial establishments, not for hire or lease to the public
M3	Parking – commercial covered	Covered parking devoted to hire or lease to the public
M4	Parking – Commercial Uncovered	Open-air parking devoted to hire or lease to the public
N1	Common Area	Indoor open space, such as circulation areas, toilets, foyers, stairwells, lift shafts, rooftops
N2	Open Space – Outdoor	Private outdoor open space, such as courtyards. Also includes unbuilt space around buildings
P1	Unoccupied – Under Construction	Space being constructed at time of survey
P2	Unoccupied – Under Renovation	Space being renovated at time of survey
P3	Unoccupied – Under Demolition, Condemned	Space under demolition or condemned at time of survey
P4	Unoccupied – Unused	Vacant or leased but not used
P5	Unoccupied – Undeveloped Site	Vacant land
TS	Transport, Storage – Uncovered	Space use to apply to a property that is a majority of unbuilt land used for storage (e.g. transport containers). These land parcels may contain some built, covered storage structures but are predominantly unbuilt
X	Performances, Conferences, Ceremonies	Space used for public presentations, generally with seating and a performance area such as a stage. Includes theatres, churches, cinemas, concert halls, courts, parliamentary chambers and conference facilities
Y	Public Display Area	Space used for (non-retail) displays, including museums, non-retail galleries, and exhibition space. Note that retail galleries and showrooms are included under space use B3

Existing Capabilities and Gaps in Data Requirements

Data is available for Melbourne and Sydney through CLUE and FES surveys that include information on space use.

The data is not available for other cities, States and Territories.

9.6 WORKFORCE CHARACTERISTICS

It is critical to understand both the number of employees and the full-time and part-time nature of employment provided by a business in an area to adequately understand the impact on income of significant business disruption. The loss of employment following disasters has significant impacts on individuals and local economies. It is necessary to have a good understanding of the number of employees in an area, the number of hours worked and the type of employment to accurately predict the impact of business loss and disruption on the local economy and household incomes.

This report covers the framework and information requirement of the number of employees in a business in the Business Size sub-section 9.3.

9.6.1 Employment Type

There can be some difficulty in defining whether a person is an employee of a business or a contractor. The framework should incorporate both the gross number of employees and the number of full-time-equivalent employees in a business.

The following are the exposure information requirements for decision-makers:

1. Number full time
2. Number part-time
3. Number casual
4. Number permanent
5. Number non-permanent
6. Number of contractors
7. Number of consultants

Employment tenure is additionally important in understanding both the liabilities of a business and assistance that may be available for employees who are no longer able to work.

Both the total number of employees (i.e. total persons) and the number of hours should be recorded.

It is important the employees are assigned to the location where they are physically working, except for workers on construction sites or similar varying locations.

Full-time – A full-time employee has ongoing employment and works, on average, more than 35 hours each week. The actual hours of work for an employee in a particular job or industry are agreed between the employer and the employee and/or set by an award or registered agreement.

Part-time – A part-time employee:

- works, on average, less than 35 hours per week
- usually works regular hours each week
- is entitled to the same benefits as a full-time employee, but on a pro rata basis
- is a permanent employee or on a fixed-term contract.

Casual – A casual employee:

- has no guaranteed hours of work
- usually works irregular hours
- does not get paid sick or annual leave
- can end employment without notice, unless notice is required by a registered agreement, award or employment contract.

Contractors – Contractors run their own business and provide services to your business. Although the definition of a contractor can vary depending on relevant legislation or regulation, a contractor usually:

- has established his or her own business
- is paid to achieve an agreed result

- provides skilled services
- controls how those services are provided
- may be free to subcontract the work to others
- is free to refuse additional work
- supplies the material or special tools to complete the job
- bears the risk and cost of fixing their faulty work
- can advertise to the general public
- has no right to employee entitlements such as paid leave.

Employment tenure

Employees can be hired as permanent employees or on a fixed-term contract.

- Permanent – Permanent employees are employed on an ongoing basis until the employer or employee ends the employment relationship.
- Fixed term – Fixed term means that the employee is employed for a specific period of time or task, for example a 6- or 12-month period, and employment ends on the date specified in the contract.

Existing Capabilities and Gaps in Data Requirements

Data is available for Melbourne and Sydney through CLUE and FES surveys, which include detailed information on employees. Limited information that may provide an insight into the number employees and type of employment is available for public companies.

ABS data through the Working Population Profile (ABS, 2011b) can be used to derive information on the location and type of employment for other businesses but this is limited to census years.

States that collect WorkCover data may have additional information available on the number and type of employees and the location of workplaces.

9.6.2 Workforce by Age and Gender

This framework identifies individual business-level information on workforce by age and gender composition as an important requirement for disaster management. Largely, there is evidence that disasters affect women and older

people disproportionately (Donner and Rodriguez, 2008; Martine and Guzman, 2002). Also, there is a range of literature in economics that relates age and gender composition of the workforce with firm performance (Pfeifer and Wagner, 2012; van Ours and Stoeldraijer, 2011). Consequently, this information is important not only for the obvious reason of count by age and gender of job loss, casualty or fatality of employees, but also for post-disaster productivity loss estimation models, business resilience and vulnerability studies at the individual business, local-area, jurisdictional or national level.

Existing Capabilities and Gaps in Data Requirements

Information on workforce by age and gender at national, state and local-area level is available through the ABS Census of Population and Housing. However, information access and availability at the individual business level is also an important requirement.

9.6.3 Workforce by Occupation

The occupational status of the workforce at the individual business level is identified as required information for disaster management. Broadly, it is important to know the nature of jobs, such as manual or administrative, that employees have in a particular business. However, depending on the nature of the business, it can be more useful to note the individual occupational categories available from the ABS. This information is also important for post-disaster productivity loss estimation models, business resilience and vulnerability studies at individual business, local-area, jurisdictional or national levels.

The ABS and Statistics New Zealand (SNZ) have completed a review of the Australian and New Zealand Standard Classification of Occupations (ANZSCO). The resulting classification (ANZSCO Version 1.2) builds on a review conducted in 2009 (ANZSCO First Edition, Revision 1) following the classification's introduction in 2006. The number of occupations identified in ANZSCO Version 1.2 represents a net increase of nine compared with ANZSCO First Edition, Revision 1. Of the new occupations created, there were one in Major Group 1 (Managers), six in Major Group 2 (Professionals), two in Major Group 3 (Technicians and Trades Workers) and one in Major Group 4 (Community and Personal Service Workers). One occupation was deleted from Major Group 2.

Existing Capabilities and Gaps in Data Requirements

Information on the occupational status of the workforce at national, state and local-area level is available through ABS and ANZSCO Version 1.2 (ABS, 2013a). However, information access and availability at the individual business level is also an important requirement.

9.6.4 Workforce Daily Turnover

The actual number of employees that turn up on a particular day at the individual business level is an important information requirement for disaster management as distinct from the actual number of recorded employees in that business. This number may vary depending on the employee attrition rate and number of employees on leave on a particular day. This is an important information requirement for time–space dynamic disaster modelling, as it gives the exact number of employees at work at the specific time of the disaster.

Existing Capabilities and Gaps in Data Requirements

It is unlikely that information is available on workforce daily turnover at the individual business or the local-area level. This information gap needs to be filled through appropriate bookkeeping practices, disaster management knowledge and awareness campaigning.

9.7 INPUT REQUIREMENTS

9.7.1 Input Composition, Output and Sectoral Dependency

Business input composition, output and sectoral dependency are the core elements of a firm's operation that define its business model. The International Integrated Reporting Council (IIRC) identifies that there is a need for organisations to disclose their business model using a consistent definition that reveals the inputs, outputs, outcomes and business activities. The IIRC background paper defines the term business model as 'the chosen system of inputs, business activities, outputs and outcomes that aims to create value over the short, medium and long term'. They highlight that current business model reporting is inconsistent, both in terms of uptake and scope. For disaster management purposes in Australia, the ANHEF identifies that there is a need for individual businesses to report their business model including the input composition, outputs and sectoral dependency using a consistent definition.

Further, this information should be collected and collated at local-area level, as this would be crucial input for post-disaster business recovery, resilience and economic loss estimation modelling at the individual business level.

Existing Capabilities and Gaps in Data Requirements

At the individual business and small-area level in Australia, there is a need to consolidate input composition, output and sectoral dependency information. This information gap needs to be filled by regulation or legislation .

9.8 EXPOSURE ELEMENTS AT THE MACRO-ECONOMIC LEVEL

At national, state or local-area level, natural disasters adversely impact macroeconomic indicators such as GDP growth, balance of trade, the public deficit and indebtedness (Hochrainer, 2009; Mechler, 2004; Murlidharan and Shah, 2003). The macroeconomic impacts comprise the aggregate impacts on economic variables like GDP, consumption and inflation due to the effects of disasters, as well as the reallocation of government resources for relief and reconstruction efforts. Because macroeconomic effects reflect indirect damage as well as relief and restoration efforts, these effects cannot simply be added up without causing duplication (Mechler, 2004).

Noy (2009) found that developing countries and smaller economies face much larger output declines following a disaster of similar magnitude than do developed countries or bigger economies. Countries with a higher literacy rate, better institutions, higher per-capita income, higher degree of openness to trade, and higher levels of government spending are better able to withstand the initial disaster shock and prevent further spill-over into the macro-economy. These all suggest an increased ability to mobilise resources for reconstruction. Financial conditions also seem to be of importance: countries with more foreign exchange reserves, and higher levels of domestic credit, but with less-open capital accounts appear more robust and better able to endure natural disasters, with less adverse spill-over into domestic production.

Based on that logic, collecting, collating and managing macroeconomic indicator information is important for disaster management even within a country at state and local-area levels. The effect of a disaster is highly correlated with the level of economic development of the State or region

affected. In practice, we see natural disasters are more localised, for example affecting an area within a state economy or affecting a regional economy (an area covering a part of two or more adjacent states). This also affects the entire country's economy. Therefore, it is important to be able to implement economic analysis and policy interventions at the regional level.

CLUE provides comprehensive information about land use, employment and economic activity across the City of Melbourne. CLUE assists the City of Melbourne's business planning, policy development and strategic decision-making. The Economic Profile in CLUE presents an appropriate range of economic indicators for the City of Melbourne. These are standard measures used to present an area's economic performance.

In line with the CLUE economic profiling of the City of Melbourne, the present framework identifies that local-area-level macroeconomic indicators that would support planning and policy-making for disaster management can broadly be categorised into the following domains:

- Size of the local economy
- Performance of the local economy
- Share of each industry sector in the local economy
- Labour force characteristics of the local economy
- Local commercial and residential property market characteristics.

9.8.1 Size and Performance of the Local Economy

The size and performance of the local economy can be evaluated through quarterly or annual time series of GDP at the Australian national and State level and GLP at local-area level.

9.8.2 Gross Domestic Product

GDP is the monetary value of all the finished goods and services produced within a country's borders in a specific time period. Though GDP is usually calculated on an annual basis, it can be calculated on a quarterly basis. GDP is normally monitored at national and state level as part of the national accounts in every country. However, the data should be structured to enable localised information to be amalgamated to be able to move between localised

microeconomic impacts at a firm level and macroeconomic impacts at local-area or state level.

Existing Capabilities and Gaps in Data Requirements

Macro-economic statistics (available through the ABS) are classified by business sector, including National Accounts Balance of Payments (BOP), International Investment Position (IIP) statistics, and Government Finance Statistics (GFS).

9.8.3 Gross Local Product

GLP, also referred to as Gross Regional Product (GRP), is conceptually the same as GDP. This measures the market value of all final goods produced in a specified region and over a given time period (typically one year). It comprises the sum of compensation of employees, gross operating surpluses of business (profits) plus taxes and less subsidies on products and production.

Although data is derived primarily from ABS data, the ABS does not provide this information as a standard product. There are a number of companies that provide a measure of GLP based on a range of models.

Economy.id (http://economy.id.com.au/) use data and modelling from the National Institute of Economic and Industry Research (NIEIR). This model is based on replicating the outputs of the National Accounts framework for local areas such as Local Government Areas (LGAs), using a range of data sources to model the accounts to show local trends. An example for the City of Adelaide is provided at http://economy.id.com.au/adelaide.

Saturn Corporate Resources developed an input and output model, which is a regional economic modelling system developed by. The model is a 20-sector industry model that seeks to minimise the use of data with potentially high statistical errors. An example of this model for the City of Melbourne is provided at http://melbourne.geografia.com.au/

The Remplan Economy (https://www.remplan.com.au/) model produces an estimate based on ABS place of work by industry sector employment data. This model uses 114 industry sectors and estimates the contributions to the local economy through employment, output, wages and salaries, regional exports and imports, and other value added by the industries. An example for the Shire of Ararat is provided at http://www.economicprofile.com.au/ararat.

Existing Capabilities and Gaps in Data Requirements

As all of the models listed above are heavily reliant on ABS census data, there are significant limitations to the models showing changes during intra-census periods. These models do typically provide for modelling based on periods from 5 years (census) down to quarterly.

NIEIR, in particular, comments that general equilibrium and top–down models of the economy can work at national and potentially state level, but do not deal with the high level of local integration of businesses when used at a local level. Instead, NIEIR emphasise the necessity of using a bottom–up model to better explain the GLP.

The Centre of Policy Studies at Victoria University uses the TERM-Australia model. Typically, this model is used to provide economic modelling for up to 205 regions across 190 sectors but it does also allow for top–down details based on statistical local areas (1300+).

9.8.4 Share of Each Industry Sector to the Local Economy

The World Bank identifies that the strength and structure of a country's economy is one of the important factors that affects vulnerability to natural disasters. In a globalised economy, the structure of the economy and the interdependence between the sectors are important factors in determining how the world's finances will be affected (World Bank, 2004). However, between countries and at a regional or local level, the economy's vulnerability to natural hazards has also been changing over time owing to globalisation and use of modern infrastructure, which have increased the interdependence between regions. Also, with time, there have been changes in the sectoral composition of GDP, with a declining and more diversified share of the agricultural sector and an increasing share of manufacturing, tourism, and financial services. The services sectors are less sensitive to anything short of a catastrophic event, and so their growth implies a reduction in the vulnerability of the economy as a whole.

This framework identifies that the following information on the share of each industry sector in the economy at the local-area level would be useful for end-users for disaster management:

- Type of major industries in the region

- Number of establishments in each industry
- Sectoral dependencies and input–output modelling
- Contribution of each industry to the GLP, and
- Annual productivity by industry.

9.8.5 Type of Major Industries in a Region

Identifying the type and composition of major industries at local-area level within Australia is important information for disaster management. The composition of primary, secondary and tertiary industries in a region primarily defines the economic activity of the area. However, obtaining this information is not a straightforward data collection exercise. The share of major industries can be identified through estimating the share of employment in different industries or through the contribution of each industry's sector to the GLP in the area and these are recorded as information requirements in their own right in this framework.

Existing Capabilities and Gaps in Data Requirements

Information on the share of employment in different industries at the small-area level needs to be estimated from the ABS Census of Population and Housing using TableBuilder software.

Information on the share of each industry in the GLP at local-area level needs to be modelled and estimated from ABS Input–Output (I–O) tables (ABS, 2014a) and CGE Modelling capability from the Centre of Policy Studies (CoPS), Victoria University.

9.8.6 Number of Establishments in Each Industry

The number of establishments in each industry in a local area is important information not only for bookkeeping requirement, but is also an important indicator of industry size. The United Nations Statistics Division in its 'Industrial Statistics Yearbook 1991 – Volume I: General Industrial Statistics' for most countries presented data related to the activity of 'establishments' in the specified industries rather than any other type of industrial unit (United Nations, 1991).

Existing Capabilities and Gaps in Data Requirements

Information on the number of establishments in each industry can be estimated from the ABR and ABS CABEE (ABS, 2014d). Access to data including the individual business name in the ABR is limited to individual searches through the web interface. ABS CABEE statistical information is only available at the national level. CLUE in the City of Melbourne Economic Profile presents this information, but information for the whole of Australia at local-area level needs to be estimated.

9.8.7 Sectoral Dependencies and Input–Output Modelling

Business sectoral dependency at the national, regional or different industry sector level has been identified as an important information requirement for business interruption loss modelling for disaster management (Chang-Richards et al., 2014). This is critical information to determine the extent of inter-dependencies between sectors that affect economic recovery and business resilience. Also, this is critical to determine what can be done to reduce sectoral vulnerability and improve business DRR activity or awareness.

It is standard practice in economics to use I-O models to study business sectoral dependencies and disaster impact at national and regional levels. Input–output analysis is a quantitative economic technique that represents the interdependencies between different branches of a national economy or different regional economies. It is a matrix of raw economic data collected by companies and governments to study the relationships between suppliers and producers and the economic impact of the import or export goods to meet consumer demand. Of particular interest is the extent to which the outputs of one industry become the inputs to another. Rose et al. (2011) highlighted that I-O analysis is the most widely used tool for regional impact analysis throughout the world. Moreover, it has been used extensively to analyse the economic impacts of earthquakes and other natural hazards (e.g. Applied Technology Council (ATC), 1991; Shinozuka et al., 1998; Gordon et al., 2007). It is especially adept at estimating ripple, or multiplier, effects. Practically every country in the world has constructed an I-O table, usually through an exhaustive census or at least an extensive survey, and there is rich literature on ways to use non-survey data-reduction, or 'downscaling', methods to generate tables for political jurisdictions at various subnational levels (Rose et al., 2011).

Pan et al. (2015) highlighted that there are alternatives to I-O analysis, for example, the CGE (computable general equilibrium) models, which are very popular. These can accommodate important price-substitution effects. Input–output models, on the other hand, assume fixed reduction coefficients.

The ANHEF identifies that information provisioning at the small-area level on sectoral dependencies and input–output modelling are important requirements for disaster management and post-disaster economic cost analysis.

Existing Capabilities and Gaps in Data Requirements

In Australia, ABS I–O tables (ABS, 2014a) are part of the National Accounts, complementing the quarterly and annual series of national income, expenditure and product aggregates. They provide detailed information about the supply and use of products in the Australian economy, and the structure of and inter-relationships between Australian industries.

ABS I-O tables 2013-14 contains input by industry and output by product group; use of domestic production and imports by industry and final demand categories, taxes and margins on supply by product, and product and industry concordances.

CoPS at Victoria University provides two broad types of CGE model:

1. Customised CGE models for governments and other organisations around the world, for example central government agencies in Australia, the USA and China.
2. Standardised user-friendly multi-regional CGE models, with some tailoring of regional and sectoral disaggregation to individual user requirements. This service is offered for Australia with the TERM-Australia model

The standardised regional TERM-Australia model can be used for any disaster-related impact assessment and workforce planning.

9.8.8 Contribution of Each Industry to the GLP

The share of each industry in the GLP is important information that may help in post-disaster economic impact analysis. Additionally, the resilience and vulnerability of an area depend on the type of major industries in that area and the share of each industry in the GLP, as some industries are more vulnerable to

natural disasters than others. For example, the agricultural sector is more vulnerable to natural disasters than the service sector. Also, this information is required for disaster-related economic management and planning.

The ANHEF identifies that information provisioning at the small-area level on share of each industry of the GLP is an important requirement for disaster management.

Existing Capabilities and Gaps in Data Requirements

This information at the small-area level needs to be modelled and estimated using information from ABS I–O tables (ABS, 2014a) and CGE modelling capability from CoPS.

9.8.9 Annual Productivity by Industry

Productivity is the ratio of outputs to inputs in production. It is calculated as the ratio of value added to total hours worked by all workers (measured in full-time-equivalents) in each industry. It measures how efficiently inputs, such as capital and labour, are used to produce outputs in the economy. Productivity is also referred to as productive efficiency. Productivity increases if output grows faster than inputs (or shrinks more slowly). Conventionally, growth of productivity is measured as the growth of output over and above the growth of inputs. Multifactor productivity is estimated as value-adding output produced per unit of combined inputs of labour and capital (ABS, 2014d). It is the measure that comes closest to the underlying concept of productivity efficiency in terms of both labour and capital. Growth of multifactor productivity is the growth of output over and above the growth of labour and capital inputs (Productivity Commission, 2015).

Labour productivity measures output produced per unit of labour input. Growth of labour productivity is the growth of output over and above the growth of labour input – it captures the value added from growth in capital that supports increased output without the increased use of labour (referred to as capital deepening) and multifactor productivity (Productivity Commission, 2015).

The ANHEF identifies that information provisioning at the small-area level on annual productivity by each industry is important for disaster management, as

this information would carry a high weight in post-disaster resilience, vulnerability and productivity loss modelling.

Existing Capabilities and Gaps in Data Requirements

CLUE in the City of Melbourne's Economic Profile presents this information. This information at the small-area level for the rest of Australia needs to be modelled and estimated.

9.8.10 Labour Force Characteristics in the Local Economy

Labour force characteristics such as employment and unemployment rates and employment type such as part-time, full-time or casual in a local area are important indicators of an economy's overall performance and of labour mobility, and thus of the vulnerability and resilience of the residents to natural disasters. Natural disasters that affect the local economy affect the employment status of people as businesses and industries close down and consequently, this adversely affects their income and wellbeing. Also, the magnitude of the impact of disasters varies across industries as different industries are affected in different ways. Consequently, while the labour force characteristics of the population at the small-area level in Australia have been listed as an exposure information requirement in the milestone report 'Built Environment Exposure Information Framework' (Nadimpalli and Mohanty, 2015), the present framework identifies the following information on the business component of labour force characteristics at the small-area level that may help in disaster management and planning:

1. Workforce distribution by industry
2. Workforce distribution by employment type by industry
3. Changes in local jobs by industry and employment type, and
4. Changes in workforce by gender.

Existing Capabilities and Gaps in Data Requirements

CLUE in the City of Melbourne's Economic Profile presents this information; however, the above information on workforce distribution by industry and type of employment and gender composition and change over time at the small-area level needs to be estimated from the ABS Census of Population and Housing data using TableBuilder software.

10 RELIABILITY ASSESSMENT FRAMEWORK

Exposure information is managed and delivered to users through an information system and provides situational awareness for decision-makers, but the reliability of the data is not presented to users. In absence of data fitness information, it is difficult for the decision-maker to objectively analyse the real situation (Goodchild et al., 1994) and this may cause a bias in implementing potential solutions (Kobus et al., 2001). Information regarding data reliability can help decision-makers to incorporate uncertainty when determining the 'best' answer to a problem (MacEachren et al., 2005). Information systems can lead users to think that their underlying databases give representations of objective truth while this may not actually be the case (Veregin, 1999). In reality, there is increasing reliance on secondary data sources such as estimates, assumptions, extrapolation and predictions where data is missing. This affects the overall reliability while the end users of exposure information systems often assume that their characteristics are uniform (Wong and Wu, 1996; Burrough, 1986). The conventional method of disclosing metadata is less useful to convey reliability. Without the reliability information, data could be considered good quality for one use may actually be useless for others as it is may not fit for purpose. Vidyattama, 2017 has outlined more details and the literature review to prepare this chapter.

10.1 DATA RELIABILITY CONSTITUENTS

The information reliability constitutes provenance; accuracy and currency; Precision and completeness; and consistency. Metadata captures some of the reliability required data items to explain the authoritative data sources and more details about the metadata is in Chapter 3.

10.1.1 Provenance

Provenance means origin, and in databases, it relates to the process by which data is produced (Buneman et al., 2001). Provenance is a fundamental factor because it is often required to assess the trustworthiness of data (Di et al., 2013). Provenance information often indicates the level of reliability as it shows how the data is produced. There may be a large amount of information on provenance because data may be produced by custodians through varied

processes. The provenance information needs to capture all these different steps. For that reason, provenance is defined as history of data in terms of workflow context as well as web context (Wong and Wu, 1996; Di et al., 2013).

There are two main components of provenance information that users need to know the data source and method of derivation. The provenance includes various subcomponents of method of derivation includes specification of processes and also include information about other reliability aspects linked to the data and method of derivation such as accuracy, currency and precision. The other issues in providing information on the provenance of a database are that the diverse types of data in different databases will require different provenance representations for different needs (Di et al., 2013). This affects the way the provenance information needs to be captured.

10.1.2 Accuracy and Currency

Accuracy means the difference between observation and reality that how good the data is at representing the reality that users need to know. The accuracy of spatial data often considers both positional and attributes accuracy. Positional accuracy, or spatial accuracy, refers to the closeness of the spatial components (Veregin, 1999) in data and determines the difference in the recorded positions of objects and features compared with perfectly measured reality (Wong and Wu, 1996). Attribute accuracy looks at the discrepancy in thematic element measurements (Veregin, 1999): it concerns error in the description of features.

Another type of data accuracy is temporal accuracy or quality of data currency. This expresses whether data is still valuable at the time it is used given the delay since its collection.

10.1.3 Precision and Completeness

Precision refers to the exactness of measurement (MacEachren et al., 2005). In spatial databases, the term that is commonly used is resolution and this relates to how detailed the data provided to the user (Veregin, 1999). The level of aggregation and categorisation determines the precision of the data (Evans, 1997). Precision also depends on the measurement parameters and the estimation procedure or device (MacEachren et al., 2005).

Like accuracy, precision can also be seen from three aspects: spatial, temporal and thematic (Veregin, 1999). Spatial precision relates to the dimension of a picture element or pixel. It can also depend on the size of community that can be represented by an area. Temporal precision relates to the recording interval. The more often the data is updated, the more precise it is. However, similarly to temporal accuracy, context is important in temporal precision as different data may have different rates of change. Thematic precision relates to the measurement scale as well as the classification used in categorical data. The more refined the classification, the more precise the data will be. Although there are many similarities between precision and accuracy, a major difference between the two is that precision is about scale while accuracy is about correctness.

Completeness can be defined as the comprehensiveness of the data and describes whether the information of interest is in the scope of the data. The completeness of the data depends on how the relationship between the object in the database and the 'abstract universe' is being represented (MacEachren et al., 2005; Veregin, 1999). This will determine which objects need to be covered by the database (Wong and Wu 1996). For example, if a person is standing beside a tree, precision may be detailed enough to put the tree in its place with good accuracy, but as the man is not covered by the database, then the database will not identify the existence of a person there.

10.1.4 Consistency

Consistency in spatial information refers to 'the fidelity of the relationships encoded in the database' (MacEachren et al., 2005). In other words, it refers to how well abstract reality is being transformed into code in the spatial database. This can be assessed from any apparent contradictions in the database (Veregin, 1999). Kainz (1995) notes that consistency means that the data follows topological rules such as that no two points are at exactly the same location or that polygons are fully bounded by lines.

The combination of different reliability factors determines the credibility of the database (MacEachren et al., 2005). It is important to note that the credibility of a database is often judged by the users' experience, and therefore, the credibility of the data also depends on the judgement of the user. The

judgement of the data provider or constructor is also an important factor, because the construction of data involves some human interpretation and judgement and thus, there is some level of subjectivity in the data.

10.2 THE FRAMEWORK

Several existing data, metadata, user identification frameworks including Foundation Spatial Data Framework (FSDF), ISO Geographic Data Framework and Data Provenance Framework were reviewed to propose a suitable framework for exposure information. Every data custodian is having unique database management environment in Australia. This framework is more generic and provides guidelines so that the data custodians will be able to customise for their specific environment.

The reliability framework to be built for exposure information systems should closely follow the ISO's data evaluation process. This means the exposure information framework needs to provide specifics about how a dataset could be released as well as the necessary advice and metadata that accompany it. For this purpose, users have to submit their requirements regarding the quality level they require in order assessing the appropriateness of the datasets. Initially, this is fulfilled by the three categorisations of users discussed in Chapter 2. The framework also adopts the data reliability assessment framework discussed by Car (2016) by using the provenance (history) of the data as one component of reliability measure while also adopting the idea of 'forward provenance' by taking into account how the data will be used. To do so, the framework requires users to submit data and its metadata to information and provenance systems. Users can also re-submit their feedback as well as requirements to adjust the initial criteria that the exposure information framework sets out as default.

Figure 10.1 shows a process that adopts the two frameworks above and can be applied in an exposure information framework. The provenance framework is prominent owing to the multiple ways in which provenance information is relevant to quality assessments. If this is not currently possible, then exposure information systems have to assist the supplier to fill in these components. In addition, the framework results for datasets should be able to change as the data supplied is updated and used by users. The framework should be able to capture the metadata from previous data to fill in the new metadata as well as

record the provenance of data change, given that product is likely to be considered as new after each change. The two components – provenance and metadata – can be seen as one package, but it might be useful to separate them as provenance could be captured directly from activities. Nevertheless, as exposure information systems do not include the capability for users to change or create new data, suppliers should be required to submit their activity information as inputs into provenance.

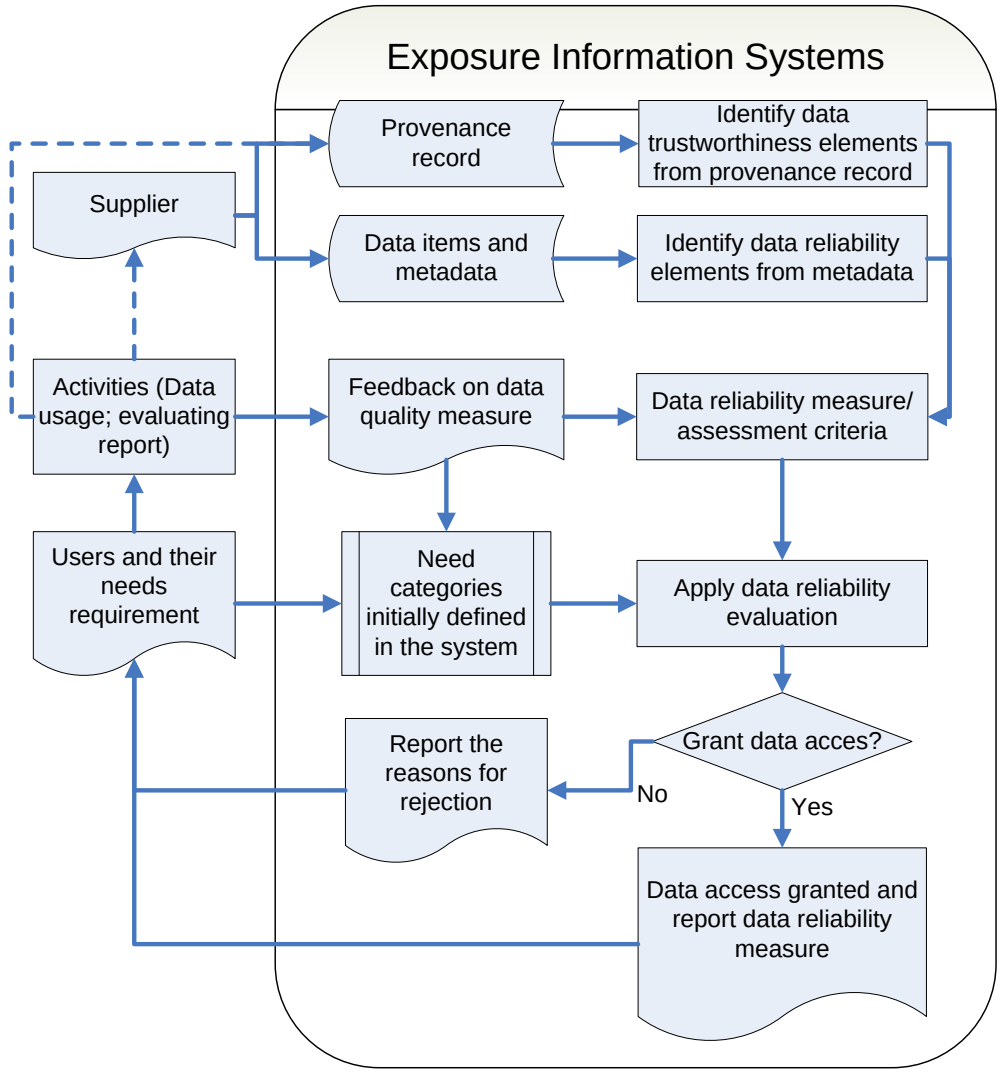


FIGURE 10.1 PROPOSED DATA RELIABILITY FRAMEWORK FOR EXPOSURE INFORMATION SYSTEMS

In the next stage, the exposure information framework will identify data reliability elements. These elements come from both the metadata and the provenance record. Given the provenance record may also contain series of metadata, the overall assessment of the provenance needs to be given first for each of the data items in the dataset. The exposure information framework is

able to extract the reliability elements of each data item from metadata. This includes extracting the precision, accuracy, currency and completeness status. In this framework, the suppliers are required to fill in the metadata but the framework also needs to be ready to use the closest available metadata based on provenance (i.e. metadata of the data being used or updated). It is important to note that users who use more aggregated data, such as the Level 1 user, are more likely to find more reliable data items for their purposes in a dataset.

10.2.1 Classification of Data Based on Reliability Information

After information is collected, it goes through the reliability measurement framework. The provenance of data items is assessed first. Initially, the framework focuses on the journey of the data, such as where it originates from, perhaps from a survey (census), satellite capture or administrative report, and then it will look at whether or not it has been estimated through sampling or other statistical techniques. It is also possible that the history of the data is unknown or unclear. An example of assessment using this classification methodology is as follows:

1. Original: survey, administrative data, satellite capture
2. Original estimate from big sample
3. Modification from original data
4. Modification from estimate
5. Modification from modified data (second in line from the origin)
6. Modification from modified data (third or more in line from the origin)
7. Unknown.

In this example, the provenance can be used to automatically update the status of the data every time it goes through modification. As stated above, the provenance may also contain historical metadata, information that can be included in the provenance assessment measure. However, the provenance classification does not carry over the information from previous metadata because this would produce complicated data with unlimited possibilities of a provenance quality level that may not be comparable with others. For

example, it can use accuracy, currency or precision and produce categories such as 'modified from estimated data with 95% accuracy', 'modified from data older than 5 years ago' and 'modified from data at States or Territories level', respectively.

The next step in the framework is to look at the data reliability component. The main components are accuracy, currency and precision. Accuracy and precision can be differentiated into spatial, temporal and thematic. Some of the issues that cannot be captured by the provenance described above can be captured by presenting reliability components directly. This is because some of the historical metadata information can be referred to in current metadata. For example, the accuracy of the current data will depend on the accuracy of the input data. The historical metadata components may be reflected by a combination of the reliability components. For example, the output data can be disaggregated from the input data, which would provide a higher precision, with the cost of lower accuracy.

The challenge at this stage is for the exposure information framework to come up with measurement criteria for the different reliability components. As discussed in the previous section, the criteria will need to vary based not only on the type of component but also on the user and the data item itself. To deal with this issue, the framework provides the initial criteria while taking input from users for further consideration. In Figure 10.1, this is shown by the arrow from the user requiring feedback after activity or interaction with the data. Here are some examples of the measurement criteria:

Accuracy:

1. At least 95% of the data is correct;
2. 80% to less than 95% of the data is correct;
3. 70% to less than 80% of the data is correct;
4. and so on.

Currency:

1. Data represents conditions less than 1 month ago;
2. Data represents conditions around 1 year ago;
3. Data represents conditions 1 to 5 years earlier;
4. Data represents conditions 5 to 10 years ago;

5. and so on.

Spatial Precision:

1. Data is captured in almost exact location with 10 × 10-m grid cells;
2. Data is captured in 1 × 1-km grid cells or is captured by SA1 area;
3. Data is captured in 5 × 5-km grid cells or is captured by SA2 area;
4. Data is captured in 50 × 50-km grid cells;
5. and so on.

As can be seen above, the list contains the measures as absolute categories and criteria rather than filled according to the needs of specific users or, as discussed in the literature review section, relative to the expected time length for which certain data is deemed to be reliable. The reasons for this are twofold. The first is for flexibility and second is to enable the user to track the reason for including the criteria in data as well as to giving their input on these criteria. As a consequence, the assessment process will need to proceed to the next stage where a different assessment can be given by and for different users.

The table10.1 below illustrates the information card resulting from applying measurement criteria to data items. The illustration includes four variables or indicators. For example, these indicators could be the building location, various types of roof in an SA1 area, vehicle ownership at the SA1 area level and the location of parking. It is important to note that exposure information systems have to generate these initial criteria based on the information they have about the needs of the data end-user and how they use the data.

TABLE 10.1 AN ILLUSTRATED SCORECARD OF DATA ITEMS

	Data Items			
	Building Location	Various Types of Roofs in SA1	Vehicle Ownership at SA1 Level	Parking Location
Provenance	1	2	3	4
Accuracy	2	1	4	3
Currency	4	1	1	2
Precision	1	2	2	1

10.2.2 The Assessment of Reliability

The criteria set by exposure information systems not only serve varied needs but also anticipate potential problems that can arise in data utilisation. Therefore,

the next stage of the framework, which is the reliability evaluation process, applies different assessment thresholds designating the quality of data': high, medium or low for different levels of user. Table 10.2 (A–C) shows an example of how this differentiation can take place. For example, 'building location' data, derived from satellite data that may include clouds, would have a reduced accuracy'. The required quality of the data is high for Level 1 and 2 users who look at the data in aggregate; thus, the effects of clouds in the data for them are insignificant. For Level 3 users, this could be a problem as they may need to look specifically at the area under cloud.

Even if the data was collected more than 5 years ago, it may still be valuable for Level 1 users since at the aggregation level they are working at, the changes of 5 years may not substantially alter patterns. However, this quality of currency will likely be considered too low for both Levels 2 and 3. Currency is, of course, also subject to both the particular end-use and the particular data item as some uses and items are sensitive to time.

Table 10.2 also shows how the quality classification of high, medium or low can be allocated differently across different data items. While Table 10.1 captures and categorises the quality information immediately from the metadata, the assessment of specific users of various data items could be different and, therefore, data items may have different thresholds that need to be stated as high, medium or low. The currency of a parked car and factory location discussed earlier is one example of this issue: the knowledge about a parked car from a year ago is not as useful as the information from the same time about factory location. In particular, Table 10.2 shows different categories are given for Level 3 users in regard to the information of various roof types and the information about car ownership at the SA1 level. In this example, the user is hoping for more detailed information about which houses have vehicles while expecting that the roof type in a certain SA1 area is more or less uniform.

As can be seen in the car and factory example, setting the assessment threshold as the second step of the process provides flexibility. This is because the characteristic described in the first step can mean a different thing for different users as well as for different data items. Therefore, it is impossible to assess the reliability criteria for the data relative to an expectation at the first step because the expectation can differ. On the other hand, if the assessment

is being done directly in the first step, then there is a possibility that the categorisation is being done randomly owing to lack of framing and the availability of too many options. This is especially relevant to the feedback loop expected from users for the advancement of assessment in the framework (Figure 10.1). Input from the users is likely to affect the assessment process in the second step, especially the threshold to categorise whether the data has high, medium or low reliability. This does not mean that the criteria in the first step cannot be changed but they are expected to be more rigid and sustainable.

TABLE 10.2. THE ASSESSMENT PROCESS FOR ILLUSTRATED DATA ITEMS IN THREE LEVELS

A

Level 1	Data Items			
	Building Location	Various Types of Roofs in SA1	Vehicle Ownership at SA1 Level	Parking Location
Provenance	High	High	Medium	Medium
Accuracy	High	High	Medium	Medium
Currency	Medium	High	High	High
Precision	High	High	High	High
Data release	Granted	Granted	Granted with warnings	Granted with warnings

B

Level 2	Data Items			
	Building Location	Various Types of Roofs in SA1	Vehicle Ownership at SA1 Level	Parking Location
Provenance	High	High	Medium	Low
Accuracy	Medium	High	Low	Medium
Currency	Low	High	High	High
Precision	High	High	High	High
Data release	Granted with warninsg	Granted	Not granted	Granted with warnings

C

Level 3	Data Items			
	Building Location	Various Types of Roofs in SA1	Vehicle Ownership at SA1 Level	Parking Location
Provenance	High	High	Low	Low
Accuracy	Medium	Medium	Low	Low
Currency	Low	Medium	High	Medium
Precision	High	High	Medium	High
Data release	Not granted	Granted with warnings	Not available	Not granted

The next stage in the framework is the decision about whether to grant the user access to the data and what warnings it needs to carry if given. The assessment of high, medium or low quality or reliability of the data should be the main reason for this decision. The criteria could again be set based on how its data quality elements behave or, at least, how we perceive the importance of the data element. If we assume provenance is the most crucial information for quality assessments, exposure information systems should not release data with low quality indicated by provenance. The important step is then to release a report to the user whether they granted access to the data or not.

10.2.3 User Feedback and Refinement of Assessment

As can be seen in Figure 10.1, the framework requires data users to always provide feedback to the system. This is important to recalibrate the data element criteria, the assessment threshold and the basis for granting the data. For example, if the data is assessed as unsuitable and the data user feels the reason for not granting the data is not strong enough, they can submit feedback arguing against the decision. The same thing would also be applied if the user felt that the standard for release of data was too low. Exposure information systems will eventually need to assess these submissions and reset the criteria and threshold to a more suitable level.

The next question for the framework is how to effectively manage and incorporate the feedback into the assessment system. The framework has an initial user level to differentiate the users who will be feedback contributors. However, within these grouping levels, there is a large variation of users regarding the frequency of usage, the variety of data required and the level of experience as well as other factors. All these can be taken into consideration in accommodating feedback using a weighting system or using an artificial intelligence process such as fuzzy logic. In doing so, the framework has to first capture these characteristics in the user profile. The user profile may also help in dealing with other issues such as determining the accuracy of feedback and reducing feedback bubbles if the usage is mostly coming from certain groups or a sub-section of users.

11 SUMMARY AND CONCLUSION

This report is the first attempt to develop a generic, consistent and standardised exposure information framework to address the needs of DRR in Australia. The framework provides the collective views of data managers, researchers and end-users on exposure information requirements that support vulnerability assessments for DRR and socio-economic impact analysis with a multi-hazard focus at all levels of resolution. More importantly, the framework identifies the gaps and overlaps in exposure information requirements at different levels of governance and provides suggestions to overcome those deficiencies. One of the key outcomes of this report is to identify a list of exposure elements across different components of the buildings, infrastructure, social and business environment, which are presented in the table 'Summary of the Exposure Information Elements' (see Annexure 12.1). In this respect, the findings presented here provide an important first step in understanding and identifying the complexity in exposure information requirements. Even though the information is available, it is difficult to assess its reliability for specific use. Assessing and communicating the reliability is significant and challenging. The framework has made an attempt to outline a provenance framework to assist data custodians to manage metadata and provide guidance as to its reliability.

Exposure information inventory, maintenance and access technologies are advancing quite rapidly. The framework is generic and not covered the information access technologies and requirements.

The present framework will increase quality, and drive consistency and continuous improvement in Australian DRR. In achieving these outcomes, the framework provides shared strategic directions and priorities for governments, communities and industry sectors to implement the entire framework to build a national exposure information system. The framework also enables and provides guidance for the end-users to identify certain exposure components as a priority for implementation.

For better utilisation, the framework needs to be aligned with other major information frameworks such as Australia's 'Foundation of Spatial Data Framework' (FSDF), HAZUS Framework, Global Exposure Database for Global

Earthquake Model etc. The FSDF underpins the spatial enablement of the data needed for a diverse range of decision-making in both government and industry. The exposure information framework is comprehensive and focuses on the community safety response and mitigation end users requirements. This alignment will enable these end-users to understand the data value chain and reliability for a specific use or user. The exposure framework needs to be translated into a proper database and needs a network to be established. The available data sources catalogued and put together into data discoverability tool for end-users to understand data gaps, and prioritise their investments and projects on national exposure information system development.

This research will assist to develop nationally consistent information systems to help government (national, state and local) and industry end-users to quantify what and how much will be and has been impacted by a range of disasters.

12 ANNEXURES

12.1 SUMMARY OF THE EXPOSURE INFORMATION ELEMENTS TABLES

FUNDAMENTAL INFORMATION			
Location	**Land Use**	**Insurance Status**	**Metadata**
Latitude	ALUM Classification	**PERSONAL**	Keywords
Longitude		Life Insurance	Geometry
Address		Income Protection Insurance	Feature Type
Geometry		Health Insurance	Definition
		Travel Insurance	Data Source
		HOUSEHOLDS	Spatial Accuracy
		Buildings Insurance	Attribute Reliability
		Contents Insurance	Attribute Source
		Car Insurance	Attribute Accuracy
		BUSINESS	Data Currency
		Worker's Compensation	Maintenance Cycle
		Professional Indemnity Insurance	Revision Date
		Liability Insurance	Limitations
		Business Continuity	Restrictions
		GOVERNMENT	Contacts
		State-Owned Assets	
		Flood Cover Insurance	
		Malevolent Cover Insurance	
		Compulsory Third Party Motor	
		Public Liability Insurance	
		INSURANCE COMPANIES	
		Re-insurance	

BUILDINGS							
Usage	**Form**	**Structure System**	**Foundation**	**External Wall Type**	**Roof Shape**	**Roof Material**	**Floor Type**
Residential Commercial Light Industrial Educational Health & Welfare Emergency Services Government Community Recreational Mixed-Use	Separate house Semi-detached house Apartment – Low Rise Apartment – Medium Rise Apartment – High Rise Multistorey Commercial Shopping Mall Complex Warehouse Light-Industrial Buildings Parking Structures Monuments, Heritage Heavy-Industrial Complex Buildings	Steel Concrete Timber Masonary	Piled foundations Spread footings (pad and strip foundations) Raft foundations	Cavity Veneer Masonry Timber Metal Sheeting Fibre Cement Mudbrick Synthetic Curtain wall Double Façade Planar Wall Foyer Wall Shop front Balcony Composite Terracotta Coper Precast Insitu Concrete	Gabled Flat Hip Clerestory Arched Sawtooth Curved Domed Skillion Mansard Mixed	Tile Metal Concrete Fibre Imitation tile Synthetic Glass Fabric	Solid timber Manufactured timber Concrete flat slabs Concrete beams & slabs Reinforced flat slabs Reinforced beams & slabs Precast Concrete Composite Others

BUILDINGS					
Year Built	**Appurtenance**	**Size**	**Emergency Exit**	**Utility Connections**	**Replacement Value**
Year Built	Towers	Land size	Signage	Location of Gas	Building Value
Construction Period	Spires	Gross Floor Area	Evacuation Floors	Location of Electricity	Contents Value
Retrofit Year	Steeples	Building Lettable Area	Evacuation Lifts	Location of Solar	
Renovation Year	Balconies	Number of Dwellings	Evacuation Stairwells	Location of Water	
	Awnings	Extensions	Evacuation Plan	Location of Hydrants	
	Signage	# of Bedrooms	Code Regulations	Location of Comm. points	
	Solar panels	# of Toilets			
	Air conditioning	# of Car Parks			
	Equipment	Size of Garage			
		Annex building			

TRANSPORT INFRASTRUCTURE

Roadway	Railway	Waterway	Bridges Culverts	Tunnels	Airports	Sea Ports	Public Transport	Multimodal	Vehicles	Functions
Name	Ownership	Channel	Ownership	Ownership	Ownership	Ownership	Terminals	Connections	Number and	Schedules
Ownership	Line Type-	-Width	Length	Usage	Functional Type	Port Name	Interchange	Containers	Type	Routes
Type	-Gauge	-Depth	Width	Length	Landing Grounds	Port Type	Bus Stops	Cranes	-Aircrafts	Patterns
Restrictions	-Usage	-Purpose	Bridge type	Width	Traffic Control	Berthing Structures	Railway Stations	Stackers	-Helicopter	Dependencies
# Lanes	-Control Facilities	Harbours	Structure Type	Type	-Tower	Platform Type	Railway Yards	Trucks	-Cargo	Capacity
Construction Material	-Rail Gates	Wharves	Design	Structure	-Systems	Protection Barriers	Control Rooms	Barges	-Buses	
Carrying Capacity	-Train, Tram	Sea Ferry	Spans	Shape	Weather Stations	Superstructures	Harbours	Ships	-Trucks	
Capacity Utilisation	-Metro networks	Networks	skewness	Materials	Safety Facilities	Carrying capacity		Planes	-Cars	
Year Upgraded	Condition		Materials	Purpose	Security	Capac. utilisation		Control Rooms	-Motorcycles	
Lane Width	Electrification		Purpose	Equipment	Fuel Depot	Year upgrade		Capacity	-Trains	
Shoulder Width	Carrying capacity		Carrying capacity	Year Built	Terminals, Gates	Connections		Reconstruction	-Trams	
Grade, Condition	Capac. utilisation		Capac. utilisation	Year Upgraded	Customs Office	Protection		Cost	-Boats	
Carriage division	Year Built		Flow capacity	Carrying capacity	Immigration	Facilities			-Ferries	
Bicycle Paths,	Year Upgraded		Year built	Capac. utilisation	Hangers	Reconstruction			-Ships	
Footpaths	Reconstruction		Year Upgraded	Reconstruction	Year	Cost				
Reconstruction Cost	Cost		Pier walls	Cost	Carrying capacity					
			Abutment		Capac. utilisation					
			Reconstruction		Traffic Patterns					
			Cost		Reconstruction Cost					

ENERGY INFRASTRUCTURE

Petroleum Well	Petroleum Refinery	Petroleum Terminals	Petroleum Transmission	Gas Processing	Gas Transmission	Gas Storage	Service Stations	Electricity Generation	Electricity Transmission	Electricity Transmission Towers, Poles	Electricity Substations
Location	Ownership	Ownership	Pipelines	Ownership	Ownership	Ownership	Ownership	Ownership	Ownership	Ownership	Ownership
-Onshore	Products	Position	-Type	Products	Pipelines	Storage Tank	Site-	Gener.type	Lines Type	Year Built	Type
-Offshore	Processing Units	-Underground	-Size	Processing -	-Type	-Wall type	Category	Capacity	Insulation	Foundation	Usage
Ownership	Capacity	-Aboveground	-Material	Units	-Size	-Capacity	Tank-	Storage	Circuit Breakers	Topography	Voltage
Well Status	Facilities	Vicinity	-Capacity	Capacity	-Material	-Compression	Material	Material	Voltage Capacity	Height (Peak)	Design
-Exploration	Storage	-Refinery	-Year built	Facilities	Capacity	Cylinders	Year Built	Conveyors	Year Built	Height (Cage)	Height
-Drilling	-Crude	-seaport	-Reconstr. Cost	Liquefaction	Year built	Storage	#Pumps	Boilers	Reconstr. Cost	Height (Body)	Equipment
-Production	-Products	-Airport	Oil Cargo Vessels	Shipping	Cargo Ships	Facilities	Facilities	Demineralisation		Width	Capacity
-Abandoned	-Waste	-Urban	-Material	Electricity	Capacity	-Cylinder fill	-Store	Generators		#Circuits	Coverage area
Depth	Shipping	Substance	-Capacity	Carrying cost	Vessel Cost	-Reliquefaction	Capital	Transformers		Conductors	Year Built
Storage Capacity	Pollutant	-Facilities	-Value	Year Built	Ship to Ship	-Blending	Fuel-	Cooling Towers		Types	Reconstr. Cost
Platform	Electricity	Capacity	Ship-Ship transfer	Reconstr. Cost	Tanker Truck	Capacity	Turnover	Chimneys		Design	
Year Built	Carrying costs	Fuel turnover	Tanker Truck		Rail Tanker	Fuel Turnover	Reconstr.	Water Supply		Materials	
Reconstr. Cost	Year Built	Year Built	Rail Tanker		Retail-Cylinders	Year Built	Cost	Switch Yard		Dead-ends	
	Year upgrade	Blending			Reconstr. Cost	Reconstr. Cost		Facilities		Reconstr. Cost	
	Reconstr. Cost	Reconstr. Cost						Load capacity			
								Year Built			
								Reconstr. Cost			

COMMUNICATION INFRASTRUCTURE						
Telephone Exchanges	**Telephone Cable Networks**	**Communication Towers**	**Submarine Cables**	**Broadcasting**	**Satellite Earth Stations**	**Postal, Courier**
Ownership	Ownership	Ownership	Ownership	Ownership	Ownership	Ownership
Area of coverage	Telephone Lines	Tower Foundation	Cable Network	Broadcasting Type	Type of Antenna	Mail-Sorting Centres
Services Offered	Switch Nodes	Site Topography	Cable Landing Station	Purpose	# of Antennas	Delivery Vehicles
Customer Size	Materials (Copper, Fibre)	Tower Purpose	Frequency, Bandwidth	Site Name	Size of Antenna	
Backup power duration	Year Built	Height of Tower (Peak)	Cable Type	TV Station	Capacity	
Backup power type	Rebuilding Timeframe	Tower Design	Cable Capacity	Radio station	Equipment	
Year Built	Reconstr. Cost	Tower Materials	Offshore Destination	Studio Facilities	Construction material	
Equipment		Year Built	Year Built	Coverage Area	Year Built	
Rebuilding Timeframe		Rebuilding Timeframe	Rebuilding Timeframe	Frequency	Rebuilding Timeframe	
Reconstr. Cost		Reconstr. Cost	Reconstr. Cost	Equipment	Reconstr. Cost	
				Cable Networks		
				Rebuilding Timeframe		
				Reconstr. Cost		

URBAN WATER INFRASTRUCTURE				WASTE MANAGEMENT	HAZARDOUS SUBSTANCES	MAJOR INDUSTRIES
Potable Water Catchment	**Potable Water Treatment**	**Wastewater Treatment**	**Water Transmission Networks**			
Catchment (Area)	Ownership	Ownership	Ownership	Collection Centres	Facility Usage	Ownership
Dams	Processing capacity	Processing capacity	Reticulation Area	Transfer Stations	List of Substances	Industry Name
-Foundation	Tank Storage	Storage Tank	Reticulation Type	Collection Trucks	Physical Characteristics	Industry Structure
-Length	Tank flocculaion	Grit chamber	Pumping Stations	Incineration Plants	Chemical Characteristics	Industry Usage
-Type	Tank foundation	Aeration Tank	Pipes Network	Recycling Plants	Airborne thresholds	Total Floor Area
-Spillway type	Tank year built	Sludge Tank	Pipes Size, Diameter	Landfills	Pictogram	Number of Buildings
-Material	- - - -	Equipment	Pipes Material	Waste Type	Hazard Code	List of Facilities
-Year Built	Disinfection plant	-Machinery	Filtering	Energy Recovery Facility	Hazard Character	Year Built
-Reconstruction Cost	Clarification Plant	-Disposal	Connectors	Reconstruction Cost	Severity of Toxicity	Building Materials
-Height	Filtration Plant	-Energy	Year Built, Upgraded		Symptoms	Equipment
Ground-Water Well	Disinfection Plant	-Odour	Repair Timeframe		Key Suggestions	Storage Warehouse
Criticality	Chemical tanks	-Disinfection	Reconstruction Cost			Working Hours
Equipment	SCADA Facilities	-Bio-chemical				Waste Management
-Pumping	Backup power	-Filtration				Liability Issues
-Repair timeframe	Reconstruction Cost	Repair Timeframe				Critical Equipment
Storage Capacity Tanks, Reservoirs		Control building				Production Capacity
		Backup power				Reconstruction Cost
		Reconstruction Cost				

PRIMARY INDUSTRIES							
Agriculture – Crops	**Agriculture – Horticulture**	**Agriculture – Dairy**	**Agriculture – Animal**	**Fisheries – Wild**	**Fisheries – Aquaculture**	**Forestry**	**Mining**
Farm Size	Farm Size	Farm Size	Farm Size	Fishing Zones	Farm Size	Ownership	Ownership
Crop Type	Plantation Type	Animals Type	Animals Type	Fishing Restrictions	Fish Type	Forest Area	Mining Area
Crop Calendar	# of Plants	# of Animals	Farming Type	Endangered Species	Fishing Stock	Status	Operating Status
Crop Value	Age of Plants	Age Mix of Animals	# of Animals	Port Location	Products Pattern	Forest Structure	Operating Type
Farmhouse	Yield Pattern	Dominant Breed	Age Mix of Animals	Trawlers	Equipment	Dominant Species	-Surface
Equipment	Equipment	Sub-Dominant Breed	Dominant Breed	Nets	Processing plants	Sub-Dominant Species	-Underground
Storage Size	Storage Size	Equipment	Sub-Dominant Breed	Total Capacity	Ancillary Buildings	Products	Commodities
Processing Plant	Processing Plant	Ancillary Buildings	Equipment	Storage Capacity	Farm Value	-Hardwood	Equipment
	Farm Value	Products	Ancillary Buildings	Processing Plants		-Softwood	Production Capacity
		Farm Value	Products			-Veneer Logs	Value
			Farm Value			-Pulp Logs	
						-Oils	

POPULATION						
Remoteness Status	**Demographic Composition**	**Socio-economic Status**	**Population Health**	**Ambient Population**	**Risk Response**	**Social Capital**
	Population Age Profile Population Density Gender Composition Migration Indigenous & Ethnic Composition Household Composition	Household Income Household Dwelling Tenure Status Insurance Status	Physical Health Status Mental Health Status Disability Status			

12.2 NATIONAL EXPOSURE INFORMATION SYSTEM (NEXIS)

Building Exposure Statistical Area Level 1 (SA1) Aggregated Metadata

1 Population estimate

a) the average population per occupied private dwelling structure type for each Statistical Area1 (SA1),
b) the proportion of unoccupied dwellings in the total dwelling stock by structure type,
c) the ratio between the 2011 Estimated Resident Population (ERP) and the Census population counts and the number of NEXIS-derived residential dwellings(ABS Census, 2011).

2 Dwelling Estimates

a) Number of residential dwellings by type : A dwelling is a structure that is intended to have people live within it, i.e. house and flat.
b) Total floor area for each dwelling type: separate and semi-detached houses, and flats or apartments with 2, 3 or 4+ storeys: sum of the building area (footprint x no. of storeys)
c) Percentage of residential dwellings with low ($1–$599), middle ($600–$1999) or high (greater than $2000) gross weekly household income: for each dwelling type (SH, SD, F0, F3 and F4), a percentage is applied to calculate if that dwelling has a Nil, Low, Medium or High gross household weekly income as a proportion of all dwellings of that type. Dwellings with a negative gross household income are included in the Nil category. Low-income households are determined by using the OECD definition of half the national median. In 2011, the national median was $1234/week, which gives a low income measure of $617/week. This has been adjusted to $600 because it is the nearest category in the Census data. High income is set to $2000/week, as this category reflects the top deciles nationally (ABS Census, 2011a).
d) Percentage of residential dwellings with Nil, Low, Middle or High equivalised[i] income: For each dwelling type (SH, SD, F0, F3 and F4), a percentage is applied to calculate if that dwelling has Nil, Low, Medium,

or High equivalised total household income as a proportion of all dwellings of that type. Dwellings with a negative equivalised total household income are included in the Nil category (ABS Census, 2011).

e) Percentage of residential dwellings by tenure; owned, rented privately, rented publicly or other tenure: For each dwelling type (SH, SD, F0, F3 and F4).

f) Percentage of residential dwellings that DO NOT have access to a motor vehicle: For each dwelling type (SH, SD F0, F3 and F4), a percentage is applied to calculate if the family, lone person or group household in that dwelling does not have access to a registered motor vehicle at or near the dwelling (on Census night) as a proportion of all dwellings of that type(ABS Census, 2011)

g) Percentage of residential dwellings with one or more persons in the household aged between 0 and 4 years: For each dwelling type (SH,SD F0, F3 and F4), a percentage is applied if that dwelling comprises a family, lone person or group household with one or more persons aged between 0 and 4 years as a proportion of all dwellings of that type(ABS Census, 2011)

h) Percentage of residential dwellings with ALL persons aged 65 years and over: For each dwelling type (SH,SD F0, F3 and F4), a percentage is applied if that dwelling comprises a family, lone person or group household with ALL persons aged 65 years and over as a proportion of all dwellings of that type(ABS Census, 2011).

i) Percentage of residential dwellings with one-parent families: For each dwelling type (SH, SD F0, F3 and F4), a percentage is applied if that dwelling comprises a one-family household containing a one-parent family with children under the age of 15 as a proportion of all dwellings of that type(ABS Census, 2011).

j) Percentage of residential dwellings with one or more persons needing assistance with core activities: For each dwelling type (SH,SD F0, F3 and F4), a percentage is applied if that dwelling comprises a family, lone person or group household where one or more persons needs assistance with a core activity as a proportion of all dwellings of that type. People with a profound or severe disability are defined as those people needing help or assistance in one or more of the three core activity areas of self-

care, mobility and communication, because of a disability, long term health condition (lasting 6 months or more) or old age(ABS Census, 2011).

k) Percentage of residential dwellings where ALL persons speak English not well or not at all: For each dwelling type (SH,SD F0, F3 and F4), a percentage is applied if that dwelling comprises a family, lone person or group household where all persons speak English not well or not at all as a proportion of all dwellings of that type(ABS Census, 2011).

l) Percentage of residential dwellings where ALL persons' highest educational attainment was Year 11 or below: For each dwelling type (SH,SD F0, F3 and F4), a percentage is applied if that dwelling comprises a family, lone person or group household where all persons highest educational attainment is Year 11 or below as a proportion of all dwellings of that type. Includes households where all persons have no educational attainment (ABS Census, 2011).

m) Percentage of residential dwellings where one or more persons undertook voluntary work: For each dwelling type (SH,SD F0, F3 and F4), a percentage is applied if that dwelling comprises a family, lone person or group household where one or more persons undertook voluntary work as a proportion of all dwellings of that type. Comprises people who spent time doing unpaid voluntary work through an organisation or group in the 12 months prior to Census night. It excludes work done as part of paid employment, if the main reason is to qualify for a Government benefit or if the work was done as part of a family business(ABS Census, 2011).

n) Percentage of residential dwellings where all persons in the household moved residential address from 2010 to 2011: For each dwelling type (SH,SD F0, F3 and F4), a percentage is applied if that dwelling comprises a family, lone person or group household where all persons in the household lived in a different SA1 in 2010 to the SA1 they lived in on Census night as a proportion of all dwellings of that type(ABS Census, 2011).

o) Percentage of residential dwellings where all persons in the household moved residential address from 2006 to 2011: For each dwelling type (SH,SD F0, F3 and F4), a percentage is applied if that dwelling comprises

a family, lone person or group household where all persons in the household lived in a different SA1 in 2006 to the SA1 they lived in on Census night as a proportion of all dwellings of that type(ABS Census, 2011).

3 Building Estimates

a) Number of residential buildings: A building consisting of one or more dwelling units and the primary use is to house people.
b) Number of residential buildings built: pre- and including 1980, post 1981 or unknown: The number of buildings is grouped into pre-1980 and post 1981 as this marks a significant change to building standards in Australia. Other age classifications are available
c) Number of separate houses (SH): A residential house that is separated from other residential dwellings and does not share a common wall
d) Number of semi-detached houses (SD): A residential dwelling sharing a common wall with another dwelling, having their own private grounds with no other dwellings above or below
e) Number of flat or apartment buildings with up to 2 storeys (F0): A residential apartment building up to two (2) storeys
f) Number of flat or apartment buildings with 3 storeys (F3): A residential apartment building with three (3) storeys
g) Number of flat or apartment buildings with 4 or more storeys (F4): A residential apartment building with four (4) or more storeys
h) Number of residential buildings with the wall type: concrete masonry, cavity and solid masonry, veneer masonry, precast concrete, timber, metal sheeting, fibre cement, mudbrick or rammed earth or synthetic: Building counts by NEXIS wall type classifications
i) Number of residential buildings with the roof type: tile, metal sheeting, concrete, fibre cement, imitation tile, synthetic: Building counts by NEXIS roof type classifications
j) Total structure value ($) for all residential buildings (rounded to the nearest million): Replacement cost is the cost to rebuild the

existing structure (size and construction material) at current building standards at the current costs.

k) Total contents value ($) for all residential buildings (rounded to the nearest million): Contents value is calculated as a proportion of the replacement cost, adjusted for depending on the gross income classification.

l) Total building footprint area for residential buildings (m2): Sum of the building footprints

Source: http://www.ga.gov.au/scientific-topics/hazards/risk-impact/nexis

12.3 ABS (2010–11) AGRICULTURAL CENSUS DATA RELEASE

The publication '7121.0 – Agricultural Commodities, Australia, 2010–11' contains final estimates for the main commodities collected in the 2010–11 Agricultural Census. Includes statistics on land use, industry activity, crop and horticultural area and production and livestock numbers. Data at national and state level including sub-state geographies such as Statistical Area 4 (SA4) and Statistical Area 2 (SA2) geographical levels are available from November 2012.

The Agricultural Census is conducted once every five years, with the Agricultural and Resource Management Survey (ARMS) and the Agricultural Survey (AS) conducted between Censuses. The main objective of the Agricultural Census is to provide benchmark information on the agriculture sector for small geographic areas. The 2010–11 Agricultural Census provides estimates for a range of agricultural commodity items, including broad acre cropping, horticultural production, livestock and land preparation. Care should be taken when comparing estimates over time as not all categories directly align between years (ABS, 2015a).

12.4 PSMA AUSTRALIA

PSMA Australia collates, standardises and enhances location data from each of the Australian State and Territory governments to deliver national aggregate datasets. These datasets deliver essential base location data including geocoded addressing, roads, land parcels and administrative boundaries.

PSMA datasets are distributed by a network of value-added partners who resell the raw datasets as well as develop products and services that cater for a wide range of industry, government and community uses for the benefit of the whole of Australia.

PSMA data is foundation data that provides spatial context to business, statistical and crowd-sourced data.

Our datasets may be purchased individually or in combination. We encourage you to talk to our VARs about how PSMA data can be used to meet your specific needs.

The following datasets are available for sale through our value-added resellers.

- Administrative Boundaries
- Features of Interest
- CadLite
- G-NAF (including G-NAF Lite)
- Land Tenure
- Postcode Boundaries
- Transport & Topography

Source: http://www.psma.com.au/

12.5 AUSTRALIAN EARLY DEVELOPMENT CENSUS (AEDC)

For information on early childhood development, the Australian Early Development Census (AEDC) can provide important information. It is an Australian Government initiative for nationwide data collection of early childhood development at the time children commence their first year of full-time school. The AEDC highlights what is working well and what needs to be improved or developed to support children and their families by providing evidence to support health, education and community policy and planning. The AEDC is held every 3 years, with the third collection having taken place from May to July 2015. It looks at five areas of early childhood development: physical health and wellbeing, social competence, emotional maturity,

language and cognitive skills, and communication skills and general knowledge.

12.6 COMMUNITY INDICATORS VICTORIA (CIV)

At the community level, Community Indicators Victoria (CIV) provides a comprehensive framework of community wellbeing measured by local-level data. Community indicators are a democratic resource for engaging citizens and communities in informed discussions about shared goals and priorities, a policy resource guiding evidence-based planning and action to address the issues identified as important by communities, and a reporting resource tracking and communicating progress towards agreed goals and outcomes. CIV is a collaborative project within the Place, Health and Liveability Research Program at the McCaughey VicHealth Centre, within the School of Population & Global Health, at the University of Melbourne.

For the state of Victoria, at community level along with a set of other wellbeing indicators, CIV provides information on

1. Child Health Assessment
2. Immunisation
3. Life Expectancy
4. Obesity
5. Risk of Alcohol Consumption
6. Self-Reported Health
7. Smoking Status
8. Subjective Wellbeing

However, it provides no information on morbidity, epidemiology and existing disease patterns in the community. More importantly, it is not a health indicators-focused database. There similar initiatives exist in other States such as 1338.1 - NSW State and Regional Indicators, Dec 2010.

12.7 PUBLIC HEALTH INFORMATION DEVELOPMENT UNIT (PHIDU)

Another important source of information on public health in Australia is the Public Health Information Development Unit (PHIDU) at the University of Adelaide. Since its establishment in 1999, PHIDU has been providing information on a broad range of health and other determinants across the life course with a particular emphasis on the publication of small-area statistics for monitoring inequality in health and wellbeing, and for supporting opportunities for the prevention of, and early intervention in, the development of adverse population health outcomes.

PHIDU offers online access to a comprehensive range of current (and some historic) data at national, jurisdictional, regional and small-area levels for Australia at no cost to users. The data describe the demographic characteristics of individuals and families, and provide various measures of socioeconomic status and health status (including estimates of the prevalence of major chronic diseases and associated risk factors), disability, community capacity and strength, early childhood development and learning outcomes and the population's use of health protection, screening and treatment services. Data are also published for premature deaths across the life course, from infants to young children (deaths at one to four years of age), youth (deaths at ages 15 to 24 years) and adults (deaths before 75 years of age), in addition to the more recent concept of avoidable mortality. Socioeconomic and geographical variations in health are demonstrated through interactive atlases and graphs, which are supported by data tables and metadata; where the data are available, they are analysed by age, sex and Indigenous status. This web-based source of data on health and its determinants is unique in Australia, and has been recognised as an innovative and useful approach internationally by agencies such as the World Health Organisation.

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