Building codes and greenhouse construction

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Code of Practice

Building Codes and Greenhouse Construction

VG13055 (August 2014)

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Media Summary:

Building Codes and Greenhouse Construction is a project that has been funded by Horticulture Australia Limited and the Australian Government in response to cost of local council compliance concerns raised by growers. This Code of Practice document provides the protected cropping industry in Australia with guidelines to reduce the cost of compliance for greenhouse or grow structure by providing local council with guidelines that encourage a consistent building approval approach across Australia.

The Code of Practice is separated into four (4) sections; these sections cover the four major areas where cost of compliance can be better controlled to achieve a smoother, more cost effective, development/building approval for growers. Sections are:

- Classification of Greenhouse/Grow Structures (G/GS)
    - Current National Construction Code (NCC) building classifications of G/GS;
    - Uniform classification through the International Building Code (IBC); and
    - Egress, height and area requirements specific for G/GS.
- Fire and Egress Directives
    - Determining fire and egress hazards within a G/GS;
    - Quantify risks through the use of a Risk-Point Matrix; and
    - Determining fire and egress consequences for the aforementioned risk.
- Structural Adequacy
    - Identifying alternative design resources to effectively design G/GS buildings.
- Farm Management
    - Documents practical farm management recommendations and procedure that decrease the risk and associated consequence of a fire within and around a G/GS structure;

It is recommended that future R&D work includes expert and industry review which will lead to recommendations to be included in the National Construction Code.

Technical Summary:

Building Codes and Greenhouse Construction provides solutions for several identified issues under the premise of ‘reducing cost of compliance’. This document provides research and recommendations for both growers and certifiers to effectively and efficiently reduce cost of compliance on greenhouse and grow structures. The nature of each issue is as follows:

Classification of Greenhouse/Grow Structures: Australia does not have a unified building classification of agricultural buildings (greenhouses/grow structures) within the National Construction Code (NCC). G/GS can be classified under the sometimes onerous and inappropriate classification of Class 7 or Class 8 within the NCC. These classifications impose requirements not suitable for the occupancy and use type of the G/GS building. This project included exhaustive literary reviews of national and international standards to determine how best to unify the classification of G/GS in Australia.

It was determined that the most practical way of defining and unifying the classification of G/GS buildings was to utilise an international standard that already documents requirements specific for G/GS. The International Building Code identifies G/GS within a Group U classification and provides tailored requirements for agricultural buildings, such as G/GS. Consultation with certifiers and fire engineers determined that the utilisation of the IBC was currently the most ideal classification process for Australia.

Fire and Egress: Identification and quantification of fire risk and its associated fire consequence is an important tool for both growers and certifiers. The use of a risk-point matrix assessment (see Section 3.3) outlines risk levels for each typical aspect of a G/GS design. Consultation with a Professional Fire Engineer underpinned steps and risk-point weighting within the assessment. Once a grower or certifier completes the risk-point matrix it is appropriate to associate the quantified risk with a fire consequence level of low, medium or high. Tailored recommendations have been given for each fire consequence level.

Structural Adequacy: Many G/GS do not have geometries or porosities that are documented within AS/NZS 1170.2 Wind Loading. As such, it is common for an inexperienced engineer/designer to drastically over-design or under-design a G/GS. This Code of Practice has identified international resources, such as EN 13031-1 Greenhouses – Design and Construction that provide designers with a greater design wind loading resource.

Farm Management: Farm management documented in this Code of Practice provides growers with a resource that documents preventative management processes to efficiently reduce the risk of a fire and to minimise the associated consequences. These processes have been obtained through literary review and consultation with growers, certifiers and fire engineers.

Consultation with growers, building certifiers, greenhouse manufacturers and fire engineers underpin recommendations made within this Code of Practice. Research and information to support the Code of Practice is also provided as a Support Document. This Support Document outlines research completed, expert consultation, field investigations and grower questionnaire responses.

It is recommended that future R&D work includes expert and industry review which will lead to recommendations to be included in the National Construction Code.

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Glossary of Abbreviations

AS	**Australian Standards**
ASTM	**American Society of Testing and Materials**
BA	**Building Approval**
BCA	**Building Code of Australia**
CPM	**Compartmentalised Plastic Membrane**
DA	**Development Application**
FPM	**Film Plastic Membrane**
FRP	**Fibre Reinforced Plastic**
G/GS	**Greenhouse and Grow Structures**
HAL	**Horticulture Australia Limited**
IBC	**International Building Code**
ICC	**International Code Council**
NCC	**National Construction Code**
OLCE	**Osborn Lane Consulting Engineers**
PM	**Plastic Membrane**
SPM	**Sheet Plastic Membrane**

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1.0 Introduction

1.1 Scope and Application

The objective of this document is to reduce the cost of compliance for construction of Greenhouse and Grow Structures (G/GS) and provide guidelines for a consistent building approval approach across Australia. Completing investigations within the following areas determine where cost reduction measures can be implemented to economically assist the protective cropping industry and provide a defined approval process:

- Literary review of national and international codes;
- Investigation into fire and egress regulations and their application to G/GS;
- The potential to include classification of G/GS within the National Construction Code (NCC); and
- Possible uses of innovative construction materials and methods.

Reference should be made to the accompanying 'Guidelines and Supporting Documentation' document while completing an assessment on new G/GS developments. This document provides supporting evidence based on recommendations and literary reviews of relevant international documents; the document also provides case studies of growers' concerns regarding issues with G/GS development.

Cost of compliance reduction measures included in this Code of Practice provide both certifiers and growers with information and procedures regarding the classification of G/GS buildings that do not rely solely on the NCC for building classification. Risk assessment matrices, also provided in this document, identify fire and egress risk associated with each G/GS development and outlines possible action upon the determined risk to reduce the consequence of a fire.

This document also provides growers with useful farm management protocol that reduces the risk of fire and the subsequent spreading and severity of the fire.

This document is not exhaustive and does not provide special considerations for every greenhouse or grow structure combination. Each greenhouse and grow structure's design and operation is unique and therefore requires an individualised approach to development approvals.

Important Note: Consultation with a Professional Fire Engineer should be undertaken if and when questions or issues arise that are not covered within this document, the National Construction Code, Australian Standards or, where appropriately used, the International Building Code.

1.2 General Background

A protective cropping structure is a structural building usually constructed from timber or steel with glass or plastic used as a covering material; coverings can be permeable or impermeable. They are used mainly for horticultural applications to control specific environmental conditions to facilitate high quality, high quantity production of a defined fruit, vegetable or flower.

Identification of a greenhouse is generally according to its basic profile shape; most commonly these profiles are flat, arch, raised dome, sawtooth, gable, skillion and tunnel. Being a technology-based investment, the higher the level of technology used, the greater the potential for achieving tighter and more accurate controlled growing conditions. Technology levels in G/GS can be categorised as ‘Low’, ‘Medium’ and ‘High’.

Low technology G/GS – these structures are very common in Australia. The greenhouses are usually less than 3 metres in height and have a tunnel or ‘igloo’ profile shape. The structures are popular because they are relatively inexpensive and easy to erect. Large span, cable-supported net structures covering large areas usually up to 6.0 m high also can be included in this category.

Medium technology G/GS – characterised by vertical walls (between 2 and 4 metres) and commonly have roof or side ventilation, or both. Medium technology greenhouses are seen as a compromise between the low and high technology or cost relative to increased environmental control (compared to low technology greenhouses).

High technology G/GS – achieve the highest level of environmental control and automation to offer potential for a higher quality and quantity of produce. These structures are usually constructed with walls at least 4 metres high with the roof peak being up to 8 metres.

In Australia, protected cropping structures such as G/GS do not currently have an individual construction code and therefore relies on general design and construction practices specified in the Australian Standards (AS) and the National Construction Code (NCC). A key concern for the protected cropping sector is that the current building codes applied to greenhouse construction are not relevant to today’s operations; this project was originally put forward as a suggestion by a levy- paying grower due to this fact.

As mentioned previously G/GS do not have their own code or exemptions; they are usually (at the discretion of a private certifier or local council) required to conform to a code that applies to commercial/storage structures. Achieving compliance for the G/GS buildings can become a large economic burden when adhering to, for example, current NCC Class 8 egress and fire regulatory requirements.

1.3 Document Utilisation

This Code of Practice document sets out practical guidelines for the design, approval and management of G/GS buildings. The Code of Practice presents design data, approval guidelines, and building management information that are a useful resource for both certifiers and growers. The document is divided into four (4) parts:

- Classification of Greenhouse/Grow Structures;
- Fire and Egress Directives;
- Structural Adequacy; and
- Farm Management and General Practices.

The information and procedures provided within this document are based on literary review of national and international codes and guidelines, along with consultation with fire engineers, building certifiers and interested manufacturers and growers. These recommendations will help obtain the maximum project economic success while providing suitable guidelines for a safe working environment.

The Code of Practice consists of four (4) technical sections, these sections can be read separately or in the order shown in the below figure (see Figure 1). The document has been developed to be utilized by both certifiers and growers, it is therefore expected that certifiers and growers will find particular value in specific sections of the Code of Practice. A brief description of each section has been provided below.

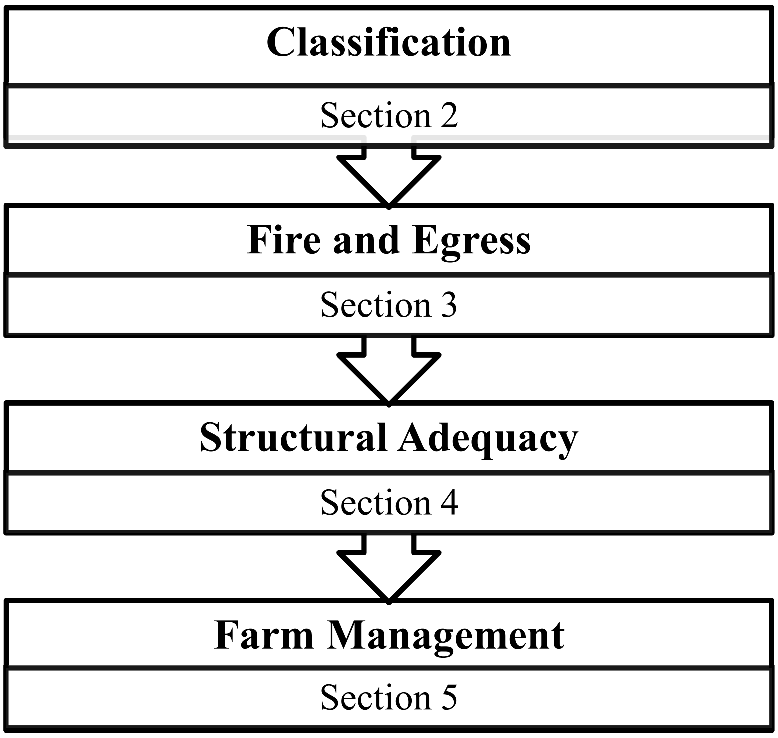


Figure 1 Document Structure

Classification – Section 2

Section 2 'Certification of Greenhouse/Grow Structures' provides guidance when determining classification of G/GS and provides alternative international resources to the National Construction Code (NCC) if the G/GS classification is found not to be covered by the NCC.

Fire and Egress – Section 3

Section 3 'Fire and Egress Directives' provides guidance in minimising fire risk and controlling associated fire consequences. A fire and egress risk-point matrix assessment tool has also been provided in this section to determine risk and then documents general measures that control/minimise the consequences.

Structural Adequacy – Section 4

Section 4 'Structural Adequacy' provides guidance if a structure is not covered by the AS/NZS 1170 Design Loading Actions set and also offers recommendations to resolve common issues such as structural geometries not supported within AS/NZS 1170.2 Wind Actions.

Farm Management – Section 5

Section 5 'Farm Management and General Practices' provide guidance for a grower to passively reduce the risk and consequences of a fire by investing in good farm practices.

<u>General document utilisation notes:</u>

1. *This Code of Practice document should be utilized and referenced by certifiers during the initial stages of development and throughout the approval stages of a proposed G/GS development. The document provides a detailed procedure for the determination of G/GS building classifications and fire risk management procedure.*
2. *This Code of Practice document should be read in conjunction with VG13055: Building Codes and Greenhouse Construction – Supporting Documentation.*
3. *The provisions documented in the following technical sections are consistent with good practices, but they are not mandatory requirements, now or in the future. This Code of Practice is not a building code; a certifier must still refer to relevant National/International Codes and Standards, and local or state authorities for regulations governing structural adequacy, human health, or fire safety.*
4. *It is important that both the certifier and grower keep an open dialogue during the application process, discussing potential issues and resolutions.*

1.4 Terms and Definitions

For the purposes of this Code of Practice, the following terms and definitions apply.

Area:
<any part of a roof> area normal to the slope.

Area:
<storey of a building> total area bounded by the inner finished surfaces of the enclosed wall or, on any side where there is no enclosing wall, by the outermost edge of the floor on that side.

Boundary:
border between land under the same occupation as the building and land under a different occupation.

Certifier:
Private and Local Government certifiers, building surveyors, development application staff, town planners and building assessors shall henceforth be referred to as certifier/s.

Compartment wall:
wall constructed between compartments to achieve a stated period of fire resistance and which is imperforate, except for openings fitted with self-closing doors or shutters having the same period of fire resistance as the wall.

Element of structure:
any loadbearing element of a structure.

Fire hazard:
physical situation with a potential for harm to persons, or damage to property, or both, from the effects of fire.

Fire risk:
probability that a damaging fire will occur as a result of the existence of a fire hazard.

Fire consequence:
the effect, result, or outcome of a fire. Consequence relates to damage to or loss of life and/ or property.

Greenhouse:
Greenhouses or grow structures refers to intensive horticultural structures growing vegetables and excludes nurseries, conservatories and flower production.

Grower:
Growers, G/GS owners, G/GS developers and farm operators shall henceforth be referred to as grower/s.

Height:
<of a building, for the purposes of fire considerations> vertical height from ground level to half the height of the roof in a pitched roof building, or to the top of the roof or parapet (whichever is the higher) in a flat roof building.

Protected area:
part of the external wall constructed to achieve the required period of fire resistance.

2.0 Classification of Greenhouse/Grow Structures

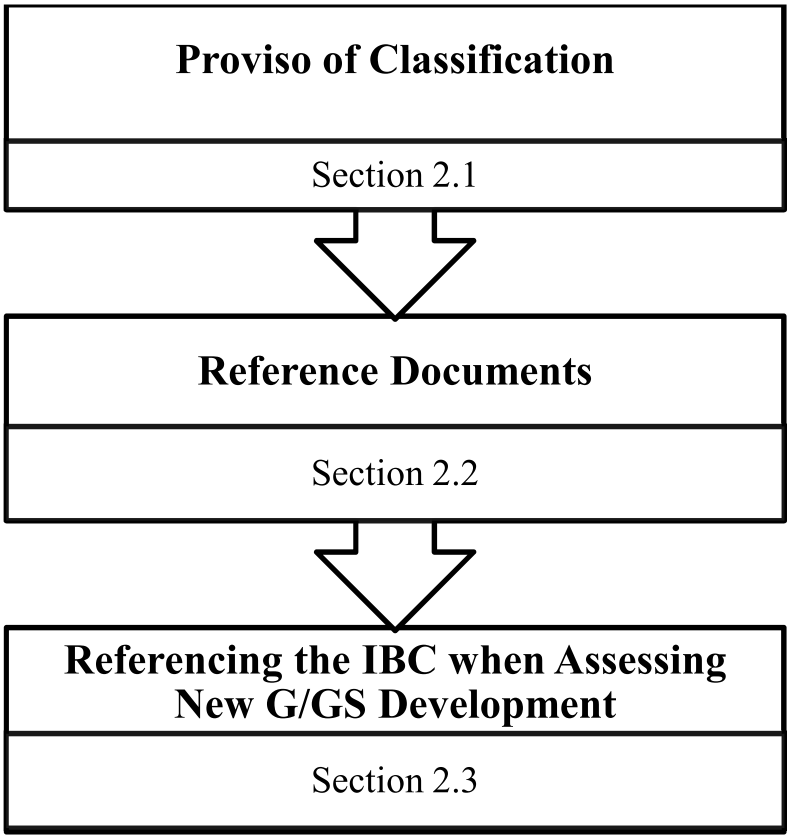


Figure 2 Section 2 Structure

Proviso of Classification – Section 2.1

Section 2.1 ‘Proviso of Classification’ documents statements that must be compliant in order to utilise the recommendations specified within the section.

Reference Documents – Section 2.2

Section 2.2 ‘Reference Documents’ provides a list of national and international documents that have been utilised during the documentation of the recommendations outlined in this section.

Referencing the IBC when Assessing New G/GS Development – Section 2.3

Section 2.3 ‘Referencing the IBC when Assessing New G/GS Development’ outlines alternative provisions in the event that the NCC does not provide relevant requirements and specifications for proposed G/GS’ being assessed for a building approval.

2.1 Proviso of Classification

This section of the Code of Practice applies to Greenhouses and Grow Structures that are commonly classified as Class 7, 8 or 10 in accordance with Part A3 of the National Construction Code Volume One, subject to the below:

1. Subject to paragraph 3, a structure which is used as a greenhouse, grow structure or crop protection structure.
2. A building used, subject to paragraph 3, for agriculture provided in each case that –
    a. No part of the building is used as a dwelling.
    b. No point of the building is less than two times its height from any point of a building that contains sleeping accommodations.
    c. No more than 30 occupants.
    d. No part of the G/GS has more than one storey.
3. The descriptions of a building in paragraphs 1 and 2 do not include a G/GS or building used for agriculture if the principal purpose of which they are used is retailing, packing or exhibiting of produce.
4. In paragraph 2, "agriculture" includes horticulture, fruit growing, growing of vegetables and seedlings through hydroponic or traditional means.

If the above paragraphs are compliant with the proposed G/GS development, it is this Code of Practice's recommendation that the International Building Code be partially adopted to determine building or performance requirements placed upon this development. The reason for this recommended adoption is the lack of information provided within the Australian NCC regarding G/GS and specific requirements for agricultural type buildings.

2.2 Reference Documents

National Construction Code of Australia (NCC, BCA), Volume One & Volume Two

International Building Code (IBC), International Code Council INC.
(See Section 2.3.1.2 for more information on the IBC and ICC)

International Fire Code (IFC), International Code Council INC.

AS 2444	Portable fire extinguishers and fire blankets – Selection and location
AS 1288	Glass in Buildings
AS 2047	Windows in Buildings
AS/NZS 1170	Structural Design Actions
AS 4100	Steel Structures
AS 1720	Timber Structures
AS 3600	Concrete Structures
AS 1664	Aluminium Structures
EN 13031-1	Greenhouses –Design and Construction
BS 5502-23	Buildings and structures for agriculture – Part 23: Fire Precautions

National Code of Practice for the Storage and Handling of Workplace Dangerous Goods (NOHSC: 2017)
Relevant existing State and Local Government documentation

2.3 Referencing the IBC when Assessing New G/GS Development

2.3.1 Adoption of the IBC

Section 2.1 has provided the user with 4 paragraphs that must be found compliant before proceeding through Section 2.3. If any of the paragraphs were found to be non-compliant, it is this Code of Practice's recommendation that all classification remains with the NCC or consultation with a Professional Fire Engineer be sought.

Utilising alternative solutions, such as the IBC, is accepted by the NCC on the condition that the alternative solutions comply with the provisions documented within the NCC (see Section 2.3.1.1).

2.3.1.1 Provisions in the NCC to use Alternative Solutions

The NCC of Australia provides provisions for alternative solutions at the compliance level of a proposed buildings assessment. The NCC stipulates in A0.8 BCA Vol. 1 & 1.0.8 BCA Vol. 2 that –

- An Alternative Solution must be assessed according to one or more of the Assessment Methods (A0.9 BCA Vol. 1 & 1.0.9 BCA Vol. 2).
- An Alternative Solution will only comply with the NCC if the Assessment Methods used to determine compliance with the Performance Requirements have been satisfied.
- The Performance Requirements relevant to an Alternative Solution must be determined in accordance with (A0.10 BCA Vol. 1 & 1.0.10 BCA Vol. 2).

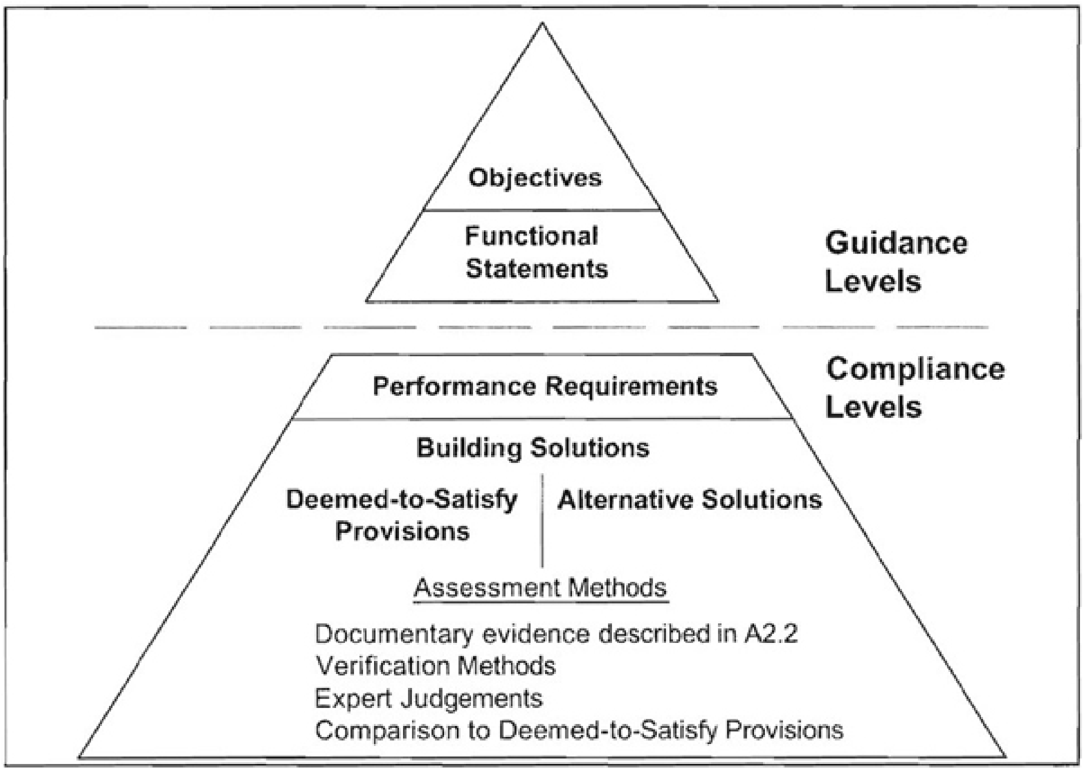


Figure 3 Vol. 1 BCA Structure (Source: NCC BCA Vol. 1)

Where Assessment Methods (A0.9 BCA Vol. 1 & 1.0.9 BCA Vol. 2) specifies the following –

The following Assessment Methods, or any combination of them, can be used to determine if a Building Solution complies with the Performance Requirements:

- Evidence to support that the use of a material, form of construction or design meets a Performance Requirement or Deem-to-Satisfy Provision as described in 1.2.2 (BCA Vol. 2) and A2.2 (BCA Vol. 1).
- Verification Methods such as –
    - The Verification Methods in the BCA; or
    - Such other Verification Methods as the appropriate authority accepts for determining compliance with the Performance Requirements.
- Comparison with Deemed-to-Satisfy Provisions.
- Expert Judgement.

Vol. 1 and Vol. 2 of the BCA documents Relevant Performance Requirements. The following method must be used to determine the Performance Requirement/s relevant to an Alternative Solution:

- Identify the relevant Deem-to-Satisfy Provision of each Section or Part that is to be subject of the Alternative Solution.
- Identify the Performance Requirements from the same Sections or Parts that are relevant to the identified Deemed-to-Satisfy Provisions.
- Identify Performance Requirements from other Sections and Parts that are relevant to any aspects of the Alternative Solution proposed or that are affected by the application of the Deemed-to-Satisfy Provisions, which are the subject of the Alternative Solution.

If the NCC and its associated BCA Volumes are found to be inadequate, costly or impractical to enforce when completing an assessment for a proposed G/GS development there are two alternatives. These are –

- Such other Verification Methods as the appropriate authority accepts for determining compliance with the Performance Requirements - Use of the International Building Code.
- Expert Judgement – Example: The engagement of a Professional Fire Engineer.

2.3.1.2 IBC Verification Method

The IBC is developed, written and published by the International Code Council (ICC). The ICC consists of professional individuals and bodies that are expert code and building officials, engineers, builders, designers, architects and firefighters.

Important Note: The IBC is revised or updated every three (3) years (2009, 2012, 2015…) to allow for new materials, technologies, products and correct technical information; it is the responsibility of the certifier to ensure the most recent version of the IBC is utilised while assessing a G/GS application.

The intent for this code is as per IBC Section 101.3, which states –

"The purpose of this code is to establish minimum requirements to safeguard the public safety, health and general welfare through affordability, structural strength, means of egress facilities, stability, sanitation, light and ventilation, energy conservation and safety to life and property from fire and other hazards attributed to the built environment and to provide safety to fire fighters and emergency responders during emergency operations."

The International Building Code (IBC) is available for adoption and use by jurisdictions internationally. Its use within a governmental jurisdiction is intended to be accomplished through adoption by reference in accordance with proceedings establishing the jurisdiction's laws.

2.3.2 Generalised Procedure for Classification under the IBC

The NCC, in its current state, does not provide adequate reference for agricultural buildings, specifically classification and determination of regulatory necessities for G/GS and other agricultural buildings. The IBC, however, provides a more relevant set of requirements for the construction of agricultural buildings. Rather than strictly following the specific 'Class' building provision, each building type is reflective of their specific usage and limited occupant load. The provisions of the Appendix C of the IBC allow reasonable heights, areas and egress requirements that are proportionate to the risk associated with agricultural buildings.

The below procedure for classification of G/GS under the IBC provides generalised instruction on the combined use of the NCC and IBC to achieve appropriate protection of life and economic viability for new G/GS developments.

Step	Clause	Procedure
1	2.3.2.1	Determine if reference to the IBC required and or recommended (see Table 2.1 and Table 2.2)
2	2.3.2.2	Determine Building Class/Group of the G/GS
3	2.3.2.3	Determine Type of Construction (see Table 2.3)
4	2.3.2.4	Confirm appropriateness of IBC use
5	2.3.2.5	What to reference in the IBC (see Table 2.5)
6	2.3.2.6	Use of the NCC and Australian Standards

2.3.2.1 STEP 1 - Is Reference to the IBC Required/Recommended?

While processing a new G/GS development a certifier should ask him/herself a series of questions which will assist in determining if reference to the IBC would benefit the assessment process and final development result for the grower. Examples of these questions are given below in Table 2.1.

Table 2.1
Self-Assessable Questions

Can the G/GS be unequivocally categorised within a NCC Classification (as per Part A3 of the NCC)? *Paying close attention to the interpretation of Class 8, refer to Note 1 below for further guidance.*	**YES / NO**
Does the NCC provide adequate information on reasonable egress requirements? *(Note 2 for definition of "reasonable").*	**YES / NO**
Does the NCC provide adequate information on reasonable fire prevention measures? *(Note 2 for definition of "reasonable").*	**YES / NO**
Does the NCC provide adequate information on reasonable building separation distances for new G/GS buildings? Does the NCC differentiate between the distance to a residential building and other agricultural buildings, for example?	**YES / NO**
Generally, does the NCC provide reasonable building regulation for the assessable G/GS?	**YES / NO**

Notes:

1. *Under current Part A3 of the NCC, a Class 8 building is one that is utilised as a laboratory, or a building in which a handicraft or process for the production, assembling, altering, repairing, finishing, or cleaning of goods or produce is carried on for trade, sale or gain. If a G/GS is not also utilised as a vegetable packing and or cleaning area the certifier should strongly consider not classifying the G/GS as a Class 8 building.*
2. *Define: Reasonable. In the case of 'reasonable', mentioned in Table 2.1, the definition is a common sense approach to the G/GS; are the imposed requirements unnecessary/impractical for the specific type of building? An example: illuminated exit signs are required to be installed in a glass-constructed greenhouse that is occupied only through daylight hours.*

It is the certifier's prerogative and responsibility to determine which of the below options (see Table 2.2) best serve the assessment of a new G/GS, and in turn serve the safety of occupants and economic viability of the grower.

If **'Yes'** was identified in all of the questions outlined in Table 2.1, it is this Code of Practice's recommendation that Option 1 (see Table 2.2) be considered.

If **'No'** was identified in any of the questions outlined in Table 2.1, it is this Code of Practice's recommendation that Option 2 (see Table 2.2) be considered.

Table 2.2
Reference to Resources

Option 1 *(Table 2.1 All 'Yes')*	Sole use of the NCC and Australian Standards when assessing a new G/GS development against regulatory requirements. Assessment should be completed in a typical manner, using the NCC and relevant Australian Standards – Termination of 2.3.2 here.
Option 2 *(Table 2.1 'Yes' & 'No')*	Combined use of the NCC, Australian Standards and the IBC when assessing a new G/GS development against regulatory requirements. Continue 2.3.2 procedure (see 2.3.2.2 STEP 2).

2.3.2.2 STEP 2 - Determine Building Class/Group of the G/GS

2.3.2.1 STEP 1 has found that it is pertinent to use the IBC when assessing a new G/GS development. It is now important to determine the building use and occupancy classification as per IBC Chapter 3. Buildings and structures, or part thereof, shall be classified with respect to occupancy in one or more of the groups listed below.

- **Group A – Assembly Buildings**
  - Civic, social or religious functions, recreation, food or drink consumption or awaiting transportation.
- **Group B – Business**
  - Offices, professional services-type transactions, including storage of records and accounts.
- **Group E – Education**
  - Occupied by six or more persons at anyone time for educational purposes through the 12th grade. Religious educational rooms and religious auditoriums.
- **Group F – Factory and Industrial**

  - o Assembling, disassembling, fabricating, finishing, manufacturing, packaging, repairing or procession operations.
- **Group H – High Hazards**
  - o Manufacturing, processing, generation or storage of materials that constitute a physical or health hazard in quantities in excess of those allowed in control areas.
- **Group I – Institutional**
  - o Buildings where people are cared for or live in a supervised environment.
- **Group M – Mercantile**
  - o Building for the display or sale of merchandise and involves stocks of goods, wares or merchandise incidental to such purposes.
- **Group R – Residential**
  - o Use of a building for sleeping purposes when not classified as another group.
- **Group S – Storage**
  - o A building, or part thereof, for storage that is not classified as hazardous.
- **Group U – Utility**
  - o Agricultural buildings, barns, **greenhouses**, livestock shelters, sheds and stables.

Refer to Chapter 3 of the IBC for detailed occupancy and utilization for each group.

Group U (Utility and Miscellaneous) buildings and structures of an accessory character and miscellaneous structures not classified in any specific occupancy shall be constructed, equipped and maintained to conform to requirements of this code commensurate with the fire and live hazard incidental to their occupancy.

2.3.2.3 STEP 3 – Determine Type of Construction

The provisions in Chapter 6 of the IBC shall control the classification of buildings as to the type of construction. Buildings and structures erected or to be erected shall be classified in one of the five construction types defined in Section 602.2 through 602.5 of the IBC or shown below. Type of construction is directly associated with the fire-resistance rating of each structural element, wall or partition.

While determining the type of construction, it is important to bear in mind that a structure is only as fire-resistant and/ or strong as its weakest or most susceptible element; it is therefore important to select the appropriate type of construction upon the most susceptible element within the structure.

There are five (5) types of construction classifications defined in Chapter 6 of the IBC, which are –

Table 2.3
Type of Construction as per the IBC

Type	Description
Type I & II	Building elements are non-combustible materials
Type III	Exterior walls are of non-combustible materials and the interior building elements are of any material permitted by the code.
Type IV	Heavy Timber – Exterior walls are of non-combustible materials and the interior building elements are of solid or laminated wood without concealed spaces.
Type V	Frame Construction: Structural elements, exterior and interior walls are of any materials permitted by the code.

Each type of construction is then classified further into A and B construction types.

- **A is protected**, meaning that all structural members of a building or structure have an additional fire-rated coating or cover by means of fire protective board, spray-on or other approved method. The additional fire-rated coating or cover extends the fire resistance of the structural member by at least 1 hour. See Table 601 in the IBC for fire-resistance rating requirements for building elements.
- **B is unprotected**, meaning that all structural members of a building or structure have no additional fire resistant properties other than their natural ability, characteristics and fire rating.

Once a Type of Construction has been stipulated for the structure it is appropriate to proceed to 2.3.2.4 STEP 4.

EXAMPLE: CLASSIFICATIONS

The following Type of Construction classifications are typical for the below common G/GS structure types (see Table 2.4). These classification examples should only be used as a guide; an accurate classification must be provided for each individual proposed G/GS development. Reference must be made to Chapter 6 of the IBC to determine appropriate classifications.

Table 2.4
Example Type of Constructions

Type	*Type of Construction*
Impermeable Plastic Membrane with Steel Support Framework (elements not protected)	*Type V B*
Permeable Plastic Membrane with Steel Support Framework (elements not protected)	*Type V B*
Fire Resistant Plastic Membrane with Steel Support Framework (elements not protected)	*Type III B*
Glass Greenhouse with Steel Support Framework (elements not protected)	*Type III B*

2.3.2.4 STEP 4 – Confirm appropriateness of IBC use

STEP 1, STEP 2 and STEP 3 have identified that the G/GS development can be partially assessed under the current IBC (see 2.3.2.1); a Building Class/Group has been selected (see 2.3.2.2) as has a Type of Construction (see 2.3.2.3), confirmation that it is appropriate to partially reference the IBC can be completed by checking compliancy of the following statements. These are –

1. The G/GS is compliant with the conditions in Part 2.1 paragraph 1 through to 4.
2. The building shall be used exclusively as a G/GS building and shall not be designed, equipped or intended for processing, cleaning or packing of produce.
3. The structure is detached, single storey building with a maximum height specified in Table C102.1 of the IBC (refer to Section 1.4 for definition of height).
4. The structure shall maintain a fire separation distance of 3000 mm measured from the building face to all of the following:
    a. The closest interior lot line,
    b. To the centreline of a street, alley or public way,
    c. To an imaginary line between two buildings on the property.
5. The means of egress for a G/GS building shall comply with the applicable provisions of Chapter 10 of the IBC, based on an occupant loading factor of 1 person per 30 m^2 of the gross floor area. Both statements below must be adhered:

   a. The maximum travel distance from any point in the building to an approved exit shall not exceed 91,440 mm.
   b. One exit is required for each 1390 m^2 of area or a fraction thereof.
6. The floor area of a G/GS building shall not be limited (see Table C102.1 IBC) if the building is surrounded and adjoined by public ways or open space no less than 18,288 mm in width. If public ways or open spaces are not provided and the G/GS exceeds 500 m^2, assessment via the IBC is not appropriate and must revert to the NCC and relevant Australian Standards or consultation with a Professional Fire Engineer.

Proceed to 2.3.2.5 STEP 5 if paragraphs 1 to 6 are conforming. If one (1) or more paragraphs are nonconforming it is not appropriate to utilise the IBC as a partial alternative to determining regulation; reference should only be made to the NCC and relevant Australian Standards or consultation with a Professional Fire Engineer.

2.3.2.5 STEP 5 – What to reference in the IBC

STEP 5 identifies the importance to recognize which elements within the IBC should be referenced and which should revert back to the NCC and relevant Australian Standards. The below table outlines the IBC clauses that can be referenced when completing assessments upon a proposed G/GS development (see Table 2.5). It is not appropriate to adopt, adapt or utilise the IBC for every assessable building element. All elements of a development assessment process which are not documented in the below table shall be referenced through the NCC and relevant Australian Standards.

Table 2.5
Elements of Reference within the IBC

Clause	Description
Chapter 3	**Chapter 3 - Use and Occupancy Classification**
312	Utility and Miscellaneous Group U
Appendix C	**Group U – Agricultural Buildings**
	Provisions and exceptions for the Group U subgroup, Agricultural Buildings (barns, G/GS, sheds etc.)
Chapter 10	**Means of Egress**
1001	Administration
1002	Definitions
1003	General Means of Egress
1004	Occupant Loading (Agricultural Building = 1 person per 30 m^2)
1005	Egress Width
1007	Accessible Means of Egress
1013	Guards
1014	Exit Access
1015	Exit and Exit Access Doorways
1016	Exit Access Travel Distance
1017	Aisles
1020	Exits
1021	Number of Exits and Continuity
1026	Exterior Exit Ramps and Stairways
1027	Exit Discharge
1028	Assembly
	Exceptions for agricultural buildings provided in Appendix C

Important Note: Consultation with Professional Fire Engineers in Australia has determined that an approved exit must be installed at 60 metre maximum intervals along each wall. This may contradict the specifications documented in the IBC; as such the lesser egress requirements should be implemented. Alternatively the services of a Professional Fire Engineer can be obtained to determine egress requirements for the assessable G/GS.

2.3.2.6 STEP 6 – Use of the NCC and Australian Standards

As mentioned in STEP 5, any and all assessable elements not specifically identified in Table 2.5 are to be assessed through the current NCC and relevant Australian Standards. For example, the NCC and Australian Standards must be used to assess the following elements:

- Fire extinguisher quantities, types and placement;
- Fire hose reel necessity, type and placement;
- Building access;
- Carparking and passenger loading facilities;
- Exit facilities (i.e. doors and openings);
- Locations and types of public safety signs (i.e. Exit and 'No Smoking' signs);
- Structural materials, membrane and glass; and
- Ventilation requirements.

3.0 Fire and Egress Directives

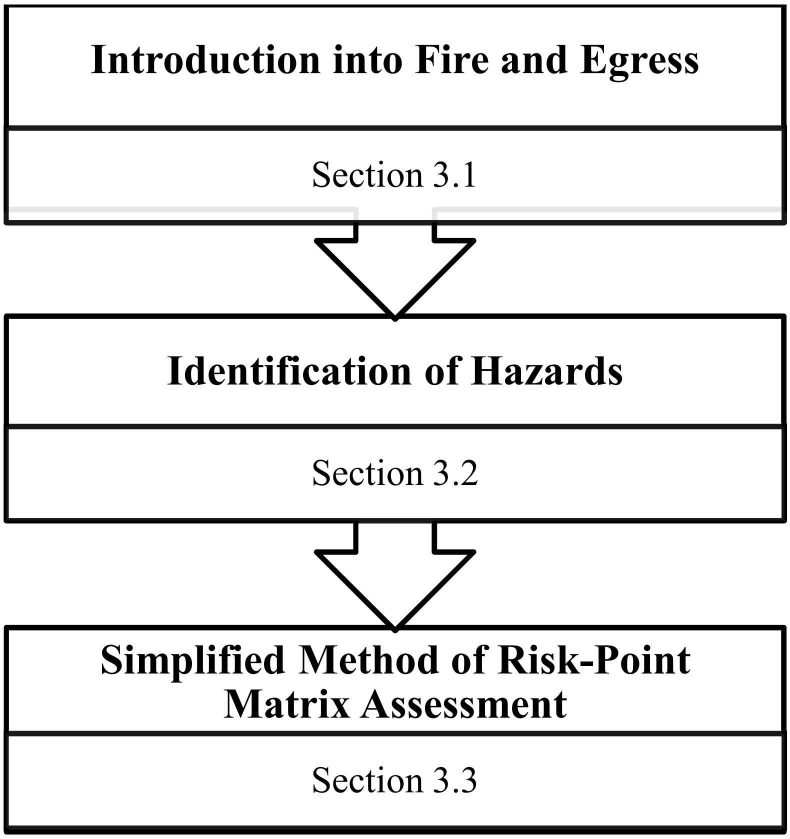


Figure 4 Section 3 Structure

Introduction into Fire and Egress – Section 3.1

Section 3.1 ‘Introduction into Fire and Egress’ provides both certifiers and growers with a general background to fire and egress and ensures only relevant requirements are imposed.

Identification of Hazards – Section 3.2

Section 3.2 ‘Identification of Hazards’ outlines several of the most common fire risks within a G/GS.

Simplified Method of Risk-Point Matrix Assessment – Section 3.3

Section 3.3 ‘Simplified Method of Risk-Point Matrix Assessment’ provides users with a detailed step-by-step process for completing the provided Risk-Point Assessment on fire risk. Completing the matrix determines risk of fire. Recommendations have also been included to control and minimise fire consequences.

3.1 Introduction into Fire and Egress

Many greenhouses/grow structures are relatively isolated from the nearest fire station and may lack adequate water supply to fight G/GS fires. As G/GS buildings become larger and evolve from low technology greenhouses to medium or high technology greenhouses the risk of faults in equipment and wiring and human error also increases. Plant containers, packaging, glazing and shade cloth are readily-available combustible fuels found throughout a typical G/GS. As a result of these compounding risk factors, fires can spread rapidly throughout the facility, causing severe economic losses, negative environmental impact and most notably, loss of human life.

Under the occupational health and safety (OH&S) and new work health and safety (WHS) legislation an employer is obliged to provide the following:

- Safe premises,
- Safe machinery and materials,
- Safe systems of work,
- Information, instructions, training and supervision,
- A suitable working environment and facilities.

The above safety obligations must also be considered by G/GS designers/manufacturers, consultants and certifying bodies, be they local government or private certifiers, during the design and approval process. It is especially important for the certifier to ask the following theoretical questions while assessing an application for a new G/GS development:

> ***"Do I have appropriate knowledge and experience to stipulate fire and egress requirements upon this development and affirm that they are both pertinent for safety and economically viable to the grower?"***
>
> ***"Am I aware of the inherent fire and egress risks associated with this specific G/GS design?"***

Answering either of the above questions as 'No,' identifies that further investigation, consultation and research is required before fire and egress regulation is imposed on any new G/GS development. It is the responsibility of the certifier or building surveyor to impose regulation stipulated within the NCC and Australian Standards upon a proposed development, this may include the application of alternative solutions. If a Standards publication does not aptly provide fire and egress requirements for a specific building, particularly a G/GS, it is important to determine risk associated with the specific synergetic relationship between the building and fire. If a certifier is unable to determine these risks unequivocally, it is important to make reference to this document and if still unclear to request a Fire Engineer be consulted as part of the development process.

Due to the fact that the duty to take reasonable care is implied in the provision of employment, the fundamental obligation owed by the employers towards employees is to ensure their safety. It is the duty of an employer to take 'reasonable care' to avoid foreseeable risk or injury. As such, growers should take an active role in the design and management of their G/GS buildings to ensure employees receive reasonable care in relation to fire, egress and other OH&S elements.

3.2 Identification of Hazards

3.2.1 Hazards in a G/GS Environment

Growing vegetables under a G/GS is an extension and the next evolutionary stage of field farming, which is often located in areas void of a prompt fire fighting response. It is common knowledge that the longer a fire is left unattended, the more difficult it is to contain. Fires commonly start at a discreet point within a building and can quickly spread through combustible materials. Due to farm expansion and development, it is common for G/GS facilities to be open and inter-connected. Although there have been relatively few documented serious greenhouse fires, each occurrence has taken place where there was high potential fire risk. This high fire risk leads to a high fire consequence, consequences including loss of life and serious property damage. The various high risks that may be present are the increased size of the installation due to add-on growth, high value of the protected crop, the use of highly combustible modern plastics and the use of automation including production, lighting and environmental controls.

Materials used within a G/GS are usually chosen for their useful structural properties and features. It is, however, common for these materials to have unwanted or unexpected risks especially in the area of fire and egress.

Though able to transmit light, plastic glazing materials are not as energy efficient as other building materials that can be insulated. Modern plastic glazing and woven fabrics have been engineered to transmit light, resist wind, hail and chemical attack while at the same time improving energy efficiency. Electronic automation of a typical G/GS is also increasing, computer controlled open vents, lamps and fans are all environment control systems commonly installed in an Australian Greenhouse. These advancements assist in increased crop yield, stability and quality. It is, therefore, reasonable to assume that modern plastics and automation offer appropriate compromise between efficiency and risk.

An increase of electronic automation in a G/GS encourages an addition risk of fire, being electrical components. A faulty electronic component can short circuit and emit sparks. Sparks can ignite combustible materials, such as plastic membrane. Growers, certifiers and designers recognise these undesirable risks, however accept the compromise because the value of these properties exceeds the alternative of designing and certifying a G/GS that is truly fireproof and useless for growing plants. It is, therefore, important to determine the appropriate balance between risk management and benefits.

In addition to the structural aspects and contents of a greenhouse, its environment is unique to all other buildings. A typical greenhouse environment includes high levels of temperature, moisture, and sometimes UV light to achieve the highest yield and crop quality. Chemicals used on plants within a G/GS can aggressively attack structural elements and membrane. All equipment, especially mechanical and electrical, is subject to wear and degradation.

Fires in a G/GS have been observed to move quickly throughout the facility. Growers have witnessed fires in plastic membrane structures, particularly woven netting, rapidly engulf an entire G/GS building. Crops, property and structures are often severely damaged if a fire occurs. Fires also interrupt the business that supports and impacts the lives of many including owners, employees and customers for weeks, months and sometimes years.

Fortunately, steps can be taken in farm planning and management that assist in minimising fire risks, and provide procedures that result in a cleaner, safer and more efficient G/GS operation. Many correlations exist between good fire risk management and good G/GS farm operation management. It is not reasonable to assume the risk of a G/GS fire will reach zero; however, risk and associated consequences can be managed to levels that will minimise threats to human life and loss of property.

3.2.2 G/GS Fire Risk Assessment

Managing fire risk and associated consequences appropriately is becoming increasingly important to the financial viability of the greenhouse and grow-structure industry in Australia. There are three major risk management tools that are commonly considered. These are:

- Risk control;
- Risk sharing; and
- Risk communication.

Risk control consists of risk assessment procedure, fire prevention, fire contingency plans and employee training. Insurance is considered a risk-sharing tool. Risk communication is usually between an employer and employees and is documented in Section 5 Farm Management and General Principals.

Fire risks in G/GS can be evaluated on a cumulative risk point matrix. The below risk assessment matrix (Section 3.3) should be utilized by certifiers when determining risk and associated fire prevention measures. The more ‘risk-points’ that are accumulated during the assessment, the more attention should be paid to control such fire risks. If high risk-points are found, certain components, materials and or procedures may need to be implemented to reduce the fire consequence.

3.3 Simplified Method of Risk-Point Matrix Assessment

For the simplified procedure, the following steps (elements) should be used to determine the Risk-Point Assessment for all assessable G/GS. Once each step has been determined, reference should be made to 3.3.11 Table 3.6, providing quantification of risk.

An example Risk-Point Matrix Assessment has been completed and documented in Appendix A of the VG13055 Supporting Document.

Step	**Clause**	**Procedure**
1	3.3.1	Determine the size of the new G/GS (see Table 3.1).
2	3.3.2	Determine flammability for typical glazing and framing materials.
3	3.3.3	Determine egress for typical glazing materials.
4	3.3.4	Determine glazing types and associated risk for smoke capture.
5	3.3.5	Determine fire risk associated with assimilation lighting.
6	3.3.6	Determine value of the G/GS and predicted crop value per year (see Table 3.2).
7	3.3.7	Determine the presence of other flammable/combustible materials.
8	3.3.8	Determine environmental control used for the G/GS (see Table 3.3).
9	3.3.9	Determine local council zoning area for the G/GS.
10	3.3.10	Determine distances between G/GS and other buildings (see Table 3.4 and Table 3.5).
11	3.3.11	Risk-Point Assessment Matrix (see Table 3.6).
12	3.3.12	Determine Risk-Point Result (see Table 3.7).

This Risk-Point Assessment is based upon the following three common glazing and covering types. These are: glass, film plastic membrane and sheet plastic membrane. Materials not documented specifically are not covered within the assessment. Consultation should be made with a Professional Fire Engineer to determine where specific glazing types fall within the zero (0) to (5) Matrix risk level (see Section 3.3.11), five (5) being the highest risk and one (1) being the least, where zero (0) is negligible risk.

Glass

Tempered or non-tempered glass, aka soda-lime glass, which commonly contains silicon dioxide, sodium oxide from sodium carbonate and lime is a non-flammable amorphous solid and has an approximate melting point of 1400 ^{0}C. Glass should be in accordance with AS 1288 Glass in Buildings and AS 2047 Windows in Buildings.

Plastic Membrane (PM)

The category of plastic membranes consists of dozens of commonly used G/GS membrane materials. It is therefore appropriate to categorise G/GS plastics as typically organic polymers of high molecular mass, usually synthetic and most commonly derived from petrochemicals. Plastic membrane cladding is typically sheet, film or permeable woven netting.

Film Plastic Membrane (FPM)
Single layer plastic film is commonly polyethylene, EVA (ethyl vinyl acetate) and PVC (poly vinyl chloride). Thickness of the film commonly varies between 150 to 200 microns in thickness and is marketed and sold on a roll. It should be noted that most chemicals will adversely affect the lifespan of polyethylene films. Plastic woven netting is considered a category of FPM. Film plastic membrane can be impermeable or permeable.

Sheet Plastic Membrane (SPM)
Plastic sheeting is commonly polycarbonate, acrylic (polymethyl methacrylate) and fibreglass. There are many forms of SPM on the market; corrugated sheets or twin-wall panels are frequently used in Australia.

These materials are commonly flame retardant and considered to be non-flammable; this should be confirmed with the SPM manufacturer.


Figure 5 A typical roll of FPM (left)

Figure 6 A typical twin-wall SPM (right)

Metal Framing – This Risk-Point Matrix Assessment element for flammability only accepts steel, aluminium or a composite of the two metals for evaluation; if an alternative framing material is provided (i.e. polyethylene PE circular hollow section members) it is important to consult with a professional fire engineer.

It is common for an unprotected metal framed building to fail much sooner than its hardwood timber counterpart in the event of a fire. Strength of steel decreases rapidly when a structural element becomes hot; this can result in a complete structural collapse long before actual flames spread through the building.

Consultation with fire engineers has determined that a solid hardwood timber column/post will typically remain structurally sound for a longer period of time in the event of a fire than its steel counterpart, therefore it would be conservative to use the risk points allocated to steel framing for solid timber framing.

3.3.1 STEP 1 - Determine G/GS Size

The appropriate area band should be selected in accordance with Table 3.1. The area of the G/GS should be taken as the footprint, in hectares, of the new development. The building footprint is any area covered by permeable or impermeable wall and /or roof cladding. Make note of the associated Band.

Important Note: If a new G/GS development is attached, or has covered access/walkway, to an existing G/GS, the total combined area of the new and existing G/GS must be considered as the total G/GS area.

Table 3.1
G/GS Area (ha)

	Band 1	Band 2	Band 3
Area (ha)	< 1 ha *(Less than 1 ha)*	1 ha to 3 ha	> 3 ha *(Greater than 3 ha)*

NOTE:

1 m^2 = 0.0001 hectares.

3.3.2 STEP 2 – Glazing/Covering Type: (Flammability)

All common G/GS materials and framing respond uniquely in the event of a fire. It is therefore important to identify which of the following three (3) typical materials should be used. See Section 3.3 for common material descriptions. Flammability is both how easily something will burn/ignite and the degree of difficulty required to cause combustion of a substance. It is again important to note what glazing type is applicable for assessment in STEP 11.

Important Note: For glazing and framing not mentioned below it is important to seek the services of a professional fire engineer.

Glazing types for G/GS flammability are provided below:

- **Glass** – Glass is considered to be non-flammable and will not support combustion.
  Glass manufactures should specify any coatings applied to the glass that may be flammable. If flammable coatings are present on the glass, it is important to utilise the Risk-Point Result for CPM instead of Glass. Glass enclosures will withstand considerable heat. The expected glass breakage temperature is approximately 400 to 450°C.

- **PM (Plastic Membrane)** – Most PM materials are coated with a fire retardant material as part of the manufacturing process. Plastic films are more likely to burn when flame is applied to the edge of a sheet rather than the flat surface of the sheet. All plastics will burn once a fire has started. However the low melting point of Plastic Membrane materials will allow smoke and heat to dissipate rapidly.

- **CPM (Compartmentalised Plastic Membrane)** – Compartmentalised plastic membrane structures have been designed to actively suppress a spreading fire by creating separation between flammable plastic membranes. Separation can come in many different forms and should be confirmed with a fire engineer; however a common means of separation for a plastic film membrane G/GS would be installing fire-resistant plastic bands, creating a separation. Compartmentalisation design should always be completed by a registered, professional fire engineer.
  More information on compartmentalisation and band separation can be found in Section 5.

3.3.3 STEP 3 - Glazing Type: (Egress)

Glazing types have a considerable influence over the means and ease of egress during a fire event. It is again important for the certifier to determine which glazing type is proposed for the new development and how the glazing type will affect egress during a fire event.

Important Note: The Simplified Method of Risk-Point Matrix Assessment assumes all escape paths and egress are to relevant Australian and International Standards (see Section 2). Also, for glazing and framing not mentioned below, it is important to seek the services of a Professional Fire Engineer.

The following three (3) materials exhibit different characteristics when exposed to a fire event:

- **FPM (Film Plastic Membrane)** – Single layer plastic film membrane on the walls/sides of a G/GS is relatively easy to penetrate in comparison to SPM and Glass. FPM's that are tested to ASTM standards can be considered to reduce risk factors associated with fire; these standards are ASTM D-1929, ASTM D-2843, and ASTM D-635 also UL-94.

- **SPM (Sheet Plastic Membrane) & Glass** –Both SPM and Glass walls/sides are rigid and commonly difficult to escape at locations other than the defined exit points. If determined necessary, it is possible to provide breakout panels in SPM materials which will allow emergency egress in the event of a fire; similarly for glass.

And,

- **No sides** – A G/GS without membrane on the walls/sides does not restrict escape; therefore egress issues with wall/side are negligible (0) within the Risk-Point Assessment.

3.3.4 STEP 4 - Glazing Type: (Smoke)

Build-up of smoke within a G/GS is a crucial concern during a fire event. In the event of a fire it is vital for occupants to escape before smoke inhalation occurs. Glazing options have been given below:

- **FPM (Film Plastic Membrane)** – Single layer FPM does not have the structural integrity to capture large quantities of heat and smoke before it fails/melts. However, a slow build-up fire can produce a substantial amount of smoke which can compromise the walls and ceiling. Permeable woven nets will allow smoke to escape.

- **SPM (Sheet Plastic Membrane) & Glass** – SPM and Glass can capture heat and smoke under the G/GS for a prolonged period. Though venting systems may be installed it is not possible to reduce Risk-Point results without a guarantee/certification from the G/GS manufacturer or Professional Fire Engineer in relation to appropriate roof ventilation.

And,

- **No sides** – If there are no sides/walls on a G/GS there is still a risk, though reduced, of smoke build-up under the G/GS.

3.3.5 STEP 5 - Lighting

Lighting makes reference to assimilation lighting and does not apply to general illumination. Assimilation lighting, also known as grow lamps or supplementary lighting, has an increased risk of being the origin of a fire, as such a high Risk-Point Assessment has been given.

> **Important Note:** Refer to Section 4.3.2.6 for lighting specification on fixture, insulation and maintenance.

3.3.6 STEP 6 - Value of Crop & G/GS

Determining the predicted value of the crop per year and value of the G/GS is an important element of the Risk-Point Assessment. Growers should be consulted to correctly determine value of both the crop and G/GS.

Table 3.2
Value of Crop & G/GS

	Low	Average	High
Predicted Value of Crop per Year	< $30,000 *(less than $30,000)*	$30,000 to $150,000	> $150,000 *(greater than $150,000)*
Value of G/GS	< $40,000 *(less than $40,000)*	$40,000 to $200,000	> $200,000 *(greater than $200,000)*

NOTES:

1.If value of crop and value of G/GS are not within the same 'value column' it is important to interpolate results within Table 3.6 Risk-Point Matrix.

3.3.7 STEP 7 - Other Flammable/Combustible Items

If any of the below listed items are located/installed within the new G/GS development, it can be assumed that 'Other Flammable Items' are present and a high Risk-Point result is given. The Risk-Point result is negligible if flammable items are not stored or used within the G/GS.

Several examples of flammable/combustible items include, but are not limited to:

- EPS foam growing containers;
- Timber and or cardboard growing containers;
- Sequential curtains;
- Combustible pallet or frames;
- Combustible flooring material (i.e. plastic or timber);
- Dry vegetation, including pruned suckers, leaves and mulch;
- Electrical lighting and other appliances; and
- Fuel powered heaters such as LPG.

3.3.8 STEP 8 - Environmental Control Systems

Which of the following environmental control systems are proposed to be implemented into the new G/GS:

Table 3.3
Environmental Control Systems

	Low Tech	Medium Tech	High Tech
Control	No mechanical or electrical environmental control.	Mechanical ventilation and fan motors for air movement.	Boilers, fan motors, mechanical vents, electronic environmental control systems, etc.

3.3.9 STEP 9 - Location of G/GS

In which local council zoning area is the G/GS located within:

- Rural, farming, industrial zones,
- Semi-rural, semi-residential zones,
- Low density residential zone

Important Note: The names of council zones may not exactly match what is above; however it is important to match the actual zone within the above three options. If zoning is not similar to that given above, additional consultation and consideration is required to determine a Risk-Point Assessment result.

3.3.10 STEP 10 - Distance from other buildings

Determining the distance between a proposed G/GS and existing combustible buildings is vital to impede fire spreading. The below distances shown in Table 3.4 are based on surrounding combustible buildings with a height no greater than 6 meters, for buildings with a height over 6 m reference should be made to Table 3.5. The below figures should be taken as minimum distances, it should be understood that the further away from other buildings a G/GS is the better.

Table 3.4
Distance from other buildings (surrounding buildings height < 6 m high)

	Distance 1	**Distance 2**	**Distance 3**
Distance (m)	> 15 m *(greater than 15 m)*	15 m to 5 m	< 5 m *(less than 5 m)*

NOTES:

1. Refer to Section 1.4 Terms and Definitions for 'Height'.

Table 3.5
Distance from other buildings (surrounding buildings height > 6 m high)

	Distance 1	**Distance 2**	**Distance 3**
Distance (m)	> 30 m *(greater than 30 m)*	30 m to 10 m	< 10 m *(less than 10 m)*

NOTES:

1. Refer to Section 1.4 Terms and Definitions for 'Height'.

3.3.11 STEP 11 - Risk-Point Matrix

The determination of Risk-Point Assessment Result for a site using 3.3 Simplified Method shall be determined in accordance with the following:

- Make note of the relevant findings in Sections 3.3.1 to 3.3.10 (Step 1 to Step 10) in relation to 3.3.11 Table 3.6.
- Using relevant tables and information, determine the Risk-Points for each of the elements outlined in Table 3.6.
- Tally, through addition, the Risk-Points for each element to give a Total Risk-Point for the STEP 1 through to STEP 10.
- Proceed to 3.3.12 STEP 12 – Risk-Point Results for appropriate certification measures (see Table 3.7).

NOTES:

1. Tally of individual Risk-Points to give the Total Risk-Point is completed as follows;
   Step 1 Risk-Point + STEP 2 Risk-Point + STEP 3 Risk-Point + … = Total Risk-Point
2. Where any of the input values contained in Table 3.6 are not appropriate for the site being assessed, the assessor should consult and gain guidance from a Profession Fire Engineer.
3. It must be kept in mind that the measures dealt within this Simplified Method of Risk Assessment cannot guarantee that a building and its inhabitants will survive and be uninjured by a fire event. This is due mainly to the unpredictable nature and belabour of fire and the difficulties associated with extreme weather conditions.

Table 3.6
Risk-Point Matrix Analysis

No.	Element	Risk-Points 0	1	2	3	4	5
1	G/GS Size	*	Band 1	*	Band 2	*	Band 3
2	Glazing Type: For Flammability	*	Glass	CPM	*	*	PM[1]
3	Glazing Type: For Egress	No Sides	*	*	*	FPM[2]	SPM & Glass
4	Glazing Type: For Smoke	*	No Sides	FPM	*	*	SPM & Glass
5	Lighting	No Assimilated Lighting	*	*	*	*	Assimilated Lighting
6	Value of Crop & G/GS	*	Low	*	Average	*	High
7	Other Flammable Items	None	*	*	*	*	Other items, such as EPS growing containers, sequential curtains
8	Environmental Control Systems	Low Tech	*	*	Medium Tech	*	High Tech
9	Location of G/GS	*	Rural / Farming / Industrial Zone	*	Semi-Rural / Residential Zone	*	Low Density Residential Zone
10	Distance from Other Buildings	*	Distance 1	*	Distance 2	*	Distance 3

Note:
1. Fire retardant and low combustion netting may have a reduced risk point of 3 for STEP 2 Flammability.
2. FPM's with low tensile strength that are easily penetrated for escape may have a reduced risk point of 2 for STEP 3 Egress.

3.3.12 STEP 12 - Risk-Point Assessment Results

This Section specifies general requirements for the certification of G/GS buildings for relevant fire risks and consequences associated with the specific building.

The Total Risk-Point, found within 3.3.11 (see STEP 11), and the corresponding Sections for the specific certification requirements are listed in Table 3.7.

Important Note: A risk assessment tool such as the one used below is only an indication of the character and magnitude of fire risks. The above point system is intended only as an aid in this process of risk assessment for commercial production G/GS.

Table 3.7
Risk-Point Results

	Lowest Risk (see 3.3.12.1)	**Medium Risk (see 3.3.12.2)**	**Highest Risk (see 3.3.12.3)**
Total Risk-Point	< 16 *(less than 16)*	16 to 38	> 38 *(greater than 38)*

3.3.12.1Lowest Risk

A G/GS that falls within the 'Lowest Risk' Risk-Point Result Bracket (see Table 3.7) has the lowest risk of a catastrophic fire event. This assessment is dependent on the following conditions:

- That good farm practices and management are implemented within the farm (see Section 5.0 Farm Management and General Practices);
- Relevant Codes are adhered to, especially in relation to egress (See Section 2.0);
- All electrical work has been installed in strict accordance with Local, State and Federal Standards by a qualified professional electrician; and
- All maintenance of electrical or other equipment is carried out under the manufacturer's recommendations.

Expectation of Fire Engineers Consultation: It is not expected that consultation with a Professional Fire Engineer would be required for a G/GS which has obtained a 'Lowest Risk' score. It is, however, at the certifier's discretion to request consultation if deemed a necessity. Discussion with the Grower is highly advised before fire engineer's consultation is commissioned. All plastic will burn; the use of shade cloth that is not fire retardant or has low combustion should be limited as the wave design of these materials allows rapid fire spread should one occur.

3.3.12.2Medium Risk

A G/GS that falls within the 'Medium Risk' Risk-Point Result Bracket (see Table 3.7) exhibits a medium risk of a catastrophic fire event. This assessment is dependent on the following conditions:

- That good farm practices and management are implemented within the farm (see Section 5.0 Farm Management and General Practices);
- Relevant Codes are adhered to, especially in relation to Egress (See Section 2.0);
- All electrical work has been installed in strict accordance with Local, State and Federal Standards by a qualified professional electrician;
- The Grower is aware of the heightened fire risk and has incorporated appropriate measures within the farm's Occupational Health and Safety Procedure; and

- Maintenance is carried out to the manufacturer's recommendations and all electrical equipment is tested and tagged 6 monthly.

Expectation of Fire Engineers Consultation: Though not recommended for all G/GS within the 'Medium Risk' bracket, it is at the discretion of the certifier to request the services of a Professional Fire Engineer. Growers should be made aware of this consultation and the associated fees. Common Professional Fire Engineer recommendations for a G/GS with Medium Risk are as follows:

- Emergency operation manual is produced and maintained to ensure all staff are aware of any risk and evacuation procedures that are to be followed in the event of an emergency.
- Emergency equipment such as extinguishers and hose reels are tested at intervals as required by AS 1851-2012.

3.3.12.3Highest Risk
A G/GS that falls within the 'Highest Risk' Risk-Point Result Bracket (see Table 3.7) exhibits the highest risk of a catastrophic fire event. This assessment is dependent on the following conditions:

- That good farm practices and management are implemented within the farm (see Section 5.0 Farm Management and General Practices);
- Relevant Codes are adhered to, especially in relation to Egress (See Section 2.0);
- All electrical work has been installed in strict accordance with Local, State and Federal Standards by a qualified professional electrician; and
- The Grower is aware of the heightened fire risk and has incorporated appropriate measures within the farm's Occupational Health and Safety Procedure.

Expectation of Fire Engineers Consultation: It is recommended that consultation with a Professional Fire Engineer is undertaken for a G/GS which has obtained a 'Highest Risk' score. Growers should be made aware of this consultation and associated consultation fees. Typical Professional Fire Engineer recommendations for a G/GS with the Highest Risk are as follows:

- Emergency operations manual is produced and maintained to ensure all staff are aware of any risks and evacuation procedures that are to be followed in the event of an emergency.
- Emergency equipment such as extinguishers and hose reels are tested at intervals as required by AS 1851-2012.
- High risk activities or equipment should be monitored automatically to provide early warning should a fire occur.
- Mechanical ventilation should be connected to automatic detection systems to allow for the dissipation of smoke and heat in a fire situation.
- Ensure combustible materials such as cardboard boxes or plastic trays are kept away from ignition sources and are disposed of and not allowed to accumulate.

4.0 Structural Adequacy

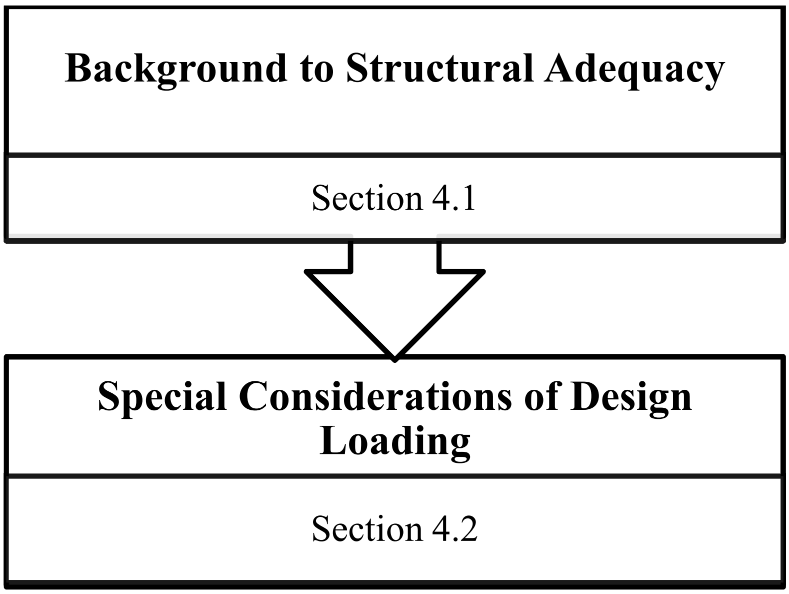


Figure 7 Section 4 Structure

Background to Structural Adequacy – Section 4.1

Section 4.1 'Background to Structural Adequacy' documents Australian Standards currently used by designers and engineers in Australia. This section also outlines limitations of the Standards and recommends special considerations where required.

Special Considerations of Design Loading – Section 4.2

Section 4.2 'Special Considerations of Design Loading' provides designers and engineers with design loading alternatives in the event that structural geometries and permeabilities are not covered in the Australian Standards, specifically AS/NZS 1170.2 Wind Actions.

4.1 Background to Structural Adequacy

High and medium-tech G/GS are usually designed by an experienced engineering firm that works closely with the protective cropping industry, whereas low-tech G/GS are often certified by the geographically closest engineering service that may not have ample experience in designing G/GS.

It is common practice for engineers to utilise the following Structural Design Actions Australian Standards while designing a G/GS located within Australia. These are -

- AS/NZS 1170.0:2002 Structural Design Actions – General Principles
- AS/NZS 1170.1:2002 Structural Design Actions – Permanent, Imposed and Other Actions
- AS/NZS 1170.2:2011 Structural Design Actions – Wind Actions

It is however important to note that the abovementioned Standards provide design loading actions and regulation upon structures that are most commonly designed in Australia/New Zealand; it is therefore common for a G/GS to require special consideration during the design process. Special consideration is provided in Section 4.2, below.

4.2 Special Consideration for Design Loading

Special consideration is required where Structural Design Actions specified in the AS/NZS 1170 set are not relevant to the structure being designed. This occurs most when designing a structure to comply with AS/NZS 1170.2 Structural Design Actions – Wind Actions. If wind loadings on structures cannot be appropriately estimated through the use of AS/NZS 1170.2 due to geometries not covered in the standard, it is appropriate to utilise the below options. These are –

- European Standards; and
- Further research, which may include wind-tunnel testing.

4.2.1 European Standards

Where appropriate, engineers have the option to utilise AS 1170.2 in conjunction with European Standard numbered EN 13031-1 Greenhouses – Design and Consideration.

EN 13031-1 provides an engineer with external pressure coefficients c_{pe} for common greenhouse structural geometries which are not documented within AS 1170.2.

4.2.2 Australian Research

Research is continually being completed to increase the inclusivity of AS/NZS 1170.2 to include actions upon all relevant structures to Australia and its industries. An example of current research is the work being completed at James Cook University to determine characteristic wind loads on large flat roofed porous canopies.

5.0 Farm Management and General Practices

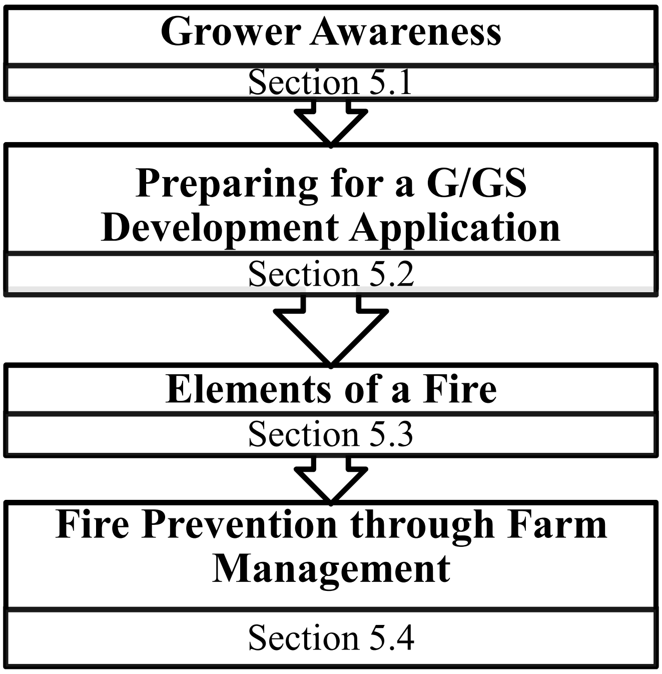


Figure 8 Section 5 Structure

Grower Awareness – Section 5.1

Section 5.1 'Grower Awareness' provides background as to why grower awareness is important, especially in relation to understanding the building approval process and common fire prevention procedures that can be implemented into a good farm management policy.

Preparing for a G/GS Development Application – Section 5.2

Section 5.2 'Preparing for a G/GS Development Application' gives growers a basic understanding of the typical process undertaken by local council/ private certifiers during a building application. It is important for a grower to engage with a certifier early in the application stage to determine specific G/GS approval processes.

Elements of a Fire – Section 5.3

Section 5.3 'Elements of a Fire' provide growers with information about the rudimentary chemical process of combustion. Knowing what three elements are required for a fire to survive is vital when developing good farm management protocol to minimise risk of fire within and around a G/GS.

Fire Prevention through Farm Management – Section 5.4

Section 5.4 'Fire Prevention through Farm Management' provides a grower with procedure/farm management procedure that reduces the risk of fire and the associated fire consequences.

5.1 Grower Awareness

The proposed outcome of Chapter 5.0 Farm Management and General Practices is to promote awareness and practical prevention measures for a Grower to implement during and after a G/GS Development. Reviewing these guidelines will assist in developing a good knowledge base of the issues of development application, fire prevention and emergency planning when working with greenhouse designers, builders, sub-contractors, insurers, local council and fire departments. The guidelines also encourage G/GS employees to practise safe work habits on a daily basis.

This Chapter is not comprehensive, and each G/GS may have special considerations that may not be addressed within these guidelines. Local government and other organisations such as State workplace health and safety bodies can provide a wealth of information on fire prevention, safe practices and emergency planning beyond the scope of this Chapter.

Important Note: All uses of the word 'you' in Section 4 of the Code of Practice refer to the grower, developer and/or owner of G/GS developments.

5.2 Preparing for a G/GS Development Application

Section 5.2 of the Code of Practice has been developed to assist growers in preparing and submitting a development application (DA) to local councils for its approval to establish, expand or modify a G/GS development within Australia. Refer to Section 1.4 of this code to establish meaning and definitions of intensive agricultural buildings. It is only appropriate to utilise the following sections when making an assessment upon intensive agricultural buildings. DAs are generally required for these structures so that potential impacts on the site and on adjoining land are managed and the potential for land use conflict diminished.

The following commissioning guidelines clearly show the path a grower typically needs to consider before a DA.

Before beginning to plan a G/GS Development:

- **Be aware of industry guidelines.**
- **Contact your local council to identify areas suitable for intensive agriculture developments and determine whether a DA is required. Several questions to ask Council are –**
  - **Ask if a DA is required for your G/GS.**
  - **Determine what provisions of the Local Environment Plans and State Environmental Planning Polices apply.**
  - **What is involved in making an application?**
  - **How long will it take to obtain approval?**
- **Consider how your development may affect the environment and neighbours. It is good practice to discuss your intentions with your immediate neighbours before submitting your DA to Council.**
- **Find out what other legislation affects your proposed development. What other permits or licences are required?**

(Source: Preparing a Development Application for Intensive Agriculture in NSW, NSW DIP 2006)

The crucial steps in a typical planning assessment are outlined in the following Figure 4 and discussed below. Every State and Local Government in Australia have documents for public viewing on how to effectively advance through the DA process. Growers are encouraged to find these specific documents and become familiar with specific and sometime unique local council steps.

STEP 1: Is a DA Required?

- Determine what type of development you are undertaking. Seek advice from your local government authority.

STEP 2: Preparation

- Determine the type of assessment required. Seek advice from your local government authority.

STEP 3: Lodgement

- Complete the appropriate application (seek advice from local government authority) and submit to your local government authority.

STEP 4: Assessment

- Local government authority will issue a Decision Notice.

Figure 9 DA Approval Steps for Local Government (Typical)

Throughout the process, the applicant may modify development applications. Depending on the nature of the change, some steps of the assessment process may need to be repeated, fees may apply. Timeframes, costs and processes for Development Approval and Building Approval vary between state and local government authorities.

The Departments of Planning and or Primary Industries in several States have documents directly related to the DA process of agricultural buildings. The "Preparing a Development Application For Intensive Agriculture in NSW" which is published and distributed by partnership between the NSW Department of Planning and NSW Department of Primary Industries can be downloaded from the Departments websites.

Contact information for each Australian State and Territory Department of Planning and Department of Primary Industries can be found in the table below (see Table 5.1).

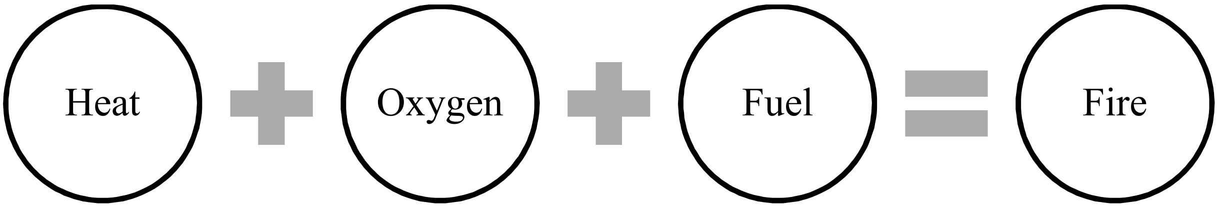
Table 5.1
State Government Contact Details

State/Territory	*Department of Planning (or Similar)*	*Department of Primary Industries (or Similar)*
New South Wales	*GENERAL* *23-33 Bridge Street, Sydney NSW 2000* *GPO Box 39, Sydney NSW 2001* *Tel: 02 9228 6111* *Fax: 02 9228 6455* *Email: information@planning.nsw.gov.au*	*HEAD OFFICE* *161 Kite Street, Orange NSW 2800* *Locked Bag 21, Orange NSW 2800* *Tel: 02 6391 3100* *(International +61 2 6391 3100)* *Fax: 02 6391 3336* *(International +61 2 6391 3336)*
Victoria	*GENERAL* *Tel: 1300 366 356* *Email: planning@diird.vic.gov.au*	*GENERAL* *Tel: 136 186* *Online Enquires*
Queensland	*GENERAL* *PO Box 15009, City East, QLD 4002* *Tel: 13 74 68* *Fax: +61 7 3224 4683* *Email: info@dsdip.qld.gov.au*	*GENERAL* *Tel: 13 25 23* *Fax: +61 7 3404 6900* *Email: callweb@daff.qld.gov.au*
Western Australia	*HEAD OFFICE* *140 William Street, Perth WA 6000* *Lock Bag 2506, Perth WA 6001* *Tel: 08 6551 9000* *Fax: 08 6551 9001*	*HEAD OFFICE* *3 Baron-Hay Court, South Perth WA 6151* *Locked Bag 4, Bentley Delivery Centre WA 6983* *Tel: 08 9368 3333* *Fax: 08 9474 2405* *Email: enquiries@agric.wa.gov.au*
South Australia	*GENERAL* *GPO Box 1533, Adelaide SA 5001* *Email: DPTI.enquiriesadministrator@sa.gov.au*	*HEAD OFFICE* *Level 14, 25 Grenfell Street, Adelaide* *GPO Box 1671, Adelaide SA 5001* *Tel: 08 8226 0900* *Fax: 08 8226 0476*
Tasmania	*GENERAL* *Level 4, 144 Macquarie Street, Hobart TAS 7001* *GPO Box 1691, Hobart TAS 7001* *Tel: 03 6165 6828* *Fax: 03 6233 5400* *Email: enquiry@planning.tas.gov.au*	*GENERAL* *GPO Box 44, Hobart TAS 7001* *Tel: 1300 368 550* *Online Enquiry*
Northern Territory	*DIRECTOR BUILDING CONTROL* *Tel: 08 8999 8985* *Email: bas.lpe@nt.gov.au*	*GENERAL* *Tel: 08 8999 5511* *Fax: 08 8999 2010* *Email: info.dpif@nt.gov.au*
Australian Capital Territory	*GENERAL* *Dame Pattie Menzies House, 16 Challis Street, Dickson ACT 2602* *GPO Box 158 Canberra ACT 2601* *Tel: 02 6207 1923* *Online Enquiry*	*REF: New South Wales Contact*

5.3 Elements of a Fire

5.3.1 Common Causes of G/GS Fires

Understanding the nature of fire is crucial to applying appropriate farm and risk management techniques and policies. Fire is dependent on the presence of three elements. These are heat, oxygen and fuel. The quantity and availability of each element directly depend on how easily a fire ignites, spreads and its duration. Removing one of the elements ensures the fire cannot survive.



To remove or mitigate the risk of G/GS fires it is first important to identify the heat, oxygen and fuel elements that are in the G/GS.

5.3.1.1 Heat

Heat can be produced by several forms of energy that are common in a greenhouse. The typical forms of energy are hot works, heating, electrical, smoking and spontaneous combustion.

- **Hot works:** Employees/maintenance staff/contractors should be made aware of the danger of welding or soldering near plastic membrane materials or other combustible materials. Sparks and molten metal can easily ignite combustible materials of fall into a confined space and smoulder until a fire breaks out hours later. A common example of this is combustible engine (tractor) exhaust.
- **Heating:** Natural gas or oil heaters, CO_2 generators and any other combustion burning equipment within the greenhouse could create a fire if appropriate clearance have not been adhered to between the equipment and the combustible materials. These may include permeable/impermeable membrane. Reference should be made to the equipment manufacturer's installation and maintenance manual/documentation to mitigate risk of fire.
- **Electrical:** Deterioration and wiring problems of electrical equipment can cause sufficient sparks/heat to ignite a fire. Even professionally installed electrical work can become faulty due to overloading or physical damage.
- **Smoking:** Fires due to discarded cigarette butts usually cause a fire risk when policy and designated smoking areas are not provided by the employer.
- **Spontaneous Combustion:** This is a type of combustion which occurs by self-heating which is followed by a thermal runaway and finally ignition. Self-heating occurs when a material, such as a store of oily rags, absorbs oxygen from the air as part of a natural chemical reaction; heat generated from the oxidation then leads to a fire.

5.3.1.2 Oxygen

Oxygen has a large influence in the speed of spread of fire and the severity of the fire damage. It is common-sense knowledge that oxygen cannot be removed from the G/GS; however mechanical ventilation systems tend to exacerbate a fire if not installed correctly. Automatic ventilation systems activate when the temperature within a G/GS rises, drawing in more oxygen from outside into the G/GS, increasing the speed and damage of the fire. The installation of automatic ventilation systems that do not have fire failsafe systems installed should be an area of consultation with a professional fire engineer and or fire department official.

5.3.1.3 Fuel

Combustible components and materials stored within the G/GS act as fuel, as does the G/GS itself. Identification of which elements within or of the structure are 'fuel' for a fire –

- G/GS membrane. All polymer coverings are combustible. Some coatings on glass panes are also combustible;
- Permeable membrane, sequential curtain and ground covers;
- Timber or plastic benches, work takes and storage racks;
- Plastic/polystyrene grow containers;
- Fertilizers, typically nitrogen based;
- Dried vegetation; and
- Oils, petroleum, diesel, propane/natural gas stored inside or around the G/GS perimeter.

5.4 Fire Prevention through Farm Management Recommendations

5.4.1 Technical Standards

To most effectively reduce the risk of a fire is to have a G/GS that is well-designed. Depending on the G/GS type (i.e. retail, commercial, institutional, private), size and location, compliance to national, state and local government regulation is important. Reference can be made to Sections 2 and 3 of the Code of Practice to determine if International Standards can be imposed on your proposed G/GS. Building codes are designed and enforced for the protection of public health, safety and welfare.

It is important for you, as a grower, to identify what will be required of your new G/GS development at the conceptual stages of development, many Local Councils are not experienced in the DA/Certification of G/GS buildings, it is important that you identify resources the certifier may require while completing your DA.

Several example documents that should be brought to the attention of the certifier are –

- International Building Code – Administered by the International Code Council.
- Code of Practice (Building Codes and Greenhouse Construction) – Administered by Horticulture Australia Limited and Osborn Lane Consulting Engineers.
- Supporting Document (Building Codes and Greenhouse Construction) – Administered by Horticulture Australia Limited and Osborn Lane Consulting Engineers.

There will be other documents/ Australian Standards not listed above that are already known to the certifier.

5.4.2 Building Materials

Greenhouse and grow structure materials vary considerably. Below is listed common building materials used by the Australian G/GS Manufacturing Industry.

1. Metal Framed Buildings

Many growers wrongly perceive metal framed structures, such as greenhouses, as "fireproof". This assumption does not stand. Although flame is unable to spread over metal, an unprotected metal frame building will commonly fail more rapidly than a wooden structure. In the event of a fire, temperatures build rapidly within the G/GS, and as the ambient temperature increases so does the temperature of the metal framing, as structural steel gets hot, causing strength to decrease rapidly leading to structural failure.

2. Glazing

Plastic Glazing - Plastic glazing, such as membrane or panels, are combustible and provide a source of fuel for a fire. As such, they need to be protected from high heat sources and open flames. Research has found that the edges of plastic sheeting are more susceptible to ignition than a flat surface; it is good practice to protect sheet edges with metal or other non-combustible materials. In order to be recognised as approved light-transmitting plastics, plastic glazing must meet minimum performance criteria which are outlined within relevant Australian and International Standards and Testing Procedures.

Glass - Glass panels are non-combustible and do not spread flame. Bear in mind that glass that has been laminated with a film may be combustible; a grower should contact their selected G/GS manufacture to determine if glass has been laminated and has an additional fire risk.

Permeable Plastic Membrane/Shade Cloth – Plastic shade cloth is typically woven from plastic filament, and as such, they are extremely flammable and spread fire quickly. Once ignited, the polymers used to weave shade cloth may melt and drip; these dripping molten polymers can cause catastrophic crop damage and ignite other combustible materials below. A denser shade cloth weave provides more fuel for a more intense burn, releasing more heat and dripping more molten polymer, which in turn results in a higher damage.

Using shade cloth also has an association with potential wiring and electrical problems that can result in fires. If electrical wires are in direct contact with shade cloth at any point over the protective area, friction between the two can wear away the insulation around the wires and expose a ‘live wire’ against the shade cloth. Preventing this potentially hazardous situation from occurring is to have all wiring encased in metal conduit or relocating the wire to locations where friction does not occur.

Flame-retardant shade cloth can be purchased on the market and band/panels can be installed between standard polymer shade cloth to create effective fire breaks along the length of the G/GS. Consultation with a G/GS manufacturer and/ or Professional Fire Engineer should be undertaken to determine if this method is appropriate and the specifics of panel width and spacing. It should be noted that flame-retardant shade cloth is generally more costly to purchase than a standard shade cloth alternative.

Shade/Energy Curtains – Shade and energy curtains are commonly woven from polymer, similar to that of the permeable plastic membrane/shade cloth (above). Curtains are commonly closed at night to conserve energy; this creates a building length panel of highly combustible material which is a disastrous situation if a fire were to ignite. There are curtains available on the market that have a flame-retardant edge which creates an inherent fire-break between each curtain. This effectively limits the risk of fire spreading throughout the G/GS.

5.4.3 Compartmentalisation

Compartmentalization, meaning the separation of two or more sections by a fire-resistant boundary, must be adhered to through the current, relevant National Construction Code and Australian Standards. To mitigate risk it is important to prevent fires from spreading. This can be achieved in following ways –

- Separate the G/GS into compartmentalised fire zones. Use non-combustible materials as the boundary/partitions. Common fire-resistant partitions include concrete tilt panels and fire-rated cladding, for example.
- Isolate generators, heaters and boilers from the G/GS with non-combustible partitions.
- Isolate ignition sources such as heating pipes, CO_2 generators and other electrical switches/panels from combustible materials (glazing, curtains etc.).

A G/GS that has been designed well will include inherent compartmentalisation between different portions of the structure. Consider using firewalls whenever two areas with different risk levels are contained in the same building. It is important for the grower to provide the G/GS designer/manufacture with appropriate information regarding proposed layout of growing area and plant areas. From there, a manufacturer, along with a Professional Fire Engineer (if required) will determine which compartmentalisation strategy is best suited for the development.

5.4.4 Power Delivery

Many fires result from electrical faults and/ or misuse of the electricity supply. Wiring can fail due to faulty installation, physical wear/deterioration, heat, overloading and moisture. All G/GS electrical work should be undertaken by a Professional Electrician and compliant with relevant Australian Standards. If new plant or equipment is installed within a G/GS it is important to have an electrical assessment completed to determine the risk of overloading. Each circuit must be protected by a fuse or breaker that will blow if safe capacity is exceeded.

Areas of excessive, prolonged moisture should be avoided when locating electrical panels/boxes; it is good practice to have the panel located in the driest and most accessible location within the G/GS. Due to the typical environment within a G/GS, it is important to ensure the panel is corrosion resistant and weatherproof. It is also recommended, in certain situations, that a secondary power supply panel and disconnect switch is located outside of the G/GS. Key staff should be instructed on how to disconnect the power supply in the event of a fire. Make sure that power systems are installed to allow continual, uninterrupted power (even while the disconnect switch has been activated) for the retraction of energy curtains and/ or the operation of misting/spray systems (H^2O mister/spray only).

Further detail and design recommendations can be obtained through the services of a Professional Fire Engineer and or Electrical Engineer.

5.4.5 Quality of Installation

Fires sometimes occur following the installation or repair of mechanical or lighting equipment. It is therefore important to have all installation or repair work completed by a qualified, licensed professional – employing such a contractor not only reduces risk of fire but also provides the grower with shared responsibility if a fire were to occur.

5.4.6 Lights

Though not common in G/GS within Australia, lights that are installed should be protected with a non-combustible conduit (i.e. metal) wherever possible. Lights should also be maintained regularly to remove dust/debris build-up and to check electrical wiring to lights. The following general installation recommendations include:

- Maintain appropriate distance between lights and combustible materials,(plastic glazing for example.)
- Use a licenced electrician during the installation and ensure approved fittings are used.
- Faulty parts should only be replaced with original or manufacture approved components.

5.4.7 Maintenance of Equipment

1. General Maintenance

Each G/GS should have protocol in place to ensure equipment, be it mechanical or electrical, is checked and maintained to ensure that it operates properly. Manufacturers of most equipment are able to provide a routine for inspection to the purchaser of the equipment. Replacement or repair of damaged or faulty equipment should be made an immediate priority and equipment should be removed from service without delay.

2. Maintenance of Fans and Motors

Motors and fans that are overheating due to a build-up of dust, overloading, sparking or poor ventilation could ignite combustible materials nearby. It is therefore important to keep the area around fans and motors clear of combustible materials. Motors should be provided with appropriate ventilation and maintained regularly to remove dust build-up.

Again, equipment including fans and motors should be wired by a licensed professional and in accordance with relevant Australian Standards. Voltages and amperage should correspond to the motor nameplate.

3. Maintenance of Appliances and Tools

One of the most common causes of G/GS fires in Australia is fire caused by faulty equipment, be it anything from a forklift to petroleum powered blower/vacuum. Over time it is common for devices to experience internal wiring failure or other electrical related issues which may result in a fire. Tools which are powered by an internal combustion engine must also be serviced and maintained as per manufacture's recommendations.

If any device is found to be not working, not performing as intended, making unusual noises/vibrations, smoke etc., it is vital that the device is immediately removed from service and replaced if required.

Vehicles, including fork-lifts and tractors, should be serviced regularly and cleaned to ensure dust and oil does not build-up around the engine block and electrical connections. A vehicle fire is extremely dangerous and difficult to extinguish. It is therefore important to ensure all reasonable maintenance is undertaken to reduce the risk of ignition.

Tools and vehicles that may be hot from operation should not be stored near combustible materials and should have an appropriate clear radius for ventilation.

5.4.8 General Housekeeping

1. General Guidelines

The following general guidelines are recommendations made by the National Greenhouse Manufactures Association of America. Note: The recommendations are not applicable for all G/GS buildings.

- Test fire and smoke alarms on regular intervals.
- If installed, flush private fire hydrants at least once a year or as instructed by the designer/manufacturer/installer.
- Check that fire doors are performing adequately, are unobstructed and in good condition.
- Regularly check all water control valves and the air and water pressures of automatic sprinkler/misting systems.
- Have a licenced electrician check all wiring, power boards and electrical equipment for faults or determination.
- Check and maintain all boilers and heating systems to ensure they are in prime operating condition.
- Clean dust and debris from fans and motors regularly; two to three times a year is advised but may be more if deemed necessary.

2. Fire Extinguishers & Fire Hose Reels

Fire extinguishers must be installed in locations as instructed by the relevant Australian Standards or Professional Fire Engineer.

Extinguisher placement is important. It is generally appropriate to installed extinguishers at locations close to potential hazards (i.e. gas storage tanks, boilers and CO_2 generators), in the middle of long aisles and near exterior doorways. More specific detail can be found in relevant Australian Standards and through consultation with the Fire Department or Professional Fire Engineer.

Fire hose reels should be installed where recommended by the relevant Australian Standards and or as directed by the Fire Department or Professional Fire Engineer. Fire hose reels typically require a minimum inlet pressure of 220 kPa and a maximum inlet pressure of 1,000 kPa (confirm with a specific manufacturer). A fire hose is only appropriate when fighting an ordinary combustible fire, (wood, paper, plastic and fabric) and is not suitable for any other type of fire. Staff should be educated in how and when it is best to use a fire hose and that they should ensure they maintain a path of egress between themselves and the nearest exit while fighting a fire.

There are different types of fires; each require a particular extinguisher to combat the flames. Types of fire extinguishers commonly found within a G/GS are identified in the below table (see Table 5.2).

Table 5.2
Fire Extinguisher Classes

Class	Type of Fire	Appropriate Extinguishers
A	Ordinary Combustibles (i.e. wood, paper, fabric, plastic)	Water, Foam, Dry Chemical, Vaporising Liquid, Halon, Wet Chemical
B	Flammable Liquids	Foam, Dry Chemical, Carbon Dioxide, Vaporising Liquid, Halon
C	Flammable Gas	Dry Chemical, Vaporising Liquid
E	Electrical	Dry Chemical, Carbon Dioxide, Vaporising Liquid, Halon

It is important to educate staff in how to effectively identify and use each type of fire extinguisher and also when to attempt to combat the fire or to evacuate. Ensuring all staff know what to do and where to go during the event of a fire is vital in minimising confusion, panic and the risk to life.

3. Storage of Combustibles

Flammable and combustible liquids and gasses are renowned fire hazards. Reference must be made to the National Code of Practice for the Storage and Handling of Workplace Dangerous Goods. Determining an appropriate location to store these combustibles should be a top priority. The ideal location for storage of such substances is in a large open outdoor area which is well separated from buildings, streets and property boundaries; its location should also have appropriate emergency access in the event of an emergency. If a large quantity of stored combustibles is required within the G/GS, it is vital that the storage is separated from the remainder of the building through the use of a firewall or similar. Fire resistance times of a fire wall are typically 30 minutes to 60 minutes – exact resistance times can be obtained through the services of a Professional Fire Engineer.

The following points should be enforced regardless of type or location of the combustibles stored:

- The storage room should be labelled and secured;
- Locations of combustible storage areas should be documented in the farm's Fire Prevention and Emergency Response Plan;
- An inventory should be kept of the type, quantity, date of purchase and location of the chemicals/combustibles;
- The inventory should be kept safe and available for inspection from emergency personnel;
- Flammable liquids should only be stored in approved containers; and
- Chemical storage rooms should have appropriate ventilation and spill contaminate design in accordance with Australian Standards (where applicable).

4. Fire Prevention and Emergency Response Plan

It is commonplace for a farm within Australia to have Workplace Health & Safety programs in place; these include evacuation plans, First Aid Kits and what to do if a dangerous situation is observed. However many farms do not have Emergency Response and Emergency Preparation protocol. The Emergency Response Plans ensure that, in the event of a fire or other emergency, all staff know what to do in order to preserve human safety and reduce loss and damages. It is the grower's responsibility to provide staff with a written Emergency Response Plan and to appropriately train all employees in how to follow the Response Plan. For assistance on how to write a Response Plan the grower should refer to State Workplace Health and Safety Commissions.

Alerting all employees to a fire emergency is vital. Common alarm systems include PA Systems, sirens or bells that are clearly audible anywhere on the farm. Protocol must be in place to ensure that management and foremen know where the alarm system is and how to activate it.

Exit routes from buildings must be clearly identified on emergency exit plans. Exits must be clearly marked with an approved EXIT sign (illuminated signs not required in a typical G/GS). If stipulated by a fire authority it is important to install 'knockout panels' in the greenhouse sidewalls and gable ends. Knockout panels must be labelled appropriately to ensure staff can identify the egress panels during an emergency. Staff should be educated as to how to evacuate the building in the event of an emergency; education should include the practice of kicking through a knockout panel.

Australian Standard 3745-2010 stipulates that workplaces are required to have a minimum of one onsite fire and evacuation drill per year. An announced fire drill should be conducted regularly so employees know what they should do in the event of a fire. A meeting should be held after the drill to discuss improvements in procedure and equipment.

The Emergency Plans Fact Sheet published by Safe Work Australia (www.safeworkaustralia.gov.au) provides quality resources for business owners in relation to Emergency Response Plans. It is recommended that G/GS growers download the document and complete the checklist; this checklist will identify any areas of immediate concern of human safety and loss/damage of property. Fire Departments and Professional Fire Engineers are also able to provide fire prevention and emergency response protocol for a fee.

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Supporting Documentation for Code of Practice

Building Codes and Greenhouse Construction

VG13055 (August 2014)

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Funding Provider: **Horticulture Australia Limited**

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HAL Horticulture Australia

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- Grower that completed and returned HAL Project Questionnaire.

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Glossary of Abbreviations

AS	**Australian Standards**
ASTM	**American Society of Testing and Materials**
BA	**Building Approval**
BCA	**Building Code of Australia**
CPM	**Compartmentalised Plastic Membrane**
DA	**Development Application**
FPM	**Film Plastic Membrane**
FRP	**Fibre Reinforced Plastic**
G/GS	**Greenhouse and Grow Structures**
HAL	**Horticulture Australia Limited**
IBC	**International Building Code**
ICC	**International Code Council**
NCC	**National Construction Code**
OLCE	**Osborn Lane Consulting Engineers**
PM	**Plastic Membrane**
SPM	**Sheet Plastic Membrane**

1.0 Introduction

1.1 Document Utilization

This document is to be referenced in conjunction with VG13055: Building Codes and Greenhouse Construction – Code of Practice. The document has been separated in the following four (4) sections. These are:

- **Section 1: Introduction**
  Outlines the objectives of the project and what methodology has been undertaken to achieve project objectives.
- **Section 2: Literary Review**
  Documents findings made from national and international resources.
- **Section 3: Ethics and Risk Assessment of Completing Project**
  Outlines the ethical risk of providing measures to reduce the cost of compliance for G/GS buildings.
- **Section 4: Consultation and Field Investigations**
  Consultation with experts and growers underpin all recommendations made in the Code of Practice. Experts have provided technical information, and growers have provided insight into issues facing the industry.

Research, information and field investigation case studies documented within this document will make direct reference to the accompanying Code of Practice. Identification of linking references can be found in the right-hand column of this document. An example of such a reference has been provided to the right. “REF: CoP 1.1” makes reference to “Code of Practice Section 1.1”.

REF: CoP 1.1

1.2 Project Methodology and Timeframe of Programme

1.2.1 Research Methodology

Much of the research accomplished throughout this project has been completed via online channels, these mainly being IEEE Database, EBSCO Host and SAI Global; other research tools used include internet search engines (such as google.com, google.scholar.com.au). All research used directly or indirectly within the document has been referenced using the Harvard Reference System with footnote references and an end of document reference list.

Literary Reviews of national and international standards, consultation with building certifier(s), fire engineer(s) and field visits are the basis of all recommendations in the investigation to reduce the cost of compliance in the investigation into the classification of G/GS’s and to provide guidelines for consistent building approval around Australia.

Field investigation has been completed by Osborn Lane Consulting Engineers (OLCE) to answer questions that remain unanswered after the literary review process and consultation with building and design professionals. The field visits also gave a good understanding of what fire and egress regulation has been imposed on existing G/GS structures. Where appropriate, the economic burden of these imposed systems has also been documented within the report.

Field investigations were an integral aspect of this project. Six (6) field investigations were undertaken to meet growers and investigate their protective structures/canopies around Australia. Grower concerns and recommendations were also documented and made available through the case studies provided in Section 4 of this document. The investigations were vital when determining:

- The success and failures of existing G/GS infrastructure;
- What fire, egress and structural requirements have been imposed on existing G/GS's;
- How the growers/owners feel the planning, design and construction were implemented – are there areas for improvement;
- Existing structural performance under extreme loading events (i.e. severe storms);
- What code recommendations do the growers/owners make; and
- Feedback on our research and recommendations over the project timeframe.

The following avenues of research methodology were utilised for this project.

- Research existing theories and concepts to help identify proposed improvements to the approval process through a literary review process.
- Complete research on the needs and desires of the industry and on the potential decrease in the cost of compliance.
- Economic research on industry and business to determine cost of compliance and reductions.
- Carry out social and communicational research to find answers to questions not discovered in point three – social research is the easiest means to determine industry perception of a specific issue.

Social and communicational research consisted of the development of a grower questionnaire. This questionnaire was completed by all growers who agreed to a site investigation and also to growers who had a particular interest in sharing their G/GS experiences. Protective Cropping Australia assisted in the questionnaire distribution.

Questionnaires that provided useful feedback and recommendations have been adapted into case studies which can be found in Section 4.0.

1.2.2 Project Staffing Resources

The following table shows those who have been utilised throughout the projects history and a description of association has also been given. Growers and G/GS manufacturers have also been utilised throughout the project.

Table 1.1
Utilised Staff

Name	Association to Project
Marcel Olivotto	VG13055 Project Leader
Eric Peter Osborn	VG13055 Project Administrator
Chris Millis	Vegetable Industry Grower Partner
Chris Lee	FERM Engineering – Fire Consultant
Milton Stennett	Acacia Building Approvals – Certifier Consultant

1.2.3 Timeframe of Programme

The below table contains programme objectives that are considered as crucial elements of the project; each element requires individual research, analysis, and documentation. Any additional unforeseen time restrictions, elements that require additional attention or regressions shall be incorporated into the existing timeframes.

Table 1.2
Timeframe of Programme

Element	Begin (month after start)	End (month after start)
Start of project communication summary	0	0
Literary review of current documentation and industry standards	0	1
Consultation with building certifier/fire engineer	0	2
Fire engineering and egress	1	5
Structural criteria	1	1
Case study of success and failure of past G/GS	2	5
Literary review on materials and new innovative systems	3	4
Determine cost reduction techniques	5	7
Field investigations	2	6
Development of final HAL report	6	9
End of project communication summary	9	9

2.0 Literary Review

2.1 G/GS Classification

2.1.1 In Australia

Reducing cost of compliance for structures, be it through regulation or design parameters, is not a new idea; the exponentially increasing availability of new technology and growth in design experience has led to greater design efficiency. Growers have benefited greatly from the progress made in structural efficiency by the design of lighter and stronger G/GS systems. National, State and Local Council regulation however often lacks efficiency, decisiveness and relevance to the expanding G/GS industry.

REF: CoP 1.2

Issues streamlining the process of government approval for G/GS originate largely from the interpretation of the National Construction Code (NCC) - Building Code of Australia (BCA) and its classification of G/GS. Further reference to the Building Code of Australia (BCA) in this project means Volume One of the National Construction Code Series (NCC) unless noted otherwise. Construction requirements for every building type are primarily associated with their classification in accordance with clauses A3.2 and 1.3.2 of the BCA. A3.2 of the BCA stipulates [1]"The classification of a building or part of a building is determined by the purpose for which it is designed, constructed or adapted to be used."

REF: CoP 2.0

In the individual States and Territories, appropriate authorities (such as local councils) may classify G/GS or other 'farm buildings' as Class 10a, which covers non-habitable buildings. A classification of 10a would only be made if Class 7 and Class 8 within the BCA were not appropriate.[2] When making the decision a certifier considers the buildings size, operations, purpose and occupation/utilization by people.

There are three basic types of Class 7 buildings. The first is Class 7a a carpark, the second, Class 7b, a building for storage and thirdly Class 7c, a building for the sale of wholesale goods. 'Wholesale' is the business of selling goods in large quantities and at low prices, typically to be sold on by retailers at a profit.[3] A G/GS structure would not fit into these categories easily without considerable interpretation of the word 'wholesale' and 'storage.' The primary use of G/GS are for growing produce. Once the produce is ready for sale, the product is picked (collected) and transported to another storage facility for wholesale. Hence, Class 7 is inappropriate for G/GS.

REF: CoP 2.3.2.1

Class 8 buildings are commonly described as a 'factory.' More specifically, this class includes buildings used as a "laboratory, or building in which a handicraft or process for the production, assembling, altering, repairing, packing, finishing, or cleaning of goods or produce is carried on for trade,

REF: CoP 2.3.2.1

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[1]NCC 2013b. Part A3.1 Building Code of Australia: Volume One. *In:* SERIES, N. C. C. (ed.).
[2]NCC 2013a. A3.3. *In:* CODE, N. C. (ed.) *Guide to the BCA Volume One.*
[3]OXFORD 2014. Oxford Dictionary. *Word Definition, Oxford Dictionary*

sale, or gain."[4] Use of the word 'production' has been problematic when decisively classifying G/GS structures in a unified category around Australia. If a certifier does not classify a G/GS as Class 10a he/she would usually classify the structure as Class 8 as people are likely to be employed to feed, clean or collect produce from animals or plants within a building. However, this can be seen as an inaccurate classification.

Practice Note 2013-64 by the Victoria Building Commission (issued January 2013) gives information on the process animal shelter buildings are required to comply with BCA requirements. [5]

2.1.2 Internationally

Europe, Canada and the United States of America have codes and standards that can either be specifically used for G/GS structures or can be adapted for the unique function and occupancy of a particular G/GS. The International Building Code that includes exceptions and specific requirements for agricultural buildings, such as, greenhouses or grow structures.

The International Building Code is published by the International Code Council in the United States. The IBC is a comprehensive building code which establishes the minimum regulations for building systems using prescriptive and performance-related provisions. The document is founded on broad-based principles that make possible the use of new materials and new building designs.[6]

REF: CoP 2.3.2

Agricultural buildings, which include G/GS, are classified as Group U buildings under the IBC.[7] Group U (Utility and Miscellaneous) buildings and structures are of an accessory nature or miscellaneous structures. The IBC specifies, structures not classified in any specific occupancy shall be constructed, equipped and maintained to conform to requirements of this code commensurate with the fire and live hazard incidental to their occupancy.

REF: CoP 2.3.2.2

Appendix C of the IBC provides exceptions and provisions for Group U buildings. These exceptions and provisions include allowances for Group U building heights and areas, distances between other buildings and exits. Exceptions for exits are as follows:[8]

REF: CoP 2.3.2.5

1. The maximum travel distance from any point in the building to an approved exit shall not exceed 91,440 mm; and
2. One exit is required for each 1,393.5 m^2 of area or a fraction thereof.

REF: CoP 2.3.2.4

[4]NCC 2013c. Part A3.2 Building Code of Australia: Volume One. *In:* SERIES, N. C. C. (ed.).
[5]VBC 2013. Practice Note: Classification of buildings. *In:* COMMISSION, V. B. (ed.). Victoria, Australia.
[6] ICC 2012c. International Building Code, Preface.
[7] ICC 2012b. International Building Code, Chapter 3.
[8] LEE, C. April 2014, ICC 2012a. International Building Code, Appendix C: Group U Agricultural Buildings.

2.2 Fire and Egress

Growing produce in greenhouses and grow structures often takes place in rural, remote locations zoned for agricultural use; due to this remoteness the buildings are almost always far from firefighting assets/stations. This means longer reaction time that gives an advantage to the spread of the fire. G/GS fires usually start in a discrete point and can quickly spread through the combustible materials. Although there have been relatively few documented serious greenhouse fires, each occurrence has taken place where there was high potential fire risk. This high fire risk leads to a high fire consequence, consequences including loss of life and serious property damage. Risk factors commonly associated with G/GS fires are as follows:

- Size of the operation;
- Structural materials used;
- Glazing/covering materials used;
- Machinery and equipment maintenance;
- The use of automation including production;
- Lighting, and
- Environmental control systems.

2.2.1 Material Use and G/GS Fires

Materials used within greenhouses are chosen for their useful growing properties and features, however, the same materials may have unforeseen risks associated with fire susceptibility and/or exacerbation. Combustible materials commonly used in G/GS are plastic glazing materials, shade cloth, energy curtains, containers, packaging products, stored chemicals and fertilizers, and plant materials.

It is a common misconception that metal-framed buildings, which is a common greenhouse construction method, are "fireproof"[9]. Unlike timber, metal has a negligible fire spread rating. It is however common for an unprotected metal framed building to fail much sooner than its hardwood timber counterpart in the event of a fire. Strength of steel decreases rapidly when a structural element becomes hot; this can result in a complete structural collapse long before actual flames spread through the building.

REF: CoP 3.3

Consultation with fire engineers has determined that a solid hardwood timber column/post will typically remain structurally sound for a longer period of time in the event of a fire than its steel counterpart.[10]

All plastic materials used as greenhouse glazing or shade cloth are combustible and need to be protected from high heat sources and open flames. Edges of glazing tend to be more susceptible to ignition than a flat surface. As such, the edges should be protected with a non-combustible material. When shade cloth or glazing is ignited or exposed to flame the polymers melt and drip. Dripping polymers cause damage to protected crops and can have the serious potential of igniting other flammable materials.

REF: CoP 3.3.2 & 5.4.2

[9] JONES, E. 2011. Preventing Greenhouse Fires. *Greenhouse Management*.
[10] LEE, C. April 2014.

Fire-retardant glazing and shade cloth has market availability and several manufacturers have had Australian testing complying with AS 1530.2.1993 and USA Standards. Manufacturers, such as Polyfab Australia, use new-generation technology that enables flame resistant additives to work with ultraviolet stabilisers to ensure maximum flame resistance while still offering long-term UV protection.[11] Fire-retardant shade cloth is generally more costly than standard shade cloth. As such, several G/GS designs within the USA have taken to effectively creating greenhouse divisions by installing wall and roof panels of flame-resistant glazing, this act as firebreaks and compartmentalisation[12]. These fire-resistant panels discourage fire to spread throughout the entire G/GS, through compartmentalisation. This compartmentalisation reduces the severity of the fire and losses. It should be noted that there were no identified laboratory tests to verify the effectiveness of this procedure, but field tests indicate that it can be an effective fire precautionary measure.

REF: CoP 3.3.2 & 5.4.2

REF: CoP 5.4.3

2.2.2 Fire Extinguishers and G/GS Fires

Fires start small and grow larger with the availability of time and fuel; an appropriate fire extinguisher in the hands of an experienced person can often prevent a small fire from becoming a major loss. Each workplace building (including G/GS) should have the appropriate types of fire extinguishers for all possible fire hazards. Extinguisher placement is stipulated within the relevant Australian Standard or by the instruction of a Professional Fire Engineer.

REF: CoP 5.4.8

Fires can be categorised into the following four (4) groups. These are:

- **CLASS A:** Paper, Wood, Cardboard
- **CLASS B:** Solvents, Paint, Petroleum, Methylated Spirits
- **CLASS E:** Electric fires
- **CLASS F:** Cooling oils and fats

Extinguishers can be categorised into the following five (5) main groups[13]. These are:

- **Carbon dioxide fire extinguisher**
  Carbon Dioxide fire extinguishers are recommended for Class ‘E’ electrical hazard fires, but also have limited capabilities for extinguishing small, indoor Class ‘A’ paper and Class ‘B’ flammable liquid fires.
- **Water fire extinguisher**
  Air/Water Fire Extinguisher contains water under pressure and is

[11] POLYFAB. 2014. *Polyfab Australia - FR Comshade* [Online]. Available: http://www.polyfab.com.au/11683.htm [Accessed Feb 2014.

[12] NGMA 2010. National Greenhouse Manufacturers Association Fire Safety. *In:* ASSOCIATION, N. G. M. (ed.) *3.C Fire-Retardant or Fire-Safe Screens.*

[13] EXTINGUISHERS. Unkown. *Types of Fire Extinguishers in Use* [Online]. Available: http://www.typesoffireextinguishers.com.au/typesoffireextinguisherstouse.html [Accessed Feb 2014.

to be used in an upright position. It is designed for use on solids such as wood, paper, rubbish or textiles, and has a discharge period of 60 - 100 seconds. Water extinguishers are unsuitable for flammable liquid fires.

- **Foam fire extinguisher**
  Air/Foam Fire Extinguisher contains an aqueous film-forming foam additive and is to be used in an upright position. It is designed for use on flammable liquid fires such as petrol, oils and paint. This extinguisher must not be used on fires involving live electrical equipment.
- **Dry chemical fire extinguisher**
  A 'BE' dry chemical fire extinguisher can be effectively used on fires involving live electrical equipment or flammable liquids and cooking oil. The 'ABE' fire extinguisher is recommended for fires where wood, paper, flammable liquid or live electrical equipment are involved.
- **Wet chemical fire extinguisher**
  Wet Chemical Fire Extinguisher contains a liquid alkaline extinguishing agent and is specifically designed for use in commercial kitchens on deep fryer fires involving fat and cooking oil. These extinguishers must never be used on fires involving live electrical equipment

Determining the most effective extinguisher location is important; it is a general rule to locate extinguishers close to the potential hazards (be it greenhouse C02 generator, fans and motors and areas of stored combustibles and accelerants), in the middle of long aisles and near external doorways.

2.2.3 Water Storage for Fire Fighting Purposes

State/Local Government applies policy in relation to above ground water storage tanks for firefighting purposes. Policies are in addition to the requirements found in the relevant Australian Standards for water storage tanks for firefighting purposes. The services of a Professional Fire Engineer may need to be sought to determine appropriate water storage for each particular G/GS.

2.2.4 Egress

The concept of occupant egress implemented through building regulations involves the provision of a designed and designated means of egress for a building. Egress should be an unobstructed path from any point in the building to the outside. Proper design includes the width of the spaces and doors, direction of door swing, lighting and marking, protection from the fire and its effects, and also the geometry of stairs or ramps. Limiting travel distances to reach a means of egress or common paths of travel, dead ends, and the provision of alternate means of egress, if the primary path is blocked by fire, are basic concepts of egress design. Part D of the NCC 2013 Building Code of Australia – Volume One provides Provisions for the aforementioned.

REF: CoP 3.3.3 & 3.3.12

Assuming a G/GS is classified as a Class 10 building the following Deem-to-Satisfy Provisions are imposed when referring to Part D1 'Provision for Escape' within the BCA. These are:

- All buildings (any Class) – Every building must have at least one exit from each story.[14]
- Minimum exit travel distances are not specified. [15]

However, if the G/GS is classified as Class 8 the following Deem-to-Satisfy Provisions are imposed when referring to Part D1 'Provision for Escape' within the BCA:

- Every building must have at least one exit from each story; a minimum of two (2) exits must be provided is the building has an effective height of more than 25 m. [16]
- No point on the floor must be more than 20 m from an exit, or a point from which travel in different directions to two exits is available, in which case the maximum distance to one of those exits must not exceed 40 m. [17]

The International Building Code provides the following egress provisions. These egress provisions are specifically for agricultural buildings that are of a compliant building type; G/GS are a compliant building type.

The means of egress for a G/GS building shall comply with the applicable provisions of Chapter 10 of the IBC, based on an occupant loading factor of 1 person per 30 m2 of the gross floor area. Both statements below must be adhered: [18]

- The maximum travel distance from any point in the building to an approved exit shall not exceed 91,440 mm.
- One exit is required for each 1390 m2 of area or a fraction thereof.

[14]NCC 2013d. Part D1.2 Building Code of Australia: Volume One. *In:* SERIES, N. C. C. (ed.).
[15]NCC 2013e. Part D1.4 Building Code of Australia: Volume One. *In:* SERIES, N. C. C. (ed.).
[16]NCC 2013d. Part D1.2 Building Code of Australia: Volume One. *In:* SERIES, N. C. C. (ed.).
[17]NCC 2013e. Part D1.4 Building Code of Australia: Volume One. *In:* SERIES, N. C. C. (ed.).
[18] ICC 2012a. International Building Code, Appendix C: Group U Agricultural Buildings.

2.3 Structural Design: G/GS Design and Construction Materials

2.3.1 Existing Construction Materials

There are two types of greenhouses commonly used around Australia. These are:

- Steel frame with glass cladding, these are also known as glasshouses, and
- Steel frame with polycarbonate (impermeable plastic membrane)

Greenhouse frames (support structure) may be constructed of timber, steel, aluminium or concrete. Modern greenhouses are usually constructed of steel or aluminium. Aluminium generally provides a stronger, rust resistant, lightweight frame but can be significantly more expensive than steel and timber. Timber is typically used for low technology G/GS. Timber can be difficult and expensive to maintain as it needs to be treated with a preservative and may require periodically painted to prevent rotting.

REF: CoP 3.0

Floors may be constructed of porous concrete, reinforced concrete, gravel or compacted clay covered with a strong polypropylene fabric. Porous concrete is usually strong enough to bear most loads encountered in greenhouse situations and allows for drainage through the surface. Reinforced concrete is more expensive and does not allow drainage through the surface.

However, reinforced concrete might be desirable in traffic areas where heavy loads occur. Concrete floors (unless used as part of the irrigation system) should have a slight grade to promote drainage and prevent puddling of water. Gravel is low cost and allows drainage, but can allow the growth of weeds and may not accommodate all types of equipment. Polypropylene fabric (weed mat) can be a low-cost alternative and can be combined with gravel, but the floor can become uneven over time, can cause puddling and algae growth.

As shown above there are three cladding systems commonly used on G/GS in Australia, these are glass panes, polycarbonate panels and poly-films or netting.

Polycarbonate panels are made from clear, rigid plastic that transmits light almost as well as glass. Panels are typically available as flat twin-wall panels, these contain two flat polycarbonate panes separated by an air space. The air space between panes improves the insulation properties of the panels.

REF: CoP 3.0

Though more expensive than poly films, polycarbonate panels are cheaper than glass within a greenhouse application. The benefit of polycarbonate is that it is almost as durable as glass while its weight is considerably less. This makes it much easier to handle and install. However, polycarbonate panels have a tendency to yellow over time which can reduce the light transmitting efficiency of the panel.

Twin-wall polycarbonate panels include a rating, in mm, that indicates the size of the separation between the individual polycarbonate panels (e.g. 4mm twin-wall panels have a 4mm air space between the panels). A larger gap between the panels provides better heat insulation properties. The lowest-price option, poly film can be a good option for G/GS where budgets are small and long-term useful life is not as important. Poly films are easy to work with, but they are the least permanent option for G/GS.

Poly films are often rated in terms of the number of useful growing seasons (e.g. 1 year useful life, 4 year useful life), this is the films life expectancy. The useful life of poly film is determined by a number of factors. These are:

- Climate;
- Film thickness;
- UV treated/stabilised;
- Installation quality; and
- Chemical attack from horticultural spray.

If a UV stabilizer has been applied to the film, it is important to check if the stabilising agent has been applied to both sides of the film. If treatment has only been applied on one side it is important to install the treated side facing the sun.

Glass is the highest-quality, highest-price option for G/GS. It is the heaviest material and so can be the most difficult to install. If installed correctly and protected from shattering, glass outlasts any other plastic option in terms of useful life. It must be noted that not all glass is the same. Annealed glass can be dangerous for greenhouse applications. When it breaks, annealed glass shatters into long, sharp shards which may cause injury. Tempered glass is four to six times more shatter-resistant than annealed glass, and when it breaks it breaks into small square pieces, making it unlikely to cause injury. There are different varieties of tempered glass (single tempered, double tempered, and more) with various tensile strengths.

2.3.2 New/Innovative Construction Materials

New and innovative construction materials show promise as future structural and glazing materials in the greenhouse and grow structure industry. Fibre composites are a prime example of this. Fibre composites are materials made from two or more constituent materials with significantly different physical and chemical properties, that when combined, produce a material with different characteristics from the individual components.[19]

Composite materials are not a new discovery, nor do they remain a costly and unrealistic alternative to existing construction materials. Concrete, for example, is one oldest and most commonly used composite which is reinforced by particles. More recent developments in composites include:

- Composites reinforced by chopped strands;
- Unidirectional composites;
- Laminates, timber ply sheeting is one such example;
- Fabric-reinforced plastics;
- Honeycomb composite structure.

Fibre-reinforced plastic (FRP) has become a notable material in structural engineering application over the past decades. Studies by academic institutions are continuing to document the potential benefits in construction. Cost-effectiveness has also been modelled against traditional concrete, masonry, steel, cast iron, and timber structures and found to be encouraging in future predictions. The fibres are usually glass, basalt, carbon or aramid while the polymer usually consists of epoxy, polyester thermosetting plastic or vinylester.[20]

Though promising, fibre-reinforced plastics are not currently being produced at a rate, consistency and controlled quality to be applicable as an alternative to steel or timber within a G/GS.

[19] DURAND, L. P. 2008. *Composite Materials Research Progress*.
[20] SPRINGER, G. 2014. Fibre and Plastic - Stanford University. *Journal of Reinforced Plastics and Composite*.

2.4 Structural Design: Wind Loading

2.4.1 Existing Loading as per AS/NZS 1170.2

AS/NZS 1170.2:2011 Wind Actions (incorporating amendment numbers 1, 2 and 3) set out procedures for determining wind speeds and resulting wind actions to be used in the structural design of structures subjected to wind actions. The processes of determining wind actions on structures as per AS/NZS 1170.2 are as follows:

a) Determine site wind speed (AS/NZS 1170.2 Clause 2.2).
b) Determine design wind speed from the site wind speeds (AS/NZS 1170.2 Clause 2.3).
c) Determine design wind pressures and distributed forces (AS/NZS 1170.2 Clause 2.4).
d) Calculate wind actions (AS/NZS 1170.2 Clause 2.5).

REF: CoP 4.1

Determining the correct/most appropriate annual probability of exceedance for each structure is also very important for structural safety and economic viability. Obtaining annual probability of exceedance is a two-step process.

Firstly, the importance levels of a structure shall be determined in accordance with Table F1 of AS/NZS 1170.0. Importance levels for G/GS are defined by the proposed use of each structure. It's common for low technology G/GS (steel hooped frames with plastic membrane) to have an Importance Level of 1 'LOW' consequence of failure; this low importance level is associated with a low consequence for loss of human life, or small or moderate economic, social or environmental consequences. Medium to high technology G/GS tend to have an Importance Level of 2 'ORDINARY' consequence of failure; definition of this is medium consequence for loss of human life, or considerable economic, social or environmental consequences.

Table 2.1
Structure Types for Importance Levels[21]

Consequence of failure	Description	Importance Level	Comment
Low	Low consequence for loss of human life, or small or moderate economic, social or environmental consequences	1	Minor structures (failure not likely to endanger human life)
Ordinary	Medium consequence for loss of human life, or considerable economic, social or environmental consequences	2	Normal structures and structures not falling into other levels
High	High consequence for loss of human life, or very great economic, social or environmental consequences	3	Major structures (affecting crowds)
		4	Post-disaster structures (post disaster functions or dangerous activities)
Exceptional	Circumstances where reliability must be set on a case by case basis	5	Exceptional structures

[21] AS 2002a. AS/NZS 1170.0 General Principals, Table F1. *In:* AUSTRALIA, S. (ed.).

Once the importance levels have been identified the annual probability of exceedance can be found through Table F2 in AS/NZS 1170.0.[22] The BCA requires that regional wind speeds of specific probability be used for building design. The more important the building, the less the allowable risk that the design speed will be exceeded in any one year and the higher the speed required in the design. Regardless of their importance level or classification, buildings should not fail when subjected to the wind event for which they are certified to withstand. Common engineered design working life of wind loading for low technology G/GS's is 25 years while high technology G/GS's tend to have a design working life of 50 years.

REF: CoP 4.1 & 2.1

2.4.2 Potential for Loading Reductions

AS/NZS 1170.2:2011 Wind Actions (Incorporating Amendment Nos 1, 2 and 3) notes in 1.1 SCOPE that: "The standard is a stand-alone document for structures within specified criteria. It may be used, in general, for all structures but other information may be necessary." And "Further advice, which may include wind-tunnel testing, should be sought for geometries not covered in this Standard, such as unusual roof geometries or support systems, very large roofs, or the roofs of podium at the base of tall buildings." [23]

REF: CoP 4.2.2

Where appropriate, engineers have the option to utilise AS 1170.2 in conjunction with European Standard numbered EN 13031-1 Greenhouses – Design and Consideration.

EN 13031-1 provides an engineer with external pressure coefficients c_{pe} for common greenhouse structural geometries which are not documented within AS 1170.2. [24]

REF: CoP 4.2.1

[22] AS 2002b. AS/NZS 1170.0 General Principals, Table F2. *In:* AUSTRALIA, S. (ed.).
[23] AS 2011. AS/NZS 1170.2: Wind actions, 1.1 Scope. *In:* AUSTRALIA, S. (ed.).
[24] ES 2001. EN 13031-1 Greenhouses - Design and construction. *In:* STANDARDS, E. (ed.).

3.0 Ethics and Risk Assessment of Completing Project

3.1 Consequential Effects / Implications / Ethics

As a single entity, Osborn Lane Consulting has an ethical responsibility to itself, its clients, staff and the wider community. Osborn Lane also needs to control how it responds to unforeseen circumstances and how that response will affect parties it has a responsibility to. During the process of this project the firm and its contributing consultants must consider the effects (both ethical and consequential) the recommendations within this report may have on all involved.

Consequential effects can be analysed through two opposing channels, the first being "effects without recommending change" and the other being "effects when recommending change". Recommending changes can have many positive effects on the G/GS industry; the main objectives of this project being reducing cost of compliance for construction of G/GS's and provide guidelines for a consistent building approval approach across Australia.

Recommending changes can also have serious negative effects on the G/GS industry – making large, unsubstantiated recommendations without providing supporting research and thorough consultation with professionals could prove to be very dangerous. Fire and egress is one such area which requires systematic and exhaustive analysis into consequential effects and risk assessment.

Osborn Lane Consulting Engineers' Workplace Health and Safety and Environmental Policy can be found in Appendix B and C respectively.

3.2 Risk Assessment

Risk assessment in an important factor in protecting staff, clients, the company and the wider community from danger; risk assessment can be described as an in-depth analysis of what could cause physical, emotional or financial harm to any effected group – protective and preventative measures have been taken by the company in relation to this project in the aim to control risk associated with the recommendations given.

Each individual recommendation given in the Code of Practice has had an associated risk assessment completed.

Recommendations given by Osborn Lane within this project are the result of research, interpretation of National and International Codes and consultation with professionals in the field of investigation. Osborn Lane Consulting does not take responsibility for action taken upon the documented recommendations; construction, design and/or approval upon the recommendations given within this project is not endorsed without obtaining specific, independent professional advice in respect of the matters set out in this document and associated appendices.

4.0 Consultation and Field Investigations

4.1 Professional Consultation

Consultation with professional fire engineers and building certifiers during the project underpins most recommendations made within the Code of Practice document.

Fire Engineer

Fire engineers have provided comments and feedback regarding Section 3 of the Code of Practice document – feedback included general risk assessment alterations, technical specifications for materials, information regarding behaviour of materials in the event of a fire, and general farm management protocol that has the potential to reduce risk and spread of fire.

Building Certifier

Recommendations made in Section 2 of the Code of Practice have been reviewed by a building certifier.

Greenhouse Manufacturer

Several G/GS manufacturers have made general comment about the G/GS industry in Australia – they identified that it was important to work with certifiers and engineers who have experience in dealing with the unique issues facing the protective cropping industry.

4.2 Field Investigations

A project questionnaire was completed by known interested growers. The document was also disseminated over the Protected Cropping Australia database – ten (10) responses were received over the length of the project, these responses provided invaluable insight and experience when determining what issues most affect growers.

Below are summaries of each completed questionnaire. The identification of each grower has been kept confidential to ensure anonymity of the grower, their farm and farming processes.

4.2.1 Site One: Regional Victoria, Australia

Grower Identification: Grower VICa

Typical crops being produced: Hydroponic seedlings, tomatoes and capsicums

Type of G/GS: Glass and steel Dutch Venlo

Technology level: High

Total area under G/GS: 26 ha

Site visit undertaken: Yes

Field Investigation Findings:

Grower VICa has identified that they are HAL levy paying growers.

Glasshouses are imported from Netherlands through the Dutch Venlo company. The greenhouses are provided with frameworks, fastening elements, glazing and steel zinc-coated metalware. Frameworks and gutters are made of aluminium, metalware for fixation and aluminium construction. Construction meet European standard EN 13031. [25]

Grower VICa's history with DA (Development Approval) and council compliancy is as follows. The first Dutch Venlo greenhouse constructed onsite required fire and egress requirements; these requirements were hydrant booster pumps, a fire ring suppression system and illuminated exit signs. Before construction of successive glasshouse structures Grower VICa approached a building surveyor and a fire engineer to investigate and engage in reducing cost of compliance. The fire engineer completed a risk assessment in relation to the possible outcomes in the event of a fire – this risk assessment was presented to local council and CFA officials which delivered an outcome that was acceptable to the grower.

DA concessions are directly related to fire and egress requirements applicable to all future glasshouse structures constructed on the growers property. Some practical fire and egress requirements were still imposed on new developments after the concession was implemented. One such requirement was the installation of fire hose reels at locations specified by the fire engineer. Other imposed requirements were the construction of concrete fire rated walls (60 minutes) between the plant equipment room and the growing areas. The installation of break-glass sensors that activate the H^2O misting/fog system which remains active till disengaged is an alternative to the fire ring suppression system that has been approved by CFA and local Council. Misting/fog fire suppression systems utilise existing infrastructure used during daily operation of the glasshouse and therefore do not require layout of dedicated fire suppression systems that may never be used. Fire extinguishers are also located at each exit and control panels.

[25]VENLO. 2010. *Venlo Greenhouse Construciton* [Online]. Available: http://www.venloprojecten.com/en/index.php?page=1 [Accessed March 2014.

Exits and egress in all glasshouses are approved by Council and CFA; exits are at the end of each row and provide a maximum escape path of 126 meters. Glass wall panes could also be shattered in the event of a fire if alternative escape is required. Emergency evacuation plans and procedures are conveyed to all staff and site visitors.

Grower VICa has not experienced structural failure due to extreme natural events nor has there been documentation of fire in any of the glasshouses onsite. Glasshouses are maintained meticulously and are kept clear of combustible materials.

4.2.2 Site Two: South-East Queensland, Australia

Grower Identification: Grower QLD

Typical crops being produced: Cucumbers
Type of G/GS: Impermeable plastic membrane on hooped steel structure
Technology level: Low
Total area under G/GS: 5.4 ha

Site visit undertaken: Yes

Field Investigation Findings:

Grower QLD has identified that they are HAL levy paying growers.

Greenhouses are imported from Adelaide, SA and constructed from steel hoops, timber/steel column supports and are covered with an impermeable plastic membrane. The greenhouses have been in operation for 20+ years and mainly produce cucumbers year round. All sides of the greenhouses remain operable throughout the growing season. There has been no extreme natural event (storm/hail etc.) that has caused structural failure documented on Grower QLD's property, nor has a fire.

The property is in a semi-rural area with houses all around. Grower QLD has had issue with residential complaints regarding noise pollution from tractors and other farming machinery, spraying and visual pollution.

Grower QLD has recently had to apply for a DA through the Logan City Council for the existing greenhouses. The process of obtaining BA has been a problematic, protracted occurrence which has caused the grower economic and emotional hardship. Grower QLD accepted that DA would have to be completed however it was the unknowingness and professional inexperience throughout the process which caused issues. These issues were:

- Local Council was unable to provide the grower with a uniform response to what process was required to complete the DA efficiently. Council was also unable to provide council fees associated with the DA process. After meeting with Grower QLD, Marcel Olivotto from Osborn Lane Consulting contacted a member of Logan City Councils Planning Department to request further information regarding the process of BA for greenhouse structures. The response from Council that was received was "DA requirements are a case-by-case issue and are dependent on the council certifier. Council does not have documented guidelines that outline what is required [for the completion of greenhouse DA]."
- To obtain structural certification of the existing greenhouses a large Brisbane based engineering firm was engaged – This resulted in the apparent noncompliance of the existing structural columns [presumably for wind loading], the only remediation measure that was offered to the grower was to replace all existing columns with a

larger size. Grower QLD was unpleased with this result and acquired a second opinion through an alternative engineering firm. The second firm was much more experienced in the design of low technology greenhouses and found the greenhouses were structurally adequate for both strength and service loading and as such no additional work was needed. Through experience it is evident that applying wind loading to low technology greenhouses, specified in AS/NZS 1170.2 Wind Loading Code can be unnecessarily conservative if the entire structural system is not understood.

Fire and egress regulation was not imposed during the DA process though Grower QLD has identified that several other growers in the area were required to comply with fire and egress during BA of new and existing greenhouses.

Grower Project Recommendation:

Produce design and classification guidelines for local councils to adhere to.

4.2.3 Site Three: West Sydney, New South Wales, Australia

Grower Identification: Grower NSWa

Typical crops being produced: Hydroponic Tomatoes and Cucumbers
Type of G/GS: Impermeable plastic on hooped/sawtooth steel structure
Technology level: Low
Total area under G/GS: 0.68 ha

Site visit undertaken: Yes

Field Investigation Findings:

Grower NSWa has identified that they are HAL levy paying growers.

Greenhouses were constructed onsite from steel hoops, steel columns and are covered by impermeable plastic membrane. The property is in a semi-rural area with several new housing subdivisions expected within the area over the next decade. Grower NSWa began building greenhouses on his property 20+ years ago and had not had any issue with design or council approval processes and outcomes.

Grower Project Recommendation:

Though Grower NSWa has not experienced an issue with design or council approval processes, he has provided recommendations in regards to G/GS approval processes. Grower NSWa has concerns that BA is not being completed homogeneously throughout the local regulatory body; he and other growers in the area are well aware of which certifiers within council are more or less stringent with approvals. Without documented regulatory/approval guidelines certifiers are left to determine compliance on the basis of previous knowledge and/or simply applying non-realistic pro forma which would otherwise be relevant for permanent industrial Class 8 buildings. Grower NSWa has identified several cases where local council has requested that growers reduce the height of pre-purchased greenhouse from France by removing 0.5m to 1.0m from the column lengths to ensure the building does not exceed a height of 4m, this height reduction has had negative impacts on quality and quantity of produce under such G/GS's.

4.2.4 Site Four: Tasmania, Australia

Grower Identification: Grower TAS

Typical crops being produced: Hydroponic Tomatoes and Seedlings
Type of G/GS: Pitched Glasshouse and Impermeable plastic on hooped/sawtooth steel structure
Technology level: High
Total area under G/GS: 1.1688 ha (excl. seedling structure)

Site visit undertaken: Yes

Field Investigation Findings:

Grower TAS has identified that they are HAL levy paying growers.

Two hydroponic tomato growing G/GS's are located onsite. The greenhouse constructed in 2007 is fabricated from steel and glass with a pitched roof profile while the greenhouse constructed in 1998 is fabricated from steel and impermeable plastic with a hooped roof profile. The first greenhouse was imported from France (Richel Greenhouse) while the second was imported from New Zealand (Faber Greenhouses).

Grower Project Recommendation:

Grower TAS recommended that this project documents design and classification guidelines for local councils to adhere to. This grower also recommended the development of a risk assessment protocol which would be used when determining fire and egress risk on individual G/GS buildings.

4.2.5 Site Five: South Australia, Australia

Grower Identification: Grower SA

Typical crops being produced: Hydroponic lettuce
Type of G/GS: Steel cable flat roofed panel system, permeable netting
Technology level: Low
Total area under G/GS: 4.0 ha

Site visit undertaken: Yes

Field Investigation Findings:

Grower SA has identified that they are HAL levy paying growers.

Grower has been in operation for approximately 20 years, during this time the farm has produced hydroponic lettuce and Asian greens for a dominantly domestic market. The steel cable with permeable membrane structure did not require specific fire and/or egress requirements other than an appropriate WH&S policy which includes an emergency response plan. The structure has not experienced failure due to winds, fire or other extreme environmental events other than localised hail damage which is expected with this type of construction.

Grower Project Recommendations:

Grower SA identified the following two (2) recommendations for the project, these are:

1. Material Usage – Grower SA encourages manufactures and growers to use materials best suited for the desired application.
2. Netting Replacement – Grower SA also recommended that growers only replace severely damaged or degraded netting; smaller areas of netting that require repair can be easily patched.

4.2.6 Site Six: New South Wales, Australia

Grower Identification: Grower NSWb

Typical crops being produced: Fresh culinary herbs
Type of G/GS: Venlo double gable
Technology level: Mixed
Total area under G/GS: 1.0 ha

Site visit undertaken: No

Questionnaire Findings:

Grower NSWb has identified that they are HAL levy paying growers.

Grower NSWb have G/GS constructed of both steel and glass and steel and impermeable membrane on their site. Structural engineering certification was obtained for the G/GS through Faber Greenhouses and the building was required to be inspected independently by the Lismore City Council as part of the final certification of occupancy. The development application required the following:

1. A certificate from a consulting engineer, certifying the footings and structural steel framework;
2. A copy of the geotechnical report, certifying the bearing capacity and compaction of the glasshouse pad with attention to the bearing pressure of the footings;
3. Certificates to be provided from the glazing provider, certifying that the glazing complies with Australian Standards;
4. Additional exit points, as indicated from a Fire Service Engineer;
5. A copy of a fire safety statement, certifying the following is in place:
   a. Emergency evacuation plan;
   b. Emergency exit operation;
   c. Portable fire extinguishers.
6. Adequate staff toilet amenities required to be provided prior to occupation of the Glasshouse.

The structure(s) have not previously failed due to winds, fire or other extreme environmental events.

Fire and egress requirements were imposed on the G/GS during the design and approval stage; escape doors/kick-out panels were required on walls at 25 meter maximum apart. Evacuation plans, staff education and procedures were also required. Evacuation plan was a minimal cost and an invaluable asset to the safety of staff and protection of the G/GS.

Certification of G/GS glass was a major issue when completing the local council development application information request. Roof glass needed to be toughened so that it shatters into small pieces. Wall glass is typically ‘float glass’ which is dangerous if broken, especially if broken by a person jumping through it.

Grower NSWb was happy with the development application approach taken by the local Council.

4.2.7 Site Seven: Regional Victoria, Australia

Grower Identification: Grower VICb

Typical crops being produced: Fresh culinary herbs
Type of G/GS: Steel and impermeable membrane
Technology level: Mixed
Total area under G/GS: 0.6 ha (3 structures)

Site visit undertaken: No

Questionnaire Findings:

Grower VICb has identified that they are HAL levy paying growers.

Structural engineering certification, local government approval and fire/egress requirements were obtained for the steel and impermeable membrane G/GS structures. Grower VICb noted that cost reduction of G/GS could occur though the design of G/GS to enable staff to work at heights; this will be used when replacing impermeable membrane covers.

Grower VICb has identified membrane/covering failure in the event of storm events with winds exceeding 130 km/hr and 170 km/hr.

4.2.8 Site Eight: South Australia, Australia

Grower Identification: Grower SAb

Typical crops being produced: Herbs
Type of G/GS: Sawtooth, Steel and Glass
Technology level: Mixed
Number of G/GS: Approximately 13 structures onsite

Site visit undertaken: No

Questionnaire Findings:

Grower SAb has identified that they are HAL levy paying growers.

Structural engineering certification and local government approval was required though fire and egress requirements were not – Grower SAb utilised an experienced engineer who was able to reduce classification of the structure which enabled the exception of fire and egress requirements.

Minor structural failure has been documented for the site, this was due to wind events. Grower SAb believes the only preventive measure would have been installing wind breaks.

4.2.9 Site Nine: New South Wales, Australia

Grower Identification: Grower NSWc

Typical crops being produced: Raspberry's
Type of G/GS: Tunnel profile, steel and impermeable membrane
Technology level: Mixed
Number of G/GS: Approximately 8 structures onsite

Site visit undertaken: No

Questionnaire Findings:

Grower NSWc is not a HAL levy paying grower. Questionnaire has been included due to issues with Local Council. Grower NSWc indicated that he will soon become a levy paying member of HAL.

Grower NSWc found dealing with Local Council very difficult – Council was not experienced in the certification of G/GS structures. The structure was purchased from a Chinese manufacturer, structural certification was also difficult as Local Council required detailed plans and steel specification before approval.

4.2.10 Site Ten: Regional Victoria, Australia

Grower Identification: Grower VICc

Typical crops being produced: Tomatoes, herbs, lettuce, eggplant and Lebanese cucumber

Type of G/GS: Sawtooth profile, steel and impermeable membrane

Technology level: Mixed

Number of G/GS: 3 structures onsite

Site visit undertaken: No

Questionnaire Findings:

Grower VICc has identified that they are HAL levy paying growers.

Structural engineering certification, local government approval and fire/egress requirements were not obtained for the steel and impermeable membrane G/GS structures. Grower VICc has identified that they are required to maintain a 250,000 litre water tank for firefighting purposes, a separate tank is also installed onsite with a CFA approved hose coupling attached in preparedness for a fire event.

Grower VICc has stated that the local government approval was difficult.

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Appendix A

Example Risk-Point Matrix Assessment

The following Risk-Point Matrix Assessment has been completed as a process example. This example should only be used as an assistive guide to the steps identified in Section 3.3 'Simplified Method of Risk-Point Matrix Assessment.'

The following parameters have been selected from an existing G/GS which was site investigated during the completion of this document. Site location shall remain anonymous to protect the grower's anonymity.

Example G/GS parameters are as follows:

- G/GS Size 1.2 ha
- Glazing/Covering Type Film Plastic Membrane
- Value of Crop & G/GS Crop = $40,000/year; G/GS = $60,000
- Location of G/GS Semi-rural
- G/GS Height 3.5 m
- Distance from Buildings 17 m
- G/GS Tech Low

Making reference to Section 3.3 of the Code of Practice, results for each step are documented below.

3.3.1 STEP 1 – Determine G/GS Size

The G/GS is 1.2 ha and therefore falls within Band 2 of Table 3.1.

Answer = Band 2

3.3.2 STEP 2 – Glazing/Covering Type: (Flammability)

G/GS glazing is Film Plastic Membrane (FPM), FPM falls within the Plastic Membrane category.

Answer = Plastic Membrane (PM)

3.3.3 STEP 3 – Grazing Type: (Egress)

As per STEP 2, glazing is FPM.

Answer = FPM

3.3.4 STEP 4 – Glazing Type: (Smoke)

As per STEP 2 & 3, glazing is FPM.

Answer = FPM

3.3.5 STEP 5 – Lighting

There is no assimilation lighting installed in the G/GS

Answer = N.A.

3.3.6 STEP 6 – Value of Crop & G/GS

Value of the crop per year is $40,000 while the value of the G/GS is $60,000. As per Table 3.2, value of both the crop and G/GS are within the 'Average' category.

Answer = Average

3.3.7 STEP 7 – Other Flammable/Combustible Items

This G/GS has the following combustible items. These are:

- Cardboard growing containers;
- Combustible pallets; and
- Dry vegetation.

Answer = Flammable/combustible items are present.

3.3.8 STEP 8 – Environmental Control Systems

No environmental control systems are installed in this G/GS

Answer = Low Tech, N.A.

3.3.9 STEP 9 – Location of G/GS

The G/GS is located in a semi-rural zone as per the Local Government planning scheme.

Answer = Semi-rural

3.3.10 STEP 10 – Distance from other buildings

The G/GS has a minimum distance of 17 metres from all buildings and boundaries. As per Table 3.4 (building height less than 6 metres) the G/GS is within 'Distance 1.'

Answer = Distance 1

Now that STEP 1 to STEP 10 has been completed under Section 3.3 it is appropriate to proceed to Section **3.3.11 STEP 11 – Risk-Point Matrix**.

Using relevant tables and information, determine the Risk-Points for each of the elements outlined in Table 3.6. Tally, through addition (+), the Risk-Points for each element to give a Total Risk-Point for the STEP 1 through to STEP 10.

The example completed above give the following risk points per step. These are:

Example Risk Points Obtained

STEP	Answer	Table 3.6 Risk Point
1	Band 2	3
2	PM	5
3	FPM	4
4	FPM	2
5	N.A.	0

6	Average	3
7	Flammable/combustible items	5
8	Low Tech, N.A.	0
9	Semi-rural	3
10	Distance 1	3
	TOTAL	**28**

The tallied Risk-Point has given a value of **28**.

Proceeding to 3.3.12 STEP 12 – Risk-Point Assessment Result and making reference to Table 3.7 determines that this specific G/GS can be classified as a 'Medium Risk' G/GS.

Section 3.3.12.2 'Medium Risk' of the Code of Practice specifies the following recommendations for a medium risk G/GS.

3.3.12.2 Medium Risk

A G/GS that falls within the 'Medium Risk' Risk-Point Result Bracket (see Table 3.7) exhibits a medium risk of a catastrophic fire event. This assessment is dependent on the following conditions:

- That good farm practices and management are implemented within the farm (see Section 5.0 Farm Management and General Practices);
- Relevant Codes are adhered to, especially in relation to Egress (See Section 2.0);
- All electrical work has been installed in strict accordance with Local, State and Federal Standards by a qualified professional electrician;
- The Grower is aware of the heightened fire risk and has incorporated appropriate measures within the farm's Occupational Health and Safety Procedure; and
- Maintenance is carried out to the manufacturer's recommendations and all electrical equipment is tested and tagged 6 monthly.

Expectation of Fire Engineers Consultation: Though not recommended for all G/GS within the 'Medium Risk' bracket, it is at the discretion of the certifier to request the services of a Professional Fire Engineer. Growers should be made aware of this consultation and the associated fees. Common Professional Fire Engineer recommendations for a G/GS with Medium Risk are as follows:

- Emergency operation manual is produced and maintained to ensure all staff are aware of any risk and evacuation procedures that are to be followed in the event of an emergency.
- Emergency equipment such as extinguishers and hose reels are tested at intervals as required by AS 1851-2012.

Appendix B

A Partnership of
Osborn Lane Pty Ltd A.C.N 061 799 979
& Gremfield Pty Ltd A.C.N 073 121 258
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A QUALITY ASSURED SUPPLIER

OSBORN LANE
CONSULTING ENGINEERS

HEALTH AND SAFETY POLICY

Osborn Lane Consulting Engineers considers workplace health and safety as an integral part of the success of the organisation and is committed to providing a safe and healthy work environment for all employees, contractors, clients and members of the public.

Osborn Lane Consulting Engineers will do this by eliminating or, where this is not practicable, managing workplace health and safety hazards to prevent all injuries, illnesses and dangerous events.

The responsibility for managing workplace health and safety ultimately rests with management, but employees also have important responsibilities that must be met.

Management is responsible for:

- Ensuring the company complies with all legislation relating to workplace health and safety
- Eliminating or minimising all workplace hazards
- Providing adequate information, procedures and training to enable all employees and contractors to do their job safely
- Encouraging and respecting the involvement of all employees in the improvement of workplace health and safety
- Providing appropriate safety equipment and personal protective equipment whenever required

All employees are responsible for:

- Following all safe work procedures, instructions and rules
- Participating in the management of workplace health and safety
- Encouraging other employees, contractors and members of the public to act in a healthy and safe way
- Participating in safety training
- Reporting health and safety issues
- Using the safety equipment and personal protective equipment provided

Our goal is to have zero work-related injuries and illnesses to employees, contractors and members of the public. This will only be achieved through the participation, co-operation and commitment of everyone at the workplace.

P. Osborn

Signed by: **ERIC PETER OSBORN**
Date: 1st July 2014

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Appendix C

A Partnership of
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& Gremfield Pty Ltd A.C.N 073 121 258
A.B.N: 51 132 296 754

A QUALITY ASSURED SUPPLIER

ENVIRONMENTAL POLICY

Osborn Lane Consulting Engineers considers the protection of the environment to be a matter great importance both personally and commercially. Osborn Lane Consulting Engineers will do this by eliminating or, where this is not practicable, managing environmental risk.

The responsibility for managing environmental risk ultimately rests with management, but employees also have important responsibilities that must be met.

Management is responsible for:

- Ensuring the company complies with all legislation relating to the environment
- Eliminating or minimising all environmental risk
- Provide training in environmental practices as appropriate to the engineering scope of the practice
- Ensure that staff are aware of the environmental management plans of all major clients

All employees are responsible for:

- Encouraging other employees, contractors and members of the public to act in a way that minimises environmental risk
- Participating in relevant training
- Reporting breaches of environmental legislation to the relevant authority
- Identify environmentally sensitive issues at commencement of a project in the design phase
- Where applicable carry out risk analysis and identify means to reduce or eliminate potential environmental dangers
- Recommend to clients the engagement of specialist environmental professionals when environmental design issues are outside our capability
- Project drawings and specifications are to note environmental risks and design solutions where applicable. Specifications are to bring to Contractors attention their legal responsibility with regard to environmental matters
- Project management and engineering supervision procedures are to include the inspection of environmental design solutions incorporated in the project documents

Our goal is to have zero negative effect on the environment as a result of our services. This will only be achieved through the participation, co-operation and commitment of everyone at the workplace.

P.Osborn

Signed by: **ERIC PETER OSBORN**
Date: 1st July 2014

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