Guideline for the Valuation of Controlled Environment Contents

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Purpose

Research is a key part of the DNA of many Australian universities with research and innovation being an important driver of reputation. Research objectives rank highly in the strategic plans of most universities with research excellence contributing to the national and global ranking of the institution. Unfortunately, research losses are not uncommon, and the practicalities of research protection are not always a feature of operational plans.

This guideline is designed to assist researchers, technical officers, laboratory managers and risk and insurance officers to consistently value research projects and samples for the purpose of adequately insuring and physically protecting them. It is divided into five parts:

1. Principles of valuing research samples and projects.
2. Methods for valuing research projects and samples.
3. Types of Controlled Environments.
4. Common research risks and causes of Controlled Environment losses.
5. Best practice protection for research projects and samples stored in Controlled Environments.

The term “value” can be considered in three ways:

1. Intrinsic value – a “good” that has an unquantifiable monetary value.
2. Financial value – the cost to create something or the price someone is prepared to pay.
3. Insurable value – the cost to replace an item.

The intent of this guideline is to provide Members with practical tools to establish the **insurable value** of research samples, projects and animals. This will facilitate more accurate declarations of sums insured, help articulate the importance of the research and contribute to the development of business cases to improve physical protection.

Background

Unimutual has provided protection for research in all its forms for many years, including spoilage of samples in Temperature Controlled Environments, research projects generally and for animals and crops. Spoilage losses have been of concern for the past 10 years but particularly more recently given a spike in the frequency and quantum of largely avoidable losses. Not only have these losses occurred in temperature-controlled environments but there has been a discernible increase in losses in controlled environments generally including animal houses, aquaria and laboratories. These losses have arisen from a variety of causes and contributing factors; however, a common theme has been an apparent lack of consistently applied risk management processes and principles.

Research losses are of increasing concern in the loss experience of the mutual and are putting pressure on the retained layer, adversely impacting the risk profile of the Unimutual

portfolio and of some Members; to the extent that the Mutual's insurance and reinsurance partners have expressed concern and requested affirmative action to curb losses.

In response, the Mutual, without removing or limiting cover, has implemented a change in the wording around research losses to drive a risk management approach and culture by Members in an effort to not only reduce the frequency and severity of losses but more importantly to protect important research endeavours undertaken by the Members.

The key change involves a new section in the protection wording for Research Projects in which:

- Reference to Temperature Controlled Environments (TCEìs) has been removed from the wording.
- The term Controlled Environments (CEìs) is introduced ó This identifies and addresses the similarities regarding the exposures within any environment that has research conducted that requires a controlling mechanism. This could be oxygenated fish tanks, freezers/fridges, animal houses, greenhouses, rooms that must be kept a set temperature, dewars, etc. This is not as exhaustive list and if an environment requires a controlling mechanism, then it is captured by these changes.
- Two clearly defined terms in relation to controlled environments Mitigated and Non- Mitigated are included

For a Controlled Environment to be considered **mitigated** it must have:

1. A back to base alarm that is monitored 24 hours a day. The alarm must be capable of detecting a change in the environment and loss of power must be serviced to manufacturer specifications.
2. Back-up Power capable of providing power in the event of a loss of mains power to the environment. Back-up power must be serviced in accordance with manufacturer specifications.
3. The controlling mechanism, for example a minus 80-degree freezer, must be serviced to manufacturer specifications.
4. Valuation assessment in accordance with Unimutual Research Valuation Guidelines or a similar, approved methodology (this document).
5. A variation of the above that has been assessed and approved by
6. Unimutual and noted within the Memberìs wording. Where the Controlled Environment does not meet the criteria of points 1-4 or the variation pre agreed by Unimutual (point 5), it will be considered non-mitigated for the purpose of claims assessment.

Accompanying these wording changes are changes to limits:

For mitigated controlled environments the current limit will remain unchanged, which for most members is a combined Section 1 and Section 2 limit of $1,000,000 any one event or as defined in the property protection schedule. Consideration of higher limits, where required will continue to be given. This may incur additional mitigating features which will be considered on a case-by-case basis. Member retentions are to remain as current.

For non-mitigated controlled environments, the limit will reduce to that defined in the property protection schedule both for individual losses and for losses in the aggregate. There will be no consideration for higher limits or reinstatement of the aggregate limit. Member retention to remain at 50% of the loss in line with the current structure.

Principles of Valuing research

Determining the value of research samples for insurance purpose can be a complex task given the wide-ranging variety of research undertaken by Australian universities. Adopting the following 10 principles can assist to simplify the process. These principles are:

1. The nature of each research project is different
2. The value of samples cannot exceed the value of the projects total funding
3. There is administration costs associated with a research project
4. Primary samples must be collected or created.
5. Samples are analysed using many different techniques.
6. There are costs associated with lab space and the storage and maintenance of samples
7. Insurable value is a function of the time, effort and cost to replace samples
8. Samples do not increase in value over time
9. Not all samples can be replaced
10. Samples derived from multiple research projects may be kept in a single device or environment.

Understanding the nature of research

Some forms of research incur greater cost to undertake than others due either to that fact that collecting or making the samples can be difficult and sample preparation and analysis is both time consuming and expensive due to the nature of the chemicals, assays and equipment used. For simplicityìs sake, research that generate samples for Controlled Environment (CE) storage can be split into three broad categories including:

1. Medical samples
2. Biological samples
3. Plant, environmental and engineering samples.

Medical samples may be collected as a part of baseline or longitudinal human health studies, clinical trials, cancer or other human health research including infectious and lifestyle diseases. In some instances, these studies will involve the use of animals and involve the storage of primary tissue samples (human and animal), DNA, RNA, blood, urine and other samples.

Biological samples are mostly derived from non-human subjects in relation to the fields of biochemistry, cell biology, virology, bacteriology (infection and immunity) animal parasitology, and microbiology.

Plant, environmental and engineering samples are in general terms easier to obtain and may relate to a broad selection of research topics ranging to marine, estuarine and freshwater ecology and environmental biology wheat and barley breeding, grain

quality, potato production and supply, molecular plant pathology, transgenic plants, gene discovery and functional genomics

Sample value cannot exceed the value of combined grant funding or total investment

The total value of the combined grant/funding of a research project provides a strong indication of the likely cost of the samples generated. A rough indication of the costs expended on the generation of samples is in the order of 65% of the total grant funding.

Grant funding may involve contributions from a funding body such as the Australian Research Council (ARC) or the National Medical Health Research Council (NMHRC) and from corporate or philanthropic sources or funds contributed by the university. A research project will incorporate a range of costs and overheads including:

- Administrative costs
- Supplies and consumables
- Sample purchases and transport costs
- Staff costs
- Cost of animals
- Field research and travel costs
- Sample preparation and analysis
- Lab space and equipment costs
- Teaching relief costs
- Paper preparation

There is administration costs associated with a research project

Research projects incur administration costs at each stage of their life cycle; from grant funding submissions, establishing and discharging any contractual obligations, various research integrity requirements (ethics, governance and compliance), recording results and publishing research findings and papers. In some cases, there may be costs associated with obtaining permits from government bodies, landowners, traditional owners, councils and land councils.

Primary samples are collected or created

Primary or laboratory samples can be either collected or created. They are then subject to analysis and key elements of the sample extracted (for example DNA or RNA) which is then kept as a product of the research to support results and research outcomes (secondary or test samples). The maintenance of primary samples is important as they form the basis of material from which further examination or analysis can take place or in the event of a loss of analysed or secondary samples, may form the basis for sample recreation.

In the case of medical research, primary samples may include but not be limited to:

- Blood, urine, fingernail and hair samples
- Tissue samples

- Tumour samples; and,
- Various samples derived from clinical trials
- Tissue samples derived from animals
- Viruses and bacteria

In the case of biological research, primary samples may include but not be limited to:

- Plant, crop and seed samples (grown in controlled environments)
- Plant and seed samples collected
- Animal tissue and organ samples (grown in controlled environments)
- Various animal tissue and other samples collected in the field
- Viruses, bacteria and cells grown in a lab

In the case of environmental research, primary samples may include but not be limited to:

- Soil and rock samples
- Water samples
- Air filter samples
- Various land, lake and ocean samples
- Plant and algae samples

Sample preparation and analysis

Sample Preparation

Once samples have been collected, some form of preparation will be required so they can be readied for analysis. Sample preparation encompasses a wide range of techniques depending upon the nature of the sample.

The sample that arrives at the laboratory is commonly called the laboratory or primary sample. This is then converted by a set of operations to the test sample, from which a test portion is created for an analytical determination. If the test portion is a particulate solid, it may be necessary to convert it to a solution. If the analyte (i.e., the species being determined) is present at low concentration, or if interfering substances are present, it may be necessary to isolate or concentrate the analyte by one or more separation and purification steps. In some cases, additives are required to mask interference, or the analyte must be chemically converted to another form to facilitate its measurement.

Tissue samples must be preserved for future examination. In general terms there are four steps in tissue preparation:

1. Fixation stabilizes and preserves the tissue.
2. Embedding converts the tissue into a solid form which can be sliced ("sectioned").
3. Sectioning (slicing) provides the very thin specimens needed for microscopy.
4. Staining provides visual contrast and may help identify specific tissue components.

Blood samples may be simply aliquoted or îspunï into serum and plasma components and then aliquoted. Whatever the form of sample preparation, it will incur researcher time, lab time and consumable costs

Sample Analysis

Sample analysis can take many forms, one of the most common forms is the use of different assays for qualitatively assessing or quantitatively measuring the presence, amount, or functional activity of a target entity (the analyte). The analyte can be a drug, biochemical substance, or cell in an organism or organic sample. The measured entity is often called the analyte, the measurand, or the target of the assay. An assay usually aims to measure an analyte's intensive property and express it in the relevant measurement unit (e.g. molarity, density, functional activity in enzyme international units, degree of effect in comparison to a standard, etc.). If the assay involves exogenous reactants (the reagents), then their quantities are kept fixed (or in excess) so that the quantity and quality of the target are the only limiting factors. The difference in the assay outcome is used to deduce the unknown quality or quantity of the target in question. Some assays (e.g., biochemical assays) may be like chemical analysis and titration. However, assays typically involve biological material or phenomena that are intrinsically more complex in composition or behaviour, or both.

Assays are typically used to express DNA, RNA, proteins, for cell counting, viability, proliferation or cytotoxicity determinations, cellular secretions, virology, environmental contaminants and many other purposes.

Sample analysis may also involve the use of specialised equipment such as mass spectrometers and electron microscopes as well as many other types of equipment depending on the nature of the research.

Again, whatever the type of sample analysis, it will incur researcher time, lab time and consumable costs

Storage of samples and maintenance of Controlled Environments

Samples need to be stored from the moment they are made, collected or harvested. Medical and biological samples are stored in fridges freezers or dewars, whereas soil, seed and plant samples may be stored in rooms, albeit rooms where temperature and humidity are controlled. There is a cost for storage of samples irrespective of the mode of storage and these costs should be factored into the cost of a project.

For example, a minus 80 freezer has a capital cost of approximately $20,000 and a reasonable asset life of 10 years. The amortised cost is $2,000. Running costs will include electricity, general maintenance and replacement parts and could amount to as much as $400 per annum. On the basis of these estimates and assuming 6 research projects are kept in the freezer, the cost per research project per annum for storage would be $400.

Similarly, the capital cost of dewars varies depending on their size. Whilst only a canister they have ongoing operating costs associated with refilling of liquid or vapour phase nitrogen (the cooling agent). Rooms that are temperature and humidity controlled also have costs associated not only with the capital cost for dehumidifiers and air conditioning but also an annual per metre rate for the use of floor space.

Some controlled environments such as animal houses are specifically designed environments which are expensive to establish and operate. Other controlled environments (in some case laboratories) are used to conduct experiments or undertake projects and incur a benchtop rate.

Insurable value is a function of what can be replaced

Whilst research projects have an intrinsic or broader îmoral value or goodï, they are made up of elements, each of which has a cost associated with it, therefore, a monetary value can reasonably be assigned. This is supported by the fact the all research is funded from one source or other grants from the ARC, NMHRC, other government body, the university, philanthropic sources or by industry.

Ideally, grant applications document the detailed cost of each element that constitute grant funds applied for. Should research samples associated with a research project be damaged, spoilt or lost, in most cases, these can be replaced. Replacement will incur administration costs, consumable costs and researcher/staff time and effort. Each of these elements can be quantified and represent the îinsurable valueï of the research.

Samples do not increase in monetary value over time, but some become more intrinsically valuable

Unlike real estate, the value of research samples does not necessarily increase in monetary value over time other than for consumer price index increases for wages and consumable items, should they need to be recreated; that is not to say that they may not become more intrinsically valuable for research purposes.

The value of research samples, after they have been analysed and the research paper has been written is, in some respects, a vexed issue. In general terms, they will have little value if kept for records purposes only, however instances where they will become îmore intrinsically valuableï over time may include:

- Where the samples can be either analysed further or are crucial as part of another research project
- Historic samples are part of a base line or longitudinal study, or
- Part of a remote community health study; or
- New analysis techniques mean that further and better data can be extracted from primary or secondary (laboratory or test samples).

Whilst such samples may have an increased intrinsic value on the basis that they may not be able to be collected or created again, do they have an insurable value? Most probably not unless they can be replaced.

Not all samples can be replaced

As mentioned in the previous section, not all samples can be replaced, particularly those taken from donors as part of a baseline or longitudinal study which commenced 20 years ago, and the sample donor is no longer alive. Some samples may be unique and there is only one in existence. These samples may be considered invaluable or

priceless and, in some instances, may not be insurable. Take for example, the Mona Lisa, it is considered priceless and is not insured.

Notwithstanding this, unique or priceless samples should at least be given a nominal value that reflects their uniqueness or criticality and can help to justify risk mitigation measures necessary to ensure their protection

More than one research project will be kept in a CE

Controlled environment storage space, particularly minus-80 freezers, generally have very high utilisation rates and space tends to be îat a premiumï. It is not uncommon to see freezers full and housing up to six different research projects, some of which may be active and some archived. Generally, the projects will be of a similar type or nature, as the freezers are largely populated with samples from the same school or research group.

From a content valuation perspective, this can cause some difficulties, particularly if detailed sample inventories have not been maintained, which is often the case. Laboratory technicians will have an îideaï of the nature of the research and samples but without individual researcher input, it may be difficult to assign a precise value.

To address this common problem, a series of costing guides have been developed to assist the valuation process. Further detail is provided in the next section.

Maintaining detailed sample inventories (including cost per sample to establish) is the recommended strategy to overcome this all too common problem. There are several proprietary products available which can be used to record controlled environment contents.

Valuation Tools

Valuing a Research Project

In general terms, research projects costs are detailed in a research grant proposal or submission. Recording in detail, the steps and costs associated with each element of the project, assists to more clearly identify the costs associated with those steps and ultimately, the creation of samples. Further, should research be lost, it facilitates a better understanding of the cost of sample recreation.

A detailed costing calculator is provided in **Appendix 1**. It is designed to assist the user to identify and cost all the elements of a research project which contribute to sample creation which include:

- Administrative costs
- Supplies and consumables
- Sample purchases and transport costs
- Staff costs
- Cost of animals
- Field research and travel costs
- Sample preparation and analysis

- Lab space and equipment costs

The 65% Method

A method for îestimatingï the cost of samples generated by a project is known as the **65% rule**. Put simply, the cost of producing samples is approximately 65% of the total cost of a research grant, the other 35% being consumed by administrative, compliance and paper writing costs.

The formula is:

$value of grant x 0.65 = $value of samples

The Time and Consumables Method

A further îestimatingï method is the **time and consumables method**. In broad terms, it involves the lead researcher estimating the amount of time (in years or months) to re-establish lost samples based on the wages costs of research assistants to undertake the required work and the cost of any consumables.

The formula is:

Number of Research Assistants x $ cost per annum + $ value of consumables = Cost to re- establish samples.

Valuing the Contents of an already full Controlled Environment

It is not uncommon to see freezers full and housing samples from multiple research projects, some of which may be active and some archived. Generally, the projects will be of a similar type or nature, as the freezers are populated with samples from the same school or research group.

From a content valuation perspective, this can cause some difficulties, particularly if detailed sample inventories have not been maintained, which is often the case. Laboratory technicians will have an îideaï of the nature of the research and samples but without individual researcher input, it may be difficult to assign a precise value.

In a pragmatic attempt to overcome îthe full unrecorded freezer syndromeï, the guides in Appendices 2 ó 7 contain costing matrices which consider the:

- The nature of the research (medical, biological or environment/engineering),
- The sample capacity of the freezer/controlled environment,
- The percentage of capacity currently utilised.

Instruction for the use of each costing guide is provided in the relevant guide.

Valuing Research Animals

Animals are an important part of the research puzzle, used primarily for medical research purposes but also for the study of populations and preservation of species

diversity. Research animals may include, but not be limited to rats and mice, rabbits and guinea pigs, lizards, fish and other marine organisms. Valuation of primates has not been included in this guideline.

The elements to consider when valuing animals include the costs associated with:

- Amortised cost of construction or per metre floor space rental,
- Purchasing or collecting animals,
- Treatments or interventions,
- Food, bedding and general agistment,
- Staff and husbandry,
- Researcher time,
- Laboratory and storage costs.

Rats and Mice

The term transgenic animal refers to an animal in which there has been a deliberate modification of the genome, the material responsible for inherited characteristics as opposed to spontaneous mutation. Transgenic rats and mice may have a range of human or non-human genes (DNA) inserted into their genome.

Pro-nuclear DNA microinjection is the oldest and most common method for mammalian transgenic creation. A solution of the transgene is injected into fertilized eggs with a micro syringe under a microscope. These microinjected eggs are then transplanted in a surrogate mother. At birth the newborn are tested for the transgene detection. After these tests, the positive animals (founders) are crossed to obtain the F1 and F2 generations (transgenic rat line).

Rats and mice are kept in purpose-built controlled environments or to a lesser extent, in locations which have been repurposed. The elements of the environments which are controlled

include temperature, humidity and light cycles. Husbandry aspects of managing rats and mice involve feeding and watering, changing bedding and cleaning and monitoring environmental conditions and the equipment which controls those conditions.

A costing sheet for mice is provided in **Appendix 7.**

Lizards

Lizards and snakes are used for a range of environmental based research projects from the impacts of climate change to behavioural and evolutionary ecology. Lizards and snakes are kept in terrariums under controlled temperature, light and humidity conditions with temperature being one of the most important environmental controls. Husbandry aspects of managing lizards involve feeding and watering, periodic terrarium cleaning and monitoring of environmental conditions and the equipment which controls those conditions.

In general terms, lizards and snakes are relatively expensive to maintain and breed because individuals require larger areas than rats, mice or fish.

A costing sheet for lizards is provided in **Appendix 8.**

Fish

Fish and marine organisms are commonly used for a range of medical, environmental, biological and ecological studies. The zebrafish is an important and widely used vertebrate model organism in scientific research, for example in drug development. They are also notable for their regenerative abilities and have been modified by researchers to produce many transgenic strains. They are generally hardy but can be susceptible to significant changes in water temperature and quality. Large numbers of fish can be kept in a single tank.

Native fish are more often used for ecological research, breeding and repopulation purposes. Many native freshwater fish are already considered extinct, endangered or seriously threatened with over 50% of freshwater species considered îunder threatï. Research efforts are focussed on identifying genetic characteristics, reproductive cycle enablers and captive breeding. Due to small numbers of îwildï populations and difficulties associated with breeding, native fish tend to be more valuable îper headï in a research or captive breeding environment.

The key environmental controls for fish include water temperature, oxygen content and water quality. Equipment which maintains environmental controls include, pumps, heaters, filters and aerators.

Costing sheets for zebrafish and native fish are provided in **Appendices 9 and 10** respectively.

Types of Controlled Environments

Dewars ó Cryostorage or Cryopreservation

Cryo-preservation or cryo-conservation is a process where organelles, cells, tissues, extracellular matrix, organs, or any other biological constructs susceptible to damage caused by unregulated chemical kinetics are preserved by cooling to very low temperatures (typically −80

±C using solid carbon dioxide or −196 ±C using liquid or vapour phase nitrogen). At low enough temperatures, any enzymatic or chemical activity which might cause damage to the biological material in question is effectively stopped. Cryopreservation methods seek to reach low temperatures without causing additional damage caused by the formation of ice crystals during freezing.

Minus-80 Freezers ó ULT Freezers

An Ultra-Low Temperature Freezer otherwise known as a ULT Freezer, a minus 80 freezer or a Minus 86 freezer, is a freezer capable of operating at extremely low temperatures. Operating freezers at an ultralow temperature takes a lot of energy and hence Ultra-Low temperature freezers have features such as thick insulation and additional inner doors to save on energy and to stop the cold air from escaping when the main door is opened. ULT freezers are typically used in research, medical and

clinical and laboratory environments for the long-term storage of biological samples such as DNA, RNA, proteins, cell extracts and reagents.

Minus 20/30 Freezers

Minus 20±C and minus 30±C laboratory freezers accommodate a variety of capacities, space challenged environments, samples and applications ranging from routine to complex. They can be either upright or chest freezers and are used to store samples that do not require ultra-cold storage, as well as a range of consumables. Items typically stored in minus 20 and 30 freezers include reagents, pharmaceuticals, biologicals, primers, siRNA molecules, foetal bovine serum and enzymes as examples.

Walk-in Freezers and Fridges

As the name suggests, walk-in freezers (minus 20 degrees) and fridges (4 degrees) are larger versions of the upright or chest models and vary in size depending upon the available space and the material to be stored. There are used to store a variety of different samples including medical, biological and environmental samples. They are also commonly used to store chemical, particularly those compounds which may be volatile at room temperatures.

Fridges

Fridges are often used in laboratories to store consumables including chemicals, buffers and kits and well as samples that will be subject to analysis. The contents tend to be more transient as fridges tend to be used for îoperationalï purposes, rather than for long term storage.

Animal Houses

Animal houses tend to be purpose-built facilities in which animals ranging from rats, mice, guinea pigs, rabbits, fish and other aquatic animals to lizards and snakes are kept. These facilities are contained, controlled environments in which temperature, humidity and light cycles are controlled and where animals are generally kept in cages, pods or tanks. The value of the animals will depend upon several variables such as the size of the facilities, the nature of the animals and research being undertaken, and the extent of breeding and genetic modification conducted. The main costs beside the cost to construct the facility will include purchase of animals, genetic intervention, husbandry costs (food, water, cleaning and bedding), utilities (power and water) and the cost of maintaining mechanical plant to control the environments.

Growth Rooms and Chambers

Plant growth chambers come in varying shapes and sizes and provides control over temperature, light and humidity for agricultural biotechnology, phytopathology, entomology and other plant science research. Naturally, experimental parameters will vary from project to project depending on the nature of the research being undertaken. Equipment that controls the environment within the growth chamber includes variable lighting controllers, heaters and air conditioning units, water spray nozzles and pumps, CO2 injectors and air-cooled condensers. The environment is monitored by a series of

probes connected to a control panel at which each environmental variable can be modified.

Glasshouses and Greenhouses

Glasshouses are typical much larger than growth chambers and are used for large scale plant growth experiments. Again, temperature, light, humidity and carbon dioxide concentrations are controlled. In general, they are PC 1 (Physical Containment) environments but can be rated to PC2 standards for experiments that involve quarantine and genetically modified material. They are typically evaporatively air-cooled and centrally heated to achieve tight temperature control. Equipment that controls the environment within the greenhouse includes heaters and air conditioning units, water spray nozzles and pumps, CO2 injectors and air condensers. The environment is monitored by a series of probes connected to a control panel at which each environmental variable can be modified.

Incubators

An incubator is a device used to grow and maintain microbiological cultures or cell cultures. The incubator maintains optimal temperature, humidity and other conditions such as the CO2 and oxygen content of the atmosphere inside. Incubators are essential for a lot of experimental work in cell biology, microbiology and molecular biology and are used to culture both bacterial and eukaryotic cells.

The simplest incubators are insulated boxes with an adjustable heater, typically going up to 60 to 65 ±C (140 to 150 ±F), though some can go slightly higher (generally to no more than 100

±C). The most used temperature both for bacteria such as the frequently used E. coli as well as for mammalian cells is approximately 37 ±C (99 ±F), as these organisms grow well under such conditions. For other organisms used in biological experiments, such as the budding yeast Saccharomyces cerevisiae, a growth temperature of 30 ±C (86 ±F) is optimal.

More elaborate incubators can also include the ability to lower the temperature (via refrigeration), or the ability to control humidity or CO2 levels. This is important in the cultivation of mammalian cells, where the relative humidity is typically >80% to prevent evaporation and a slightly acidic pH is achieved by maintaining a CO2 level of 5%.

Aquaria

Aquaria are tanks, bowls, or other water-filled enclosures in which living fish or other aquatic animals and plants are kept. Aquatic animals used for research will fall into the categories of finfish, molluscs or crustaceans. Depending upon their natural habitat they will require varying environmental conditions such as specific water temperature, salinity, oxygen content and turbidity or water clarity. Equipment controlling these environmental variables include, pumps, water heaters, filters, aerators and chemical dosing units.

Terrariums

A terrarium (plural: terraria or terrariums) is usually a sealable glass container containing soil and plants and can be opened for maintenance to access the plants inside. From a research perspective, terrariums are mostly used to house animals (usually terrestrial reptiles, amphibians and invertebrates). The key environmental controls are temperature and light.

Temperature can be centrally controlled by the building Heating, Cooling and Ventilation (HVAC) system and supplemented by a combination of local split systems and heat lights/lamps. Light cycles are controlled by timing switches.

Insectaries

Insectaries are sealed and contained environments where insects are kept, bred and observed. The type of insects will vary widely depending upon the nature of the research and may include but are not limited to flies and fruit flies, mosquitoes, beetles, and butterflies. The key environmental controls include temperature, humidity, light and oxygen content.

Herbaria

Herbaria are used to store collections of preserved plant specimens and associated data used for scientific study. The specimens may be whole plants or plant parts; these will usually be in dried form mounted on a sheet of paper (called "exsiccate") but depending upon the material, may also be stored in boxes or kept in alcohol or other preservatives. The specimens in herbaria are often used as reference material in describing plant taxa; some specimens may be types.

The environment in herbaria is controlled both for temperature and humidity where a combination of HVAC, split system air conditioners and dehumidifiers are used. High humidity can lead to mould growth on specimens and as well as insect activity, both of which can cause significant damage to specimens.

Seed Stores

Seeds are commonly stored in a variety of locations where temperature and humidity are controlled within defined parameters. Some seed stores are purpose-built facilities but in the context of a university setting, many seed stores are repurposed rooms. The environmental conditions that are controlled are temperature, humidity and light. Should seed stores be too hot humid or light, there is a risk of seeds becoming unviable or potentially seed germinating.

Laboratories

A laboratory is a facility that provides controlled environmental conditions in which scientific or technological research, experiments, and measurement are be performed. They can consist of discrete areas such as wet lab, dry lab and office areas.

Due to the nature of processes undertaken in laboratories, the environmental conditions may need to be carefully considered and controlled using a cleanroom or

pressure control (PC) system. Labs will have a variety of environmental controls ranging from pressure, temperature and amount and nature of light. On-bench experiments, such as growth of bacteria or other organisms can be very light and temperature sensitive. In general terms, temperature in laboratories is control by the building heating, cooling and ventilation (HVAC) system, which is turn controlled by the building management system (BMS). A failure in either of these systems can result in losses of on-bench experiments.

Common Risks and Causes of Controlled Environment Losses

Controlled environments rely on three fundamental operational components:

1. Electrical power;
2. Mechanical/electrical systems; and
3. Human intervention and oversight.

Without power, the environmental controls cannot be established or maintained as the mechanical and electrical systems cannot operate. A single point of failure in either mechanical or electrical systems can render the environmental controls inoperable as can human errors during general operation and minor maintenance.

The risks to effective and ongoing control of the variables in controlled environments used for research purposes, can be divided into two categories:

1. Physical risks (hard and hardware aspects),
2. Human element risks (soft and procedural).

Physical risks

Physical risks relate to the îhard and hardwareï components of controlled environments which could lead to loss of power or result in machinery breakdown. The following is a summary of potential causes of physical risks.

Mains Power

Loss of mains power could occur due to an issue with the energy supplierìs distribution network such as a failure within a local substation or transformer or an on-campus transformer failure

Dirty Power

Dirty Power is the term given to fluctuations is the quality of power supplied which can cause brown outs, power spikes and surges resulting in both equipment failure and tripping of electrical circuits. In extreme cases, this can result in damage to high value equipment, HVAC systems failing, freezers containing valuable samples being left without power and Building Management Systems failing.

Circuit Failure

The risk of local power supply failure increases significantly if electrical circuits are overloaded. Localised power failures can typically occur for one of the following reasons:

a. Devices connected to a circuit are drawing too much power causing the circuit to overheat and the circuit-breaker to trip,
b. A îshort-circuitï occurs due to an electrical fault in an item of equipment causing the circuit breaker to trip,

A power surge which involves the incoming voltage rising significantly above the normal supply voltage causes the main breaker to trip resulting in no power being supplied from the affected switchboard.

Voltage rating

The voltage rating of some models of freezer can also lead to failure of firmware which controls the logic function of the freezer. This occurs where the voltage of the power delivered is greater than the maximum design voltage the device.

Equipment Breakdown

Equipment breakdown can occur in all machinery used to regulate or control an environment including but not limited to chillers, boilers, HVAC, freezers, fridges, pumps, fans, valves, seals and compressors.

Ice

Icing of freezers and environments where a negative temperature is required presents risks such as damage to seals, latches, shelf doors and other components. It also is a self- perpetuating problem; seals become increasingly ineffective as more ice develops, ice acts as an insulator between the freezer coils and contents, putting strain on mechanical components such as compressors which are required to work harder to maintain the required temperature, potentially leading to compressor failure.

Human Element risks

Human element risks involve both procedural matters and human error during interaction with controlled environments. Human error is one of the most common causes of spoilage losses. Typical human errors include but are not limited to:

- Failing to close the doors properly,
- Leaving doors open,
- Inadvertently removing the wrong plug from the power outlet,
- Bumping the plug from the power outlet,
- Cleaners and contractors removing plugs and not replacing them,
- Not responding to alarms due to alarm fatigue,
- Setting temperature alarms at inappropriate temperatures,
- Not reconnecting freezers to the BMS or monitoring system after a move.

Policies and Standard Operating Procedures (SOPs)

A lack of procedural and instructional documentation potentially leads to inconsistent use and maintenance of controlled environments. New staff may not be familiar with the CE models in use and revert to îhow they always did thingsï. Clear instructional

documentation can assist to ensure a consistent approach to CE use and maintenance.

Placement and location of freezers

Minus 80 freezers generate significant heat under normal operating conditions and placing numerous freezers in a room that is not adequately air conditioned can cause mechanical components of the freezers to overheat resulting in sub-optimal performance. If left unaddressed this can place additional stress on the compressors, eventually contributing to their failure.

Placing freezers in locations other than dedicated freezer rooms or laboratories presents a range of risks from cleaners removing and not replacing plugs and accidental or inadvertent opening of the freezers. Locating freezers in corridors and other common, highly trafficked areas should be avoided.

Procurement

Uncontrolled procurement of freezers particularly minus 20 freezers and fridge freezers can present hidden risks. Some models of domestic fridge freezers have an automatic defrost cycle which could adversely impact the integrity of samples as a result of automatic defrosting. Also, some minus 80 may not comply with relevant Australian Standard, particularly in relation to their voltage rating. A formal procurement specification will assist to minimise these and other risks.

Contractor Management

Contractors such as trades people, cleaners, technicians and others not familiar with the conduct of research can pose significant risk to samples and research stored in controlled environments. The most common issue is the removal of CE power plugs from general power outlets (GPOs), using the GPO for power tools or vacuum cleaners and not replacing the CE power plug.

Maintenance regimes and clean outs

Freezers will fail, it is not a matter of if rather than when. Icing of freezers presents one of the most common risks resulting in damage to seals, doors not closing properly and added stress on the mechanical parts of the freezer. Ice acts as an insulator between the freezer coils and contents compounding stress on the mechanical parts of the freezer. Regular de-icing and annual defrosting are important to ensure ongoing optimal performance. It is recommended that freezers be serviced every six months by a reputable company.

Regular cleans out of surplus samples increases available sample capacity and emergency storage capacity. Racks and boxes should not block grills, vents or obstruct airflow. Where there are empty shelves these should be filled with polystyrene ice boxes to assist to maintain the thermal mass inside the freezer as much of the energy spent by the freezer is used to cool air after a door opening.

Best practice protection

Physical Improvements

OP1 Install standalone monitoring and alarming system in the form of an automatic dialler or SMS sender as a back up to the BMS monitoring system, particularly for minus 80 freezers and those minus 20 freezer containing high value samples. This system should contact staff directly should there be a loss of power or change in temperature. The staff list should comprise at least 3 people and be reviewed at the beginning of every trimester or semester, or when a nominated staff member is on leave or not able to respond to an alarm.

OP2 Alarm circuits should be on a maintenance testing programme to verify the successful transmission of alarm signals to automatic diallers or SMS senders, and to ensure environmental sensors within CEs are appropriately calibrated.

OP3 Alarms should be connected to emergency power or have adequate battery back up to ensure they continue to work in the event of an extended power outage.

OP5 Consider installing temperature probes and SMS alarming on all minus 20 freezers containing high value active research samples.

OP5 Ensure that temperature settings on alarms permit enough time for a successful response but are set such that constant alarms do not de-sensitise users.

OP6 Power requirements for all CEs should be reviewed against the available backup generator supply at least every six months.

OP7 The CE power plugs should be inspected every six months to ensure they are fully inserted into a red power socket (connected to a backup generator) and ideally have captive plugs installed (for both mains and emergency supplies).

OP8 Where there is fluctuating quality of power to the site, consider either

a. the installation of Automatic Voltage Regulators (AVR) on critical minus 80 freezers to ensure supply of consistent voltage or
b. the use of a UPS battery bank at the point of delivery to ensure the supply of consistent voltage.

OP9 Investigate the practicality of either limiting the number of freezers on any given circuit and where possible upgrade the electrical circuits such that individual critical CEs are supplied by dedicated electrical circuits.

OP10 Where there are many CEs on a single electrical circuit(s), consider installing an alarm at the main switchboard capable of notifying a loss of power to a circuit(s).

OP11 The power supply to the unit at local distribution boards and in the main electrical switch room should be marked as supplying critical environmental units and must not be isolated without the express approval of the unit owner and the building Facilities Manager.

OP12 Include walk-in freezers and fridges and temperature-controlled rooms on a preventative maintenance schedule focussing on compressors, motors and fans.

OP13 Understand how emergency backup power is supplied to controlled environments.

Request generator or other backup power testing logs from Building Facilities Manager or responsible person.

OP14 Consider storing copies of critical samples off site in a geographically diverse location. This could be as a reciprocal arrangement with another university or institute, or with a third-party service (e.g. Cryosite, CellBank Australia).

Human Element Improvements

OP15 Develop a university-wide policy and procedure (or guidance material) for the management and protection of CEs and research samples which addresses matters including but not limited to maintenance requirements and cycles, procurement standards, monitoring and alarming, provision of emergency back-up power and the use of sample inventory software.

OP16 Mandate the use of sample inventory software (freezer works) to ensure that sample records are regularly updated including type, location and value.

OP17 Establish formal procurement guidelines for the purchase of CEs which addresses îend- of-lifeï and equipment standards.

OP18 Develop a staged replacement program for all CE's.

OP19 Establish a formal protocol and programmed maintenance schedule for CEs including the clean out of redundant samples, regular de-icing and annual defrosting of freezers.

OP20 Consider installing temperature monitoring probes connected to an alarm into minus 20 freezers containing high value samples and contents.

OP21 Maintain a central log of below excess spoilage losses.

OP22 Split high value samples between CEs in order that not all samples are lost should a CE fail.

OP23 Include controlled environment awareness as an item in contractor inductions.

Appendix 1 – Research Project Cost Calculator

Section 1 – Administration Costs				
Item	**Comments/Observation**	**Units/Hours**	**Rate $**	**Value/Cost $**
Preparation of a grant funding proposal	Proposition, outcomes, methods and costs			
Obtaining required permits	May involve permits to enter enclosed or restricted lands or permits to import certain products goods and products			
Contractual matters	Must contracts or agreements be prepared			
Ethics and governance submissions	Submissions to human and animal research ethics and governance committees involve researcher time to prepare			
Are there costs involved with securing financial or political support for grant funding?	Reports, submissions, meetings and interviews			
Research compliance requirements	Must compliance reports or submission be prepared			
Documenting results	Time to document results			
Preparing the research paper	Time to prepare a peer reviewed paper			
		Cost	**$**	

Section 2 - Items to be Purchased				
Item	Details	Units/Hours	Rate $	Value/Cost $
What reagents and other chemicals are required • Reagents • Chemicals • Buffers • Enzymes • Assays	Type and Volumes - - -			
What supplies, consumables or specialised equipment will need to be purchased in order to collect or analysis samples or specimens? These may include but not be limited to items such as collection jars, vials, pipettes, etc	List - - - - -			
Can samples be purchased from another researcher or supplier? For example, specific knock out mice, specialised cell lines or other items	Sample type and Number/Volume - - -			
Is there a cost for the purchase of a specific licence for quarantine purposes or use of GMOs or for other reasons?	Type of licence required			
Are the transport costs for purchased samples?	Local, National, International Shipping			
		Cost	**$**	

Section 3 - Items to be Made				
Item	Comments/Observation/	Units/Hours	Rate	Value/Cost $
What items need to be specifically made to undertake the research – such as plasmas, organisms, compounds, other items	Item and Volume or Number - - -			
Are there any other specific costs associated with importing or transporting materials or equipment to make samples?				
		Cost	**$**	

Section 4 - Animals to be bred				
Item	Comments/Observation/	Units/Hours	Rate	Value/Cost $
Will animals need to be purchased or bred to create a specific gene characteristic for the research?	Type of animal and number of animals - - -			
Are there quarantine costs involved?	Describe			
Are there costs associated with additional housing requirements or modifications?	Explain the nature of the modifications or additional costs - -			
		Cost	**$**	

Section 5 - Sample collection or Field Work				
Item	**Comments/Observation/**	**Units/Hours**	**Rate**	**Value/Cost $**
What are the transport costs associated with gaining access to access field locations?	Airline tickets Hire Cars Fuel costs Camping/Equipment Hire Provision of meals Specialised equipment Research or transport vessel			
What staff costs will be incurred to collect samples in the field?	Number of junior staff Number of senior staff Students			
Are there any outsourcing costs to collect samples?	Contractor or third-party costs			
			Cost	**$**

Section 6 - Preparation and Analysis of Samples				
Item	**Comments/Observation/**	**Units/Hours**	**Rate**	**Value/Cost $**
How many staff hours are required to prepare samples?	Number of staff Hours per staff member			
How many staff hours are required to analyse the samples?	Number of staff Hours per staff member			
Are there any outsourcing costs associated with preparing samples?	Describe:			
Are there any additional laboratory equipment purchases associated with preparing or analysing the samples?	Describe:			
Are there any additional hiring, leasing or usage fees associated with preparing or analysing the samples?	Describe:			
Are there any other costs associated with preparing or analysing samples?	Describe:			
		Cost	**$**	

Section 1	Administration Costs	$
Section 2	Items to be Purchased	$
Section 3	Items to be Remade	$
Section 4	Animals to be re-established	$
Section 5	Sample collection or Field Work	$
Section 6	Preparation and Analysis of Samples	$
	Grand Total	$

Appendix 2 – Minus 80 Freezer Contents Costing Guide

1. Identify the sample capacity of the ULT freezer in which the samples are stored
2. Identify the nature of the samples either Medical, Biological or Plant, Environmental/Engineering samples.
3. If the samples are extremely difficult to replace or remake – select High
4. If most of the samples can reasonably be replaced or remade – select Average
5. If the samples can be easily replaced or remade – select Low
6. Estimate the percentage of total freezer space occupied by samples (somewhere between 0 – 100%)
7. Multiple the value of your selection (steps 2 to 5) by a figure between 0.1 and 1.0 to obtain an estimate of the value of the freezer contents.
8. Where you consider the value of the freezer contents to be greater than the largest number in the table below, you should submit that number with an explanation of the rationale for the value submitted and detail of protection in place (alarming, back-up power etc).

Note: You can use a number other than one contained in the matrix below if you have already formally determined the value of the freezer contents.

Maximum Sample Capacity of the Minus 80 freezer	**Medical Samples** Baseline or longitudinal human health studies, clinical trials, cancer or other human health research human (cancer research, infectious diseases etc) involving the storage of primary tissue samples, DNA and RNA.			**Biological Samples** Primary samples derived from non-human subjects. Not limited to the fields of, biochemistry, cell biology, virology, bacteriology (infection and immunity) animal parasitology, microbiology veterinary science.			**Plant, Environmental/Engineering samples** Plant microbiology, marine, estuarine and freshwater ecology and environmental biology wheat and barley breeding, grain quality, potato production and supply, molecular plant pathology, transgenic plants, gene discovery and functional genomics.		
	Lower	Average	High	Lower	Average	High	Lower	Average	High
24,000	495K	840K	1.2M	480K	720K	960K	240K	480K	840K
32,000	660K	1.12M	1.6M	640K	960K	1.28M	320K	640K	1.12M
40,000	825K	1.4M	2M	800K	1.2M	1.6M	400K	800K	1.4M
60,000	1.24M	2.1M	3M	1.2M	1.8M	2.4M	600K	1.2M	2.1M

Appendix 3 – Minus 20 and 30 Freezer Contents Costing Guide

1. Identify the size (L) and type of the freezer in which the samples are stored.
2. Identify the nature of the samples either Medical, Biological or Plant, Environmental/Engineering samples.
3. If the samples and consumables are extremely difficult to replace or remake – select High.
4. If most of the samples and consumables can reasonably be replaced or remade – select Average.
5. If the samples and consumables can be easily replaced or remade – select Low.
6. Estimate the percentage of total freezer space occupied by samples (somewhere between 0 – 100%).
7. Multiple the value of your selection (steps 2 to 5) by a figure between 0.1 and 1.0 to obtain an estimate of the value of the freezer contents.
8. Where you consider the value of the freezer contents to be greater than the largest number in the table below, you should submit that number with an explanation of the rationale for the value submitted and detail of protection in place (alarming, back-up power etc).

Note: You can use a number other than one contained in the matrix below if you have already formally determined the value of the freezer contents.

Size (Litres) of the Minus 20 or 30 freezer	**Medical Samples** Storage of samples or in lab working samples such as DNA, human muscle or organ samples, chemicals, assay kits.			**Biological Samples** Animal based samples across the fields of marine, and freshwater ecology, cell biology, virology, animal parasitology, veterinary science, plus chemicals and assay kits			**Plant, Environmental/Engineering samples** Plant samples including molecular plant pathology, transgenic plants, gene discovery and functional plant genomics, plus chemicals and assay kits.		
	Lower	Average	High	Lower	Average	High	Lower	Average	High
100-120 L Under bench	10K	20K	50K	10K	20K	50K	10K	20K	50K
300L Upright	50K	200K	500K	50K	150K	500K	20K	100K	250K
700L Chest	200K	700K	1.5M	100K	500K	1M	50K	200K	500K

Appendix 4 – Liquid Nitrogen and Vapour Phase Dewars - Contents Costing Guide

1. Identify the sample capacity (closest option) of the Dewar in which the samples are stored.
2. Identify the nature of the samples as either:
    a. Combination of ATCC cell lines, cell line extensions, collected primary samples,
    b. Primary samples and derived cell lines collected from local specimens or from clinical trials,
    c. Semen and other AI or reproductive material for agricultural, animal breeding and veterinary practices.
3. Estimate the percentage of Dewar space occupied (somewhere between 0 – 100%).
4. Multiple the value of your selection by a figure between 0.1 and 1.0 to obtain an estimate of the value of the Dewar contents.
5. Where you consider the value of the Dewar contents to be greater than the largest number in the table below, you should submit that number with an explanation of the rationale for the value submitted. (**Refer to comments over page on caution required when valuing Dewar contents**).

Note: You can use a number other than one contained in the matrix below if you have already formally determined the value of the freezer contents.

Dewar straw and vial capacity – assume 1.2 and 2ml vials	**5100 Straws HC20**	**8500 Straws HC35**	**2000 MVE Cryosystem**	**6000 MVE Cryosystem**	**16,000 MVE 815P**	**20,000 MVE 800**	**42,000 MVE 1500**	**80,000 MVE 1979P**	**94,500 MVE 1800**
Combination ATCC cell lines, extensions and primary samples ($300/vial)	-	-	600,000	1,800,000	4,800,000	6,000,000	12,600,000	24,000,000	28,200,000
Primary samples collected from local specimens or clinical trials, cells lines and related extensions ($100)	-	-	200,000	600,000	1,600,000	2,000,000	4,200,000	8,000,000	9,450,000
Semen and other AI and reproductive material	255,000	425,000	-	-	-	-	-	-	-

Appendix 5 – Refrigerators and Fridge/Freezers - Contents Costing Guide

1. Identify the size of the fridge or fridge freezer.
2. Identify the nature of the contents.
3. If the samples and consumables are very difficult to replace or remake – select High.
4. If most of the samples and consumables can reasonably be replaced or remade – select Average.
5. If the samples and consumables can be easily replaced or remade – select Lower.
6. Where you consider the value of the refrigerator or fridge/freezer contents to be greater than the largest number in the table below, you should submit that number with an explanation of the rationale for the value submitted.

Note: You can use a number other than one contained in the matrix below if you have already formally determined the value of the freezer contents.

Refrigerator Type and Size	Bar Fridge 80-120 Litres			Upright fridges 170-400 Litres			Commercial glass door Fridges (Skope and similar)			Fridge/freezers 300-440 Litres		
	Lower	Average	High	Lower	Average	High	Lower	Average	High	Lower	Average	High
Working samples, kits, chemicals, plates, other consumables	2K	10K	20K	10K	30K	100K	10K	30K	100K	20K	60K	200K
Stored samples, kits, chemicals, plates, other consumables	2K	10K	30K	10K	50K	120K	10K	50K	120K	50K	100K	250K
Chemicals, kits	1K	5K	10K	10K	30K	80K	10K	30K	80K	10K	30K	100K

Appendix 6 – Walk-in Fridges and Freezers - Contents Costing Guide

1. Identify the volume of the walk-in fridge or freezer (either less than or greater than > 16m^3) in which material is stored.
2. Identify the nature of the samples either medical/biological, plant/environmental/engineering samples or chemicals.
3. If the samples are extremely difficult to replace or remake – select High.
4. If most of the samples can reasonably be replaced or remade – select Average.
5. If the samples can be easily replaced or remade – select Low.
6. Estimate the percentage of the total capacity occupied by samples (somewhere between 0 – 100%).
7. Multiple the value of your selection (in steps 2 to 5) by a figure between 0.1 and 1.0 to obtain an estimate of the value of the freezer contents.
8. Where you consider the value of the freezer contents to be greater than the largest number in the table below, you should submit that number with an explanation of the rationale for the value submitted and detail of protection in place (alarming, back-up power etc).

Note: You can use a number other than one contained in the matrix below if you have already formally determined the value of the TCE contents.

Size of the Walk-in fridge or freezer	**Medical and Biological Samples** Samples, reagents, chemicals, primary muscle and tissue etc			**Plant, Environmental/Engineering samples** Soil, rocks, seeds, plant material, water samples, fruit flies, fungi, plates and			**Chemicals** Various chemicals required to be kept under cold storage. (Values may vary significantly)		
	Lower	Average	High	Lower	Average	High	Lower	Average	High
Walk-in Fridge <16m3	20K	80K	150K	10K	50K	100K	10K	30K	80K
Walk-in Fridge >16m3	30K	100K	200K	20K	80K	150K	20K	50K	150K
Walk-in Freezer <16m3	50K	200K	500K	30K	100K	200K	10K	30K	80K
Walk-in Freezer >16m3	100K	400K	1M	50K	150K	300K	20K	50K	150K
Warm room	20K	50K	100K	50K	200K	350K	-	-	-

Appendix 7 – Mouse Valuation Criteria

Item	Capital Cost	Operating life	Annualised Cost	Per Mouse Cost	Comments
Mouse house construction OR	Say $20M	50 years	$400K	$20/mouse	Based on 20,000 mice
Floor space rental $/m2			$-		
Capacity (Total # of mice)	20,000				Numbers of mice will vary year to year
Colonising mice (1,000)	50,000			$50	Cost to purchase
Staff costs			$625K	$32	5 full time staff @$125k p.a. including on costs
Food and bedding costs			$250K	$13	Type of food and bedding
Utility costs			50K	$10	Power and water
Researchers wages cost			$1.5M	$75	10 researchers at $150,000 per annum
Lab costs			100K	$5	$1K/m2 assume 1000m2 per annum
Total				**$205**	These costs will vary from location to location. This figure does not include specific genetic interventions

Appendix 8 – Lizard Valuation Criteria

Item	Capital Cost	Operating life	Annualised Cost	Per Lizard Cost	Comments
Lizard House construction and fit out Costs OR	Say $5M	50 years	$100K	$280	Number of lizards 360 Lizards – 5 species Include enclosures
Floor space rental $/m2			$-	$-	
Lizard Collection costs	$150K			$415	Collected or Purchased One off cost
Staff costs			$500K	$1,390	4 full time staff @$125k p.a. including on costs
Food			$50K	$140	Insects and “other”
Utility costs			$50K	$140	Power and water
Researchers wages cost	$1M		$333K	$2,780	Based on wages component of the grant over 3 years
Per Lizard Cost for 360 Lizards and research replacement cost				**$5,145**	**$1,852,200**

Appendix 9 – Aquarium Valuation Criteria (Zebra Fish)

Item	Capital Cost	Operating life	Annualised Cost	Per Fish Cost	Comments
Aquarium construction costs	Say $20M	50	$400K	$	Not used in this example
Floor space rental $/m2			$650,000	$3.60	650m2 @ $1000/m2
Tanks, Pumps filters	$150,000	10	$15,000	$0.08	$30/tank x 500 tanks plus sand filters and pumps
Fish collection or purchase costs			-	$	No fish required
Staff costs			$500,000	$2.70	Staff time (4 full-time staff @ $125k p.a. including on costs)
Food and consumables			$60,000	$0.30	Food and chemical costs
Utility costs			$100,000	$0.55	Power and Water, Heating and Cooling
Researchers wages cost			$1,400,000	$7.80	5 groups – 4 assistants per group @ $40K ea, 1 lead researcher @$150k per group
Lab costs			$300,000	$1.67	300m2 @$1000/m2
180,000 Zebra Fish - Per Fish Cost and Research replacement cost				**$16.70**	**$3,006,000**

Appendix 10 – Aquarium Valuation Criteria (Native Fish)

Item	Capital Cost	Operating life	Annualised Cost	Per Fish Cost	Comments
Aquarium construction costs	Say $300K	10	$30,000K	$30	Will vary upon size and construction
Floor space rent $/m2			$	$	
Tanks, Pumps filters	$8,000	10	$800	$0.80	$100/tank x 80 serviced tanks incl filters and pumps
Fish collection or purchase costs			$ -	$ -	Included in researcher time below
Staff costs			$72,800	$72.80	Staff time ($1,400 per week part time pro rata)
Food and consumables			$2,600	$2.60	$50/week
Utility costs			$5,000	$5.00	Power and Water
Researchers wages cost			$312,000	$312.00	40hrs/week@$150/hr x52 weeks
Lab costs			$-	$-	
1,000 native fish - Per Fish Cost and Research replacement cost				**$423.20**	**$423,200**

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