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Benefit Cost Analysis of Wine Australia R&D Investments 2021-22 – Strategy 3, 4, and 5

Report

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Australian Government
Wine Australia

Wine Australia for Australian Wine

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Executive Summary

Economic analyses of four research and development (R&D) projects funded by Wine Australia has been undertaken. The main purpose was to demonstrate the outcomes and benefits that have emerged or are likely to emerge from investment. This forms part of the process for the Council of Rural Research & Development Corporations (CRRDC) that aims to demonstrate the impact, effectiveness and return on investment from the Rural Research and Development Corporations. Wine Australia is funded by statutory levies paid by industry participants, with matching funding provided by the Australian Government up to 0.5 per cent of the industry's gross value of production.

Each of the four analyses provides a description of the constituent projects including objectives, outputs, activities, costs, outcomes, and benefits. Benefits are described qualitatively according to their contribution to the triple bottom line of economic, environmental, and social benefits. While a range of potential benefits of each project are identified, the analysis focused on the most likely and most significant benefit stream. A number of potential benefits therefore remained unquantified and hence the estimated net benefits of some projects may be considered conservative. The analyses were undertaken for total benefits and Wine Australia benefits, including those expected in the future as a result of the investment.

Investment in all four projects yielded positive results at a 5% discount rate and a 30 year analysis period.

Table ES1: Benefit Cost Analyses Four Wine Australia R&D Investments 2021-22 (discount rate 5%)

Investment Criteria	Investment Project			
	Collecting and disseminating information on agrochemicals (AWR 1701-1.5.1)	**Low and no-alcohol (NOLO) wine products – understanding technical and sensory related challenges and opportunities (AER 1701-3.1.1)**	**Bioprospecting Australian microbial genetic diversity (AWR 1701-4.4.3)**	**Putting microbial diversity to work in shaping wine style (AWR 1701-3.2.1)**
Benefit–cost ratio	1.85	4.00	2.43	1.28
Benefit-cost ratio range - core assumption sensitivity	0.93 to 2.78	1.96 to 9.96	1.32 to 4.7	0.70 to 2.49
Quantified benefits	Avoided cost of market closure due to failure to meet revised agrochemical residue limits,	The potential for additional profitable sales of wine-like NOLO products than would otherwise have occurred.	A potential increase in Australian wine value with high quality wild-ferments and distinct inoculated ferments that express regional terroir.	A potential future increase in the value of some Australian wine with a share of winemakers adopting commercial versions of the new yeasts developed by the project.
Unquantified benefits	Grapes and wine with lower agrochemical residues enhancing blending opportunities and winemaker profit.	Wine Australia research efficiencies with better targeted NOLO investment.	Capacity – increased research capacity with 18,000 wine yeast isolates catalogued. Catalogued isolates will facilitate further genomic research on yeast.	Potential future improvements in fermentation efficiency with some winemakers adopting commercial versions of the new yeasts developed by the project.

	Increased winegrape grower productivity with access to new agrochemicals.	potential reduction in production risk for wine grape growers and winemakers with development of new wine products.	Capacity – increased capacity in AWRI and industry in understanding and managing wild-wine ferments.	Capacity - additional wine yeast isolates that will facilitate further yeast genomics research.
	Minimization of chemical residues on-farm.	Protection of the industry's social licence to operate with additional development of products that benefit consumer health.	Additional profitable sales of wild and unique Australian wine will generate income, and employment benefits in regional Australia (spill-over impact).	Capacity - additional AWRI staff skills in genetics, CRISPR, and yeast breeding.
		Capacity – increased capacity in AWRI and industry in the assessment of NOLOs and the creation of wine-like NOLO products.		Additional profitable sales of unique Australian wine will generate income, and employment benefits in regional Australia (spill-over impact).
	Additional profitable wine sales in the absence of market closures will generate income, and employment in regional Australia (spill-over impact).	Improved health outcomes for Australian wine consumers with increased consumption of wine-like NOLO products (e.g., improved sleep).		
		Additional profitable sales of wine-like NOLO product will generate income, and employment benefits in regional Australia (spill-over impact).		

Comparisons between project results should be made with caution due to uncertainties involved with assumptions and differing frameworks for each of the analyses.

Technical Summary

This report presents the results of economic analyses of investments within the R&D Program of Wine Australia Strategy 3, 4, and 5. The Program is funded by statutory levies paid by industry participants, with matching funding provided by the Australian Government up to 0.5 per cent of the industry's gross value of production.

The main purpose of undertaking the analyses was to demonstrate the outcomes and benefits that have emerged or are likely to emerge from investments. This forms part of the process for the Council of Rural Research & Development Corporations (CRRDC) that aims to demonstrate the impact, effectiveness and return on investment of the Rural Research and Development Corporations.

Wine Australia provided AgEconPlus with a list of the completed projects which the analyst numbered 1 to 32. An online random number generator was used to select projects. The results of random project selection is shown in Table 1.

Table 1 Projects Randomly Selected for Benefit Cost Analysis 2021-22

Code	Project Title	Investment
AWR 1701-1.5.1	Collecting and disseminating information on agrochemicals.	656,584
AWR 1701-3.1.1	Low and no-alcohol wine products-understanding technical and sensory related challenges and opportunities.	404,471
AWR 1701-4.4.3	Bioprospecting Australian microbial genetic diversity.	1,716,775
AWR 1701-3.2.1	Putting microbial diversity to work in shaping wine style.	1,994,923
	Investment in projects for analysis	4,772,753
	Total of Wine Australia investment in completed projects	37,676,331
	Analysis projects share of total investment	13%

Documentation for each of these projects was assembled with assistance from Wine Australia personnel and included project plans, progress reports, and final reports. Each of the analyses provides a description of the constituent projects including objectives, outputs, activities, costs, outcomes, and benefits. Benefits are described qualitatively according to their contribution to the triple bottom line of economic, environmental, and social benefits. While a range of potential benefits of each project are identified, the analysis focused on the most likely and most significant benefit stream. A number of potential benefits therefore remained unquantified and hence the estimated net benefit of some projects may be considered conservative.

Benefit cost analysis was conducted on the four projects to generate investment criteria. The Present Value of Benefits (PVB) and Present Value of Costs (PVC) were used to estimate investment criteria of Net Present Value and Benefit-Cost Ratio (BCR) at a discount rate of 5%. The Internal Rate of Return and Modified Internal Rate of Return were also estimated from the annual net cash flows. The PVB and PVC are the sums of the discounted streams of benefits and costs. All dollar costs and benefits were expressed in 2022 dollar terms. Future costs and benefits were discounted to the 2022 year while past costs were inflated to 2022 using the Gross Domestic Product deflator. A 30-year benefit time frame was used in all analyses, with benefits estimated for 30 years from the year of last investment in each project. Costs for the R&D projects included cash contributions (includes both Wine Australia and industry investment), as well as any other resources contributed by third parties (e.g., researchers or additional industry funds). Investment criteria were reported for 5-year intervals of benefits from zero to 30 years.

The analyses were undertaken for total benefits, including benefits expected in the future as a result of the investment. A degree of conservatism was used when finalising assumptions.

Sensitivity analysis was undertaken for several assumptions that had the greatest degree of uncertainty or for those that were seen to be key drivers of the investment criteria.

Table 2 presents the investment criteria for each of the projects analysed at a 5% discount rate and expressed in 2022 dollar terms. Given the assumptions made for each evaluation, all four investments are expected to produce positive net benefits over 30 years from the last year of investment.

Table 2: Benefit Cost Analyses for Four Wine Australia R&D Investments 2021-22 (discount rate 5%)

Investment Criteria	Investment Project			
	Collecting and disseminating information on agrochemicals (AWR 1701-1.5.1)	**Low and no-alcohol (NOLO) wine products – understanding technical and sensory related challenges and opportunities (AER 1701-3.1.1)**	**Bioprospecting Australian microbial genetic diversity (AWR 1701-4.4.3)**	**Putting microbial diversity to work in shaping wine style (AWR 1701-3.2.1)**
Benefit–cost ratio	1.85	4.00	2.438	1.28
Benefit-cost ratio range - core assumption sensitivity	0.93 to 2.78	1.96 to 9.96	1.32 to 4.7	0.70 to 2.49
Quantified benefits	Avoided cost of market closure due to failure to meet revised agrochemical residue limits,	The potential for additional profitable sales of wine-like NOLO products than would otherwise have occurred.	A potential increase in Australian wine value with high quality wild-ferments and distinct inoculated ferments that express regional terroir.	A potential future increase in the value of some Australian wine with a share of winemakers adopting commercial versions of the new yeasts developed by the project.
Unquantified benefits	Grapes and wine with lower agrochemical residues enhancing blending opportunities and winemaker profit.	Wine Australia research efficiencies with better targeted NOLO investment.	Capacity – increased research capacity with 18,000 wine yeast isolates catalogued. Catalogued isolates will facilitate further genomic research on yeast.	Potential future improvements in fermentation efficiency with some winemakers adopting commercial versions of the new yeasts developed by the project.
	Increased winegrape grower productivity with access to new agrochemicals.	potential reduction in production risk for wine grape growers and winemakers with development of new wine products.	Capacity – increased capacity in AWRI and industry in understanding and managing wild-wine ferments.	Capacity - additional wine yeast isolates that will facilitate further yeast genomics research.
	Minimization of chemical residues on-farm.	Protection of the industry's social licence to operate with additional development of products that	Additional profitable sales of wild and unique Australian wine will generate income, and employment benefits	Capacity - additional AWRI staff skills in genetics, CRISPR, and yeast breeding.

		benefit consumer health.	in regional Australia (spill-over impact).	
		Capacity – increased capacity in AWRI and industry in the assessment of NOLOs and the creation of wine-like NOLO products.		Additional profitable sales of unique Australian wine will generate income, and employment benefits in regional Australia (spill-over impact).
	Additional profitable wine sales in the absence of market closures will generate income, and employment in regional Australia (spill-over impact).	Improved health outcomes for Australian wine consumers with increased consumption of wine-like NOLO products (e.g., improved sleep).		
		Additional profitable sales of wine-like NOLO product will generate income, and employment benefits in regional Australia (spill-over impact).		

1. Introduction

This report presents the results of economic analyses of investments within the R&D Program of Wine Australia Strategy 3,4, and 5. The Program is funded by statutory levies paid by industry participants, with matching funding provided by the Australian Government up to 0.5 per cent of the industry's gross value of production.

The main purpose of undertaking the analyses was to demonstrate the outcomes and benefits that have emerged or are likely to emerge from investments made in the program. This forms part of the process for the Council of Rural Research & Development Corporations (CRRDC) that aims to demonstrate the impact, effectiveness and return on investment from the Rural Research and Development Corporations.

Four R&D projects were randomly selected by AgEconPlus for evaluation.

Ascertaining the extent of benefits that have accrued as a result of the program investment can demonstrate to stakeholders such as levy payers, the impact of research investment. In addition, it can inform Wine Australia management regarding program performance from past investment decisions as well as for future allocation of program resources.

A summary of methods used in the analysis is provided in Section 2, including the process of project selection and the steps involved with individual benefit evaluation. Section 3 reports a summary of the benefits and of the investment criteria estimated for the four projects. A brief conclusion is provided in Section 4. Appendices 1 to 4 provide the detailed analyses for each of the projects.

2. Materials and Methods

2.1 Projects for Evaluation

Wine Australia provided AgEconPlus with a list of the completed projects which the analyst numbered 1 to 8. An online random number generator was used to select four projects. The results of random project selection are shown in Table 2.1.

Table 2.1 Projects Randomly Selected for Benefit Cost Analysis 2021-22

Code	Project Title	Investment
AWR 1701-1.5.1	Collecting and disseminating information on agrochemicals.	656,584
AWR 1701-3.1.1	Low and no-alcohol wine products-understanding technical and sensory related challenges and opportunities.	404,471
AWR 1701-4.4.3	Bioprospecting Australian microbial genetic diversity.	1,716,775
AWR 1701-3.2.1	Putting microbial diversity to work in shaping wine style.	1,994,923
	Investment in projects for analysis	4,772,753
	Total of Wine Australia investment in completed projects	37,676,331
	Analysis projects share of total investment	13%

2.2 Individual Analyses

Each investment was evaluated through the following steps:

1. Information from the original project plan, progress reports, and final report or other relevant reports and material was assembled with assistance from Wine Australia.
2. An initial description of the project background, rationale, objectives, activities, outputs and expected outcomes and impacts was drafted.
3. Initial drafts were forwarded to project principal investigators, members of any project steering committees, industry representatives, and Wine Australia personnel for comment.
4. Initial drafts were modified in light of stakeholder feedback.
5. Further information was assembled where appropriate, including from contact with industry representatives, and the quantitative analysis undertaken.
6. Some analyses proceeded through several drafts, both internally within the project team as well as externally via Wine Australia personnel and others.
7. Final drafts were passed to Wine Australia personnel for comment.

The potential benefits from each investment were identified and described in a triple bottom line context. The value of some of these benefits was then quantified.

The factors that drive the investment criteria for R&D include:

- The cost of the R&D.
- The magnitude of the net benefit per unit of production affected; this net benefit per unit also takes into account the costs of implementation.
- The quantity of production affected by the R&D, in turn a function of the size of the target audience or area, and the level of initial and maximum adoption ultimately expected, and level of adoption in the intervening years.
- The discount rate.
- The time elapsed between the R&D investment and commencement of the accrual of benefits.
- The time taken from first adoption to maximum adoption.
- An attribution factor can apply when the specific project or investment being considered is only one of several pieces of research or activity that has contributed to the outcome being evaluated.

It is also necessary when quantifying benefits to define a 'without R&D' scenario, referred to as the 'counterfactual'. The counterfactual usually lies somewhere between the *status quo* or business as usual case and the more extreme positions that the research would have happened anyway but at a later time; or the benefit would have been delivered anyway through another mechanism. The important issue is that the definition of the counterfactual scenario is made as consistently as possible between analyses.

Benefit cost analysis was conducted on all projects to generate investment criteria. The Present Value of Benefits (PVB) and Present Value of Costs (PVC) were used to estimate investment criteria of Net Present Value and Benefit-Cost Ratio (BCR) at a discount rate of 5%. The Internal Rate of Return and Modified Internal Rate of Return were also estimated from the annual net cash flows. The PVB and PVC are the sums of the discounted streams of benefits and costs. All dollar costs and benefits were expressed in 2022 dollar terms. Future costs and benefits were discounted to the 2022 year while past costs were inflated to 2022 using the Gross Domestic Product deflator. A 30-year benefit time frame was used in all analyses, with benefits estimated for 30 years from the year of last capital investment in each project. Costs for the R&D projects included the cash contributions of the Project (includes both Wine Australia and industry investment), as well as any other resources contributed by third parties (e.g., researchers or additional industry funds). Investment criteria were reported for 5-year intervals of benefits from zero to 30 years.

The analyses were undertaken for total benefits, including benefits expected in the future as a result of the investment. A degree of conservatism was used when finalising assumptions.

Sensitivity analysis was undertaken for several assumptions that had the greatest degree of uncertainty or for those that were seen to be key drivers of the investment criteria.
Some identified benefits were not quantified mainly due to:

- A suspected, weak, or uncertain scientific or causal relationship between the research investment and the actual R&D outcomes and associated benefits; and/or
- The magnitude of the value of the benefit was thought to be only minor.

3. Summary of Results

3.1 Qualitative Results

Table 3.1 identifies the benefits from investment in each of the projects. Each benefit is categorised as economic, environmental, or social.

Table 3.1: Summary of Benefits for the Four Projects

Project	Benefits
Collecting and disseminating information on agrochemicals (AWR 1701-1.5.1)	Economic • Avoided cost of market closure due to failure to meet revised agrochemical residue limits, • Grapes and wine with lower agrochemical residues enhancing blending opportunities and winemaker profit. • Increased winegrape grower productivity with access to new agrochemicals. Environmental • Minimization of chemical residues on-farm. Social • Additional profitable wine sales in the absence of market closures will generate income, and employment in regional Australia (spill-over impact).
Low and no-alcohol wine products – understanding technical and sensory related challenges and opportunities (AER 1701-3.1.1)	Economic • The potential for additional profitable sales of wine-like NOLO products than would otherwise have occurred. • Wine Australia research efficiencies with better targeted NOLO investment. • Protection of the industry's social licence to operate with additional development of products that benefit consumer health. Environmental • Nil. Social • Social – improved health outcomes for Australian wine consumers with increased consumption of wine-like NOLO products (e.g., improved sleep). • Additional profitable sales of wine-like NOLO product will generate income, and employment benefits in regional Australia (spill-over impact).
Bioprospecting Australian microbial genetic diversity (AWR 1701-4.4.3)	Economic • A potential increase in Australian wine value with high quality wild-ferments and distinct inoculated ferments that express regional terroir. Environmental • Nil. Social • Capacity – increased research capacity with 18,000 wine yeast isolates catalogued. Catalogued isolates will facilitate further genomic research on yeast. • Additional profitable sales of wild and unique Australian wine will generate income, and employment benefits in regional Australia (spill-over impact).

Putting microbial diversity to work in shaping wine style (AWR 1701-3.2.1)	Economic • Potential future increase in the value of some Australian wine with a share of winemakers adopting commercial versions of the new yeasts developed by the project. • Potential future improvements in fermentation efficiency with some winemakers adopting commercial versions of the new yeasts developed by the project. Environmental • Nil. Social • Capacity - additional wine yeast isolates that will facilitate further yeast genomics research. • Capacity - additional AWRI staff skills in genetics, CRISPR, and yeast breeding. • Additional profitable sales of unique Australian wine will generate income, and employment benefits in regional Australia (spill-over impact).

3.2 Quantitative Results

The investment criteria calculated for each research area were the Net Present Value (NPV), the Benefit Cost Ratio (B/C Ratio), the Internal Rate of Return (IRR) and the Modified IRR (MIRR). The NPV is the difference between the Present Value of Benefits (PVB) and the Present Value of Costs (PVC). Present values are the sum of discounted streams of benefits and/or costs. The B/C Ratio is the ratio of the PVB to the PVC. The IRR is the discount rate that would equate the PVB and the PVC, thus making the NPV zero and the B/C Ratio 1:1. The MIRR is the same as the IRR but assumes that the reinvestment rate is the same as the assumed discount rate i.e. 5%, rather than the level of the estimated IRR.

Table 3.2 presents the investment criteria for each of the project investments analysed at a 5% discount rate.

Further details on each of these investments and the associated results are provided in the individual project reports (Appendices 1 to 4).

Table 3.2: Investment Criteria for Four Wine Australia Investments (discount rate 5%, 30 years from last year of investment)

Investment Criteria	Investment Project			
	Collecting and disseminating information on agrochemicals (AWR 1701-1.5.1)	**Low and no-alcohol wine products – understanding technical and sensory related challenges and opportunities (AER 1701-3.1.1)**	**Bioprospecting Australian microbial genetic diversity (AWR 1701-4.4.3)**	**Putting microbial diversity to work in shaping wine style (AWR 1701-3.2.1)**
Present value of benefits ($m)	1.98	4.00	5.93	3.54
Present value of costs ($m)	1.07	0.55	2.44	2.77
Net present value ($m)	0.91	1.65	3.49	0.78
Benefit–cost ratio	1.85	4.00	2.43	1.28
Benefit-cost ratio range - core assumption sensitivity	0.93 to 2.78	1.96 to 9.96	1.32 to 4.7	0.70 to 2.49
Internal rate of return (%)	180.6	16.0	14.0	7.3
Modified internal rate of return (%)	10.9	10.0	8.2	5.9

4. Conclusion

All four investment analyses yielded positive results at the 5% discount rate, with B/C Ratios of 1.85, 4.00, 2.43, and 1.28.

The results from the analyses are dependent on the assumptions made, which in places are uncertain. Assumptions and frameworks could be refined in the future as research outputs are realised, to improve the overall analysis. Comparisons between project results should be made with caution due to uncertainties involved in assumptions and differing frameworks for each of the four analyses.

Appendix 1: Economic Analysis of Wine Australia's Investment in Collecting and Disseminating Information on Agrochemicals

1. Background

Since 1993, AWRI has provided regulatory and technical advice on agrochemicals and Maximum Residue Limits (MRLs) to grape and wine producers. AWRI has researched, collected, and disseminated up-to-date information on agrochemicals, formulated restrictions for grapes destined for export wine and tabulated MRLs set by Australia's major export markets.

This project was to continue to provide information to enable producers to make informed decisions regarding agrochemicals in order to avoid potential barriers to international trade and, in the process, maintain Australia's "clean and green" image.

Agrochemicals are essential for the management of insect pests, fungal diseases, weeds, and the regulation of plant growth. Countries regulate the use of agrochemicals to maintain the health of consumers and the environment. Information on agrochemicals requires constant updating. New chemicals are placed on the market and new information becomes available about the safety of existing chemicals. Agrochemical residues can also be used as a barrier to international trade in agricultural products including wine.

2. Summary of Projects

Table 2.1 provides a description of the project in a logical framework.

Table 2.1 Project Description

AWR 1701-1.5.1: Collecting and Disseminating Information on Agrochemicals	
Project Details	Research Organisation: Australian Wine Research Institute (AWRI) Period: July 2017 to June 2022 Principal Investigator: Marcel Essling
Rationale	Up-to-date information on agrochemicals and market requirements ensures ongoing access to markets for Australian wine, the safety of consumers, and the natural environment. Accurate and timely information is needed on regulatory and technical aspects of chemicals registered for use in viticulture and the MRL requirements of those chemicals in export markets.
Objectives	This project, together with other industry activities, was to ensure: • Technical barriers to international trade are identified and managed to the satisfaction of stakeholders. • The registration process for key agrochemicals for use in viticulture is supported.
Activities and Outputs	• Review of Australian Pesticides and Veterinary Medicines Authority (APVMA) Gazettes to identify new agrochemicals registered for winegrapes along with changes to existing registrations. • Source information on new registrations of agrochemicals from chemical companies and incorporate this information into the project database. • Examples of new product registrations made during the project include cyflumetofen for use against grapevine mites, and polyoxin D for use against Botrytis and powdery mildew. The new active ingredient *Aureobasidium pullulans* was registered as a bio-pesticide. APVMA provided permits for use of fipronil baits for the control of European wasps and methiocarb for the control of snails. The new insecticide abamectin + chlorantraniliprole was made available for viticulture. • Preparation of up-to-date lists of registered agrochemicals for viticulture with documentation of recommended withholding periods for grapes intended for use in the production of export wines. • Collation of additional details about the "actives" in agrochemical products and recording this information in the project database. • Recorded information was made available to industry via hard copy, searchable online format, and a mobile phone app. • Preparation of updates for new international MRLs and changes in social and environmental expectations for communication to industry. Examples of MRL changes included a decline in tolerance for chlorpyrifos in Japan and a relaxation of withholding periods for dimethomorph and fenpyrazamine if their use was restricted to one application per season. The project worked with the Agrochemical Reference Group to review the status of Group M3 fungicides and recommended a maximum of 3 applications per season. • Issue of e-Bulletins as required about changes in registration and MRLs and report implications to industry and the Agrochemical Reference Group. • Maintain communication with chemical manufacturers and suppliers and develop tools with the chemical industry to facilitate the collection of information about agrochemical products.

	• Work with industry bodies to prioritise and secure funding for new Minor Use Chemical Permits for use in winegrape production. • Engage with regional viticulture associations and other stakeholder groups to gain further insight into spray program trends and make recommendations to ensure international MRLs are met. • Project outputs included e-Bulletins on significant changes in agrochemical requirements, annual updates of the booklet: Agrochemicals Registered for Use in Australian Viticulture (the "Dog Book"), updates of the MRL database, update of the online search facility; and the web- and mobile-based extension platforms. Electronic updates were supplied within the required two weeks of a change in agrochemical or MRL requirements. • The project also produced a project plan and nine progress reports.
Outcomes	• Accurate, adequate, and timely information on agrochemicals communicated to industry to minimize the risk of loss of export markets, environmental damage, and adverse impacts on human health. As a consequence, industry was able to respond to agrochemical and MRL issues and make informed production and marketing decisions. • Registration of new chemicals for use in winegrape growing to enhance industry productivity without risking access to Australian wine markets.
Impacts	• Economic – avoided cost of market closure due to failure to meet revised agrochemical residue limits. • Economic – grapes and wine with lower agrochemical residues enhancing the flexibility of wine production in terms of increasing blending opportunities. • Economic - opportunity to facilitate evidence-based public policy using up-to-date science. • Economic - increased winegrape growing productivity with the registration of new, more effective agrochemicals. • Environmental – minimization of chemical residues on-farm with the potential to avoid adverse impacts on biodiversity and water catchments. • Health – regulatory compliance on agrochemicals with wine consumers less likely to be exposed to harmful residues. • Social – additional profitable wine sales in the absence of market closures will generate income, and employment benefits in regional Australia (spill-over impact).

3. Match with National Priorities

Table 3.1 Australian Government Research Priorities

Australian Government Strategies and Priorities	
National Science and Research Priorities[1]	**National Agricultural Innovation Priorities[2]**
1. Food – optimising food and fibre production and processing; agricultural productivity and supply chains within Australia and global markets. **2. Soil and Water** – improving the use of soils and water resources, both terrestrial and marine. **3. Transport** – boosting Australian transportation: securing capability and capacity to move essential commodities; alternative fuels; lowering emissions. **4. Cybersecurity** – improving cybersecurity for individuals, businesses, government, and national infrastructure. **5. Energy and Resources** – supporting the development of reliable, low cost, sustainable energy supplies and enhancing the long-term viability of Australia's resources industries. **6. Manufacturing** – supporting the development of high value and innovative manufacturing industries in Australia. **7. Environmental Change** – mitigating, managing or adapting to changes in the environment. **8. Health** – improving the health outcomes for all Australians.	On 11 October 2021, the National Agricultural Innovation Policy Statement was released. It highlights four long-term priorities for Australia's agricultural innovation system to address by 2030. These priorities replace the Australian Government's Rural Research, Development and Extension Priorities which were published in the 2015 Agricultural Competitiveness White Paper. **1.** Australia is a trusted exporter of premium food and agricultural products by 2030. **2.** Australia will champion climate resilience to increase the productivity, profitability, and sustainability of the agricultural sector by 2030. **3.** Australia is a world leader in preventing and rapidly responding to significant incursions of pests and diseases through futureproofing our biosecurity system by 2030. **4.** Australia is a mature adopter, developer, and exporter of digital agriculture by 2030.

The Wine Australia project has addressed National Science/Research Priority 1 and potentially Priority 8. The major focus of the project has been on the first of the National Agricultural Innovation Priorities.

4. Identification of Potential Costs and Benefits

4.1 Costs

4.1.1 R&D Investment

The R&D investment costs comprised:

- Direct financial outlays by Wine Australia, the project funding body. These costs include both project and overhead expenditures.
- In-kind contributions to the research project – non-cash contributions made by the research partner (AWRI).
- In-kind contributions to the research project – time associated with meetings between the researchers and Wine Australia and a larger group of project collaborators – grape and wine producers serving on the Agrochemical Reference Group, APVMA, Crop Life Australia (representing the agrochemical industry), and Australian Grape and Wine.

4.1.2 Administration

No additional administration costs were identified.

[1] See: 2015 Australian Government Science and Research Priorities. https://www.industry.gov.au/data-and-publications/science-and-research-priorities

[2] See: 2021 National Agriculture Innovation Policy Statement. https://www.awe.gov.au/agriculture-land/farm-food-drought/innovation/research_and_development_corporations_and_companies#government-priorities-for-investment

4.1.3 Extension
Extension costs such as communication of project outputs to grape growers and winemakers were included in the project budget.

4.1.4 Adoption
No incremental additional adoption costs have been identified. Grape growers will incur costs making the transition from current practice to accommodate changes in MRLs, but this is part of the base case counterfactual and would have occurred regardless of the benefits realised from the project.

4.2 Benefits
4.2.1 Research Output and Impact Pathway
The key output from the project is a risk identification process to manage and respond to changed agrochemical residue requirements for Australian wine in export markets.

The impact pathway for the project is:

1. Up-to-date information on regulatory and technical aspects of agrochemicals registered for use in Australia viticulture plus MRLs assembled through this project (AWR 1701-1.5.1).
2. AWR 1701-1.5.1 communicates up-to-date chemical information to growers through the "Dog book", website, e-Bulletins, and mobile phone app.
3. Growers respond to regulatory, technical, and MRL data and produce grapes that are "fit for purpose" ensuring ongoing market access, health, and environmental benefits.

4.2.2 Triple Bottom Line Benefits
A summary of potential benefits from the project in triple bottom line categories is shown in Table 4.1.

Table 4.1 Triple Bottom Line Categories Benefits from Project Investment

Levy Paying Industry	**Spillovers**		
	Other Industries	**Public**	**Foreign**
Economic Benefits			
Avoided cost of market closure due to failure to meet revised agrochemical residue limits. Grapes and wine with lower agrochemical residues enhancing blending opportunities and winemaker profit. Increased winegrape grower productivity with access to new agrochemicals.	Nil.	Avoided costs associated with any forced change from agrochemical MRL self-regulation to legislated and compulsory compliance.	Wine consumers in overseas markets less likely to be exposed to harmful chemicals.
Environmental Benefits			
Minimization of chemical residues on-farm.	Nil.	Minimization of chemical residues downstream with the potential to adversely impact biodiversity and water catchments.	Nil.

Social Benefits			
Additional profitable wine sales in the absence of market closures will generate income, and employment benefits in regional Australia (spill-over impact).	Nil.	Regulatory compliance on agrochemicals with wine consumers less likely to be exposed to harmful residues.	Nil.

4.2.3 Public versus Private Benefits

Most benefits generated by this project will be private in nature. Private benefits will include avoided market closure, additional blending opportunities for winemakers, and improved productivity associated with new agrochemicals. Public benefits will include minimisation of chemicals in the environment and the potential for improved health outcomes.

4.2.4 Distribution of Benefits along the Supply Chain

The benefits to the wine industry from investment in this project will be shared along the supply chain with wine grape growers, winemakers, and exporters all sharing some of the benefits.

4.2.5 Benefits to other Primary Industries

No benefits to other primary industries were identified. Market access protocols and regulations are product specific and in this case focus on wine.

4.2.6 Benefits Overseas

Wine consumers in domestic and overseas markets less likely to be exposed to harmful chemicals.

4.3 Summary of Costs and Benefits

A summary of principal categories of costs and benefits from the project is shown in Table 4.2.

Table 4.2 Incremental Cost and Benefit Categories

Costs	Benefits
R&D investment costs (cash and in-kind) incurred by Wine Australia and AWRI as well as project administration costs.	Avoided cost of market closure due to failure to meet revised agrochemical residue limits.
Overhead costs including time associated with meetings between the researchers, Wine Australia and collaborating organisations.	Grapes and juice with lower agrochemical residues enhancing blending opportunities and winemaker profit.
	Increased winegrape growing productivity with the registration of new, more effective agrochemicals.
	Minimization of chemical residues on-farm with the potential to avoid adverse impacts on biodiversity and water catchments.
	Additional profitable wine sales in the absence of market closures will generate income, and employment benefits in regional Australia (spill-over impact).

5. Valuation of Costs and Benefits

5.1 Costs

5.1.1 R&D Investment Costs including Administration

The following table shows annual investment in the project by Wine Australia (Table 5.1).

Table 5.1 Investment by Wine Australia in the Project for Years Ending June 2018 to June 2022

Project Code	2018	2019	2020	2021	2022	Total
AWR 1701-1.5.1 – Wine Australia	117,328	109,185	130,474	125,431	174,166	**656,584**
Total	117,328	109,185	130,474	125,431	174,166	**656,584**

Source: Wine Australia record of project expenditure

The other investor in AWR 1701-1.5.1 was AWRI. Data is not available on AWRI contributions to individual Wine Australia projects (Mara Khem, RD&A Administrator, Wine Australia, written communication, December 2022). However, in 2021/22 AWRI invested a total of $893,389 in thirty-four Wine Australia projects at an average investment of $26,276 per project and this per project average has been applied to each year of the AWR 1701-1.5.1 investment (Table 5.2).

Table 5.2 Investment by Others in the Project for Years Ending June 2018 to June 2022

Project Code	2018	2019	2020	2021	2022	Total
AWR 1701-4.4.3 – Wine Australia	26,276	26,276	26,276	26,276	26,276	**131,380**
Total	**26,276**	**26,276**	**26,276**	**26,276**	**26,276**	**131,380**

Source: AgEconPlus estimate

Table 5.3 provides the total investment by year for both sources.

Table 5.3 Annual Investment in the Project (nominal $)

Year Ending 30 June	Wine Australia	Others	Total
2018	117,328	26,276	**143,604**
2019	109,185	26,276	**135,461**
2020	130,474	26,276	**156,750**
2021	125,431	26,276	**151,707**
2022	174,431	26,276	**200,442**
Total	**656,584**	**131,380**	**787,964**

5.1.2 Overhead Costs including Meetings between the Researchers and Wine Australia

Wine Australia overhead costs are in addition to those shown in the above tables and are estimated at 12%.

5.1.3 Industry and Agency Costs

Industry and agency contributions to the project include costs incurred by grape and wine producers serving on the Agrochemical Reference Group, APVMA, Crop Life Australia and Australian Grape and Wine. These costs are estimated at $10,000 per annum each year of the project.

5.2 Benefits

Counterfactual: in the absence of this project, alternative sources of information on changes to MRLs and the registration of new agrochemicals might be made available to industry through other sources e.g., advisory notes from countries that import Australian wine relayed to industry by Wine Australia. For this reason, it is not appropriate to "claim" all of the benefits associated with reduced risk of market closure for the project and a counterfactual of 80% has been assumed. That is, it is 20% likely that potential project benefits would have been realised in the absence of project investment.

5.2.1 Reduced Risk of Market Closure Due to Failure to Meet Revised Agrochemical Residue Limits

AWR 1701-1.5.1 research and industry notifications has reduced the risk of Australian wine being shut out of an export market due to failure to meet a revised agrochemical residue limit. When a previous iteration of this project, covering the period 2013-2017, was subject to economic analysis, researchers were able to identify a specific case study where Australian wine could have been excluded from a market – failure to meet revised European Union MRLs for the fungicide Captan (AgEconPlus 2019). During the current project period (2018-2022) a potential threat was identified when the EU announced a planned phase-out of the use of mancozeb. The ramifications of this change were difficult to forecast, but a likely outcome would be the removal of the tolerance for residues in grapes and wine. Based on this threat, data was gathered about the residue status of Australian wine and the use of the active constituent was restricted in 2020 to three sprays per season and a longer withholding period imposed. A collaboration with the key global supplier of mancozeb products led to identifying a use pattern that did not result in residues in grapes or wine and this new position was implemented in 2021. The project also identified changes to the MRL for the fungicide chlorpyrifos in Japan, but wine residue data managed by the project indicated no reason to modify practices or withholding period policy. Nevertheless, changes in MRLs for chlorpyrifos in Australian wine destined for Japan illustrates the potential of project outputs to reduce the risk of market closure.

A summary of key assumptions used to quantify this benefit is shown in Table 5.4.

Table 5.4 Summary of Assumptions

Variable	Assumption	Source
Reduced Risk of Market Closure		
Australian wine exports to Japan[3].	$50.9 M/year	Wine Australia Export Report for the 12 months to 31 December 2022.
Reduction in risk of Japan market closure due to this project.	10%	Analyst estimate to be tested using sensitivity analysis.
Potential loss of value of wine affected by changes in MRLs.	20%	Assumes "next best" market is less profitable than suppling Australian wine to Japan.
Year of first benefit.	2021	Reduction in risk associated with supplying Australian wine to Japan occurs before the end of the project and following release of relevant updates.
Year of last benefit.	2025	Project outputs superseded by advice from a new agrochemical project.
Attribution of benefit to project AWR 1701-1.5.1.	70%	Analyst estimate based on other costs that will be incurred to realise potential project benefit (e.g., actions taken by winemakers and grape growers to meet any revised MRLs).
Probability of output.	90%	Analyst assumption after review of project literature.

[3] Using the Japan/chlorpyrifos provides a far lower indicator of potential impact as the market is very small compared to say the EU. A previous assessment of Wine Australia investment in collecting and disseminating information on agrochemicals (AgEconPlus 2019) addressed benefits of protecting access to the EU market.

Probability of usage.	90%	Analyst assumption after review of project literature.
Probability of impact.	90%	Analyst assumption after review of project literature.

5.2.2 Other Potential Benefits

Other potential benefits identified but not valued are summarised in Table 4.2. Other potential benefits were not quantified due to their relatively minor contribution to total impact and difficulty in securing data for quantification.

6. Results

All past costs were expressed in current dollar terms using the implicit price deflator for GDP. All costs and benefits from 2022 onwards were discounted to current dollar terms using a discount rate of 5%. A reinvestment rate of 5% was used for estimating the Modified Internal Rate of Return (MIRR). The base run used the best estimates of each variable, notwithstanding a high level of uncertainty for some of the estimates. All analyses ran for the length of the investment period plus 30 years from the last year of investment (2022).

Table 6.1 and Table 6.2 show the investment criteria estimated for the different periods of benefits for both the total investment and for Wine Australia investment. The present value of benefits (PVB) for the Wine Australia investment, shown in Table 6.2, is estimated by multiplying the total PVB by the Wine Australia proportion of investment.

Table 6.1 Investment Criteria for Total Investment by Wine Australia and Project Partners (discount rate 5%)

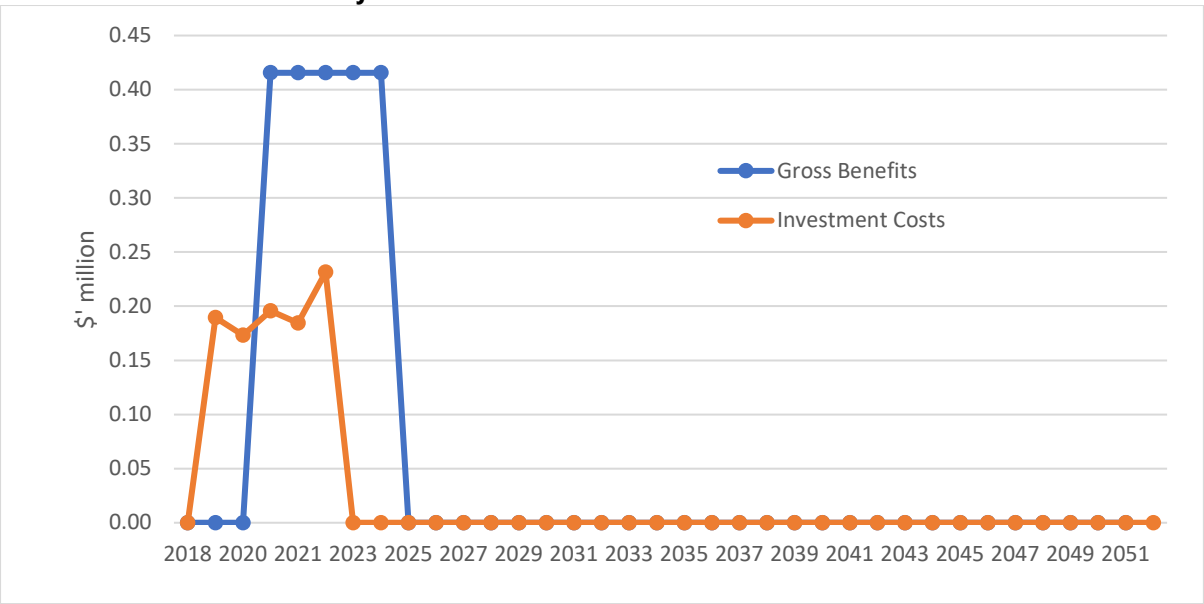
Years	0 years	5 years	10 years	15 years	20 years	25 years	30 years
Present value of benefits ($m)	0.85	1.98	1.98	1.98	1.98	1.98	1.98
Present value of costs ($m)	1.07	1.07	1.07	1.07	1.07	1.07	1.07
Net present value ($m)	-0.22	0.91	0.91	0.91	0.91	0.91	0.91
Benefit–cost ratio	0.80	1.85	1.85	1.85	1.85	1.85	1.85
Internal rate of return (%)	Negative	180.6	180.6	180.6	180.6	180.6	180.6
MIRR (%)	Negative	45.7	23.7	17.1	14.0	12.1	10.9

Table 6.2 Investment Criteria for Wine Australia (discount rate 5%)

Years	0 years	5 years	10 years	15 years	20 years	25 years	30 years
Present value of benefits ($m)	0.68	1.59	1.59	1.59	1.59	1.59	1.59
Present value of costs ($m)	0.86	0.86	0.86	0.86	0.86	0.86	0.86
Net present value ($m)	-0.18	0.73	0.73	0.73	0.73	0.73	0.73
Benefit–cost ratio	0.80	1.85	1.85	1.85	1.85	1.85	1.85
Internal rate of return (%)	Negative	180.6	180.6	180.6	180.6	180.6	180.6
MIRR (%)	Negative	45.7	23.7	17.1	14.0	12.1	10.9

The annual undiscounted benefits and cost cash flows for the total investment for the duration of the investment period plus 30 years from the last year of the initial investment are shown in Figure 6.1.

Figure 6.1 Annual Undiscounted Cash Flows for Estimated Total Benefits and Total RD&E Investment Costs for the Project



7. Sensitivity Analysis

A sensitivity analysis was carried out for the central analysis results reported in Section 6 and variations in the discount rate. Table 7.1 presents the results. The results are not sensitive to the discount rate. This is because some project benefits are realised during the project investment period.

Table 7.1 Sensitivity to Discount Rate (Total investment, 30 years)

Investment Criteria	Discount rate		
	0%	5% (base)	10%
Present value of benefits ($m)	2.08	1.98	1.91
Present value of costs ($m)	0.97	1.07	1.18
Net present value ($m)	1.10	0.91	0.73
Benefit-cost ratio	2.13	1.85	1.62

Sensitivity analyses were undertaken for those variables where there was greatest uncertainty or for those that were identified as key drivers of the investment criteria. The analyses were performed for the total investment and with benefits taken over the life of the investment plus 30 years from the last year of investment. All other parameters were held at their base values.

For this project, the greatest uncertainty related to the reduction in risk of Japan market closure due to project outputs and the reduction in wine value avoided - Table 7.2 and Table 7.3. Results show that the benefit cost ratio is sensitive to both these key assumptions. If reduction in market closure risk is only 5% then project costs exceed project benefits. If reduction in wine value avoided is as little as 10%, project costs will also exceed project benefits.

Table 7.2 Sensitivity to Reduction in Risk of Japan Market Closure Due to Project Outputs (Total investment, 30 years)

Investment Criteria	Reduction in Risk due to AWR 1701-3.5.1 (%)		
	5%	10% (base)	20%
Present value of benefits ($m)	0.99	1.98	3.97
Present value of costs ($m)	1.07	1.07	1.07
Net present value ($m)	-0.08	0.91	2.90
Benefit-cost ratio	0.93	1.85	3.70

Table 7.3 Sensitivity to Reduction in Wine Value Avoided (Total investment, 30 years)

Investment Criteria	Reduction in Wine Value – Aust Wine to Japan (%)		
	10%	20% (base)	30%
Present value of benefits ($m)	0.99	1.98	2.98
Present value of costs ($m)	1.07	1.07	1.07
Net present value ($m)	-0.08	0.91	1.90
Benefit-cost ratio	0.93	1.85	2.78

8. Confidence Ratings

The results produced are highly dependent on the assumptions made, many of which are uncertain. There are two factors that warrant recognition. The first factor is the coverage of benefits. Where there are multiple types of benefits it is often not possible to quantify all the benefits that may be linked to the investment. The second factor involves uncertainty regarding the assumptions made, including the linkage between the research and the assumed outcomes.

A confidence rating based on these two factors has been given to the results of the investment analysis (Table 8.1). The rating categories used are High, Medium, and Low, where:

High: denotes a good coverage of benefits or reasonable confidence in the assumptions made

Medium: denotes only a reasonable coverage of benefits or some uncertainties in assumptions made

Low: denotes a poor coverage of benefits or many uncertainties in assumptions made

Table 8.1 Confidence in Analysis of Program

Coverage of Benefits	Confidence in Assumptions
Medium	Medium

9. Summary of Results

Funding for AWR 1701-1.5.1 'Investment in collecting and disseminating information on agrochemicals' had a total cost of $1.07 million (present value terms) and is expected to produce aggregate total benefits of approximately $1.98 million (present value terms). This gives an estimated net present value of $0.91 million, a benefit-cost ratio of approximately 1.85, an internal rate of return of 181% and a modified internal rate of return of 11%.

Analysis results are dependent on assumptions made and are positive for core assumptions and do not become negative until 'lower end' assumptions are applied.

Abbreviations

APVMA	Australian Pesticides and Veterinary Medicines Authority
AWRI	Australian Wine Research Institute
MRL	Maximum Residue Limit
OCS	Office of Chief Scientist
R&D	Research and Development
RD&E	Research, Development and Extension

Persons Contacted

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Marcel Essling, Principal Researcher, AWRI

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Appendix 2: Economic Analysis Wine Australia's Investment in Low- and No-Alcohol Wine Products – Understanding Technical & Sensory-Related Challenges/Opportunities

1. Background

The category of no- and low-alcohol (NOLO) beverages has experienced positive growth over the past few years. Some consumers are seeking products that contain the aroma, flavour, and texture of traditionally produced alcoholic beverages but with little or no alcohol. A small number of Australian wine producers are embracing this market with success, but the NOLO wine category is lagging both NOLO beer and spirits by value and volume, according to sales figures.

No alcohol wine is defined as having less than 0.5% alcohol. Low alcohol wine is between 0.5% and 1.15% alcohol. In 2021, NOLO accounted for 3.4 million litres of wine sales in Australia (Wine Intelligence 2022). The forecast is for the category to grow to 7.8 million litres by 2026 (Wine Australia, reported in The Australian Newspaper, 20 November 2022).

The trend toward consumption of NOLO beverages is also apparent in other countries where Australia exports wine including the United States, Canada, United Kingdom, Germany, Japan, and China. The World Health Organisation has asked national governments to review taxation of alcoholic beverages in light of the significant health impacts of alcohol consumption. Provision of acceptable NOLO wine-like products has the potential to diversify winemaker income, reduce risk, and enhance the wine industry's social licence to operate. Consumers identify 'health' as the most important reason for NOLO purchase and 'quality' as the most important impediment to purchase (Wine Intelligence 2022).

2. Summary of Projects

Table 2.1 provides a description of the project in a logical framework.

Table 2.1 Project Description

AWR 1701-3.1.10: Low- and No-Alcohol Wine Products – Technical and Sensory Challenges	
Project Details	Research Organisation: Australian Wine Research Institute (AWRI) Period: December 2020 to September 2022 Principal Investigator: Dr Wes Pearson
Rationale	Research was required to define the desirable sensory attributes of existing NOLO wines and beverages in the market and use this information to support development of wine-like beverages that can satisfy consumers demands. The project was to also evaluate production practices, technologies, and ingredients required to give NOLO products the palate attributes found in full-bodied dry wine. Prior to this project there appeared to be no published material available on the sensory attributes of NOLO wine.
Objectives	The project aimed to identify: • Desirable sensory attributes of existing NOLO wine and beverages and provide a basis for changing production approaches for wine-based and wine-like beverages made from grapes with zero and less than 5% alcohol. • Production practices, technologies, and ingredients required for NOLO imitations of full-bodied dry wine.
Activities and Outputs	• Establishment of an Industry Reference Group to guide identification of reference products, market failures and development needs. Membership of the Industry Reference Group included all links in the wine supply chain. • Identification and evaluation of 120 NOLO products including wine, wine-like products, grape-based products, cider, beer, and spirits. • Initial evaluation used a comparison scale where the taster assessed the product against what wine should smell and taste like (the 'vinosity scale'). • The initial evaluation highlighted the lack of wine-likeness of most products with sparkling and white NOLO better than the red NOLO category. • Better products were subject to more comprehensive compositional and sensory descriptive analysis. Analysis was completed on ten sparkling, sixteen white and rose, and eight red wine NOLO products. • For sparkling wines positive vinosity was associated with 'astringency' and 'banana confection' but most products were too sweet to be considered 'wine-like'. The viscosity of sparkling wine NOLO products was acceptable. • For white wine NOLO products, the most 'wine-like' products were Sauvignon Blanc which exhibited appropriate 'warmth on the palate'. • Red NOLO products were less uniform with scores below white wine NOLOs. Three Shiraz and one Cabernet Sauvignon were identified as the most vinous. • Piquette is a grape-based product made by fermenting rehydrated grape marc. It is naturally low in alcohol (2.5% to 6.5%) and the study found that it may have potential as a NOLO beverage. Piquette could be a new product for the Australian wine industry from what is currently wasted grape marc. • The study found that removal of alcohol to achieve a NOLO product removed most of the aroma/flavour characters from the beverage along with the textural, warming effects of the alcohol. • Chemical analysis also revealed that the de-alcoholisation process substantially reduced concentrations of most aroma/flavour compounds. • Flavour and textural additives were evaluated for their effectiveness in replacing the sensory effects of alcohol.

	• While more work is needed, the amino acid proline in combination with glycosides recovered from grape marc, was found to be promising in adding back mouthfeel and texture to NOLO wines. • The project delivered additional knowledge on the sensory attributes, chemical composition, and wine-likeness of current NOLO products. • Some additional knowledge was also generated on additives/ingredients required to improve the quality of wine-like NOLO products. • The project collated opinions from wine industry professionals on where the wine-like NOLO category currently sits and where R&D efforts need to focus. • The project delivered two progress reports, a final technical report, an online abstract, conference and technical presentations, and mainstream press and wine press articles. Peer-reviewed journal articles were not prepared as this project was a scoping study for a larger investigation beginning 2022/23. The larger investigation might focus on consumers, the technical aspects of removing alcohol, varietal selection, viticultural and winemaking techniques.
Outcomes	• Progress towards the creation of improved wine-like products that meet consumer demand and prevent substitution of wine for alternative non-grape beverages e.g., NOLO cider, beer, and spirit. • Research priorities to guide Wine Australia investment.
Impacts (potential)	• Economic – the potential for additional profitable sales of wine-like NOLO products than would otherwise have occurred. • Economic – Wine Australia research efficiencies with better targeted NOLO investment. • Economic – potential reduction in production risk for wine grape growers and winemakers with development of new wine products. • Economic – protection of the industry's social licence to operate with additional development of products that benefit consumer health. • Capacity – increased capacity in AWRI and industry in the assessment of NOLOs and the creation of wine-like NOLO products. • Social – improved health outcomes for Australian wine consumers with increased consumption of wine-like NOLO products (e.g., improved sleep). • Social – additional profitable sales of wine-like NOLO product will generate income, and employment benefits in regional Australia (spill-over impact).

3. Match with National Priorities

Table 3.1 Australian Government Research Priorities

Australian Government Strategies and Priorities	
National Science and Research Priorities[4]	**National Agricultural Innovation Priorities[5]**
1. Food – optimising food and fibre production and processing; agricultural productivity and supply chains within Australia and global markets. **2. Soil and Water** – improving the use of soils and water resources, both terrestrial and marine. **3. Transport** – boosting Australian transportation: securing capability and	On 11 October 2021, the National Agricultural Innovation Policy Statement was released. It highlights four long-term priorities for Australia's agricultural innovation system to address by 2030. These priorities replace the Australian Government's Rural Research, Development and Extension Priorities which were published in the 2015 Agricultural Competitiveness White Paper.

[4] See: 2015 Australian Government Science and Research Priorities. https://www.industry.gov.au/data-and-publications/science-and-research-priorities

[5] See: 2021 National Agriculture Innovation Policy Statement. https://www.awe.gov.au/agriculture-land/farm-food-drought/innovation/research_and_development_corporations_and_companies#government-priorities-for-investment

capacity to move essential commodities; alternative fuels; lowering emissions. 4. **Cybersecurity** – improving cybersecurity for individuals, businesses, government and national infrastructure. 5. **Energy and Resources** – supporting the development of reliable, low cost, sustainable energy supplies and enhancing the long-term viability of Australia's resources industries. 6. **Manufacturing** – supporting the development of high value and innovative manufacturing industries in Australia. 7. **Environmental Change** – mitigating, managing or adapting to changes in the environment. 8. **Health** – improving the health outcomes for all Australians.	1. Australia is a trusted exporter of premium food and agricultural products by 2030. 2. Australia will champion climate resilience to increase the productivity, profitability, and sustainability of the agricultural sector by 2030. 3. Australia is a world leader in preventing and rapidly responding to significant incursions of pests and diseases through futureproofing our biosecurity system by 2030. 4. Australia is a mature adopter, developer, and exporter of digital agriculture by 2030.

The Wine Australia project has addressed National Science/Research Priority 1 and 8 and potentially Priority 6. The major focus of the project has been on the first of the National Agricultural Innovation Priorities.

4. Identification of Potential Costs and Benefits

4.1 Costs

4.1.1 R&D Investment

The R&D investment costs comprised:

- Direct financial outlays by Wine Australia, the project funding body. These costs include both project and overhead expenditures.
- In-kind contributions to the research project – non-cash contributions made by the research partners (AWRI and members of the Industry Reference Group).
- In-kind contributions to the research project – time associated with meetings between the researchers and Wine Australia (project overhead costs).

4.1.2 Administration

No additional administration costs were identified.

4.1.3 Extension

The project was focussed on defining the desirable sensory attributes of existing NOLO wine-like products, winemaking techniques, and scoping further areas for research that will, in time, generate more acceptable NOLO wine. Investment in extension is not appropriate at this time. Further research, development, and extension (RD&E) investment will be required to realise potential project impacts.

4.1.4 Adoption

The project has created foundational knowledge for improved NOLO wine-like products and additional sales of these products. Additional investment will be required in RD&E and costs will be incurred by winemakers. Winemaker costs may, in time, include changes to infrastructure, purchase and use of additional inputs (e.g., proline, glycosides), training, and marketing expenses.

4.2 Benefits

4.2.1 Research Output and Impact Pathway

The potential impact pathway for the project is:

1. Information generated by this project (AWR 1701-3.1.10) on sensory attributes, additives, ingredients, and the potential of piquette is further developed through a new research project that commences in July 2023.

2. The new project delivers additional insight on consumers, the technical aspects of removing alcohol, varietal selection, viticulture, and winemaking techniques.
3. Insight from both projects extended to Australian winemakers who deliver improved wine-like NOLOs.

4.2.2 Triple Bottom Line Benefits

A summary of potential benefits from the project in triple bottom line categories is shown in Table 4.1.

Table 4.1 Triple Bottom Line Categories Benefits from Project Investment

Levy Paying Industry	**Spillovers**		
	Other Industries	**Public**	**Foreign**
Economic Benefits			
The potential for additional profitable sales of wine-like NOLO products than would otherwise have occurred. Wine Australia research efficiencies with better targeted NOLO investment. Potential reduction in production risk for wine grape growers and winemakers with development of new wine products. Protection of the industry's social licence to operate with additional development of products that benefit consumer health.	Additional profitable sales of wine-like NOLO products may provide opportunities for flavour companies, ingredient manufacturers, and technology providers that offer strategies to remove alcohol from beverages.	Nil.	If industry choses to share or licence any eventual production technology, NOLO improvements may be relevant to overseas wine producers.
Environmental Benefits			
Nil	Nil	Nil	Nil
Social Benefits			
Increased capacity in AWRI and industry in the assessment of NOLOs and the creation of wine-like NOLO products. Improved health outcomes for Australian wine consumers with increased consumption of wine-like NOLO products (e.g., improved sleep and mood). Additional profitable sales of wine-like NOLO product will generate income, and employment benefits in regional Australia (spill-over impact).	Capacity developed during the project may assist with the development of NOLO beverages in other industries e.g., apple and pear cider production.	Improved public health and lower health care costs incurred by the community.	Nil

4.2.3 Public versus Private Benefits

The project has the potential to generate both private and public benefits. The private benefits will be captured by wine grape growers, winemakers, and the supply chain. Private benefits will be realised as additional profitable sales of wine-like NOLO products, a reduction in production risk, and a more secure social licence to operate. Potential public benefits may include improved environmental outcomes (i.e., reduced disposal of grape marc to landfill), health benefits (i.e., from consumption of NOLO wine) and capacity benefits (e.g., additional skills in NOLO assessment and production).

4.2.4 Distribution of Benefits along the Supply Chain

The benefits to the wine industry from investment in this project will be shared along the supply chain with wine grape growers, winemakers, wholesalers, retailers, and exporters all sharing some of the benefits. Other potential beneficiaries include flavour companies, ingredient manufacturers, and technology providers that offer strategies to remove alcohol from beverages.

4.2.5 Benefits to other Primary Industries

Capacity developed during the project may assist with NOLO production in other horticultural industries including apple and pear cider production.

4.2.6 Benefits Overseas

If industry choses to share or licence any eventual production technology, NOLO improvements may be relevant to overseas wine producers.

4.3 Summary of Costs and Benefits

A summary of principal categories of costs and benefits from the project is shown in Table 4.2.

Table 4.2 Incremental Cost and Benefit Categories

Costs	Benefits
R&D investment costs (cash and in-kind) as well as project administration costs.	Economic – the potential for additional profitable sales of wine-like NOLO products than would otherwise have occurred.
Overhead costs including time associated with meetings between the researchers and Wine Australia.	Economic – Wine Australia research efficiencies with better targeted NOLO investment.
Industry costs including investment of time by the Industry Reference Group.	Economic – potential reduction in production risk for wine grape growers and winemakers with development of new wine products.
Research costs – additional investment will be required to further develop AWR 1701-3.1.10 findings.	Economic – protection of the industry's social licence to operate with additional development of products that benefit consumer health.
Winemaker costs which may in time include changes in infrastructure, purchase, and use of additional inputs (e.g., proline, glycosides), training, and marketing expenses.	Capacity – increased capacity in AWRI and industry in the assessment of NOLOs and the creation of wine-like NOLO products.
	Social – improved health outcomes for Australian wine consumers with increased consumption of wine-like NOLO products (e.g., improved sleep).
	Social – additional profitable sales of wine-like NOLO product will generate income, and employment benefits in regional Australia (spill-over impact).

5. Valuation of Costs and Benefits

5.1 Costs

5.1.1 R&D Investment Costs including Administration

The following table shows annual investment in the project by Wine Australia (Table 5.1).

Table 5.1 Investment by Wine Australia in the Project for Years Ending June 2021 to June 2022

Project Code	2021	2022	Total
AWR 1701-3.1.10 – Wine Australia	150,193	254,278	**404,471**
Total	**150,193**	**254,278**	**404,471**

Source: Wine Australia record of project expenditure

The other investor in AWR 1701-3.1.10 was AWRI. Data is not available on AWRI contributions to individual Wine Australia projects (Maria Khem, RD&A Administrator, Wine Australia, written communication, December 2022). However, in 2021/22 AWRI invested a total of $893,389 in thirty-four Wine Australia projects at an average investment of $26,276 per project and this per project average has been applied to both years of AWRI investment (Table 5.2).

Table 5.2 Investment by Others in the Project for Years Ending June 2021 to June 2022

Project Code	2021	2022	Total
AWR 1701-3.1.10 – AWRI	26,276	26,276	52,552
Total	**26,276**	**26,276**	**52,552**

Source: AgEconPlus estimate

Table 5.3 provides the total investment by year for both sources.

Table 5.3 Annual Investment in the Project (nominal $)

Year Ending 30 June	Wine Australia	Others	Total
2021	150,193	26,276	176,469
2022	254,278	26,276	280,554
Total	**404,471**	**52,552**	**457,023**

5.1.2 Overhead Costs including Meetings between the Researchers and Wine Australia

Wine Australia overhead costs are in addition to those shown in the above tables and are estimated at 12%.

5.1.3 Industry Costs including Investment of Time by the Industry Reference Group

An Industry Reference Group of eight has been assumed and engagement with the project is estimated to have taken three days per year at a time cost of $500 per day.

5.1.4 Research and Adoption Costs

Further research is required to build on this scoping study. Investment will also be needed by the winemaker and may include changes in infrastructure, purchase, and use of additional inputs (e.g., proline, glycosides), training, and marketing expenses. These costs are accounted for in the analysis through the application of a research benefit attribution factor – see Table 5.4 below.

5.2 Benefits

Counterfactual: in the absence of this project, there is a possibility that large Australian wine companies would have invested in R&D to improve wine-like NOLO products. Consequently, a counterfactual of 75% has been assumed i.e., it is 25% likely that potential project benefits would have been realised in the absence of project investment.

5.2.1 Winemaker Profit on Additional Sales of Wine-like NOLO

The project has delivered progress toward the creation of improved wine-like products that meet consumer demand and prevent substitution of wine for alternative non-grape beverages. Additional R&D is required before these returns are realised and winemaker profit per litre of NOLO is likely to be less than that achieved for full strength wine. Consumers are not prepared to pay a premium for NOLO wines and production is more expensive than full strength wine e.g., alcohol removal cost and purchase of wine additives (Pearson 2021).

A summary of key assumptions used to quantify winemaker profit associated with additional wine-like NOLO sales is summarised in Table 5.4.

Table 5.4 Summary of Assumptions

Variable	Assumption	Source
Benefit 1: Winemaker Profit on Additional Sales of Wine-like NOLO		
Year of first benefit – NOLO products incorporating AWR 1701-3.1.10 research findings available to consumers.	2026	Information generated by this project on sensory attributes, additives, ingredients, and the potential of piquette is further developed through a three-year project that commences in July 2023.
Wine-like NOLO production with research project findings in 2026.	21.6 million litres (a)	IWSR report Australian production of NOLO wine of 10.6 million litres in 2021 increasing to 21.6 million litres in 2026 (Angelica Crabb, Wine Australia, pers. comm., March 2023).
Wine-like NOLO production without research project findings in 2026.	17.3 million litres (b)	Analyst's estimate – 10% less than forecast if quality not improved.
Research contribution including the current project.	2.2 million litres	(a) – (b)
Profit on additional NOLO production.	$1/litre	Derived from net revenue estimate of $1.22/litre (Wine Australia 2019) after allowing for additional production costs and consumer expectations that NOLO should not cost more than full strength wine (Wine Intelligence 2022).
Attribution of benefits to this project (AWR 1701-3.1.10).	20%	Further research is required to build on this scoping study. Investment will also be needed by the winemaker and may include changes in infrastructure, purchase, and use of additional inputs (e.g., proline, glycosides), training, and marketing expenses. AWR 1701-3.1.10 is only one, relatively small part of the overall investment 'picture'.
Probability of valuable outputs.	100%	Outputs have been delivered.
Probability of valuable outcomes.	80%	Progress has been made in the creation of improved wine-like products that meet consumer demand and prevent substitution of wine for alternative non-grape beverages.
Probability of impact.	75%	It is likely that improved wine-like products will generate additional profitable sales for

		winemakers. There is also a relatively small risk that this will not occur.
Counterfactual	75%	See above explanation.

5.2.2 Other Potential Benefits

Other potential benefits identified but not valued are summarised in Table 4.2. Other potential benefits were not quantified due to their relatively minor contribution to total impact and difficulty in securing data for quantification.

6. Results

All past costs were expressed in current dollar terms using the implicit price deflator for GDP. All costs and benefits from 2022 onwards were discounted to current dollar terms using a discount rate of 5%. A reinvestment rate of 5% was used for estimating the Modified Internal Rate of Return (MIRR). The base run used the best estimates of each variable, notwithstanding a high level of uncertainty for some of the estimates. All analyses ran for the length of the investment period plus 30 years from the last year of investment (2022).

Table 6.1 and Table 6.2 show the investment criteria estimated for the different periods of benefits for both the total investment and for Wine Australia investment. The present value of benefits (PVB) for the Wine Australia investment, shown in Table 6.2, is estimated by multiplying the total PVB by the Wine Australia proportion of investment.

Table 6.1 Investment Criteria for Total Investment by Wine Australia and Project Partners (discount rate 5%)

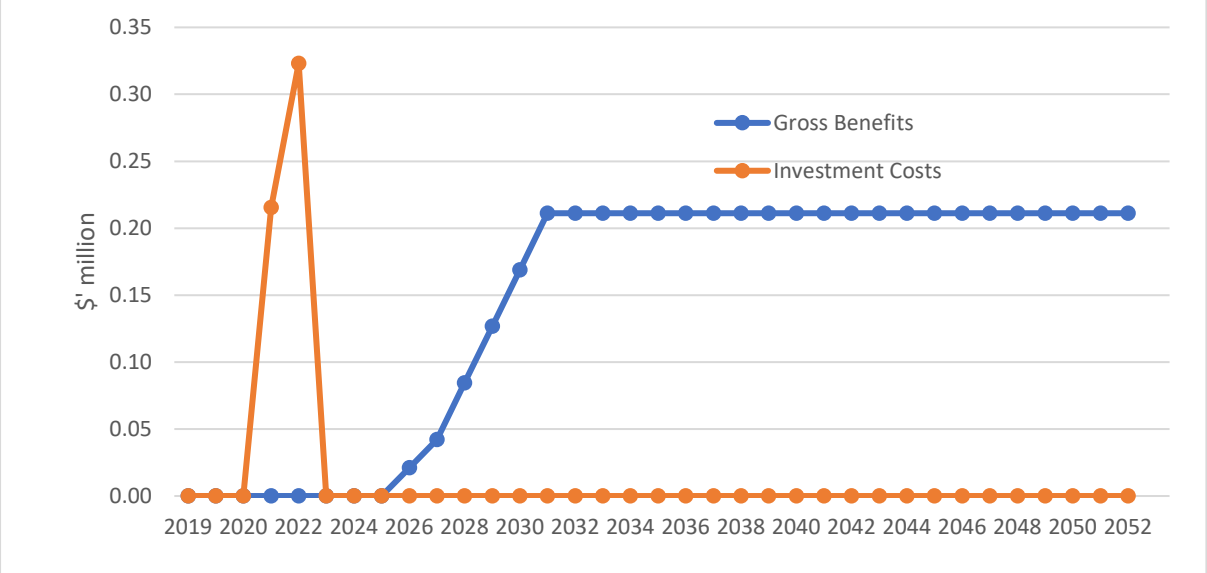
Years	0 years	5 years	10 years	15 years	20 years	25 years	30 years
Present value of benefits ($m)	0.00	0.05	0.58	1.15	1.58	1.93	2.20
Present value of costs ($m)	0.55	0.55	0.55	0.55	0.55	0.55	0.55
Net present value ($m)	-0.55	-0.50	0.03	0.60	1.04	1.38	1.65
Benefit–cost ratio	0.00	0.09	1.06	2.08	2.88	3.51	4.00
Internal rate of return (%)	Negative	Negative	5.8	12.9	14.9	15.7	16.0
MIRR (%)	Negative	Negative	5.6	10.3	10.7	10.4	10.0

Table 6.2 Investment Criteria for Wine Australia (discount rate 5%)

Years	0 years	5 years	10 years	15 years	20 years	25 years	30 years
Present value of benefits ($m)	0.00	0.04	0.50	0.98	1.35	1.65	1.88
Present value of costs ($m)	0.47	0.47	0.47	0.47	0.47	0.47	0.47
Net present value ($m)	-0.47	-0.43	0.03	0.51	0.89	1.18	1.41
Benefit–cost ratio	0.00	0.09	1.06	2.08	2.88	3.51	4.00
Internal rate of return (%)	Negative	Negative	5.8	12.9	14.9	15.7	16.0
MIRR (%)	Negative	Negative	5.6	10.3	10.7	10.4	10.0

The annual undiscounted benefits and cost cash flows for the total investment for the duration of the investment period plus 30 years from the last year of the initial investment are shown in Figure 6.1.

Figure 6.1 Annual Undiscounted Cash Flows for Estimated Total Benefits and Total RD&E Investment Costs for the Project



7. Sensitivity Analysis

A sensitivity analysis was carried out for the central analysis results reported in Section 6 and variations in the discount rate. Table 7.1 presents the results. The results are only moderately sensitive to discount rate due to the short interval between investment in AWR 1701-3.1.10 and the creation of wine industry benefits.

Table 7.1 Sensitivity to Discount Rate (Total investment, 30 years)

Investment Criteria	Discount rate		
	0%	5% (base)	10%
Present value of benefits ($m)	5.09	2.20	1.10
Present value of costs ($m)	0.54	0.55	0.56
Net present value ($m)	4.55	1.65	0.54
Benefit-cost ratio	9.45	4.00	1.96

Sensitivity analyses were undertaken for those variables where there was greatest uncertainty or for those that were identified as key drivers of the investment criteria. The analyses were performed for the total investment and with benefits taken over the life of the investment plus 30 years from the last year of investment. All other parameters were held at their base values.

For this project, the greatest uncertainty related to the increase in profitable wine-like NOLO sales attributable to research and the subsequent profit on those sales – Table 7.2 and Table 7.3. Results show that the benefit cost ratio is sensitive to both these key assumptions and additional NOLO sales would need to fall to 2.5% or profit on additional wine-like NOLO products be as low at $0.25/litre before project costs equal project benefits.

Table 7.2 Sensitivity to Increase in Sales of NOLO due to Research (Total investment, 30 years)

Investment Criteria	Additional Sales Due to Research (including AWR 1701-3.1.10) (%)		
	2.5%	5%	10% (base)
Present value of benefits ($m)	0.55	1.10	2.20
Present value of costs ($m)	0.55	0.55	0.55
Net present value ($m)	0.00	0.55	1.65
Benefit-cost ratio	1.00	2.00	4.00

Table 7.3 Sensitivity to Profit Earned on Wine-like NOLO Sales (Total investment, 30 years)

Investment Criteria	Profit Earned by Winemakers on Additional NOLO Sales ($/litre)		
	$0.25/litre	$0.50/litre	$1/litre (base)
Present value of benefits ($m)	0.55	1.10	2.20
Present value of costs ($m)	0.55	0.55	0.55
Net present value ($m)	0.00	0.55	1.65
Benefit-cost ratio	1.00	2.00	4.00

8. Confidence Ratings

The results produced are highly dependent on the assumptions made, many of which are uncertain. There are two factors that warrant recognition. The first factor is the coverage of benefits. Where there are multiple types of benefits it is often not possible to quantify all the benefits that may be linked to the investment. The second factor involves uncertainty regarding the assumptions made, including the linkage between the research and the assumed outcomes.

A confidence rating based on these two factors has been given to the results of the investment analysis (Table 8.1). The rating categories used are High, Medium, and Low, where:

High: denotes a good coverage of benefits or reasonable confidence in the assumptions made

Medium: denotes only a reasonable coverage of benefits or some uncertainties in assumptions made

Low: denotes a poor coverage of benefits or many uncertainties in assumptions made

Table 8.1 Confidence in Analysis of Program

Coverage of Benefits	Confidence in Assumptions
Medium	Medium

9. Summary of Results

Funding for AWR 1701-3.1.10 'investment in low- and no-alcohol wine products – understanding technical and sensory-related challenges and opportunities' had a total cost of $0.55 million (present value terms) and is expected to produce aggregate total benefits of approximately $2.2 million (present value terms). This gives an estimated net present value of $1.65 million, a benefit-cost ratio of approximately 4.00, an internal rate of return of 16% and a modified internal rate of return of 10%.

Analysis results are dependent on assumptions made and are positive for core assumptions and do not become negative until 'lower end' assumptions are applied.

Additional investment in the technical aspects of removing alcohol, varietal selection, viticulture, and winemaking techniques are required before benefits will be realised.

Abbreviations

AWRI	Australian Wine Research Institute
NOLO	No-and Low-Alcohol Wines
OCS	Office of Chief Scientist
R&D	Research and Development
RD&E	Research, Development and Extension

Persons Contacted

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Wes Pearson, Principal Researcher, AWRI

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Appendix 3: Economic Analysis Wine Australia's Investment in Bioprospecting Australian Microbial Genetic Diversity

1. Background

Wild-fermented wine uses native yeasts that are found on the fruit and in the winery environment. Wild-ferments have the potential to produce wine with improved mouthfeel, aroma, and flavour complexity compared to inoculated-ferments but at the expense of reliability and reproducibility. Inoculated ferments mostly rely on the major wine yeast *Saccharomyces cerevisiae*.

Wine is complex, comprising thousands of metabolites that are produced through the action of yeasts and bacteria in fermenting grape must. When grapes are crushed and allowed to ferment naturally, a complex microbial succession of yeasts and bacteria is observed. In the early stages of fermentation, aerobic and apiculate yeasts and yeast-like fungi reside on the surface of intact grape berries or winery equipment, representing the majority of microbiota.

However, most of these species succumb to the succession of the fermentation in response to falling oxygen levels and increasing ethanol concentrations. Some mildly fermentative yeasts can proliferate and survive well into the fermentation but fall in numbers as ethanol concentrations increase. Despite the vastly higher numbers of non-*Saccharomyces* yeasts early in the fermentation, *S cerevisiae* is responsible for the bulk of the ethanolic fermentation. From mid-fermentation *S cerevisiae* establishes as a virtual monoculture.

While traditional microbiological techniques have provided insights into the microbial succession that occurs in spontaneous ferments, much remains unknown. Recent advances in culture-independent methods for species analysis, such as amplicon-based phylo-typing ("meta-barcoding") and meta-genomics, provide a rapid way of analysing large numbers of microbiological samples in great depth.

This project (AWR 1701-4.4.3) was to apply a combination of genomic and microbiological techniques to investigate Australian wine microbiomes and how non-*Saccharomyces* yeasts and winemaking interventions can be used to shape wine outcomes through altering microbial composition. The project was to build on past research completed by AWRI. Outputs from the research were to benefit the production of both wild-fermented and inoculate-fermented Australian wine.

In early 2023, AWRI reports that as a result of AWR 1701-4.4.3 winemakers that use wild fermentation can do so with increased confidence knowing that the approaches they use are promoting diverse microflora in their ferments. This can translate into additional marketing opportunities surrounding the wild yeasts that are uniquely associated with a particular place and time (Anthony Borneman, Research Manager, AWRI, pers. comm., January 2023).

2. Summary of Projects

Table 2.1 provides a description of the project in a logical framework.

Table 2.1 Project Description

AWR 1701-4.4.3: Bioprospecting Australian Microbial Genetic Diversity	
Project Details	Research Organisation: Australian Wine Research Institute (AWRI) Period: July 2017 to September 2022 Principal Investigator: Anthony Borneman
Rationale	The contribution of wild wine microorganisms promises to be a critical driver of Australian regional terroir and a means for wineries to increase profits through the production of unique wine with distinction.
Objectives	The project aimed to leverage the analytical power of next generation genomics and high-throughput screening to advance knowledge of wild wine microbiota and how they can be exploited to aid winemaking goals.
Activities and Outputs	• To investigate the yeast microbiomes of Australian wild fermentations, a DNA-based yeast profiling framework was established and used to investigate commercial uninoculated Chardonnay and Shiraz wines. This work was later expanded to include Pinot Noir and a smaller number of ferment samples from other varieties. • Results were obtained from 852 wines from 34 wineries across 12 Australian winemaking GIs and showed that wines contained a highly variable yeast microbiome that differed across regions, vintages, wineries, and vineyards. • The genomic and microbiological techniques employed provided detailed information on ferment microbiology, but results were not available until after the completion of vintage and did not allow ferment intervention. • Subsequently, a method was developed that allowed substantial progress toward 'in-field' testing and it is now conceivable that larger wine laboratories could perform the testing technique on-site. • Experiments were completed that assessed the impact of common and relatively easily performed interventions that could be used to improve the consistency of wild-fermented wine – addition of sulfur dioxide (the major antimicrobial used in wine), aeration, and temperature changes. • Increased temperature adversely impacted wine quality. • Sulfur dioxide and aeration provided a means to alter flavour and aroma (using sulfur dioxide) and to affect fermentation efficiency (judicious use of aeration). By combining the ability to monitor microbial populations through the yeast profiling techniques with the winemaker interventions investigated, the risk of a negative wild-ferment outcome can be decreased. • The project assembled a collection of more than 18,000 wine yeast isolates from wild-ferment wine samples. These samples were made up of 35 different yeast species– a foundational germplasm resource which has been used to identify novel non-*Saccharomyces* isolates for use as commercial starter strains and for further yeast genomics research. • The project identified 3 candidate strains for use in commercial yeast starter cultures for inoculated-wine production. These strains can be used to provide novel and/or complex flavour profiles relative to the use of *S cerevisiae* alone. • In summary, the project delivered a holistic view of the yeast and fungal microbiology that underpins wild fermentations across Australia. It has provided winemakers with a method for altering wine characteristics and aiding in fermentation efficiency. Selections of non-*Saccharusesces* strains were developed to provide options for the significant sectors of the Australian industry that use commercial starter strains but desire winemaking properties that go beyond those provided by standard wine yeast.

	• The project delivered nine progress reports, a final technical report, an online abstract, two technical conference presentations, and wine press articles. Further research is needed before extension materials can be produced and winemakers can adopt project findings.
Outcomes	• Increased confidence that wild-ferment wines promote diverse microflora in ferments. • Progress toward more consistent wild-ferment wines (with a reduction in production of unsalable wild-wine product). • New commercial yeasts that can be tested by winemakers to enhance the unique character of Australian wine (and produce high value products).
Impacts (potential)	• Economic – potential improvement in wild-fermented wine with greater understanding of wild-ferment processes and fermentation interventions. • Economic – potential increase in value of some yeast-inoculated wines with addition of non-standard yeasts identified during this project. • Capacity - 18,000 wine yeast isolates catalogued that will facilitate further yeast genomics research. • Capacity – increased capacity in AWRI and industry in understanding and managing wild-wine fermentation. • Social – additional profitable sales of wild and unique Australian wine will generate income, and employment benefits in regional Australia (spill-over impact).

3. Match with National Priorities

Table 3.1 Australian Government Research Priorities

Australian Government Strategies and Priorities	
National Science and Research Priorities[6]	**National Agricultural Innovation Priorities[7]**
1. Food – optimising food and fibre production and processing; agricultural productivity and supply chains within Australia and global markets. **2. Soil and Water** – improving the use of soils and water resources, both terrestrial and marine. **3. Transport** – boosting Australian transportation: securing capability and capacity to move essential commodities; alternative fuels; lowering emissions. **4. Cybersecurity** – improving cybersecurity for individuals, businesses, government and national infrastructure. **5. Energy and Resources** – supporting the development of reliable, low cost, sustainable energy supplies and enhancing the long-term viability of Australia's resources industries. **6. Manufacturing** – supporting the development of high value and innovative manufacturing industries in Australia.	On 11 October 2021, the National Agricultural Innovation Policy Statement was released. It highlights four long-term priorities for Australia's agricultural innovation system to address by 2030. These priorities replace the Australian Government's Rural Research, Development and Extension Priorities which were published in the 2015 Agricultural Competitiveness White Paper. **1.** Australia is a trusted exporter of premium food and agricultural products by 2030. **2.** Australia will champion climate resilience to increase the productivity, profitability, and sustainability of the agricultural sector by 2030. **3.** Australia is a world leader in preventing and rapidly responding to significant incursions of pests and diseases through futureproofing our biosecurity system by 2030. **4.** Australia is a mature adopter, developer, and exporter of digital agriculture by 2030.

[6] See: 2015 Australian Government Science and Research Priorities. https://www.industry.gov.au/data-and-publications/science-and-research-priorities

[7] See: 2021 National Agriculture Innovation Policy Statement. https://www.awe.gov.au/agriculture-land/farm-food-drought/innovation/research_and_development_corporations_and_companies#government-priorities-for-investment

7. **Environmental Change** – mitigating, managing or adapting to changes in the environment. 8. **Health** – improving the health outcomes for all Australians.	

The Wine Australia project has addressed National Science/Research Priority 1. The major focus of the project has been on the first of the National Agricultural Innovation Priorities.

4. Identification of Potential Costs and Benefits

4.1 Costs

4.1.1 R&D Investment

The R&D investment costs comprised:

- Direct financial outlays by Wine Australia, the project funding body. These costs include both project and overhead expenditures.
- In-kind contributions to the research project – non-cash contributions made by the research partners (AWRI).
- In-kind contributions to the research project – time associated with meetings between the researchers and Wine Australia, contributions made by the Wine Innovation Cluster and AWRI Sensory Team and the value of juice and wine samples provided by industry for project research.

4.1.2 Administration

No additional administration costs were identified.

4.1.3 Extension

The project was focussed on techniques to produce more consistent wild-wine products and alternative yeasts to enhance the regional terroir of inoculated ferments. Further research will be required before wild-ferment processes are ready for adoption and commercial partners will be needed to supply project generated non-*Saccharomyces* yeasts. Some extension costs may be inured in the interim to increase winemaker awareness of the new yeasts and to incentivise their commercial production.

4.1.4 Adoption

Techniques to improve wild-wine production and yeasts to improve inoculated ferments will have modest adoption costs. Production techniques such as use of sulfur dioxide and aeration come with few capital or operating costs. Purchase of non-*Saccharomyces* yeasts will require only modest investment.

4.2 Benefits

4.2.1 Research Output and Impact Pathway

The potential impact pathway for the project is:

1. Information generated by this project (AWR 1701-4.4.3) on techniques to produce more consistent wild-wine products and alternative yeasts to enhance the regional terroir of inoculated ferments will require further investment before commercial outcomes are realised.
2. The further development of in-field testing applications is required so that winemaker interventions are possible during fermentation. Work is also required to enable rapid identification of fungi responsible for contamination outside of primary fermentation. Alternatives to difficult and expensive cold chain logistics are needed that would allow for standard courier delivery of winery samples. Further winery scale tests are required to confirm the effectiveness of wild-ferment quality interventions including sulfur dioxide and aeration. Partnerships with commercial yeast suppliers are needed to advance the non-*Saccharomyces* strains identified as part of AWR 1701-4.4.3.

3. With further research and development there is the potential for a reduction in waste associated with unsaleable wild-wine products and an increase in the value of some inoculated ferments that make use of non-standard yeast.

4.2.2 Triple Bottom Line Benefits

A summary of potential benefits from the project in triple bottom line categories is shown in Table 4.1.

Table 4.1 Triple Bottom Line Categories Benefits from Project Investment

Levy Paying Industry	**Spillovers**		
	Other Industries	**Public**	**Foreign**
Economic Benefits			
A potential increase in Australian wine value with high quality wild-ferments and distinct inoculated ferments that express regional terroir.	Additional profitable yeast sales for commercial yeast producers and suppliers of ferment additives such as sulfur dioxide.	Nil.	If industry choses to share or licence any eventual improvements in fermentation technology, these may be relevant to overseas wine producers.
Environmental Benefits			
Nil	Nil	Nil	Nil
Social Benefits			
Increased research capacity with 18,000 wine yeast isolates catalogued. Catalogued isolates will facilitate further genomic research on yeast. Increased capacity in AWRI and industry in understanding and managing wild-wine fermentation. Additional profit on sales of wild and unique Australian wine will generate income, and employment benefits in regional Australia (spill-over impact).	Nil	Nil	Nil

4.2.3 Public versus Private Benefits

Most potential benefits generated by the project will be private. Private benefits will be captured by wine grape growers, winemakers, and the supply chain. Private benefits will be realised as an increase in Australian wine value via high quality wild-ferments and distinct inoculated ferments that express regional terroir. Potential public benefits may include additional research capacity and spill-over benefits for regional Australia.

4.2.4 Distribution of Benefits along the Supply Chain

The benefits to the wine industry from investment in this project will be shared along the supply chain with wine grape growers, winemakers, wholesalers, retailers, and exporters all sharing some of the benefits. Other potential beneficiaries include commercial yeast producers and suppliers of ferment additives such as sulfur dioxide.

4.2.5 Benefits to other Primary Industries
No benefits to other primary industries have been identified.

4.2.6 Benefits Overseas
If industry choses to share or licence any eventual improvements in fermentation technology, these may be relevant to overseas wine producers.

4.3 Summary of Costs and Benefits
A summary of principal categories of costs and benefits from the project is shown in Table 4.2.

Table 4.2 Incremental Cost and Benefit Categories

Costs	Benefits
R&D investment costs (cash and in-kind) as well as project administration costs.	Economic – a potential increase in Australian wine value with high quality wild-ferments and distinct inoculated ferments that express regional terroir.
Overhead costs including time associated with meetings between the researchers and Wine Australia.	Capacity – increased research capacity with 18,000 wine yeast isolates catalogued. Catalogued isolates will facilitate further genomic research on yeast.
Industry costs including donations of juice and wine for testing.	Capacity – increased capacity in AWRI and industry in understanding and managing wild-wine ferments.
Research costs – additional investment will be required to further develop AWR 1701-4.4.3 findings.	Social – additional profitable sales of wild and unique Australian wine will generate income, and employment benefits in regional Australia (spill-over impact).
Winemaker costs which may in time include changes to production practices (e.g., aeration) and additional purchased inputs (e.g., purchase of non-*Saccharomyces* yeasts).	

5. Valuation of Costs and Benefits

5.1 Costs
5.1.1 R&D Investment Costs including Administration
The following table shows annual investment in the project by Wine Australia (Table 5.1).

Table 5.1 Investment by Wine Australia in the Project for Years Ending June 2018 to June 2022

Project Code	2018	2019	2020	2021	2022	Total
AWR 1701-4.4.3 – Wine Australia	294,835	284,654	303,804	341,172	492,310	**1,716,775**
Total	**294,835**	**284,654**	**303,804**	**341,172**	**492,310**	**1,716,775**

Source: Wine Australia record of project expenditure

The other investor in AWR 1701-4.4.3 was AWRI. Data is not available on AWRI contributions to individual Wine Australia projects (Maria Khem, RD&A Administrator, Wine Australia, written communication, December 2022). However, in 2021/22 AWRI invested a total of $893,389 in thirty-four Wine Australia projects at an average investment of $26,276 per project and this per project average has been applied to each year of the AWR 1701-4.4.3 investment (Table 5.2).

Table 5.2 Investment by Others in the Project for Years Ending June 2018 to June 2022

Project Code	2018	2019	2020	2021	2022	Total
AWR 1701-4.4.3 – Wine Australia	26,276	26,276	26,276	26,276	26,276	**131,380**
Total	**26,276**	**26,276**	**26,276**	**26,276**	**26,276**	**131,380**

Source: AgEconPlus estimate

Table 5.3 provides the total investment by year for both sources.

Table 5.3 Annual Investment in the Project (nominal $)

Year Ending 30 June	Wine Australia	Others	Total
2018	294,835	26,276	**321,111**
2019	284,654	26,276	**310,930**
2020	303,804	26,276	**330,080**
2021	341,172	26,276	**367,448**
2022	492,310	26,276	**518,586**
Total	**1,716,775**	**131,380**	**1,848,155**

5.1.2 Overhead Costs including Meetings between the Researchers and Wine Australia

Wine Australia overhead costs are in addition to those shown in the above tables and are estimated at 12%.

5.1.3 Industry Costs

Contributions to the project were made by both the Wine Innovation Cluster and AWRI Sensory Team as well as donations of juice and wine for testing. These costs are estimated at $10,000 per annum for each year of the project.

5.1.4 Research and Adoption Costs

Further research is required before project outputs and outcomes generate profits for winemakers. Winemakers will incur costs in training and experimentation using the new wild-ferment wine making techniques. Investment will be needed by producers of commercial starter yeasts to make the new yeasts available to winemakers. These costs are accounted for in the analysis through the application of a research benefit attribution factor – see Table 5.4 below.

5.2 Benefits

Counterfactual: in the absence of this project, there is only a small possibility that fundamental science on alternative microbes contributing to Australian wine fermentation would have been completed. Consequently, a counterfactual of 90% has been assumed i.e., it is 10% likely that potential project benefits would have been realised in the absence of project investment.

5.2.1 Increased Winemaker Profit, High Quality Wild-ferments and Distinct Inoculated-ferments

The project has delivered progress toward more consistent wild-ferment wines with a reduction in production of unsaleable wild-wine as well as new commercial yeasts that can be used by winemakers to enhance the character of inoculated Australian wine. These benefits will manifest themselves as an increase in winemaker profit. Outputs from the project will not be relevant to all Australian winemakers. Data is not available on the share of Australian production that is wild-ferment wine and it is not known what share of production will be attracted to experimental new yeasts for use in inoculated-wine. In the absence of these data the analyst has assumed that project outputs will be relevant to a maximum of 5% of Australian wine production.

A summary of key assumptions used to quantify increased winemaker profit associated with adoption of project findings for wild-wine and inoculated-wine production are summarised in Table 5.4.

Table 5.4 Summary of Assumptions

Variable	Assumption	Source
Benefit 1: Increased Winemaker Profit, High Quality Wild-ferments and Distinct Inoculated ferments		
Australian wine production.	1.3 billion litres	Wine Australia 2022.
Share of Australian wine production that will make use of project findings.	5%	Analyst's estimate after considering that wild-ferment and experimental inoculation will be a relatively small (but unknown) share of total Australian wine production.
Increase in winemaker profit with adoption of project outputs.	$0.12/litre	Derived from net revenue estimate of $1.22/litre (Wine Australia 2019) and assumes a 10% premium for superior wild-ferment wines and inoculate-ferment wines using project generated non-*Saccharomyces* yeasts.
Attribution of benefits to this project (AWR 1701-4.4.3).	35%	Attribution of benefits to this project was estimated after considering past work on wine ferment microbial genetic diversity (e.g., AWR 1501), and future RD&E investment required to realise improved winemaker profit.
Year of first benefit.	2027	Five years is required post project completion for delivery of research to verify project findings (e.g., effectiveness of sulfur dioxide and aeration) and secure commercial production of project generated non-*Saccharomyces* yeasts.
Year of last benefit.	2041	Project outputs are superseded by findings from new microbial genetic research projects.
Probability of valuable outputs.	100%	Outputs have been delivered.
Probability of valuable outcomes.	50%	There is a risk that future research will not confirm project identified interventions and that commercial yeast suppliers will not produce new non-*Saccharomyces* yeasts.
Probability of impact.	70%	It is likely that superior wild-ferment wines and inoculate-ferment wines will be more profitable for winemakers. There is also a relatively small risk that this will not occur.
Counterfactual	90%	See above explanation.

5.2.2 Other Potential Benefits

Other potential benefits identified but not valued include:

- Increased research capacity with 18,000 wine yeast isolates catalogued. Catalogued isolates will facilitate further genomic research on yeast.
- Increased capacity in AWRI and industry in understanding and managing wild-wine ferments.
- Additional profitable sales of wild and unique Australian wine will generate income, and employment benefits in regional Australia (spill-over impact).

Other potential benefits were not quantified due to their relatively minor contribution to total impact and difficulty in securing data for quantification.

6. Results

All past costs were expressed in current dollar terms using the implicit price deflator for GDP. All costs and benefits from 2022 onwards were discounted to current dollar terms using a discount rate of 5%. A reinvestment rate of 5% was used for estimating the Modified Internal Rate of Return (MIRR). The base run used the best estimates of each variable, notwithstanding a high level of uncertainty for some of the estimates. All analyses ran for the length of the investment period plus 30 years from the last year of investment (2022).

Table 6.1 and Table 6.2 show the investment criteria estimated for the different periods of benefits for both the total investment and for Wine Australia investment. The present value of benefits (PVB) for the Wine Australia investment, shown in Table 6.2, is estimated by multiplying the total PVB by the Wine Australia proportion of investment.

Table 6.1 Investment Criteria for Total Investment by Wine Australia and Project Partners (discount rate 5%)

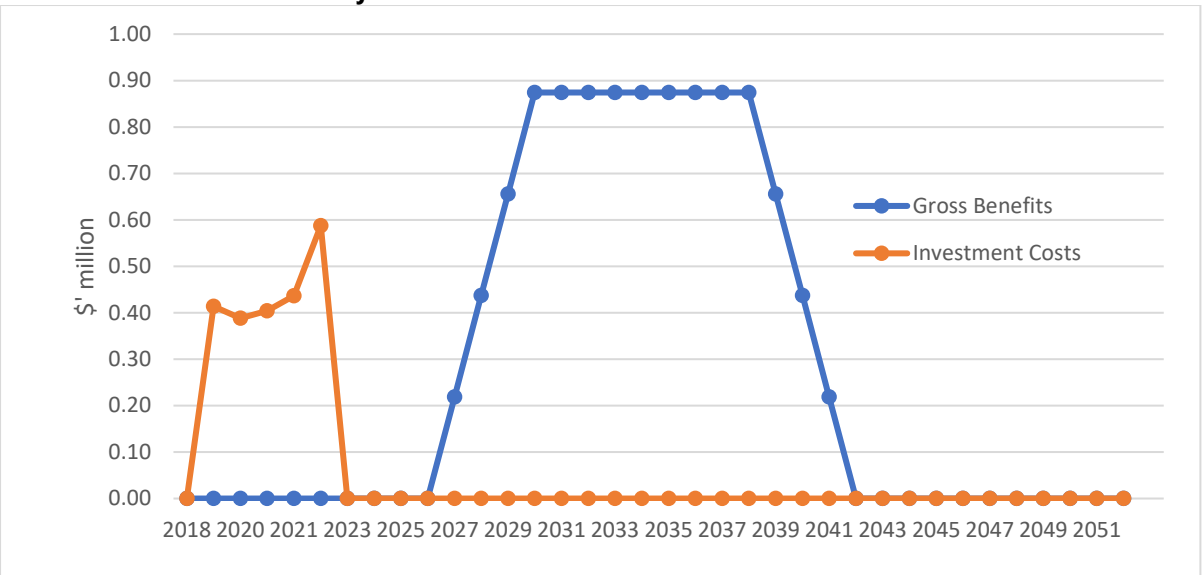
Years	0 years	5 years	10 years	15 years	20 years	25 years	30 years
Present value of benefits ($m)	0.00	0.17	2.66	4.98	5.93	5.93	5.93
Present value of costs ($m)	2.44	2.44	2.44	2.44	2.44	2.44	2.44
Net present value ($m)	-2.44	-2.27	0.21	2.54	3.49	3.49	3.49
Benefit–cost ratio	0.00	0.07	1.09	2.04	2.43	2.43	2.43
Internal rate of return (%)	Negative	Negative	6.1	12.7	14.0	14.0	14.0
MIRR (%)	Negative	Negative	5.9	10.1	9.8	8.8	8.2

Table 6.2 Investment Criteria for Wine Australia (discount rate 5%)

Years	0 years	5 years	10 years	15 years	20 years	25 years	30 years
Present value of benefits ($m)	0.00	0.16	2.42	4.55	5.42	5.42	5.42
Present value of costs ($m)	2.23	2.23	2.23	2.23	2.23	2.23	2.23
Net present value ($m)	-2.23	-2.08	0.19	2.32	3.19	3.19	3.19
Benefit–cost ratio	0.00	0.07	1.09	2.04	2.43	2.43	2.43
Internal rate of return (%)	Negative	Negative	6.1	12.7	14.0	14.0	14.0
MIRR (%)	Negative	Negative	5.9	10.1	9.8	8.8	8.2

The annual undiscounted benefits and cost cash flows for the total investment for the duration of the investment period plus 30 years from the last year of the initial investment are shown in Figure 6.1.

Figure 6.1 Annual Undiscounted Cash Flows for Estimated Total Benefits and Total RD&E Investment Costs for the Project



7. Sensitivity Analysis

A sensitivity analysis was carried out for the central analysis results reported in Section 6 and variations in the discount rate. Table 7.1 presents the results. The results are only moderately sensitive to discount rate due to the relatively short interval between investment in AWR 1701-4.4.3 and the creation of wine industry benefits.

Table 7.1 Sensitivity to Discount Rate (Total investment, 30 years)

Investment Criteria	Discount rate		
	0%	5% (base)	10%
Present value of benefits ($m)	10.49	5.93	3.55
Present value of costs ($m)	2.23	2.44	2.68
Net present value ($m)	8.26	3.49	0.87
Benefit-cost ratio	4.70	2.43	1.32

Sensitivity analyses were undertaken for those variables where there was greatest uncertainty or for those that were identified as key drivers of the investment criteria. The analyses were performed for the total investment and with benefits taken over the life of the investment plus 30 years from the last year of investment. All other parameters were held at their base values.

For this project, the greatest uncertainty related to the share of Australian wine production likely to benefit from project outputs and the increase in profit realised by winemakers – Table 7.2 and Table 7.3. Results show that the benefit cost ratio is sensitive to both these key assumptions but that additional profit realised by winemakers could be as little as $0.05/litre and the project would still generate a positive return on investment.

Table 7.2 Sensitivity to Share of Aust Wine Production Benefiting from Project (Total investment, 30 years)

Investment Criteria	Share of Aust Wine Production Benefiting from AWR 1701-4.4.3) (%)		
	2.5%	5% (base)	10%
Present value of benefits ($m)	2.97	5.93	11.87
Present value of costs ($m)	2.44	2.44	2.44
Net present value ($m)	0.52	3.49	9.42
Benefit-cost ratio	1.21	2.43	4.86

Table 7.3 Sensitivity to Increase in Profit Earned Adopting Project Findings (Total investment, 30 years)

Investment Criteria	Profit Earned by Winemakers Adopting Project Findings ($/litre)		
	$0.05/litre	$0.06/litre	$0.12/litre (base)
Present value of benefits ($m)	2.43	2.97	5.93
Present value of costs ($m)	2.44	2.44	2.44
Net present value ($m)	-0.01	0.52	3.49
Benefit-cost ratio	1.00	1.21	2.43

8. Confidence Ratings

The results produced are highly dependent on the assumptions made, many of which are uncertain. There are two factors that warrant recognition. The first factor is the coverage of benefits. Where there are multiple types of benefits it is often not possible to quantify all the benefits that may be linked to the investment. The second factor involves uncertainty regarding the assumptions made, including the linkage between the research and the assumed outcomes.

A confidence rating based on these two factors has been given to the results of the investment analysis (Table 8.1). The rating categories used are High, Medium, and Low, where:

High: denotes a good coverage of benefits or reasonable confidence in the assumptions made

Medium: denotes only a reasonable coverage of benefits or some uncertainties in assumptions made

Low: denotes a poor coverage of benefits or many uncertainties in assumptions made

Table 8.1 Confidence in Analysis of Program

Coverage of Benefits	Confidence in Assumptions
High	Medium

9. Summary of Results

Funding for AWR 1701-4.4.3 'bioprospecting Australian microbial genetic diversity' had a total cost of $2.44 million (present value terms) and is expected to produce aggregate total benefits of approximately $5.93 million (present value terms). This gives an estimated net present value of $3.49 million, a benefit-cost ratio of approximately 2.43, an internal rate of return of 14.0% and a modified internal rate of return of 8.2%.

Analysis results are dependent on assumptions made and are positive for both core assumptions and more negative estimates.

Abbreviations

AWRI	Australian Wine Research Institute
GI	Geographical Indication
OCS	Office of Chief Scientist
R&D	Research and Development
RD&E	Research, Development and Extension

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Appendix 4: Economic Analysis Wine Australia's Investment in Putting Microbial Diversity to Work in Shaping Wine Style

1. Background

With the exception of the small but growing wild-ferment wine sector, most wine is produced via inoculation with the wine yeast *Saccharomyces cerevisiae*. However, there is substantial genetic diversity both within and between yeast species and this diversity has the potential to provide benefits for winemakers.

While there are many commercially supplied yeasts available for winemaking, genetic analysis has shown that diversity among these yeasts is limited. This lack of depth means that there is scope to expand the genetic diversity of wine yeasts through breeding and selection to deliver wines with unique properties.

This project was to build on previous Wine Australia-funded research in which the major wine yeast *Saccharomyces cerevisiae* was mated with non-*cerevisiae* members of the *Saccharomyces* genus to produce genetically complex hybrids and where non-Genetically Modified (GM) methods of selection were employed to develop low hydrogen sulphide and low acetate producing yeasts. Together these breeding and selection strategies delivered non-GM germplasm for winemakers seeking a point of difference in their wines.

Past reviews of flavour-active and aromatic non-*Saccharomyces* wine yeasts revealed the limited extent of understanding about the environmental and genetic factors that determine yeast performance. Past reviews also showed that the bioconversion potential of non-*cerevisiae* and non-*Saccharomyces* yeast can be harnessed to benefit a range of commercial fermentation industries.

To deliver this project AWRI drew on a reservoir of Australian yeast germplasm developed as part of a previous project (Project 3.2.3). Previous projects have generated yeast flavour volatile profile datasets in defined medium and Chardonnay juice (AWR 1301) providing a baseline understanding of strain-dependent characteristics that can be employed.

2. Summary of Projects

Table 2.1 provides a description of the project in a logical framework.

Table 2.1 Project Description

AWR 1701-3.2.1: Putting Microbial Diversity to Work in Shaping Wine Style	
Project Details	Research Organisation: Australian Wine Research Institute (AWRI) Period: July 2017 to September 2022 Principal Investigator: Simon Schmidt
Rationale	It is still the case that inoculation with selected active dry wine yeast represents one of the lowest cost inputs in wine production, yet with one of the most significant impacts on winemaking outcomes. In putting the available diversity of yeast to work, this project was to contribute a set of tools that winemakers can use to achieve their stylistic ambitions.
Objectives	The project, together with others underway in the industry, was to contribute to: • An improved toolbox to create a target wine style. • New or enhanced yeast and bacterial germplasm to enhance winemaking processes and realise performance and economic gains, through improved fermentation efficiency and differentiation of wine products/styles.
Activities and Outputs	• Review existing yeast strain stock to identify opportunities for strain refinement. This activity focussed on *S. cerevisiae* strains that were not constrained by third-party, intellectual property restrictions. • Three robust *S. cerevisiae* strains were identified that exhibited strong fermentation kinetics, an absence of negative quality attributes and produced a variety of compounds associated with positive aromas in wine. • A review of microorganisms identified by Wine Australia-funded bioprospecting project (AWR 1701-4.4.3) was completed. The review was to identify opportunities for strain refinement. • Some 250 genetically distinct yeast isolates were screened; approximately 1% were classified as low hydrogen sulphide producers, seven were identified as exhibiting potential for varietal thiol (aroma, e.g., fruity flavours). One isolate exhibited robust fermentation kinetics and released high levels of thiol. • Use and refinement of CRISPR (marker assisted breeding) technology for the development of non-GM interspecies hybrid yeast. The refined technology was documented, and its future use will be relevant to the development of yeasts for a wide variety of industrial fermentations. • Investigation of species from the non-*Saccharomyces* yeast genera *Hanseniaspora* to identify precursors for the delivery of phenyl methanethiol which provides the desirable, "flinty" quality to some wines. • Five yeast isolates that produce desirable "rose-like aroma" were tested in a pilot-scale fermentation of Chardonnay must for their ability to produce aromatic higher alcohols phenyl ethanol (2-PE), tryptophol, and tyrosol. This work allowed assessment of wine styles that may be more compatible with enhanced "rose" aromas. These wine styles include Chardonnay, Pinot Gris, sparkling Chardonnay, and sparkling Grenache Rose. • A second generation 2-PE overproducing yeast was developed that is better suited to the production of sparkling wine. The yeast produced more intense "rose" and "fruity" aromas and was characterised by an intense "brioche" aroma. • Two new hybrids containing partial genomes of *S. eubayanus* and *S. arboricola* were created and added to the body of yeast products produced from previous Wine Australia-funded research. These two new hybrids were

	characterised in pilot-scale fermentations of red and white grapes. The new yeasts delivered fruity aromas of cherry, red berry, baking spice and vanilla. However, some strains produced wines with more prominent and less desirable "boiled egg" and "canned vegetable" aromas. Some of these new strains are well suited to red wine production. • White wines made using hybrids developed as part of the project differed in yellow colour intensity, tropical fruit aroma, passionfruit aroma, banana aroma and flavour, honey aroma, and stone fruit flavour. • One *S. cerevisiae* and *S uvarum* hybrid displayed robust fermentation properties in high sugar juices while producing lower concentrations of acetic acid. Acetic acid is the sour taste associated with vinegar. • The project also assisted with commercialisation of yeasts generated by a previous Wine Australia project. • The project has put the genetic diversity within and between different yeast species to work. It has characterised existing strains to help build the foundations of future strain development, introducing new traits through targeted selection, and expanding the range of characteristics available through introgression of genetic elements not previously accessible in a winemaking context. In achieving these tasks, the project team developed new methods which will help to build future generations of wine yeast. • While the project was to deliver practical advice and extension materials, further R&D will be required prior to the need to communicate project output to winemakers. The project did deliver technical articles, content for a technical workshop, and a peer reviewed journal publication. Other outputs included a project plan, and nine progress reports.
Outcomes	• New yeasts that when available commercially, may help to improve fermentation efficiency. • Refined CRISPR, marker assisted breeding techniques, that can be used to produce new yeasts for a variety of commercial fermentation processes. • Progress toward new commercial yeasts that can be trialed by winemakers to enhance the unique character of Australian wine (and produce high value differentiated wine products).
Impacts (potential)	• Economic – potential future increase in the value of Australian wine with some winemakers adopting commercial versions of the new yeasts developed by the project and producing differentiated, higher value wine. • Economic – potential future improvements in fermentation efficiency with some winemakers adopting commercial versions of the new yeasts developed by the project. • Capacity – additional wine yeast isolates that will facilitate further yeast genomics research. • Capacity – additional AWRI staff skills in genetics, and yeast breeding. • Capacity – increased capacity to develop yeasts using CRISPR technology. Technology will be relevant to many industries including fermented foods, bread, beer, cider, and sake. • Social – additional profitable sales of unique Australian wine will generate income, and employment benefits in regional Australia (spill-over impact).

3. Match with National Priorities

Table 3.1 Australian Government Research Priorities

Australian Government Strategies and Priorities	
National Science and Research Priorities[8]	**National Agricultural Innovation Priorities[9]**
1. Food – optimising food and fibre production and processing; agricultural productivity and supply chains within Australia and global markets. **2. Soil and Water** – improving the use of soils and water resources, both terrestrial and marine. **3. Transport** – boosting Australian transportation: securing capability and capacity to move essential commodities; alternative fuels; lowering emissions. **4. Cybersecurity** – improving cybersecurity for individuals, businesses, government, and national infrastructure. **5. Energy and Resources** – supporting the development of reliable, low cost, sustainable energy supplies and enhancing the long-term viability of Australia's resources industries. **6. Manufacturing** – supporting the development of high value and innovative manufacturing industries in Australia. **7. Environmental Change** – mitigating, managing or adapting to changes in the environment. **8. Health** – improving the health outcomes for all Australians.	On 11 October 2021, the National Agricultural Innovation Policy Statement was released. It highlights four long-term priorities for Australia's agricultural innovation system to address by 2030. These priorities replace the Australian Government's Rural Research, Development and Extension Priorities which were published in the 2015 Agricultural Competitiveness White Paper. **1.** Australia is a trusted exporter of premium food and agricultural products by 2030. **2.** Australia will champion climate resilience to increase the productivity, profitability, and sustainability of the agricultural sector by 2030. **3.** Australia is a world leader in preventing and rapidly responding to significant incursions of pests and diseases through futureproofing our biosecurity system by 2030. **4.** Australia is a mature adopter, developer, and exporter of digital agriculture by 2030.

The Wine Australia project has addressed National Science/Research Priority 1. The major focus of the project has been on the first of the National Agricultural Innovation Priorities.

4. Identification of Potential Costs and Benefits

4.1 Costs

4.1.1 R&D Investment

The R&D investment costs comprised:

- Direct financial outlays by Wine Australia, the project funding body. These costs include both project and overhead expenditures.
- In-kind contributions to the research project – non-cash contributions made by the research partner (AWRI).
- In-kind contributions to the research project – such as time associated with meetings between the researchers and Wine Australia.

4.1.2 Administration

No additional administration costs were identified.

[8] See: 2015 Australian Government Science and Research Priorities. https://www.industry.gov.au/data-and-publications/science-and-research-priorities

[9] See: 2021 National Agriculture Innovation Policy Statement. https://www.awe.gov.au/agriculture-land/farm-food-drought/innovation/research_and_development_corporations_and_companies#government-priorities-for-investment

4.1.3 Extension

The project has delivered refined CRISPR technology and identified prospective hybrid yeasts with potential for improved fermentation and desirable winemaking traits. Further research and commercialisation will be required prior to winemaker adoption. Commercial partners will be needed to supply project generated, hybrid yeasts. Some extension costs may be incurred in the interim to increase winemaker awareness of the new yeasts and to incentivise their commercial production.

4.1.4 Adoption

Winemaker adoption of project generated yeasts will be low cost. Yeast is one of the lowest cost inputs in wine making and new yeasts should cost no more than current *S. cerevisiae*.

4.2 Benefits

4.2.1 Research Output and Impact Pathway

The potential impact pathway for the project is:

1. Prospective new yeasts identified as part of this project (AWR 1701-3.2.1) will require further investment before commercial outcomes are realised.
2. New yeasts will require additional pilot- and industry-scale evaluation. If the potential of new yeasts is confirmed, partnerships with commercial yeast suppliers will be needed so that supply can be made available to winemakers.
3. Some winemakers will adopt the new project generated yeasts and produce differentiated, higher value wine.

4.2.2 Triple Bottom Line Benefits

A summary of potential benefits from the project in triple bottom line categories is shown in Table 4.1.

Table 4.1 Triple Bottom Line Categories Benefits from Project Investment

Levy Paying Industry	**Spillovers**		
	Other Industries	**Public**	**Foreign**
Economic Benefits			
Potential future increase in the value of some Australian wine with a share of winemakers adopting commercial versions of the new yeasts developed by the project. Potential future improvements in fermentation efficiency with some winemakers adopting commercial versions of the new yeasts developed by the project.	Potential for the development of new yeasts for other industries (fermented foods, bread, beer, cider, sake, etc.) using project refined CRISPR, marker assisted breeding techniques. Potential sales of new project developed commercial yeast producers.	Nil.	If industry choses to share or licence the new yeasts, these may be relevant to overseas wine producers.
Environmental Benefits			
Nil	Nil.	Nil.	Nil.
Social Benefits			
Additional wine yeast isolates that will facilitate further yeast genomics research.	Capacity developed during the project may assist with the development of other fermentation products.	Nil.	Nil

Additional AWRI staff skills in genetics, CRISPR, and yeast breeding. Additional profitable sales of unique Australian wine will generate income, and employment benefits in regional Australia (spill-over impact).			

4.2.3 Public versus Private Benefits

The project has the potential to generate both private and public benefits. The private benefits will be captured by wine grape growers, commercial yeast producers, winemakers, and the supply chain. Private benefits will be realised as an increase in Australian wine value via more efficient ferments and the production of differentiated, higher value wine. Potential public benefits may include additional research capacity and spill-over benefits for regional Australia.

4.2.4 Distribution of Benefits along the Supply Chain

The benefits to the wine industry from investment in this project will be shared along the supply chain with wine grape growers, commercial yeast producers, winemakers, wholesalers, retailers, and exporters all sharing some of the benefits.

4.2.5 Benefits to other Primary Industries

Capacity developed during the project, especially in relation to the refinement of CRISPR technology for use in yeast development, may be relevant to other commercial fermentation industries.

4.2.6 Benefits Overseas

If industry choses to share or licence the new yeasts, they may be relevant to overseas wine producers.

4.3 Summary of Costs and Benefits

A summary of principal categories of costs and benefits from the project is shown in Table 4.2.

Table 4.2 Incremental Cost and Benefit Categories

Costs	Benefits
R&D investment costs (cash and in-kind) as well as project administration costs.	Economic – potential future increase in the value of some Australian wine with a share of winemakers adopting commercial versions of the new yeasts developed by the project.
Overhead costs including time associated with meetings between the researchers and Wine Australia.	Economic – potential future improvements in fermentation efficiency with some winemakers adopting commercial versions of the new yeasts developed by the project.
Research costs – additional investment will be required to further develop AWR 1701-3.2.1 findings.	Capacity - additional wine yeast isolates that will facilitate further yeast genomics research.
Winemaker costs which may include time required to experiment with new yeasts and any additional cost associated with the purchase of new yeasts.	Capacity - additional AWRI staff skills in genetics, CRISPR, and yeast breeding.
	Social – additional profitable sales of unique Australian wine will generate income, and employment benefits in regional Australia (spill-over impact).

5. Valuation of Costs and Benefits

5.1 Costs

5.1.1 R&D Investment Costs including Administration

The following table shows annual investment in the project by Wine Australia (Table 5.1).

Table 5.1 Investment by Wine Australia in the Project for Years Ending June 2018 to June 2022

Project Code	2018	2019	2020	2021	2022	Total
AWR 1701-3.2.1 – Wine Australia	366,759	343,392	400,012	379,234	505,526	**1,994,923**
Total	**366,759**	**343,392**	**400,012**	**379,234**	**505,526**	**1,994,923**

Source: Wine Australia record of project expenditure

The other investor in AWR 1701-3.2.1 was AWRI. Data is not available on AWRI contributions to individual Wine Australia projects (Maria Khem, RD&A Administrator, Wine Australia, written communication, December 2022). However, in 2021/22 AWRI invested a total of $893,389 in thirty-four Wine Australia projects at an average investment of $26,276 per project and this per project average has been applied to each year of the AWR 1701-3.2.1 investment (Table 5.2).

Table 5.2 Investment by Others in the Project for Years Ending June 2018 to June 2022

Project Code	2018	2019	2020	2021	2022	Total
AWR 1701-4.4.3 – Wine Australia	26,276	26,276	26,276	26,276	26,276	**131,380**
Total	**26,276**	**26,276**	**26,276**	**26,276**	**26,276**	**131,380**

Source: AgEconPlus estimate

Table 5.3 provides the total investment by year for both sources.

Table 5.3 Annual Investment in the Project (nominal $)

Year Ending 30 June	Wine Australia	Others	Total
2018	366,759	26,276	**393,035**
2019	343,392	26,276	**369,668**
2020	400,012	26,276	**426,288**
2021	379,234	26,276	**405,510**
2022	505,526	26,276	**531,802**
Total	**1,994,923**	**131,380**	**2,126,303**

5.1.2 Overhead Costs including Meetings between the Researchers and Wine Australia

Wine Australia overhead costs are in addition to those shown in the above tables and are estimated at 12%.

5.1.3 Industry Costs

No industry contributions to the project were identified.

5.1.4 Research and Adoption Costs

Further research is required before project outputs and outcomes generate profits for winemakers. Winemakers will incur costs in training and experimentation using the new project-generated yeasts. These costs are accounted for in the analysis through the application of a research benefit attribution factor – see Table 5.4 below.

5.2 Benefits

Counterfactual: in the absence of this project, there is only a small possibility that an organisation other than Wine Australia would have invested in R&D to develop new yeasts with superior fermentation and

improved wine style characters. Consequently, a counterfactual of 90% has been assumed i.e., it is 10% likely that potential project benefits would have been realised in the absence of project investment.

5.2.1 Increased Winemaker Profit on Ferment Efficient, Unique Style Wine

The project has delivered progress toward the creation of new yeasts that may help to improve fermentation efficiency and deliver differentiated Australian wine with unique character. These benefits will manifest themselves as an increase in profit for some output adopting winemakers. It is not known what percentage of Australian winemakers and production will be attracted to, and successful with, these new project-generated yeasts. In the absence of these data a maximum of 2.5% of Australian production has been assumed.

A summary of key assumptions used to quantify increased winemaker profit associated with yeasts that deliver more efficient ferments and wines of unique style is summarised in Table 5.4.

Table 5.4 Summary of Assumptions

Variable	Assumption	Source
Benefit 1: Increased Winemaker Profit on Ferment Efficient, Unique Style Wine		
Australian wine production.	1.3 billion litres p.a.	Wine Australia 2022.
Share of Australian wine production that will make use of project findings.	2.5%	Analyst's estimate after considering that experimental winemaking using new yeasts is likely to be a "niche" activity.
Increase in winemaker profit with adoption of project outputs.	$0.12/litre.	Derived from net revenue estimate of $1.22/litre (Wine Australia 2019) and assumes a 10% increase in profit. Increase in profit due to "cost savings on the wine making end through efficiencies'' (Angelica Crabb, Wine Australia, pers. Comm., March 2023).
Attribution of benefits to this project (AWR 1701-3.2.1).	35%	Attribution of benefits to this project was estimated after considering past R&D on hybridisation of yeast, the creation of an Australian yeast germplasm reservoir, yeast profile research, bioprospecting, and management of micro-organism culture. Further investment will be needed to turn project generated yeasts into commercial products.
Year of first benefit.	2027	Five years is required post project completion for completion of additional research and the production of new commercial yeasts.
Year of last benefit.	2041	Project outputs are superseded by findings from new microbial genetic research projects.
Probability of valuable outputs.	100%	Outputs have been delivered.
Probability of valuable outcomes.	50%	Progress has been made in creation of superior yeast strains.
Probability of impact.	85%	It is likely that improved yeasts will generate an increase in winemaker profit. There is also a relatively small risk that this will not occur.
Counterfactual	90%	See above explanation.

5.2.2 Other Potential Benefits

Other potential benefits identified but not valued are summarised in Table 4.2. Other potential benefits were not quantified due to their relatively minor contribution to total impact and difficulty in securing data for quantification.

6. Results

All past costs were expressed in current dollar terms using the implicit price deflator for GDP. All costs and benefits from 2022 onwards were discounted to current dollar terms using a discount rate of 5%. A reinvestment rate of 5% was used for estimating the Modified Internal Rate of Return (MIRR). The base run used the best estimates of each variable, notwithstanding a high level of uncertainty for some of the estimates. All analyses ran for the length of the investment period plus 30 years from the last year of investment (2022).

Table 6.1 and Table 6.2 show the investment criteria estimated for the different periods of benefits for both the total investment and for Wine Australia investment. The present value of benefits (PVB) for the Wine Australia investment, shown in Table 6.2, is estimated by multiplying the total PVB by the Wine Australia proportion of investment.

Table 6.1 Investment Criteria for Total Investment by Wine Australia and Project Partners (discount rate 5%)

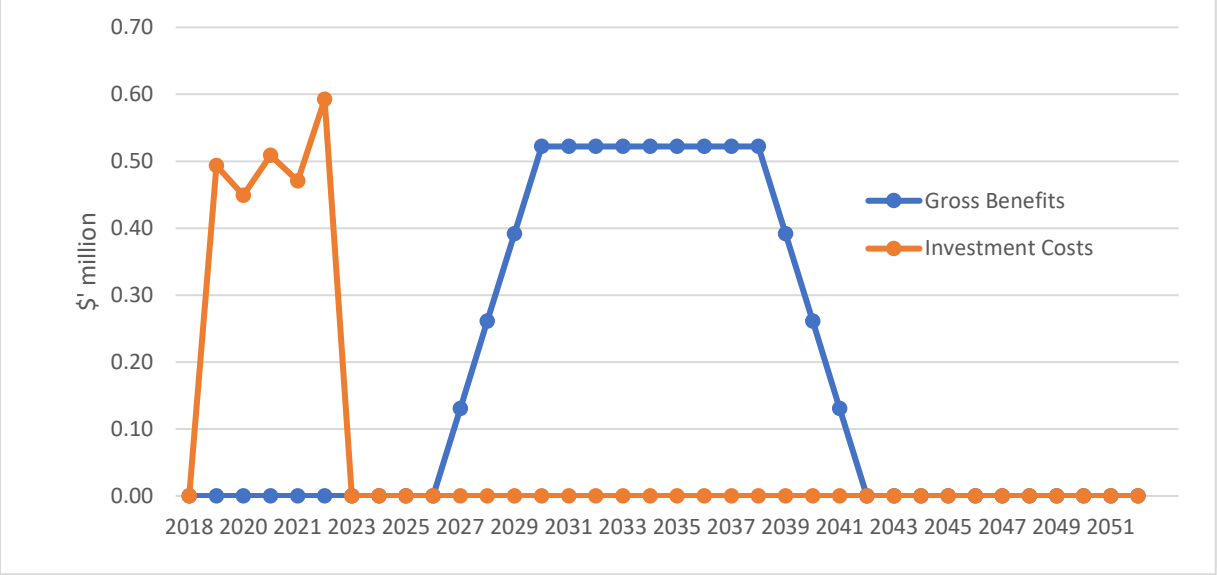
Years	0 years	5 years	10 years	15 years	20 years	25 years	30 years
Present value of benefits ($m)	0.00	0.10	1.59	2.97	3.54	3.54	3.54
Present value of costs ($m)	2.77	2.77	2.77	2.77	2.77	2.77	2.77
Net present value ($m)	-2.77	-2.67	-1.18	0.21	0.78	0.78	0.78
Benefit–cost ratio	0.00	0.04	0.57	1.07	1.28	1.28	1.28
Internal rate of return (%)	Negative	Negative	Negative	5.7	7.3	7.3	7.3
MIRR (%)	Negative	Negative	Negative	5.5	6.3	6.0	5.9

Table 6.2 Investment Criteria for Wine Australia (discount rate 5%)

Years	0 years	5 years	10 years	15 years	20 years	25 years	30 years
Present value of benefits ($m)	0.00	0.10	1.50	2.81	3.35	3.35	3.35
Present value of costs ($m)	2.61	2.61	2.61	2.61	2.61	2.61	2.61
Net present value ($m)	-2.61	-2.52	-1.12	0.19	0.73	0.73	0.73
Benefit–cost ratio	0.00	0.04	0.57	1.07	1.28	1.28	1.28
Internal rate of return (%)	Negative	Negative	Negative	5.7	7.3	7.3	7.3
MIRR (%)	Negative	Negative	Negative	5.5	6.3	6.0	5.9

The annual undiscounted benefits and cost cash flows for the total investment for the duration of the investment period plus 30 years from the last year of the initial investment are shown in Figure 6.1.

Figure 6.1 Annual Undiscounted Cash Flows for Estimated Total Benefits and Total RD&E Investment Costs for the Project



7. Sensitivity Analysis

A sensitivity analysis was carried out for the central analysis results reported in Section 6 and variations in the discount rate. Table 7.1 presents the results. The results are sensitive to the discount rate and a negative result is recorded when the rate is increased to 10%.

Table 7.1 Sensitivity to Discount Rate (Total investment, 30 years)

Investment Criteria	Discount rate		
	0%	5% (base)	10%
Present value of benefits ($m)	6.27	3.54	2.12
Present value of costs ($m)	2.51	2.77	3.05
Net present value ($m)	3.75	0.78	-0.93
Benefit-cost ratio	2.49	1.28	0.70

Sensitivity analyses were undertaken for those variables where there was greatest uncertainty or for those that were identified as key drivers of the investment criteria. The analyses were performed for the total investment and with benefits taken over the life of the investment plus 30 years from the last year of investment. All other parameters were held at their base values.

For this project, the greatest uncertainty related to the share of Australian wine production likely to benefit from project outputs and the increase in profit realised by winemakers - Table 7.2 and Table 7.3. Results show that the benefit cost ratio is sensitive to both these key assumptions and that if share of wine production adopting was only 2% and increase in profit as low as $0.10/litre, project costs would approximately equal project benefits.

Table 7.2 Sensitivity to Share of Aust Wine Production Benefiting from Project (Total investment, 30 years)

Investment Criteria	Share of Aust Wine Production Benefiting from AWR 1701-3.2.1) (%)		
	2%	2.5% (base)	4%
Present value of benefits ($m)	2.83	3.54	5.67
Present value of costs ($m)	2.77	2.77	2.77
Net present value ($m)	0.07	0.78	2.90
Benefit-cost ratio	1.02	1.28	2.05

Table 7.3 Sensitivity to Increase in Profit Earned Adopting Project Findings (Total investment, 30 years)

Investment Criteria	Profit Earned by Winemakers Adopting Project Findings ($/litre)		
	$0.10/litre	$0.12/litre (base)	$0.20/litre
Present value of benefits ($m)	2.95	3.54	5.91
Present value of costs ($m)	2.77	2.77	2.77
Net present value ($m)	0.19	0.78	3.14
Benefit-cost ratio	1.07	1.28	2.13

8. Confidence Ratings

The results produced are highly dependent on the assumptions made, many of which are uncertain. There are two factors that warrant recognition. The first factor is the coverage of benefits. Where there are multiple types of benefits it is often not possible to quantify all the benefits that may be linked to the investment. The second factor involves uncertainty regarding the assumptions made, including the linkage between the research and the assumed outcomes.

A confidence rating based on these two factors has been given to the results of the investment analysis (Table 8.1). The rating categories used are High, Medium, and Low, where:

High: denotes a good coverage of benefits or reasonable confidence in the assumptions made

Medium: denotes only a reasonable coverage of benefits or some uncertainties in assumptions made

Low: denotes a poor coverage of benefits or many uncertainties in assumptions made

Table 8.1 Confidence in Analysis of Program

Coverage of Benefits	Confidence in Assumptions
High	Medium

9. Summary of Results

Funding for AWR 1701-3.2.1 'investment in putting microbial diversity to work in shaping wine style' had a total cost of $2.77 million (present value terms) and is expected to produce aggregate total benefits of approximately $3.54 million (present value terms). This gives an estimated net present value of $0.78 million, a benefit-cost ratio of approximately 1.28, an internal rate of return of 7.3% and a modified internal rate of return of 5.9%.

Analysis results are dependent on assumptions made and are positive for core assumptions and do not become negative until 'lower end' assumptions are applied.

Abbreviations

2-PE	phenyl ethanol
AWRI	Australian Wine Research Institute
GI	Geographical Indication
GM	Genetically Modified
OCS	Office of Chief Scientist
R&D	Research and Development
RD&E	Research, Development and Extension

Persons Contacted

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Paul Smith, Senior RD&E Program Manager, Wine Australia
Simon Schmidt, Principal Researcher, AWRI

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