Developing Information Herds within the Resilient Dairy Program – Initial Case Outline

Prepared for

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Executive summary

This report outlines some initial considerations around developing an "info-herd program" as a group of herds contributing next-generation trait measurements that support the implementation of a broader range of traits and data sources in dairy industry genetic evaluation programs. The program would have a key focus on genomics as a technology to leverage investment in trait measurement into the wider dairy industry, while also generating other benefits from the technology.

This report has focussed on a high level consideration of:

1. What potential traits might be assessed for dairy industry genetic programs, to provide some context and tangible view of how an info-herd program might fit with next-generation trait measurements.
2. What is the potential for participants to benefit from genotyping and phenotyping in their herds, and whether there is a case for participants to co-fund some of the investment in genotyping particularly.

A non-exhaustive list of potential data sources and traits for industry evaluations was developed. Emerging from a consideration of how these traits might fit with an info-herd program are some key strategic observations:

1. For several traits, the frequency of herd recording is a key factor, and the value of in-line milk recording and other automated data collection technologies is of interest. Further investigation of recording frequency on trait definitions and measurements should be undertaken, and this might become a key criteria for selection of herds to participate in the info-herd program.
2. For some traits, data is already collected for other purposes and held in a variety of places. Extracting further value from this data would require technical work (to define traits, data requirements and to establish automated data pipelines) and business-level agreements around contribution of data.
3. It is highly unlikely that all herds will contribute to all traits, so some tiered levels of participation in the info-herd program are likely to be required. This will need to be balanced with the need for representation of different environments, systems, breeds and other factors.
4. Information technology to support data collection, transfer, storage and reporting must be a vital part of delivery, both within the info-herd program but also more widely within NZAEL structures.

The best path to facilitate co-investment from info-herd participants in genotyping would be to work with herds that are already using genotyping for parentage assignment routinely on a high proportion of retained female calves. An analysis of NZAEL data recording structures suggests that in 2020 there are approximately 860 herds which would meet this criteria, with 550,000 genotyped females in these herds (average herd size of 709 females). This would equate to approximately 100 new genotyped calves retained in each herd annually. This initially appears to provide scope to select a subset of these herds to work with, although multiple other criteria would need to be applied and further analysis is needed to understand the impact of applying these criteria on the pool of herds which would be suitable participants. Using some approximations as to how the program might be configured (as

detailed design work is yet to be undertaken), using 10% of the 860 herds would result in approximately $200k of participant co-investment in genotyping alongside an equal industry contribution. This would not include any requirement to re-genotype existing females at higher density genotypes, which would likely need to be 100% funded from the program. The requirement to re-genotype cows would depend on the program design and timing of measurements, but might be necessary in the initial years of the program.

Overall, the program will have a range of impacts, both benefits and costs, on participating herds. Some of these have been identified in this report and a qualitative assessment made on their impact on likely participating herds. Once a more detailed program design has been developed it is intended to provide a further assessment of the value proposition from the Info-herd program to participating farmers.

Recommendations include:

1. That the info-herd program seeks initially to work with herds already making extensive use of genotyping for parentage verification, and seeks to share investment in higher density genotyping with participants with the program paying at least the difference between genotyping costs for parentage panel vs higher density.
2. That further work is undertaken to better understand the segmentation profiles of herds in terms of use of parentage verification combined with multiple other criteria of importance to the info-herd program including data quality, breed composition, geographic distribution, herd size, etc.
3. That investigation of the need for increased frequency of herd recording through to use of automated milk recording and other measurement systems in Info-herds is undertaken.
4. That a more detailed analysis of the indirect costs to participating farm businesses is completed and factored in to any potential subsidisation of existing farm costs such as semen, AB and herd recording.
5. That the implementation of the info-herd program gives strong consideration to the non-financial motivations of participants in becoming part of a program, and seeks to maximise these "value add" aspects to maintain long-term commitment to the program.

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Background and introduction

DairyNZ intends to incorporate genomics into its genetic evaluation system, NZAEL3.0 and later versions. To date genomics has been used in NZ dairy breeding primarily by breeding companies to significantly decrease generation interval while selecting for existing core productivity traits which are "easy (or easier) to measure". However, genomics has broader benefits and wider application than simply decreasing generation interval. Another application of genomics is to enable selection on "next generation" traits, which might be restricted in ability to measure due to cost, practicality, impact on farm business, etc. The core principle being exploited is that these traits can be measured on a relatively small proportion of the population and genomics used to leverage the impact of these measurements into selection emphasis through a much wider population. Other benefits from genomics are also available, and will be covered in later reports.

Applying genomics to "next generation" traits requires a core sub-population of animals which are both genotyped and phenotyped, to generate the key associations which can then be used in genomic selection. This requires herds which are able to collect phenotypes on "hard to measure" traits, combined with a suitable representation of industry genetics with genotype information (the genotyping is generally the easy part). Current herd recording structures available in the industry include:

1. Research herds – generally owned and run by institutions, and used to develop, test and validate new concepts and phenotype measurements. There are limited numbers of these herds in New Zealand, owned by institutions such as DairyNZ, AgResearch, Massey and Lincoln Universities, and cows in these herds can be subject to competing requirements for other research needs.
2. Sire proving herds – these are generally privately owned commercial herds, and used to collect data to prove sires. Generally there is a focus on providing quality data but typically only on the core set of traits currently measured and used in the National Breeding Objective. These herds are associated with the dairy bull breeding companies.
3. Elite herds – herds which have good quality data and follow breeding practices to maximise rates of genetic gain. These herds are the source of many bulls used by the breeding companies.
4. Commercial dairy herds – the rest of the industry, not specifically focussed on collecting data for genetic purposes, and the data is often of poor quality.

None of these current structures fit all of the attributes required to develop phenotypic measures and genomic calibrations for hard to measure traits (although some Sire proving herds and Elite herds might have capacity to add other trait measurements). To implement genomics using new and "next generation" traits, a group of herds with a different set of attributes are required. These herds might also be useful for other purposes, such as validating genomics on the current core set of traits. These herds will be referred to hereafter as Info-Herds in this report, and the attributes which differentiate these herds from research herds, elite herds and sire proving herds include:

1. Are commercially operated herds that are willing and able to co-operate with science providers to scale up new phenotypic measurements developed in research herds.

2. Have sufficient numbers of herds and animals to provide the scale required to accurately calibrate genomic selection, with representation across regions and systems.
3. Are willing to use emerging sires from diverse backgrounds (and across breeding companies) so that the full range of industry genetics are represented.
4. Able to collect some core data on a day-to-day basis in the absence of research staff and potentially at lower cost compared to research herds (e.g. records of animal health treatments, or anything else that needs to be recorded as events occur rather than at one point in time).

Developing and supporting these herds will require significant investment, and there will be a medium to long-term need for these herds to operate. From an industry investment viewpoint, the more financially self-sustaining the Info-herds can be, the better the long-term outlook to support these herds. Investment in genotyping and phenotyping which is beyond normal commercial practice will be required. The herd owners will incur some in-kind costs to their business, in areas such as time for involvement, management complications, defined use of genetics, time cows are off feed for measurements, etc. The herd owners will also receive some benefits to their business, and in time some of these benefits are likely to be associated with genotyping their own cows. At this point, genotyping cows at higher densities is not a widely used commercial practice, although there is some use of genotyping on limited panels for parentage verification. Consequently genotyping at higher density will be an additional expense. A key question for this report lies around what might reasonably be expected in terms of contribution of herd owners towards genotyping and phenotyping vs what should be covered from industry funding to support the Info-herd program?

Info-herd requirements

The proposed role of Info-herds is just one part of the overall picture for dairy genetic evaluations, and so it seems sensible when considering what the Info-herds might look like to take account of other components. This could be thought of in terms of what are potential new traits that might contribute to dairy evaluations, what data might be required, whether this data already exists and where it might come from. Some “new” traits (new being in terms of contribution to genetic evaluations) might be “simply” a matter of importing data already collected into the DIGAD database (without diminishing the need to address barriers such as data ownership, commercial considerations, intellectual property, data transfer agreements and infra-structure and then development of analysis protocols and pipelines). Other new traits are emerging from research programs, and validated in research herds (e.g in research institution herds or the puberty scale-up herds).

Table 1 documents a large list of potential traits which could be considered for incorporation into NZAEL. This should be regarded as a point in time, and the list could be expanded (or traits deleted) as new research is conducted, new technology opportunities arise, etc. These traits can be broadly grouped as addressing fertility, health & survival, production & efficiency, and novel traits around environmental emissions (e.g. feed intake and methane) and adaption to changed environment (e.g. facial eczema and heat tolerance).

In terms of the info-herd program, the actions and decisions required to incorporate these trait measurements are varied. They might include actions such as:

- Increase the frequency of herd recording
- Use in-line milk meters and/or automated recording systems (e.g. walk-over weighing) – likely by choosing to work with herds already investing in these systems.
- Use activity monitoring devices
- Implement special measurement programmes (e.g. progesterone profiles, ano-genital distance measures, etc)
- Modify some existing measurement programmes (e.g. collect foetal age data when pregnancy scanning, with requires some more skill and slower work rate)
- Score some traits and collate data.
- Collect information on environmental challenge (e.g. FE spore counts, THI from nearby weather stations, etc).

Considering these types of actions is enlightening, and raises several considerations for info-herd farms.

1. It is almost certain that not every info-herd farm will be able (or willing) to collect every trait, and **spread of trait collection needs to be considered when designing info-herd criteria and distribution**. For example, only herds in areas with natural FE challenge would be suitable for inclusion into a FE trait measurement.
2. The **frequency of herd recording will be a key issue** that should be addressed. Frequent herd recording will be required for some traits, and some traits would be reliant on in-line monitoring systems. Some modelling of the impact of different levels of herd recording should be undertaken to inform what are the minimum viable levels for different traits.
3. **Some traits have potential for commercial co-investment**. This might not always be in the form of a per-measurement type of co-investment, but in some instances might be investment in developing data pipelines and analysis protocols. For example, in-line monitoring companies may benefit from added product features if data collected from their systems were automatically made available to DIGAD and an analysis of benefit to the farmer were returned (this might be a novel trait, or even increased accuracy of existing traits).
4. **The majority of the traits are likely to require information technology infrastructures**. With the possible exception of traits collected with involvement of research technicians, almost all data collected will require a convenient and seamless way of entry, transfer and storage on DIGAD (or other appropriate database). Moreover, to maintain incentive to collect data it also requires a convenient channel to provide benefits back to help on-farm decisions – which might be in the form of raw phenotypic data, or with some level of phenotypic or genetic analysis wrapped around it.

Table 1 List of potential traits contributing to NZAEL genetic evaluations, their current data status, actions required and potential for industry co-investment.

Trait Group	Trait	Phenotype	Animals Recorded	Collection Method	Data Collection Status	Data Location	Action	Potential for Industry Co-Investment
Fertility	Fertility	Ano-genital distance	Cows & Replacement Heifers	Digital caliper measurement	Recorded in Puberty Scaleup (PBS) herds. New measurement for non-PBS herds.	Research database	Link to DIGAD	Low
Fertility	Age of puberty	Progesterone concentration	Replacement Heifers	Blood samples - 6 weekly intervals prior to first mating	Recorded in Puberty Scaleup (PBS) herds. New measurement for non-PBS herds.	Research database	Link to DIGAD	Low
Fertility	Conception date	Conception date	Cows	Foetal aging during PD scan	PD records recorded in most herds.	Various. Some records held by vets/scanners. LIC obtains some data for fertility focus herds.	Better understanding of data flows required.	Data is already collected.
Fertility	Heat/Cycling activity	Various phenotypes relating to cycling activity and timing	Cows	Activity monitoring devices	Some herds are recording using commercial devices.	Highly fragmented. Some sits within commercial companies.	Better understanding of data quality and data flows required. Negotiation with device suppliers. Needs herd testing certification.	Data is already collected in some herds.
Fertility	Age of puberty	Heifer liveweight	Replacement Heifers	Weight records collected pre-mating	Recorded in Puberty Scaleup (PBS) herds. New measurement for non-PBS herds.	Research database	Link to DIGAD	Low

Trait Group	Trait	Phenotype	Animals Recorded	Collection Method	Data Collection Status	Data Location	Action	Potential for Industry Co-Investment
Fertility	Age of puberty	Heifer liveweight	Replacement Heifers	Weight records collected pre-mating	Recorded in LIC herds under MINDA Weights	LIC/MINDA	Negotiate access and Link to DIGAD	Low
Health/ Survival	Lameness	Assessment of freedom of movement while walking	Cows	Visual score	Some herds may be recording/monitoring.	Various/Unknown	Better understanding of data flows required.	Data is partially recorded. Benchmarking holds some value
Health/ Survival	Lameness	Novel eg White line, hoof trimmer scoring etc	Cows	Depends on phenotype	New measurement.	New measurement.	Survey data recorders to understand level of recording and potential to include in service, share data etc.	Benchmarking holds some value
Health/ Survival	Survival	Culling date and culling reason	Cows	Recording date and reason/s associated with every cow culling event	Data is already recorded but requires greater quality control and accessibility	DIGAD	Target high data quality herds	Data is already collected to suitable standard in some herds.
Health/ Survival	Udder Support	Udder depth and strength of suspensory ligament	Cows (1st parity)	Visual score as per TOP	Data is already recorded in SPS herds. Would be a new measurement in non-SPS herds	New measurement.	Build into TOP scoring package for info herds	Low
Health/ Survival	Clinical Mastitis	Identifying cows presenting with clinical mastitis	Cows	Records of masititis detection and treatment for individual cows, and preventative treatments across herds.	Montitoring for mastitis cases is part of routine management. Case records need to be collected and collated.	Veterinary databases	Negotiate access and Link to DIGAD	Data is already recorded.

Trait Group	Trait	Phenotype	Animals Recorded	Collection Method	Data Collection Status	Data Location	Action	Potential for Industry Co-Investment
Health/ Survival	Facial Eczema	Tolerance based on production response under challenge	Cows	Herd test data from challenged herds to ID more tolerant animals	Data is already recorded. Need to understand level of challenge for individual herds and timing of challenge.	DIGAD has production data. Need link to spore count data.	Better understanding of collection and storage of spore count data. Understand frequency of production recording that is required to detect FE driven fluctuations.	Production data is already collected in herds with in-line meters. Installation of meters is a potential area of co-investment in other herds.
Health/ Survival	Facial Eczema	Clinical incidences	Cows	Clinical case records	New measurement.	New measurement.	Develop a potential data recording and collection protocol	Low
Novel	Heat tolerance	Heat tolerance	Cows	Combination of summer milk test records and weather station data.	Production data is already recorded. Need to increase frequency to generate sufficient data under challenge. Need to link to weather station data.	Data is in DIGAD and NIWA.	Understand frequency of production recording that is required.	Production data is already collected in herds with in-line meters. Installation of meters is a potential area of co-investment in other herds.
Novel	Feed intake	Daily feed consumption	Cows	TBD	New measurement.	New measurement.	Continue to explore collection methods.	Potential co-investment from NZ Govt.
Novel	Methane emissions	Daily methane emissions	Cows	Sniffer units	New measurement.	New measurement.	Cost-benefit assessment of portable (field)	Potential co-investment from NZ Govt.

Trait Group	Trait	Phenotype	Animals Recorded	Collection Method	Data Collection Status	Data Location	Action	Potential for Industry Co-Investment
							versus fixed units, or shifting focus to measurement via research herds.	
Novel	Nitrogen emissions	Urinary nitrogen concentration	Cows	Nitrogen sensors attached to cow	New measurement.	New measurement.	Await research results.	Potential co-investment from NZ Govt.
Health/ Survival	BCS	Cow BCS score at peak lactation	Cows	Visual score	Currently recorded in SPS herds but not routinely outside (except Breed Society members).	DIGAD	Extend beyond SPS herds and evaluate automated systems.	Data and benchmarking holds some value for decision making.
TOP	Milking Speed	TOP score	Cows	TOP score	Currently recorded in SPS herds but not routinely outside (except Breed Society members).	DIGAD	Extend beyond SPS herds and evaluate automated systems.	Low
TOP	Udder Overall	TOP score	Cows (1st parity)	TOP score	Currently recorded in SPS herds but not routinely outside (except Breed Society members).	DIGAD	Extend beyond SPS herds	Low
Production/ Efficiency	Liveweight	Cow liveweight	Cows	Various - spot weighing to WOW systems with continuous records	Partially recorded. Lots of unaccessed potential data. Needs greater standardisation.	Various. SPS records in DIGAD. Other data is in proprietary systems or on-farm	Better understanding of data flows required. Develop standard data analysis protocol for WOW.	Data and benchmarking holds some value for decision making.

Trait Group	Trait	Phenotype	Animals Recorded	Collection Method	Data Collection Status	Data Location	Action	Potential for Industry Co-Investment
Production/ Efficiency	Milk Production	Daily production records (composition, temperature, SCC)	Cows	In-line meters	Reasonable level of recording already occurring.	Data is held within proprietary systems.	Evaluate data structures and level of recording. Explore standardisation of data collection. Negotiate access and Link to DIGAD	Production data is already collected in herds with in-line meters. Installation of meters is a potential area of co-investment in other herds.
Production/ Efficiency	Milk Production	Herd test records	Cows	More frequent herd testing	Increase frequency of existing testing program	DIGAD	Compare cost-benefit versus current testing and in-line systems	Potential for partial co-investment from participants. Worst case would require funding of additional testing over and above current levels.

Herd segmentation including current genotyping investment

The costs of running info herds, the data quality available from them, and the potential for co-investment by the farm businesses, will be dependent on the existing practices and technologies routinely used by the herds. For example, info-herd program investment in genotyping would be smaller if working with herds that already genotype, even if only to a parentage verification standard. As a second example, the quality and quantity of data available from herds which have implemented automated systems such as in-line milk monitoring and walk-over weighing will be significantly greater than could be achieved in other herds even if herd testing frequency was significantly increased, and this may open up opportunities for some additional traits (or conversely be of little additional value for other traits). Thus **the selection of herds to work with will be critical to the success and cost-effectiveness of the program**.

Consequently it is useful to understand the segmentation of herds fitting different criteria. An info-herd program will need to select herds to work with which will create the best outcomes for the least investment. A range of criteria might be assessed, some of which might be based on data already held while others will need to be assessed on an individual basis. Criteria could include:

1. Current use of genotyping
2. Breed mix
3. Sire mix (or amenability to variations in sire mix)
4. Herd recording frequency
5. Automated data collection systems
6. Regional distribution
7. Herd size (either look for a spread, or minimum size to ensure overheads spread over sufficient cows)
8. Participant willingness and capability
9. Ownership structure/stability of commitment to the program

A file on data quality and extent of recording for all industry herds was available from DairyNZ. A simple analysis was undertaken to quantify the number of females which are genotyped (indicated by a count of sire verified animals), and classified into animals in Sire Proving Scheme (SPS) herds vs other herds. The outcomes of this are given in Table 2. It is apparent that even in sire proving herds, only approximately 50%-60% of animals are genotyped.

A second analysis focussed on herds where greater than 80% of animals are genotyped (Table 3), as this might be a criteria for selecting Info-herds. The analysis shows that in 2020, 867 herds fit this criteria, with an average of 90% of females genotyped representing 635 females of a total of 709 in these herds (average herd numbers). A total of 550,000 females are genotyped across all herds fitting this criteria. The 2020 data did not have information on which herds were SPS herds, but based on the data from 2016-2018 it is likely that between 60 and 70 of these herds would be SPS, with the remaining approximately 800 herds non-SPS. This suggests that there is a good (and growing) pool of herds currently making extensive use of genotyping (sire verification), which might be candidates for an info-herd program.

Table 2. Distribution of genotyped animals across Sire Proving Scheme (SPS) herds vs non-SPS herds. Note that the flag for SPS herd is not available for 2019 and 2020, and so total numbers genotyped are given. Fields are based on females in the herd so could include calves and replacement heifers.

Year		Genotyped females	Total females	% Genotyped
2016	SPS	77,633	147,276	53%
	Non-SPS	865,877	6,823,507	13%
	Total	943,510	6,970,783	14%
2017	SPS	69,558	116,546	60%
	Non-SPS	973,944	6,803,664	14%
	Total	1,043,502	6,920,210	15%
2018	SPS	68,414	123,879	55%
	Non-SPS	1,080,407	6,683,314	16%
	Total	1,148,821	6,807,193	17%
2019	All	1,258,643	6,762,751	19%
2020	All	1,326,333	6,697,584	20%

Table 3. Key statistics based on herds where greater than 80% of females are genotyped.

Year		Number of herds	Average Percent Genotyped	Average number genotyped	Average herd total	Total Genotyped females	Total females
2016	SPS	62	89%	492	557	30,521	34,535
	Non-SPS	373	90%	531	599	197,911	223,452
	Total	435	90%	525	593	228,432	257,987
2017	SPS	69	89%	491	549	33,907	37,913
	Non-SPS	500	90%	557	631	278,549	315,352
	Total	569	90%	549	621	312,456	353,265
2018	SPS	67	91%	510	564	34,186	37,779
	Non-SPS	624	90%	575	647	358,625	403,486
	Total	691	90%	568	639	392,811	441,265
2019	All	803	90%	628	704	504,513	565,326
2020	All	867	90%	635	709	550,962	614,343

Farmer engagement and participation in the Info-herd program

In our view, decisions regarding financial contribution of the info-herd program to info-herd participants should be made in a broad context, with the goal of making the overall program the most successful it can be for the given level of industry investment. The success of the program will be critically reliant on its ability to create and retain strong relationships with highly engaged farmer participants. It is critical to acknowledge that farmer engagement is not a simple transaction based on a balance of financial considerations, but encompasses many non-financial considerations.

Overall farmer engagement in on-farm programs can be considered as a balance of factors which bring positive benefits vs those bringing negatives – the more positive factors created and the more negative factors eliminated leads to stronger engagement, better co-operation and greater "social capital". This "social capital" can be applied to implementing some of the more challenging aspects of participation, and will undoubtedly be required during the program. This is especially important in programs which require long-term engagement. Where-as a short term program (such as a research trial) might be completed in 6 months and it is possible to tolerate this as an acute disruption to a commercial business, the outlook for participation in a long-term program (3-5 years plus) is quite different.

The info herd program is likely to require timeframes in the order of 5 years and has potential to evolve into a core piece of industry infra-structure. As the program is currently at a conceptual stage, there is not a detailed design to describe or assess. But to outline just one possible design, an initial phase might require 2 cohorts (seasons) of animals which are run from mating decisions (to achieve a required sire diversity and breeding structure via design rather than circumstance) through to second lactation of daughters. Having established genomic calibrations for some traits which are “hard to measure”, there will be an on-going need to collect some data to maintain calibrations for future generations – with a question as to whether this will require an on-going info-herd or whether this can be achieved via co-operation with other herds (e.g. SPS, research herds, etc). There might be different levels of commitment required at different stages and in different herds, with a tiered approach possible – with this detail still to be developed. However, in general the program should be run with an outlook that some components or herds might be required as partners for 5+ year timeframe.

Given this potential timeframe, it is particularly important to ensure that the overall balance of factors remains in the positive zone. These factors need to be considered at the personal level of the decision maker(s), rather than from a business viewpoint only, as many of these factors operate at a social level rather than an operational level (see Table 4 for a list of some factors influencing both individual and business motivation to participate in on-farm research programs). For example, individuals often derive satisfaction from the feeling of contributing to something they believe will bring positive benefits for their industry and for future generations over and above the benefit their own business will individually derive. But conversely, where a program receives “bad press”, or isn’t seen to be delivering positive and practical benefits, then participation in the program can be a source of embarrassment for the individual among their social networks and peers, and willingness to participate declines even if there is a strong direct benefit for their business.

Table 4 Potential motivations influencing engagement and commitment of farmer participants in on-farm research programs

Potential Positive factors	Potential Negative factors
Individual motivations	
• Contribution to industry – being a part of something positive	• Negative program reputation/poor program delivery
• Engagement with experts	• Lack of visible-to-farmer outcomes from the program
• Individual reputation and personal development	• Additional time and labour requirements.
• Opportunities to mix with like-minded farmers (if the program creates these)	
Business motivations	
• Direct financial business benefits (e.g. payments for services)	• Direct financial costs to business
• Indirect financial business benefits (cost savings, productivity gains, increased herd quality)	• In-kind costs borne by business
• Development opportunities for staff	• Additional complexity of management
• Job interest for staff (aligned to personal motivation factors, but for staff – business benefits from higher staff engagement)	• Limitation on ability to follow commercial opportunities • Additional workload for staff

Benefits and costs for participating farmers

We have conducted a qualitative assessment of the benefits and costs of participation in the Info-herd program, and in some cases supported this with an indicative quantitative assessment. This assessment focusses on the "business motivations" factors rather than the "personal motivations" which are more subjective and vary from individual to individual. The assessment is performed in the absence of specific detail of the science program (e.g; what phenotypes are collected, what management constraints are imposed, etc), but has encompassed most of the "givens" of running such a program (e.g. need for specialist phenotype measurements, genotyping, herd recording, etc).

Farmers will evaluate their participation in the Info-Herd program based on assessment of the perceived benefits versus potential costs and risks. While some of these might be quantifiable from data, and impact on budgets are apparent, these benefits and costs are all factors that add either positive or negative weightings to the overall balance in the mind of the participant/decision maker.

For participants to recognise and value the potential benefits, the benefits must be:

- Of tangible value that makes a meaningful difference to farm profitability (scale of benefit)
- Must be highly realisable so that the farmer is confident that the benefit will be received
- Must have a reasonably visible impact so that the farmer can see the impact of the benefit

These factors could be considered to be multiplicative, such that a lower score in any of them would lead to a significant discounting in terms of assessment of benefits. If a benefit is either not highly realisable, or is not highly recognisable, then the overall weighting of the benefit in the assessment of the participant will be significantly diminished. Thus, greatest weighting should be attributed to potential benefits that score highly across all measures; valuable, realisable and visible.

A similar set of criteria could be applied to assessing costs and risks. A cost that is significant, real, and highly recognisable will create a higher negative weighting in the assessment of the participant. At the higher end this would involve any cost which involves the farmer signing a cheque which would not normally be incurred without the Info-herd program – in this instance the cost is very realisable (direct impact on profitability) and highly recognisable, and the only question is how great is the cost in the context of the farm operation, and are there any associated benefits to off-set this cost?

We should also be mindful that the info-herd program itself may impact on the ability to realise benefits. Often on-farm research has associated restrictions on management practices which prevent the farmer from realising benefits that might otherwise be derived from the additional measurements. An example of this could be the culling policies imposed – often a trial design will be such that the farmer is required to retain animals which have been designated as likely poorer performers (from some research measurement or criteria, in this case possibly a genomic prediction), as the project needs to validate the extent to which the measurement has successfully predicted poor performance. In this instance, a potential benefit from participation in on-farm research is not actually realisable (at least until the trial is over). In our experience this is a common feature across many on-farm programs.

In other instances, the program might contain some benefits which are also off-set by costs, so the net benefit is significantly diminished. For example, a herd might have access to leading genetics, but is also required to use a proportion of other genetics which might be sub-optimal from a profitability viewpoint. These sub-optimal genetics might mean the net benefit from elite genetics is small, and might even create some erosion in capital value of the herd. Thus it should not be assumed that every benefit identified can be realised without accounting for other off-setting costs.

Participants could derive benefit from access to genomic information collected on their herd, as well as use of phenotypic data. These benefits could comprise:

- Direct benefits from genomic technologies, outlined in Table 5 below.
- Opportunities to accelerate BW progress
- Access to independent experts among the project staff.
- Use of project data in culling and management decisions
- Opportunities for the project to absorb/subsidise routine operational costs (this will be dependent on project policy decisions).

Table 5 and Table 6 present summaries of potential participant benefits around genotyping and phenotypic measurements, with a more complete description given in Appendix 1: Info-herd participation costs and benefits.

Table 5 Benefits from access to genomic data

Potential Benefit	**Scale of Benefit**	**Realisability of Benefit**	**Visibility of Benefit**
Use of genomics to improve replacement heifer merit	✓✓	✓✓✓✓	✓✓✓
Use of genomics for parent verification (avoid calf tagging and mothering up)	✓	✓	✓✓✓✓
Use of genomics for parent verification (avoid pedigree errors)	✓	✓	✓
Selection of heifers and cows for A2 status	✓	✓✓	✓✓✓
Identification of genetic condition status for heifers and cows	✓	✓	✓
Screening heifers and cows for Facial Eczema tolerance	✓*	✓✓	✓✓✓
Environmental trait auditing	✓	✓	✓

*Only of benefit to farmers in Facial Eczema regions.

Table 6 Benefits from access to phenotypic data

Potential Benefit	Scale of Benefit	Realisability of Benefit	Visibility of Benefit
Improved phenotypic data and genetic linkage	✓	✓	✓
Access to independent genetic advice	✓	✓✓	✓
Access to novel trait phenotypes	✓	✓	✓
Save testing costs (dependent on project funding policy)	✓✓✓*	✓✓✓✓ ✓	✓✓✓✓ ✓
Save semen and breeding costs (dependent on project funding policy)	✓✓✓✓*	✓✓✓✓ ✓	✓✓✓✓ ✓
Access to data storage system	✓	✓	✓✓
Access to herd health data and health benchmarking	✓✓	✓✓✓	✓✓
Improved heat detection	✓✓✓	✓✓	✓✓
Access to technical expertise for health and reproduction advice	✓✓	✓✓	✓

*Savings are dependent on level of subsidy applied, if any.

Potential costs and risks associated with participation are presented in Table 7 below and described in further detail within Appendix 1. Potential costs and risks are highly dependent on the scope of on-farm activity, and the extent to which the scope (and subsequent protocols) are designed to minimise these costs and risks.

Table 7 Potential costs and risks of participation

	Scale of Impact	**Realisability of Impact**	**Visibility of Impact**
Use of sub-optimal sire teams	✓✓✓	✓✓✓	✓✓✓
Restrictions on culling and replacement policies	✓✓	✓✓✓	✓✓
Management limitations	✓✓	✓✓✓	✓✓
Impact on cow performance	✓✓✓✓	✓✓✓✓	✓✓✓
Farmer/staff time (data collection)	✓✓	✓✓✓✓ ✓	✓✓✓✓ ✓
Farmer/staff time (animal management)	✓✓	✓✓✓✓ ✓	✓✓✓✓ ✓
Farmer/staff time (biosecurity & OH&S risk management)	✓✓	✓✓✓✓ ✓	✓✓✓✓ ✓
Impact of Biosecurity or OH&S incident	✓✓✓✓ ✓	✓	✓✓✓✓ ✓

Key points from the assessment of participation benefits and costs, from the participant viewpoint, comprise:

- The most attractive benefits are cost savings – these have the greatest realisability and visibility. The most obvious potential areas for cost saving incorporate the subsidisation of genotyping and semen/breeding costs, as well as the potential for the project to duplicate (and replace) third party testing costs.
- Collaboration must be designed to minimise imposts on farmer/staff time. This is a highly visible and tangible area of potential participation cost. It is vital to consider these imposts in the context of both the active burden of collecting data and managing the info herd, as well as the indirect burden associated with interaction with project staff (including risk management).
- Opportunities for the participants to benefit from increased productivity or accelerated genetic progress exist but the potential of scale of benefit is modest and of low/moderate visibility. It will be difficult to build a case for co-investment on the basis of these items.
- Info herd protocols must recognise the significant impact of reductions in cow productivity. This could occur via cows spending additional time in the yards, disruptions/disturbance to grazing behaviour, stress from additional handling and sample collection, and restrictions on management interventions. Lost production is tangible and visible, and will form a key part of farmer decision making.

Summary

Farmer engagement and participation is dependent on a range of factors, and only some of these are concerned with business and operational factors. Overall, to maintain long-term farmer engagement it is vital that the balance of these factors (positives vs negatives) remains strongly positive.

Genotyping benefits

The major direct benefit from genotyping which scores strongly across factors of scale, ability to realise and visibility is the potential ability to select replacement heifers with greater accuracy. However, this benefit is something that would be developed during the lifetime of the program rather than being immediately available.

In terms of the value proposition to a participant to justify a share of genotyping costs, **this is likely to be dependent on selecting farms who are already using genotyping for parentage extensively**. Where herds are not currently genotyping a significant proportion of their females, then the value proposition for sharing genotyping costs would be more difficult (assuming that the current decision not to genotype is made on sound economic rationale based on circumstances for that herd). Paying for genotyping costs which wouldn't ordinarily be incurred meets all the criteria for a highly weighted factor on the negative side – it is significant scale, it is highly realisable, and is very visible, and is not offset by a compelling benefit (beyond that associated with parentage). If necessary it might be possible to find a price point at which herds not currently genotyping would switch to genotyping – for example, if the break-even value proposition to a herd for the parentage genotyping was $20, with the current cost of parentage at $27, then the herd might invest at a level of $20 if the info-herd program payed the balance (this also assumes the business can re-configure to realise the $20 benefit, which might not be possible in the short-term). However, this would mean a greater portion of the genotyping costs would be borne by the info-herd program compared the quantum which might be required working with herds already genotyping (where the value proposition clearly already meets the commercial cost of parentage genotypes).

Where herds are already genotyping for parentage, it may be possible to share genotyping costs on **new animals** (calves not already genotyped), with the participant paying for the equivalent of parentage costs (that they would pay in any case), and the info-herd program funding the upscaling of this from a parentage panel to a higher density panel. In approximate terms this might represent a 50:50 split of genotyping costs (depending on the cost of the higher density panel and the willingness of the program to provide some financial benefit back to the farmer). It does not account for any need to obtain higher density phenotypes on females in the herd which have already been genotyped for parentage – for these animals the value proposition to the farm business from re-genotyping is low (at least in the initial years, in the absence of new deliverables from the info-herd program) and so it is likely that the program would need to meet 100% of any higher density genotyping costs for existing animals.

An initial look at data available suggests that there could be up to 860 potential herds already using parentage genotyping on 80%+ of females in the herd, including 60-70 SPS herds. Average herd size of these farms in 2020 was 709 females (including calves and replacement heifers), which would suggest an average of approximately 100 new calves genotyped (and retained) in these herds per year, and a total of 86,000. These statistics would suggest that it initially seems viable to select info-herd farms from this pool, with enough herds to select from to develop a rigorous program. However, **further investigation of other factors in these herds (eg. data quality, frequency of herd testing, etc) should be undertaken to understand the extent to which the pool of potential herds might reduce after applying other criteria**.

To put some hypothetical numbers around the scale of co-investment that might be made in genotyping, it might be assumed that 10% of the 86,000 calves currently genotyped might become part of the info-herd program (this would make the program a similar size to the current SPS herds). At a total genotyping cost of $50 per animal, and a 50:50 sharing of investment would mean that farmer participants would contribute $215,000 annually towards the program, with industry investment contributing the same amount (genotyping cost only). If re-genotyping of existing cows in the herd was required (e.g. to more rapidly implement the program using current cow herds for measurement), the program would likely need to pay 100% of that cost, adding to the overall expenditure on genotyping and increasing the proportion of genotyping investment to be met by industry. Re-genotyping of existing cows would only apply in the first 1-2 years of the program, depending on overall program design and timeframes required.

Phenotyping benefits

The major benefits from phenotypic measurements are the potential ability to save cost which might otherwise be incurred (e.g. herd testing and breeding costs), and improved heat detection. The former (cost savings) would depend on the project policy towards these costs, and to minimise the program costs it is possible that these costs would be required to be borne by the farmer (so therefore wouldn't represent a benefit). Improved heat detection would be dependent on the phenotyping program, but with fertility a likely area of emphasis it seems reasonable to assume this as a benefit.

Overall, the costs and risks associated with participation are likely to be more significant, realisable and recognisable than the benefits.

If co-investment is sought, **asking the participants to fund a commercial level of cost for herd testing and semen/breeding costs is likely to be a much lower impact approach**, as these costs would be budgeted even in the absence of the info-herd program. This will intuitively seem to be fairer to the participant, and will achieve some investment without creating a negative sentiment.

Significant attention should also be given to minimising the practical over-head to info-herd participants. This would include ensuring that the program places a premium on ensuring measurements and management requirements are simple and do not add significant complexity or risk. **It also includes having a very effective information pipeline,** which makes information simple to collect, enter (ideally direct electronic entry as much as possible), submit (automatically) and retrieve (by the farmer). These actions will reduce the negative factors associated with the info-herd program and so are important in maintaining an overall positive balance of sentiment.

Finally, **significant consideration should be given to maximising the personal benefits from program participation**. These benefits are "softer" (less well defined), but in many ways can be stronger factors than financial or business benefits derived from participation. Maximising the personal dimension of benefits would include providing opportunities to mix with other farmer participants and to develop a team approach and feeling of comradery, such as via holding an annual Info-herd participant conference. This has been highly successful in similar situations that we have been involved in (e.g. Beef + Lamb NZ programs such as Beef Progeny Test program and the Demonstration Farm program), and is readily translatable into the Info-herd program context.

Recommendations

6. That the info-herd program seeks initially to work with herds already making extensive use of genotyping for parentage verification, and seeks to share investment in higher density genotyping with participants with the program paying at least the difference between genotyping costs for parentage panel vs higher density.
7. That further work is undertaken to better understand the segmentation profiles of herds in terms of use of parentage verification combined with multiple other criteria of importance to the info-herd program including data quality, breed composition, geographic distribution, herd size, etc.
8. That investigation of the need for increased frequency of herd recording through to use of automated milk recording and other measurement systems in Info-herds is undertaken.
9. That a more detailed analysis of the indirect costs to participating farm businesses is completed and factored in to any potential subsidisation of existing farm costs such as semen, AB and herd recording. This analysis is already identified for the final milestone of this work, so will be undertaken once a more detailed info-herd program design has been completed.
10. That the implementation of the info-herd program gives strong consideration to the non-financial motivations of participants in becoming part of a program, and seeks to maximise these “value add” aspects to maintain long-term commitment to the program.

Appendix 1: Info-herd participation costs and benefits

Table 8 Assessment of benefits from genotyping

Potential Benefit	Description of Benefit	Scale and Realisability of Benefit	Potential Value	Visibility of Benefit
Use of genomics to breed improved replacement heifers	Farmers can use genomics to either identify which cows to use for production of their replacement heifers (most likely pathway), or select the most elite heifers from a mob of replacement candidates.	In reality farmers are unlikely to be applying no form of selection to the dams from which they breed their heifer replacements. Without genomics, farmers would likely refer to herd test data and milk production data to determine lower merit cows and avoid breeding heifers from these. On this basis the farmer probably already captures part of the potential value via phenotypic selection. Current fertility rates and replacement rates also produce low levels of potential selection intensity. With reference to current annual BW progress of $10/cow per year, opportunity could potentially be worth an additional $1-$2 per cow per year.	Estimated to potentially be worth $1-$2 per cow per year of additional genetic progress. Annualizing the NPV of the cumulative benefit over 20 years is worth approximately $13.50/cow per year ($5805 per year for a 430 cow herd).	Changes in BW progress are highly visible but linking this to a specific cause is somewhat challenging for a farmer. There is reasonable visibility of the difference in BW of the selected cows versus herd average.
Use of genomics for parent verification	Farmers can reduce pedigree errors by using genomics for parent verification. This could result in an increased herd value due to a more robust BW and increased progress due to elimination of parentage errors on retained heifer replacements (accidentally keeping a replacement from a low-merit dam).	Small and intangible value that is very herd specific. Capability to use genomics in this role is available but not adopted due to overall cost-benefit.	Negligible value.	Some benefits are reasonably visible. Farmers will be able to see the parentage errors detected by genomics and may be able to picture the economic impact of inadvertently retaining the wrong animal. Benefits to herd BW and value are very difficult for the farmer to see.
Use of genomics for parent verification	Farmers can save the cost (labour) of tagging calves at birth and mothering up in the paddock, instead using genomic parent verification to ID dams of heifer replacements.	Calf tagging and mothering up might be 2 hours per day for 80 days ($3200 @ $20/hr). Practical realisation of this benefit is uncertain based on the need to either retain all heifer calves while awaiting genomic results and incur additional cost of keeping unwanted heifers for an extra 1-2 weeks, or having split calving groups, or some way of differntiating calves without dam idenftification (eg use of beef sires over low-merit dams). Could potentially produce benefit of $1500/farm per year.	Benefit is potentially worth $1500 per farm per year but questionable realisability	Labour savings will be highly visible.

Potential Benefit	Description of Benefit	Scale and Realisability of Benefit	Potential Value	Visibility of Benefit
Identification of A2 milk status	Genomic testing can identify whether heifers/cows are A2 carriers or homozygous A2. Farms producing A2 milk receive price premiums.	Potential benefit is associated with the cost saving of alternate, standalone A2/A2 testing - approx $20/test (depending on sample). A standard 430 cow herd might spend $2000-$3000 per year testing its replacement heifers to determine their A2 status.	Benefit is only tangible if the farmer is considering pursuing an A2 herd status. Could be worth $1900 per year if applicable.	Benefit is of low visibility as it represents a potential minor acceleration of the transition to an A2 herd.
Identification of genetic condition status of replacement heifers	Genomic testing can identify heifers/cows that carry alleles associated with recessive disorders and other genetic conditions	If a herd is affected by recessive conditions or is concerned about potential impact, simplest action is to avoid sires that are carriers (including heterozygotes). On this basis the potential benefit is negligible.	Negligible value.	Recessive status of the herd is visible but the contribution of this benefit and the economic outcome is less visible.
Determining Facial Eczema susceptibility	Genomic testing could be used to determine the level of facial eczema tolerance across the herd and support selection for increased tolerance.	Farmers can select for facial eczema tolerance via their sire genetics. Benefit is mainly through the faster transition via selection pressure on dams. Potential to accelerate progress is modest via female selection.	Negligible value. Only applicable in herds/regions where facial eczema is prevalent.	Low visibility - benefit will occur over a long time horizon. Economic benefit will be captured within overall costs and impacts of FE that will also have environmental and separate management influences.
Environmental auditing	As farmers become liable for their farm emissions, genomics could be utilised to support farm emission estimates by accounting for animal/herd variation. In addition, incentive schemes could be utilised to encourage farmers to select low-emission animals once methane and nitrogen traits/indexes are developed.	No current benefit and uncertain future benefit. Methane and Nitrogen traits are not yet available. Genetic mitigation has high marginal cost of abatement and may not be economically feasible.	Negligible current value.	Difficult to comment on the visibility due to the area being a potential benefit with numerous contingencies.

Table 9 Assessment of benefits from phenotyping

Potential Benefit	Description of Benefit	Scale and Realisability of Benefit	Potential Value	Visibility of Benefit
Improved phenotypic data and stronger genetic linkage	Potential to increase BV accuracy on heifers and cows via improved performance recording and optimal linkage to the industry reference population.	Benefit is only realised if the farm is using genomics to select its heifers or identify cull cows. BVs of sire teams not affected though potential G x E effects are minimised.	At an extra $1/cow/year of BW progress comprises an annualised value (based on 20 year NPV) of $8.90/cow or $3827 for a 430 cow herd.	Very low visibility, will be hard to differentiate overall contribution to any observable change in genetic progress.
Additional access to independent genetic advice	The farmer may derive benefit via the interaction with technical experts among the project staff. Benefit would comprise independent perspective on genetic improvement.	Benefit is very farm-specific. Will be of no value on some farms but could be significant on others.	Intangible value due to farm and situation context. Most farmers already have access to genetic support.	Benefits could be moderately visible but are highly dependent on the nature of any advice that is sought.
Access to novel trait phenotypes	Participating farms could benefit from earlier access to novel trait information via phenotypes collected on their animals. Traits could include feed intake, health traits, environmental traits etc.	Benefit is not an enduring benefit, it only comprises earlier access while BVs are under development. Realisability is heavily dependent on heritability of the novel trait. Benefit also depends on economic value.	Negligible value as benefit is hard to capture and only provides a temporary advantage.	Benefits will only be visible once a BV is developed and progress is measurable.
Save some testing and recording costs	Participation in the program may cover, or partially cover, costs associated with herd testing, disease/health testing etc.	LIC herd testing is approximately $1500/ test for a 430 cow farm ($3000 to $4500 per year). Additional avoidance of herd testing and recording could also occur across animal health and reproduction.Benefit is dependent on the design of the program and the phenotypic data collection strategy/protocols, as well as the normal testing/recording program undertaken by the farm.	Participating farmers might derive benefit of $5000 per year if the program negates the need for some independent testing and recording costs. This is difficult and uncertain to quantify without further detail to understand the potential level of overlap.	Benefits will be highly visible.
Access to a data storage and information system	Access to a data collection and information system could enable the farmer to derive benefit from more efficient collection	Benefit is intangible and highly specific to each participant. Will depend on current system, type of data collected and the interest and aptitude of the farmer.	Intangible value. Depends on current access to systems like MINDA and the level of data/technical/IT competence of the farmer. Also difficult	Benefits are only visible if the farmer is able to avoid a paid subscription to an alternate platform. Benefits are otherwise poorly visible.

Potential Benefit	Description of Benefit	Scale and Realisability of Benefit	Potential Value	Visibility of Benefit
	and storage of key data and records.		to identify a tangible economic benefit.	
Improved awareness of herd health status and sub-clinical disease prevalence	The program will likely incorporate some focus on collection of phenotypic data for health traits, lameness and structural traits etc. This data could be reported back to farmers via reports that benchmark each participating herd. This could create greater awareness of opportunities to improve herd health status.	Data and reports could provide useful insight into herd health status, particularly the extent sub-clinical health problems. This could enable more timely and effective intervention. Assuming a replacement cost of $2000, annual benefits of a 5% reduction in replacement requirements could be worth $5000 per year for a 430 cow herd (after allowance for mitigation costs).	Participating farmers might derive $5000 of net benefit per year but this is contingent on the specific data collection program, farmer access to the data, and cost of mitigation/prevention of whatever problems are uncovered.	In some context the benefits are visible based on the potential to track herd health status over time, however this will need to occur over several years to demonstrate clear cause and effect. Economic benefits will also be of lower visibility.
Improved heat detection	Data collection for fertility traits may improve the accuracy of heat detection via different measurement systems and techniques. Improved heat detection could increase the 6 week in calf rate.	Benefit depends on whether there is a focus on collecting phenotypic data that could better inform cow cycling activity.	Benefit is contingent on the performance recording focus and the existing accuracy of heat detection. Based on an estimated benefit of $9/cow per 1% increase in the 6 week in calf rate, an increase of 2% could be worth $7740 per year in a 430 cow herd.	In some context the benefits are visible based on the potential to track conception rates over time, however this will need to occur over several years to demonstrate clear cause and effect. Economic benefits will also be of lower visibility.
Improved access to technical expertise for health and reproduction	The farmer may derive benefit via the interaction with technical experts among the project staff. Benefit would comprise independent perspective and advice across animal health and reproduction.	Benefit is very farm-specific. Will be of no value on some farms but could be significant on others.	Benefit is unpredictable and very farm-specific. Also hard to differentiate and assume additionality relative to other areas of potential benefit (eg improved knowledge of health and disease status).	In some context the benefits are visible based on the potential to track herd health status over time, however this will need to occur over several years to demonstrate clear cause and effect. Economic benefits will also be of lower visibility.

Table 10 Potential costs and risks to farm business from info-herd participation

Potential Impact	Description of Impact	Scale of Impact	Potential Cost	Visibility of Impact
Use of sub-optimal sire teams	Participants may not be able to use their preferred or optimal sire teams due to the need to evaluate diverse genetics, create linkage etc.	Impact will represent a reduction in potential BW progress with consequential forgoing of potential productivity/profitability.	Every $1 of lost annual progress is worth $8.90 per cow in cumulative annual impact over 20 years.	Impact is not overly visible as it is an opportunity cost. Visibility is also affected by the difficulty of determining the impact on annual BW progress due to the impact of other variables.
Restrictions on cow culling and replacement policies	Participants may be restricted in the extent to which they can undertake discretionary culling, or in their heifer replacement selections due to protocols including contemporary grouping, linkage, genetic sampling etc.	Impact will represent a reduction in potential BW progress with consequential forgoing of potential productivity/profitability.	Every $1 of lost annual progress is worth $8.90 per cow in cumulative annual impact over 20 years. Potential impact is likely to be lower than those realised through sire restrictions.	Impact is not overly visible as it is an opportunity cost. Visibility is also affected by the difficulty of determining the impact on annual BW progress due to the impact of other variables.
Management limitations	Participants could be impacted via requirements that limit optimal management of the farm or livestock due to protocols requiring contemporary grouping, genetic linkage or genetic sampling.	Impact is difficult to predict without knowledge of the scope of activity and the subsequent limitations this may place on optimal management. Impacts could include the need to retain and breed extra heifers, change culling practices, or change herd segregation practices.	Impacts are difficult to predict. Could comprise lower BW progress due to culling or retention changes, labour costs associated with extra heifers or herd segregation, or loss of cow productivity. Modest impacts could potentially be in the range of $5,000-$10,000 but could easily escalate under greater levels of disruption.	Visibility depends on the nature of the limitation. Limitations that impact labour will be most visible.
Impact on cow performance	Cow productivity could be affected by additional time in yards for data collection and observation, stress due to data or sample collection (including use of measurement devices), disturbances to grazing behaviour etc	Impact is difficult to predict without knowledge of the scope of activity. Impact will most likely comprise a reduction in cow ME intake due to time off feed or disturbance to grazing/feeding. Reduced ME intake will affect milk solids production, with potential for tangible impact to farm revenue.	Each 1% reduction in milk solids production is worth approximately $10,320 per year in lost milk solids for a 430 cow herd.	Impact is moderately visible based on seasonal milk production trends.

Potential Impact	Description of Impact	Scale of Impact	Potential Cost	Visibility of Impact
Farmer time associated with data collection and trial management	Impact will comprise a time/cost burden associated with animal monitoring and data collection. Depending on the nature of the on-farm program, staff training may be required.	Impact is difficult to predict without knowledge of the scope of activity and the subsequent demands this places on farm management and farm staff.	An hour per week of management time at $50/hour is worth $2500 per year. 2 hours per week of staff time at $20/hour is worth $2000 per year.	Additional time commitments are highly visible and quantifiable.
Labour associated with management of herd in accordance with trial protocol	Impact will comprise a time/cost burden associated with additional animal movements and management. Depending on the nature of the on-farm program, staff training may be required.	Impact is difficult to predict without knowledge of the scope of activity and the subsequent demands this places on farm management and farm staff.	An hour per week of management time at $50/hour is worth $2500 per year. 2 hours per week of staff time at $20/hour is worth $2000 per year.	Additional time commitments are highly visible and quantifiable.
Management of biosecurity and WH&S risks	Participants should be mindful of biosecurity risks associated with project staff and contractors entering the farm. WH&S inductions will also be required as will risk management planning for farm staff based on changes to work routines, potential new hazards etc.	Impact will comprise a time/cost burden associated with site inductions and compliance. Depending on the nature of the on-farm program, staff training may be required.	An hour per week of management time at $50/hour is worth $2500 per year. 2 hours per week of staff time at $20/hour is worth $2000 per year.	Additional time commitments are highly visible and quantifiable.
Impact of a biosecurity or WH&S incident	Impact could arise via inadvertent introduction of a biosecurity issue via project staff or contractors arriving from other farms. An incident could also occur via introduction of new risks and hazards (eg new animal handling requirements).	Impact is potentially substantial irrespective of the potential to access compensation.	Depends on the incident and legal outcomes regarding liability and availability of compensation. Unlikely compensation would cover the true cost in lost time and other disruptions, stress etc.	Highly visible impact if an incident were to occur.