Gallagher eShepherd Virtual Fencing technology in the prevention of sedimentation run-off from animal agriculture for the protection of the Great Barrier Reef

Protection of the Great Barrier Reef from sedimentation run-off

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1 Acknowledgements

The Gallagher eShepherd Virtual Fencing technology in the prevention of sedimentation run-off from animal agriculture for the protection of the Great Barrier Reef is funded by the partnership between the Australian Government's Reef Trust and the Great Barrier Reef Foundation, with support from the Wentworth Cattle Company.

2 Executive Summary

Excluding livestock from riparian zones can reduce erosion, sedimentation, water contamination and bacterial loads that flow into wetlands and, ultimately, the Great Barrier Reef. The objective of this project was to demonstrate the ability of eShepherd to protect sensitive catchments and waterways from damage caused by cattle. Research was conducted to investigate the Gallagher eShepherd Virtual Fencing technology to prevent sedimentation run-off from animal agriculture for the protection of the Great Barrier Reef. Wagyu-cross 18-24 month old females (n = 577) were fitted with the eShepherd system, which was successfully used to subdivide larger paddocks to intensify grazing in underutilised sections of the pasture. The flexibility of virtual fences allowed them to be placed anywhere regardless of physical features or impediments – in places where physical fencing would be impractical or impossible, such as across waterways. Utilising the eShepherd virtual fencing solution, the cattle were held in the underutilised areas of pasture followed by a period of rest to stimulate regrowth. However, over the course of the trial, it became evident that complete exclusion of cattle from these areas was not necessary, nor desirable, to achieve the target environmental outcomes.

The eShepherd product management team conducted interviews with several trial customers during 2021, seeking to align the customers willingness to pay with the overall eShepherd value proposition. The feedback received highlighted that the upfront costs of the neckbands and base stations was unlikely to be sustainable in the long term, however once the additional benefits associated with the implementation of Intensive Rotational grazing systems (cell grazing) are implemented, better management of animals and land will result. Additional factors that have yet to be included in value proposition (and hence reduce the cost of implementation) are expected to improve the value proposition of eShepherd and lead to improved management of land and animals.

Furthermore, there continues to be a strong public interest in the technology as evidenced by information gathered through website enquiries as well as feedback received from Gallagher field representatives.

The eShepherd technology is currently undergoing hardware changes to ensure a more robust virtual fencing solution that will provide producers with an effective tool for the management of cattle within riparian zones, thus reducing sediment run-off into Great Barrier Reef catchments.

3 Introduction

Sedimentation poses a significant threat to the health of the Great Barrier Reef. Where agricultural land borders wetlands and waterways, grazing cattle on riverbanks significantly contribute to the sedimentation of water bodies. Compaction due to cattle movement on moist soil increases soil bulk density which reduces water infiltration into the soil. This, in turn, increases surface water flow, erosion and sediment loss into waterways (Dunne & Dietrich 2011). The sediment washes from these sensitive riparian zones into the Great Barrier Reef and has a notably negative impact on the health of the marine environment, including corals, seagrasses, fauna and general water quality. The fine sediment particles remain suspended in water causing turbidity, which reduces the quantity and quality of light available for photosynthesis for seagrasses and coral and can thus reduce their growth. High concentrations of suspended sediment can also interfere with filter feeding by organisms such as clams and reduce coral recruitment (QLD Govt 2019). The *Environmental Protection Act 1994* requires commercial beef cattle graziers in the Great Barrier Reef catchments to comply with minimum practice agricultural standards under the Reef protection regulations to protect the health of the Great Barrier Reef by reducing pollutant run-off (nutrients, sediment and pesticides) in waterways that flow to the Reef.

The catchments with some of the highest sedimentation in the Great Barrier Reef Foundation region are the Upper Burdekin, East Burdekin and the Bowen Bogie (Kroon et al. 2012). The most common grazing practice in the catchment area is continuous grazing and set stocking; allowing livestock to graze the same area throughout the year. Naturally the most fertile soils are near waterways and animals tend to spend most of their time grazing in those areas. Further away from the waterways, the grass is underutilised and becomes stale and unpalatable.

This leads to a perpetual cycle of overgrazing closest to the waterways. As a result, this overgrazing leads to a deterioration of the pasture, leaving the soil bare and exposed, and then during the wet season, the topsoil is washed downstream into the reef lagoon (Rafiefi *et al*. 2020).

The Paddock to Reef Report Card for 2017/18 (QLD Govt 2019) indicates that there has been poor progress in efforts to reduce fine sediment and particulate nutrients and Very Poor progress in reducing dissolved inorganic nitrogen in the Burdekin catchment. These waterways share borders with thousands of acres of land utilised for agriculture. Excluding cattle from the stream banks will reduce erosion, sedimentation, and contamination of the water that inevitability runs into the Great Barrier Reef. However, the installation and ongoing maintenance of barbed wire or electric fencing is not only cost prohibitive, but impossible in some cases because of the undulating nature of the terrain/ landscape. The impact of wet season floods and dry season fires make the cost of installing and maintaining conventional fencing in broad-scale riparian situations prohibitive. Additionally, the installation and maintenance of traditional fencing requires some vegetation clearing, impacting local flora and fauna, and disturbing the soil in these highly sensitive zones.

It is known that sedimentation in water flowing into the Great Barrier Reef has a significantly detrimental impact on the health of the Reef (QLD Govt 2019). Excluding livestock from riparian zones can reduce erosion, sedimentation, water contamination and bacterial loads that flow into wetlands and, ultimately, the Great Barrier Reef. The eShepherd virtual fencing system allows farmers to control the location and movement of cattle using a neckband and cloud-based application without requiring any physical fences in riparian zones. The eShepherd technology by its very nature is not subject to the limitations of traditional physical fencing, particularly the underlying nature of the terrain and will enable cattle to be effectively and rapidly “fenced out” of sensitive catchments and waterways, reducing sedimentation and improving the overall water quality and run off into the Great Barrier Reef. A very early eShepherd prototype was successfully used to temporarily exclude cattle from a riparian zone (Campbell *et al.* 2018).

The Gallagher eShepherd (previously Agersens) virtual fencing product is an agricultural technology used to control the location and movement of cattle in a similar manner to a traditional barbed wire or electric fence, but with no physical barriers and the ability to change the boundaries using a cloud-based application. Cattle are fitted with GPS enabled, solar powered, intelligent neckbands and the farmer creates or modifies a virtual paddock using a web application on their laptop. The virtual paddock GPS co-ordinates are sent wirelessly to each animal's neckband via the eShepherd platform. The neckbands then operate autonomously to train each animal to the location of the virtual paddock using a CSIRO patented, integrated training algorithm based on sound animal behaviour, learning and welfare principles. The sequence of stimuli (non-aversive audio cue followed, if necessary, by a pulse) is predictable and the animal can quickly learn to avoid the pulse by responding to the audio cue alone. The pulse is sufficiently aversive to deter an animal from moving through the virtual fence.

Previous trials have demonstrated that cattle can be contained within a virtual paddock up to 99% of the time and animals that move beyond the virtual fence are "shepherded" back to the virtual paddock. The eShepherd system also monitors and tracks animal behaviour and location 24/7, allowing for independent, auditable evidence of animal grazing patterns as well as data to support future environmental and agricultural decisions. The system has been designed to allow farmers and other stakeholders to capture data, facilitate decision making and automate movement and control of cattle using a smartphone-app, thereby unlocking value right across the digital value chain. Animal behaviour, physiology and welfare has been shown to be no more adversely impacted by virtual fencing stimuli than by other commonly encountered stimuli, including electric tape fencing (Lee *et al*. 2008; Campbell *et al*. 2019; Kearton *et al.* 2019).

4 Aim & Hypothesis

The objective of this project is to demonstrate the ability of eShepherd to exclude cattle from sensitive riparian zones >97% of the trial period and assess the impact of this exclusion on the water quality in local waterways that empty into the Great Barrier Reef.

The hypothesis was that excluding cattle from rivers and wetlands would reduce soil erosion and sedimentation which, in turn, would support the health of the Great Barrier Reef whilst encouraging environmentally sustainable agricultural practices.

5 Animal Research Trials Method

5.1 Qualify customer suitability

During the selection process, several sites were visited, and customer interviews conducted to find the right customer to work with.

When introducing new technology to change farming practices, finding a suitable operator to partner with will impact the success of the trial. The chosen operator had demonstrated leadership in the adoption of the leading grazing management practices and the ability to work with and apply the latest technology to improve the performance of their operation.

5.2 Property Overview

An extensive cattle grazing operation, located along the Burdekin River near Bowen, North Queensland was identified as a suitable location to undertake the project (Figure 1). The station is approximately 52,000 ha and at the time of the trial, was stocking paddocks at one animal per 4 ha across the property (Figure 2). The property is heavily treed with relatively flat terrain. Cattle numbers fluctuate over each 12-month period, with 10-12 bulls put out into cow mobs during Spring. Providing a 90-day calving window. The wet season rainfall occurs predominantly between November and December, making it difficult to access the property reliably during this period, with operations generally resuming in March/April.

Since acquisition in 2004, the owners have made significant infrastructure improvements, including the construction of 150km of new fence lines, laying 90km of pipeline, installing 60 troughs and 25 water tanks. Capital investment on such a scale is rare in this area and has allowed the station to increase cattle carrying capacity whilst improving environmental outcomes by introducing rotational grazing plans. Despite these infrastructural improvements, paddock sizes still range between 400-600 ha, leaving some parts of the pasture overgrazed while others are underutilized. The reason that cattle do this are for a number of reasons, including a preference for specific features within a landscape such as riparian zones or areas with preferred feed or shelter (Hunt *et al.* 2007).

Figure 1 - The Burdekin River running alongside the property

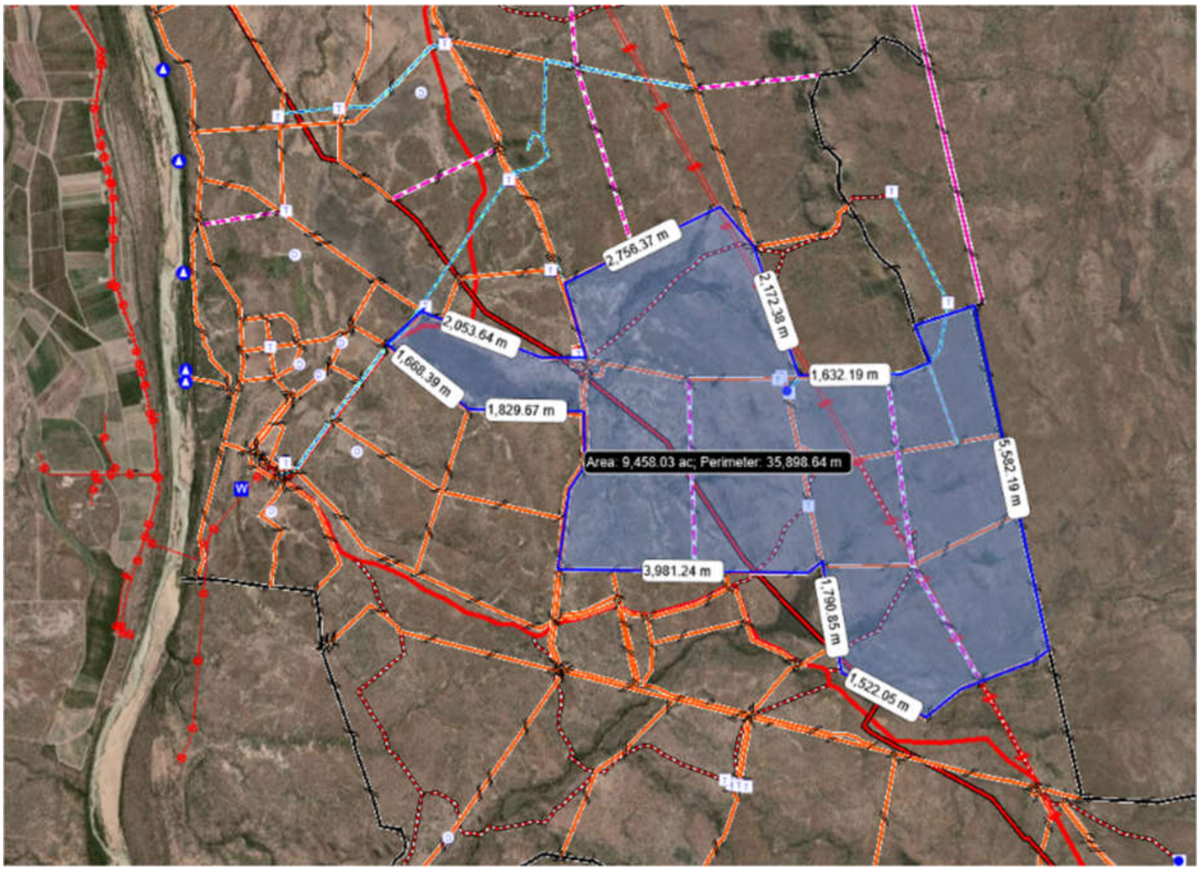

Figure 2: Approximate trial area

5.3 Base Station Site Survey

The Site Assessment was conducted in December 2020. Topography was determined to be a cause of challenge for LoRa communication range due to the sparsely wooded areas. There were no concerns with operations and infrastructure. Comprehensive on ground range testing were used to gain these results. In April 2021, a site survey was conducted to determine where to put the base station to limit the challenges of topography. To place the base station in the best location for achieving a suitable operational communication range, three (3) temporary hilltop locations were assessed using a desktop evaluation tool. Figure 3 identifies the locations chosen where the green area denotes where communication is possible, and the nominated operational areas are marked in red. A site south of the operational area was selected to supplement a base station on a significant hill with an elevation of 284m (Figure 4, Base Station South). The operational area at 100m elevation significantly reduced the vegetation penetration distances required as well as providing comprehensive fill-in cover, thus extending the possible operational area to the south and east.

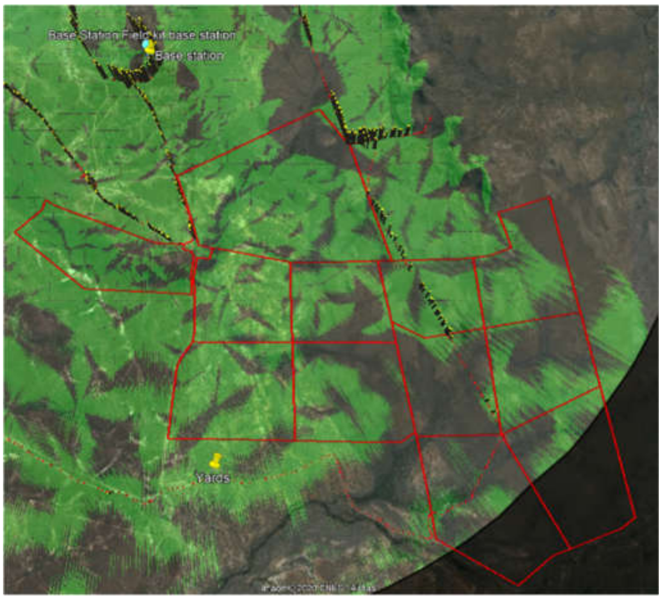

Figure 3: Base station coverage

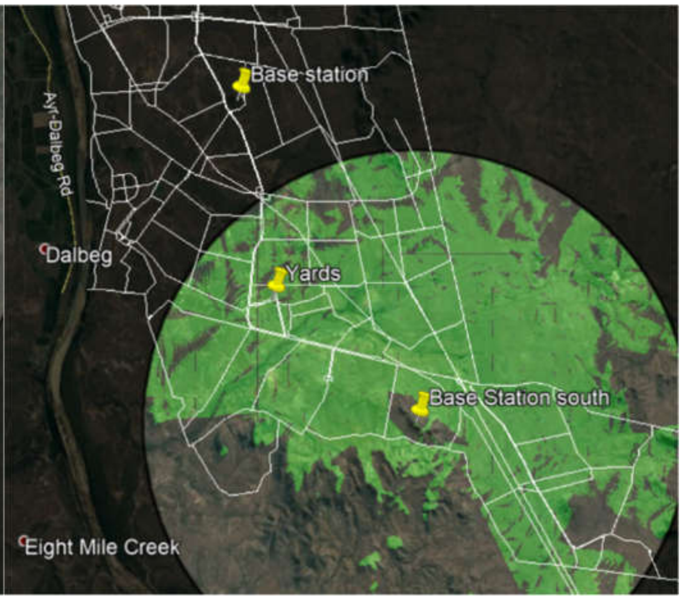

Figure 4: Base station south coverage.

After base station installation, range testing was conducted in the operational area. Testing indicated that with both base station complete coverage would be provided with some marginal areas where hills provided areas with no communication from both base stations. Observations while testing highlighted the value locating the southern base station at the peak of the hill, justifying the additional effort. The range covered by the base station was wooded and the hill could often be seen amongst the crest of the trees indicating only the local trees (within the first few hundred meters) would be affecting LoRa communications.

The base station was introduced to the eShepherd Web App where the property map data was created, including physical fences and watering points. Once Neckbands were fitted and animals complete the virtual fence training, animal location and containment could be observed through the web app.

5.4 Pre-operational Checks

Prior to fitment, all Neckbands underwent pre-operational checks including battery charge status, GPS location accuracy and LoRa communication connectivity. Each Neckband was individually assessed and, provided it passed inspection, was approved for trial usage. Neckbands that did not pass the pre-operational checks were triaged and where possible, fixed for use in the trial. It is worthwhile noting that the Neckbands used were still undergoing development.

5.5 Commencement of Virtual Fencing

The field work component commenced on 20 April 2021 with the fitment of the eShepherd Neckbands to Wagyu-cross females between 18 months and 2 years of age (n = 577). Utilising the eShepherd virtual fencing solution, the cattle were held in the underutilised areas of pasture followed by a period of rest to stimulate regrowth (Figure 5). This cycle continued as the riparian areas were rested and allowed to regenerate.

Figure 5: Virtually fenced, previously underutilised pasture (outlined) in a larger paddock.

6 Animal Research Trial Results

In April 2021, Neckbands were fitted to heifers (n=577). The virtual paddock was activated the following day. In July 2021, a Neckband unit check was conducted, and faulty units were replaced (n=34). An additional 110 Neckbands were fitted in October 2021, and further faulty units were removed to bringing the trial herd size to 687 individuals. The trial ceased in December 2021.

6.1 Virtual Fencing Effectiveness for Rotational and Regenerative Grazing

The eShepherd system was successfully used to divide larger paddocks to intensify grazing in underutilised sections of the pasture. The flexibility of virtual fences allowed them to be placed anywhere regardless of physical features or impediments – in places where physical fencing would be impractical or impossible, such as across waterways (Figure 6).

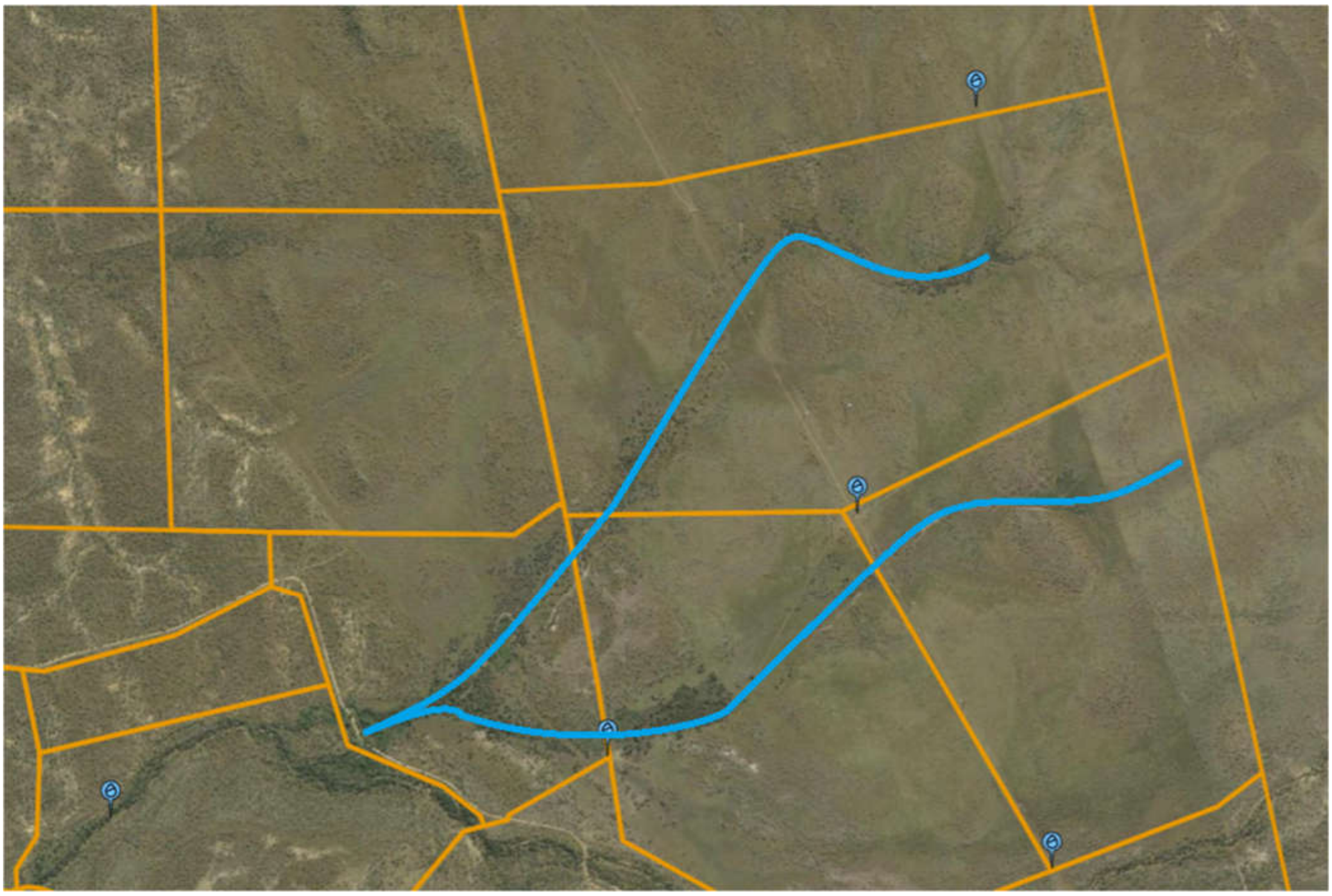

Figure 6: Main water tributaries through trial area (blue lines) with physical paddocks (yellow lines)

This flexibility allowed the operator to target specific areas and move animals along remotely to improve pasture utilisation and regeneration (Figure 7).

Figure 7: Animals regenerating stale pastures

Solar panels were affected by temperature cycling causing micro-cracks in in the silicon wafer. These cracks resulted in a slow degradation of the panels power harvesting capability and finally, the device was not able to maintain power autonomy. The pulse delivery circuit of the Neckbands was susceptible to the failure of the high voltage switching components. When this occurred, the Neckband was no longer able to deliver the aversive pulse stimulus. As a result, 150 poor performing Neckbands were removed and replaced with new Neckbands.

The virtual fencing performance over the course of the trial gradually declined as Neckband reliability issues allowed a portion of the animals to roam outside of the designated Virtual Paddock (Figure 8). However, this did not have a significant impact on the overall benefits that were derived; whilst some of the animals were not contained within the virtual paddock, the majority of the animals were, enabling those areas to derive the benefits (Table 1). The project was stopped in December 2021 primarily as a result of ongoing wide-spread Neckband reliability issues.

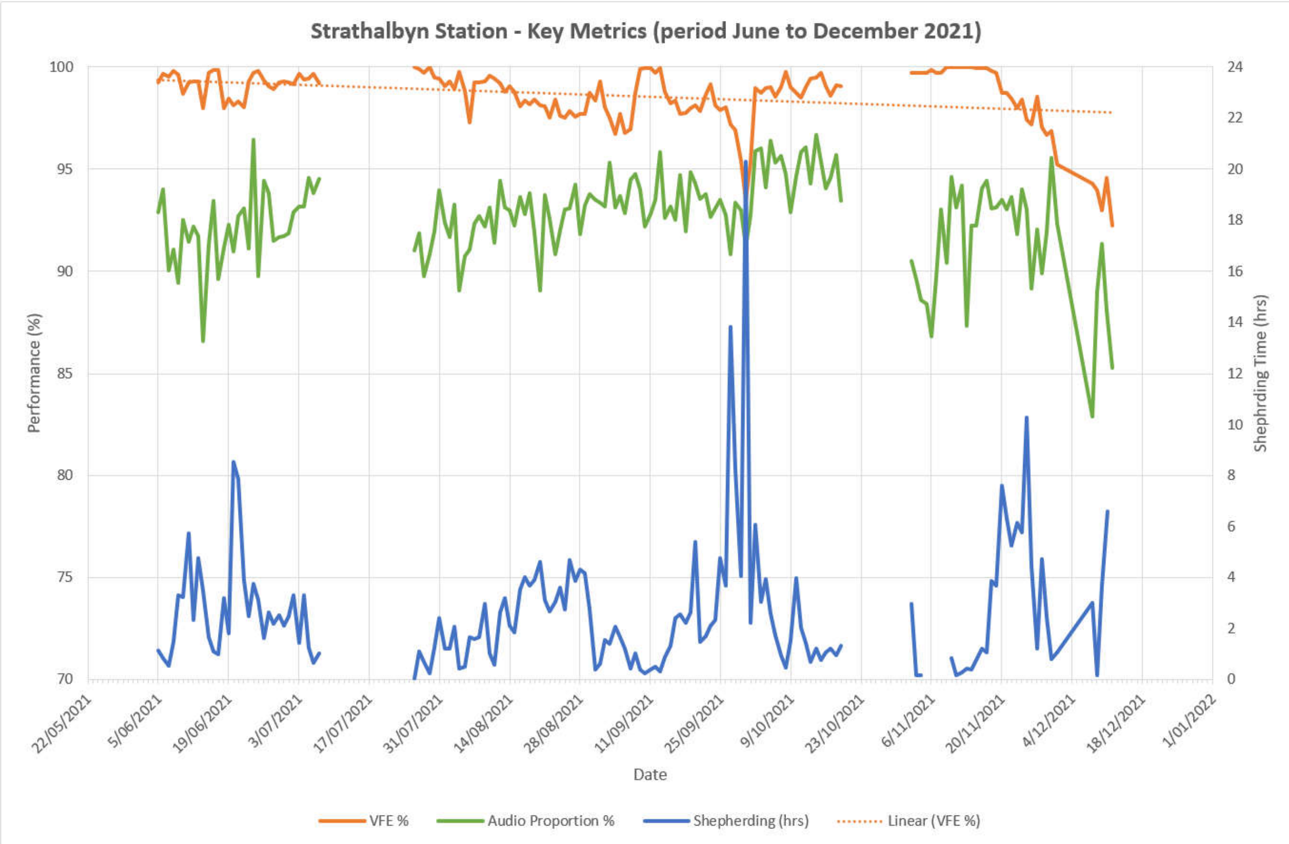

Figure 8: Key trial metrics collected daily at a herd level to determine how effective the virtual fence was at containing cattle within the set boundary. Measures include the proportion of animals that were contained each day (solid orange line, VFE (%)), the proportion of audio stimulus to pulse stimuli (solid green line, Audio Proportion (%)), the length of time the neckbands were shepherding animals back into the virtual paddock (solid blue line, Shepherding (hrs)), and the predicted change in virtual fence effectiveness over time (dotted orange line, VFE (%)).

Table 1 - Aggregated performance metrics

Period	Activity	VFE%	Audio Proportion	Shepherding (hrs.)
5/6/21 – 12/12/21	In operation	98.58	92.56	2.60

The eShepherd virtual fencing product reliability issues identified over the past 12 months delayed further product deployments at scale. Whilst the observed virtual fencing effectiveness was considered satisfactory during the trial, as many neckbands were replaced, the reliability of this measure and how the results are more accurately reported on is currently under review.

7 Desktop Study

7.1 Method

Thomas Elder Consultancy (TEC) were engaged in July 2021 to complete two desktop studies which aimed to understand how eShepherd virtual fencing technology can be incorporated within a whole of property grazing land management program and the impact of virtual fencing technology on end of catchment water quality.

These studies focused on landholders in far north Queensland impacted by sensitive water ways which pose environmental risks to the Great Barrier Reef (GBR), and aimed to:

- Evaluating the effectiveness of the technology to perform jobs relating to pasture and animal management for farms with sensitive waterways
- Determining the costs of implementing the full systems in these environments
- Developing a cost model associated with adoption against current practices
- Assessment of the potential to use technology to exclude cattle from high-risk sites associated with end of catchment water quality zones and the associated benefits in doing so.

On completion of the desktop studies, TEC developed a business case that considered the potential barriers to adoption, the benefits to landholders and what investment is required to support landholders to take up eShepherd virtual fencing technology and associated risks.

7.2 Desktop Study Results

The work undertaken by Thomas Elder Consulting found that once the product is operating reliably over an expected useful life of up to 7 years, implementation of intensive rotational, time-control grazing with eShepherd is likely to result in an abatement of approximately $26.76/tonne of fine sediment (TSS) with upfront costs of neckbands, base station, software subscription and grazing advice included (approximately $6.03/tonne of fine sediment annually thereafter). This outcome was calculated based on a Neckband purchase price of $315 per unit, totalling a $1,063,061 upfront cost spread over 7-year life-span of a Neckband. This compares favourably with the Alluvium (2016) report, which has priced under change of land condition under grazing in the Burdekin catchment from 'C' condition to 'B' condition at an estimated $158/tonne of fine sediment abated. This takes into consideration the costs associated with land management practice change, improved irrigation practices, gully remediation, streambank repair, wetland construction, a process used across GBR catchments to evaluate the cost effectiveness of alternative investments for delivering water quality targets. Due to ongoing reliability issues, because of repairs, replacement parts and labour costs, the unit cost per Neckband for this study was more closely estimated at $350 per unit. This additional expense is reported here for transparency, however it must be documented that this study led has led to an ongoing redevelopment of the eShepherd neckband to resolve the reliability issues.

Under the property scenarios – the 'do nothing', grazing scenario of high stocking rate (HSR) results in higher runoff and erosion (contributing more suspended sediment to GBR), made the least profit and caused degradation to C- condition pastures. The Moderate stocking (MSR) at or near long-term carrying capacity (LTCC) generates more profit in the longer term than other scenarios and results in higher groundcover and less runoff. The MSR was more profitable than the more complicated WSR and IRG (eShepherd) strategies. The MSR, WSR and IRG strategies would maintain pasture in B+ condition and abate sediment. Through implementation of intensive rotational, time-control grazing (IRG) with eShepherd, cattle numbers can remain same, and abatement be achieved. Under the scenarios above, the cost of eShepherd collars would need to come down to $125/collar to produce returns in line with the wet season rotation (WSR) and moderate stocking rate (MSR) scenarios. However, this modelling does not account for higher cattle prices than prices used in this modelling (current at time), and other intangible benefits like less mortality (through being able to monitor cattle movement -This has not been quantified through trial work and has not been included in this modelling). The use of eShepherd to facilitate intensive rotations (also known as 'cell' grazing) could allow for better grazing management, with existing cattle numbers, and better land management with increasing levels of ground cover and less runoff.

While virtual fencing technology like eShepherd can play a significant role in providing solutions for graziers to improve grazing practices, improving pasture growth, land cover and reduction in sediment run-off, the adoption of the technology could be slow without funding to help manage the implementation cost or reduction in costs of individual collars. The cost of implementing eShepherd on a 20,000Ha property (predominantly grassy woodlands and open woodlands) in the dry tropics of north Queensland, under an Intensive Rotational Time-controlled Grazing system, are shown in Table 2.

While eShepherd technology has the potential to exclude cattle from multiple high-risk areas to improve land management and water quality, property mapping and an inventory of natural resources needs to be conducted beforehand to enable objective assessment of long-term carrying capacity and stocking rate. Under the recently introduced Reef Regulations in Queensland, if there is less than 50 percent ground cover at 30 September each year; land is in poor or degraded land condition and action/s are required. Graziers are required to take measures to improve areas of poor land condition; and are required to take measures to improve areas of degraded land condition or prevent areas of degraded land condition from further degrading or expanding.

Table 2: Costs of four different grazing scenarios in the Burdekin region: High Stocking Rate (HSR), Moderate Stocking Rate (MSR), Wet Season Rotational (WSR) and Intensive Rotational Grazing (IRG) with eShepherd

	Do Nothing	**Best Management – conventional approaches**		**eShepherd – intensive rotational (cell) grazing**
Scenario	**1. HSR**	**2. MSR (SR=LTCC)**	**3. WSR**	**4. IRG (eShepherd)**
Base station ($6,500); 10yr life.	-	-	-	$650
Neckbands ($315); 7yr. life	-	-	-	$149,985*
Neckband replacement (7%)	-	-	-	$73,395
Subscription	-	-	-	$6,666
Grazing advice	$7,500	$7,500	$7,500	$7,500
Labour (cattle movement)	$1,500	$1,500	$1,500	-
Helicopter	$5,550	$5,550	$5,550	-
Fence maintenance	$10,000 (200km)	$10,000 (200km)	$10,000 (200km)	$3,000 (60km boundary)
Extra Labour (rotating cattle)	-	-	$2,000	-
GM for system/Yr.	**$31,471**	$395,744	$392,905	**$471,746**
Annual Cost of system	$24,550	$24,550	$24,550	$241,196
Difference in Gross Margin & changed overheads (i.e. How much extra profit)	**$6,921**	**$371,194**	**$368,355**	**$230,550**
TSS abatement $ benefit per Ha – upfront cost	**No abatement**	**Abatement – no cost over does nothing**	**Abatement – no cost over does nothing**	**$26.76/Tonne/TSS**
TSS abatement $ benefit per Ha – (annually)				**$6.03/Tonne/TSS**

* 7-year collar life. Cost spread across 7 years.

7.3 Desktop Study Conclusions

Much of the area in the Burdekin and Bowen/Broken River catchment has sodic and/or magnesic (fragile, dispersible or 'sugary') soils. It is very hard to get ecosystems repair, let alone ascertain soil loss and total suspended sediment (TSS) rates in comparison to bedload in short timeframes (bedload refers to the sediment which is in almost continuous contact with the bed, or stream flowing across ground, carried forward by rolling, sliding or hopping, normally >16 µm). Once such erosion takes place, mechanical intervention needs to occur for any rehabilitation. Earthworks and repair of such is normally in excess of $50,000/Ha; and over $1,000,000/Ha where gully earthworks and reshaping and batters are required. The amount of total suspended sediment (TSS), lost in runoff events and soil loss under erosion varies, dependent on the soil texture, particle size, and chemical composition. The key to reducing all forms of soil erosion is to reduce runoff.

8 Customer Insights & Conclusion

The eShepherd product management team conducted interviews with several trial customers during 2021, seeking to align the customers willingness to pay with the overall eShepherd value proposition. The feedback received, as was confirmed in the independent TEC desktop studies, highlighted that the upfront costs of the neckbands and base stations was unlikely to be sustainable in the long term. Once hardware reliability of the eShepherd technology is achieved, the additional benefits associated with the implementation of Intensive Rotational grazing systems (cell grazing), which will result in better management to adjust stock numbers, manage groundcover, etc., additional factors that have yet to be included in value proposition (and hence reduce the cost of implementation) include:

- Possible carbon sequestration (soil carbon) projects and Reef credits.
- Reduction in labour costs.
- Decrease in requirement for capital investment in fencing and water infrastructure.
- Cleaner musters of cattle to be processed for sale.
- Track animals to prevent loss of sick or escaped animals.

There continues to be a strong public interest in the technology as evidenced by information gathered through website enquiries as well as feedback received from Gallagher field representatives.

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10 Appendices

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