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Feedlot hydrological modelling incorporation into MEDLI

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Abstract

The aim of this project was to update the outdated feedlot hydrological modelling component of the Model for Effluent Disposal Using Land Irrigation (MEDLI) to a new platform and make it available through the new MEDLI version. This would make the feedlot module available to all consultants servicing the feedlot sector through the Queensland Department of Environment and Science (DES) and the Department of Agriculture and Fisheries (DAF).

The resulting software, MEDLI Pro V2, will be a fully tested and functional software program that includes a module enabling modelling of multiple variable catchments simultaneously to emulate the diversity of surfaces and waste streams present at cattle feedlots and similar facilities.

The software, MEDLI Pro V2, will be commercially released for public use from June 2020.

MEDLI Pro V2 software is anticipated to be used by consultants servicing the feedlot sector, researchers, government regulators, and other assessment agencies and interested parties to model cumulative environmental impacts of the various waste streams and catchment types associated with feedlots and other facilities.

Executive summary

MEDLI is a hydrological model for designing and analysing effluent disposal systems using land irrigation. It is widely used by consultants, regulators and researchers to model and assess system sustainability of intensive rural industries, agri-industrial processors, and sewage treatment plants. However, the current version of MEDLI, which was recently updated by the Queensland Department of Environment and Science (DES; formerly Science, Information Technology and Innovation (DSITI)) to a new software platform, does not include the component for feedlot hydrological modelling.

Currently, the old version of the MEDLI feedlot hydrological model runs under older computer operating systems (Windows 2000 SP4 or less). Additionally, FSA Consulting (now Premise Australia Pty Ltd; Premise) has, as a result of a number of MLA funded projects, made significant enhancements to the model. The enhanced feedlot hydrological model was never formally released.

The aim of this project was to update the feedlot hydrological modelling component to the new software platform, incorporating enhancements made by Premise. It will then be made available through the new MEDLI version, ensuring it becomes available, through DES, to all consultants servicing the feedlot sector.

The project has involved:

- Consultation between MLA, Premise, DES, and the Department of Agriculture and Fisheries (DAF),
- Development of a working version of the Feedlot module based on the robust MEDLI V2 platform to produce MEDLI Pro V2 by re-engineering the previous feedlot code,
- Conversion of the feedlot code from FORTRAN to C#,
- Embedding the re-engineered feedlot code into the MEDLI solution,
- Designing and writing the output report pages for the feedlot module,
- Conducting usability, output, and stress testing and bug fixing, and
- Developing an operating manual (technical and user).

The resulting software, MEDLI Pro V2, will be a fully tested and functional software program that includes a module enabling modelling of multiple variable catchments simultaneously to emulate the diversity of surfaces and waste streams present at cattle feedlots and similar facilities.

The software, MEDLI Pro V2, will be commercially released for public use from June 2020.

MEDLI Pro V2 software is anticipated to be used by consultants servicing the feedlot sector, researchers, government regulators, and other assessment agencies and interested parties to model cumulative environmental impacts of the various waste streams and catchment types associated with feedlots and other facilities.

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1 Background

1.1 Model for Effluent Disposal using Land Irrigation

The Model for Effluent Disposal using Land Irrigation (MEDLI) was developed jointly by the CRC for Waste Management and Pollution Control, the Queensland Department of Natural Resources (now the Department of Environment and Science; DES); and the Queensland Department of Primary Industries (now the Department of Agriculture and Fisheries; DAF). It is a hydrological model for designing and analysing effluent disposal systems using land irrigation and is widely used by consultants, regulators and researchers to model and assess system sustainability of intensive rural industries, agri-industrial processors, and sewage treatment plants (STPs). MEDLI underwent a significant upgrade, being released commercially as MEDLI V2 in 2015, and several updates have been released for the upgraded version.

1.2 MEDLI feedlot module

Most feedlots are exposed to rain, and hydrological modelling is required to understand feedlot processes and characteristics such as:

- Runoff generation;
- Pond sizing requirements;
- Pen depth and moisture predictions;
- Relationship of manure depth and moisture content to odour generation and dag formation;
- Predicting greenhouse gas (GHG) emissions; and
- Climate change impacts.

MLA funded a project to develop a hydrology model for feedlots in 2003-04 (Atzeni et al. 2014) and a feedlot module was developed within the original MEDLI program. In addition to considering standard MEDLI parameters, such as climate, waste volumes, effluent pre-treatment, pond chemistry, pond water balance, irrigation, shandying, soil water movement, soil nutrient movement, plant growth, and groundwater transport, the feedlot module enabled users to include feedlot specific parameters, such as market composition of the herd, occupancy rates, manure excretion rates, stocking density, catchment configurations, manure pad hydrology, runoff behaviour of non-pen areas, pen maintenance rules, manure harvesting limitations, surface and sub-surface manure depth, surface and subsurface pad moisture content, pad nutrient and salt concentrations, pad surface temperature, pen evaporation, and equivalent USDA runoff estimates.

The feedlot module is a niche product and its use increases when there is growth in the feedlot industry or when research and development funding for feedlots is available. While not widely used, the feedlot module has enabled consultants, regulators, and researchers to predict and assess manure depth and odour generation of cattle feedlots for development, expansion, environmental management, and animal welfare assessments. Because of this, the MEDLI-based feedlot module forms part of the capability of Australia's foremost feedlot consultancies.

Since 2003, Premise (previously operating as FSA Consulting) has used the feedlot module in 90 projects with a total net value of over $3.8 million. Most of these projects are feedlot development applications and research and development projects. However, the module can be used for innovative assessments, such as its recent use in an odour modelling project addressing how improved management can lead to reduced S-factor-based separation requirements, which resulted in approval of the expansion of a feedlot on the Darling Downs, Queensland. The application of the feedlot module could also be extended to predictions of feedlot GHG emissions and estimations of the impacts of climate change on feedlot hydrology, which may lead to wider adoption of its use across Australia.

Despite being successfully used by consultants and researchers to model various aspects of feedlot runoff processes, the feedlot module was not made commercially available in the MEDLI V2. Therefore, prior to this project, the feedlot module was only available in the legacy MEDLI V1.3 framework, which was only able to be run on Windows 2000 SP4 or earlier. Furthermore, modelling products including the feedlot module based on the MEDLI V1.3 framework had been discontinued and were unsupported in subsequent MEDLI upgrades. Consequently, prior to receiving approval for this project, there was only one known computer with the feedlot module running on the MEDLI V1.3 framework. Due to the age of the computer (it was 10 years old at the time of preparing the scope for this project), the feedlot modelling capacity was at risk of being lost to the feedlot industry. This project has involved redevelopment of the feedlot module into the successful MEDLI V2 platform, which was developed with state-of-the-art software engineering and has been well received by the modelling community.

MEDLI came into the custodianship of DES in 2012. Prior to that, there had been unsuccessful attempts to redevelop the MEDLI V1.3 framework to allow MEDLI to run on modern Windows operating systems. In mid-2012, a professional software development team in DES took on the challenge to re-attempt MEDLI V2 development. Within less than 3 years (in June, 2015), MEDLI V2 was commercially released. The legacy products built on the MEDLI V1.3 framework were supported until February 2016, when they were discontinued. MEDLI V2 features a completely rewritten Graphical User Interface (GUI) and is built with latest software engineering technologies. It is compatible with all current Windows operating systems. MEDLI V2 provides detailed modelling output with a graphically rich interactive report. To promote the science behind the MEDLI model, DES has decided to provide all future upgrades of MEDLI V2 free to licensed users. The omission of the feedlot module from MEDLI V2 was based on the complexity of the module combined with DES's resource limitations during the MEDLI V2 scoping study.

This project has involved collaboration between Premise, DES, DAF, and MLA. The project involved redevelopment of the feedlot module within a new version of MEDLI, MEDLI Pro V2[1]. DES conducted the software engineering and Premise and DAF provided administrative support, technical input and beta testing of the new feedlot module. The feedlot module performance has been well tested and approved by feedlot science experts from Premise for use within the feedlot industry and provides for future enhancements in its design architecture. Throughout the project, improvements identified by experienced users of the feedlot module have been incorporated into the final product. The testing regime and improvements have resulted in a product with enhanced usability and robustness.

MEDLI Pro V2 will be commercially released from June 2020 and can be used by consultants servicing the feedlot sector, researchers, government regulators, and other assessment agencies and interested parties to model cumulative environmental impacts of the various waste streams and catchment types associated with feedlots and other facilities. To support its use, Premise and DES have contributed to preparation of the MEDLI Pro V2 user and technical manual, to incorporate the feedlot module components.

This project contributes to the continued use of the feedlot module to assist and benefit the feedlot industry. Furthermore, the model may have wider adoption and application through its potential to be used as a tool for prediction of GHG emissions, dag formation, and climate change impacts.

2 Project objectives

The objectives of the project were to:

[1] MEDLI Pro V2 may be released under the name "MEDLI V2 +Feedlots" due to concerns that the "Pro"may inadvertently be highlighting a more "professional" version compared to the existing MEDLI V2. The qualifier "+Feedlots" more accurately indicates that it is MEDLI with an addition feature of being able to model feedlots.

1. Develop a modern, well-tested, working version of the feedlot hydrological module that runs within the MEDLI V2 framework and produces output which is presented as part of MEDLI's output report as well as daily outputs, which are saved as csv files.
2. This new product, built on the MEDLI V2 framework, to be made available commercially as "MEDLI Pro V2" by the Queensland Department of Environment and Science.

3 Methodology

The work was carried out in 3 stages to ensure that the objectives described were fully achieved. This section describes the methodology proposed at project outset. Due to the complex nature of the project, and unforeseen challenges that arose as a result of the method originally used for developing MEDLI V2, integration of the newly developed feedlot module into the GUI for MEDLI ProV2 took longer than anticipated. Many tasks were carried over into a new Stage – Stage 2.5.1 – Remaining tasks, which were completed after submission of the report for Milestone 6. Details of this are provided in Table 4-1.

3.1 Stage 1 – Project initiation

Stage 1 involved project initiation between MLA and Premise to discuss the project and confirm the project scope and desired outcomes.

3.2 Stage 2 – Develop working version of Feedlot module based on the robust MEDLI V2

Stage 2 involved development of a modern working version of the feedlot module within the MEDLI platform. Stage 2 was broken down into five tasks. These are described below.

3.2.1 Stage 2.1 Re-engineering of Feedlot code

This stage involved:

a. Remove any extraneous code, rewrite where necessary, and test against the original Feedlot model.
b. Add code to write the daily output in csv format.
c. Identify user requirements to facilitate GUI Input and Output Report design
d. Define and map the Feedlot input and output parameters (name, description and unit information) to a standard XSD model (as done within MEDLI) in preparation for linking the feedlot module to the MEDLI V2 framework. The XSD model also prescribes the structure of the input and output files.
e. Document the business logic and validation required for the feedlot module's input parameters.

A milestone report (Milestone 2) was completed and submitted to MLA at the conclusion of Stage 2.1.

3.2.2 Stage 2.2 Conversion to C#

This stage involved:

a. Decision to convert the feedlot code from FORTRAN (original code language) to ensure C#.NET uplifts the legacy programming technology to modern software engineering platform and allows for future maintenance of the code by contemporary software engineers and is in keeping with the overall code maintenance plan for MEDLI.

b. This C# code will then be tested against the FORTRAN code to ensure performance accuracy.

A milestone report (Milestone 3) was completed and submitted to MLA at the conclusion of Stage 2.2.

3.2.3 Stage 2.3 Embed the re-engineered Feedlot code into the MEDLI solution

This stage involved:

a. Integrating the re-engineered Feedlot code to the MEDLI solution.
b. Design and implement the new GUI fields required into the MEDLI V2 framework.
c. Expand the MEDLI XSD model to include the finalised Feedlot input XSD model components and link these components to the new Feedlot GUI data fields. This step prescribes the new MEDLI Pro V2 input file structure.
d. Extend the FORTRAN code to read MEDLI Pro V2 input files to provide a feedlot module testbed for testing against.

A milestone report (Milestone 4) was completed and submitted to MLA at the conclusion of Stage 2.3.

3.2.4 Stage 2.4 Design and write the Output Report pages for Feedlot module

This stage involved:

a. Design and implement the new Output Report fields required for the Feedlot module into MEDLI V2 framework.
b. Expand the MEDLI XSD model to include the finalised Feedlot output XSD model components and link these components to the new Output Report data fields.

A milestone report (Milestone 5) was completed and submitted to MLA at the conclusion of Stage 2.3.

3.2.5 Stage 2.5 Usability and output and stress testing, bug fixing

This stage involved:

a. Appraise and test MEDLI Pro V2 for robustness and ease of use.
b. Check the reasonableness of output predictions against the measured data where possible.
c. Resolution of bugs and issues.

A milestone report (Milestone 6) was completed and submitted to MLA at the conclusion of Stage 2.3.

3.3 Stage 3 Development of operating manual (Technical and User)

Stage 3 involved development of the feedlot module section for the MEDLI Pro V2 technical manual.

4 Results

4.1 Deliverables

4.1.1 MEDLI Pro V2 commercial release

The MEDLI Pro V2 software has been completely re-engineered as the major deliverable of this project. DES are currently in the stage of completing testing, debugging in preparation for commercialising the software, and the expected release date from June 2020. The software can be obtained by contacting Evan Thomas (DES) to receive a link to the web-based repository. This repository will be kept up to date with the latest working version. A roadmap for commercial delivery is provided in Appendix B.

4.1.2 Technical and user manual

The Feedlot (Waste Estimation) section of the technical and user manuals will be provided to users with the software.

4.1.3 Additional deliverables

The following additional deliverables have been included as appendices to this report:

- Appendix A – Wishlist
- Appendix B – Roadmap for commercial delivery

4.2 Completion of tasks

Table 4-1 lists the methodology that was proposed at the start of the project and indicates tasks that were delayed until after the completion of Milestone 6. To accommodate these delayed tasks, Stage 2.5.1 – Remaining tasks was created. These tasks were carried out between April and December 2019.

Table 4-1. Methodology and task status table.

Stage	Task		Expected completion date/milestone	Complete/status	Actual completion date/milestone
Proposed methodology and task completion status					
1	Project initiation		Upon project execution - Milestone 1	Complete	July 2017/Milestone 1
2.1	a.	Remove any extraneous code, rewrite where necessary, and test against the original Feedlot model.	15th September 2017 - Milestone 2	Complete	March 2018/Milestone 3
	b.	Add code to write the daily output in csv format.	15th September 2017 - Milestone 2	Complete	March 2018/Milestone 3
	c.	Identify user requirements to facilitate GUI Input and Output Report design	15th September 2017 - Milestone 2	Complete	November 2017/Milestone 2
	d.	Define and map the Feedlot input and output parameters (name, description and unit information) to a standard XSD model (as done within MEDLI) in preparation for linking the feedlot module to the MEDLI V2 framework. The XSD model also prescribes the structure of the input and output files.	15th September 2017 - Milestone 2	Complete	March 2018/Milestone 3
	e.	Document the business logic and validation required for the feedlot module's input parameters.	15th September 2017 - Milestone 2	Complete	
2.2	a.	Decision to convert the feedlot code from FORTRAN (original code language) to ensure C#.NET uplifts the legacy programming technology to modern software engineering platform and allows for future maintenance of the code by contemporary software engineers and is in keeping with the overall code maintenance plan for MEDLI.	15th January 2018 - Milestone 3	Skipped until Stage 2.5b	
	b.	This C# code will then be tested against the FORTRAN code to ensure performance accuracy.	15th January 2018 - Milestone 3	Skipped until Stage 2.5b	
2.3	a.	Integrating the re-engineered Feedlot code to the MEDLI solution.	15th April 2018 - Milestone 4	Skipped until Stage 2.5b	

	b.	Design and implement the new GUI fields required into the MEDLI V2 framework.	15th April 2018 - Milestone 4	Skipped until Stage 2.5b	
	c.	Expand the MEDLI XSD model to include the finalised Feedlot input XSD model components and link these components to the new Feedlot GUI data fields. This step prescribes the new MEDLI Pro V2 input file structure.	15th April 2018 - Milestone 4	Skipped until Stage 2.5b	
	d.	Extend the FORTRAN code to read MEDLI Pro V2 input files to provide a feedlot module testbed for testing against.	15th April 2018 - Milestone 4	Complete	February 2019/Milestone 6
2.4	a.	Design and implement the new Output Report fields required for the Feedlot module into MEDLI V2 framework.	15th July 2018 - Milestone 5	Complete	September 2018/Milestone 5
	b.	Expand the MEDLI XSD model to include the finalised Feedlot output XSD model components and link these components to the new Output Report data fields.	15th July 2018 - Milestone 5	Complete	September 2018/Milestone 5
2.5	a.	Appraise and test MEDLI Pro V2 for robustness and ease of use.	15th October 2018 - Milestone 6	Complete	February 2019/Milestone 6
	b.	Check the reasonableness of output predictions against the measured data where possible.	15th October 2018 - Milestone 6	Complete	February 2019/Milestone 6
	c.	Resolution of bugs and issues.	15th October 2018 - Milestone 6	Ongoing into Stage 2.5b	
Remaining tasks					
2.5.1	a.	Complete refactoring the GUI (original tasks 2.3 a-c, 2.5b). Tasks include control of refactoring and fixing memory leaks.	June – December 2019		
	b.	Interfacing new GUI with FORTRAN (original tasks 2.3 a-c). Tasks include integrating GUI with Feedlot FORTRAN modules and verifying multiple waste stream modules, input fields and daily outputs	June – December 2019		
3	a.	Development of feedlot module section for MEDLI Pro V2 technical manual and User manual	15th December 2018 - Milestone 7	Partially complete and Technical Manual provided with Milestone 5	

4.3 Scope alterations

As listed in Table 4-1, throughout the project, several alterations had to be made to the project scope due to technical issues with the software engineering. Details of the major alterations are provided below:

- Conversion of FORTRAN Feedlot simulation Code to C#.net for Stage 2.2 was deferred until when all MEDLI FORTRAN code converted to C#.net (after this project). This was to allow easier debugging of the simulation code by DES staff.
- Milestone 2.2 involved conversion of the reading and writing part of the Feedlot code to C#.net by DES staff during building of the MEDLIPro Graphical User Interface (GUI). This was to allow other DES staff to continue the reengineering of the Feedlot code and complete the remaining tasks for Milestone 2.1.
- Instead of re-engineering the Feedlot module code so it could be incorporated as an entire module into the MEDLI code base, the Feedlot module code was rebuilt into the MEDLI code base, code block by code block. This was to allow each code block to be tested against the original in the Feedlot module code and to alleviate issues around bugs in the original Feedlot module code.
- The new MEDLI simulation code architecture accommodates an expanded Waste Estimation module within MEDLIPro where the Feedlot module code was split into separate Livestock yard, grassed surface and hard surface runoff quantity and quality estimation modules. Each of these, along with a new Roof runoff module, forms a new rainfall-dependent waste stream estimator option. This allows the user to choose any combination of waste stream types to simulate a feedlot.

4.4 Wishlist

During this project, a wishlist was developed and maintained to track identified improvements to the feedlot module. Some of the wishlist tasks have been carried out as part of this project, however, due to budget and time constraints, many tasks have not yet been undertaken. It is recommended that this wishlist be referred to regularly when undertaking routine upgrades to MEDLI ProV2 and, if possible, that additional funding be sought to encourage increased adoption of MEDLI Pro V2 by the feedlot industry. The wishlist task list and status is provided as Appendix A.

5 Discussion

The project will result in commercial release of MEDLI Pro V2, which contains the Feedlot (Waste Estimation) module. MEDLI Pro V2 will soon be used by consultants servicing the feedlot sector, researchers, government regulators, and other assessment agencies and interested parties to model cumulative environmental impacts of the various waste streams and catchment types associated with feedlots and other facilities. In addition to development of MEDLI Pro V2, Premise and DES have contributed to preparation of the MEDLI Pro V2 user and technical manuals, which incorporates components of the feedlot module. This will facilitate targeted use of the Feedlot module by the feedlot industry, modellers and regulators.

As a side project, Premise are now developing a validation dataset that will represent feedlot catchment characteristics for Queensland, New South Wales, Victorian, and South Australian feedlots. This will ensure that modelling outputs can robustly and reliably predict impacts for a range of different Australian climates. Another side project is being funded by the Queensland Water Modelling Network (QWMN), which will critically assess the science underpinning MEDLI. Both these side projects will contribute to continual improvement of MEDLI Pro V2 and subsequent upgrades.

This project contributes to the continued use of the feedlot module to assist and benefit the feedlot industry. Furthermore, the model may have wider adoption and application through its potential to be used as a tool for prediction of GHG emissions, dag formation, and climate change impacts.

6 Conclusions/recommendations

A number of recommendations for the project are included in the wishlist in Appendix A. Two of these recommendations are already being carried out as part of the following two side projects:

1. B.FLT.5004 - Development of a validation dataset for MEDLI Pro V2
2. DES19129 QWMN MEDLI Science Review

It is recommended that the wishlist be referred to be the ongoing custodians of MEDLI Pro V2 and elements incorporated, where possible, into software upgrades. In addition, it is recommended that additional side projects be carried out to address the following:

- Improved estimate of potable water demand (Item 1 in Appendix A)
- Increase cattle management options (Item 37 & 38 in Appendix A)
- Improve the feedlot nutrient algorithms (Item 39 in Appendix A)

7 Key messages

The key messages to come out of this project are as follows:

1. MEDLI Pro V2 is finalised and will soon commence beta testing. It will be commercially released from June 2020. It includes the feedlot (Waste Estimation) Module. This module enables modelling of multiple variable catchments simultaneously to emulate the diversity of surfaces and waste streams present at cattle feedlots and similar facilities.
2. MEDLI Pro V2 software is anticipated to be used by consultants servicing the feedlot sector, researchers, government regulators, and other assessment agencies and interested parties to model cumulative environmental impacts of the various waste streams and catchment types associated with feedlots and other facilities.
3. This project contributes to the continued use of the feedlot module to assist and benefit the feedlot industry. Furthermore, the model may have wider adoption and application through its potential to be used as a tool for prediction of GHG emissions, dag formation, and climate change impacts.
4. There are a number of potential improvements that have been identified by experts in feedlot waste generation and management and modelling. Many of these have been incorporated in the current project but some are noted as recommendations for future improvements of MEDLI Pro V2.

8 Bibliography

Vieritz A.M., Lowry M.M., Sullivan, T.J, Atzeni M.G., Hope-O'Connor A.J. and Watts P.J. (2019). Modelling feedlots using the MEDLI model framework. 23rd International Congress on Modelling and Simulation, Canberra, ACT, Australia, 1 to 6 December 2019 mssanz.org.au/modsim2019.

9 Appendix A – Wishlist

The table below contains the wish list of identified improvements for the feedlot module. Some of these have been carried out as part of this project. However, others remain as recommended actions for further improvements of the feedlot module to promote optimal industry adoption.

#	Title	User Story	Status
1	Improved estimate of potable water demand	A brief review of relevant RD&A has also been undertaken to show the current understanding of water use in Australian feedlots. Premise has been involved in the majority of RD&A in Australia on water usage at feedlots: • B.FLT.0147 – Impact of Increased Climate Variability on Australian Feedlots (Perkins et. al. 2015) • B.FLT.0486 – Environmental Performance Review of Australian Feedlots (Watts et. al. 2014) • B.CCH.2026 – Water Footprint of Livestock: Impact assessment of beef production systems in NSW (Ridoutt et. al. 2011) • B.FLT.0348 – Treatment Technologies for Feedlot Effluent Reuse (Tucker et. al. 2011) • P.PIP.0171 – Investigation of Lot Fed Cattle Drinking Water Consumption (Carter 2008) • B.FLT.0350 – Quantifying the water and energy usage of individual activities within Australian feedlots: Part A (Davis et. al. 2009) • FLOT.328 - Environmental Sustainability Assessment of the Australian Feedlot Industry: Parts A and E (Davis, Watts & Tucker 2006) We find that available licensed water supply is the main constraint to feedlot development. Hence, a good estimate of potable water demand would be great. We know a lot about water requirements and it could be included in MEDLI Pro V2 if time permits.	Recommended future improvement
2	Generate runoff quantity from multiple catchments	Generate runoff from multiple catchments discharging into effluent system + allow for user defined catchments where the user selects the curve number for the USDA NRCS runoff model. For example, the following are incorporated into WaterBal for use in the dairy industry: Concrete, Earth, Hard, Grass, Roof	Completed as part of this project.
3	Generate runoff quality from multiple catchments	Generate runoff from multiple catchments discharging into effluent system, where the user will be able to assign an N, P, EC value to each runoff stream. The choice of N, P, EC will depend on the competence of the user (which is a perennial problem).	Completed as part of this project. Implemented by allowing the user to define pen yards, vegetated and non-vegetated surfaces and roof surfaces as well as generic where daily data can be directly inputted for the simulation run. For non-vegetative surfaces, the user specifies the K value.
4	Improve Pen Management	Lot feeders do not clean when the pen surface is too dry and dusty. Can we add that condition?	Beta completed as part of this project (cleaning waste stream)
5	Feedlot code check - pad layer depths	We should test the layer depths (upper and lower) as they change during each simulation run to make sure that they are behaving correctly – i.e. is an interface layer left (or removed) if the inputs say that the depth maintained above base when harvesting is set to 0 mm.	Recommended future improvement This can be done by graphing selected Pen's pad, following implementation of the graphics module.

6	Feedlot code check - Include USDA runoff model outputs	I found the USDA runoff model comparison 'comforting' as a verification check. If they start to diverge, then which model do you trust?	Will not do. The USDA runoff model check for the livestock yard area can be done by re-running MEDLI and entering the yard K values for a "non-vegetated" surface.
7	Feedlot user Manual	We need to include a figure in the Manual similar to Fig 11 in the 2015 - B.FLT.0369_Final_Report_Part_B.pdf.	User manual is still to be completed as part of this project
12	Allow more shandying options	Allow shandying (dilution) of effluent irrigation with clean water based on a fixed ratio basis.	Recommended future improvement
16	Feedlot model output	Comprehensive standard output tables and graphs; e.g. pond storage levels and spill volumes overlaid.	Recommended future improvement
20	What about including a multi-run capability as part of MEDLI itself	Load up a range of soils, and a range of climates, and a range of parameter files and run all combinations of them outputting tabulated results. This sort of thing is handy for developing guidelines.	Recommended future improvement
24	Outputs for Odour models	CSV file for odour model	Beta Completed as part of this project - yet to be implement in the GUI
27	Feedlot code check - predicted runoff volumes	There is a simple way of doing a reality check on the predicted runoff volumes. Catchments 1 to 5 are all runoff generated using Curve Number method. There would be different K2 for each catchment. A "hard" catchment would have high K2 (e.g. 90). A "soft" catchment would have a lower K2 (e.g. 65) with a resulting different (lower) mean annual runoff. There might be different "hard" catchments – concrete pads, gravel roads, compost pads. There might be different "soft" catchments – grass inside feedlot area, outdoor pig pens, outdoor chicken runs. Expressing the mean annual runoff (mm) as a percentage of mean annual rainfall (mm) is a quick reality check. For any surface, this percentage increases as mean annual rainfall increases. The percentage also increases with increasing KII. For a modern feedlot, we know from the MLA research that this percentage should be something between 25% and 40% for the pens depending on pen management, stocking density, local rainfall. As pen management improves (i.e. changing pen cleaning parameters – thinner pad, more frequent cleaning), this percentage should increase. By presenting the total volume of runoff from each sub-catchment, the user gets an idea of where most runoff is coming from. By presenting the total nutrient load for each sub-catchment, the user gets an idea of where the most nutrient load is coming from. By calculating the mean annual nutrient concentration in the total runoff, the user can see how the combination of catchments dilutes nutrient concentrations.	Beta Completed as part of this project - yet to be implement in the GUI

28	Feedlot code check - report accessible before MEDLI run	Given that the user should get these checks "right" before doing the pond and irrigation area balance, it would be good to be able to present them after the first stage MEDLI model is run and is presented before the main MEDLI model is run. The user could then tweak the catchments before the usual MEDLI modelling is undertaken.	Beta completed as part of this project - yet to be implement in the GUI
29	Modelling dag wash-off – abattoir end vs feedlot end	A real logistics problem in the industry that a Feedlot MEDLI can help with.	Completed as part of this project
30	User-specified reporting pen	User-defined pen no to report data.	Completed as part of this project
31	Use specification of generic wastestream as a Livestock yard primary wastestream	Peter asked if MEDLI can import generic waste stream from another application. This led to the discussion on the merits of implementing a mechanism in MEDLI where the generic option can be designated as a "Feedlot" or some other waste stream type for the purpose of running the main part of MEDLI.	Recommended future improvement
32	Shortcut for pre-treatment inputting across waste streams	Shortcut for pretreatment… The primary waste stream's pre-treatment settings can be applied to all using a menu selection.	Recommended future improvement
33	Graphic plot cut & paste	Ensure graphic plots can be cut & pasted or imported as an image file into a user document.	Recommended future improvement
34	Vegetative surfaces wastestream – linked to the MEDLI paddock module.	Vegetative surfaces waste stream currently uses two sets of K values for dormant and non-dormant seasons to estimate the runoff volume. Dormancy is assigned to days falling between days 120 and 240 in the year which is inappropriate for northern hemisphere locations. MEDLI does have a better runoff estimation approach on board (in the Paddock Module). For the Vegetative surface waste stream, the K values could be replaced with the plant and soil library selectors to allow the user to define the vegetative surface of the catchment for the paddock module to predict surface runoff due to rainfall.	Recommended future improvement
35	Water for dust control	Amount per unit pen area of fresh water applied to control dust.	Recommended future improvement
36	Include a non-effluent pond to supply fresh water for various requirements	Optionally have clean runoff (e.g. from roofs) go to a storage other than the effluent pond. This ties in with a recent DAF project which MA did which argued the case for a separate/parallel non-effluent pond modelling option in MEDLI.	Recommended future improvement

37	Increase cattle management options	Include input to specify the % time spent in the pen. This could be useful for a dairy lot which is only occupied for part of the day.	Recommended future improvement
38	Increase cattle management options	Include inputs of the percentage of pens with shade and the percentage of each pen shaded as this impacts on pen pad evaporation. Depending on the type of shade structure (e.g. roof or shade cloth), there's practical value incorporating a 'percentage pad covered' to prevent 'rain gain' on a fully covered pad e.g. Note, otherwise the roof area could be excluded from the catchment to model the loss to the system	Recommended future improvement
39	Improve the feedlot nutrient algorithms	Perhaps consider scaling nutrient enrichment ratios according to the pad depth so that more dissolved nutrient will be lost when the pad is deeper. There is scope for a more process-based enrichment ratio modelling approach to take into account the different ways N, P and salts move (e.g. adsorptive processes, nutrient transformations and dissolution).	Recommended future improvement
40	Add calibration module for Livestock yard enrichment ratios	By calibrating these inputs against measured/expected pond concentration data, and checking that the values do not fall below 1.0, meaningful input values are better assured.	Beta completed as part of this project - yet to be implement in the GUI

10 Appendix B – Roadmap for commercial delivery

10.1 Phase 1: Alpha testing of the Feedlot module core

This is currently in progress to fix known issues.

10.2 Phase 2: Beta testing of the Feedlot module core

The final commercialisation phase includes extensive testing both within DES and industry. Components which are extra to the Feedlot module core will be marked as “beta” but hopefully some components will have this status lifted during this phase as they are tested as fit for use. Remaining components will have this status lifted after testing after commercial release in subsequent minor version releases.

It is intended to invite the following industry testers:

Experts

- Eugene McGahan – Agricultural & Environmental Engineering Consultant
- Dr Peter Watts – Semi retired Principal Agricultural Engineer and Feedlot expert
- Tim Sullivan – Senior Agriculture Engineer Premise
- Martin Haege – Principal Environmental Engineer at Premise Orange
- Mark Lowry – Geotechnical Engineer at Butler Partners Toowoomba

Medli Feedlot Novices (provided introduction training)

- Melissa Wells – Environmental Engineer, Orange
- Steve Dudgeon – Principal Scientist Premise, Brisbane
- Emile Seiler – Agricultural Engineer Premise Toowoomba
- Dr Kimberley Wockner – Principal Agricultural Scientist Premise Brisbane

10.3 Phase 3: Commercial release

Commercial release will include setting up of the licencing server and payment portal to allow distribution of the software, and pre-release notifications to our existing clients through emails and the MEDLI user forum.

The timing of the release is dependent on the completion of the previous phases.