final report

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BIODEGRADABLE PLASTIC – COST BENEFIT ANALYSIS

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CONTENTS

1.0 EXECUTIVE SUMMARY

Using data provided by Novatein Ltd (Novatein) as a basis, a process for producing biopolymer using blood meal as a major feedstock was refined and analysed. The major assumptions made were for an Earnings Before Income Tax (EBIT) scenario, 7% discount rate, product sale value of $2100 per tonne, 3605 tonnes per annum (tpa) annual sales and that the payback period is considered from when full production commences (i.e. assumes that total capital investment (TCI) and all start-up costs are expended at the start of the first year of full scale production). Additional assumptions and major equipment requirements are outlined throughout the report. The results for the base case are summarized in Table 1.1 below.

Table 1.1: Base case results for Novatein's biopolymer production process.

Metric	Result
Main Plant Equipment Cost (MPEC)	$537,000
Total Capital Investment (TCI)	$2,290,000
Discounted Payback period (DPP)	0.81 years
Simple Present Value $ / head	$3.59 / head
Net Present Value (NPV) $ / head	$NPV 2.51 / head
Discounted Annual Net Benefit (DANB)	$2,826,531
Net Present Value (NPV)	$29,800,000

A large number of alternative scenarios were also considered. The economic results are most sensitive to the bioplastic value and tonnes of bioplastic sold, followed by the operating costs. The results of the various scenarios are presented in Table 1.2 below.

Table 1.2: Effect of various scenarios on the discounted payback period (DPP) and simple value per head.

Scenario	DPP years	Simple $ / head
Purchase of used extruder ($35k; 16% TCI reduction).	0.70	3.65
Reduction in Total Capital Investment (TCI) 50%.	0.42	3.68
Increase in Total Capital Investment (TCI) by 50%	1.19	3.49
Increase in biopolymer sales price (or tonnes sold per annum) by 50%	0.35	7.74
Decrease in biopolymer sales price by 50%	NA (not in life of plant)	-0.57
Increase in operating costs by 50%	3.22	1.32
Manufacture of biopolymer for 8000 hrs per annum at equipment capacity (289% increase to base case)	0.30	10.56
Wet blood meal (18% moisture) as feedstock	0.80	3.60

2.0 INTRODUCTION

Lycopodium Process Industries Pty Ltd (Lycopodium) was invited to provide cost benefit services to MLA Ltd. MLA is considering supporting a technology via R&D funding that value adds blood meal by using it as a major feedstock for the manufacture of a bio-polymer. The cost benefit analysis was performed at a processor enterprise level.

This report considers the economics of the facility proposed by Novatein Ltd (Novatein) for the generation of the blood meal based second generation bioplastic. Blood meal is considered a low value by-product of the meat industry and is currently sold as animal feed due to its high protein content. The technology is owned by Novatein and was developed in conjunction with the University of Waikato. The product is intended to be sold as a master-batch material, with mechanical properties similar to low density polyethylene (LDPE) which makes it suitable for injection moulding applications. The target market for this product is the agricultural and horticultural industry, with possible applications such as seedling trays, disposable planting pots, vine clips, protective netting and plastic products used throughout the meat.

This report summarizes the data discovery and analytical works completed by Lycopodium as part of the cost benefit analysis.

3.0 UPDATED PROCESS FLOW DIAGRAM

Based on discussions with Novatein and vendors expert in materials handling (Kockums Bulk Systems Pty Ltd), the process requirements were modified and an updated process flow diagram was generated as per Figure 3.1 below. The process below was used to generate a base case.

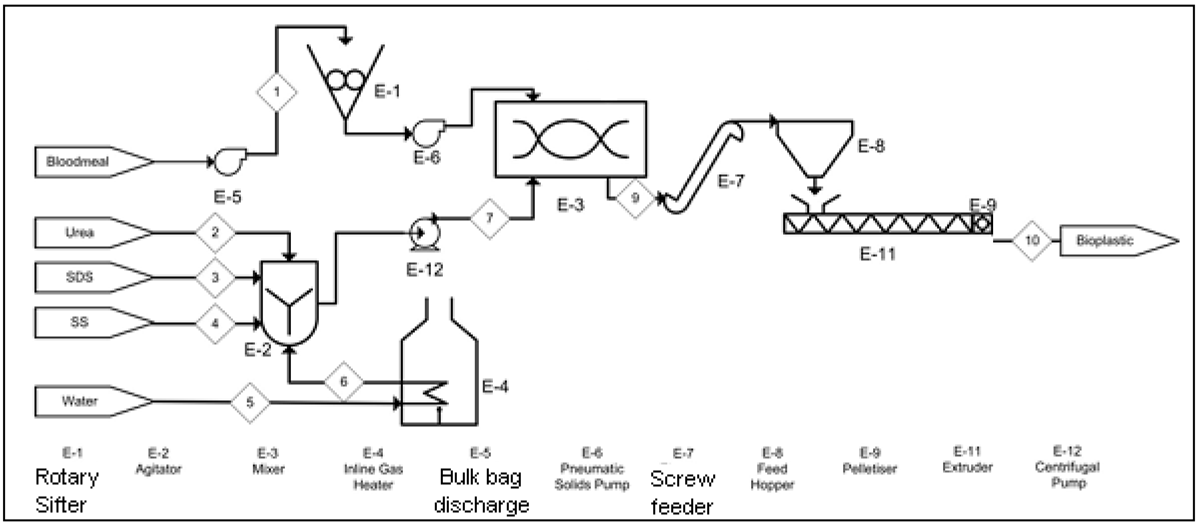

Figure 3.1: Updated Block Flow Diagram used as the system for the Base Case Analysis as per this report.

4.0 METHOD

This report was completed in accordance with the document "MLA Guide to Value Propositions and Cost/Benefit Analysis v1.0".

This product has relevance to the following MLA AOP KPI's:

- 2.3: Developing new products
- 3.2: Increasing cost efficiency and productivity – off farm.

Cost estimation for construction works, where appropriate, was made in accordance with Rawlinsons Construction Handbook (2011, indexed to 2012). Other cost estimations were in accordance with standard industry cost estimation techniques, such as the AACE International Recommended Practice No. 18R-97, "Cost Estimate Classification System – As Applied in Engineering, Procurement, and Construction for the Process Industries".

4.1 Assumptions

The following key assumptions were made in order to generate a "base case" analysis:

- Results are for an Earnings Before Income Tax (EBIT) scenario where no consideration has been given to depreciation, company tax, government funding, or tax rebates.
- 7% discount rate as per MLA Guide to Value Propositions and Cost/Benefit Analysis v1.0".
- Product value of $2100 per tonne. This is an agreed price acceptable to Novatein and MLA based on listed LDPE market prices of $1765 to $2538 / t, with a 15% margin on biodegradable LDPE taking these process to $2030 to $2920. Variations in this price are accounted for in the sensitivity analysis. Based on discussions with industry, this is a conservative price point position.
- 350 batches per year yielding 3605 tpa of product sold.
- Other assumptions as per sections 5, 6, and 7 of this report.

5.0 CAPITAL COST ESTIMATION

5.1 Introduction - Study Deliverables at Each Level of Accuracy

The table below summarizes the works that need to be completed to achieve certain capital cost estimation accuracies. Based on this analysis which takes into account works completed by Novatein (Black writing) and works completed by Lycopodium or requiring further work (red writing), it may be concluded that the highest level of accuracy for the capital cost estimate is -15 to +50% based on the method proposed by the American Association of Cost Engineers (AACE) and more likely to be in the range of -20 to +100%.

Table 5.1: Summary of: AACE International Recommended Practice No. 18R-97, "COST ESTIMATE CLASSIFICATION SYSTEM – AS APPLIED IN ENGINEERING, PROCUREMENT, AND CONSTRUCTION FOR THE PROCESS INDUSTRIES", TCM Framework: 7.3 – Cost Estimating and Budgeting.

Deliverable	**Concept Study (Class 5 -20 to +100)**	**Pre-Feasibility Study (Class 4 -15 to +50%)**	**Feasibility Study / FEED (Class 3 -10 to +30%)**	**Novatein Project as per data received and works completed to generate this report.**
General Project Data	General	Preliminary	Defined	
Project Scope Description	Assumed	Preliminary	Defined	Defined
Plant Production/Facility Capacity	General	Approximate	Specific	Specific
Plant Location	None	Preliminary	Defined	Assumed
Soil & Hydrology	None	Preliminary	Defined	None
Integrated Project Plan	None	Preliminary	Defined	None
Project Master Schedule	None	Preliminary	Defined	None
Escalation Strategy	None	Preliminary	Defined	None
Work Breakdown Structure	None	Preliminary	Defined	None
Contracting Strategy	Assumed	Assumed	Preliminary / Defined	Some consideration
Engineering Deliverables				
Block Flow Diagrams	Started / Preliminary	Preliminary / Complete	Complete	Complete
Plot Plans		Started	Preliminary / Complete	Preliminary
Process Flow Diagrams (PFDs)		Started / Preliminary	Preliminary / Complete	None

Utility Flow Diagrams (UFDs)		Started / Preliminary	Preliminary / Complete	None
Piping & Instrument Diagrams (P&IDs)		Started	Preliminary / Complete	None
Heat & Material Balances		Started	Preliminary / Complete	Mass: updated Heat: preliminary
Process Equipment List		Started / Preliminary	Preliminary / Complete	Major units
Utility Equipment List		Started / Preliminary	Preliminary / Complete	Preliminary
Electrical single Line Drawings		Started / Preliminary	Preliminary / Complete	None
Specifications & Datasheets		Started	Preliminary / Complete	Started for main unit ops
General Arrangement Drawings		Started	Preliminary / Complete	Preliminary
Mech / Elec Discipline Drawings		Started	Started / Preliminary	None
Inst / Control System Drawings			Started / Preliminary	None
COST APPROXIMATION	0.5% of project costs	1 to 2% of project costs	5% of project costs	

5.2 Equipment selection

The equipment requirements were reviewed with Novatein and reduced where appropriate. Expert materials handling advice was sought (Kockums Bulk Systems Pty Ltd) with regards to minimum requirements for this facility and a final main equipment list was developed as per table 5.2 below. Exchange rates were updated as per 24th April 2012 and appropriate indexing was made to the Australian CPI.

In comparison to the 2008 Novatein report, capital savings have been identified by no requirement for titanium dioxide receiving, handling or addition, no requirement for a roll mill which results in removing the need for a second pneumatic conveyor, via good design and appropriate equipment selection removing the need for a ribbon mixer, via good design removing the need for an elevator.

Table 5.2: Major Equipment List - Estimation of total cost of equipment and materials (TEMC).

Equipment	**QUANTITY**		
1. Gas heating			
Power vent 870 (NZ, 2008)	**1**		
SUB-TOTAL			
2. Agitator			
Ross 6000 L atmospheric mixer (US, 2008)	1		
SUB-TOTAL			
3. Agitator			
Ross 6000 L atmospheric mixer (US, 2008)	1		
SUB-TOTAL			
4. Extruder			
Hopper [Euro, 2008]	1		
TDS95D 315 kW [Euro, 2008]	1		
SUB-TOTAL			
5. Materials transfer			
Diaphragm pump, Airdraulics PD10P-BPS-PAA [AUS, 2012]	1		
Rotary screw compressor 7.5 bar [AUS, 2012]	1		
Bulk bag discharger [AUS, 2012]	1		
Dust collection system [AUS, 2012]	1		
Rotary sieve [AUS, 2012]	1		
Batch feeding hopper [AUS, 2012]	1		
Weighing system [AUS, 2012]	1		
Screw feeder [AUS, 2012]	1		
Pneumatic feeder [AUS, 2012]	1		
Fork lift	1		
SUB-TOTAL			
6. Detection : assays and quality control (QC)			
Quality control assay equipment			
TOTAL - Main Plant Equipment Cost (MPEC)			**536,967**

6.0 MAINTENANCE AND OPERATION

6.1 Labour

Tables 6.1 and 6.2 below summarize the results of the labour requirements.

Table 6.1: Indirect labor cost estimate.

Indirect Labor	Hourly Rate	Number	Base Salary, AUS $	Annual individual with 43% add-on	Sub-totals
Managing Director		0.2	200,000.00	286000	57200
Sales Manager		1	97,200.00	138996	138996
Accountant		0.2	64,800.00	92664	18532.8
Secretary		0.2	43,200.00	61776	12355.2
Production Manager		1	115200	164736	164736
Sub-total		1.6	**405,200.00**		391820

Table 6.2: Direct labor cost estimation.

Direct Labor	Hourly Rate	Number	Base Salary, AUS $	Annual individual with 43% add-on	Sub-totals
Operators	30	4	70000	100100	400,400.00
7. QC	50	0.5	104000	148720	74,360.00
Sub-total		7.1			**474,760.00**
TOTAL labor costs per annum					866,580.00

6.2 Waste management

Land filling costs and trade waste (sewerage) costs for industrial waste in Australia make a noticeable contribution to overheads for operating industrial facilities. It is recommended that any waste generated be treated in on-site systems before discharge e.g. those attached to an abattoir.

More ideally, SOPs and CIPs should be developed to minimise waste, thereby making more product for the same feedstock whilst reducing overheads. Operating in a continuous rather than batch process will assist to achieve this.

7.0 BASE CASE RESULTS

Tables 7.1 and 7.2 below summarize the findings of the Base Case results as per the assumptions and calculations in sections 3 to 6.

Table 7.1: Annual sales, production and operating costs.

Year of production	ANNUAL GROSS SALES	ANNUAL TOTAL PRODUCTION COST	ANNUAL OPERATING INCOME
1	7,569,765	4,704,977	2,864,788
2	8,008,811	4,846,126	3,162,685
3	8,473,322	4,991,510	3,481,812
4	8,964,775	5,141,255	3,823,520
5	9,484,732	5,295,493	4,189,239
6	10,034,847	5,454,358	4,580,489
7	10,616,868	5,617,989	4,998,879
8	11,232,646	5,786,528	5,446,118
9	11,884,139	5,960,124	5,924,015
10	12,573,420	6,138,928	6,434,492

Table 7.2: Cash flow analysis of base case process.

Interest Rate	7%									
Year	2013.00	2014	2015	2016	2017	2018	2019	2020	2021	2022
Cash Flow	574968.38	3162685	3481812	3823520	4189239	4580489	4998879	5446118	5924015	6434492
Discounted NCF	574968.38	2955780	3041150	3121131	3195950	3265825	3330964	3391568	3447831	3499937
Cumulative NCF	574968.38	3530749	6571899	9693030	12888980	16154805	19485769	22877338	26325169	29825106
Net Present Value (NPV)	**29,825,106**	**$**								
Discounted Payback period (DPP)	**0.81**	**years**								
Net Present Value per Head	**2.51**	**$ NPV/head**								
ANB	**2,982,511**	**$ Annual Net Benefit**								
Simple Value per Head	**3.59**	**$ Simple / head**								

8.0 MAXIMUM PRODUCTION

The Novatein report states a TDS95D extruder design throughput of 1296 kg/h and a maximum throughout of 1733 kg/h. As a general rule, rotating equipment is recommended to be run at 80% of maximum capacity to ensure equipment longevity, which for the extruder equates to 1386 kg/h. Assuming that the extruder can produce biopolymer at a rate of 1.30 tph for 8000 hours per annum, it is possible to generate 10.4 kt pa. However, it must be noted that the USEON Extrusion quotation for the TDS95D 315 kW states a capacity of 300 to 1200 kg / hr.

By using a 2.89 multiplier for total production costs, the DPP reduces to 0.30 years and the net present value (NPV) per head increases to $7.59 / head whilst the simple value per head increases to $10.69 per head. However, due to the continuous operation there will be a much greater demand on equipment. Assuming all equipment is fully replaced after 5 years (add an additional “Fixed Capital Investment” cost of $1.544 mil at the end of the 5th year), the DPP remains at 0.30 but the $NPV / head reduces slightly to $7.49 whist the simple value per head reduces slightly to $10.56.

9.0 SENSITIVITY ANALYSIS

The findings of the sensitivity analysis are presented graphically for the discounted payback period (DPP) in Figure 10.1 and for the simple value per head in Figure 10.2.

The economic viability of the project is most sensitive to revenue generated. That is, the value of the bioplastic and tonnes per annum sold both have an equally high impact on the economic viability of the project. A 1.1% decrease in either of these parameters results in the simple value per head dropping below $3.50 per head. A 2% increase in operating costs results in the simple value per head dropping below $3.50.

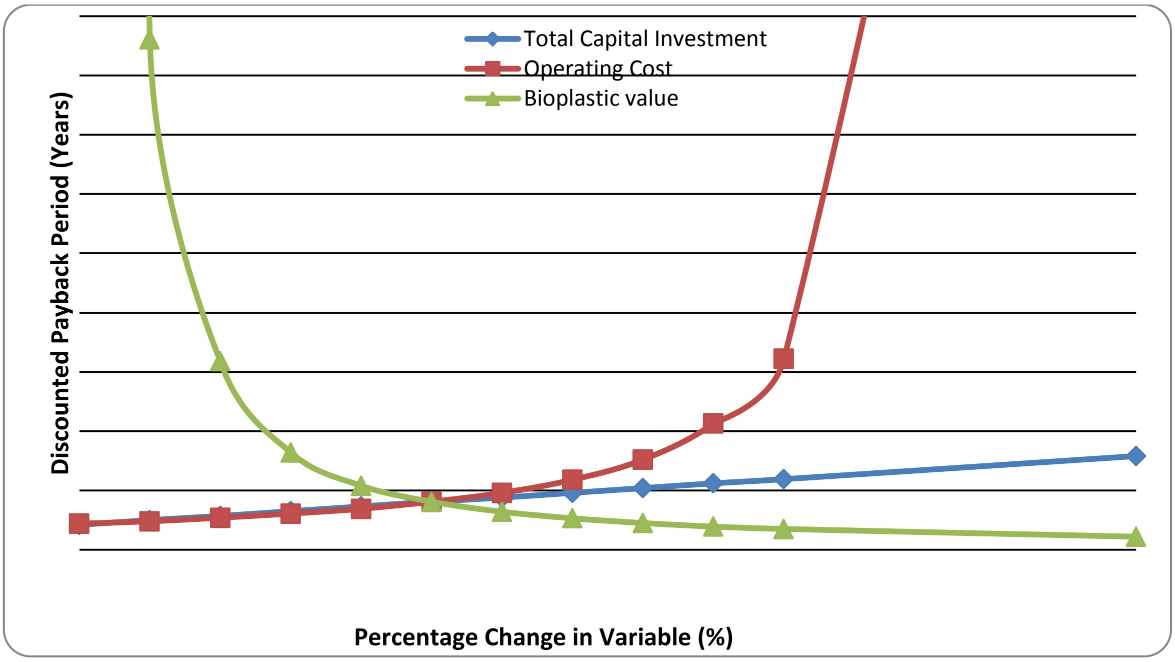

Figure 10.1: Graphical ouput of effect of variation in bioplastic value (same impact of tonnes per annum sold), total capital investment (TCI) and operating cost on the discounted payback period (DPP).

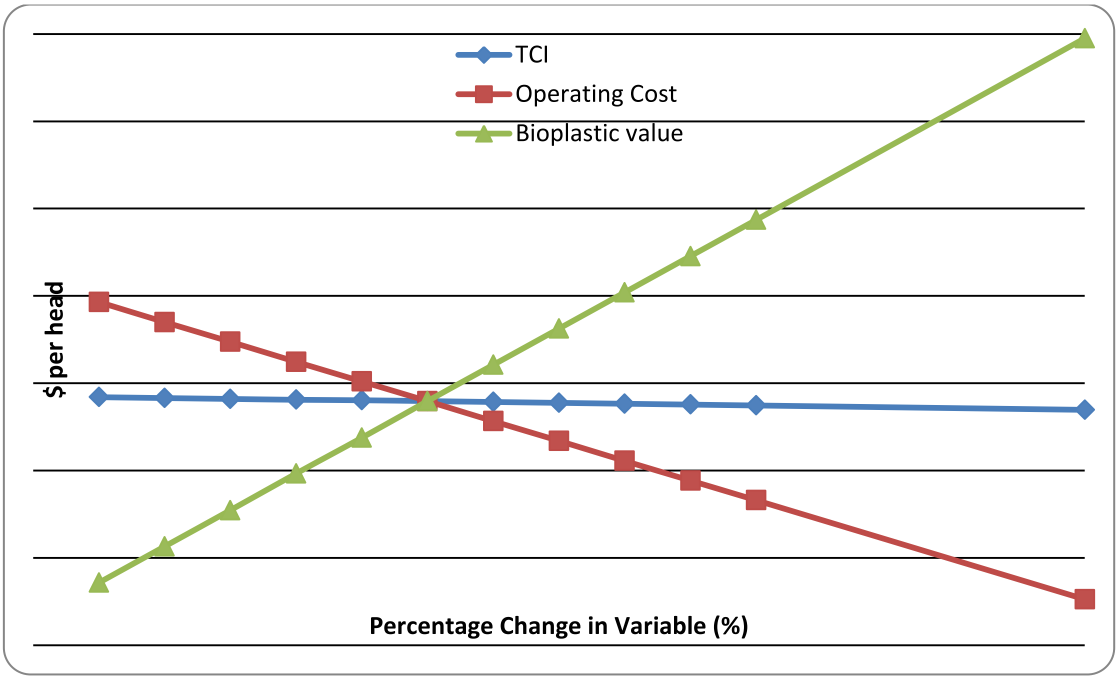

Figure 10.2: Graphical ouput of effect of percentage change in total capital investment on simple value per head ($ / head).

Detailed findings for the effect of variations in Total Capital Investment (TCI) are presented in Table 10.1. It has been suggested that a major cost saving would be procurement of used processing equipment. Based on the findings of the capital cost estimate accuracy as per section 4.1, the sensitivity analysis has escalated the TCI by up to 100% and reduced it by up to 50%.

Table 10.1: Effect of reduced extruder cost on project economics.

Action	Total Capital Investment TCI	Effect on TCI	DPP	$ NPV / head
Base Case	$2,290,000	0%	0.81	3.59
Used extruder for $35k	$1,989,000	-16%	0.70	3.65

10.0 BIOPOLYMER MARKET

Global LDPE demand was estimated at 17.76 million tonnes in 2009 (http://www.chemsystems.com/about/cs/news/items/POPS09_Executive%20Report.cfm). Growth is predicted to be between 0 to 9% year on year through to 2025. The maximum production rate of 10.4 ktpa represents 0.06% of the global LDPE market.

Global biopolymer demand was estimated at 258 million tonnes in 2010 (http://www.plastemart.com/upload/Literature/Biopolymerhasagoodgrowthprospects.asp). The maximum production rate of 10.4 ktpa represents 0.004% of the global LDPE market.

Biopolymers have a huge limitation of higher pricing compared to conventional polymers. While the conventional commonly used polymers cost around US$1000-1500/t, biopolymers cost from about US$4000/t to as high as US$15,000/t for material such as polyhydroxybutyrates. Hence, offering a biopolymer close to current market prices for other polymers is a major selling point.

11.0 CONCLUSIONS AND DISCUSSION

This report was completed in accordance with the document "MLA Guide to Value Propositions and Cost/Benefit Analysis v1.0". In relation to the MLA AOP KPI 3.2 (Increasing cost efficiency and productivity – off farm) the base case results in a simple value per head of $3.59 versus a $3.50 / head requirement. Small changes in the revue or operating costs, as outlined in section 10, could drop the simple payback below the $3.50 threshold.

Drastically reducing the Total Capital Investment (TCI) by 50% only improves the simple payback to $3.69 per head. To achieve the same economic outcome, the value of bioplastic sold or amount sold need only be increased by 1.2%.

Hence, efforts should be directed towards receiving the highest $/t for product and continuously producing saleable bioplastic at a rate as close as possible to the plant capacity.

Items for future consideration are:

- Determining with greater accuracy the market value for the proposed biopolymer.
- Determining with greater accuracy the amount of biopolymer that could be sold at this rate.
- De-bottlenecking to increase production rates.
- Analysis to determine where operating costs could be reduced.
- Logistics of transportation and degradation of feed over time.
- More accurate facility cost estimate required. See section 3.0.
- Reducing cost of blood meal via receiving high moisture feed, with associated lab experimentation.
- Waste reduction and OHS issues (powders and powders handling, any temperatures over 60 ^{o}C, bio-safety).