Treated Timber Waste Minimisation Project

Milestone 5: Scenario Pilot Trials

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MINISTRY FOR THE ENVIRONMENT
WASTE MINIMISATION FUND PROJECT

TREATED TIMBER WASTE MINIMISATION

MILESTONE 5: SCENARIO PILOT TRIALS

FRASER SCOTT, TRUE NORTH CONSULTING, DECEMBER 2013

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1.0 EXECUTIVE SUMMARY

The key focus of this project to date has been to "identify and/or create a business case, supply chain and financial model, and end use for the collection, reuse, recycling and recovery of up to 20% (5,000 tonnes) of waste treated timber in Canterbury in such a way that it presents compelling economic and/or brand benefits to all participants in the supply chain (waste owners, processors, logistics providers and end users)."

As the project has progressed and evaluated different processing options, four potential solutions emerged which have remained the focus for the project in Milestones 3 to 5. These four processing options are:

- Using hydrothermal processing to create lignin and biofuels (Solvent Rescue Limited)
- Using the TERAX process to create methane gas (Scion Research)
- Using pyrolysis to create carbon-based products (Waste Transformationz Limited)
- Using pyrolysis to create biofuels (AES Bioenergy Limited)

The focus of Milestone 5 has been on working with key solution providers to refine further their business cases and to initiate testing programmes to verify the technical feasibility of their proposed solutions. Unfortunately, none of the testing processes have progressed as quickly as hoped and, for most, testing results will not be available until January, 2014. It is intended that a Supplementary Update for this project be issued in February, 2014 to report on progress made through testing programmes.

While testing progress has been less than anticipated, other activity undertaken by the potential solution providers has enabled an update of risk profiles and further assisted in final feasibility assessment.

The assessed feasibility of each of the four solutions, within the context of this project, is as follows:

Table 1.1 – Feasibility Assessments for Solutions

Risk	Solvent Rescue	Scion/TERAX	Waste Trans.	AES Bioenergy
Overall Assessment of Feasibility	MODERATE	LOW TO MODERATE	MODERATE TO HIGH	MODERATE
Financial Feasibility	MODERATE	LOW TO MODERATE	MODERATE TO HIGH	MODERATE
Supply Chain Feasibility	MODERATE	LOW TO MODERATE	HIGH	HIGH
Deployment Timeframe Feasibility	LOW TO MODERATE	LOW	HIGH	LOW
Processing Volume Feasibility	HIGH	HIGH	HIGH	HIGH
Technical feasibility	MODERATE TO HIGH	MODERATE	MODERATE	MODERATE

Based on the information provided and available at the time of publication of this report, the solutions offered by AES, Waste Transformationz Limited and Solvent Rescue are determined to have the best potential for feasibility as a solution for objectives of this project. Waste Transformationz Limited is considered to offer the best potential for feasibility, particularly based on deployment timeframes. The solution offered by Scion is considered unlikely to be feasible in terms of the objectives of this project.

It should be noted, however, that the testing programme outcomes produced by the solution providers may alter these assessments substantially.

The latest financial models for each option are shown in Table 1.2. These projections have been taken into account in terms of the assessed financial feasibility for each option.

Table 1.2 – Financial Comparison for Solutions

Description	Solvent Rescue	Scion/TERAX	Waste Trans.	AES Bioenergy
Capital Expenditure				
Expected capital outlay for solution	**78,000,000**	**10,000,000**	**4,000,000**	**12,250,000**
Expected grant/public funding (e.g. MFE)	7,750,000	3,000,000	1,500,000	4,000,000
Subsidised capital cost	**70,250,000**	**7,000,000**	**2,500,000**	**8,250,000**
Expected lifespan of solution equipment (years)	25	20	10	15
Amount of wood inputted per day (tonnes)	88	143	150	90
Days solution would operate each year	336	350	300	350
Volume of wood processed per year (tonnes)	**29,600**	**50,000**	**45,000**	**31,500**
Volume of wood processed over lifespan (tonnes)	**768,000**	**999,999**	**450,000**	**472,500**
Capital cost per tonne of wood processed	**122**	**10**	**9**	**26**
Grant funding per tonne of wood processed	**10**	**3**	**3**	**8**
Revenue				
Saleable outputs sale revenue				
Annual volume of saleable outputs	15,072	6,325	35,100	13,860
Output revenue per tonne of wood processed	529	152*	277	250*
Total revenue from saleable outputs	16,990,400	7,589,992	12,479,625	3,465,000
Waste timber gate fee revenue				
Waste timber revenue per tonne of wood processed	45	60	80	70
Total revenue from Waste timber gate fees	1,332,000	2,999,997	3,600,000	2,205,000
Total annual revenue	**16,990,400**	**10,589,989**	**16,079,625**	**5,670,000**
Total revenue per tonne of wood processed	**574**	**212**	**357**	**193**
Expenditure				
Fixed costs				
Total annual fixed costs (excl. depreciation)	1,960,000	250,000	1,334,000	687,500
Fixed costs per tonne of wood processed	66	5	30	22
Depreciation	4,680,000	700,000	540,000	1,041,250
Variable costs				
Total annual variable costs	3,248,600	6,412,494	8,010,000	1,455,300
Variable costs per tonne of wood processed	110	128	178	46
Total annual expenditure	**9,888,600**	**7,362,494**	**9,884,000**	**3,184,050**
Total expenditure per tonne of wood processed	**265**	**147**	**138**	**101**
Summary and profitability				
Annual volume of wood processed (tonnes)	29,600	50,000	45,000	31,500
Revenue per tonne of wood processed	574	212	357	180
Expenditure per tonne of wood processed	334	147	220	101
Profit per tonne of wood processed	**240**	**65**	**138**	**79**
Total annual revenue	16,990,400	10,589,989	16,079,625	5,670,000
Total annual expenditure	9,888,600	7,362,494	9,884,000	3,184,050
Annual profit	**7,101,800**	**3,227,496**	**6,195,625**	**2,485,950**

Description	Solvent Rescue	Scion/TERAX	Waste Trans.	AES Bioenergy
Total profit over lifespan of solution	**177,545,000**	**64,459,916**	**61,956,250**	**37,289,250**
Annual return on subsidised capital investment	**10%**	**46%**	**248%**	**30%**
Total return on subsidised capital investment (lifetime)	**153%**	**822%**	**2378%**	**352%**

* Estimates have been prepared by solution provider, but altered where there is a clear justification for doing so. For this comparison, the average of pessimistic and optimistic estimates has been used. For Scion's model, it is assumed that methane will be sold as a transportation fuel. For AES' model it is assumed that treatment chemicals cannot be recovered. Returns are calculated as simply the net return divided by the subsidised capital cost. Where differing scale options have been provided, the larger is shown. Where a feasible and unfeasible (unprofitable) model have been presented, the feasible model is shown.

Solvent Rescue has materially altered the assessed level of feasibility of its business model through market engagement. By connecting with a highly motivated potential customer Solvent Rescue has been able to partially verify its financial projections and demonstrate that the highest perceived risk around its model - the absence of a lignin market - may not in fact be a significant cause for concern. Solvent Rescue remains, however, a high-investment solution with a capital requirement more than six times greater than the next most expensive option. The ability to raise this level of capital remains a huge challenge for a small business like Solvent Rescue, albeit that is somewhat mitigated by indicated interest from its potential customer in assisting with capital development. In terms of the objectives of this project, the deployment timeframes for Solvent Rescue's full scale solution, being potentially in excess of four years, are also a detraction but new market interest may assist in reducing these timeframes.

Scion's TERAX process offers great potential due to the range of wastes it can handle and its successful deployment as a municipal biosolids solution, but has limited appeal to the objectives of this project due to its relatively early stage of technology development as a treated timber solution. Currently the model lacks market validation and endorsement as a treated timber solution, making evaluation of the market potential for their solution a challenge. Scion is well-respected and its technical skill is world-class, suggesting that when licensing and market engagement occurs the response is likely to be one of genuine interest, but as yet this is an unknown. The business model developed by Scion, in which a licensee/operator assumes most of the operational risk, plus the nature of the primary saleable output, being methane gas, potentially limit the scope of partners and customers to which TERAX is likely to appeal. As Scion progresses through its technology development timeline, the number of partners available to it may substantially decrease due to the level of activity in Christchurch around treated timber waste. The process of developing these relationships may also further add to the lengthy timeframes (four years) for solution deployment.

Waste Transformationz Limited has vigorously pursued every aspect of its proposed supply chain in order to verify its target markets and financial projections. While awaiting technology development and testing process completion to verify its technical feasibility, WTL has invested heavily in ensuring every other aspect of the business is ready for deployment as soon as a successful testing outcome is delivered. Should WTL be able to successfully handle treated timber waste, it is likely that its solution for treated timber (and tyres) will be active within the first half of 2014.

AES Bioenergy has also successfully engaged with its supply chain, and reached a point where it is 'ready to go' with its business model once technical feasibility and associated risks have been satisfactorily concluded. In all likelihood AES' greatest challenge will be securing the equity needed to develop and finalise its technology, undertake a testing programme, then deploy its solution into the market. Delays in these activities, as are currently being experienced, may further extending the already lengthy timeframes (3.5 years) until full scale deployment.

In addition to the four core options being considered, two additional options were uncovered during Milestone 5 and given a basic evaluation.

The first of these, wood-plastic composite products manufactured by Motueka-based Prowood, has the apparent potential to succeed in New Zealand as a solution for building formwork, but faces real challenges in breaking into its primary target market - home decking – based on a price that may be in excess of three times that of treated timber. The model's appeal is also diminished by the practicalities of handling the wood-plastic composite material at end of life. While this can be recycled into new wood-plastic composite products, the logistics of capturing waste and transporting it to a central processing point appear too unwieldy to be sustainable.

The second new option considered is being pursued by Materials Processing Limited in the North Island. While relatively little is known about this solution, and its owners are unwilling to share information for commercial sensitivity reasons, it is understood the operation has a consent for processing up to 8% of CCA treated timber through a gasification and torrefaction process producing bio-coal for boiler use. The overall model is apparently feasible, at least in the context in which it operates, but would likely struggle to operate in Christchurch given the lack of predictability in feedstock and the likely high proportion of treated timber in rebuild waste.

The final aspect of Milestone 5 was the testing and validation of a process for identifying treated timber in a demolition context. A draft process for Milestone 3.2 was considered by Frews Contracting, and refined to produce the following final recommended process as shown in Figure 1.1 below:

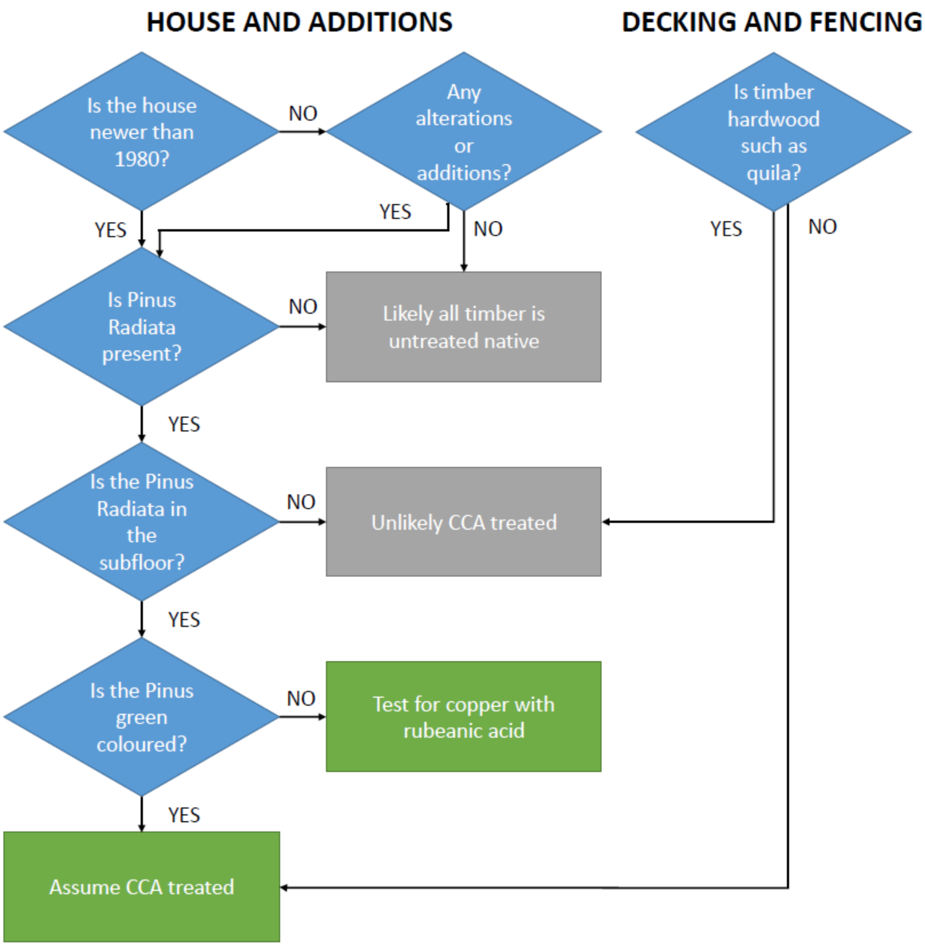

Figure 1.1 – Updated Decision-making Flowchart for Identifying Waste Treated Timber

2.0 INTRODUCTION

The Treated Timber Waste Minimisation project was launched on 4 March, 2013 with its overall goal being "to test the feasibility of, and subsequently develop a sustainable business model for the large scale collection and reuse, recycling and/or recovery of hazardous treated timber waste, with a particular focus on earthquake-related building and demolition waste."

This Environment Canterbury led project has received Ministry for the Environment funding of $144,900 towards the project's overall cost of $190,900, with the remainder coming from the project's governance group, consisting of:

- Environment Canterbury (ECAN) – Project owner
- Christchurch City Council (on behalf of the Canterbury Waste Joint Committee)
- BRANZ Limited
- Scion

The feasibility study has three key objectives:

- Identify and/or create a business case, supply chain and financial model, and end use for the collection, reuse, recycling and recovery of up to 20% (5,000 tonnes) of waste treated timber in Canterbury in such a way that it presents compelling economic and/or brand benefits to all participants in the supply chain (waste owners, processors, logistics providers and end users).

- Identify an appropriate, effective, easy to use and low-cost tool to be used by demolition companies and/or waste processors[1] for identifying treated timber on demolition and/or waste processing sites[2].

- Increase collaboration between timber waste minimisation stakeholders including demolition, timber and waste industries, Environment Canterbury, Canterbury territorial authorities, construction interest groups and the wider community to improve waste minimisation management of treated timber over its lifecycle.

Overall, the project is aimed at creating a sustainable and economically viable process or processes for the productive use of waste treated timber.

The project has been split into five key milestones:

1. **Industry Overview** (completed 10 May, 2013)

   A situation analysis and overview of the current waste treated timber industry and potential applications for treated timber waste.

2. **International Industry Trends** (completed 14 June, 2013)

   An overview of key international trends and technological developments in the waste treated timber industry internationally and how the application of different elements of these might work in New Zealand.

[1] Target users are demolition workers, transfer station workers, builders and surveyors
[2] Primarily it would be used on the demolition site, but could also be used at transfer stations, landfills and re-use locations.

3. **Part 1 – Potential Scenarios** (completed 16 August, 2013)

   A report detailing potential new waste treated timber collection and reuse, recycling and/or recovery systems for application in New Zealand, and the risks, financial implications and potential benefits of each scenario.

   Part 2 - Timber Identification Tool Development (completed 16 August, 2013)

   A report providing an overview of international research related to waste treated timber identification on demolition and/or waste processing sites and undertake a feasibility study on the application of this research to create a tool or toolkit suitable for use in New Zealand.

4. **Detailed Business Cases and Stakeholder Collaboration** (completed 4 October, 2013)

   Detailed business cases for each preferred scenario, including pilot trial plans.

5. **Scenario Pilot Trials** (completed 20 December, 2013)

   A final report detailing pilot processes and outcomes, and scenario details and implementation plan for the preferred option or options.

This report addresses the requirements of the fifth milestone: 'Scenario Pilot Trials'.

At the conclusion of Milestone 3, four potentially feasible options for utilising treated timber waste were determined, namely:

- Using hydrothermal processing to create lignin and biofuels (Solvent Rescue Limited)
- Using the TERAX process to create methane gas (Scion Research)
- Using pyrolysis to create carbon-based products (Waste Transformationz Limited)
- Using pyrolysis to create biofuels (AES Bioenergy Limited)

During Milestone 4, detailed business cases were prepared for each of these options, and the relative risks of each evaluated. The final assessed risks for each option are shown in Table 1.1 below:

Table 1.1 – Risk Comparison for Solutions

Risk	SR	SCION	WTL	AES
Overall business model	HIGH RISK	MODERATE TO HIGH RISK	LOW TO MODERATE RISK	MODERATE RISK
Financial viability	HIGH RISK	MODERATE TO HIGH RISK	LOW TO MODERATE RISK	MODERATE TO HIGH RISK
Primary output sales revenue	HIGH RISK	HIGH RISK	LOW TO MODERATE RISK	LOW TO MODERATE RISK
Supply chain	MODERATE RISK	MODERATE TO HIGH RISK	LOW TO MODERATE RISK	LOW TO MODERATE RISK
Deployment plan	HIGH RISK	HIGH RISK	LOW RISK	MODERATE RISK
Time until commence operation	3 years	4 years	0.5 years	1.5 years
Time until full scale operation	4.5 years	4 years	1.5 years	3.5 years
Testing plan	LOW TO MODERATE RISK	MODERATE RISK	MODERATE RISK	MODERATE TO HIGH RISK

The financial models prepared for each option are shown in Table 1.2 below:

Table 1.2 – Financial Comparison for Solutions

Description	SR*	SCION*	WTL*	AES*
Capital Expenditure				
Expected capital outlay for solution	**78,000,000**	**10,000,000**	**4,000,000**	**12,250,000**
Expected grant/public funding (e.g. MFE)	7,750,000	3,000,000	1,500,000	4,000,000
Subsidised capital cost	**70,250,000**	**7,000,000**	**2,500,000**	**8,250,000**
Expected lifespan of solution equipment (years)	25	20	10	15
Amount of wood inputted per day (tonnes)	88	143	150	90
Days solution would operate each year	336	350	300	350
Volume of wood processed per year (tonnes)	**29,600**	**50,000**	**45,000**	**31,500**
Volume of wood processed over lifespan (tonnes)	**768,000**	**999,999**	**450,000**	**472,500**
Capital cost per tonne of wood processed	**122**	**10**	**9**	**26**
Grant funding per tonne of wood processed	**10**	**3**	**3**	**8**
Revenue				
Saleable outputs sale revenue				
Annual volume of saleable outputs	15,072	6,325	35,100	13,860
Output revenue per tonne of wood processed	554	152*	277	250*
Total revenue from saleable outputs	16,398,400	7,589,992	12,479,625	3,465,000
Waste timber gate fee revenue				
Waste timber revenue per tonne of wood processed	45	60	80	70
Total revenue from Waste timber gate fees	1,332,000	2,999,997	3,600,000	2,205,000
Total annual revenue	**17,730,400**	**10,589,989**	**16,079,625**	**5,670,000**
Total revenue per tonne of wood processed	**599**	**212**	**357**	**193**
Expenditure				
Fixed costs				
Total annual fixed costs (excl. depreciation)	1,960,000	250,000	1,334,000	687,500
Fixed costs per tonne of wood processed	66	5	30	22
Depreciation	4,680,000	700,000	540,000	1,041,250
Variable costs				
Total annual variable costs	3,248,600	6,412,494	8,010,000	1,455,300
Variable costs per tonne of wood processed	110	128	178	46
Total annual expenditure	**9,888,600**	**7,362,494**	**9,884,000**	**3,184,050**
Total expenditure per tonne of wood processed	**265**	**147**	**138**	**101**
Summary and profitability				
Annual volume of wood processed (tonnes)	29,600	50,000	45,000	31,500
Revenue per tonne of wood processed	599	212	357	180
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Profit per tonne of wood processed	**265**	**65**	**138**	**79**
Total annual revenue	17,730,400	10,589,989	16,079,625	5,670,000
Total annual expenditure	9,888,600	7,362,494	9,884,000	3,184,050
Annual profit	**7,841,800**	**3,227,496**	**6,195,625**	**2,485,950**
Total profit over lifespan of solution	**196,045,000**	**64,459,916**	**61,956,250**	**37,289,250**
Annual return on subsidised capital investment	**11%**	**46%**	**248%**	**30%**
Total return on subsidised capital investment (lifetime)	**179%**	**822%**	**2378%**	**352%**

* Estimates have been prepared by solution provider, but altered where there is a clear justification for doing so. For this comparison, the average of pessimistic and optimistic estimates has been used. For Scion's model, it is assumed that methane will be sold as a transportation fuel. For AES' model it is assumed that treatment chemicals cannot be recovered. Returns are calculated as simply the net return divided by the subsidised capital cost.

The original project objectives for Milestone 5 were:

- Build detailed evaluation criteria and mechanisms for pilot trials, and gain endorsement from stakeholders.
- Implement limited term (8 – 12 week) pilot trial of feasible scenario(s).
- Test concepts and/or prototypes of timber identification toolkit, if applicable.
- Evaluate pilot trials against agreed criteria, including use of participant satisfaction surveys.
- Undertake a presentation and workshop with project partners to analyse and ensure understanding of implications of trials before preparing final report.
- Produce a summary of whether the business case is accepted by project partners and supply chain participants.

Ultimately, as the project has progressed, the final phase and milestone has shifted to focus on technical feasibility, rather than piloting of actual business models, as the solution providers are not yet ready to launch at this level.

While the business cases have been thoroughly analysed and a preliminary snapshot assessment of commercial risk and viability have been made, Milestone 5 focuses on the testing processes outlined by the solution providers in their Testing Plans submitted as part of Milestone 4.

To this end, the assessment of options in Milestone 5 moves from one of **risk** to one of **feasibility**.

Because of the modification to the original plan for Milestone 5 the objectives of this milestone have been modified to:

- Implement technical feasibility testing for proposed scenarios to confirm ability to process treated timber waste safely.
- Test concepts and/or prototypes of timber identification toolkit, if applicable.
- Evaluate testing results.
- Produce a summary of whether the overall solutions are deemed to be feasible.

Prior to release of this report, each of the solution providers was provided with the opportunity to review the sections relating to their solution, correct any factual errors and add relevant information.

All figures in this report are in New Zealand Dollars. Where converted from United States Dollars, a rate of US$0.80 to NZ$1.00 has been used.

3.0 FEASIBILITY ASSESSMENT – SOLVENT RESCUE / HYDROTHERMAL PROCESSING

3.1 Scenario Overview and Risk Profile

Solvent Rescue has developed a two stage process that outputs lignin from the first stage and bio-crude oil from the second stage. The second stage, which is the focus of Solvent Rescue's ongoing technology development, utilises a supercritical water reactor that treats the remaining dry matter after lignin extraction. Solvent Rescue has a pilot plant based in Christchurch and has received public funding for testing of treated timber waste through this plant. This process is currently underway.

Solvent Rescue aims to generate the majority of its operating revenue from the sale of lignin, with additional revenue coming from inwards waste 'gate fees' and the sale of marine diesel, naphtha and bitumen form the second stage process. Solvent Rescue plans to scale up to a 20 tonne per day plant initially, and eventually move to a 100 tonne per day plant as its full scale operation.

Solvent Rescue's overall risk profile as assessed at the conclusion of Milestone 4 (TNC, 2013) is detailed in Table 3.1 below:

Table 3.1 – Solvent Rescue Risk Assessment Overview

Risk	Current Assessment
Overall financial viability • Lignin sales revenue • Naphtha sales revenue • Bitumen sales revenue • Marine diesel sales revenue	**HIGH RISK** • **HIGH RISK** • **MODERATE RISK** • **MODERATE TO HIGH RISK** • **MODERATE RISK**
Supply chain	**MODERATE RISK**
Deployment plan • Time till commence operation • Time till full scale operation	**HIGH RISK** • 3 years • 4.5 years
Testing plan	**LOW TO MODERATE RISK**
Overall business model	**HIGH RISK**

At the conclusion of Milestone 4 the key perceived risks in Solvent Rescue's business model were based around its dependence on lignin sales, where such a market did not currently exist, and on the projected time to generate revenue in the marketplace. Both of these factors reduced the appeal of Solvent Rescue as an option for this project.

3.2 Financial Feasibility

Solvent Rescue has proposed four saleable output markets from its process: lignin (63 – 73% of proposed revenue), naphtha (10 – 13%) marine diesel (5 – 9%), and bitumen (7 – 9%). In addition inwards gate fees are projected to generate 5 to 6% of revenues.

As noted in Table 3.1, Solvent Rescue's three secondary saleable outputs were considered moderate or moderate to high risk, whereas lignin was considered a high risk. It is in this area that Solvent Rescue has made considerable ground since the conclusion of Milestone 4.

Solvent Rescue was recently approached by a plastics manufacturer, which expressed an interest in developing bio-plastics made using high quality lignin. The plastics manufacturer had previously trialled the use of lignin in plastics manufacture, but found (given its origin as a waste product) that it was of a poor quality and had an offensive odour. Based on its previous experience, Solvent Rescue is confident in its ability to produce high quality lignin, and its current samples have no unappealing odour.

The plastics manufacturer is focused on moving the relationship with Solvent Rescue forward with a view to utilising bio-plastic as a point of difference in attempting to secure sales contracts. The company is a strong performer domestically and internationally, but is not named for commercial sensitivity reasons.

The plastics manufacturer has engaged Scion to assist with testing and ensure a robust manufacturing process and aims to have production in place, subject to quality testing, in time for meeting the requirements of some key potential contracts in October, 2014. The manufacturer believes they may be able to secure a premium, or at the very least a competitive advantage, by offering more environmentally friendly plastic products.

An immediate desire for 20,000 tonnes of lignin per annum has been suggested, but volumes may potentially be larger if the production capacity can be increased. Solvent Rescue has the ability to produce up to 1,760 tonnes per annum with its proposed 20 tonne plant, and up to 8,800 tonnes with its full sized 100 tonne plant. Producing at lower volumes is not believed to be problematic for the potential customer, as lignin can replace polymers at a range of proportions.

The plastics manufacturer has indicated they would be “happy to pay” prices close to the projected price sought by Solvent rescue, and the financial models below have been altered to reflect this updated pricing information. Market pricing for polymers suggest that Solvent Rescue may be able to secure a slightly higher price than indicated by the manufacturer if quality and performance support this.

The work that Solvent Rescue has done in securing a market for its lignin output is encouraging. It was apparent in Milestone 4 that the lack of an existing market for lignin was the major risk in Solvent Rescue’s business model, and the work undertaken in the interim has drastically reduced this risk profile.

While it is clear that no firm agreement has yet been signed with the potential customer, the business relationship appears dependent only on quality testing. This is not an insignificant challenge, but the nature of the intended lignin use may allow for a level of ‘safe’ CCA treatment chemical contamination, provided there is no possibility of leaching. Leachate testing will be included in Solvent Rescue’s testing regime. As a result of these market developments the market for lignin has been re-assessed as ‘Low Risk’, from its previous assessment as ‘High Risk’.

At the conclusion of Milestone 4, Solvent Rescue had provided two financial models, one for a plant that operates at 20 tonnes per day, and a second for a plant that operates at 100 tonnes per day. The pessimistic estimate allows for greater costs and lower income levels, whereas the optimistic estimate represents Solvent Rescue’s expectations in terms of revenue and expenditure. These models have been updated with new revenue projections based on the successful engagement of a potential lignin buyer.

The financial model for a 20 tonne per day plant was as follows:

Table 3.2 – Solvent Rescue 20 Tonne Plant Financial Projections

Description	Pessimistic Estimate*	Optimistic Estimate*
Capital Expenditure		
Expected capital outlay for solution	**28,000,000**	**24,000,000**
Expected grant/public funding (e.g. MFE)	1,000,000	2,000,000
Subsidised capital cost	**27,000,000**	**22,000,000**
Expected lifespan of solution equipment (years)	12	20
Estimated depreciation rate (SL using IRD rates)	10.5%	7.0%
Amount of wood (all types) inputted per day (tonnes)	15	20
Days solution would operate each year	320	352
Volume of wood processed per year (tonnes)	**4,800**	**7,040**
Volume of wood processed over lifespan (tonnes)	**57,600**	**140,800**
Capital cost per tonne of wood processed	**486**	**170**
Revenue		
Lignin sales revenue (re-assessed as LOW risk)		
Lignin revenue (per tonne sold)	1,500	1,900
Volume of Lignin per tonne of wood processed (tonnes)	0.20	0.25
Annual volume of Lignin (tonnes)	960	1,760
Lignin revenue per tonne of wood processed	**300**	**475**
Total revenue from Lignin sales	**1,440,000**	**3,344,000**
Naphtha sales revenue (assessed as MODERATE risk)		
Naphtha revenue (per tonne sold)	600	700
Volume of Naphtha per tonne of wood processed (tonnes)	0.07	0.12
Annual volume of Naphtha (tonnes)	336	845
Naphtha revenue per tonne of wood processed	**42**	**84**
Total revenue from Naphtha sales	**201,600**	**591,360**
Bitumen sales revenue (assessed as MODERATE TO HIGH risk)		
Bitumen revenue (per tonne sold)	500	600
Volume of Bitumen per tonne of wood processed (tonnes)	0.06	0.10
Annual volume of Bitumen (tonnes)	288	704
Bitumen revenue per tonne of wood processed	**30**	**60**
Total revenue from Bitumen sales	**144,000**	**422,400**
Marine diesel sales revenue (assessed as MODERATE risk)		
Marine diesel revenue (per tonne sold)	300	400
Volume of Marine diesel per tonne of wood processed (tonnes)	0.09	0.10
Annual volume of Marine diesel (tonnes)	432	704
Marine diesel revenue per tonne of wood processed	**27**	**40**
Total revenue from Marine diesel sales	**129,600**	**281,600**
Waste timber gate fee revenue		
Waste timber gate fee revenue per tonne of wood processed	**50**	**50**
Total revenue from Waste timber gate fees	**240,000**	**352,000**
Total annual revenue	**2,155,200**	**4,991,360**
Total revenue per tonne of wood processed	**449**	**709**

Description	Pessimistic Estimate*	Optimistic Estimate*
Annual volume of saleable outputs from solution (tonnes)	**2,016**	**4,013**
Expenditure		
Fixed costs		
Rental and other site costs	70,000	60,000
Management/administrative staff	180,000	160,000
Wages and salaries for solution operation	140,000	120,000
Insurances	90,000	70,000
Marketing costs	200,000	180,000
Repairs and maintenance	200,000	180,000
Depreciation	2,940,000	1,680,000
Other fixed costs	0	0
Total annual fixed costs	**3,820,000**	**2,450,000**
Fixed costs per tonne of wood processed	**796**	**348**
Variable costs		
Electricity costs	120,000	140,800
Other processing costs	0	0
Inwards transportation costs	0	0
Outwards transportation costs	360,000	457,600
Waste stream disposal/processing costs	127,200	56,320
Total annual variable costs	**607,200**	**654,720**
Variable costs per tonne of wood processed	**127**	**93**
Total annual expenditure	**4,427,200**	**3,104,720**
Total expenditure per tonne of wood processed	**922**	**441**
Summary and profitability		
Annual volume of wood processed (tonnes)	4,800	7,040
Revenue per tonne of wood processed	449	709
Expenditure per tonne of wood processed	922	441
Profit per tonne of wood processed	**-473**	**268**
Total annual revenue	2,155,200	4,991,360
Total annual expenditure	4,427,200	3,104,720
Annual profit	**-2,272,000**	**1,886,640**
Total profit over lifespan of solution	**-27,264,000**	**37,732,800**
Annual return on subsidised capital investment	**Less than 0%**	**9%**
Total return on subsidised capital investment over lifetime	**Less than 0%**	**72%**

The financial model for a 100 tonne a day plant is as follows:

Table 3.3 – Solvent Rescue 100 Tonne Plant Financial Projections

Description	Pessimistic Estimate*	Optimistic Estimate*
Capital Expenditure		
Expected capital outlay for solution	**84,000,000**	**72,000,000**
Expected grant/public funding (e.g. MFE)	7,000,000	8,500,000
Subsidised capital cost	**77,000,000**	**63,500,000**
Expected lifespan of solution equipment (years)	20	30
Estimated depreciation rate (SL using IRD rates)	7.0%	5.0%
Amount of wood (all types) inputted per day (tonnes)	75	100
Days solution would operate each year	320	352
Volume of wood processed per year (tonnes)	**24,000**	**35,200**
Volume of wood processed over lifespan (tonnes)	**480,000**	**1,056,000**
Capital cost per tonne of wood processed	**175**	**68**
Revenue		
Lignin sales revenue (re-assessed as LOW risk)		
Lignin revenue (per tonne sold)	1,500	1,900
Volume of Lignin per tonne of wood processed (tonnes)	0.20	0.25
Annual volume of Lignin (tonnes)	4,800	8,800
Lignin revenue per tonne of wood processed	**300**	**475**
Total revenue from Lignin sales	**7,200,000**	**16,720,000**
Naphtha sales revenue (assessed as MODERATE risk)		
Naphtha revenue (per tonne sold)	600	700
Volume of Naphtha per tonne of wood processed (tonnes)	0.07	0.12
Annual volume of Naphtha (tonnes)	1,680	4,224
Naphtha revenue per tonne of wood processed	**42**	**84**
Total revenue from Naphtha sales	**1,008,000**	**2,956,800**
Bitumen sales revenue (assessed as MODERATE TO HIGH risk)		
Bitumen revenue (per tonne sold)	500	600
Volume of Bitumen per tonne of wood processed (tonnes)	0.06	0.10
Annual volume of Bitumen (tonnes)	1,440	3,520
Bitumen revenue per tonne of wood processed	**30**	**60**
Total revenue from Bitumen sales	**720,000**	**2,112,000**
Marine diesel sales revenue (assessed as MODERATE risk)		
Marine diesel revenue (per tonne sold)	300	400
Volume of Marine diesel per tonne of wood processed (tonnes)	0.09	0.10
Annual volume of Marine diesel (tonnes)	2,160	3,520
Marine diesel revenue per tonne of wood processed	**27**	**40**
Total revenue from Marine diesel sales	**648,000**	**1,408,000**
Waste timber gate fee revenue		
Waste timber gate fee revenue per tonne of wood processed	**45**	**45**
Total revenue from Waste timber gate fees	**1,080,000**	**1,584,000**
Total annual revenue	**10,656,000**	**24,780,800**
Total revenue per tonne of wood processed	**444**	**704**

Description	Pessimistic Estimate*	Optimistic Estimate*
Annual volume of saleable outputs from solution (tonnes)	**10,080**	**20,064**
Expenditure		
Fixed costs		
Rental and other site costs	70,000	60,000
Management/administrative staff	270,000	240,000
Wages and salaries for solution operation	280,000	240,000
Insurances	270,000	210,000
Marketing costs	600,000	540,000
Repairs and maintenance	600,000	540,000
Depreciation	5,880,000	3,600,000
Other fixed costs	0	0
Total annual fixed costs	**7,970,000**	**5,430,000**
Fixed costs per tonne of wood processed	**332**	**154**
Variable costs		
Electricity costs	600,000	704,000
Other processing costs	0	0
Inwards transportation costs	0	0
Outwards transportation costs	1,800,000	2,288,000
Waste stream disposal/processing costs	636,000	281,600
Total annual variable costs	**3,036,000**	**3,273,600**
Variable costs per tonne of wood processed	**127**	**93**
Total annual expenditure	**11,006,000**	**8,703,600**
Total expenditure per tonne of wood processed	**459**	**247**
Summary and profitability		
Annual volume of wood processed (tonnes)	24,000	35,200
Revenue per tonne of wood processed	444	704
Expenditure per tonne of wood processed	459	247
Profit per tonne of wood processed	**-15**	**457**
Total annual revenue	10,656,000	24,780,800
Total annual expenditure	11,006,000	8,703,600
Annual profit	**-350,000**	**16,077,200**
Total profit over lifespan of solution	**-7,000,000**	**482,316,000**
Annual return on subsidised capital investment	**Less than 0%**	**25%**
Total return on subsidised capital investment over lifetime	**Less than 0%**	**660%**

Based on the projections from Milestone 4, which were slightly worse in the case of the Pessimistic Scenario and slightly better in the case of the Optimistic Scenario (when compared to the revised projections), the overall risk for Solvent Rescue's financial feasibility in terms of this project was considered high.

It was specifically noted in Milestone 4 that Solvent Rescue's risk profile would change substantially if it found a customer for its lignin output. Subject to contractual negotiations and quality requirements, this appears to have been achieved. It was also noted that, while capital requirements were particularly high, the successful engagement of a customer for lignin would likely increase the chances of securing capital investment. This also now appears to be a possibility for Solvent Rescue.

Based on the current projections, the price secured for lignin will need to be at the higher end of the suggested range. If this can be achieved, the business model appears attractive.

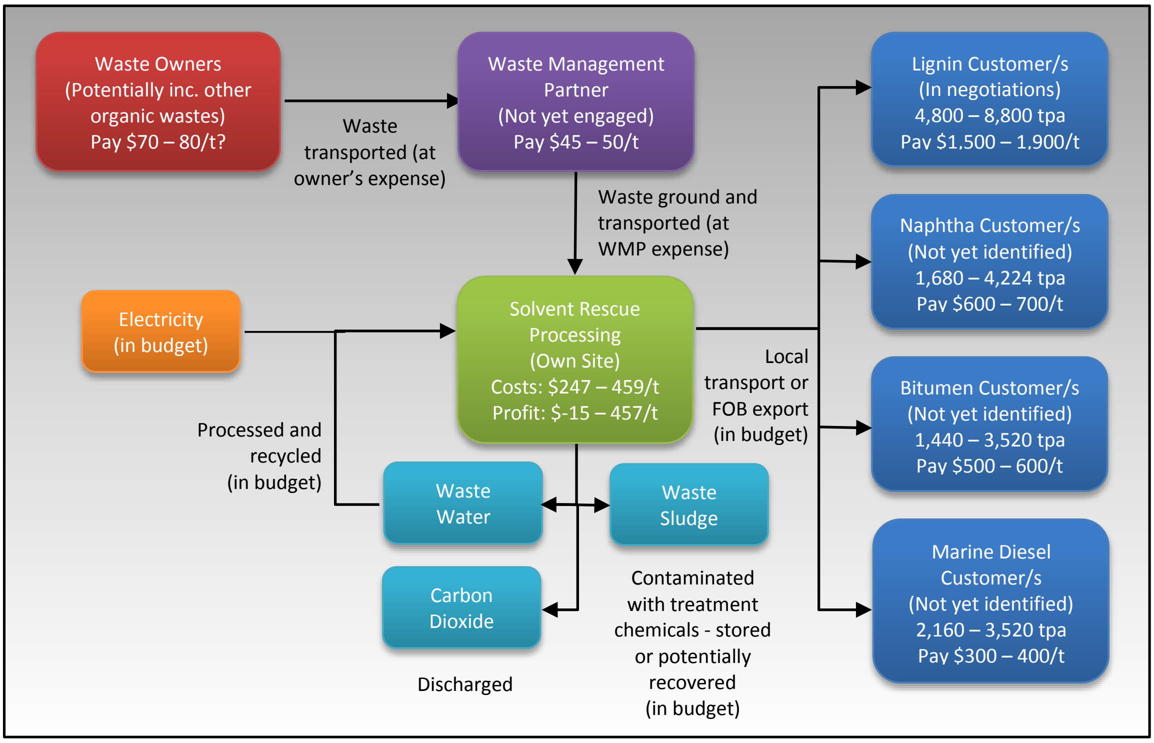
Raising the necessary funds to build larger plants will prove very challenging for Solvent Rescue, but the potential involvement of their newly engaged lignin customer in this process, and the profitability of their current projections, may make this more realistic than previously thought, at least at the 20 tonne plant level. One of the key needs in securing this kind of investment will, in all likelihood, be building on Solvent Rescue's increasing professionalism and ability to project cohesion and organisational strength to other market players.

Therefore, the **financial feasibility** for Solvent Rescue's process as a solution for treated timber waste in Christchurch is considered **MODERATE.**

3.3 Supply Chain Feasibility

Solvent Rescue's overall supply chain model is detailed in Figure 3.1 below:

Figure 3.1 – Solvent Rescue Supply Chain and Resource Flows Overview



Based on the lack of a waste management partner, at the conclusion of Milestone 4 Solvent Rescue's supply chain risk was considered moderate.

As most of Christchurch's prominent waste management companies are currently seeking to create strategic links with waste treated timber solution providers, the opportunities to forge such links are now limited, although the failure of any other option providers to secure technical feasibility will likely create new opportunities. Solvent Rescue's model requires a waste management company to receive and grind treated timber waste and transport it frequently to Solvent Rescue's site. This only highlights the importance of such a partner and the vulnerability in having few current options to do so.

Despite this, the high level of demand for an outlet for waste treated timber in Christchurch is likely to prompt a desire from waste management companies to partner with whichever operator emerges as the 'first mover' solution provider.

For this reason, the **supply chain feasibility** for Solvent Rescue's process as a solution for treated timber waste in Christchurch is considered **MODERATE.**

3.4 Deployment Timeframe Feasibility

Subject to technical feasibility, Solvent Rescue has estimated the following key timeframes for the launch of its solution:

- Commencement of receipt of treated timber: Quarter 4, 2016
- Commencement of sale of outputs: Quarter 2, 2017
- Operation at full capacity (100 tonnes per day): Quarter 2, 2018

Following its engagement with a plastic manufacturer and potential lignin customer, Solvent Rescue has been forced to reconsider its deployment timeframes and determine how these might be fast-tracked with support from this customer.

Currently Solvent Rescue estimates that they could have their 20 tonne plant in operation between the end of 2014 and mid-2015. This is approximately one year ahead of initial projections, allowing for the shortening of time allowed for market and capital investor development.

Operating at 20 tonnes per day would utilise between 4,800 and 7,040 tonnes of timber waste per annum, well in excess of the target volumes for this project. It is likely that the actual volume of treated timber would be considerably lower and mixed with larger volumes of untreated timber, but this level of operation within eighteen months significantly improves the attractiveness of Solvent Rescue's solution if it can be achieved. Whether it is realistic or not is difficult to determine.

A 20 tonne plant would require a new site (which has not yet been identified) and would require new and notified resource consents. Given the nature of the processing, a timeframe of eighteen months to achieve this, including construction, appears very optimistic.

Any substantial delay in commencing the receipt of treated timber waste in Christchurch is problematic as the opportunity to divert earthquake-related timber waste diminishes with each month that passes without a viable solution. Based on the challenges Solvent Rescue has faced in the development of its technology, it is reasonable to conclude that scaling up will introduce unforeseen problems and delays and, when combined with the need to secure a new site and consents, the receipt of significant volumes of treated timber is more likely to be two to two and a half years away.

Therefore, the **deployment timeframe feasibility** for Solvent Rescue's process as a solution for treated timber waste in Christchurch is considered **LOW TO MODERATE.**

3.5 Processing Volume Feasibility

This project has an aim of diverting 20% of waste treated timber in Christchurch. Based on the estimates concluded in Milestone 1 this equates to 3,370 tonnes per annum.

Solvent Rescue's projections are that they would aim to process up to 7,040 tonnes of wood annually with their 20 tonne plant then scale up to a 100 tonne plant processing up to 35,200 tonnes of wood waste annually. There are no projected limitations as to the proportion of this volume that is treated timber. It is probable that much of the wood waste processed by Solvent Rescue would be a mix of treated and untreated, but the projected top-end volume requires only 10% to be treated to meet this project's volume target.

Therefore, on the basis of this estimate, the **processing volume feasibility** for Solvent Rescue's process as a solution for treated timber waste in Christchurch is considered **HIGH.**

3.6 Technical Feasibility

The key aspects and milestones of Solvent Rescue's testing plans as prepared for Milestone 4 were as follows:

Table 3.4 – Solvent Rescue Testing Plan

Testing hypothesis:	Solvent Rescue believes they already know what will happen, as a testing regime has previously been undertaken and they are using the same key plant. In addition to replicating earlier testing under stricter conditions, the testing will consider materials handling efficiency to minimise labour input.
Testing goals:	The goals are to verify the efficiency of the entire process and establish actual costs such as electricity and labour inputs.
Types of treated timber to be tested:	H5 CCA treated pinus radiata house timber piles. Only CCA treated timber will be tested initially.
Testing quantities:	Sufficient quantities so as to give proven steady state efficiency numbers.
Testing process:	Testing will be undertaken using Solvent Rescue's pilot plant rated at up to one tonne per day.
Testing personnel:	Solvent Rescue has engaged a Project Manager (Brett Mongillo) who was previously a senior officer with Environment Canterbury handling waste material contaminants in soils.
Expected reliability of results:	Solvent Rescue aim to establish reliability "from an industrial point of view", establishing mass balances for all materials including emissions.
Verification process:	Independent laboratory verification of results will be sought.
Output quality testing:	Testing will include consideration of the industrial specifications for fuels, and for minimum permissible contaminants in the case of lignin.
Testing timeframes:	The testing is now underway and will continue through 2014.
Key milestones:	The key milestones are around the permissible levels of copper, chrome, and arsenic in the timber products. In addition Solvent Rescue aim to verify that the process is economic and that saleable products have commercial validity.
Other testing information:	Solvent Rescue aims to demonstrate that their solution is practical for New Zealand conditions and is a promising option for alternative export income given the excellent conditions that exist for growing timber in New Zealand.

While Solvent Rescue had expected to have preliminary results available as to the ability of their process to handle treated timber, unexpected delays in their testing process mean these will not be available until mid-January 2014.

Ultimately Solvent Rescue has, during this project, had the lowest perceived technical feasibility risk of all the solution providers, based on its experience and positive initial testing results using treated timber in its process. These testing results did not achieve a mass balance, and so must be treated with caution, but they indicate potential and suggest treatment chemicals may not pollute saleable outputs, at least in concentrations unacceptable to the target customer.

The recent engagement of a potential customer by Solvent Rescue further improves its technical feasibility in that it is likely that the intended use for the lignin will tolerate small amounts of treatment chemical contamination. This theory will be tested by Solvent Rescue, including leachate tests, but provides further positive indications of technical feasibility.

Until testing is completed technical feasibility cannot be reliably established. For this reason, while bearing in mind initial positive indications, the **technical feasibility** for Solvent Rescue's process as a solution for treated timber waste in Christchurch is considered **MODERATE TO HIGH.**

3.7 Overall Assessment of Feasibility

At the conclusion of Milestone 4, the overall risk presented by Solvent Rescue's business model in terms of this project was considered high.

The primary reason for this was the complete absence of an existing market for Solvent Rescue's primary saleable output: lignin. Without the ability to sell lignin for its projected price, Solvent Rescue stood no chance of achieving financial feasibility or attracting the level of capital investment required to expand.

Solvent Rescue's recent engagement of a potential customer that is highly motivated, willing to pay the price sought by Solvent Rescue and open to capital investment, has materially altered Solvent Rescue's risk profile and feasibility in terms of this project.

There are, of course, still barriers to address. Solvent Rescue is currently a small owner-run business with limited administrative and management resource. Transitioning to a company operating a nearly $100 million dollar plant and generating up to $30 million in revenue will require adept management and strategic focus. Such a transition is inherently risky and typically a difficult experience for all involved. The large capital investment required to achieve this growth is also a daunting proposition.

Solvent Rescue must also move quickly to secure the partners needed to deliver on its business model, as well as initiating the process of building a new plant, on a new site, with new notified resource consents. All of this requires working capital and management resource, both of which Solvent Rescue lacks. These factors will also test Solvent Rescue's ability to deliver on its deployment timeframe expectations, the creepage of which will diminish any contribution Solvent Rescue can make to this project's objectives.

Table 3.5 – Solvent Rescue Feasibility Assessment

Key Feasibility Criteria	Assessed Feasibility	Rationale
Financial feasibility	MODERATE	• High demand potential customer engaged at target price • Customer may assist with capital needs • Capital costs are extremely high • Targeted grant funding is extremely high
Supply chain feasibility	MODERATE	• No potential waste management partner has yet been identified or engaged and many have already sought solution partners • Waste management partner critical in supply chain • Frequent transportation movements of waste necessary prior to expansion
Deployment timeframe feasibility	LOW TO MODERATE	• Minimum eighteen month delay in deployment. Two years or more is probably more likely • Significant volumes of earthquake-related rebuild and demolition waste would likely be landfilled in this timeframe
Processing volume feasibility	HIGH	• 7,040 tonne per year target for initial expansion • 35,200 tonne per year target at capacity • At capacity target, only 10% of timber waste needs to be treated to reach project target
Technical feasibility	MODERATE TO HIGH	• Early informal testing appears positive • Targeted application may tolerate some treatment chemical contamination • No testing or verified evidence of ability to handle treated timber

Based on these factors it is concluded that, in relation to the project objective of:

> "identifying or creating a business case, supply chain and financial model, and end use for the collection, reuse, recycling and recovery of up to 20% of waste treated timber in Canterbury in such a way that it presents compelling economic and/or brand benefits to all participants in the supply chain (waste owners, processors, logistics providers and end users)"

the current probability of Solvent Rescue's process being feasible is considered **MODERATE.**

4.0 FEASIBILITY ASSESSMENT – SCION / TERAX WET OXIDATION

4.1 Scenario Overview and Risk Profile

Scion's TERAX process has two phases: a biological phase and a wet oxidation phase. The process dissolves organic matter and produces a soluble carbon - which can be converted into a number of potentially saleable outputs - as well as water, carbon dioxide and residual ash. TERAX is new technology but Rotorua District Council has committed to build and deploy a full scale plant processing up to 11,500 tonnes of waste a year from late 2014. Scion's business model is to license the technology to a third party operator, which would logically be a waste management company. Scion has advised it is now in dialogue with a number of potential licensees.

It is important to note that Scion is following a developmental timeline that is currently focused on ensuring that its core TERAX technology works with treated timber. Once this development has concluded, Scion advises that it will fully engage with potential supply chain partners and end users, and then focus on the application of its technology to specific end uses. This current process is based on the core technology itself, and not on the detailed refinement and integration of the technology, which will follow later. This means that all of Scion's projections, potential end uses and supply chain are best estimates only, at a high level, and may be altered considerably once development moves into a market engagement phase.

The two financial models that Scion has provided are based on different potential end uses for the methane gas that would likely be produced by the TERAX plant. The first option is to sell methane gas into the existing Burwood Landfill Gas Pipeline. This was viewed as a potentially attractive option by Christchurch City Council (CCC) as landfill gas levels decline, but the indicated buy price from CCC fell far short of the price required by Scion. The second option is to sell methane as an alternative transportation fuel for a large fleet operator such as a bus operator or waste management company.

Scion's overall risk profile as assessed at the conclusion of Milestone 4 (TNC, 2013) is detailed in Table 4.1 below:

Table 4.1 – Scion/TERAX Risk Assessment Overview

Risk	Current Assessment
Overall financial viability • Methane sales revenue (pipeline) • Methane sales revenue (transport fuel)	MODERATE TO HIGH RISK • UNACCEPTABLE RISK • HIGH RISK
Supply chain	MODERATE TO HIGH RISK
Deployment plan • Time till commence operation • Time till full scale operation	HIGH RISK • 4 years • 4 years
Testing plan	MODERATE RISK
Overall business model	MODERATE TO HIGH RISK

The key risks in Scion's business model were around its proposed revenue streams and time to market. Scion had not yet engaged with potential markets, so the ability to attract revenue through the production and sale of methane (or some other output) was speculative. A four year timeframe until Scion would begin receiving treated timber was also considered a significant barrier to the feasibility of TERAX as a solution to the needs of this project. This timeframe is in accordance with the stage of its development process.

4.2 Financial Feasibility

While still in the core technology phase in relation to treated timber, Scion have determined that the most likely revenue source from the TERAX process would be the sale of methane gas. The two currently identified end uses for this are supplementary gas supply to the Burwood Landfill Gas Treatment Plant, or for use as a transportation fuel for an operator of a large commercial transportation fleet. This would be the sole saleable output other than gate fees for inwards waste.

In Scion's 'Optimistic Scenario' which focuses on the sale of methane as a transportation fuel and is currently considered the only potentially feasible scenario for TERAX, methane sales represent 91% of projected revenue, whereas inwards gate fees represent the remaining 9%. As noted in Table 4.1, the sale of methane to the Burwood pipeline was not considered economically feasible, whereas the sale of methane as a transportation fuel was considered high risk.

Scion have noted that a further option for the use of methane is electricity and heat cogeneration on site. Focusing on such outputs widens the potential scope for operational partners, and there is precedent in New Zealand for such activities, including Dunedin's Green Island Gas to Energy Project and Christchurch's own Burwood gas pipeline and biosolids drying plant.

Scion has not prepared cost and revenue estimates for this alternative, based on the current stage of its development process, but believe it would fall within the projections provided for utilising methane as a transportation fuel. The asset costs for cogeneration plant considered in Milestone 1 (TNC, 2013a) would suggest this view may be optimistic.

The key challenge for Scion in pursuing this alternative is not the electricity component of cogeneration, although the capital investment required for this (as detailed in Milestone 1) is not insignificant, but rather the heat component. It is likely that at least one third of the energy produced in such an operation – and possibly more than one half – would be in the form of heat. For such an enterprise to be economically feasible it is probable that a productive use for the heat would need to be found and revenue generated accordingly, but Scion advises that the heat may be able to be included back into the TERAX process itself.

Finding an external revenue stream for heat is not an easy proposition in Christchurch, as discussed in detail in Milestone 1. The two examples given above for effective cogeneration from waste both have an immediate use for the heat generated: waste water and biosolids treatment. If Scion can utilise heat internally in its process, and this offsets substantial energy costs, then cogeneration may be feasible. Without more information from Scion, this is difficult to establish with any certainty.

Ultimately, once Scion moves out of its current development phase and fully engages with potential licensees and end use partners, these issues may be able to be satisfactorily resolved.

As previously noted, Scion is working through a development timeframe that focuses on the core development of their technology prior to market engagement and consideration of particular outputs and end uses. Until this occurs, as intended by Scion, it is difficult to form a solid conclusion as to the financial feasibility of Scion's proposed market application for the TERAX technology in Christchurch.

For Milestone 4 Scion prepared a financial model for a plant receiving 143 tonnes of waste a day. The pessimistic scenario contained in this model reflects sale of methane for supply to the Burwood pipeline (which was not considered economically feasible), whereas the optimistic scenario relates to successfully securing a transportation fuels market:

Table 4.2 – Scion 143 Tonne Plant Financial Projections

Description	Pessimistic Estimate*	Optimistic Estimate*
Capital Expenditure		
Expected capital outlay for solution	**14,000,000**	**6,000,000**
Expected grant/public funding (e.g. MFE)	2,000,000	4,000,000
Subsidised capital cost	**12,000,000**	**2,000,000**
Expected lifespan of solution equipment (years)	20	20
Estimated depreciation rate (SL using IRD rates)	7.0%	7.0%
Amount of wood (all types) inputted per day (tonnes)	143	143
Days solution would operate each year	350	350
Volume of wood processed per year (tonnes)	**50,000**	**50,000**
Volume of wood processed over lifespan (tonnes)	**999,999**	**999,999**
Capital cost per tonne of wood processed	**14**	**6**
Revenue		
Biogas/methane sales revenue (assessed as HIGH to UNACCEPTABLE risk)		
Biogas/methane revenue (per tonne sold)	100	1,200
Volume of biogas/methane per tonne of wood processed (tonnes)	0.08	0.17
Annual volume of biogas/methane (tonnes)	4,150	8,500
Biogas/methane revenue per tonne of wood processed	**8**	**204**
Total revenue from Biogas/methane sales	**415,000**	**10,199,990**
Waste timber gate fee revenue		
Waste timber gate fee revenue per tonne of wood processed	**100**	**20**
Total revenue from Waste timber gate fees	**4,999,995**	**999,999**
Total annual revenue	**5,414,995**	**11,199,989**
Total revenue per tonne of wood processed	**108**	**224**
Annual volume of saleable outputs from solution (tonnes)	**4,150**	**8,500**
Expenditure		
Fixed costs		
Rental and other site costs	0	0
Management/administrative staff	0	0
Wages and salaries for solution operation	0	0
Insurances	0	0
Marketing costs	0	0
Repairs and maintenance	0	0
Depreciation	980,000	420,000
Other fixed costs	300,000	200,000
Total annual fixed costs	**1,280,000**	**620,000**
Fixed costs per tonne of wood processed	**26**	**12**
Variable costs		
Electricity costs	999,999	899,999
Other processing costs (chemicals)	5,999,994	3,999,996
Inwards transportation costs	0	0
Outwards transportation costs	0	0

Description	Pessimistic Estimate*	Optimistic Estimate*
Waste stream disposal/processing costs	649,999	275,000
Total annual variable costs	**7,649,992**	**5,174,995**
Variable costs per tonne of wood processed	**153**	**104**
Total annual expenditure	**8,929,992**	**5,794,995**
Total expenditure per tonne of wood processed	**179**	**116**
Summary and profitability		
Annual volume of wood processed (tonnes)	50,000	50,000
Revenue per tonne of wood processed	108	224
Expenditure per tonne of wood processed	179	116
Profit per tonne of wood processed	**-70**	**108**
Total annual revenue	5,414,995	11,199,989
Total annual expenditure	8,929,992	5,749,995
Annual profit	**-3,514,998**	**5,404,994**
Total profit over lifespan of solution	**-70,299,955**	**108,099,880**
Annual return on subsidised capital investment	**Less than 0%**	**270%**
Total return on subsidised capital investment over lifetime	**Less than 0%**	**5,305%**

Based on the optimistic scenario shown the overall risk for Scion’s financial feasibility in terms of this project was considered moderate to high.

Scion has advised that these projections currently reflect a representative level of accuracy for the current stage of TERAX development.

Assessing financial feasibility is challenging given the stage of the TERAX development, which has not yet focused on end uses and lacks direct feedback from the market. The feedback that has been obtained suggests that Scion faces real barriers in its proposed markets for sale or utilisation of methane.

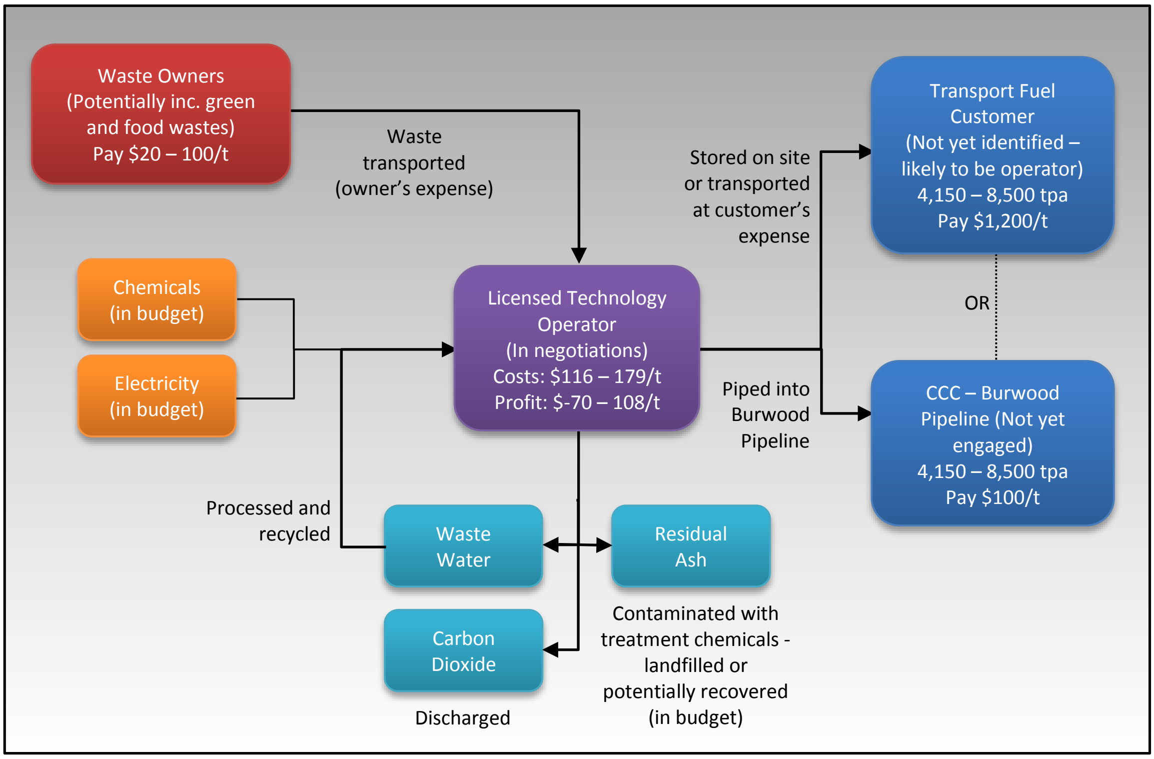
At the current stage of development no potential customers have been engaged that would support Scion’s revenue projections.

Therefore, until further engagement with potential partners and customers is undertaken to verify estimates for revenue, the **financial feasibility** for Scion’s TERAX process as a solution for treated timber waste in Christchurch is considered **LOW TO MODERATE.**

4.3 Supply Chain Feasibility

Scion’s overall supply chain model is detailed in Figure 4.1 below.

Figure 4.1 – Scion/TERAX Supply Chain and Resource Flows Overview



Based on the fact that Scion is not yet at a stage of development in which it has fully engaged with supply chain partners, at the conclusion of Milestone 4 Scion's supply chain risk was considered moderate to high.

Scion's intention with its technology is to license it to a third party operator who would handle all aspects of deployment and operation, with support from Scion. No such operator has yet been confirmed, although Scion advises that early stage discussion are in place with a number of potential licensees.

The feasibility of the supply chain would likely come down to the nature of the licensee operator. A licensee that can receive waste treated timber, operate the TERAX technology and both store the methane gas and utilise it in its own transportation fleet offers a high degree of feasibility. Other models, in which these elements are split, become less feasible due to the financial and convenience impacts of transportation movements and other logistical considerations resulting from the division of the process among multiple operators, potentially at multiple sites. For example, a waste management company might receive the timber, then truck this to the TERAX operator at a separate site. The resulting gas might then have to be picked up or trucked to the actual user, perhaps a bus company. This is not an untenable situation, but may not be particularly efficient and could drive up projected costs.

For the supply chain to be feasible a waste management company, a technology operator and a user must all be found that are willing to invest in the process. As none of these participants have yet been identified, and given the challenges inherent in the target saleable output market for TERAX, the **supply chain feasibility** for Scion's TERAX process as a solution for treated timber waste in Christchurch is considered **LOW TO MODERATE.**

4.4 Deployment Timeframe Feasibility

Subject to technical feasibility Scion has estimated the following key timeframes for the potential deployment of the TERAX technology in Christchurch:

- Commencement of receipt of treated timber: Quarter 3, 2017
- Commencement of sale of outputs: Quarter 3, 2017
- Operation at full capacity (100 tonnes per day): Quarter 3, 2017

A four year development and deployment timeframe for commencing the receipt of treated timber waste in Christchurch is substantial. While such a timeframe would certainly not render the solution without merit in terms of earthquake-related waste (and non-earthquake related waste could certainly still be diverted) it is probable that a substantial proportion of the rebuild waste would be sent to landfill in these four years if no solution is available. It is almost certain that any remaining earthquake demolition activity would be concluded within this timeframe and any treated timber waste produced would be lost to landfill.

Therefore, while the timeframes for the deployment of such a sizable and capital intensive solution as TERAX are far from unreasonable, the **deployment timeframe feasibility** for Scion's TERAX process as a solution for treated timber waste in Christchurch is considered **LOW.**

4.5 Processing Volume Feasibility

This project has an aim of diverting 20% of waste treated timber in Christchurch. Based on the estimates concluded in Milestone 1 this equates to 3,370 tonnes per annum. Scion's projections are that they would aim to process up to 50,000 tonnes of wood annually, with no limitation as to the proportion of this volume that is treated timber. Meeting the project target would only require that 7% of the waste wood used be treated.

Therefore, on the basis of this estimate, the **processing volume feasibility** for Scion's TERAX process as a solution for treated timber waste in Christchurch is considered **HIGH.**

4.6 Technical Feasibility

The key aspects and milestones of Scion's testing plans as prepared for Milestone 4 were as follows:

Table 4.3 – Scion/TERAX Testing Plan

Testing hypothesis:	Treatment chemicals can be stabilised and retained in residual solids.
Testing goals:	Not stated.
Types of treated timber to be tested:	CCA and Boron treated timbers.
Testing quantities:	Testing will be at laboratory scale of 10 - 500g of timber per test.
Testing process:	Testing will be undertaken utilising existing processing and analytical facilities at laboratory scale. Pilot testing may take place later in 2014.
Testing personnel:	Scion science staff.
Expected reliability of results:	The testing will be undertaken based on robust experimental design. Testing will be based on significant experience with TERAX technology. Mass balancing will be essential in confirming the fate of contaminants.

Verification process:	Independent laboratory of results may be sought depending on the level of confidence in the results produced.
Output quality testing:	The quality of methane production will be assessed separately to timber degradation at a later date in 2014, depending on the research programme in place.
Testing timeframes:	It is anticipated testing of treated timber will be undertaken as part of an existing research programme evaluating a wide variety of municipal organic wastes. This programme will end in 2015.
Key milestones:	Results confirming the fate of treatment chemicals through the process should be available by the end of 2013. Results should be able to be made public with the agreement of other stakeholders and funding parties.
Other testing information:	While innovative in its development, the TERAX technology is essentially a specific combination of known processes. These individual unit processes are well established internationally, providing a sound basis for construction and operation of the system. The key questions are around performance, which the planned testing will seek to address.

At the time of writing, Scion had not yet commenced testing of treated timber through the TERAX process. In accordance with its testing plan, Scion is expecting to have preliminary results within the next month.

It is therefore impossible to determine with any certainty the technical feasibility of the process Scion is proposing in relation to a new waste stream.

Scion's process is proven in a different application in that it is being deployed for use with Rotorua District Council as a means to process municipal waste. The ability of the TERAX process to handle organic waste is established. Yet the introduction of hazardous treatment chemicals into this process is completely new and, while Scion is confident in its ability to handle these without undue difficulty, the impact these elements will have on the process and on processing costs will not be known until testing is completed.

Because the fundamental basis for the TERAX technology has been proven and a confident - though untested - theoretical basis for handling treatment chemicals determined, the **technical feasibility** for Scion's TERAX process as a solution for treated timber waste in Christchurch is considered **MODERATE.**

4.7 Overall Assessment of Feasibility

At the conclusion of Milestone 4, the overall risk presented by Scion's business model in terms of this project was considered moderate to high.

The key reason for the level of assessed risk was the relatively early stage of the TERAX development process in relation to treated timber. The current phase did not yet include extensive interaction with the potential operators and customers for the TERAX process and outputs. The approach taken by Scion, being the pursuit of application specific development of its technology prior to market engagement, is perfectly understandable given the novelty of its process and the need for rigorous testing prior to market launch. Yet this approach makes an assessment of feasibility difficult, and indicates that TERAX may not yet be ready for application to the objectives of this project.

It is likely the case that, as partnerships are being formed in Christchurch to tackle waste treated timber – partly as a result of this project – potential supply chain partners and end use customers for the TERAX process are pursuing other solutions. Scion may find, that when it reaches the stage of its development timeline that involves engaging with the market and supply chain partners, that potential strategic alliance opportunities have been lost. This is particularly challenging given the potentially narrow pool of supply chain partners and end use customers that may be able to successfully deploy and profit from the TERAX technology.

Despite this, it would be foolish to dismiss what Scion is doing and their reputation for creating successful technology solutions is well known. It may be that the level of interest in Christchurch in technologies that can process treated timber waste will, once Scion engages with the market with a verified and technically feasible solution, both drive and fast-track technology deployment. Fast tracking the technology deployment for the purposes of this project is certainly possible, but at this stage cannot be considered probable.

Table 4.4 – Scion TERAX Feasibility Assessment

Key Feasibility Criteria	Assessed Feasibility	Rationale
Financial feasibility	LOW TO MODERATE	• No potential customer has yet been engaged • The targeted revenue streams offer significant barriers to realisation • Capital costs are relatively high • Targeted grant funding is relatively high
Supply chain feasibility	LOW TO MODERATE	• Potential supply chain partners have been identified but with limited engagement to date • Key waste management companies already forming partnerships with other providers • Supply chain optimisation may require a single entity to handle all process functions and also be output user
Deployment timeframes	LOW	• Currently still in development phase • Four year timeframe till deployment • The majority of earthquake-related demolition waste and substantial rebuild waste would likely be landfilled in this timeframe
Processing volumes	HIGH	• 50,000 tonne per year target at capacity • At capacity target, only 7% of timber waste needs to be treated to reach project target

Technical feasibility	MODERATE	• Technology already operating successfully, although not with treated timber • Theoretical basis for handling treated timber • No testing or verified evidence of ability to handle treated timber

Based on these factors it is concluded that, in relation to the project objective of:

> "identifying or creating a business case, supply chain and financial model, and end use for the collection, reuse, recycling and recovery of up to 20% of waste treated timber in Canterbury in such a way that it presents compelling economic and/or brand benefits to all participants in the supply chain (waste owners, processors, logistics providers and end users)"

the current probability of Scion's TERAX process being feasible is considered **LOW TO MODERATE.**

5.0 FEASIBILITY ASSESSMENT – WASTE TRANSFORMATIONZ LIMITED / PYROLYSIS

5.1 Scenario Overview and Risk Profile

Waste Transformationz Limited (WTL) is an experienced producer of domestic charcoal from forestry waste. WTL has a close relationship with Massey University and has experimented with biochar production from a number of different biowastes including sewage sludge. More recently WTL has focused development efforts on the pyrolysis of treated timber waste, for which they believe they have an effective technology solution.

WTL has created containerised pyrolysis units which they intend to deploy as clusters, based on demand. Their pyrolysis process, which essentially cooks wood at a relatively low temperature in the absence of oxygen, is a *slow pyrolysis* solution which tends to produce more solid output (char) rather than gas or liquid. WTL intend to focus on high value output markets such as activated carbon and carbon black, with charcoal as a boiler fuel providing a 'fallback' revenue contingency.

WTL is currently working with Massey University to test treated timber through their process – which has not yet been completed – in the belief that they can capture treatment chemicals separately to saleable outputs.

WTL's overall risk profile as assessed at the conclusion of Milestone 4 (TNC, 2013) is detailed in Table 5.1 below:

Table 5.1 – WTL Risk Assessment Overview

Risk	Current Assessment
Overall financial viability • Charcoal sales revenue • Carbon black sales revenue • Activated carbon sales revenue • Producer gas sales revenue	LOW TO MODERATE RISK • LOW TO MODERATE RISK • LOW TO MODERATE RISK • MODERATE RISK • MODERATE TO HIGH RISK
Supply chain	LOW TO MODERATE RISK
Deployment plan • Time till commence operation • Time till full scale operation	LOW RISK • 0.5 years • 1.5 years
Testing plan	MODERATE RISK
Overall business model	LOW TO MODERATE RISK

At the conclusion of Milestone 4 WTL's business model was considered relatively low risk from a commercial perspective. WTL had invested significantly in addressing risks and engaging with their targeted markets to reduce uncertainty in their projections and business model. Ultimately the risk in WTL's business lay with its unproven technical feasibility; its ability to safely and effectively process treated timber waste.

5.2 Financial Feasibility

WTL have identified four saleable outputs from their process: activated carbon (11 – 37% of proposed revenue), carbon black (30 – 35%), charcoal (2 – 9%) and producer gas (13 – 17%). Timber waste gate fees account for the remaining 18 to 28% of projected revenue. WTL's pessimistic scenario is a focus on the production of charcoal as a coal replacement for commercial boilers. Their optimistic scenario is to focus on the production of the higher value outputs, being activated carbon and carbon black.

As noted in Table 5.1, WTL's key saleable outputs were considered low to moderate risks, with producer gas being considered a moderate to high risk.

Since the conclusion of Milestone 4 WTL have advised that their market knowledge and confidence has increased, particularly as they further engage with their newly acquired market distribution partner. WTL has formed other new partnerships based on its projected ability to process treated timber waste in addition to its proven ability to process used tyres with the same equipment. The treated timber project, and the assessment of WTL's business model that has been undertaken, has provided momentum on which WTL is capitalising both in New Zealand and internationally. As new relationships are still forming, and are of a highly sensitive commercial nature, WTL is unwilling to publish further details of its market development activities other than to advise that previous revenue estimates and evaluation of potential are now considered 'conservative'.

WTL also advises that they have "received confirmation from two major users of solid fuel in the South Island that, subject to normal testing of a new fuel, the companies would negotiate with WTL to purchase charcoal as an additional boiler fuel".

At the conclusion of Milestone 4 WTL provided two financial models, one for a plant that operates at 50 tonnes per day, and a second for a plant that operates at 150 tonnes per day.

The financial model for a 50 tonne per day plant is as follows:

Table 5.2 – WTL 50 Tonne Plant Financial Projections

Description	Pessimistic Estimate*	Optimistic Estimate*
Capital Expenditure		
Expected capital outlay for solution	**2,000,000**	**2,000,000**
Expected grant/public funding (e.g. MFE)	100,000	500,000
Subsidised capital cost	**1,900,000**	**1,500,000**
Expected lifespan of solution equipment (years)	10	10
Estimated depreciation rate (SL using IRD rates)	13.5%	13.5%
Amount of wood (all types) inputted per day (tonnes)	50	50
Days solution would operate each year	300	300
Volume of wood processed per year (tonnes)	**15,000**	**15,000**
Volume of wood processed over lifespan (tonnes)	**150,000**	**150,000**
Capital cost per tonne of wood processed	**13**	**13**
Revenue		
Charcoal sales revenue (assessed as LOW TO MODERATE risk)		
Charcoal revenue (per tonne sold)	200	200
Volume of Charcoal per tonne of wood processed (tonnes)	0.12	0.08

Description	Pessimistic Estimate*	Optimistic Estimate*
Annual volume of Charcoal (tonnes)	1,800	1,200
Charcoal revenue per tonne of wood processed	**24**	**16**
Total revenue from Charcoal sales	**360,000**	**240,000**
Carbon black sales revenue (assessed as LOW TO MODERATE risk)		
Carbon black revenue (per tonne sold)	1,000	1,300
Volume of Carbon black per tonne of wood processed (tonnes)	0.08	0.10
Annual volume of Carbon black (tonnes)	1,200	1,500
Carbon black revenue per tonne of wood processed	**80**	**130**
Total revenue from Carbon black sales	**1,200,000**	**1,950,000**
Activated carbon sales revenue (assessed as MODERATE risk)		
Activated carbon revenue (per tonne sold)	1,500	2,000
Volume of Activated carbon per tonne of wood processed (tonnes)	0.03	0.05
Annual volume of Activated carbon (tonnes)	450	750
Activated carbon revenue per tonne of wood processed	**45**	**100**
Total revenue from Activated carbon sales	**675,000**	**1,500,000**
Producer gas sales revenue (assessed as MODERATE TO HIGH risk)		
Producer gas revenue (per tonne sold)	65	98
Volume of Producer gas per tonne of wood processed (tonnes)	0.55	0.55
Annual volume of Producer gas (tonnes)	8,250	8,250
Producer gas revenue per tonne of wood processed	**36**	**54**
Total revenue from Producer gas sales	**536,250**	**808,500**
Waste timber gate fee revenue		
Waste timber gate fee revenue per tonne of wood processed	**80**	**80**
Total revenue from Waste timber gate fees	**1,200,000**	**1,200,000**
Total annual revenue	**5,171,250**	**6,898,500**
Total revenue per tonne of wood processed	**345**	**460**
Annual volume of saleable outputs from solution (tonnes)	**11,700**	**11,700**
Expenditure		
Fixed costs		
Rental and other site costs	350,000	250,000
Management/administrative staff	300,000	300,000
Wages and salaries for solution operation	300,000	300,000
Insurances	15,000	15,000
Marketing costs	60,000	50,000
Repairs and maintenance	60,000	50,000
Depreciation	270,000	270,000
Other fixed costs (inc. materials handling, consent monitoring)	215,000	213,000
Total annual fixed costs	**1,300,000**	**1,178,000**
Fixed costs per tonne of wood processed	**87**	**79**
Variable costs		
Electricity costs	0	0
Other processing costs (diesel and wood sorting & preparation)	690,000	660,000
Inwards transportation costs	0	0

Description	Pessimistic Estimate*	Optimistic Estimate*
Outwards transportation costs	1,935,000	1,935,000
Waste stream disposal/processing costs	60,000	60,000
Total annual variable costs	**2,685,000**	**2,655,000**
Variable costs per tonne of wood processed	**179**	**177**
Total annual expenditure	**4,255,000**	**4,103,000**
Total expenditure per tonne of wood processed	**284**	**274**
Summary and profitability		
Annual volume of wood processed (tonnes)	15,000	15,000
Revenue per tonne of wood processed	345	460
Expenditure per tonne of wood processed	284	274
Profit per tonne of wood processed	**61**	**186**
Total annual revenue	5,171,250	6,898,500
Total annual expenditure	4,255,000	4,103,000
Annual profit	**916,250**	**2,795,500**
Total profit over lifespan of solution	**9,162,500**	**27,955,000**
Annual return on subsidised capital investment	**48%**	**186%**
Total return on subsidised capital investment over lifetime	**382%**	**1764%**

The financial model for a 150 tonne per day plant is as follows:

Table 5.3 – WTL 150 Tonne Plant Financial Projections

Description	Pessimistic Estimate*	Optimistic Estimate*
Capital Expenditure		
Expected capital outlay for solution	**4,000,000**	**4,000,000**
Expected grant/public funding (e.g. MFE)	1,000,000	2,000,000
Subsidised capital cost	**3,000,000**	**2,000,000**
Expected lifespan of solution equipment (years)	10	10
Estimated depreciation rate (SL using IRD rates)	13.5%	13.5%
Amount of wood (all types) inputted per day (tonnes)	150	150
Days solution would operate each year	300	300
Volume of wood processed per year (tonnes)	**45,000**	**45,000**
Volume of wood processed over lifespan (tonnes)	**450,000**	**450,000**
Capital cost per tonne of wood processed	**9**	**9**
Revenue		
Charcoal sales revenue (assessed as LOW TO MODERATE risk)		
Charcoal revenue (per tonne sold)	200	200
Volume of Charcoal per tonne of wood processed (tonnes)	0.10	0.05
Annual volume of Charcoal (tonnes)	4,500	2,250
Charcoal revenue per tonne of wood processed	**20**	**10**
Total revenue from Charcoal sales	**900,000**	**450,000**

Description	Pessimistic Estimate*	Optimistic Estimate*
Carbon black sales revenue (assessed as LOW TO MODERATE risk)		
Carbon black revenue (per tonne sold)	1,000	1,300
Volume of Carbon black per tonne of wood processed (tonnes)	0.10	0.10
Annual volume of Carbon black (tonnes)	4,500	4,500
Carbon black revenue per tonne of wood processed	**100**	**130**
Total revenue from Carbon black sales	**4,500,000**	**5,850,000**
Activated carbon sales revenue (assessed as MODERATE risk)		
Activated carbon revenue (per tonne sold)	1,500	2,000
Volume of Activated carbon per tonne of wood processed (tonnes)	0.03	0.08
Annual volume of Activated carbon (tonnes)	1,350	3,600
Activated carbon revenue per tonne of wood processed	**45**	**160**
Total revenue from Activated carbon sales	**2,025,000**	**7,200,000**
Producer gas sales revenue (assessed as MODERATE TO HIGH risk)		
Producer gas revenue (per tonne sold)	65	98
Volume of Producer gas per tonne of wood processed (tonnes)	0.55	0.55
Annual volume of Producer gas (tonnes)	24,750	24,750
Producer gas revenue per tonne of wood processed	**36**	**54**
Total revenue from Producer gas sales	**1,608,750**	**2,425,500**
Waste timber gate fee revenue		
Waste timber gate fee revenue per tonne of wood processed	**80**	**80**
Total revenue from Waste timber gate fees	**3,600,000**	**3,600,000**
Total annual revenue	**16,233,750**	**23,125,500**
Total revenue per tonne of wood processed	**361**	**514**
Annual volume of saleable outputs from solution (tonnes)	**35,100**	**35,100**
Expenditure		
Fixed costs		
Rental and other site costs	350,000	250,000
Management/administrative staff	300,000	300,000
Wages and salaries for solution operation	300,000	300,000
Insurances	15,000	15,000
Marketing costs	60,000	50,000
Repairs and maintenance	150,000	150,000
Depreciation	540,000	540,000
Other fixed costs (inc. materials handling, consent monitoring)	215,000	213,000
Total annual fixed costs	**1,930,000**	**1,818,000**
Fixed costs per tonne of wood processed	**43**	**40**
Variable costs		
Electricity costs	0	0
Other processing costs (diesel and wood sorting & preparation)	2,070,000	1,980,000
Inwards transportation costs	0	0
Outwards transportation costs	5,805,000	5,805,000
Waste stream disposal/processing costs	180,000	180,000
Total annual variable costs	**8,055,000**	**7,965,000**

Description	Pessimistic Estimate*	Optimistic Estimate*
Variable costs per tonne of wood processed	**179**	**177**
Total annual expenditure	**9,985,000**	**9,783,000**
Total expenditure per tonne of wood processed	**222**	**217**
Summary and profitability		
Annual volume of wood processed (tonnes)	45,000	45,000
Revenue per tonne of wood processed	361	514
Expenditure per tonne of wood processed	222	217
Profit per tonne of wood processed	**139**	**297**
Total annual revenue	16,233,750	23,125,500
Total annual expenditure	9,985,000	9,783,000
Annual profit	**6,248,750**	**13,342,500**
Total profit over lifespan of solution	**62,487,500**	**133,425,000**
Annual return on subsidised capital investment	**208%**	**667%**
Total return on subsidised capital investment over lifetime	**1,983%**	**6,571%**

Based on these projections, the overall risk for WTL's financial feasibility in terms of this project was considered low to moderate. Although WTL now believes that its projected revenue figures in these models may now be too low, they have advised that they do not wish to change these projections and instead leave them as conservative estimates.

WTL presents financial models which are profitable at every level and validated by available market data. WTL has strong partnerships and has ready access to the capital required to reach production capacity. WTL's relatively modest capital and public funding requirements also enhance its appeal as a solution provider for this project.

WTL's solution is also made more compelling by the range of secondary wastes it can process. While these have not been fully examined or considered under this project, WTL's units are currently processing tyres in the North Island. Their intention is that this difficult, and potentially lucrative, waste stream be processed alongside treated timber waste in Christchurch. If pursued successfully, such complementary waste streams will further add to the profitability and viability of WTL's technology and process.

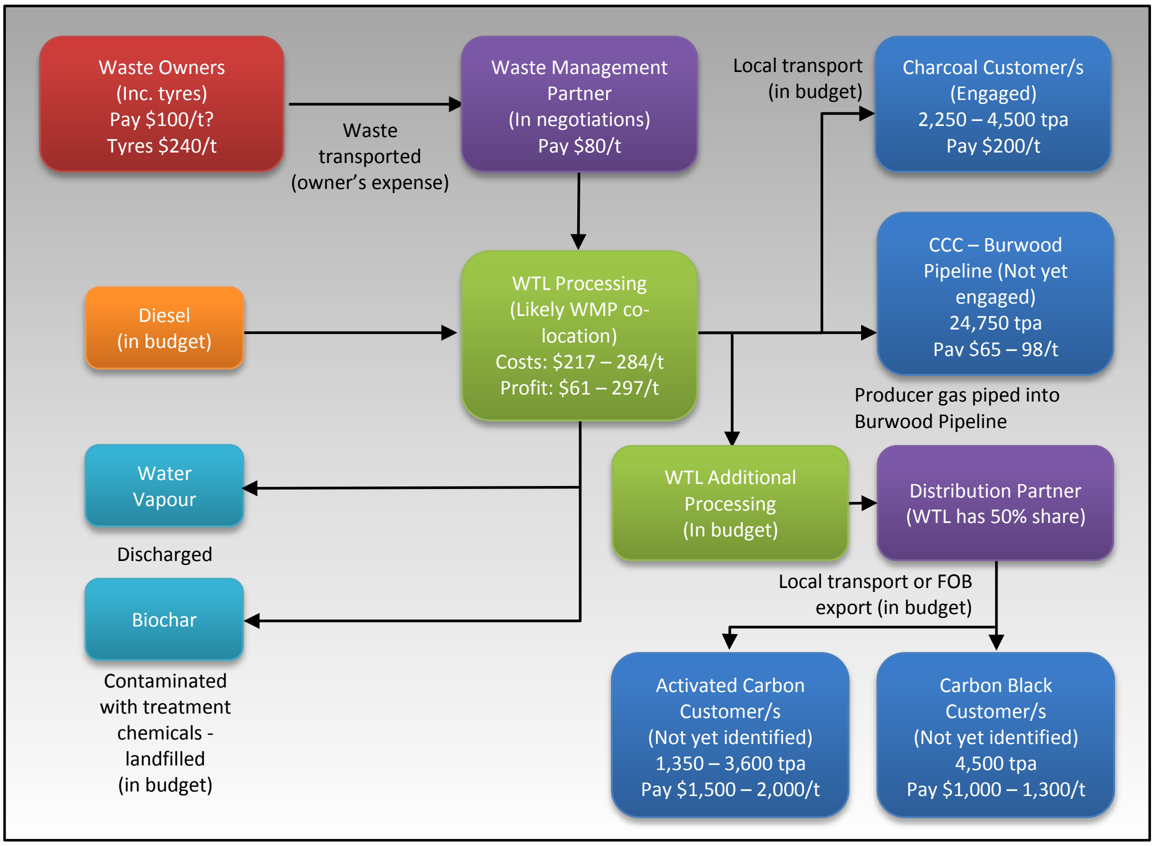
Perhaps the strongest aspect of WTL's model in terms of financial feasibility is the range and flexibility of its saleable outputs. The ability to sell biochar as a coal alternative while the technology is still being refined, and the presence of engaged customers for this is extremely useful. The ability to then pursue higher value carbon products with safe revenue streams still in place is strategically beneficial and prudent.

As with all providers, WTL must prove the technical feasibility of its process before any revenue streams may be realised but, subject to this, the **financial feasibility** for WTL's process as a solution for treated timber waste in Christchurch is considered MODERATE TO HIGH.

5.3 Supply Chain Feasibility

WTL's overall supply chain model is detailed in Figure 5.1 below.

Figure 5.1 – Supply Chain and Resource Flows Overview



Based on the simplicity of its supply chain and the level of engagement of supply chain partners, at the conclusion of Milestone 4 WTL's supply chain risk was considered low to moderate.

WTL has engaged extensively with the market and undertaken substantial due diligence in understanding its supply chain and customers. As a result of this, WTL has invested in a distribution partner and acquired access to the company's customers, which are in the higher value saleable output markets. This has further developed its market-readiness and knowledge and helped validate its financial projections.

Based on the degree to which this supply chain is in place, the **supply chain feasibility** for WTL's process as a solution for treated timber waste in Christchurch is considered **HIGH.**

5.4 Deployment Timeframe Feasibility

Subject to technical feasibility, WTL has estimated the following key timeframes for the launch of its solution:

- Commencement of receipt of treated timber: Quarter 1, 2014
- Commencement of sale of outputs: Quarter 2, 2014
- Operation at full capacity (150 tonnes per day): Quarter 1, 2015

WTL have advised that they have a number of manufacturers for their pyrolysis units 'standing by' for production and that, should testing prove successful, they will move forward quickly. The relative simplicity and low cost of their units and WTL's access to capital seem to support this view, although their timeframes may be optimistic.

Even allowing for some timeframe 'creepage' WTL's deployment timeframes are very much a best case scenario in terms of this project, and the genuine possibility that treated timber waste may be being processed in the first quarter or half of 2014 is a promising one.

The most likely delay to WTL's deployment timeframe will come from complications arising from its current testing and development project with Massey University. While the pursued solution is considered a simple one, it seems likely that at least some engineering or other design specification changes will need to be made, delaying production. Based on current information, however, this may still result in a deployment in 2014 which would be an entirely acceptable and desirable outcome.

Therefore, while some delays are not unlikely in WTL's deployment, the **deployment timeframe feasibility** for WTL' process as a solution for treated timber waste in Christchurch is considered **HIGH.**

5.5 Processing Volume Feasibility

This project has an aim of diverting 20% of waste treated timber in Christchurch. Based on the estimates concluded in Milestone 1 this equates to 3,370 tonnes per annum. WTL's projections are that they would initially aim to process up to 15,000 tonnes of wood annually, with no limitation as to the proportion of this volume that is treated timber. The process would then scale up such that 45,000 tonnes of waste wood would be processed annually. At this level, only 7% would need to be treated to meet the project objectives.

Therefore, on the basis of this estimate, the **processing volume feasibility** for WTL's process as a solution for treated timber waste in Christchurch is considered **HIGH.**

5.6 Technical Feasibility

The key aspects and milestones of WTL's testing plan as prepared for Milestone 4 were as follows:

Table 5.4 – WTL Testing Plan

Testing hypothesis:	WTL is following existing processes for the pyrolysis of CCA wood, but is using a batch rather than a continuous process, which was not able to eliminate volatile arsenic compounds. WTL expect the same result, which is a contaminated char from which heavy metals can be extracted. WTL state that the essential part of this project is to demonstrate that a technique of refluxing the emissions back through the substrate which produced them will result in volatile arsenic being retained either in a tar or through adherence to the substrate.
Testing goals:	WTL expect that the batch process determined by Professor Jim Jones will completely eliminate volatile arsenic from emissions, and that CCA will be able to be physically removed from the char using centrifuge equipment.

Types of treated timber to be tested:	Construction timber treated with CCA
Testing quantities:	Initial lab test will include small quantities and commercial test will use small loads in a scaled pyrolysis kiln
Testing process:	Initial lab testing followed by pilot kiln and emission testing equipment
Testing personnel:	The tests will be undertaken by post-doctoral researchers at Massey University. The principal researcher is Professor Jim Jones, Director of Research at Massey Engineering School, also head of Pyrolysis and Biochar research.
Expected reliability of results:	The results will be reliable with laboratory testing then engineering models being constructed prior to commercial models. The testing is based on mass balance so all elements present prior to pyrolysis will be accounted for.
Verification process:	Professor Jones and his team are acknowledged experts and will write up their methodology for peer review if required.
Output quality testing:	Tests will be required for sales of higher value products which will be manufactured to a saleable specification – these are customer specified.
Testing timeframes:	Testing begins September 2013 and ends December 2013.
Key milestones:	The first milestone is elimination of volatile arsenic in emissions – target date October 2013. Pilot tests should be completed in December 2013. High value product tests will begin in January 2014 and continue as part of delivery requirements.
Other testing information:	WTL notes that there is established literature and a number of recommendations from scholars recommending low temperature batch pyrolysis for treating CCA wood. WTL believe they are the first to attempt a mobile solution suitable for small or remote aggregations of waste CCA wood. The research is not simply to get rid of arsenic from emissions. It is also to commercialise the separation of heavy metals from CCA treated wood.

WTL have advised that, due to other academic responsibilities, Professor Jim Jones of Massey University was slightly late in commencing the testing project, and completion will now be in mid-January, 2014. No preliminary results are yet available as mass-balancing is the last stage of the testing programme.

WTL are very confident in the ability of their process to successfully and safely process treated timber waste and they report that Professor Jones has reached a conclusion as to how to handle the issue of treatment chemicals in the pyrolysis and is also very confident in its efficacy. WTL has also had the concept informally peer reviewed by another leading scientist with a background in biotechnology who is also of the view that the simple solution will work effectively.

Pyrolysis is one of the few processes internationally to successfully handle treated timber waste (albeit at a high processing cost) which increases confidence here. Despite this fact it is important to note that WTL and Professor Jones are attempting to achieve something that has been attempted by many (inexpensively and safely pyrolysing treated timber) with no sustainable successes to date. Certainly a positive outcome from this testing process would have far reaching commercial implications.

Based on the inherent difficulties of the technical challenge at hand, the **technical feasibility** for WTL's process as a solution for treated timber waste in Christchurch is considered **MODERATE.**

5.7 Overall Assessment of Feasibility

At the conclusion of Milestone 4, the overall risk presented by WTL's business model in terms of this project was considered low to moderate.

As with other solution providers, it is extremely unfortunate that testing of CCA treated timber through WTL's process had, at the time of writing, not been completed. It is simply not logical or prudent to conclude that a process for utilising treated timber is definitively feasible until this process has actually been tested with treated timber.

WTL's market feasibility continues to strengthen and has certainly attracted the attention of influential operators within the waste management sector domestically and internationally. WTL has made a strong case for its revenue projections, backed up by motivated customers, and has set in place the supply chain and other market mechanisms to deliver a sustainable and profitable business model.

The implications of WTL's strategic business model are also significant. WTL intends to produce relatively inexpensive and easy to operate pyrolysis units that can be operated throughout New Zealand – including rural settings – by small 'family businesses'. Should technical feasibility be established, the potential impact that this model could have on waste minimisation in New Zealand is impressive, particularly based on its scalability. The potential inclusion of another troublesome waste streams – used tyres – further enhances the appeal of the solution.

In terms of technical feasibility, the confidence of both WTL and their research partners at Massey University in their process is encouraging. The solution for treated timber being tested is considered by the research team as both robust and simple and does not require expensive process inputs in order to succeed. Yet, until this testing is completed and the process is verified as being safe and effective, feasibility is not assured.

Table 5.5 – WTL Feasibility Assessment

Key Feasibility Criteria	Assessed Feasibility	Rationale
Financial feasibility	MODERATE TO HIGH	• Potential customers engaged and prices verified • Diverse and flexible saleable outputs • Strong profitability in all scenarios • Ability to process other lucrative waste streams • Relatively low capital and funding requirements
Supply chain feasibility	HIGH	• Most supply chain partners have been identified or engaged • Waste management and distribution partners in place

Key Feasibility Criteria	Assessed Feasibility	Rationale
Deployment timeframes	HIGH	• Planned deployment in early 2014 • Testing not yet complete and design alterations likely • Provided testing successful, design delays unlikely to result in substantial deployment delays
Processing volumes	HIGH	• 15,000 tonne per year target for initial expansion • 45,000 tonne per year target at capacity • At capacity target, only 7% of timber waste needs to be treated to reach project target
Technical feasibility	MODERATE	• Technology solution designed by leading expert and validated by others • Reportedly simple technology solution • Pyrolysis if treated timber done internationally, but not economically • No testing or verified evidence of ability to handle treated timber

Based on these factors it is concluded that, in relation to the project objective of:

> "identifying or creating a business case, supply chain and financial model, and end use for the collection, reuse, recycling and recovery of up to 20% of waste treated timber in Canterbury in such a way that it presents compelling economic and/or brand benefits to all participants in the supply chain (waste owners, processors, logistics providers and end users)"

the current probability of WTL's pyrolysis process being feasible is considered MODERATE TO HIGH.

6.0 FEASIBILITY ASSESSMENT – AES BIOENERGY LIMITED / PYROLYSIS

6.1 Scenario Overview and Risk Profile

Alternative Energy Solutions Limited (AES) is an Auckland-based company that has developed pyrolysis technology to focus on the processing of forestry waste. In partnership with a Canadian company AES has licensed, and subsequently improved on, existing pyrolysis technology with a view to including treated timber waste as a feedstock.

AES' system is a *fast pyrolysis* unit that processes organic material more quickly that that employed by WTL and is more focused on the production of liquid bio-oil rather than char. AES believes their proprietary process will capture treatment chemicals in the char leaving an uncontaminated bio-oil. The apparent similarities between bio-oil and heavy marine fuel have inspired AES to focus on this as their chief source of revenue for their business model, and they have engaged a potential customer that is helping guide their development and quality specifications. They are also testing the feasibility of treatment chemical extraction and resale from contaminated char.

AES' overall risk profile as assessed at the conclusion of Milestone 4 (TNC, 2013) is detailed in Table 6.1 below:

Table 6.1 – AES Risk Assessment Overview

Risk	Current Assessment
Overall financial viability • Bio-oil sales revenue • Treatment chemical sales revenue • Biochar sales revenue	MODERATE TO HIGH RISK • LOW TO MODERATE RISK • MODERATE RISK • LOW TO MODERATE RISK
Supply chain	LOW TO MODERATE RISK
Deployment plan • Time till commence operation • Time till full scale operation	MODERATE RISK • 1.5 years • 3.5 years
Testing plan	MODERATE TO HIGH RISK
Overall business model	MODERATE RISK

While AES' overall risk profile was not relatively high, there were concerns at the conclusion of Milestone 4 about its testing plan, the technical feasibility of its process, and the timeframes required for full solution deployment.

6.2 Financial Feasibility

AES's primary output market focus is on marine fuel which accounts for 65 to 66% of its projected revenues. Additional income is sourced through timber waste gate fees (26 – 34%), biochar sales (0 – 4%) and treatment chemical sales (0 – 5%).

As noted in Table 6.1, AES' primary saleable output, being marine fuel, was considered low to moderate risk, as was the sale of biochar. The successful sale of treatment chemicals was considered a moderate risk.

At the conclusion of Milestone 4 AES provided financial models for processing 30 tonnes of treated timber a day and 90 tonnes of treated timber a day. In each model, the pessimistic scenario would be enacted if AES are not able to recover and resell treatment chemicals, whereas the optimistic scenario allows for sale of biochar and treatment chemicals.

Table 6.2 – AES 30 Tonne Plant Financial Projections

Description	Pessimistic Estimate*	Optimistic Estimate*
Capital Expenditure		
Expected capital outlay for solution	**6,000,000**	**8,500,000**
Expected grant/public funding (e.g. MFE)	2,000,000	2,750,000
Subsidised capital cost	**4,000,000**	**5,750,000**
Expected lifespan of solution equipment (years)	15	15
Estimated depreciation rate (SL using IRD rates)	8.5%	8.5%
Amount of wood (all types) inputted per day (tonnes)	30	30
Days solution would operate each year	350	350
Volume of wood processed per year (tonnes)	**10,500**	**10,500**
Volume of wood processed over lifespan (tonnes)	**157,500**	**157,500**
Capital cost per tonne of wood processed	**38**	**54**
Revenue		
Bio-oil sales revenue (assessed as LOW TO MODERATE risk)		
Bio-oil revenue (per tonne sold)	250	250
Volume of Bio-oil per tonne of wood processed (tonnes)	0.38	0.50
Annual volume of Bio-oil (tonnes)	3,990	5,250
Bio-oil revenue per tonne of wood processed	**95**	**125**
Total revenue from Bio-oil sales	**997,500**	**1,312,500**
Treatment chemical sales revenue (assessed as MODERATE risk)		
Treatment chemical revenue (per tonne sold)	0	1,000
Volume of Treatment chemical tonne of wood processed (tonnes)	0.00	0.02
Annual volume of Treatment chemicals (tonnes)	0	158
Treatment chemical revenue per tonne of wood processed	**0**	**15**
Total revenue from Treatment chemical sales	**0**	**157,500**
Biochar sales revenue (assessed as LOW TO MODERATE risk)		
Biochar revenue (per tonne sold)	0	100
Volume of Biochar per tonne of wood processed (tonnes)	0.00	0.10
Annual volume of Biochar (tonnes)	0	1,050
Biochar revenue per tonne of wood processed	**0**	**10**
Total revenue from Biochar sales	**0**	**105,000**
Waste timber gate fee revenue		
Waste timber gate fee revenue per tonne of wood processed	**70**	**70**
Total revenue from Waste timber gate fees	**735,000**	**735,000**
Total annual revenue	**1,732,500**	**2,310,000**
Total revenue per tonne of wood processed	**165**	**220**
Annual volume of saleable outputs from solution (tonnes)	**3,990**	**6,458**

Description	Pessimistic Estimate*	Optimistic Estimate*
Expenditure		
Fixed costs		
Rental and other site costs	0	0
Management/administrative staff	60,000	60,000
Wages and salaries for solution operation	200,000	200,000
Insurances	10,000	20,000
Marketing costs	0	0
Repairs and maintenance	200,000	287,500
Depreciation	510,000	722,500
Other fixed costs	0	0
Total annual fixed costs	**980,000**	**1,290,000**
Fixed costs per tonne of wood processed	**93**	**123**
Variable costs		
Electricity costs	201,600	304,500
Other processing costs (diesel)	105,000	105,000
Inwards transportation costs	0	0
Outwards transportation costs	0	0
Waste stream disposal/processing costs	124,950	0
Total annual variable costs	**431,550**	**490,500**
Variable costs per tonne of wood processed	**41**	**39**
Total annual expenditure	**1,411,550**	**1,699,500**
Total expenditure per tonne of wood processed	**69**	**108**
Summary and profitability		
Annual volume of wood processed (tonnes)	10,500	10,500
Revenue per tonne of wood processed	165	220
Expenditure per tonne of wood processed	134	162
Profit per tonne of wood processed	**31**	**58**
Total annual revenue	1,732,500	2,310,000
Total annual expenditure	1,411,550	1,699,500
Annual profit	**320,950**	**610,500**
Total profit over lifespan of solution	**4,814,250**	**9,157,500**
Annual return on subsidised capital investment	**8%**	**11%**
Total return on subsidised capital investment over lifetime	**20%**	**59%**

Table 6.3 – AES 90 Tonne Plant Financial Projections

Description	Pessimistic Estimate*	Optimistic Estimate*
Capital Expenditure		
Expected capital outlay for solution	**11,000,000**	**13,500,000**
Expected grant/public funding (e.g. MFE)	3,500,000	4,500,000
Subsidised capital cost	**7,500,000**	**9,000,000**
Expected lifespan of solution equipment (years)	15	15

Description	Pessimistic Estimate*	Optimistic Estimate*
Estimated depreciation rate (SL using IRD rates)	8.5%	8.5%
Amount of wood (all types) inputted per day (tonnes)	90	90
Days solution would operate each year	350	350
Volume of wood processed per year (tonnes)	**31,500**	**31,500**
Volume of wood processed over lifespan (tonnes)	**472,500**	**472,500**
Capital cost per tonne of wood processed	**23**	**29**
Revenue		
Bio-oil sales revenue (assessed as LOW TO MODERATE risk)		
Bio-oil revenue (per tonne sold)	250	250
Volume of Bio-oil per tonne of wood processed (tonnes)	0.38	0.50
Annual volume of Bio-oil (tonnes)	11,970	15,750
Bio-oil revenue per tonne of wood processed	**95**	**125**
Total revenue from Bio-oil sales	**2,992,500**	**3,937,500**
Treatment chemical sales revenue (assessed as MODERATE risk)		
Treatment chemical revenue (per tonne sold)	0	1,000
Volume of Treatment chemical tonne of wood processed (tonnes)	0.00	0.02
Annual volume of Treatment chemicals (tonnes)	0	473
Treatment chemical revenue per tonne of wood processed	**0**	**15**
Total revenue from Treatment chemical sales	**0**	**472,500**
Biochar sales revenue (assessed as LOW TO MODERATE risk)		
Biochar revenue (per tonne sold)	0	100
Volume of Biochar per tonne of wood processed (tonnes)	0.00	0.10
Annual volume of Biochar (tonnes)	0	3,150
Biochar revenue per tonne of wood processed	**0**	**10**
Total revenue from Biochar sales	**0**	**315,000**
Waste timber gate fee revenue		
Waste timber gate fee revenue per tonne of wood processed	**70**	**70**
Total revenue from Waste timber gate fees	**2,205,000**	**2,205,000**
Total annual revenue	**5,197,500**	**6,930,000**
Total revenue per tonne of wood processed	**165**	**220**
Annual volume of saleable outputs from solution (tonnes)	**11,970**	**19,373**
Expenditure		
Fixed costs		
Rental and other site costs	0	0
Management/administrative staff	60,000	60,000
Wages and salaries for solution operation	200,000	200,000
Insurances	10,000	20,000
Marketing costs	0	0
Repairs and maintenance	375,000	450,000
Depreciation	935,000	1,147,500
Other fixed costs	0	0
Total annual fixed costs	**1,580,000**	**1,877,500**
Fixed costs per tonne of wood processed	**50**	**60**

Description	Pessimistic Estimate*	Optimistic Estimate*
Variable costs		
Electricity costs	604,800	919,800
Other processing costs (diesel)	315,000	315,000
Inwards transportation costs	0	0
Outwards transportation costs	0	0
Waste stream disposal/processing costs	374,850	0
Total annual variable costs	**1,294,650**	**1,234,800**
Variable costs per tonne of wood processed	**41**	**39**
Total annual expenditure	**2,874,650**	**3,112,300**
Total expenditure per tonne of wood processed	**91**	**99**
Summary and profitability		
Annual volume of wood processed (tonnes)	31,500	31,500
Revenue per tonne of wood processed	165	220
Expenditure per tonne of wood processed	91	99
Profit per tonne of wood processed	**74**	**121**
Total annual revenue	5,197,500	6,930,000
Total annual expenditure	2,874,650	3,112,300
Annual profit	**2,322,850**	**3,817,700**
Total profit over lifespan of solution	**34,842,750**	**57,265,500**
Annual return on subsidised capital investment	**31%**	**42%**
Total return on subsidised capital investment over lifetime	**365%**	**536%**

Based on these projections, the overall risk for AES' financial feasibility in terms of this project was considered moderate to high.

Key in this assessment were the fact that strong profitability does not come until full scale operation is achieved, which would take three to four years. This situation is somewhat exacerbated by the absence of some costings (such as site rental and marketing costs) from AES' projections. The marginal profitability over an extended period of time, matched with high capital costs, then places a great emphasis on AES' access to capital. This is an inherently vulnerable situation, but not an untenable one.

At the conclusion of Milestone 4, AES advised that they required $70,000 to complete their testing programme. At this stage AES explained that they would seek funding for this process, but that they would pursue it with internal funds if no other funding was available. AES has not yet commenced its testing programme because it has not yet secured any external funding, although they have reasserted their ability to self-fund this process if no external funding is available. The timeframes for making this decision are not yet known.

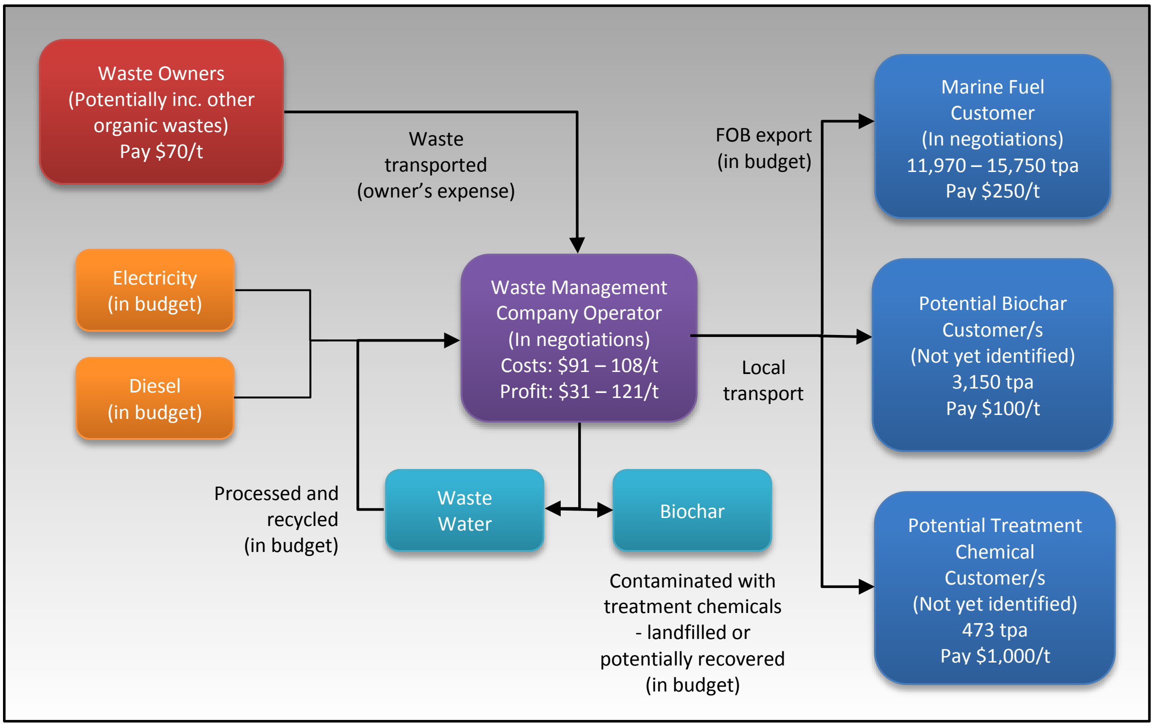
Of great importance in assessing financial feasibility for AES is that fact that it has secured a potential customer for its primary saleable output, at scale, and that the price sought has been accepted in principle. This is a considerable advantage for AES in building financial feasibility for its model.

Overall, based on the scale needed for strong profitability and the challenges AES is likely to face in reaching this scale, the **financial feasibility** for AES' process as a solution for treated timber waste in Christchurch is considered **MODERATE.**

6.3 Supply Chain Feasibility

AES' overall supply chain model is detailed in Figure 6.1 below.

Figure 6.1 – Supply Chain and Resource Flows Overview



Based on the simplicity of its supply chain and the level of engagement of supply chain partners, at the conclusion of Milestone 4 AES' supply chain risk was considered low to moderate.

AES has already secured a tentative partnership with a waste management company partner which would operate their proprietary technology. This partner is highly motivated and engaged. The addition of a key customer with whom basic supply chain logistics have already been agreed, aids the overall robustness of AES' proposed model.

Based on these factors, the **supply chain feasibility** for AES' process as a solution for treated timber waste in Christchurch is considered **HIGH.**

6.4 Deployment Timeframe Feasibility

Subject to technical feasibility, AES has estimated the following key timeframes for the launch of its solution:

- Commencement of receipt of treated timber: Quarter 3, 2015
- Commencement of sale of outputs: Quarter 3, 2015
- Operation at full capacity (60 tonnes per day): Quarter 4, 2016

AES would aim to commence operations in Christchurch within eighteen months, but would not achieve capacity for three and a half years. As noted in Section 4.4 the ramifications of this magnitude of delay to the objectives of this project are substantial.

Furthermore, delays in AES' testing programme and the importance and challenge in securing high levels of equity investment increase the likelihood that these timeframes are extended beyond what has been indicated.

Therefore, based on indicated timeframes and the potential for extensions, the **deployment timeframe feasibility** for AES' process as a solution for treated timber waste in Christchurch is considered **LOW.**

6.5 Processing Volume Feasibility

This project has an aim of diverting 20% of waste treated timber in Christchurch. Based on the estimates concluded in Milestone 1 this equates to 3,370 tonnes per annum. AES' projections are that they would initially aim to process up to 10,500 tonnes of wood annually, with no limitation as to the proportion of this volume that is treated timber. As the company grew, these volumes would double then potentially increase to 31,500 tonnes per annum. At this level, only 11% of the waste wood needs to be treated to meet the project objectives.

Therefore, on the basis of this estimate, the **processing volume feasibility** for Scion's TERAX process as a solution for treated timber waste in Christchurch is considered **HIGH.**

6.6 Technical Feasibility

The key aspects and milestones of AES' testing plan as prepared for Milestone 4 were as follows:

Table 6.4 – AES Testing Plan

Testing hypothesis:	AES believe that the right combination of low temperature and fast pyrolysis time will ensure CCA components are captured in the char produced, rather than in the liquid or gas phases. AES believe that treatment chemicals can be economically separated from the char to allow resale of both the chemicals and the char.
Testing goals:	The overall testing goal is to validate the hypotheses as above. The aim is the analysis and complete mass balance accounting of all CCA compounds in the char.
Types of treated timber to be tested:	CCA treated pinus radiata chip.
Testing quantities:	2 -3 tonnes in total.
Testing process:	Initially a series of tests will be performed on virgin wood to test recent plant modifications and the new high temperature filter. CCA timber will initially be laboratory tested, then samples process through a 1 tonne modified demonstration plant. It is intended that approximately 6 samplings will be processed with various plant parameters. Full scale pilot testing would require the construction of a 30 tonne plant.
Testing personnel:	Initial testing and analysis will be undertaken by Australian firm Covey Consultants.

Expected reliability of results:	It is expected that testing results will be very reliable. Any variant factors will be explicitly noted. A mass balance must be achieved.
Verification process:	Results will be verified by Canterbury University wood scientists.
Output quality testing:	Output quality will not considered in initial testing. This will need to be undertaken by the waste management partner.
Testing timeframes:	Late October/November.
Key milestones:	All sample runs will be milestones.
Other testing information:	AES will be applying for an Auckland Tourism, Events and Economic Development (ATEED) grant for this testing.

As previously noted, the inability to secure the $70,000 in public funding required to undertake the planned testing process has prevented AES from further progressing in this regard. AES has made application to the Callaghan Institute to fund the research into, and testing of, its planned filtration systems for removing treatment chemicals from pyrolysed wood waste, but they do not yet know if their application has been successful.

The details of AES' proposed filtration system for removing treatment chemicals from treated timber waste are not known, but AES describes the solution as relatively straightforward and is confident of success. As with the solution being pursued by WTL, AES has the benefit of precedent in that pyrolysis of treated timber waste has been undertaken successfully internationally and the technology that was used can be learned from and built upon. Yet, also like WTL, AES faces the reality that an economically sustainable model for safely pyrolysing treated timber has eluded well-funded companies throughout the world.

Based on the international precedent for processing treated timber waste through pyrolysis, but bearing in mind the lack of testing and evidence for AES' solution, the **technical feasibility** for AES' process as a solution for treated timber waste in Christchurch is considered **MODERATE.**

6.7 Overall Assessment of Feasibility

At the conclusion of Milestone 4, the overall risk presented by AES' business model in terms of this project was considered moderate.

Table 6.5 – AES Feasibility Assessment

Key Feasibility Criteria	Assessed Feasibility	Rationale
Financial feasibility	**MODERATE**	• Potential customer engaged at desired price and scale • Financial feasibility only indicated at larger scale • Access to capital critical but ability to access unknown • Some substantial expenses absent in financial projections • Capital costs are relatively high • Targeted grant funding is relatively high

Key Feasibility Criteria	Assessed Feasibility	Rationale
Supply chain feasibility	HIGH	• Potential customer engaged • Waste management partner engaged • Key supply chain logistics agreed in principle among participants
Deployment timeframes	LOW	• Eighteen month timeframe till initial deployment • Three and a half year delay in full capacity deployment • Delays in testing may further increase deployment timeframes • The majority of earthquake-related demolition waste and substantial rebuild waste would likely be landfilled in this timeframe
Processing volumes	HIGH	• 10,500 tonne per year target for initial expansion • 31,500 tonne per year target at capacity • At capacity target, only 11% of timber waste needs to be treated to reach project target
Technical feasibility	MODERATE	• Reportedly simple technology solution • Pyrolysis if treated timber done internationally, but not economically • No testing or verified evidence of ability to handle treated timber

AES has developed a model and solution with strong potential, particularly given the demonstrated market interest in its primary saleable output. It is likely that, if AES can successfully test its process and deploy its technology at scale, it will succeed.

Yet the probable challenges in securing capital and achieving the scale that AES requires to be financially sustainable are large. AES is a small scale start-up and, even with a successful testing programme outcome, securing the amount of investment require to deploy at full scale will not, in all likelihood, be easy. This reality is likely to further extend AES' lengthy deployment timeframes, which have the potential of greatly diminishing the contribution AES can make to the objectives of this project.

Based on these factors it is concluded that, in relation to the project objective of:

> "identifying or creating a business case, supply chain and financial model, and end use for the collection, reuse, recycling and recovery of up to 20% of waste treated timber in Canterbury in such a way that it presents compelling economic and/or brand benefits to all participants in the supply chain (waste owners, processors, logistics providers and end users)"

the current probability of AES' pyrolysis process being feasible is considered **MODERATE.**

7.0 ADDITIONAL SOLUTIONS

In the final stages of Milestone 4 and during Milestone 5, largely due to the degree of publicity around this project, the project team became aware of two additional potential solutions that may be able to productively utilise treated timber waste.

These solutions have, due to the late stage of the project, not been given the same robust analysis and consideration as those presented in sections 3 to 6 and any conclusions should be interpreted in this light. For this reason, no overall assessment of feasibility is given.

The two additional solutions are outlined in Sections 7.1 and 7.2.

7.1 Prowood

Prowood Limited is a Motueka-based company, owned by John and Brenda Woodman, which has been in operation since 2007. Prowood produces and sells a range of wood products, but has focused on the Pro-Lam brand of laminated timber for use as posts, beams and other similar applications.

More recently Prowood has begun to evaluate the feasibility of local production of wood-plastic composite (WPC) decking and formwork. Prowood has formed a relationship with American company ABC Corporation which has been using treated timber in WPC products for over twenty years and is keen to bring this technology to New Zealand.

Figure 7.1 - Wood Plastic Composite Decking (CCCME, 2013)

The process by which treated timber would be utilised in WPC decking or formwork products is relatively simple. Treated timber waste would be ground into a very fine powder or 'wood flour' and mixed with plastics and other ingredients. The mix is then processed through an extruder to produce boards in whatever lengths and profiles are required. This process has been in use in the US and elsewhere for some time and the incorporation of treated timber waste is apparently not uncommon.

Managing Director of Prowood, John Woodman, advises that other wood wastes can also be used as WPC feedstock, including MDF, particle board and plywood. Recycled high density polyethylene plastic may also be able to be used, subject to contamination levels. Post-industrial, rather than post-consumer, waste is likely to be most suitable.

While not currently manufacturing WPC products, Prowood has the ability to acquire the technology and training to produce WPC from ABC Corporation, and is currently seeking confirmation of market potential in New Zealand as well as equity backing to launch this new arm of their business. Woodman projects that it would take less than two years year from ‘green lighting’ a project around production of WPC products until production commenced. Based on a successful assessment of market demand, Prowood would aim to be manufacturing in New Zealand and selling products by the end of 2015.

Woodman says that the two focus products for Prowood would be decking and concrete formwork for construction. Decking would likely be 85 – 90% of their business, with formwork representing the remaining 10 – 15%.

The key advantages of WPC decking over traditional timber decking are in terms of durability and performance. WPC decking doesn’t split, crack or fade like timber decking. However it would retail at roughly three times the price of timber, which may be a significant barrier to large-scale market uptake. The consideration of WPC decking in Milestone 1 of this project suggested that the market segment in New Zealand that had sought out WPC decking had done so based on the fact it was not made from treated timber, so no skin contact with CCA treatment chemicals would result. Woodman says that where this is a concern a polyethylene coating can be added to the decking, however this would increase cost.

With formwork the major advantage of WPC is its straightness. Unlike timber, WPC does not warp over time, which is clearly important for such an application. Prowood advise that their WPC formwork would be about 10% dearer than current alternatives but, unlike timber, it does not require sealing and so would likely present an attractive option. As Woodman has noted, however, this represents only a small percentage of their intended overall business.

Currently Prowood does not have any substantial data on the size of the market or its potential in New Zealand. It is recognised that this is a key risk for their proposed business offering, and little market development has so far taken place. Woodman intends, regardless of the market response in New Zealand, to export container loads of decking into the USA where, according to Woodman, “the WPC decking market is growing by 30% a year”. Export to Australia would also be part of the plan. New Zealand manufacture and shipping to Australia may offer a cost advantage for Australian consumers over importing from the US.

No reliable data as to the size of the WPC decking and formwork markets in New Zealand is readily available, but there are approximately seven manufacturers of WPC decking in New Zealand and numerous importers. Estimates as to the size of the WPC products markets internationally are also hard to obtain, and typically out of date, but a 2003 estimate stated that the “US total market for WPC products in the two key market sectors was estimated to be in excess of US$350 million in 2001 with predictions to grow to more than $2,000 million by 2011” (WRAP, 2003). This was considered to be largely the result of effective marketing of WPC products as being of superior quality to traditional alternatives.

In fact the US market has plateaued somewhat over the past five years, with sales hovering around 2.25 million tonnes per annum. Recent growth has fuelled a prediction of a doubling in volume over the next few years, but currently this is only speculation (BCC, 2012). Most of this predicted growth is in the building products sector.

In 2003 the Waste and Resources Action Programme (WRAP) in the UK considered the market in the UK and Europe to be basically non-existent, with growth being extremely slow. At that stage (2003) it was considered that a market surge should be expected and "it has even been suggested that the European market for WPCs will eventually exceed that in the USA in the longer term (10 years from now)" WRAP (2003). This surge is not understood to have taken place as WRAP predicted.

WRAP further noted:

"There is, however, a general reluctance amongst potential manufacturers and end-users, in the UK especially, to consider plastic recyclate as a feedstock for WPC materials. Issues such as material consistency, security of supply, lack of material standards and product performance have all been cited as reasons for this reluctance. Recycled wood, i.e. post-consumer wood waste, will not be considered at all due to the risk of contamination, lack of traceability and quality issues. Only wood from primary and secondary wood processing will be a suitable option for WPCs. Currently, the preference would be to use virgin polymer and wood flour or fibre from traceable sources and it is likely that this is how the market will develop in the short term. There is an issue, however, relating to the high costs of these materials in the UK and the rest of Europe at the moment" (WRAP, 2003).

Concern is also expressed regarding contaminated wood waste being utilised in WPC production: "Cleanliness [of waste wood] is a priority and the wood should be free of any non-wood contaminants. Small amounts of glue, paint or laminates can generally be tolerated as long as the amount does not exceed 5%. Feedstock consistency is one of the most important factors" WRAP (2003). Woodman acknowledges the need for waste to be clean and of a regular size for processing.

Another key consideration around the use of waste treated timber in WPC products is, of course, how treatment chemicals (particularly copper, chromium and arsenic) will deport during manufacture. Prowood are confident that the manufacturing process and nature of the end products will ensure all chemicals are permanently contained within the output products, with little chance of leaching.

American firm Strandex Corporation, which also produces WPC decking and with whom Prowood has a commercial relationship, recently approached Washington State University (WSU), which has had considerable experienced in leachate testing of WPC products made using treated timber. Dr Karl Englund, Assistant Research Professor at WSU's Composite Materials & Engineering Centre says in a letter to Strandex:

"In response to your question on the leaching of chromated copper arsenic (CCA) treated wood flour in a thermoplastic composite, there are significant differences between the commonly utilized borate-based preservatives that are added to a WPC. CCA treated wood creates a chemical bond to the wood constituents that results in a durable bond in the presence of water. This fixation of CCA to wood minimizes the amount of material that will leach out of the product. Borates, on the other hand, are often water soluble and will leach out at a much greater amount, rendering the wood susceptible to biodeterioration." (WSU, 2013)

This is somewhat reassuring with regard to CCA leaching, but does raise concerns about the appropriateness of utilising boron-treated timber waste, which will be prevalent in waste streams from the Christchurch rebuild.

Prowood is planning to ship one tonne of treated timber waste to ABC Corporation in the US which will, along with Strandex Corporation, facilitate leachate testing in accordance with the American Society for Testing and Materials' standard test for leaching. It has been recommended to Prowood that this testing include boron-treated timber waste also. Testing is expected to take place in early 2014.

Concern has also been raised about the life-cycle issues that WPC raises, particularly whether it merely shifts the issue of recycling treated timber and creates a more significant problem by 'locking it up' with plastic. This has been a major objection to the utilisation of treated timber waste in WPC in the past, and was also raised as an issue in Milestone 1 of this project.

Woodman asserts that WPC decking and formwork can be ground and recycled back into new product, with 'endless recycling' a viable proposition. The obvious challenge in achieving this, if it is technically feasible, is the likelihood of actually receiving waste product back, particularly from consumers at the end of the product's usable life. Prowood maintain that they would actively promote a 'waste take-back' programme, but it is likely that, even with this in place, the logistics of collection and recycling would result in most of the waste being sent to landfill with very few options for recycling or recovery. The WPC would, arguably, be more desirable than unprocessed treated timber waste in a landfill.

In terms of rollout, Prowood's current intention is to trial small-scale production of WPC products in 2014 with a view to demonstrating that a viable market exists. Should production prove unfeasible in the short term, Prowood would aim to import product from the US and use this to test market uptake. Prowood plan to spend 2014 proving that a market exists so as to secure the equity investment they would need to establish a Christchurch site and produce product locally.

Prowood has prepared a financial projection for this expansion as detailed in Table 7.1. Key to understanding these projections is the fact that one tonne of waste treated timber would be combined with one tonne of plastic and other ingredients to produce 2 tonnes of WPC products. The costs of these other input factors, along with processing costs, are included. Prowood states that there are essentially no waste outputs from the process.

Table 7.1 – Prowood WPC Production Plant Financial Projections

Description	Pessimistic Estimate*	Optimistic Estimate*
Capital Expenditure		
Expected capital outlay for solution	**8,000,000**	**5,992,035**
Expected grant/public funding (e.g. MFE)	500,000	600,000
Subsidised capital cost	**7,500,000**	**5,392,035**
Expected lifespan of solution equipment (years)	15	15
Estimated depreciation rate (SL using IRD rates)	8.5%	8.5%
Amount of wood (all types) inputted per day (tonnes)	9	11
Days solution would operate each year	350	350
Volume of wood processed per year (tonnes)	**3,150**	**3,937**
Volume of wood processed over lifespan (tonnes)	**47,250**	**58,905**
Capital cost per tonne of wood processed	**169**	**102**
Revenue		
WPC products sales revenue		
WPC products revenue (per tonne sold)	1,800	2,500
Volume of WPC products per tonne of wood processed (tonnes)	2.00	2.00
Annual volume of WPC products (tonnes)	6,300	7,854
WPC products revenue per tonne of wood processed	**3,600**	**5,000**
Total revenue from WPC products sales	**11,340,000**	**19,635,000**

Description	Pessimistic Estimate*	Optimistic Estimate*
Waste timber gate fee revenue		
Waste timber gate fee revenue per tonne of wood processed	**80**	**80**
Total revenue from Waste timber gate fees	**252,000**	**314,160**
Total annual revenue	**11,592,000**	**19,949,160**
Total revenue per tonne of wood processed	**3,680**	**5,080**
Annual volume of saleable outputs from solution (tonnes)	**6,300**	**7,854**
Expenditure		
Fixed costs		
Rental and other site costs	280,000	220,000
Management/administrative staff	450,000	320,000
Wages and salaries for solution operation	564,000	468,000
Insurances	320,000	320,000
Marketing costs	230,000	185,000
Repairs and maintenance	285,000	212,058
Depreciation	680,000	509,323
Other fixed costs	0	0
Total annual fixed costs	**2,129,000**	**1,725,058**
Fixed costs per tonne of wood processed	**646**	**439**
Variable costs		
Electricity costs	535,500	595,804
Other processing costs (plastic and other ingredients)	5,455,800	5,654,880
Inwards transportation costs	0	0
Outwards transportation costs	1,134,000	942,480
Waste stream disposal/processing costs	0	0
Total annual variable costs	**7,125,300**	**7,193,164**
Variable costs per tonne of wood processed	**1,131**	**916**
Total annual expenditure	**9,934,300**	**9,427,545**
Total expenditure per tonne of wood processed	**2,023**	**1,485**
Summary and profitability		
Annual volume of wood processed (tonnes)	3,150	3,927
Revenue per tonne of wood processed	3,600	5,000
Expenditure per tonne of wood processed	2,023	1,485
Profit per tonne of wood processed	**1,657**	**3,595**
Total annual revenue	11,592,000	19,949,160
Total annual expenditure	9,934,300	9,427,545
Annual profit	**1,657,700**	**10,521,615**
Total profit over lifespan of solution	**24,865,500**	**157,824,219**
Annual return on subsidised capital investment	**22%**	**195%**
Total return on subsidised capital investment over lifetime	**232%**	**2,827%**

* Estimates have been prepared by solution provider, but altered where there is a clear justification for doing so.

It is important to note that the overall volume of treated timber waste that would be processed by Prowood’s solution is relatively low compared to the four primary options evaluated in this report. Whereas the other solutions being considered range from 29,600 to 50,000 tonnes of treated timber waste processed per year, Prowood aims to use only 3,150 to 3,927 tonnes per annum, or about 10% of the volume of other solution providers. While this volume is low, it would still potentially meet or exceed the volume target of this project, which is estimated at 3,370 tonnes per annum, if treated timber is used exclusively.

Managing Director John Woodman has stated that, should market demand allow, the production line could be expanded and processing volumes doubled for about two-thirds the size of the initial capital investment (approximately $4 to 5 million as opposed to $6 to 8 million). The resulting treated timber waste volume would, obviously, still fall far short of other options for a similar capital investment.

Furthermore, the solution presents two other key risks: market demand and environmental performance.

The first risk is around proof of market demand. It is believed that sales of WPC decking in New Zealand are still small, and the market is a niche one, in stark contrast to the US. The size of the US market has been attributed to effective marketing, but more extreme climactic extremes in the US may highlight the durability characteristics and benefits of WPC products, stimulating demand. Creating a substantial and sustainable market demand in New Zealand when the consumer is required to pay three times the cost of traditional timber decking would be no easy task.

In Milestone 1 of this project it was concluded, based on the comments of a manufacturer of WPC decking, that inclusion of treated timber in the product would be unattractive to the primary purchasers of the product, being those keen to avoid contact with CCA treated timber. Prowood suggests that the recycled nature of their products may appeal to those who avoid CCA treated timber on environmental grounds, and the addition of a polyethylene coating would allay any skin-contact concerns. There may be merit in these assertions, but if the addition of an optional coating increases price, this would further increase the challenge of establishing a market.

Conversely, the benefits of WPC formwork appear compelling considering the small price premium charged. Prowood report that they have tested its proposed products with potential consumers and received strong positive feedback. This is not surprising. It is not known if the market for formwork, which is used over and over again, is particularly large, but Prowood are only projecting 10 – 15% of revenues from this market.

The second key risk is around environmental performance. From an environmental perspective, the information currently to hand suggests that CCA treated timber presents a low risk as a feedstock for WPC products, both form a processing and end product leaching perspective. It has been used in the US for some time, and Prowood is planning to pursue testing to confirm this view. The nature of the product would indeed suggest that the timber waste would be locked into a stable product that would be unlikely to cause environmental harm. Prowood’s own information suggests that boron-treated timber may present a risk, however, and the practicalities of separating different forms of treated timber would be unmanageable. In this regard Prowood would need to provide testing to show that borates would not leach from their products, or demonstrate an acceptable level of risk. In any case, the risks presented by the leaching of boron-treated timber are certainly lower than those presented by CCA-treated timber.

End of life concerns are also a risk in regard to WPC products’ environmental performance. Prowood maintains that WPC products can be repeatedly recycled. This claim has not been tested or verified, but the US-based Healthy Building Network, which rated the environmental performance of WPC products, raised concerns at the potential difficulties in recycling because of the mix in biological and synthetic materials (HBN, 2005). Even if recycling is practical and cost effective from a cost perspective, actually obtaining the waste and transporting to a processing site is unlikely to be.

At this stage, Prowood's plans to manufacture WPC products are still being developed. The financial model appears solid, but depends on initially proving a sustainable market demand and then using evidence of this to secure the capital necessary to initiate production. The success of their operation clearly depends on overcoming a number of substantial market barriers, but the growth of the WPC decking market in the US suggests it is not impossible to stimulate market demand.

For the purposes of this project Prowood's proposed activity certainly does not offer a complete solution to the problem of waste treated timber in Christchurch due to low projected volumes. Environmental performance also remains a concern, and more work would be required to better understand these risks and the feasibility of product recycling at end of life. Should these issues be satisfactorily resolved, Prowood may provide an additional solution that can boost the productive use of waste treated timber in Christchurch.

7.2 Materials Processing Limited

Materials Processing Limited (MPL) state that they are "solid waste recovery experts based in the upper North Island regions of Northland, Bay of Plenty and Waikato" (MPL, 2013). In addition to managing the recycling operations for Rotorua District Council, MPL also works closely with the Kawerau and Kinleith Pulp and Paper Mills converting wood waste into boiler fuel. The company is primarily owned by Managing Director Peter Fredricsen and has been operating since 1995.

Currently, little information is known about MPL's treated timber operations, and requests for further information have been declined based on concerns about commercial sensitivity. MPL has advised, however, that they has a resource consent to process up to 8% CCA treated timber through their bio-coal production system.

The system is understood to be two stage. The first stage is a gasification unit into which treated and untreated wood waste is fed. This gasification system co-generates power and heat. The power is "not currently being used", but is designed for 1.5MW capacity and it is intended this will eventually be supplied to the national grid. The heat is used to fuel the second stage of the system, being a torrefaction plant.

Untreated wood waste is fed into the torrefaction phase to produce a bio-coal which is sold as an alternative boiler fuel for dairy factory use. This bio-coal is free of CCA treatment chemical contamination.

MPL advise that securing a consent for their system was challenging and that issues around formaldehyde PM_{10} emissions were of particular concern. A wet scrubber was installed on the gasifier and CCA was limited to between 4 and 6% to ensure air quality standards were consistently met. An air quality programme is in place to monitor emission levels.

It is understood that MPL's solution has been well tested and that MPL is constructing a larger plant that will handle "between two and two and a half tonnes of wood waste per hour", equating to up to 21,000 tonnes of wood waste per annum, assuming the operation is 24 hour. At the current ratios of treated timber this would include 840 to 1,260 tonnes of CCA treated timber. Additional to this figure would be boron-treated timber which can be processed without limitation.

Managing Director Peter Fredricsen says that MPL has a desire to operate in Canterbury, but would seek to "prove the technology first" then build a Christchurch-based unit for a licensee or partner.

Given the limited amount of information available, it is not appropriate to make a definitive determination of the feasibility of this potential solution in terms of the current project. No information as to financial feasibility, deployment timeframes or supply chain is known, although technical feasibility seems to be somewhat established. MPL has stated that the operation has three income streams: inwards waste, electricity generation and bio-coal and that only "two out of three" need to be operating for the business to be profitable.

It is likely that the strict limitations on treated timber as a proportion of feedstock would be difficult to work with. Rebuild waste may at times offer concentrations of CCA treated timber that are higher than allowable limits, and demolition waste has a practically indeterminable composition. MPL is currently using XRF technology to sort inwards waste and advises that it has a robust and detailed process in place to ensure waste is kept within allowable limits. Yet such limitations on processing are inherently risky, and the potential for exceeding air emission targets would be ever present. The model is not untenable, but presents a high risk profile.

Despite this, the track record of MPL, and the fact that it has a consent to process treated timber (a rarity in New Zealand) suggest that the development of this technology should be closely monitored.

8.0 TIMBER IDENTIFICATION FLOWCHART

In the Milestone 3.2 report BRANZ and Scion produced "an overview of international research related to waste treated timber identification onsite and a specification and rationale for a decision making process, or "toolkit", suitable for Christchurch". The report concluded that "visual assessments and chemical tests are unlikely to be cost-effective for identifying and sorting large quantities of mixed, stockpiled, timber waste" and that "automated identification and sorting of mixed timber waste using [X-ray fluorescence spectrometry and similar] techniques on an industrial scale still requires significant improvements in accuracy".

Instead, a flowchart decision-making tool was produced for use by those responsible for sorting waste timber as a quick reference guide. This tool is shown in Figure 8.1 below:

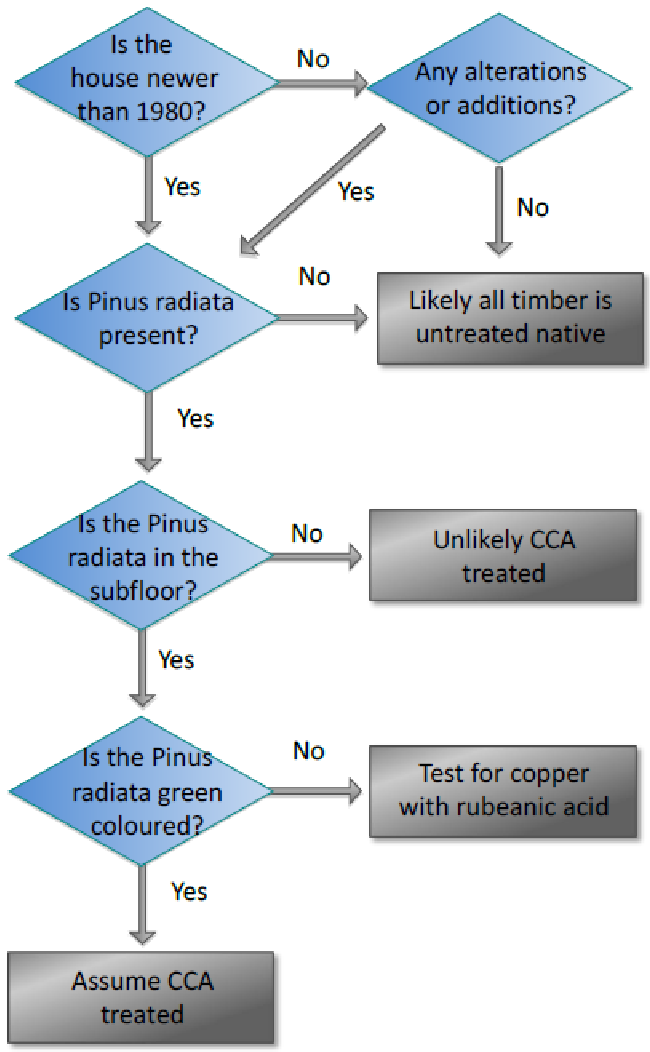


Figure 8.1 – Decision-making Flowchart for Identifying Waste Treated Timber

This flowchart was made available for evaluation to Tom Clark at Frews Contracting which is one of the primary contractors involved in Christchurch earthquake-related demolition. Clark felt the flowchart was useful and largely represented the approach already taken by the industry and noted "the rubeanic acid would potentially be useful to determine what is treated wood in some cases. Previously we would have assumed that all soft woods were treated and hard woods were not."

Clark suggested that the flowchart also consider fencing and decking, which are key sources of CCA treated timber. Clark's advice is that timber in this context is either hardwood (such as kwila) which is easy to identify, or else it is assumed to be CCA-treated. Based on Clark's advice, the flowchart has been updated as shown in Figure 8.2 below:

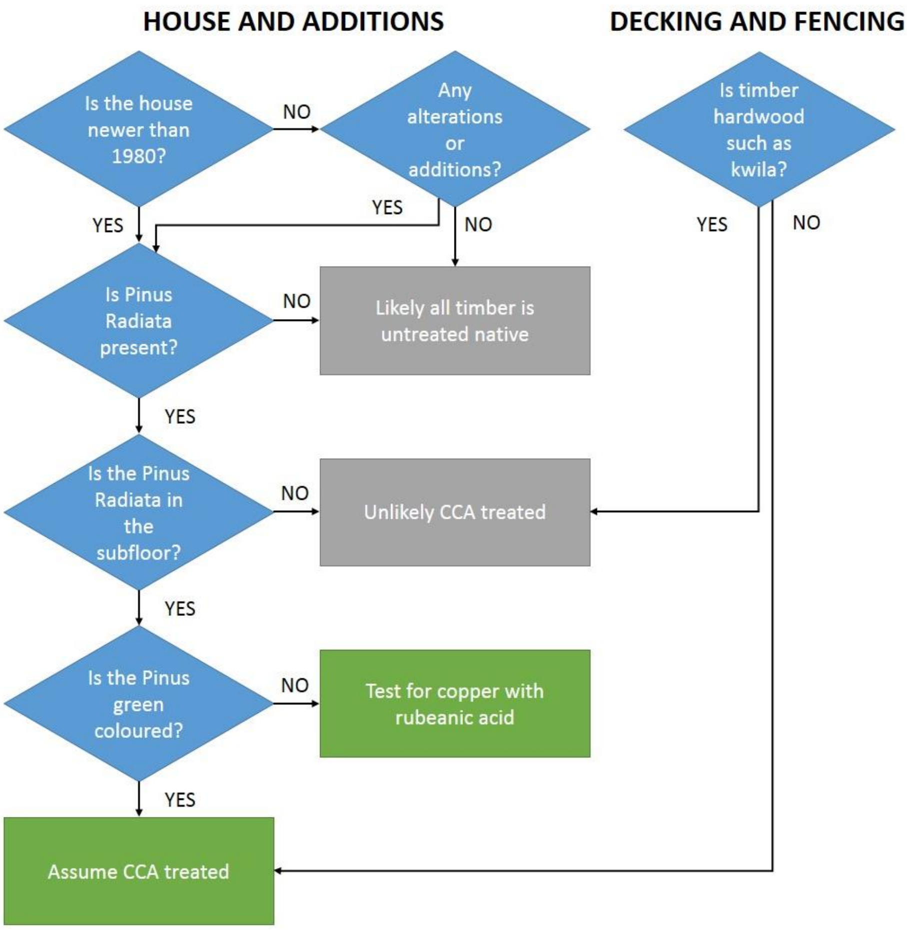


Figure 8.2 – Updated Decision-making Flowchart for Identifying Waste Treated Timber

9.0 CONCLUSIONS

This project has been conducted based on three key objectives:

- Identify and/or create a business case, supply chain and financial model, and end use for the collection, reuse, recycling and recovery of up to 20% (5,000 tonnes) of waste treated timber in Canterbury in such a way that it presents compelling economic and/or brand benefits to all participants in the supply chain (waste owners, processors, logistics providers and end users).

- Identify an appropriate, effective, easy to use and low-cost tool to be used by demolition companies and/or waste processors for identifying treated timber on demolition and/or waste processing sites.

- Increase collaboration between timber waste minimisation stakeholders including demolition, timber and waste industries, Environment Canterbury, Canterbury territorial authorities, construction interest groups and the wider community to improve waste minimisation management of treated timber over its lifecycle.

The conclusions for this project are based around these three key objectives.

9.1 Business Models

In terms of the first objective, determining a **sustainable business model** around the productive use of treated timber, the assessed feasibility of each of the four current solutions being considered are as follows:

Table 9.1 – Feasibility Assessments for Solutions

Risk	Solvent Rescue	Scion/TERAX	Waste Trans.	AES Bioenergy
Overall Assessment of Feasibility	MODERATE	LOW TO MODERATE	MODERATE TO HIGH	MODERATE
Financial Feasibility	MODERATE	LOW TO MODERATE	MODERATE TO HIGH	MODERATE
Supply Chain Feasibility	MODERATE	LOW TO MODERATE	HIGH	HIGH
Deployment Timeframe Feasibility	LOW TO MODERATE	LOW	HIGH	LOW
Processing Volume Feasibility	HIGH	HIGH	HIGH	HIGH
Technical Feasibility	MODERATE TO HIGH	MODERATE	MODERATE	MODERATE

The current financial projections for each of these potential solutions is show in Table 9.2.

Table 9.2 – Financial Comparison for Solutions

Description	Solvent Rescue	Scion/TERAX	Waste Trans.	AES Bioenergy
Capital Expenditure				
Expected capital outlay for solution	**78,000,000**	**10,000,000**	**4,000,000**	**12,250,000**
Expected grant/public funding (e.g. MFE)	7,750,000	3,000,000	1,500,000	4,000,000
Subsidised capital cost	**70,250,000**	**7,000,000**	**2,500,000**	**8,250,000**
Expected lifespan of solution equipment (years)	25	20	10	15
Amount of wood inputted per day (tonnes)	88	143	150	90
Days solution would operate each year	336	350	300	350
Volume of wood processed per year (tonnes)	**29,600**	**50,000**	**45,000**	**31,500**
Volume of wood processed over lifespan (tonnes)	**768,000**	**999,999**	**450,000**	**472,500**
Capital cost per tonne of wood processed	**122**	**10**	**9**	**26**
Grant funding per tonne of wood processed	**10**	**3**	**3**	**8**
Revenue				
Saleable outputs sale revenue				
Annual volume of saleable outputs	15,072	6,325	35,100	13,860
Output revenue per tonne of wood processed	529	152*	277	250*
Total revenue from saleable outputs	16,990,400	7,589,992	12,479,625	3,465,000
Waste timber gate fee revenue				
Waste timber revenue per tonne of wood processed	45	60	80	70
Total revenue from Waste timber gate fees	1,332,000	2,999,997	3,600,000	2,205,000
Total annual revenue	**16,990,400**	**10,589,989**	**16,079,625**	**5,670,000**
Total revenue per tonne of wood processed	**574**	**212**	**357**	**193**
Expenditure				
Fixed costs				
Total annual fixed costs (excl. depreciation)	1,960,000	250,000	1,334,000	687,500
Fixed costs per tonne of wood processed	66	5	30	22
Depreciation	4,680,000	700,000	540,000	1,041,250
Variable costs				
Total annual variable costs	3,248,600	6,412,494	8,010,000	1,455,300
Variable costs per tonne of wood processed	110	128	178	46
Total annual expenditure	**9,888,600**	**7,362,494**	**9,884,000**	**3,184,050**
Total expenditure per tonne of wood processed	**265**	**147**	**138**	**101**
Summary and profitability				
Annual volume of wood processed (tonnes)	29,600	50,000	45,000	31,500
Revenue per tonne of wood processed	574	212	357	180
Expenditure per tonne of wood processed	334	147	220	101
Profit per tonne of wood processed	**240**	**65**	**138**	**79**
Total annual revenue	16,990,400	10,589,989	16,079,625	5,670,000
Total annual expenditure	9,888,600	7,362,494	9,884,000	3,184,050
Annual profit	**7,101,800**	**3,227,496**	**6,195,625**	**2,485,950**
Total profit over lifespan of solution	**177,545,000**	**64,459,916**	**61,956,250**	**37,289,250**
Annual return on subsidised capital investment	**10%**	**46%**	**248%**	**30%**
Total return on subsidised capital investment (lifetime)	**153%**	**822%**	**2378%**	**352%**

* Estimates have been prepared by solution provider, but altered where there is a clear justification for doing so. For this comparison, the average of pessimistic and optimistic estimates has been used. For Scion's model, it is assumed that methane

will be sold as a transportation fuel. For AES' model it is assumed that treatment chemicals cannot be recovered. Returns are calculated as simply the net return divided by the subsidised capital cost. Where differing scale options have been provided, the larger is shown. Where a feasible and unfeasible (unprofitable) model have been presented, the feasible model is shown.

Unfortunately, due to the delays in initiating testing processes, none of the potential solutions can be definitively assessed as feasible or unfeasible. While financial, supply chain, deployment timeframe and processing volume feasibility can and has been reasonably determined, the absence of sufficient verified data to assess technical feasibility with certainty is too material a factor to allow for an absolute and complete determination of overall feasibility. However, with some of the solution providers, proven technical feasibility will not ensure overall feasibility, and other business model considerations will still hamper or prevent successful deployment.

Solvent Rescue's recent engagement of a potential large-scale customer for its lignin output, based on the characteristics and quality of that output, is a very positive step that has fundamentally altered the assessment of Solvent Rescue's feasibility in terms of this project. Having a customer engaged that has a practically unlimited and sustainable demand for this output, which creates a competitive and cost advantage for the customer, is a highly attractive situation for the company. The customer's assistance in pursuing capital development and growth is a further enhancement to Solvent Rescue's model.

The key risks to overall feasibility remain around the capital costs of Solvent Rescue's solution and the scale it must operate at to be financially sustainable. Reaching this level is far from impossible, but it will require a transformation in Solvent Rescue from a small, hands-on, technical-focused business to a large, professional, market-led business. The ability of Solvent Rescue to contribute to the objectives of this project will grow only as it scale up and moves forward with this transformation.

Yet, as it progresses in scaling up to meet apparent market demand, Solvent Rescue stands to develop a technology that could potentially swallow up most or all of the available treated timber waste in Christchurch and utilise it to produce materials which reduce reliance on fossil fuels. The implications of this domestically and internationally are obvious. The next two to three months, in which Solvent Rescue will seek to prove its ability to process treated timber and supply quality lignin product for its potential customer will determine whether it meets the first milestone of feasibility for this project. Securing the capital needed to expand, and doing so in a shorter than expected timeframe, will be needed to achieve overall feasibility.

Scion's TERAX solution has the advantage of having been already accepted as a viable technology by the Rotorua District Council, with full scale deployment being implemented over the next year. Yet, like Solvent Rescue's solution, the TERAX technology is relatively expensive and requires significant capital investment. On the positive side, Scion has a strong reputation and the credibility to justify such an investment. On the negative side Scion is seeking to license its technology and does not carry a direct risk in terms of sustainable profitable operation.

Currently the ability of TERAX to generate methane from treated timber waste is theoretical. It has not been tested, and the likely challenges presented by the inclusion of treatment chemicals have not been tackled. A profitable market for large volumes of methane in Christchurch is also theoretical, and has not yet been validated by a potential customer. In fact, potential customers approached to date have indicated an unwillingness to invest in the infrastructure required to utilise methane as a transportation fuel. This does not render this income stream as unfeasible, but until Scion reached the stage of its development timeline where it engages proactively with supply chain partners and potential customers in Christchurch, feasibility cannot be established with any certainty.

Due to this lack of market activity, combined with the complexity of TERAX, the timeframes for deployment of the technology are also relatively long, being at least four years. Again, this delay does not render Scion's proposed solution unfeasible, but further diminishes its value to the objectives of this project.

As the most 'market-engaged' of the potential solution providers, Waste Transformationz Limited has been the 'front runner' in this project for most of its duration. WTL has gone to great lengths to understand market needs and build its business model around its understanding of the marketability of targeted saleable outputs. Its investment in a distribution partner already active in its targeted high value markets is strong evidence of this approach.

WTL has developed a simple and scalable solution developed in partnership with a researcher based at Massey University. This synergy of academic rigour and commercial astuteness is strategically significant. WTL has yet to test and verify the technical feasibility of its approach, but is certainly confident and has invested in developing its business model in parallel with pursuing technical optimisation.

WTL has a relatively inexpensive solution that benefits from a business model that is able to evolve as it progresses from lower value outputs (bio-coal) to higher value outputs (activated carbon and carbon black) as it becomes established and stable. This flexibility of income streams, combined with the modular nature of WTL's units allows for a staged deployment that is lower risk from an investment perspective than an 'all or nothing' large scale rollout.

Subject to successful testing WTL offers an attractive business model with strong potential. It is greatly enhanced from the perspective of this project, in that WTL aims to be operating in Christchurch in the first half of 2014. This timeframe is not considered unrealistic.

AES Bioenergy is also pursuing a simple technology solution for pyrolysing treated timber waste. As a fast pyrolysis system, AES is focused on producing bio-oil for use as a heavy marine fuel. AES is in a strong strategic position in that it has already engaged a customer for this fuel that is willing to take practically unlimited volumes at a pre-agreed price, subject to consistent quality. With the specifications and quality requirements of this customer in hand, AES has been able to focus its attention on technology development.

AES has not yet commenced its testing process, but (like all solution providers) is very confident in its proposed technology solution, and even aims to be able to extract and resell treatment chemicals, an option which other providers have not pursued.

Perhaps the biggest challenges for AES in achieving a sustainable business model with appeal to this project are around financial feasibility and timeframes. AES' model requires scale for strong profitability and, as a solution that requires high levels of capital investment and public funding, achieving this scale will take time. As a small business, funding the working capital needed for this deployment will likely prove difficult. AES projects that it will take three and a half years to reach capacity with its operations, but is already delayed in this plan due to issues securing funding for its testing programme. These delays, and the overall timeframe, reduce the potential impact AES can have on the requirements of this project.

In the later stages of this project two additional solutions came to the attention of the project team. These have not been fully evaluated, and no determination as to feasibility is given, but they have been considered as potential solutions in development.

Prowood is seeking to move into the manufacture of wood-plastic composite (WPC) decking and formwork for construction. There is a large market for WPC decking in the US, and Prowood believes it can develop such a market in New Zealand also. From a technical feasibility perspective, there is evidence to suggest that CCA treated timber will effectively be contained in WPC products, and not cause leachate problems, whereas there is some doubt over boron-treated timber.

Ultimately the biggest challenge to Prowood's model is establishing a market for decking, which is to be its market focus. At roughly three times the price of treated timber decking, Prowood has a difficult challenge ahead to convince consumers to change. Adding a polyethylene coating to the WPC decking to avoid any skin contact with CCA treatment chemicals – which is a key reason for consumers to buy WPC decking – would further add cost. In addition, while WPC products can be recycled into new WPC products at end of life, the logistics of doing so would be challenging, suggesting that much of the treated timber used in the products would eventually end up in landfill.

Materials Processing Limited (MPL) is a solid waste recovery company operating in the North Island. It has developed a processing solution and has a consent to process up to 8% CCA treated timber. Boron treated timber can be processed without limitation. MPL's solution first gasifies treated and untreated wood waste, then uses the heat this generates to torrefy untreated wood waste. The resulting output is sold as bio-coal.

Information about MPL's model is limited, but potential challenges exist around quality assurance of its feedstock and the potential for exceeding the 8% CCA treated timber limitation. Ultimately it would be preferable to be able to process treated and untreated timber without concern for composition, and any technology for sorting these wastes is likely to pose reliability issues. Yet MPL's system should not be dismissed and has the substantial advantage of already being in operation with a consent for treated timber.

Ultimately the conclusion of this project is that, of the many different processing and end use technologies considered for use as a system for the productive use of treated timber in Christchurch in accordance with the objectives of this project, those being developed by Waste Transformationz Limited, AES Bioenergy and Solvent Rescue offer the best chance of sustainable success, with Waste Transformationz Limited being the current best option.

The next three to six months will determine with greater certainty the technical feasibility of these processes, and that being pursued by Scion, and the conclusions of this project should be read in conjunction with the eventual outcomes of the testing processes being currently pursued by these providers.

9.2 Timber Identification Tool

In Milestone 3.2 (BRANZ, 2013) BRANZ and Scion undertook a sub-project to consider different technologies and processes that might be utilised to identify treated and untreated timber wastes. This report concluded:

"Techniques using X-ray fluorescence spectrometry, laser induced breakdown spectroscopy, and/or near infrared spectroscopy can characterise the treatment components present in timber qualitatively or quantitatively, even at very low concentration levels. Overseas, they are believed to show promise for fast, cost-effective, online sorting of mixed timber waste. Progress has been made in small-scale trials using relatively simple timber mixes, particularly in the USA. However, automated identification and sorting of mixed timber waste using these techniques on an industrial scale still requires significant improvements in accuracy." (BRANZ, 2013)

"Overall, it is expected that well trained staff will be able to identify and sort waste timbers from known sources (at the demolition site) using visual inspection together with chemical stains, with reasonably high efficiency and accuracy. However, this is considered unlikely to be feasible due to time and resource requirements. That said, a 'coarse' sort may be possible using the tool, i.e. segregation of subfloor and wall timbers in post 1990 houses." (BRANZ, 2013)

The report produced a flow chart suggested as an 'on-site' tool for use in the demolition industry. This tool was evaluated by Tom Clark of Frews Contracting who considered it closely aligned with existing practice and, overall, a helpful tool. The tool was slightly modified, and the final version is shown in Figure 9.1

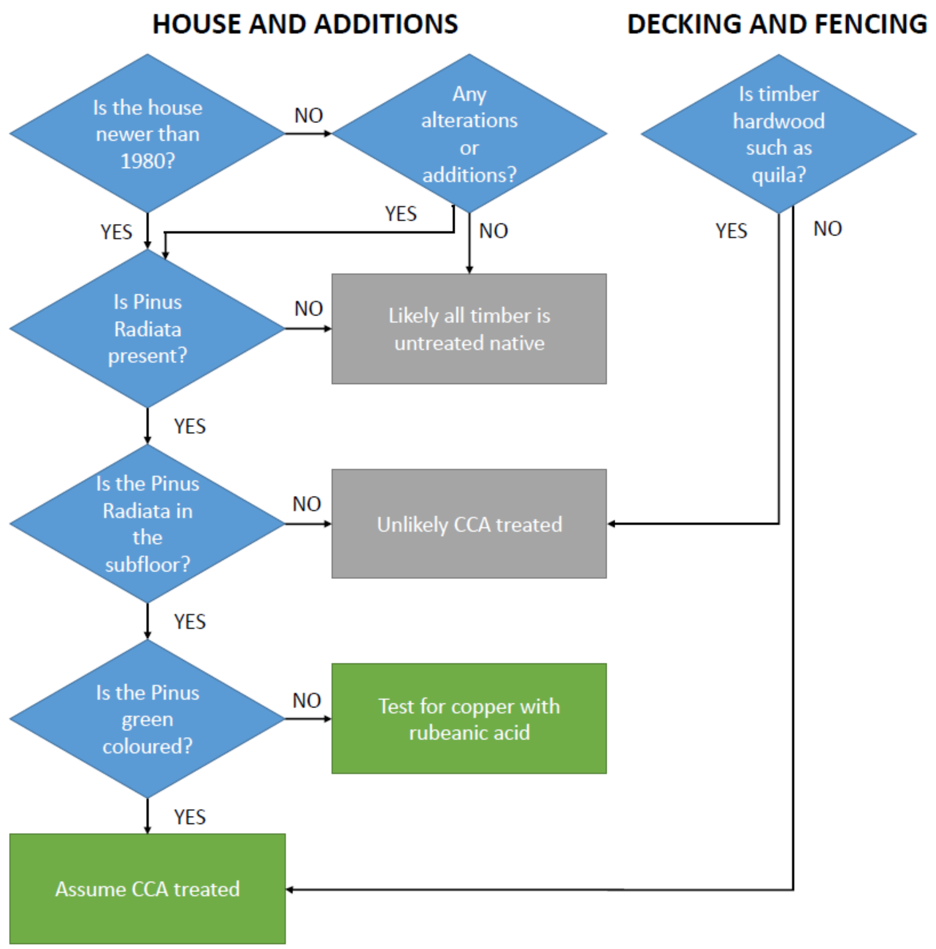


Figure 9.1 – Updated Decision-making Flowchart for Identifying Waste Treated Timber

9.3 Collaboration

A particularly positive aspect to this project has been the degree of cooperation and collaboration that has been prompted by it. The active participation and feedback from a wide range of sector participants, including academics, engineers, commercial operators, waste management companies, demolition companies, regulatory bodies and many others is gratifying and has assisted in the quality of the project's process and conclusions.

In addition to undertaking the feasibility study, the project team has actively accelerated the market by introducing key players to one another and assisting in the formation of commercial partnerships. A key aspect of this facilitation is that the project work has been undertaken by an independent and commercially-focused consultant. This is considered to have given the project credibility and encouraged the participation of other commercial operators.

The private sector has responded energetically to the challenges that this project has promoted, and the investment and relationship building that has been undertaken, particularly by the four solution providers considered in this report is commendable, particularly as they have acted quickly under challenging timeframe requirements.

While it is regrettable that the timeframes of this project do not allow oversight and reporting of the final outcomes of testing and development processes, the level of private sector momentum and activity gives confidence that these processes will not stall, but be pursued with a rigour driven by commercial interest.

Perhaps the key aspect in prompting this collaboration and activity is simply the act of the Ministry for the Environment and the project partners forming and funding the project, illustrating both the priority of treated timber as a problematic waste stream and the commitment of the project stakeholders to seeing a solution identified.

9.4 Next Steps

Currently all the proposed solutions are awaiting testing for technical feasibility. Obviously, the results of these testing programmes will greatly influence the overall feasibility of these solutions. Realistically, technical refinement and problem-solving may take a number of months.

As these solutions emerge and begin to focus on deployment, it may be that more than one solution operates in the Christchurch market simultaneously. This would be a very positive outcome. The volumes in Christchurch, matched with the scalability of some of the solutions, means that a multi-solution provider is likely to be beneficial to the market. Not only would this solution potentially constrain gate fees, driven by market competition, but would also ensure a continuity of demand for waste treated timber should one provider face technical difficulties or some other impediment to operation. In short: a single operator model is inherently vulnerable and may drive up gate fees.

It may be that one provider is able to come on-line and handle limited volumes over the next one to three years. A second provider may then come online and begin operation at this point, increasing overall volumes and potentially reducing gate fees. This would be a desirable outcome, and there is no suggestion based on information to hand, that the treated timber volumes in Christchurch could not support more than one operator, particularly when volumes of other waste streams that are likely to be able to be processed, including untreated wood waste, are included.

As new proposed solutions emerge, such as those found in Section 7 of this report, it is recommended that these be evaluated based on the conclusions of the Milestone 1 and 2 reports, and against the financial evaluation models of Milestone 3, to determine whether they offer a compelling business case. Particular attention should be paid to the proposed end uses/saleable outputs of proposed new solutions and whether these revenue streams are realistic and sustainable. Proof of technical feasibility will also, of course, be important.

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