TRANSPORT OF SOLID WASTE - ROAD TRANSPORT VERSUS RAIL TRANSPORT- CASE STUDY CHRISTCHURCH

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Abstract:
The focus of this study is to analyse the operations of solid waste transport from Christchurch (New Zealand) to a recently opened regional landfill 70km north of Christchurch by comparing two scenarios - road and rail transport. The thrust of the research is based on the logistics of transporting solid waste and identifying the CO_2 emissions or in simple terms the energy used by the two modes. The study takes into consideration solid waste data from 2000-2005 and extrapolates future waste data to assess the situation in 2015. The modelling looks separately at road and a combination of rail-road operations by outlining the various planning and logistics requirements for transporting solid household waste from Christchurch to the new Kate Valley landfill.

Key Words: *Christchurch* Solid Waste, Waste Transport by Road versus Rail, CO_2 emissions

1. SETTING THE SCENE

Solid waste management is a topic of increasing worldwide concern and debate. The two most common ways of disposal of solid waste is to discharge it to a landfill or incinerate it prior to dump the ashes to a landfill. However, irrespectively whether it is pre-treated or not, a substantial amount of waste or residues will end up at a landfill. Surely separating some contents of the waste like recycling materials and green waste or bio-waste can reduce the original amount of solid waste but recycling material and green waste or bio-waste need also to be transported. It is hence often only a cosmetic play with transport figures as green waste transport seems more acceptable than unsorted solid waste.

The transport of solid waste is often described as waste tourism due to being carted over long distances. The whole waste issue is usually kept quiet up to the point that the local landfill is reaching its capacity and the problem requires urgent attention. The minimisation of the overall costs of discharging waste is often associated with long-distance transport if all close-by landfills have high dumping fees. World-wide many trucking firms are specialised in solid waste management prefer as it secures long-term transport contracts as waste is an on-going business for them. It is also flexible and quick to set up and minimises stakeholder involvement. From a sustainability point of view, it is often perceived that rail should be given the first option though the reality is that departure points (usually transfer stations) and the point of destination (landfills) are usually not connected by rail and thus require additional truck movements to transfer onto rail. This leads to a combination of road and rail transport, associated with regulations to comply for both modes, road/rail transfers and in-transit transfer stations that may impact on the general population as solid waste management operations are always perceived to generate a negative impact on society. In terms of modal choice it will largely depend on the country's transport and energy policies, fuel prices and time line. In many cases, authorities are looking for interim solutions – that do last usually for a long period – where road transport becomes the only viable option. It is important to highlight that waste management involve usually lengthy political decision-making that will give priority to road transport as easy to set up at the last minute.

2. RESEARCH OBJECTIVES

This research focuses on a New Zealand case study, analysing the transport of solid waste from Christchurch, located in the South Island of New Zealand, to Kate Valley, a new landfill operated approximately 70km north of Christchurch (Figure 1). The closure of the existing landfill in Christchurch, located in Burwood (approximately 7km northeast of the city) in 2005 required looking at an efficient mode of transporting solid waste to the new landfill as the distance was over 70km. Road transport was chosen in the end. This study completed in 2007 investigates whether road transport in the current form is the best option available for this specific landfill by taking a holistic approach across the literature.

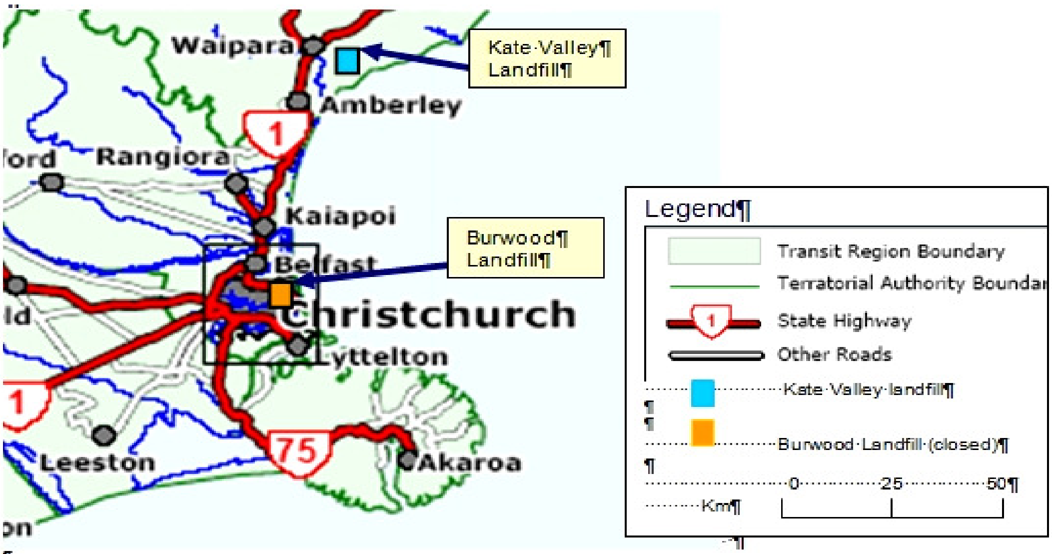

Figure 1 Canterbury Road Network (Transit NZ, 2006)

This study investigates the current operation of transporting solid waste by road from three Christchurch Transfer Stations (Parkhouse Road, Metro & Styx Mill) (Figure 2) to Kate Valley Landfill against a number of other scenarios including rail transport and discusses how sustainable these are from a triple bottom line point of view. A triple bottom line approach is defined by Land Care Research (2006) as an impact study taking into consideration economics, environmental effects and the community.

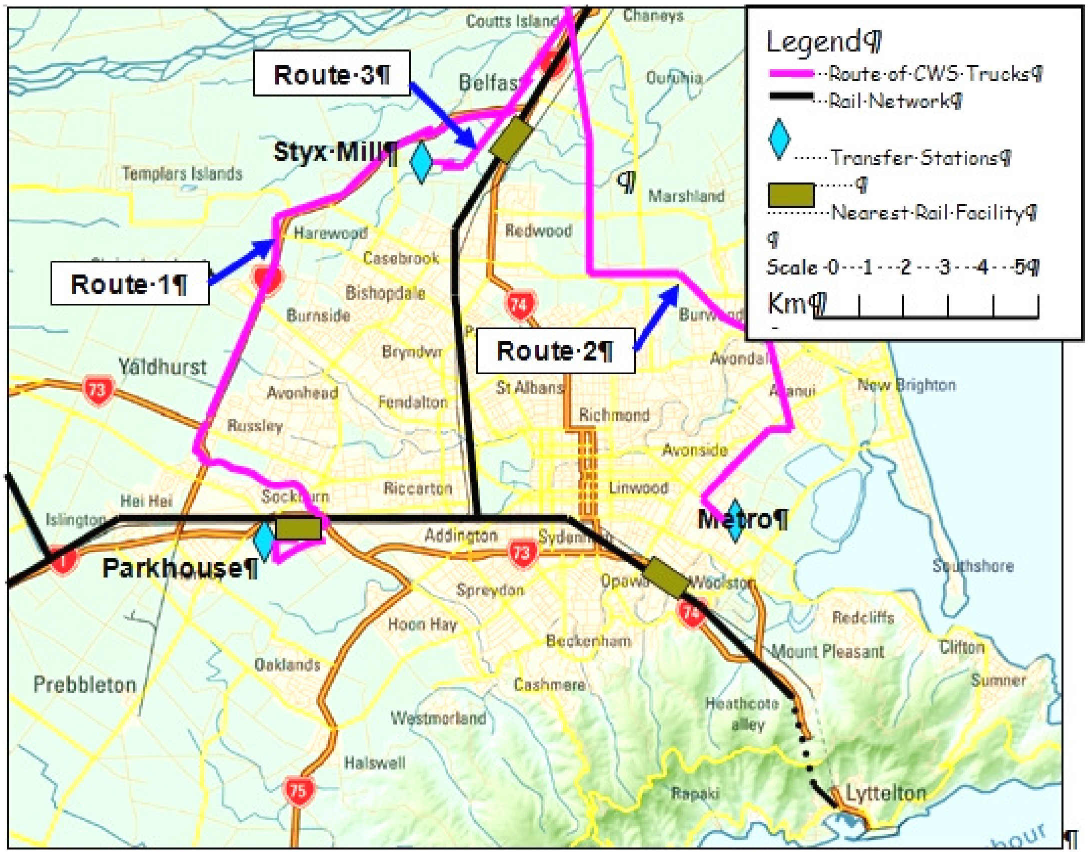

Figure 2 Location of waste transfer stations and route taken by trucks (Schriiffer, 2006)

3. METHODOLOGY

The methodology was broken down into the following parts:

- Review of existing information relating to solid waste data
- Data gathering, feasibility and analysis of current operations
- Identification of further transport options and assessment of their practical feasibility
- Number crunching to compare various options

4. CHRISTCHURCH SOLID WASTE SITUATION

The introduction of recycling - waste minimisation campaign, contributed to a reduction of solid waste transported to landfills. The population of Christchurch was around 350,000 in 2005 but in terms of exact figures of collected solid waste, it was difficult to obtain exact figures from authorities. The data available were usually displayed in different ways (e.g. waste from Christchurch, from metropolitan Christchurch, waste discharged at the landfill, waste including or excluding commercial activities). Hence it became difficult to analyse the data and a number of assumptions were taken to conduct this study. It was interesting to see though the population growth on its own was responsible for increased the amount of solid waste (e.g. 15% from 2003-2004 and 2004 to 2005) (Transwaste Ltd, 2005) as indicated in table 1. Table 1 shows the solid waste quantities from Christchurch and the surrounding areas discharged at Burwood Landfill, the previous Christchurch landfill located seven kilometres north east of Christchurch.

Table 1 Christchurch City Council (CCC) Solid Waste & Population data (CCC, 2006a).

Year	Total CCC Waste [to]	Increase / Decrease [%]	Christchurch Population	Population Increase / Decrease
1999	230,822	1.00%	324,300	
2000	227,423	-2.50%	325,400	1,100
2001	215,910	-5.10%	327,200	1,800
2002	219,872	1.80%	332,000	4,800
2003	229,981	4.50%	338,800	6,800
2004	264,477	14.90%	344,100	5,300
2005	304,148	15.00%	345,857	1,757

The waste increased to 263,000 to in 2004/2005 and 304,148 to in 2005/2006 (CCC, 2005). A good example is the recycling business – you can achieve 70 to 90% recycling efficiency and the difference will go to landfill. Hence, depending on recycling market prices, the recycling process or efficiency will be adjusted to match the market and the rest will end up on landfills. There are few countries with a clear objective to recycle as much as possible as usually it is not economic. This is not different in Christchurch and hence, transparency is not given. Having said this, for the purpose of this research, a number of assumptions were taken. The economic boom in Christchurch has caused an increase of waste sent to landfills since 2002, despite record volumes of recycling materials being recovered in the same period

There are currently four waste streams Residential, Household, Commercial Industrial, Council and Agricultural that are collected in Christchurch and transported to the Kate Valley Landfill from the three transfer stations. Agricultural waste was though not part of this study. Table 2 below indicates the operation hours of the three transfer stations and an overview of the container volumes from the transfer stations to Kate Valley. * Styx Mill is restricted by the resource consent allowing it to operate for eleven hours per day from 7am to 6pm; all waste must be removed from the transfer station floor every night. This is relevant for the logistics of container movements later in this study.

Table 2 Percentage of Waste by Transfer Station

Transfer Station	Opening Hours	Closing Hours	Waste [%]
Parkhouse	5.30am	7.00pm	45%
Metro	5.30am	7.00pm	33%
Styx Mill *	7.00am*	6.00pm*	22%
Solid Waste Total [%]			**100%**

The statistics of the solid waste weight quantities per person and per day shows a reduction of solid waste for the Christchurch population from 1996 onwards with the introduction of kerbside recycling with a negative trend from 2002/03 onwards.

The solid waste collected in Christchurch shown in Table 3 was approximately 2.25 kilos per person per day in 1994. This figure dropped to a low of 1.81 kilos per person per day in 2000 and 2001. Since then it has increased each year until 2004 to reach 2.1 kilos / person and day. Projections for 2005 show this figure has increased to 2.41 kg per person per and day. Table 3 shows that the population has increased by 8.9% in the past ten years, while waste quantities have risen by 11.4%. However the waste quantity per person and day has increased by 2%.

Table 3 Christchurch Solid Waste per kg / per Person / per Day (CCC, 2005a)

Year	Population	Christchurch Waste Quantity	Kg / per Person / per Day
1994	302,800	249,139	**2.25**
1995	308,800	240,777	**2.14**
1996	317,500	273,000	**2.36**
1997	321,000	233,392	**1.99**
1999	324,300	230,822	**1.95**
2001	327,200	215,910	**1.81**
2003	338,800	229,981	**1.86**
2004	344,100	264,477	**2.11**
2005	345,857	304148	**2.41**

Table 4 below shows the total waste sent to landfill including CCC black rubbish bags in column C, the percentage increase or decrease from the previous year in column D. The waste from other local authorities (LA) is in column E. The balance is green waste/kerbside recycling and the amount of hard fill in columns G, H and I. The last column of figure is the population of Christchurch for the corresponding year.

Table 4 Actual Christchurch Solid Waste Quantities Sent to Landfill, (CCC, 2005b)

Year A	Rubbish Bags B	Total CCC Waste Including Bags [t] C	Change [%] D	Other Local Authorities Waste [t] E	Total Refuse sent to Landfill [t] F	Green Waste [t] G	Waste Recycled at Kerb[t] H	Hard fill and Rubble [t] I	Chch Population J
1994	38,242	249,139	-3.40%	0	**249,139**	2,640	0	29,823	302,800
1996	38,707	235,376	-2.30%	0	**235,376**	22,331	0	33,448	317,500
1998	38,258	228,582	-3.10%	8,096	**236,677**	27,536	11,856	19,263	323,000
1999	38,325	230,822	1.00%	13,084	**243,907**	32,909	13,219	17,104	324,300
2000	38,320	227,423	-2.50%	14,990	**242,413**	34,503	14,374	14,067	325,400
2001	37,485	215,910	-5.10%	19,254	**235,164**	30,538	15,686	13,438	327,200
2002	36,903	219,872	1.80%	21,349	**241,221**	34,320	17,251	19,797	332,000
2003	35,878	229,981	4.50%	30,857	**260,838**	35,179	20,885	14,670	338,800
2004	34,189	264,477	14.90%	36,001	**290,478**	31,074	24,044	10,577	344,100

5. SOLID WASTE PREDICTIONS TOWARDS 2015

This section will look at the waste figures projected from 2004 through to 2015 by the Christchurch City Council (CCC) and the private waste management company Transwaste. The estimates by the author are based on previous, current and projected trends in population. It shows that it is difficult to predict waste quantities as dependent on many external factors.

Prediction of Waste for Christchurch by Christchurch City Council

Table 5 shows data from 1994, 2005 and indicates predictions for the future. In 2004 solid waste was predicted to reduce by 1.1% continuing until 2012, then 2.1% until 2015. The actual figure increased by fifteen percent from 2004/2005 to 304,148 tonnes. The Christchurch population is predicted to grow two point five percent to reach 354,642 in 2010 with solid waste reducing by five point four percent to 287,783. By 2015 the population is predicted to grow at 2.5% to 363,360 with a further solid waste reduction of 0.8%.

Table 5 Predicted Christchurch Solid Waste Quantities to Kate Valley (CCC, 2005c).

Year A	Rubbish Bags B	Total CCC Waste Including Bags [t] C	Change [%] D	Other LA* Waste [t] E	Total Refuse Sent to Landfill [t] F	Green Waste [t] G	Kerbside Recycling [t] H	Hard fill and Rubble [t] I	Chch Population J
1994	38,242	249,139	-3.40%	0	249,139	2,640	0	29,823	302,800
2005	**39,488**	**304,148**	**15.50%**	**40,501**	**384,137**	**35,890**	**27,777**	**16,394**	**345,857**
2010		287,783	0.057						354,642
:	:	:	:	:	:	:	:	:	:
2015		**265,000**							**363,360**

Table 6 shows the total predicted Christchurch solid waste sent to landfill divided by the predicted Christchurch population, multiplied by three hundred and sixty five days to obtain the solid waste predictions per person and per day in the future.

Table 6 Predicted Solid Waste per Person [kg] per Day

Year	2005	2010	2015	2020
Population	345,857	354,642	363,360	372,123
Christchurch Waste Quantity [t]	304,148	287,783	264,123	246,469
Waste per person [kg] and per day	**2.41**	**2.22**	**2.00**	**1.815**

Prediction of Waste by Transwaste Ltd

In 2003 Transwaste predicted that the upper bound waste increase would be 0.7% per year in the next year and one point one percent for the lower bound per year from 2004 to 2012 as shown in Table 7. The predictions were based on the years 2002/2003, though Transwaste was not able to foresee the housing and economic boom in both Christchurch and Canterbury, nor the recession that started in 2008.

Table 7 shows a five years projected waste quantity abstracted from thirty five years but keeping in mind all unknown (e.g. technology, legislation, economy) and being aware that predictions will always need to be re-adjusted and operations adapted.

Table 7 Predicted Waste Quantities to Kate Valley Landfill (Transwaste, 2002).

Landfill Year	Assumed Year	Upper Bound [t]	Lower Bound [t]	Most Likely [t] Upper Bound	Most Likely [t] Lower Bound
		0.68% / year	1.1% / year	0.5% / Year	1.1% / Year
1	2004	240,000	220,000	240,000	220,000
2	2005	241,632	217,580	238,800	217,580
9	2012	253,053	201,369	230,566	201,369
:	:	:	:	:	:
25	2028	279,160	N/A	212,797	168,707
35	2038	295,477	N/A	202,393	151,042

Solid Waste in Canterbury

From historical figures provided by Transwaste's Resource Consent Application in 2003, the population to predicted solid waste figure was set at:

- 1.56 kg per person and day to landfill lower bound
- 1.95 kg per person and day to landfill upper bound (Transwaste, 2002)

The estimated solid waste to be disposed of in 2004 was predicted to be 240,000 tonnes for Canterbury. The actual figure published for 2004 was 295,000 tonnes, thus an increase of 55,000 to or 23% above the upper-bound prediction.

Figure 3 below was published on the Christchurch City Council (CCC) website in 2005 as part of a media release by Transwaste which indicated an actual volume of 2.1 kg of solid waste per person per day- hence an increase of 0.70 kg on the projected figure of 1.4 kg (Transwaste, 2002). At the time the figures were projected in 2002, no allowance was made for an 8.9% growth in the population of Christchurch or Canterbury.

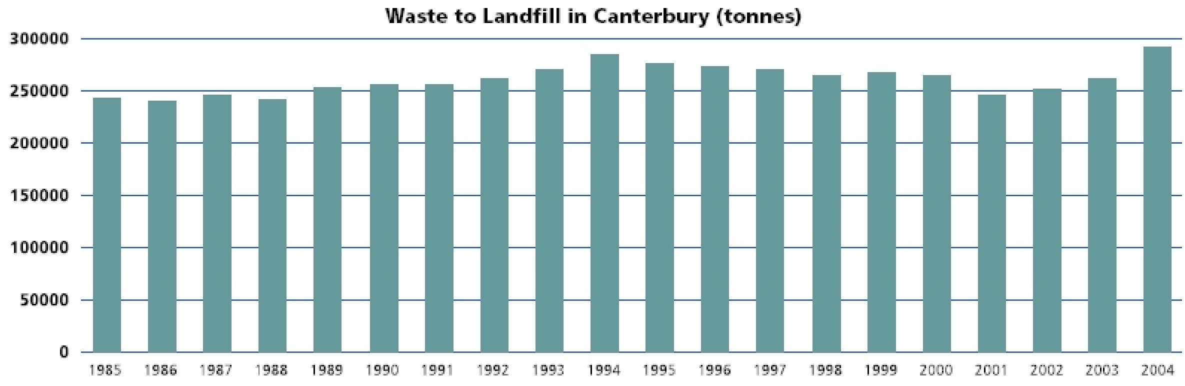

Figure 3 Solid Waste Sent to Landfill in Canterbury (Transwaste, 2005)

The 295,000 to of solid waste shown in Figure 3 are 55,000 to above the upper bound figure projected by Transwaste in its Resource Consent Application and 75,000 to above the lower bound figure (Transwaste, 2003).

Estimation of Waste Quantities

The analysis of data produced by the CCC and Transwaste were slightly different to the data identified by the author. However, in order to proceed with the study, it was important to identify data that were feasible. The comparison between road and rail looked at 2005-2006 data of 304,148 tonnes but concentrated on the 2015 prediction estimation of 265,000 tonnes of solid waste per year.

Estimation of Waste Quantities by Author

The figures for 2004/2005 in table 8 are the actual solid waste quantities provided by the Christchurch City Council (CCC, 2005d), whereas 2015 is estimated by the author.

Table 8 Estimated Waste Quantities in kg per person and day by author.

Year	Christchurch Waste Amount [t]	Christchurch Population	Christchurch Waste [kg] per person per day
1995	240,777	308,800	2.14 kg
1999	243,907	324,300	2.06 kg
2004	264,477	344,100	2.11 kg
2005	304,148	345,857	2.41 kg
2015	**265,000**	363,360	2.00 kg

The quantity of solid waste for 2015 is estimated by the author on a realistic approach of 2kg/person and a target that could be set government. The waste predication per person and day shows that prior to the introduction of recycling in early 2001/2002 the amount of waste per person sent to landfill was lower than the amount for 2005 and the projected amount for 2010.

The Ministry for the Environment's Solid Waste Analysis Protocol (SWAP) classification system estimated that the quantity of solid waste sent to landfill in New Zealand in 2004 was equivalent to 2.09 kg per person per day (MfE, 2006).

6. ROAD TRANSPORT

This section focuses on the transport operation from the three Christchurch Transfer Stations to the Kate Valley, including specifications of the truck and trailer units used.

Figure 4 Mercedes Truck & Trailer Unit

Figure 5 Trucks at Kate Valley

The NZ regulations currently allow a maximum gross weight of 44 tonnes for a standard truck and trailer configuration. The transport operation in 2006 used:

- 3 Mercedes trucks operated by META, one based at each transfer station, each fitted with a hydraulic operated hook and arm
- 12 long haul Mercedes truck and trailer units operated by Canterbury Waste Services (CWS)
- 4 Mercedes trucks operated by CWS based at the landfill.

The solid waste sent to Kate Valley from the three transfer stations is based on a population of 363,360 in Christchurch (CCC, 2004d) (see Table 9) and a waste quantity of 264,477 tonnes in 2004/2005 which equates to a quantity per capita of two kilos per day and per person.

Table 9 Waste Collection by Transfer Station for various periods (CCC, 2005e).

Transfer Stations	**Waste Quantity [%]**	**Waste Quantity per Year [tonne]**		
		2004/2005 [t]	**2005/2006 [t]**	**Prediction for 2015 [t]**
Parkhouse	45%	119,015	136,867	119,250
Metro	33%	87,277	100,369	87,450
Styx Mill	22%	58,185	66,913	58,300
	100%	**264,477**	**304,148**	**265,000**

The next table (Table 10) outlines the truck, trailer and container specifications including payloads, with 2 options for containers: A compacted closed containers and B non compacted open top containers, maximum payload allowances and the hydraulic operated hook and arm lifting system.

Table 10 Solid Waste Weight Variations Trucked to Kate Valley (META, 2005)

Truck & Trailer Specifications	**Minimum Payload [t]**	**Maximum Payload [t]**	**Variation [t]**
Truck (tare)	12.8	12.7	120 kg
Trailer (tare)	4.6	4	
Closed containers (2)	6.6	6.6	
Total Empty Weight (tare)	24	23.3	700 kg
Allowed Gross Weight	44	44	
Solid Waste Payload Total	**20**	**20.7**	**700 kg**
***Max Overloading Allowance [t]**	**1.5**	**1.5**	

*Includes a 1.5 tonnes Overloading Allowance by Land Transport New Zealand (LTNZ).

Container Options

The currently used containers are fully closed and are designed to take compacted waste. They carry a payload of 20.4 tonnes due to their tare weight of approx 3.3 to each. There is an option of using open top containers in which the waste is non-compacted. They are constructed from lighter steel plate and hence allow a bigger payload of approximately 22.4 tonnes. This higher payload comes with the disadvantage of potential smell developing over time on hot summer days should a filled container stay in transit for a certain time. The debate about the relevance whether household waste should be compacted for transport is not relevant as compacted household waste can be difficult to get out of containers at the landfill. The volume of containers is not restricted to a certain size like it is the case in Germany (e.g. 25m3 container to reduce vehicle height to fit under bridges). So really the only reason for compacting the waste was that the equipment was already existent at the three transfer stations.

The Commercial Vehicle Investigation Unit (CVIU) confirmed that the CWS truck and trailer units are generally speaking 45 tonnes and thus 500 kg under the tolerated limit of 45.5 tonnes but 1 tonne above the official limit.

Maximum Payload Allowance

By taking a median payload figure for closed containers (Option A) of 20.4 tonnes and adding 1 tonne (1.5 tonnes being the legal overweight allowance), the 21.4 tonnes will also be the basis of later calculations for option A, as it is close to the current practice. A proposal to use open top containers would lift the 22.4 tonnes to 23.4 tonnes as option B.

Return Trips to Kate Valley for 2006

This section looks at the number of return trips to Kate Valley in 2005/2006 year and provides predictions for return trips in 2015. The routes are shown in figure 3 and the distances are for Parkhouse (route 1) 83km, Metro (route 2) 81km and Styx Mill (route 3) 68km. The route from Belfast to Kate Valley via the northern motorway on SH1 is fifty five kilometres to the intersection of SH1 and SH7. From there it is an additional nine kilometres on the Mt Cass Road to reach the Kate Valley Landfill site. The return trip from the transfer stations to Kate Valley is based on an average three hour trip turn around time to travel the approximately one hundred and forty kilometre trip. This includes both picking up of the full container and dropping off of the empty container.

Table 11 below shows the current transfer stations hours of operation and the solid waste amount of 304,148 tonnes. Included are the number of truck and trailer trips to Kate Valley per week and per annum using closed containers and a payload of 20.4 tonnes and 21.4 tonnes.

Table 11 Modelling of annual trips for Closed containers for 2006 (payloads of 20.4t/21.4t)

Transfer Station	Hours Open	Waste [%]	2005/2006 Waste [t]	Trips per a at 20.4[t]	Trips per Week at 20.4[t]	Trips per annum at 21.4[t]	Trips per Week at 21.4[t]
Parkhouse	13.5	45%	136,867	6,709	129	6,396	123
Metro	13.5	33%	100,369	4,920	95	4,690	90
Styx Mill	11	22%	66,913	3,280	63	3,127	60
	Total	**100%**	**304,148**	**14,909**	**287**	**14,213**	**273**

By increasing the closed container payload from 20.4 tonnes and 21.4 tonnes (see Table 11) the saving in the number of trips to Kate Valley is 696 per annum. By taking an average of the three trips (A, B C from Table 23 of 77 kilometres) the saving is 107,184 kilometres.

The amount of solid waste sent to Kate Valley in the year 2005 / 2006 by using open top containers is 304,148 tonnes per annum based using open top containers and a payload of 22.4 tonnes and 23.4 tonnes as shown below in Table 12. Using the lower payload of each container type a comparison using the 20.4 tonne payload for closed container trips and 22.4 tonne payload for open top container trips a the saving is 1,331 trips or 204,974 kilometres per annum can be achieved.

Table 12 Modelling of annual trips for Open Top Containers for payloads of 22.4t/23.4t

Transfer Station	Hours Open	Waste [%]	2005 /2006 Waste [t]	Trips per annum at 22.4[t]	Trips per Week at 22.4[t]	Trips per annum at 23.4[t]	Trips per Week at 23.4[t]
Parkhouse	13.5	45%	136,867	6,110	118	5,849	112
Metro	13.5	33%	100,369	4,481	86	4,289	82
Styx Mill	11	22%	66,912	2,987	57	2,860	55
	Total	**100%**	**304,148**	**13,578**	**261**	**12,998**	**250**

Predicted Return Trips in 2015

This next section outlines a similar scenario but adding a totally new option to the decision-making process that is not in favour of rail transport. The New Zealand government enabled a two year trial lifting overall vehicle weight from 44t to 53t. A similar trial was conducted in Germany (Gig liner). The German trial was not implemented whereas the New Zealand trial is getting granted for some routes and some companies. CWS was able to conduct a trial over the last year but has not yet obtained an official go-ahead. However, this new option will be part of the 2015 evaluation as likely to be implemented after a successful trial – this will lift the payload from 20.4to to 28.4to or with some tolerance to approximately 29 to (Option C).

Table 13 looks at the number of return trips by taking the 2015 predictions into account and comparing the closed and open top containers. Table 13 outlines clearly that option C is by far more efficient than the original option A: reduction of trips of 27%.

Table 13 Number of Predicted Return Trips to Kate Valley for Year 2015

				Closed Container (A)s		Open Container (B)s		Closed Containers (C)	
Transfer Station	**Hours Open**	**Waste [%]**	**Predicted 2015 Waste [t]**	**Trips per annum at 21.4[t]**	**Trips per Week at 21.4[t]**	**Trips per annum at 23.4[t]**	**Trips per Week at 23.4[t]**	**Trips per annum at 29[t]**	**Trips per Week at 29[t]**
Parkhouse	13.5	45%	119,250	5,572	108	5,097	98	4,112	79
Metro	13.5	33%	87,450	4,086	79	3,738	53	3,016	58
Styx Mill	11	22%	58,300	2,724	53	2,492	48	2,011	39
Total		**100%**	**265,000**	**12,383**	**240**	**11,327**	**199**	**9,139**	**176**

7. RAIL TRANSPORT

From a triple bottom line point of view, rail is usually perceived as the obvious choice whenever possible. This case study requires a combination of road/rail operation, with trucking waste from the transfer stations to the next rail transfer station, railing the containers to Glasnevin (3km north of Amberley and transferring back to road for the last road section to the landfill. This option involves additional handling of the waste containers over the present system. Land purchase would be required at Glasnevin to build a rail/road container transfer handling facility. This would be used to store the wagons/containers while awaiting transport to Kate Valley. The containers would be unloaded at Kate valley and left in the container park to be emptied on to the landfill by specific trucks only operating on the landfill. Empty containers would be loaded on to the truck and trailer units and returned to Glasnevin where they would be loaded on to the rail wagons for the return trip to Christchurch.

Kiwirail has locomotives and wagons able to handle option. By using the UK/UKA class of flat deck wagon and a combination of different locomotives, the maximum numbers of containers able to be transported per trip is one hundred using the combination of the DX and DFT locomotives, however the most efficient use of a locomotive is using one DX as it is able to take up to sixty containers per trip. The proposed rail scenario put forward for transporting Christchurch's solid waste maybe able to be duplicated by other councils in Canterbury to take advantage of the rail system to transport their solid waste to Kate Valley. This would mean up to three or four trains per day could possibly be required. However, this research project is limited to the three Christchurch Transfer Stations.

8. CONTAINER OPERATION

The transport mode will dictate the number of containers required at each transfer station. From the transfer stations the full containers are taken to Kate Valley by CWS truck and trailer unit where they are unloaded from the truck and trailer units. Empty containers are picked and returned to the transfer stations as shown below in Figure 6 and the cycle begins again.

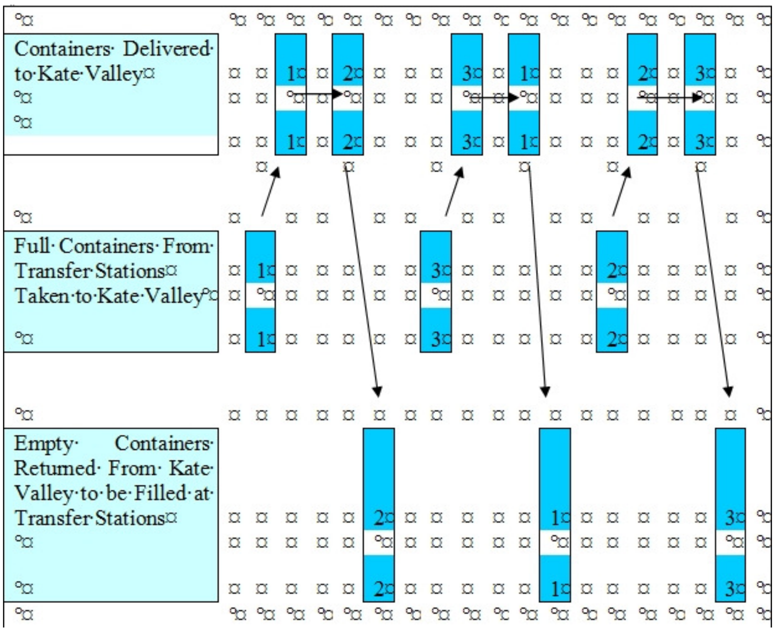

Figure 6 Container Movements from the Transfer Stations to Kate Valley & Return

Table 14 provides the number of containers required for a daily operation in relation to the number of truck and trailer units and return trips.

The number of container required will depend on a number of factors that have been modelled in the main study. The parameters looked at 6 or 7 days operations, closed or open top containers, various payloads (including 1.5t tolerance). Table 15 outlines the scenarios for all transfer stations by detailing Parkhouse transfer station as an example taking a payload of 21.4t.

Table 14 Number of Containers Required for the Transport System Needs

	Number of Return Trips to Kate Valley				
Number of Truck & Trailer Units Required per Transfer Station	**1**	**2**	**3**	**4**	**5**
1	4	6	6	6	6
2	8	12	12	12	12
3	12	18	18	18	18
4	16	24	24	24	24
5	20	30	30	30	30
6	24	36	36	36	36
7	28	42	42	42	42

Table 15 Container number per transfer station with closed containers & 21.4 tonne Payload

Waste per Annum [t] 2015		**Truck and Trailer / Trip [t]**			
119,250		**21.4**			
Return Trips per Week		**7 Day Operation**		**6 Day Operation**	
107		15.3->15		17.8->18	
Number of Trips		**3 Trips / Day**	**4 Trips / Day**	**3 Trips / Day**	**4 Trips / Day**
		5	3.8	6	4.5
Number of Trucks		**5**	**4**	**6**	**5**
		5 Trucks	4 Trucks	6 Trucks	5 Trucks
Number of Containers		3 Trips **30**	4 Trips **24**	3 Trips **36**	4 Trips **30**
20% extra allowance		6	5	7	6
Total containers	Parkhouse	36	29	43	36
	Metro	29	22	36	22
	Styx	14	14	22	14
TOTAL Containers		**79**	**65**	**101**	**72**

Table 15 clearly outlines that 4 trips a day reduce significantly the number of required containers

Container requirements for rail transport

Table 16 Container number for rail transport and 21.4 t Payload Closed Container 2015

265,000 [t] per annum 21.4[t] per Truck and Trailer / Trip Closed Containers						
Transfer Station	**Waste per Annum [t]**	**Waste per Week[t]**	**Waste per Day 6 Day Operation [t]**	**Waste per Day 7 Day Operation [t]**	**Container Numbers 6 Day Op**	**Container Numbers 7 Day Op**
Parkhouse	119,250	2,293	382	328	36	31
Metro	87,450	1,682	280	240	26	22
Styx Mill*	58,300	1,121	187	160	17	15
			849	**728**	**79**	**68**
20% Allowance for Peak Periods & Repairs					**16**	**14**
Total Numbers of Container Required					**95**	**82**
Set 2 Total Number of Containers (at Glasnevin)					**79**	**68**
Total Container Numbers					**174**	**150**

Two sets of containers will be required for the rail operation, set A to be at the transfer stations in Christchurch being loaded while set B to be at Glasnevin being unloaded. An allowance of 20% was made in the calculation for peak periods where the number of containers required increases and for ongoing repairs of the container fleet.

- **Return trip to Kate Valley**

Currently CWS uses approx 140 containers for their operations. The number of truck & trailers required is shown in table 17. The calculations are based on a 6 day operations.

Table 17 Number of truck & trailer required for 6 days operations & 21.4to payload

Number of Truck & Trailer required	Trips /annum	Operation Days	Return Trips per Day	Truck & Trailer 3 Return Trips	Truck & Trailer 4 Return Trips
Parkhouse	5,572	311	18	6	5
Metro	4,086	311	14	5	4
Styx Mill *	2,724	311	9	3	3
	12,383		**41**	**14****	**12****

9. CONCLUSION

Table 18 and 19 show the annual fuel consumption for both solely road transport and rail/road combination for closed containers (Option A) and 20.4t payload.

Table 18 Annual fuel consumption for road transport

			Truck fuel consumption 57 litres per 100 kilometres	
Transfer Station	**Total Road [km]**	**Trip Numbers**	**Total Distance [km]**	**Total Litres of Fuel Used**
Parkhouse	83	6,709	556,847	317,403
Metro	81	4,920	398,520	227,156
Styx Mill	68	3,208	218,144	124,342
Totals		14,837	1,173,511	668,901
One Way			1,173,511	668,901
Total Return Trips Kilometres and Fuel Used			**2,347,022**	**1,337,803**

Table 19 Annual fuel consumption for combined rail/road transport

Rail Transport		**Payload 20.4 [t]**							
	Total Road	**Fuel at .61 / km**	**Road Trips**	**Road Fuel / Trip [l]**	**Total Rail [km]**	**6 Day Rail Trips**	**Rail Litres One Way**	**Total Rail Fuel [l]**	**Total Fuel [l]**
Parkhouse	12.2	7.442	6,709	49,928	76	140	437.5	61,250	111,178
Metro	15.4	9.394	4,920	46,218	79	103	437.5	45,063	91,281
Styx Mill	12.3	7.503	3,208	24,070	58	69	437.5	30,188	54,257
Totals			14,837	120,216		312	437.5	136,500	256,716
Fuel Litres One Way									**256,716**
Total Fuel Litres Used									**513,432**

It is pretty obvious through comparing table 18 and 19 that the rail option is the more sustainable one in terms of energy consumption. This gap could though be reduced by allowing a much higher payload (53 to truck & trailer units) as indicated earlier in the study as option C but this scenario was not calculated as not passed by New Zealand Parliament.

Comparison of Fuel Use between Road and Rail Transport

An increase of payload from 20.4 tonne to 22.4 tonne has a potential saving is 114,347 litres per annum. Comparing road and road/rail mix indicates a potential saving of 824,371 litres per annum. A comparison with 22.4 tonne payload using open top containers for both road and rail shows a potential saving using rail of 730,502 litres per annum as indicated in table 20. The fuel saving using a rail option is over sixty one percent. That equates to a saving of 14,900 trips per year with rail.

Table 20 Comparative fuel consumption analysis

Containers	Payload	Road Fuel Used Litres	Rail Fuel Used Litres	Fuel Saving Litres	Fuel Saving [%]
Closed	20.4[t]	1,337,803	513,432	824,371	**62**
Open Top	22.4 [t]	1,223,456	492,954	730,502	**60**
Difference		**114,347**	**20,478**	**93,869**	

Using a triple bottom line perspective, the benefits of rail are shown in table 21.

Table 21 Benefits of using Rail

Heading	Topic	Outcome
Economic	Operational Costs	Rail offers reduced operating costs
Environmental	Energy Consumption	Rail uses over 50% less energy than road
	Emissions	Rail produced 10% to 20% the levels of road
Community	Accidents	Rail is less than 0.5% of the equivalent of road
	Noise & Vibration	Rail would reduce noise & vibration (improve life quality)
	Congestion	1 train carries the payload of 50 truck and trailer units

In conclusion, rail transport using closed container or open top containers would deliver a sixty percent fuel saving over road transport. Rail is likely to have less impact on local communities, except for a few landowners next to Glasnevin and produces fewer emissions. Accident rates are likely to be lower but not proven. However, in rush hours and especially in the outskirts of the city there will be reduced congestion and less frustrated motorists trying to pass the truck & trailer units as a principle but probably not because of their driving capacities as CWS drivers are highly trained and monitored. It is also highly likely that trucks will contribute to increased road damage in extreme weather conditions. Option C with higher payload has not yet been properly assessed though it is likely that considering just the economics in a holistic way will give advantage to road transport as the number of trips will be able to get reduced by around 35%. Option C could though not be transported by existing rail wagons as the payload is too high.

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