
Report prepared for the Ministry of Health

Estimating the costs of the 2013 Raetihi Diesel Spill

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About Sapere Research Group Limited

Sapere Research Group is one of the largest expert consulting firms in Australasia and a leader in provision of independent economic, forensic accounting and public policy services. Sapere provides independent expert testimony, strategic advisory services, data analytics and other advice to Australasia's private sector corporate clients, major law firms, government agencies, and regulatory bodies.

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Executive summary

In late 2013, the town of Raetihi experienced a unique event with wide-ranging and deeply-felt impacts. The town water supply was contaminated with diesel that spilled from a storage tank on nearby Mt Ruapehu. The town water supply was shut down for around four weeks. We were asked to estimate, and where possible, quantify the costs of such a spill using an economic approach.

Our findings can be summarised as follows:

- It is extremely difficult to quantify and monetise impacts; no firm guidance is provided in the literature, many of the impacts are intangible and/or absorbed into “everyday life”.
- Estimates presented relied on judgment and assumptions as much as “hard data”.
- The quantifiable impacts total around \$2 million (conceptually equivalent to over half the households in Raetihi being without income for the two month duration), the majority of which is time-specific (i.e. while the event was underway), but some impacts endure.
- The major element of cost relates to the restoration of secure water supply as well as the provision of alternative water supply, while that restoration work was underway.
- The costs to households were the most difficult to calculate with precision. The midpoint of estimated costs being sought in a potential representative action was used as a proxy for household costs. Such costs are the second largest cost element, responsible for over a third of total costs.
- Business impacts were relatively minor and direct health impacts negligible.
- Not all impacts were negative; some interviewees reported positive impacts in the form of better cohesion and cooperation of Raetihi residents as a result of the sense of shared experience.
- The response to the incident involved a large number of agencies and people. The intensive efforts (and consequent toll taken on them) are not easily captured in full.

There are some idiosyncratic features that are noteworthy. In our view, these features reduced the estimated impact. In addition, such unique features make extrapolation to other water contamination events tricky. These features are:

- Significant “resilience” in the town. The residents of Raetihi are a hardy bunch and while the diesel contamination had a major psychological effect (i.e. the event is still very much alive in people’s memories and consciousness) there was no sense of panic and people appeared to adjust in a very practical manner.
- A replacement water supply was geographically proximate. The availability of such a supply eased the pressure somewhat in terms of needing to rapidly bring back on-line the existing supply, meaning that the risk of haste resulting in re-contamination was reduced.

- A significant storm event that occurred while the water supply was shut off assisted in the flushing of the stream that supplied the town water.
- A pro-active and intensive effort by the major local authority responsible for Raetihi water supply provided leadership and comfort, helping residents and agencies alike cope with the event.

Introduction

1. Sapere Research Group Ltd (Sapere) was commissioned by the Ministry of Health to assess the costs of a water contamination incident (via a diesel spill) that affected Raetihi in September/October 2013. The focus of the study was on the wider impacts felt by key stakeholders (i.e. residents, businesses, government agencies, non-profit service providers, suppliers) as a result of the spill, as opposed to public health concerns.
2. The motivation for the study was a desire to better understand the full range of costs associated with water contamination (and by analogy the benefits that society gains from water quality initiatives). In addition to bringing to light localised and event-specific impacts, the study is also intended to provide lessons in terms of management of any similar events that might occur again in Raetihi or in other communities.
3. In essence, the study is a contribution to the stock of knowledge on the value of safe, high quality potable water. It is not intended to be a “how to” guide. Nor is it intended to play any role in determining the quantum, or bringing about the resolution of claims against parties perceived as being responsible for the spill. To the extent that such claims are relevant to the study, treatment of them will be impartial and as “matter of fact” as possible. Furthermore, the study is silent on issues such as efficient levels of water infrastructure investment, engineering solutions, ownership and governance of freshwater.

Understanding the event

4. This section provides contextual and factual information on the spill event and the setting within which the event took place. It starts by describing, in general terms, the characteristics of the Raetihi population and the nature of the water supply for the town. It then details chronologically the relevant activities that took place in September and October 2013.

Scoping the population and area

5. According to the 2013 Census, Raetihi has a total resident population of 1,002 and 345 occupied dwellings (with 126 unoccupied). In Raetihi, around 56 per cent of households in occupied private dwellings owned the dwelling or held it in a family trust. The comparable figure for New Zealand is around 65 per cent. For households who rented the dwelling they lived in in Raetihi, the median weekly rent paid was \$150, compared to \$280 for New Zealand as a whole.
6. The most common ethnic group in Raetihi is Māori (65 per cent, compared to 15 per cent nationally), followed by European (55 per cent, versus 75 per cent nationally). The unemployment rate in Raetihi is 12.3 per cent, which is above the rate for New Zealand as a whole (7.1 per cent). The most common occupational group in Raetihi is “labourers” followed by “machinery operators and drivers” while “professionals” is the most common occupation nationally.
7. The median (i.e. half earn more, half earn less) income in Raetihi was \$20,300, compared with \$24,000 for the Ruapehu District and \$28,500 for New Zealand. In terms of the distribution of household incomes, Table 1 compares Raetihi with the rest of New Zealand, in terms of household income quartiles. Household incomes in New Zealand (the benchmark) are split into four equal parts (i.e. each quartile has 25 per cent of all households). The table clearly shows where Raetihi sits relative to New Zealand. Raetihi is over-represented in lower quartiles, particularly the lowest quartile (37 per cent versus 25 per cent for New Zealand). At the other end, the proportion of Raetihi households with incomes in the top quartile for New Zealand is only around a third.
8. In terms of impacts, this relative poverty could be mixed. On the one hand, poverty could limit the extent to which people are able to mitigate the effects of the event. On the other hand, the resilience of the community and the ability to “make do” would be a positive, that reduces the levels of discomfort felt, and hence the consequent ability to “get through” the event. Ultimately in our view, determining the degree to which relative poverty affects things requires more research.

Table 1 Household income distribution

Quartile	Proportion
Lowest group	36.9%
Medium lowest	34.4%
Medium highest	20.1%
Highest group	8.6%

Source: <http://profile.idnz.co.nz/ruapehu/household-income-quartiles?WebID=140>

9. There were 101 business locations in Raetihi, with 340 paid employees. The top five industries (by employee count) are shown in Table 2. This reflects the rural locality as well as highlighting the importance of the “hospitality and tourism” sectors to Raetihi. In addition, the table shows how concentrated industry is, with the top five industries accounting for around 70 per cent of employment in Raetihi, whereas the top five industries nationally account for around 48 per cent of paid employment.

Table 2 Industry make-up

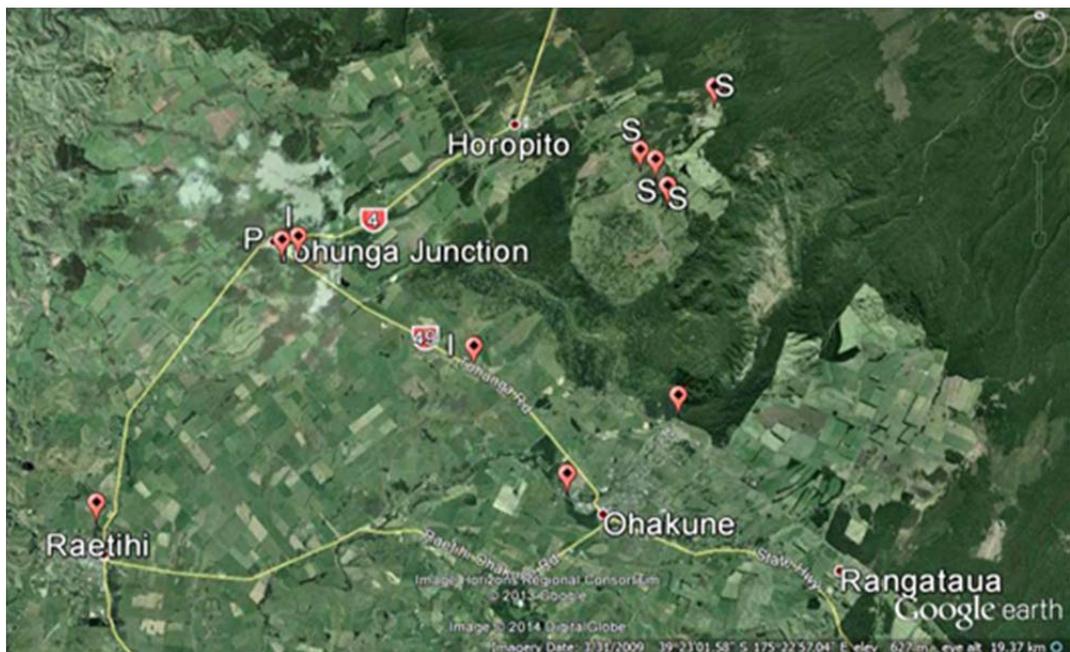
Industry	Employee count	Proportion
Agriculture, forestry and fishing	120	35.3%
Accommodation and food services	40	11.8%
Education and training	30	8.8%
Public administration and safety	25	7.4%
Health care and social assistance	25	7.4%

10. The figures that follow provide some idea of the locality of Raetihi and the particular water source that was affected. Raetihi is situated on almost level ground near the upper reaches of the Mangawhero River. The surrounding country is hilly. The town is around 15 kilometres west of Ohakune by road (see Figure 1). The main highway

between Wanganui, 91 kilometres south-west, and Taumarunui, 79 kilometres north, passes through Raetihi. National Park is 35 kilometres north-east.

11. Raetihi town water supply is abstracted from the Makotuku River at Tohunga Junction. The diesel spill contaminated this river. While the river was contaminated, an alternative water supply from the nearby Makara Stream was sourced. This stream, while fortuitous in terms of proximity and accessibility, has lower flows than the Makotuku River. In addition it flows through lots of open farmland. As a result it is susceptible to greater algae growth, with associated taste and odour effects.
12. For the purposes of this study, two factors are important. Firstly, an alternative source (the Makara Stream) was relatively freely available, once the primary source was contaminated. This was fortuitous and reduced the length and severity of the event. Secondly, the contamination was quite tightly confined to Raetihi. Despite Raetihi's close proximity to Ohakune, the latter is supplied water from another source and was thus not negatively impacted by the spill.¹

Figure 1 Location overview



Source: Ruapehu District Council

¹ Indeed, it was claimed anecdotally that Ohakune may have actually benefitted from the misfortune of Raetihi due to an influx of discouraged consumers and Raetihi residents who travelled there to shower, and secure additional supplies of water. It was noted that the price of bottled water in Ohakune rose considerably, but there is insufficient evidence to adequately ascertain the nature and scale of the relationship between this and the spill.

Timeline

13. This summary draws heavily on material produced by MidCentral DHB and Ruapehu District Council during and after the event and delivered in public forums.² It is an overview rather than a comprehensive record, to provide background and context. The overview describes the two key components of relevance – recovery and welfare.
14. Recovery relates to what was done to “put right” the incident (i.e. restore things to where they had been prior to the spill). It is more concerned with the physical side of the event. Welfare relates to the more human side; making sure that everybody has the necessities of life and minimising, as far as possible, the harm resulting from the event. Both give rise to costs.

The first week

15. The exact time of the diesel spill is not known. Sometime between Friday 27 September and Monday 30 September 2013. Approximately 19,000 litres of diesel was lost from the storage system on Turoa ski field, operated by Ruapehu Alpine Lifts (RAL). RAL contacted Horizons Regional Council to notify the spill over the weekend.
16. A small number of complaints from Raetihi residents concerning the taste and odour of the domestic water supply were received on Monday 30 September. Ruapehu District Council (RDC) arranged for Veolia (their water contractors) to investigate. The initial prognosis was that a seasonal algal presence was the cause.
17. By Wednesday 2 October 2013 two more complaints are received and council staff checks raw water storage facilities. At this stage, visible hydrocarbon sheen was seen on water surface. RDC notified the Medical Officer of Health at MidCentral DHB and a decision to shut-off Raetihi water supply under the precautionary principle was made, as potential unknown substance in water supply being consumed. Tanker supplies were arranged by RDC, from Ohakune, for Raetihi residents’ drinking water purposes. The Ministry of Health was notified by the Medical Officer of Health.
18. On Thursday 3 October 2013 it became clear that there was a link between the spill at Turoa and the drinking water supply in Raetihi (i.e. other explanations were discounted). RDC initiates Civil Defence emergency procedures and opens Emergency Operations Centre, but no State of Emergency is declared. RDC make arrangements for on-going supply of potable water (see Table 3), with no fixed termination date.

² MidCentral Health (Undated) “*Raetihi Diesel Contamination Incident 2013*” Presentation slidepack authored by Peter Wood and Margaret Tunbridge.
(2013) “*Health effects of Drinking water Contaminated with Diesel.*” 4 October.
Health Protection Agency (Undated) “*Diesel Toxicological Overview*”
RDC (2013) “*Raetihi Water Supply- Debrief Final 2013*”
“*Raetihi Water Supply – Public Meeting 22 October 2013*”
“*Raeti Water Supply – Waimarino Water Supply?*”

Table 3 Tanks installed

	RDC Supplied	Private	Total
Residential	5	44	49
Commercial		12	12
Community Facilities	7		7
Street Supply	10		10
Total	22	56	78

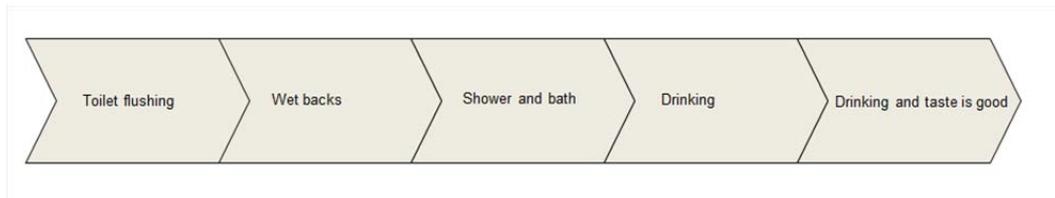
Source: Ruapehu District Council

19. Delivery and installation arrangements for temporary toilets and showers are also made by RDC, drawing on local armed forces expertise and availability of resource. A public information campaign is commenced.
20. A public meeting was held on Friday 4 October 2013 and plans were detailed around finding an alternative water source. The next day, flushing of the raw water ponds and Makotuku stream by the Fire Service and others started. Portable showers and toilets were installed in town at Heartlanz Inn and various Marae. Water pods were installed throughout Raetihi (78 in total).

Weeks two and three

21. The focus on this period was on works necessary to restore supply. An alternative source of water (the Makara stream) was identified and pumps and pipes installed between the 7th and 9th of October. Following sampling, on 9 October 2013 RDC applied (under section 69X of the Health Act) for registration of the Makara Stream as a new source for Raetihi. Cleaning of pipes leading to the reservoir and the reservoir itself, as well as the flushing of main pipes and the delivery of bottled water throughout town commenced.
22. During the mains cleaning process, residents were advised not to use water at all, despite it reaching their homes. The release of water use types (in order) after three days of clear samples is shown below. Replacement services (e.g. bottled water) were not withdrawn until the house had functioning services.

Figure 2 Order of release of water use types



23. Final mains flushing, inspection of Raetihi and the clearance of water use for washing, laundry and showering took place between 14 October and 18 October respectively. Drinking water clearance was obtained on 22 October, following the removal of portable showers and toilets the day before.

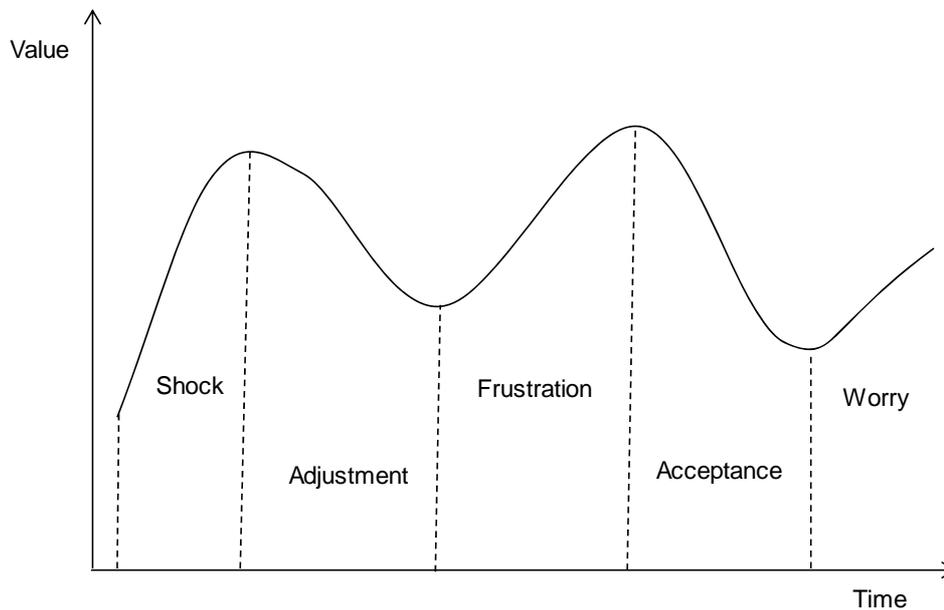
Week four

24. This week saw the phasing out of water deliveries (both bottle and mass tanker), communications issued around the return of council-supplied tanks, and the removal of water pods around the town. Between 25 October and 1 November a single tanker was maintained and negotiations between individuals and the RDC “man on the ground” in terms of the removal of RDC-provided tanks and the acceptability of other arrangements took place.

A stylised response function

25. The time period without usable water was reasonably significant. The likely costs and reactions given such a time interval would vary in a time-dependent manner. Combining the insights we received from our interviews with insights from relevant literature, we posit the following characterisation value of water over time (see Figure 3).
26. Initially, there is an element of shock and disbelief. In a relatively short space of time, the value that people place on water availability jumps. Following this initial reaction, there is an adjustment period, where alternative sources of water become available and while inconvenient, there is growing acceptance of the makeshift conditions. The value placed on water availability falls accordingly, though does not reach pre-event levels. This period lasts slightly longer than the shock, but over time frustration levels rise and so too that value of water. In other words, the novelty wears off and people start wondering whether a solution is possible, shifting the value of water back up as a means of “hoarding.”
27. After this period a degree of acceptance of the situation becomes apparent and sees that value of water reduce to levels similar to the initial adjustment phase. However, even towards the end of the event, worry sets in around the actual quality of the water supply (i.e. is it as clean and safe as it once was?) and residual worries about the likelihood of similar events occurring again. This means that the value people place on safe and accessible water availability ends up higher than previously, and is likely to represent a new steady state.

Figure 3 Response function



Source: Sapere

Categories of impact

28. This section describes the types of effects likely to result from a water contamination incident. Petroleum products are composed of volatile organic compounds. Any oil spill can pose a serious threat to human health and the environment, requires remediation that extends beyond normal boundaries, and results in substantial cleanup costs. Even a small spill can have a serious impact. A litre of oil released into the water can cover almost a hectare of water surface area and can seriously damage an aquatic habitat. A spill of only one litre of oil can contaminate one million litres of water.
29. It may take years for an ecosystem to recover from the damage caused by an oil spill. The location of the facility must be considered in relation to drinking water wells, streams, ponds and ditches (perennial or intermittent), storm or sanitary sewers, wetlands, mudflats, sandflats, farm drain tiles, or other navigable waters. Factors such as the distance to drinking water wells and surface water, volume of material stored, worse case weather conditions, drainage patterns, land contours, and soil conditions must also be taken into account.³

³ Environmental Protection Agency, USA (2001) "Managing Above Ground Storage Tanks to Prevent Contamination of Drinking Water." Source Water Protection Practices Bulletin at: http://water.epa.gov/infrastructure/drinkingwater/sourcewater/upload/2006_08_28_sourcewater_fs_swpp_ast.pdf

30. We sought to take a broad approach to identifying types of costs, in order to form as comprehensive an assessment as possible. Based on the literature, we classified costs into the following four categories:

- **Indirect costs:** costs that are not directly attributable to the event (instead these are costs of the fact that there is contamination);
- **Direct costs:** those directly attributable to the event (although the cost might potentially be faced by someone else);
- **Tangible costs:** those costs that are measurable or otherwise quantifiable (though not necessarily in dollar values); and
- **Intangible costs:** costs that are not straightforward to measure/quantify.

31. The following table sets out the types of costs we included in each category.

Table 4 Costs considered in our assessment

Cost category	Cost type
Direct tangible	<ul style="list-style-type: none"> • Health and welfare costs • Lost productivity of workers • Replacement water being made available • Clean-up costs • Transport costs associated with travel to sites with water • Communication and coordination costs
Direct intangible	<ul style="list-style-type: none"> • Health outcomes • Hassle factor (not otherwise captured) • Business interruption • Environmental and aquatic damage
Indirect tangible	<ul style="list-style-type: none"> • Costs for authorities dealing with the contamination <ul style="list-style-type: none"> – Diagnosis of problem, treatment of such and remediation • Costs of managing water quality and availability during the event <ul style="list-style-type: none"> – Staff time dealing with communications aspects as well as coordination of response • Costs of the aftermath of the outbreak <ul style="list-style-type: none"> – Installation of monitoring and warning equipment – Staff time dealing with administrative aspects (e.g. insurance claims)
Indirect intangible	<ul style="list-style-type: none"> • Loss of faith in water quality

Approach

32. This section describes the approach taken to the measurement of costs associated with the spill. We conducted a brief literature review, which was useful in terms of developing an economic conception of water and understanding what work has been done elsewhere, there was only limited direct relevance to this project (see Appendix 1). The key practical insights are as follows:
- Just because water is not priced does not mean it has no value
 - Water is an essential part of life, but this essentiality accounts for only a small amount of the total value, and values will differ both across and within user types
 - Issues of location, timing, quality and variability/uncertainty impact heavily. To a user, one litre of water is not necessarily the same as another litre of water if it is available at a different location, at a different point in time, with a different quality or with a different probability of occurrence. As a result, marginal values for water may be much more important than average values
 - While there is generally no property right on water, the expectation in developed countries is that people will have access to safe, high quality water
 - Water is different from other economic goods and commodities, particularly in relation to emotional and psychological aspects, but water is amenable to many of the tools and techniques of economics to analyse.

Analysis components

33. Given the lack of relevant insight from our literature search, the main component of the analysis was 17 stakeholder interviews, involving over 20 people. The majority of interviews took place in-person on the 29th and 30th May 2014 in Taumarunui, Raetihi and Whanganui. In addition, a smaller number of interviews/conversations were conducted by telephone. The table below provides a summary, while an outline of questions is contained as an appendix. These questions are focused on businesses and providers of services, as opposed to residents, but were tailored verbally for respective audiences.
34. Careful consideration was given to the apparent under-representation of households in our interview count. Given the focus on economic costs, much of the emphasis of the interview programme was on business and other financial impacts as opposed to personal costs). We saw utilisation of a potential representative action on behalf of residents as a way to include household/individuals/families' perspectives in a way that did not require significant resources, while also applying a monetary lens. That allowed us to capture the importance of the household sector without necessarily spending a large amount of time interviewing individuals/families/households, where confidentiality considerations meant that access to a pre-prepared "database" was not possible.

Table 5 Interview summary

Group	Description	Number
Households	Individual residents and their representative/s	3
Businesses	Providers of relevant goods and services	3
Officials	Local authority staff, contractors and elected representative/s	5
Service providers	Health, emergency and other “public” service providers, Iwi organisations	6

Impacts on households

35. Relatively early in the piece, households that were considered to be particularly vulnerable (e.g. heavily reliant on water supplies and/or severely restricted in their ability to access alternative sources of water) were identified and prioritised by relevant authorities and those in the know. Thus, the household impacts are neither uniform nor linear. Household composition (e.g. number of children, parental situations, age/s) all influence the range of impacts that might arise. In addition, attitudes and previous experiences also shape responses to events and the ways in which they are dealt with.
36. The main source of costs to residents/households was inconvenience. There were no medical costs (i.e. illness) directly attributable to the spill. We were unaware of any residents/households that were unable to source at least some water (principally for drinking purposes), albeit not necessarily instantaneously and in lower volumes than residents were used to. Household inconvenience and the extent to which day-to-day living was compromised is categorised as follows:
- Nutrition - hygienic preparation of food, the cooking process (particularly where wetbacks are used), and the ability to keep dishes cleaned
 - Laundry – regular washing of clothes, manchester and towels
 - Hygiene – both personal hygiene (showering/bathing) and household hygiene (toilet flushing)
 - General cleaning- internal and external surfaces, pathways and the like
 - Transport and time costs of accessing replacement water supplies
 - Stress and other mental health factors

Impacts on businesses

37. Businesses under the broad rubric of tourism (e.g. accommodation, restaurants, cafes, leisure and recreation services) were identified as most affected by the spill. This is to be expected in something of a “ski town” where accommodation needs are highly seasonal.⁴ However, to the extent that discretionary expenditure of residents is negatively affected by the need to spend on essentials, other businesses may also see negative impacts. Finally, those businesses that rely on readily available water, either to undertake the activities they routinely engage in or to ensure that employees are able to be adequately hydrated and have sanitary conditions, would also feel impacts. In short, we would expect almost all businesses to feel some impact, not all of which would be negative.
38. Particular impacts discussed were:
- Loss of revenue- closure, cancellation of bookings, discouraged demand
 - Loss of productivity- shorter shifts, staff distractions
 - Damage to equipment- at commencement and as a result of alternatives
 - Increased costs associated with operations (i.e. even if activities were not interrupted, it simply costs more and takes longer to get things done in an environment without permanently available, *in situ*, water supply)

Impacts on officials/authorities

39. Authorities and officials face both direct and indirect impacts. Not only do they have responsibility for remediation (i.e. corrective action in a physical/engineering sense), but they also play a role in looking to minimise the impact on other parties in their jurisdiction (i.e. in a metaphysical and comfort-related sense). Both are equally important, and require specialist skills and commitment.
40. Relevant physical dimensions identified were:
- Assessment and diagnosis costs associated with detecting the nature, scope and cause of the spill
 - Treatment costs once contamination confirmed
 - Equipment costs associated with remedial and preventive actions in terms of existing water supply
 - Costs of finding, securing and delivering alternative water supplies while current supply unavailable

⁴ It is difficult to get an accurate picture of bed availability in Raetihi, but a “back of the envelope” calculation indicates that Raetihi could readily accommodate 150 people, given the approximately 52 rooms available (assuming between two and three people per room each with their own bed, on average). That equates to an almost 15 per cent increase in population if all beds are taken.

41. Relevant non-physical dimensions identified were:
- Information and communications-development of appropriate resources and the provision of such
 - Planning and execution of response actions- assessing, monitoring and responding to residents' various needs
 - Other administrative and coordination-type responsibilities

Impacts on service providers

42. A number of different agencies were involved in the response side of the event, each with particular parts to play in the overall programme. Despite these separate and distinct roles, there was some commonality across groups in terms of the cost impacts. The impacts felt by service-based organisations largely relate to the opportunity costs of reacting to the initial event and preparations for further response, if required. By opportunity costs we mean resources that could have been deployed elsewhere, but were required for the spill. There are few direct financial costs associated with the deployment to assist with the spill, but there is a resource cost nonetheless.
43. Possible impacts are:
- Staff costs- time, salary, overheads, allowances
 - Expenses- staff-based travel/accommodation; equipment usage and readiness/dedication to spill

An Iwi/ Māori perspective

44. As described in the demographics section above, almost two-thirds of Raetihi's population identify as Māori. Given that over half of the population also identify as European, a reasonable assumption might be that a distinct Māori perspective would be difficult to discern. Such an assumption is reinforced in respect of the main impact categories of interest- in this case economic and financial impacts, which are likely to be felt in similar ways by Māori and non- Māori.
45. One prominent Iwi leader talked of a focus on the needs of people, which may be similar regardless of race, but which may differ in terms of the method of delivery. In particular, Māori have a clear preference for relatively frequent, face-to-face communications and for protocols around the nature and manner of communications. Moreover, the standing of the person who delivers the communications (and consequently the order by which communications are transmitted) is of importance. Partnership principles are relevant, and the speed of communication matters from a Māori perspective.
46. In addition, environmental and cultural impacts are closely aligned for Māori. This is especially so for water. From a practical perspective, particular impacts might arise where the location of the spill was a traditional food gathering site. From a more ethereal perspective, the *mauri*, or life force of water ways has significance. In the case of the existing water source, altered flows as a result of shutting off town supply is relevant, while the flow and use of the water from the alternative source may give rise to impacts peculiar to Māori.

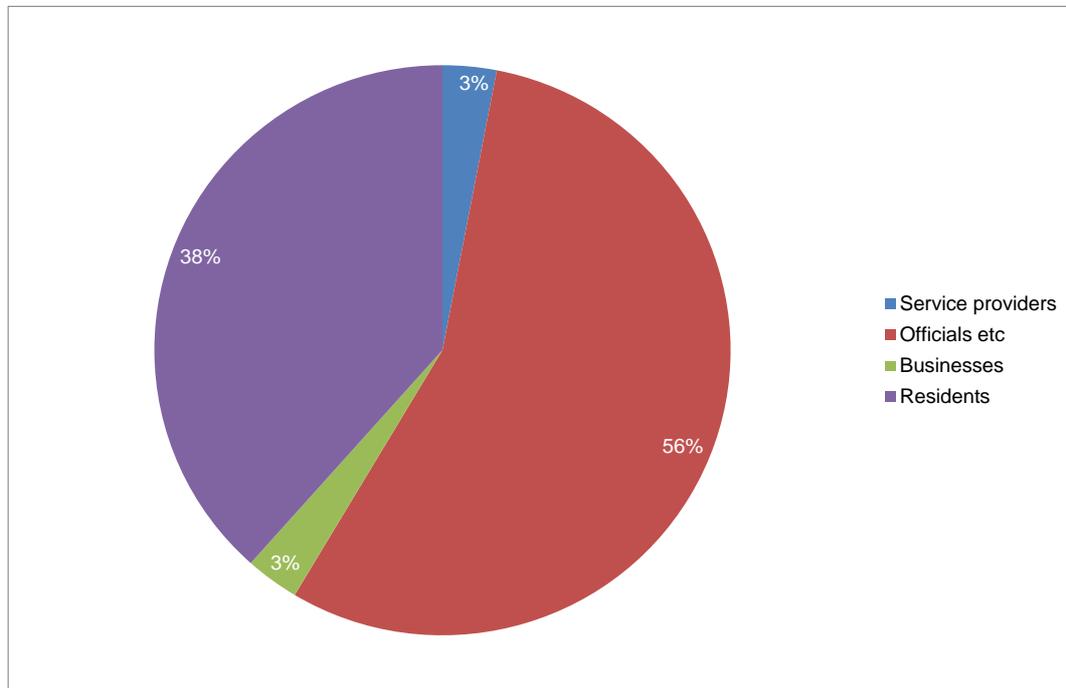
47. While we sought views from local iwi contacts, our treatment in this report is somewhat limited. This is not to say that iwi/ Māori views are not important; only that resources available for the project determined where effort was best directed. We understand that impact statements have been prepared from both of the major iwi involved in the spill response that deal with effects in a manner that would not be done justice in a report such as this. In addition, our understanding of the role that iwi played (as “service providers”) would be difficult to accurately separate from normal activities and/or would be captured in existing cost estimates. For this reason, we note the existence of a Māori perspective, but leave the expression of that to others more qualified than us to describe it.

Cost calculations

48. The estimated costs associated with the spill event were calculated to total around \$1.9 million across a period of two years. The vast majority of these costs were “time bound” (i.e. response and remediation), but approximately \$97,000 of on-going costs from impacts that continue after the event have been estimated. Figure 4 shows that, residents are responsible for the majority of “one-off” costs/impacts. This is a function of volume as much as anything else.
49. Moreover, these impacts are subject to relatively more uncertainty given the qualitative nature of some of the identified impacts. Ongoing costs accrue largely as a result of further monitoring work required by RDC as well as (estimated) discouraged demand faced by operators in the accommodation and food services sectors, which we have assumed would bleed out in two years’ time.
50. To put this estimate in perspective, one-off event costs (of around \$1.8 million) represent the equivalent of almost 89 homes (26 per cent of the total in Raetihi) being without income for an entire year.⁵ While the cost estimates derived in this study are not strictly financial costs (i.e. they are not “out-of-pocket” costs as such) putting the cost impact in these terms illustrates the equivalent hardship faced in Raetihi, when translated into household impacts (who ultimately bear the costs in the long run).

⁵ Drawing on median annual household income of \$20,300.

Figure 4 Breakdown of cost impacts by broad stakeholder grouping



Caveats and assumptions

51. Before outlining the cost estimates (and their basis) a number of points which limit the nature and scale of information that can be reported should be noted.
 - *Confidentiality*- as indicated earlier, the detail around cost impacts came from the collective “horse’s mouth.” Participants were assured that not only would comments not be ascribed to any particular person or organisation, but that commercial sensitivity would be maintained. This is especially important in the context of on-going and unresolved insurance claims.
The consequence of this limitation is that cost estimates are reasonably highly aggregated.
 - *Observability*- while every effort was made to capture and verify as much information as possible, it is likely that a number of costs remain unseen, either because the scale or incidence of costs weren’t in the immediate consciousness of interviewees, or they were thought of, but seen as just part of “pitching in.”
The consequence of this visibility limitation is that cost estimates may be understated (i.e. actual costs may be higher than those estimated). While this is a risk for most studies of this type, in the case of unusual events that involve a high degree of implicit or indirect impact, the risk may be more acute.
 - *Verifiability*- for many of the costs (e.g. staff time) either systems do not exist to accurately capture all of the time costs, or the time was simply not recorded, as that time was not being paid, or through oversight or because timekeeping was a low priority activity in the midst of the event.

There are two points worth highlighting. The first is that recording of time involves an element of judgment (particularly as it was largely done ex-post), meaning the figures used could over or under estimate the actual time costs. The second concerns the additionality of time estimates. In analyses such as these we are interested in marginal (additional) costs only. That is, costs which would not have otherwise occurred. Using average costs would likely result in overstatement of costs as averages include sunk costs and some fixed costs which are not necessarily affected by the event.

The basic “rule” we applied was that staff time was included only to the extent that it was additional to what staff would have competed in the normal work day, or resulted in the deferral or abandonment of activities that would otherwise have taken place. Again, we were unable to fully verify the degree to which event-related activities crowded out other planned tasks, but discussed the issues with relevant interviewees at some length and exercised judgment around the extent to which costs were included in the analysis.⁶

Overhead costs were excluded as our judgment was that the structure of overhead costs would not have been materially altered by the event.⁷ Finance charges are also excluded on the basis that they are financial transfers from one party to another, and do not affect resources available in society as a whole.

Costs to households (\$700,000)

52. We present a “top down” estimate and no breakdown is available in terms of the components of the respective household claims. We understand that the basis of any claims is emotional suffering and inconvenience. In the interests of consistency, comparison with other general damages claim situations is underway. In the interests of completeness we include the provisional estimate in our calculations, but acknowledge that the action may not proceed and therefore establishing the costs to households remains extremely difficult. Nevertheless, the fact that representative actions are being considered at all, does point to a potential cost impact that might not otherwise be contemplated (and ergo adds to the beneficial value of high quality, secure drinking water).
53. We are not able to determine the precise cost to households. A representative action is being investigated, with average claim amounts that range from \$1,000 to \$3,000

⁶ The most relevant application of this rule was in respect of the contribution of Fire Services resources from Whanganui. We were told that the involvement of trucks and manpower was essentially “business as usual” (i.e. the response was part of what the fire service is there to do) and did not represent any “additional” cost as a result. Our assessment was that there is still an opportunity cost (even though reserves were available) and that wear and tear on trucks and extended work periods were necessary (with some back-filling). We used a figure of 50 per cent of estimated fire service costs to account for such effects. For other emergency management resources utilised, two factors led to the decision to include costs as estimated. Firstly, the event was considered unusual in the sense that impacts were felt simultaneously and by all parties, as opposed to being felt by specific groups of people or being locationally distinct. The second was that cost estimates provided were based on “extraordinary” and specific uses of resources, and so were a reasonable approximation of marginal or additional costs.

⁷ This approach is in line with Treasury advice on cost-benefit analysis (section 2.3.4 Cost-Benefits Analysis Primer).

per household, depending on the composition of the household (e.g. number of children, number of parents and/or income earners, etc.).⁸ For the purposes of this study, we have used a central figure of \$700,000 as an indicative estimate of costs to residents. This equates to around \$2,000 per household (for 345 households). While this is midpoint of the indicative range above, it is at the lower end of the total figure we understand may be sought by the action.⁹ Given the likely range of costs, the focus of the work being more about economic costs/commercial losses and the significant burden involved in interviewing large numbers of householders, we took a conservative approach to this category of cost.

Costs to businesses (\$55,000)

54. The picture is somewhat mixed in terms of impacts on business. Those with a focus on hospitality/tourism indicated that they faced a drop in business as a result of the event (i.e. lost bookings and discouraged demand), though the interview process was not able to confirm with any surety the magnitude of lost business. Non-tourist-related businesses reported no discernible impact on turnover/revenue or other aspects such as worker productivity.
55. Anecdotally, there were indications that for some businesses, the effect may have been positive. The rationale for this was the extent to which residents spent more time in the street (i.e. outside of their homes) and as a consequence were more amenable to spending on items such as food, coffee, etc. We were unable to confirm this. Rather than include any possible positive revenue impacts, we have conservatively zero-rated the impacts (i.e. any negative effect is entirely offset by a positive effect).
56. There were no reported instances of employee productivity being affected. While the whole town was concerned around the time it would take to restore potable water supplies, it did not seem to manifest in terms of worker performance. The inconvenience factor associated with personal hygiene seemed to be “taken in their stride” by workers. Damage to equipment was reported twice, but was relatively minor in one case, and is included in total damages in another.
57. Commercial sensitivity precludes us from individually itemising business costs. We estimate that, in total, the spill resulted in one-off/event-related costs to business of around \$55,000.¹⁰ On an individual basis, this equates to an average of around \$545 per business, although obviously the impacts would be heavily concentrated in a much smaller number of firms.
58. We note that this estimate relates exclusively to Raetihi. In the case of cancelled bookings and/or discouraged demand, it is possible (and likely) that alternatives

⁸ <http://www.stuff.co.nz/waikato-times/business/9316051/Insurance-claim-for-Raetihi-diesel-spill>

⁹ Personal communication with lawyer leading the development of the action.

¹⁰ Note again that costs to RAL have not been included in these estimates. We understand that such costs may be sizeable, and include fines, direct and indirect staff time, provision of water supplies and other resources to residents, and reputational costs.

would have been sought. This is especially so given the spill occurred during the ski season. When viewed from a broader perspective (e.g. regionally) there may not have been perceptible business impacts (i.e. Raetihi's loss may be Ohakune's gain, as Raetihi is not necessarily a standalone destination in its own right.). However, our scope is limited to impacts on Raetihi and thus we include these costs in the calculations.

59. We note that one particular business-related impact that appeared to be negligible was production or stock losses. Given the importance of agriculture, forestry and fisheries (at least in terms of employment) this was potentially an important factor in assessing actual impacts. However, we received no confirmation of losses in production or stock numbers as a result of the water contamination. The major explanation offered was that farmers were either easily able to find alternative water supplies or were already using these alternative supplies.¹¹

Costs to officials/authorities (\$1,000,000)

60. Ruapehu District Council (RDC) led the process of compilation and verification of a lot of the cost impacts of the spill, both internally as an organisation and on behalf of its constituents. That is, RDC has played coordination and a response role. In assessing costs, we were careful not to “double count” costs that might be included in both the RDC numbers and those relating to businesses or residents.
61. In addition to RDC cost estimates, which are far and away the largest component of this category of costs, we have included actual costs for Wanganui District Council (WDC), Waikato DHB, and modelled costs for Horizons Regional Council.
62. These costs are yet to be finalised and should be considered as indicative.¹² The lions' share of costs in this category appears to relate to staff time, although given nearly all Council staff were involved with the emergency effort and were performing their other duties at the same time it was very difficult to accurately identify specific “spill-related” costs. Major activities undertaken were:
- Monitoring and checking up with residents in terms of the extent to which their needs are being met;
 - Provision and distribution of information;
 - Organisation and attendance at public meetings;
 - Call centre staffing for enquiries;
 - Record-keeping of actions, events and responses;
 - Oversight and facilitation of recovery actions;
 - Coordinating and collaborating with other agencies involved;
 - Follow-up (post water being turned back on) meetings with businesses, residents, agencies); and

¹¹ Non-production related farming impacts are noted further below in the intangible costs section.

¹² However, it should also be noted that the exact costs are highly unlikely to be below the figures cited here.

- Extraneous information-sharing activities (i.e. aspects that would not normally be in the remit of council staff, but arise due to the nature of the event, and where synchronisation of information and understanding is important; involves assessing health status, iwi liaison and mediation for example).
63. The total combined (physical and non-physical) costs associated with the spill to date are estimated to be around \$1,000,000, almost all of which were faced by RDC. High-level indicative costs are outlined below in as much detail as possible.

Category	Description	Amount
Welfare	Plumbing/installation of temporary tanks	\$70,000
	Toilet and shower operations	\$200,000
	Water delivery and tanks	\$200,000
Recovery	Contractors' costs to clean/flush, repair and restore town pipes and conduct tests for alternative supply	\$302,000
	Sourcing alternative supply (pipes, installation of sensor, hire of pumping systems)	\$170,000

Costs to service providers (\$60,000)

64. The service-based organisations included are:
- New Zealand Fire Service- costs associated with flushing the Makotuku stream and water ponds, as well as delivery of alternative water supplies
 - Red Cross- costs for oversight and coordination of welfare-based responses to people in need.
 - MidCentral (MCDHB) and Whanganui DHB's- costs of arranging alternative care for those in need (including transport), lead public health advice, sampling and testing water quality, provision of public information, assessing the extent of health-related impact (including liaison with GPs), provision of services (e.g. laundry, showers) for those in most need, provision of supplies (e.g. handwash and medical supplies).
 - Waimarino Health Limited- while this is a private practice and should probably be considered under the general business rubric, the involvement of staff in the practice was akin to community health and wider service provision rather than there being a commercial effect *per se*.

- Raetihi School- the two components of cost faced by the school were the sourcing of water filters (which were precautionary and separate from the major works done elsewhere) and staffing time costs.¹³.
65. The main component of fire service costs was the opportunity cost of the use of fire trucks. The basis of the estimate was the cost used by the service to charge for “false alarms” at commercial premises where units attend. In such situations the business is charged \$400/hr and we use that as a proxy for the resource costs incurred as a result of the spill. As indicated earlier, we discounted the estimated cost by 50 per cent to reflect that fire services are by their nature, responsive and that the opportunity cost of attendance may be zero (but could also be substantially higher where units are tied up and a “real” call-out occurs).
 66. In addition, staff costs across four full days totalled an estimated \$1500, inclusive of overtime. Again, we discounted that figure by 50 per cent in our calculations to reflect the “on call” nature of fire service resources.
 67. Red Cross costs were estimated relative to WDC costs. We received actual costs from WDC and assumed, based on discussions with relevant WDC staff, that the personnel costs (i.e. time) were around 25 per cent greater for Red Cross, while travel and transport costs were equivalent.
 68. For Waimarino Health Limited, the practice manager was made available to assist in any way needed for the duration of the event. Salary costs for standard work hours were met by the practice, while any time outside the norm were provided on a volunteer basis. We were informed that paid hours totalled two weeks (i.e. 80 hours) while unpaid time totalled a further half week (20 hours). We used annual estimated salaries available in public domains for the “paid” hours¹⁴ and valued the “unpaid” hours at a third of that rate.
 69. In the case of MCDHB, the major cost component was the staff time for Health Protection Officer, Drinking Water Assessor and Medical Officer of Health resources, who had responsibility for allowing the water to be “turned back on.” Drawing on publicly available collective agreements (rather than personal data) estimated salary costs of \$75,000 and \$165,000 respectively are used.¹⁵ A total of 150 hours between all staff was used, around half of which relates to Health Protection Officer and Medical Officer of Health time, with the remainder accounted for by the Drinking Water Assessor. In addition, we assume \$1,000 of costs to produce and distribute information.
 70. Raetihi School was on holiday for some of the time that town water was not available, minimising the impacts to some extent. Nevertheless, they installed water

¹³ We note that similar costs would be faced by the Nancy Winter Early Childhood Centre, but were not able to confirm the nature and scale of such costs. We have included only a nominal amount in the cost estimates to account for this.

¹⁴ <http://www.nzma.org.nz/sites/all/files/Wage%20Clauses%202012%20MECA.pdf>

¹⁵ http://www.wdhhcareers.co.nz/core/lib/other/wysiwyg/uploaded/SMOMECA2011to2013_1.pdf; and District Health Boards/PSA Allied, public Health and Technical Multi Employer Collective Agreement <http://www.dhbsharingservices.health.nz/site/er/eas/mecas.aspx>

purification filters as a result of concerns that residual contamination was present in the water even after the all clear had been given. Through assistance from RDC the filters were obtained at a discounted cost of around \$2,000. Other costs included in this report relate to greater use of relieving teachers due to illness of teachers. While it is acknowledged that staff illness is influenced by many factors, the additional cost in the year immediately following the spill was over 100 per cent greater than average. This cost has been estimated at \$17,000 in the year following the incident.

71. The impacts on the early childhood centre in Raetihi would be similar in nature, though smaller in magnitude. We were unable to confirm precise impacts in time for reporting here, but have allowed for \$8,000 in total as a ballpark estimate.
72. No allowance has been made for the cost of bottled water at the homes of the children as it is difficult to determine whether bottled water was purchased and such costs are likely to be captured in the household cost element. We are aware, however, that a group of parents had their children use bottled water. We are aware that the incidence of “tummy bugs” and “sore bellies” for the children at school was approximately 30 per cent higher in the following year. Again, evidence of costs associated with such impacts (e.g. medical attention) is scant, and such impacts are likely to be included in the representative action household cost estimates, so are mentioned here only for the sake of completeness.
73. We calculate the total estimated cost impact for service providers to be in the order of \$60,000. As detailed, the total represents a combination of “opportunity costs” and financial/remuneration costs.

Ongoing costs (\$97,000)

74. While the event is somewhat discrete in nature (i.e. the water supply was shut off and put back on in a defined period) some impacts are likely to be felt for some time after water supply restoration. The ongoing effects are difficult to discern, both in terms of quantum and duration. This is especially so in respect of householders’ concerns expressed about the quality of water following the event. Anecdotal reports of slight discolouration and inferior taste are unable to be accurately verified.
75. Two categories of ongoing cost have been included in this study. The first relates to ongoing welfare and recovery costs for RDC, which includes monitoring, addressing enquiries, documentation/record-keeping and the like. Such costs have been estimated by RDC.
76. The second category relates to a potential reputational effect on providers of accommodation and food services to tourists. While we accept the prospect of discouraged demand, we also acknowledge that it is difficult to accurately determine (or even directly observe). Put simply, such impacts generally remain hidden and thus need to be approximated.
77. For this category of costs, we assume the impacts would be felt for two years (i.e. after two years there is no affect at all) and that the quantum in the second year is half that of the first year. We use actual estimated costs for RDC and approximate ongoing discouraged demand as 10 per cent of the “one-off” event-related impact. The latter is purposefully conservative, given the uncertainty inherent in calculating

such effects. Further we present the estimated cost impacts in present value terms, using a discount rate of eight per cent (i.e. \$1 received in a year is only worth \$0.92 in today's terms, or equivalently, you would need to receive \$1.08 in a year's time in order to forego \$1 today).

Intangible effects

78. A range of intangible impacts were identified, but not included in calculations. Not all of these intangible elements are costs; mention was frequently made of beneficial impacts as a result of the spill. Intangible costs identified were:
- *Volunteer time*- a range of volunteers gave their time to assist in the procurement and delivery of information, (bottled) water supplies, transportation options as well as other social activities. Such volunteers came from formal (i.e. organisational) and informal (i.e. community-based) sources, particularly local iwi. Attempting to get a sense of the quantum of such assistance was deemed futile. Nevertheless, it was a real and major observation across interviewees.
 - *Pro bono contributions*-physical equipment (e.g. trailers, pumps, pipes) was reportedly provided free of charge by some commercial operators for aspects of the recovery phase. In addition, some facilities outside of Raetihi were provided by local iwi for medical use (i.e. birthing) without charge. Getting an understanding of the nature and quantum of this assistance is difficult. It is however, important to be aware that such contributions were made.
 - *Hassle factor*- this element of intangible costs relates to the inability (through lack of water) to be able to do things in the normal manner by which you do them when water is freely available. It includes new activities (e.g. attending public meetings to gain information) as well as existing activities (e.g. showering in less familiar and perhaps less comfortable surroundings). In most instances, the "hassle factor" does not involve the entire loss of the ability to undertake beneficial activities.

Rather, it means they are less enjoyable (showering), take more time (collecting drinking water as opposed to having it delivered), are delayed or put on hold (laundry) or constrained as to frequency or volume (toilet flushing). In addition, there is the additional burden of staying informed (e.g. public meetings, phone calls and other discussions) that weigh on the minds of both residents and businesses alike.

A further subset of impacts under this category is stress. Stress was reported as a major factor for those involved in the response to the spill (particularly RDC staff and representatives) as well as those who to whom the response was directed (i.e. residents). While the time costs associated with longer working hours captures some of the impact on response personnel, a residual that is not able to be adequately captured would remain. Placing a specific value on such impacts is impractical. The representative (class) action estimate for households would contain some factor relating to inconvenience and stress, so to some degree this element is already included in the totals for this study, though not in a separable and identifiable fashion.
 - *Confidence*- while some values have been applied to loss of confidence in water quality in another study, they related to the additional actions required to gain

confidence that the water was safe to consume following waterborne disease outbreak (i.e. boiling water for a certain time, or installing a filter).¹⁶ It is not clear what the equivalent actions (if any) might be in relation to diesel contamination. Moreover, they are likely to be captured in the representative (class) action estimate for households, so no specific treatment of such impacts is included in this study.

The study also raised some concerns around the degree to which trust in public authorities (e.g. RDC) was reduced following the spill. Our assessment is that attributing any diminution of trust to this particular event is extremely difficult and that pre-existing attitudes are more likely to be a greater contributor. In addition, we also heard views to the contrary- that trust was *enhanced* following the event. For these reasons we have not included any confidence-related impacts in our calculations.

- *Environmental degradation*- we did not delve deeply into this aspect. To the best of our knowledge, there were no noticeable ecological or environmental effects as a result of the spill. The common view was that the occurrence of a 1-in-40 year storm event which took place while the water supply was cut off assisted in the flushing of any hydrocarbons from natural water systems and that no residual traces were left as a result.

79. Intangible benefits mentioned were:

- *Cohesion*- within Raetihi it was reported that there was a much greater degree of positive contact between residents than normally. People congregated and talked in the main street, had more face-to-face contact with neighbours and others and the general sense of community was enhanced through the common bond of “being in this together.” The event provided an opportunity for the townspeople of Raetihi to show their resilience and there was a reasonably strong feeling that they demonstrated that well.
- *Preparedness*- the event seemed to assist the community to be aware of possible emergency situations and to prepare accordingly. This was not a strong feature, but was mentioned as a positive result.
- *Interaction*- in addition to the greater degree of within-town interactions, it was also evident that the relationship between Raetihi residents (i.e. “the town”) and RDC (and others) was strengthened. Both parties saw this as a positive, as residents had previously felt somewhat marginalised and RDC had felt a degree of separation from, and suspicion towards RDC from residents. This may be a temporary effect but was noticeable from the interviews.

¹⁶ Sapere (2013) “The 2012 waterborne disease outbreak in a small town in New Zealand: an estimate of costs.” Report to the Ministry of Health.

Appendix 1 Literature overview

80. While we find that there is a significant volume of literature involving the economic costs to society of water contamination, very little of this material is directly relevant. This area of research primarily consists of discussions about the prevalence and magnitude of health-related effects caused by contamination of drinking water supplies.
81. Several studies have shown that these adverse health effects are very significant, and the economic costs to society are substantial. For example, one case in particular prepared by Harris Consulting estimated that the economic cost of 18,000 cases of water-borne diseases in New Zealand is about \$25 million per annum.¹⁷
82. Although there is some discussion of other effects of water contamination that are not health-related, we find that there is very limited research on the quantification of these impacts. Some of the examples of other non-health related impacts in existing literature include the effect on industry (e.g., decreases in commercial property value), the impact on agricultural production (i.e., ecological / environmental damages), and the effect on residential households (i.e., procurement of alternative water supplies).¹⁸
83. Reddy et al. (2006) found evidence to suggest that there are substantial monetary losses to agricultural production, human health and livestock when comparing the effect of water pollution of two villages in India.¹⁹
84. Other adverse impacts of water contamination that have also been studied in existing literature include the impact on property value and is discussed extensively in Page et al. (1993). Page et al. (1993) finds that there is evidence to suggest that contamination of toxic chemicals to groundwater sources negatively affects commercial and industrial property value.²⁰
85. Other discussions extend their analysis to include the socio-economic impacts of water contamination on low-income and high-income communities. The study conducted by Balazs (2010) finds that smaller water drinking systems that serve a

¹⁷ Harris Consulting Ltd, Cowie B, Nokes C. 2006. Economic Appraisal and Section 32 Preparation for Sources of Human Drinking-water. Unpublished report prepared for the Ministry for the Environment.

¹⁸ “Chapter 2: Groundwater Contaminations and Its Impacts”, Protecting the Nation’s Groundwater From Contamination: Volume II (Washington, DC: U.S. Congress, Office of Technology Assessment, OTA-O-276, October 1984)

¹⁹ Reddy, V. R., and Behera, B., “Impact of water pollution on rural communities: An economic analysis”, Ecological Economics Volume 58, Issue 3, 25 June 2006, Pages 520-537

²⁰ Page, G. W., and Rabinowitz, H., “Groundwater Contamination: Its Effects on Property Values and Cities”, Journal of the American Planning Association, Volume 59, Issue 4, 1993

higher proportion of minority and low-income communities in California's San Joaquin Valley received drinking water with proportionately higher levels of nitrate.²¹

86. There has also been some discussion about the economic cost of acquiring alternative water supply as a result of contamination to primary water sources. A report authored by the World Bank finds that contamination of water supplies further exacerbates the water scarcity issue in some regions in China. The authors estimate that the overall cost of water scarcity is about one per cent of China's national GDP.²²
87. Although the costs of water contamination has been discussed extensively and widely in existing literature, we find that there is very limited evidence to suggest that there are significant non-health related impacts to society.

The economic conception of water

88. While there is some debate around whether water should be treated as just another economic good, what is clear is that water has had a central place in the thinking of economists for some time. Perhaps the most famous of economic thinkers, Adam Smith wrote of the diamond-water paradox in respect of the economic value of particular goods:²³

The things which have the greatest value in use have frequently little or no value in exchange; and, on the contrary, those which have the greatest value in exchange have frequently little or no value in use. Nothing is more useful than water; but it will purchase scarce anything; scarce anything can be had in exchange for it. A diamond, on the contrary, has scarce any value in use; but a very great quantity of other goods may frequently be had in exchange for it.

89. Water is perceived as having special significance that other commodities or goods do not. The system of property rights around water as opposed to say, land illustrates this. It also has some economic features that make it distinctive:²⁴
- *Public and private good properties-* when used in the home, factory or farm water is essentially seen as a private good. However, when water is left *in situ*, whether for navigation, for people to enjoy for the view or for recreation, and aquatic habitat, it is functioning as a public good.²⁵ Other commodities considered as

²¹ Balazs, Carolina (2010). Just Water? Social Disparities in Nitrate Contaminated Drinking Water in California's Central Valley. Berkeley, CA: University of California at Berkeley. Dissertation in preparation.

²² The World Bank report, "Cost of Pollution in China: Economic Estimates of Physical Damages", Conference Edition, State Environmental Protection Administration, P.R. China, 2007

²³ Smith, A (1776) "The Wealth of Nations" Book I, chapter IV, cited in Hanemann (2006).

²⁴ Havemann, W (2006) "The Economic Conception of Water." In "Water Crisis: Myth or Reality?" Rogers P, Llamas, R and L Martinez-Cortina (eds). Taylor and Francis, London: New York.

²⁵ Public goods, in economic terms are those that are non-rival in consumption (i.e. my consumption of the good does not reduce the amount left for consumption by others) and non-excludable (i.e. people cannot be restricted from consuming the good).

necessities, such as food, clothing and shelter have no public good characteristics.

Two important consequences arise in relation to public goods. First, they will likely be undersupplied as people have an incentive to “free ride” as exclusion from consumption is not possible. Second, the pricing of public goods is very difficult as it reflects the value of all those who value the item, which is different from the highest value placed on the item by an individual in an efficient (private) market.

- *Variability of water*- there is considerable variability on both the supply and demand sides for water. Spatial distribution of water is very uneven across and within countries. Similarly, water quality is non-uniform, and the timing of precipitation can also vary considerably across locations. The demand for water is also intermittent and highly seasonal, particularly for agricultural uses. Storage and diversion issues are particularly acute in respect of water.
- *Cost of water*- water is bulky and expensive to transport/transfer, relative to its value per unit of weight. This has implications for supply in times of shortage. Unlike electricity, say, there is no water “grid” onto which water can be imported in times of shortage. In dealing with unexpected shortages of water, recourse to stored supplies or rationing are the most obvious responses. There are also substantial economies of scale and bulky capital requirements for water, in relation to storage and water supply respectively. Moreover, as well as being expensive, water related assets are largely immovable and of little use for any other purpose. They are generally long-lived, however.

The capital intensity and economies of scale associated with surface water supply have profound economic and social implications. For one thing, because these are classic preconditions for a natural monopoly, they make it more likely that there will be a single provider in any given area. More generally, they foster public provision of a surface water supply rather than individual, self-provision, whether the public provision is by a collective of the users or a monopoly seller.

- *Price of water*- to the extent they exist, the prices faced by consumers often reflect the physical cost of supply, rather than the scarcity value of water. That is, users pay the operating and capital costs of water supply infrastructure, not the water *per se*. In this regard water is different from oil, coal and other minerals that are owned and managed by the state.

In places where water is cheap, this tends to reflect the fact that the supply infrastructure is relatively inexpensive, rather than there being an abundance of water in the area. Water may be further under-priced given the propensity for agencies to set prices on the basis of recovering historic costs as opposed to the future replacement cost.

- *Mobility*- an obvious, though nonetheless important feature of water is its mobility. Water tends to move around. It flows, it seeps, and it evaporates. Water used in the field either seeps into the ground or runs off as tailwater. Similarly, use in the household most often results in an outflow of wastewater. Thus, there can be several sequential uses of the same molecule of water, as water is rarely consumed fully by a given user and what is left is physically available, in principle, for use by others. In this regard water is very different to land, where multiple, sequential uses are impossible and enforcing excludability

and establishing property rights is relatively easy. Collective rights of access to water are often the solution to these features.

- *Essentialness*- water is essential for life, be it human, animal or plant life. Economics has a concept of essentialness that relates to something that is an input to production or something that is consumed as a final product. For the former, no production is possible without the input, while in the case of final consumption, no amount of any other final good can compensate for having a zero level of consumption of the original commodity. Water fits the definition of both.

However, the notion of essentialness conveys no information about the productivity or value of water past the essentiality threshold. That is, past the minimum quantity of water that is needed for human survival, the notion of essentialness tells us nothing about the contribution of water to the enjoyment and satisfaction of life. When a piped water supply first became available in the early 19th century, the initial household uses were the same ones that had existed when family members had to fetch water from an external source – drinking, cooking, hand washing, and limited bathing.²⁶ Over time the number and nature of uses has expanded to include tubs for bathing, water borne sanitary waste disposal, outdoor landscape and garden watering, automatic clothes washers, swimming pools, automatic dish washers, car washing, garbage disposal, indoor evaporative cooling, hot-tubs, lawn sprinklers, etc.

The major conclusion that can be drawn from historical experience is that, in developed countries, the fact that water is essential for human life is almost certainly irrelevant when assessing the value of residential water supply because the ways in which water is used are nowhere near the threshold level at which essentialness applies. This consumption pattern presents challenges in respect of measuring the value of water, particularly the difference in value households place on access to piped, public water supply relative to existing alternative alternatives and versus no access to water at all.

Previous studies by the World Bank indicated that water and sanitation projects in developing countries were not viable if they required households to pay more than 3-5% of their income as that was the limit people could afford or were willing to pay. However, further more detailed studies showed that some households spend considerably more than this on access to traditional, unimproved water and sanitation, including purchasing water from vendors at prices that can be much higher than the cost of piped water.

²⁶ Blake N (1956) *Water for the Cities*. Syracuse University Press; and Tarr J (1979) *The Separate vs Combined Sewer Problem: A Case Study in Urban Technology Design Choice*. Journal of Urban History, 5, May, pp308-309.

Appendix 2 Interview outline

Estimating the (economic) costs of the 2013 Raetihi Diesel Spill

Sapere has been commissioned by the Ministry of Health to estimate the costs to society of the 2013 diesel spill. The focus is on economic costs- that is, how much worse off society is as a result of the incident. The study is not solely concerned with financial costs, though these will be considered. A key part of the study is talking with affected parties such as businesses, residents/households and other organisations (with civic and other public service functions) impacted, in a resource use sense.

Impacts

1. Could you please describe the impacts on you/your business?
 - Direct: turnover/revenue; business disruption
 - Customers not purchasing
 - Additional costs of operation, including possible workarounds needed that would otherwise not be; costs of mitigation
 - Not being able to operate at all- sanitary conditions, etc
 - Staff availability and/or productivity
 - Can you give a profile/distribution of impacts in terms of magnitude and incidence?
2. Attribution- how well are you able to isolate the effects of the spill- can you supply evidence (e.g. comparisons with previous year's results)?
3. Recovery-
 - a. what type of insurance arrangements do you have? How much is covered versus effects that indirectly affect you?
 - b. Are impacts still being felt? Please describe
4. Are there personal costs as well- what is the relative weighting between personal and business costs?
5. Are other businesses being impacted because of this- actual and potential ?
 - a. Suppliers-
 - b. Downstream purchasers (locally and elsewhere)
 - c. Other businesses in town?
6. Have you thought about the extent you are willing to pay to avoid such a happening?
7. Is there anything else you would like to comment on?
8. Can you recommend other people/businesses that we should talk to?