1.1 Health Impact of Odorous Contaminants

Some submitters expressed concern not only about the odour coming from activities within Carey’s Gully but also about possible toxicity, especially since the odours (or the contaminants that cause the odours) at times make some people feel sick, or result in headaches or irritation and other symptoms.

Concern about odorous contaminants causes many more complaints from the public than do contaminants with relatively low odour (that are not associated with odour issues or with other public issues) such as nitrogen dioxide (which is emitted from all fuel burning equipment) and sulphur dioxide (emitted when burning sulphur-containing fuels). However, it is fair to say that, in respect to industrial wood processing emissions for example, a contaminant such as formaldehyde (which is relatively non-odorous) is often blamed for causing eye, nose, and throat irritation and other adverse health effects, even when the cause of the issues has little or nothing to do with formaldehyde. In this case, the emission from industry of objectionable odour and at times irritating contaminants coupled with earlier publicity about indoor formaldehyde emissions from certain building materials gave reason for concern about what was perceived to be a dangerous contaminant.

Exposure to odorous contaminants at concentrations many times less than the lowest concentrations that are observed to cause irritation or other classical physical health symptoms appear to cause health effects in some people. The complex relationship between physiological, and behavioural and psychological factors, is not fully understood. Nor has the possible synergistic effects of mixtures of odorous contaminants in low concentrations received much scientific attention. It may be possible that a mixture of odorous contaminants could generate adverse heath effects even when the concentration of the individual components is very much lower than that recognised to cause physical health effects.

There are a variety of studies that discuss whether objectionable odours cause illness and some of these relate specifically to odours from wastewater treatment plant biosolids (sludge). Some researchers have advanced the view that odours associated with animal manures and biosolids can produce adverse physical health effects. Schiffman et al (2002)\(^1\) comment that complaints to public health agencies suggest that odours may not simply serve as a warning of potential risks but that odour sensations themselves may cause health symptoms. Objectionable odours emitted from large animal production facilities and wastewater treatment plants, for example, cause complaints such as eye, nose, and throat irritation; headache; nausea; chest tightness and shortage of breath; stress; and alterations in mood. The authors comment that there are at least three ways in which ambient air odours may produce physical health symptoms:

- The first way is when the concentration of an odorous contaminant is sufficiently high to be odorous and also produces symptoms from irritation or by other mechanisms, but the symptoms are not caused by odour (odour is incidental or can be regarded is a warning of possible health effects at elevated contaminant concentrations). An example is ammonia which has an odour threshold of 15 ppmv or more and an irritation threshold of 20 to 25 ppmv or possibly less.
- The second way is that health symptoms can occur at odour concentrations that are above odour thresholds but are well below irritation levels. An example is hydrogen sulphide which has an odour threshold ranging from 0.0005 to 0.03 ppmv (or lower) while the irritant threshold range is around 15 ppmv – the lowest irritation threshold being around 500 times higher than the highest reported odour threshold.

The third way is that symptoms may be due to other contaminants in the odorous mix that are present at irritating concentrations but not in themselves are odorous. Odour is then incidental to the health impact of the other contaminants. (This mechanism is often deliberately used to indicate the possible danger of some gases – for example, adding odorants, which are a mixture of mercaptans and other volatile odorous sulphur-containing compounds, to treated natural gas and to LPG to warn of gas leaks). Such other contaminants that have relatively low odour or are non-odorous include nitrogen dioxide and carbon monoxide, fine particulate matter, and bacteria, pollen, and fungi.

Schiffman et al (2002) comment that the mechanism for health symptoms occurring from exposure to odour at concentrations that are above odour thresholds but are not irritating is not well understood but several factors appear to be involved. Humans are genetically coded so that pleasant and unpleasant odours activate different parts of the brain – aversion to unpleasant odours appears to have an evolutionary basis thus is biologically developmentally driven (alerts humans to potentially unsafe food and air). A second factor may be that the sensitivity of the human nose to some contaminants (for example, hydrogen sulphide) may be a protective mechanism to prevent upsetting certain metabolic processes. In addition, unpleasant odours can change breathing patterns. Exposure to objectionable odours may also cause stress and mood changes and these changes may cause illness or worsen existing illness. It may also be that health symptoms from odour at non-irritating concentrations is due to innate or learned aversions (for example, if an objectionable odour has previously been associated with influenza, later exposure to the odour may recreate these symptoms in the absence of the influenza virus).

There are other confounding factors that must be accounted for when assessing odour impact. When exposed to odour for some time (typically within minutes) a person’s sensation of the intensity of odour reduces by adaptation. When exposure to odour ceases, normal sensitivity is regained within 5 to 10 minutes (Danish Environmental Protection Agency 2002). This why many people find that they quickly become accustomed to the odour of hydrogen sulphide in Rotorua, and is one of the reasons why short-term wafting odour may cause more annoyance than long-term relatively consistent odour (providing odour is of sufficient intensity for adaptation to occur). Sensitisation can also occur. Following exposure to a relatively high dose of odorous chemicals (strong odour), a low dose may produce the same symptoms, whether it is annoyance or physical health effects such as nausea or headaches.

The perception of the intensity of odour in relation to odour concentration is not linear (for example, halving the concentration of odorous contaminants does not halve the smell). The relationship is logarithmic – a similar relationship to that experienced with the loudness of sound and sound pressure. If the concentration of odour increases by 10 times, the perceived increase in intensity (smell) will increase by a much smaller amount (Ministry for the Environment (2003)). In fact, the actual relationship between odour concentration and intensity of the smell is complicated and depends of the nature of the contaminant or mixture of contaminants. For example, for people on average to perceive a reduction in smell by half (smells half as strong) the concentration of odour may have to reduce by between 5 to more than 15 times. There is only limited information in the literature about specific

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contaminants, but Rolfe (2000)\(^4\) states that a 10-fold increase in concentration of hydrogen sulphide is approximately equal to a unit increase in odour intensity. This logarithmic relationship between odour concentration and intensity has important ramifications. Dispersion of odorous contaminants in the air with increasing distance from the source does not achieve the same level of improvement as demonstrated for contaminants such as fine particulate and sulphur dioxide. This is one of the reasons why the odour from Carey's Gully activities is obvious to people at often considerable distance from the sources at levels that often appear to be of similar intensity.

Odorous contaminants may be present in air as discrete compounds, or more often, as a mixture of compounds. A mixture of odorous compounds may smell quite different to the odour of the individual compounds, and the odour may change in character as distance increases down wind.

Not unexpectedly, the most common complaints about emissions from activities such as processing of biosolids (for example, wastewater treatment plant sludge) start with the perception of objectionable odours and these odours are often perceived as either causing adverse health effects or as indicators of possible adverse health effects. In the past, many public health and environmental authorities regarded unpleasant odours and resulting complaints as nuisance and quality of life issues (social and mental well-being) and were secondary to complaints about actual adverse health effects. However, if the odour issues persisted then complaints about a variety of physical symptoms also occurred even though generally there was no evidence that the concentration of odorous contaminants were approaching or exceeding the threshold where physical effects could be expected. Frequently, significant reduction in the frequency and intensity of odour emissions did not necessarily show a proportionate reduction in odour complaints, nor a reduction in concern in the public about physical health effects.

The distinction between adverse physical health effects and social and mental well-being has become blurred due to the policy of many environmental and public health of accepting that good health includes a good quality of life not just the absence of disease or infirmity, and that some researchers linking odours and physical health effects has blurred the issue. This may have reinforced the public view that objectionable odours and health problems are closely linked.

In respect to odours from biosolids, anecdotal reports imply a pattern like that associated with other industrial odours. According to the Water Environment Research Foundation\(^5\), symptoms claimed in connection to odours from biosolids seem to come from their smell rather than irritating stimulation. This conclusion was reached from studies that indicate concentrations of emissions of the principal contaminants from wastewater treatment plants failed to reach irritating levels even within the facility premises. The symptoms associated with wastewater treatment plant odours seemed to occur from annoyance, anxiety, and frustration, with persons who did not experience distress not demonstrating health symptoms. However, objectionable odours may worsen symptoms and signs of illness in persons who suffer from certain chronic disorders such as asthma and migraine with vulnerability varying considerably from person to person.

There is a large range of gaseous contaminants emitted from sewage sludge, generated from composting of dewatered sludge with bulking agents, and emitted from refuse landfilling activities,


especially under anaerobic conditions. Some of these contaminants, their odour thresholds and irritation thresholds, and public health guideline concentrations in air, are presented in Table 2. The information about some of the contaminants is incomplete. The notes to the table are as follows.

**Odour Thresholds:** GM = geometric mean of all reported values as published by the American Industrial Hygiene Association 1989\(^6\). The highest values reported were selected. For odour thresholds reported in parenthesis [ ] these are single values from a variety of published sources. All odour thresholds should be regarded as indicative. Few, if any, of these odour thresholds are from recent studies using the more sophisticated assessment techniques now available – actual odour thresholds may be somewhat lower than indicated.

**Irritation Levels:** Most of the examples are from Ruth (1986)\(^7\) and these, because of age, should only be regarded as indicative. Other sources are – G&P = Gaffney & Paustenbach (2006)\(^8\); WHO = World Health Organisation Air Quality Guidelines for Europe, 2\(^{nd}\) Edition, 2000, and earlier documents; and WERF = Water Environment Research Foundation, California, 2004.

**Ambient air guidelines:** We have reported the N.Z ambient quality air guideline levels (2002) and the World Health Organisation's guidelines where applicable. Most of the guideline levels quoted are the Texas ESL’s. The Texas Commission on Environmental Quality (TCEQ) publishes effects screening levels (ESL’s) as 1-hour and annual averages for a large range of substances. They are similar to design ground level concentrations for dispersion modelling – down wind ground level concentrations which, if not exceeded, are believed to be acceptable. If the ESL’s are exceeded then additional studies may be warranted to assess the effects on the environment.

**Workplace exposure standards:** These are mainly from the N.Z. Department of Labour's Workplace Exposure Standards Effective from 2002. We have selected the shortest term exposure standard available – the TWA is an 8-hour time-weighted average, and the STEL is a 15 minute exposure period not to be exceeded at any time. We obtained the basis for the standards from the USA ACGIH Threshold Limit Values for Chemical Substances and Chemical Agents, 1999. Some workplace exposure standards from this document are also included in the table in the absence of N.Z. standards (identified as ACGIH). The acronym CNS means effects on the central nervous system. An A1 carcinogen is a confirmed human carcinogen based on the weight of evidence from epidemiological studies. An A3 carcinogen is a confirmed animal carcinogen with unknown relevance to humans.

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\(^6\) American Industrial Hygiene Association. Odor Thresholds for Chemicals with Established Occupational health Standards. 1989
