



**PORT GEOGRAPHE SEA GRASS HYDROGEN SULPHIDE
ASSESSMENT OF THE HUMAN HEALTH RISK AND ITS MANAGEMENT
Department of Health - April 2009**

Scope

This report provides an assessment of the health risks posed to residents of the Port Geographe residential area as a result of hydrogen sulphide (H₂S) emissions from decomposing seagrass on adjacent beaches. It also discusses and makes recommendations on risk management. This is based on the relevant reports held by Department of Health (DOH) as outlined below, noting that DOH had a limited amount of time to consider the information provided.

Relevant Reports

1. *Port Geographe Removal of Accumulated Backlog Sand and Seagrass Bypassing – Report on Works Completed to Period Ending 20 September 2008* – MP Rogers and Associates Pty Ltd – 23 September 2008

Provided to DOH on 29 September 2008 by Department of Environment and Conservation (DEC) for information

2. *Port Geographe Removal of Accumulated Backlog Sand and Seagrass Bypassing – Report on Works Completed to Period Ending 18 October 2008* – MP Rogers and Associates Pty Ltd – 21 October 2008

Provided to DOH on 29 October 2008 by DEC for information

3. *Port Geographe Seagrass Relocation Operation 2008 – Final Report* – Shire of Busselton - 4 November 2008

Provided to DOH on 5 December 2008 by DEC for reference and general comment

4. Letter of 7 March 2009 to Ms Judy Clarke and Mr Patrick Ayers from Dr Jack Thrasher, Consultant Toxicologist providing an assessment on hydrogen sulphide air levels in Port Geographe.

Provided to DOH on 13 March 2009 by the media for comment

5. Electronic spreadsheet of hydrogen sulphide air concentrations measured at 8 Leseuer Close and 399 Marine Terrace, Port Geographe on behalf of the Port Geographe Action Group.

Provided to DOH on 16 March 2009 by DEC for information

6. *Port Geographe Removal of Accumulated Backlog Sand and Seagrass Bypassing – Report on Works Completed to Period Ending 6 September 2008* – MP Rogers and Associates Pty Ltd – 9 September 2008





Provided to DOH on 20 March 2009 by Department of Environment and Conservation (DEC) for information

7. *Technical Memorandum_3 – Port Geographe Fortnightly Report_20081001 – Monitoring 23 – 30 September 2008 – The Odour Unit Pty Ltd – 1 October 2008*

Provided to DOH on 20 March 2009 by Department of Environment and Conservation (DEC) for information

8. *Port Geographe Removal of Accumulated Backlog Sand and Seagrass Bypassing – Report on Works Completed to Period Ending 1 November 2008 – MP Rogers and Associates Pty Ltd – 4 November 2008*

Provided to DOH on 20 March 2009 by Department of Environment and Conservation (DEC) for information

Background to Reports

Most of the documents were provided to DOH for information and a few for comment. Half of the reports were only received after DOH was approached with media queries in March 2009, and in no case was all the raw monitoring data provided, only primarily summary information.

References 1, 2, 6, 7 and 8 relate to the reporting of the results of an Odour Monitoring Plan, among other things, that the Port Geographe developer was required to prepare as part of sand and seagrass bypass activity from September – October 2008. The Odour Unit Pty Ltd (TOU) undertook the monitoring. The major monitoring was done at the Main Works area (piping operation – east end of beach) at Western Beach, the Truck Haulage area (initially) at Western Beach (west end of beach) and at the Wonnerup Beach Discharge Point, with a range of additional inland monitoring on the first bypass monitoring day.

Some baseline monitoring was done (Reference 6) on 21 August 2008 before the bypass operations commenced. The first bypass monitoring period was 7 – 13 September with summary comments primarily being provided. Three subsequent reports were prepared for monitoring periods up to 20 October with period and peak daily monitoring graphs and, summary comments being provided, and on one occasion meteorological data.

The Shire also undertook a program of air monitoring (Reference 3), including summary comments, period graphs, meteorological data and summary tables. Monitoring occurred in 4 residential locations, 3 of which were in vicinity of the TOU main beach monitoring areas, and therefore the likely main sources of air emissions. This monitoring ran for almost 2 months, from about 29 August to 23 October 2008.

Reference 4 provides a toxicological assessment of air monitoring results based on work commissioned by the Port Geographe Action Group (PGAG). The assessment includes summaries and graphs of the data.

Reference 5 consists of the raw data from the PGAG monitoring. It was undertaken at two residential sites one of which was near the Main Works site and the other between it and the Haulage operation. The latter monitor also coincided with a Shire monitoring site. This monitoring was conducted between 19 August and 14 October 2008.





Assessment of the Monitoring

DOH has not attempted to assess the adequacy of the different monitoring procedures or equipment, nor does it have all the necessary information to do so. Although there may be some uncertainty about their accuracy it is worth noting that the readings from the different monitoring programs for monitors clustered in the Main Works area on Western Beach are reasonably consistent.

Western Beach – Main Works Emissions

The main information about the source emission comes from the TOU studies. Although some early TOU work investigated possible residential impacts this was just a snatch in time and was not pursued subsequently, and therefore reduces confidence in their conclusions about residential impacts.

Table 1 summarises data from the three different monitoring programs associated with the Main Works area. It concentrates on 9 impact days from 23 September to 13 October 2008 when some of the highest H₂S levels were measured. High readings seem to coincide with light on shore winds. The map on page 6 provides some indicative locations of all of the monitoring sites.

Table 1 - Selected Dates and H₂S Monitoring Results for Locations Associated with the Main Works Site at Western Beach, Port Geographe (ppm)

Date/Location	TOU MW1	TOU MW2	PGAG 1	Shire 1	Comments
23 September	Peak 3.5 24h 0.0	NA	1.7 0.012	5.2 15min 3.99	1 complaint
24 September	Peak 5.0 24h 0.1	NA	4.5 0.115*	3.5	5 complaints
3 October	Peak 9.9 24h 0.2	12.6 0.2	5.8 0.14 30min 2.16	6.5 8h 5.73??	1 complaint, light wind
6 October	Peak 8.3 24h 0.3	18.0 0.6 40min 5.7 90min 4.2	7.5 0.21 30min 3.49 30min 2.96	5 15min 4.2	1 complaint, light wind, Bth MW2 pks = PGAG pk
7 October	Peak 7.1 24h 0.1	15.7 0.3 60min 5.0	3.2 0.11 30min 2.1	1	PGAG pk coincides with earlier MW2
8 October	Peak 5.9 24hr 0.1	28.9 0.8 40min 9.0 120mn 5.1	5.4 0.13 30min 3.55	1.5	light wind, 2 nd MW2 pk = PGAG pk
9 October	Peak 34.5 24hr 0.3	-	3.1 0.0 30min 2.1	1.6	
11 October	Peak 25 24hr 0.4	39.4 0.1	7.7 0.08	2.2	





				30min 2.8		
13 October	Peak 24hr	22.8 0.1	12.1 0.0	5 0.02	1.8	3 complaints, light wind

*Exceedences in bold of DOH recommended public standards. See text on following page.

The Main Works site had some relatively high peak H2S levels detected, being about 35ppm and 40ppm, respectively, for Main Works Monitor 1 (MW1) and 2 (MW2) (relocated from the Haulage site). They both also had some significant sustained levels for instance 9ppm for 40 minutes, 5.1ppm for 120 minutes and 24 hour averages of up to 0.8ppm. Levels at MW2 generally seem to be the highest. The period of highest levels was in the October period near the end of the bypass operation when stockpiles were large and aged.

The TOU concluded that the H2S was more of a worker health issue and “that peaks would undergo sufficient dispersion to ensure that off-site perceived impacts for H2S exposure are not evident.” Furthermore, “.off-site impacts in the order of that representative of TWA and STEL values are considered nil”. DOH notes that the Time Weighted Average (8hours)(TWA) and Short Term Excursion Limits (15minutes)(STELs) that apply to H2S in Australia are purely for occupational exposure being 10ppm and 15ppm, respectively.

DOH subscribes to international guidance in regard to protecting the public ie the community from H2S. This includes the World Health Organisation (WHO) 24 hour averaging limit of 0.1ppm and a 30minute limit of 2ppm designed to prevent respiratory effects in asthmatics. DOH has also recommended a 14 day limit of 0.07ppm and a 90 day limit of 0.014ppm based on WHO guidelines. Standards and health effects are discussed in detail in the next section.

How the worksite H2S levels influence the local residential air quality is provided by the PGAG and Shire monitoring. One of the PGAG monitors (PGAG1) is very close to the Main Works site and to MW2 in particular. It is evident that there is a reduction the H2S concentrations in the nearest residential area, but it is not sufficient to meet public protection levels on the days selected. On five of the days the WHO 24 hour average of 0.1ppm is exceeded and in six instances the 2ppm protection limit for asthmatics. Two other 24 hour and five 30 minute limit exceedences also occurred on other days not covered by Table 1.

The Shire program also identified higher H2S levels associated with its site near the Main Works area (S1). S1 was not as close to the operational area as PGAG1. Readings included peaks of up to 6.5ppm and elevated 15 minute averages of about 4ppm. These seem to mimic the PGAG1 results although normally not as high as those. However, in contrast to PGAG1, S1 results for September (not fully covered in Table 1) seem to be higher than for October. Unfortunately the TOU data is not adequate in September to help explain the difference. Also, DOH does not have the raw Shire monitoring data to be able to analyse the information any further. Furthermore there is some uncertainty about the accuracy of some of the averaged figures produced by the Shire monitoring work, eg the TWA (8hours) of 5.73ppm for 3 October is only just below the peak measurement of 6.5ppm for that monitoring site and far above figures for all the other sites.

Although noting the possible risks associated with these type levels for local residences, the Shire also noted that they were below TWA and STEL standards.





Delivering a Healthy WA

Based on the available data, DOH was able to estimate some of the longer term H₂S average levels. For the period 23 September – 20 October 2008, the average level at MW1 was about 0.07ppm. Also for the 30 September – 20 October 2008 the MW2 average H₂S level was of the order of 0.1ppm. Although these results are at or slightly above the DOH's 14 day guideline of 0.07ppm, these were not at public or residential sites but in a workplace from which the public was excluded.

For Leseuer Close (PGAG1) the H₂S average level for 1-14 October (one of the high emission periods) was about 0.05ppm, which met the DOH recommended 14 day limit. For the period from 19 August to 14 October, at Leseuer Close the average was 0.025ppm. If this was spread over 3 months (even without further H₂S emissions being included) the calculated figure of 0.016 is slightly in excess of the DOH recommended 3 month limit of 0.014ppm.

It is worth noting that the bypass operation also maintained a complaint register. The pattern of complaints seems to follow increased H₂S emission levels (5 of the 9 days in Table 1) and includes residences from around the Main Works operation.

Western Beach – Other Monitoring Sites

Other monitoring sites associated with the Western Beach area include:

- TOU monitoring of the Haulage Site near the western end of the beach – TOU H;
- PGAG and Shire monitors on the same site on Marine Terrace – PGAG 2 and Shire 2
- A Shire monitor about 250m inland from Shire 2 – Shire 3

The nature of H₂S levels associated with the Haulage site and other locations on Western Beach are still uncertain. Presumably the Haulage site is the other primary area of concern after the Main Works site and this is why it originally was monitored. The results of that short period of monitoring persuaded the TOU to relocate the monitor to the Main Work site as MW2. Indications are that at least for peak level emissions, the Haulage site may reach levels about 30% of those at the Main Works site.

The readings for PGAG 2 and Shire 2 at Marine Terrace indicate H₂S levels about several fold less than those associated with the Main Works site. Despite peaks of about 5ppm, such levels are not sustained except for a minute or so. Time averages also look to be below acceptable limits. Although the pattern of peaks seems to be similar for both monitors, their date correlation seems to be wayward.

A third Shire monitoring site (S3) that was about 250m directly inland from S2 showed lower levels of H₂S by a factor of around 5-6x. Interestingly, in some of its early work the TOU calculated a 37x reduction over 500m. Both the Shire and TOU results suggest that a dilution of about 2x per 100m may occur under some circumstances.

Western Beach - Conclusions

The results of all this monitoring suggests that levels of H₂S are around occupational limits on quite a few occasions at the Main Works site and this can be translated into nearly similar levels at close residences in suitable the wind conditions. Residences further inland will experience lower levels which will depend on their distance and the strength and direction of the wind. Under adverse conditions the reduction of the H₂S levels will not be as pronounced as it normally would be (possibly only 2 fold per 100m).





Uncertainty remains about the level and impact of emissions associated with other parts of Western Beach but these are likely to be significantly less than what is experienced at and around the Main Works site.

Wonnerup Beach

TOU and Shire data indicate very low and rare hydrogen sulphide detections at Wonnerup Beach. The current data only indicates a very occasional and slight odour problem.

The Human Health Risk

In considering human health risks associated with H2S exposure it is important to encompass both odour issues and also potential direct health effects. Many chemicals including H2S can be smelt at much lower levels than are known to produce direct health effects. However, the odour itself especially if it is unpleasant (e.g. H2S) or is perceived to be dangerous can generate anxiety and annoyance which can manifest as odour-related health effects (indirect health effects). The nature and degree of these indirect effects can depend on a number of additional factors including the odour strength, duration, frequency and the psychological and physiological sensitivity of the exposed population. Symptoms associated with odour-related exposure, sometimes just above the odour threshold have included headaches, nausea, stress, eye and throat irritation, fatigue and a range of negative mental states.

Direct human health effects associated with exposure to H2S in air are likely to only occur at much higher levels than the odour effects. These also will be determined by the level and duration of exposure, and the nature of the exposed population, some of who may be more susceptible such as the elderly or asthmatics. It is important to keep H2S exposure below the point that will produce direct health effects and preferably odour-related health effects on sensitive groups and the community as a whole. It is worth noting that some direct and odour-related health effects may be similar such as throat irritation.

DOH makes use of the exposure/effect hierarchy in Table 2 to determine possible direct health effects of H2S on the Port Geographe community. It is derived from key international sources including the World Health Organisation (WHO) and Concise International Chemical Assessment Document (CICAD) Series. Except for odour detection, at least about a 30 minute or more exposure time is usually required to produce these effects.

Table 2 – Exposure – Effect Levels for H2S in Air

Exposure (ppm)	Effect/Observation
0.008	Odour threshold
>0.008	Increasing possibility of annoyance/amenity effects eg headache, nausea, throat irritation etc
2	Bronchial restriction in asthmatics
4	Increased eye complaints
5 to 10	Minor metabolic effects
20	Neurological effects including fatigue, memory loss, dizziness

From this information international and national agencies have derived H2S exposure limits for a range of timeframes designed to protect the public (See Table 3). Such limits usually





have safety margins built into them and relate to the most sensitive individual. So health consequences do not automatically follow if they happen to be exceeded slightly.

Table 3 - DOH Recommended H2S Exposure Limits for Public Protection Purposes

Limit (ppm)	Averaging Timeframe
2	30 minute
0.1	24 hours
0.07	14 days

Although some of the monitoring has been previously interpreted in terms of TWA and STEL limits, it is important to note that these figures apply in the workplace and not to public risk. Occupational risks differ from public risks because workers may be exposed for a shorter period of time, take on these risks voluntarily, do not normally include vulnerable populations such children and the aged, and also are subject to workplace protective measures.

Based on the thresholds of direct health effects, the recommended public exposure limits and the exposure levels that were measured, possible health impacts on the Port Geographe community can be estimated.

The population most affected are likely to be those living close to the Main Works site. They will have experienced 30 minute and 24 hour H2S levels that could trigger asthmatic impacts in sensitive individuals and eye irritation. There may have been other respiratory effects and also odour-related effects such as headaches and anxiety. Some residents registered complaints during the peak H2S episodes.

In other residential areas near the Western Beach and further away from the Main Works site the impacts are likely to be significantly less. However, the odour-related health effects could occur in such areas and more broadly in Port Geographe though reducing in frequency and magnitude with distance.

These predicted possible direct and odour-related health effects are consistent with what was found in the PGAG Health Survey of 2007, noting that only general conclusions can be drawn from this survey and that emission levels and exposures between years may vary. Some of the most common effects reported were headaches, and eye and throat irritation.

Although unpleasant and undesirable these effects are transient and would not result in any longer term harm and also only occur for brief periods during one part of the year. DOH also considers that being indoors is likely to reduce the peak H2S exposure levels though probably not the longer timeframe averages such as that for 24 hours.

To afford sufficient protection to the community the above recommended limits at least should be adhered to and preferably lower levels achieved so as to also reduce the odour-related health effects. It may be that if adequate levels of protection can be afforded to the residences in close proximity to the Main Works site, then the other residential areas will receive even better protection benefits as a consequence.

In conclusion, the impacts of the H2S emissions are considered to relate to odour annoyance and odour-related health effects in the broader area and to some direct irritation health





effects in residences close to the Main Works site. These are likely confined to limited periods in part of the year and are transitory. However they all need to be properly managed.

Regardless of this assessment and any H₂S emission management measures put in place, community members should feel free to seek medical advice if they experience any effects of concern to them.

DOH Comments on Dr Thrasher's Report

DOH toxicologists generally agree with the material that Dr Thrasher has drawn upon in making his toxicological assessment, although greater use could have been made of international regulatory guidance and reviews rather than mainly on a collection of individual studies. Key references should have included WHO, CICAD and the US Agency for Toxic Substances and Disease Registry (ATSDR).

A major toxicological difference DOH has with Dr Thrasher is that we do not accept the suggestion of neurological effects such as toxic encephalopathy being a result of even the worst H₂S exposures found at Port Geographe. CICAD (Reference 1) quotes 28ppm on a daily work basis for "long-term" exposure as producing a range of neurological effects including fatigue, memory loss, and dizziness, such as may result from toxic encephalopathy. The sort of figure found at PGAG1 near the Main Works site was 0.016ppm for 3 month average which is of the order of 1000 times less than the 28ppm. Also it is about 150 times less than the single case study provided by Dr Thrasher in regard to a 20month year old child developing toxic encephalopathy from a 0.6ppm 12 month exposure.

DOH also disagrees with Dr Thrasher on how the toxicology of H₂S translates into human risk based on the exposure levels found at Port Geographe. He extrapolates the levels found in a specific residential area near the Main Works site to apply more broadly to the population in all of Port Geographe and surrounding suburbs. It must be remembered that the H₂S levels he uses were limited in time and area. Although he presumably also had the PGAG data from the Marine Terrace monitoring site he does not make use of these much lower readings. Therefore, he neglects to qualify his comments in regard to: the timeframes involved; the residential circumstances; and any uncertainty in regard to the reliability of the monitoring equipment. The PGAG and Shire data from Marine Terrace show short-lived peaks and time averages all likely to be below DOH recommended health limits.

Finally, DOH does not agree with views held by Dr Thrasher about widespread and multifaceted health effects, for instance one of his concluding remarks is that "I am encouraging the residents of Port Geographe to seek appropriate medical and neurobehavioral diagnostic testing to determine the extent of their injuries." As discussed above, monitoring results have indicated that neurobehavioral effects are unlikely to be seen.

Going Forward

DOH understands that monitoring undertaken by the TOU and the Shire was not intended to be comprehensive but as a preliminary means to determine risks and to assist development of better final odour monitoring and management arrangements. The Developer has also commissioned an expert toxicological report utilising all available monitoring data to help inform the process.





Delivering a Healthy WA

DOH considers that the appropriate group to supervise further work is the Port Geographe Consultative Committee, consisting of representatives from the Shire, the Developer, the Department for Planning and Infrastructure and the Department of Environment and Conservation. DOH also identifies the following measures as possible means of managing the emissions issue:

- Developing and implementing a communications strategy;
- Consideration of additional monitoring and management of the Haulage site;
- Consideration of future integrated operational and residential site monitoring;
- Consideration of monitoring to be in real time and linked to H₂S air trigger levels for action;
- Consideration of a hierarchy of management actions based on trigger levels;
- Regular and timely reporting to regulators and the community.





References

1. *Concise International Chemical Assessment Document 53 – Hydrogen Sulfide: Human Health Aspects* International Programme on Chemical Safety and World Health Organisation, Geneva 2003.
2. *Air Quality Guidelines - 2nd Edition* – World Health Organisation Regional Office for Europe, Copenhagen, Denmark 2000.
3. *Toxicology Profile for Hydrogen Sulfide* – July 2006 - US Agency for Toxic Substances and Disease Registry.

