Antimony review by Professor Dick Wettenhall

Potential environmental impacts of chemical pollutants released at the proposed new Grantville sand mining and processing site:

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Save Western Port Woodlands asked him to analyse the expert witness statement on Hydrogeology that accompanied an application by Dandy Premix Quarry to expand its current Grantville sand pit and open another.

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Executive Summary:

The Expert Witness Statement in support of the proposed new sand mining operation near Grantville does not adequately assess the risks of releasing toxic effluents into the environment. In particular, the documents lack: consideration of the complex chemistries of potential toxic pollutants; precise quantitative estimates of the specific forms of pollutants to be released into the aquatic environments; and provisions for the ongoing monitoring of at least the most toxic forms of the pollutants, as well as any environmental harm they might cause. This failure to adequately assess the risks contravene State Government Guidelines for ensuring the protection of sensitive natural environments against potentially toxic pollutants.

Specific concerns relate to two classes of toxic chemical contaminants of the wastewater that will be released from the proposed new sand processing operation into the region's highly environmentally sensitive aquatic ecosystems:

(i) Preparations of emulsion-type acrylamide polymers and coagulants used for removal of fine sand particles from the sludge and large quantities of wastewater generated during the sand extraction and washing operations;

(ii) Heavy metal compounds released into the both the soluble phase of wastewater and the dredge pond's fine sand sediments containing particulate-bound heavy metals.

Acrylamide emulsion preparations are of concern, mainly because they contain highly toxic acrylamide monomer contaminants. The high quantities of the preparations required for sand processing will result in waste waters containing residual acrylamide monomers, as well as soluble fragments of polyacrylamide, both of which exhibit toxicities to a range of aquatic organisms.

Antimony (Sb) is the heavy metal of greatest concern. It exists in either the reduced trivalent SbIII or oxidised pentavalent SbV states, mainly as hydroxylated compounds. Water-soluble and, hence, environmentally mobile forms of these compounds pose the greatest risks to the environment.

Increasing global awareness of the environmental risks of Sb pollution has resulted in Sb being: declared a priority global pollutants by the US Environmental Protection Agency (EPA) and the European Union; listed as hazardous substance under the

United Nations-sponsored Basel Convention; and included in the US-EPA's list of ten most frightening risks to the environment.

Concerns about Sb environmental toxicities relate mainly to industrial and other sites (e.g., rifle ranges) where extraordinarily high levels of Sb are released into the environment. However, lower levels also have the potential to harm the environment through the of transfer and accumulation of Sb compounds from soils and aquatic sediments into plants. The Sb accumulated in plants can enter the food chain, as well as eliciting toxicities directly. Therefore, Sb pollution poses risks to the health of aquatic organisms and ultimately humans, as occurs with arsenic and mercury.

Such concerns have led to the recent global upgrading of environmental safeguards, with maximum acceptable concentrations of Sb compounds released into aquatic environments set in the low microgram/litre range (e.g., 5-6 ug/l in the USA and EU).

A primary concern with the proposed new and mining operation is that the release of Sb into ground water is likely to result in selective increases in the levels of the more toxic hydroxylated Sb**III** compounds in the down-stream aquatic environments. These increases will be favoured by the anoxic conditions prevailing in both the stagnate waters of the slow-flowing regions of the creeks receiving wastewater and the marine sediments of Western Port Bay's tidal zones and mudflats. The increases are attributable to the reduction of pentavalent Sb compounds to the Sb**III** forms, as well as to the reduction of the ferric hydroxide Sb binding sites in soil particles and water-borne colloids under anoxic conditions.

An additional concern is that anoxic environments favour microbial production of the potentially even more harmful ***methylated Sb compounds***. Relatively little is known about the environmental behaviours of these compounds but, by analogy with chemically related metalloid arsenic, it seems likely that their bioaccumulation in plants and other organisms will pose considerable environmental risks.

Given the multiple forms of acrylamide and Sb, with variable toxic potencies and environmental mobilities, to be released, meaningful evaluation of the environmental risks posed by the proposed new sand mining operation will require comprehensive measurements of the levels of the individual potential pollutant compounds in each of the impacted aquatic environments.

The full report presented below elaborates on these concerns, particularly in relation to the chemistries and toxicities of acrylamide and antimony pollutants and their potential for harming the extremely sensitive aquatic environments in the vicinity of the new proposed sand mining project:

Sections A and B outlines current knowledge underpinning the recent classification of acrylamide and Sb compounds as environmental pollutants of global concern, as well as assessing their potential for impacting on the natural aquatic ecosystems in the vicinity of the proposed new sand mining operation.

Section C evaluates the consultant's assessments of the potential for environmental impacts of the pollutants to be released into the ground water, local creeks and Western Port Bay's tidal zone.

Section D outlines Government Guidelines for protecting the environment against toxic pollutants that need to be considered in the evaluation of the case for approving proposed new sand mining project.

Section E lists my detailed conclusions.

Section F lists questions that need to be addressed satisfactorily before further considering the new sand mining development proposal for approval.

Full Report

A. Emulsion-type polymers and coagulants:

The possibility of environmental damage caused by the highly toxic acrylamide compounds and related chemicals contaminating the wastewater to be released into the ground water table at the Grantville site has not been adequately addressed and needs to be considered further.

A1: Proposed use of acrylamide compounds in the sand extraction process:

Reactive acrylamide monomer is a contaminant of the SNF emulsion-type acrylamide polymer and coagulant preparations to be used to generate sand sediments/filter cake from the large volumes of sand washings (EMA8335 emulsion and LI4440 coagulant). The filter cake sludge and wastewater containing residual polyacrylamide and the contaminating reactive acrylamide monomer will be pumped into the proposed dredge pond, and from there released into the proximal ground water and, eventually, the local creeks systems and Western Port Bay.

A2: Monomer acrylamide toxicities:

Of concern is that both the polymer and monomer forms of acrylamide are known to elicit toxicities in humans and animal models, as well as in a various aquatic organisms including algae, shrimps and fish.

Monomer acrylamide impairs neurological and immunological functions in humans and animals, as well as causes reproductive anomalies, gene mutagenic defects and cancers in animal models. While human toxicities require the ingestion of high concentrations of reactive acrylamide, the possibility of lower concentrations of the pollutant harming animals in sensitive ecosystems cannot be ruled out. Apart from acute toxicities in organisms living in aquatic zones where acrylamide accumulates, the potential for the mutagenicity of the pollutant causing long term damage to these organisms and, therefore, disruption to the eco systems needs to be considered..

A3: Polyacrylamide toxicities:

Given the substantial quantities of emulsion that will be required to process the sand slurry and waste waters, considerable quantities of residual polyacrylamide are likely to accumulate in the dredge pond, including water-soluble- and colloidal-particle-bound forms of the polymer, and eventually released into the aquatic environments downstream of the dredge pond.

Of concern, is that the polyacrylamide pollutants can eliciting environmental toxicities in the following ways:

(i) The photo degradation polyacrylamide into the more toxic acrylamide monomer in aquatic environments;

(ii) Water-soluble forms of polyacrylamide can directly harm aquatic organisms, for example, by impairing fish osmoregulation critical for survival, by accumulating in the lungs of fish.

The different forms of polyacrylamide (PAM) used in formulations for water purification vary in toxicity. Neutral or cationic PAMs, are reported to be appreciably more toxic than anionic PAMs and are, therefore, considered safer to use in environmental applications. Also, oil-based formulations of PAMs can be appreciably more toxic to aquatic organisms than water-based formulations. It is not known, which of these forms of PAM are incorporated into SNF's EMA8335 emulsion to be used in the sand processing operations.

In the absence of any data on the actual levels of residual polyacrylamide likely to be released into ground water via the sand mine's dredge pond, and eventually into the creek systems and mud flats, it is not possible to assess the risks of these pollutants harming the environment.

A4: **Guidelines limiting the release of acrylamide compounds into the environment:**

The European Union and the WHO guidelines limit the acceptable concentrations of acrylamides in drinking water to 0.1 and 0.5ug per litre, respectively.

Relatively little attention has been given to guidelines limiting release of acrylamide into the environment. This neglect is in part attributable to the extensively documented degradation of acrylamide monomers by chemical photo action of sunlight and environmental microbes, which mitigates the risk of toxicities. However, these processes are quite slow, with the complete degradation of low microgram concentrations of acrylamide in fresh water taking 8-12 days, and slightly longer in estuarine saltwater environments. Also, the stability of acrylamide is appreciably greater in aquatic environments unfavourable conditions for bacterial viability such as might be the case for the proposed dredge pond.

Importantly, the global uncertainty concerning possible ecological risks posed by acrylamide monomer and water-born polyacrylamides, creates the need to exercise with caution before granting approvals for projects that will release acrylamides into the environment. In this context***, in the case of the proposed new Grantville sand mining project, it seems imperative that estimates of the actual levels of***

acrylamide and chemically related pollutants to be released into the aquatic ecosystems are provided and provisions are included in the proposal for ongoing monitoring of the pollutants in these environments, as well as any environmental harm they may cause before further consideration is given to the project.

B. Heavy metals, particularly antimony pollutants

While several heavy metals to be released from the proposed Grantville sand processing sites (see Table 1, Expert Evidence Statement)) could harm the environment, I have focussed on antimony (Sb), because it is classified as a priority pollutant of concern internationally. In fact, the estimated levels reported in test samples from the mining operation, of up to 50ug per litre of wastewater (Table 1), are well in excess of the maximum Sb concentrations considered environmentally acceptable internationally (see below).

B1: Recent classification of Antimony as a priority global pollutant:

Sb exists in geosystems mainly as the immobile mineral oxides and sulphides, valentinite and stibnite, respectively, incorporated into ancient rocks and fossil sediments. However, Sb is also ubiquitously present in the environment as mobile water-soluble hydroxides and gaseous sulphides. These are released from ores into waterways and the air by a variety natural chemical and biological processes, as various well as by human activities (particularly Sb mining and sites where Sb-containing wastes accumulate such as rifle ranges).

The mobile Sb compounds have been declared to be priority global pollutants by both the USEPA and the EU and are listed as hazardous substances under the United Nations-sponsored Basel Convention.

In recent decades, there is escalating awareness globally that potentially toxic Sb compounds released into waterways and the atmosphere, from industrial and other relevant sites of human activity (e.g., rifle ranges), risk harming sensitive environments particularly natural aquatic systems. The increasing levels of the Sb compounds released into the environment, and the rapidly accumulating evidence of their high 'mobility' in aqueous environments, has led to the ***inclusion of the potentially toxic Sb compounds in the US-EPA's list of the 10 most frightening risks to the environment***. These developments have led governments around the world to legislate guidelines setting limits for maximum acceptable levels of Sb compounds in natural soils and aquatic environments in the low ug range.

B2: Maximum acceptable levels of Sb compounds in natural soils and aquatic environments.

In soils, the limits for Sb are set in the low mg per Kg soil range. These limits are based on world estimates of particulate-bound Sb in natural soils, which are typically in the range 1 – 2 mg/Kg soil. Several hundred-fold higher concentrations of Sb compounds are found in the vicinity of mining and other industrial sites, as well as sites where Sb deposits accumulate such as shooting ranges.

Greater attention has been given to setting maximum acceptable levels of Sb compounds in natural aquatic systems. This reflects the importance of water for the transmission of mobile forms of Sb in the environment. World estimates show that the average Sb concentrations in rivers and oceans are 1ug/L and 0.36 ug/L, respectively. These estimates underpin the ***widespread government legislation to safeguard aquatic life in the environment, setting maximum acceptable Sb concentrations in the low ug per litre range***: for example, the acceptable limits in natural aquatic environments have been set at 6ug (i.e., 6ppm) /litre and 5ug/litre, in the USA and European Union, respectively. Australian Water Quality guidelines set appreciably higher limits for Sb at 30ug/litre in fresh waterways, but these have not been upgraded since 1992, well before much of the current knowledge of the acute risks of Sb toxicities to the environment have been documented.

B3: **Assessments of the environmental impact of Sb pollution need to consider the complexities of Sb chemistry, particularly in relation to redox properties:**

Sb exists in the trivalent SbIII and pentavalent SbV states and is mainly present in nature as the neutral trihydroxy SbIII and the negatively charged hexahydroxy SbV forms. Both compounds are water soluble and, hence, highly mobile in the environment. The SbV hydroxide predominates in 'oxic' environments (e.g., fast-flowing rivers and sea water), whereas the reduced SbIII hydroxide predominates in anoxic environments ('e.g., waterlogged soils, estuarial sediments, stagnate creek waters and waste pond sludge).

An additional complexity, is that while the water-soluble forms of Sb are primarily responsible for effecting environmental harm, ***sediment-bound forms constitute a substantial reservoir of potentially water-soluble Sb***. Also, water-borne forms include suspensions of colloids comprising Sb compounds complexed with hydroxides of iron and manganese. Up to 70% of the Sb in the 'soluble' phase of both fresh water and sea water is associated with colloidal matter of <500 Dalton diameter. The mobility and precipitation of these colloids are dominant factors in the formation and widespread distribution of Sb in aquatic sediments.

Importantly,

(i) the oxidised hydroxides of iron (ferric) and manganese (multiple oxidation states) associated with soil and sediment particles, as well as colloids, selectively bind the more toxic trivalent Sb compounds;
(ii) the bound forms of Sb are released into the soluble/mobile phase following acidification of soils and the reduction of the ferric and manganese Sb-binding sites under low oxygen/anoxic conditions.

Thus, the anoxic conditions prevailing in water-logged soils and aquatic sediments favour the release of mobile forms of Sb into the environment, rendering the ecosystems of these environments more vulnerable to harm by Sb pollution.

B3: Potential toxicities of mobile Sb compounds:

Sb compounds exhibit several human toxicities, as well as harmful effects on a range of environmental organisms.

As with the chemically similar metalloid element arsenic, Sb is not metabolised in humans, but toxicities arise if large quantities are ingested in drinking water or foods. Low levels of Sb are detected in a variety of human tissues. However, toxicities have only been linked with diseases in humans (including acute metabolic toxicities, cancers and other chronic health abnormalities) exposed to the extremely high levels of Sb compounds released into the environments exposed to very high levels of Sb pollution such as mining sites and shooting ranges.

In the case of natural environments, the ongoing escalation in the levels of Sb compounds resulting from seepage into waterways, risks harm to a range of individual animal and plant species and the disruption of associated eco systems. Adverse environmental effects of exposure to high levels of Sb compounds have already been documented, including compromised health of birds and fish, abnormalities in earthworm morphology and the growth of plants (e.g., pond weed, wheat and cabbages), mosses, lichens and fungi. Of particular concern is the capacity of plants to accumulate high levels of Sb compounds and, hence, enable movement of the metalloid up the food chain.

B4: An additional complexity is the biomethylation of Sb compounds in natural aquatic systems by anaerobic microbes.

Another potential determinant of environmental toxicity is ***the prevalence and accumulation of high levels of methylated Sb compounds in the anoxic environments,*** for example***,*** marine harbours, estuarine sediments, waterlogged soils, flood plains, swamps, rice paddies, etc. (e.g., in the extensive wetlands of in China). Sb biomethylation is carried out by anaerobic bacteria living in these anoxic environments, particularly those rich in organic matter and other nutrients. This process is considered likely to be a microbial Sb detoxification defence mechanism. In addition to the microbial activity, biomethylation of Sb has also been detected in laboratory plant cultures, but it is not known whether this also occurs in nature.

The precise bacterial origins of the methylated Sb compounds in natural environments are uncertain. However, laboratory cultures of specific environmental relevant anaerobic bacteria have been shown to methylate inorganic Sb. The main products are the monomethyl and dimethyl derivatives, distributed between the SbIII and SbV states, whereas in natural environments, the trimethylated form is the most the prevalent. As with the hydroxy forms, the trivalent methyl SbIII form displays greater environmental toxicities compared with its pentavalent counterpart.

B5: The environmental impacts of Sb compounds in soils and aquatic systems are dependent on the redox (oxidative-reductive) states of these environments.

The relative levels of the mobile trivalent and pentavalent Sb compounds in aquatic environments depend on the prevailing redox conditions, which are closely related to the water dynamics and soil water regime: Oxic environments favour the oxidised pentavalent Sb(V) hydroxy and methylated compounds, whereas ***anoxic environments favour the reduced trivalent SB(III) hydroxy and methyl compounds***. Also, the reducing conditions of anoxic soils and sediments favour the release of additional trivalent Sb compounds from their complexes with ferric and manganese ions incorporated into soil and sediment particles. This release is due to the reductive transformation of the ferric and manganese ions to their reduced states. In addition, the release of Sb compounds from soil particles is enhanced by the acidification of soils that can occur in anoxic soils.

C: Issues arising from the consultant's Expert Evidence Statement and responses to questions

The Leonard Expert Evidence Statement focusses on hydrology issues. It is rather dismissive of the potential for the release of environmental pollutants. Also, of concern is the at-best superficial reporting of quantitative estimates of these metals in waste effluents entering the ground water in the vicinity of the proposed sand processing operations***.***

C1: Waterways impacted by effluent from the proposed sand processing operations:

The information provided on the potential impact of the sand processing on the water quality, drainage flows and discharge into Western Port Bay is noteworthy.

The chemical wastes from these operations will be, either dissolved in waste waters, or bound to waste sand particles released into the proposed dredge pond. The considerable capacity of this pond (3500 mega litres) needs to be considered in the evaluation of any environmental risks.

Importantly, much of the dredge pond water carrying potentially toxic wastes will seep into the sub terrarium ground water, which in turn will be discharged into local creeks downstream of their intersection with ground water systems. While this intersection is estimated to occur close to Western Port Bay, the potentially polluted creek waters will still have to flow through up to 600 metres of foreshore land (Consultant's estimate) before entering the Bay. The creek is slow-flowing and consists mainly of stagnate ponds during dry periods; that is, conditions likely to create the low oxygen/anoxic environment which favour the microbial conversion of Sb compounds to their more toxic trivalent hydroxylated and methylated form and the release of particle-bound forms of these compounds into the mobile water-soluble phase.

In addition to the creek waters, a considerable amount of the polluted ground water will empty directly into Western Port Bay's extensive tidal transition zone via subterranean aqua flows.

Either way, the entry of appreciable quantities of potentially toxic wastes into the Bay would be of concern as the deep and extensive mud flats of tidal zone form extraordinarily complex and environmentally sensitive ecosystems, living under anoxic conditions that support the accumulation of the more toxic trivalent forms of Sb compounds in the water-soluble mobile phase of these environments.

C2: Heavy metal pollutants:

The Evidence Statement is rather dismissive of the potential risks of harmful effects to the environment of heavy metal pollutants. At-best, only superficial quantitative estimates of these metals in waste effluents from the sand mining operations are reported (Table 1, Evidence Statement). In the case of Sb, the only data given are from a preliminary assessment of the levels of Sb in one sample of leach cake. The actual Sb concentration is not given; the level of Sb presented is only as < 50ug per litre. ***This is unsatisfactory given that the upper acceptable limits for environmental Sb pollution in the USA and Europe are less than 10 ug/litre.***

Also of concern is that relatively little or no attention has been given to either the complexities of heavy metals chemistry, or the potential risks posed by the release into the environment of the more toxic forms of heavy metals such as the trivalent Sb compounds. This concerns particularly relates to potential for the entry of these more toxic forms into the environmentally- sensitive aquatic ecosystems bordering Westernport Bay.

C3: Potential acrylamide pollutants:

The environmental impact assessments outlined in the Statement have also not adequately addressed the potential for adverse environmental impacts of the potentially toxic acrylamide compounds used in sand processing and released via wastewater into these aquatic environments.

Potentially adverse environmental impacts of any acrylamide released are dismissed on the grounds that similar polymer- and coagulant-preparations are approved for use to generate clean (potable) water in catchment areas for human consumption (including in the Bass Shire water storages). However, this conclusion is questionable, given that

(i) achieving the potable-water standard requires the use of high-grade preparations of the polymers and coagulants with demonstrably low acrylamide contamination.

(ii) The documents provided do not stipulate whether portable-water-standard preparations of polymers containing only low levels of reactive acrylamide are to be used. If not, acrylamide contamination of wastewaters could exceed levels safe for the environment.

While the degradation of acrylamide by either chemical photo degradation or environmental microbes can mitigate the risk of acrylamide toxicities, it is not possible to assess the environmental risks without further information. In particular, estimates of the actual quantities of the different forms of acrylamide likely to be released quality of polymer and coagulant preparations to be used and the testing for acrylamide wastes are required.

C4: Possible release of acrylamide compounds into creeks, estuaries and Western Port Bay:

Aqueous effluent containing any polyacrylamide and acrylamide monomer contaminants and other potentially toxic wastes will be released via the water table into the Deep Creek and Colbert Creek systems close to the Westernport shore. Of concern is that direct assessments have not been made of either the actual levels of these wastes entering the dredge pond, ground water and creek waters, or the potential environmental impact of toxic acrylamide compounds on marine organisms living in these environments.

C5: The need for comprehensive quantitative testing of pollutants released into the environment

The release of potentially harmful wastes impacting on these environments will depend on the following factors:

(i) the extent to which toxic chemical effluents from sand extraction/processing pits for processing fine, medium and coarse sands (abbreviated as FMSEPs and CSEPs in the Statement) accumulate in the large dredge pond;
(ii) the oxygen content of the aqueous environment of the dredge pond including the sedimentary layers in the creek beds and tidal zone
(iii) the extent of the release of Sb compounds from complexes with sand particles as water-soluble compounds; that is to say, the release caused by the chemical reduction of sand-bound ferric and manganese within low oxygen/anaerobic regions of the impacted aquatic systems;
(iv) any direct chemical transformations of Sb compounds to potentially more hazardous the trivalent hydroxy and methylated forms (see above), that will be favoured by the low oxygen conditions prevailing in the stagnate waters and aquatic sediments;
(v) the extent to which toxic pollutants in the dredge pond water enter the ground water, creek systems and tidal flats.

Each of these factors need to be investigated before the environmental risks of the pollutants to be released can be adequately assessed.

D: Government guidelines for addressing potential threats to the environment:

As refenced in the consultant's Expert Evidence Statement, the Victorian Government's Department of Jobs, Precincts and Regions Guidelines stipulates that new project proposals require "***an assessment of the risk of harm arising from the proposed changed operations to local ground water users and hydraulically-connected sensitive environmental segments such as wetlands or ground water dependent eco systems".***

Additionally, the relevant provision of the Victorian Government Water Act 1989 requires that consideration be given to ***“the need to protect the environment, including riverine and riparian environment(s)”.***

Based on the Expert Evidence Statement and supporting documents, it would not appear that the proposal to establish the Grantville new sand mining operation has attempted to address these guidelines, given the following:

(i) the failure to adequately address the potential environmental toxicities of acrylamide and Sb compounds to be released into the environment,

(ii) the lack of provisions for ongoing testing of the levels of the specific forms of acrylamide and Sb pollutants in the various aquatic environments to be impacted on by wastewater release from the dredge pond.,

(iii) the lack of provisions for ongoing investigation of any toxic effects of the pollutants on biota living in the diverse aquatic environments impacted by the sand mining effluent.

Section E: Conclusions:

The overall conclusion is that the potential environmental impacts of the toxic chemical to be released from the proposed new sand mining processing operations at the Grantville site have not been adequately assessed.

This failure is attributable to the lack of consideration given to:

(i) the complex chemistries of the potentially toxic Sb and acrylamide pollutants, which give rise to several different compounds with differing toxic potencies:

(ii) the need for assessing the potential risks of harm to any of the impacted aquatic environments that might be caused by the release of the individual forms of the Sb and acrylamide pollutants into the environment;

(iii) the need for provisions for comprehensive testing of the levels of various chemical forms of Sb and acrylamide compounds in all locations within the aquatic environments likely to be impacted by the effluents from the sand mining operations;

(iv) the need to investigate the chemical transformations of Sb compounds into more toxic forms, as well as their selective release, that are likely to occur under the low oxygen/anoxic conditions prevailing within the impacted aquatic environments.

More detailed conclusions relating to the properties and potential toxicities of the individual pollutants to be released into the environment are listed below:

<u>Re Acrylamide toxicities:</u>

1. Reactive acrylamide monomer is a contaminant of the SNF emulsion-type acrylamide polymer and coagulant preparations to be used to generate sand sediments/filter cake from the large volumes of sand washings (EMA8335 emulsion and LI4440 coagulant). Residual polyacrylamide and the contaminating reactive acrylamide monomer are likely to be leached into the

proximal ground water and, eventually, the local creeks systems and Western Port Bay.

2. Both polymer (particularly neutral and cationic forms) and monomer forms of acrylamide have been shown to harm humans and animal models, as well as to a variety of aquatic organisms including algae, shrimps and fish.

3. Minimizing potential environmental risks posed by acrylamide compounds requires the use of high-grade preparations of anionic acrylamide polymers and coagulants with demonstrably low reactive acrylamide contamination. Unless portable-water-standard preparations of polymers containing only low of reactive acrylamide are to be used in the proposed Grantville sand processing operations, acrylamide contamination of wastewaters could exceed levels safe for the environment.

4. Given the global uncertainty concerning possible ecological risks posed by acrylamide compounds, it is generally accepted that caution in granting approvals to projects releasing acrylamide into the environment is needed until longer term investigations of the impact on environmental ecosystems are carried out.

5. The consultant's submissions do not address this need. Potentially adverse environmental impacts of any acrylamide released are dismissed on the grounds that similar polymer- and coagulant-preparations are approved for use to generate clean (potable) water in catchment areas for human consumption.

<u>Re Antinomy (Sb) toxicities:</u>

6. The Sb compounds are considered as priority global pollutants by both the USEPA and the EU and are listed as hazardous substances under the United Nations-sponsored Basel Convention. Antimony pollution is a recent inclusion in the US-EPA's list of the 10 most frightening risks to the environment.

7. Sb is released into aquatic environments mainly (90%) as the water-borne mobile hydroxyl compounds, particularly the neutral trihydroxy SbIII and the negatively charged hexahydroxy SbV.

8. While these Sb compounds are water soluble, 70% of the Sb in the 'soluble' phase of waterways is associated with colloidal matter of <500 Dalton diameter, in which they are complexed with colloidal hydroxides of oxidised iron (ferric) and manganese.

9. An additional complexity is that the oxidised forms of the soil- and sediment-bound iron (ferric) and manganese ions selectively bind the more toxic trivalent Sb hydroxides.

10. The immobilised forms of Sb bound to ferric and manganese hydroxides in soil particles and sediments constitute a substantial reservoir of Sb compounds. The release of these compounds into the soluble phase is triggered by the reduction of the particulate ferric and manganese Sb-binding sites in anoxic environments. Such reductive events occur under the low oxygen/anoxic environments of the type prevailing in the sedimentary layers of the sand mine’s dredge pond, as well as in the stagnate creek waters downstream of the dredge pond and the mudflats of Western Port Bay.

11. The reductive conditions of anoxic environments also favour the transformation of pentavalent SbV compounds into the more toxic SbIII forms.
12. Also, under anoxic conditions, a small (10%), but potentially environmentally-significant portion of the Sb released is transformed into the more toxic tri- and penta-valent methylated derivatives by anaerobic bacteria living in these anoxic environments.

13. The prevalence of bacterial biomethylation of Sb compounds in the eutrophic environments of wetlands and other aquatic sediments rich in organic matter and other nutrients, creates the need for caution in granting approval for projects involving the release of Sb compounds into such environments, such as will occur with the proposed new sand mining operation at Grantville.

14. The particular concern is that the accumulation of these methylated forms of Sb in tidal plants and other biota might have adverse environmental effects and compromise the food chain as has been extensively documented for methylated forms of other metals, particularly arsenic and mercury (see point 19 below).

15. Globally, safeguards have recently been upgraded, reducing the maximum acceptable concentrations of Sb compounds in natural aquatic environments to the low microgram per litre range: for example, in the European Union and the USA the limits have been set at 5 ug and 6 ug per litre of fresh water, respectively.

16. Australian Water Quality guidelines set appreciably higher limits for Sb at 30 microgram per litre in fresh waterways, but these were established in 1992, well before the potentially serious environmental risks of Sb pollution were recognised.

17. Sb compounds are considered pollutants of primary concern because of its toxicities to humans and and a range of environmental organisms.

18. Human toxicities have only been observed at the high concentrations of Sb compounds present in waste-water effluents from mining and other Sb

processing industrial sites, as well rifle ranges where the Sb incorporated into bullets as a hardening agent is released into soils.

19. The relatively low concentrations of Sb compounds in waterways and marine environments are insufficient to directly cause acute human toxicities. However, the possibility remains that harmful effects of the long-term accumulation of Sb in human tissues can result from the ingestion of methylated Sb compounds concentrated up through the food chain. This possibility seems real given the known accumulation of Sb in plants and the poisoning of humans by foods contaminated via the food chain with the chemically similar metal arsenic.

20. The highest risks to the health of humans and the environment are posed by the more toxic hydroxy- and methylated- forms of trivalent Sb prevalent in low oxygen or anoxic environments.

21. The existence of multiple Sb compounds with variable toxic potencies and environmental mobilities underpins the need for comprehensive measurements of the concentrations of the individual compounds in each of the aquatic environments impacted on by the Sb-polluted waste waters released from the sand mining operation*.*

22. In the documentation provided, the only Sb measurement reported (Table 1) were of the levels of 'Sb' and other heavy metals in leach cake. But only indicative estimates were given. In the case of Sb, the concentration in leaf cake extract was only recorded as < 50 micrograms per litre. The lack of (i) a precise estimate of the actual overall concentration of Sb and (ii), estimates of the distribution of Sb between its individual chemical forms, means that it is not possible to assess the environmental risks of Sb pollution.

E.2: Questions that should be addressed satisfactorily before the proposed new sand mining development is approved:

<u>Re: the risk of acrylamide toxicity:</u>

(i) Is the polyacrylamide-based SNF emulsion preparation to be used in sand/wastewater processing of a potable water- grade and has it been assessed for reactive acrylamide contaminants?

(ii) What levels of residual acrylamide monomer and polymer compounds are likely to exist in the dredge pond, either in the soluble or sediment bound phase?

(iii) Will the release of potentially toxic residual acrylamide monomer and polyacrylamides into the dredge pond, ground water, creeks and Western Port Bay environments be monitored?

(iv) What procedures will be in place to test for any acrylamide toxicities to biota living within the ecosystems that could be affected by the release of acrylamide compounds into the local creeks and tidal mud flats of Western Port Bay?

Re: the risks of antimony toxicities:

(i) The Leonard Evidence Statement provides only preliminary estimates of 'antinomy' to be released in leach cake (Table 1 of Witness Statement) and only a vague reference to ground water measurement. Will comprehensive assessments of the individual water- soluble Sb compounds released into the dredge pond and impacted aquatic environments be carried out?

(ii) Will the levels of Sb compounds bound to colloidal particles and sediment in the dredge pond and impacted aquatic environments be assessed?

(iii) Will provisions be made for monitoring the levels of oxygen within the different environments (including the dredge pond sedimentary layer and the tidal mud flats) likely to be exposed to the Sb compounds released from the sand mining operation?

(iv) Will quantitative assessments of the release and chemical transformations of Sb compounds into their water-soluble and potentially more toxic trivalent hydroxy and methylated forms be carried out? Such assessments will be particularly important for the low oxygen/anaerobic environments of the dredge pond sedimentary layer, ground water, stagnate creek ponds and Western Port Bay tidal zones where these transformation events are most likely to occur.

(v) What provisions will be made for ongoing monitoring of potentially harmful changes to biota living in the ecosystems impacted by toxic wastes released into the aquatic environments from the sand mining operation?

Report prepared by Dick Wettenhall,

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