Summary of evidence statement: Ray Henderson

I have spent a lifetime undertaking research and preparing evidence for the Environmental Risk Management Authority (ERMA) and New Zealand Food Safety Authority (NZFSA). Both these authorities have rigorous standards for toxic substances that are designed to protect our environment and food quality. The work I have done previously has pertained to registration of 5 vertebrate toxic agents (VTAs) that include cholecalciferol, re-registration of 1080, registration of PAPP (para-aminopropiophenone), registration of an anticoagulant/cholecalciferol combination, registration of zinc phosphide, and deregistration of one VTA on the conservation estate. The substance de-registered was brodifacoum, a substance with very similar HSNO classifications to that of the heavy metals found in solar panels. Some evidence used for risk assessments comes from literature reviews of published science, and where there are "information gaps" I have undertaken the research necessary to bridge those gaps.

During risk assessment of solar panels at Brookside I have followed the same research protocols. A literature review of risks and benefits of solar technologies has compiled for over 250 science publications on issues relating to leaching studies, ecotoxicology, ecology, environmental impacts, impacts on soils, impacts on plant communities, and release of contaminants into the air in the event of a fire. It became self-evident from this literature there were long-term risks from solar panels. How then have I independently assessed the "information gaps" on risks at Brookside?

In the first instance I remained cognisant of the findings from the previous hearing on this matter (RC225180) where the commissioner felt the environmental effects and impacts on 'highly productive lands from solar technologies were more than minor. Mr. McMath in an attempt to counter "the loss of productive potential" of agricultural land has pointed to solar panels on the Ward property where he had photographic evidence of good spring growth. Similar panels exist on the Dalley property where the owner decided to initiate research near panels to establish whether those panels were having an impact on his "highly productive lands". At the request of Mr. Dalley I was asked to assist with this work. We have written a progress report for this hearing that detail results to date. That report remains the intellectual property of Michael Dalley who has submitted it with his personal evidence. As a co-author to the report, I have also presented some of the science in my evidence statement.

From published literature on solar technologies, I produced a standard table of HSNO classifications. This indicates 'hazards' in solar technologies <u>are high</u>, especially for both aquatic ecosystems and soils. The next step was to explore pathways for 'exposure' of hazardous substances to soils, aquatic ecosystems, and terrestrial vertebrates. The results indicate that for each genus of plants or animals there exist obvious and measurable routes of 'exposure' to heavy metals from solar panels. In some scenarios 'exposure' is high, and this creates serious issues for <u>the organisms exposed</u>. Within the model 'Risks=Hazards x Exposure' for both soil organisms and aquatic organisms the measured exposure and measured risks are high.

In the study at Michael Dalley's property none of the panels were damaged, but we found high contaminant levels in soil, it was found soil organisms (microbes and earthworms) were impacted by leachates; we found that leachates from panels changed the NPK and pH of soils; that aluminium and iron leached in high amounts occluded essential macronutrients for plant growth; that clover plants struggled to survive near panels; and these things cumulatively changed the structure of plant communities growing on that land. These issues arose at Brookside because the silt loams there have a propensity to accumulate leachates rather than allow them to permeate deep underground out of the root zone of plants.

My synopsis is that the types of soils at Brookside are degraded by high levels of aluminium and iron, the regular occurrence of surface waters on heavy loams washes some of the contaminants into creeks, the proximity of panels to streams receiving heavy metals places aquatic organisms at risk, and there is a proliferation of plants at the site that bioaccumulate heavy metals (e.g., ryegrass, blackberry and briar) create obvious routes for transfer of hazardous substances to birds, sheep grazing under panels, and people living within the district. Solar farms have a place in New Zealand, but it is not in a place where the risks to soils, aquatic organisms, terrestrial vertebrates, and people are greater than the requirement to facilitate the NPS-REG. If this project proceeds, then potentially there are irreversible long-term impacts on the ecosystem at Te Waihora, and from what has been written about soils in Wales the impacts on highly productive soils may also be irreversible (*see* ADAS 2023).

So why are these results so inconsistent with the findings of Mr. Beechey-Gradwell? The simple answer to that question is, they are not. The leaching trials at Coombes Farm and in the Wairau valley measured only those contaminants found in the core of panels where their escape into the environment is minimized by encapsulants and glass panels: the research at the Dalley measured substances mainly leached from the outside of the panel by natural weathering, and assays identified just a few additional contaminants from the core.

Those materials from the very outside glass of the Dalley panels include aluminium, silica, and boron (in borosilicate glass), those materials from the anti-reflective coating (ARC) include silicon nitride (Si_3N_4) and/or sodium nitride (NaN), titanium dioxide (TiO2) as potential leachates, and then in the semi-conductor layer we have pyrites (FeS_2) layered on an indium-tin foil. Having descended to this level we reach the tunnel diode that contains silver (Ag) and aluminium. Finally as we delve down we have the encapsulant layer and below that the highly toxic substances in the form of cadmium, chromium, arsenic, lead, nickel, and zinc. After 10-years of weathering those highly toxic heavy metals in the core are just starting to appear in soil samples.

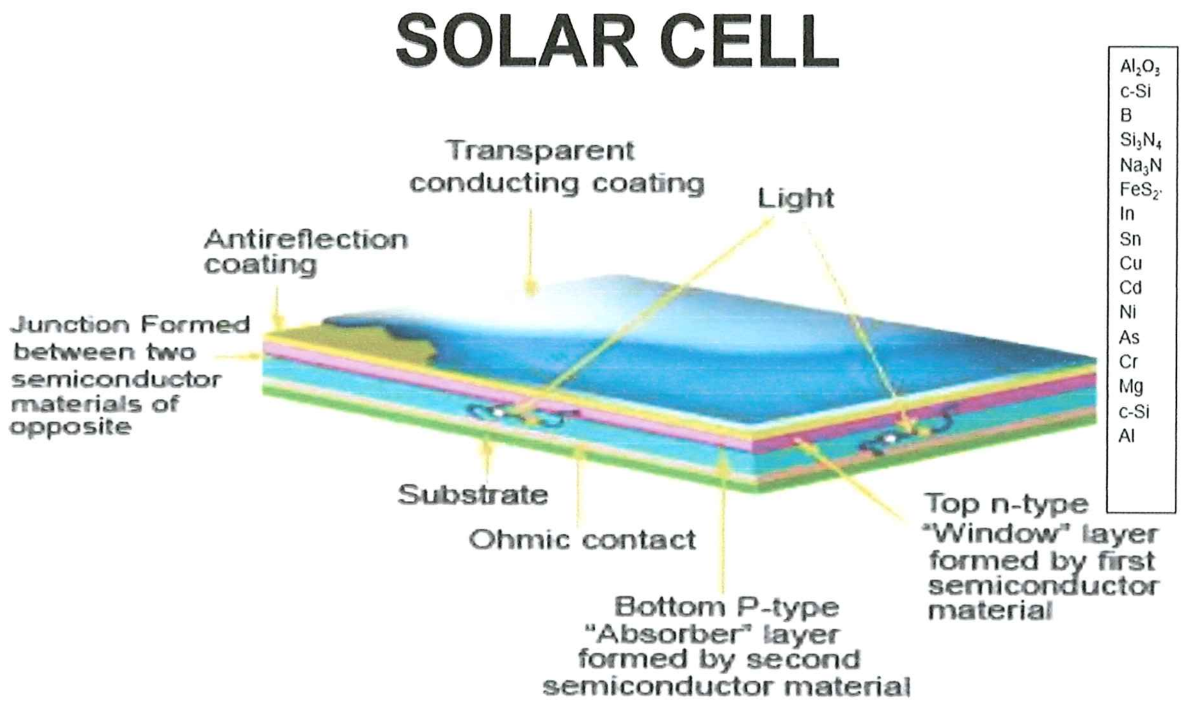
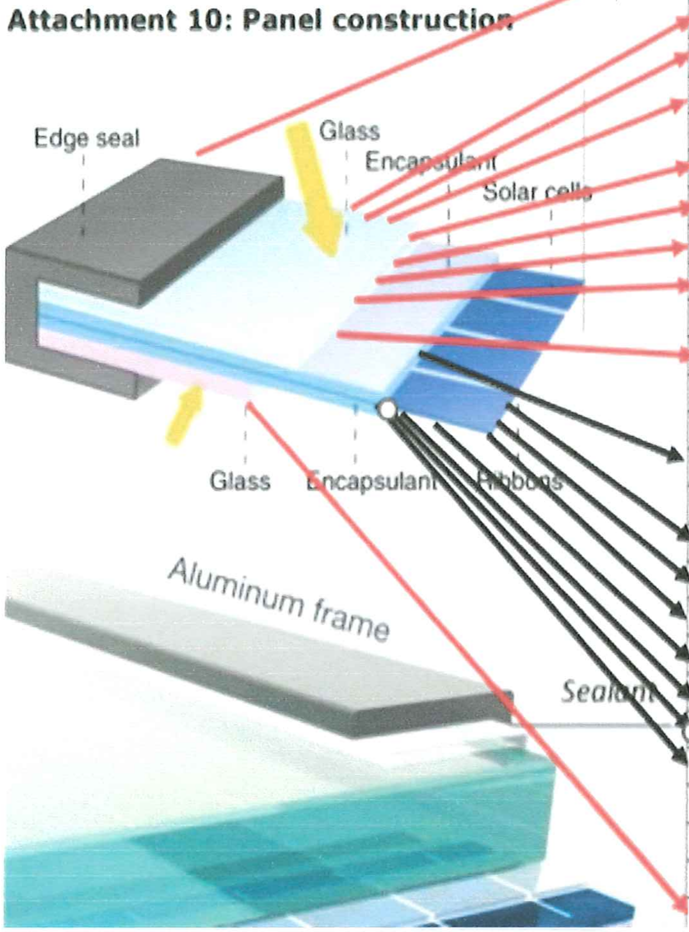


Fig. 1. Structure of polycrystalline panels at Michael Dalley property.

Let us now look at the Mr. Beechey-Gradwell leaching trial. They measured none of the materials leached from the outside of panels. What they measured instead were the materials in the core of panels (see Fig. 2). The fact that growth of clovers at Wairau was impeded indicates that all the unmeasured contaminants (Al, B, Si, TiO_2 Ag, etc) found at the surface of the Dalley panels, are most likely there in soils destroying soil fungi, protozoa, and bacteria; and occluding potassium and phosphates. The essential difference is that the

Kea-X trials chose not to measure them, and focussed instead on highly toxic metals from the core of panels.



Medium	Chemical Leachate	Aquatic Toxicity	HSNO Soils	KEA-X Study
Edging	Al	9.1A	9.2B	Not measured
Glass	Si	9.1B	n/a	Not measured
Glass	B	9.1B	9.2D	Not measured
Bottom glass	Al	9.1A	9.2B	Not measured
ARC	SiO_2	9.1B for Si nanoparticles		Not measured
ARC	Si_3N_4	9.1B	n/a	Not measured
ARC	TiO_2	9.1B	n/a	Not measured
ARC	BN	9.1B	9.2D	Not Measured
Bifacials	Ag	9.1A	9.2B	Not Measured
Bifacials	Al			Not measu
encapsulant	Maybe Pb	EC_{50}=1.3	9.2B	Measured
Ribbons	Cd	9.1B		Measured
Ribbons	Co			Measured
Ribbons	Pb	9.1A	9.2B	Measured
Ribbons	Ni	9.1B		Measured
Ribbons	Zn	9.1A		Measured
Ribbons	Cr	9.1A	9.2B	Measured
Ribbons	As	9.1A	9.2B	Measured
Encapsulant	Maybe Pb	9.1A	9.2B	Measured
Backing glass	Al, B, Si etc	9.1A	9.2B	Not measure

Figure 2. <u>**Unaddressed contaminants**</u> **at Wairau valley from panels are in red, measured contaminants at Wairau valley (in the core sandwiched between 2 layers of encapsulant) are in black.**

The issue of contaminants in water from Queen Elizabeth Reservoir in London is similarly fraught. The amount of water discharged from QEII reservoir in 2.5 diameter pipes is given by Thames water as 84,000,000,000 litres annually, which all passes through sand filters (silica nanoparticles) and synthetics to remove >99.9% of bacteria and dissolved particulates. If you do water tests after it has been filtered then naturally it is very unlikely contaminants will be found. The volumes of leachates from solar panels on QEII reservoir are an unknown.

Mr. Ford in his evidence stated several times that Brookside soils were poorly drained. That poor drainage is exacerbated by soil compaction (Appendix 1). Consequently, when it rains a sizeable proportion of that rainwater runs off soils into streams. That stormwater will contain increasing concentrations of leachates that will progressively accumulate in surface waters decade after decade. The impacts of these substances (heavy metals and PFAS) on aquatic life are significant.

Bird populations since 1970 have declined by 65%, with 19.5% of that decline attributed to heavy metals and around 8% to polyfluoroalkyl substances (Richard et al. 2021). Birds are also likely to be impacted at Brookside.

Appendix 1. Reduced permeability of soils and increased surface runoff of water in Wales (ADAS 2023). erosion.

EXECUTIVE SUMMARY

This report is part of an evidence-based assessment of the impact of solar photovoltaic (PV) sites on agricultural land and soil. The work, under the Welsh Government's Soil Policy Evidence Programme SPEP 2021-22/03, is to inform Welsh Government and Natural England specialists when dealing with solar photovoltaic (PV) planning applications.

- Work Package 1- Literature Review
- Work Package 2- Development and history of solar PV sites
- Work Package 3- Review of solar PV site impacts on land and soil

The literature review found that there are few in-field studies on solar PV sites, which consider the impact of the development on soil and land. There are studies on the impact of solar PV sites on microclimate, carbon cycling and vegetation management (Armstrong et al, 2016).

There has been a significant increase in projects with a generating capacity close to 50MW (BEIS Renewable Energy Planning Database June 2021). The land area of such projects (close to 50MW) is typically between 60 ha and 80 ha. The preparation of the planning application, often taking over 12 months, and process, itself taking up to 2 years, makes up a large part of the development cost.

The key impact of solar PV sites on land and soil may be caused by compaction leading to soil structural damage. The effects of soil compaction on soil structure lead to reduced permeability to water and air as well as increased surface runoff and erosion. Compaction near the surface and generally above a depth of 45cm can be alleviated. However the alleviation of deep compaction requires equipment such as a bulldozer and winged tine set to a depth to 60cm. The reversibility of soil compaction may take many years and in some cases compaction may be permanent. An assessment on the effect of compaction on the Best and Most Versatile agricultural land (land in MAFF Agricultural Land Classification grades 1, 2 and 3a) shows that the loss of high quality agricultural land is likely to occur in wetter parts of England and Wales. There may also be a loss of versatility of the high quality agricultural land in other parts of England and Wales. After decommissioning it should be possible to reverse the site to agricultural use in the context of moderate or lower quality land, providing all physical infrastructure is removed from the site. On higher quality land the success of physically reversing to the pre-construction grade will depend on the management of the soil and land from the early stages of construction through to decommissioning. A soil resources and management plan is key to the understanding of the soils present on a site. However the outcomes at decommissioning will depend on the quality of the initial soil resources and management plan, the quality of the soil handling on site and the robustness of enforcement.

There have been claimed benefits for soil properties such as increased carbon storage and improved soil structure arising from the conversion of arable land to grassland as part of the solar PV site development. The potential benefits will depend on the land use and the soil properties before any construction phase.

There are gaps in evidence, knowledge and experience on solar PV sites and their impact on soil and land. Key gaps are on recovery times of soil characteristics following compaction, the extent and depth of soil compaction on solar PV sites, interactions between the soil and piles/beams, corrosion of the piles/beams and more knowledge about soil contamination from galvanised piles/beams in the soil for 40 years.