BEFORE A COMMISSIONER APPOINTED BY THE SELWYN DISTRICT COUNCIL

IN THE MATTER OF	the Resource Management Act 1991
AND	
IN THE MATTER OF	applications by KeaX Limited for resource consent to establish a solar array at 150 Buckleys Road, Brookside.

STATEMENT OF EVIDENCE OF DR. ZAC BEECHEY-GRADWELL

ON BEHALF OF THE APPLICANT

(SOIL CONTAMINATION AND LEACHING)

Dated: 16 February 2024

KeaX Limited
Applicant
Campbell McMath
(campbell@keaenergy.nz)

Applicant
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1 INTRODUCTION

1.1 My full name is Dr. Zachariah Beechey-Gradwell. I am employed as a scientist by AgResearch Limited.

1.2 I hold a Bachelor of Science from Victoria University of Wellington, a Master of Science from Massey University and A Doctor of Philosophy from Lincoln University.

1.3 I have 7 years' experience as an agricultural researcher with AgResearch Limited. I spent four years doing a PhD with the Plant Biotechnology team working with pasture grasses engineered to accumulate lipids. Then three years as a post-doc, then scientist with the global change laboratory, working on the long term impacts of climate change on pasture ecosystems, with an emphasis on the effects of elevated CO_2.

1.4 I was engaged by KeaX Limited in December 2023 to provide evidence on the potential for leaching of soil contaminants from solar panels that could result from the proposed solar array on Buckleys Road, Brookside. Specifically, this evidence is based on my experience as a pastoral agricultural researcher and the results of measurements of plant and soil properties at the Kea X Limited Wairau Valley solar array.

1.5 In preparing this evidence, I have reviewed the following:

(a) The resource consent applications for the Proposal (including the AEE);

(b) The evidence of Campbell McMath (Applicant);

(c) The joint submission of Donna Irons and Simon Robinson, the joint submission of Ewan Chapman, Anneka Dalley and Michael Dalley (Haurere Farms) and the submission of Clark Casey.

(d) The Section 42A report for Selwyn District Council; and

(e) The report on independent soil leaching/contamination measurements made at the 'Coombe farm' in the United Kingdom, provided by Nick Keeler; and

(f) Proposed consent conditions.

1.6 Whilst this is a Council hearing, I acknowledge that I have read and agree to comply with the Environment Court's Code of Conduct for Expert Witnesses, contained in the Environment Court Practice Note 2023. My qualifications as an expert are set out above. Other than where I state that I am relying on the advice of another person, I confirm that the issues addressed in this statement of evidence are within my area of expertise. I have not omitted to consider material facts known to me that might alter or detract from the opinions that I express.

2 EXECUTIVE SUMMARY

2.1 My evidence covers the potential for leaching of soil contaminants from solar panels and possible negative downstream effects on pasture growth created by the proposed Buckleys Road solar farm. Estimates of these effects are based on measurements from a replicated agronomic field trial at the Kea Energy solar array in Wairau Valley and from the Coombe farm solar array in the United Kingdom.

2.2 The Wairau Valley measurements show that in the topsoil directly below solar panels which have been operational for 3 years, there was no detectable increase in the concentration of 7 potential soil contaminants (Cadmium, Cobalt, Lead, Nickel, Zinc, Fluoride, Chromium), compared to corresponding control topsoil samples from outside the solar array, while a further 3 potential soil contaminants (Mercury, Molybdenum, Selenium) were consistently below detectable limits.

2.3 Per unit ground area pasture growth rates near one of the panel driplines, where any unmeasured potential leached contaminants would be expected to concentrate, were similar to growth rates in the corresponding sample areas outside the solar array.

2.4 These results are consistent with measurements of the same 10 potential contaminants in soil samples taken from the Coombe farm solar array in the United Kingdom, which has been operational for 12 years.

2.5 The results are consistent with a number of recent scientific literature reviews (I can provide these to the Commissioner, if that would be helpful) which suggest that encapsulated solar cells are manufactured for durability which prevents exposure of internal components to rainwater, hence negligible leaching is expected under normal operating conditions. There is evidence in the scientific literature that severely broken panels in landfills may leach metals into groundwater, but this is not relevant to the proposed development.

2.6 On this basis, it is extremely unlikely that the proposed solar array at Buckleys Road, Brookside, will lead to leaching of contaminants into the soil or groundwater.

3 SCOPE OF EVIDENCE

3.1 My evidence addresses:

(a) The proposed activities;

(b) The receiving environment;

(c) Measurements made at a replicated agronomic field trial at the Kea Energy solar array in the Wairau Valley, and how they can be used to estimate the potential for leaching of soil contaminants from solar panels and downstream effects on pasture growth at the proposed Buckleys Road solar farm.

(d) Measurements made at the 'Coombe farm' solar array in the United Kingdom, which has been operational for 12 years and how they can be used to estimate the potential for long-term leaching of soil contaminants from solar panels at the proposed Buckleys Road solar farm.

(e) The submissions of Donna Irons and Simon Robinson, Ewan Chapman, Anneka Dalley and Michael Dalley (Haurere Farms), David Green, and Clark James Casey, that raise issues about the potential for leaching from solar panels to contaminate the soil.

(f) The s42A ECan Officer's Report in relation to the application and matters raised by submitters; and

(g) The proposed conditions of consent.

4 THE PROPOSED ACTIVITIES

4.1 Of relevance to leaching/soil contamination from solar panels, the Proposal (as limited notified) seeks consent to construct and operate a 111ha solar array on the site which will have a generating capacity of 100G MW on completion. The solar array will comprise a total of 140,000 tracking panels with thirteen inverters.

4.2 I understand that the solar farm will operate for at least 35 years, during which time regular maintenance checks will ensure that broken panels will be replaced in a timely manner. The panels may also be replaced with a more efficient type, if economically viable. Should the solar farm stop operating at any time, the panels will be cleared from the Site and disposed of appropriately, likely by recycling the component parts.

5 THE RECEIVING ENVIRONMENT

5.1 The solar farm is proposed to be constructed on 111 ha of existing dairy farms as identified in the AEE document. The Site is currently characterized by irrigation infrastructure, some existing dwellings, farm buildings, and shelter belts, with vegetation consisting primarily of exotic pasture species. After the proposed development, vegetation within the Site will remain predominantly exotic pasture species, with grazing by sheep.

5.2 The soil type at the site is characterised on SMap as 67% Ayreburn soil and 33% Leeston soil which is affected by waterlogging and has been chemically reduced. There are no known waterways that run through the Site, although a water race runs adjacent to Branch Drain Road which eventually discharges into Boggy Creek.

6 EFFECTS ON THE ENVIRONMENT (SECTION 104(1)(a) RMA)

6.1 Although the size of the proposed solar array is greater than the KeaX Limited Wairau Valley solar array, the underlying solar panel technology and panel configuration is similar to that used at the Wairau Valley site. At both sites, the panels are bifacial and silicon-based, with each solar cell surrounded by an encapsulant within glass and surrounded by edge seals (See evidence of Campbell McMath). For this reason, measurements of soil leaching/contamination and

pasture growth made at the Wairau Valley site can be used to estimate expected effects at the Buckley's Road site.

6.2 The report on my soil leaching/contamination measurements made at Wairau Valley are attached as Attachment 1 to this evidence. The key findings are:

- Measurements from a replicated agronomic field trial at a solar farm which has been operational for 3 years show that there is no statistically significant increase in the concentration of 7 potential topsoil contaminants (Total recoverable Cadmium, Cobalt, Lead, Nickel, Zinc, Fluoride, Chromium) below solar panels - compared to corresponding control sampling points outside the solar array.
- A further 3 potential topsoil contaminants (Total recoverable Mercury, Molybdenum, Selenium) were consistently below detectable limits.

6.3 The report on my pasture growth measurements at Wairau Valley are attached as Attachment 2 to this evidence. The key findings are:

- Replicated measurements at sampling points corresponding with the solar panel dripline showed similar pasture growth rates to control sampling points situated away from rainwater runoff from the panels.
- Given that driplines are where potential leached contaminants would be expected to concentrate, this indicates that any potentially unmeasured contaminants in the rainwater which runs off panels have no negative impact on pasture production.
- Spatial variation in pasture growth below solar arrays is likely explained by the varied and dynamic light, rainfall and microclimatic environment under solar arrays, rather than soil contamination.

6.4 The report on independent soil leaching/contamination measurements made at the 'Coombe farm' in the United Kingdom are attached as Attachment 3 to this evidence. The key findings are:

- Measurements from a solar farm which has been operational for 12 years show that there was no increase in the concentration of 7 potential topsoil contaminants (Cadmium, Copper, Fluoride, Selenium, Lead, Zinc and Chromium), below solar panels compared to corresponding control sampling points outside the solar array.
- A further 3 potential topsoil contaminants (Molybdenum, Nickel and Mercury) were consistently below detectable limits.

6.5 Overall, the findings set out above confirm that it is extremely unlikely that the proposed solar array at Buckleys Road, Brookside, will lead to leaching of these soil contaminants over the long-term.

7 SUBMISSIONS

7.1 Four out of six submissions received relate to the potential for leaching of soil contaminants from solar panels.

7.2 The submissions of Donna Irons and Simon Robinson express the concern that heavy metals leaching into the soil has the potential to not only destroy the microorganisms in the soil but also affect their ability to grow vegetables, hay and grass for livestock and the public.

7.3 The data presented in Attachment 2 from the KeaX Wairau Valley solar array indicates that any elements or compounds in the rainwater which runs off panels have no negative impact on pasture production. I acknowledge that there is a lack of data on soil microorganisms, but in my expert opinion, given no evidence of soil contamination, there would be no impact of leached contaminants influencing soil microorganisms.

7.4 Donna Irons and Simon Robinson also express the concern that leaching has the potential to drastically alter the chemical balance of said soil, resulting in the need for significant investment into testing and management fertilizer/spreading in order to remediate this or mitigate the long-lasting effects.

7.5 The data presented in Attachment 3 from the Coombe farm solar array shows that there is no plausible mechanism by which the Proposal could cause leaching which alters the soil chemistry of neighbouring farms long term.

7.6 Donna Irons and Simon Robinson also express the concern that chemical leaching will affect the water that they pump up from their well and (generate) other possible airborne toxins.

7.7 Given that solar panels will not alter the chemistry of the soil directly below the panels, I consider that they will not influence the chemistry of groundwater. The internal components of solar panels are not volatile and therefore do not contaminate air. Furthermore,

encapsulated solar cells are manufactured for durability which limits the exposure of internal components to rainwater or air.

7.8 The submission of Ewan Chapman, Anneka Dalley and Michael Dalley (Haurere Farms) expresses the concern that the productivity of the land will be compromised by compaction, clods, irons, water, run-off and cover, and take more land out of our food chain/economy, and that the value of lamb meat and wool will be reduced due to contamination by metals. They suggest that compacted soils with little organic matter will reduce productive capacity of the grass and crops. The submitters also express concern that clover will not grow within the array.

7.9 The data presented in Attachment 2 show that at the KeaX Wairau Valley solar array, no reduction in estimated pasture production occurs at the paddock scale due to solar panels. While there is no data for crops in New Zealand, this indicates that pasture production can sometimes benefit from an intermittent shading regime. Any minor negative effects of, for example, compaction during solar panel installation are outweighed by the benefits of intermittent shading at the paddock scale. Spatial variation in pasture growth below solar arrays is likely to be observed, but this can be explained by the varied and dynamic light, rainfall and microclimatic environment under the array, rather than soil contamination. Consequently, there are no plausible mechanisms by which lamb meat could become contaminated. A reduction in clover content below panels maybe be offset by a slight increase in clover content between panels (Attachment 2, Figure 4).

7.10 The submission of David Green expresses the concern that weeds under panels pose a fire risk and are difficult to control.

7.11 I understand that the Site will remain in exotic pasture species, with grazing by sheep, therefore, in my opinion, it is extremely unlikely that there will be a change in the prevalence of weeds or fire risk.

7.12 The submission of David Green also expresses concern that soil contamination from the wash of metals from the panels over time will flow into local drains that flow into Lake Ellesmere. He refers to reports from Denmark which show contamination beneath panels after a

number of years means that soils cannot be used for agricultural production.

7.13 The reports from Denmark have not been provided, so I cannot comment on these. However, data from NZ (Attachment 2) shows that solar panels are compatible with agricultural production, and given that broken panels will be replaced before they can leach metals into groundwater, it is my opinion that the panels will not alter the chemistry of the soil. So, there is little reason to believe they could influence the chemistry of groundwater.

7.14 The submission of Clark James Casey expresses the concern that contamination by panels will compromise the use of highly productive land.

7.15 The data presented in Attachment 2 show that at the KeaX Wairau Valley solar array show that no reduction in estimated pasture production occurs at the paddock scale due to solar panels. Pasture production can sometimes benefit from an intermittent shading regime.

8 SECTION 42A OFFICER'S REPORT

8.1 Mr Bigsby prepared the section 42a report for Selwyn District Council (SDC) in relation to KeaX Limited's land use consent application. He sought expert advice from Ms Stout from PDP on the matters of potential soil contamination.

8.2 I have read the s42a report and Ms Stouts's report and agree with her findings. There are no other issues requiring clarification that relate to my area of expertise.

9 CONSENT CONDITIONS

9.1 I have reviewed the draft proposed consent conditions to be attached to the planning evidence of Ms Kelly and confirm that they reflect my recommendations.

10 CONCLUSION

10.1 My key conclusions are as follows:

(a) It is extremely unlikely that the Proposal will lead to leaching of these soil contaminants over the long-term.

(b) Spatial variation in pasture growth below solar arrays can be expected and this can be explained by the varied and dynamic light, rainfall and microclimatic environment under the array, rather than soil contamination.

Dr. Zac Beechey-Gradwell

16 February 2024

1 ATTACHMENT 1 - Soil leaching/contamination measurements made at Wairau Valley

Site characteristics

- The local latitude is -41.61020 degrees North and the longitude is 173.43259 degrees West (Figure 1).
- The address is 3649 Wairau Valley Road, New Zealand.
- The site terrain is very flat.
- The panels were installed in 2020 by KeaX Limited.
- The height of the panels is 2.077 m at the centreline. The width of the panels is 4.084 m.
- Panels are bifacial and silicon-based and track East to West throughout the day using a 2P solar tracking system.
- The soil underneath the array is classified as silt loam and is stony.
- The pasture underneath the array consists of a diverse mix of exotic grasses, forbs and legumes which are grazed by sheep.

Figure 1. Aerial view of the KeaX Limited Wairau Valley solar array

Experimental design and soil sampling

- The experimental design accounts for the dynamic light environment within the array.
- This was mathematically modelled by AgResearch Limited for a clear day on October 1 2023 (Figure 2).

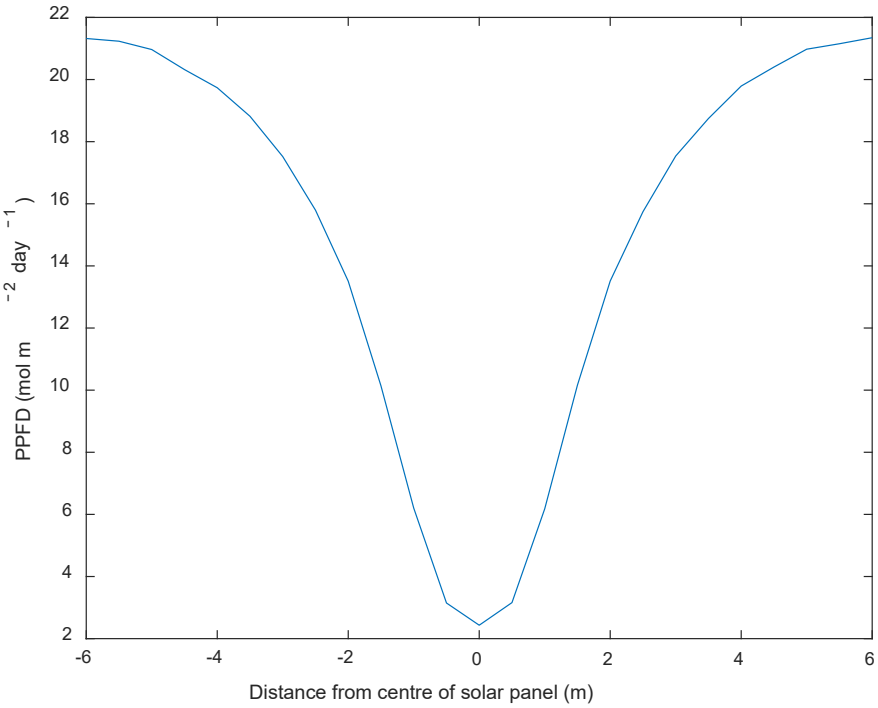


Figure 2. Mathematical model of daily PPFD (Photosynthetic photon flux density) in relation to horizontal distance from the centre of a row of panels at the KeaX Limited Wairau Valley solar array on a clear day on October 1 2023.

- To be representative, sampling of plants and soils at this site must account for a range of different light, rainfall and microclimatic situations within the array.
- There are 4 experimental blocks, each consisting of a transect within the solar array (Figure 3), and 1 matched control area just outside the array.
- Control sampling areas were selected such that they would not be impacted by rainwater runoff or shading from the panels.
- There are 5 sampling points down a transect and 1 sampling point in the control area. Each sampling point had a 1 x 2 m grazing exclusion cage placed on top to prevent stock access (Figure 4).

- 2/4 transect reps face West, while 2/4 face East.
- Note that there are 3 possible sources of contamination in the Proposal; the panels, the support frames they are mounted on and the inverter/transformer models. The experimental design and sampling regime used here specifically addresses to the possibility of soil contamination from the panels and the support frames they are mounted on, but not the inverter/transformer models.

Central of a row of solar panels	1	2	3	4	5	Midway point between two adjacent rows of panels

Figure 3. Example of sampling regime within the solar array at the KeaX Limited Wairau Valley site. A 'transect' begins at the centre of a row of panels and ends at the midway point between two rows of panels. This transect sampling strategy is representative of the dynamic light environment within the array. Because it is representative of possible microenvironments within the array, this allows projections of pasture growth onto a paddock scale to be made.


1
2
3
4
5

Figure 4. Top: Example of sampling regime within the solar array at the KeaX Limited Wairau Valley site for one of four replicate experimental blocks. Numbers indicate the sampling points along a transect. Bottom: Example of corresponding control sampling point outside the solar array for one of four replicate experimental blocks.

- On 22-23 August 2023, soil samples were taken along each 6.25 m transect and at each control area.
- A 2 cm diameter corer was used to collect 15 soil cores to a depth of 7.5 cm from each location.
- The cores from each location were bulked, mixed, gently oven-dried then passed t hrough a 4mm sieve.
- Soil chemical analysis was performed at Hill Labs, 28 Duke Street, Frankton, Hami lton 3204 using the methods shown in Figure 5.
- The scientific literature states that a solar panels can contain a number of metal a nd metalloid internal components which could be regarded as potential contamina nts. These include Cadmium, Chromium, Copper, Lead, Tin, Alimnium, Silicon and Silver.
- The analysis performed here considered Cadmium, Chromium, Copper and Lead, b ut not Tin, Alimnium, Silicon or Silver.

Sample Type: Soil			
Test	**Method Description**	**Default Detection Limit**	**Sample No**
Total Recoverable Cadmium	Dried sample, sieved as specified (if required). Nitric/Hydrochloric acid digestion, ICP-MS, screen level. US EPA 200.2.	0.10 mg/kg dry wt	1-8
Total Recoverable Chromium	Dried sample, sieved as specified (if required). Nitric/Hydrochloric acid digestion, ICP-MS, screen level. US EPA 200.2.	2 mg/kg dry wt	1-8
Total Recoverable Copper	Dried sample, sieved as specified (if required). Nitric/Hydrochloric acid digestion, ICP-MS, screen level. US EPA 200.2.	2 mg/kg dry wt	1-8
Total Recoverable Lead	Dried sample, sieved as specified (if required). Nitric/Hydrochloric acid digestion, ICP-MS, screen level. US EPA 200.2.	0.4 mg/kg dry wt	1-8
Total Recoverable Mercury	Dried sample, sieved as specified (if required). Nitric/Hydrochloric acid digestion, ICP-MS, screen level. US EPA 200.2.	0.10 mg/kg dry wt	1-8
Total Recoverable Molybdenum	Dried sample, sieved as specified (if required). Nitric/Hydrochloric acid digestion, ICP-MS, screen level. US EPA 200.2.	0.4 mg/kg dry wt	1-8
Total Recoverable Nickel	Dried sample, sieved as specified (if required). Nitric/Hydrochloric acid digestion, ICP-MS, screen level. US EPA 200.2.	2 mg/kg dry wt	1-8
Total Recoverable Selenium	Dried sample, sieved as specified (if required). Nitric/Hydrochloric acid digestion, ICP-MS, screen level. US EPA 200.2.	20 mg/kg dry wt	1-8
Total Recoverable Zinc	Dried sample, sieved as specified (if required). Nitric/Hydrochloric acid digestion, ICP-MS, screen level. US EPA 200.2.	4 mg/kg dry wt	1-8
Total Fluoride in Solids*	Ion selective electrode. Methods of Soil Analysis 2nd Edition, Pt2, 26-4.3.3. (modified).	20 mg/kg dry wt	1-8

These samples were collected by yourselves (or your agent) and analysed as received at the laboratory.

Testing was completed between 25-Sep-2023 and 09-Oct-2023. For completion dates of individual analyses please contact the laboratory.

Figure 5. Soil analysis methods used by at Hill Laboratories.

Results and interpretation

- The data were analysed statistically with a linear mixed model with 'treatment' (array vs control) as the fixed effect and block as the random effect. P values <0.05 were classified as statistically significant.

- Total recoverable Molybdenum, Selenium and Mercury were below detection limits and not statistically analysed. Total recoverable Chromium levels under the arrays and in controls areas were identical in all blocks, and therefore were also not statistically analysed (Figure 6).

- Total recoverable Cadmium, Cobalt, Lead, Nickel, Fluoride, did not statistically differ between the array samples and the control samples (Figure 6).

- Total recoverable Zinc was 8% higher under the array. The difference was nearly statistically significant (p=0.065).

- One possible explanation is that Zinc is distributed in sheep dung so this difference reflects changes in stock camping behaviour rather than Zinc leaching from panels. Regardless, the magnitude of the difference was small.

- Another possible explanation is that Zinc came from the support frames which are made of galvanised steel. Zinc is an essential trace element for plants and is not a priority contaminant in New Zealand soils.

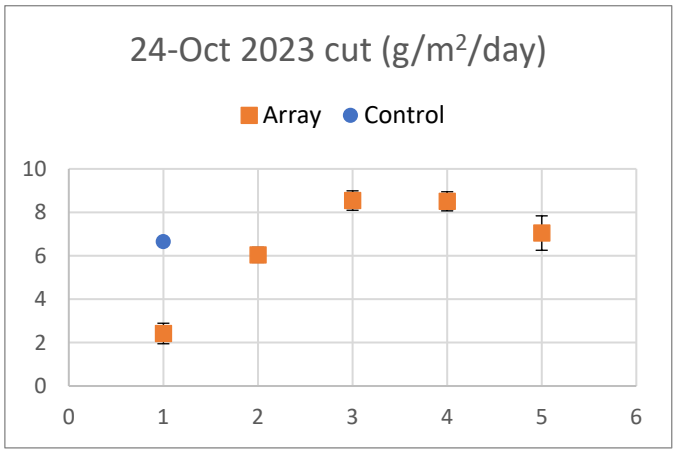
	Total Recoverable Cadmium	Total Recoverable Copper	Fluoride	Total Recoverable Mercury	Total Recoverable Molybdenum	Total Recoverable Selenium	Total Recoverable Lead	Total Recoverable Zinc	Total Recoverable Nickel	Total Recoverable Chromium
Array mean	0.18	7.75	166	BDL	BDL	BDL	9.33	50.0	7.50	9.8
Control mean	0.20	8.25	156	BDL	BDL	BDL	9.13	46.3	7.50	9.8
p value	0.675	0.613	0.307	NA	NA	NA	0.75	0.065	1	NA

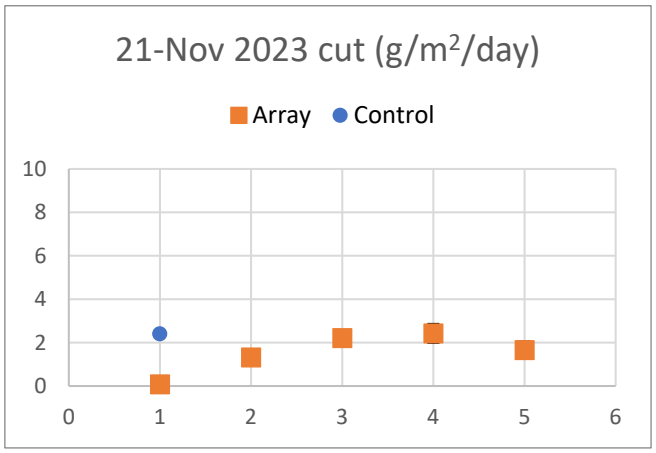
Figure 6. Mean values of potential soil contaminants. Values represent averages from 4 samples. P values are outputs from a linear mixed model with 'treatment' (array vs control) as the fixed effect and experimental block as the random effect. BDL=Below Detection Limit. NA= Not Analysed statistically.

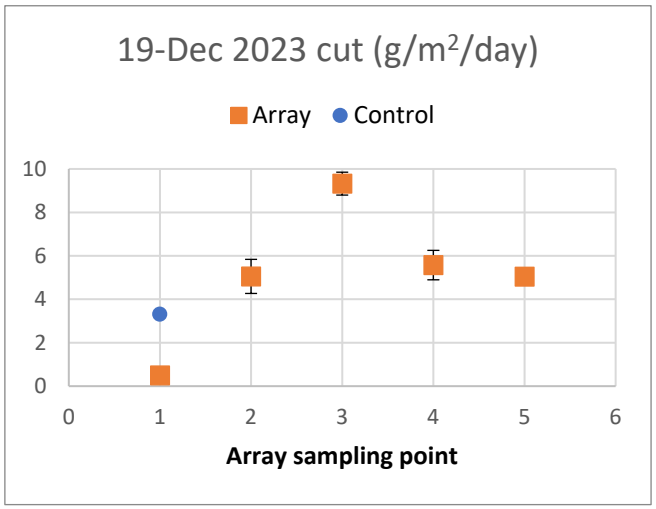
1 ATTACHMENT 2 – Pasture growth measurements made at Wairau Valley

- After the soil was sampled on 22-23 August 2023, the pasture at each sampling point (See appendix 1, Figure 3 and 4) was cut to 2 cm above the soil surface.
- This was effectively the beginning of a pasture growth trial.
- There have been 3 pasture cuts to 2 cm above the soil surface since August 22, 2023 as the first part of a year-long study into the seasonal impacts of solar panels on potential pasture production.
- At each cut, a strip of pasture 1 m length and 0.078 m width was cut at each sampling point. The plant material was dried then weighed, then converted onto a growth rate per unit ground area basis.

Results







- **Figure 1 – pasture growth rates at the at the KeaX Limited Wairau Valley solar array. The numbers on the x axis indicate sampling points along transects within the array. Sampling point 1 corresponds with the most shaded location, directly below the centreline of a row of panels. The units for pasture growth rate are g/m²/day.**

- Array sampling point 1 (directly under panels – high degree of shading) displayed lower pasture growth than the control sampling point (full sunlight), but array sampling points 2-5 (intermittent shading) had equal or greater growth than the control sampling points (Figure 1).

- Array sampling point 2 corresponds with the peripheral panel dripline (2.077 m from the centreline of the row when the panels are flat; Figure 2), where any potential leached contaminants would be expected to concentrate. This sampling point had similar pasture growth rates to control sampling points.

- Array sampling point 1 corresponds with the central panel dripline (Figure 2). This sampling point displayed lower pasture production than the control sampling point.

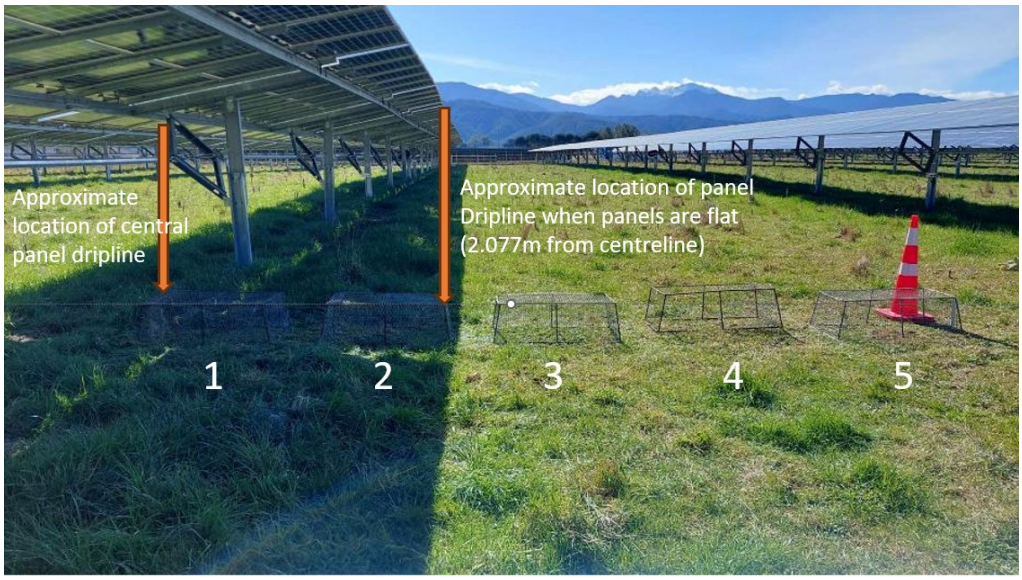


Figure 2. Approximate dripline locations within the solar array at the KeaX Limited Wairau Valley solar array. Numbers indicate the sampling points along a transect

- The large discrepancy in growth between sampling point 1 and sampling point 2 is unlikely to be the result of contaminant leaching from solar panels because both sampling points correspond with panel driplines but have very different pasture growth rates. Instead it is likely that the reduced growth at sampling point 1 is due to light limitation which becomes severe near the centre line of the row of panels (Appendix 1, figure 1).

- Pasture growth rates can be averaged for all the sampling points within the array to get an estimation of pasture growth rate if an entire paddock was filled with solar panels.

- These can be compared to the average pasture growth rates for the control sampling points to get an estimate of pasture production if there were no solar panels in the paddock.

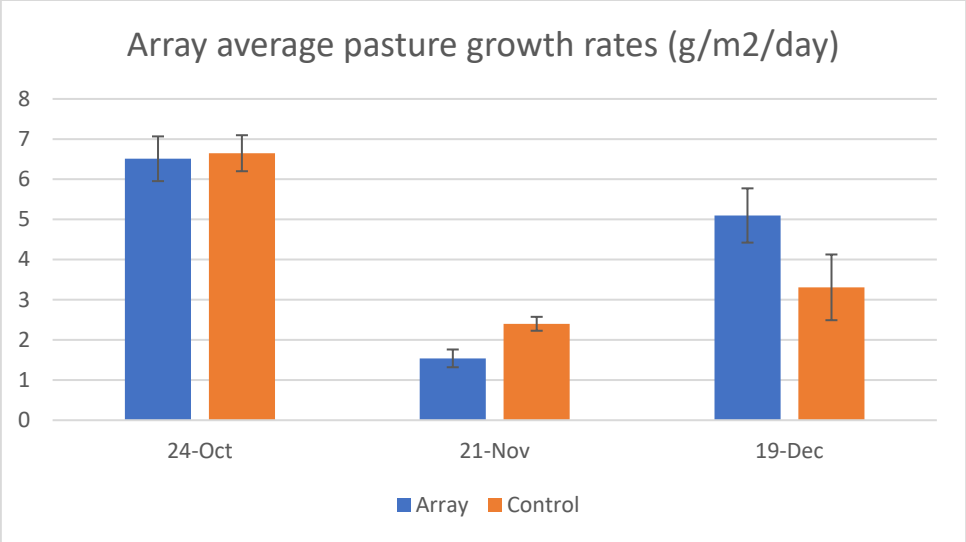


Figure 3. Projected paddock scale pasture growth rates if an entire paddock was filled with solar panels.

- The results of this averaging show no reduction in projected pasture production at the paddock scale due to solar panels between August 2023 and December 2023.

- This preliminary evidence indicates that pasture production can sometimes benefit from an intermittent shading regime.

- Spatial variation in pasture growth below solar arrays can be expected and this can be explained by the varied and dynamic light, rainfall and microclimatic environment under the array, rather than soil contamination.

- At cut 1 (October 24), clover proportion was decreased at transect sampling position 1 (under panels) but was similar below panels but was slightly increased at transect position 5 (between panels) compared to corresponding control areas.

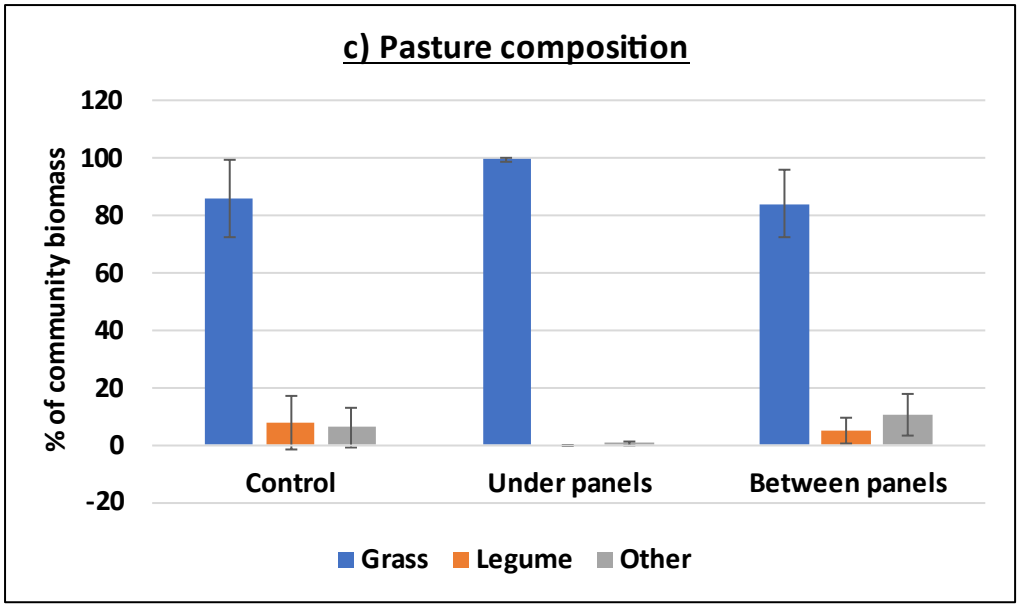


Figure 4. Pasture botanical composition on October 24 2023.

ATTACHMENT 3 - Soil leaching/contamination measurements made at Coombe farm

Site characteristics and soil sampling

- The address is Coombe Farm Flats, Roundham, Crewkerne, UK (TA18 8RR).
- The local latitude is 50.88483 North, -2.83250 West.
- The solar array has been in place for 12 years.
- Soil samples were taken in duplicate from two locations within the solar array at Coombe farm (Figure 2, Figure 3), and in duplicate from one control area just outside the array (Figure 1).
- The data and the information about sampling were provided by Nick Keeler of Ethical Power.
- Samples within the array were taken from near the panel dripline.
- Control sampling areas were selected such that they would not be impacted by rainwater runoff from the panels.
- The soils were analysed by Cawood Scientific Limited (NRM, Coopers Bridge, Braziers Lane, Bracknell, Berkshire RG42 6NS)

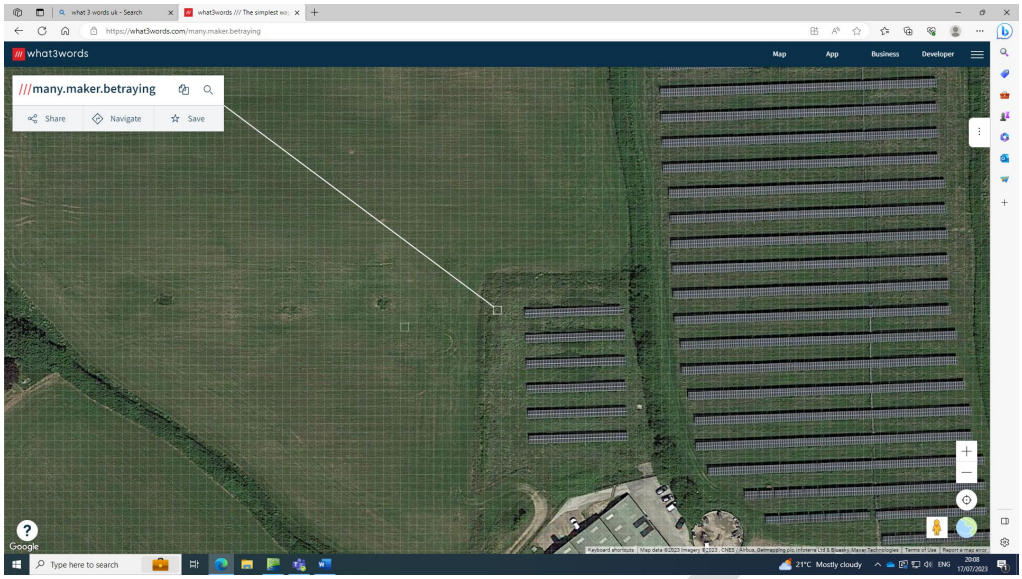


Figure 1. Control sampling location.

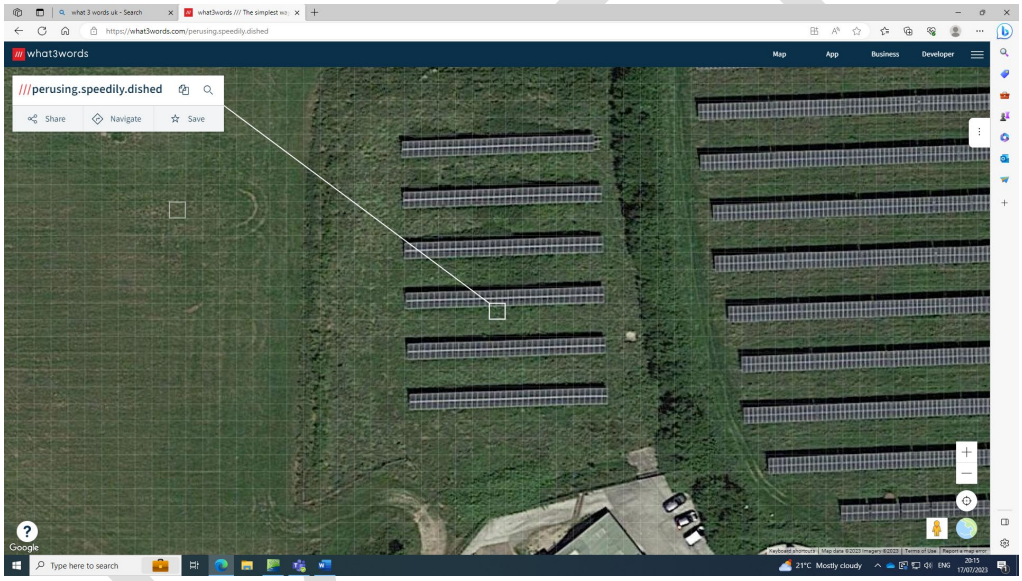


Figure 2. Row 3 sampling location.

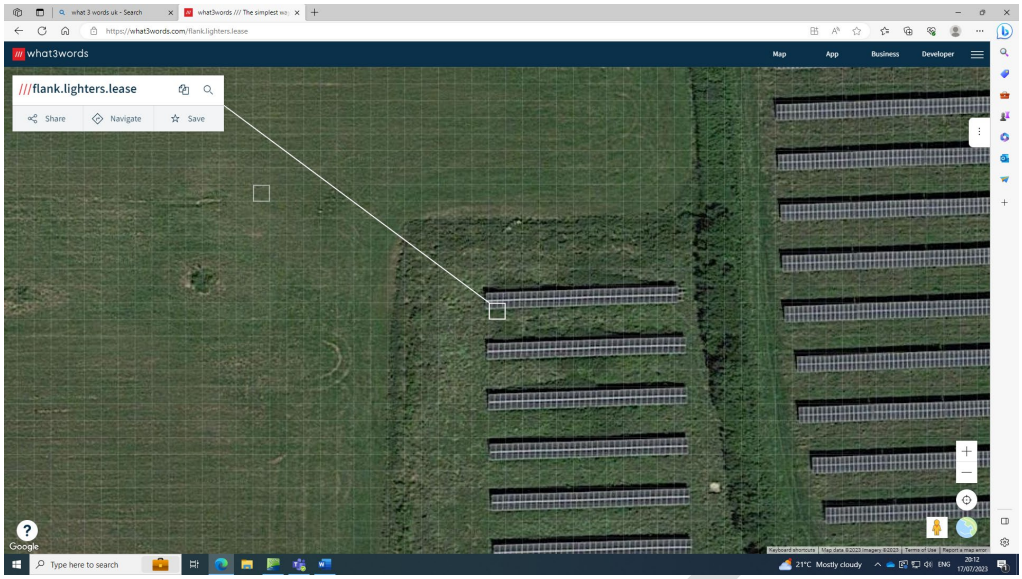


Figure 3. Row 6 sampling location.

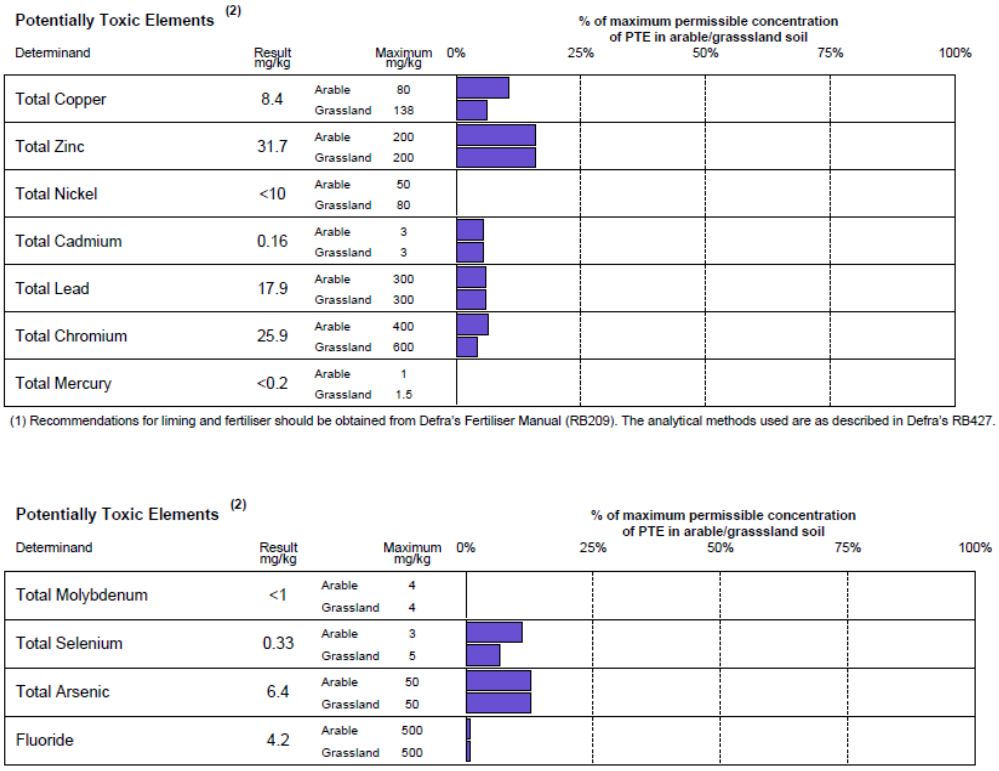
Results and interpretation

- The data were not analysed statistically due to the unbalanced experimental design.

- Instead, mean values and % differences in mean values between the array and control sampling points were calculated. % difference were calculated as *(Array Mean – Control Mean)/Control Mean x 100*.

- Total recoverable Molybdenum, Nickel and Mercury were consistently below detection limits.

- Concentrations of Cadmium, Copper, Fluoride, Selenium, Lead, Zinc and Chromium were well below the maximum permissible concentration of Potentially toxic elements in soil for both the array and the control samples (Figure 4.).



Potentially Toxic Elements (2)

% of maximum permissible concentration of PTE in arable/grassland soil

Determinand	Result mg/kg		Maximum mg/kg	0% 25% 50% 75% 100%
Total Copper	8.4	Arable	80	
		Grassland	138	
Total Zinc	31.7	Arable	200	
		Grassland	200	
Total Nickel	<10	Arable	50	
		Grassland	80	
Total Cadmium	0.16	Arable	3	
		Grassland	3	
Total Lead	17.9	Arable	300	
		Grassland	300	
Total Chromium	25.9	Arable	400	
		Grassland	600	
Total Mercury	<0.2	Arable	1	
		Grassland	1.5	

(1) Recommendations for liming and fertiliser should be obtained from Defra's Fertiliser Manual (RB209). The analytical methods used are as described in Defra's RB427.

Potentially Toxic Elements (2)

% of maximum permissible concentration of PTE in arable/grassland soil

Determinand	Result mg/kg		Maximum mg/kg	0% 25% 50% 75% 100%
Total Molybdenum	<1	Arable	4	
		Grassland	4	
Total Selenium	0.33	Arable	3	
		Grassland	5	
Total Arsenic	6.4	Arable	50	
		Grassland	50	
Fluoride	4.2	Arable	500	
		Grassland	500	

Figure 4. Row 6 sample 1 potentially toxic elements. This sample is used as an example of potentially toxic element concentrations relative to maximum permissible concentrations in soils. Element concentrations varied little between replicate samples.

- % differences between mean values from array and the control samples ranged from +29% for Copper to -30% for Fluoride (Figure 5).
- This range of values in % differences between mean values from within the array and mean values from the control samples can likely be attributed to random variation due to the small number of samples taken.
- In my expert opinion this variation is unlikely to be of significance with regards to the potential for soil contamination.

	Total Recoverable Cadmium	Total Recoverable Copper	Fluoride	Total Recoverable Mercury	Total Recoverable Molybdenum	Total Recoverable Selenium	Total Recoverable Lead	Total Recoverable Zinc	Total Recoverable Nickel	Total Recoverable Chromium
6 1	0.16	8.4	4.2	BDL	BDL	0.33	17.9	31.7	BDL	25.9
6 2	0.11	6.3	2.5	BDL	BDL	0.28	13.9	24.8	BDL	19.4
3 1	0.15	7.2	6.5	BDL	BDL	0.31	12.3	37.6	BDL	28.2
3 2	0.12	6.5	6.6	BDL	BDL	0.27	11.6	30.9	BDL	25
C 1	0.14	6	7	BDL	BDL	0.34	14	29.1	BDL	36.4
C 2	0.13	5	7.2	BDL	BDL	0.32	12.8	25.5	BDL	25.7
Array average	0.14	7.1	5.0			0.30	13.9	31.3		24.6
Control average	0.14	5.5	7.1			0.33	13.4	27.3		31.1
% difference	0	29	-30			-10	4	14		-21

Figure 5. Raw and Mean values of potential soil contaminants at Coombe farm solar array. BDL=Below Detection Limit. 6 1 = Array row 6, sample 1 (See Figure 3). C 2 = Control, sample 2 (See figure 1).