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2 July 2024

Phil Nevill
Senior Environmental Assessment officer
Department of Planning, Housing and Infrastructure
4 Parramatta Square | 12 Darcy Street
Parramatta NSW 2150

Re: Response to request for additional information - groundwater

Dear Phil,

Please find enclosed a memo prepared in response to:

- A request for additional information received from the Department of Planning, Housing and Infrastructure (DPHI) dated 28 May 2024, in relation to the independent peer review of the groundwater model, prepared to support the Cowal Gold Operations – Open Pit Continuation Project EIS.
- Information requested by the independent peer reviewer (Noel Merrick) and the NSW Department of Climate Change, Energy, the Environment and Water at the meeting held 3 June 2024.

The enclosed memo addresses the additional information requested by the independent peer reviewer, specifically:

1. *To assess the influence of the northern constant head boundary, two additional model scenarios are to be run:*
    a) *Bland Creek Paleochannel Borefield - no mine borefield pumping. Compare water budget with borefield pumping case to obtain the flux induced from the northern constant head boundary cells due to the mine borefield.*
    b) *Landholder pumping switched off. Compare water budget with landholder pumping case to obtain the flux induced from the northern constant head boundary cells due to landholder pumping.*
2. *To assess the suitability of adopted hydraulic conductivity values, the spatial distribution of hydraulic conductivity in m/day (not log values) are to be provided as maps for all model layers.*

The outcomes of the additional modelling presented in the attached memo show, as anticipated, larger modelled impacts at the northern boundary from landowner bores than abstraction from the Bland Creek Paleochannel Borefield (BCPB).

In response to the independent peer review comments and recommendations for future works regarding the groundwater model, these recommendations are noted and will be considered as part of future groundwater model reviews to be undertaken every three years, in line with existing conditions of consent, and previously committed to in the EIS.

Should you have any questions or require any additional information regarding this matter, please feel free to contact me on 0407 207 530 or email jwearne@emmconsulting.com.au.

Yours sincerely

James Wearne
Associate
jwearne@emmconsulting.com.au

Enclosed:

- Memo - Cowal Gold Operations groundwater model scenario testing (EMM, 7 June 2024)

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Adelaide SA 5000
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Memorandum

2 July 2024

To: Dr Noel Merrick

From: Tom Neill

Subject: Cowal Gold Operations groundwater model scenario testing

This memo prepared in response to:

- A request for additional information received from the Department of Planning, Housing and Infrastructure (DPHI) dated 28 May 2024, in relation to the independent peer review of the groundwater model, prepared to support the Cowal Gold Operations – Open Pit Continuation Project EIS (EMM 2024a, 2024b).
- Information requested by the independent peer reviewer (Noel Merrick) and the NSW Department of Climate Change, Energy, the Environment and Water at the meeting held 3 June 2024.

This memo addresses the additional information requested by the independent peer reviewer, specifically:

1. *To assess the influence of the northern constant head boundary, two additional model scenarios are to be run:*
   a) *Bland Creek Paleochannel Borefield - no mine borefield pumping. Compare water budget with borefield pumping case to obtain the flux induced from the northern constant head boundary cells due to the mine borefield.*
   b) *Landholder pumping switched off. Compare water budget with landholder pumping case to obtain the flux induced from the northern constant head boundary cells due to landholder pumping.*
2. *To assess the suitability of adopted hydraulic conductivity values, the spatial distribution of hydraulic conductivity in m/day (not log values) are to be provided as maps for all model layers.*

This memo presents the outcomes of four predictive scenarios, showing larger modelled impacts at the northern boundary from landowner bores than abstraction from the BCPB.

1 Model scenarios

To assess the influence of the northern constant head boundary, two scenarios were proposed in addition to the two presented in EMM (2024a) and EMM (2024b). These are based on the predictive model from the Open Cut Continuation Project (EMM 2024b), with modifications to delineate the source of modelled impacts. The model scenarios are as follows:

3. No groundwater abstraction, 'background' climatic stresses only. Equivalent to Prediction 1 by EMM (2024b) but with no landowner pumping.

4. Full abstraction for approved and expansion project. Equivalent to Prediction 3 by EMM (2024b).

5. Scenario 2 with no landowner bore pumping.

6. Scenario 2 with no mine-related bore pumping from the BCPB.

Each model scenario was run using the base realisation parameters through to the end of mining, in accordance with the request by the independent model reviewer made on 3 June 2024.

2 Model results

2.1 Flux

Modelled flux results are presented in Figure 2.1. These plots show simulated flux via all constant head boundary cells for the four scenarios detailed above. Background modelled flux (Scenario 1) is shown in green, with variability due to climatic stresses. The yellow series shows modelled flux from all mining-related activities and landowner pumping (Scenario 2), with a net reduction of 1.5 ML/d at the end of mining. The other two scenarios, showing the deactivation of landowner bores (Scenario 3) and BCPB (Scenario 4), are shown in blue and black, respectively. Deactivation of landowner pumping (the blue series) results in a net flux reduction relative to background of 0.5 ML/d, and deactivation of BCPB pumping (the black series) results in a net flux reduction relative to background of 1.1 ML/d. Proportionally, the landowner bore pumping is simulated to induce a net constant head boundary flux change over double the change associated with BCPPB bore pumping. The modelled flux change includes an increase to inflows and decrease to outflows.

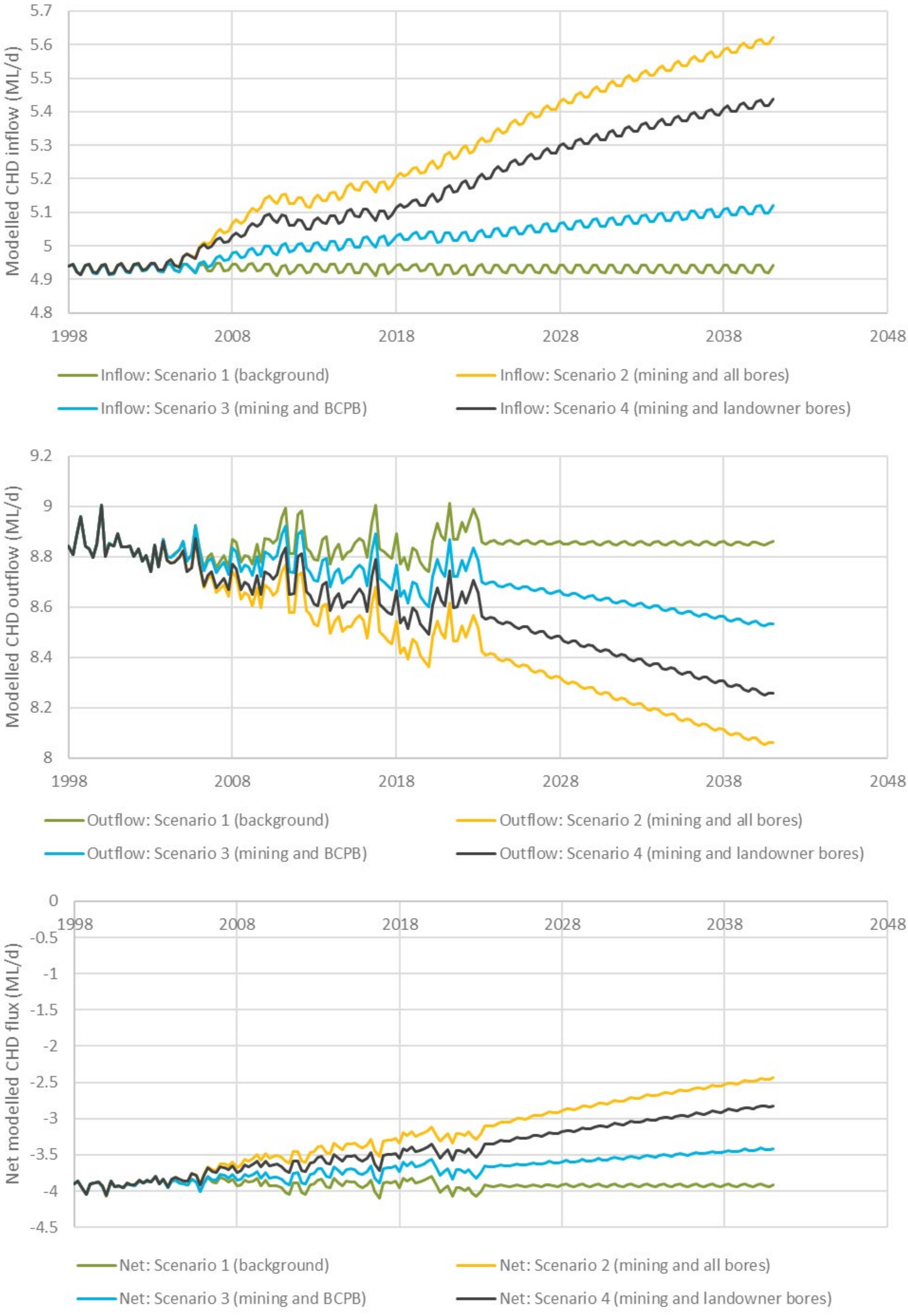

Figure 2.1 **Modelled constant head boundary fluxes per scenario**

2.2 Drawdown

Modelled drawdown contours in the Lower Cowra and Lachlan Formation are presented in Figure 2.2 and Figure 2.3, respectively. Drawdown is calculated at the end of mining against the background hydraulic heads (Scenario 1), removing any variability associated with climatic stresses. For clarity of presentation, only the 1 m drawdown contour has been presented for each scenario. The orange contour is the full mining and all bores scenario (Scenario 2), and the removal of landowner bores (Scenario 3) and BCPB (Scenario 4) are presented as the blue and black series, respectively. In both HSUs, the black line corresponding to drawdown from landowner pumping is closer to the northern boundary than the blue line corresponding to drawdown from the BCPB.

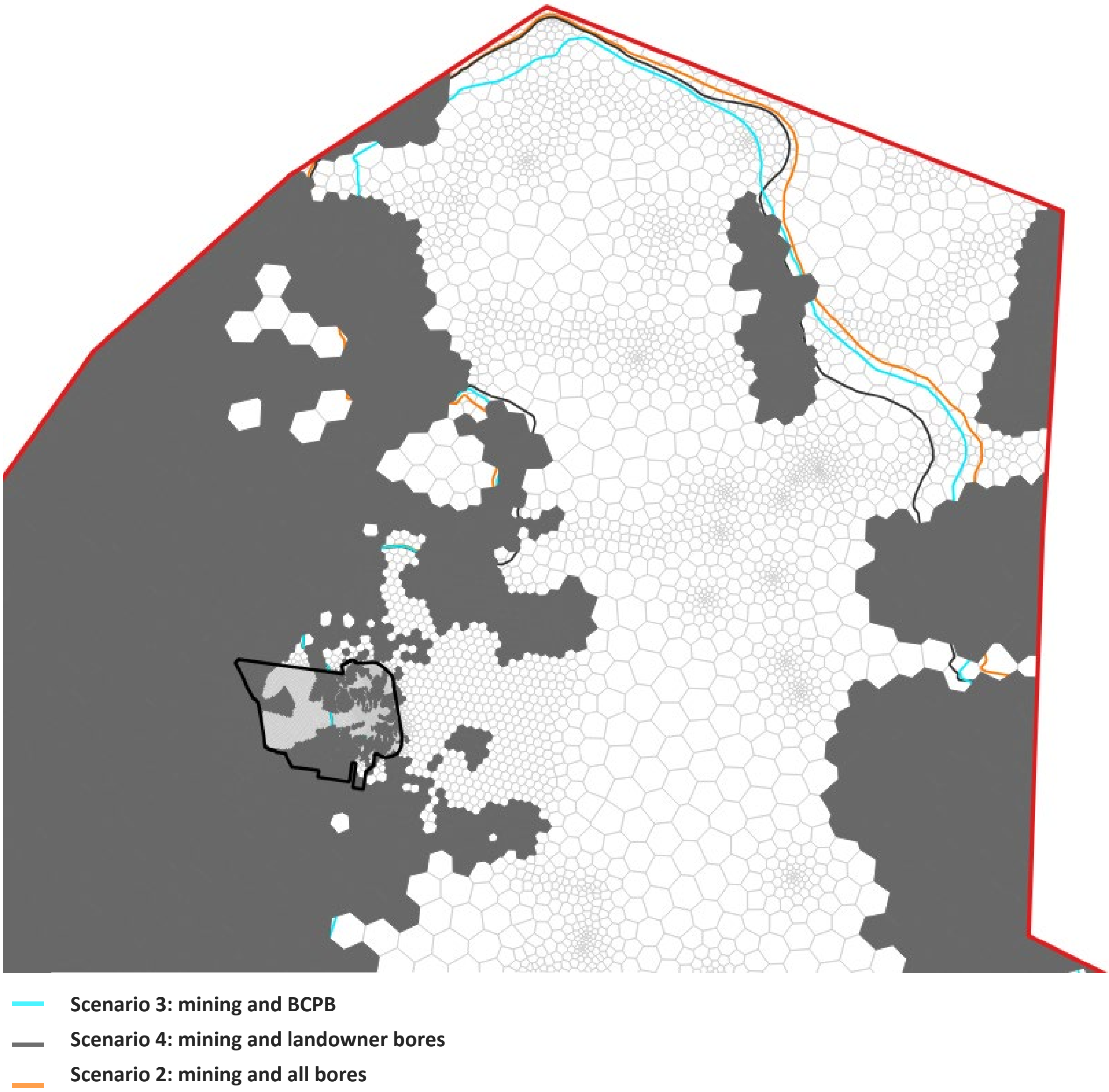

Figure 2.2 Modelled 1 m drawdown contour at end of mining in Lower Cowra

Scenario 3: mining and BCPB
Scenario 4: mining and landowner bores
Scenario 2: mining and all bores

Figure 2.3 Modelled 1 m drawdown contour at end of mining in Lachlan Formation

3 Additional modelling outputs

Following the request for additional display of modelled properties, spatial distributions have been prepared and compiled into appendices. With the exception of Appendix C, all figures show the modelled properties of the base realisation.

- Appendix A: horizontal hydraulic conductivity. As requested, properties are presented on a linear scale.
- Appendix B: horizontal hydraulic conductivity, presented on a log scale due to apparent 'washing out' of properties on a linear scale.
- Appendix C: the standard deviation of modelled horizontal hydraulic conductivity, calculated as a log cycle due to the log transformation of the parameter. This gives an indication of locations where, across the ensemble, there is higher or lower variability in horizontal hydraulic conductivity.
- Appendix D: anisotropy; horizontal hydraulic conductivity divided by vertical hydraulic conductivity. Larger values mean a smaller value of vertical hydraulic conductivity.
- Appendix E: specific storage. Model layer 1 is not presented, as only specific yield is used for an unsaturated layer.
- Appendix F: specific yield.

4 Response to review comments

Remaining peer review comments are detailed and responded to in Table 4.1. As discussed, the relevant reports (EMM 2024a, 2024b) are not planned to be reissued. Therefore modifications to figures etc. will be taken on as recommendations for future studies.

Table 4.1 Response to review comments

Report	Issue number	Section	Comment	Response
EMM 2024a	68	2.3, 5.3.5, Att.A	The latest UA guide is not referenced. Retain both in Attachment A, as 2018 has more detail and a difference in approach.	Noted. As discussed, the EIS report was prepared prior to the release of the updated UA guide.
EMM 2024a	69	3.6.5	Figures 3.10, 3.11: Flow arrows are not generally perpendicular to contours as claimed – see my version (pink arrows). Particular year has been added by EMM.	Noted, and will be updated in future works.
EMM 2024a	70	4.4	Figures 2.1 & 2.2 in Attachment C are corrected for positions of ESB and BCPB. Do the same for Figures 4.3 & 4.4. And add ET.	Noted, and will be updated in future works.

Report	Issue number	Section	Comment	Response
EMM 2024b	71	2.3.1	A bore response is given in Fig 2.1 next to Warroo No.1 Channel to indicate the effect of a potential flood recharge event in 2016, noting correctly that it "cannot be separated from that of diffuse infiltration of rainfall". The rainfall recharge alternative could have been tested by observing the response at nearby bores away from flooding influence (e.g. GW036552 & GW036551 to west): all 3 bores rose about 2 m, suggesting no more than a minor (sustained) influence from flooding.	Noted
EMM 2024b	72	2.5	Figs 2.3 & 2.4. ET is not indicated, though it is said to be the dominant discharge mechanism. It is not the same as evaporation.	Noted. Evapotranspiration has been erroneously written as evaporation in several places in the report. This will be rectified in future works.
EMM 2024b	73	4.1.3.ii	Refer back to Table 3.5 where the source is Coffey (2020a).	Noted, and will be updated in future works.
EMM 2024b	74	4.2.3	Again, a concerning confusion between evaporation and ET as if they are the same process ("evaporation extinction depth"). They are not.	Noted, refer above.
EMM 2024b	75	4.3	Clarify what "mean" is used in Table 4.4. Kh should use arithmetic mean, with harmonic mean for Kv.	Arithmetic mean was used for all parameters. More representative measures will be used in future works.
EMM 2024b	76	4.3	In Table 4.4, should Sy be a fraction rather than %?	Yes. This will be clarified in future works.
EMM 2024b	77	4.3	Figure 4.3 has >> 5% of samples gathered at the bounds, contrary to expectation. Seems to be about 15-30% instead of 5%.	Assuming that this comment refers to Figure 4.13, the figure shows modelled properties per cell (following kriging) whereas Figure 4.12 shows modelled properties per pilot point. Additional figures of layer-wide modelled properties are provided in Appendix A to F of this memo.
EMM 2024b	78	5.1.1	Figure 5.3 has strange units showing values of 200-600 ML/day. Aggregating rates is not a reasonable definition for a quantity of interest.	Noted. More representative quantities of interest will be used for convergence analyses in future works.

5 Conclusion

The updated scenario results demonstrate that landowner pumping is simulated to be the primary influence of groundwater level impacts at the northern model boundary.

Yours sincerely,

Tom Neill
Senior Groundwater Modeller
tneill@emmconsulting.com.au

References

EMM 2024a Cowal Gold Operations – Open Cut Continuation Project Groundwater Impact Assessment, report prepared for Evolution Mining (Cowal) Pty Ltd, January 2024, report reference J190417a RP43.

EMM 2024b Cowal Gold Operations – Open Cut Continuation Project Numerical Groundwater Modelling, report prepared for Evolution Mining (Cowal) Pty Ltd, January 2024, report reference J190417a RP51.

Appendix A

Horizontal hydraulic conductivity

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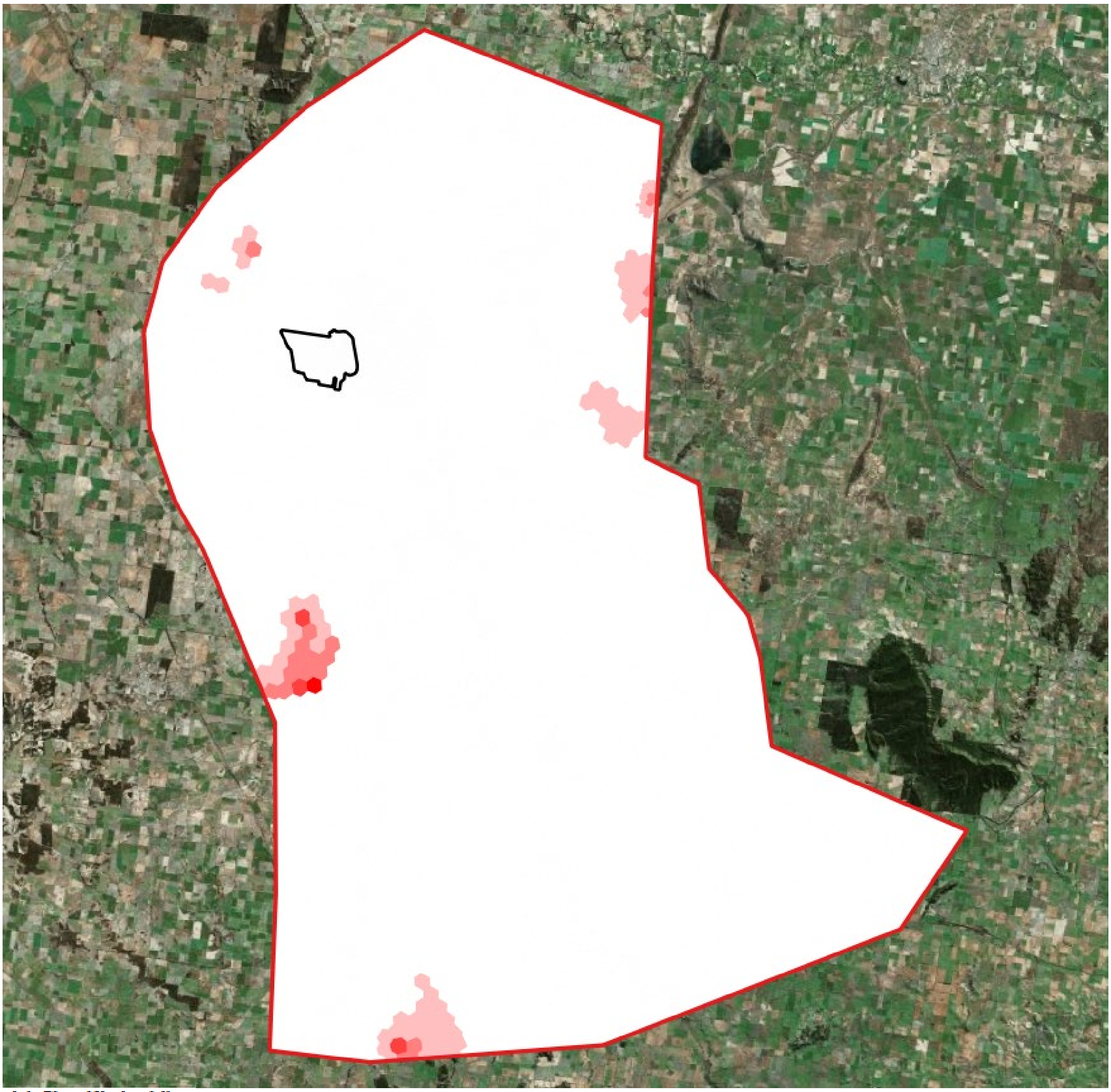
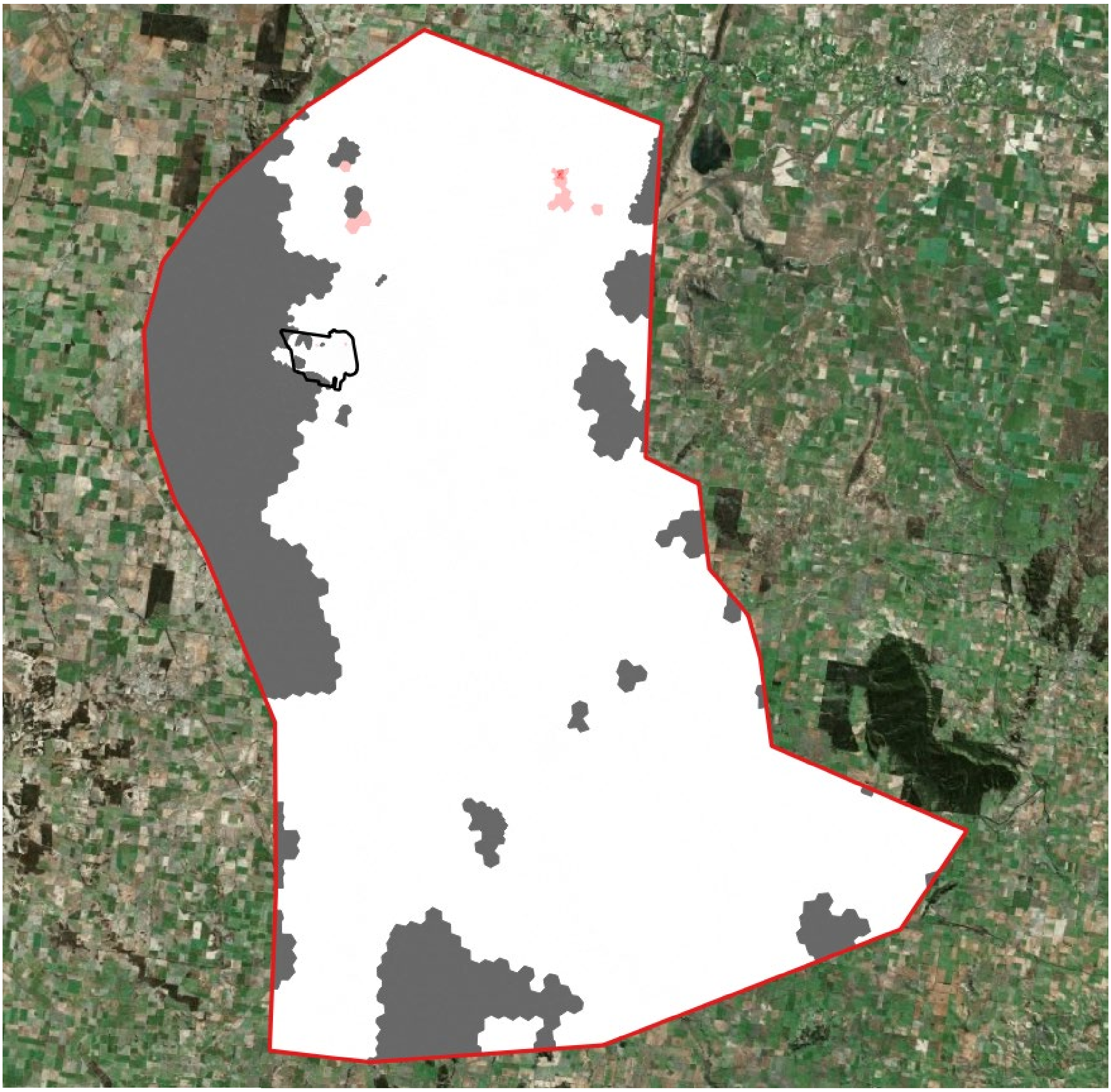
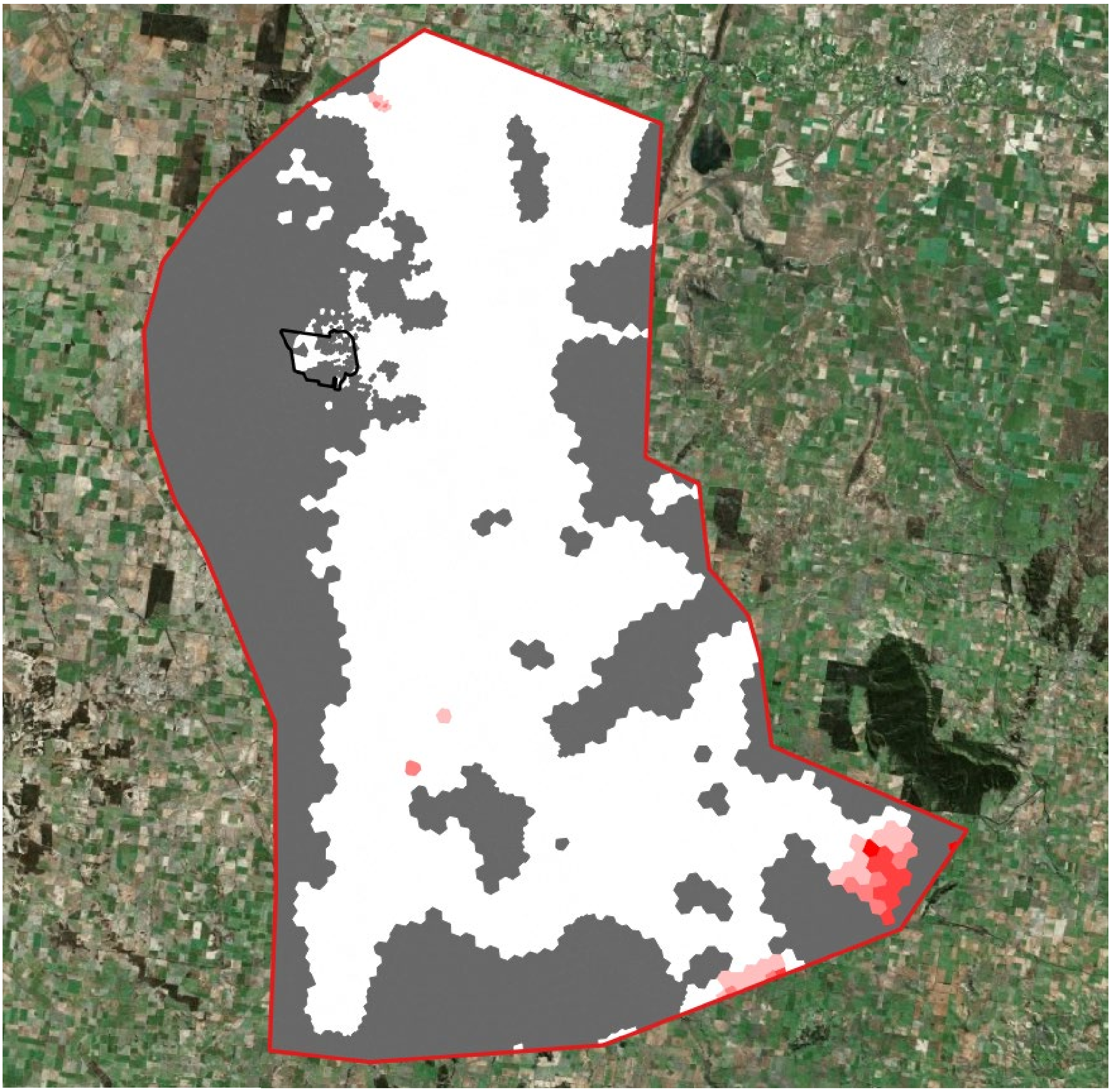


L1 Clay Kh (m/d)
- 0 - 0.2
- 0.2 - 0.4
- 0.4 - 0.6
- 0.6 - 0.8
- 0.8 - 1



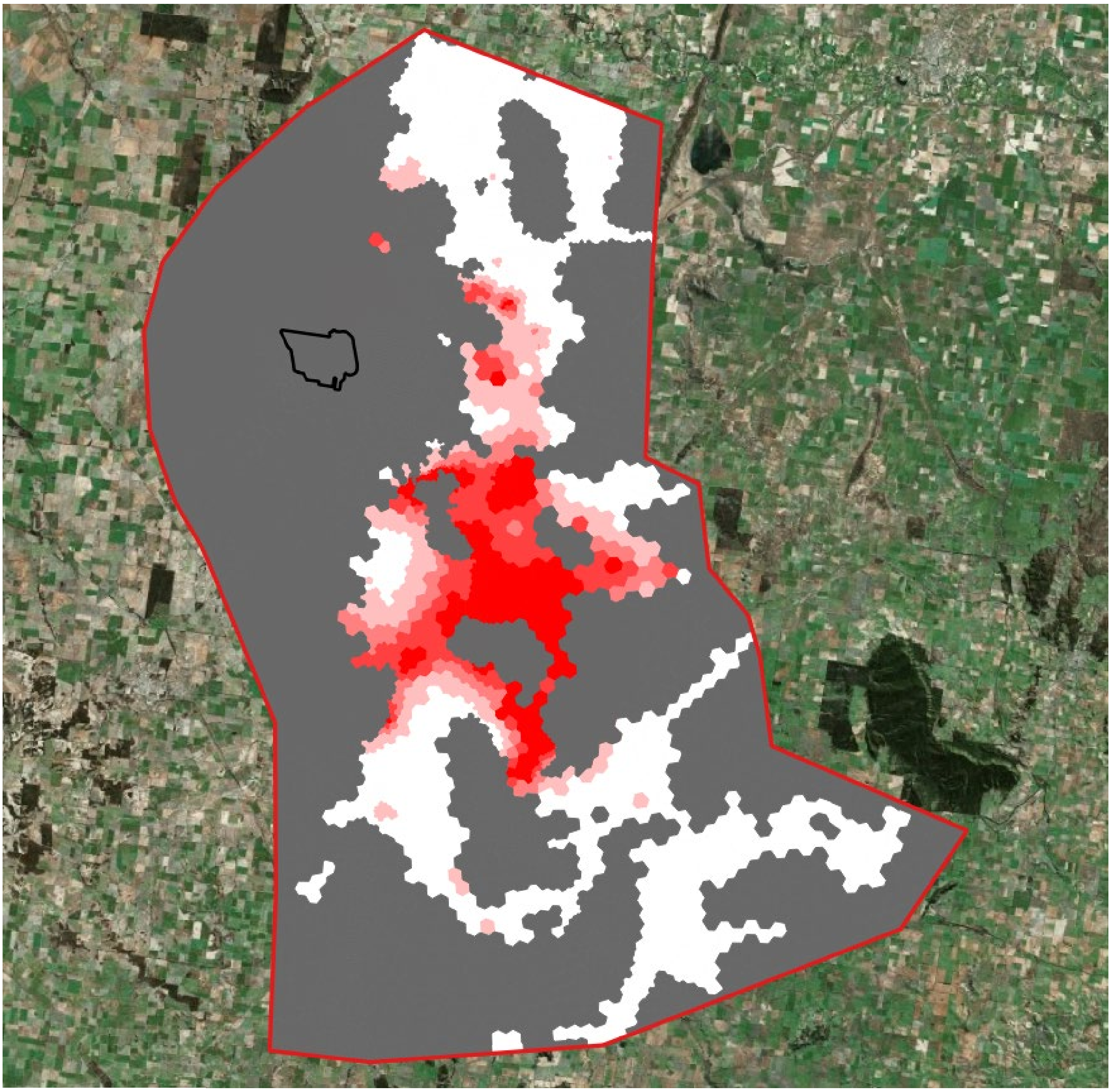
L2 Upper Cowra Kh (m/d)

- 0 - 0.2
- 0.2 - 0.4
- 0.4 - 0.6
- 0.6 - 0.8
- 0.8 - 0.93



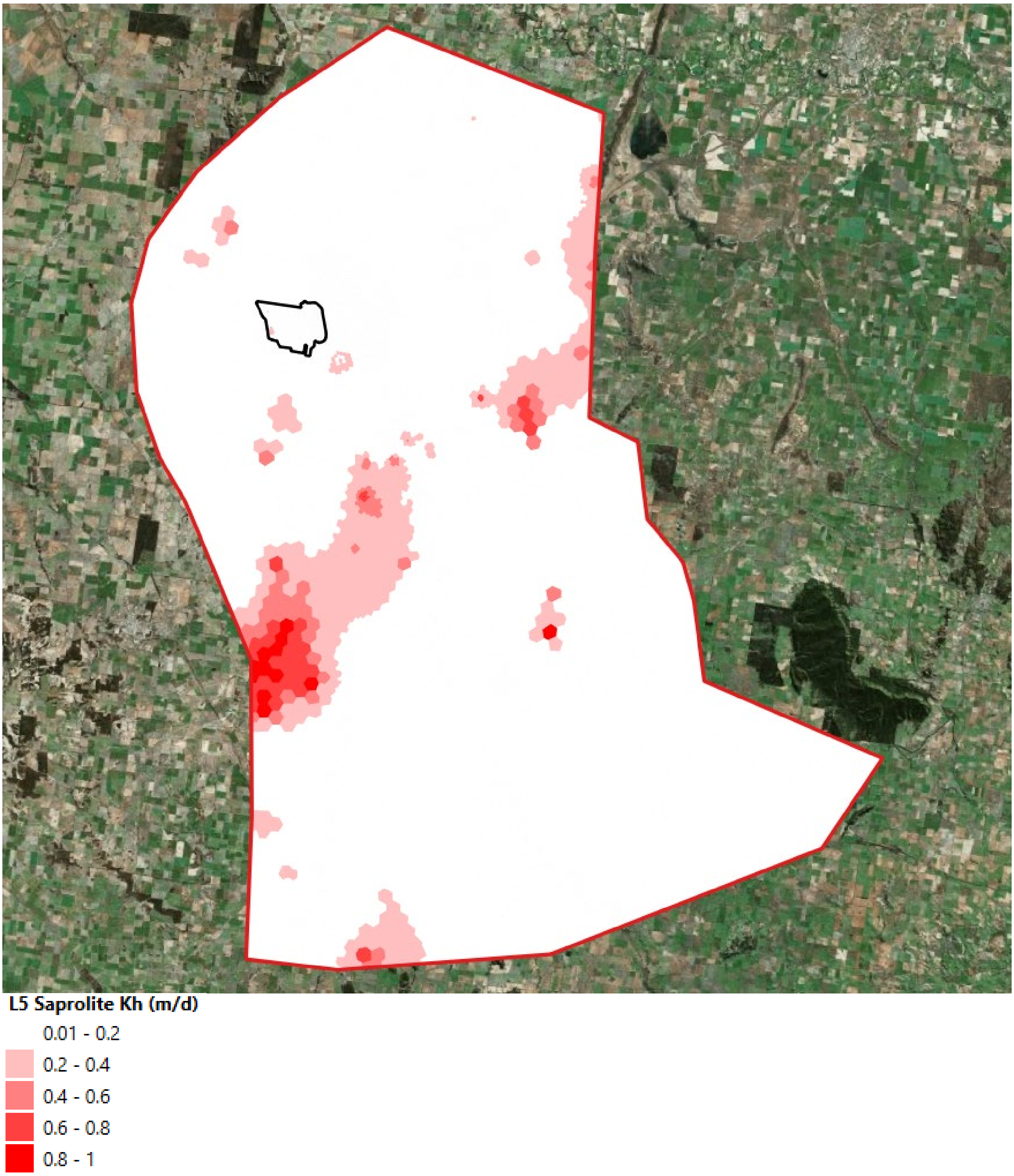
L3 Lower Cowra Kh (m/d)

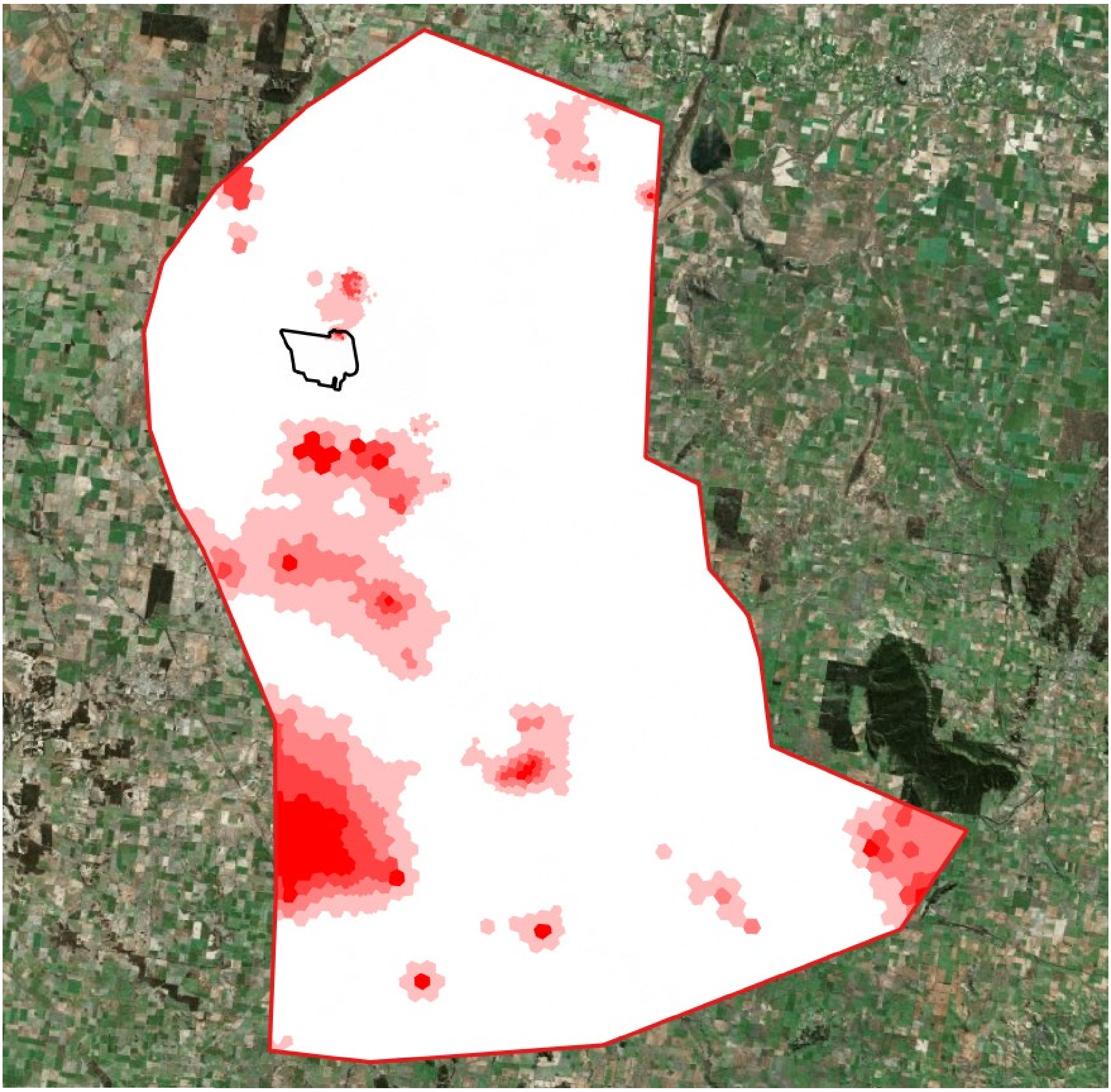
	0 - 2
	2 - 4
	4 - 6
	6 - 8
	8 - 10



L4 Lachlan Kh (m/d)

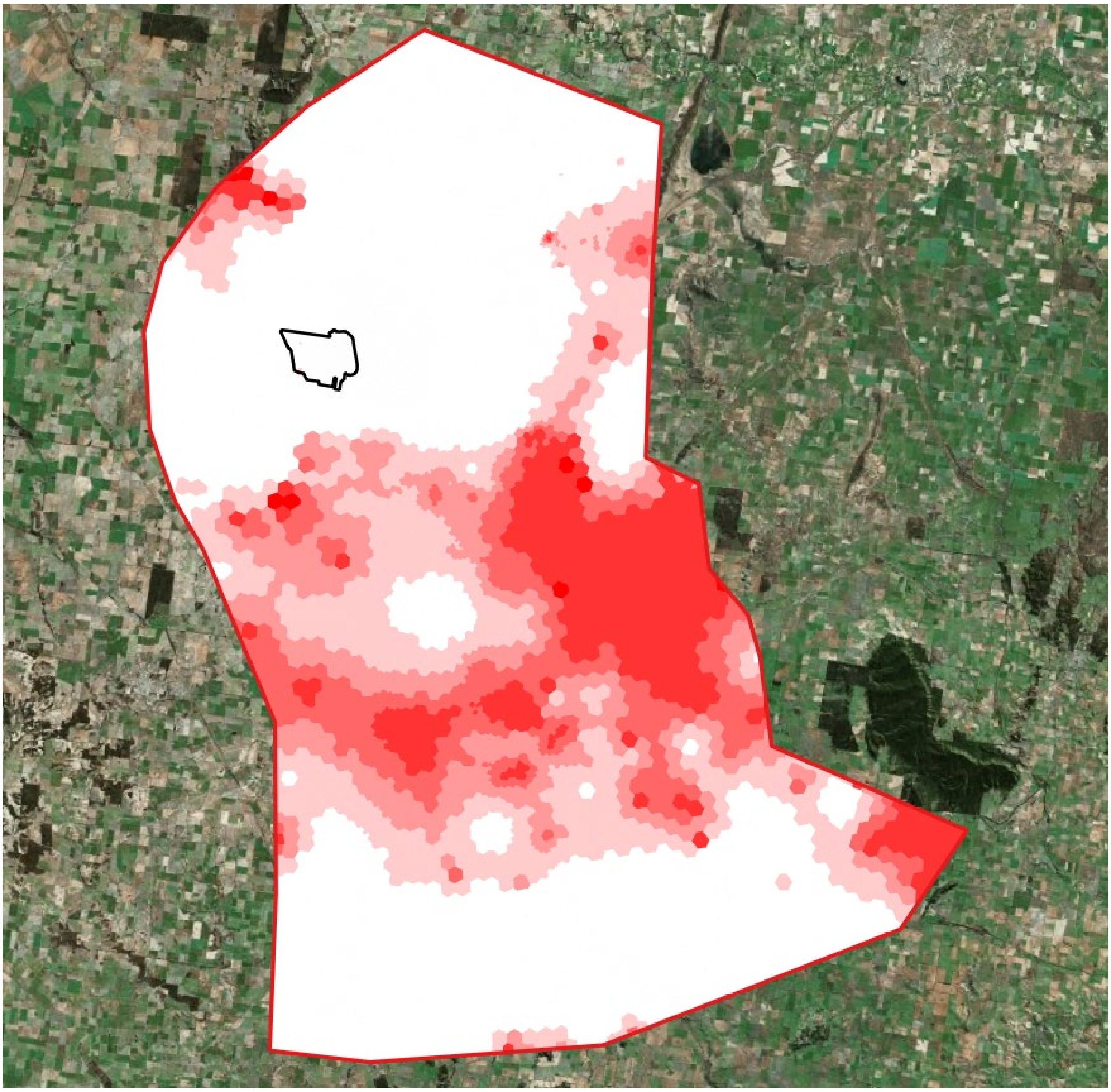
- 0 - 10
- 10 - 20
- 20 - 30
- 30 - 40
- 40 - 50


L5 Saprolite Kh (m/d)
0.01 - 0.2
0.2 - 0.4
0.4 - 0.6
0.6 - 0.8
0.8 - 1



L6 Saprock Kh (m/d)

- 0.001 - 0.02
- 0.02 - 0.04
- 0.04 - 0.06
- 0.06 - 0.08
- 0.08 - 0.1



L12 Basement Kh (m/d)

0.0001 - 0.01
0.01 - 0.02
0.02 - 0.03
0.03 - 0.04
0.04 - 0.05
0.05 - 0.050000018

Appendix B

Horizontal hydraulic conductivity (log scaled)

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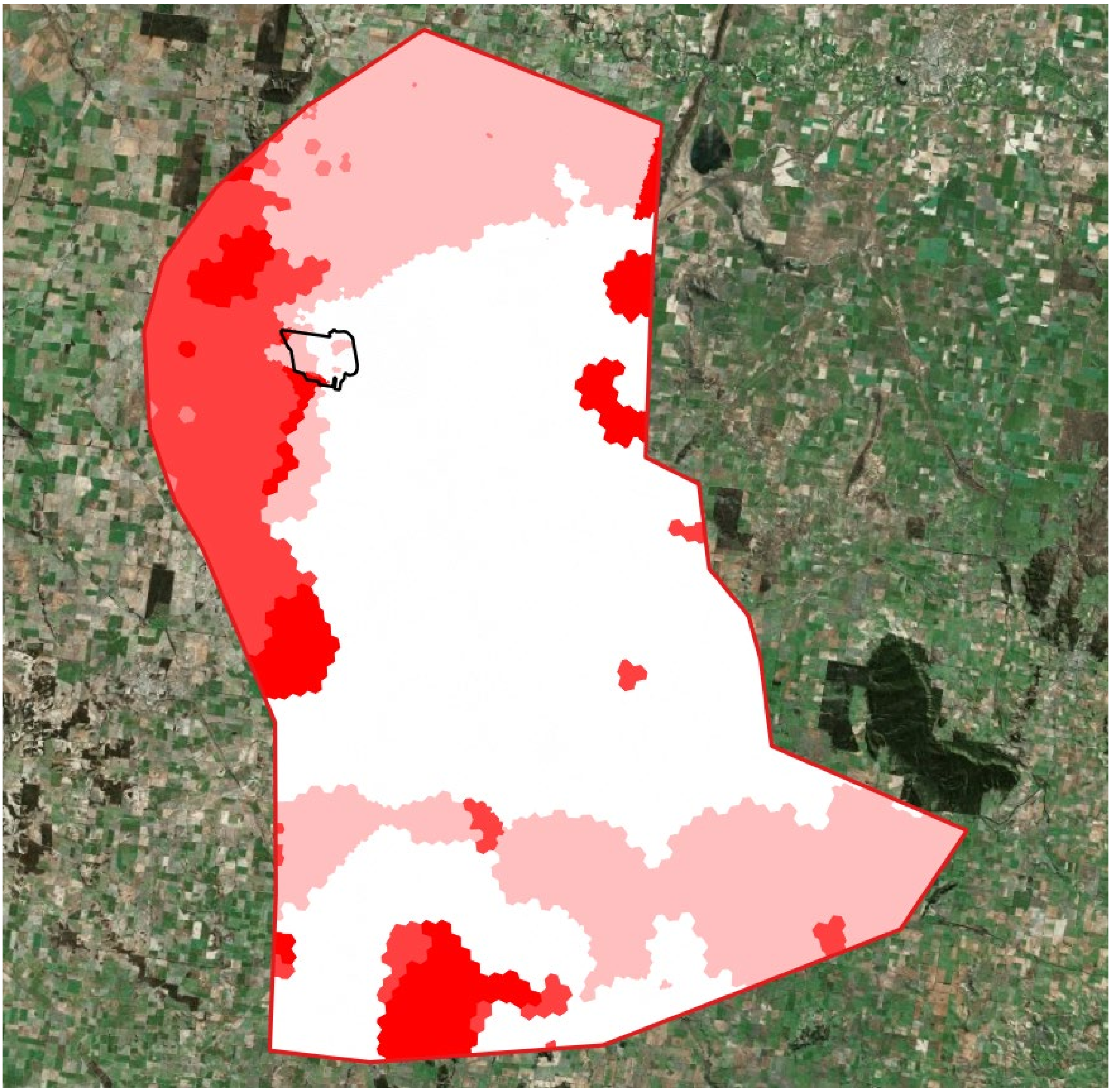
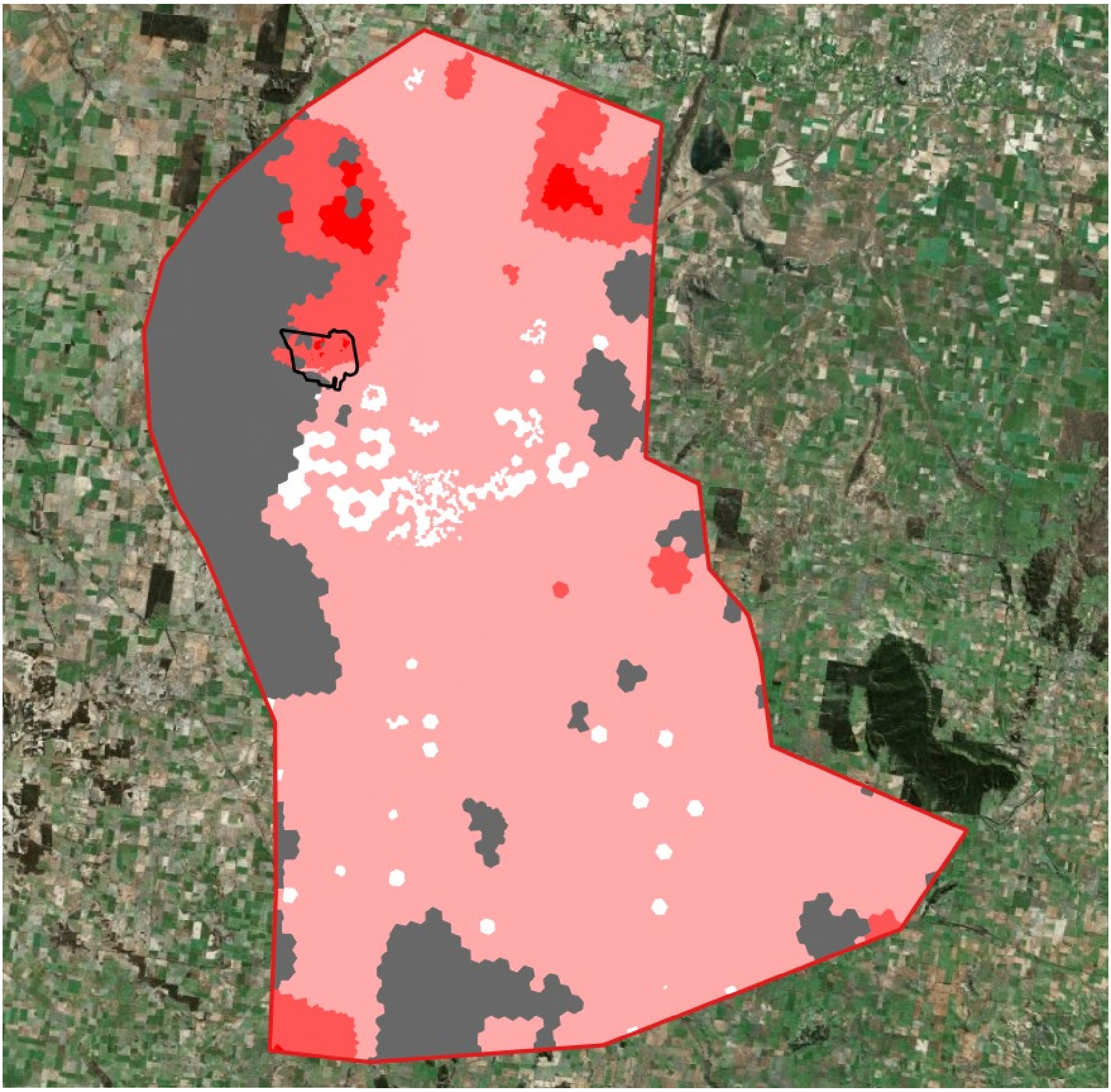


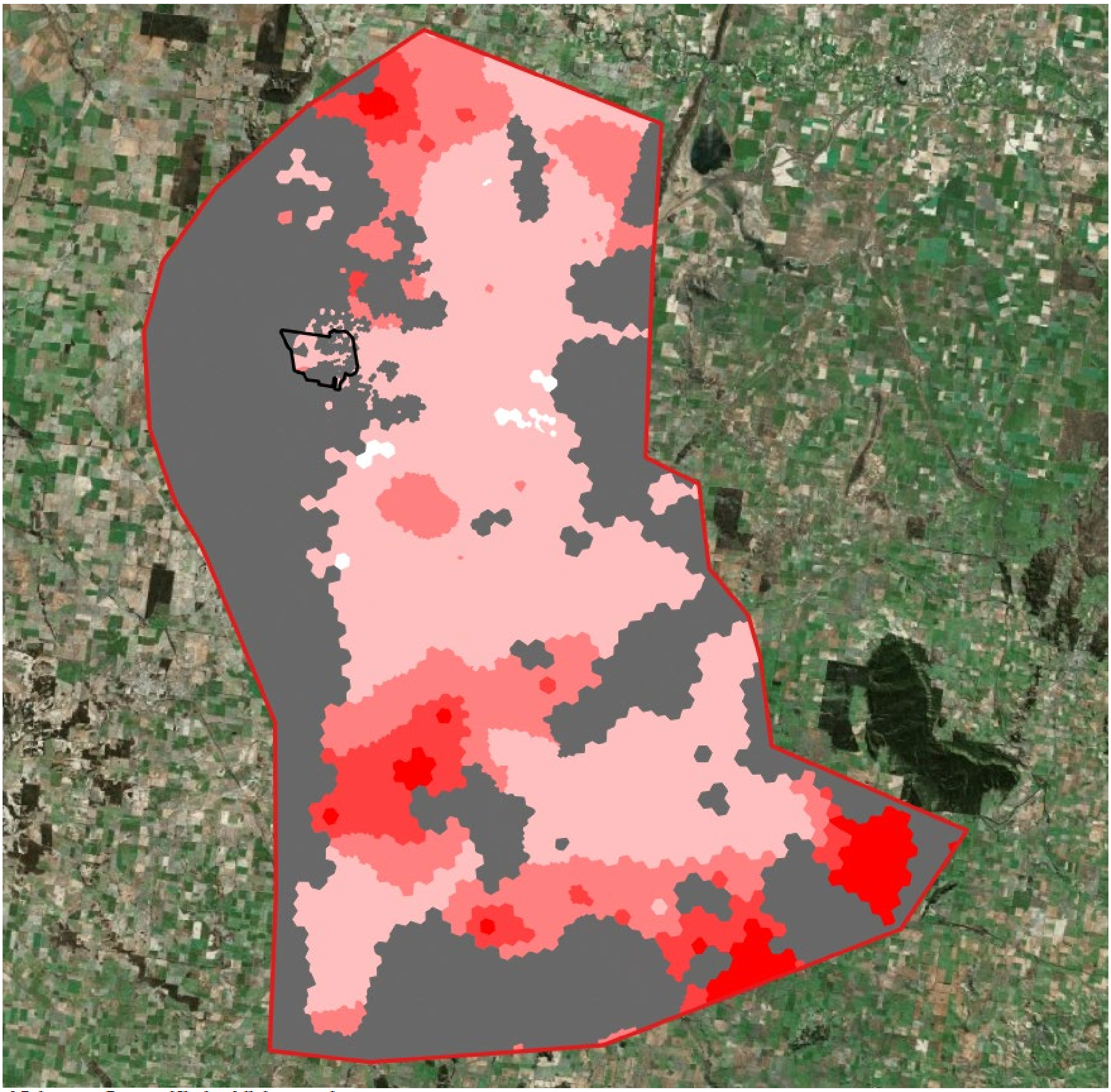
L1 Clay Kh (m/d) log scale

- 0.00001 - 10^-4
- 10^-4 - 10^-3
- 10^-3 - 10^-2
- 10^-2 - 10^-1
- 10^-1 - 10^0



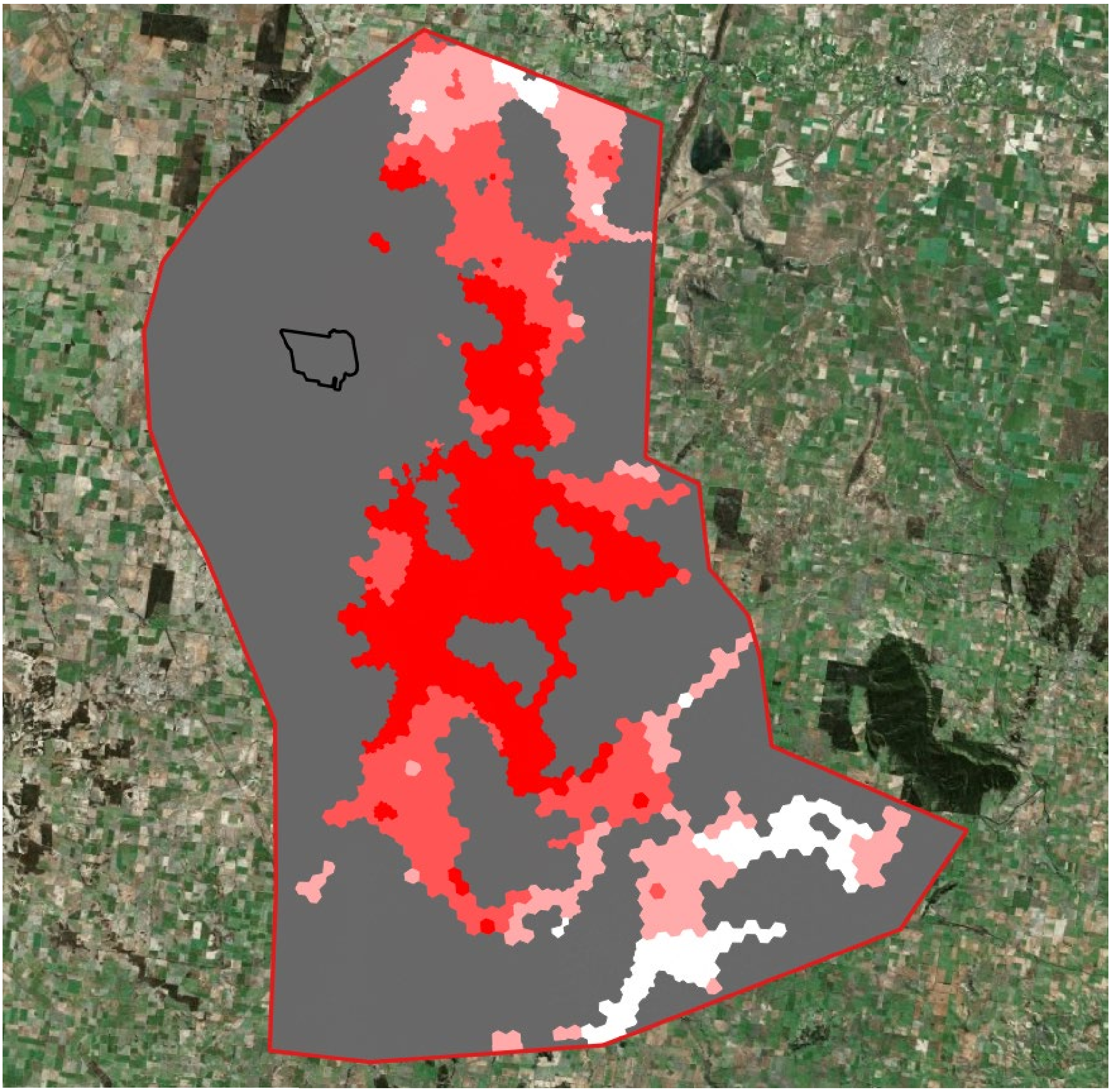
L2 Upper Cowra Kh (m/d) log scale

- 0.0009973 - 10^-3
- 10^-3 - 10^-2
- 10^-2 - 10^-1
- 10^-1 - 10^0



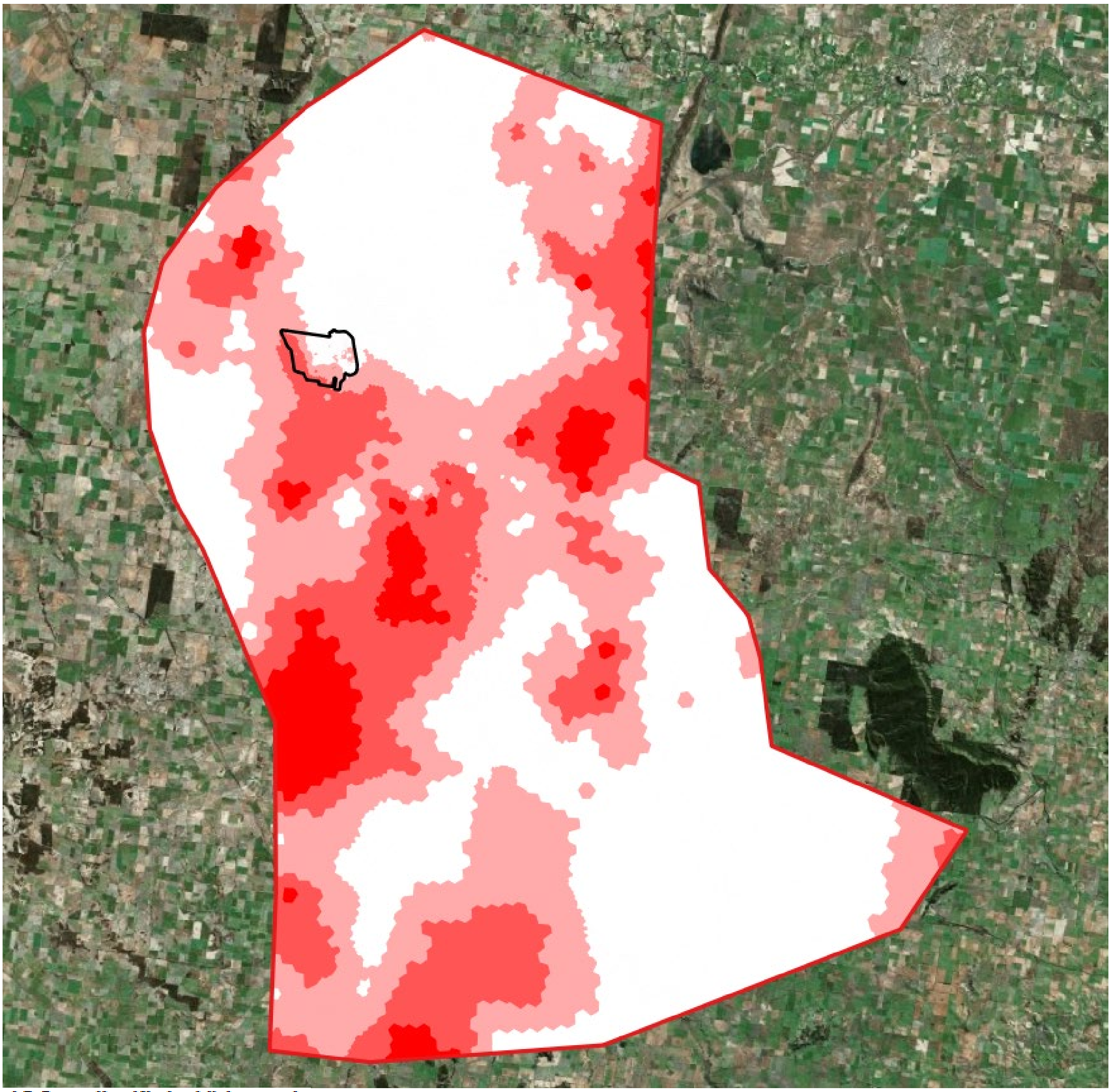
L3 Lower Cowra Kh (m/d) log scale

- 0.000999999 - 10^-3
- 10^-3 - 10^-2
- 10^-2 - 10^-1
- 10^-1 - 10^0
- 10^0 - 10^1



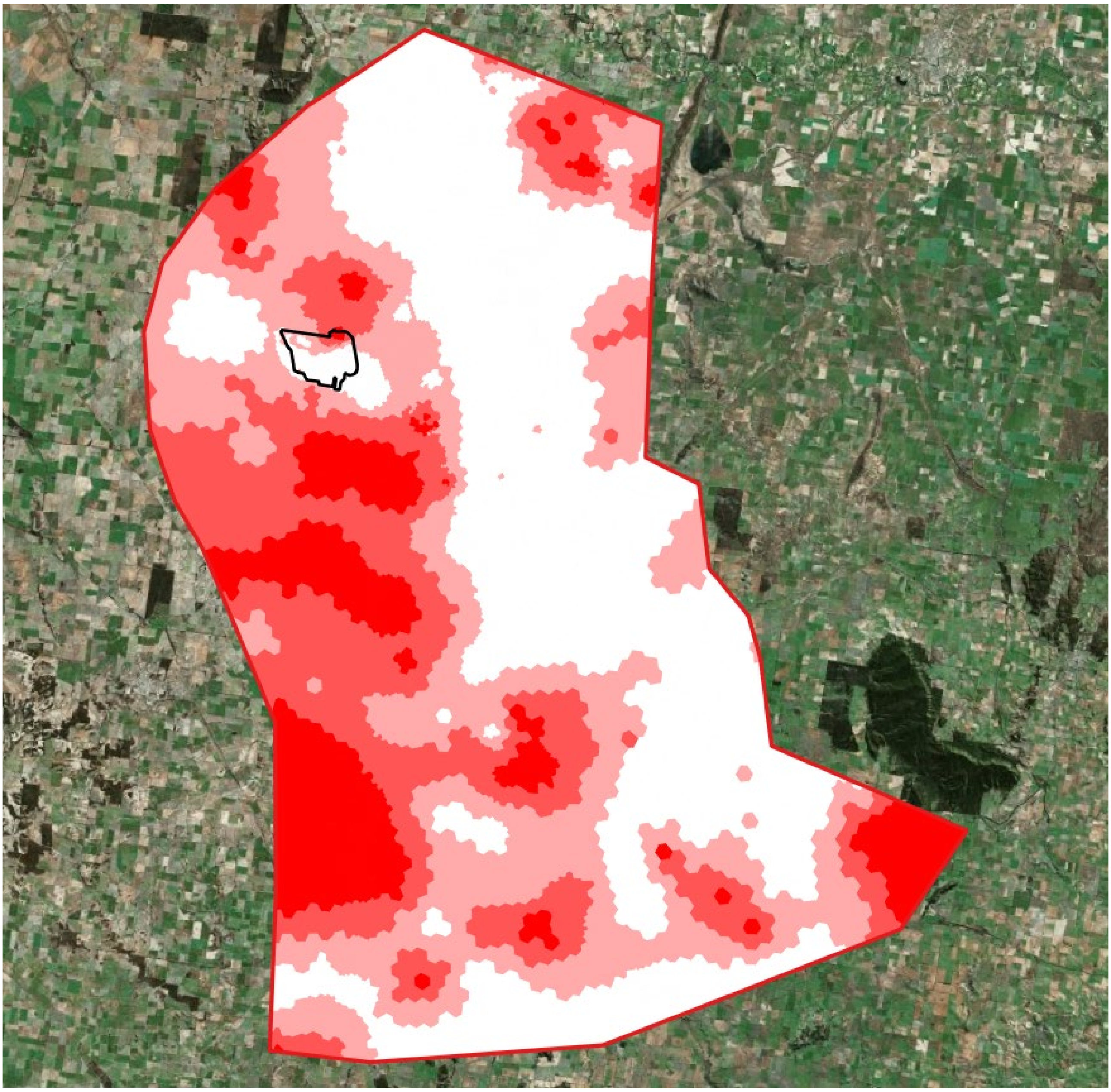
L4 Lachlan Kh (m/d) log scale

0.05 - 10^-1
10^-1 - 10^0
10^0 - 10^1
10^1 - 10^2



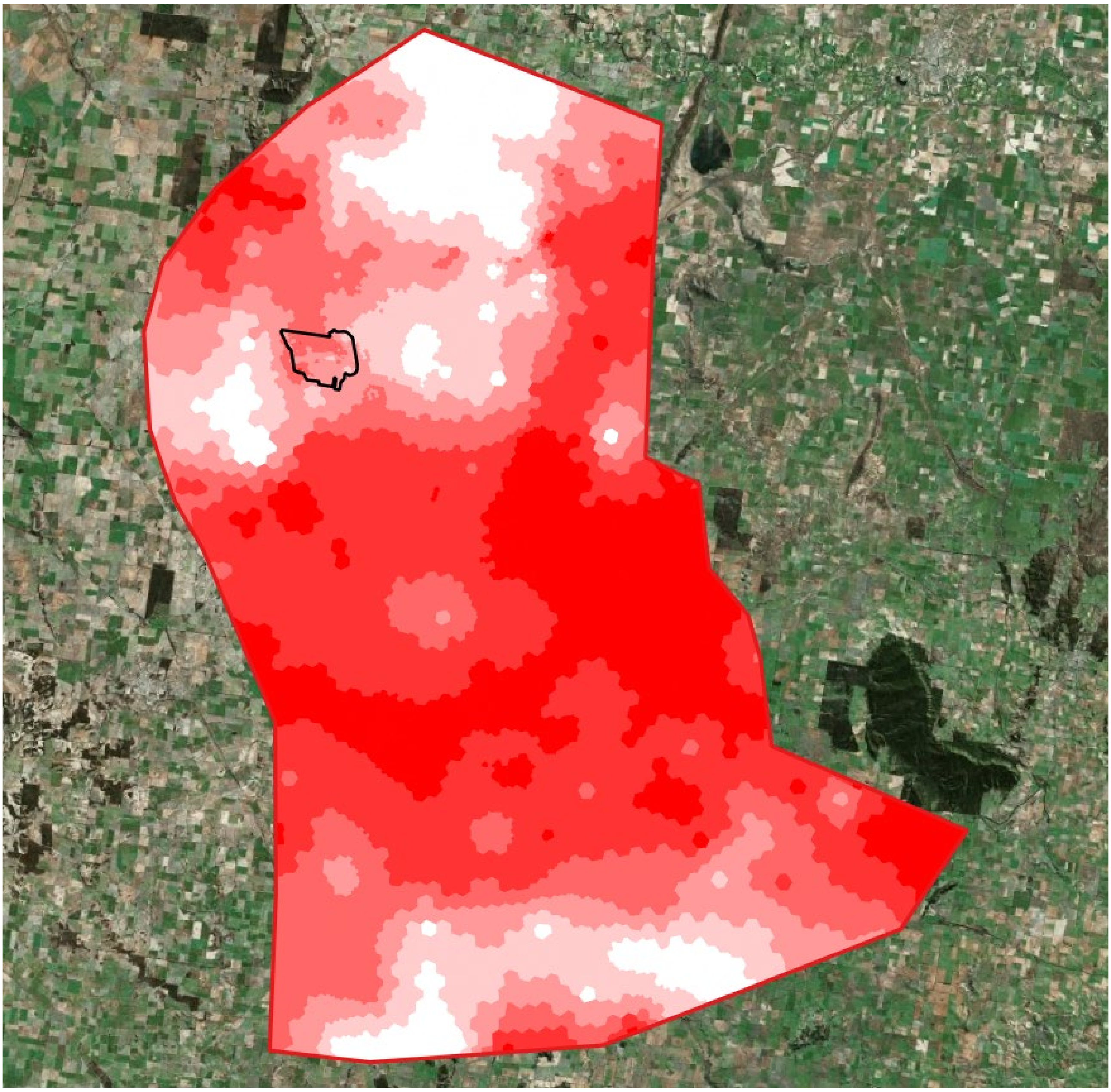
L5 Saprolite Kh (m/d) log scale

- 0.01 - 10^-1.5
- 10^-1.5 - 10^-1
- 10^-1 - 10^-0.5
- 10^-0.5 - 10^0



L6 Saprock Kh (m/d) log scale

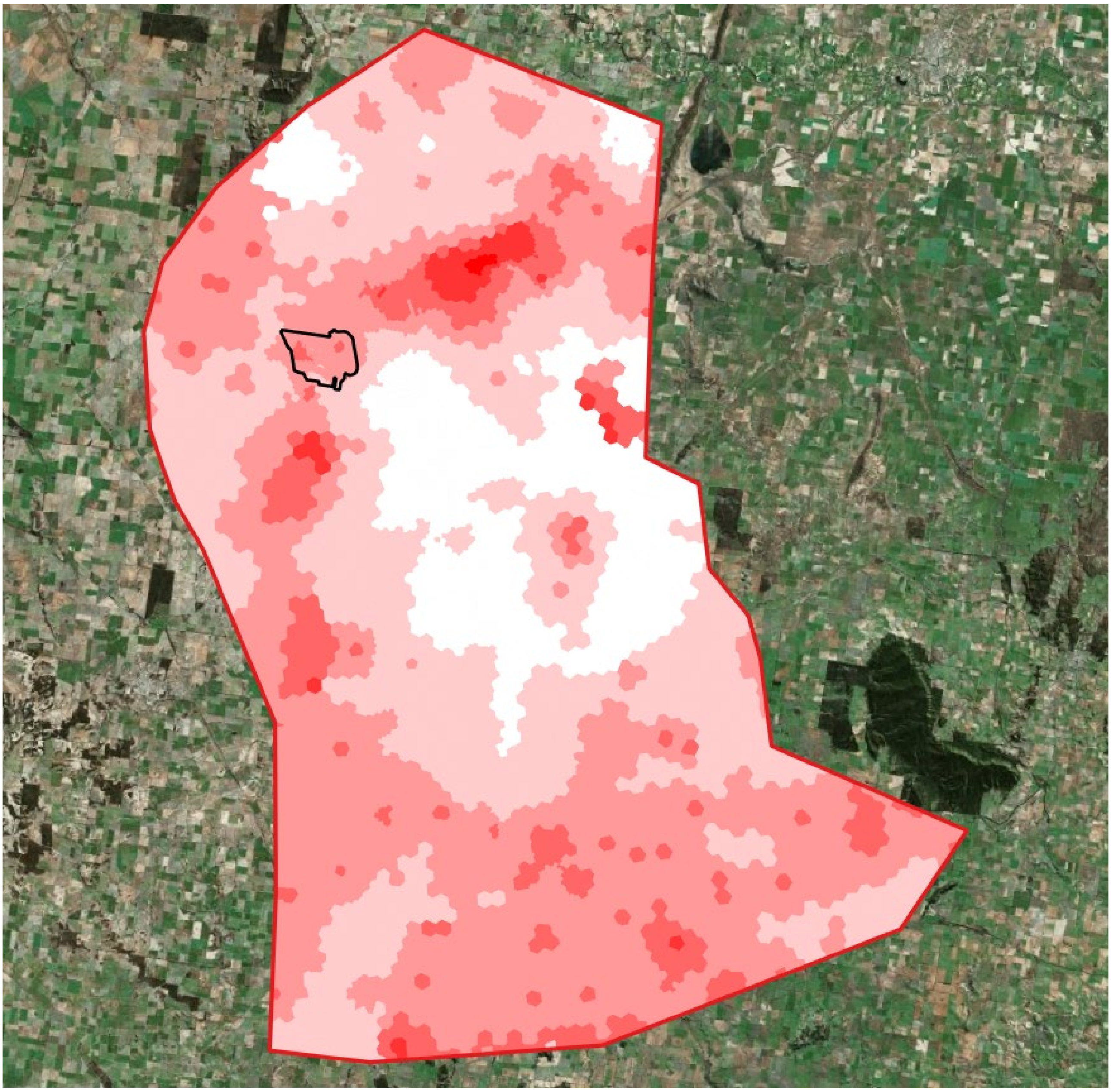
- 0.001 - 10^-2.5
- 10^-2.5 - 10^-2
- 10^-2 - 10^-1.5
- 10^-1.5 - 10^-1



L12 Basement Kh (m/d) log scale

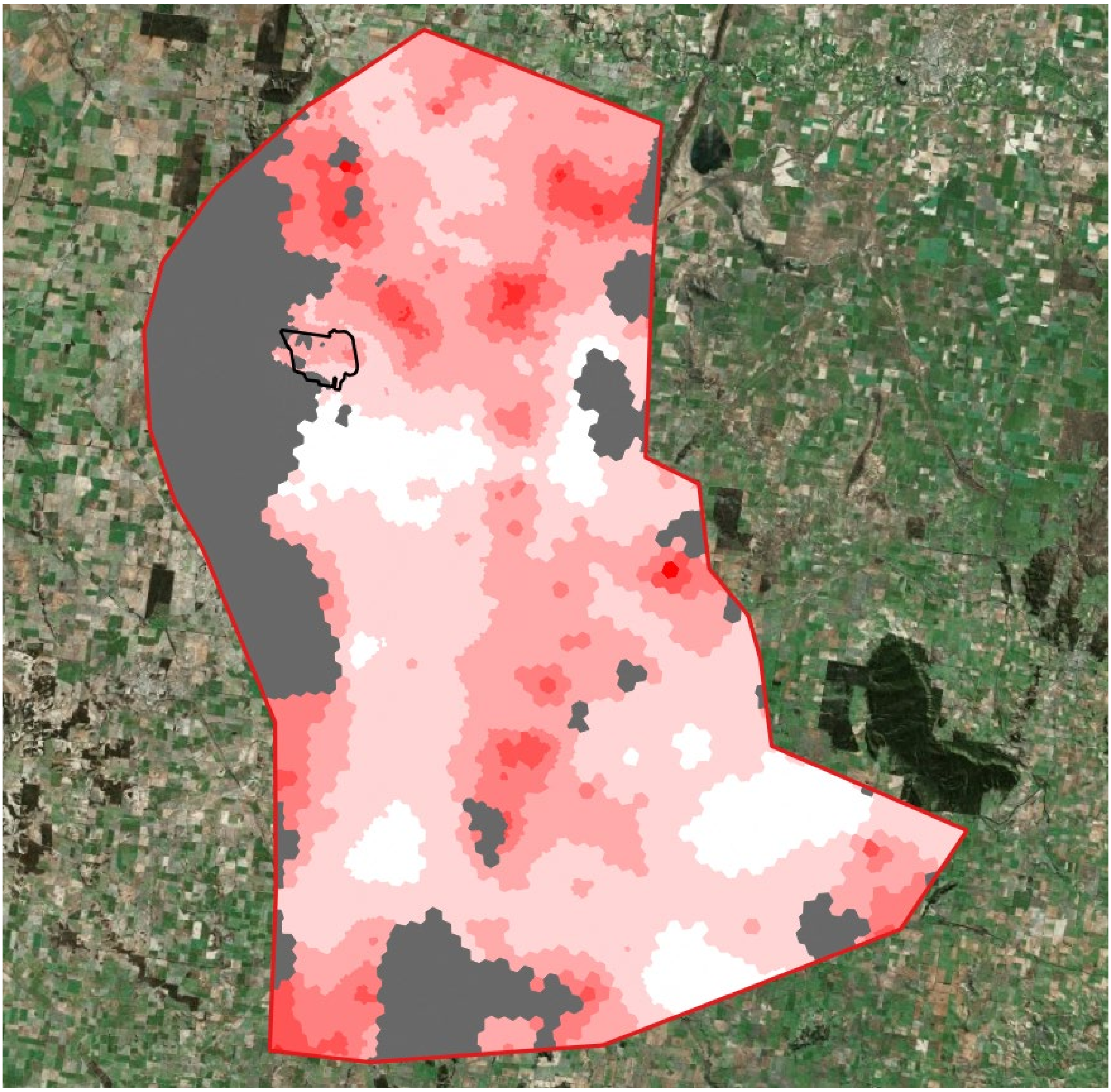
- 0.0001 - 10^-3.5
- 10^-3.5 - 10^-3
- 10^-3 - 10^-2.5
- 10^-2.5 - 10^-2
- 10^-2 - 10^-1.5
- 10^-1.5 - 10^-1

Appendix C
Horizontal hydraulic conductivity standard deviation



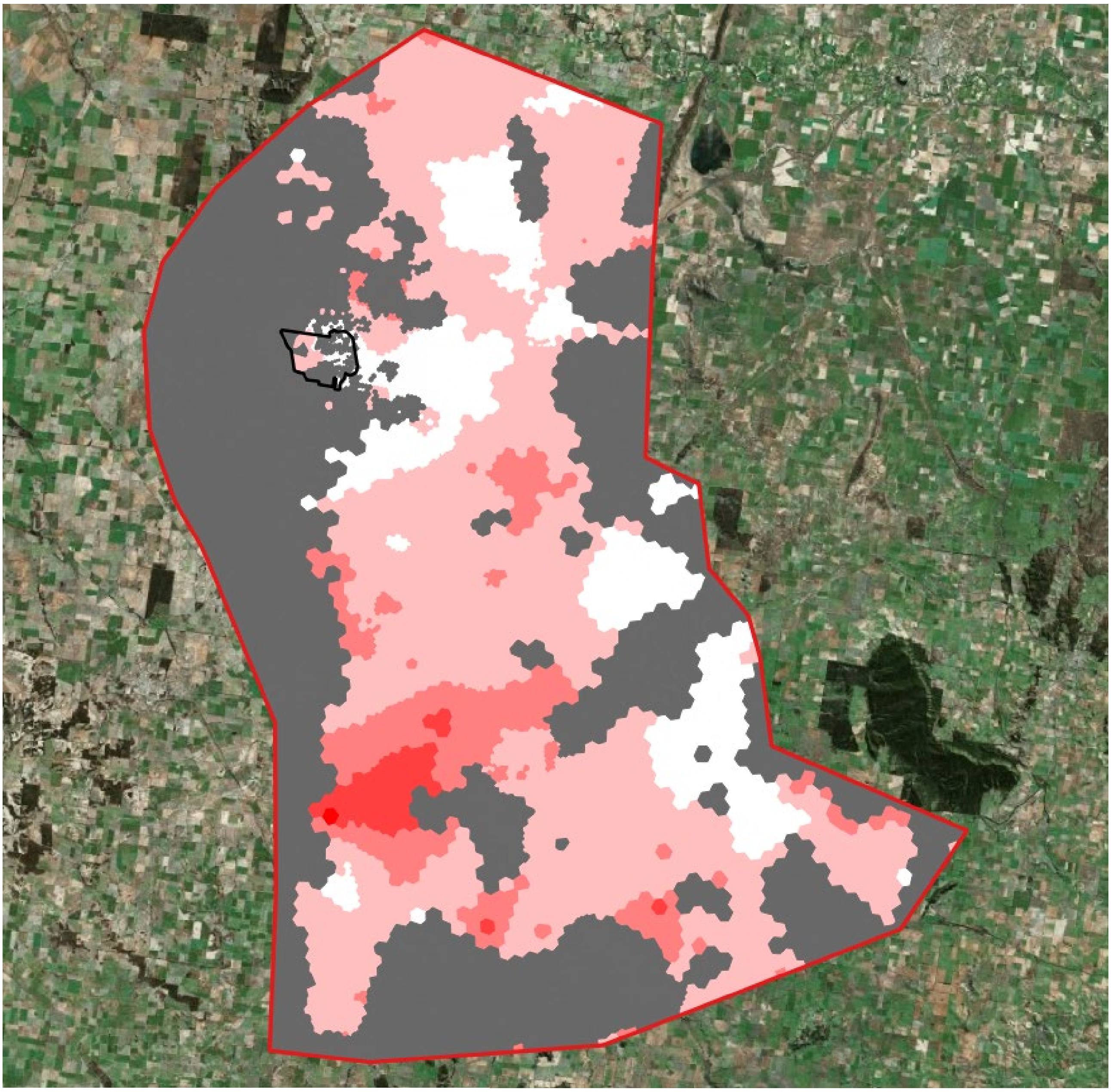
L1 Clay Kh standard deviation (log scale)

- 0.007 - 0.1
- 0.1 - 0.2
- 0.2 - 0.3
- 0.3 - 0.4
- 0.4 - 0.5
- 0.5 - 0.57



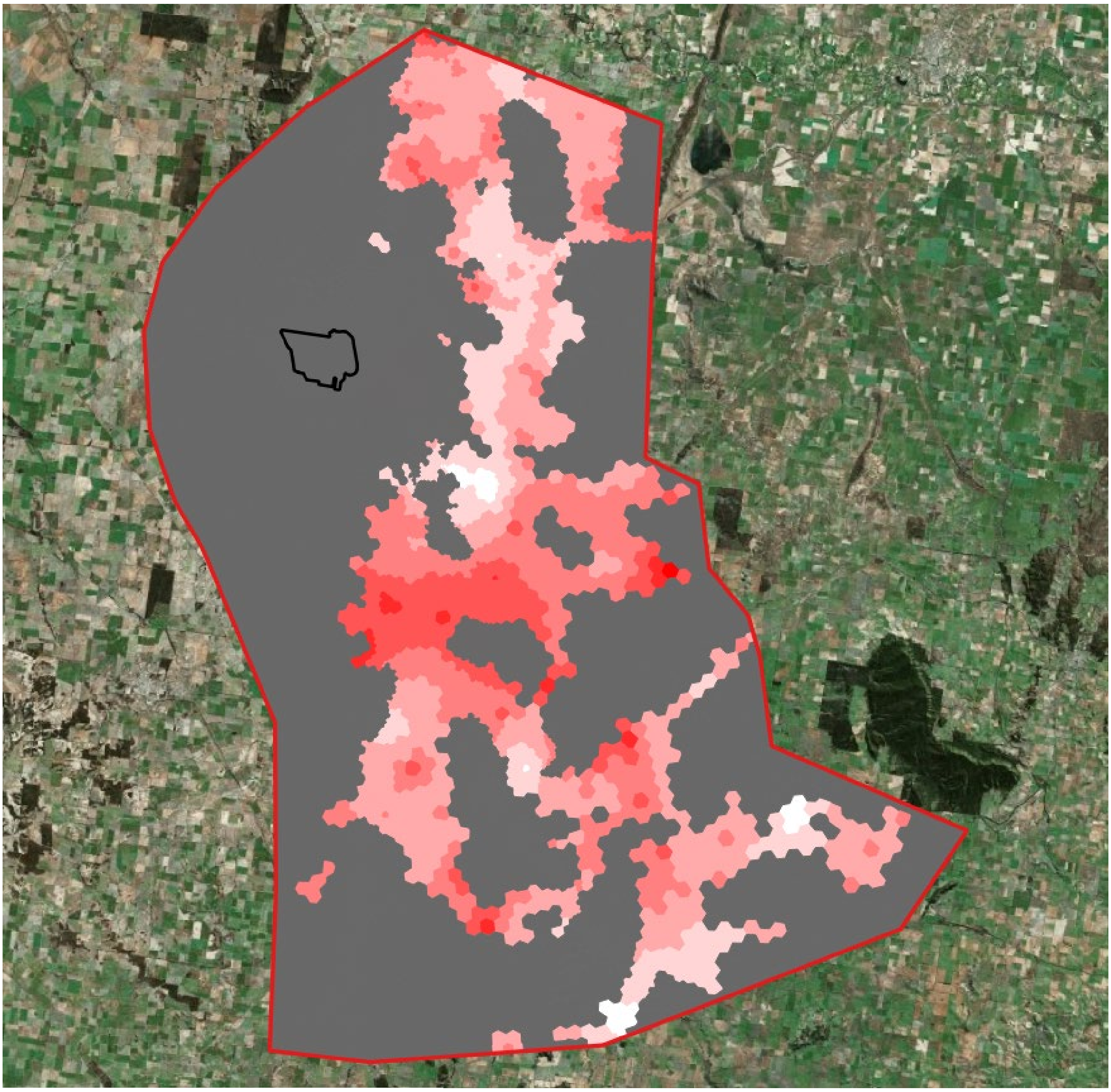
L2 Upper Cowra Kh standard deviation (log scale)

- 0.024 - 0.1
- 0.1 - 0.2
- 0.2 - 0.3
- 0.3 - 0.4
- 0.4 - 0.5
- 0.5 - 0.6
- 0.6 - 0.649



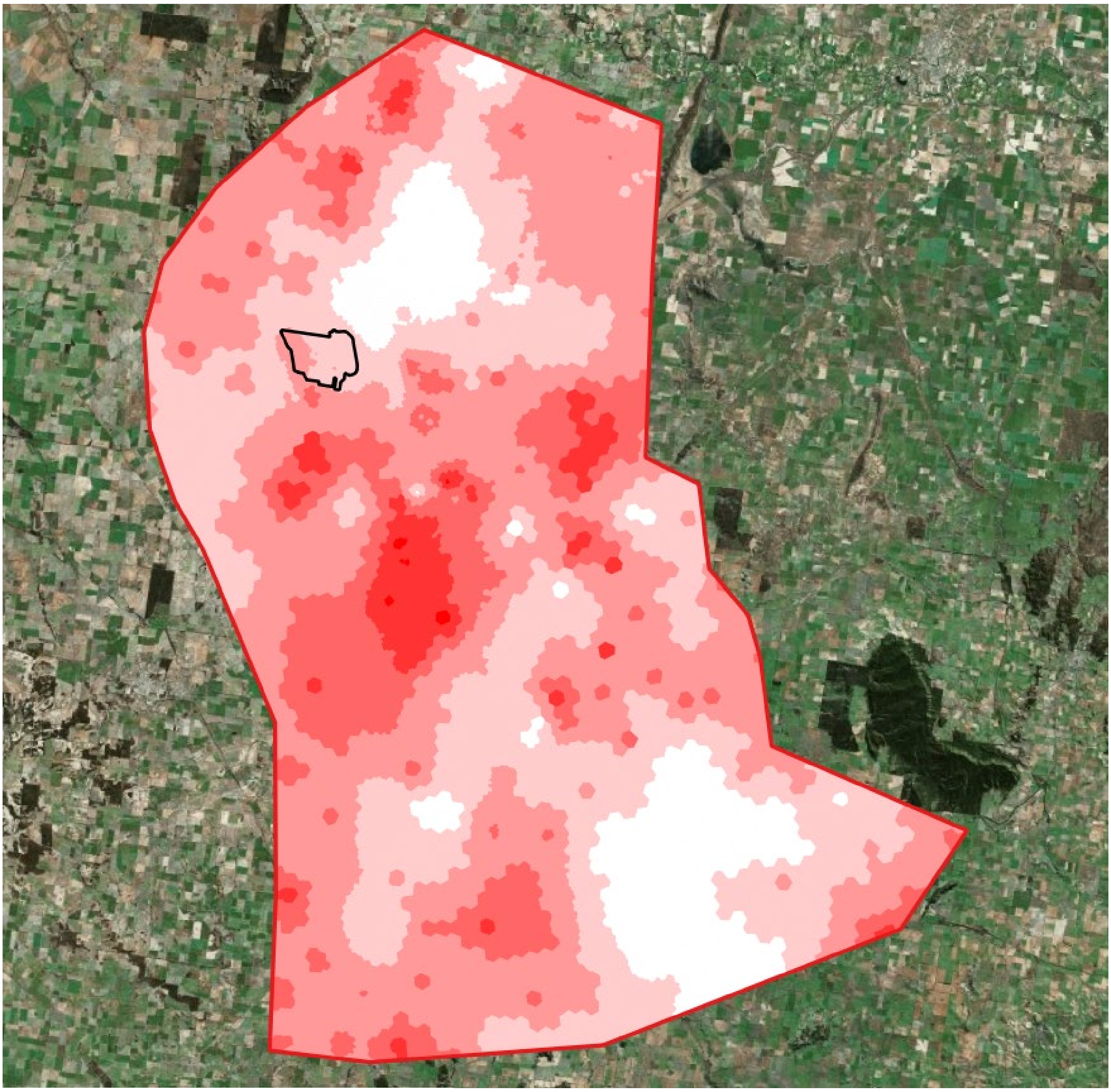
L3 Lower Cowra Kh standard deviation (log scale)

- 0 - 0.2
- 0.2 - 0.4
- 0.4 - 0.6
- 0.6 - 0.8
- 0.8 - 0.82



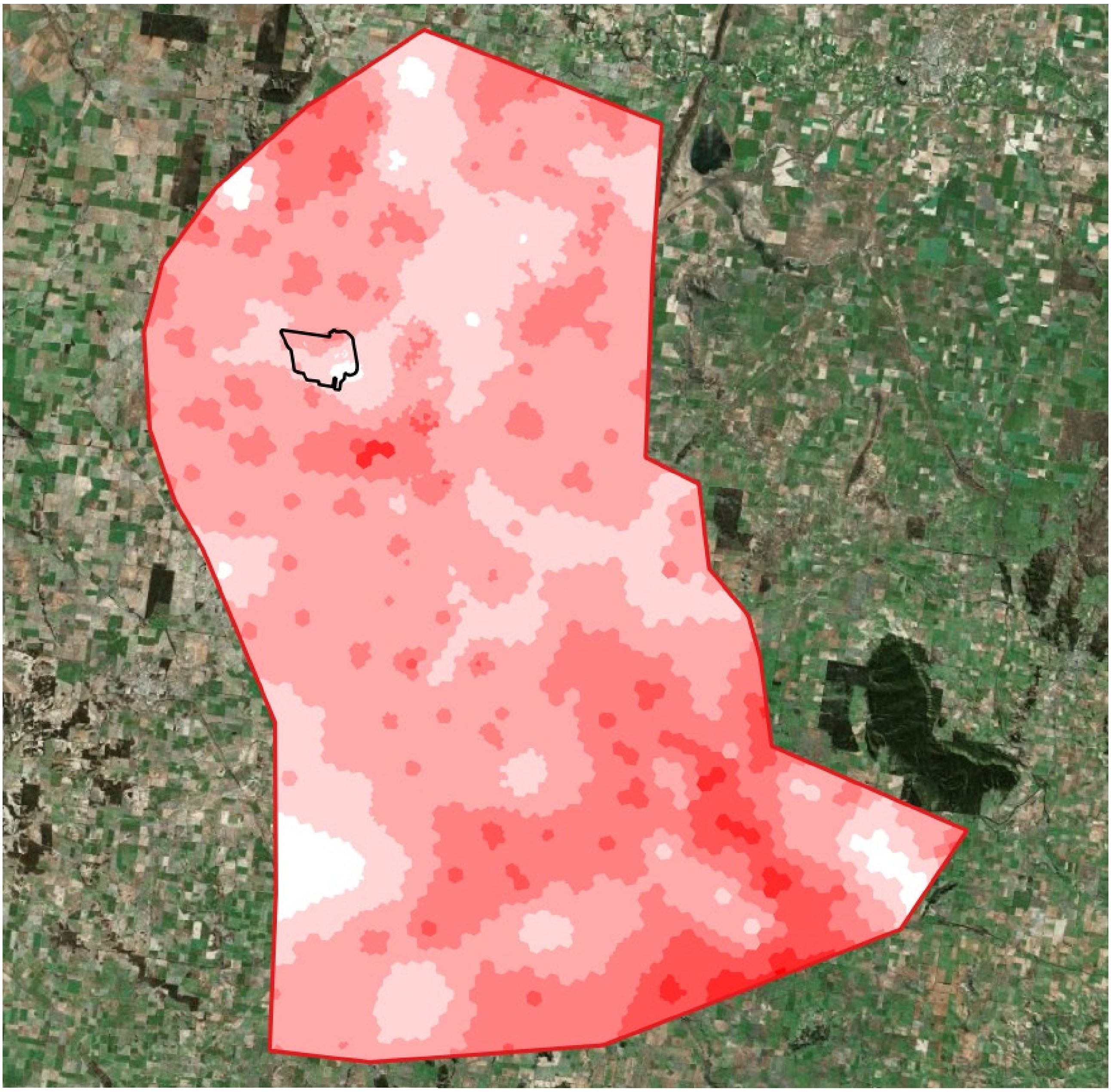
L4 Lachlan Kh standard deviation (log scale)

0.066 - 0.1
0.1 - 0.2
0.2 - 0.3
0.3 - 0.4
0.4 - 0.5
0.5 - 0.6
0.6 - 0.693



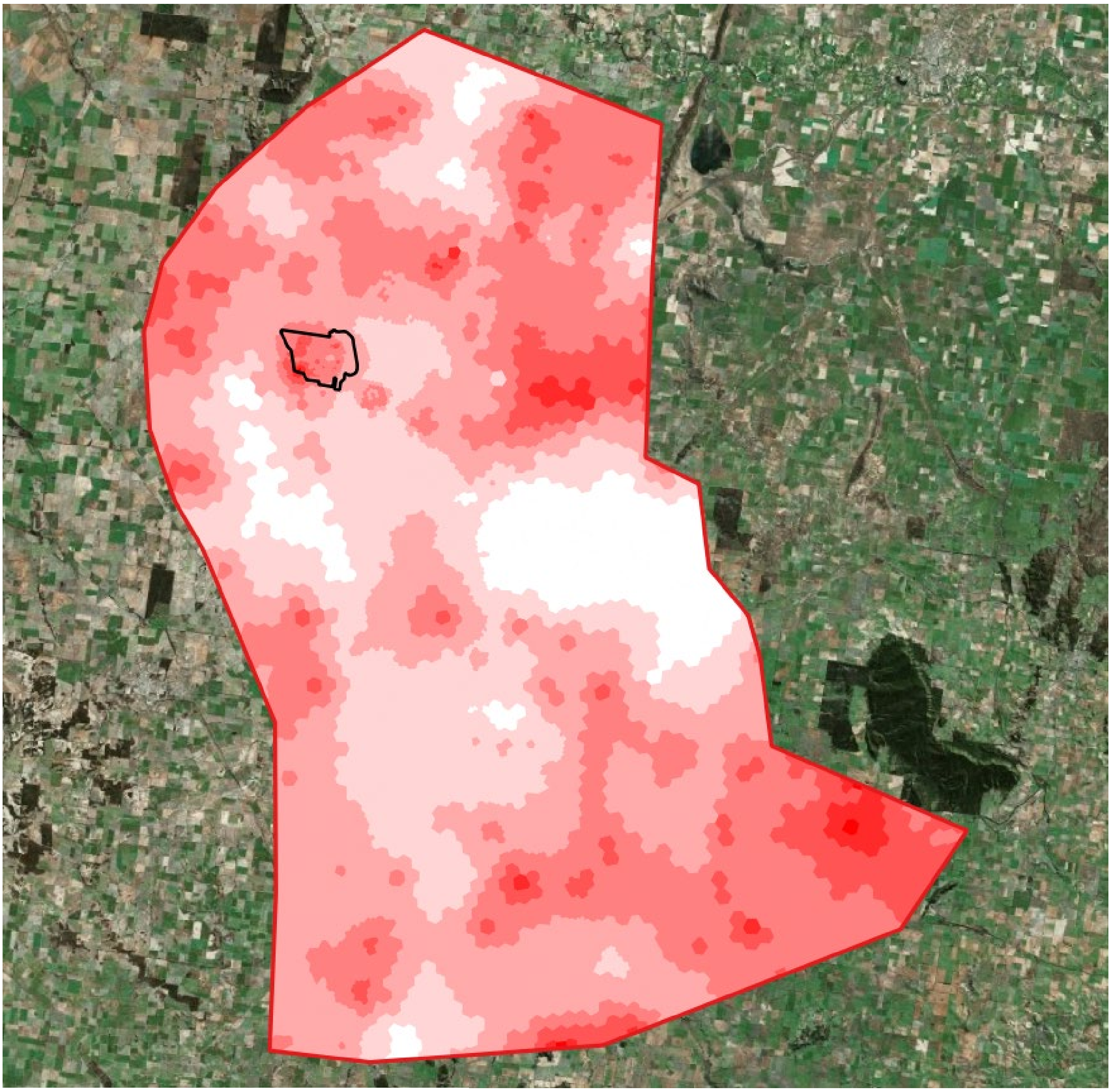
L5 Saprolite Kh standard deviation (log scale)

0.008 - 0.1
0.1 - 0.2
0.2 - 0.3
0.3 - 0.4
0.4 - 0.5
0.5 - 0.55



L6 Saprock Kh standard deviation (log scale)

- 0.001 - 0.1
- 0.1 - 0.2
- 0.2 - 0.3
- 0.3 - 0.4
- 0.4 - 0.5
- 0.5 - 0.6
- 0.6 - 0.613



L12 Basement Kh standard deviation (log scale)

- 0.008 - 0.1
- 0.1 - 0.2
- 0.2 - 0.3
- 0.3 - 0.4
- 0.4 - 0.5
- 0.5 - 0.6
- 0.6 - 0.667

Appendix D
Anisotropy

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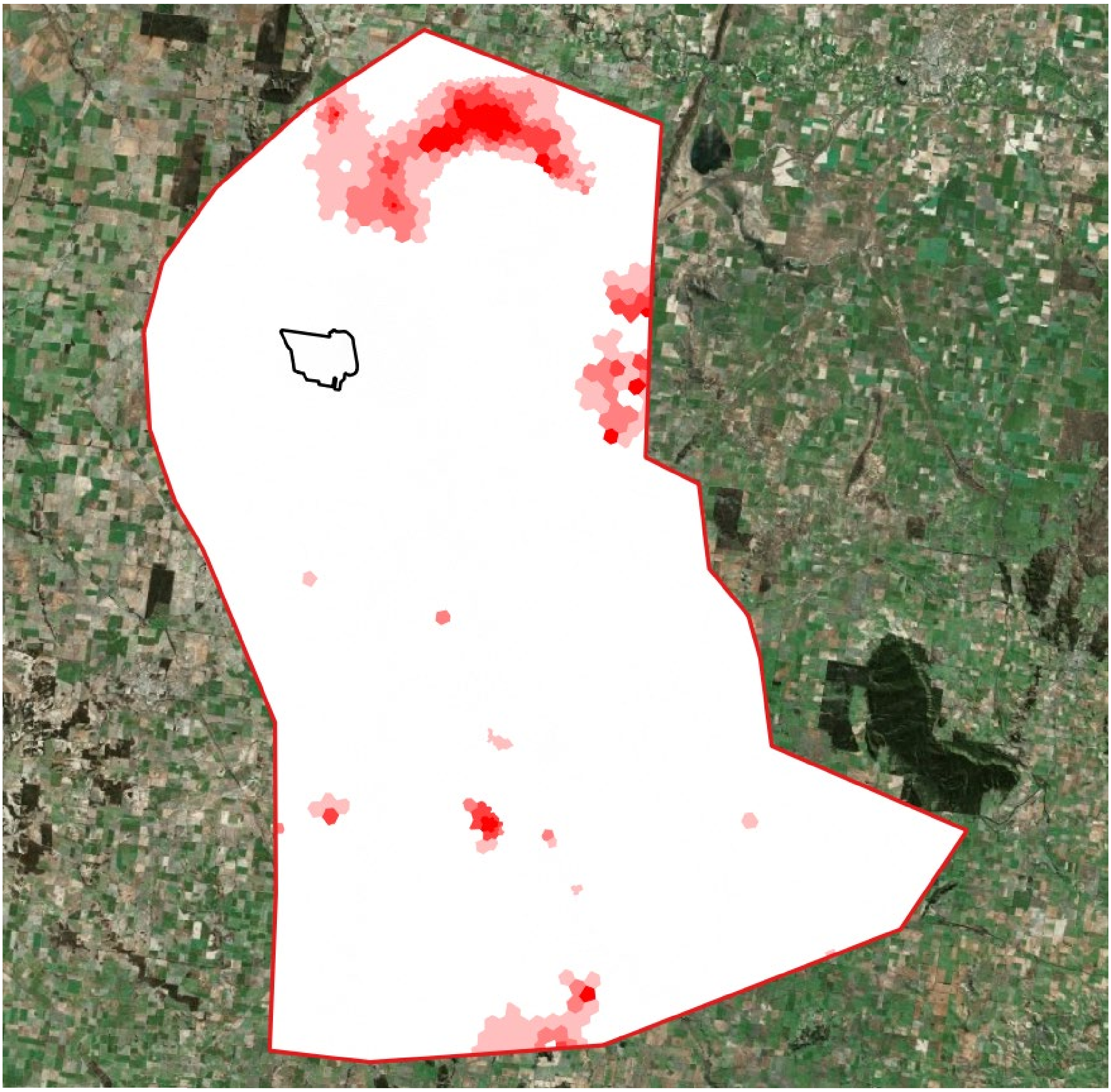
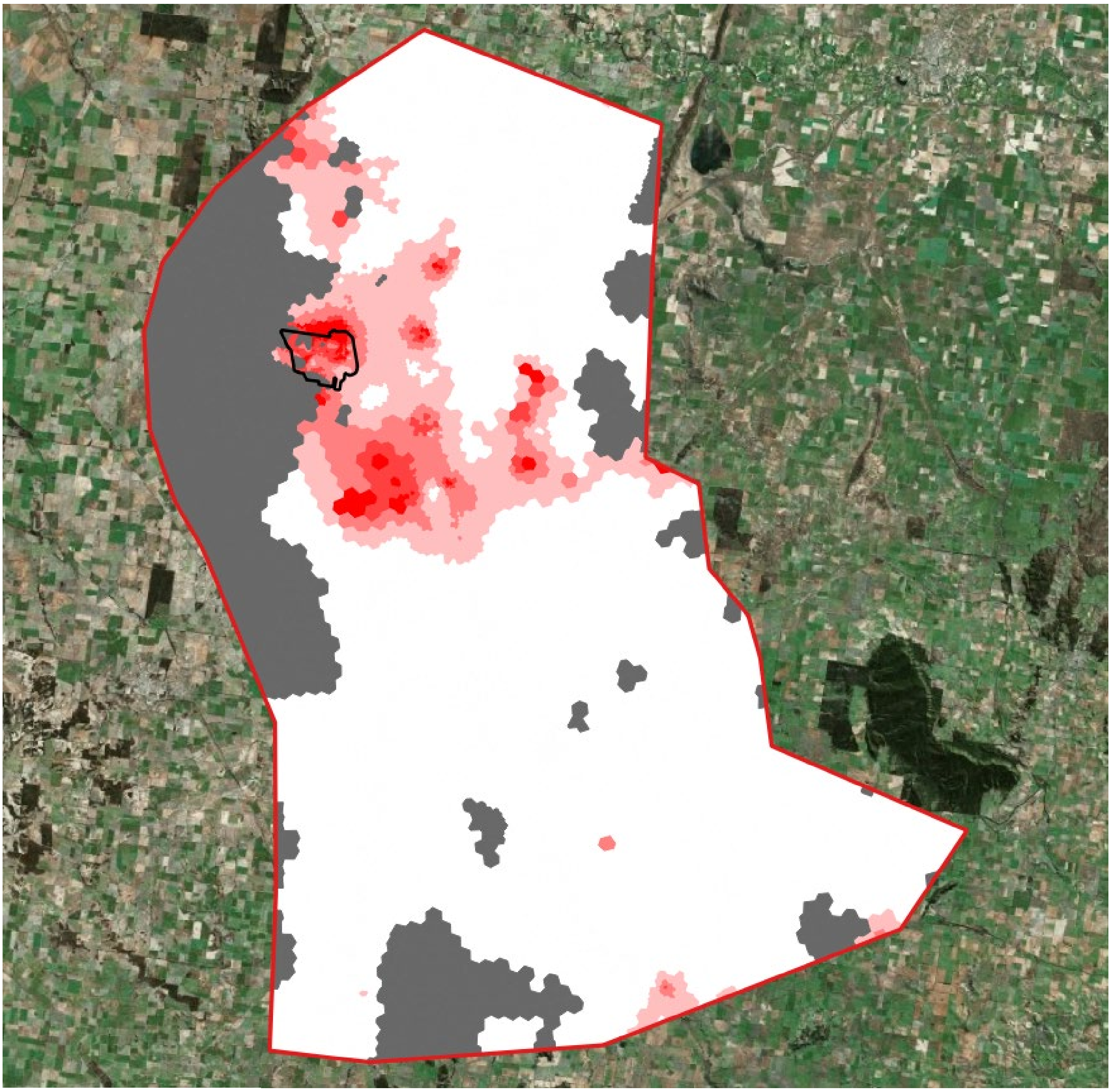
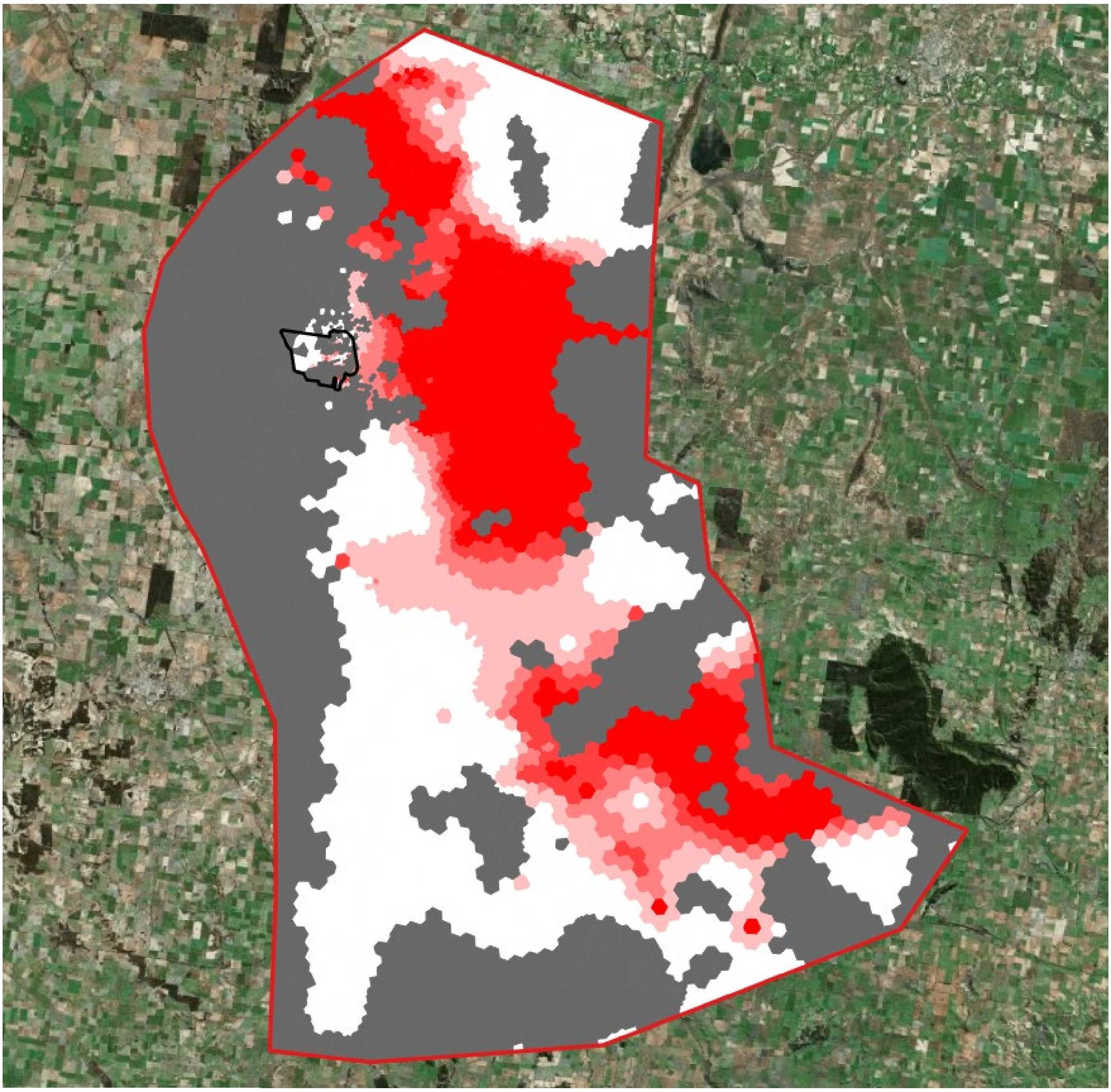


L1 Clay Kh/Kv (-)
1 - 200
200 - 400
400 - 600
600 - 800
800 - 1000



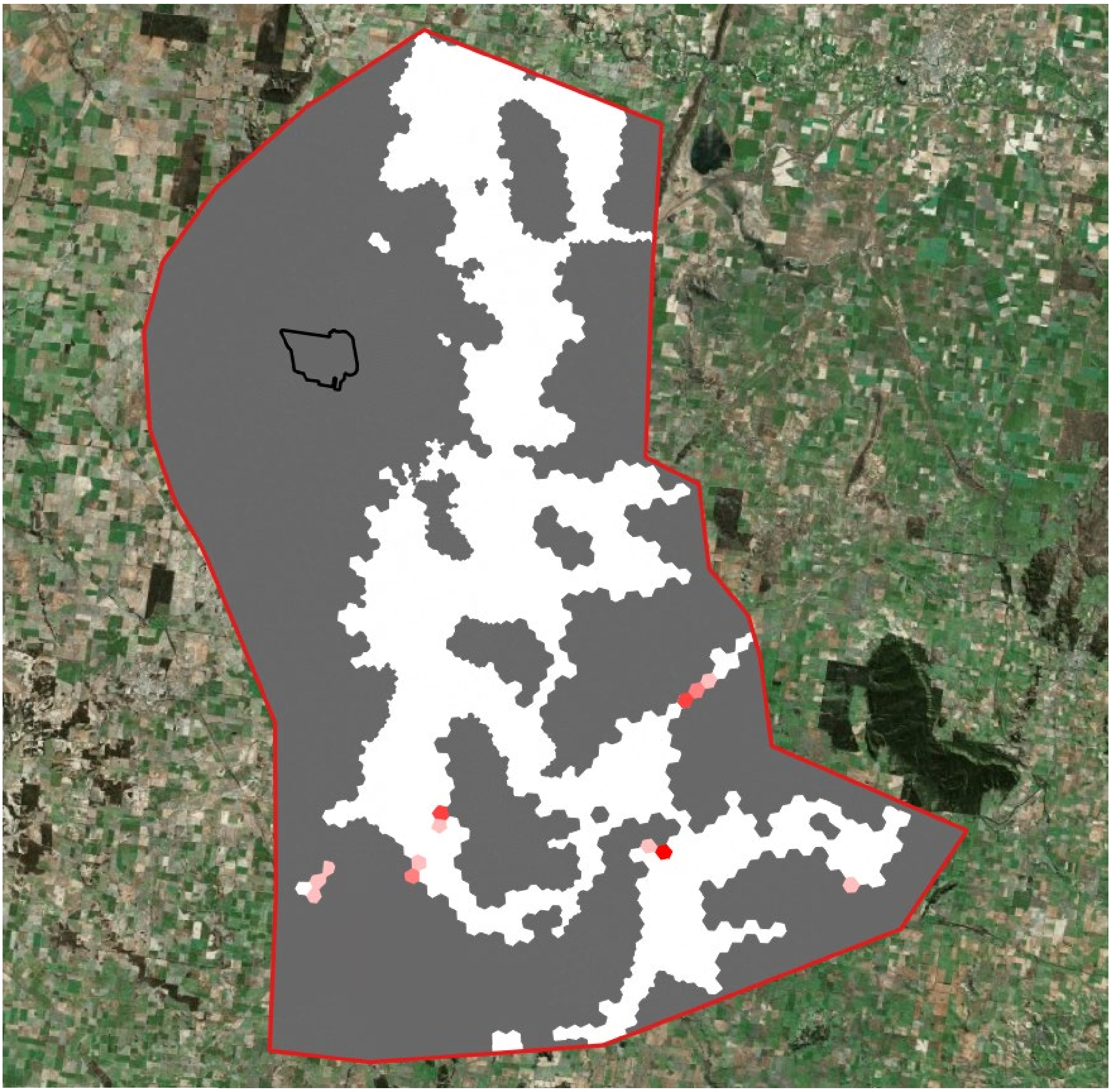
L2 Upper Cowra Kh/Kv (-)

- 1 - 200
- 200 - 400
- 400 - 600
- 600 - 800
- 800 - 1000



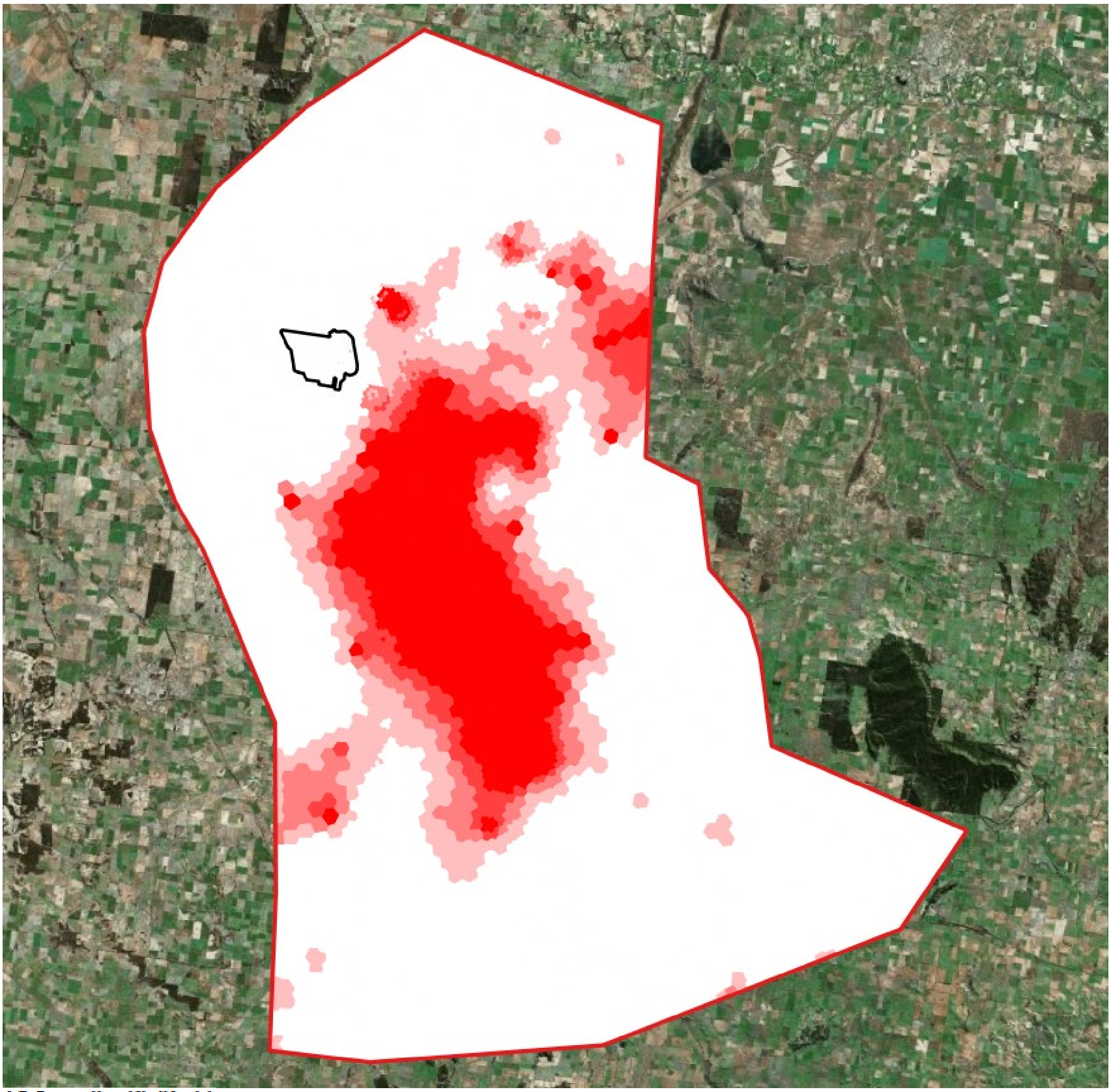
L3 Lower Cowra Kh/Kv (-)

- 1 - 200
- 200 - 400
- 400 - 600
- 600 - 800
- 800 - 1000



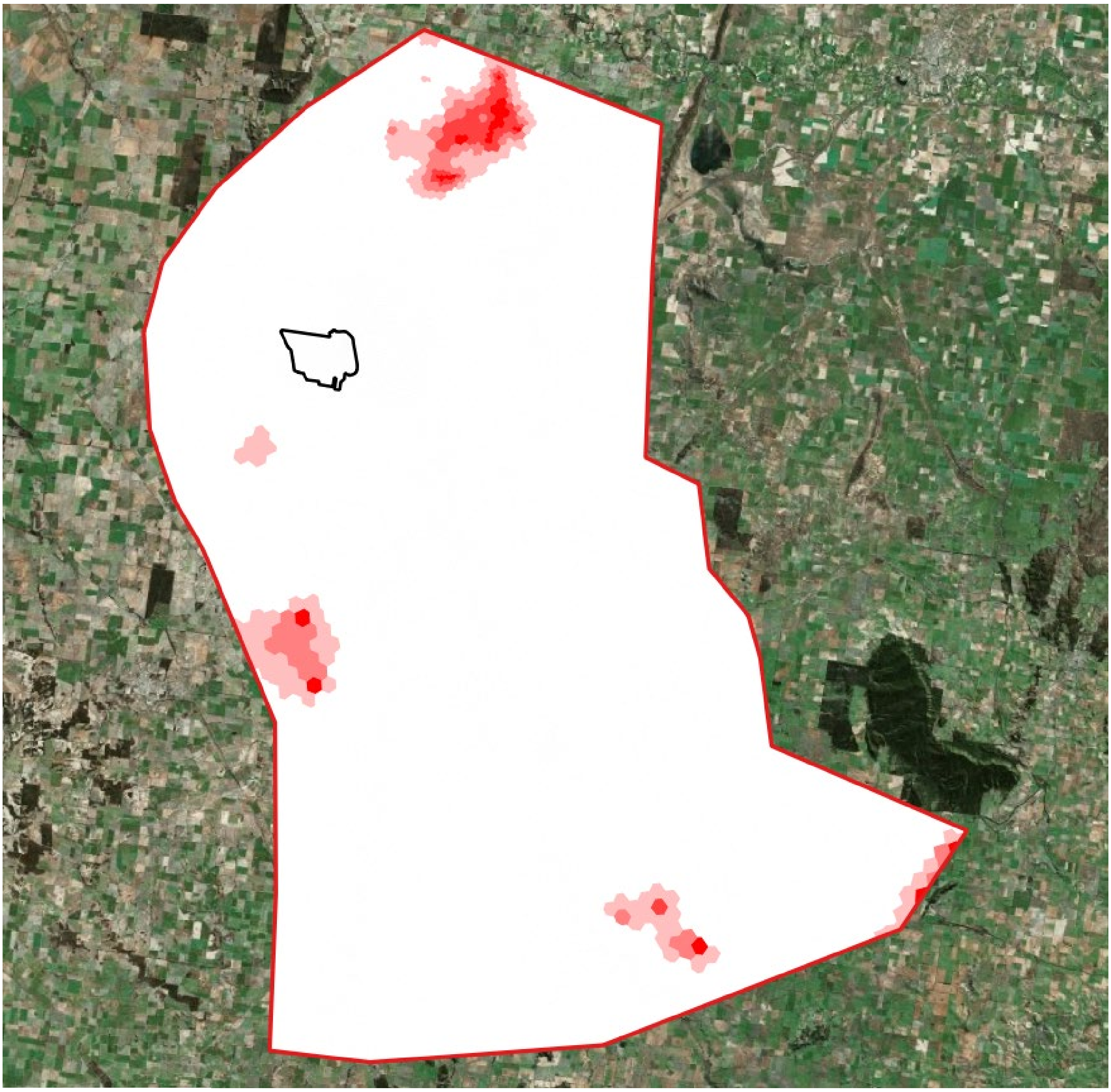
L4 Lachlan Kh/Kv (-)

1 - 200
200 - 400
400 - 600
600 - 800
800 - 1000



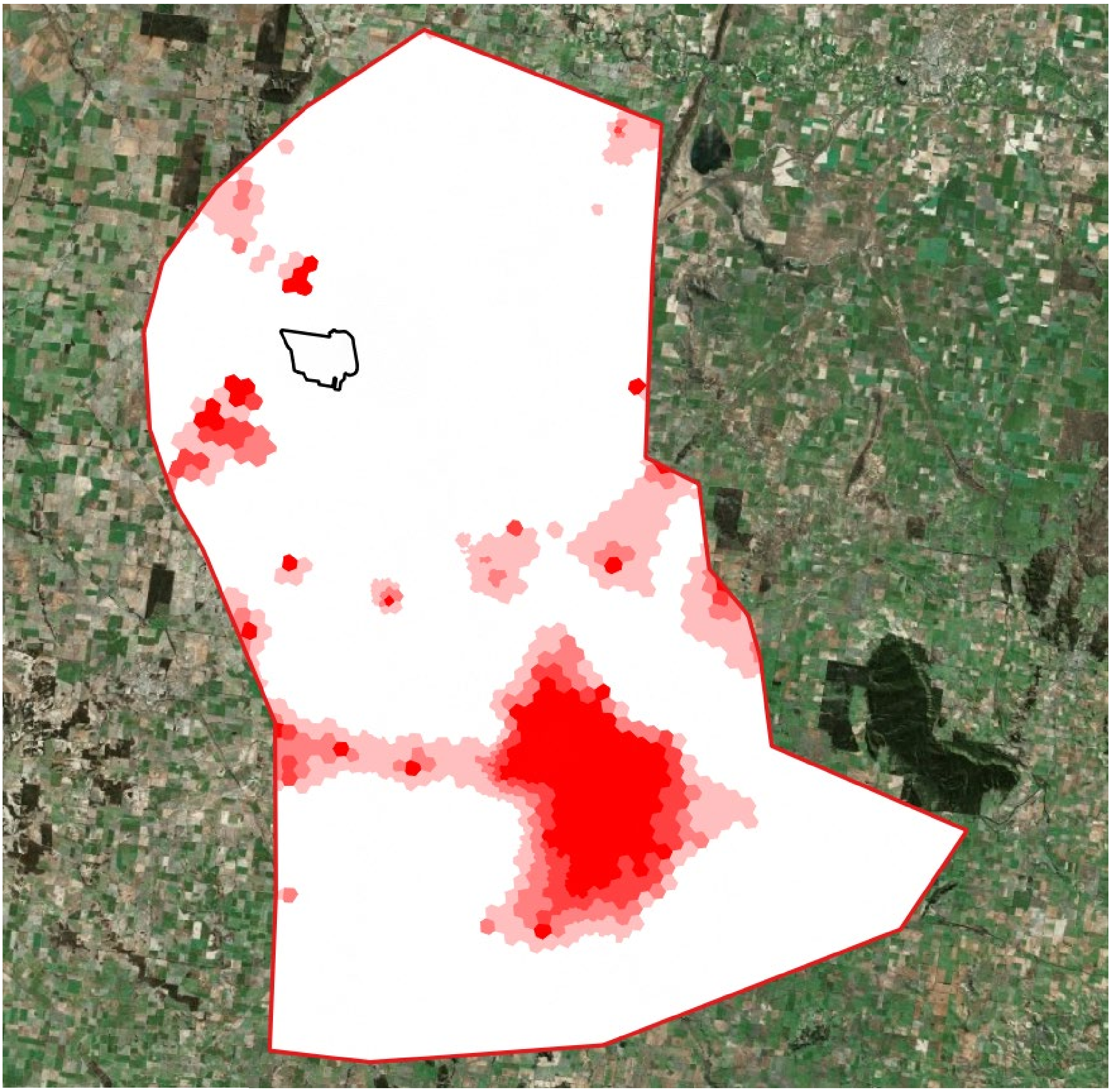
L5 Saprolite Kh/Kv (-)

- 1 - 200
- 200 - 400
- 400 - 600
- 600 - 800
- 800 - 1000



L6 Saprock Kh/Kv (-)

1 - 200
200 - 400
400 - 600
600 - 800
800 - 1000



L12 Basement Kh/Kv (-)

- 1 - 200
- 200 - 400
- 400 - 600
- 600 - 800
- 800 - 1000

Appendix E

Specific storage

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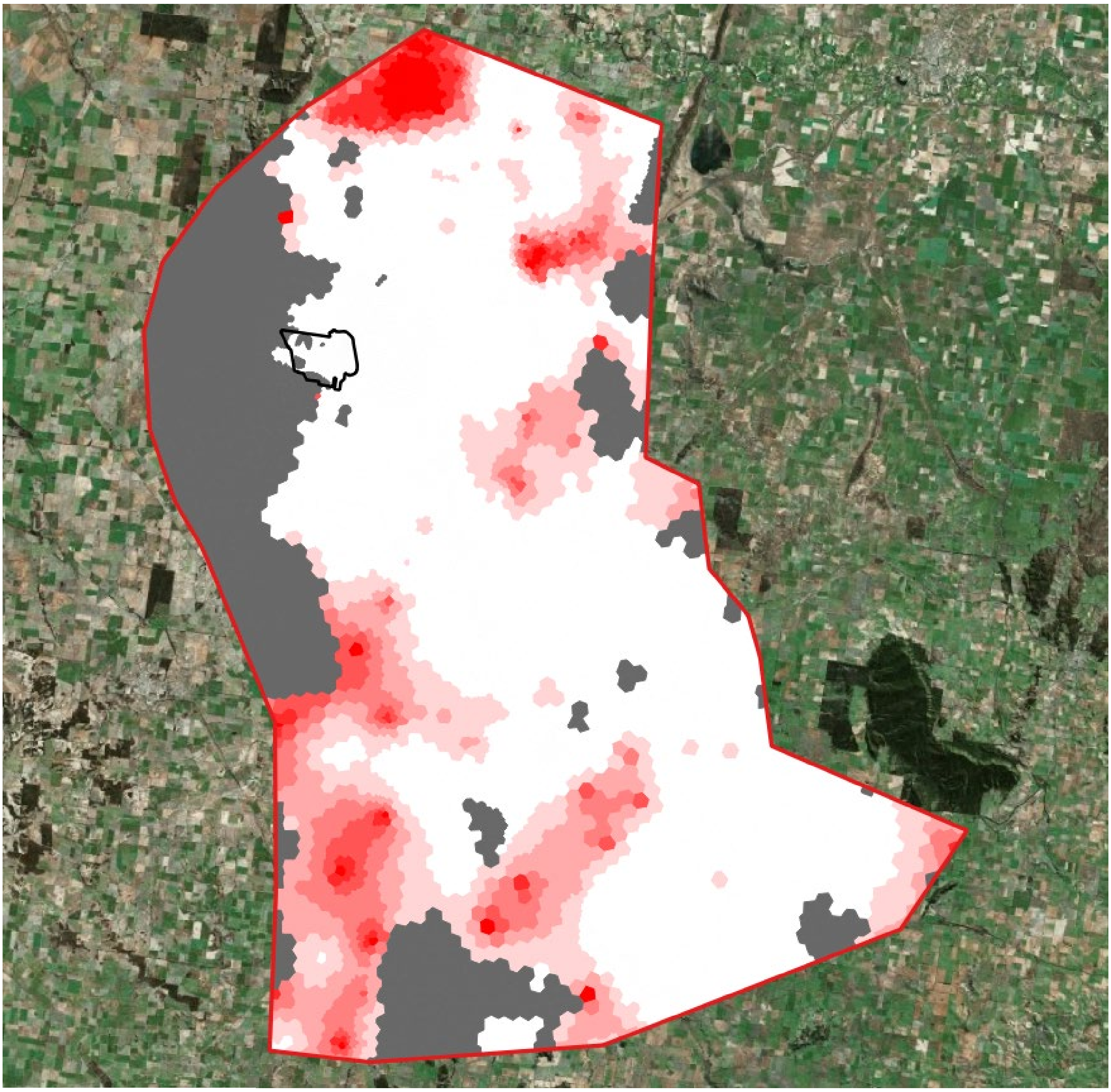
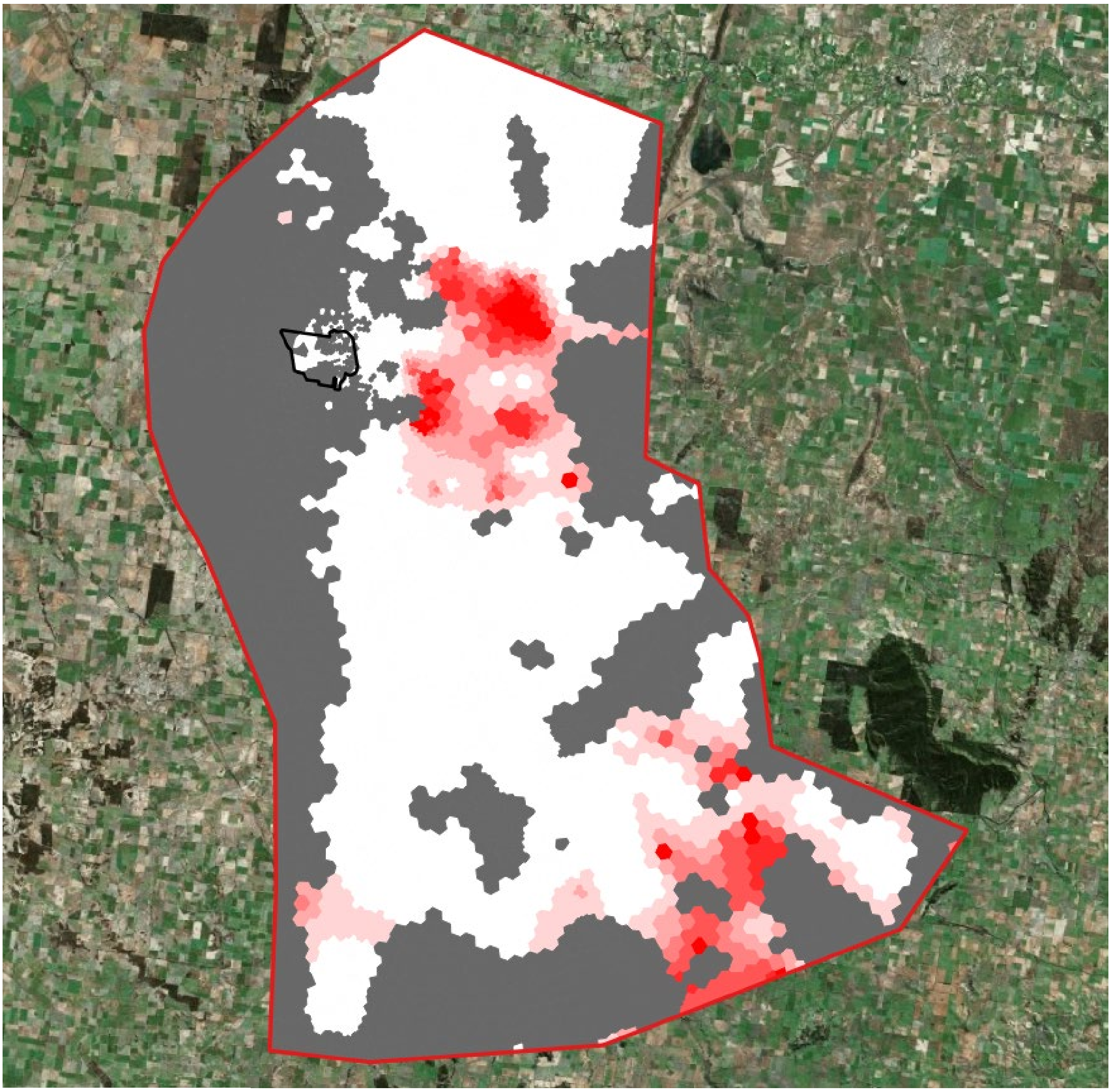


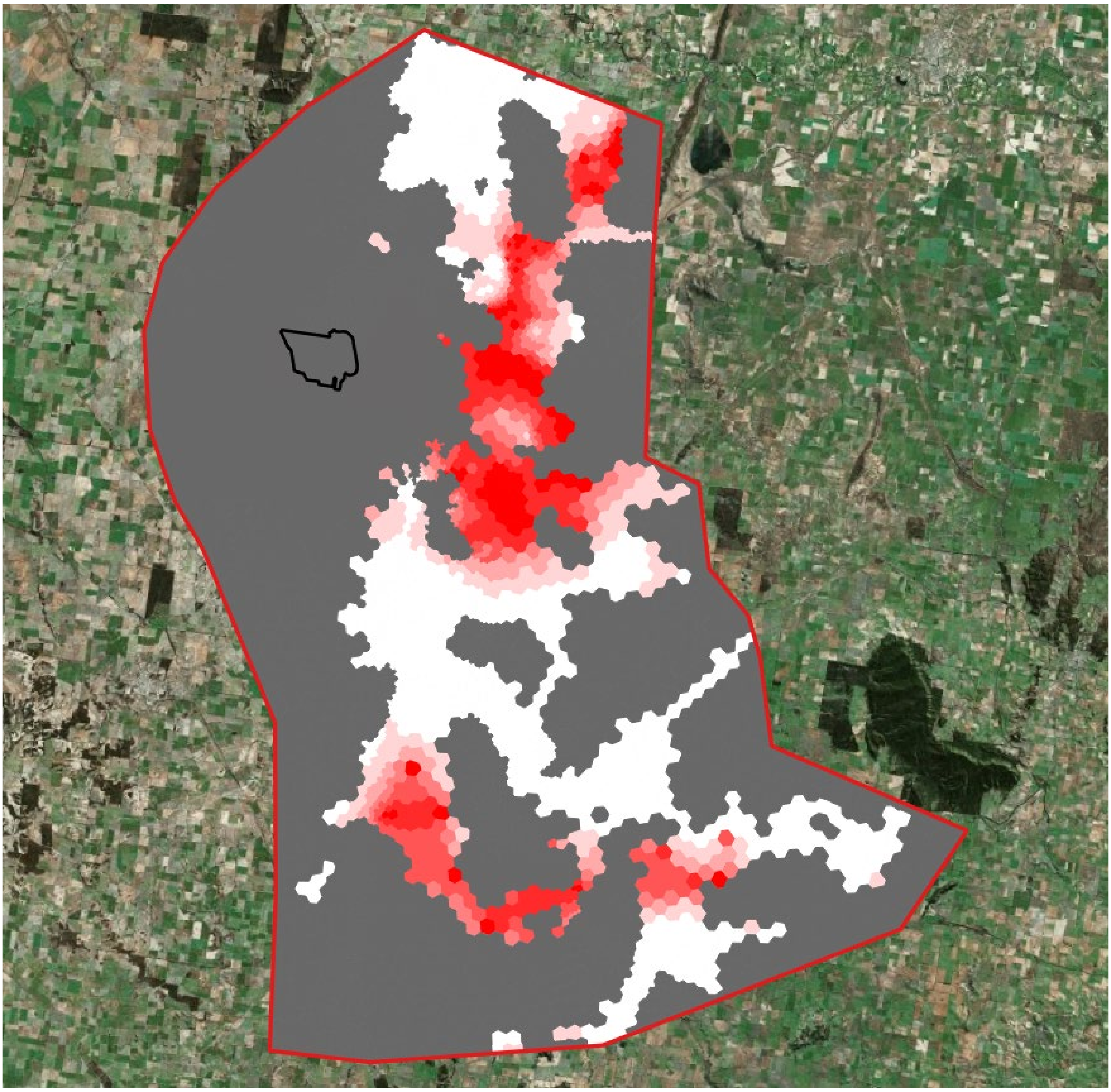
L2 Upper Cowra Ss (1/m)

- 0.0000001 - 0.000002
- 0.000002 - 0.000004
- 0.000004 - 0.000006
- 0.000006 - 0.000008
- 0.000008 - 0.00001
- 0.00001 - 0.000012
- 0.000012 - 0.000013



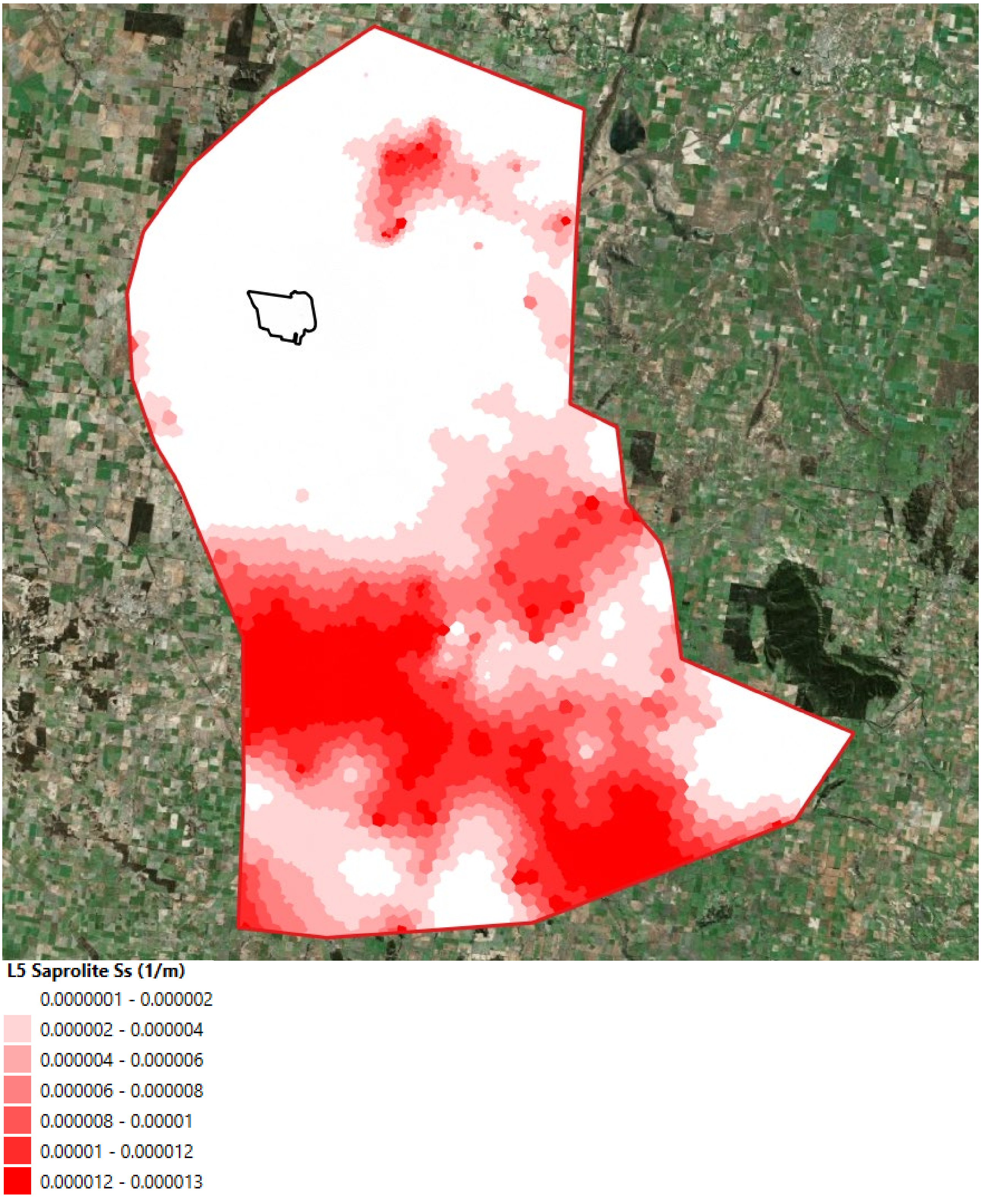
L3 Lower Cowra Ss (1/m)

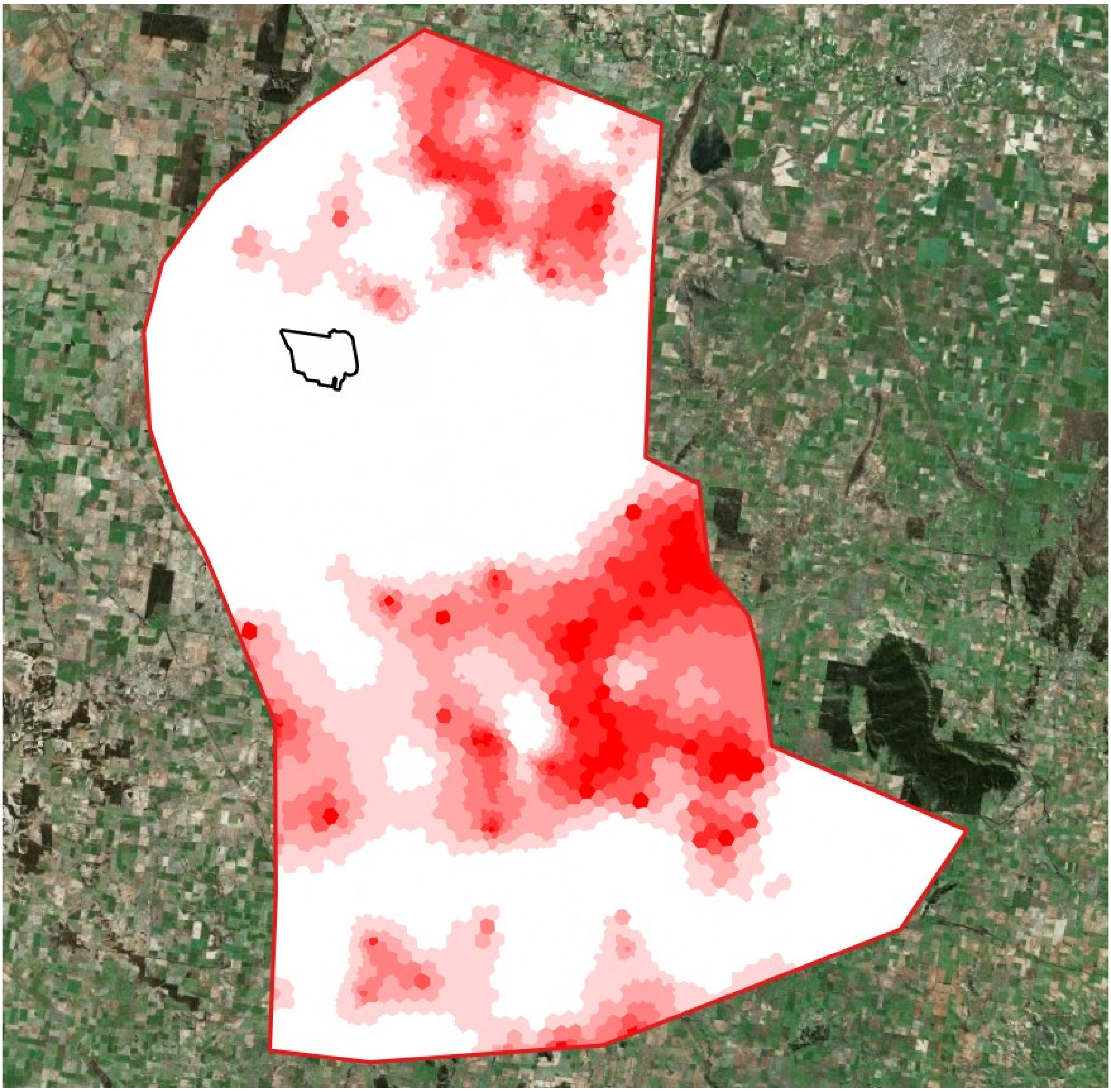
- 0.0000001 - 0.000002
- 0.000002 - 0.000004
- 0.000004 - 0.000006
- 0.000006 - 0.000008
- 0.000008 - 0.00001
- 0.00001 - 0.000012
- 0.000012 - 0.000013



L4 Lachlan Ss (1/m)

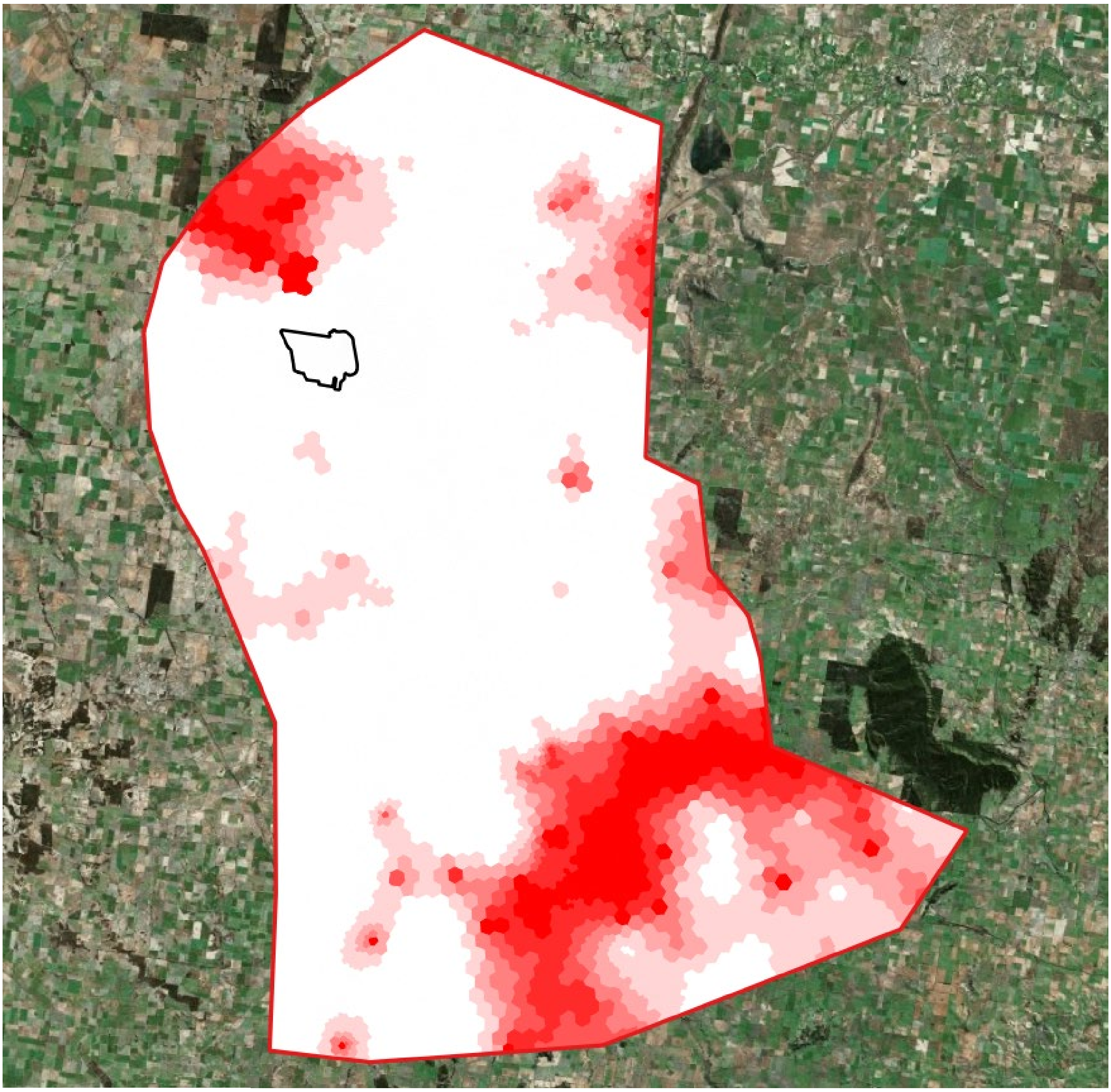
0.0000001 - 0.000002
0.000002 - 0.000004
0.000004 - 0.000006
0.000006 - 0.000008
0.000008 - 0.00001
0.00001 - 0.000012
0.000012 - 0.000013


L5 Saprolite Ss (1/m)
0.0000001 - 0.000002
0.000002 - 0.000004
0.000004 - 0.000006
0.000006 - 0.000008
0.000008 - 0.00001
0.00001 - 0.000012
0.000012 - 0.000013



L6 Saprock Ss (1/m)

- 0.0000001 - 0.000002
- 0.000002 - 0.000004
- 0.000004 - 0.000006
- 0.000006 - 0.000008
- 0.000008 - 0.00001
- 0.00001 - 0.000012
- 0.000012 - 0.000013

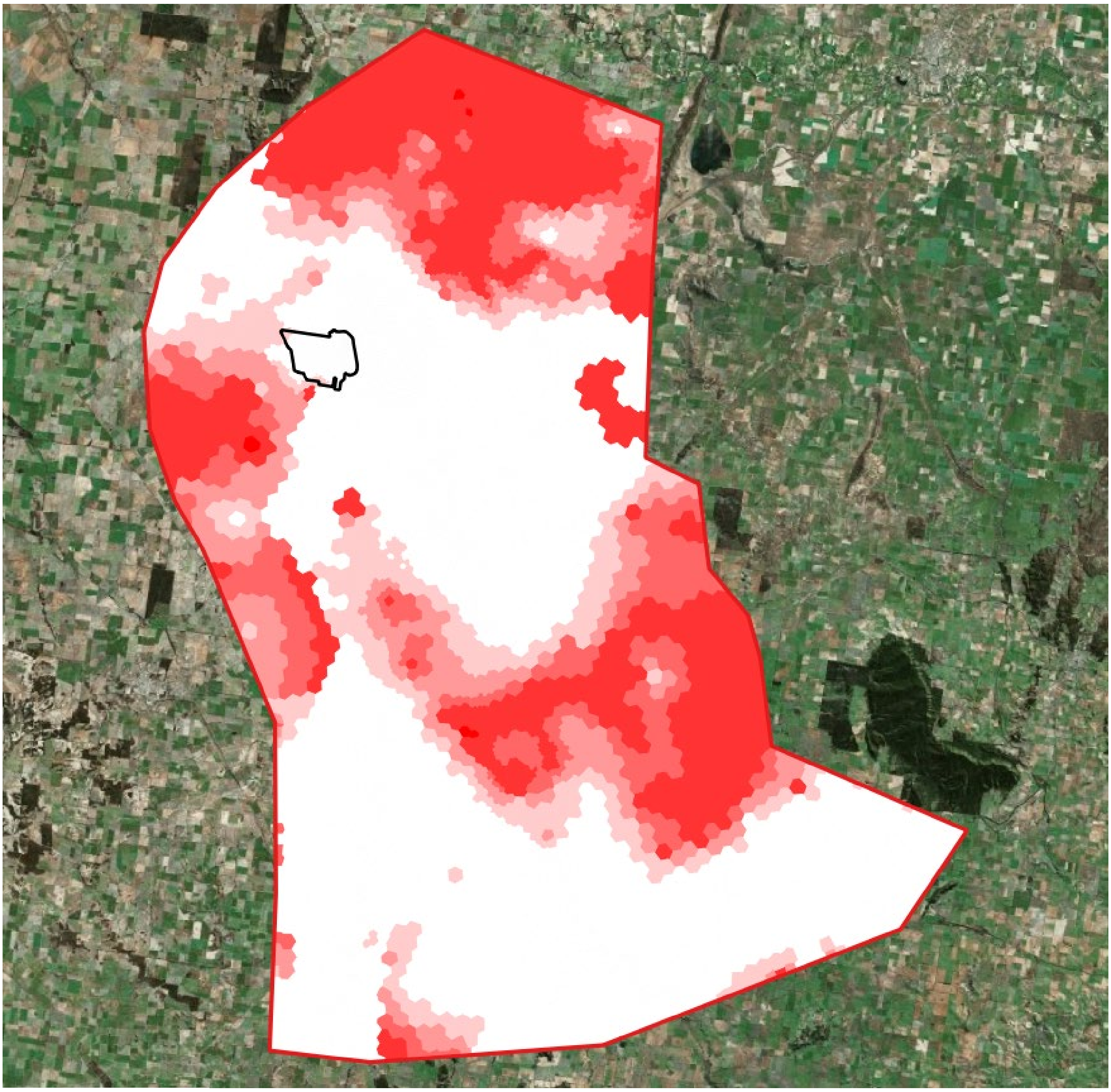


L12 Basement Ss (1/m)

0.0000001 - 0.000002
0.000002 - 0.000004
0.000004 - 0.000006
0.000006 - 0.000008
0.000008 - 0.00001
0.00001 - 0.000012
0.000012 - 0.000013

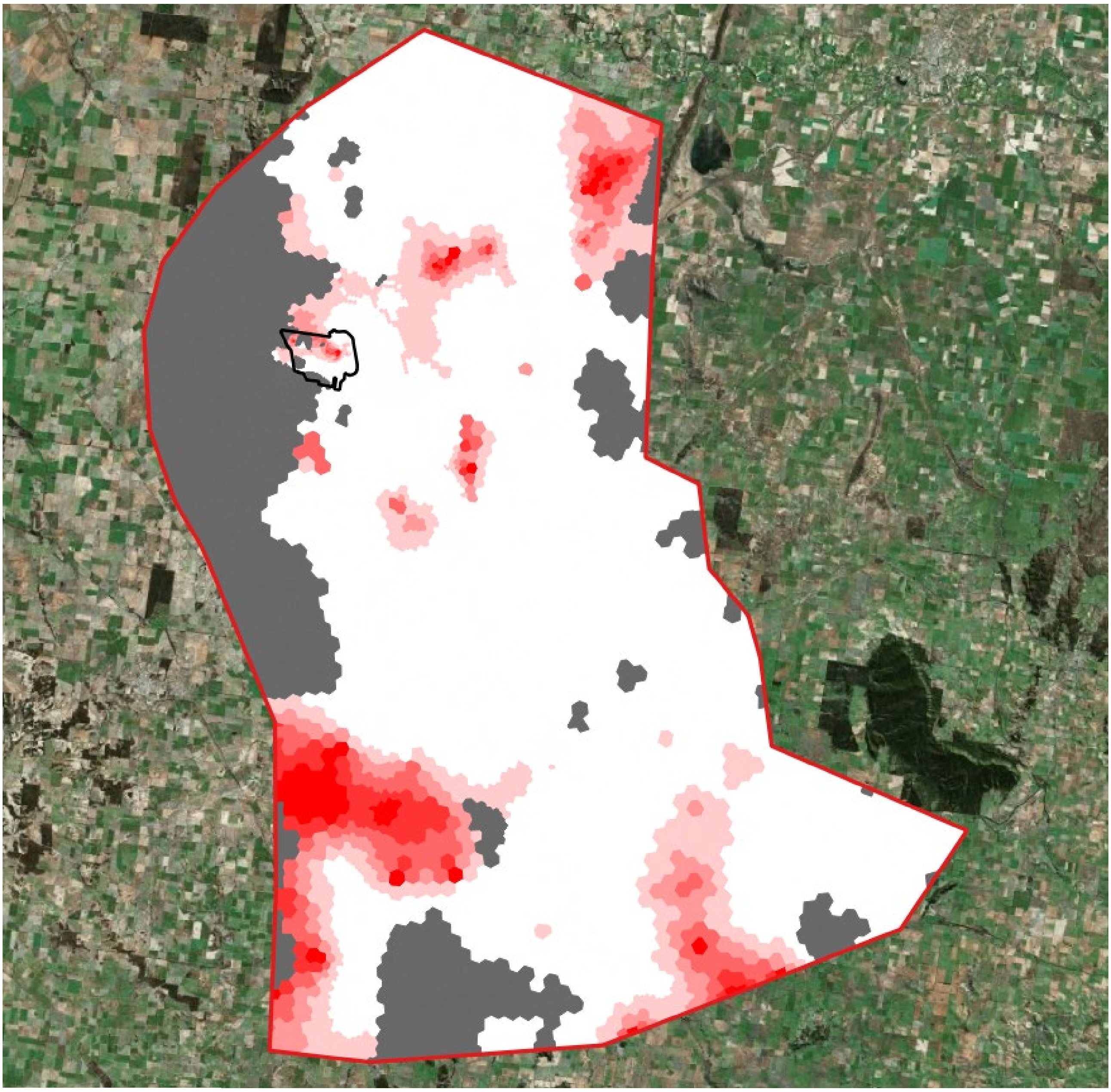
Appendix F
Specific yield

EMM
creating opportunities



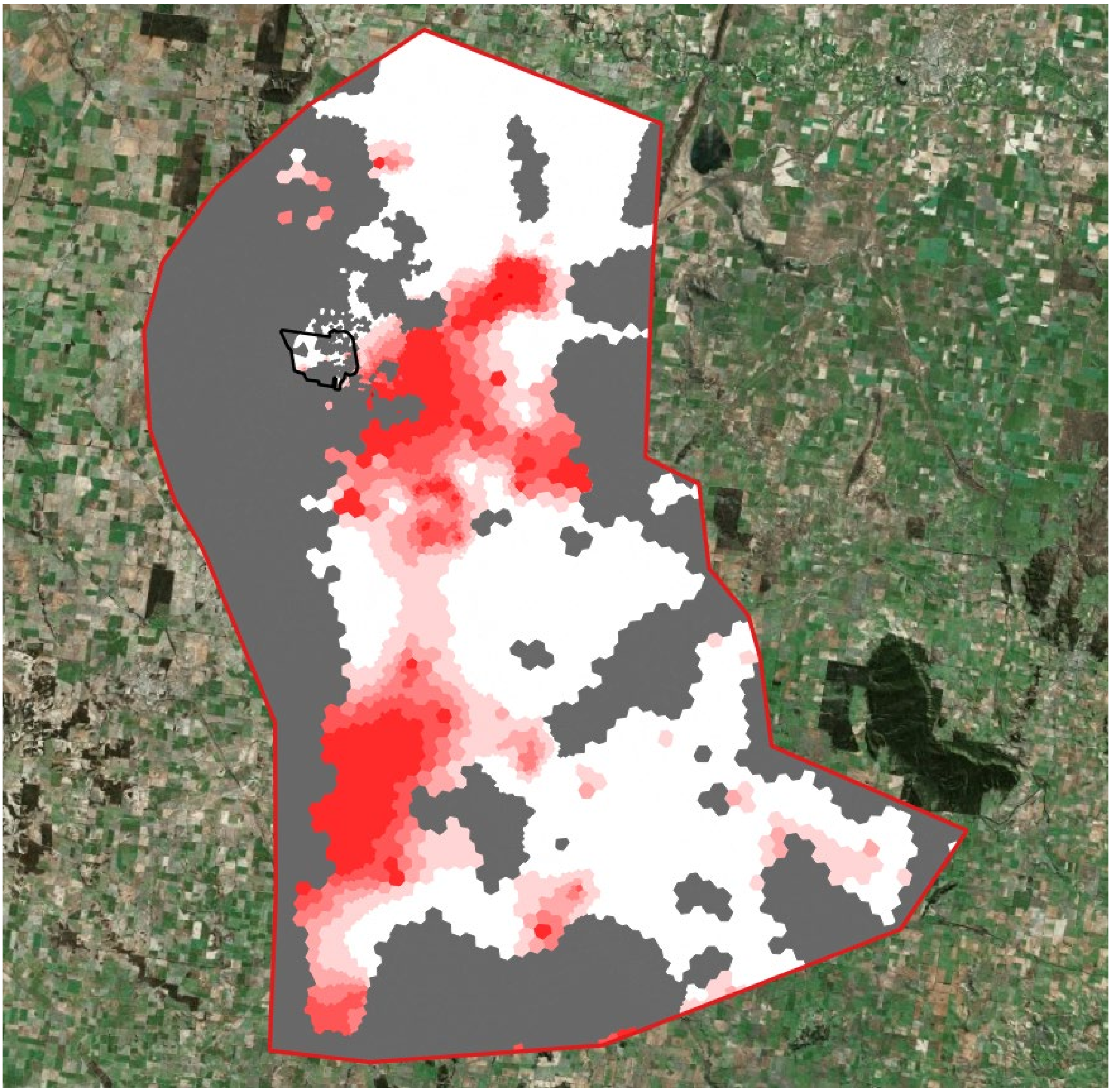
L1 Clay Sy (-)

	0.001 - 0.02
	0.02 - 0.04
	0.04 - 0.06
	0.06 - 0.08
	0.08 - 0.1
	0.1 - 0.10024



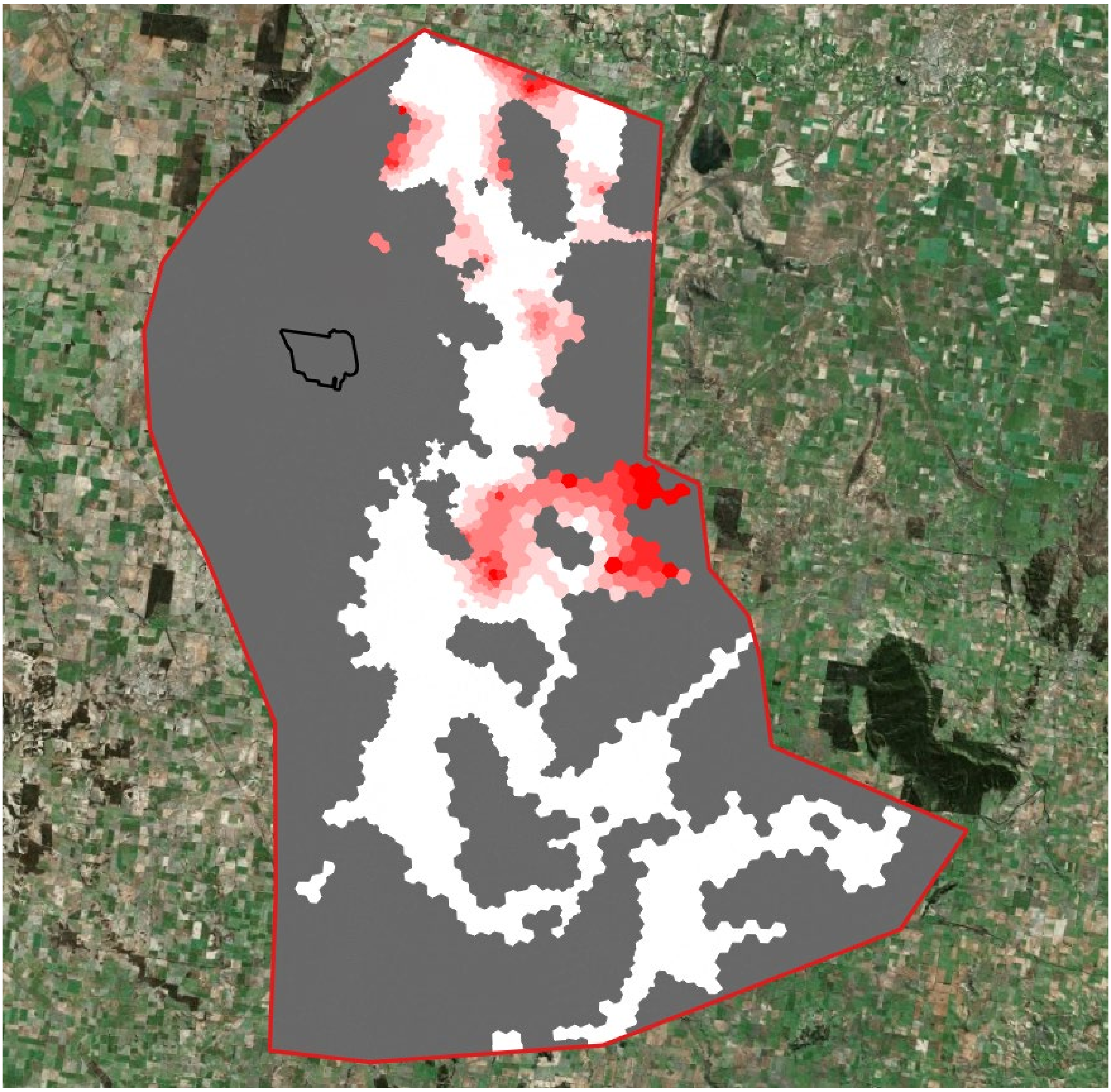
L2 Upper Cowra Sy (-)

- 0.001 - 0.05
- 0.05 - 0.1
- 0.1 - 0.15
- 0.15 - 0.2
- 0.2 - 0.25
- 0.25 - 0.3



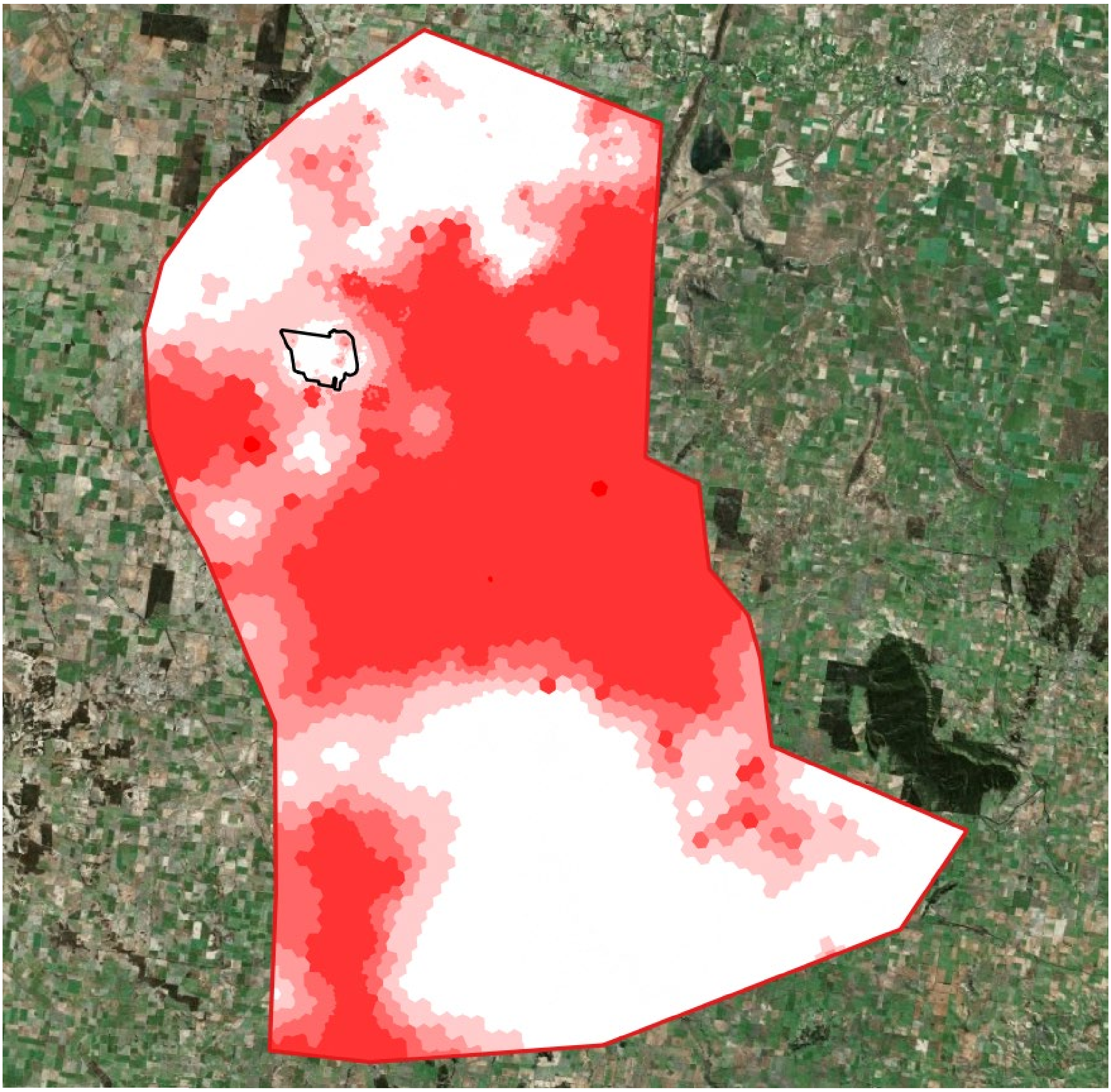
L3 Lower Cowra Sy (-)

- 0.001 - 0.05
- 0.05 - 0.1
- 0.1 - 0.15
- 0.15 - 0.2
- 0.2 - 0.25
- 0.25 - 0.3
- 0.3 - 0.3025



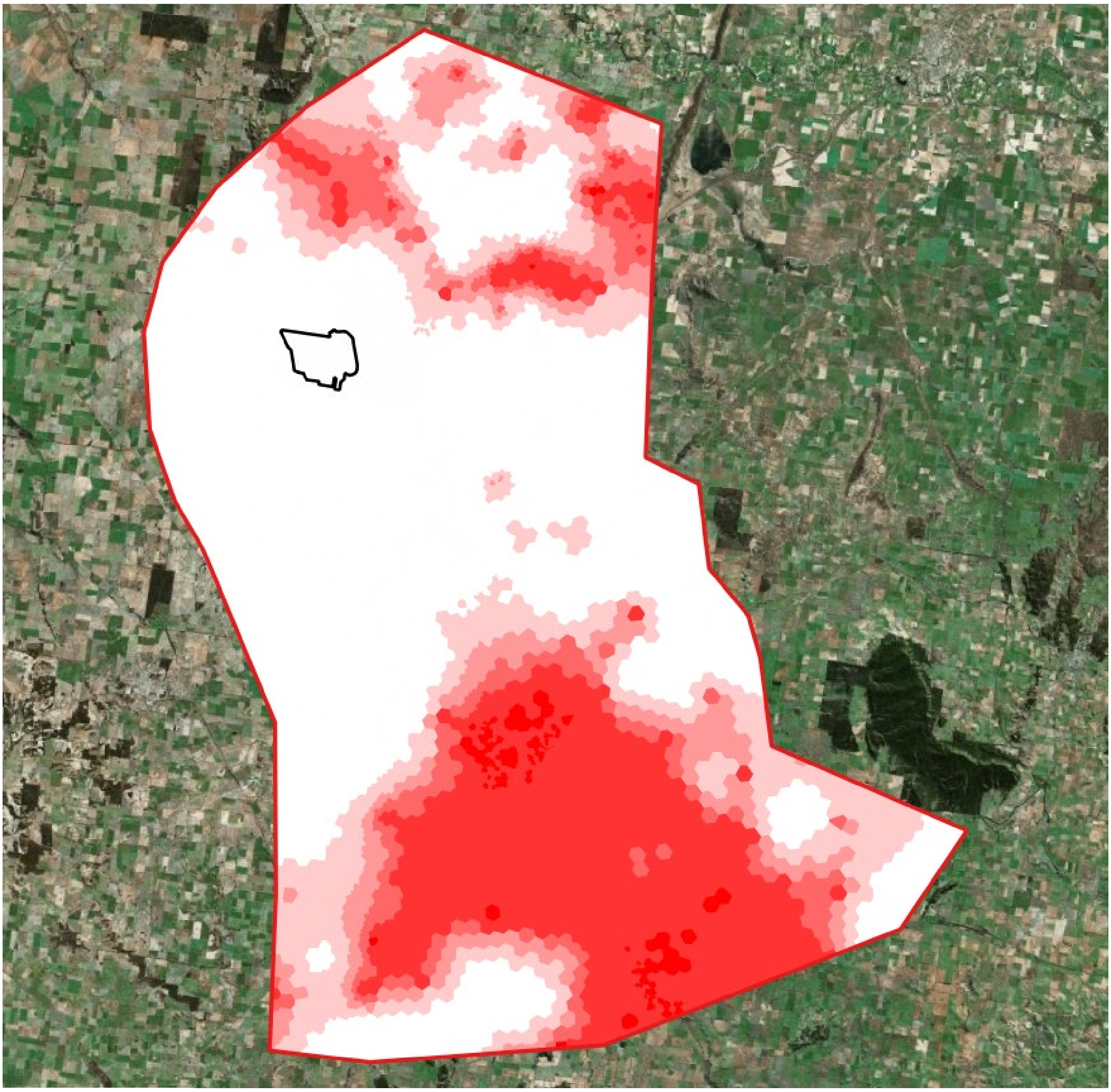
L4 Lachlan Sy (-)

- 0.001 - 0.05
- 0.05 - 0.1
- 0.1 - 0.15
- 0.15 - 0.2
- 0.2 - 0.25
- 0.25 - 0.3
- 0.3 - 0.35



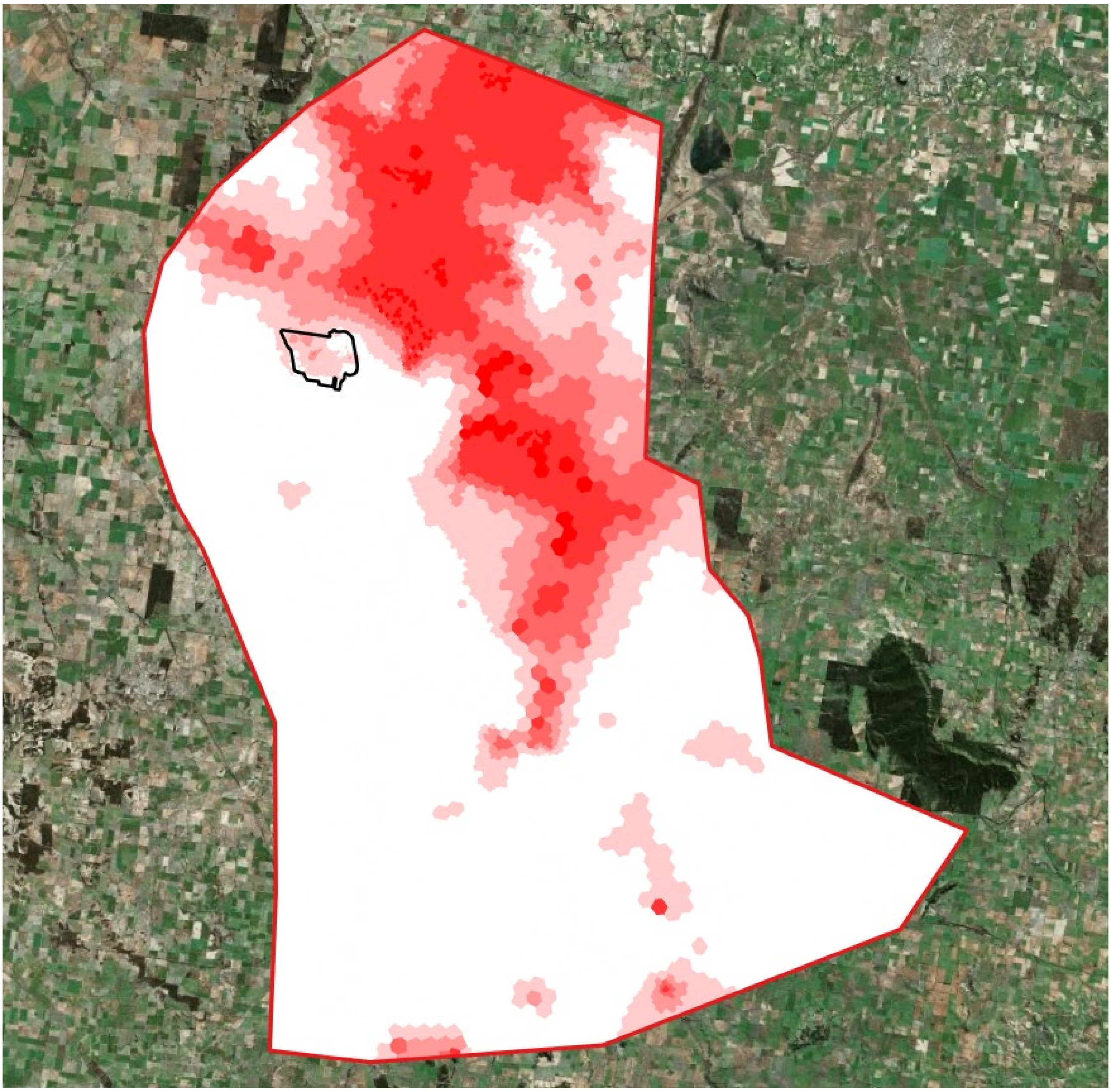
L5 Saprolite Sy (-)

- 0.001 - 0.02
- 0.02 - 0.04
- 0.04 - 0.06
- 0.06 - 0.08
- 0.08 - 0.1
- 0.1 - 0.100045



L6 Saprock Sy (-)

- 0.001 - 0.01
- 0.01 - 0.02
- 0.02 - 0.03
- 0.03 - 0.04
- 0.04 - 0.05
- 0.05 - 0.0501



L12 Basement Sy (-)

0.0001 - 0.01
0.01 - 0.02
0.02 - 0.03
0.03 - 0.04
0.04 - 0.05
0.05 - 0.05000002