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National Scan of Vineyards Milestone Report Y1.8

National Scan 2018

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1. Introduction

In this document we first present the headline results for the National Scan 2018 and provide high-level data relating to the total area of satellite imagery on which GAIA's machine learning algorithm was run. Following this we detail, for each state, the total area of vineyards and total length of vine rows within each Geographical Indication (Zones, Regions and Subregions).

These results we present to Wine Australia are the inaugural results obtained by a machine learning approach to the measurement and reporting of such ***Foundation data***, noting prior approaches relied on voluntary survey responses. Given its novelty, the methodology used to generate these results may contain imperfections but can offer much deeper insights into the state of the industry than could ever be achieved via survey response. The geolocation of vineyard blocks and individual vine rows will allow for much more detailed analyses to be developed, and the methodology and outputs will be incrementally improved and updated as capability matures and new imagery and data is ingested.

In the remainder and bulk of this report, we detail the Quality Assurance (QA) results. We first describe the QA process and then review the regions used for performing QA on GAIA (Section 2.1). Highlighted are the reasons for a small number of changes in some QA regions compared to their use in the first pass reports. We then document the additional metrics we're now reporting as compared to previous Milestone reports; we're now reporting misses, mistakes, unions and intersections. We believe that by reporting these additional properties, the performance of the machine learning system at the heart of GAIA can be better understood (both strengths and weaknesses). Following is a brief explanation of how we've calculated the error that might be present in the total vineyard area as computed from GAIA. Finally, we present the quality assurance results for each state as follows:

- Western Australia (Section 3)
- Tasmania (Section 4)
- South Australia (Section 5)
- Victoria (Section 6)
- New South Wales (Section 7)
- Queensland (Section 8)

1. Headline Results

1.1 Scan Summary

Wine grapes are known to typically be grown in certain areas of Australia. To find every vineyard block in the country we tried to source as much information as we could to roughly scope where we would search for vineyards. From this information we generated Areas of Interest (AOIs) to represent the areas we wanted to search for vineyards within, and assigned each AOI to an appropriate satellite image or images. Appropriate satellite images are recent images from the growing months of the years prior to the 2018 vintage. It was not always possible to find a recent and/or growing month

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match, and for these cases we would broaden our search to include older imagery and non-growing months. 85% of the total area of the AOIs was matched to imagery from the last 4 years.

The satellite images covering the AOIs were ***scanned*** - we ran GAIA's machine learning algorithm over the extraction of each AOI from its corresponding satellite image(s) and yielded vineyard block shapes. To perform the National Scan 2018, we scanned ~**5.1 million** hectares of satellite imagery, finding ~**146,128** hectares of vineyard blocks. A breakdown of total area scanned and total area of vineyards found by state is outlined in Table 1. A detailed breakdown of vineyard areas and lengths in each state, for each GI, is provided in Tables 2-7. The GI boundary files used for this per-GI analysis consist of the South Australia GI boundaries updated in mid-2018, and the updated boundaries for GIs in other states from early 2019. Consilium Technology thanks Wine Australia for providing these updated GI boundaries.

The output of GAIA yields "single-value" results. Definite boundaries are produced by GAIA and hence definite areas are computed for each vineyard block that is detected. The total area of all vineyards obtained by considering the area of each detected vineyard is **146,128** hectares. However, because there is obviously some inherent error or uncertainty in the predictions and thus areas computed by GAIA, we'd like to quantify this error or uncertainty. The calculation of the error and bounds on the "single-value" Australia-wide result is outlined in Section 2.2; we calculate the error to be ± 8,669 hectares with better than 95% confidence. The total area of vineyards as detected by GAIA is thus between **137,459** and **154,797** hectares.

Table 1. *Summary statistics of wine vineyard block area of wine vine row length in each state and Australia.*

State	Total area "scanned" (ha)	Total area of vineyards (ha)	Total length of vine rows (km)
WA	294269	11371	34992
TAS	358346	1941	6981
SA	1322969	74521	240395
VIC	832154	23633	76524
NSW (incl ACT)	1844899	34031	102929
QLD	448143	630	1897
TOTAL	**5,100,780**	**146,128 ± 8,669**	**463,718**

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1.2 Western Australia

Table 2. *Vineyard area and vine row length of all Geographical Indications in WA.*

GI name	GI type	Total area of vineyards (ha)	Total length of vine rows (km)
Central Western Australia	Zone	47	145
Eastern Plains Inland and North	Zone	2	5
Greater Perth	Zone	990	2850
South West Australia	Zone	10333	31993
Western Australia South East Coastal	Zone	0	0
Blackwood Valley	Region	360	1107
Geographe	Region	868	2692
Great Southern	Region	2370	7056
Manjimup	Region	224	720
Margaret River	Region	5840	18397
Peel	Region	55	179
Pemberton	Region	645	1953
Perth Hills	Region	166	485
Swan District	Region	756	2159
Albany	Subregion	84	227
Denmark	Subregion	93	279
Frankland River	Subregion	1137	3330
Mount Barker	Subregion	934	2845
Porongurup	Subregion	96	297
Swan Valley	Subregion	508	1476

1.3 Tasmania

Table 3. *Vineyard area and vine row length of all Geographical Indications in Tasmania.*

GI name	GI type	Total area of vineyards (ha)	Total length of vine rows (km)
Tasmania	Zone (state)	1941	6981

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1.4 South Australia

Table 4. *Vineyard area and vine row length of all Geographical Indications in SA.*

GI name	GI type	Total area of vineyards (ha)	Total length of vine rows (km)
Barossa	Zone	13103	40276
Far North	Zone	176	522
Fleurieu	Zone	14919	49648
Limestone Coast	Zone	15126	51804
Lower Murray	Zone	21492	65651
Mount Lofty Ranges	Zone	9648	32305
The Peninsula	Zone	57	188
Adelaide Hills	Region	3854	13906
Adelaide Plains	Region	600	1733
Barossa Valley	Region	10871	33272
Clare Valley	Region	5009	16101
Coonawarra	Region	5170	17737
Currency Creek	Region	1022	3502
Eden Valley	Region	1984	6233
Kangaroo Island	Region	136	427
Langhorne Creek	Region	5930	20556
Mclaren Vale	Region	6999	22273
Mount Benson	Region	478	1563
Mount Gambier	Region	271	849
Padthaway	Region	4022	13885
Riverland	Region	21058	64427
Robe	Region	681	2428
Southern Fleurieu	Region	476	1584
Southern Flinders Ranges	Region	176	522
Wrattonbully	Region	2647	8868
High Eden	Subregion	404	1237
Lenswood	Subregion	271	987
Piccadilly Valley	Subregion	213	866

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1.5 Victoria

Table 5. *Vineyard area and vine row length of all Geographical Indications in Victoria.*

GI name	GI type	Total area of vineyards (ha)	Total length of vine rows (km)
Central Victoria	Zone	4272	14001
Gippsland	Zone	175	613
North East Victoria	Zone	2886	9527
North West Victoria	Zone	10502	32062
Port Phillip	Zone	4238	15149
Western Victoria	Zone	1561	5171
Alpine Valleys	Region	295	941
Beechworth	Region	130	465
Bendigo	Region	622	1974
Geelong	Region	423	1560
Glenrowan	Region	176	570
Goulburn Valley	Region	1211	4004
Grampians	Region	595	1916
Heathcote	Region	1636	5287
Henty	Region	136	501
King Valley	Region	1468	5050
Macedon Ranges	Region	192	593
Mornington Peninsula	Region	891	3108
Murray Darling Vic	Region	8358	25641
Pyrenees	Region	781	2590
Rutherglen	Region	765	2352
Strathbogie Ranges	Region	529	1804
Sunbury	Region	99	330
Swan Hill Vic	Region	2140	6411
Upper Goulburn	Region	252	873
Yarra Valley	Region	2533	9201
Great Western	Subregion	454	1440
Nagambie Lakes	Subregion	494	1569

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1.6 New South Wales

Table 6. *Vineyard area and vine row length of all Geographical Indications in NSW.*

GI name	GI type	Total area of vineyards (ha)	Total length of vine rows (km)
Big Rivers	Zone	24875	74042
Central Ranges	Zone	4402	13864
Hunter Valley	Zone	2499	7790
Northern Rivers	Zone	82	240
Northern Slopes	Zone	106	327
South Coast	Zone	306	959
Southern New South Wales	Zone	1750	5673
Western Plains	Zone	11	34
Canberra District	Region	316	1040
Cowra	Region	907	2871
Gundagai	Region	631	2113
Hastings River	Region	13	40
Hilltops	Region	607	1939
Hunter	Region	2499	7790
Mudgee	Region	1919	5806
Murray Darling Nsw	Region	7043	24117
New England Australia	Region	82	253
Orange	Region	1078	3909
Perricoota	Region	395	1226
Riverina	Region	16653	46168
Shoalhaven Coast	Region	41	120
Southern Highlands	Region	143	472
Swan Hill Nsw	Region	227	646
Tumbarumba	Region	176	551
Broke Fordwich	Subregion	481	1617
Pokolbin	Subregion	1328	4009
Upper Hunter Valley	Subregion	447	1402

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1.7 Queensland

Table 7. *Vineyard area and vine row length of all Geographical Indications in QLD.*

GI name	GI type	Total area of vineyards (ha)	Total length of vine rows (km)
Granite Belt	Region	319	975
South Burnett	Region	191	574

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2. Completing National Scan 2018

2.1 Use of External Data Sets

External data sets have been used for various purposes in undertaking the first National Scan of Australia. A variety of data sets were initially used to scope where GAIA should look for vineyards. That is, data sets giving some level of geolocation specification of where vineyards might exist in Australia were collated to define the general areas to be scanned. These general areas are represented by the AOIs illustrated for each state in Figure 2 (WA), Figure 3 (TAS), Figure 4 (SA), Figure 5 (VIC), Figure 6 (NSW), Figure 7 (QLD).

During the training of the machine learning models that were ultimately used for performing the National Scan 2018, GAIA was not trained to distinguish between vineyards growing grapes used for different purposes: at the time of training ***production models***, there was insufficient ground truth data to achieve this. Since then, two ground truth data sets have become available that will allow such a model to be trained:

- **Western Australia's Department of Primary Industries and Regional Development (DPIRD)** data set that differentiates vineyards growing grapes for different purposes in the Swan Valley/Swan District GIs in WA.
- **SunRISE Mapping** data set that differentiates vineyards growing grapes for different purposes in the Murray Darling/Swan Hill GIs in VIC & NSW.

Thus the other significant use of external data sets in National Scan 2018 was post-scan in the ***scan curation*** (review) process. The vineyard block predictions generated by GAIA undergo a general review, with failings and obvious errors corrected where possible by manual edit (performed by a human). External data sets such as DPIRD and SunRISE Mapping were leveraged to assist in this scan curation process, specifically for the purpose of correcting the classification of vineyards blocks. The National Scan 2018 results presented herein have been through a review and curation process such that minimal non-wine vineyards are present in the areas covered by these two data sets.

2.2 National Scan Quality Assurance

The National Scan Quality Assurance process was described in detail in '*GAIA - National Scan Quality Assurance*' (CT-TR-2018-00018). Broadly, Quality Assurance for the National Scan 2018 is achieved by computing a suite of metrics on a number of regions, the ***National Scan Quality Assurance Regions (NSQARs)***. The 31 NSQARs, selected from Geographical Indications (GIs) from all over Australia, are documented in Table 8.

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Table 8. *National Scan Quality Assurance Regions.*

State	1st pass QA region	2nd pass QA region
WA	1. Margaret River 2. Swan Valley (#1) 3. Mount Barker 4. Geographe	1. Swan Valley (#2)
TAS	1. Tasmania "North" (Launceston) 2. Tasmania "South" (Hobart)	
SA	1. Riverland 2. Clare Valley 3. Wrattonbully 4. Barossa Valley	1. Adelaide Hills 2. Coonawarra 3. McLaren Vale
VIC	1. Murray Darling VIC (#1) 2. King Valley 3. Goulburn Valley 4. Yarra Valley	1. Strathbogie Ranges 2. The Grampians 3. Gippsland 4. Murray Darling VIC (#2) 5. Mornington Peninsula
NSW	1. Riverina 2. Canberra District 3. Hunter 4. Orange	1. Shoalhaven 2. Swan Hill NSW
QLD	1. South Burnett	1. Granite Belt
Total	**19 regions**	**12 regions**

In practice, each NSQAR is represented by a satellite image and corresponding labels generated by a human labeller. The labels generated by the human labeller are considered the ground-truth against which vineyard block predictions generated by GAIA are compared. Each NSQAR is at least 300 hectares as specified in *'GAIA - National Scan Quality Assurance'*, with the exception of Swan Hill NSW, which comes in at 281 hectares. Pertinent details relating to the satellite imagery/labels, such as imagery date, total area of imagery and total area of vineyards is included in the results table for each NSQAR.

There are changes to some first pass NSQARs from their definition and use in earlier Milestone reports:

- Updated labels for Swan Valley (#1) based on ground truth data provided by the Department of Primary Industries and Regional Development in Western Australia.

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- Updated labels for Murray Darling VIC (#1) based on ground truth data provided by SunRISE Mapping.
- What was referred to as “Barossa Valley” in the first pass (and Milestone Y1.3) is now referred to as “Adelaide Hills”. This change was made because the labelled region actually resided in the Adelaide Hills GI rather than the Barossa Valley GI; the satellite image that was originally acquired for the Barossa Valley covered a large area of the Adelaide Hills as well as the Barossa Valley. A portion in the Barossa Valley was labelled (becoming the Barossa Valley NSQAR) and the portion overlapping the Adelaide Hills was reassigned as the Adelaide Hills NSQAR.
- We were unable to ascertain the validity of the labels we had generated for South Burnett, so we acquired and labeled new imagery for a different area within the GI where we were more certain there were vineyards.

As per feedback received from Wine Australia, we have added additional properties to our suite of reporting metrics:

- Misses - the total area of misses (existed in ground truth, did not exist in prediction)
- Mistakes - the total area of mistakes (did not exist in ground truth, existed in prediction)
- Union - the total area of the union of ground truth and prediction
- Intersection - the total area of the intersection of ground truth and prediction

The inclusion of these additional properties should assist in understanding the performance of the GAIA machine learning system.

In the figures for each NSQAR that follows, the labels are coloured using a consistent palette, this palette is shown in the association of label colour to label category in Figure 1. The first four label categories (vineyard, young vines, sparse vines, covered vines) are considered to be vineyards. That is, models were trained to learn that any pixels that belong to these four categories was a true positive vineyard.



Fig 1:Legend associating label colour with label category.

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2.3 Quality Assurance Summary Statistics

For each NSQAR, a suite of metrics and properties is reported. For metrics such as Recall, Precision, Category Accuracy, Area Accuracy and Jaccard and False Positive Rate, direct summary statistics taken across all 31 samples are computable and insightful. However, direct summary statistics are not meaningful for the remaining metrics or properties that have units of area (ha): Total Area (ha), Truth Area (ha), Prediction Area (ha), Misses Area (ha), Mistakes Area (ha), Union Area (ha), Intersection Area (ha). For some such properties, specifically truth, prediction, misses and mistakes areas, per-area representations can be meaningful, so these are also presented. The QA summary statistics are presented in Table 9. Not shown in Table 9 is the standard error calculated for area accuracy, which is 0.5893.

Table 9. Summary statistics of QA metrics/properties.

	Mean	StdDev	Min	Max
Truth / ha	0.15473	0.16727	0.00201	0.77456
Prediction /ha	0.15053	0.15863	0.00210	0.70835
Misses / ha	0.01284	0.01916	0.00019	0.10641
Mistakes / ha	0.00873	0.00941	0.00012	0.03846
Recall	91.0962	4.4900	81.2330	98.4815
Precision	92.9557	4.2473	82.1304	98.4120
Category accuracy	98.2850	1.7134	91.3578	99.9527
Area accuracy	95.2228	3.2813	88.9183	99.8666
Jaccard	85.2779	6.0130	72.8978	94.3458
False Positive Rate (/m^2)	0.00873	0.00941	0.00012	0.03846

2.4 Vineyard Area Error Analysis

A conservative estimate of total area in Australia can be computed using a lower bound estimate of area accuracy (94.068%). This gives a range of **137,459** to **154,797** hectares, based on the observed measurement of **146,128** hectares for the total area of vineyards identified in the national scan search region.

The area accuracy bounds were estimated by calculating the standard error (0.5893) and using the 95% confidence interval. This provides both an upper and lower estimate of the true area accuracy. The assumptions include that the area accuracy is normally distributed and that the 31 samples used are representative of the entire search region used for the national scan. This gives a lower bound estimate of area accuracy of 94.068% and an upper bound of area accuracy of 96.378%.

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3. Quality Assurance in Western Australia

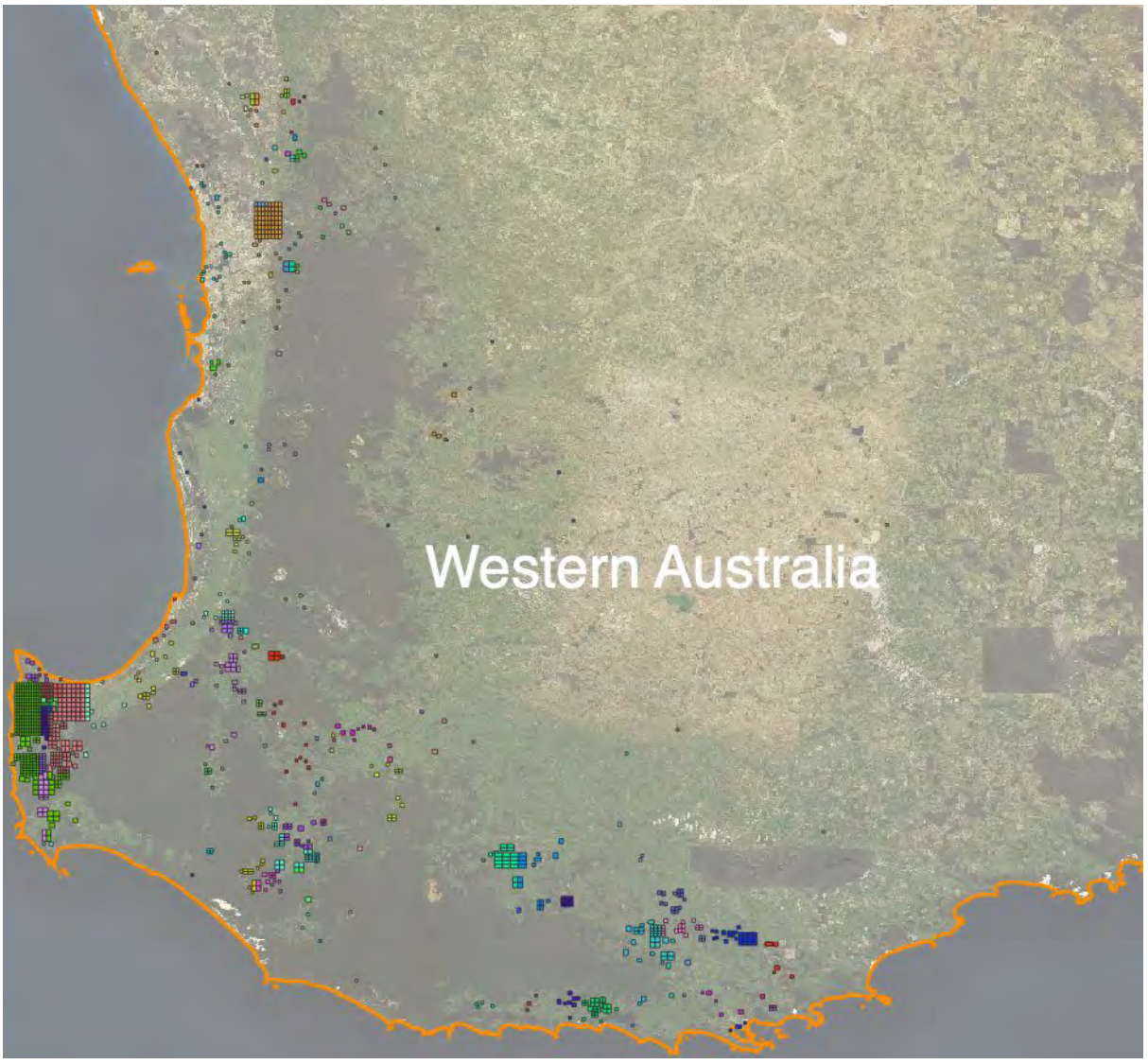


Fig 2: A visualisation of the AOIs in Western Australia that were scanned by GAIA. The different colours represent different satellite images that were used to scan each AOI.

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3.1 Margaret River

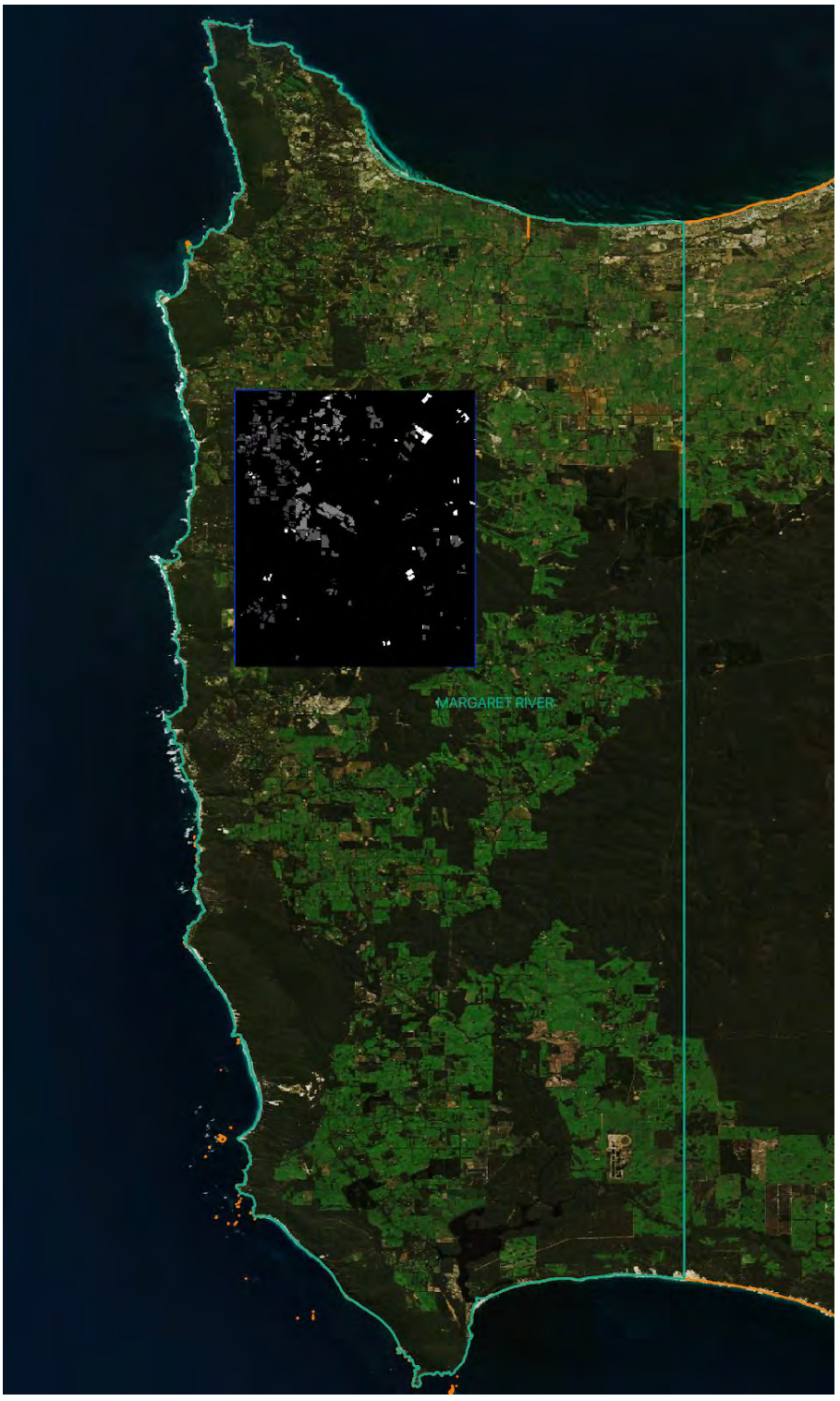


Figure A.1. The Margaret River NSQAR in the context of the Margaret River GI. The entire labelled region (greyscale rectangle) is used for Quality Assurance to maintain consistency with earlier reporting.

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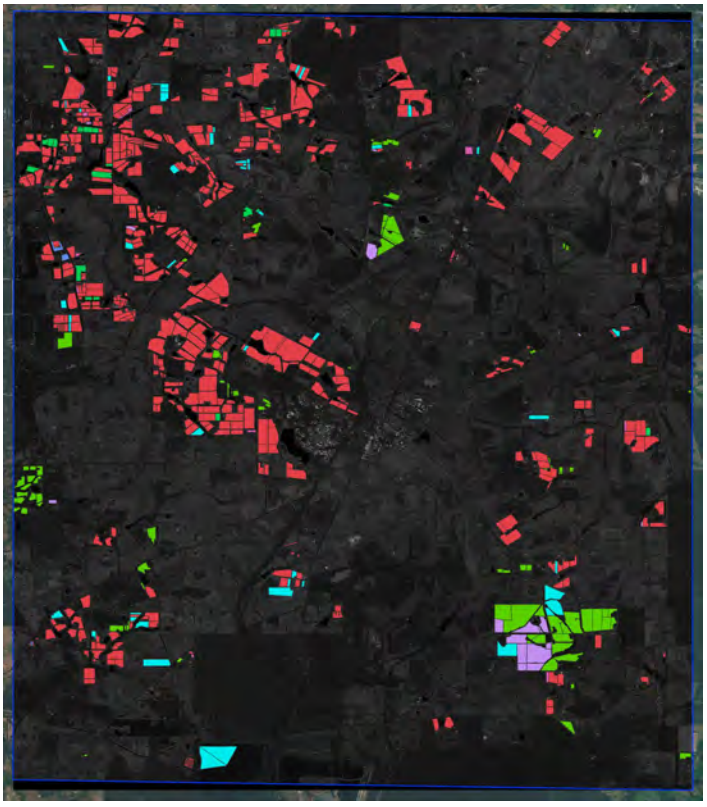


Figure A.2. The Margaret River labels overlaid on the Panchromatic satellite imagery.

Date of imagery used for ground truth	2017-01-15T02:50:50.846Z
Total area (ha)	25961.6
Truth area (ha)	1570.1
Prediction area (ha)	1572.2
Misses area (ha)	103.7
Mistakes area (ha)	104.5
Union area (ha)	1674.7
Intersection area (ha)	1467.7
Recall	93.40 %
Precision	93.35 %
Category accuracy	99.27 %
Area accuracy	99.87 %
Jaccard	87.58 %
False positive rate (/m^2)	0.0040

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3.2 Swan Valley #1

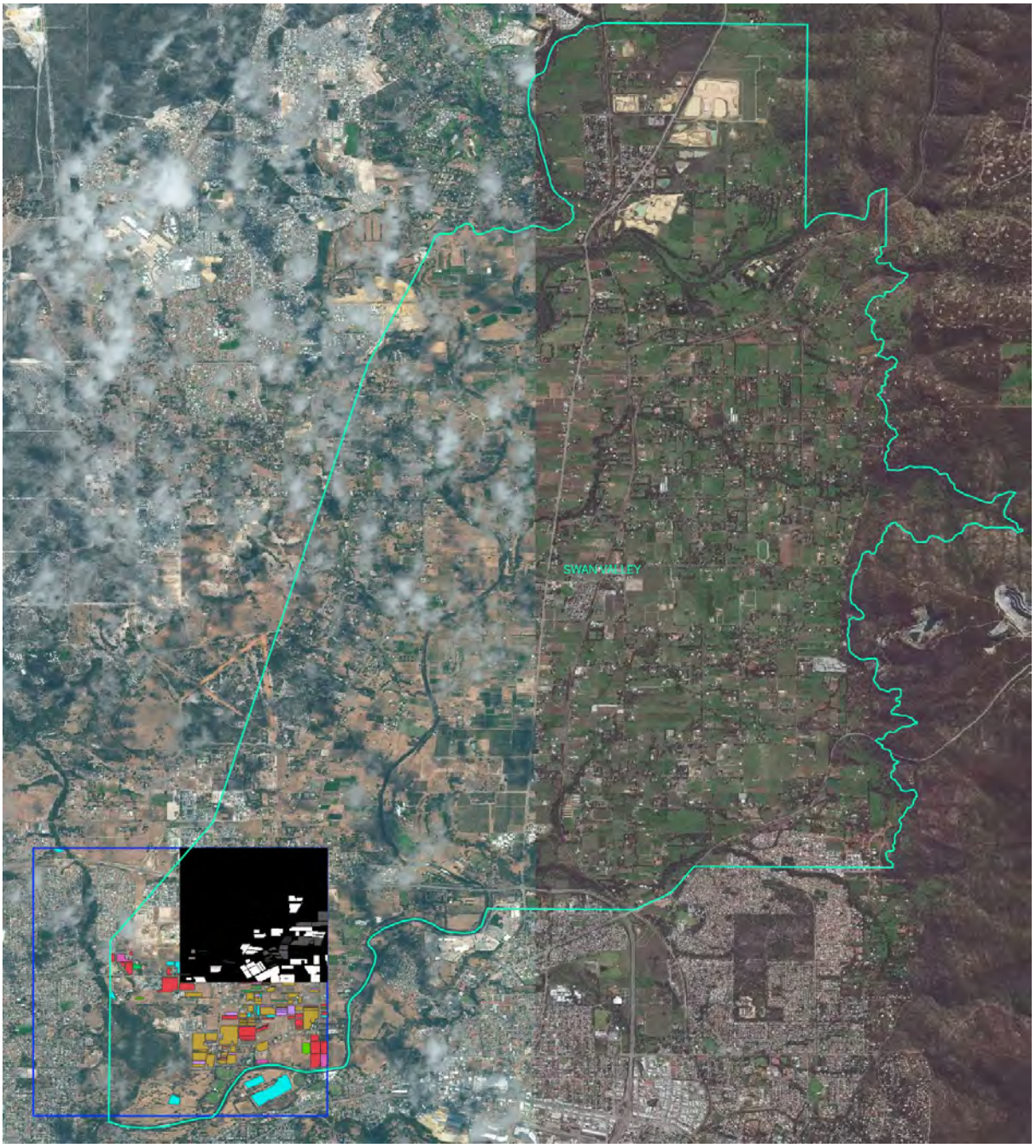


Figure B.1. The Swan Valley #1 NSQAR in the context of the Swan Valley GI. The entire area within the blue rectangle has been labelled (labels shown as multi-coloured shapes), but only the top right greyscale rectangle is used for Quality Assurance.

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Figure B.2. The Swan Valley #1 labels overlaid on the Panchromatic satellite imagery. These labels correspond with the ground truth as represented in the DPIRD dataset.

Date of imagery used for ground truth	2018-02-06T02:48:14.000Z
Total area (ha)	354.5
Truth area (ha)	6.6
Prediction area (ha)	6.9
Misses area (ha)	0.4
Mistakes area (ha)	0.6
Union area (ha)	7.2
Intersection area (ha)	6.3
Recall	94.42 %
Precision	91.66 %
Category accuracy	99.74 %
Area accuracy	96.74 %
Jaccard	86.95 %
False positive rate (/m^2)	0.0016

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3.3 Mount Barker



Figure C.1. The Mount Barker NSQAR in the context of the Mount Barker GI. The entire area within the blue rectangle has been labelled (labels shown as multi-coloured shapes), but only the top left greyscale rectangle is used for Quality Assurance.

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Figure C.2. The Mount Barker labels overlaid on the Panchromatic satellite imagery.

Date of imagery used for ground truth	2018-01-24T02:27:00.000Z
Total area (ha)	344.1
Truth area (ha)	38.6
Prediction area (ha)	37.6
Misses area (ha)	2.2
Mistakes area (ha)	1.2
Union area (ha)	39.8
Intersection area (ha)	36.4
Recall	94.35 %
Precision	96.84 %
Category accuracy	99.11 %
Area accuracy	97.43 %
Jaccard	91.53 %
False positive rate (/m^2)	0.0035

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3.4 Geographe



Figure D.1. The Geographe NSQAR in the context of the Geographe GI. The entire area within the blue rectangle has been labelled (labels shown as multi-coloured shapes), but only the top left greyscale rectangle is used for Quality Assurance.

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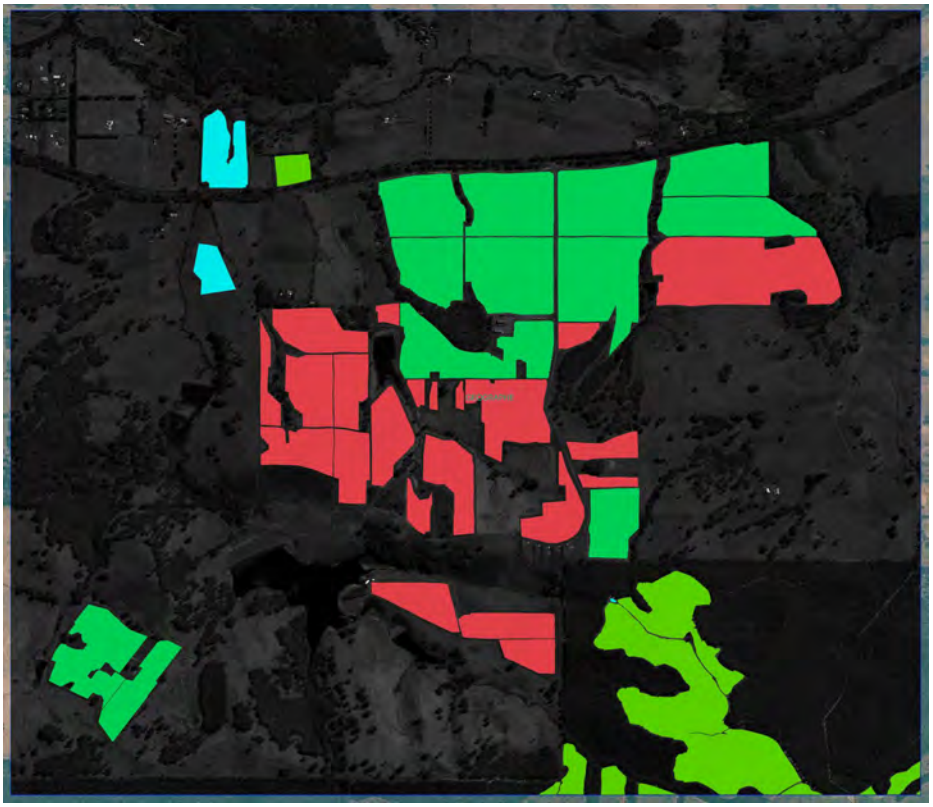


Figure D.2. The Geographe labels overlaid on the Panchromatic satellite imagery.

Date of imagery used for ground truth	2016-03-09T02:22:14.748Z
Total area (ha)	340.2
Truth area (ha)	40.9
Prediction area (ha)	40.6
Misses area (ha)	1.4
Mistakes area (ha)	1.0
Union area (ha)	41.9
Intersection area (ha)	39.6
Recall	96.66 %
Precision	97.52 %
Category accuracy	99.35 %
Area accuracy	99.27 %
Jaccard	94.35 %
False positive rate (/m^2)	0.0030

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3.5 Swan Valley #2

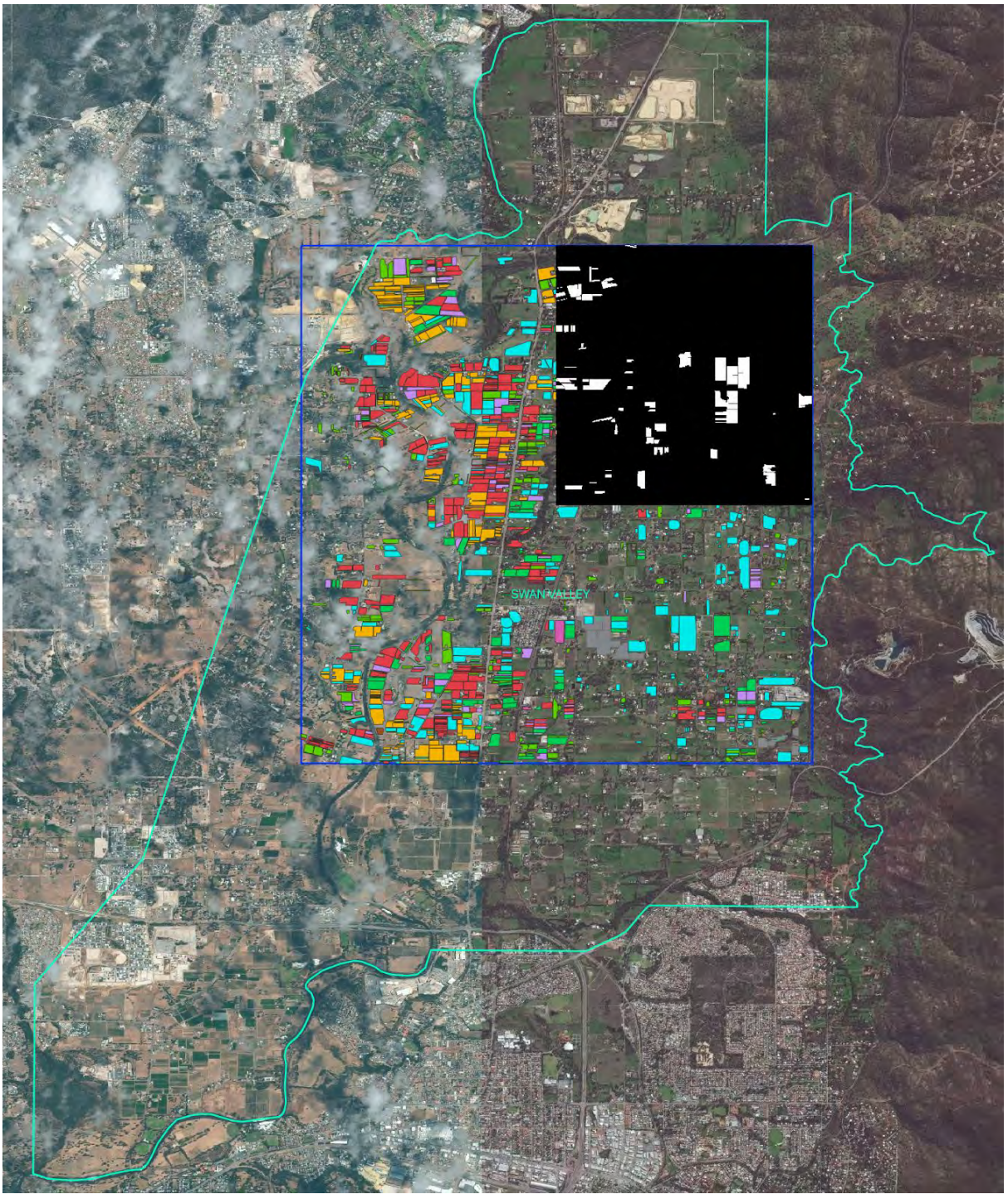


Figure E.1. The Swan Valley #2 NSQAR in the context of the Swan Valley GI. The entire area within the blue rectangle has been labelled (labels shown as multi-coloured shapes), but only the top right greyscale rectangle is used for Quality Assurance.

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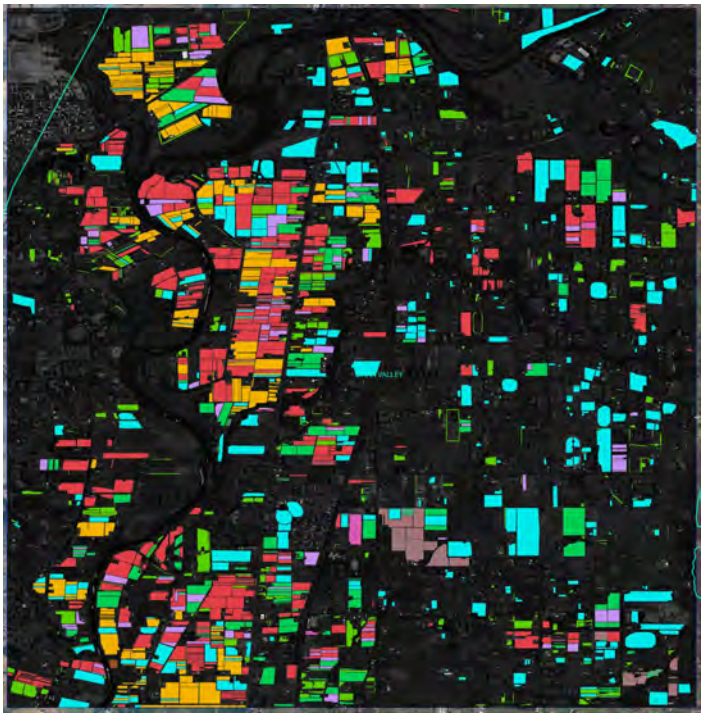


Figure E.2. The Swan Valley #2 labels overlaid on the Panchromatic satellite imagery. These labels correspond with the ground truth as represented in the DPIRD dataset.

Date of imagery used for ground truth	2018-02-06T02:48:14.000Z
Total area (ha)	1082.3
Truth area (ha)	55.5
Prediction area (ha)	49.5
Misses area (ha)	10.4
Mistakes area (ha)	4.1
Union area (ha)	59.7
Intersection area (ha)	45.2
Recall	81.23 %
Precision	91.64 %
Category accuracy	98.72 %
Area accuracy	88.92 %
Jaccard	75.63 %
False positive rate (/m^2)	0.0038

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4. Quality Assurance in Tasmania

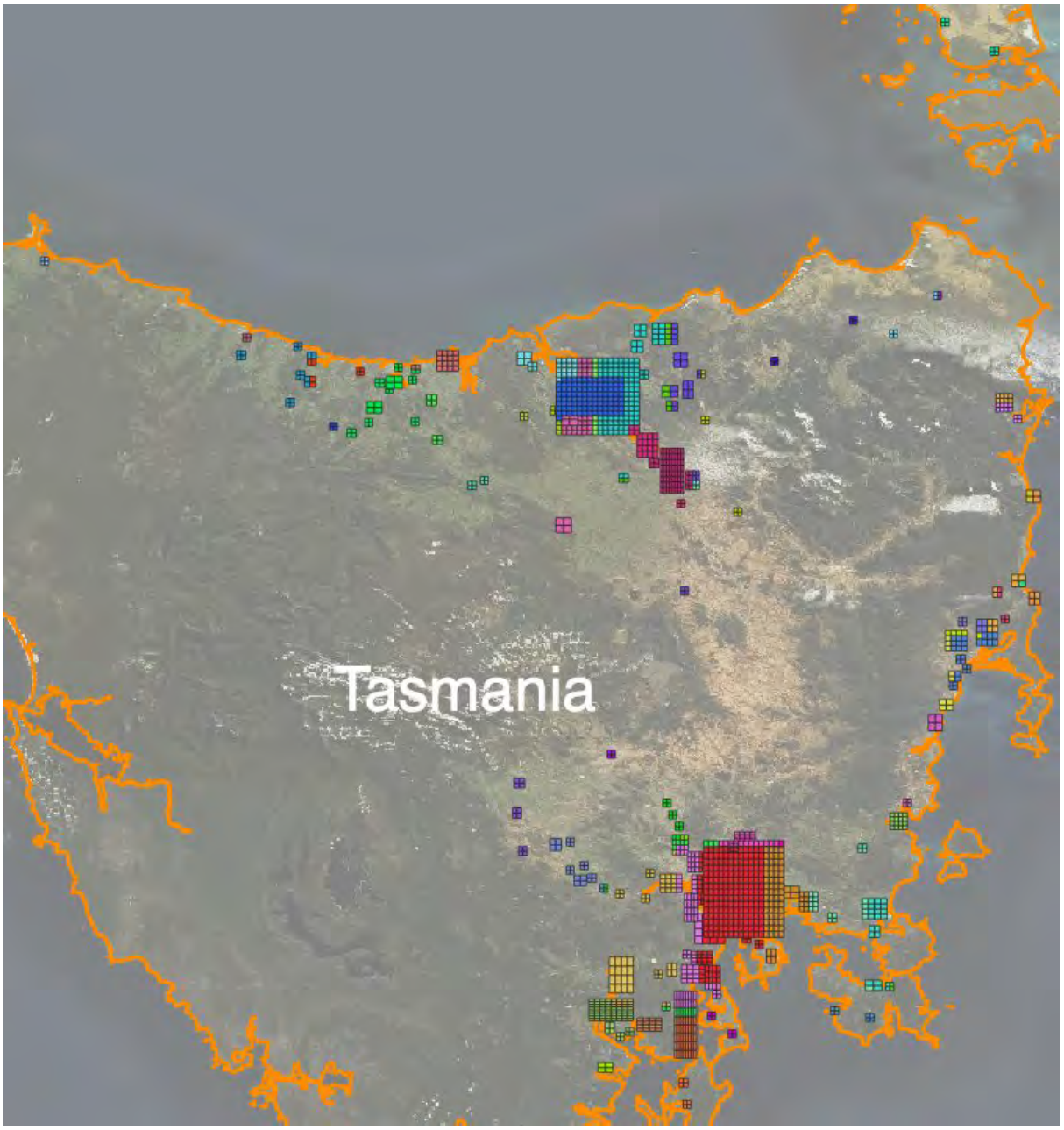


Fig 3: A visualisation of the AOIs in Tasmania that were scanned by GAIA. The different colours represent different satellite images that were used to scan each AOI.

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Figure F.1. The Tasmania North and Tasmania South NSQARs in the context of Tasmania. The entire areas within the coloured rectangles has been labelled (details shown in Figures F.2 and F.3), and the entire areas are used for Quality Assurance to maintain consistency with earlier reporting.

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4.1 Tasmania North

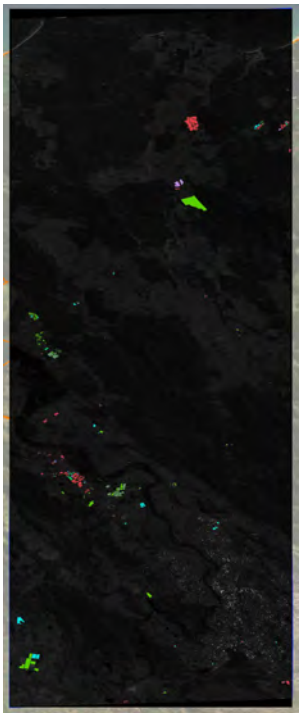


Figure F.2. Tasmania North labels overlaid on the Panchromatic satellite imagery.

Date of imagery used for ground truth	2017-02-14T00:23:00.539Z
Total area (ha)	109242.4
Truth area (ha)	219.6
Prediction area (ha)	229.7
Misses area (ha)	20.9
Mistakes area (ha)	30.9
Union area (ha)	250.6
Intersection area (ha)	198.8
Recall	90.48 %
Precision	86.55 %
Category accuracy	99.95 %
Area accuracy	95.62 %
Jaccard	79.33 %
False positive rate (/m^2)	0.00028

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4.2 Tasmania South

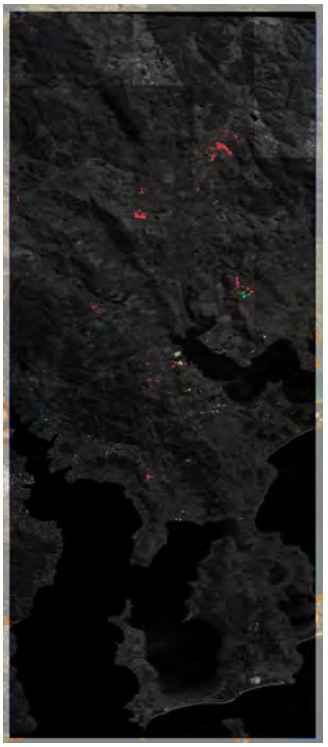


Figure F.3. Tasmania South labels overlaid on the Panchromatic satellite imagery.

Date of imagery used for ground truth	2017-02-28T00:06:35.760Z
Total area (ha)	96188.9
Truth area (ha)	363.2
Prediction area (ha)	344.7
Misses area (ha)	56.7
Mistakes area (ha)	38.1
Union area (ha)	401.3
Intersection area (ha)	306.6
Recall	84.39 %
Precision	88.96 %
Category accuracy	99.90 %
Area accuracy	94.90 %
Jaccard	76.39 %
False positive rate (/m^2)	0.00040

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5. Quality Assurance in South Australia

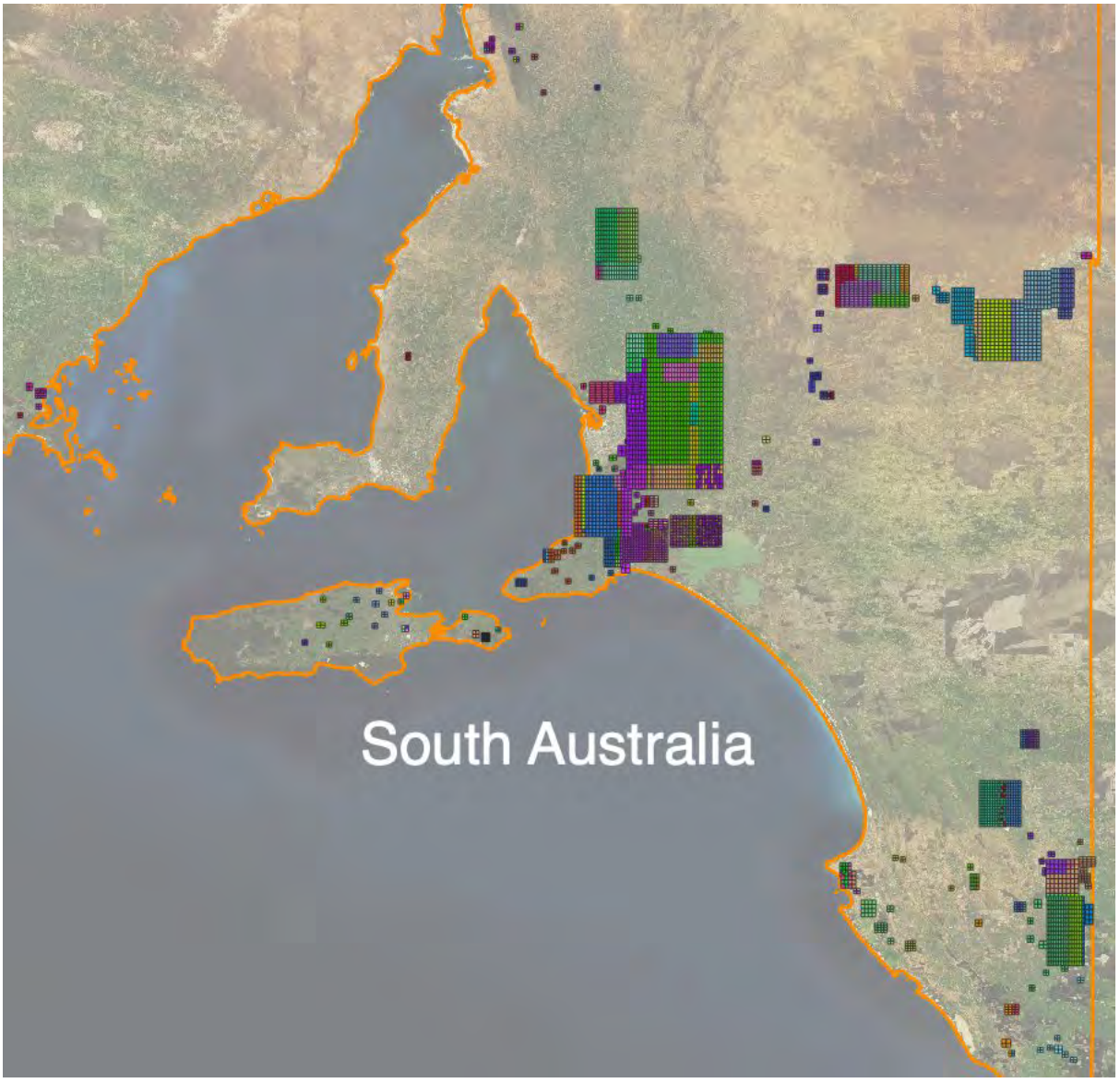


Fig 4: A visualisation of the AOIs in South Australia that were scanned by GAIA. The different colours represent different satellite images that were used to scan each AOI.

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5.1 Riverland



Figure G.1. The Riverland NSQAR in the context of the Riverland GI. The entire area within the blue rectangle has been labelled (labels shown as multi-coloured shapes), but only the top left greyscale rectangle is used for Quality Assurance.

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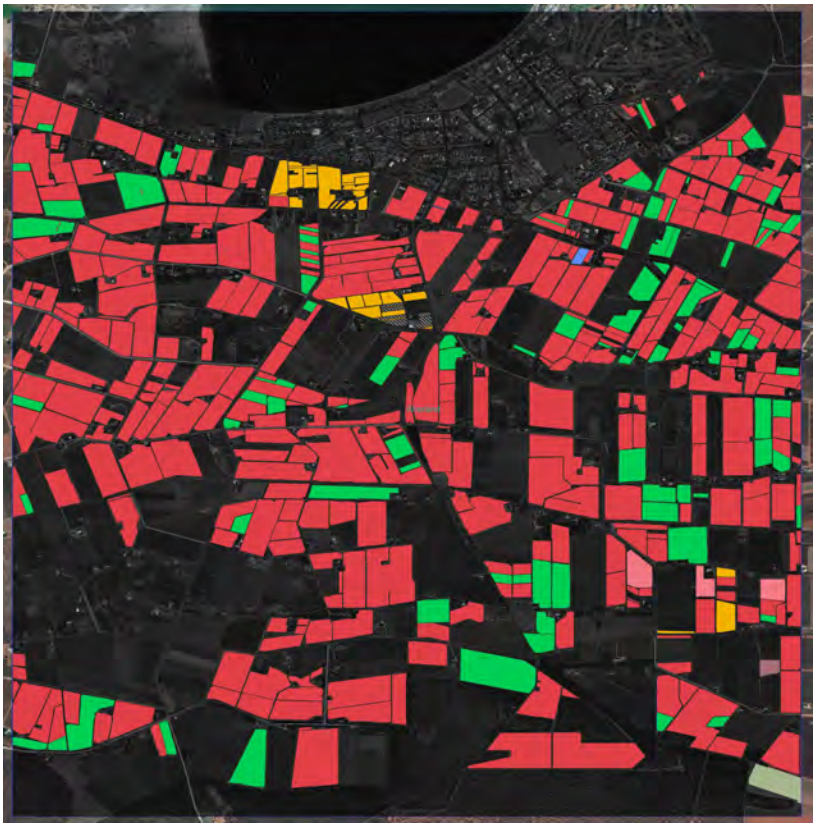


Figure G.2. Riverland labels overlaid on the Panchromatic satellite imagery.

Date of imagery used for ground truth	2014-01-15T01:02:35.127Z
Total area (ha)	729.3
Truth area (ha)	245.2
Prediction area (ha)	235.3
Misses area (ha)	14.8
Mistakes area (ha)	4.8
Union area (ha)	250.0
Intersection area (ha)	230.5
Recall	93.96
Precision	97.97
Category accuracy	97.85
Area accuracy	95.96
Jaccard	92.17
False positive rate (/m^2)	0.0065

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5.2 Clare Valley



Figure H.1. The Clare Valley NSQAR in the context of the Clare Valley GI. The entire area within the blue rectangle has been labelled (labels shown as multi-coloured shapes), but only the top left greyscale rectangle is used for Quality Assurance.

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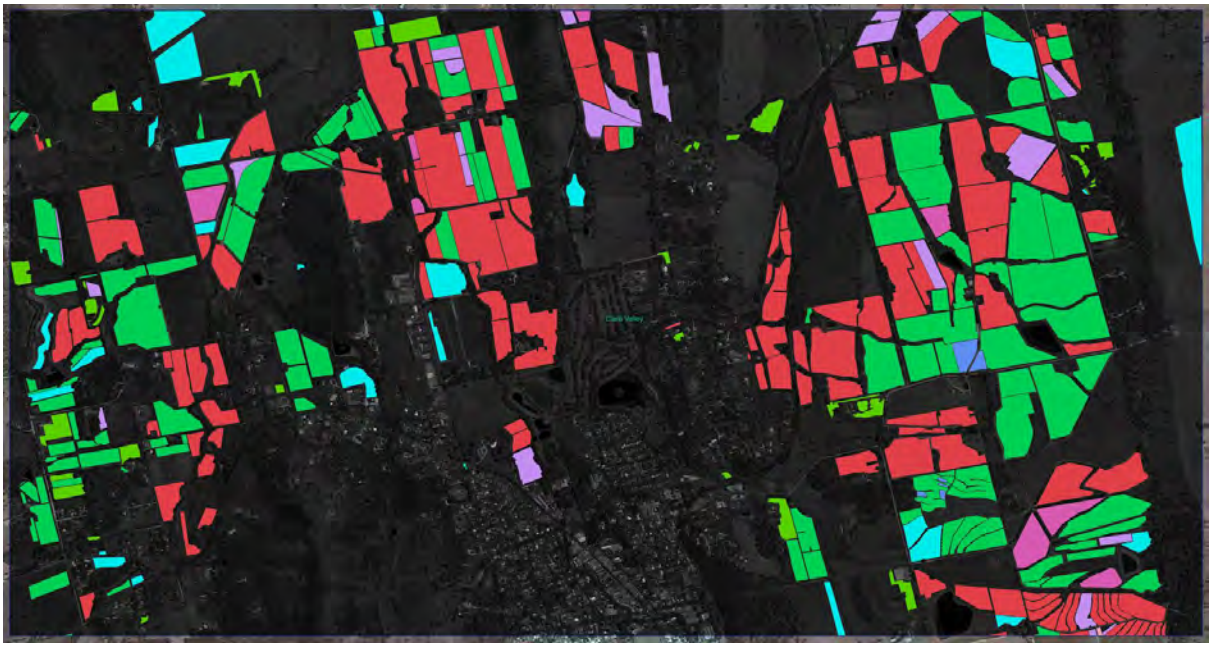


Figure H.2. Clare Valley labels overlaid on the Panchromatic satellite imagery.

Date of imagery used for ground truth	2016-02-08T00:47:01.404Z
Total area (ha)	725.4
Truth area (ha)	180.2
Prediction area (ha)	175.7
Misses area (ha)	15.5
Mistakes area (ha)	10.6
Union area (ha)	193.4
Intersection area (ha)	165.1
Recall	91.44 %
Precision	93.99 %
Category accuracy	97.12 %
Area accuracy	97.47 %
Jaccard	86.39 %
False positive rate (/m^2)	0.0146

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5.3 Wrattonbully

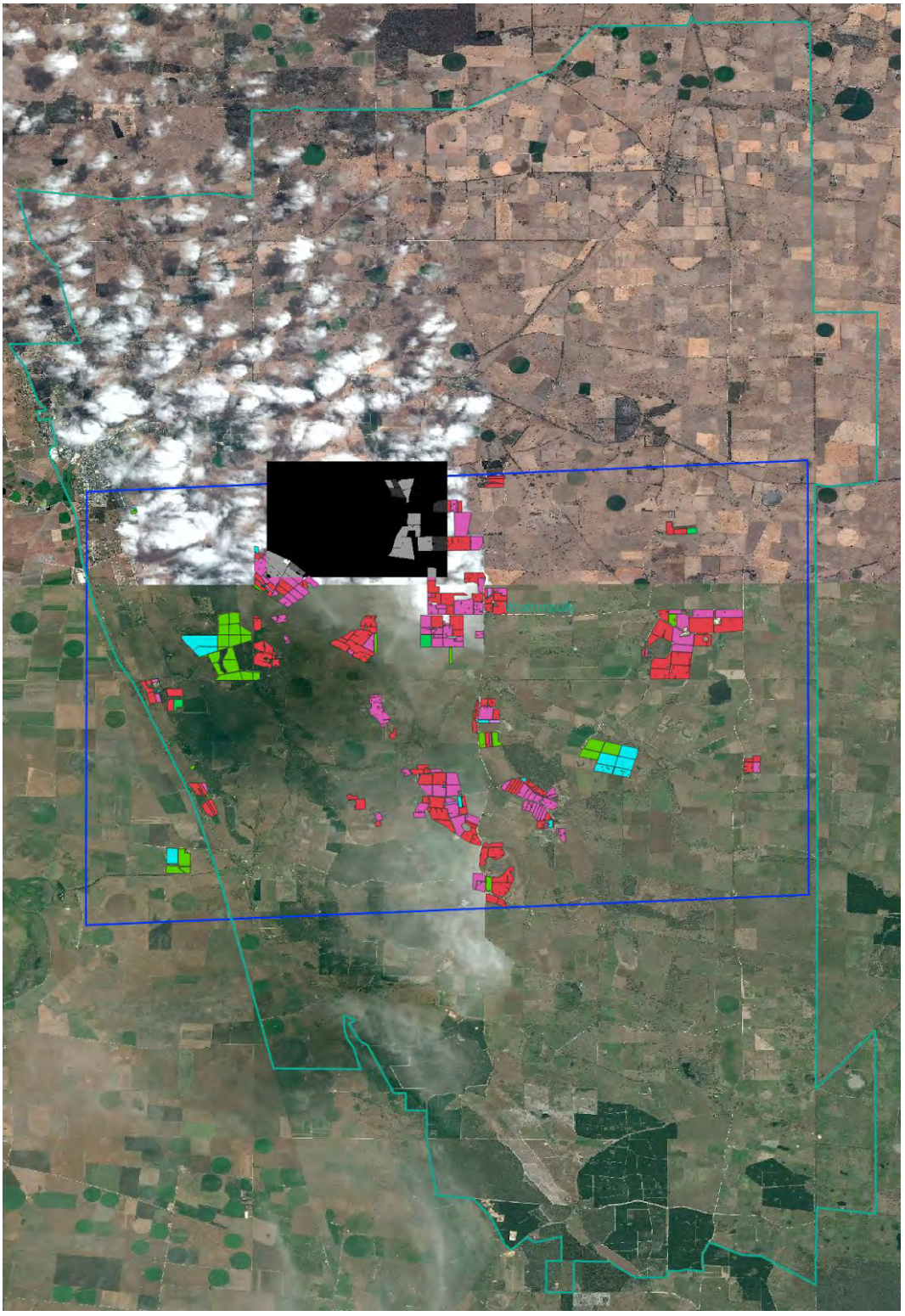


Figure I.1. The Wrattonbully NSQAR in the context of the Wrattonbully GI. The entire area within the blue rectangle has been labelled (labels shown as multi-coloured shapes), but only the greyscale rectangle is used for Quality Assurance to maintain consistency with earlier reporting.

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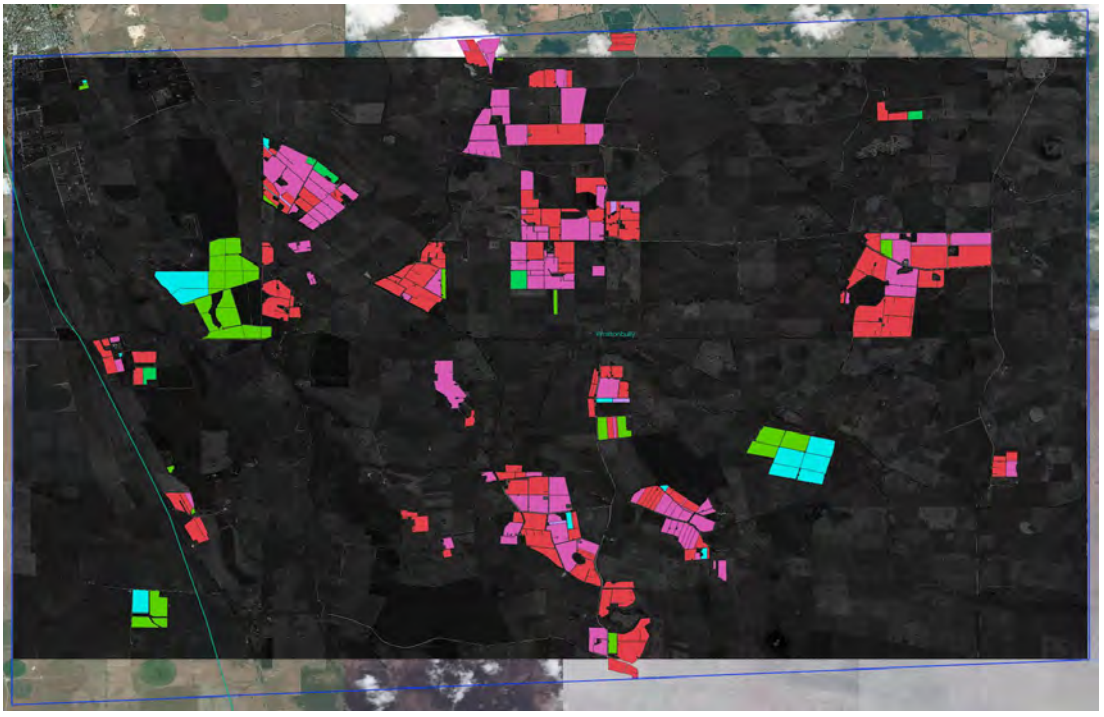


Figure I.2. Wrattonbully labels overlaid on the Panchromatic satellite imagery. The skewed bounds (dark blue) shows the bounds of the entire capture that was taken by the satellite WorldView 2: most other NSQARs are small extractions, with the exception of Margaret River, Tasmania North and South, Barossa Valley and Adelaide Hills.

Date of imagery used for ground truth	2017-11-22T01:02:28.000Z
Total area (ha)	1810.4
Truth area (ha)	284.4
Prediction area (ha)	282.3
Misses area (ha)	11.7
Mistakes area (ha)	8.6
Union area (ha)	293.6
Intersection area (ha)	273.6
Recall	95.89 %
Precision	96.94 %
Category accuracy	98.96 %
Area accuracy	99.29 %
Jaccard	93.07 %
False positive rate (/m^2)	0.0048

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5.4 Barossa Valley

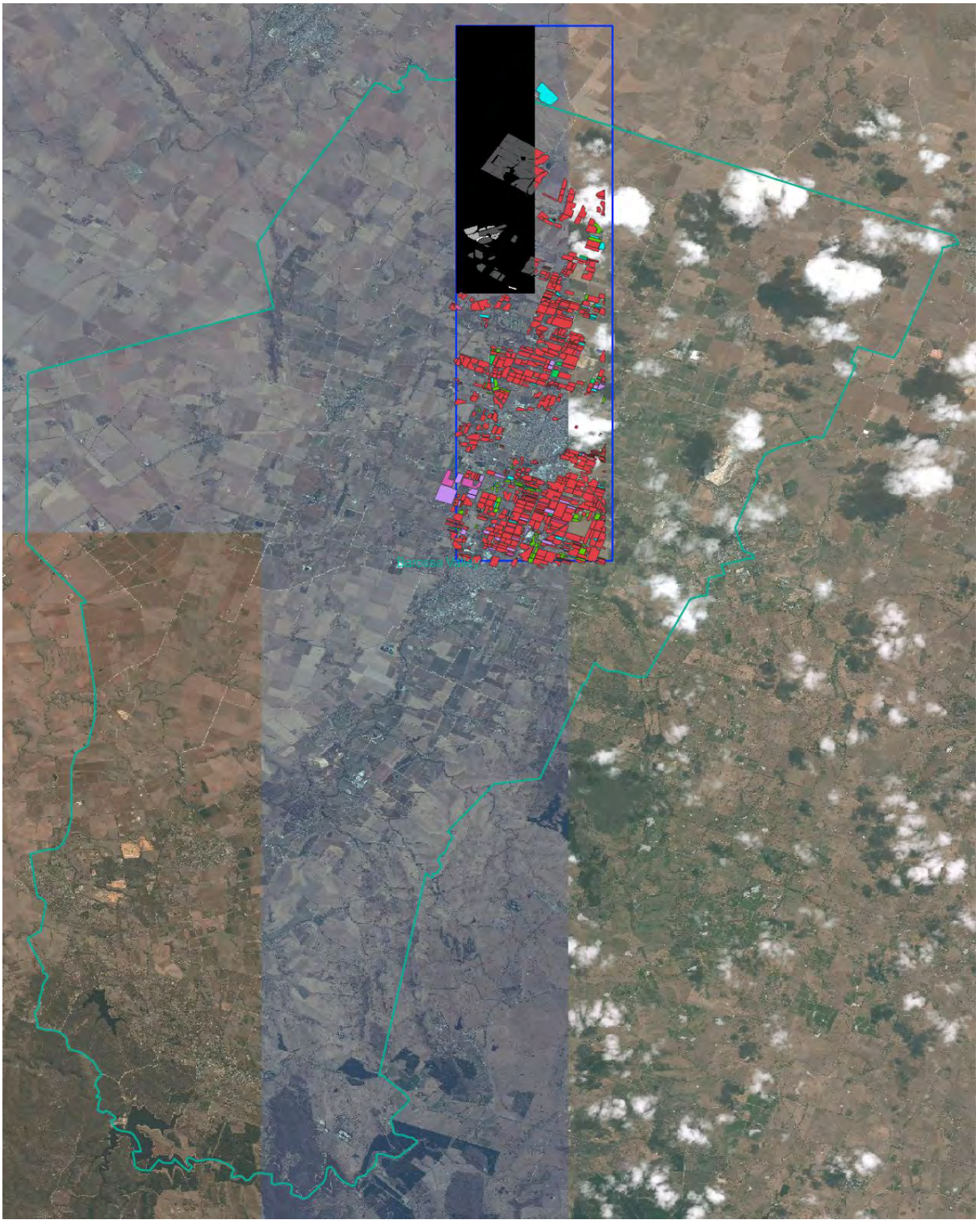


Figure J.1. The Barossa Valley NSQAR in the context of the Barossa Valley GI. The entire area within the blue rectangle has been labelled (labels shown as multi-coloured shapes), but only the top left greyscale rectangle is used for Quality Assurance.

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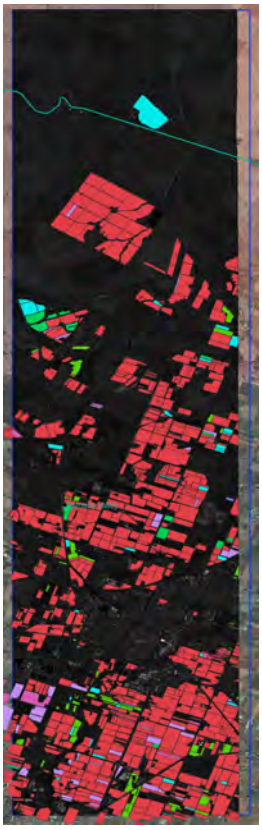


Figure J.2. Barossa Valley labels overlaid on the Panchromatic satellite imagery.

Date of imagery used for ground truth	2017-02-10T01:08:22.132Z
Total area (ha)	2188.7
Truth area (ha)	254.8
Prediction area (ha)	230.6
Misses area (ha)	42.7
Mistakes area (ha)	17.2
Union area (ha)	272.0
Intersection area (ha)	213.4
Recall	83.31 %
Precision	92.54 %
Category accuracy	97.51 %
Area accuracy	90.51 %
Jaccard	78.07 %
False positive rate (/m^2)	0.0079

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5.5 Adelaide Hills

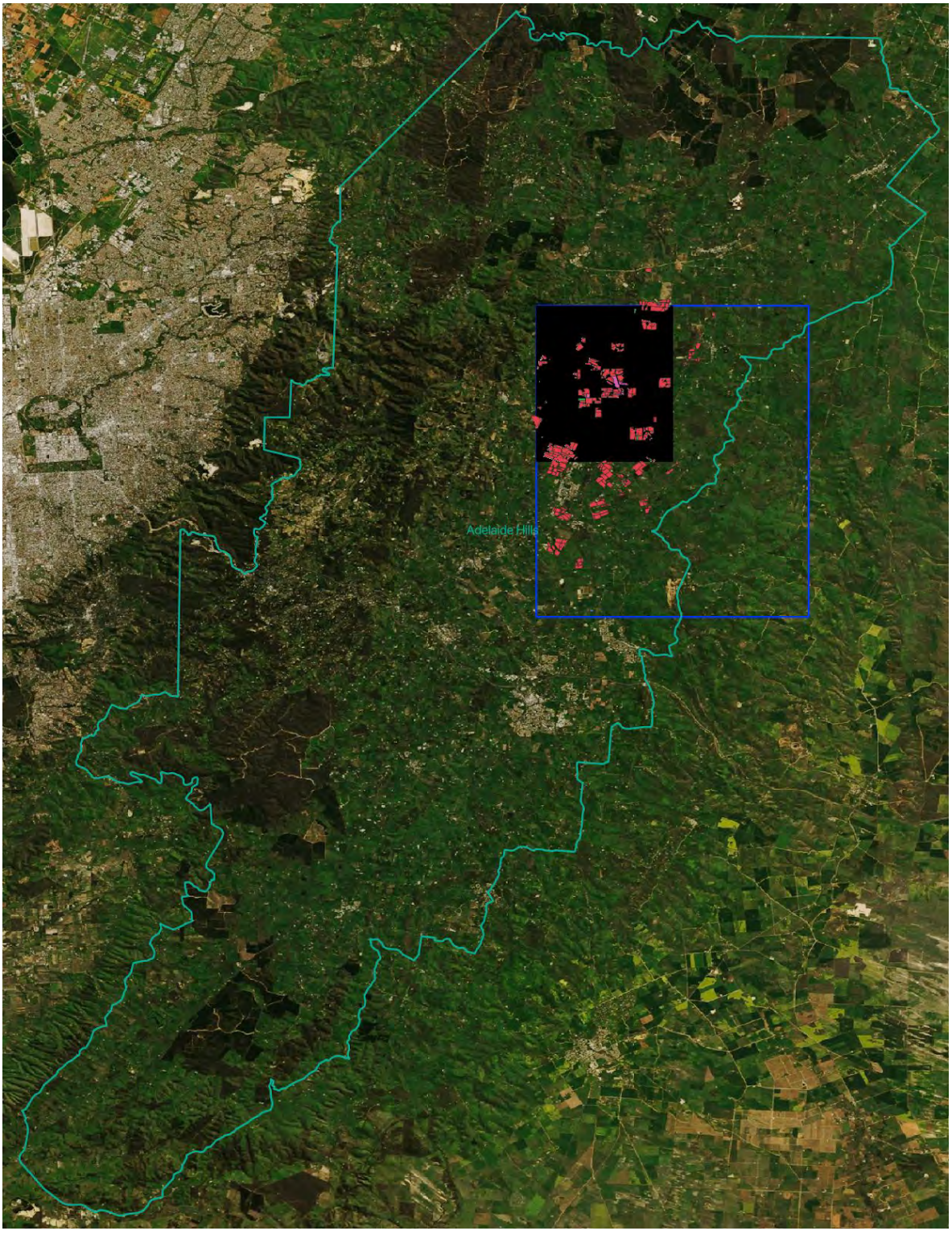


Figure K.1. The Adelaide Hills NSQAR in the context of the Adelaide Hills GI. The entire area within the blue rectangle has been labelled (labels shown as multi-coloured shapes), but only the top left greyscale rectangle is used for Quality Assurance.

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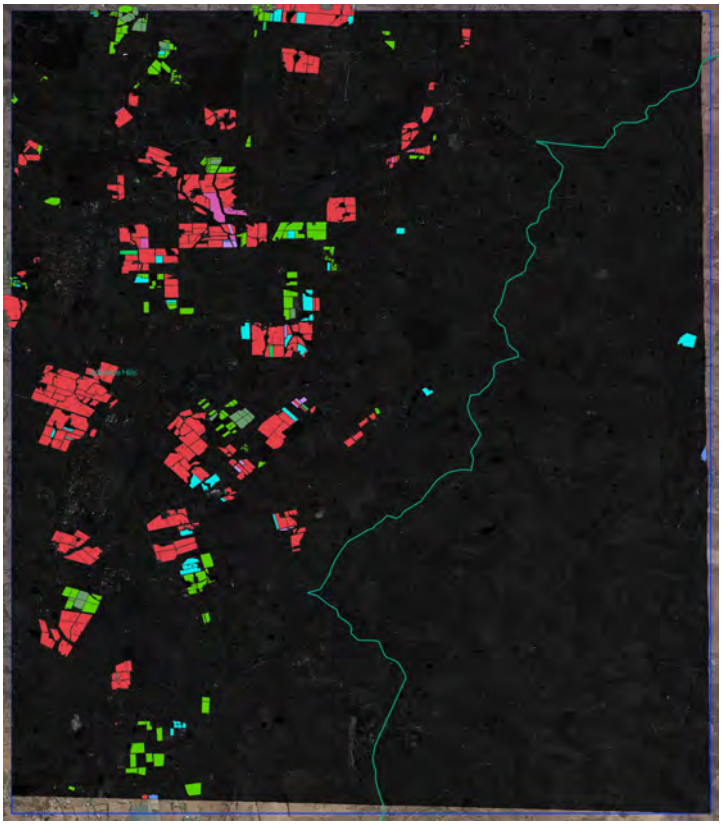


Figure K.2. Adelaide Hills labels overlaid on the Panchromatic satellite imagery.

Date of imagery used for ground truth	2017-02-10T01:08:22.132Z
Total area (ha)	6507.0
Truth area (ha)	579.7
Prediction area (ha)	590.3
Misses area (ha)	33.1
Mistakes area (ha)	40.4
Union area (ha)	620.4
Intersection area (ha)	549.7
Recall	94.32 %
Precision	93.15 %
Category accuracy	98.96 %
Area accuracy	98.20 %
Jaccard	88.19 %
False positive rate (/m^2)	0.0062

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5.6 Coonawarra

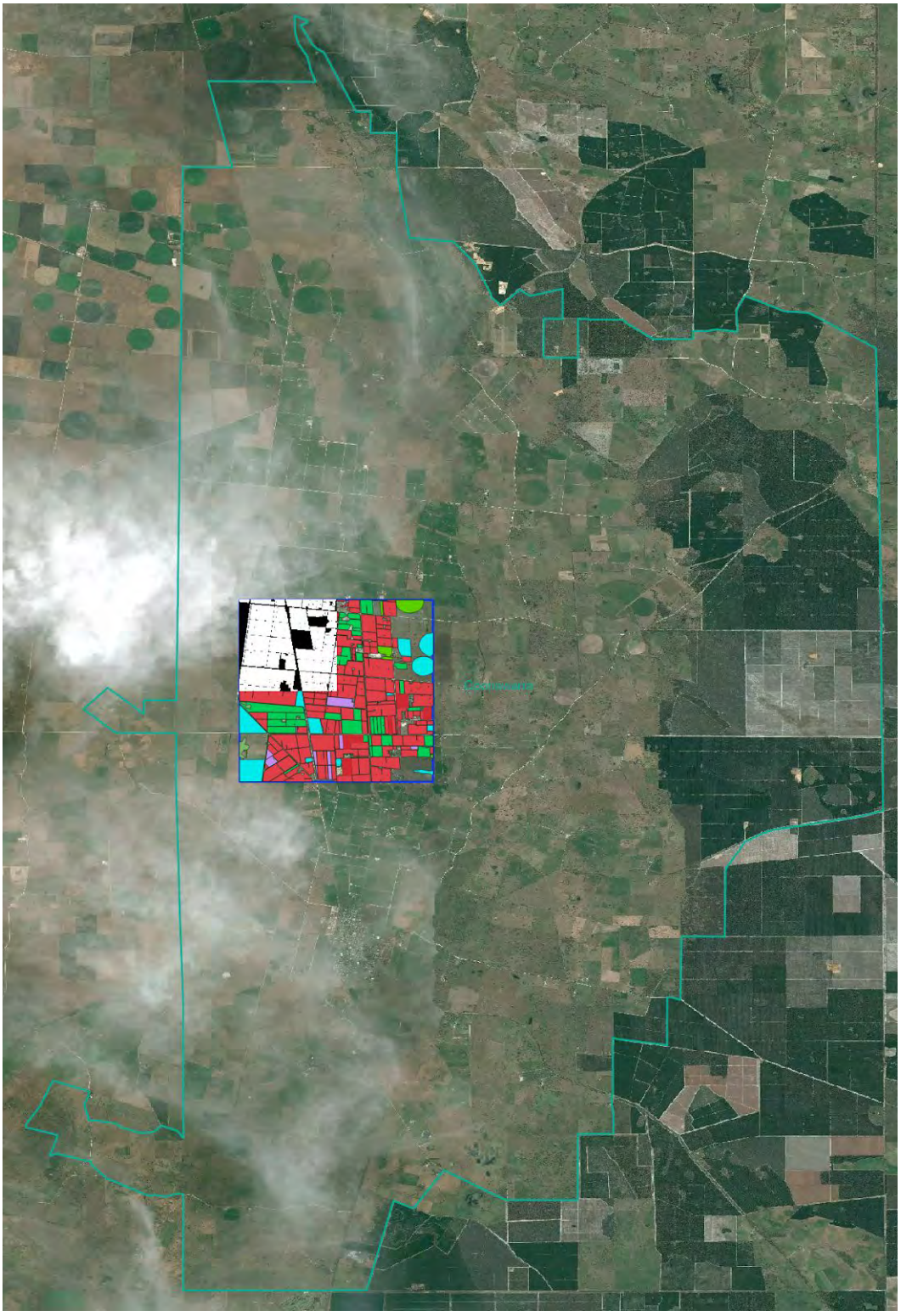


Figure L.1. The Coonawarra NSQAR in the context of the Coonawarra GI. The entire area within the blue rectangle has been labelled (labels shown as multi-coloured shapes), but only the top left greyscale rectangle is used for Quality Assurance.

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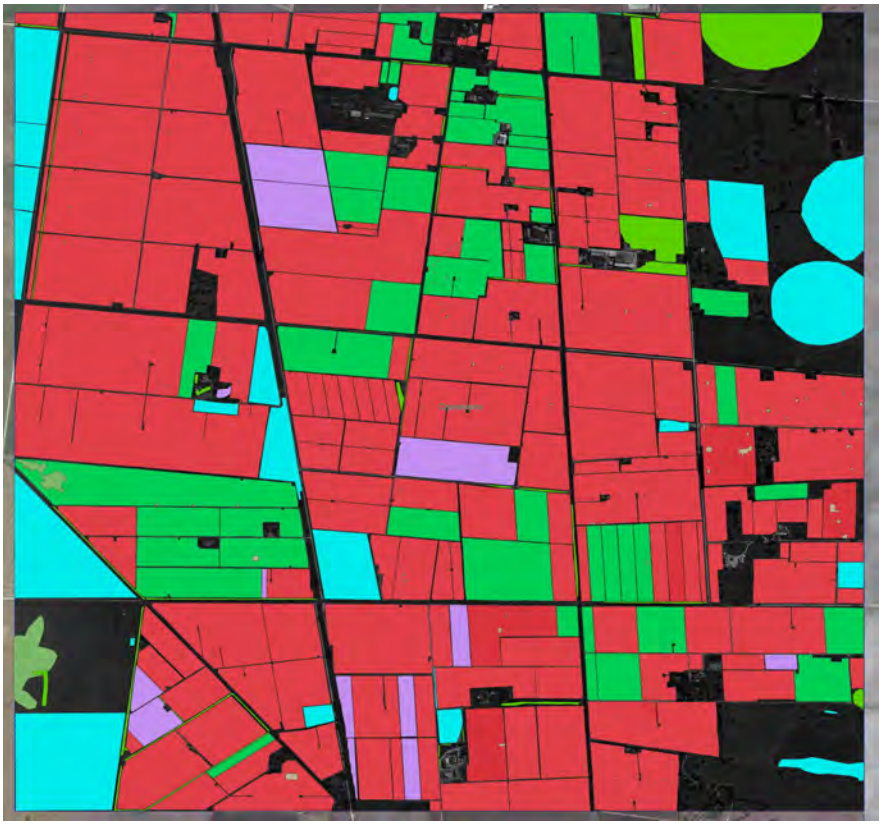


Figure L.2. Coonawarra labels overlaid on the Panchromatic satellite imagery.

Date of imagery used for ground truth	2016-03-17T00:47:50.808Z
Total area (ha)	571.3
Truth area (ha)	442.5
Prediction area (ha)	404.7
Misses area (ha)	60.8
Mistakes area (ha)	21.9
Union area (ha)	464.6
Intersection area (ha)	382.6
Recall	86.29 %
Precision	94.57 %
Category accuracy	91.36 %
Area accuracy	91.45 %
Jaccard	82.22 %
False positive rate (/m^2)	0.038

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5.7 McLaren Vale

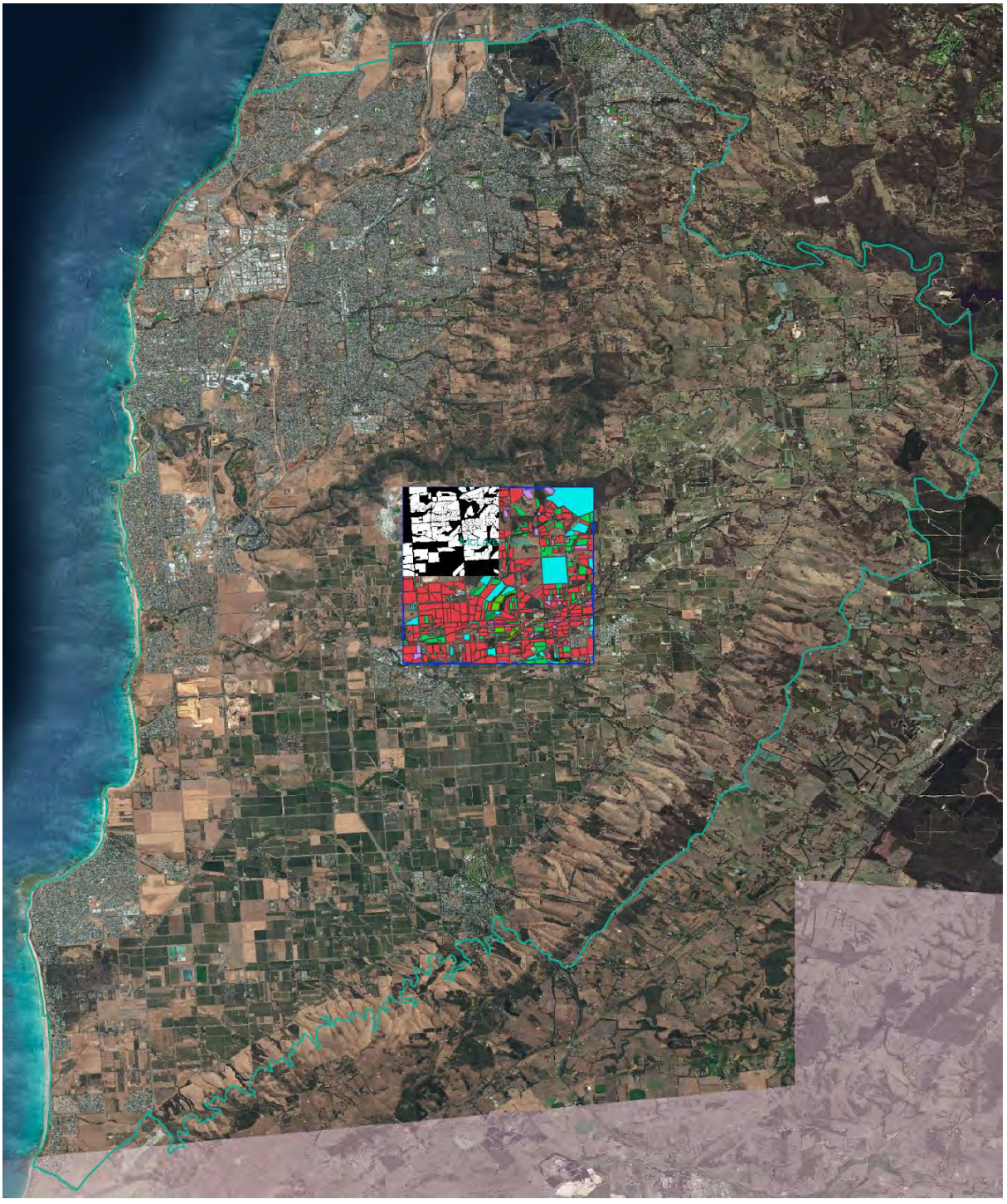


Figure M.1. The McLaren Vale NSQAR in the context of the McLaren Vale GI. The entire area within the blue rectangle has been labelled (labels shown as multi-coloured shapes), but only the top left greyscale rectangle is used for Quality Assurance.

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Figure M.2. McLaren Vale labels overlaid on the Panchromatic satellite imagery.

Date of imagery used for ground truth	2017-01-06T01:00:55.382Z
Total area (ha)	557.8
Truth area (ha)	272.9
Prediction area (ha)	274.2
Misses area (ha)	16.6
Mistakes area (ha)	16.7
Union area (ha)	289.9
Intersection area (ha)	257.1
Recall	93.92 %
Precision	93.89 %
Category accuracy	95.77 %
Area accuracy	99.55 %
Jaccard	88.51 %
False positive rate (/m^2)	0.029

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6. Quality Assurance in Victoria

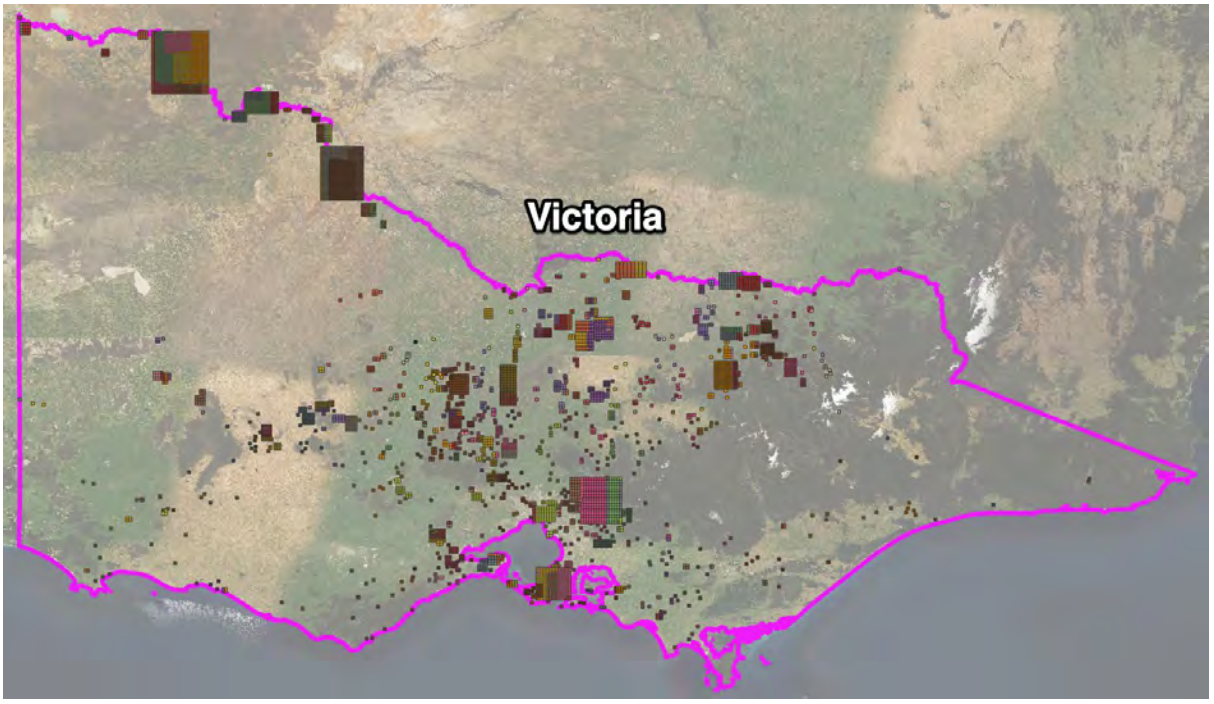


Fig 5: A visualisation of the AOIs in Victoria that were scanned by GAIA. The different colours represent different satellite images that were used to scan each AOI.

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6.1 Murray Darling VIC #1



Figure N.1. The Murray Darling #1 NSQAR in the context of the Murray Darling GI (VIC). The entire area within the blue rectangle has been labelled (labels shown as multi-coloured shapes), but only the top left greyscale rectangle is used for Quality Assurance.

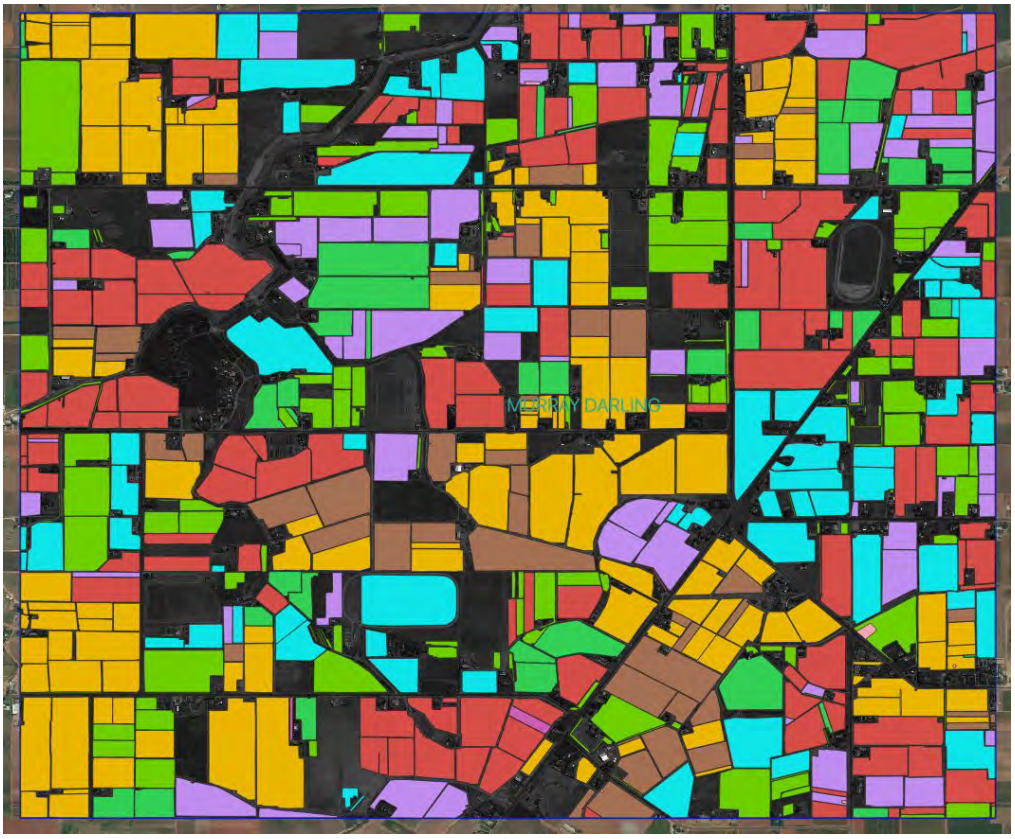


Figure N.2. Murray Darling #1 labels overlaid on the Panchromatic satellite imagery. These labels correspond with the ground truth as represented in the SunRISE Mapping dataset.

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Date of imagery used for ground truth	2018-09-07T00:38:29.000Z
Total area (ha)	413.4
Truth area (ha)	137.4
Prediction area (ha)	140.6
Misses area (ha)	4.9
Mistakes area (ha)	8.1
Union area (ha)	145.5
Intersection area (ha)	132.5
Recall	96.44 %
Precision	94.27 %
Category accuracy	97.53 %
Area accuracy	97.75 %
Jaccard	91.10 %
False positive rate (/m^2)	0.019

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6.2 King Valley

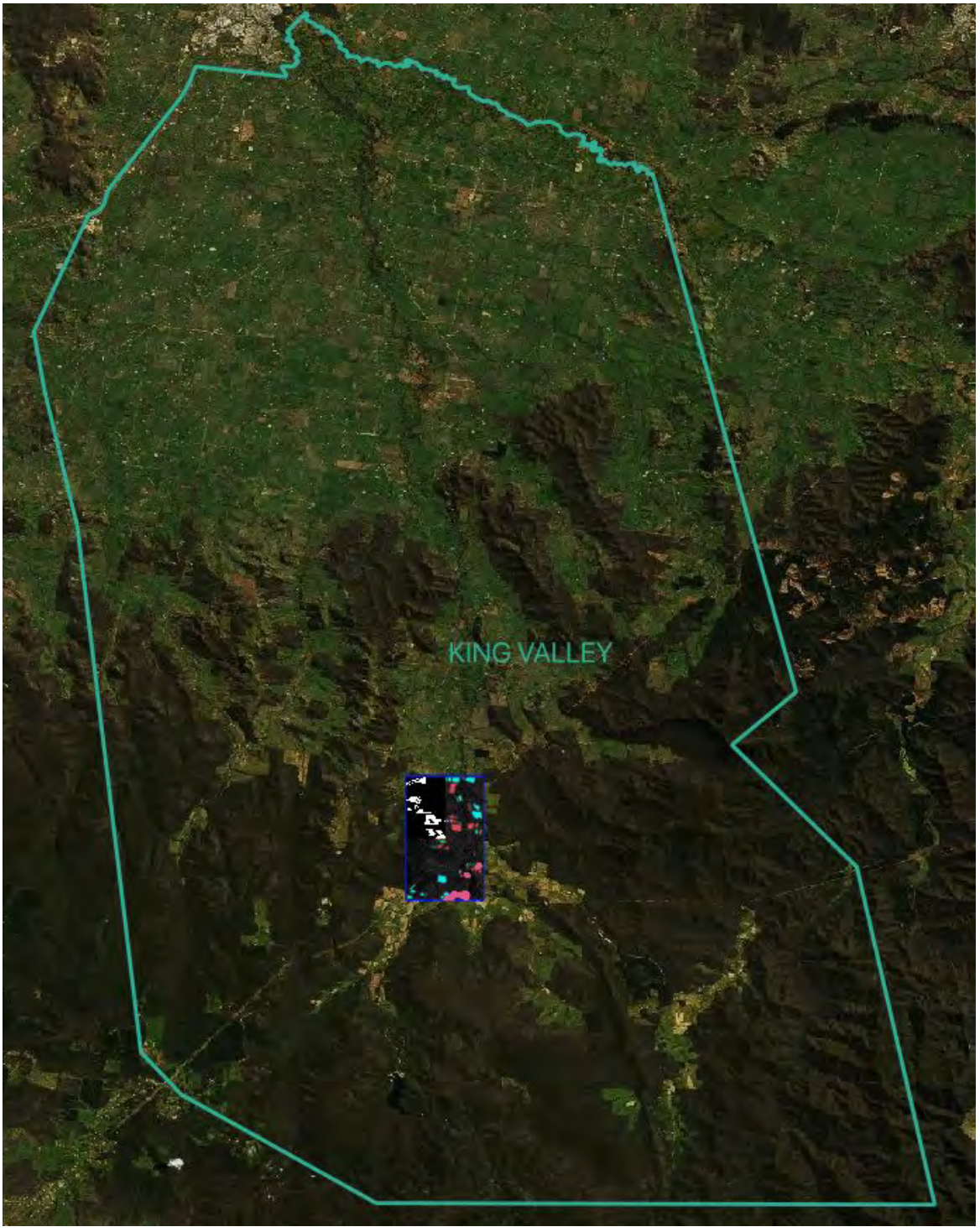


Figure O.1. The King Valley NSQAR in the context of the King Valley GI. The entire area within the blue rectangle has been labelled (labels shown as multi-coloured shapes), but only the top left greyscale rectangle is used for Quality Assurance.

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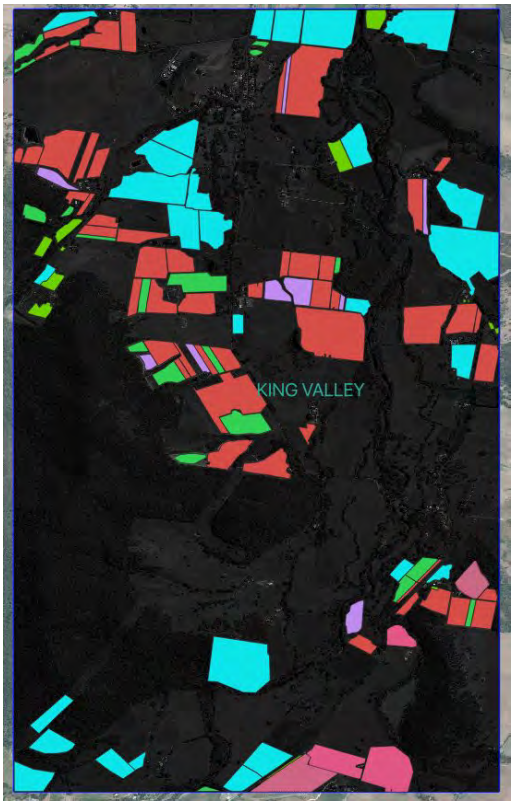


Figure O.2. King Valley labels overlaid on the Panchromatic satellite imagery.

Date of imagery used for ground truth	2015-02-02T00:34:20.060Z
Total area (ha)	630.7
Truth area (ha)	99.9
Prediction area (ha)	96.9
Misses area (ha)	5.6
Mistakes area (ha)	2.56
Union area (ha)	102.5
Intersection area (ha)	94.3
Recall	94.39 %
Precision	97.33 %
Category accuracy	98.86 %
Area accuracy	97.00 %
Jaccard	92.00 %
False positive rate (/m^2)	0.0041

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6.3 Goulburn Valley

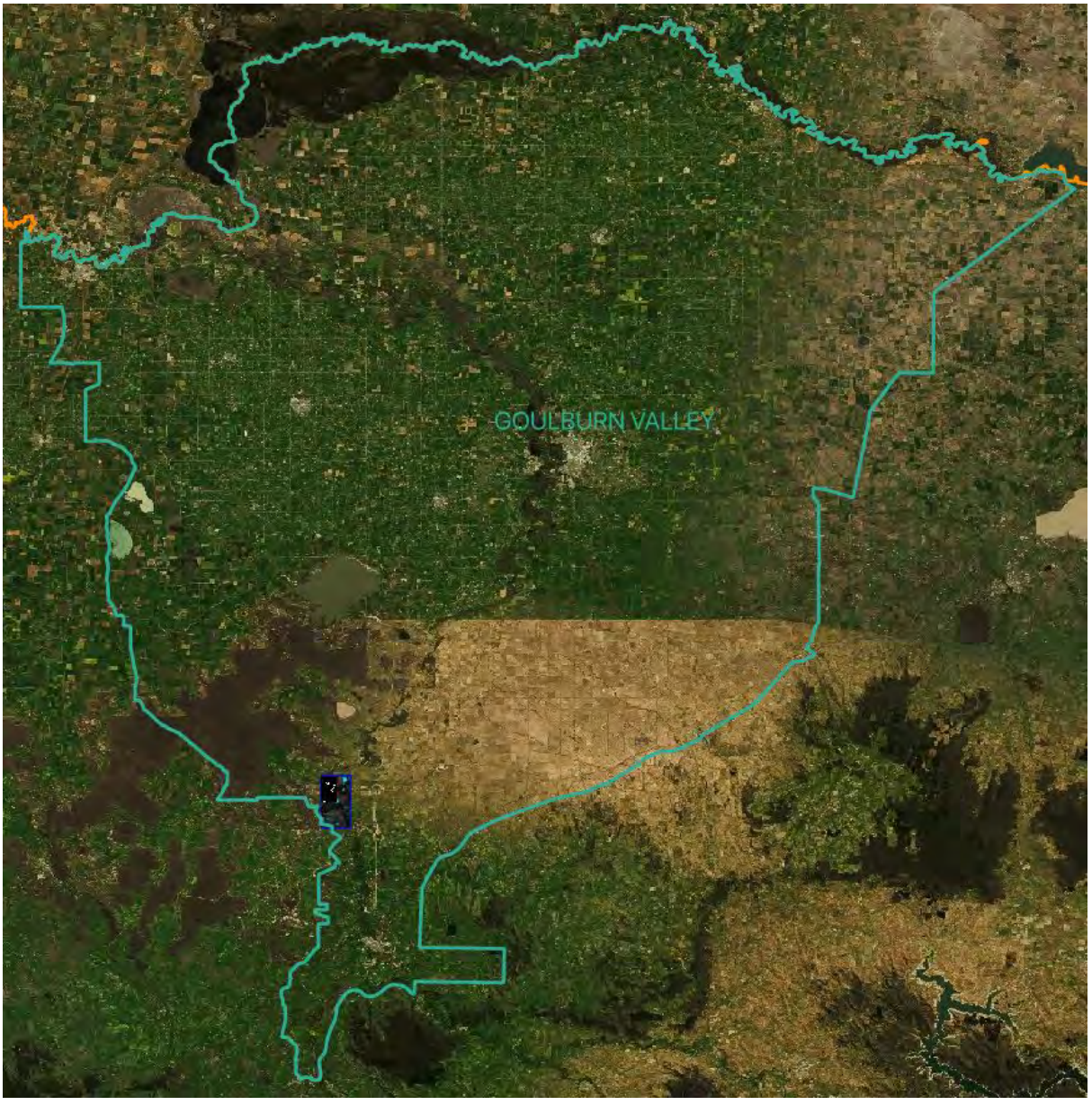


Figure P.1. The Goulburn Valley NSQAR in the context of the Goulburn Valley GI. The entire area within the blue rectangle has been labelled (labels shown as multi-coloured shapes), but only the top left greyscale rectangle is used for Quality Assurance.

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Figure P.2. Goulburn Valley labels overlaid on the Panchromatic satellite imagery.

Date of imagery used for ground truth	2018-04-02T00:48:09.000Z
Total area (ha)	634.8
Truth area (ha)	37.1
Prediction area (ha)	39.6
Misses area (ha)	3.0
Mistakes area (ha)	5.5
Union area (ha)	42.6
Intersection area (ha)	34.1
Recall	91.94 %
Precision	86.16 %
Category accuracy	98.74 %
Area accuracy	93.63 %
Jaccard	80.11 %
False positive rate (/m^2)	0.0087

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6.4 Yarra Valley



Figure Q.1. The Yarra Valley NSQAR in the context of the Yarra Valley GI. The entire area within the blue rectangle has been labelled (labels shown as multi-coloured shapes), but only the top left greyscale rectangle is used for Quality Assurance.

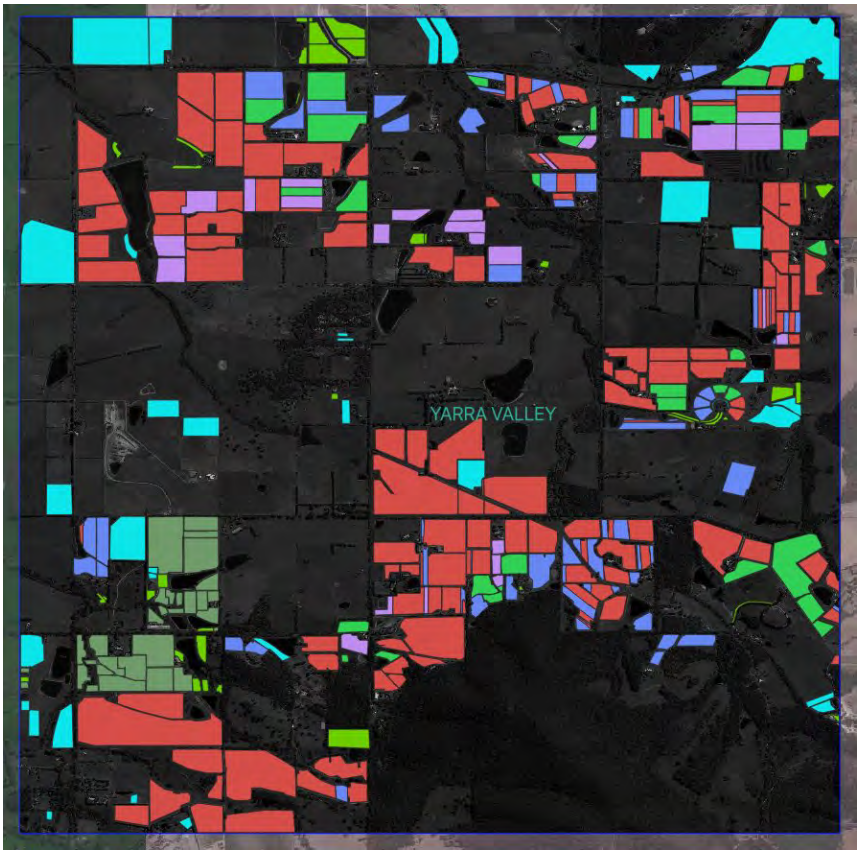


Figure Q.2. Goulburn Valley labels overlaid on the Panchromatic satellite imagery.

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Date of imagery used for ground truth	2017-03-02T00:31:05.911Z
Total area (ha)	637.4
Truth area (ha)	110.5
Prediction area (ha)	115.5
Misses area (ha)	5.8
Mistakes area (ha)	8.2
Union area (ha)	118.7
Intersection area (ha)	107.3
Recall	94.88 %
Precision	92.90 %
Category accuracy	98.15 %
Area accuracy	95.61 %
Jaccard	88.46 %
False positive rate (/m^2)	0.013

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6.5 Strathbogie Ranges



Figure R.1. The Strathbogie Ranges NSQAR in the context of the Strathbogie Ranges GI. The entire area within the blue rectangle has been labelled (labels shown as multi-coloured shapes), but only the top right greyscale rectangle is used for Quality Assurance.

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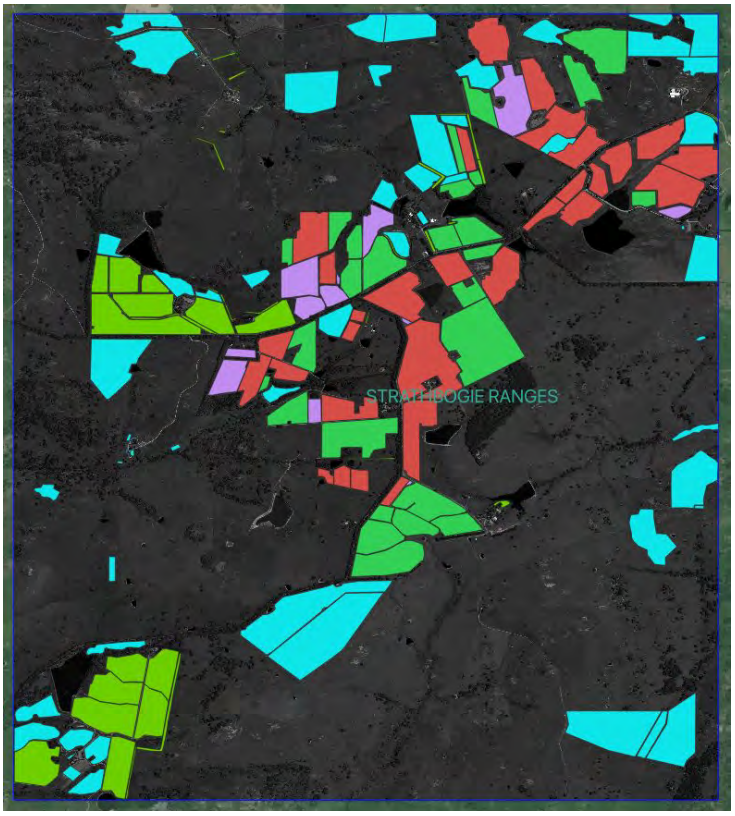


Figure R.2. Strathbogie Ranges labels overlaid on the Panchromatic satellite imagery.

Date of imagery used for ground truth	2016-11-19T00:33:01.540Z
Total area (ha)	706.3
Truth area (ha)	171.3
Prediction area (ha)	171.7
Misses area (ha)	11.0
Mistakes area (ha)	11.1
Union area (ha)	182.5
Intersection area (ha)	160.6
Recall	93.61 %
Precision	93.52 %
Category accuracy	97.45 %
Area accuracy	99.79 %
Jaccard	87.91 %
False positive rate (/m^2)	0.016

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6.6 Grampians



Figure S.1. The Grampians NSQAR in the context of the Grampians GI. The entire area within the blue rectangle has been labelled (labels shown as multi-coloured shapes), but only the bottom right greyscale rectangle is used for Quality Assurance.

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Figure S.2. Grampians labels overlaid on the Panchromatic satellite imagery.

Date of imagery used for ground truth	2014-02-11T01:08:40.583Z
Total area (ha)	689.6
Truth area (ha)	152.6
Prediction area (ha)	145.5
Misses area (ha)	10.3
Mistakes area (ha)	2.3
Union area (ha)	154.9
Intersection area (ha)	143.2
Recall	93.30 %
Precision	98.41 %
Category accuracy	98.51 %
Area accuracy	95.34 %
Jaccard	91.91 %
False positive rate (/m^2)	0.0034

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6.7 Gippsland



Figure T.1. The Gippsland NSQAR in the context of the Gippsland GI. The entire area within the blue rectangle has been labelled (labels shown as multi-coloured shapes), but only the top left greyscale rectangle is used for Quality Assurance.

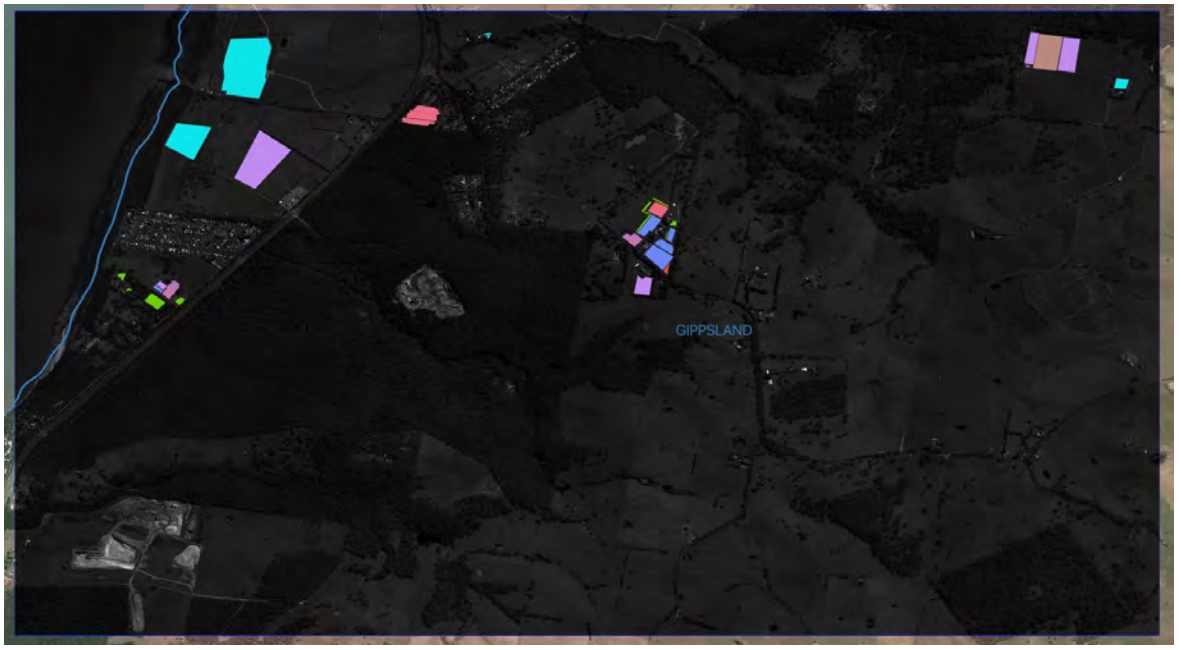


Figure T.2. Gippsland labels overlaid on the Panchromatic satellite imagery.

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Date of imagery used for ground truth	2017-02-22T00:27:29.001Z
Total area (ha)	2426.5
Truth area (ha)	9.2
Prediction area (ha)	8.7
Misses area (ha)	1.0
Mistakes area (ha)	0.3
Union area (ha)	9.5
Intersection area (ha)	8.4
Recall	89.14 %
Precision	96.51 %
Category accuracy	99.95 %
Area accuracy	94.51 %
Jaccard	86.36 %
False positive rate (/m^2)	0.00012

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6.8 Mornington Peninsula



Figure U.1. The Mornington Peninsula NSQAR in the context of the Mornington Peninsula GI. The entire area within the blue rectangle has been labelled (labels shown as multi-coloured shapes), but only the top left greyscale rectangle is used for Quality Assurance.

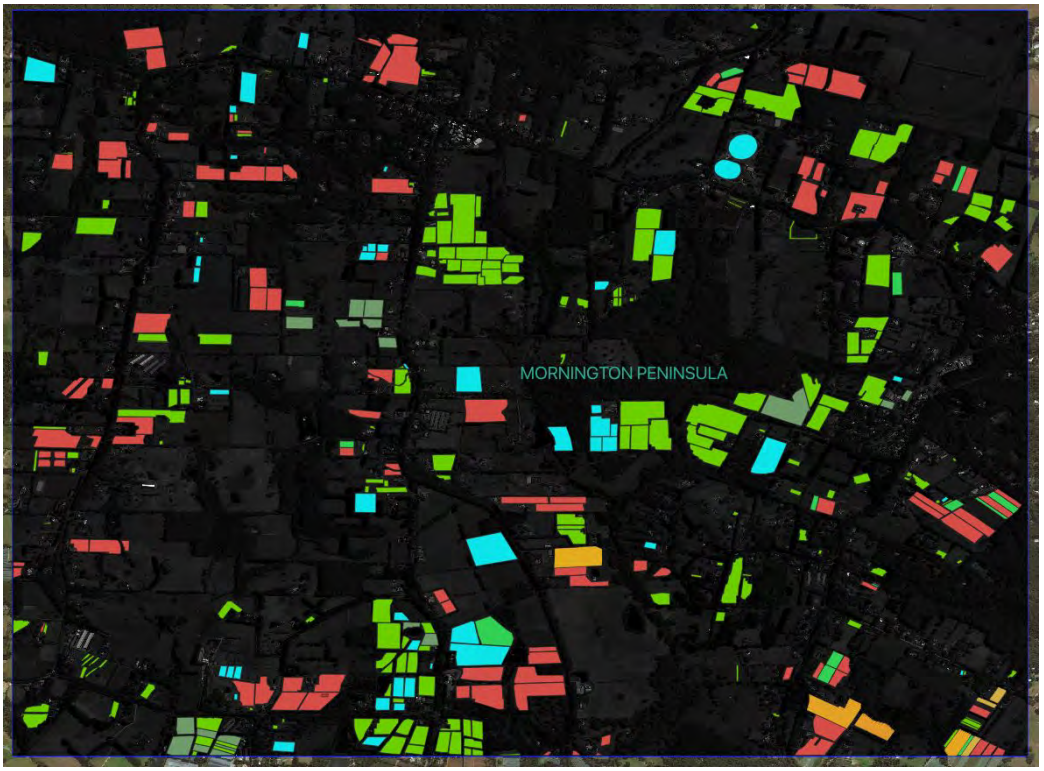


Figure U.2. Mornington Peninsula labels overlaid on the Panchromatic satellite imagery.

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Date of imagery used for ground truth	2017-02-08T00:43:34.980Z
Total area (ha)	649.8
Truth area (ha)	29.9
Prediction area (ha)	32.8
Misses area (ha)	2.9
Mistakes area (ha)	5.7
Union area (ha)	35.6
Intersection area (ha)	27.1
Recall	90.47 %
Precision	82.66 %
Category accuracy	98.75 %
Area accuracy	91.28 %
Jaccard	76.04 %
False positive rate (/m^2)	0.0087

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6.9 Murray Darling VIC #2



Figure V.1. The Murray Darling #2 NSQAR in the context of the Murray Darling GI (VIC). The entire area within the blue rectangle has been labelled (labels shown as multi-coloured shapes), but only the top left greyscale rectangle is used for Quality Assurance.



Figure V.2. Murray Darling #2 labels overlaid on the Panchromatic satellite imagery. These labels correspond with the ground truth as represented in the SunRISE Mapping dataset.

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Date of imagery used for ground truth	2018-02-04T00:41:01.000Z
Total area (ha)	413.2
Truth area (ha)	41.2
Prediction area (ha)	43.5
Misses area (ha)	5.5
Mistakes area (ha)	7.8
Union area (ha)	49.0
Intersection area (ha)	35.7
Recall	86.64 %
Precision	82.13 %
Category accuracy	97.10 %
Area accuracy	94.77 %
Jaccard	72.90 %
False positive rate (/m^2)	0.019

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7. Quality Assurance in New South Wales

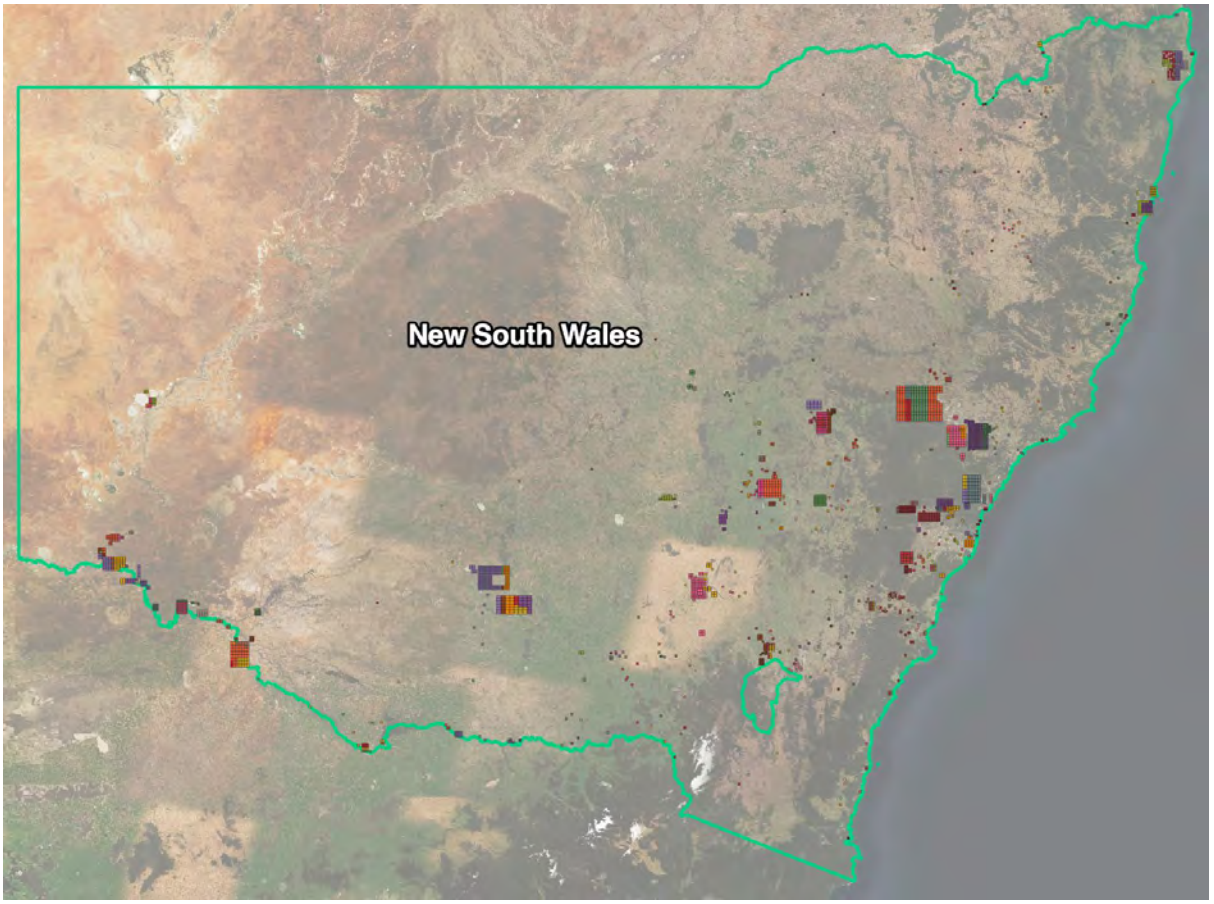


Fig 6: A visualisation of the AOIs in New South Wales that were scanned by GAIA. The different colours represent different satellite images that were used to scan each AOI.

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7.1 Riverina

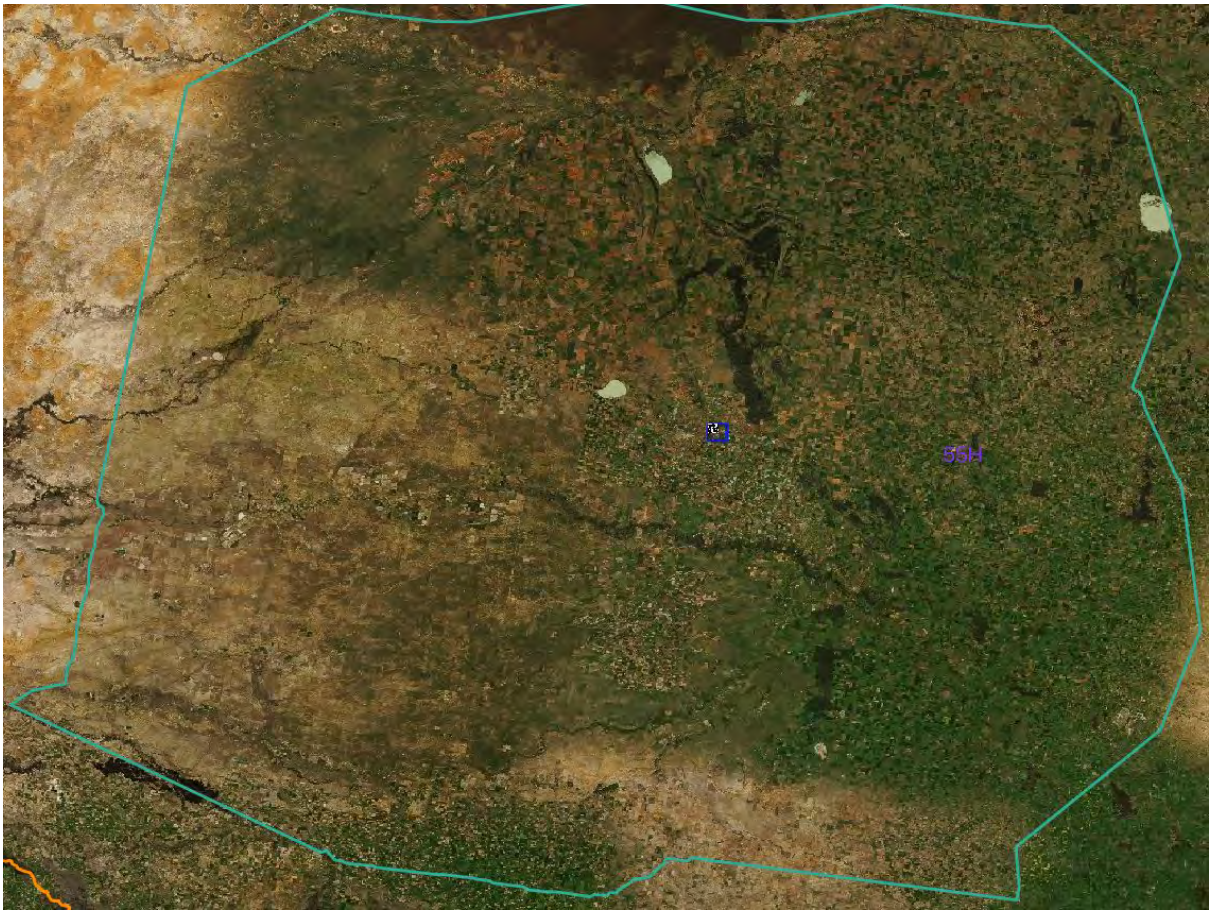


Figure W.1. The Riverina NSQAR in the context of the Riverina GI. The entire area within the blue rectangle has been labelled (labels shown as multi-coloured shapes), but only the top left greyscale rectangle is used for Quality Assurance.

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Figure W.2. Riverina labels overlaid on the Panchromatic satellite imagery.

Date of imagery used for ground truth	2018-02-07T00:31:20.000Z
Total area (ha)	680.4
Truth area (ha)	263.1
Prediction area (ha)	253.8
Misses area (ha)	17.4
Mistakes area (ha)	18.5
Union area (ha)	271.1
Intersection area (ha)	245.7
Recall	93.40 %
Precision	92.98 %
Category accuracy	95.81 %
Area accuracy	96.46 %
Jaccard	87.25 %
False positive rate (/m^2)	0.027

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7.2 Canberra District

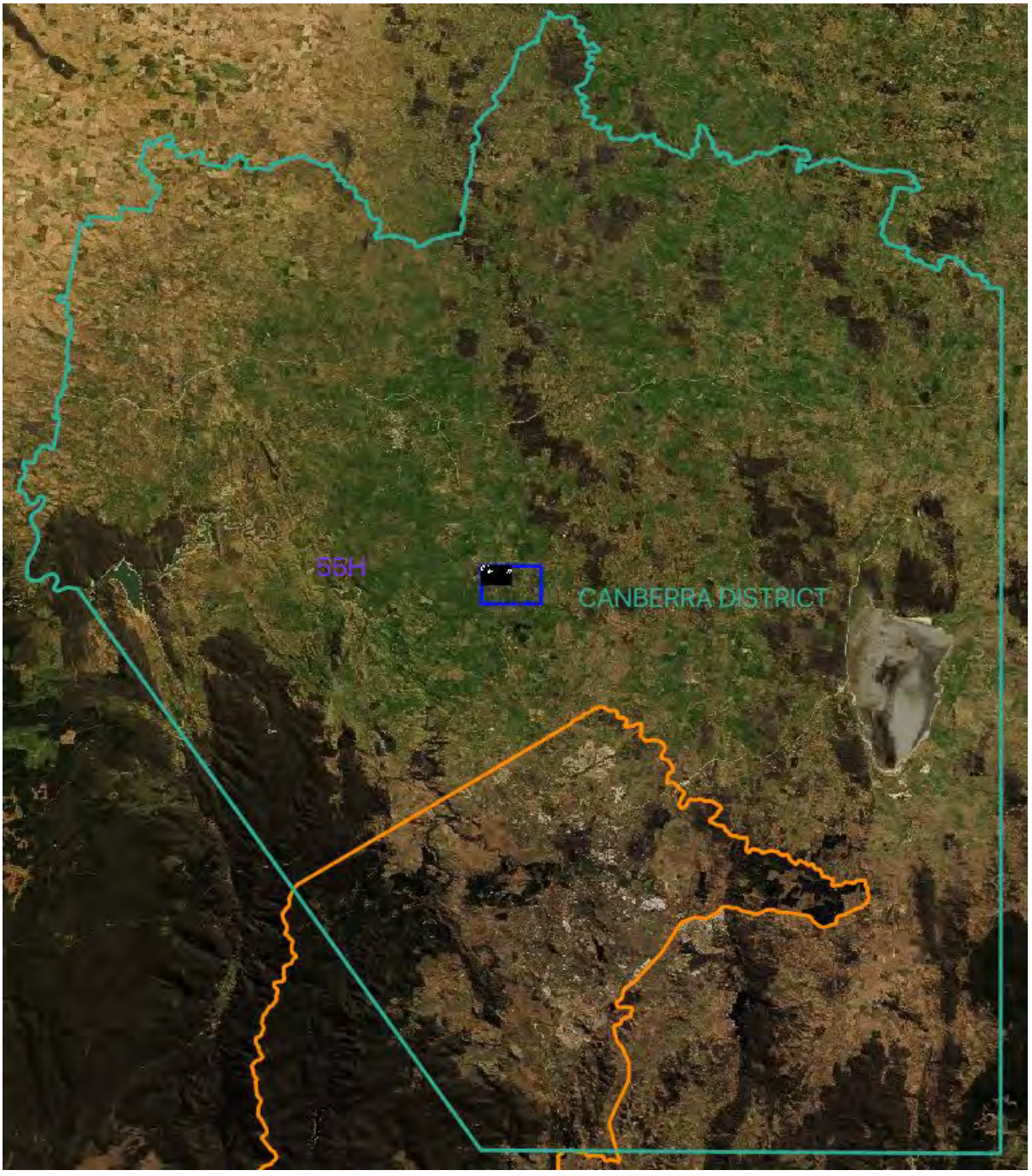


Figure X.1. The Canberra District NSQAR in the context of the Canberra District GI. The entire area within the blue rectangle has been labelled (labels shown as multi-coloured shapes), but only the top left greyscale rectangle is used for Quality Assurance.

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Figure X.2. Canberra District labels overlaid on the Panchromatic satellite imagery.

Date of imagery used for ground truth	2016-03-31T23:53:59.781Z
Total area (ha)	605.3
Truth area (ha)	45.1
Prediction area (ha)	42.3
Misses area (ha)	4.5
Mistakes area (ha)	1.6
Union area (ha)	48.1
Intersection area (ha)	40.7
Recall	90.03 %
Precision	96.13 %
Category accuracy	99.05 %
Area accuracy	93.71 %
Jaccard	86.89 %
False positive rate (/m^2)	0.0027

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7.3 Hunter

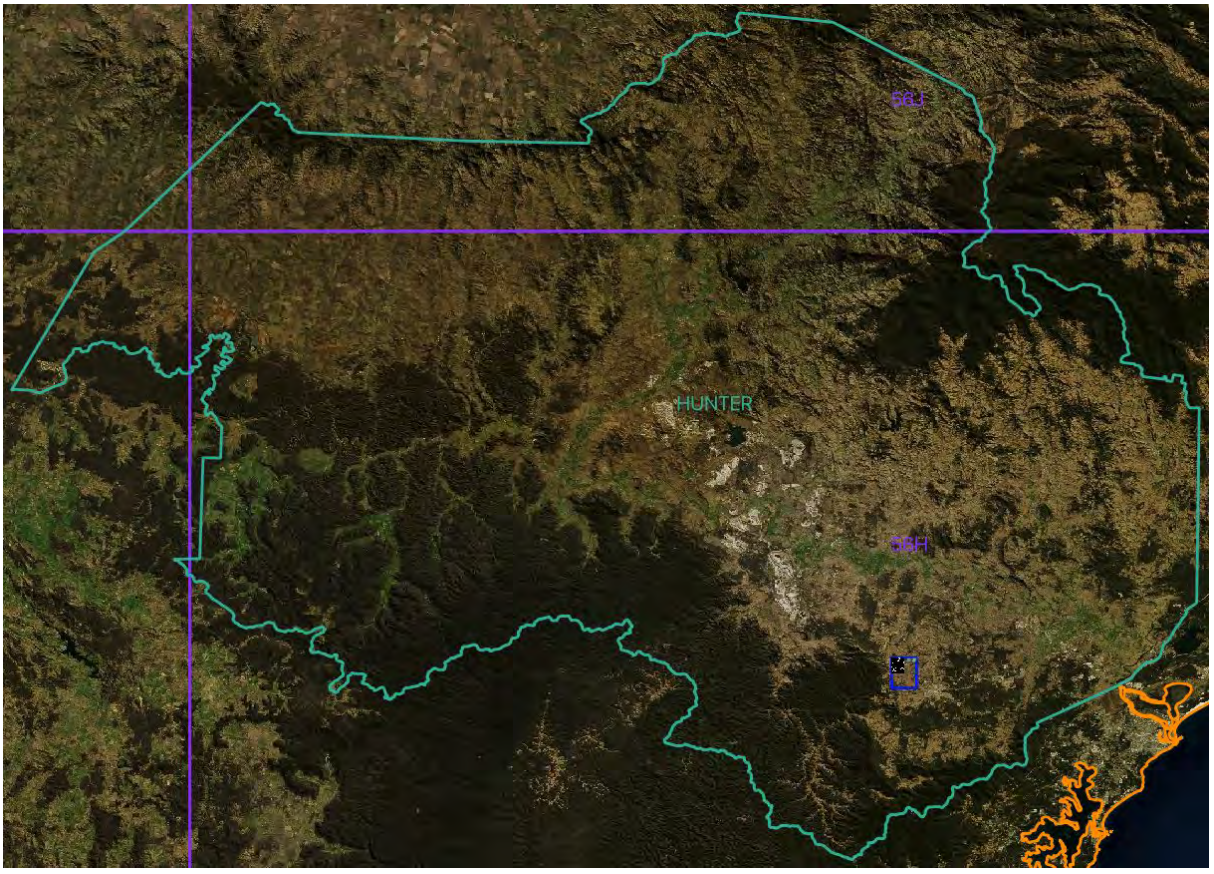


Figure Y.1. The Hunter NSQAR in the context of the Hunter (Region) GI. The entire area within the blue rectangle has been labelled (labels shown as multi-coloured shapes), but only the top left greyscale rectangle is used for Quality Assurance.

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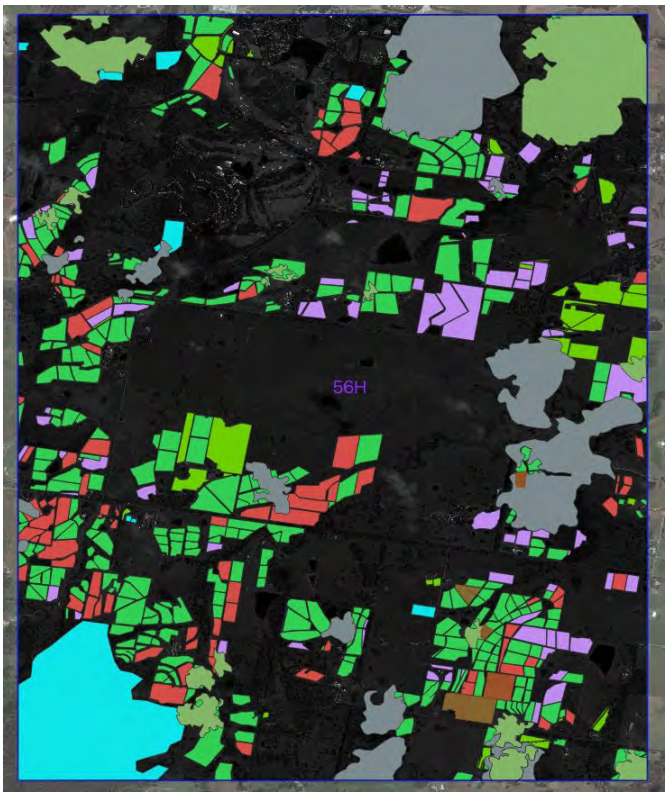


Figure Y.2. Hunter labels overlaid on the Panchromatic satellite imagery.

Date of imagery used for ground truth	2018-02-10T00:20:19.000Z
Total area (ha)	645.8
Truth area (ha)	64.3
Prediction area (ha)	58.3
Misses area (ha)	10.5
Mistakes area (ha)	4.5
Union area (ha)	68.8
Intersection area (ha)	53.8
Recall	83.65 %
Precision	92.29 %
Category accuracy	97.88 %
Area accuracy	90.56 %
Jaccard	78.18 %
False positive rate (/m^2)	0.0070

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7.4 Orange

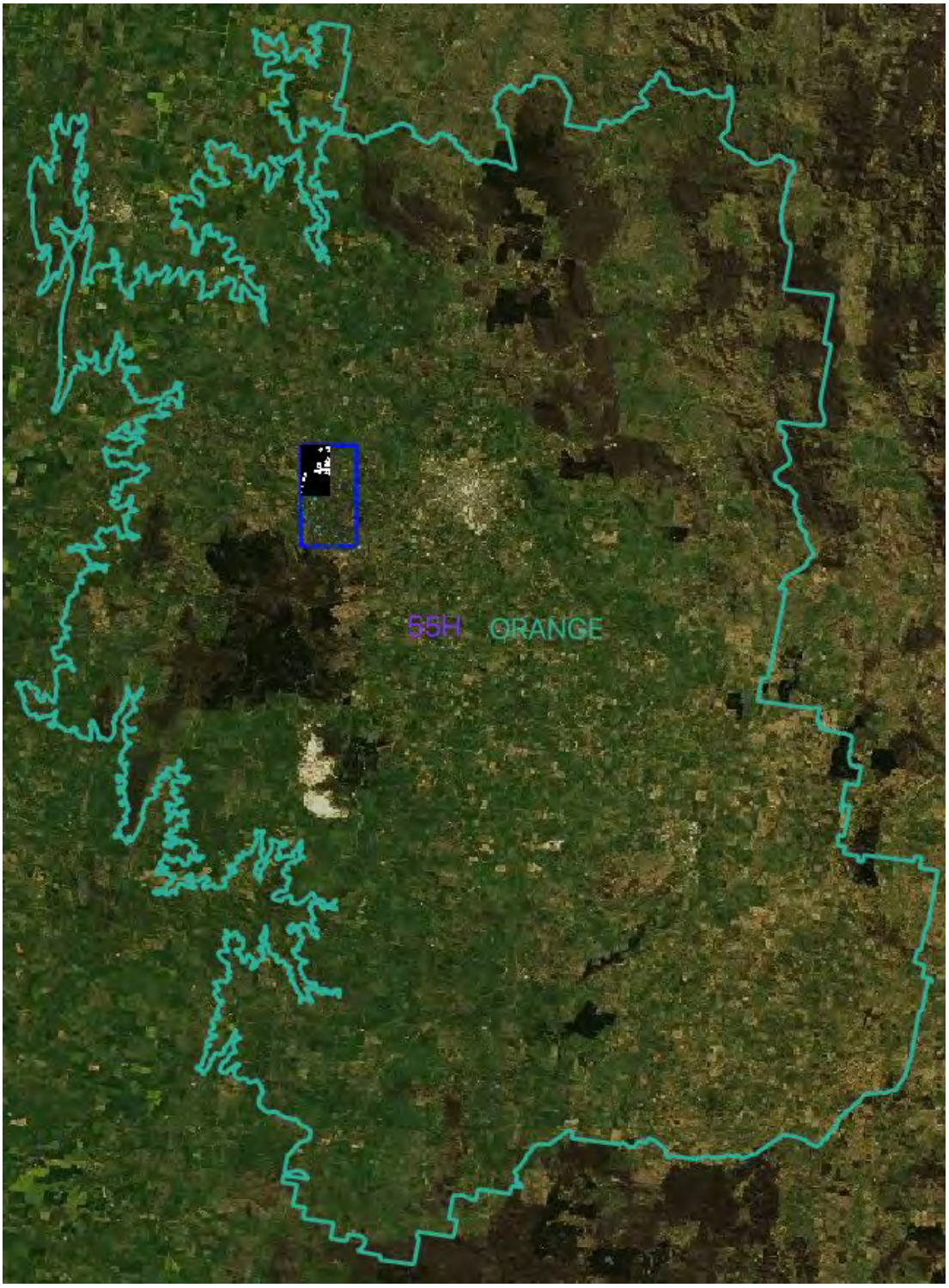


Figure Z.1. The Orange NSQAR in the context of the Orange GI. The entire area within the blue rectangle has been labelled (labels shown as multi-coloured shapes), but only the top left greyscale rectangle is used for Quality Assurance.

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Figure Z.2. Orange labels overlaid on the Panchromatic satellite imagery.

Date of imagery used for ground truth	2018-03-09T00:27:50.000Z
Total area (ha)	667.0
Truth area (ha)	90.5
Prediction area (ha)	80.8
Misses area (ha)	13.3
Mistakes area (ha)	3.6
Union area (ha)	94.1
Intersection area (ha)	77.2
Recall	85.32 %
Precision	95.57 %
Category accuracy	97.57 %
Area accuracy	89.28 %
Jaccard	82.07 %
False positive rate (/m^2)	0.0054

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7.5 Shoalhaven Coast



Figure AA.1. The Shoalhaven Coast NSQAR in the context of the Shoalhaven Coast GI. The entire area within the blue rectangle has been labelled (labels shown as multi-coloured shapes), but only the top left greyscale rectangle is used for Quality Assurance.

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Figure AA.2. Shoalhaven Coast labels overlaid on the Panchromatic satellite imagery.

Date of imagery used for ground truth	2018-03-15T00:09:21.000Z
Total area (ha)	2527.5
Truth area (ha)	14.7
Prediction area (ha)	13.1
Misses area (ha)	2.1
Mistakes area (ha)	0.5
Union area (ha)	15.2
Intersection area (ha)	12.6
Recall	85.51 %
Precision	96.28 %
Category accuracy	99.90 %
Area accuracy	89.14 %
Jaccard	82.77 %
False positive rate (/m^2)	0.00019

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7.6 Swan Hill (NSW)



Figure AB.1. The Swan Hill (NSW) NSQAR in the context of the Swan Hill GI (NSW). The entire area within the blue rectangle has been labelled (labels shown as multi-coloured shapes), but only the top right greyscale rectangle is used for Quality Assurance.

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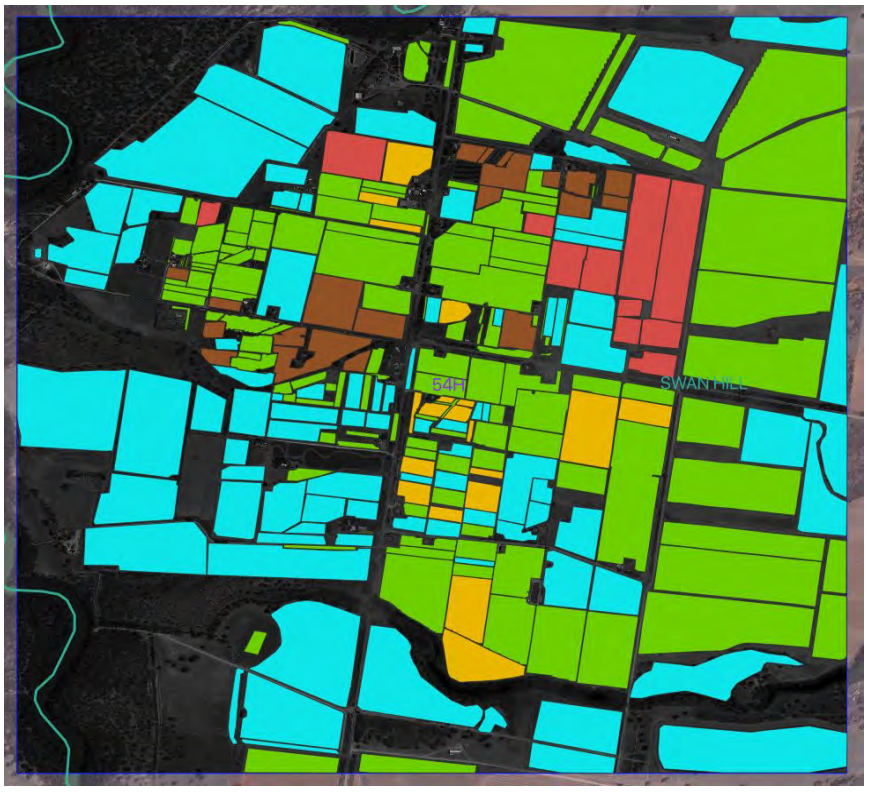


Figure AB.2. Swan Hill (NSW) labels overlaid on the Panchromatic satellite imagery. These labels correspond with the ground truth as represented in the SunRISE Mapping dataset.

Date of imagery used for ground truth	2018-12-19T00:51:08.000Z
Total area (ha)	281.4
Truth area (ha)	28.1
Prediction area (ha)	27.3
Misses area (ha)	2.3
Mistakes area (ha)	1.6
Union area (ha)	30.0
Intersection area (ha)	25.8
Recall	91.71 %
Precision	94.28 %
Category accuracy	98.75 %
Area accuracy	97.27 %
Jaccard	86.87 %
False positive rate (/m^2)	0.0056

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8. Quality Assurance in Queensland



Fig 7: A visualisation of the AOIs in Queensland that were scanned by GAIA. The different colours represent different satellite images that were used to scan each AOI.

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8.1 South Burnett

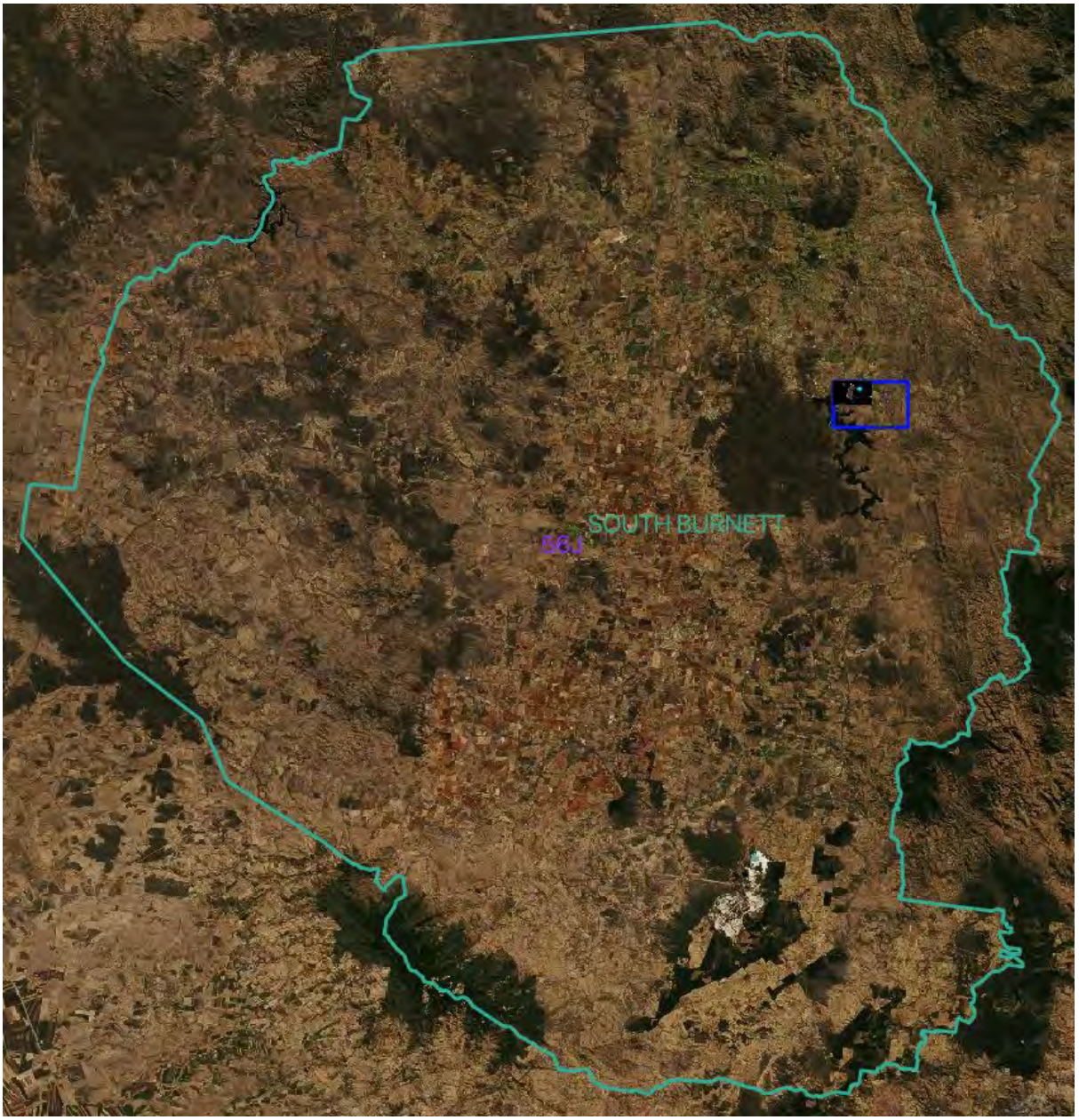


Figure AC.1. The South Burnett NSQAR in the context of the South Burnett GI. The entire area within the blue rectangle has been labelled (labels shown as multi-coloured shapes), but only the top left greyscale rectangle is used for Quality Assurance.

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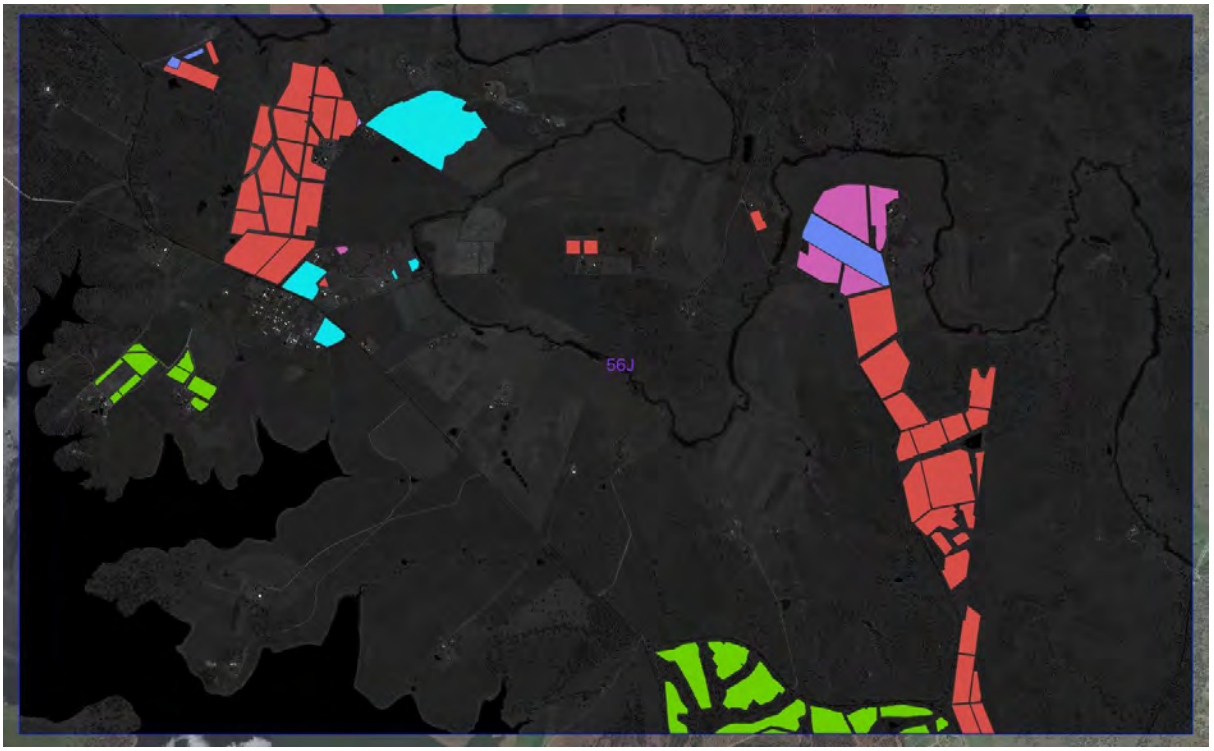


Figure AC.2. South Burnett labels overlaid on the Panchromatic satellite imagery.

Date of imagery used for ground truth	2012-04-02T00:18:57.429Z
Total area (ha)	926.8
Truth area (ha)	67.1
Prediction area (ha)	70.6
Misses area (ha)	1.0
Mistakes area (ha)	4.5
Union area (ha)	71.7
Intersection area (ha)	66.1
Recall	98.48 %
Precision	93.62 %
Category accuracy	99.44 %
Area accuracy	95.06 %
Jaccard	92.29 %
False positive rate (/m^2)	0.0048

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8.2 Granite Belt

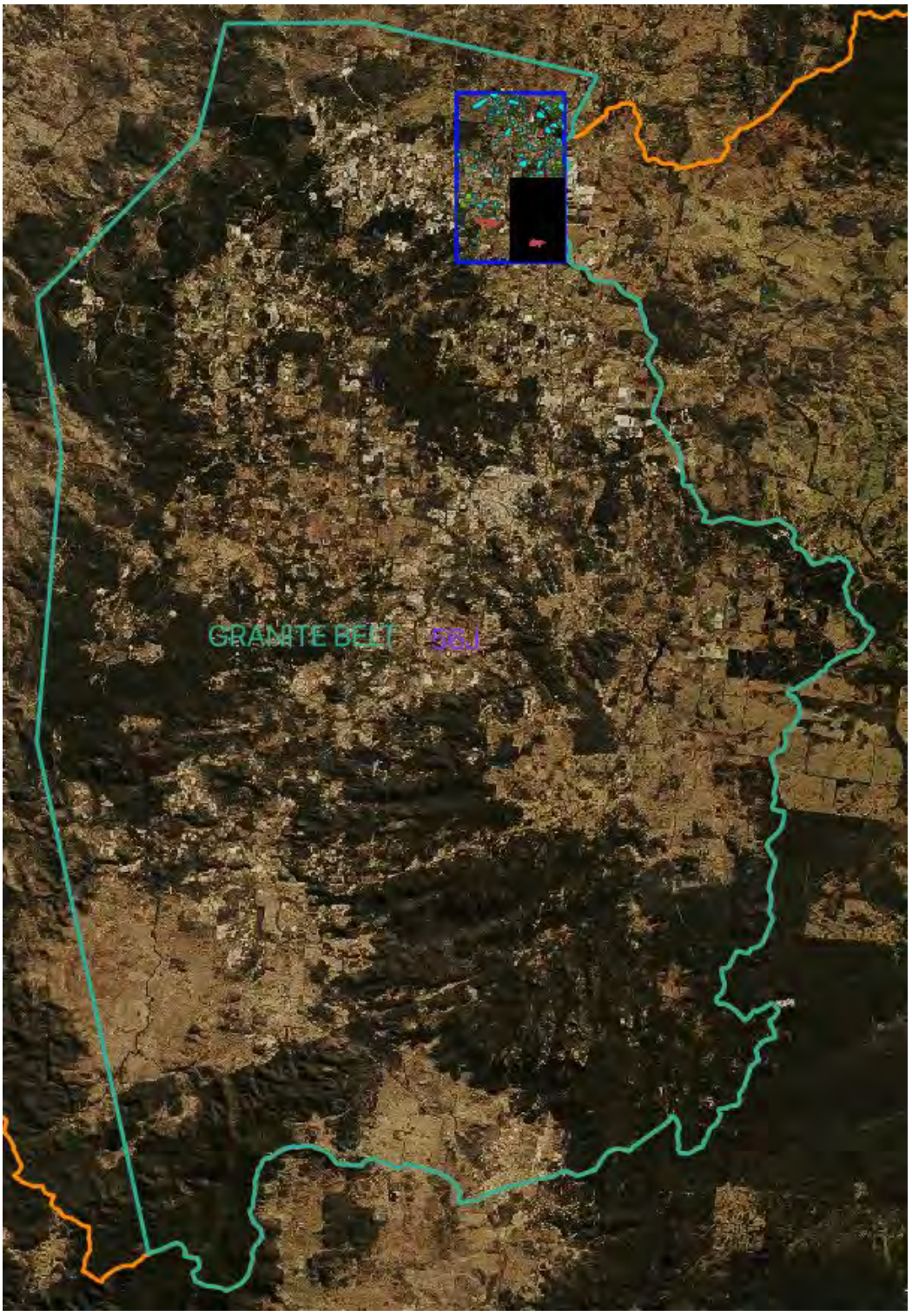


Figure AD.1. The Granite Belt NSQAR in the context of the Granite Belt GI. The entire area within the blue rectangle has been labelled (labels shown as multi-coloured shapes), but only the bottom right greyscale rectangle is used for Quality Assurance.

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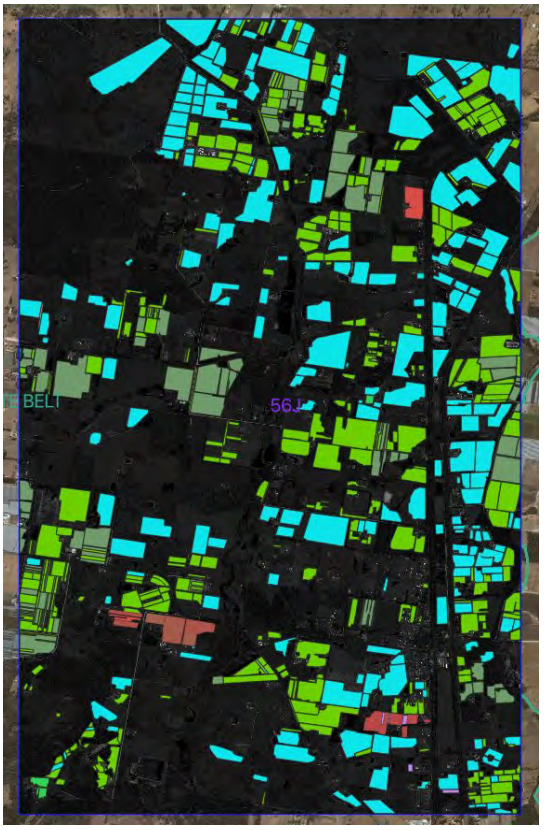


Figure AD.2. Granite Belt labels overlaid on the Panchromatic satellite imagery.

Date of imagery used for ground truth	2016-11-17T00:05:17.787Z
Total area (ha)	741.7
Truth area (ha)	4.6
Prediction area (ha)	4.8
Misses area (ha)	0.4
Mistakes area (ha)	0.6
Union area (ha)	5.2
Intersection area (ha)	4.2
Recall	91.03 %
Precision	87.01 %
Category accuracy	99.86 %
Area accuracy	95.58 %
Jaccard	80.14 %
False positive rate (/m^2)	0.00085