

HRL 2018 look & feel verification report for Imperviousness density 2018 (IMD)

I. Administrative part

HRL	<i>type the name of the verified layer</i>
Verified area, region	Finland
Institution carrying out the work	Finnish Environment Institute (SYKE)
Overall visual checking done by (name, position and e-mail)	Iida Autio, coordinator, iida.autio@syke.fi
Look & feel verification done by (name, position and e-mail)	Iida Autio, coordinator, iida.autio@syke.fi
Statistical verification done by (name, position and e-mail)	Iida Autio, coordinator, iida.autio@syke.fi Markus Törmä, research engineer, markus.torma@syke.fi
In situ data used. <i>Replace Data-x with the full name of the dataset. Mention quality issues if relevant.</i>	<i>National Ortho photo database/The National Land Survey Natural color/black and white ortho photos Resolution: 0.25-0.5m Reference years: 2017-2019 (partial coverages)</i>
	<i>National high resolution Corine Land Cover 2018 (HR CLC2018)/Finnish Environment Institute National Corine raster dataset Resolution 20x20m Reference year: 2018</i>
	<i>Topographic Database/The National Land Survey Compilations of object groups (buildings, car traffic areas) Vector data Reference year: 2018</i>
	<i>The Finnish Land Parcel Information System (FLPIS)/Finnish Food Authority Based on farming subsidy reports Vector data Reference year: 2018</i>
	<i>Railway tracks/The Finnish Transport Infrastructure Agency Vector data Reference year 2012 (has not changed)</i>
	<i>Biotope data/Metsähallitus Biotope classes used: heathlands, permanently snow covered areas Vector data Reference years 2005-2015</i>
	<i>Google Earth aerial images Reference year 2018</i>
	<i>Google street view photos</i>
Reporting done by (name, position and e-mail)	Iida Autio, coordinator, iida.autio@syke.fi
Date and place of writing the report	22 nd June, 2021, Helsinki

II. General overview of the verified data

The total area of the HRL Imperviousness degree feature layer (later HRL IMD18) is 4414 km². The low imperviousness (1-29%) area is 2237 km² and high imperviousness (30-100%) area is 2177 km². The built-up area according to the National High Resolution Corine Land Cover 2018 data (20x20m) (later HR CLC18) is 7423 km². This includes CLC18 classes 1.1.1, 1.1.2, 1.2.1, 1.2.2, 1.2.3 and 1.2.4. The total coverage of the impervious area in the HRL IMD18 is 41% smaller than in the national reference data. This is partly explained by the fact that these two datasets are not fully comparable, since the HRL IMD18 represents pure land cover, while HR CLC18 is a mixture of land cover and land use. Thus, discontinuous urban fabric class 1.1.2 of the HR CLC18 includes significant amount of green areas around houses. Also airport class 1.2.4 in HR CLC18 includes also the grass covered areas of the airports. The Table 1 presents the overall statistics of the HRL IMD18 data and Figure 1 shows the HRL IMD18 areas in Finland.

Table1. Overall statistics

HRL IMD18 Finland	Value	Km2	%
Non impervious areas	0	342616,31	98,73 %
Imperviousness 1-29 %	1-29	2236,74	0,64 %
Imperviousness 30-100%	30-100	2176,77	0,63 %
Unclassifiable	245	0,00	0
Outside area (no data)	255	428904,35	
SUM (Non impervious and impervious (1-100%))		347029,82	100,00 %
Total impervious surface¹		1615,00	0,47 %

¹ The sum of all impervious (sealed) areas calculated as the arithmetical product of the imperviousness value and the area of the cell.

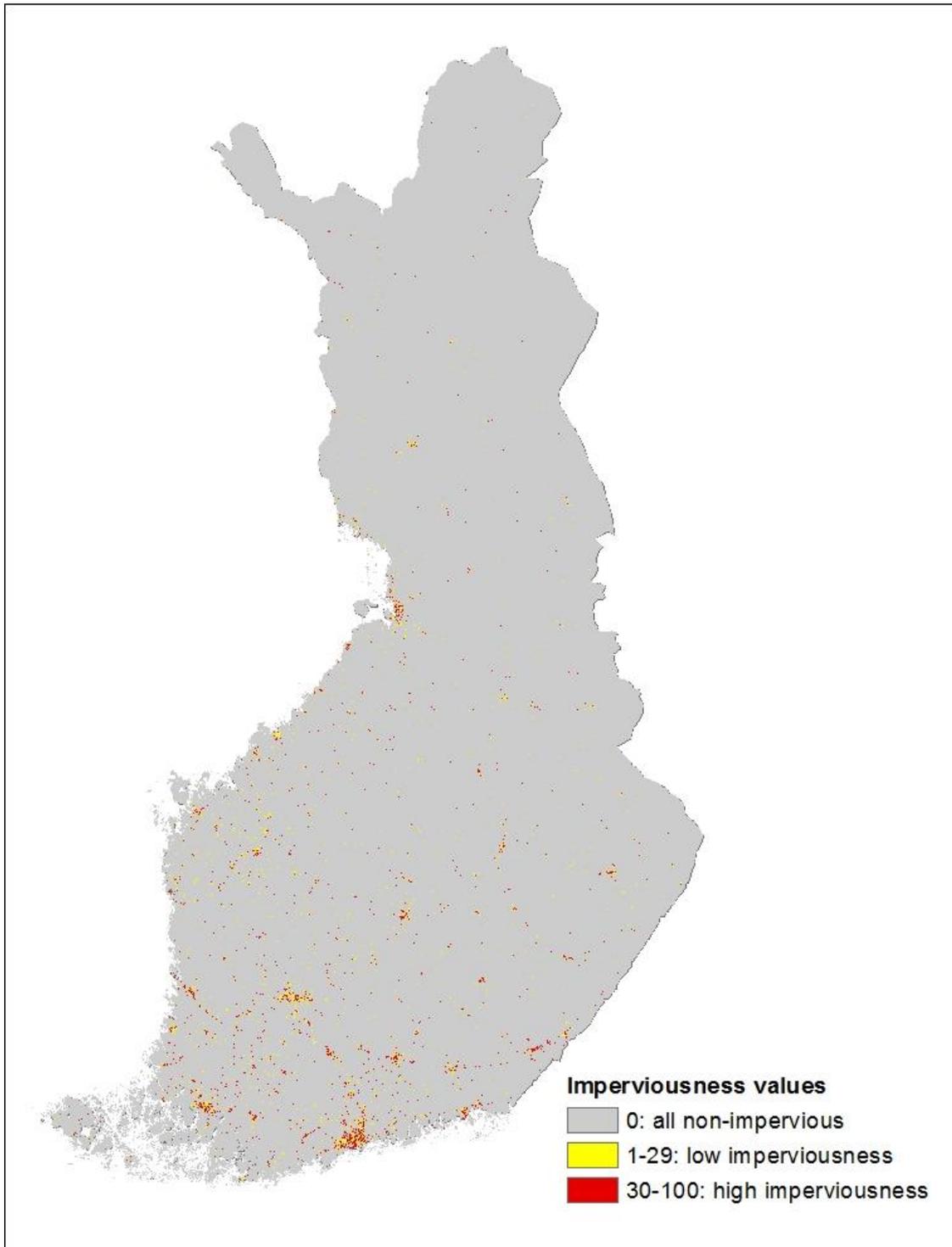


Figure 1. Overview map

The HRL IMD18 data was compared to the national in situ data (HR CLC18) statistically as well as with GIS analysis methods and these results are presented in Tables 2 and 3 as well as Figure 2. Especially high potential commission errors seem to be found in Green urban

areas, Sport and leisure areas and Racecourses. Major omission errors according to statistical comparison with HR CLC18 are in Discontinuous urban fabric, Commercial units, Industrial units, Road and rail networks and associated land, Airports and Summer cottages. Partly this can be explained by the different definitions, production methods and resolutions of the datasets.

Table 2. Comparison of relevant statistical values for HRL IMD18 with HR CLC18.

General overview of the verified data	km2	% of the area of Finland
HRL Imperviousness in Finland (IMD >0%)	4413,5143	1,30 %
Sealed soil area in national reference layer (HR CLC18)	7422,5992	2,19 %
Coinciding sealed soil area between HRL IMD18 and national reference layer	3265,1548	0,96 %
Sealed soil (IMD >0%) in HRL IMD18 (not in national reference layer)	1144,6232	0,34 %
Sealed soil in national reference layer (not in HRL IMD18)	4157,4008	1,23 %
Coinciding permeable soil in HRL-IMD18 and national reference layer	337823,4728	99,82 %

Table 3. HR CLC18 compared to impervious area in HRL IMD18. **Blue: Potential commission errors;**
Red: potential omission errors

HR CLC18 code (Level 4)	HR CLC18 class name	Area in HR CLC18 km2	Share from country area (%)	Impervious area in HRL IMD18 km2	IMD content in HR CLC18 class	Remaining area (not matching with HRL IMD18) in HR CLC18 class
1.1.1.1	Continuous urban fabric	171,0	0,0 %	148,4	86,8 %	13,2 %
1.1.2.1	Discontinuous urban fabric	3176,1	0,8 %	1336,3	42,1 %	57,9 %
1.2.1.1	Commercial units	956,6	0,2 %	474,1	49,6 %	50,4 %
1.2.1.2	Industrial units	623,9	0,2 %	337,4	54,1 %	45,9 %
1.2.2.1	Road and rail networks and associated land	2378,1	0,6 %	927,4	39,0 %	61,0 %
1.2.3.1	Port areas	39,9	0,0 %	30,9	77,4 %	22,6 %
1.2.4.1	Airports	77,0	0,0 %	24,5	31,8 %	68,2 %
1.3.1.1	Mineral extraction sites	421,9	0,1 %	15,6	3,7 %	96,3 %
1.3.1.2	Open cast mines	28,9	0,0 %	1,8	6,2 %	93,8 %
1.3.2.1	Dump sites	134,0	0,0 %	7,0	5,3 %	94,7 %
1.3.3.1	Construction sites	27,5	0,0 %	9,3	33,9 %	66,1 %
1.4.1.1.	Green urban areas	33,8	0,0 %	9,8	28,9 %	71,1 %
1.4.2.1	Summer cottages	1367,2	0,3 %	38,1	2,8 %	97,2 %

1.4.2.2	Sport and leisure areas	134,9	0,0 %	46,2	34,2 %	65,8 %
1.4.2.3	Golf courses	87,1	0,0 %	2,5	2,9 %	97,1 %
1.4.2.4	Racecourses	9,9	0,0 %	3,0	30,4 %	69,6 %
2.1.1.1	Non-irrigated arable land	21774,7	5,6 %	127,8	0,6 %	99,4 %
2.2.2.1	Fruit trees and berry plantations	62,6	0,0 %	0,6	0,9 %	99,1 %
2.3.1.1	Pastures	39,7	0,0 %	0,2	0,5 %	99,5 %
2.3.1.2	Natural pastures	93,9	0,0 %	0,7	0,7 %	99,3 %
2.4.3.1	Arable land outside farming subsidies	2125,2	0,5 %	26,0	1,2 %	98,8 %
2.4.4.1	Agro-forestry areas	35,3	0,0 %	0,1	0,3 %	99,7 %
3.1.1.1	Broad-leaved forest on mineral soil	9795,5	2,5 %	20,2	0,2 %	99,8 %
3.1.1.2	Broad-leaved forest on peatland	562,7	0,1 %	0,1	0,0 %	100,0 %
3.1.2.1	Coniferous forest on mineral soil	114100,1	29,2 %	240,6	0,2 %	99,8 %
3.1.2.2.	Coniferous forest on peatland	32643,2	8,4 %	5,8	0,0 %	100,0 %
3.1.2.3	Coniferous forest on rocky soil	3060,2	0,8 %	4,8	0,2 %	99,8 %
3.1.3.1	Mixed forest on mineral soil	36411,7	9,3 %	140,1	0,4 %	99,6 %
3.1.3.2	Mixed forest on peatland	8723,2	2,2 %	1,4	0,0 %	100,0 %
3.1.3.3.	Mixed forest on rocky soil	227,7	0,1 %	0,9	0,4 %	99,6 %
3.2.1.1	Natural grassland	107,9	0,0 %	0,0	0,0 %	100,0 %
3.2.2.1	Moors and heathland	7382,0	1,9 %	0,6	0,0 %	100,0 %
3.2.4.1	Transitional woodland/shrub cc <10%	8477,9	2,2 %	97,8	1,2 %	98,8 %
3.2.4.2	Transitional woodland/shrub, cc 10-30%, on mineral soil	14768,9	3,8 %	285,1	1,9 %	98,1 %
3.2.4.3	Transitional woodland/shrub, cc 10-30%, on peatland	8623,5	2,2 %	3,7	0,0 %	100,0 %
3.2.4.4	Transitional woodland/shrub, cc 10-30%, on rocky soil	1542,9	0,4 %	7,6	0,5 %	99,5 %
3.2.4.6	Transitional woodland/shrub under power lines	384,3	0,1 %	6,4	1,7 %	98,3 %
3.3.1.1	Beaches, dunes, and sand plains	64,1	0,0 %	0,5	0,7 %	99,3 %
3.3.2.1	Bare rock	1779,9	0,5 %	3,2	0,2 %	99,8 %
3.3.3.1	Sparsely vegetated areas	541,7	0,1 %	0,3	0,1 %	99,9 %
4.1.1.1	Inland marshes, terrestrial	373,6	0,1 %	0,6	0,1 %	99,9 %
4.1.1.2	Inland marshes, aquatic	1066,2	0,3 %	0,7	0,1 %	99,9 %
4.1.2.1	Peatbogs	19087,9	4,9 %	1,7	0,0 %	100,0 %
4.1.2.2	Peat production sites	1026,2	0,3 %	0,5	0,1 %	99,9 %
4.2.1.1	Salt marshes, terrestrial	300,6	0,1 %	1,4	0,5 %	99,5 %
4.2.1.2	Salt marshes, aquatic	292,2	0,1 %	0,5	0,2 %	99,8 %
5.1.1.1	Water courses	1168,5	0,3 %	4,5	0,4 %	99,6 %
5.1.2.1	Water bodies	32299,1	8,3 %	10,8	0,0 %	100,0 %
5.2.3.1	Sea and ocean	52197,4	13,4 %	5,9	0,0 %	100,0 %

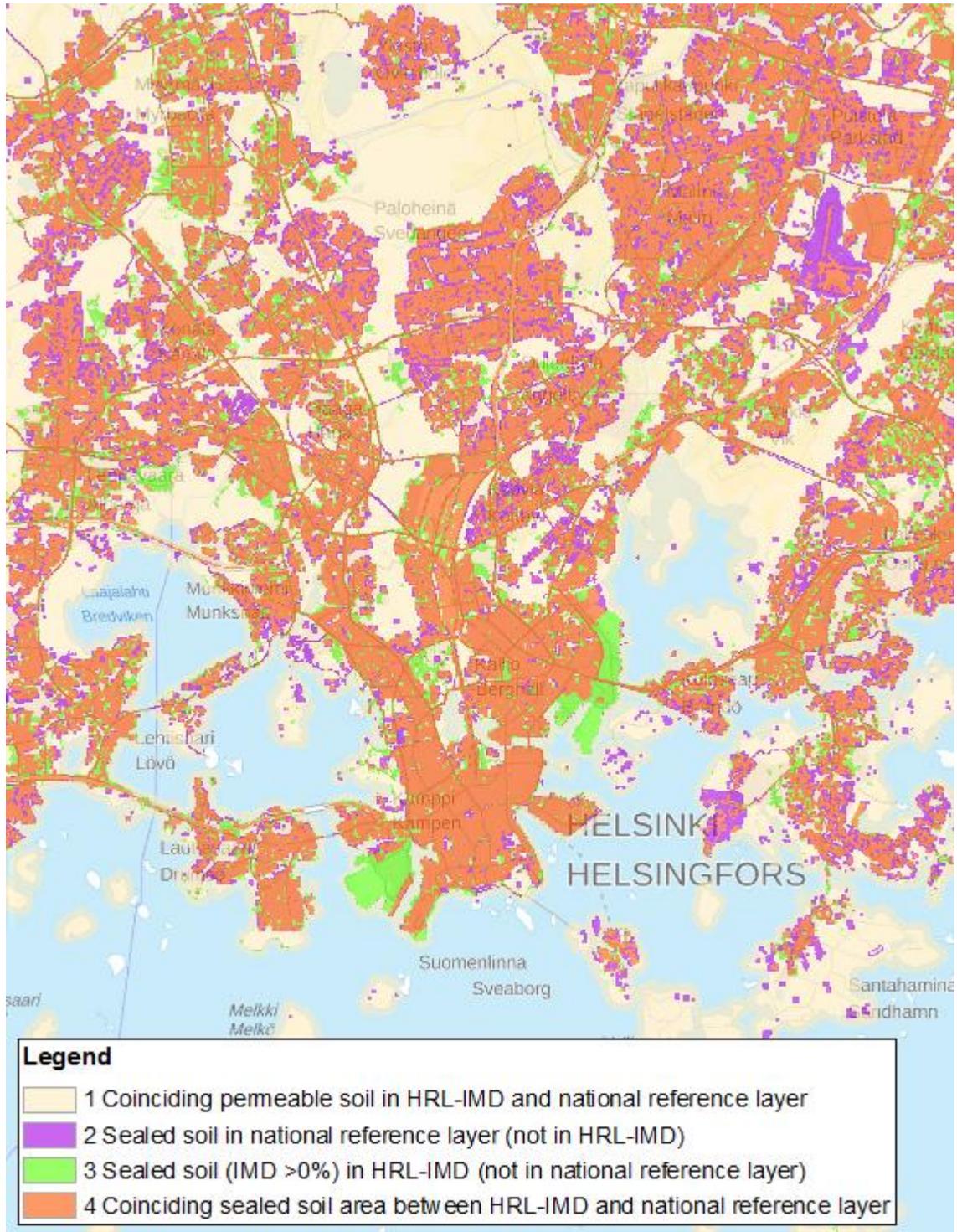


Figure 2. Comparison of HRL IMD18 and HRCLC18 in the Helsinki City area. Purple areas indicate possible omission errors and green areas commission errors.

III. Overall visual checking

Positional accuracy			
Relative positional accuracy	Quick visual comparison of HRL data with available EO imagery (identifying large positional errors)	Mostly OK	Large positional errors were not detected in the data. Slight positional shift (1-2 pixels) can sometimes be detected and is most evident in roads (the data is slightly shifted to south-east).
Thematic accuracy			
Classification correctness	Simple look & feel thematic check (identifying basic thematic mistakes)	OK	The quick visual comparison of the HRL IMD18 data with national orthophoto images indicate that the HRL IMD18 feature layer represents the impervious areas accurately. Compared to the data from the previous production cycle (HRL IMD15) the accuracy seems to have improved due to the smaller resolution (10x10m).

IV. Look & feel verification results

Details of look & feel verification

1. Included elements, possible OMISSIONS

Stratum	Name of the stratum	Number of samples verified	<i>Results of the verification by strata (excellent, good, acceptable, insufficient, very poor):</i>
1	Housing areas (even with scattered houses)	16 (polygons)	Good (4)
2	Single (farm) houses	22 (points)	Very poor (1)
3	Traffic areas (airports, harbours, railway yards, parking lots)	14 (polygons)	Good (4)
4	Roads	10 (points)	Acceptable (3)
5	Railway tracks associated to other impervious surfaces (i.e. inside built-up area)	10 (polygons)	Excellent (5)
6	Industrial and commercial areas, factories, energy production and distribution facilities	12 (polygons)	Acceptable (3)
7	Sealed surfaces, which are part of categories, such as e.g. allotment gardens, cemeteries, sport and recreation areas, camp sites, excluding green areas associated with them	18 (points)	Good (4)
8	Artificial grass-covered sport pitches	3 (polygons)	Acceptable (3)
9	Construction sites with significant built-up structures	10 (polygons)	Good (4)
10	Greenhouses (covered through the year)	11 (points)	Good (4)
Overall evaluation			Good/Acceptable (3 ½)
Comments, overview of results			<p>Some of the strata was evaluated as polygons (Case I) and some with points (Case II) depending on how these contradicting areas were located (referring to the verification guidelines, page 52). These are attached as separate shapefiles to this report (IMD2018_LookFeelSamples_polygons_FI.shp and IMD2018_LookFeelSamples_points_FI.shp).</p> <p>Two recommended strata were not evaluated:</p>

	<ul style="list-style-type: none"> - Solar panel parks were not considered relevant for Finland. - Paved borders of water edges could not be located (not with in situ data or visual scanning). <p>In the strata “Artificial covered sport pitches” only 3 contradicting areas were identified in the GIS comparison with in-situ data.</p> <p>Overall, the accuracy was varied both between and within the checked strata. In general, large areas such as traffic areas, industrial areas, construction sites and greenhouses were well located in the data. There was variation between the checked sites in these strata (e.g. Industrial and commercial sites were graded between 1-5 and traffic areas between 2-5). Small objects (single farm houses) were mostly omitted.</p>
--	---

2. Excluded elements, possible COMMISSIONS

Stratum	Name of the stratum	Number of samples verified	<i>Results of the verification by strata (excellent, good, acceptable, insufficient, very poor):</i>
1	Construction sites (without significant built-up structures)	14 (polygons)	Acceptable (3)
2	Mines, quarries, peat extraction areas	8 (polygons)	Insufficient (2)
3	Sand, sand pits	16 (polygons)	Very poor (1)
4	Dump sites	12 (polygons)	Very poor (1)
5	Un-vegetated or sparsely vegetated areas	20 (polygons)	Very poor (1)
6	Bare rocks	10 (polygons)	Very poor (1)
7	Un-vegetated agricultural fields, arable land/ Agriculture areas around built-up	40 (polygons)	Very poor (1)
8	Natural, artificial and cultivated vegetated areas	15 (polygons)	Acceptable (3)
9	Vineyards, fruit plantations	10 (points)	Excellent (5)

10	Railway tracks not associated to other impervious surfaces (i.e. outside built-up area)	10 (polygons)	Insufficient (2)
11	Sport fields, recreation areas with grass cover	11 (polygons)	Insufficient (2)
12	Glaciers, snow, water	17 (snow: polygons, water: points)	Excellent (5)
Overall evaluation			Acceptable (3)
Comments, overview of results			<p>Some of the strata was evaluated as polygons (Case I) and some with points (Case II) depending on how these contradicting areas were located (referring to the verification guidelines, page 52). These are attached as separate shapefiles to this report (IMD2018_LookFeelSamples_polygons_FI.shp and IMD2018_LookFeelSamples_points_FI.shp)</p> <p>Some strata were evaluated differently than recommended in the guidelines:</p> <ul style="list-style-type: none"> - Sand, sand pits: Sand pits were evaluated separately, and natural sand was evaluated in the strata “Un-vegetated or sparsely vegetated areas” - In the strata Unvegetated or sparsely vegetated areas, natural sand and moors and heathlands were included - Unvegetated agricultural areas and Agriculture areas around built-up were evaluated together as the areas cannot be separated in the in-situ data - Natural, artificial and cultivated vegetated areas: only artificial areas were evaluated here and these include mostly urban parks. - Temporal plastic coverage on agricultural fields: these areas could not be found and possibly not relevant for Finland - Sport fields, recreation areas with grass cover: also areas covered with gravel were evaluated here - Glaciers, snow, water: only snow and water were evaluated but separately: snow with contradicting polygons and water with selected points

	<ul style="list-style-type: none">- Green roofs: these could not be found (not with in situ data or visual scanning).- <p>Overall, the accuracy between the checked strata was varied. Unvegetated "light" areas (e.g. unvegetated agricultural fields, mines, sand pits, natural sand, dump sites and bare rocks) were generally poorly identified in the data and were mostly misclassified as impervious. Vegetated areas were better identified as non-impervious.</p>
--	---

V. Documentation of errors and critical findings

Omission errors

Examples and screenshots of omission errors of the strata checked in look and feel verification are presented in this chapter. The SAMPLE_ID in the figure captions is referring to the associated GIS-data-files: IMD2018_LookFeelSamples_polygons_FI.shp and IMD2018_LookFeelSamples_points_FI.shp. The background image is an aerial orthophoto from reference years 2017-2019 (The National Land Survey).

Housing areas: This strata is fairly well detected in the HRL IMD-data (grades between 3-4) but single buildings (>MMU) are often omitted when situated within green gardens (Figure 4).

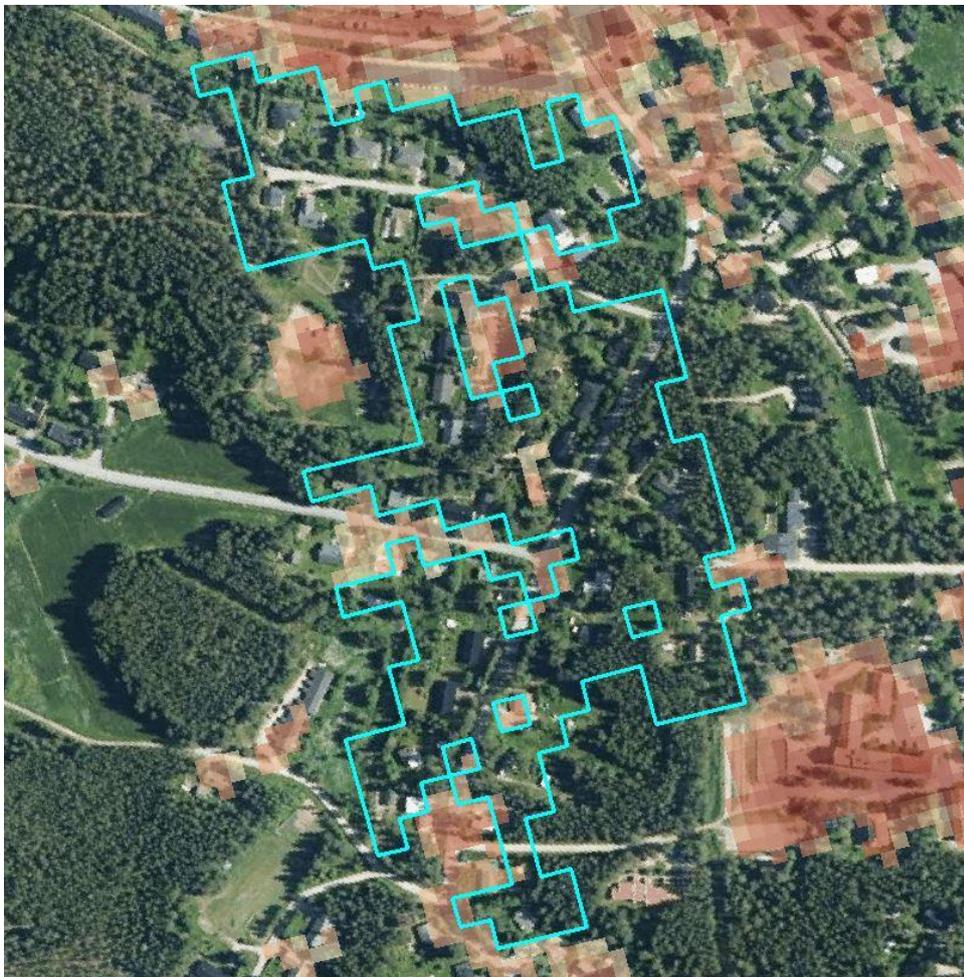


Figure 4. Omission errors in a neighborhood of single houses surrounded by gardens. The turquoise polygon is the contradicting area derived from the GIS comparison of in-situ data and the HRL IMD18. HRL IMD18 data is presented with shades of red. SAMPLE_ID 4, scale 1:3000, coordinates (ETRS_1989_LAEA) E: 5136213, N: 4967515, orthophoto reference year 2018.

Single (farm) houses: Single (farm) houses are mostly omitted from the data (grades 1-2), even when >MMU (Figure 5).

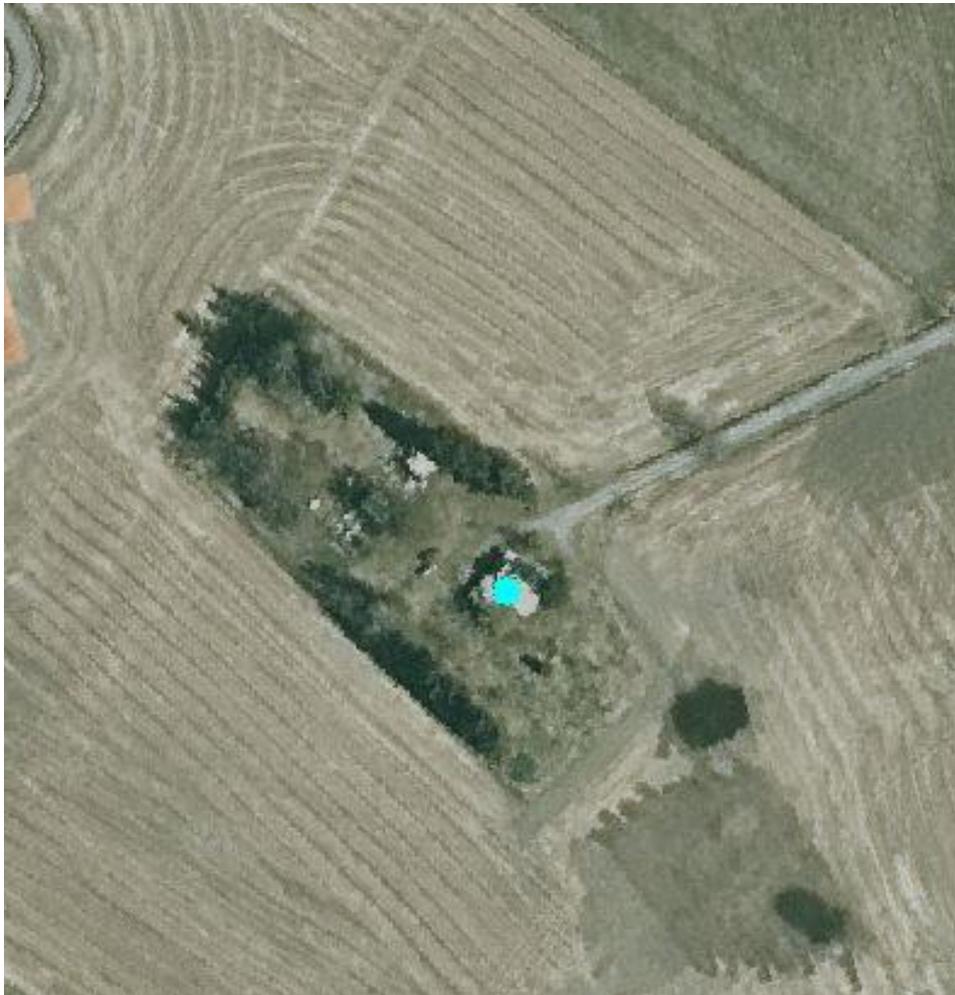


Figure 5. Omission error of a single farm house >MMU. The turquoise point is indicating the contradicting area that was selected manually based on a-priory knowledge supported by visual interpretation of VHR aerial imagery. SAMPLE_ID 230, scale 1:2000, coordinates (ETRS_1989_LAEA) E:5166566, N:4258367, ortophoto reference year 2018.

Traffic areas: Several of the omission errors found in traffic areas are located in airports and include paved areas connected to runways that have been left out from the IMD-data (Figure 6). In general this strata is quite varied in HRL IMD18 data (grades 2-5).



Figure 6. Omission error in an airport. Runways, roads and buildings are impervious but are not included in the HRL IMD18 data. The turquoise polygon is the contradicting area derived from the GIS comparison of in-situ data and the HRL IMD18. Sample_ID 25, Scale 1:5000, coordinates (ETRS_1989_LAEA) E: 5010855, N:4259574, ortophoto reference year 2017.

Roads: Roads are quite well included in the HRL IMD18 data but sometimes there are mistakes in the continuity of highways (Figure 7). Grades of the checked locations vary between 2-4.



Figure 7. Omission error on a highway. The turquoise point is indicating the contradicting area that was selected manually based on a-priori knowledge supported by visual interpretation of VHR aerial imagery. HRL IMD18 data is presented with shades of red. SAMPLE_ID 283, scale 1:3000, coordinates (ETRS_1989_LAEA) E:5217304, N:4505954, ortophoto reference year 2019.

Railway tracks associated to other impervious surfaces: There were no errors found in this strata. A typical example is presented in Figure 8.

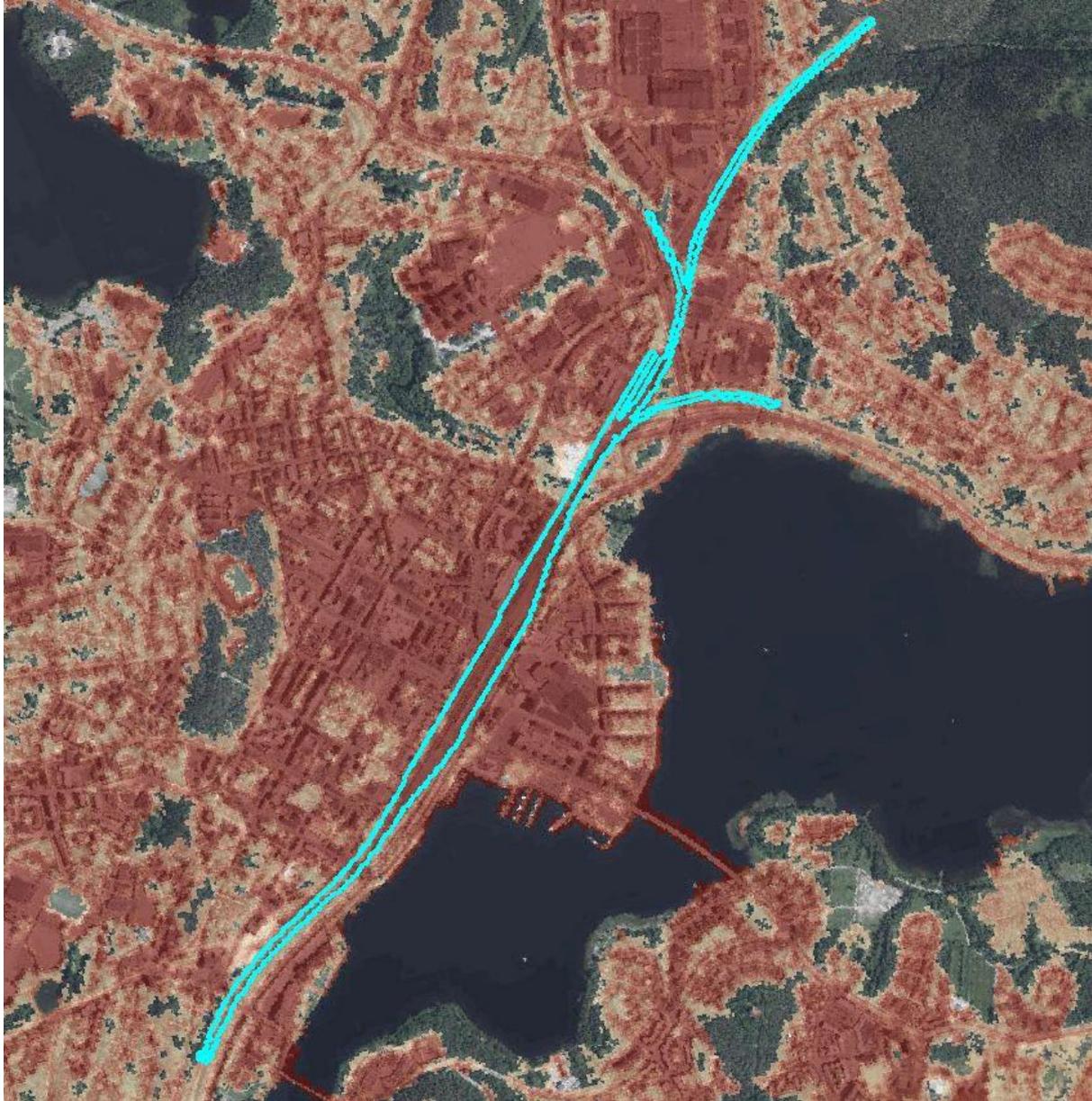


Figure 8. No omission errors were found in railway tracks associated to other impervious surfaces. The turquoise polygon is the area checked that was located with in-situ data. HRL IMD18 data is presented with shades of red. SAMPLE_ID 35, scale 1:16 000, coordinates (ETRS_1989_LAEA) E:5135435, N:4440686, orthophoto reference year 2019.

Industrial and commercial areas, factories, energy production and distribution facilities: The accuracy of this strata is very varied; polygons checked in the look and feel verification got notes between 1-5. Example here (Figure 9) is from a polygon where there are omission errors.



Figure 9. Omission errors at an industrial site; the paved area (where wood is stored) is omitted. The turquoise polygon is the contradicting area derived from the GIS comparison of in-situ data and the HRL IMD18. HRL IMD18 data is presented with shades of red. SAMPLE_ID 44, scale 1:3000, coordinates (ETRS_1989_LAEA) E:5076297, N:4378518, or-topphoto reference year 2019.

Sealed surfaces, which are part of categories, such as e.g. allotment gardens, cemeteries, sport and recreation areas, camp sites, excluding green areas associated with them: This strata is fairly well detected in the HRL IMD18 data (grades between 3-5) and no major omission errors were found. The example is from an allotment garden (Figure 10).



Figure 10. Small omission errors in an allotment garden. Most small buildings are included in the data. The turquoise point is indicating the contradicting area that was selected manually based on a-priory knowledge supported by visual interpretation of VHR aerial imagery. HRL IMD18 data is presented with shades of red. SAMPLE_ID 264, scale 1:2500, coordinates (ETRS_1989_LAEA) E:5045818, N:4336979, ortophoto reference year 2018.

Artificial grass-covered sport pitches: In the locations identified in the GIS-comparison (3) the artificial grass field is mostly omitted (Figure 11).



Figure 11. Artificial grass-covered sports field (darker green), is omitted in the right side of the turquoise polygon which is the contradicting area derived from the GIS comparison of in-situ data and the HRL IMD18. HRL IMD18 data is presented with shades of red. SAMPLE_ID 53, scale 1:3000, coordinates (ETRS_1989_LAEA) E:5047775 N:4735699, orthophoto reference year 2017.

Construction sites with significant built-up structures: Construction sites were fairly well detected in the data (grades 4-5) but some buildings and sealed surfaces were omitted (Figure 12).



Figure 12. Buildings omitted in a construction site. The turquoise polygon is the contradicting area derived from the GIS comparison of in-situ data and the HRL IMD18. HRL IMD18 data is presented with shades of red. SAMPLE_ID 59, scale 1:3500, coordinates (ETRS_1989_LAEA) E:5215133, N:4529817, orthophoto reference year 2018.

Greenhouses: Greenhouses are well located in the HRL IMD18 data but there is some variation in the checked locations (grades 2-5). A few omission errors were found (an example is shown in Figure 13).



Figure 13. Some greenhouses are omitted. The turquoise point is indicating the contradicting area that was selected manually based on a-priori knowledge supported by visual interpretation of VHR aerial imagery. HRL IMD18 data is presented with shades of red. SAMPLE_ID 261, scale 1:2000, coordinates (ETRS_1989_LAEA) E:5020349, N:4336976, orthophoto reference year 2017.

Commission errors

Examples and screenshots of commission errors of the strata checked in the look and feel verification are presented in this chapter. The SAMPLE_ID in the figure captions is referring to the associated GIS-data-files: IMD2018_LookFeelSamples_polygons_FI.shp and IMD2018_LookFeelSamples_points_FI.shp. The background image is an aerial orthophoto from reference years 2017-2019 (The National Land Survey).

Construction sites (without significant built-up structures): There is much variation in the detection of this strata (grades 1-4) in the HRL IMD18 data. The example (Figure 14) is from a site where commission errors are present in the other half of the polygon.



Figure 14. Commission errors in the bottom half of the construction area: HRL IMD18 data shows impervious (shades of red), but no structures are yet present. The turquoise polygon is the contradicting area derived from the GIS comparison of in-situ data and the HRL IMD18. SAMPLE_ID 67, scale 1:5000, coordinates (ETRS_1989_LAEA) E:5033247, N:4332586, orthophoto reference year 2018.

Mines, quarries, peat extraction areas: There are some commission errors in this strata (grades 1-3). In open cast mines there is often large areas misclassified as impervious (Figure 15).

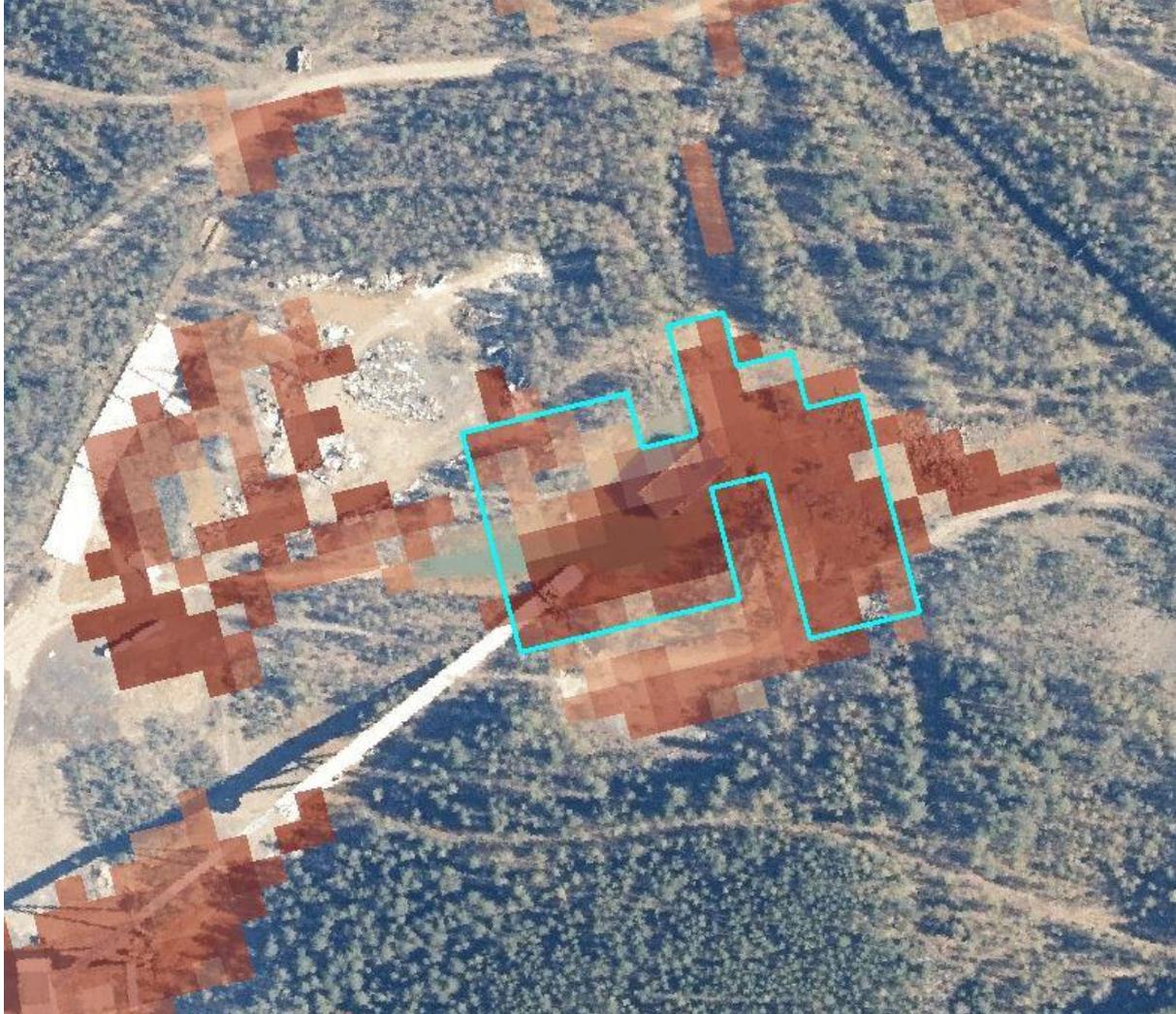


Figure 15. There is gravel, vegetation, sand and water misclassified as impervious in an open cast mine. The turquoise polygon is the contradicting area derived from the GIS comparison of in-situ data and the HRL IMD18. HRL IMD18 data is presented with shades of red. SAMPLE_ID 83, scale 1:2000, coordinates (ETRS_1989_LAEA) E:5286875, N4539057, orthophoto reference year 2017.

Sand pits: Sand pits are very poorly identified in the HRL IMD18 data and all sites checked got a grade 1. In the sample site (Figure 16), the light sand areas have gotten values of almost 100% imperviousness.

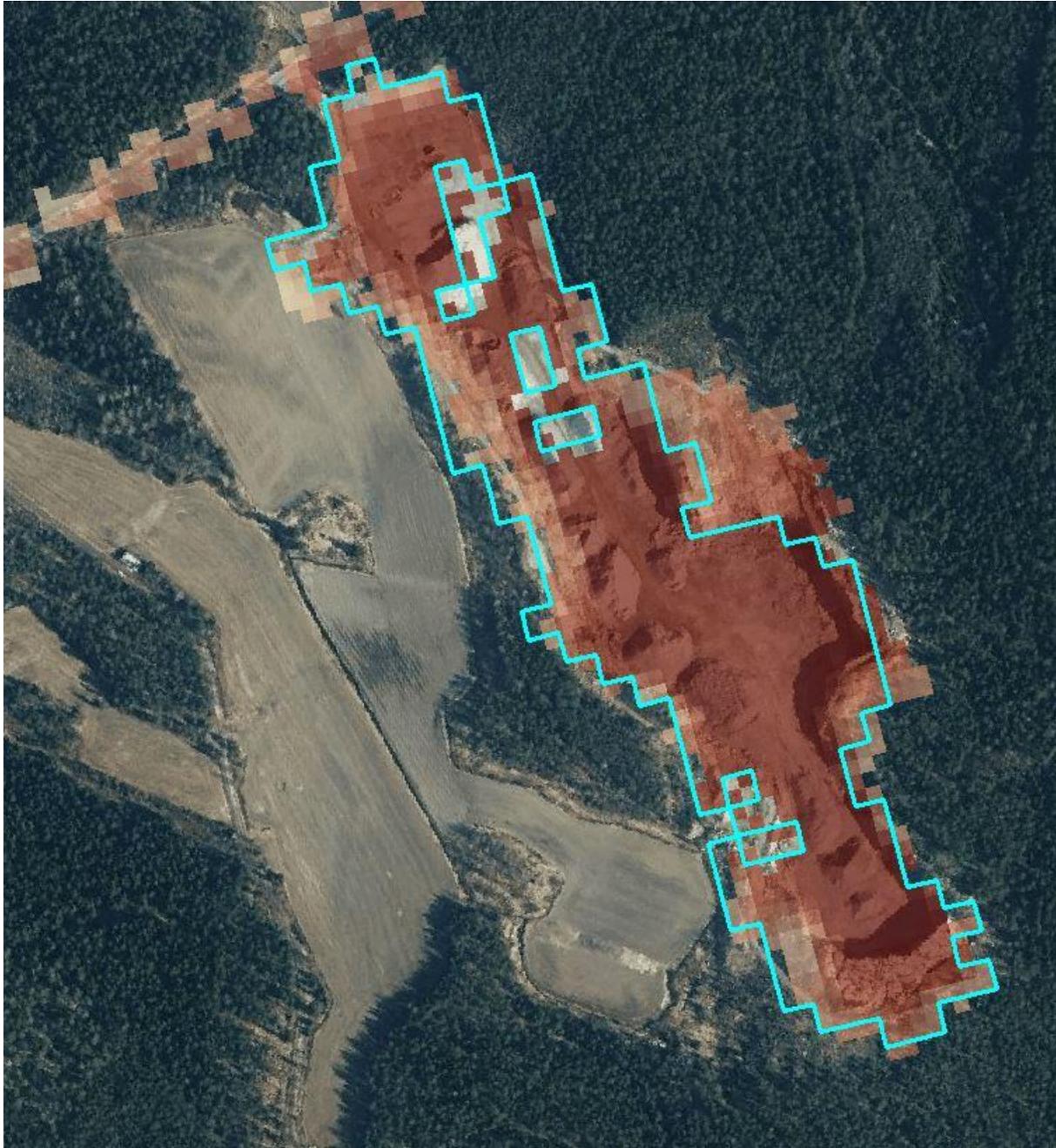


Figure 16. A sand pit where the whole sand area is erroneously classified as impervious (shades of red). The turquoise polygon is the contradicting area derived from the GIS comparison of in-situ data and the HRL IMD18. SAMPLE_ID 95, scale 1:3500, coordinates (ETRS_1989_LAEA) E:5005087, N:4306419, orthophoto reference year 2019.

Dump sites: There are lots of commission error in dumpsites (grades 1-2) where the waste material, vegetation and sand/gravel roads are misclassified as impervious (Figure 17). The reason to this might be that the sites are confused with industrial sites which have similar elements and structures.



Figure 17. A dump site, that is mostly misclassified as impervious. The turquoise polygon is the contradicting area derived from the GIS comparison of in-situ data and the HRL IMD18. HRL IMD18 data is presented with shades of red. SAMPLE_ID 111, scale 1:4000, coordinates (ETRS_1989_LAEA) E:4968158, N:4301985, orthophoto reference year 2019.

Un-vegetated or sparsely vegetated areas: Natural sand and heathland areas were checked in this strata and their detection in the HRL IMD18 data is poor (grades 1-2). Often the misclassified sand areas are located by water (Figure 18).

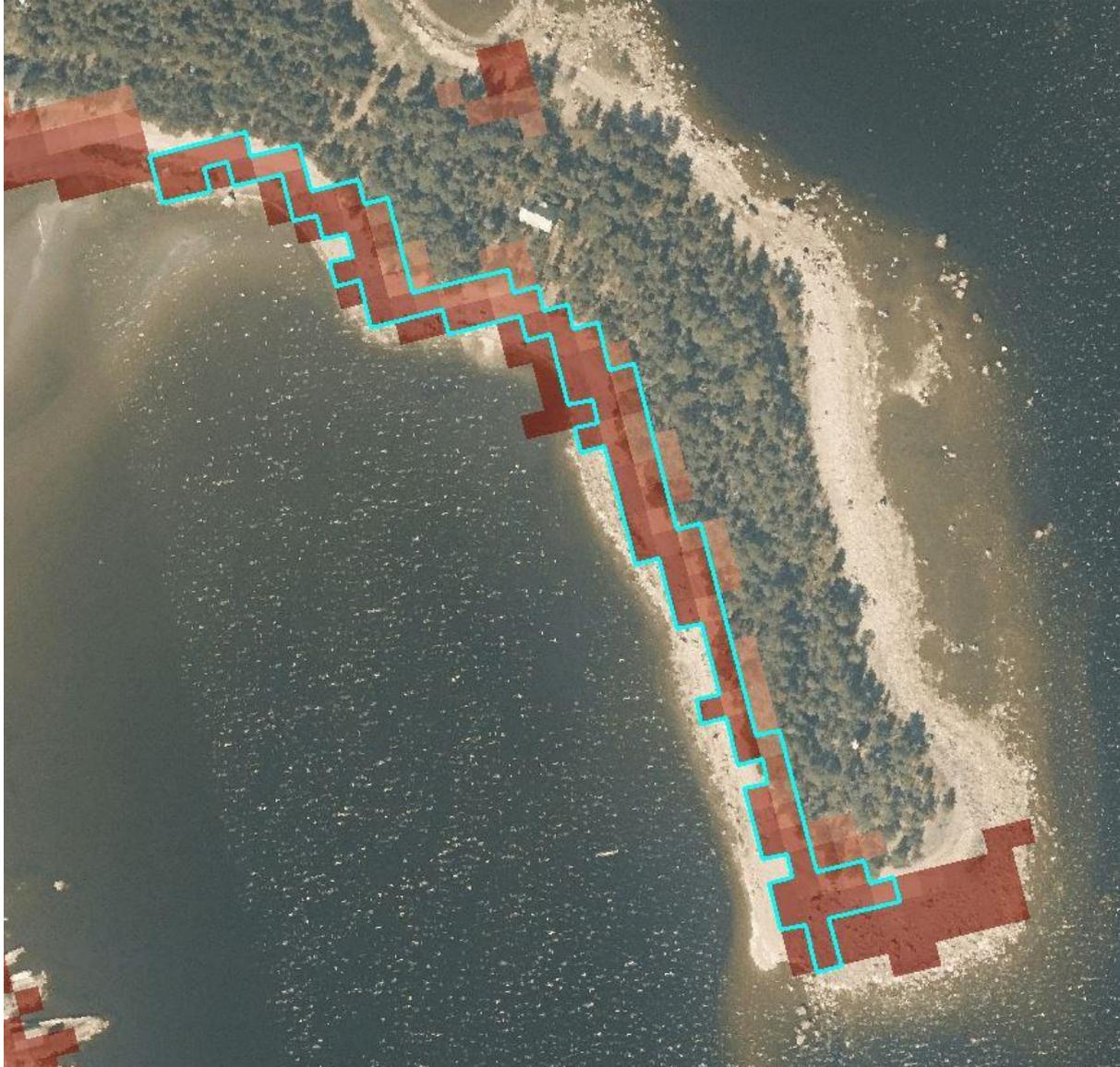


Figure 18. Sandy beach misclassified as impervious. The turquoise polygon is the contradicting area derived from the GIS comparison of in-situ data and the HRL IMD18. HRL IMD18 data is presented with shades of red. SAMPLE_ID 130, scale 1:2000, coordinates (ETRS_1989_LAEA) E:5240178, N:4248339, orthophoto reference year 2018.

Bare rocks: This strata has lots of commission errors (all grades were 1). These were found in small islands (Figure 19), at the coastline and in urban areas.



Figure 19. An example of a commission error on a small rocky island. The turquoise polygon is the contradicting area derived from the GIS comparison of in-situ data and the HRL IMD18. HRL IMD18 data is presented with shades of red. SAMPLE_ID 137, scale 1:1500, coordinates (ETRS_1989_LAEA) E:5258617, N:4260533, ortophoto reference year 2017.

Un-vegetated agricultural fields, arable land & Agriculture areas around built-up:

These strata were poorly detected in the HRL IMD18 data and all sites checked had commission errors (grade 1). The example is from an un-vegetated and possibly already harvested fields (Figure 20).

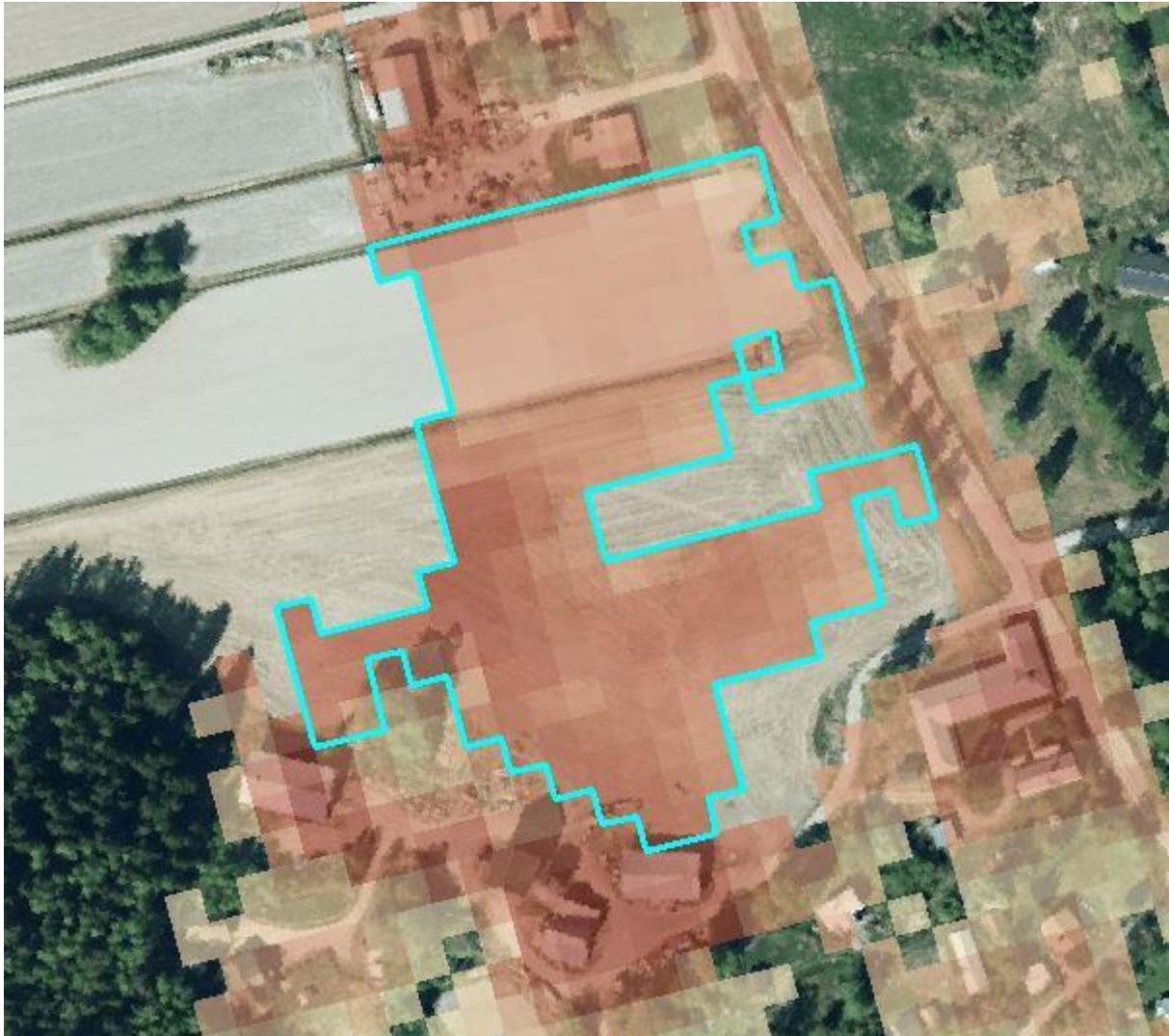


Figure 20. An un-vegetated (top part of the polygon) and an already harvested (bottom of the turquoise polygon, with stripes as marks from a tractor) field with commission errors. The turquoise polygon is the contradicting area derived from the GIS comparison of in-situ data and the HRL IMD18. HRL IMD18 data is presented with shades of red. SAMPLE_ID 154, scale 1:2000, coordinates (ETRS_1989_LAEA) E:4916800, N:4506758, orthophoto reference year 2018.

Natural, artificial and cultivated vegetated areas: Only artificial vegetated areas were checked in this strata and these include green and gravel areas of urban parks (Figure 21). The overall quality of the strata was varied (grades 2-4).

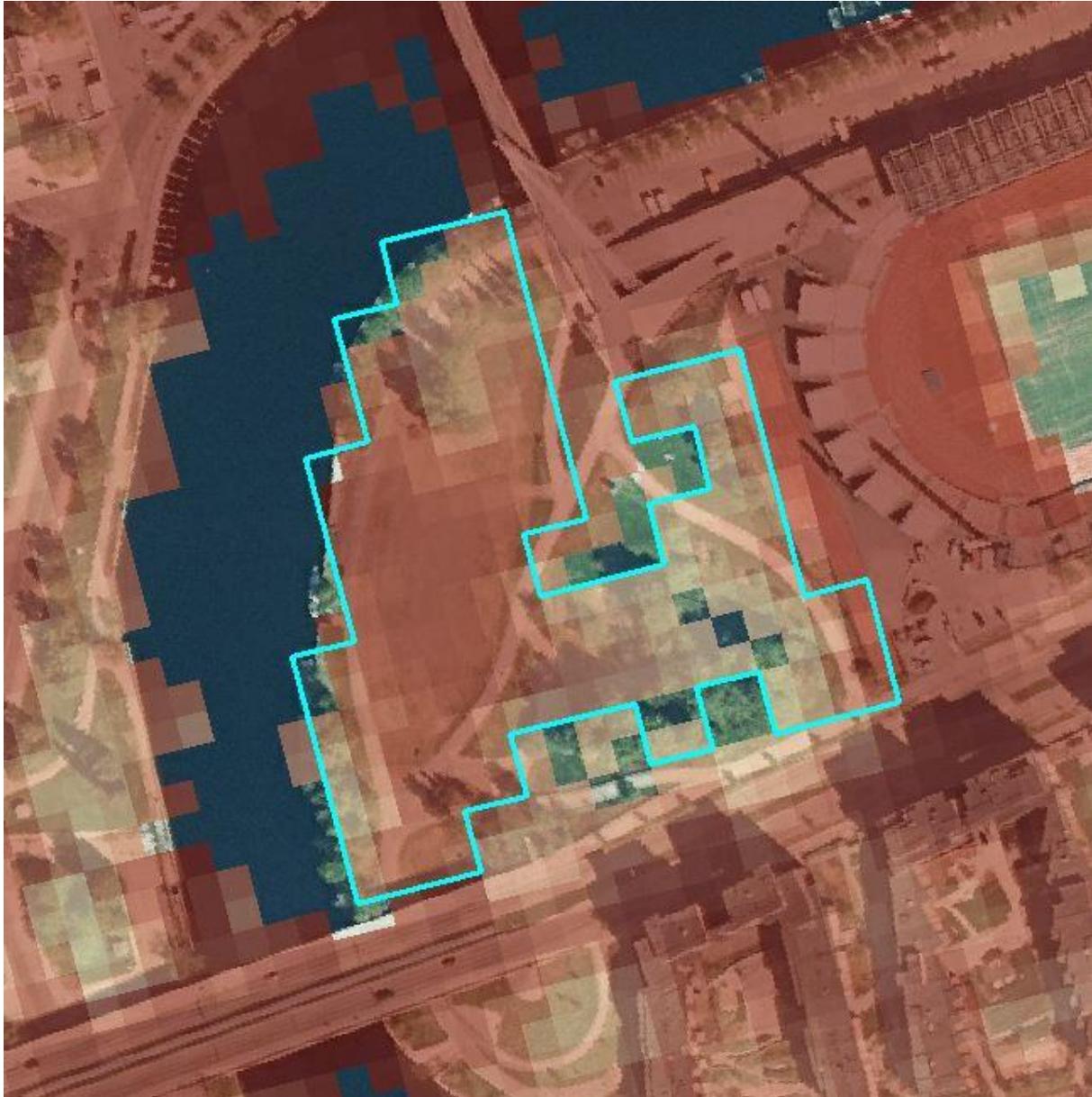


Figure 21. An urban park where grassy areas as well as gravel roads are classified as impervious. The turquoise polygon is the contradicting area derived from the GIS comparison of in-situ data and the HRL IMD18. HRL IMD18 data is presented with shades of red. SAMPLE_ID 191, scale 1:2000, coordinates (ETRS_1989_LAEA) E:5051149, N:4337194, orthophoto reference year 2018.

Fruit plantations: Apple orchards were checked in this strata. They were well identified in the HRL IMD18 data (grades 4-5). The example is from a large apple orchard in the Åland islands (Figure 22).

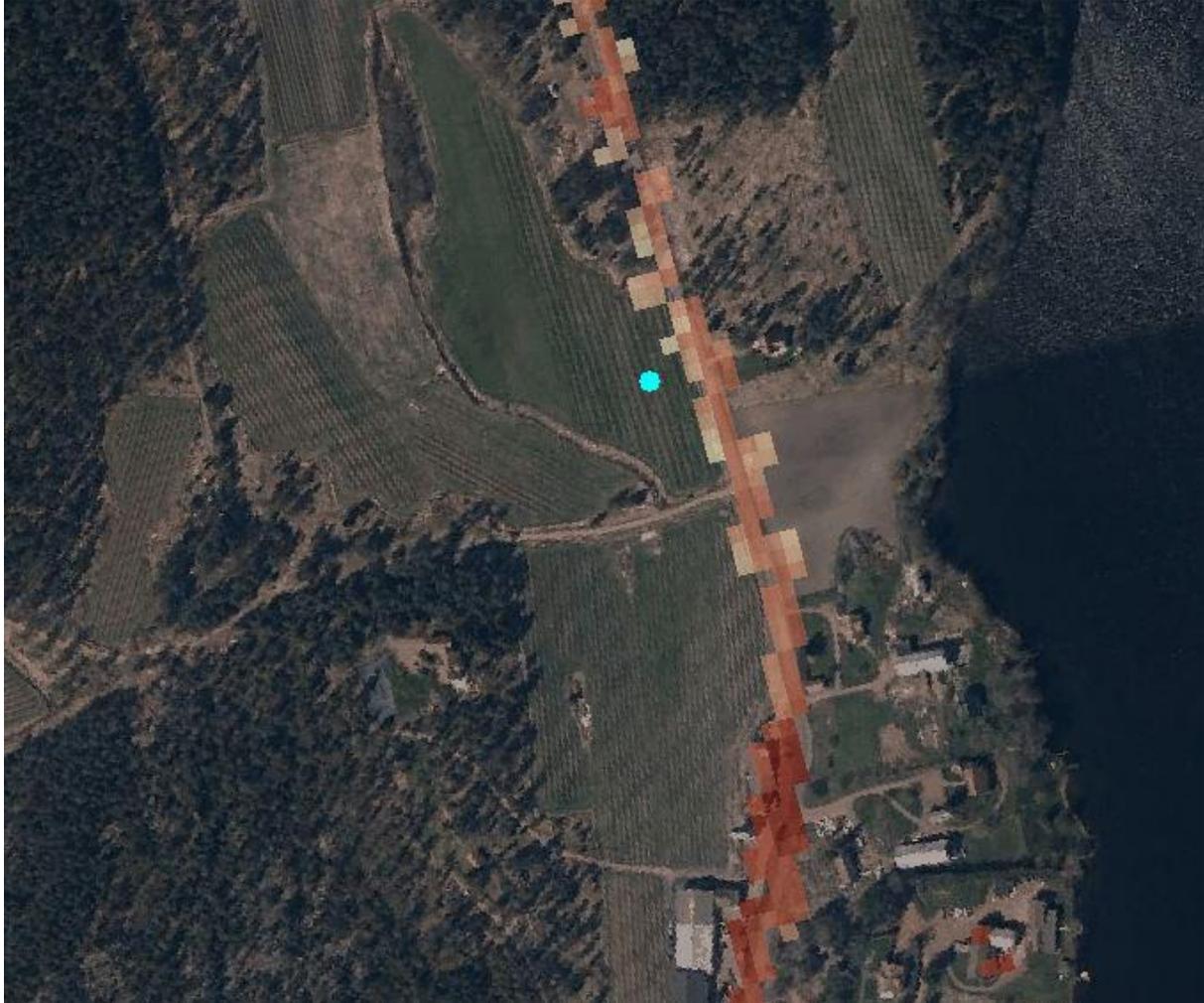


Figure 22. No commission errors can be seen in the apple orchard (striped fields). The turquoise point is indicating the contradicting area that was selected manually based on a-priori knowledge supported by visual interpretation of VHR aerial imagery. HRL IMD18 data is presented with shades of red. SAMPLE_ID 290, scale 1:4000, coordinates (ETRS_1989_LAEA) E:4868608, N:4176773, orthophoto reference year 2018.

Railway tracks not associated to other impervious surfaces (i.e. outside built-up area):
This strata was mostly misclassified as impervious (grades 1-2), especially close to urban areas (Figure 23).



Figure 23. Parts of the railway tracks located outside the urban area are misclassified as impervious. The turquoise polygon is the contradicting area derived from the GIS comparison of in-situ data and the HRL IMD18. HRL IMD18 data is presented with shades of red. SAMPLE_ID 201, scale 1:20000, coordinates (ETRS_1989_LAEA) E:4983158, N:4592834, orthophoto reference year 2018.

Sport fields, recreation areas with grass cover: Mostly areas with gravel and sand cover were evaluated here. Majority of the contradicting areas checked were unpaved horse tracks and associated unpaved areas (Figure 24). The quality of the HRL IMD18 data in the location was varied (grades 1-5).

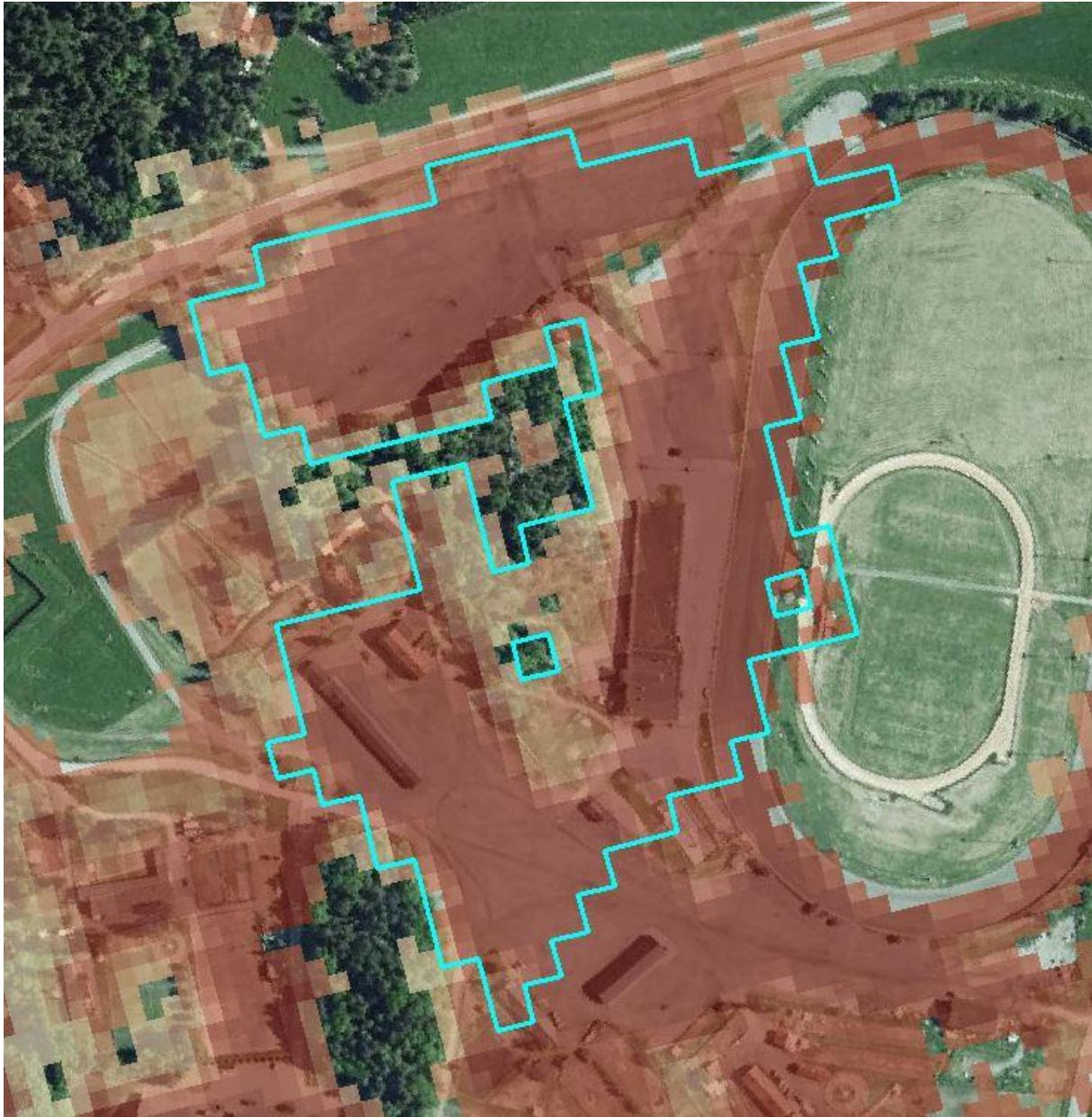


Figure 24. An unpaved horse track and associated unpaved areas are erroneously classified as impervious. The turquoise polygon is the contradicting area derived from the GIS comparison of in-situ data and the HRL IMD18. HRL IMD18 data is presented with shades of red. SAMPLE_ID 217, scale 1:3000, coordinates (ETRS_1989_LAEA) E:4997489, N:4214130, ortophoto reference year 2017.

Glaciers, snow, water: Snow and water were checked in this strata. The former were sites in northern Finland where snow stays all year along (Figure 25). There were no commission errors in either (grade 5).



Figure 25. A permanently snow-covered area in northern Finland. These sites were correctly classified as non-impervious. The turquoise polygon is the area checked that was located with in situ data. HRL IMD18 data is presented with shades of red. SAMPLE_ID 226, scale 1:4000, coordinates (ETRS_1989_LAEA) E:5088778, N:5109111, orthophoto reference year 2018.

VI. Statistical verification (optional)

<p>Description of methodology and software</p>	<p>Statistical verification was performed using GIS-software. Samples were selected with Matlab (rand-function) and they were validated against national in-situ datasets using ArcMap 10.8. Random samples were selected as following:</p> <ul style="list-style-type: none"> - All non-impervious areas: 300 samples were selected from stratified non-impervious (0%) area of the HRL IMD18 data. One (1) sample was excluded due to positional shift in the data (referring to the recommendations in the guidelines: page 72, footnote 18). This point was left in the data but not included in the analysis, thus total number of samples in the analysis was 299. - Low imperviousness: 300 samples were selected from the low-impervious area (1-29%) of the HRL IMD18 data. Six (6) samples were excluded due to positional shift in the data (referring to the recommendations in the guidelines: page 72, footnote 18). These points were left in the data but not included in the analysis, thus total number of samples in the analysis was 294. - High imperviousness: 300 samples were selected from the high-impervious area (30-100%) of the HRL IMD18 data. There was 1 overlapping point, thus final number of validated pixels was 299. Four (4) samples were excluded due to positional shift in the data (referring to the recommendations in the guidelines: page 72, footnote 18). These points were left in the data but not included in the analysis, thus total number of samples in the analysis was 295. <p>These sample pixels were checked against relevant in-situ datasets and assessed as correct/incorrect. In case of incorrect, an accurate class was given. For all checked pixels, comments on the land cover of the location was given. These pixels are attached to the report (IMD2018_QuantitativeSamples_FI.shp).</p> <p>The results of the statistical verification were used as an input to the Map Accuracy Tool using following steps:</p> <p>Step1: Create a matrix with the probabilities (number of samples in a raster cell / sum of row)</p> <p>Step 2: Convert probabilities to areas (area of stratum * probability)</p> <p>Step 3: Calculate Producer accuracies (area of agreement / sum area in the column)</p> <p>This way the areas of the different strata were used as weights in the tool to calculate Producer's accuracies. These areas were:</p> <ul style="list-style-type: none"> - non-impervious: 4157km² - low imperviousness: 2237km² - high imperviousness: 2177km² <p>These steps are also demonstrated in the attached Excel-file: IMD2018_MapAccuracyToolResults.xlsx</p>
--	--

Stratification	Stratification was used to select non-impervious sample points. These points were selected from an area, that national in-situ data indicates to be built/impervious but is non-impervious according to the HRL IMD18 data. The in-situ data used was the National High Resolution Corine Land Cover data for year 2018. Classes considered to be built up were 111=Continuous urban fabric, 112=Discontinuous urban fabric, 121=Industrial or commercial units, 122=Road and rail networks and associated land, 123=Port areas, 124=Airports. This area was in total 4157 km2.
Comments	

Confusion Matrix

		Reference Data			UserAccuracy	UserAccuracyVariance
		Non-impervious	Low imperviousness	High imperviousness		
Classification Data	Non-impervious	3351	542	264	80,61 %	0,01202
	Low imperviousness	1210	631	396	28,21 %	0,018653
	High imperviousness	620	332	1225	56,27 %	0,020843
	Weights	4157	2237	2177		
ProducerAccuracy		64,68 %	41,93 %	64,99 %		
ProducerAccuracyVariance		0,008452	0,021994	0,018243		
PortmanteauAccuracy		69,25 %	71,07 %	81,19 %		
PortmanteauAccuracyPartial		55,97 %	20,28 %	43,18 %		

OverallAccuracy	0,607514
OverallAccuracyVariance	0,009258
AllocationDisagreement	0,273014
Shift	0,007467
Exchange	0,265547
QuantityDisagreement	0,119473
AMI	0,200543

AMIAdjusted	0,200543
AMIVariance	0,01541
Kappa	0,351405
KappaVariance	0,016537