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Executive summary

This report is the continuation of a series of triennial crop reports first produced in 1997 with the aim of accurately measuring irrigation status and development in the Mallee catchment.

The Mallee catchment has irrigated horticulture along the Murray River from Woorinen South to the South Australian border and in the Murrayville Groundwater Management Area (GMA). This report is the first of the series to include Murrayville GMA irrigation and irrigation at Woorinen South and west of Swan Hill that has expanded into the Mallee catchment. The mapping and information presented has been amended to include these additional irrigation areas where applicable to each of the report years from 1997 to 2018.

Key findings from the report

Crop types in 2018

Almond trees were the dominant crop in the Mallee catchment in 2018, with 99% of plantings grown in the private diverter river reaches.

The main crops, in order of dominance in the Mallee catchment, were:

1. almonds; 24,485 hectares (30% of the irrigable area) predominantly grown in the Boundary Bend and Wemen river reaches;
2. table grapes; 8,965 hectares (11% of the irrigable area) predominantly grown in the Robinvale and Mildura irrigation districts;
3. wine grapes; 8,050 hectares (10% of the irrigable area) predominantly grown in the Colignan to Koorlong river reach and the Red Cliffs irrigation district;
4. field crops; 5,685 hectares (7% of the irrigable area) predominantly grown in the Nyah and Boundary Bend river reaches;
5. citrus; 4,135 hectares (5% of the irrigable area) predominantly grown in the Colignan to Koorlong river reach;
6. olives; 3,815 hectares (5% of the irrigable area) predominantly grown in the Boundary Bend river reach;
7. potatoes; 3,410 hectares (4% of the irrigable area) predominantly grown in the Boundary Bend river reach and the Murrayville Groundwater Management Area;
8. dried grapes; 3,145 hectares (4% of the irrigable area) predominantly grown in the Colignan to Koorlong river reach and the Mildura and Merbein irrigation districts; and
9. vegetables other than carrots and potatoes, 2,685 hectares (3% of the irrigable area) predominantly grown in the Wemen and Colignan river reaches.

Crop types 1997 to 2018

Almond trees were the dominant crop in the Mallee catchment from 2009 to 2018, while wine grape plantings were dominant from 1997 to 2006.

Almond trees increased by 22,740 hectares; a 1303% increase from 1,745 hectares in 1997 to 24,485 hectares in 2018. Plantings of table grapes and olives also increased significantly, by 4,810 hectares and 3,655 hectares respectively.

From 1997 to 2018, the largest removal of plantings was in dried and wine grape plantings with a net decrease of 3,195 hectares and 1,915 hectares respectively.

Key findings from the report

Table 1 shows the dominant crop in 1997 and in 2018 for each study area.

Table 1: Change in the dominant crop in each study area from 1997 to 2018

Study area	1997	2018		
	dominant crop	dominant crop	hectares	% of the study area's irrigable area
Nyah irrigation district	wine grapes	wine grapes	455	29%
Robinvale irrigation district	table grapes	table grapes	2,080	86%
Red Cliffs irrigation district	wine grapes	wine grapes	1,090	25%
Mildura irrigation district	dried grapes	table grapes	1,955	34%
Merbein irrigation district	dried grapes	dried grapes	635	21%
Nyah private diverters	field crops	almonds	2,935	30%
Boundary Bend private diverters	field crops	almonds	11,040	50%
Wemen private diverters	carrots	almonds	7,475	59%
Colignan private diverters	wine grapes	citrus	3,125	26%
Mildura private diverters	wine grapes	table grapes	440	22%
Lock 10 to SA private diverters	almonds	almonds	1,845	58%
Murrayville GMA	potatoes	potatoes	1,670	70%
Mallee catchment total	wine grapes	almonds	24,485	30%

Development of permanent plantings (new or redeveloped in the previous three years)

In 1997, 2003, 2006 and 2009, at least 21% of permanent crops were new or redeveloped, having been planted or top-worked in the previous three years.

Development activity fell to 9% of permanent plantings in 2012 and 10% in 2015, but by 2018, activity was again on the increase with at least 17% (9,295 ha) of new plantings, three years old or younger. These new plantings were predominantly: almonds (4,100 ha), table grapes (2,200 ha), citrus (640 ha), olives (620 ha), dried grapes (610 ha), wine grapes (320 ha) and pistachios (200 ha).

Planting trends - permanent plantings, seasonal crops and vacant areas

From 1997 to 2018, the irrigable area in the Mallee catchment increased by 40,825 hectares, from 40,325 hectares to 81,150 hectares. The irrigable area includes permanent plantings, seasonal crops and vacant areas. Vacant areas are not irrigated, they may be in redevelopment, abandoned or eventually retired from irrigation.

There was little change in the proportion of permanent plantings, from 69% of the irrigable area in 1997 to 68% in 2018. However, seasonal cropping decreased from 28% of the irrigable area in 1997 to 16% in 2018 and vacant areas increased from 3% of the irrigable area in 1997 to 15% in 2018.

The proportion of vacant, not irrigated areas was up to 20% of the irrigable area by 2009 when drought conditions and high water prices had an impact on irrigation activity. Activity improved slightly in 2012 and 2015 with a drop to 17% of the irrigable area vacant, mostly due to an increase in the area of irrigated seasonal cropping. Renewed activity in development of permanent plantings from 2015 to 2018 saw the proportion of vacant areas drop to 15%.

In 1997, 57% of permanent crops were in the pumped irrigation districts, but by 2018, 79% were in the private diverter river reaches.

Key findings from the report

Table 2 shows the proportion permanent plantings, seasonal crops and vacant areas across the Mallee catchment from 1997 to 2018.

Table 2: Planting trends in the Mallee catchment from 1997 to 2018

Mallee catchment	1997	2003	2006	2009	2012	2015	2018
% Permanent	69%	70%	71%	71%	68%	67%	68%
% Seasonal	28%	24%	19%	9%	15%	16%	16%
% Vacant, not irrigated	3%	6%	10%	20%	17%	17%	15%
Total irrigable area (hectares)	40,325	51,350	59,450	72,255	75,280	76,245	81,150

Irrigation development - new and retired areas

The irrigable area in the Mallee catchment increased by 40,825 hectares; a 101% increase from 40,325 hectares in 1997 to 81,150 hectares in 2018. The net increase of 40,825 hectares was the balance of 42,715 hectares expansion and 1,890 hectares retired from irrigation.

Expansion was predominantly in the private diverter river reaches where 39,940 hectares of expansion occurred, while retirement predominantly occurred in the irrigation districts where 1,205 hectares were retired from irrigation between 1997 and 2018.

From 1997 to 2018, the largest growth in irrigable area occurred in the Boundary Bend and Wemen river reaches with expansion of 16,550 hectares and 10,550 hectares respectively.

Irrigation methods

In 2018, drippers were the dominant irrigation method in all of the study areas except for the Robinvale irrigation district where lowlevel sprinklers were dominant and in the Murrayville GMA where pivots were the dominant method.

Drip irrigation was the dominant irrigation method from 2006 to 2018 across the Mallee catchment. Prior to this, overhead sprinklers were dominant in 2003 and furrow/flood irrigation in 1997.

The use of pressurised systems (drip, low level and overhead irrigation) increased from 61% of the irrigated area in 1997 to 97% in 2018. Gravity systems (furrow and flood) decreased from 39% of the irrigated area in 1997 to 3% in 2018.

Salinity impact zones (*does not apply to the Murrayville GMA*)

In 1997, the irrigable area in the Mallee catchment (excluding the Murrayville GMA) was predominantly (29%) in the high salinity impact zone, HIZ. However, from 2003 to 2018 it was predominantly in the lowest river salinity impact zone, L1, as most expansion in this period occurred in L1 and areas retired from irrigation were mostly in HIZ.

From 1997 to 2018, the irrigable area in HIZ decreased by 840 ha; a 7% decrease from 11,435 ha to 10,595 ha, while the area in LIZ (i.e. L1, L2, L3 and L4) increased by 39,875 ha; a 120% increase from 28,305 ha to 68,180 ha.

By 2018, the irrigable area in the Mallee catchment of 78,775 ha was 51% (40,470 ha) in L1, 20% (15,500 ha) in L2, 3% (2,480 ha) in L3, 12% (9,730 ha) in L4 and 13% (10,595 ha) in the high impact zone, HIZ.

Key findings from the report

Irrigation properties

In 2018, there were approximately 1,925 irrigation properties in the Mallee catchment with an average irrigable area of 42 hectares. 77% of properties were in the pumped irrigation districts, 22% were private diverters and 1% Murrayville GMA irrigators.

Average property size (irrigable area) in the private diverter areas increased from 45 hectares in 1997 to 143 hectares in 2018, while in the pumped districts it increased from 9 hectares to 11 hectares. In the Murrayville GMA, it increased from approximately 84 hectares to 183 hectares.

Across the Mallee catchment from 1997 to 2018, the number of properties decreased by 523, while property size (irrigable area) increased from 16 hectares to 42 hectares. Properties with an irrigable area less than 20 hectares decreased by 586, while the number over 20 hectares increased by 63.

Introduction

This report was commissioned by the Mallee Catchment Management Authority (Mallee CMA) to provide an accurate snapshot of irrigation status and change in the Mallee catchment. Information from the report enhances understanding of the dynamics of irrigation and its impact on salinity and water quality.

The Mallee catchment has irrigated horticulture along the Murray River from Woorinen South to the South Australian border and in the Murrayville Groundwater Management Area (GMA). This report is the first of the series to include Murrayville GMA irrigation and irrigation at Woorinen South and west of Swan Hill that has expanded into the Mallee catchment.

Purpose of the report

The report will inform the Mallee CMA with respect to:

- Monitoring and evaluating implementation of the Victorian Mallee Irrigation Region - Land and Water Management Plan (LWMP);
- Planning for future irrigation modernisation programs;
- Analysis and modelling of salinity impacts from new irrigation development;
- Mallee region reporting to State and Commonwealth Governments including review of regional items on the Basin Salinity Management Strategy registers;
- Achieving high-level, long-term goals of the Mallee Regional Catchment Strategy 2013-2019. Specifically:
  - 'To protect and enhance the environmental values of the Mallee's watercourses and their associated riparian ecosystems and, in turn, the social, economic and environmental services that they provide to the community';
  - 'To protect and enhance the environmental values of the Mallee's wetlands and, in turn, the social, economic and environmental services that they provide to the community'; and
  - 'To optimise the productive capacity of Mallee agricultural landscapes, while minimising any adverse impacts of associated management practices (both current and historical) on our natural and cultural landscapes'.
- Investment priorities of State programs, in particular Sustainable Irrigation Program priorities:
  - Reduce the adverse environmental impacts of irrigation;
  - Increase the capacity of the irrigation sector to respond to a variable water future; and
  - Guide irrigation rationalisation and consolidation in a water scarce future to maximise productive, social and environmental benefits of irrigation water use and enhance the resilience of regional communities.

Method

SunRISE Mapping and Research - crop mapping

SunRISE crop mapping is captured to the individual patch or variety level using a map base of high-resolution aerial imagery (scale accurate imagery processed from aerial photography). Details for each crop patch such as type, variety, year planted and irrigation method are collected from irrigators, field surveys and aerial imagery interpretation. Some details are discernible from the imagery while others, such as variety, are only obtainable from irrigators.

Details are also collected in collaboration with local agencies and industry bodies to support specific programs, such as planting statistics for industry planning and management, and spatial information for infrastructure development, biosecurity, economic assessments and environmental monitoring.

SunRISE records crop and property details from irrigators on an on-going basis. This is generally in response to mapping and information needs for property planning and development, such as irrigation design, redevelopment, property sales, soil surveys, spray records, export registration, organic certification and environmental management. The privacy of individual property details is maintained and only aggregated information is published.

Details provided by irrigators are more accurate and comprehensive than those derived from imagery interpretation. As more details are collected, earlier databases are backfilled where relevant; hence, the databases are continually improved. This may mean that information in current reports varies slightly from older reports.

Aerial imagery

SunRISE crop mapping is based on aerial imagery that has been updated every three years since 1997 (Figure 1).

Figure 1: Three-yearly aerial imagery used by SunRISE to map irrigated horticulture

Method

Irrigation areas in the Mallee catchment

The Mallee catchment has irrigated horticulture along the Murray River from Woorinen South to the South Australian border and in the Murrayville Groundwater Management Area (GMA). This report is the first of the series to include irrigation in the Murrayville GMA, and irrigation at Woorinen South and Swan Hill that has expanded west into the Mallee catchment.

A separate chapter is included in this report for the Murrayville GMA. Irrigation areas at Woorinen South and west of Swan Hill are included as private diverters in the 'Nyah river reach' study area. Hence, areas for the Nyah river reach are greater in this 2018 report than in earlier reports.

Irrigation seasons

Information presented in this report is for the years: 1997, 2003, 2006, 2009, 2012, 2015 and 2018. The aerial imagery used for each of these years was captured at the start of the year. Hence the information represents the 1996-97, 2002-03, 2005-06, 2008-09, 2011-12, 2014-15 and 2017-18 irrigation seasons respectively.

The 2018 crop mapping is based on imagery acquired between 31st December 2017 and 9th January 2018 by the Coordinated Imagery Program, Department of Environment, Land, Water and Planning.

Positional and area accuracies

The aerial imagery is generally processed to sub-metre positional accuracy and the crop mapping has been captured at a scale of 1:2,000 or better from the imagery.

Hectares for seasonal plantings of vegetables and field crops (such as pasture) have a lesser reliability as the imagery provides only one snapshot of the season, making it difficult to determine irrigation activity in a given season. This is particularly the case for the Murrayville Groundwater Management Area (GMA) where 98% of crops are seasonal and limited imagery was available for the area. Information for the Murrayville GMA should be treated as estimates only.

Hectare totals were rounded to the nearest five hectares.

Development of permanent crops

The report includes information on permanent crops planted or redeveloped in the previous three-year period.

The purpose of the information is to provide an indication of development activity that is otherwise not evident in information on changes in areas and crop types. Particularly in the pumped irrigation districts where expansion of the irrigable area is limited, it may appear that little development has occurred; however, redevelopment and top-working to different varieties can be significant. Little change in net crop type areas does not mean that there is little development or redevelopment activity.

Development activity, including redevelopment, with respect to permanent plantings is relatively easy to measure from the mapping databases, but it does not account for all activity. Hence, the information on three-year development in permanent plantings is an indication only of the level of activity. In addition, the figures are conservative, as top-worked plantings can be difficult to interpret from the three-yearly aerial imagery.

Definitions

The following definitions apply in this report.

Irrigable area Irrigable area is the irrigated area and vacant, not irrigated areas that were irrigated and still could be irrigated. Some vacant areas may eventually be retired or they may be in redevelopment. An increase in irrigable area can arise from new 'greenfield' development and/or from an increase in the area irrigated following redevelopment and the removal of furrow irrigation, drying racks etc.

Property One property is a holding with the one owner or corporate entity. A property generally comprises more than one 'farm', 'fruit block' or land parcel. Property numbers are determined from grower/owner input and are estimates only due to difficulties in maintaining change in ownership details.

Some property owners irrigate in more than one irrigation district or river reach. Hence, property numbers across the Mallee catchment are less than the sum of property numbers for each of the study areas.

Retired Areas 'retired' from irrigation have undergone a change in land use that precludes them from being irrigated. SunRISE generally relies on updated aerial imagery, or digital cadastre, for evidence of land use change such as residential development, buildings, sheds and dams. Areas set aside for conservation purposes are also 'retired' from the crop mapping. 'Retired' areas are excluded from the 'irrigable' area.

Vacant The crop mapping includes a crop type of 'vacant'. Vacant areas were irrigated, but not in the season that the crop mapping refers to. Where the vacant area was previously a permanent planting, it is termed **Vacant P**. Where the vacant area was previously a seasonal planting, such as pasture or vegetables, it is termed **Vacant S**.

Salinity impact zones Salinity impact zones are mapped zones in north-west Victoria that correlate to tonnes of salt displaced to the Murray River from new irrigation. Salinity impact zones in this report refer to 'Salinity Offset Charging Zones'; comprising four low impact zones (L1, L2, L3 and L4) and one high impact zone (HIZ).

Charging zones are used to determine levy charges for new developments, and have been used in this study, for ease of presentation, rather than the twelve 'Salinity Accountability Zones' (seven low impact zones and 5 high impact zones) which are used for reporting river salinity impacts to the Murray-Darling Basin Authority (salinity register).

The relationship between salinity offset charging zones and salinity accountability zones is shown in Table 3.

Table 3: Salinity impact zones

	Salinity offset charging zones	Salinity accountability zones
Low salinity impact zones	L1	LIZ 1, LIZ 2
	L2	LIZ 3
	L3	LIZ 4, LIZ 5
	L4	LIZ 6, LIZ 7
High salinity impact zones	HIZ	HIZ 1, HIZ 2, HIZ 3, HIZ 4, HIZ 5

Crop type descriptions

Table 4 describes the main crops irrigated in the Mallee catchment and how they were grouped for this report.

Table 4: Description of irrigated crop types and categories

	Crop type	Category	Description
Permanent plantings	Grapevine	Dried	
		Table	
		Wine	Includes a very small proportion of juiced grapes
	Citrus		Grapefruit, lemon, lime, mandarin, navel, blood orange, other, pummelo, tangelo, valencia
	Fruit tree	Olive	
		Other	Avocado, date palm, fig, jujube, mango, persimmon, pome fruit, pomegranate, stone fruit
	Nut tree	Almond	
		Other	Pecan, pistachio, walnut
	Other	Miscellaneous	Aquaculture, flowers, herbs, mushroom, native plants, nursery, passionfruit, strawberry, tree plantation
	Permanent crops		
Seasonal crops	Field crop		Canola, cereal, cover crop, lucerne, lupin, maize, pasture, turf
	Vegetable	Carrot	
		Potato	
		Other	Asparagus, bean, beetroot, broccoli, cabbage, capsicum, cauliflower, chili, cucumber, eggplant, garlic, lettuce, melon, onion, pea, pumpkin, salad greens, sweet corn, tomato, zucchini
	Seasonal crops		
	Vacant P		Vacant (not irrigated), previously an irrigated permanent planting
	Vacant S		Vacant (not irrigated), previously an irrigated seasonal crop

Irrigation type descriptions

Irrigation methods are grouped as drip, lowlevel, overhead and furrow as described in Table 5.

Many irrigators use dual systems, such as drip with overhead sprinklers or cooling sprays; however, only the main irrigation method is used in this report.

Table 5: Description of irrigation methods

Irrigation method	Description
Drip	Including; subsurface-drip, trickle
Lowlevel	Including; micro jet, micro sprinkler, sprinkler, waterbird
Overhead	Including; pivot, travel (lateral move)
Furrow	Gravity systems including flood
Vacant	Vacant (not irrigated) areas that were previously irrigated and could still be irrigated

Study area

The report covers twelve study areas in the Mallee catchment: five pumped irrigation districts, six river reaches of private diverters and the Murrayville Groundwater Management Area (GMA) as shown in Map 1. All references to the 'Mallee catchment' in this report refer to the twelve study areas (i.e. includes the Murrayville GMA).

Pumped irrigation districts

1. Nyah irrigation district
2. Robinvale irrigation district
3. Red Cliffs irrigation district
4. Mildura irrigation district
5. Merbein irrigation district

River reaches (private diverters)

6. Nyah river reach - Woorinen South to the Wakool River junction
7. Boundary Bend river reach - Wakool River junction to the Euston weir
8. Wemen river reach - Euston weir to Liparoo
9. Colignan river reach - Colignan to Yatpool
10. Mildura river reach - Mildura to Lock 10
11. Lock 10 to SA river reach - Lock 10 to the South Australian border

Murrayville Groundwater Management Area (GMA)

12. Murrayville GMA

Map 1: Map of the twelve study areas in the Mallee catchment

1. Mallee catchment summary

In summary for irrigated horticulture in the Mallee catchment from 1997 to 2018

Crop types 2018

In 2018, dominant plantings in the Mallee catchment were:

1. almonds; 24,485 ha (30% of the irrigable area);
2. table grapes; 8,965 ha (11% of the irrigable area);
3. wine grapes; 8,050 ha (10% of the irrigable area);
4. field crops; 5,685 ha (7% of the irrigable area);
5. citrus; 4,135 ha (5% of the irrigable area);
6. olives; 3,815 ha (5% of the irrigable area);
7. potatoes; 3,410 ha (4% of the irrigable area);
8. dried grapes; 3,145 ha (4% of the irrigable area); and
9. vegetables other than carrots and potatoes[1], 2,685 ha (3% of the irrigable area).

Crop types 1997 to 2018

Almond trees were the dominant crop from 2009 to 2018, whereas wine grape plantings were dominant from 1997 to 2006.

The main changes to plantings from 1997 to 2018 were:

- almond trees increased by 22,740 ha; from 1,745 ha to 24,485 ha;
- table grape plantings increased by 4,810 ha; from 4,155 ha to 8,965 ha;
- olive trees increased by 3,655 ha; from 160 ha to 3,815 ha;
- dried grape plantings decreased by 3,195 ha; from 6,340 ha to 3,145 ha; and
- wine grapes decreased by 1,915 ha; from 9,965 ha to 8,050 ha.

Development of permanent plantings (new or redeveloped in the previous three years)

Development activity with respect to permanent plantings continued to increase from 1997 to 2009; 21% of plantings were new or redeveloped[2] in 1997 and 31% in 2009. Development fell to 9% in 2012 and 10% in 2015, but by 2018, activity was again on the increase with at least 17% (9,295 ha) of new plantings, predominantly:

1. almonds (4,100 ha);
2. table grapes (2,200 ha);
3. citrus (640 ha);
4. olives (620 ha);
5. dried grapes (610 ha);
6. wine grapes (320 ha); and
7. pistachios (200 ha).

[1] Carrots and potatoes are significant crops in the Mallee catchment and are reported on separately to 'other' vegetables

[2] New or redeveloped within the previous three years

In summary for irrigated horticulture in the Mallee catchment

Planting trends - permanent plantings, seasonal crops and vacant areas

In 2018, the Mallee catchment had an irrigable area of 81,150 ha comprising:

- 68% (55,470 ha) permanent plantings;
- 16% (13,320 ha) seasonal crops; and
- 15% (12,360 ha) vacant, not irrigated areas.

From 1997 to 2018:

- permanent plantings decreased from 69% to 68% of the irrigable area;
- seasonal crops decreased from 28% to 16% of the irrigable area; and
- vacant, not irrigated areas increased from 3% to 15% of the irrigable area.

Private diverters accounted for 79% of permanent plantings and 73% of seasonal crops in 2018.

Irrigation development - new and retired areas

The irrigable area in the Mallee catchment increased by 40,825 ha, a 101% increase from 40,325 ha in 1997 to 81,150 ha in 2018. The net increase of 40,825 ha was the balance of 42,715 ha expansion and 1,890 ha retired from irrigation.

Expansion was predominantly in the private diverter river reaches (39,940 ha) while retirement predominantly occurred in the irrigation districts (1,205 ha).

Irrigation methods

Drip irrigation was the dominant irrigation method in the Mallee catchment from 2006 to 2018. Prior to 2006, overhead sprinklers were dominant in 2003 and furrow irrigation was dominant in 1997.

In 2018, the irrigable area of 81,150 ha comprised:

- 58% (47,105 ha) drip irrigation;
- 10% (8,495 ha) lowlevel irrigation;
- 13% (10,930 ha) overhead sprinklers and pivots;
- 3% (2,260 ha) furrow irrigation; and
- 15% (12,360 ha) vacant, not irrigated.

From 1997 to 2018 (Figure 2):

- drip irrigation increased by 43,140 ha; a 1,088% increase from 3,965 ha to 47,105 ha;
- lowlevel irrigation increased by 2,590 ha; a 44% increase from 5,905 ha to 8,495 ha;
- overhead irrigation decreased by 3,105 ha; a 22% decrease from 14,035 ha to 10,930 ha; and
- furrow irrigation decreased by 12,970 ha, an 85% decrease from 15,230 ha to 2,260 ha.

In summary for irrigated horticulture in the Mallee catchment

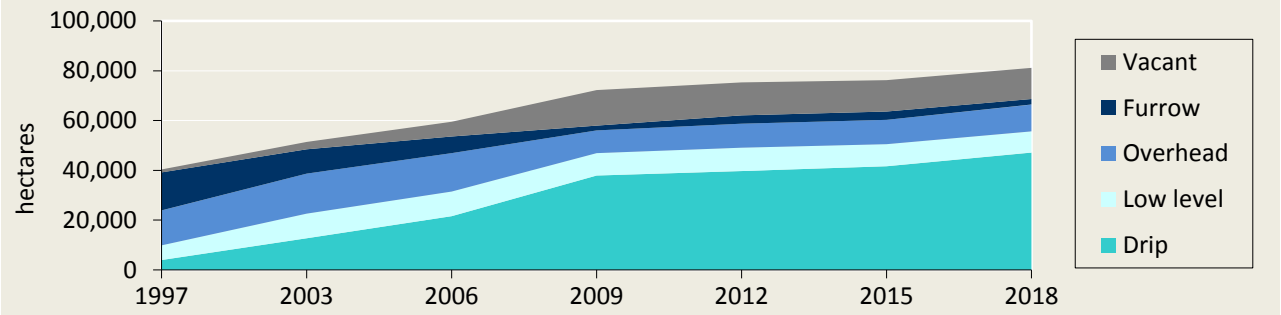


Figure 2: Change in irrigation methods from 1997 to 2018 in the Mallee catchment

Salinity impact zones (*does not apply to the Murrayville GMA*)

The irrigable area in the Mallee catchment was predominantly in the lowest river salinity impact zone, L1, from 2003 to 2018, whereas in 1997 it was predominantly (29%) in the high impact zone, HIZ (Figure 3).

In 2018, the irrigable area of 78,775 ha comprised:

- 51% (40,470 ha) in L1;
- 20% (15,500 ha) in L2;
- 3% (2,480 ha) in L3;
- 12% (9,730 ha) in L4; and
- 13% (10,595 ha) in the high impact zone, HIZ.

From 1997 to 2018 the irrigable area in:

- HIZ decreased by 840 ha, a 7% decrease from 11,435 ha to 10,595 ha (the net decrease was the balance of HIZ areas retired from irrigation and expansion on existing HIZ properties); and
- L1 to L4 increased by 39,875 ha, a 120% increase from 28,305 ha to 68,180 ha.

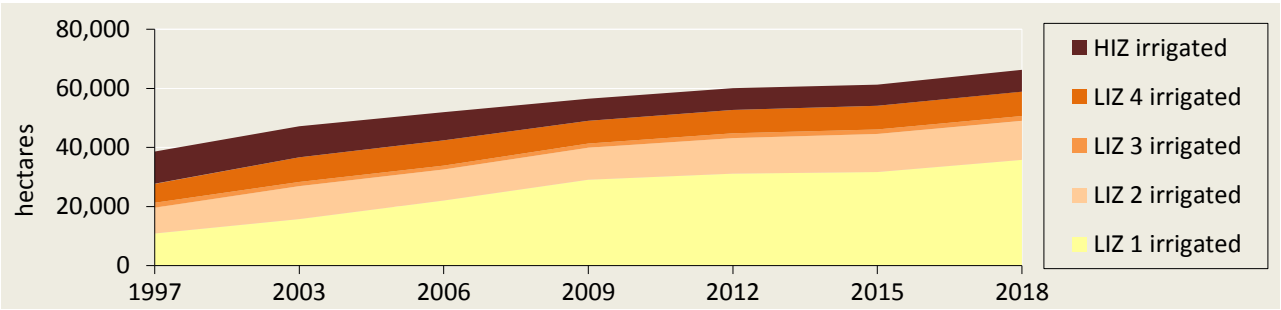


Figure 3: Change in salinity impact zones from 1997 to 2018 in the Mallee catchment

Irrigation properties

In 2018, there were approximately 1,925 irrigation properties in the Mallee catchment, with an average irrigable area of 42 ha. 77% of properties were in the pumped districts, 22% were private diverters and 1% Murrayville irrigators. From 1997 to 2018:

- the number of properties decreased by 523, while average property size (irrigable area) increased from 16 ha to 42 ha; and
- properties with an irrigable area less than 20 ha decreased by 586, while the number over 20 ha increased by 63.

1.1 Mallee catchment - crop types in 2018

Table 6 lists horticultural crops in the Mallee catchment (i.e. pumped irrigation districts, private diverter river reaches and the Murrayville GMA) in 2018.

- Dominant plantings were:
    1. almonds; 24,485 ha (30% of the irrigable area);
    2. table grapes; 8,965 ha (11% of the irrigable area);
    3. wine grapes; 8,050 ha (10% of the irrigable area);
    4. field crops; 5,685 ha (7% of the irrigable area);
    5. citrus; 4,135 ha (5% of the irrigable area);
    6. olives; 3,815 ha (5% of the irrigable area);
    7. potatoes; 3,410 ha (4% of the irrigable area);
    8. dried grapes; 3,145 ha (4% of the irrigable area);
    9. vegetables other than carrots and potatoes3; 2,660 ha (3% of the irrigable area);
    10. fruit trees other than olives; 1,800 ha (2% of the irrigable area); and
    11. carrots; 1,565 ha (2% of the irrigable area).

Table 6: Mallee catchment - irrigated crops in 2018

	Crop type	Category	2018 (ha)	2018 %	Description
Permanent plantings	Grapevine	Dried	3,145	4%	
		Table	8,965	11%	
		Wine	8,050	10%	Includes a very small proportion of juiced grapes
	Citrus		4,135	5%	Grapefruit, lemon, lime, mandarin, navel, blood orange, other, pummelo, tangelo, valencia
	Fruit tree	Olive	3,815	5%	
		Other	1,800	2%	Avocado, date palm, fig, jujube, mango, persimmon, pome fruit, pomegranate, stone fruit
	Nut tree	Almond	24,485	30%	
		Other	490	1%	Pecan, pistachio, walnut
	Other	Miscellaneous	585	1%	Aquaculture, flowers, herbs, mushroom, native plants, nursery, passionfruit, strawberry, tree plantation
	Permanent crops (sub-total)		55,425	68%	
Seasonal crops	Field crop		5,685	7%	Canola, cereal, cover crop, lucerne, lupin, maize, pasture, turf
	Vegetable	Carrot	1,565	2%	
		Potato	3,410	4%	
		Other	2,660	3%	Asparagus, bean, beetroot, broccoli, cabbage, capsicum, cauliflower, chili, cucumber, eggplant, garlic, lettuce, melon, onion, pea, pumpkin, salad greens, sweet corn, tomato, zucchini
	Seasonal crops (sub-total)		13,215	16%	
Vacant	Vacant P		6,475	8%	Vacant (not irrigated), previously an irrigated permanent crop
	Vacant S		5,885	7%	Vacant (not irrigated), previously an irrigated seasonal crop
	Total all crop areas		81,150	100%	

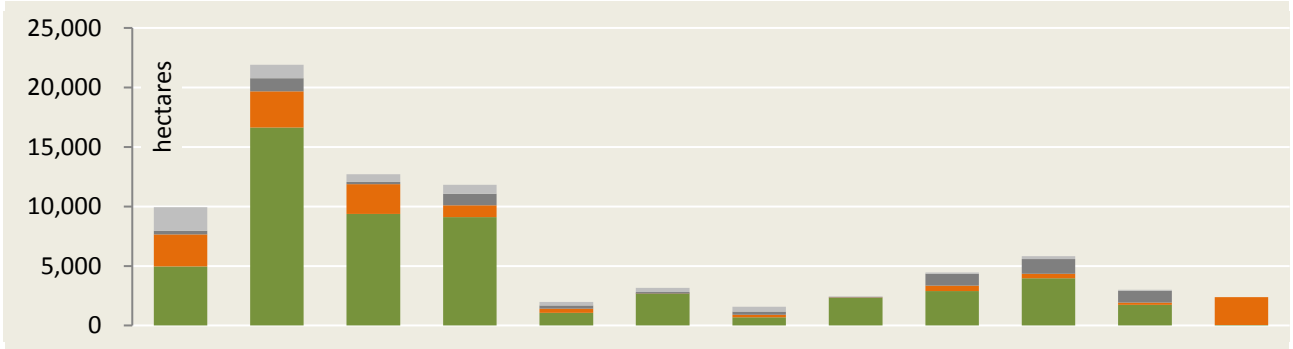
[3] Carrots and potatoes are significant crops in the Mallee catchment and are reported on separately

1.1.1 Mallee catchment - 2018 plantings in each study area

Figure 4 shows the proportion of permanent crops, seasonal crops and vacant areas in each of the Mallee catchment study areas in 2018.

- In 2018:
  - 76% of the irrigable area was in the private diverter river reaches;
  - 21% of the irrigable area was in the pumped irrigation districts; and
  - 3% of the irrigable area was in the Murrayville GMA.

- 79% of permanent plantings were irrigated in private diverter river reaches, 21% in the irrigation districts and less than 1% in the Murrayville GMA.
- 73% of seasonal crops were irrigated in private diverter river reaches, 10% in the irrigation districts and 17% in the Murrayville GMA.
- 55% of vacant areas, but previously irrigated permanent crops (Vacant P) were in the irrigation districts and 45% in the private diverter river reaches.
- 86% of vacant areas, but previously irrigated seasonal crops (Vacant S) were in private diverter areas and 14% in the irrigation districts.



	Nyah	Boundary Bend	Wemen	Colignan	Mildura	Lock 10 to SA	Nyah	Robin-vale	Red Cliffs	Mildura	Merbein	Murray-ville
	Private diverters						Pumped districts					
Permanent	4,955	16,635	9,365	9,145	1,060	2,665	675	2,335	2,880	3,970	1,740	45
Seasonal	2,695	3,040	2,500	1,105	350	10	235	10	475	380	190	2,330
Vacant P	300	1,090	205	950	260	135	260	70	1,000	1,225	980	0
Vacant S	1,995	1,150	630	625	300	345	400	5	85	255	95	0
2018 ha	9,945	21,915	12,700	11,825	1,970	3,155	1,570	2,420	4,440	5,830	3,005	2,375
	61,510						17,265					2,375
Permanent	79%						21%					<1%
Seasonal	73%						10%					17%
Vacant P	45%						55%					0%
Vacant S	86%						14%					0%
% of 2018	76%						21%					3%

Figure 4: Mallee catchment - permanent plantings, seasonal crops and vacant areas in 2018

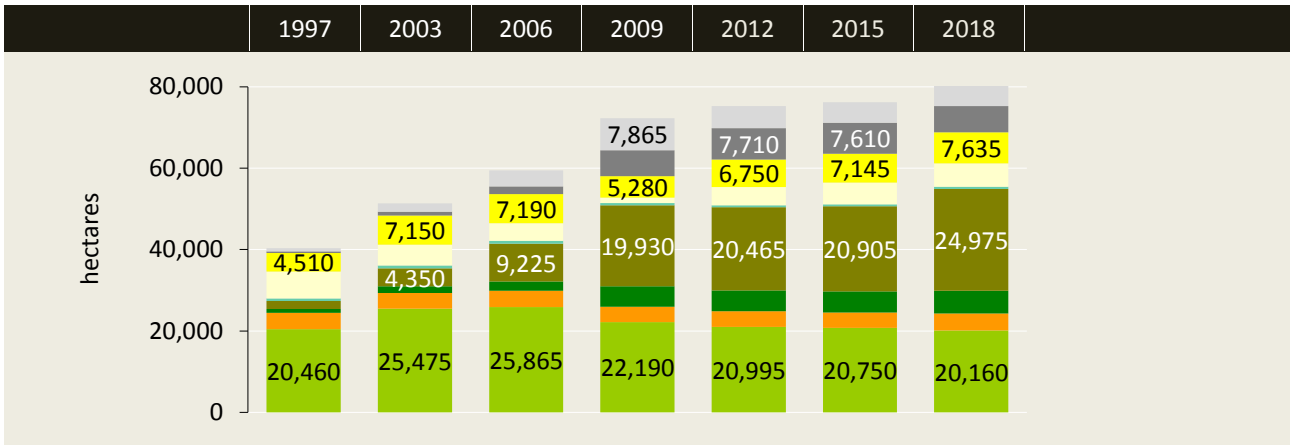
1.2 Mallee catchment - crop types from 1997 to 2018

Figure 5 summarises horticultural crops in the Mallee catchment from 1997 to 2018.

- The dominant crop changed from:
  - wine grape plantings from 1997 to 2006; to
  - almond trees from 2009 to 2018.

- Wine grape plantings peaked around 2006 at 15,850 ha, but areas continued to decrease from 2006 to 2018.

- Almond trees increased by 22,740 ha, a 1,303% increase from 1,745 ha in 1997 to 24,485 ha in 2018.



Crop type		1997	2003	2006	2009	2012	2015	2018	% of 2018 total	Change 1997-2018
Permanent	Grape Dried	6,340	4,925	4,210	3,015	3,035	3,045	3,145	4%	-3,195
	Grape Table	4,155	5,805	5,805	5,650	6,430	7,280	8,965	11%	+4,810
	Grape Wine	9,965	14,745	15,850	13,525	11,530	10,425	8,050	10%	-1,915
	Citrus	3,995	3,830	4,005	3,720	3,830	3,760	4,135	5%	+140
	Fruit Olive	160	745	1,285	4,075	3,805	3,670	3,815	5%	+3,655
	Fruit Other	795	945	1,030	970	1,305	1,530	1,800	2%	+1,005
	Nut Almond	1,745	4,145	9,010	19,695	20,190	20,610	24,485	30%	+22,740
	Nut Other	185	205	215	235	275	295	490	1%	+305
	Other	635	730	755	575	490	510	585	1%	-50
Seasonal	Field Crop	6,650	5,160	4,280	1,270	4,480	5,300	5,685	7%	-965
	Veg. Carrot	1,575	2,600	2,540	2,490	2,410	2,395	1,565	2%	-10
	Veg. Potato	1,705	2,745	2,830	1,805	2,695	2,725	3,410	4%	+1,705
	Veg. Other	1,230	1,805	1,820	985	1,645	2,025	2,660	3%	+1,430
	Vacant P	425	920	1,890	6,380	7,710	7,610	6,475	8%	+6,050
	Vacant S	765	2,045	3,925	7,865	5,450	5,065	5,885	7%	+5,120
Total (ha)		40,325	51,350	59,450	72,255	75,280	76,245	81,150	100%	+40,825
Dominant		wine grape	wine grape	wine grape	almond	almond	almond	almond		

Figure 5: Mallee catchment - crop types from 1997 to 2018

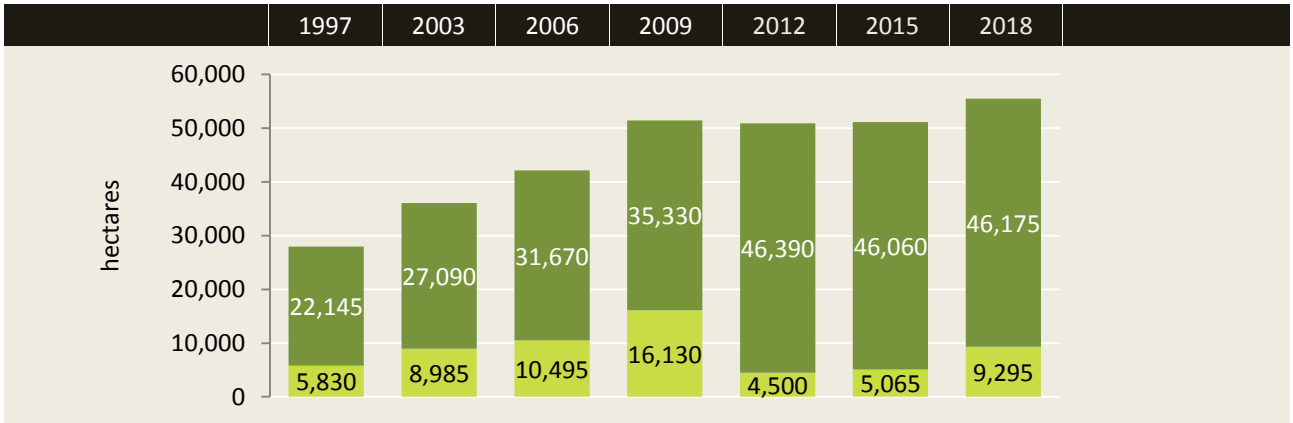
1.3 Mallee catchment - development of permanent crops

Figure 6 shows the proportion of permanent crops planted or redeveloped in the previous three years in the Mallee catchment from 1997 to 2018.

The information provides an indication of development activity that is otherwise not evident in information on changes in areas and crop types, as it includes replanting and top working to different varieties. The figures are conservative, as top-worked plantings can be difficult to interpret from the three-yearly aerial imagery, particularly for grapevines.

- In 2018, at least 9,295 ha (17%) of permanent crops were planted or redeveloped in the previous three years. Development was predominantly:
    1. almonds (4,100 ha);
    2. table grapes (2,200 ha);
    3. citrus (640 ha);
    4. olives (620 ha);
    5. dried grapes (610 ha);
    6. wine grapes (320 ha); and
    7. pistachios (200 ha).

- New or redeveloped permanent plantings were highest in 2009 with 16,130 ha (31%) planted in the previous three years.
- New or redeveloped permanent plantings were lowest in 2012 with 4,500 ha (9%) planted in the previous three years.



Permanent plantings	1997	2003	2006	2009	2012	2015	2018	% of 2018 total
≤3yr old plantings	5,830	8,985	10,495	16,130	4,500	5,065	9,295	17%
>3yr old plantings	22,145	27,090	31,670	35,330	46,390	46,060	46,175	83%
Total (ha)	27,975	36,075	42,165	51,460	50,890	51,125	55,470	100%
% 3yr development	21%	25%	25%	31%	9%	10%	17%	

Figure 6: Mallee catchment - three-year development of permanent crops from 1997 to 2018

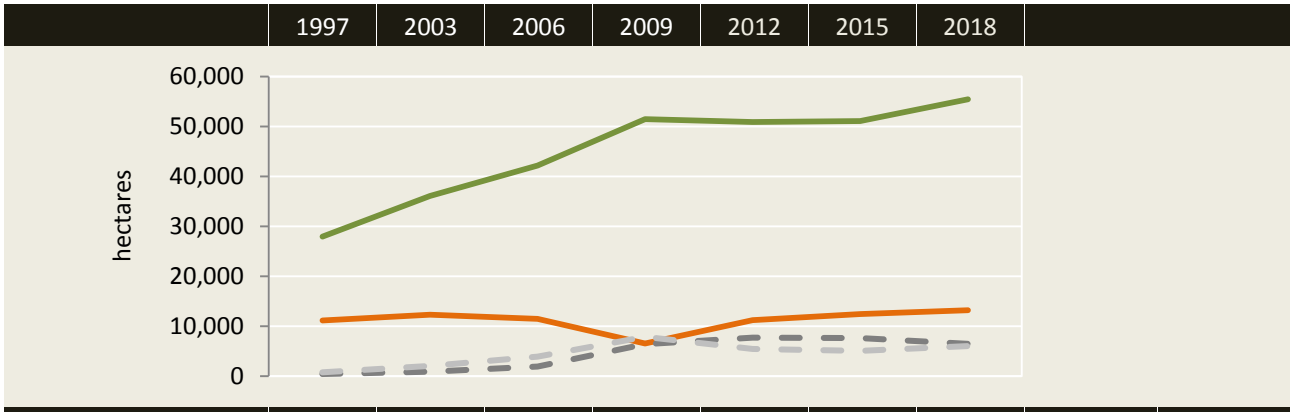
1.4 Mallee catchment - planting trends

Figure 7 summarises planting trends in the Mallee catchment from 1997 to 2018.

- In 2018, the irrigable area of 81,150 ha comprised:
  - 68% (55,470 ha) irrigated permanent plantings;
  - 16% (13,320 ha) irrigated seasonal crops; and
  - 15% (12,360 ha) vacant, not irrigated areas.

- The proportion of permanent plantings, seasonal cropping and vacant areas changed from:
  - 69% permanent, 28% seasonal and 3% vacant in 1997; to
  - 68% permanent, 16% seasonal and 15% vacant in 2018.

- From 1997 to 2018:
  - irrigated permanent crops increased by 27,495 ha;
  - irrigated seasonal crops increased by 2,160 ha;
  - vacant, not irrigated areas increased by 11,170 ha; and
  - the irrigable area increased by 40,825 ha.



	1997	2003	2006	2009	2012	2015	2018	% of 2018 total	Change 1997-2018
Permanent - irrigated	27,975	36,075	42,165	51,460	50,890	51,125	55,470	68%	+27,495
Seasonal - irrigated	11,160	12,310	11,470	6,550	11,230	12,445	13,320	16%	+2,160
Vacant - permanent	425	920	1,890	6,380	7,710	7,610	6,475	8%	+6,050
Vacant - seasonal	765	2,045	3,925	7,865	5,450	5,065	5,885	7%	+5,120
Total (ha)	40,325	51,350	59,450	72,255	75,280	76,245	81,150	100%	+40,825
% Permanent	69%	70%	71%	71%	68%	67%	68%		
% Seasonal	28%	24%	19%	9%	15%	16%	16%		
% Vacant	3%	6%	10%	20%	17%	17%	15%		

Figure 7: Mallee catchment - planting trends from 1997 to 2018

1.5 Mallee catchment - irrigation development

Table 7 summarises irrigation development with respect to new development (expansion) and areas retired from irrigation in the Mallee catchment from 1997 to 2018.

- The irrigable area in the Mallee catchment increased by 40,825 ha, a 101% increase from 40,325 ha in 1997 to 81,150 ha in 2018. The net increase of 40,825 ha was the balance of 42,715 ha expansion and 1,890 ha retired from irrigation.

- Across the pumped districts the irrigable area decreased by 220 ha, a 1% decrease from 17,485 ha in 1997 to 17,265 ha in 2018. The net decrease was the balance of 985 ha expansion and 1,205 ha retired from irrigation.

- In the private diverter areas the irrigable area increased by 39,255 ha, a 176% increase from 22,255 ha in 1997 to 61,510 ha in 2018. The net increase of 39,255 ha was the balance of 39,940 ha expansion and 685 ha retired from irrigation.

Table 7: Mallee catchment - irrigation development from 1997 to 2018

	Study area	1997 (ha)	1997 to 2018		2018 (ha)	Change (ha) 1997-2018	Growth % 1997-2018
			Retired[4]	New			
Pumped irrigation districts	Nyah	1,120	-10	+460	1,570	+450	+40%
	Robinvale	2,320	-30	+130	2,420	+100	+4%
	Red Cliffs	4,450	-135	+125	4,440	-10	-<1%
	Mildura	6,450	-890	+270	5,830	-620	-10%
	Merbein	3,145	-140	0	3,005	-140	-4%
	Sub-total	17,485	-1,205	+985	17,265	-220	-1%
Private diverters	Nyah	4,730	-45	+5,260	9,945	+5,215	+110%
	Boundary Bend	5,365	-230	+16,780	21,915	+16,550	+308%
	Wemen	2,150	-50	+10,600	12,700	+10,550	+491%
	Colignan	6,925	-75	+4,975	11,825	+4,900	+71%
	Mildura	1,445	-65	+590	1,970	+525	+36%
	Lock10 to SA	1,640	-220	+1,735	3,155	+1,515	+92%
	Sub-total	22,255	-685	+39,940	61,510	+39,255	+176%
Murrayville GMA		585	0	+1,790	2,375	+1,790	+306%
Mallee catchment total		40,325	-1,890	+42,715	81,150	+40,825	+101%

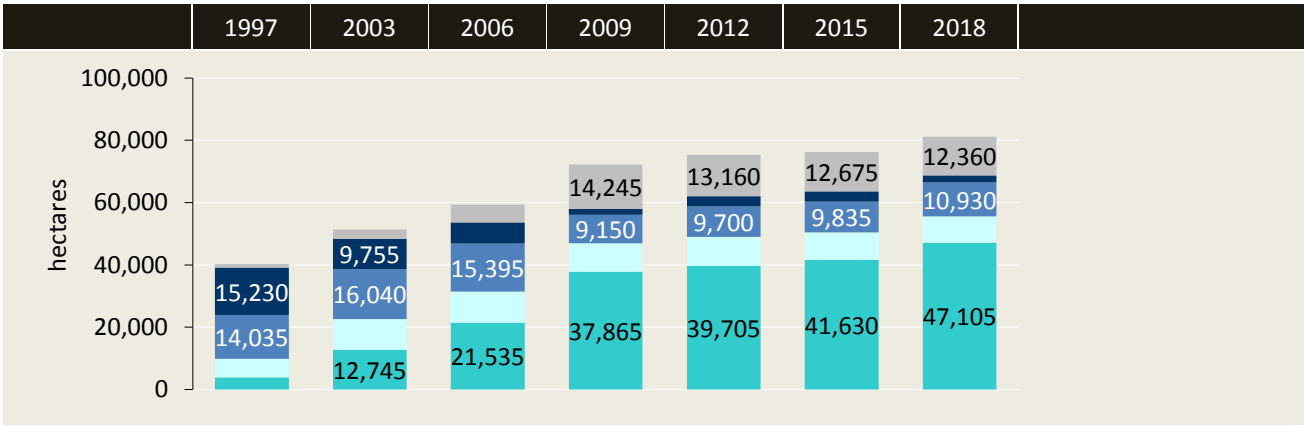
[4] Retired areas were previously irrigated but have undergone a change in land use that precludes use for irrigation e.g. urban development, housing, sheds, dams and land set aside for conservation purposes.

1.6 Mallee catchment - irrigation methods

Figure 8 summarises irrigation methods across the Mallee catchment from 1997 to 2018.

- In 2018, the irrigable area of 81,150 ha comprised:
  - 58% (47,105 ha) drip irrigation;
  - 10% (8,495 ha) lowlevel irrigation;
  - 13% (10,930 ha) overhead sprinklers and pivots;
  - 3% (2,260 ha) furrow irrigation; and
  - 15% (12,360 ha) vacant, not irrigated.

- Drip irrigation increased by 43,140 ha; a 1,088% increase from 3,965 ha in 1997 to 47,105 ha in 2018.
  - Drip irrigation was the dominant irrigation method from 2006 to 2018.
- Lowlevel irrigation increased by 2,590 ha; a 44% increase from 5,905 ha in 1997 to 8,495 ha in 2018.
- Overhead irrigation decreased by 3,105 ha; a 22% decrease from 14,035 ha in 1997 to 10,930 ha in 2018.
  - Overhead sprinklers were the dominant irrigation method in 2003.
- Furrow irrigation decreased by 12,970 ha, an 85% decrease from 15,230 ha in 1997 to 2,260 ha in 2018.
  - Furrow irrigation was the dominant irrigation method in 1997.



Irrigation method[5]	1997	2003	2006	2009	2012	2015	2018	% of 2018 total	Change 1997-2018
Drip	3,965	12,745	21,535	37,865	39,705	41,630	47,105	58%	+43,140
Lowlevel	5,905	9,845	9,920	9,060	9,350	8,860	8,495	10%	+2,590
Overhead	14,035	16,040	15,395	9,150	9,700	9,835	10,930	13%	-3,105
Furrow	15,230	9,755	6,785	1,935	3,365	3,245	2,260	3%	-12,970
Vacant	1,190	2,965	5,815	14,245	13,160	12,675	12,360	15%	+11,170
Total (ha)	40,325	51,350	59,450	72,255	75,280	76,245	81,150	100%	+40,825
Dominant	furrow	overhead	drip	drip	drip	drip	drip		

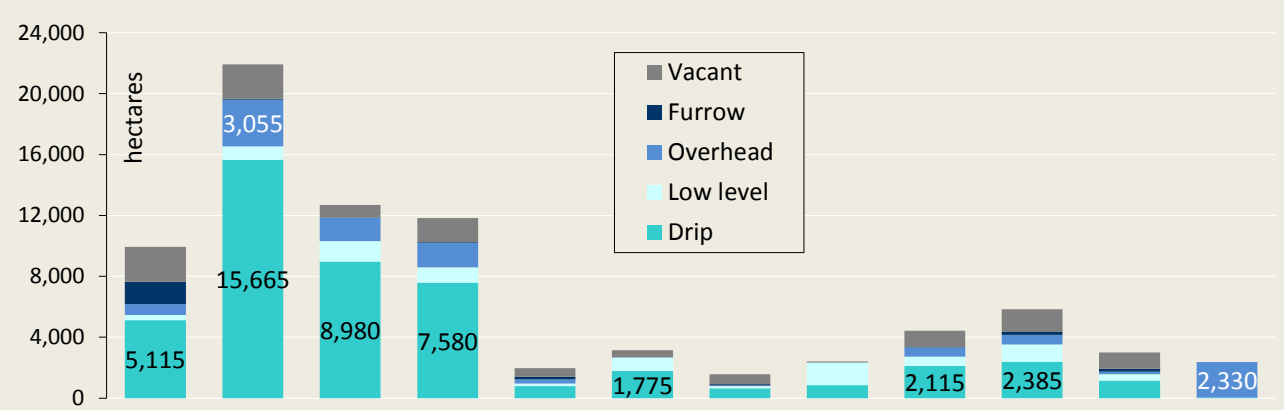
Figure 8: Mallee catchment - irrigation methods from 1997 to 2018

[5] Overhead irrigation includes pivots and lateral move systems. Furrow includes flood irrigation. (Table 5)

Irrigation methods in 2018 in each of the study areas

Figure 9 compares irrigation methods in each of the eleven Mallee catchment study areas in 2018.

- Drip irrigation was the dominant method in each of the study areas in 2018, except for the Robinvale district where lowlevel sprinklers were dominant and the Murrayville GMA where pivots were the dominant method.



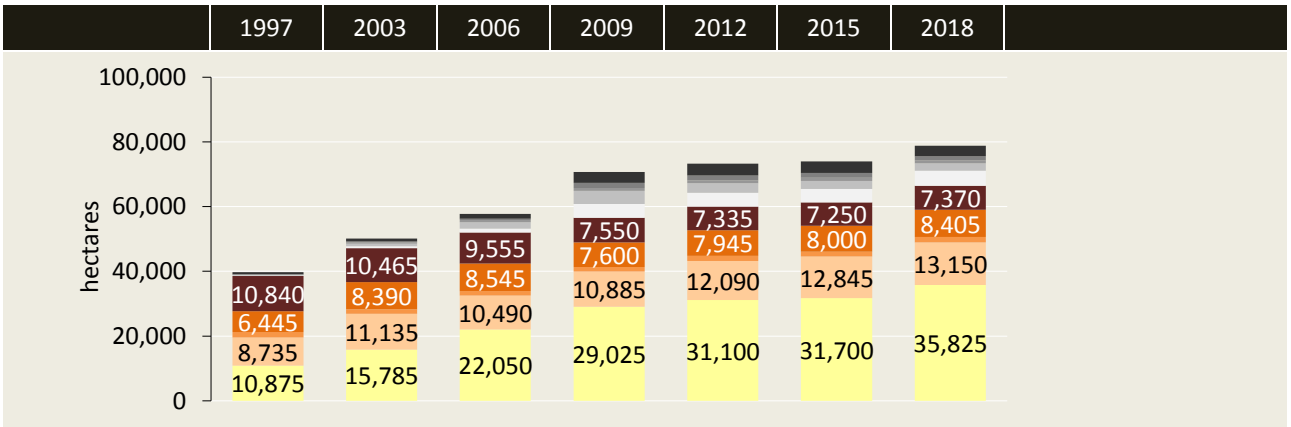
2018 ha	Nyah	B. Bend	Wemen	Colignan	Mildura	L10-SA	Nyah	R'vale	RedCliffs	Mildura	Merbein	M'ville
	9,945	21,915	12,700	11,825	1,970	3,155	1,570	2,420	4,440	5,830	3,005	2,375
% of 2018 total	12%	27%	16%	15%	2%	4%	2%	3%	5%	7%	4%	3%
	Private diverters 76% of irrigable area						Pumped districts 21% of irrigable area					3%
Dominant method	drip	drip	drip	drip	drip	drip	drip	low-level	drip	drip	drip	pivot

Figure 9: Mallee catchment - irrigation methods in each study area in 2018

1.7 Mallee catchment - salinity impact zones

Figure 10 summarises the irrigable area in each Murray River salinity impact zone in the Mallee catchment (excluding the Murrayville GMA[6]) from 1997 to 2018.

- In 2018, the irrigable area of 78,775 ha comprised:
  - 51% (40,470 ha) in the lowest impact zone, L1;
  - 20% (15,500 ha) in L2;
  - 3% (2,480 ha) in L3;
  - 12% (9,730 ha) in L4; and
  - 13% (10,595 ha) in the high impact zone, HIZ.
- The area irrigated in:
  - L1 to L4 increased by 31,335 ha, a 113% increase from 27,710 ha in 1997 to 59,045 ha in 2018;
  - HIZ decreased by 3,470 ha, a 32% decrease from 10,840 ha in 1997 to 7,370 ha in 2018.
- The irrigable area in:
  - L1 to L4 increased by 39,875 ha, a 120% increase from 28,305 ha in 1997 to 68,180 ha in 2018;
  - HIZ decreased by 840 ha, a 7% decrease from 11,435 ha in 1997 to 10,595 ha in 2018. The decrease is the balance of HIZ areas retired from irrigation and expansion on existing 'HIZ' properties.



Salinity impact zone		1997	2003	2006	2009	2012	2015	2018	% of 2018 total	Change (ha) 1997-2018
Irrigated	L1	10,875	15,785	22,050	29,025	31,100	31,700	35,825	45%	+24,950
	L2	8,735	11,135	10,490	10,885	12,090	12,845	13,150	17%	+4,415
	L3	1,655	1,370	1,340	1,455	1,605	1,505	1,665	2%	+10
	L4	6,445	8,390	8,545	7,600	7,945	8,000	8,405	11%	+1,960
	HIZ	10,840	10,465	9,555	7,550	7,335	7,250	7,370	9%	-3,470
Not Irrigated	L1	145	565	1,220	4,325	4,175	4,200	4,645	6%	+4,500
	L2	225	850	1,995	4,015	2,965	2,450	2,350	3%	+2,125
	L3	55	390	640	920	915	970	815	1%	+760
	L4	170	330	465	1,525	1,495	1,485	1,325	2%	+1,155
	HIZ	595	830	1,495	3,460	3,610	3,570	3,225	4%	+2,630
Total (ha)		39,740	50,110	57,795	70,760	73,235	73,975	78,775	100%	+39,035
Dominant zone		HIZ	L1	L1	L1	L1	L1	L1		

Figure 10: Mallee catchment - irrigable area in each salinity impact zone from 1997 to 2018

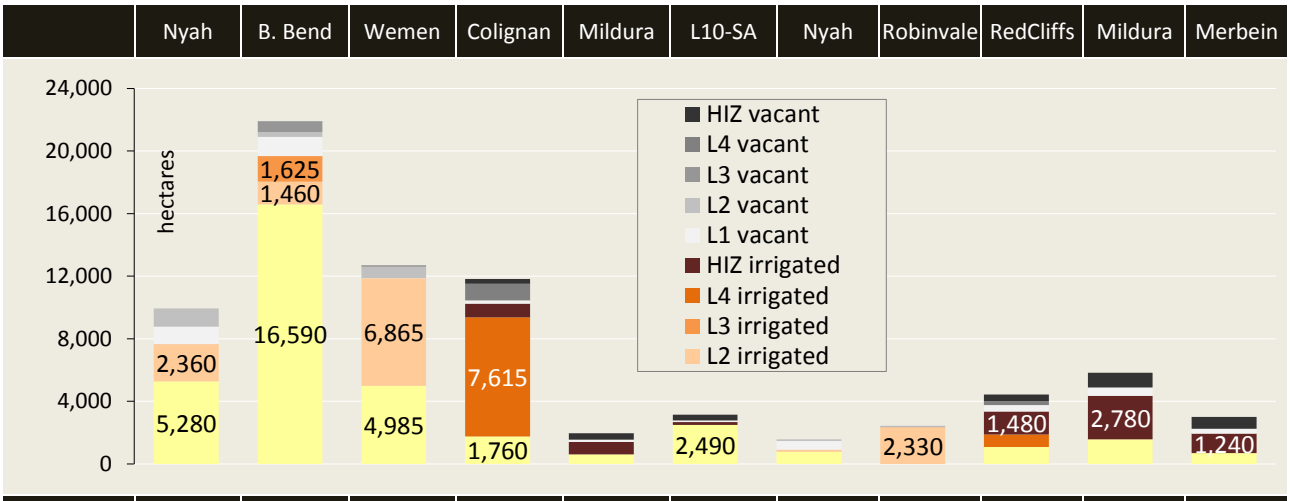
[6] Salinity impact zones do not apply in the Murrayville GMA.

Salinity zones in each study area in 2018

Figure 11 show salinity impact zones in each private diverter river reach and irrigation district in 2018. Salinity zones do not apply in the Murrayville GMA.

- The total irrigable area in the high salinity impact zone was 10,595 ha:
  - 28% (2,980 ha) of the HIZ area was in the private diverter river reaches; and
  - 72% (7,615 ha) of the HIZ area was in the irrigation districts.

- The Mildura irrigation district had the highest proportion of HIZ areas, 35% (3,715 ha) in 2018.



	Nyah	B. Bend	Wemen	Colignan	Mildura	L10-SA	Nyah	Robinvale	RedCliffs	Mildura	Merbein
Total 2018 ha	9,945	21,915	12,700	11,825	1,970	3,155	1,570	2,420	4,440	5,830	3,005
HIZ ha	-	-	-	1,175	1,235	570	-	-	1,910	3,715	1,990
% of HIZ total	-	-	-	11%	12%	5%	-	-	18%	35%	19%
	Private diverters 28% of the HIZ area						Irrigation districts 72% of the HIZ area				
Dominant zone	L1	L1	L2	L4	HIZ	L1	L1	L2	HIZ	HIZ	HIZ
	L1						HIZ				

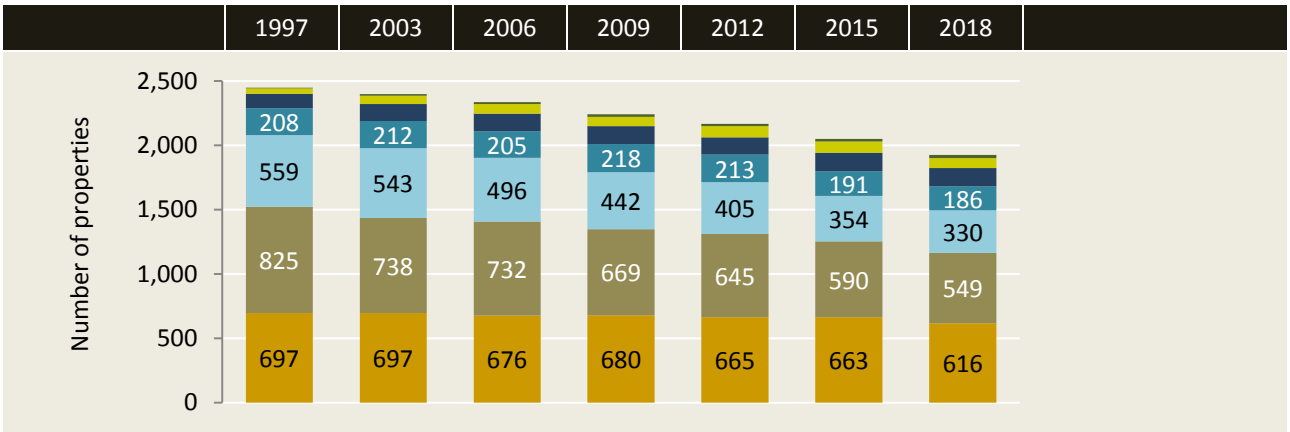
Figure 11: Mallee catchment - salinity impact zones in each study area in 2018

1.8 Mallee catchment - property change

Figure 12 provides estimates of property numbers and average property size (irrigable area) in the Mallee catchment from 1997 to 2018.

- In 2018:
  - there were approximately 1,925 irrigation properties; and
  - most properties (78%) had an irrigable area less than 20 ha.
  - 77% of properties were in the pumped districts, 22% were private diverters and 1% Murrayville irrigators. Average property size was 11 ha, 143 ha and 183 ha respectively (Figure 21, Figure 61 and Figure 101).

- From 1997 to 2018:
  - the number of properties decreased by 523; a 21% decrease from 2,448 to 1,925 properties;
  - properties with an irrigable area less than 20 ha decreased by 586, while the number over 20 ha increased by 63; and
  - average property size (irrigable area) increased from 16 ha to 42 ha.



Property size (irrigable area)	1997	2003	2006	2009	2012	2015	2018	% of 2018 total	Change 1997-2018
1 to 5 ha	697	697	676	680	665	663	616	32%	-81
5 to 10 ha	825	738	732	669	645	590	549	29%	-276
10 to 20 ha	559	543	496	442	405	354	330	17%	-229
20 to 40 ha	208	212	205	218	213	191	186	10%	-22
40 to 100 ha	113	131	137	141	135	146	142	7%	+29
100 to 500 ha	42	66	75	73	86	87	78	4%	+36
> 500 ha	4	11	15	19	17	19	24	1%	+20
Total properties	2,448	2,398	2,336	2,242	2,166	2,050	1,925	100%	-523
Average size (ha)	16	21	25	32	35	37	42		

Figure 12: Mallee catchment - property numbers and sizes from 1997 to 2018

Note: Total property numbers across the Mallee catchment are less than the sum of property numbers in each of the twelve study areas as some property owners irrigate in more than one study area.

2. Pumped irrigation districts

2.1 Pumped irrigation districts summary

In summary for the pumped irrigation districts; Nyah, Robinvale, Red Cliffs, Mildura and Merbein

Crop types

In 2018, dominant plantings in the pumped irrigation districts were:

1. table grapes; 5,590 ha (32% of the irrigable area);
2. wine grapes; 2,880 ha (17% of the irrigable area);
3. dried grapes; 1,865 ha (11% of the irrigable area); and
4. vegetables including carrots; 720 ha (4% of the irrigable area).

Crop types 1997 to 2018

Table grape plantings were the dominant crop from 2012 to 2018, whereas wine grapes were dominant from 2003 to 2009 and dried grapes in 1997.

The main changes to plantings from 1997 to 2018 were:

- table grape plantings increased by 2,545 ha; an 84% increase from 3,045 ha to 5,590 ha;
- dried grape plantings decreased by 4,105 ha; a 69% decrease from 5,970 ha to 1,865 ha; and
- wine grape plantings decreased by 3,000 ha; a 51% decrease from 5,880 ha to 2,880 ha.

Development of permanent plantings (new or redeveloped in the previous three years)

Development[7] activity with respect to permanent plantings continued to decline from 1997 to 2009 with only 9% of plantings under development in 2009. Activity increased slightly to 13% in 2012 and 2015, and then to 16% in 2018 with at least 1,905 ha of new plantings, predominantly:

1. table grapes (1,200 ha);
2. dried grapes (230 ha);
3. wine grapes (100 ha);
4. pistachios (85 ha);
5. citrus (65 ha);
6. nursery (60 ha);
7. almonds (50 ha); and
8. avocados (50 ha).

[7] New or redeveloped in the previous three years

In summary for the pumped irrigation districts; Nyah, Robinvale, Red Cliffs, Mildura and Merbein

Planting trends - permanent plantings, seasonal crops and vacant areas

In 2018, the irrigable area of 17,265 ha comprised:

- 67% (11,600 ha) permanent plantings;
- 7% (1,290 ha) seasonal crops; and
- 25% (4,375 ha) vacant, not irrigated areas.

From 1997 to 2018:

- permanent plantings decreased from 92% to 67% of the irrigable area;
- seasonal crops increased from 6% to 7% of the irrigable area; and
- vacant, not irrigated areas increased from 2% to 25% of the irrigable area.

Vacant, not irrigated areas continued to increase from 2% of the irrigable area in 1997 to 29% of the irrigable area in 2012. There was a slight decrease to 28% vacant in 2015 and a more significant drop to 25% vacant in 2018.

Irrigation development - new and retired areas

The irrigable area in the pumped districts decreased by 220 ha; a 1% decrease from 17,485 ha in 1997 to 17,265 ha in 2018.

The net decrease of 220 ha was the balance of 985 ha of expansion and 1,205 ha retired from irrigation, predominantly for urban development.

Irrigation methods

Drip irrigation was the dominant irrigation method in the irrigation districts from 2012 to 2018. Prior to 2012, the dominant method changed from furrow in 1997 and 2003 to lowlevel sprinklers in 2006 and 2009.

In 2018, the irrigable area of 17,265 ha comprised:

- 41% (7,145 ha) drip irrigation;
- 22% (3,840 ha) lowlevel irrigation;
- 8% (1,415 ha) overhead sprinklers;
- 3% (490 ha) furrow irrigation; and
- 25% (4,375 ha) not irrigated.

From 1997 to 2018:

- drip irrigation increased by 6,370 ha; a 822% increase from 775 ha to 7,145 ha;
- lowlevel irrigation increased by 1,150 ha; a 43% increase from 2,690 ha to 3,840 ha;
- overhead irrigation decreased by 2,905 ha; a 67% decrease from 4,320 ha to 1,415 ha; and
- furrow irrigation decreased by 8,875 ha; a 95% decrease from 9,365 ha to 490 ha.

In summary for the pumped irrigation districts; Nyah, Robinvale, Red Cliffs, Mildura and Merbein

Salinity impact zones

The irrigable area in the irrigation districts was predominantly in the high river salinity impact zone, HIZ, from 1997 to 2018.

In 2018, the irrigable area of 17,265 ha comprised:

- 34% (5,955 ha) in the lowest salinity impact zone, L1;
- 15% (2,625 ha) in L2;
- < 1% (25 ha) in L3;
- 6% (1,045 ha) in L4; and
- 44% (7,615 ha) in HIZ.

From 1997 to 2018 the irrigable area in:

- L1 to L4 increased by 665 ha; a 7% increase from 8,985 ha to 9,650 ha; and
- HIZ decreased by 885 ha; a 10% decrease from 8,500 ha to 7,615 ha.

Irrigation properties

In 2018, there were approximately 1,525 irrigation properties in the irrigation districts, with an average irrigable area of 11 ha.

From 1997 to 2018:

- the number of properties decreased by 341; a 17% decrease from 1,987 to 1,525 properties;
- properties with an irrigable area less than 20 ha decreased by 400, while the number over 20 ha increased by 59; and
- average property size (irrigable area) increased from 9 ha to 11 ha.

2.1.1 Pumped districts summary - crop types in 2018

Table 8 lists horticultural crops in the five pumped irrigation districts in 2018.

- Dominant plantings in 2018 were:
    1. table grapes; 5,590 ha (32% of the irrigable area);
    2. wine grapes; 2,880 ha (17% of the irrigable area);
    3. dried grapes; 1,865 ha (11% of the irrigable area); and
    4. vegetables including carrots; 720 ha (4% of the irrigable area).

Table 8: Pumped irrigation districts - crop types in 2018

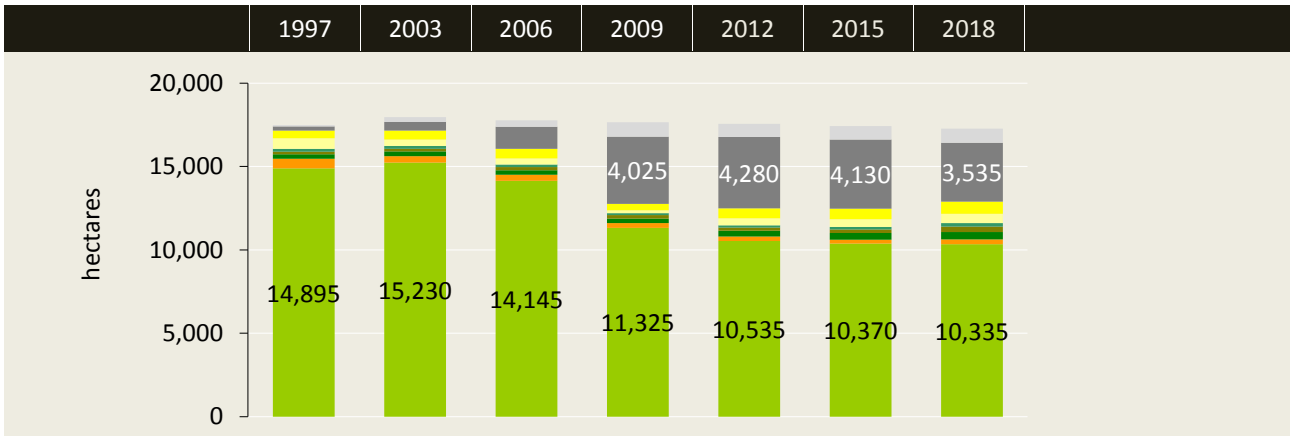
	Crop type	Category	2018 (ha)	2018 %	Description
Permanent plantings	Grapevine	Dried	1,865	11%	
		Table	5,590	32%	
		Wine	2,880	17%	Includes a very small proportion of juiced grapes
	Citrus		285	2%	Grapefruit, lemon, lime, mandarin, navel, blood orange, tangelo, valencia
	Fruit tree	Olive	105	1%	
		Other	335	2%	Avocado, date palm, fig, jujube, mango, persimmon, pomefruit, pomegranate, quince, stone fruit
	Nut tree	Almond	190	1%	
		Other	150	1%	Pistachio, walnut
	Other	Miscellaneous	200	1%	Aquaculture, flowers, herbs, mushroom, native plants, nursery, passionfruit, strawberry, tree plantation
	Permanent crops (sub-total)		11,600	67%	
Seasonal crops	Field crop		570	3%	Cereal, cover crop, lucerne, pasture, turf
	Vegetable	Carrot	50	<1%	
		Potato	-	-	
		Other	670	4%	Asparagus, bean, beetroot, broccoli, cabbage, capsicum, cauliflower, chili, cucumber, eggplant, garlic, lettuce, melon, onion, pumpkin, sweet corn, tomato, zucchini
	Seasonal crops (sub-total)		1,290	7%	
Vacant	Vacant P		3,535	20%	Vacant (not irrigated), previously an irrigated permanent crop
	Vacant S		840	5%	Vacant (not irrigated), previously an irrigated seasonal crop
	Total all crop areas		17,265	100%	

2.1.2 Pumped districts summary - crop types from 1997 to 2018

Figure 13 summarises horticultural crops in the Mallee pumped irrigation districts from 1997 to 2018.

- The dominant crop changed from:
  - dried grape plantings in 1997; to
  - wine grapes from 2003 to 2009; and
  - table grapes from 2012 to 2018.

- From 1997 to 2018:
  - table grape plantings increased by 2,545 ha; an 84% increase from 3,045 ha to 5,590 ha;
  - dried grape plantings decreased by 4,105 ha; a 69% decrease from 5,970 ha to 1,865 ha; and
  - wine grape plantings decreased by 3,000 ha; a 51% decrease from 5,880 ha to 2,880 ha.



Crop type		1997	2003	2006	2009	2012	2015	2018	% of 2018 total	Change 1997-2018
Permanent	Grape Dried	5,970	4,135	3,390	2,280	2,200	2,090	1,865	11%	-4,105
	Grape Table	3,045	3,975	3,890	3,855	4,265	4,735	5,590	32%	+2,545
	Grape Wine	5,880	7,120	6,865	5,190	4,070	3,545	2,880	17%	-3,000
	Citrus	560	395	360	275	270	240	285	2%	-275
	Fruit Olive	65	85	80	95	120	115	105	1%	+40
	Fruit Other	215	185	190	170	215	285	335	2%	+120
	Nut Almond	115	130	140	175	145	155	190	1%	+75
	Nut Other	35	40	50	45	55	60	150	1%	+115
	Other	165	160	150	105	135	140	200	1%	+35
Seasonal	Field Crop	635	395	365	185	425	475	570	3%	-65
	Veg. Carrot	10	20	30	30	40	50	50	<1%	+40
	Veg. Potato	-	-	-	-	-	-	-	-	-
	Veg. Other	455	520	540	355	550	585	670	4%	+215
	Vacant P	245	500	1,325	4,025	4,280	4,130	3,535	20%	+3,290
	Vacant S	90	290	395	865	790	820	840	5%	+750
Total (ha)		17,485	17,950	17,770	17,650	17,560	17,425	17,265	100%	-220
Dominant		dried grape	wine grape	wine grape	wine grape	table grape	table grape	table grape		

Figure 13: Pumped irrigation districts - crop types from 1997 to 2018

2.1.3 Pumped irrigation districts - development of permanent crops

Figure 14 shows the proportion of permanent crops planted or redeveloped in the previous three years across the pumped irrigation districts from 1997 to 2018.

The information provides an indication of development activity that is otherwise not evident in information on changes in areas and crop types, as it includes replanting and top working to different varieties. The figures are conservative, as top-worked plantings can be difficult to interpret from the three-yearly aerial imagery, particularly for grapevines.

- In 2018, at least 1,905 ha (16%) of permanent crops were planted or redeveloped in the previous three years. Development was predominantly:
    1. table grapes (1,200 ha);
    2. dried grapes (230 ha);
    3. wine grapes (100 ha);
    4. pistachios (85 ha);
    5. nursery (60 ha);
    6. citrus (60 ha);
    7. almonds (50 ha); and
    8. avocados (50 ha).

- New or redeveloped permanent plantings were highest in 1997 with 2,965 ha (18%) planted in the previous three years.

- New or redeveloped permanent plantings were lowest in 2009 with 1,095 ha (9%) planted in the previous three years.

Permanent plantings	1997	2003	2006	2009	2012	2015	2018	% of 2018 total
≤3yr old plantings	2,965	2,725	1,975	1,095	1,450	1,475	1,905	16%
>3yr old plantings	13,085	13,500	13,140	11,095	10,025	9,890	9,700	84%
Total (ha)	16,050	16,225	15,115	12,190	11,475	11,365	11,600	100%
% 3yr development	18%	17%	13%	9%	13%	13%	16%	

Figure 14: Pumped irrigation districts - three-year development of permanent crops 1997 to 2018

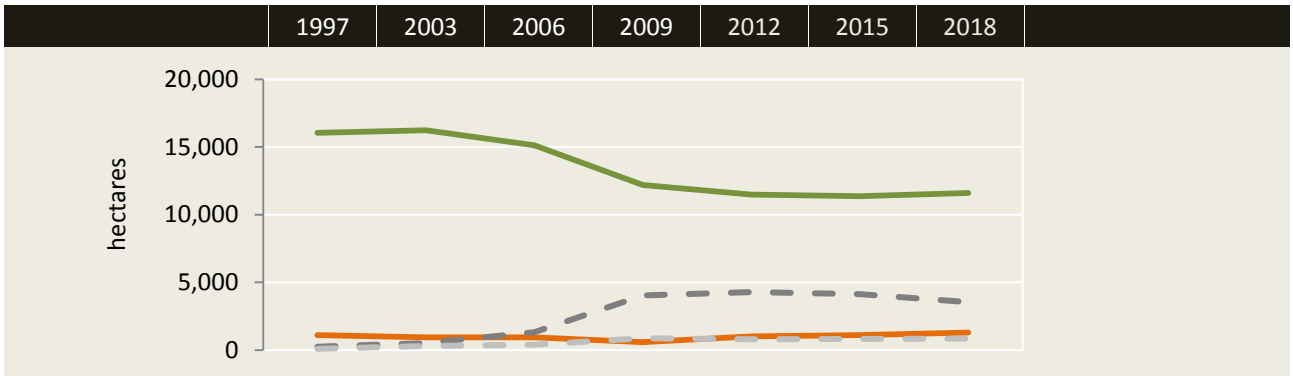
2.1.4 Pumped irrigation districts - planting trends

Figure 15 summarises planting trends in the irrigation districts from 1997 to 2018.

- In 2018, the irrigable area of 17,265 ha comprised:
  - 67% (11,600 ha) irrigated permanent plantings;
  - 7% (1,290 ha) irrigated seasonal crops; and
  - 25% (4,375 ha) vacant, not irrigated areas.

- The proportion of permanent plantings, seasonal cropping and vacant areas changed from:
  - 92% permanent, 6% seasonal and 2% vacant in 1997; to
  - 67% permanent, 7% seasonal and 25% vacant in 2018.

- From 1997 to 2018:
  - irrigated permanent crops decreased by 4,450 ha;
  - irrigated seasonal crops increased by 190 ha;
  - vacant, not irrigated areas increased by 4,040 ha; and
  - the irrigable area decreased by 220 ha.



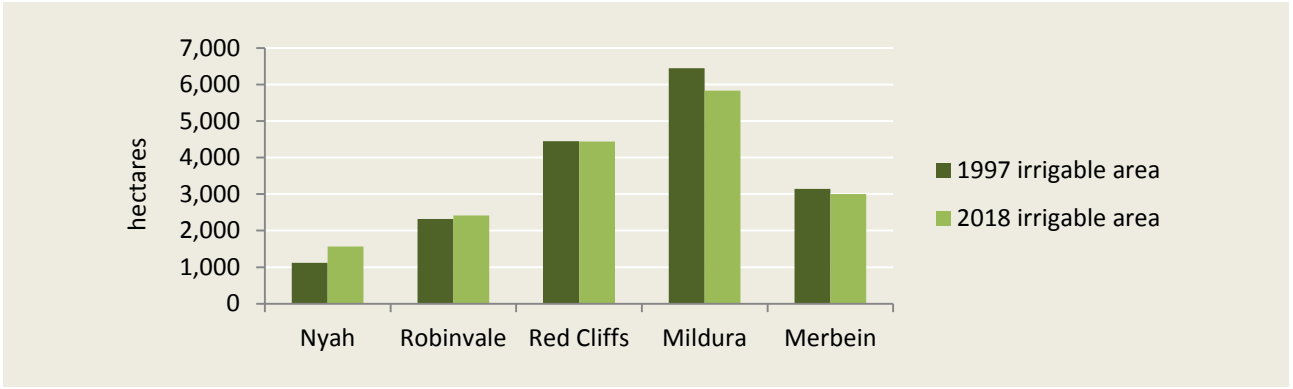
	1997	2003	2006	2009	2012	2015	2018	% of 2018 total	Change 1997-2018
Permanent - irrigated	16,050	16,225	15,115	12,190	11,475	11,365	11,600	67%	-4,450
Seasonal - irrigated	1,100	935	935	570	1,015	1,110	1,290	7%	+190
Vacant - permanent	245	500	1,325	4,025	4,280	4,130	3,535	20%	+3,290
Vacant - seasonal	90	290	395	865	790	820	840	5%	+750
Total (ha)	17,485	17,950	17,770	17,650	17,560	17,425	17,265	100%	-220
% Permanent	92%	90%	85%	69%	65%	65%	67%		
% Seasonal	6%	5%	5%	3%	6%	6%	7%		
% Vacant	2%	4%	10%	28%	29%	28%	25%		

Figure 15: Pumped irrigation districts - planting trends from 1997 to 2018

2.1.5 Pumped districts summary - irrigation development

Figure 16 summarises irrigation development with respect to new development (expansion) and areas retired[8] from irrigation in the pumped irrigation districts from 1997 to 2018.

- The irrigable area decreased by 220 ha, a 1% decrease from 17,485 ha in 1997 to 17,265 ha in 2018. The net decrease of 220 ha was the balance of 985 ha of expansion and 1,205 ha retired from irrigation.
- The irrigable area in the Nyah and Robinvale districts increased by 40% (450 ha) and 4% (100 ha) respectively.
- The irrigable area in the Mildura, Red Cliffs and Merbein districts decreased by 10% (620 ha), <1% (10 ha) and 4% (140 ha) respectively.



District	1997 (ha)	1997 to 2018		2018 (ha)	Change 1997-2018	Growth 1997-2018
		Retired	New			
Nyah[9]	1,120	-10	+460	1,570	+450	+40%
Robinvale	2,320	-30	+130	2,420	+100	+4%
Red Cliffs	4,450	-135	+125	4,440	-10	-<1%
Mildura	6,450	-890	+270	5,830	-620	-10%
Merbein	3,145	-140	0	3,005	-140	-4%
Total	17,485	-1,205	+985	17,265	-220	-1%

Figure 16: Pumped irrigation districts - irrigation development from 1997 to 2018

[8] Retired areas were previously irrigated but have undergone a change in land use that precludes use for irrigation e.g. urban development, housing, sheds, dams and land set aside for conservation purposes.

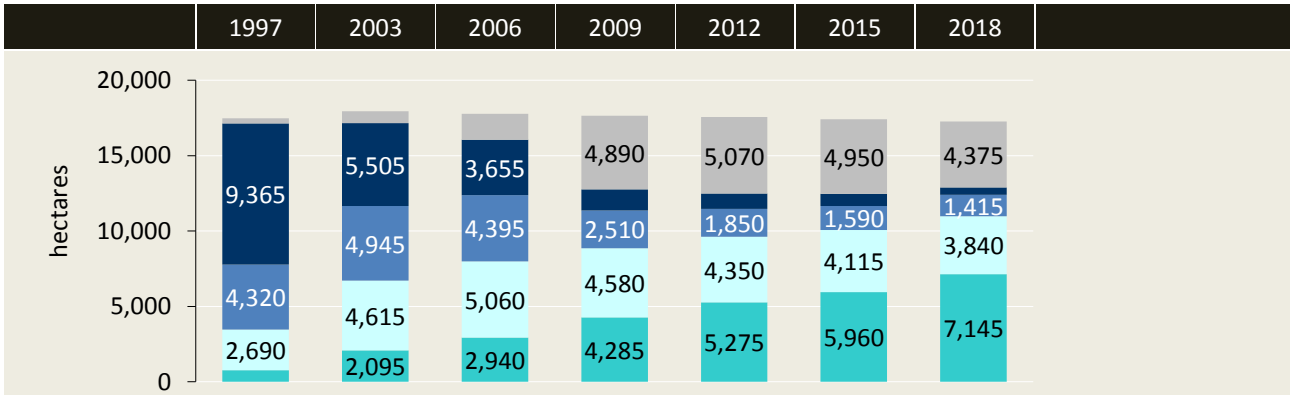
[9] Hectares for the Nyah irrigation district include areas outside the district but supplied with water from the district, whereas figures for the other districts only include areas inside the district boundary.

2.1.6 Pumped districts summary - irrigation methods

Figure 17 summarises irrigation methods in the pumped irrigation districts from 1997 to 2018.

- In 2018, the irrigable area of 17,265 ha comprised:
  - 41% (7,145 ha) drip irrigation;
  - 22% (3,840 ha) lowlevel irrigation;
  - 8% (1,415 ha) overhead sprinklers;
  - 3% (490 ha) furrow irrigation; and
  - 25% (4,375 ha) not irrigated.

- Drip irrigation increased by 6,730 ha, an 822% increase from 775 ha in 1997 to 7,145 ha in 2018.
  - Drip irrigation was the dominant irrigation method from 2012 to 2018.
- Lowlevel irrigation increased by 1,150 ha, a 43% increase from 2,690 ha in 1997 to 3,840 ha in 2018.
  - Lowlevel irrigation was the dominant method in 2006 and 2009.
- Overhead irrigation decreased by 2,905 ha, a 67% decrease from 4,320 ha in 1997 to 1,415 ha in 2018.
- Furrow irrigation decreased by 8,875 ha, a 95% decrease from 9,365 ha in 1997 to 490 ha in 2018.
  - Furrow irrigation was the dominant irrigation method in 1997 and 2003.



Irrigation method[10]	1997	2003	2006	2009	2012	2015	2018	% of 2018 total	Change 1997-2018
Drip	775	2,095	2,940	4,285	5,275	5,960	7,145	41%	+6,370
Lowlevel	2,690	4,615	5,060	4,580	4,350	4,115	3,840	22%	+1,150
Overhead	4,320	4,945	4,395	2,510	1,850	1,590	1,415	8%	-2,905
Furrow	9,365	5,505	3,655	1,385	1,015	810	490	3%	-8,875
Vacant	335	790	1,720	4,890	5,070	4,950	4,375	25%	+4,040
Total (ha)	17,485	17,950	17,770	17,650	17,560	17,425	17,265	100%	-220
Dominant	furrow	furrow	lowlevel	lowlevel	drip	drip	drip		

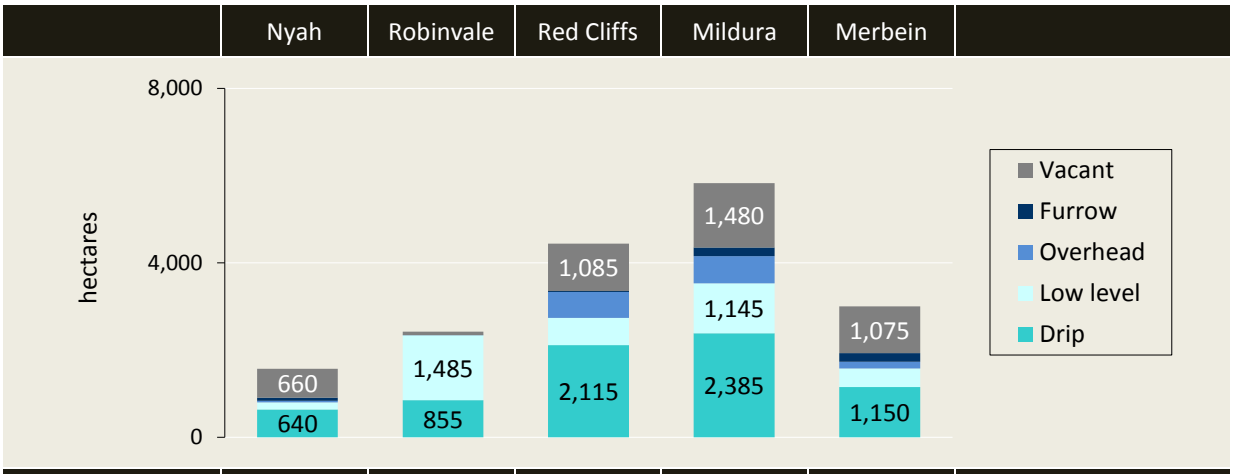
Figure 17: Pumped irrigation districts - irrigation methods from 1997 to 2018

[10] Overhead irrigation includes pivots and lateral move systems. Furrow includes flood irrigation. (Table 5)

Irrigation methods in each pumped irrigation district in 2018

Figure 18 shows irrigation methods in each pumped irrigation district in 2018.

- Drip irrigation was the dominant method in each of the pumped districts in 2018, except for the Robinvale district where lowlevel sprinklers were dominant.



	Nyah	Robinvale	Red Cliffs	Mildura	Merbein	2018 total
Hectares in 2018	1,570	2,420	4,440	5,830	3,005	17,265
% of 2018 total	9%	14%	26%	34%	17%	100%
Dominant	drip	lowlevel	drip	drip	drip	drip

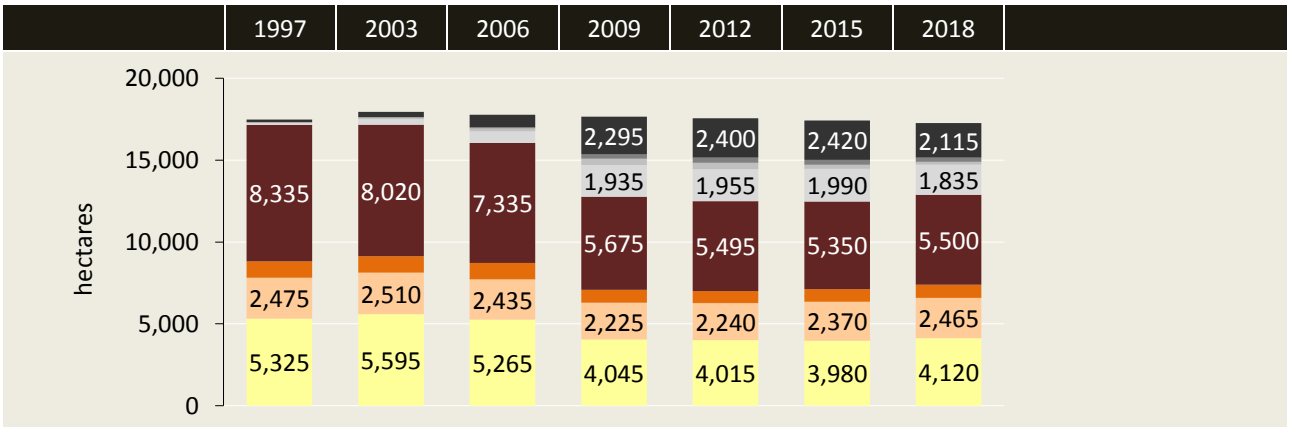
Figure 18: Pumped irrigation districts - irrigation methods in each district in 2018

2.1.7 Pumped districts summary - salinity impact zones

Figure 19 summarises river salinity impact zones of irrigated areas in the five pumped irrigation districts from 1997 to 2018.

- In 2018, irrigable areas across the pumped districts were predominantly in the high salinity impact zone, HIZ. The irrigable area of 17,265 ha comprised:
  - 34% (5,955 ha) in the lowest salinity impact zone, L1;
  - 15% (2,625 ha) in L2;
  - < 1% (25 ha) in L3;
  - 6% (1,045 ha) in L4; and
  - 44% (7,615 ha) in HIZ.

- The area irrigated in:
  - L1 to L4 decreased by 1,425 ha, a 16% decrease from 8,815 ha in 1997 to 7,390 ha in 2018; and
  - HIZ decreased by 2,835 ha, a 34% decrease from 8,335 ha in 1997 to 5,500 ha in 2018. The area irrigated in HIZ continued to decrease from 1997 to 2015, but increased by 150 ha between 2015 and 2018. The increase was largely due to vacant areas in HIZ being brought back into production.
- The irrigable area in:
  - L1 to L4 increased by 665 ha, a 7% increase from 8,985 ha in 1997 to 9,650 ha in 2018; and
  - HIZ decreased by 885 ha, a 10% decrease from 8,500 ha in 1997 to 7,615 ha in 2018.



Salinity impact zone		1997	2003	2006	2009	2012	2015	2018	% of 2018 total	Change (ha) 1997-2018
Irrigated	L1	5,325	5,595	5,265	4,045	4,015	3,980	4,120	24%	-1,205
	L2	2,475	2,510	2,435	2,225	2,240	2,370	2,465	14%	-10
	L3	20	20	20	20	15	10	15	<1%	-5
	L4	995	1,015	995	795	725	765	790	5%	-205
	HIZ	8,335	8,020	7,335	5,675	5,495	5,350	5,500	32%	-2,835
Not Irrigated	L1	125	345	710	1,935	1,955	1,990	1,835	11%	+1,710
	L2	20	85	185	395	380	250	160	1%	+140
	L3	0	0	5	5	10	10	10	<1%	+10
	L4	25	45	65	260	325	280	255	1%	+230
	HIZ	165	315	755	2,295	2,400	2,420	2,115	12%	+1,950
Total (ha)		17,485	17,950	17,770	17,650	17,560	17,425	17,265	100%	-220
Dominant zone		HIZ	HIZ	HIZ	HIZ	HIZ	HIZ	HIZ		

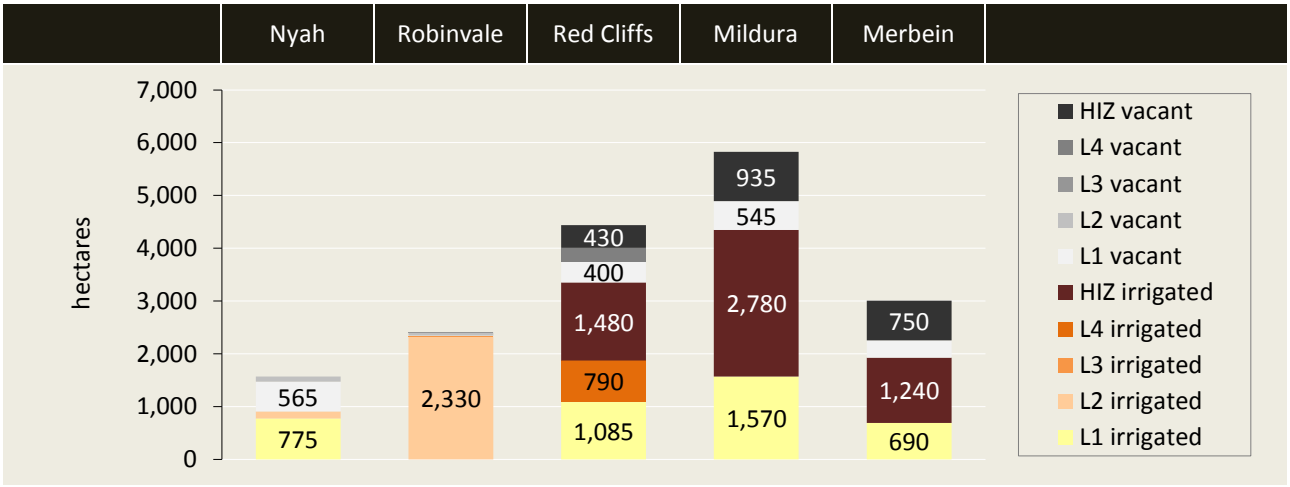
Figure 19: Pumped irrigation districts - irrigable area in each salinity impact zone from 1997 to 2018

Salinity impact zones in each pumped irrigation district

Figure 20 compares salinity impact zones in each of the pumped irrigation districts in 2018.

- The Nyah and Robinvale irrigation districts are predominantly in L1 and L2 respectively, and have no irrigable areas in HIZ.

- The Red Cliffs, Mildura and Merbein irrigation districts are predominantly in the HIZ.



Irrigation district	Nyah	Robinvale	Red Cliffs	Mildura	Merbein	2018 total
HIZ hectares	-	-	1,910	3,715	1,990	7,615
% of HIZ total	-	-	25%	49%	26%	100%
Dominant zone	L1	L2	HIZ	HIZ	HIZ	HIZ

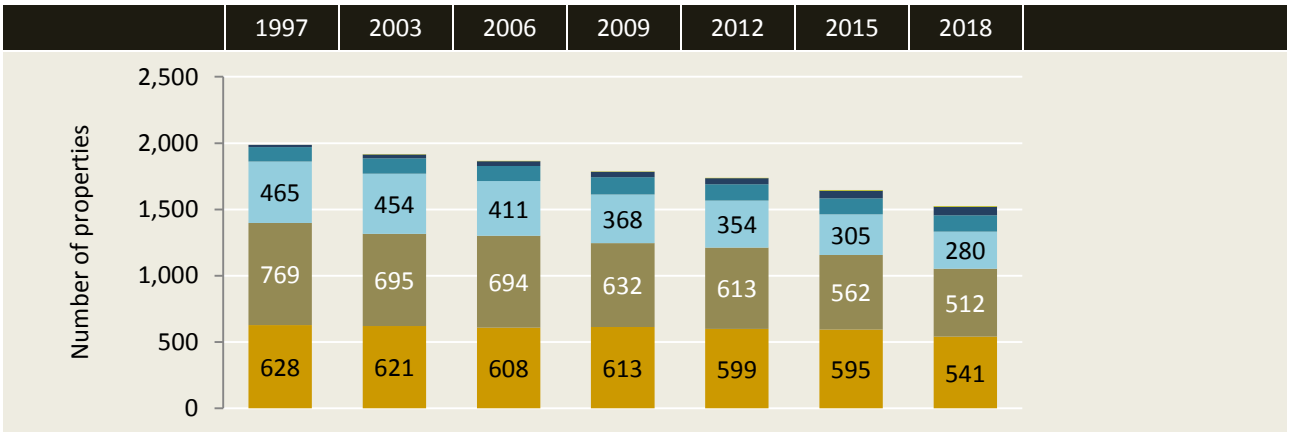
Figure 20: Pumped irrigation districts - salinity impact zones in each district in 2018

2.1.8 Pumped districts summary - property change

Figure 21 provides an estimate of property numbers and average property size (irrigable area) across the five pumped irrigation districts from 1997 to 2018.

- In 2018:
  - there were approximately 1,525 irrigation properties; and
  - most properties (89%) had an irrigable area less than 20 ha.

- From 1997 to 2018:
  - the number of properties decreased by 341; a 17% decrease from 1,987 to 1,525 properties;
  - properties with an irrigable area less than 20 ha decreased by 400, while the number over 20 ha increased by 59; and
  - average property size (irrigable area) increased from 9 ha to 11 ha.



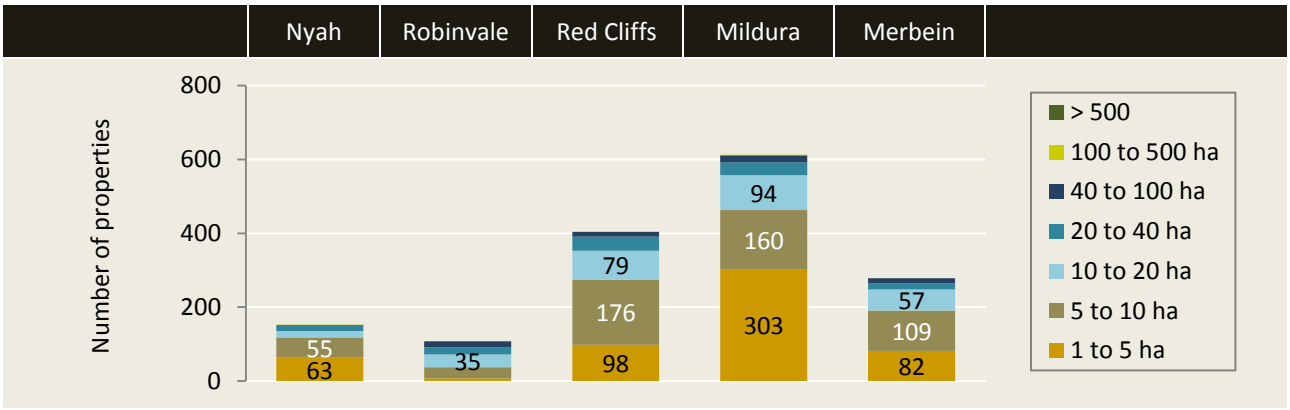
Property size (irrigable area)	1997	2003	2006	2009	2012	2015	2018	% of 2018 total	Change 1997-2018
1 to 5 ha	628	621	608	613	599	595	541	36%	-33
5 to 10 ha	769	695	694	632	613	562	512	34%	-207
10 to 20 ha	465	454	411	368	354	305	280	19%	-160
20 to 40 ha	108	116	115	131	125	121	124	7%	+13
40 to 100 ha	17	29	37	40	45	59	63	4%	+42
100 to 500 ha	0	1	2	3	3	4	5	<1%	+4
> 500 ha	-	-	-	-	-	-	-	-	-
Total properties	1,987	1,916	1,867	1,787	1,739	1,646	1,525	100%	-341
Average size (ha)	9	9	10	10	10	11	11		

Figure 21: Pumped irrigation districts - property numbers and sizes from 1997 to 2018

Irrigation properties in each of the pumped districts in 2018

Figure 22 provides an estimate of property numbers and average property size (irrigable area) in each of the five pumped irrigation districts in 2018.

- The largest number of irrigation properties, 613 (39%), were in the Mildura irrigation district in 2018.
- Each of the districts had an average irrigable area of 9 to ha, except for the Robinvale district where the average irrigable area was 22 ha.



	Nyah	Robinvale	Red Cliffs	Mildura	Merbein	2018 total
Total properties	153	108	404	613	278	1,556/1,525[11]
% of 2018 total	10%	7%	26%	39%	18%	100%
Average size – irrigable area (ha)	10	22	10	9	10	11

Figure 22: Pumped irrigation districts - property numbers and average size in each district in 2018

[11] The total number of properties from each irrigation district (1,556 properties, Figure 22) is greater than the total number of properties across the irrigation districts (1,525 properties, Figure 21) as some property owners irrigate in more than one district.

2.2 Nyah irrigation district

In summary for the Nyah irrigation district

Crop types in 2018

In 2018, dominant plantings in the Nyah irrigation district were:

1. wine grape plantings: 455 ha (29% of the irrigable area);
2. vegetables other than carrot or potato: 130 ha (8% of the irrigable area); and
3. dried grapes: 115 ha (7% of the irrigable area).

Crop types 1997 to 2018

Wine grape plantings were the dominant crop from 1997 to 2018.

The main changes in crops from 1997 to 2018 were:

- wine grape plantings increased by 140 ha; a 44% increase from 315 ha to 455 ha;
- field crops decreased by 215 ha; an 80% decrease from 270 ha to 55 ha;
- dried grape plantings decreased by 120 ha; a 51% decrease from 235 ha to 115 ha; and
- carrots increased by 40 ha; a 400% increase from 10 ha to 50 ha.

Development of permanent plantings (new or redeveloped in the previous three years)

In 2018, at least 25 ha (4%) of permanent crops were planted or redeveloped in the previous three years, predominantly:

1. dried grapes (10 ha);
2. wine grapes (10 ha); and
3. stone fruit (5 ha).

Development activity ranged from 8% of permanent plantings to 18% from 1997 to 2006, but decreased to 4% from 2009 to 2018.

Planting trends - permanent plantings, seasonal crops and vacant areas

In 2018, the irrigable area of 1,570 ha comprised:

- 43% (675 ha) was irrigated permanent plantings;
- 15% (235 ha) was irrigated seasonal crops; and
- 42% (660 ha) was vacant or not irrigated.

From 1997 to 2018:

- permanent plantings decreased from 60% to 43% of the irrigable area;
- seasonal crops decreased from 38% to 15% of the irrigable area; and
- vacant, not irrigated areas increased from 2% to 42% of the irrigable area.

In summary for the Nyah irrigation district

Irrigation development - new and retired areas

In the Nyah irrigation district, the irrigable area increased by 450 ha, a 40% increase from 1,120 ha in 1997 to 1,570 ha in 2018.

The net increase of 450 ha was the balance of 460 ha of expansion and 10 ha retired from irrigation.

Irrigation methods

Drip irrigation was the dominant irrigation method in the Nyah irrigation district from 2006 to 2018, whereas furrow irrigation was dominant from 1997 to 2003.

In 2018, the irrigable area of 1,570 ha comprised:

- 41% (640 ha) drip irrigation;
- 10% (160 ha) lowlevel irrigation;
- 3% (40 ha) overhead sprinklers;
- 4% (70 ha) furrow irrigation; and
- 42% (660 ha) vacant, not irrigated.

Salinity impact zones

The Nyah irrigation district is in low salinity impact zones L1 and L2.

In 2018, the irrigable area of 1,570 ha comprised:

- 85% (1,340 ha) in the lowest salinity zone L1; and
- 15% (230 ha) in L2.

From 1997 to 2018 the irrigable area in:

- L1 increased by 415 ha, a 45% increase from 925 ha to 1,340 ha; and
- L2 increased by 35 ha, an 18% increase from 195 ha to 230 ha.

Irrigation properties

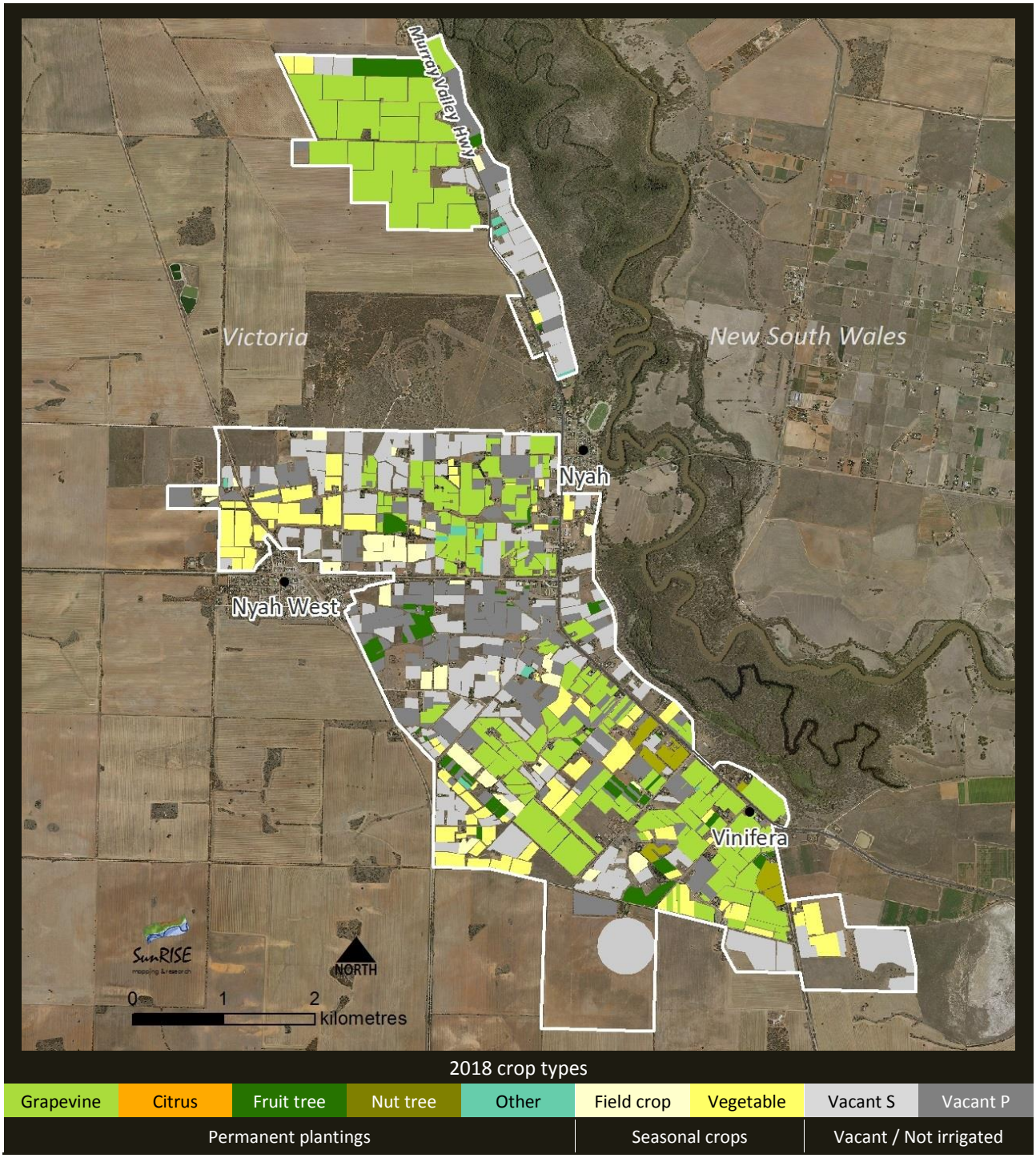
In 2018, there were approximately 153 irrigation properties with an average irrigable area of 10 ha.

From 1997 to 2018:

- the number of properties decreased by 4; a 3% decrease from 157 to 153 properties;
- properties with an irrigable area less than 20 ha decreased by 14, while the number over 20 ha increased by 10; and
- average property size (irrigable area) increased from 7 ha to 10 ha.

2.2.1 Nyah irrigation district - crop types in 2018

Map 2 shows the Nyah irrigation district and crop types in 2018. The district shown in the map is the gazetted district plus adjacent areas irrigated with water from the district.



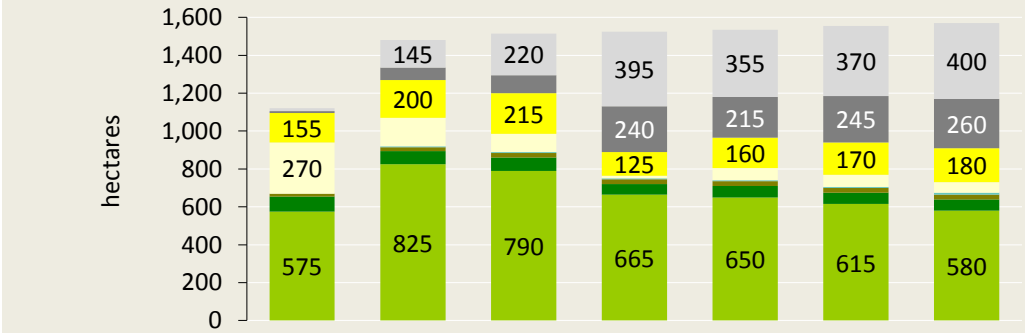
Map 2: Nyah irrigation district showing 2018 crop types

2.2.2 Nyah irrigation district - crop types from 1997 to 2018

Figure 23 summarises crop types in the Nyah irrigation district from 1997 to 2018.

- Dominant plantings in 2018 were:
    1. wine grape plantings: 455 ha (29% of the irrigable area);
    2. vegetables other than carrots and potatoes[12]: 130 ha (8% of the irrigable area); and
    3. dried grapes: 115 ha (7% of the irrigable area).

- Wine grape plantings were the dominant crop from 1997 to 2018. Plantings increased by 140 ha; a 44% increase from 315 ha in 1997 to 455 ha in 2018.
- Second to wine grapes, with respect to an increase in plantings, were carrots with a 400% increase from 10 ha in 1997 to 50 ha in 2018.



Crop type		1997	2003	2006	2009	2012	2015	2018	% of 2018 total	Change 1997-2018
Permanent	Grape Dried	235	170	160	140	140	125	115	7%	-120
	Grape Table	25	25	20	15	20	20	10	1%	-15
	Grape Wine	315	630	610	510	490	470	455	29%	+140
	Citrus	-	-	-	-	-	-	-	-	-
	Fruit Olive	10	10	10	10	10	10	10	1%	0
	Fruit Other	70	60	60	45	50	50	50	3%	-20
	Nut Almond	5	5	5	5	5	5	5	0%	0
	Nut Other	10	15	20	20	20	20	20	1%	+10
	Other	0	5	5	5	5	5	10	1%	+10
Seasonal	Field Crop	270	150	95	15	65	65	55	4%	-215
	Veg. Carrot	10	20	30	30	40	50	50	3%	+40
	Veg. Potato	-	-	-	-	-	-	-	-	-
	Veg. Other	145	180	185	95	120	120	130	8%	-15
	Vacant P	10	65	95	240	215	245	260	17%	+250
	Vacant S	15	145	220	395	355	370	400	25%	+385
Total (ha)		1,120	1,480	1,515	1,525	1,535	1,555	1,570	100%	+450
Dominant		wine grape	wine grape	wine grape	wine grape	wine grape	wine grape	wine grape		

Figure 23: Nyah irrigation district - crop types from 1997 to 2018

[12] Carrots and potatoes are significant crops in the Mallee catchment and are reported on separately

2.2.3 Nyah irrigation district - development of permanent crops

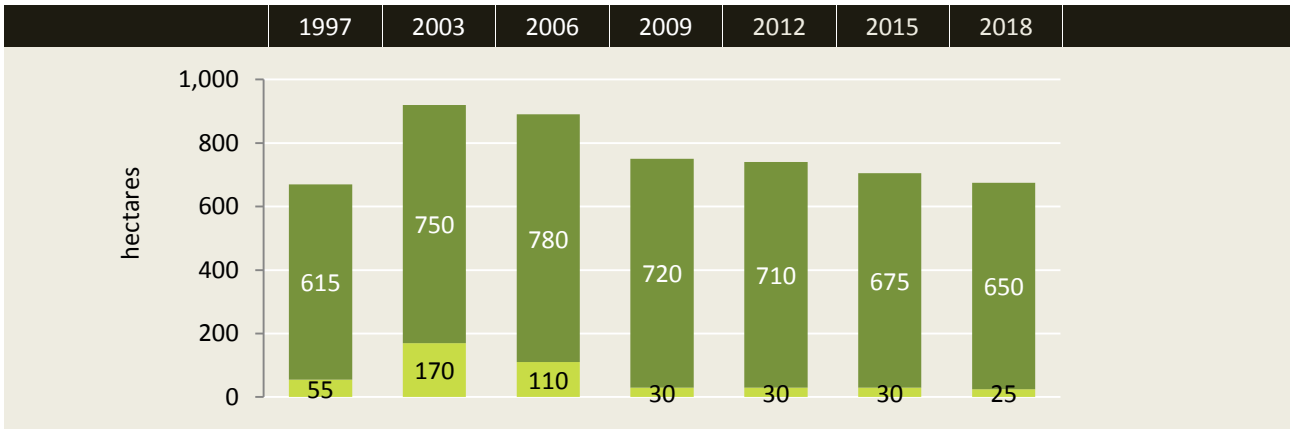
Figure 24 shows the proportion of permanent crops planted or redeveloped in the previous three years in the Nyah irrigation district from 1997 to 2018.

The information provides an indication of development activity that is otherwise not evident in information on changes in areas and crop types, as it includes replanting and top working to different varieties. The figures are conservative, as top-worked plantings can be difficult to interpret from the three-yearly aerial imagery, particularly for grapevines.

- In 2018, 25 ha (4%) of permanent crops were planted or redeveloped in the previous three years. Development was predominantly:
    1. dried grapes (10 ha);
    2. wine grapes (10 ha); and
    3. stone fruit (5 ha).

- New or redeveloped permanent plantings were highest in 2003 with 170 ha (18%) planted in the previous three years.

- New or redeveloped permanent plantings were lowest in 2018.



Permanent plantings	1997	2003	2006	2009	2012	2015	2018	% of 2018 total
≤3yr old plantings	55	170	110	30	30	30	25	4%
>3yr old plantings	615	750	780	720	710	675	650	96%
Total (ha)	670	920	890	750	740	705	675	100%
% 3yr development	8%	18%	12%	4%	4%	4%	4%	

Figure 24: Nyah irrigation district - three-year development of permanent crops from 1997 to 2018

2.2.4 Nyah irrigation district - planting trends

Figure 25 summarises planting trends in the Nyah irrigation district from 1997 to 2018.

- In 2018, the irrigable area of 1,570 ha comprised:
  - 43% (675 ha) irrigated permanent plantings;
  - 15% (235 ha) irrigated seasonal crops; and
  - 42% (660 ha) vacant or not irrigated areas.

- The proportion of permanent plantings, seasonal cropping and vacant areas changed from:
  - 60% permanent, 38% seasonal and 2% vacant in 1997; to
  - 43% permanent, 15% seasonal and 42% vacant in 2018.

- The area vacant was at its highest in 2018 with 42% of the irrigable area not irrigated.

- From 1997 to 2018:
  - irrigated permanent crops increased by 5 ha;
  - irrigated seasonal crops decreased by 190 ha;
  - vacant, not irrigated areas increased by 635 ha; and
  - the irrigable area increased by 450 ha due to expansion of the district to include adjacent areas irrigated with water from the district.

	1997	2003	2006	2009	2012	2015	2018	% of 2018 total	Change 1997-2018
Permanent - irrigated	670	920	890	750	740	705	675	43%	+5
Seasonal - irrigated	425	350	310	140	225	235	235	15%	-190
Vacant - permanent	10	65	95	240	215	245	260	17%	+250
Vacant - seasonal	15	145	220	395	355	370	400	25%	+385
Total (ha)	1,120	1,480	1,515	1,525	1,535	1,555	1,570	100%	+450
% Permanent	60%	62%	59%	49%	48%	45%	43%		
% Seasonal	38%	24%	20%	9%	15%	15%	15%		
% Vacant	2%	14%	21%	42%	37%	40%	42%		

Figure 25: Nyah irrigation district - planting trends from 1997 to 2018

2.2.5 Nyah irrigation district - irrigation development

Map 3 shows irrigation development from 1997 to 2018 in the Nyah irrigation district with respect to new development (expansion) and areas retired[13] from irrigation.

- The irrigable area increased by 450 ha, a 40% increase from 1,120 ha in 1997 to 1,570 ha in 2018.
- The net increase of 450 ha comprised 460 ha of expansion and 10 ha retired from irrigation.

Map 3: Irrigation development in the Nyah irrigation district from 1997 to 2018

	Hectares		% of 1997
Irrigation areas in 1997 (1996-97 season)	1,120		
Retired between 1997 and 2018	-10		-1%
Expansion between 1997 and 2018	+460		+41%
Irrigation areas in 2018 (2017-18 season)	1,570		

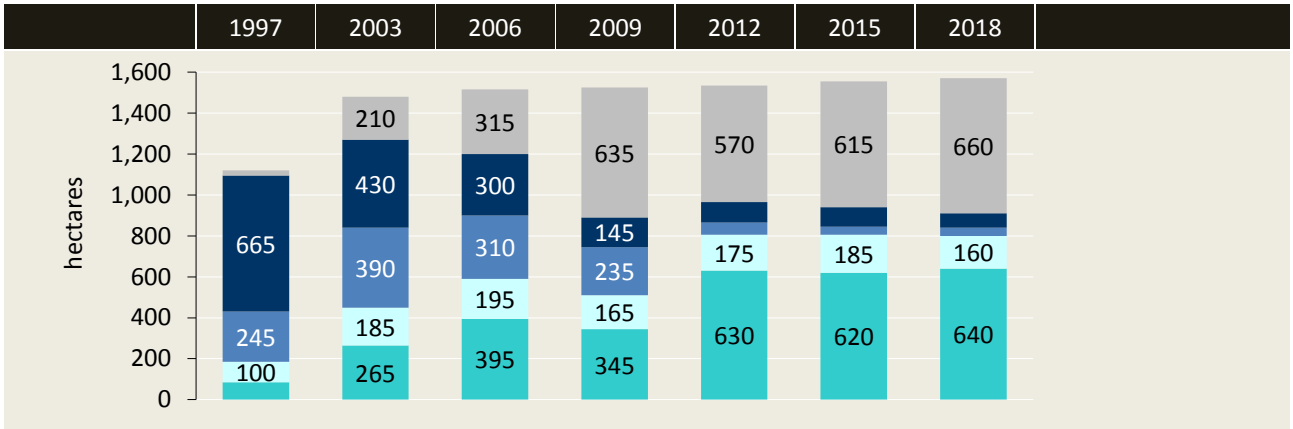
[13] Retired areas have undergone a change in land use that precludes use for irrigation e.g. urban development, housing, sheds, dams and land set aside for conservation purposes.

2.2.6 Nyah irrigation district - irrigation methods

Figure 26 summarises irrigation methods in the Nyah irrigation district from 1997 to 2018.

- In 2018, the irrigable area of 1,570 ha comprised:
  - 41% (640 ha) drip irrigation;
  - 10% (160 ha) lowlevel irrigation;
  - 3% (40 ha) overhead sprinklers;
  - 4% (70 ha) furrow irrigation; and
  - 42% (660 ha) not irrigated.

- Drip irrigation increased by 555 ha, a 653% increase from 85 ha in 1997 to 640 ha in 2018.
  - Drip irrigation was the dominant irrigation method from 2006 to 2018.
- Lowlevel irrigation increased by 60 ha, a 60% increase from 100 ha in 1997 to 160 ha in 2018.
- Overhead irrigation decreased by 205 ha, an 84% decrease from 245 ha in 1997 to 40 ha in 2018.
- Furrow irrigation decreased by 595 ha, an 89% decrease from 665 ha in 1997 to 70 ha in 2018.
  - Furrow irrigation was the dominant irrigation method from 1997 to 2003.



Irrigation method[14]	1997	2003	2006	2009	2012	2015	2018	% of 2018 total	Change 1997-2018
Drip	85	265	395	345	630	620	640	41%	+555
Lowlevel	100	185	195	165	175	185	160	10%	+60
Overhead	245	390	310	235	60	40	40	3%	-205
Furrow	665	430	300	145	100	95	70	4%	-595
Vacant	25	210	315	635	570	615	660	42%	+635
Total (ha)	1,120	1,480	1,515	1,525	1,535	1,555	1,570	100%	+450
Dominant	furrow	furrow	drip	drip	drip	drip	drip		

Figure 26: Nyah irrigation district - irrigation methods from 1997 to 2018

[14] Overhead irrigation includes pivots and lateral move systems. Furrow includes flood irrigation. (Table 5)

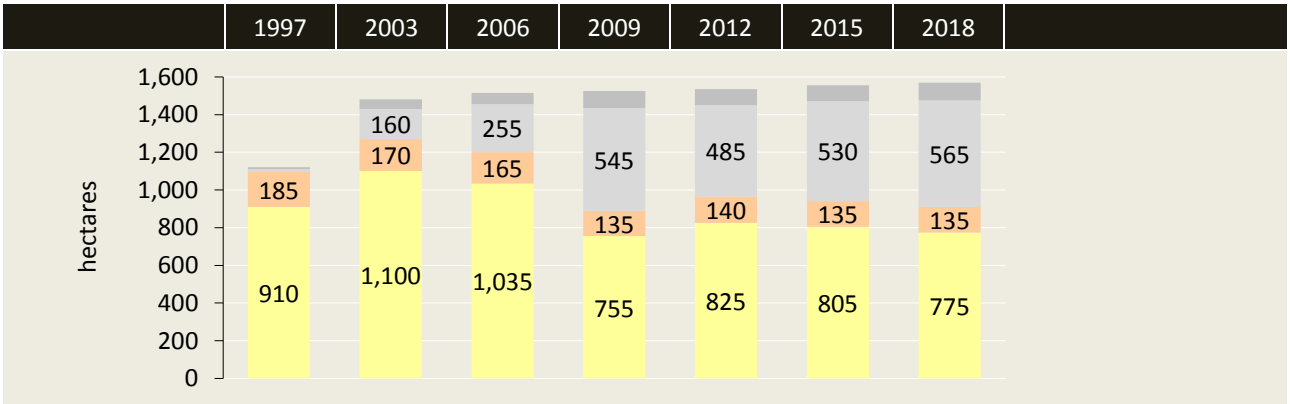
2.2.7 Nyah irrigation district - salinity impact zones

Figure 27 summarises river salinity impact zones of irrigated areas in the Nyah irrigation district from 1997 to 2018. The Nyah district is in low salinity impact zones L1 and L2. No irrigable areas are in the high salinity impact zone.

- In 2018, the irrigable area of 1,570 ha comprised:
  - 85% (1,340 ha) in the lowest salinity impact zone, L1; and
  - 15% (230 ha) in L2.

- The area irrigated in:
  - L1 decreased by 135 ha, a 15% decrease from 910 ha in 1997 to 775 ha in 2018; and
  - L2 decreased by 50 ha, a 27% decrease from 185 ha in 1997 to 135 ha in 2018.

- The irrigable area in:
  - L1 increased by 415 ha, a 45% increase from 925 ha in 1997 to 1,340 ha in 2018; and
  - L2 increased by 35 ha, an 18% increase from 195 ha in 1997 to 230 ha in 2018.



Salinity impact zone		1997	2003	2006	2009	2012	2015	2018	% of 2018 total	Change (ha) 1997-2018
Irrigated	L1	910	1,100	1,035	755	825	805	775	49%	-135
	L2	185	170	165	135	140	135	135	9%	-50
	L3	-	-	-	-	-	-	-	-	-
	L4	-	-	-	-	-	-	-	-	-
	HIZ	-	-	-	-	-	-	-	-	-
Not Irrigated	L1	15	160	255	545	485	530	565	36%	+550
	L2	10	50	60	90	85	85	95	6%	+85
	L3	-	-	-	-	-	-	-	-	-
	L4	-	-	-	-	-	-	-	-	-
	HIZ	-	-	-	-	-	-	-	-	-
Total (ha)		1,120	1,480	1,515	1,525	1,535	1,555	1,570	100%	+450
Dominant zone		L1	L1	L1	L1	L1	L1	L1		

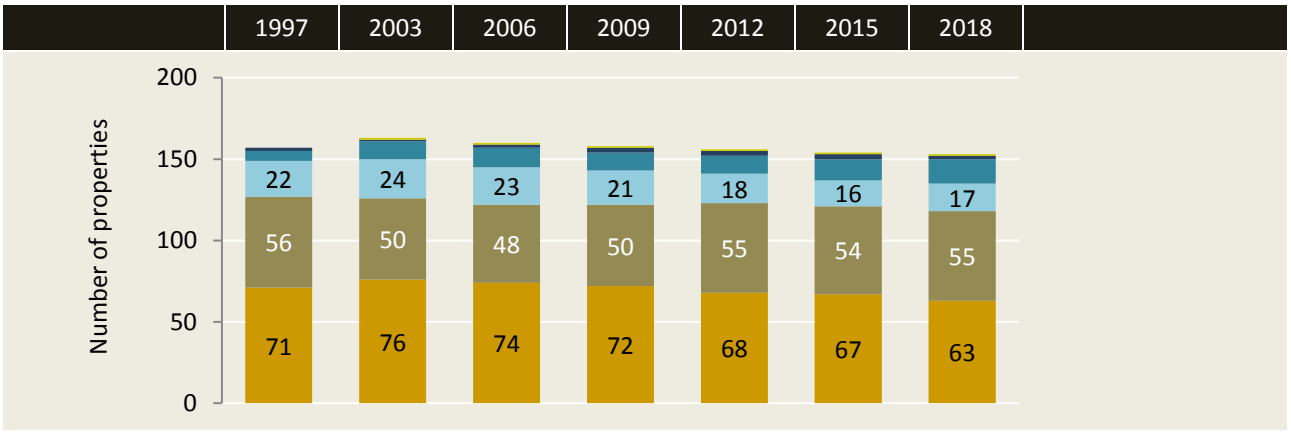
Figure 27: Nyah irrigation district - irrigable area in each salinity impact zone from 1997 to 2018

2.2.8 Nyah irrigation district - property change

Figure 28 provides estimates of property numbers and average property size (irrigable area) in the Nyah irrigation district from 1997 to 2018.

- In 2018:
  - there were approximately 153 irrigation properties; and
  - most properties (88%) had an irrigable area less than 20 ha.

- From 1997 to 2018:
  - the number of properties decreased by 4; a 3% decrease from 157 to 153 properties;
  - properties with an irrigable area less than 20 ha decreased by 14, while the number over 20 ha increased by 10; and
  - average property size (irrigable area) increased from 7 ha to 10 ha.



Property size (irrigable area)	1997	2003	2006	2009	2012	2015	2018	% of 2018 total	Change 1997-2018
1 to 5 ha	71	76	74	72	68	67	63	41%	-8
5 to 10 ha	56	50	48	50	55	54	55	36%	-1
10 to 20 ha	22	24	23	21	18	16	17	11%	-5
20 to 40 ha	6	11	12	11	11	13	15	10%	+9
40 to 100 ha	2	1	2	3	3	3	2	1%	0
100 to 500 ha	0	1	1	1	1	1	1	1%	+1
> 500 ha	-	-	-	-	-	-	-	-	-
Total properties	157	163	160	158	156	154	153	100%	-4
Average size (ha)	7	9	9	10	10	10	10		

Figure 28: Nyah irrigation district - number of properties and average size from 1997 to 2018

2.3 Robinvale irrigation district

In summary for the Robinvale irrigation district

Crop types in 2018

Dominant plantings in the Robinvale irrigation district in 2018 were:

1. table grape plantings; 2,080 ha (86% of the irrigable area);
2. fruit trees, predominantly avocado; 115 ha (5% of the irrigable area); and
3. wine grapes; 75 ha (3% of the irrigable area).

Crop types 1997 to 2018

Table grape plantings were the dominant crop from 1997 to 2018.

The main changes in crops from 1997 to 2018 were:

- table grape plantings increased by 675 ha; a 48% increase from 1,405 ha to 2,080 ha;
- fruit trees, predominantly avocados, increased by 100 ha; a 667% increase from 15 ha to 115 ha;
- wine grape plantings decreased by 385 ha; an 84% decrease from 460 ha to 75 ha; and
- dried grape plantings decreased by 355 ha; a 92% decrease from 385 ha to 30 ha.

Development of permanent plantings (new or redeveloped in the previous three years)

In 2018, at least 300 ha (13%) of permanent crops were planted or redeveloped in the previous three years, predominantly:

1. table grapes (250 ha);
2. nursery (20 ha); and
3. avocados (20 ha).

Development activity ranged from 11% of permanent plantings to 21% between 1997 and 2018.

Planting trends - permanent plantings, seasonal crops and vacant areas

The irrigable area in 2018 was 2,420 ha of which:

- 96% (2,335 ha) was irrigated permanent plantings;
- <1% (10 ha) was irrigated seasonal crops; and
- 4% (75 ha) was vacant, not irrigated.

From 1997 to 2018:

- permanent plantings decreased from 99% to 96% of the irrigable area;
- seasonal crops decreased from 1% to <1% of the irrigable area; and
- vacant, not irrigated areas increased from <1% to 3% of the irrigable area.

In summary for the Robinvale irrigation district

Irrigation development - new and retired areas

In the Robinvale irrigation district, the irrigable area increased by 100 ha, a 4% increase from 2,320 ha in 1997 to 2,420 ha in 2018.

The net increase of 100 ha was the balance of 130 ha expansion and 30 ha retired from irrigation.

Irrigation methods

Lowlevel sprinklers were the dominant irrigation method in the Robinvale district from 2003 to 2018, whereas furrow irrigation was dominant in 1997.

In 2018, the irrigable area of 2,420 ha comprised:

- 35% (855 ha) drip irrigation;
- 61% (1,485 ha) lowlevel irrigation;
- <1% (5 ha) overhead sprinklers;
- 0% (0 ha) furrow irrigation; and
- 3% (75 ha) not irrigated.

Salinity impact zones

The Robinvale irrigation district is in low salinity impact zones L2 and L3.

In 2018, the irrigable area of 2,420 ha comprised:

- 99% (2,395 ha) in the second lowest salinity impact zone, L2; and
- 1% (25 ha) in L3.

From 1997 to 2018 the irrigable area in:

- L2 increased by 95 ha, a 4% increase from 2,300 ha to 2,395 ha; and
- L3 increased by 5 ha, a 25% increase from 20 ha to 25 ha.

Irrigation properties

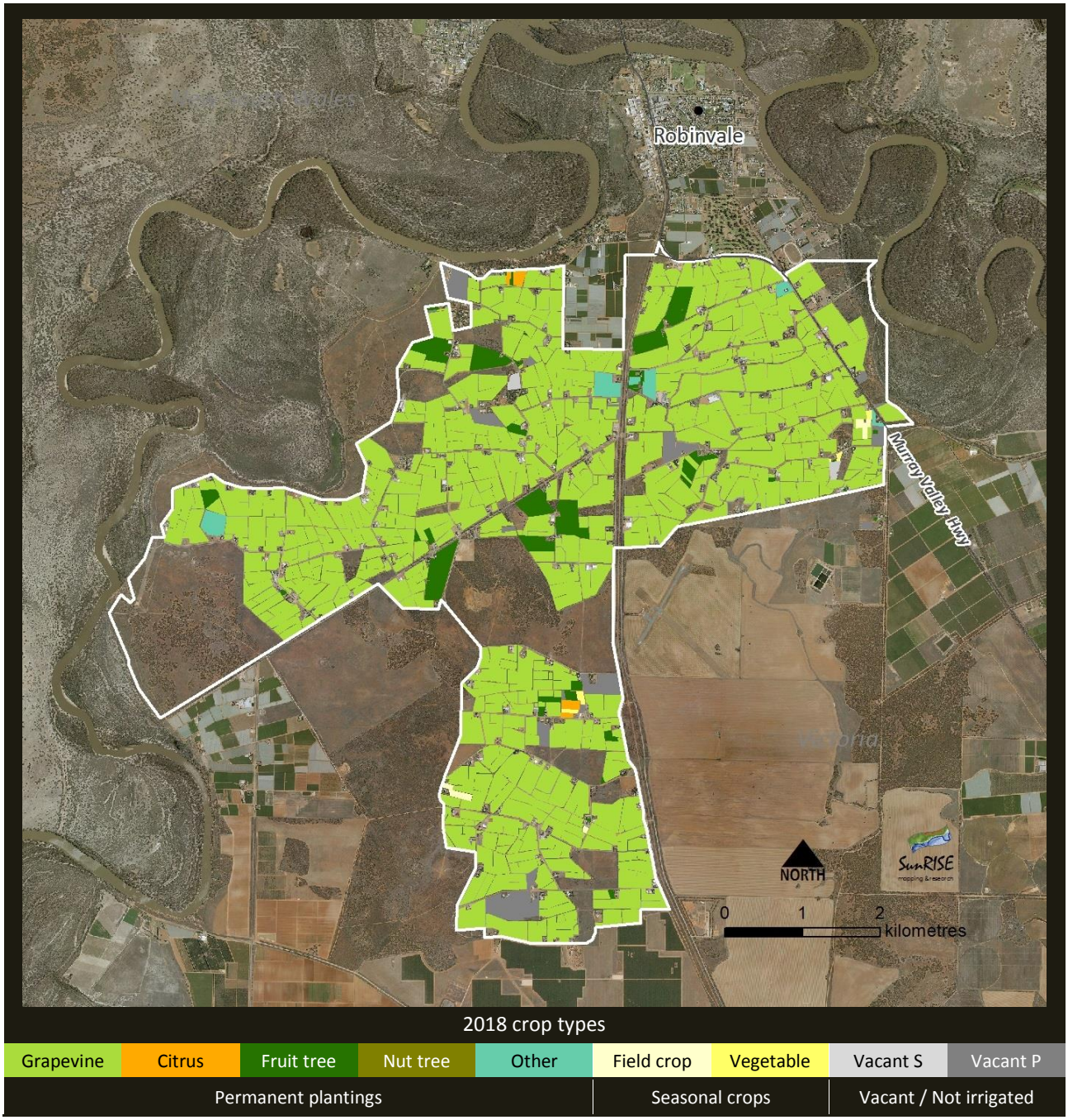
In 2018, there were approximately 108 irrigation properties with an average irrigable area of 22 ha.

From 1997 to 2018:

- the number of properties decreased by 61; a 36% decrease from 169 to 108 properties;
- properties with an irrigable area less than 20 ha decreased by 72, while the number over 20 ha increased by 11; and
- average property size (irrigable area) increased from 14 ha to 22 ha.

2.3.1 Robinvale irrigation district - crop types in 2018

Map 4 shows the Robinvale irrigation district and crop types in 2018.



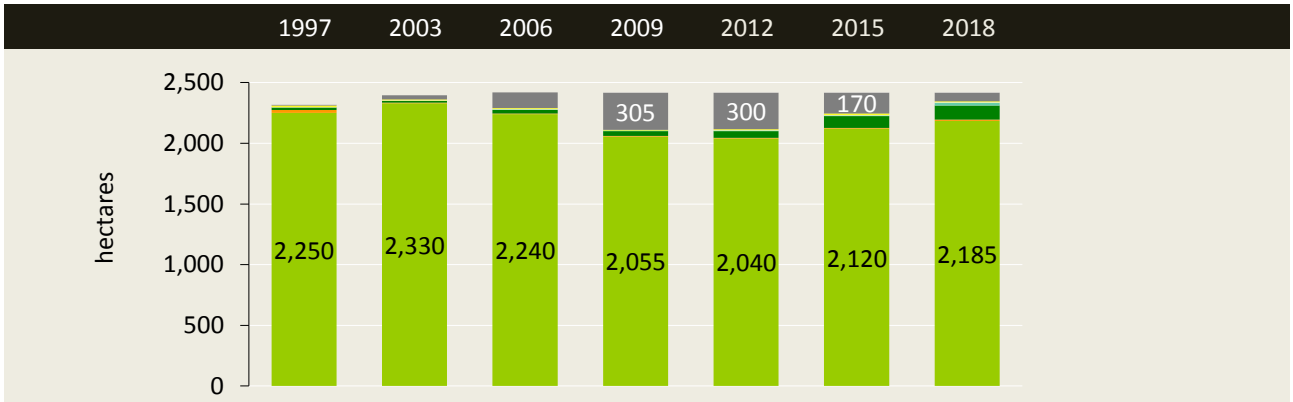
Map 4: Robinvale irrigation district showing 2018 crop types

2.3.2 Robinvale irrigation district - crop types from 1997 to 2018

Figure 29 summarises crop types in the Robinvale irrigation district from 1997 to 2018.

- Dominant plantings in 2018 were:
    1. table grape plantings; 2,080 ha (86% of the irrigable area);
    2. fruit trees, predominantly avocados; 115 ha (5% of the irrigable area); and
    3. wine grapes; 75 ha (3% of the irrigable area).

- Table grape plantings remained the dominant crop from 1997 to 2018. Plantings increased by 675 ha; a 48% increase from 1,405 ha in 1997 to 2,080 ha in 2018.
- Second to table grapes, with respect to an increase in plantings, were fruit trees (predominantly avocados) with a 667% increase from 15 ha in 1997 to 115 ha in 2018.



Crop type		1997	2003	2006	2009	2012	2015	2018	% of 2018 total	Change 1997-2018
Permanent	Grape Dried	385	155	125	90	85	75	30	1%	-355
	Grape Table	1,405	1,730	1,680	1,650	1,765	1,915	2,080	86%	+675
	Grape Wine	460	445	435	315	190	130	75	3%	-385
	Citrus	25	5	5	5	5	5	10	0%	-15
	Fruit Olive	5	0	0	0	0	0	0	0%	-5
	Fruit Other	15	15	30	40	55	100	115	5%	+100
	Nut Almond	-	-	-	-	-	-	-	-	-
	Nut Other	-	-	-	-	-	-	-	-	-
	Other	0	0	5	5	5	5	25	1%	+25
Seasonal	Field Crop	5	5	5	0	5	5	5	0%	0
	Veg. Carrot	-	-	-	-	-	-	-	-	-
	Veg. Potato	-	-	-	-	-	-	-	-	-
	Veg. Other	10	5	5	5	5	10	5	0%	-5
Vacant P		5	35	130	305	300	170	70	3%	+65
Vacant S		5	0	0	5	5	5	5	0%	0
Total (ha)		2,320	2,395	2,420	2,420	2,420	2,420	2,420	100%	+100
Dominant		table grape	table grape	table grape	table grape	table grape	table grape	table grape		

Figure 29: Robinvale irrigation district - crop types from 1997 to 2018

2.3.3 Robinvale irrigation district - development of permanent crops

Figure 30 shows the proportion of permanent crops planted or redeveloped in the previous three years in the Robinvale irrigation district from 1997 to 2018.

The information provides an indication of development activity that is otherwise not evident in information on changes in areas and crop types, as it includes replanting and top working to different varieties. The figures are conservative, as top-worked plantings can be difficult to interpret from the three-yearly aerial imagery, particularly for grapevines.

- In 2018, 300 ha (13%) of permanent crops were planted or redeveloped in the previous three years. Development was predominantly:
    1. table grapes (250 ha);
    2. nursery (20 ha); and
    3. avocados (20 ha).

- New or redeveloped permanent plantings were highest in 2006 with 490 ha (21%) planted in the previous three years.

- New or redeveloped permanent plantings were lowest in 2009 with 240 ha (11%) planted in the previous three years.

Permanent plantings	1997	2003	2006	2009	2012	2015	2018	% of 2018 total
≤3yr old plantings	300	445	490	240	345	425	300	13%
>3yr old plantings	1,995	1,905	1,790	1,865	1,760	1,805	2,035	87%
Total (ha)	2,295	2,350	2,280	2,105	2,105	2,230	2,335	100%
% 3yr development	13%	19%	21%	11%	16%	19%	13%	

Figure 30: Robinvale irrigation district - development of permanent crops from 1997 to 2018

2.3.4 Robinvale irrigation district - planting trends

Figure 31 summarises planting trends in the Robinvale irrigation district from 1997 to 2018.

- In 2018, the irrigable area of 2,420 ha comprised:
  - 96% (2,335 ha) irrigated permanent plantings;
  - <1% (10 ha) irrigated seasonal crops; and
  - 4% (75 ha) vacant or not irrigated areas.

- The proportion of permanent plantings, seasonal cropping and vacant areas changed from:
  - 99% permanent, 1% seasonal and <1% vacant in 1997; to
  - 96% permanent, <1% seasonal and 3% vacant in 2018.

- The area vacant was at its highest in 2009 with 13% of the irrigable area not irrigated. The proportion of vacant areas decreased to 3% by 2018.

- From 1997 to 2018:
  - irrigated permanent crops increased by 40 ha;
  - irrigated seasonal crops decreased by 5 ha;
  - vacant, not irrigated areas increased by 65 ha; and
  - the irrigable area increased by 100 ha.

	1997	2003	2006	2009	2012	2015	2018	% of 2018 total	Change 1997-2018
Permanent - irrigated	2,295	2,350	2,280	2,105	2,105	2,230	2,335	96%	+40
Seasonal - irrigated	15	10	10	5	10	15	10	<1%	-5
Vacant - permanent	5	35	130	305	300	170	70	3%	+65
Vacant - seasonal	5	0	0	5	5	5	5	<1%	0
Total (ha)	2,320	2,395	2,420	2,420	2,420	2,420	2,420	100%	+100
% Permanent	99%	98%	94%	87%	87%	92%	96%		
% Seasonal	1%	<1%	<1%	<1%	<1%	1%	<1%		
% Vacant	<1%	1%	5%	13%	13%	7%	3%		

Figure 31: Robinvale irrigation district - planting trends from 1997 to 2018

2.3.5 Robinvale irrigation district - irrigation development

Map 5 shows irrigation development from 1997 to 2018 in the Robinvale irrigation district with respect to new development (expansion) and areas retired[15] from irrigation.

- The irrigable area increased by 100 ha, a 4% increase from 2,320 ha in 1997 to 2,420 ha in 2018.
- The net increase of 100 ha comprised 30 ha retired from irrigation and 130 ha of expansion.

Map 5: Robinvale irrigation district - irrigation development from 1997 to 2018

	Hectares		% of 1997
Irrigation areas in 1997 (1996-97 season)	2,320		
Retired between 1997 and 2018	-30		-1%
Expansion between 1997 and 2018	+130		+6%
Irrigation areas in 2018 (2017-18 season)	2,420		

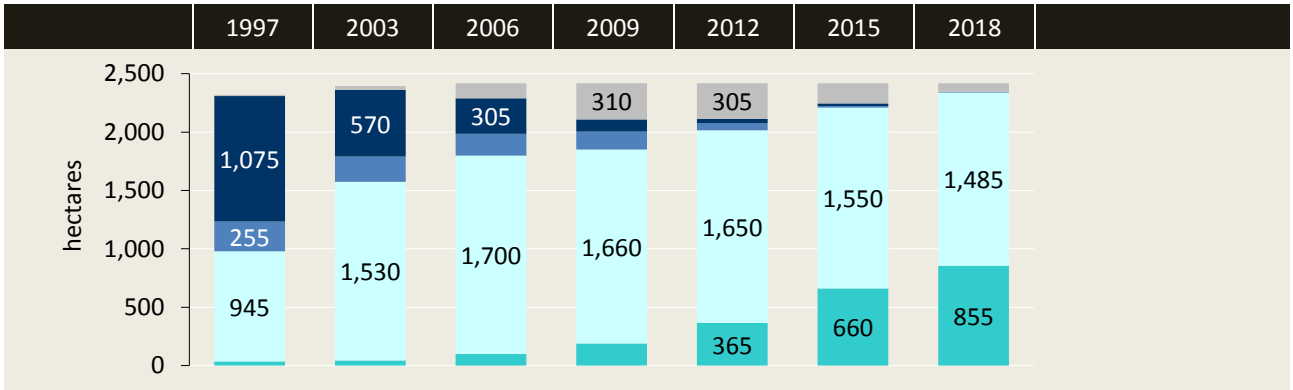
[15] Retired areas were previously irrigated but have undergone a change in land use that precludes use for irrigation e.g. urban development, housing, sheds, dams and land set aside for conservation purposes.

2.3.6 Robinvale irrigation district - irrigation methods

Figure 32 summarises irrigation methods in the Robinvale irrigation district from 1997 to 2018.

- In 2018, the irrigable area of 2,420 ha comprised:
  - 35% (855 ha) drip irrigation;
  - 61% (1,485 ha) lowlevel irrigation;
  - <1% (5 ha) overhead sprinklers;
  - 0% (0 ha) furrow irrigation; and
  - 3% (75 ha) not irrigated.

- Drip irrigation increased by 820 ha, a 2,343% increase from 35 ha in 1997 to 855 ha in 2018.
- Lowlevel irrigation increased by 540 ha, a 57% increase from 945 ha in 1997 to 1,485 ha in 2018.
  - Lowlevel irrigation was the dominant method from 2003 to 2018.
- Overhead irrigation decreased by 250 ha, a 98% decrease from 255 ha in 1997 to 5 ha in 2018.
- Furrow irrigation decreased by 1,075 ha, a 100% decrease from 1,075 ha in 1997 to 0 ha in 2018.
  - Furrow irrigation was the dominant irrigation method in 1997.



Irrigation method[16]	1997	2003	2006	2009	2012	2015	2018	% of 2018 total	Change 1997-2018
Drip	35	45	100	190	365	660	855	35%	+820
Lowlevel	945	1,530	1,700	1,660	1,650	1,550	1,485	61%	+540
Overhead	255	215	185	155	60	15	5	<1%	-250
Furrow	1,075	570	305	105	40	20	0	0%	-1,075
Vacant	10	35	130	310	305	175	75	3%	+65
Total (ha)	2,320	2,395	2,420	2,420	2,420	2,420	2,420	100%	+100
Dominant	furrow	lowlevel	lowlevel	lowlevel	lowlevel	lowlevel	lowlevel		

Figure 32: Robinvale irrigation district - irrigation methods from 1997 to 2018

[16] Overhead irrigation includes pivots and lateral move systems. Furrow includes flood irrigation. (Table 5)

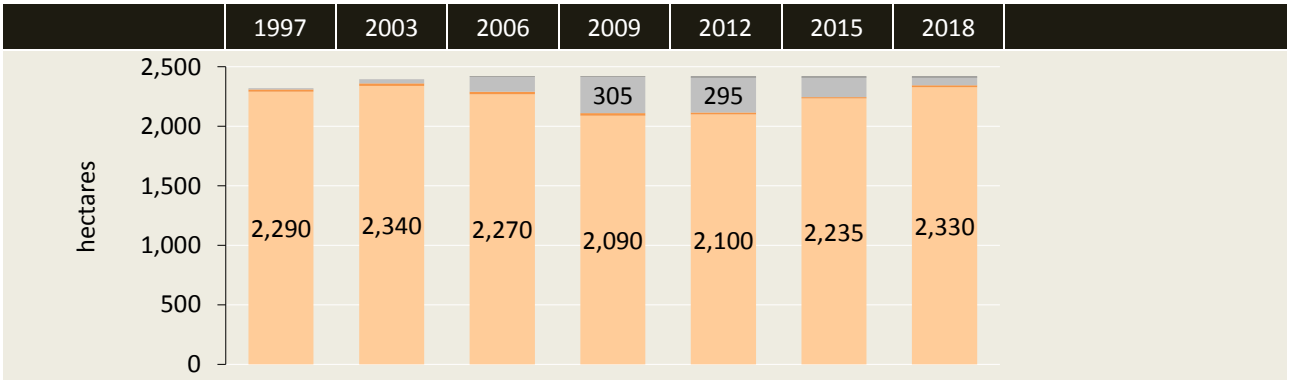
2.3.7 Robinvale irrigation district - salinity impact zones

Figure 33 summarises river salinity impact zones of irrigated areas in the Robinvale irrigation district from 1997 to 2018. The Robinvale district is in low salinity impact zones L2 and L3. No irrigable areas are in the high salinity impact zone.

- In 2018, the irrigable area of 2,420 ha comprised:
  - 99% (2,395 ha) in the second lowest salinity impact zone L2; and
  - 1% (25 ha) in L3.

- The area irrigated in:
  - L2 increased by 40 ha, a 2% increase from 2,290 ha in 1997 to 2,330 ha in 2018; and
  - L3 decreased by 5 ha, a 25% decrease from 20 ha in 1997 to 15 ha in 2018.

- The irrigable area in:
  - L2 increased by 95 ha, a 4% increase from 2,300 ha in 1997 to 2,395 ha in 2018; and
  - L3 increased by 5 ha, a 25% increase from 20 ha in 1997 to 25 ha in 2018.



Salinity impact zone		1997	2003	2006	2009	2012	2015	2018	% of 2018 total	Change (ha) 1997-2018
Irrigated	L1	-	-	-	-	-	-	-	-	-
	L2	2,290	2,340	2,270	2,090	2,100	2,235	2,330	96%	+40
	L3	20	20	20	20	15	10	15	1%	-5
	L4	-	-	-	-	-	-	-	-	-
	HIZ	-	-	-	-	-	-	-	-	-
Not Irrigated	L1	-	-	-	-	-	-	-	-	-
	L2	10	35	125	305	295	165	65	3%	+55
	L3	0	0	5	5	10	10	10	<1%	+10
	L4	-	-	-	-	-	-	-	-	-
	HIZ	-	-	-	-	-	-	-	-	-
Total (ha)		2,320	2,395	2,420	2,420	2,420	2,420	2,420	100%	+100
Dominant zone		L2	L2	L2	L2	L2	L2	L2		

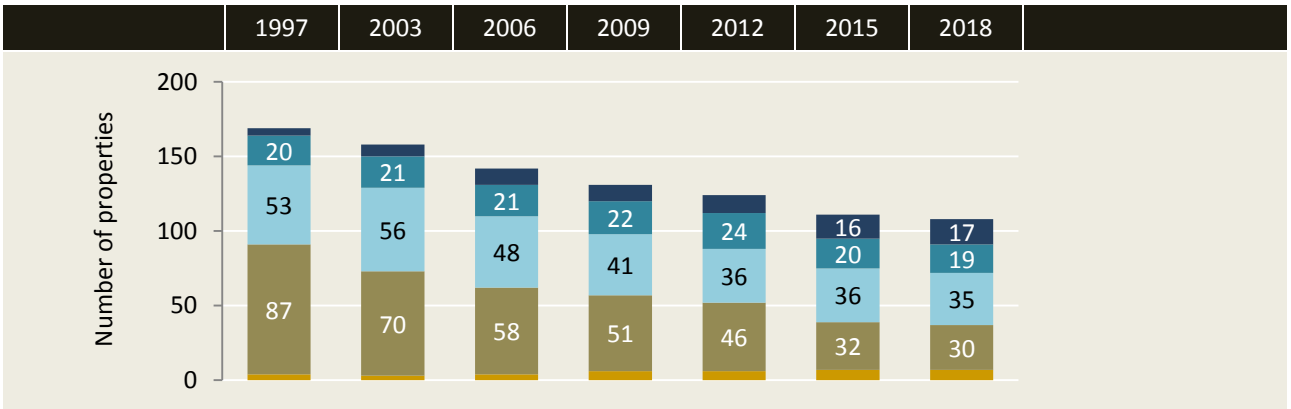
Figure 33: Robinvale irrigation district - irrigable area in each salinity impact zone from 1997 to 2018

2.3.8 Robinvale irrigation district - property change

Figure 34 provides estimates of property numbers and average property size (irrigable area) in the Robinvale irrigation district from 1997 to 2018.

- In 2018:
  - there were approximately 108 irrigation properties; and
  - most properties (67%) had an irrigable area less than 20 ha.

- From 1997 to 2018:
  - the number of properties decreased by 61; a 36% decrease from 169 to 108 properties;
  - properties with an irrigable area less than 20 ha decreased by 72, while the number over 20 ha increased by 11; and
  - average property size (irrigable area) increased from 14 ha to 22 ha.



Property size (irrigable area)	1997	2003	2006	2009	2012	2015	2018	% of 2018 total	Change 1997-2018
1 to 5 ha	4	3	4	6	6	7	7	6%	+3
5 to 10 ha	87	70	58	51	46	32	30	28%	-57
10 to 20 ha	53	56	48	41	36	36	35	32%	-18
20 to 40 ha	20	21	21	22	24	20	19	18%	-1
40 to 100 ha	5	8	11	11	12	16	17	16%	+12
100 to 500 ha	-	-	-	-	-	-	-	-	-
> 500 ha	-	-	-	-	-	-	-	-	-
Total properties	169	158	142	131	124	111	108	100%	-61
Average size (ha)	14	15	17	18	20	22	22		

Figure 34: Robinvale irrigation district - property numbers and sizes from 1997 to 2018

2.4 Red Cliffs irrigation district

In summary for the Red Cliffs irrigation district

Crop types in 2018

Dominant plantings in the Red Cliffs irrigation district in 2018 were:

1. wine grape plantings: 1,090 ha (25% of the irrigable area);
2. table grapes: 995 ha (22% of the irrigable area); and
3. dried grapes: 360 ha (8% of the irrigable area).

Crop types 1997 to 2018

Wine grape plantings were the dominant crop from 1997 to 2018.

The main changes in crops from 1997 to 2018 were:

- dried grape plantings decreased by 1,015 ha; a 74% decrease from 1,375 ha to 360 ha;
- wine grape plantings decreased by 860 ha; a 44% decrease from 1,950 ha to 1,090 ha; and
- table grape plantings increased by 520 ha; a 109% increase from 475 ha to 995 ha.

Development of permanent plantings (new or redeveloped in the previous three years)

In 2018, at least 410 ha (14%) of permanent crops were planted or redeveloped in the previous three years, predominantly:

1. table grapes (230 ha);
2. almonds (40 ha);
3. dried grapes (40 ha);
4. avocados (25 ha); and
5. citrus (25 ha).

Development activity ranged from 9% of permanent plantings in 2009 to 27% in 1997.

Planting trends - permanent plantings, seasonal crops and vacant areas

In 2018, the irrigable area of 4,440 ha comprised:

- 65% (2,880 ha) irrigated permanent plantings;
- 11% (475 ha) irrigated seasonal crops; and
- 24% (1,085 ha) vacant or not irrigated.

From 1997 to 2018:

- permanent plantings decreased from 92% to 65% of the irrigable area;
- seasonal crops increased from 5% to 11% of the irrigable area; and
- vacant, not irrigated areas increased from 3% to 24% of the irrigable area.

In summary for the Red Cliffs irrigation district

Irrigation development - new and retired areas

In the Red Cliffs irrigation district, the irrigable area decreased by 10 ha, a <1% decrease from 4,450 ha in 1997 to 4,440 ha in 2018.

The net decrease of 10 ha was the balance of 125 ha of expansion and 135 ha retired from irrigation.

Irrigation methods

Drip irrigation was the dominant irrigation method in the Red Cliffs district from 2009 to 2018, whereas overhead sprinklers were dominant in 2003 and 2006, and furrows in 1997.

In 2018, the irrigable area of 4,440 ha comprised:

- 48% (2,115 ha) drip irrigation;
- 14% (620 ha) lowlevel irrigation;
- 13% (595 ha) overhead sprinklers;
- 1% (25 ha) furrow irrigation; and
- 24% (1,085 ha) not irrigated.

Salinity impact zones

The Red Cliffs irrigation district is in salinity zones: L1, L4 and HIZ.

In 2018, the irrigable area of 4,440 ha comprised:

- 33% (1,485 ha) in the lowest salinity impact zone, L1;
- 24% (1,045 ha) in L4; and
- 43% (1,910 ha) in HIZ.

From 1997 to 2018 the irrigable area in:

- L1 increased by 10 ha, a 1% increase from 1,475 ha to 1,485 ha;
- L4 increased by 25 ha, a 2% increase from 1,020 ha to 1,045 ha; and
- HIZ decreased by 45 ha, a 2% decrease from 1,955 ha to 1,910 ha in 2018. The net decrease of HIZ was predominantly areas retired from irrigation for housing development.

Irrigation properties

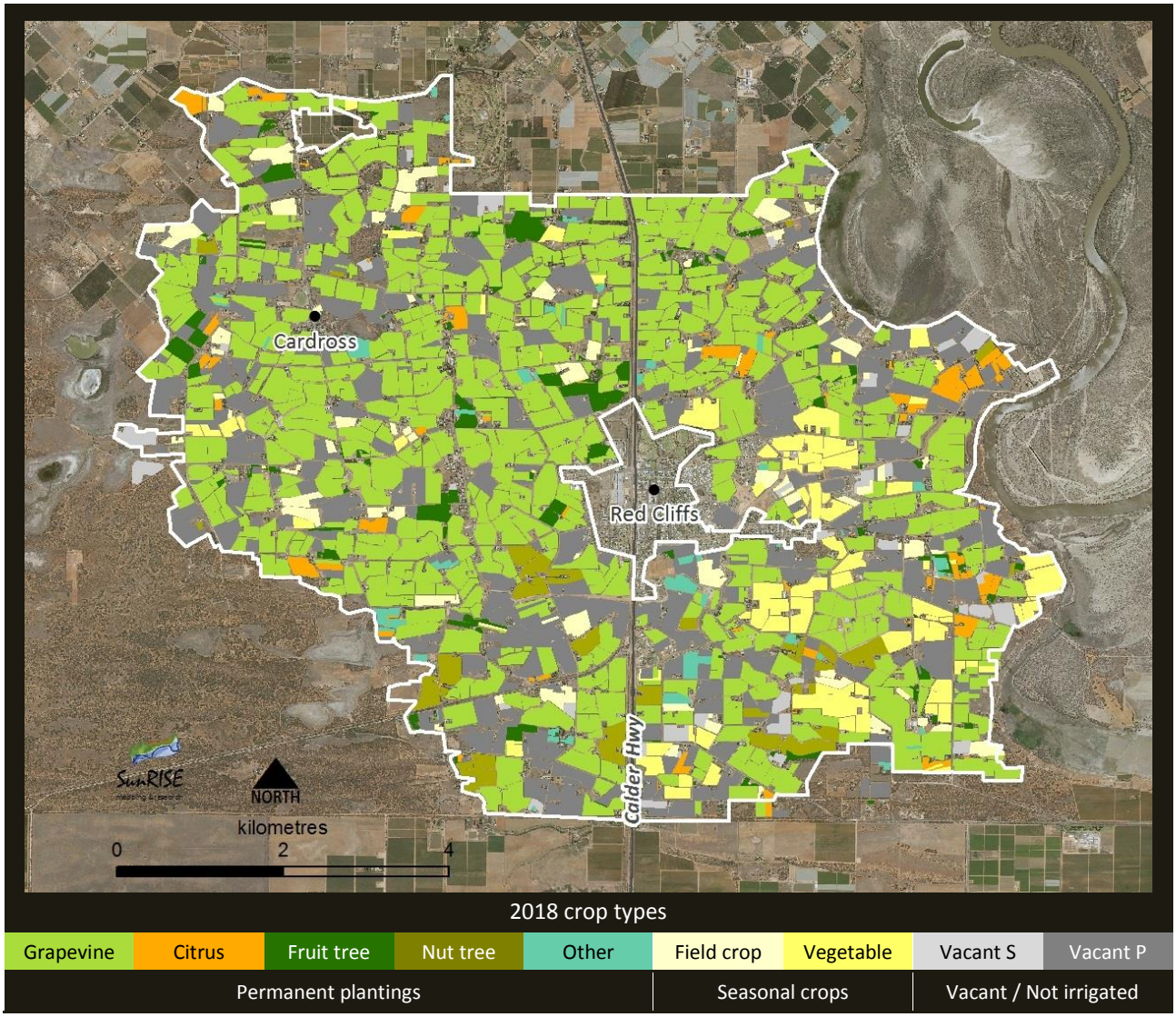
In 2018, there were approximately 404 irrigation properties with an average irrigable area of 11 ha.

From 1997 to 2018:

- the number of properties decreased by 109; a 21% decrease from 513 to 404 properties;
- properties with an irrigable area less than 20 ha decreased by 140, while the number over 20 ha increased by 31; and
- average property size (irrigable area) increased from 9 ha to 11 ha.

2.4.1 Red Cliffs irrigation district - crop types in 2018

Map 6 shows the Red Cliffs irrigation district and crop types in 2018.



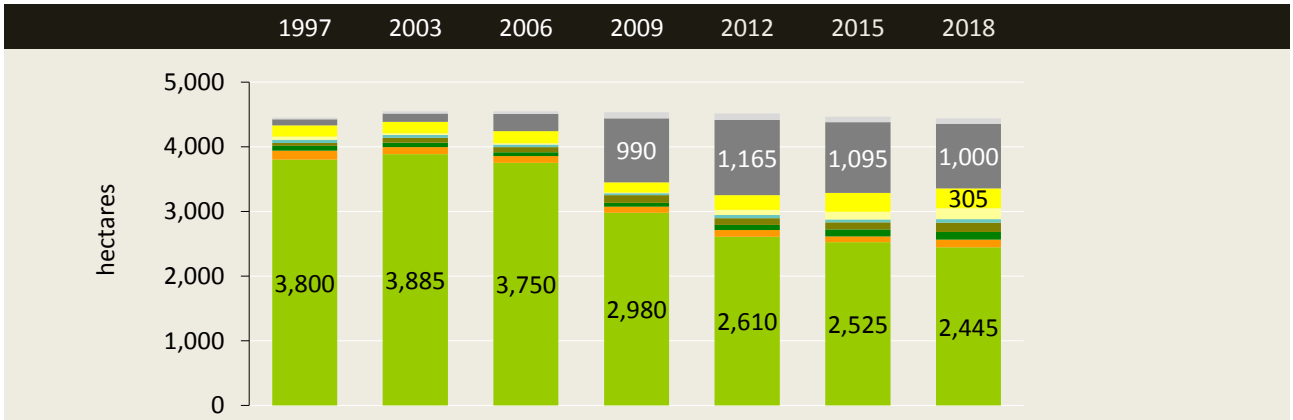
Map 6: Red Cliffs irrigation district showing 2018 crop types

2.4.2 Red Cliffs irrigation district - crop types from 1997 to 2018

Figure 35 summarises crop types in the Red Cliffs irrigation district from 1997 to 2018.

- Dominant plantings in 2018 were:
    1. wine grape plantings: 1,090 ha (25% of the irrigable area);
    2. table grapes: 995 ha (22% of the irrigable area); and
    3. dried grapes: 360 ha (8% of the irrigable area).

- Wine grape plantings were the dominant crop from 1997 to 2018. Plantings decreased by 860 ha; a 44% decrease from 1,950 ha in 1997 to 1,090 ha in 2018.
- The highest increase in plantings was 520 ha of table grapes; a 109% increase from 475 ha in 1997 to 995 ha in 2018.



Crop type		1997	2003	2006	2009	2012	2015	2018	% of 2018 total	Change 1997-2018
Permanent	Grape Dried	1,375	830	680	440	395	395	360	8%	-1,015
	Grape Table	475	665	640	660	740	825	995	22%	+520
	Grape Wine	1,950	2,390	2,430	1,880	1,475	1,305	1,090	25%	-860
	Citrus	140	110	105	95	100	90	120	3%	-20
	Fruit Olive	20	30	25	35	50	50	40	1%	+20
	Fruit Other	55	40	35	25	30	55	80	2%	+25
	Nut Almond	40	65	75	110	95	95	120	3%	+80
	Nut Other	5	5	5	5	10	15	20	0%	+15
	Other	45	45	40	30	50	45	55	1%	+10
Seasonal	Field Crop	50	25	20	10	80	120	170	4%	+120
	Veg. Carrot	-	-	-	-	-	-	-	-	-
	Veg. Potato	-	-	-	-	-	-	-	-	-
	Veg. Other	175	180	185	160	225	290	305	7%	+130
Vacant P		95	130	270	990	1,165	1,095	1,000	23%	+905
Vacant S		25	35	40	95	100	85	85	2%	+60
Total (ha)		4,450	4,550	4,550	4,535	4,515	4,465	4,440	100%	-10
Dominant		wine grape	wine grape	wine grape	wine grape	wine grape	wine grape	wine grape		

Figure 35: Red Cliffs irrigation district - crop types from 1997 to 2018

2.4.3 Red Cliffs irrigation district - development of permanent crops

Figure 36 shows the proportion of permanent crops planted or redeveloped in the previous three years in the Red Cliffs irrigation district from 1997 to 2018.

The information provides an indication of development activity that is otherwise not evident in information on changes in areas and crop types, as it includes replanting and top working to different varieties. The figures are conservative, as top-worked plantings can be difficult to interpret from the three-yearly aerial imagery, particularly for grapevines.

- In 2018, 410 ha (14%) of permanent crops were planted or redeveloped in the previous three years. Development was predominantly:
    1. table grapes (230 ha);
    2. almonds (40 ha);
    3. dried grapes (40 ha);
    4. avocados (25 ha); and
    5. citrus (25 ha).

- New or redeveloped permanent plantings were highest in 1997 with 1,105 ha (27%) planted in the previous three years.

- New or redeveloped permanent plantings were lowest in 2015 with 305 ha (11%) planted in the previous three years.

Permanent plantings	1997	2003	2006	2009	2012	2015	2018	% of 2018 total
≤3yr old plantings	1,105	815	550	310	325	305	410	14%
>3yr old plantings	3,000	3,365	3,485	2,970	2,620	2,570	2,470	86%
Total (ha)	4,105	4,180	4,035	3,280	2,945	2,875	2,880	100%
% 3year development	27%	19%	14%	9%	11%	11%	14%	

Figure 36: Red Cliffs irrigation district - development of permanent crops from 1997 to 2018

2.4.4 Red Cliffs irrigation district - planting trends

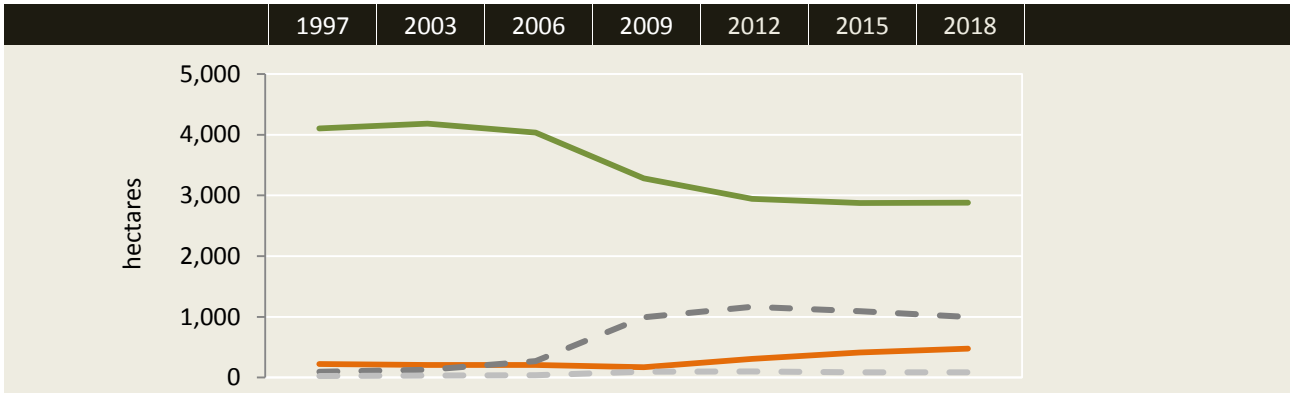
Figure 37 summarises planting trends in the Red Cliffs irrigation district from 1997 to 2018.

- In 2018, the irrigable area of 4,440 ha comprised:
  - 65% (2,880 ha) irrigated permanent plantings;
  - 11% (475 ha) irrigated seasonal crops; and
  - 24% (1,085 ha) vacant or not irrigated.

- The proportion of permanent plantings, seasonal cropping and vacant areas changed from:
  - 92% permanent, 5% seasonal and 3% vacant in 1997; to
  - 65% permanent, 11% seasonal and 24% vacant in 2018.

- The area vacant was at its highest in 2012 with 28% of the irrigable area not irrigated. The proportion of vacant areas decreased to 26% in 2015, then 24% in 2018.

- From 1997 to 2018:
  - irrigated permanent crops decreased by 1,225 ha;
  - irrigated seasonal crops increased by 250 ha; and
  - vacant, not irrigated areas increased by 965 ha.



	1997	2003	2006	2009	2012	2015	2018	% of 2018 total	Change 1997-2018
Permanent - irrigated	4,105	4,180	4,035	3,280	2,945	2,875	2,880	65%	-1,225
Seasonal - irrigated	225	205	205	170	305	410	475	11%	+250
Vacant - permanent	95	130	270	990	1,165	1,095	1,000	23%	+905
Vacant - seasonal	25	35	40	95	100	85	85	2%	+60
Total (ha)	4,450	4,550	4,550	4,535	4,515	4,465	4,440	100%	-10
% Permanent	92%	92%	89%	72%	65%	64%	65%		
% Seasonal	5%	5%	5%	4%	7%	9%	11%		
% Vacant	3%	4%	7%	24%	28%	26%	24%		

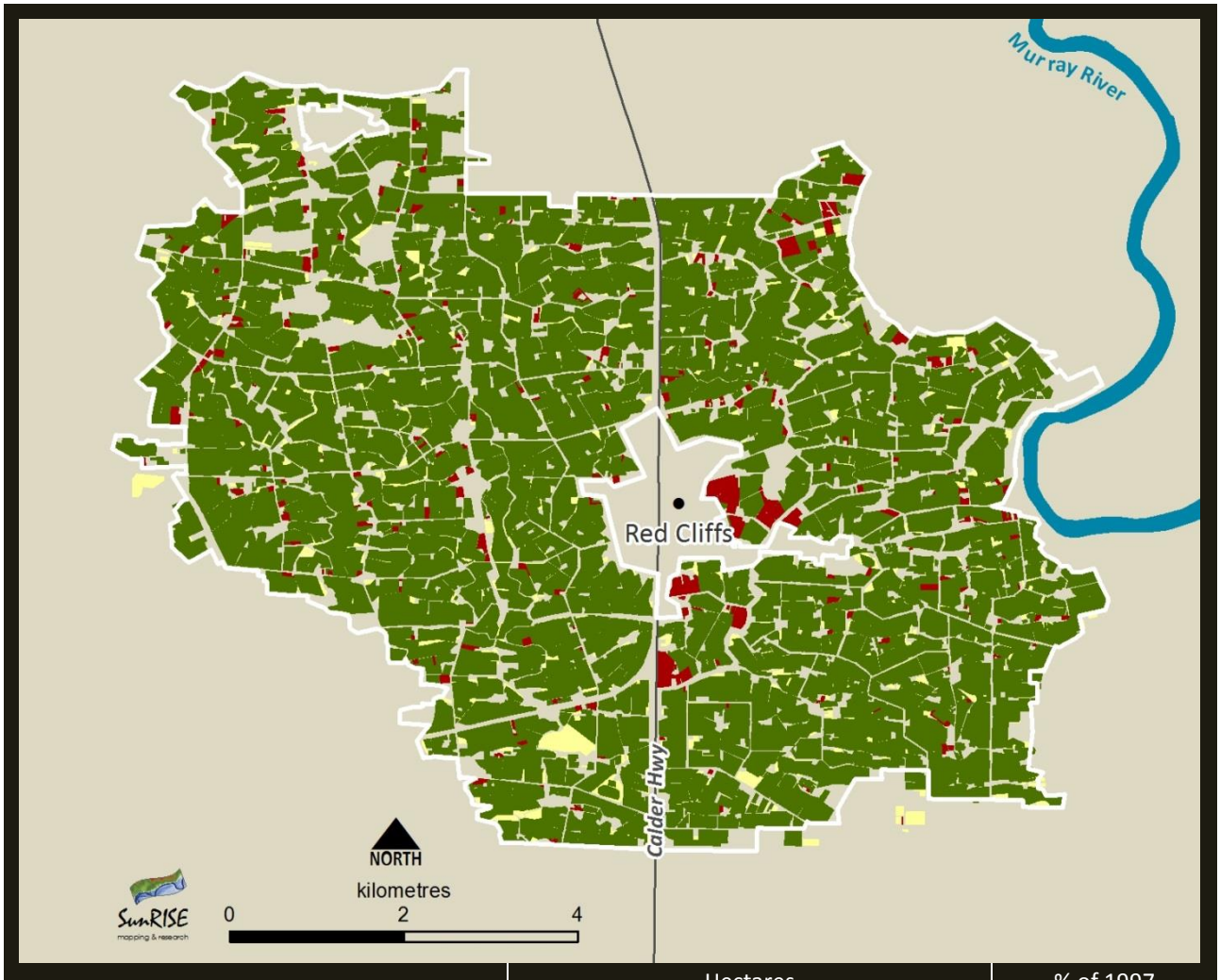
Figure 37: Red Cliffs irrigation district - planting trends from 1997 to 2018

2.4.5 Red Cliffs irrigation district - irrigation development

Map 7 shows irrigation development from 1997 to 2018 in the Red Cliffs irrigation district with respect to new development (expansion) and areas retired[17] from irrigation.

- The irrigable area decreased by 10 ha, a < 1% decrease from 4,450 ha in 1997 to 4,440 ha in 2018.
- The net decrease of 10 ha comprised 135 ha retired from irrigation and 125 ha of expansion.

Map 7: Red Cliffs irrigation district - irrigation development from 1997 to 2018



	Hectares		% of 1997
Irrigation areas in 1997 (1996-97 season)	4,450		
Retired between 1997 and 2018	-135		-3%
Expansion between 1997 and 2018	+125		+3%
Irrigation areas in 2018 (2017-18 season)	4,440		

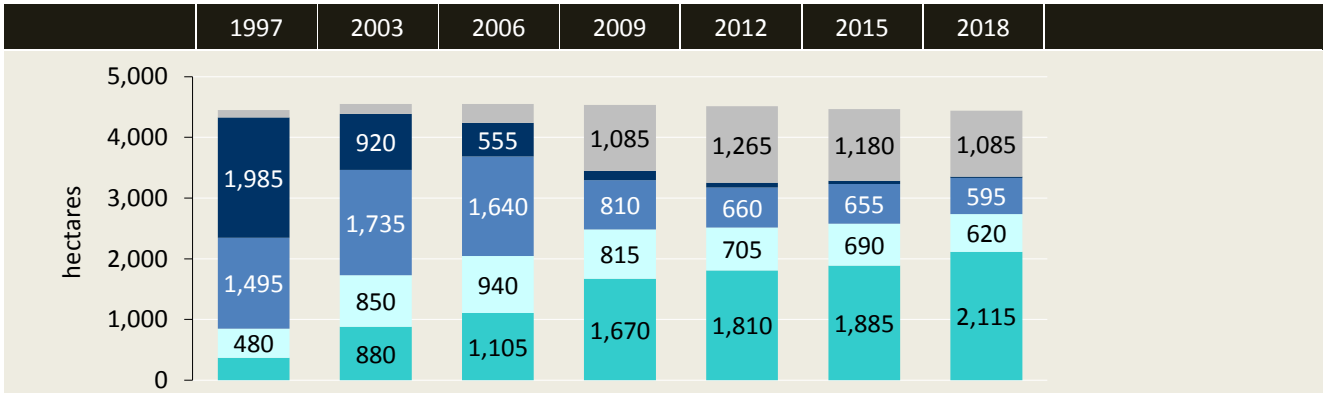
[17] Retired areas were previously irrigated but have undergone a change in land use that precludes use for irrigation e.g. urban development, housing, sheds, dams and land set aside for conservation purposes.

2.4.6 Red Cliffs irrigation district - irrigation methods

Figure 38 summarises irrigation methods in the Red Cliffs irrigation district from 1997 to 2018.

- In 2018, the irrigable area of 4,440 ha comprised:
  - 48% (2,115 ha) drip irrigation;
  - 14% (620 ha) lowlevel irrigation;
  - 13% (595 ha) overhead sprinklers;
  - 1% (25 ha) furrow irrigation; and
  - 24% (1,085 ha) not irrigated.

- Drip irrigation increased by 1,745 ha, a 472% increase from 370 ha in 1997 to 2,115 ha in 2018.
  - Drip irrigation was the dominant method from 2009 to 2018.
- Lowlevel irrigation increased by 140 ha, a 29% increase from 480 ha in 1997 to 620 ha in 2018.
- Overhead irrigation decreased by 900 ha, a 60% decrease from 1,495 ha in 1997 to 595 ha in 2018.
  - Overhead irrigation was the dominant irrigation method from 2003 to 2006.
- Furrow irrigation decreased by 1,960 ha, a 99% decrease from 1,985 ha in 1997 to 25 ha in 2018.
  - Furrow irrigation was the dominant irrigation method in 1997.



Irrigation method[18]	1997	2003	2006	2009	2012	2015	2018	% of 2018 total	Change 1997-2018
Drip	370	880	1,105	1,670	1,810	1,885	2,115	48%	+1,745
Lowlevel	480	850	940	815	705	690	620	14%	+140
Overhead	1,495	1,735	1,640	810	660	655	595	13%	-900
Furrow	1,985	920	555	155	75	55	25	1%	-1,960
Vacant	120	165	310	1,085	1,265	1,180	1,085	24%	+965
Total (ha)	4,450	4,550	4,550	4,535	4,515	4,465	4,440	100%	-10
Dominant	furrow	overhead	overhead	drip	drip	drip	drip		

Figure 38: Red Cliffs irrigation district - irrigation methods from 1997 to 2018

[18] Overhead irrigation includes pivots and lateral move systems. Furrow includes flood irrigation. (Table 5)

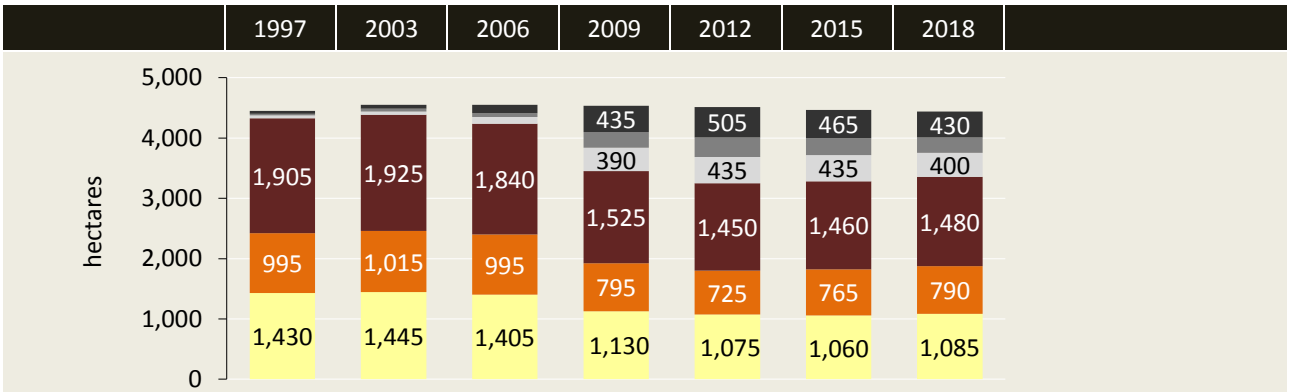
2.4.7 Red Cliffs irrigation district - salinity impact zones

Figure 39 summarises river salinity impact zones of irrigated areas in the Red Cliffs irrigation district from 1997 to 2018. The Red Cliffs district is in low salinity impact zones L1 and L4, and in the high salinity impact zone, HIZ.

- In 2018, the irrigable area of 4,440 ha comprised:
  - 33% (1,485 ha) in the lowest salinity impact zone, L1;
  - 24% (1,045 ha) in L4; and
  - 43% (1,910 ha) in HIZ.

- The area irrigated in:
  - L1 decreased by 345 ha, a 24% decrease from 1,430 ha in 1997 to 1,085 ha in 2018;
  - L4 decreased by 205 ha, a 21% decrease from 995 ha in 1997 to 790 ha in 2018; and
  - HIZ decreased by 425 ha, a 22% decrease from 1,905 ha in 1997 to 1,480 ha in 2018.

- The irrigable area in:
  - L1 increased by 10 ha, a 1% increase from 1,475 ha in 1997 to 1,485 ha in 2018;
  - L4 increased by 25 ha, a 2% increase from 1,020 ha in 1997 to 1,045 ha in 2018; and
  - HIZ decreased by 45 ha, a 2% decrease from 1,955 ha in 1997 to 1,910 ha in 2018. The net decrease of HIZ was predominantly areas retired from irrigation for housing development.



Salinity impact zone		1997	2003	2006	2009	2012	2015	2018	% of 2018 total	Change (ha) 1997-2018
Irrigated	L1	1,430	1,445	1,405	1,130	1,075	1,060	1,085	24%	-345
	L2	-	-	-	-	-	-	-	-	-
	L3	-	-	-	-	-	-	-	-	-
	L4	995	1,015	995	795	725	765	790	18%	-205
	HIZ	1,905	1,925	1,840	1,525	1,450	1,460	1,480	33%	-425
Not Irrigated	L1	45	55	110	390	435	435	400	9%	+355
	L2	-	-	-	-	-	-	-	-	-
	L3	-	-	-	-	-	-	-	-	-
	L4	25	45	65	260	325	280	255	6%	+230
	HIZ	50	65	135	435	505	465	430	10%	+380
Total (ha)		4,450	4,550	4,550	4,535	4,515	4,465	4,440	100%	-10
Dominant zone		HIZ	HIZ	HIZ	HIZ	HIZ	HIZ	HIZ		

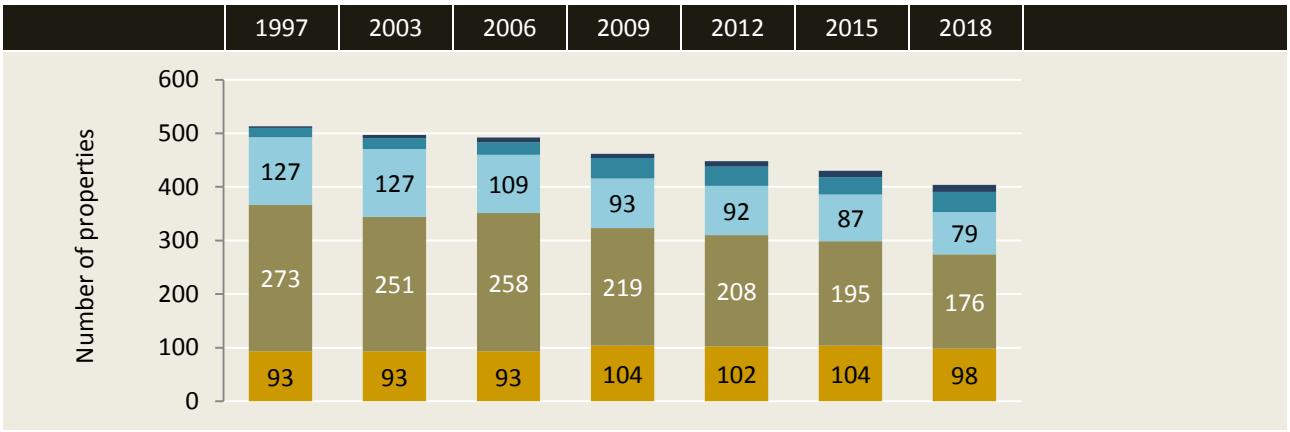
Figure 39: Red Cliffs irrigation district - irrigable area in each salinity impact zone from 1997 to 2018

2.4.8 Red Cliffs irrigation district - property change

Figure 40 provides estimates of property numbers and average property size (irrigable area) in the Red Cliffs irrigation district from 1997 to 2018.

- In 2018:
  - there were approximately 404 irrigation properties; and
  - most properties (87%) had an irrigable area less than 20 ha.

- From 1997 to 2018:
  - the number of properties decreased by 109; a 21% decrease from 513 to 404 properties;
  - properties with an irrigable area less than 20 ha decreased by 140, while the number over 20 ha increased by 31; and
  - average property size (irrigable area) increased from 9 ha to 11 ha.



Property size (irrigable area)	1997	2003	2006	2009	2012	2015	2018	% of 2018 total	Change 1997-2018
1 to 5 ha	93	93	93	104	102	104	98	24%	+5
5 to 10 ha	273	251	258	219	208	195	176	44%	-97
10 to 20 ha	127	127	109	93	92	87	79	20%	-48
20 to 40 ha	17	20	23	38	36	32	38	9%	+21
40 to 100 ha	3	6	9	8	10	12	13	3%	+10
100 to 500 ha	-	-	-	-	-	-	-	-	-
> 500 ha	-	-	-	-	-	-	-	-	-
Total properties	513	497	492	462	448	430	404	100%	-109
Average size (ha)	9	9	9	10	10	10	11		

Figure 40: Red Cliffs irrigation district - property numbers and sizes from 1997 to 2018

2.5 Mildura irrigation district

In summary for the Mildura irrigation district

Crop types in 2018

Dominant plantings in the Mildura irrigation district in 2018 were:

1. table grapes; 1,955 ha (34% of the irrigable area);
2. wine grapes; 960 ha (16% of the irrigable area); and
3. dried grapes; 725 ha (12% of the irrigable area).

Crop types 1997 to 2018

Table grape plantings were the dominant crop from 2012 to 2018, whereas wine grapes were dominant from 2003 to 2009 and dried grapes in 1997.

The main changes in crops from 1997 to 2018 were:

- dried grape plantings decreased by 1,610 ha; a 69% decrease from 2,335 ha to 725 ha;
- wine grape plantings decreased by 1,280 ha; a 57% decrease from 2,240 ha to 960 ha; and
- table grape plantings increased by 965 ha; a 97% increase from 990 ha to 1,955 ha.

Development of permanent plantings (new or redeveloped in the previous three years)

In 2018, at least 735 ha (19%) of permanent crops were planted or redeveloped in the previous three years, predominantly:

1. table grapes (520 ha);
2. dried grapes (100 ha);
3. wine grapes (50 ha); and
4. citrus (30 ha).

Development activity ranged from 9% of permanent plantings in 2009 to 19% in 2018.

Planting trends - permanent plantings, seasonal crops and vacant areas

In 2018, the irrigable area of 5,830 ha comprised:

- 68% (3,970 ha) irrigated permanent plantings;
- 7% (380 ha) irrigated seasonal crops; and
- 25% (1,480 ha) vacant or not irrigated.

From 1997 to 2018:

- permanent plantings decreased from 92% to 68% of the irrigable area;
- seasonal crops increased from 6% to 7% of the irrigable area; and
- vacant, not irrigated areas increased from 2% to 25% of the irrigable area.

In summary for the Mildura irrigation district

Irrigation development - new and retired areas

In the Mildura irrigation district, the irrigable area decreased by 620 ha, a 10% decrease from 6,450 ha in 1997 to 5,830 ha in 2018.

The net decrease of 620 ha was the balance of 270 ha expansion and 890 ha retired from irrigation.

Irrigation methods

Drip irrigation was the dominant irrigation method in the Mildura district from 2009 to 2018, whereas overhead sprinklers were dominant in 2003 and 2006, and furrows in 1997.

In 2018, the irrigable area of 5,830 ha comprised:

- 41% (2,385 ha) drip irrigation;
- 20% (1,145 ha) lowlevel irrigation;
- 11% (625 ha) overhead sprinklers;
- 3% (195 ha) furrow irrigation; and
- 25% (1,480 ha) not irrigated.

Salinity impact zones

The Mildura irrigation district is in the lowest salinity impact zone, L1 and in the high impact zone, HIZ.

In 2018, the irrigable area of 5,830 ha comprised:

- 36% (2,115 ha) in L1; and
- 64% (3,715 ha) in the HIZ.

From 1997 to 2018 the irrigable area in:

- L1 increased by 95 ha, a 5% increase from 2,020 ha to 2,115 ha; and
- HIZ decreased by 715 ha, a 16% decrease from 4,430 ha to 3,715 ha. The decrease of irrigable area in the HIZ was predominantly areas retired from irrigation for urban development.

The area irrigated in HIZ continued to decrease from 1997 to 2015, but increased by 110 ha between 2015 and 2018. The increase was largely due to vacant areas in HIZ being brought back into production.

Irrigation properties

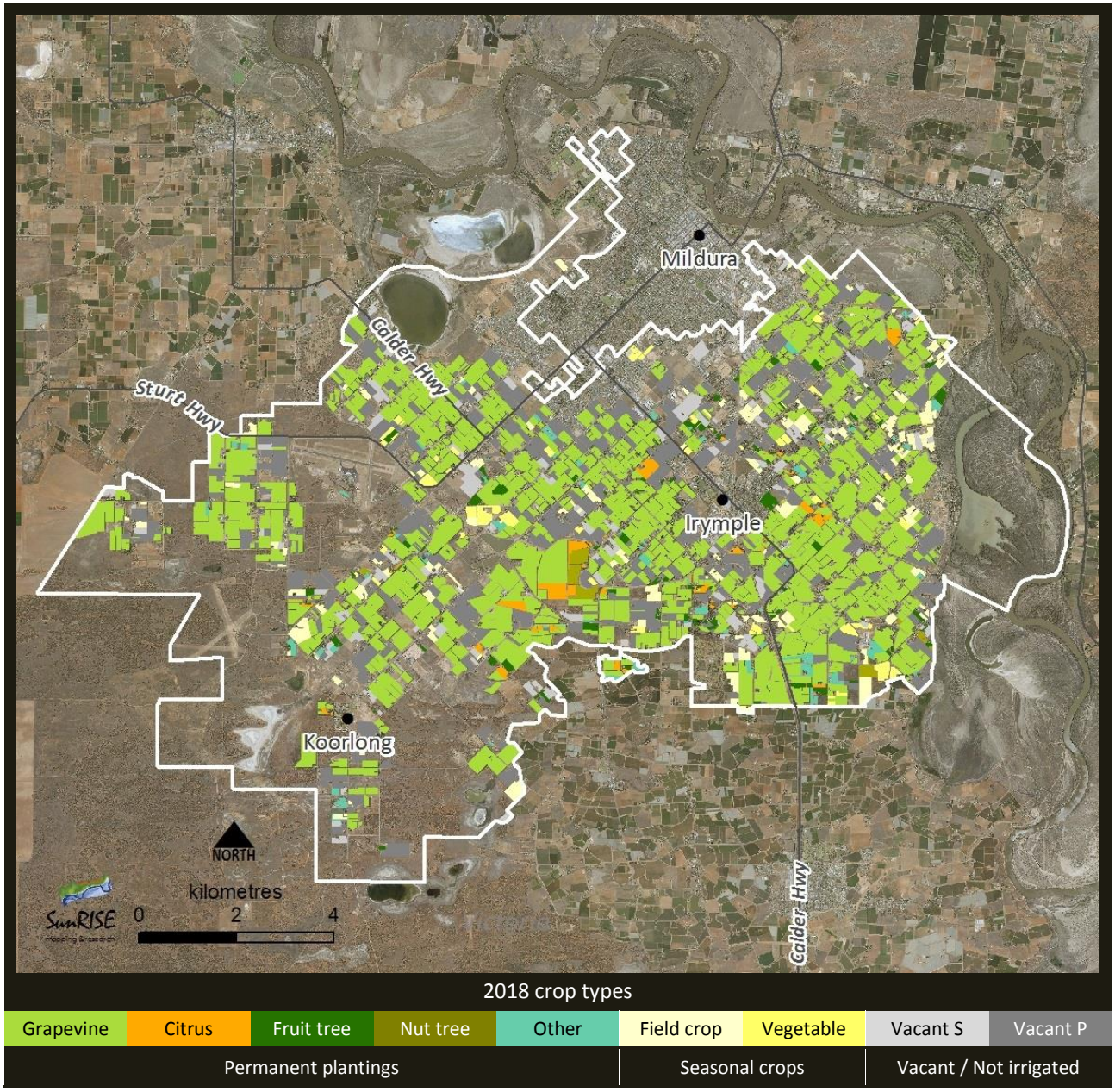
In 2018, there were approximately 613 irrigation properties with an average irrigable area of 10 ha.

From 1997 to 2018:

- the number of properties decreased by 222; a 27% decrease from 835 to 613 properties;
- properties with an irrigable area less than 20 ha decreased by 229, while the number over 20 ha increased by 7; and
- average property size (irrigable area) increased from 8 ha to 10 ha.

2.5.1 Mildura irrigation district - crop types in 2018

Map 8 shows the Mildura irrigation district and crop types in 2018.



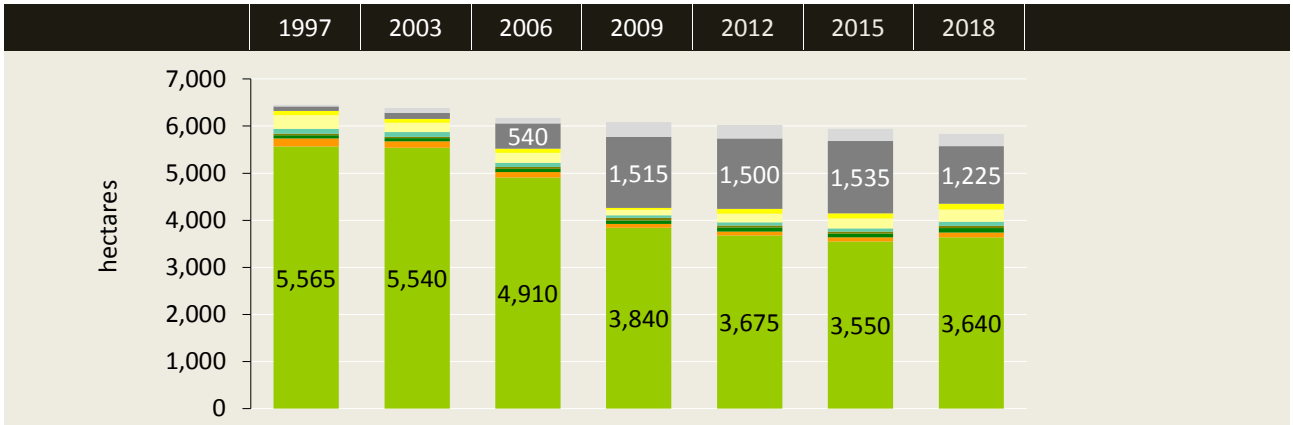
Map 8: Mildura irrigation district showing 2018 crop types

2.5.2 Mildura irrigation district - crop types from 1997 to 2018

Figure 41 summarises crop types in the Mildura irrigation district from 1997 to 2018.

- Dominant plantings in 2018 were:
    1. table grape plantings; 1,955 ha (34% of the irrigable area);
    2. wine grapes; 960 ha (16% of the irrigable area); and
    3. dried grapes; 725 ha (12% of the irrigable area).

- The dominant crop changed from dried grape plantings in 1997 to wine grapes from 2003 to 2009 then to table grapes from 2012 to 2018.
- The highest increase in plantings was 965 ha of table grapes; a 97% increase from 990 ha in 1997 to 1,955 ha in 2018.
- Dried and wine grape plantings decreased in area from 1997 to 2018, by 1,610 ha and 1,280 ha respectively.



Crop type		1997	2003	2006	2009	2012	2015	2018	% of 2018 total	Change 1997-2018
Permanent	Grape Dried	2,335	1,685	1,310	880	865	785	725	12%	-1,610
	Grape Table	990	1,315	1,275	1,260	1,430	1,590	1,955	34%	+965
	Grape Wine	2,240	2,540	2,325	1,700	1,380	1,175	960	16%	-1,280
	Citrus	175	135	115	85	85	85	100	2%	-75
	Fruit Olive	25	35	35	40	45	40	40	1%	+15
	Fruit Other	40	35	30	30	45	45	55	1%	+15
	Nut Almond	30	25	30	45	30	35	40	1%	+10
	Nut Other	5	5	10	10	10	5	10	0%	+5
	Other	105	100	90	55	65	70	85	1%	-20
Seasonal	Field Crop	290	195	215	115	185	205	255	4%	-35
	Veg. Carrot	-	-	-	-	-	-	-	-	-
	Veg. Potato	-	-	-	-	-	-	-	-	-
	Veg. Other	85	85	85	40	100	110	125	2%	+40
	Vacant P	95	130	540	1,515	1,500	1,535	1,225	21%	+1,130
	Vacant S	35	100	115	310	285	265	255	4%	+220
Total (ha)		6,450	6,385	6,175	6,085	6,025	5,945	5,830	100%	-620
Dominant		dried grape	wine grape	wine grape	wine grape	table grape	table grape	table grape		

Figure 41: Mildura irrigation district - crop types from 1997 to 2018

2.5.3 Mildura irrigation district - development of permanent crops

Figure 42 shows the proportion of permanent crops planted or redeveloped in the previous three years in the Mildura irrigation district from 1997 to 2018.

The information provides an indication of development activity that is otherwise not evident in information on changes in areas and crop types, as it includes replanting and top working to different varieties. The figures are conservative, as top-worked plantings can be difficult to interpret from the three-yearly aerial imagery, particularly for grapevines.

- In 2018, 735 ha (19%) of permanent crops were planted or redeveloped in the previous three years. Development was predominantly:
    1. table grapes (520 ha);
    2. dried grapes (100 ha);
    3. wine grapes (50 ha); and
    4. citrus (30 ha).

- The area of new or redeveloped permanent plantings was highest in 1997 with 985 ha (17%) planted in the previous three years.

- New or redeveloped permanent plantings were lowest in 2009 with 380 ha (9%) planted in the previous three years.

Permanent plantings	1997	2003	2006	2009	2012	2015	2018	% of 2018 total
≤3yr old plantings	985	905	555	380	515	490	735	19%
>3yr old plantings	4,960	4,970	4,665	3,725	3,440	3,340	3,235	81%
Total (ha)	5,945	5,875	5,220	4,105	3,955	3,830	3,970	100%
% 3year development	17%	15%	11%	9%	13%	13%	19%	

Figure 42: Mildura irrigation district - development of permanent crops from 1997 to 2018

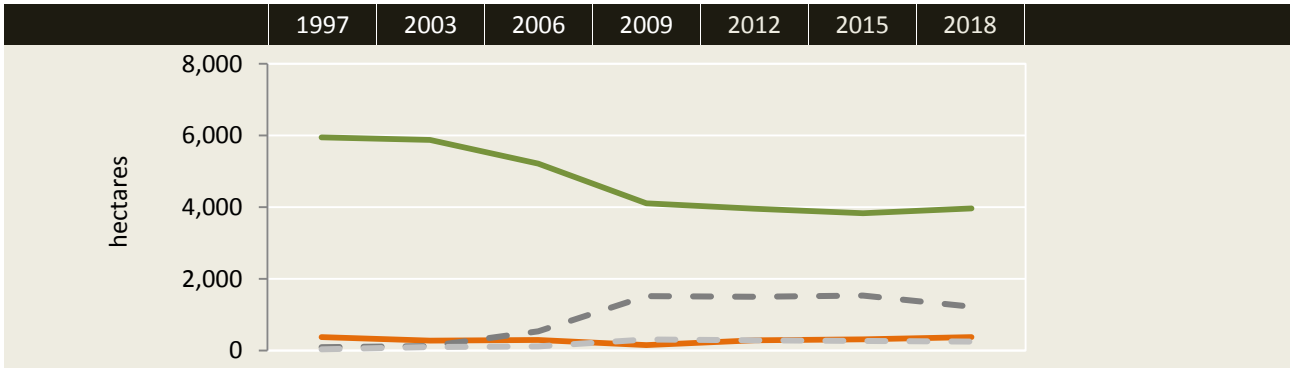
2.5.4 Mildura irrigation district - planting trends

Figure 43 summarises planting trends in the Mildura irrigation district from 1997 to 2018.

- In 2018, the irrigable area of 5,830 ha comprised:
  - 68% (3,970 ha) irrigated permanent plantings;
  - 7% (380 ha) irrigated seasonal crops; and
  - 25% (1,480 ha) vacant or not irrigated.

- The proportion of permanent plantings, seasonal cropping and vacant areas changed from:
  - 92% permanent, 6% seasonal and 2% vacant in 1997; to
  - 68% permanent, 7% seasonal and 25% vacant in 2018.

- From 1997 to 2018:
  - irrigated permanent crops decreased by 1,975 ha;
  - irrigated seasonal crops increased by 5 ha; and
  - vacant, not irrigated areas increased by 1,350 ha.



	1997	2003	2006	2009	2012	2015	2018	% of 2018 total	Change 1997-2018
Permanent - irrigated	5,945	5,875	5,220	4,105	3,955	3,830	3,970	68%	-1,975
Seasonal - irrigated	375	280	300	155	285	315	380	7%	+5
Vacant - permanent	95	130	540	1,515	1,500	1,535	1,225	21%	+1,130
Vacant - seasonal	35	100	115	310	285	265	255	4%	+220
Total (ha)	6,450	6,385	6,175	6,085	6,025	5,945	5,830	100%	-620
% Permanent	92%	92%	85%	67%	66%	64%	68%		
% Seasonal	6%	4%	5%	3%	5%	5%	7%		
% Vacant	2%	4%	11%	30%	30%	30%	25%		

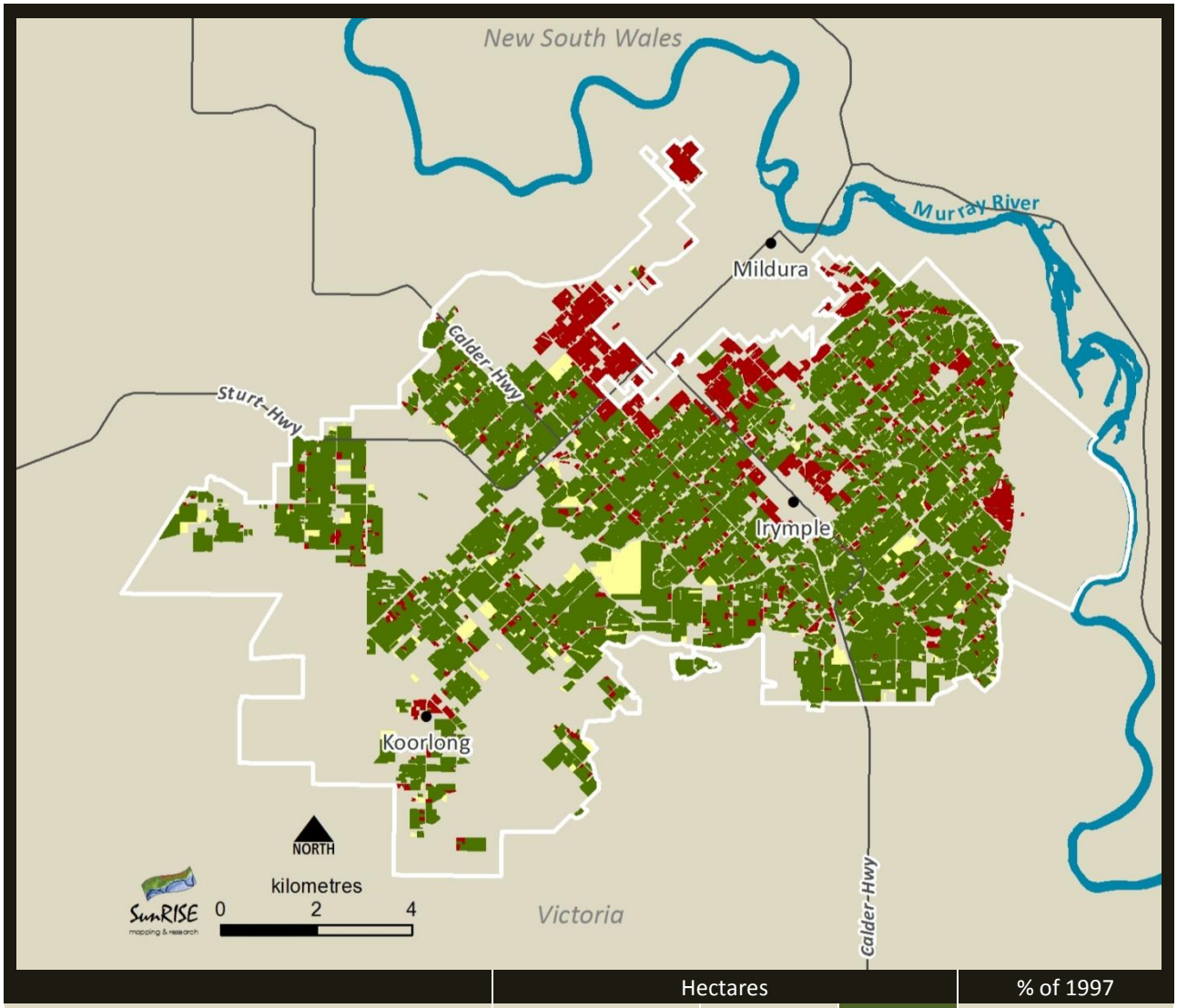
Figure 43: Mildura irrigation district - planting trends from 1997 to 2018

2.5.5 Mildura irrigation district - irrigation development

Map 9 shows irrigation development from 1997 to 2018 in the Mildura irrigation district with respect to new development (expansion) and areas retired[19] from irrigation.

- The irrigable area decreased by 620 ha, a 10% decrease from 6,450 ha in 1997 to 5,830 ha in 2018.
- The net decrease of 620 ha comprised 890 ha retired from irrigation and 270 ha of expansion.

Map 9: Mildura irrigation district - irrigation development from 1997 to 2018



	Hectares		% of 1997
Irrigation area in 1997 (1996-97 season)	6,450		
Retired between 1997 and 2018	-890		-14%
Expansion between 1997 and 2018	+270		+4%
Irrigation area in 2018 (2017-18 season)	5,830		

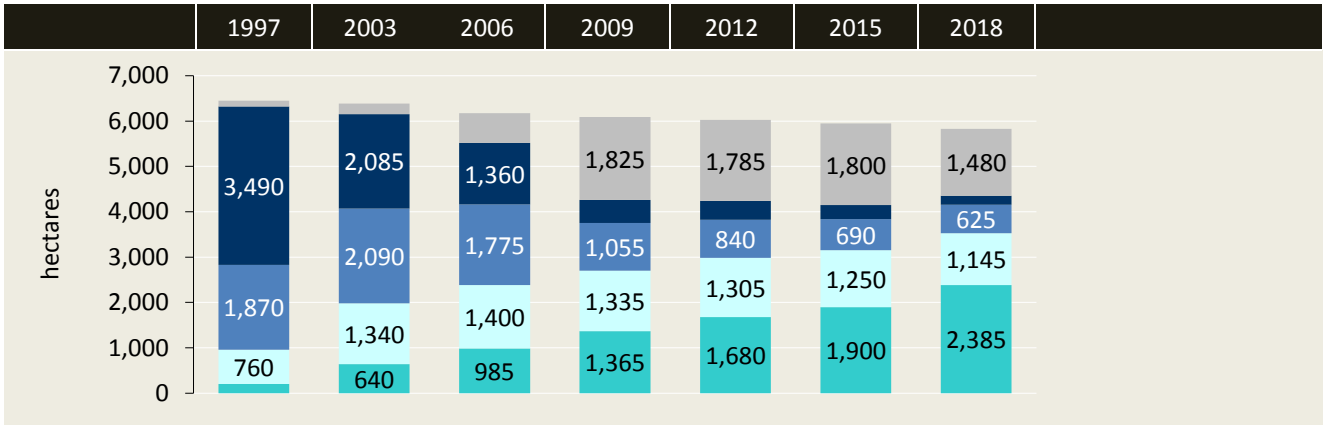
[19] Retired areas were previously irrigated but have undergone a change in land use that precludes use for irrigation e.g. urban development, housing, sheds, dams and land set aside for conservation purposes.

2.5.6 Mildura irrigation district - irrigation methods

Figure 44 summarises irrigation methods in the Mildura irrigation district from 1997 to 2018.

- In 2018, the irrigable area of 5,830 ha comprised:
  - 41% (2,385 ha) drip irrigation;
  - 20% (1,145 ha) lowlevel irrigation;
  - 11% (625 ha) overhead sprinklers;
  - 3% (195 ha) furrow irrigation; and
  - 25% (1,480 ha) not irrigated.

- Drip irrigation increased by 2,185 ha, a 1,093% increase from 200 ha in 1997 to 2,385 ha in 2018.
  - Drip irrigation was the dominant irrigation method from 2009 to 2018.
- Lowlevel irrigation increased by 385 ha, a 51% increase from 760 ha in 1997 to 1,145 ha in 2018.
- Overhead irrigation decreased by 1,245 ha, a 67% decrease from 1,870 ha in 1997 to 625 ha in 2018.
  - Overhead irrigation was the dominant irrigation method from 2003 to 2006.
- Furrow irrigation decreased by 3,295 ha, a 94% decrease from 3,490 ha in 1997 to 195 ha in 2018.
  - Furrow irrigation was the dominant irrigation method in 1997.



Irrigation method[20]	1997	2003	2006	2009	2012	2015	2018	% of 2018 total	Change (ha) 1997-2018
Drip	200	640	985	1,365	1,680	1,900	2,385	41%	+2,185
Lowlevel	760	1,340	1,400	1,335	1,305	1,250	1,145	20%	+385
Overhead	1,870	2,090	1,775	1,055	840	690	625	11%	-1,245
Furrow	3,490	2,085	1,360	505	415	305	195	3%	-3,295
Vacant	130	230	655	1,825	1,785	1,800	1,480	25%	+1,350
Total (ha)	6,450	6,385	6,175	6,085	6,025	5,945	5,830	100%	-620
Dominant	furrow	overhead	overhead	drip	drip	drip	drip		

Figure 44: Mildura irrigation district - irrigation methods from 1997 to 2018

[20] Overhead irrigation includes pivots and lateral move systems. Furrow includes flood irrigation. (Table 5)

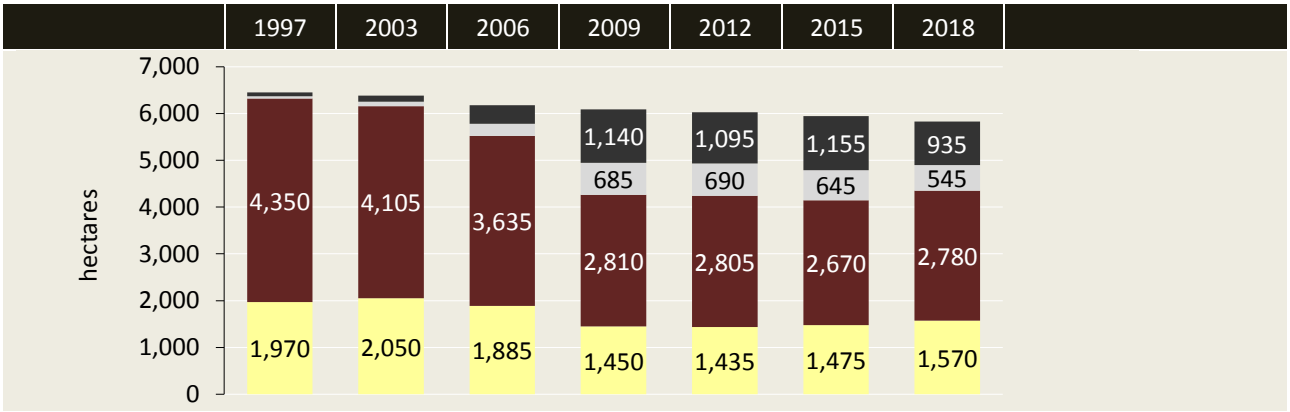
2.5.7 Mildura irrigation district - salinity impact zones

Figure 45 summarises river salinity impact zones of irrigated areas in the Mildura irrigation district from 1997 to 2018. The Mildura district is in the lowest salinity impact zone, L1 and in the high salinity impact zone, HIZ.

- In 2018, the irrigable area of 5,830 ha comprised:
  - 36% (2,115 ha) in L1; and
  - 64% (3,715 ha) in the HIZ.

- The area irrigated in:
  - L1 decreased by 400 ha, a 20% decrease from 1,970 ha in 1997 to 1,570 ha in 2018; and
  - HIZ decreased by 1,570 ha, a 36% decrease from 4,350 ha in 1997 to 2,780 ha in 2018.
  - HIZ continued to decrease from 1997 to 2015, but increased by 110 ha between 2015 and 2018. The increase was largely due to vacant areas in HIZ being brought back into production.

- The irrigable area in:
  - L1 increased by 95 ha, a 5% increase from 2,020 ha in 1997 to 2,115 ha in 2018; and
  - HIZ decreased by 715 ha, a 16% decrease from 4,430 ha in 1997 to 3,715 ha in 2018. The decrease of irrigable area in the HIZ was predominantly areas retired from irrigation for urban development.



Salinity impact zone		1997	2003	2006	2009	2012	2015	2018	% of 2018 total	Change (ha) 1997-2018
Irrigated	L1	1,970	2,050	1,885	1,450	1,435	1,475	1,570	27%	-400
	L2	-	-	-	-	-	-	-	-	-
	L3	-	-	-	-	-	-	-	-	-
	L4	-	-	-	-	-	-	-	-	-
	HIZ	4,350	4,105	3,635	2,810	2,805	2,670	2,780	48%	-1,570
Not Irrigated	L1	50	95	260	685	690	645	545	9%	+495
	L2	-	-	-	-	-	-	-	-	-
	L3	-	-	-	-	-	-	-	-	-
	L4	-	-	-	-	-	-	-	-	-
	HIZ	80	135	395	1,140	1,095	1,155	935	16%	+855
Total (ha)		6,450	6,385	6,175	6,085	6,025	5,945	5,830	100%	-620
Dominant zone		HIZ	HIZ	HIZ	HIZ	HIZ	HIZ	HIZ		

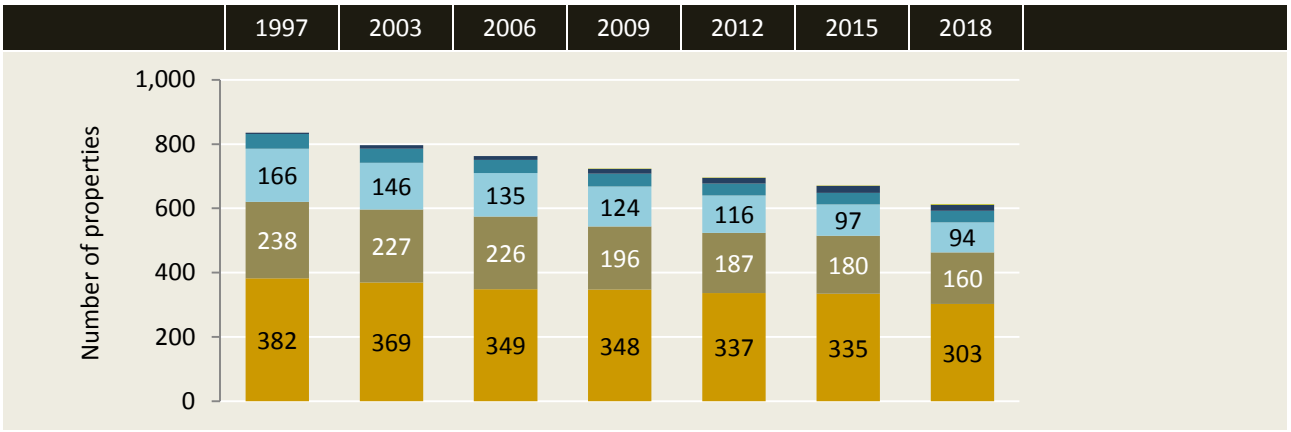
Figure 45: Mildura irrigation district - irrigable area in each salinity impact zone from 1997 to 2018

2.5.8 Mildura irrigation district - property change

Figure 46 provides estimates of property numbers and average property size (irrigable area) in the Mildura irrigation district from 1997 to 2018.

- In 2018:
  - there were approximately 613 irrigation properties; and
  - most properties (91%) had an irrigable area less than 20 ha.

- From 1997 to 2018:
  - the number of properties decreased by 222; a 27% decrease from 835 to 613 properties;
  - properties with an irrigable area less than 20 ha decreased by 229, while the number over 20 ha increased by 7; and
  - average property size (irrigable area) increased from 8 ha to 10 ha.



Property size (irrigable area)	1997	2003	2006	2009	2012	2015	2018	% of 2018 total	Change 1997-2018
1 to 5 ha	382	369	349	348	337	335	303	49%	-79
5 to 10 ha	238	227	226	196	187	180	160	26%	-78
10 to 20 ha	166	146	135	124	116	97	94	15%	-72
20 to 40 ha	45	44	41	40	37	36	35	6%	-10
40 to 100 ha	4	11	12	15	18	22	19	3%	+15
100 to 500 ha	0	0	0	1	1	1	2	<1%	+2
> 500 ha	-	-	-	-	-	-	-	-	-
Total properties	835	797	763	724	696	671	613	100%	-222
Average size (ha)	8	8	8	8	9	9	10		

Figure 46: Mildura irrigation district - property numbers and sizes from 1997 to 2018

2.6 Merbein irrigation district

In summary for the Merbein irrigation district

Crop types in 2018

Dominant plantings in the Merbein irrigation district in 2018 were:

1. dried grape plantings, 635 ha (21% of the irrigable area);
2. table grapes, 550 ha (18% of the irrigable area); and
3. wine grapes, 300 ha (10% of the irrigable area).

Crop types 1997 to 2018

Dried grape plantings were the dominant crop from 1997 to 2018, except for in 2009 when wine grapes were dominant.

The main changes in crops from 1997 to 2018 were:

- dried grape plantings decreased by 1,005 ha; a 61% decrease from 1,640 ha to 635 ha;
- wine grape plantings decreased by 615 ha; a 67% decrease from 915 ha to 300 ha; and
- table grape plantings increased by 400 ha; a 267% increase from 150 ha to 550 ha.

Development of permanent plantings (new or redeveloped in the previous three years)

In 2018, at least 430 ha (25%) of permanent crops were planted or redeveloped in the previous three years, predominantly:

1. table grapes (200 ha);
2. dried grapes (80 ha);
3. pistachios (80 ha); and
4. wine grapes (30 ha).

Development activity ranged from 7% of permanent plantings in 2009 to 25% in 2018.

Planting trends - permanent plantings, seasonal crops and vacant areas

In 2018, the irrigable area of 3,005 ha comprised:

- 58% (1,740 ha) irrigated permanent plantings;
- 6% (190 ha) irrigated seasonal crops; and
- 36% (1,075 ha) vacant or not irrigated.

From 1997 to 2018:

- permanent plantings decreased from 97% to 58% of the irrigable area;
- seasonal crops increased from 2% to 6% of the irrigable area; and
- vacant, not irrigated areas increased from 1% to 36% of the irrigable area.

In summary for the Merbein irrigation district

Irrigation development - new and retired areas

In the Merbein irrigation district, the irrigable area decreased by 140 ha, a 4% decrease from 3,145 ha in 1997 to 3,005 ha in 2018.

The 140 ha decrease were areas retired from irrigation, predominantly for urban development.

Irrigation methods

Drip irrigation was the dominant irrigation method in the Merbein district from 2009 to 2018, whereas furrow irrigation was dominant from 1997 to 2006.

In 2018, the irrigable area of 3,005 ha comprised:

- 38% (1,150 ha) drip irrigation;
- 14% (430 ha) lowlevel irrigation;
- 5% (150 ha) overhead sprinklers;
- 7% (200 ha) furrow irrigation; and
- 36% (1,075 ha) not irrigated.

Salinity impact zones

The Merbein district is in the lowest salinity impact zone, L1 and in the high salinity impact zone, HIZ.

In 2018, the irrigable area of 3,005 ha comprised:

- 34% (1,015 ha) in L1; and
- 66% (1,990 ha) in HIZ.

From 1997 to 2018 the irrigable area in:

- L1 decreased by 15 ha, a 1% decrease from 1,030 ha to 1,015 ha; and
- HIZ decreased by 125 ha, a 6% decrease from 2,115 ha to 1,990 ha, predominantly due to areas retired from irrigation for urban development.

Irrigation properties

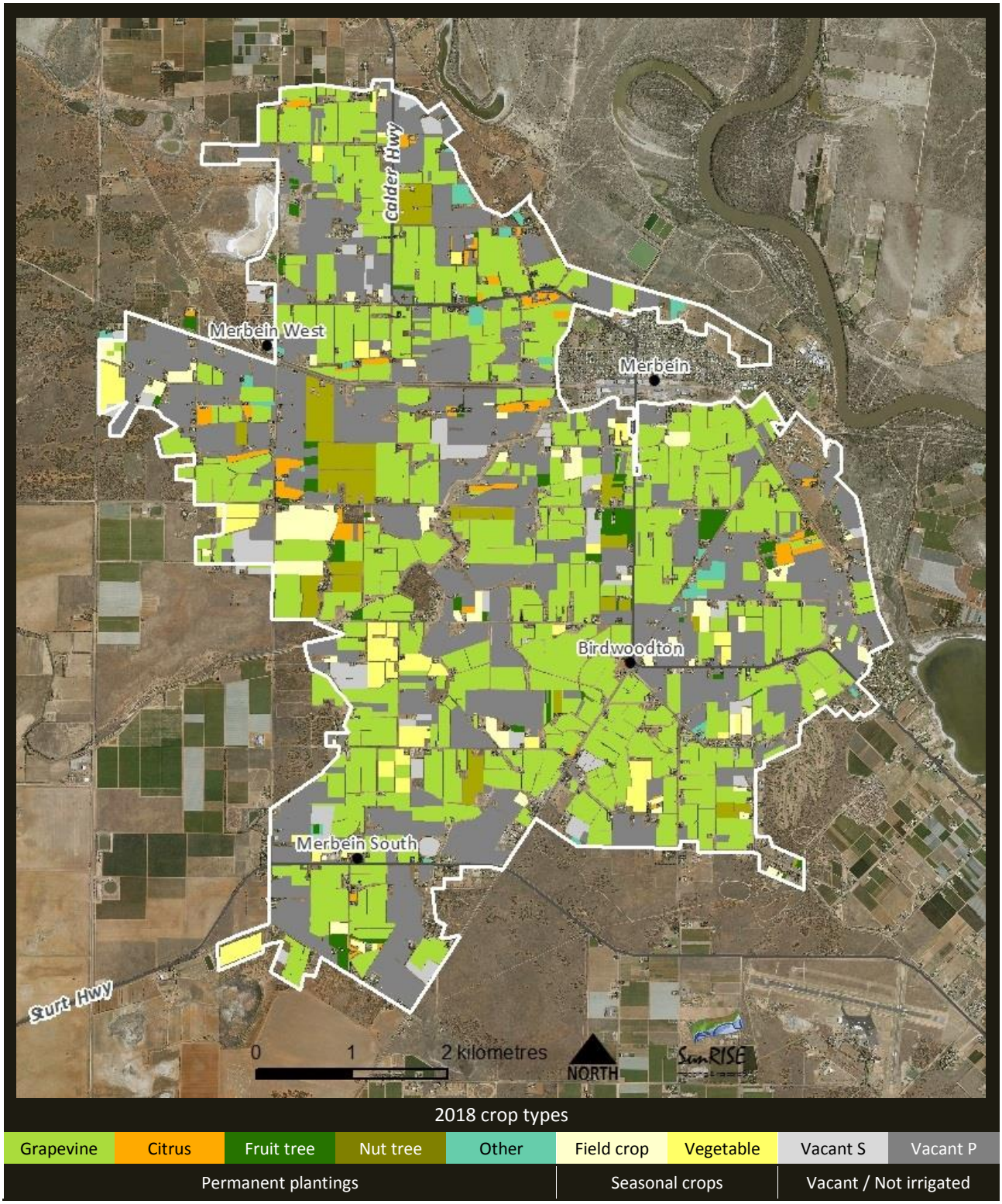
In 2018, there were approximately 278 irrigation properties with an average irrigable area of 11 ha.

From 1997 to 2018:

- the number of properties decreased by 52; a 16% decrease from 330 to 278 properties;
- properties with an irrigable area less than 20 ha decreased by 63, while the number over 20 ha increased by 11; and
- average property size (irrigable area) increased from 10 ha to 11 ha.

2.6.1 Merbein irrigation district - crop types in 2018

Map 10 shows the Merbein irrigation district and crop types in 2018.



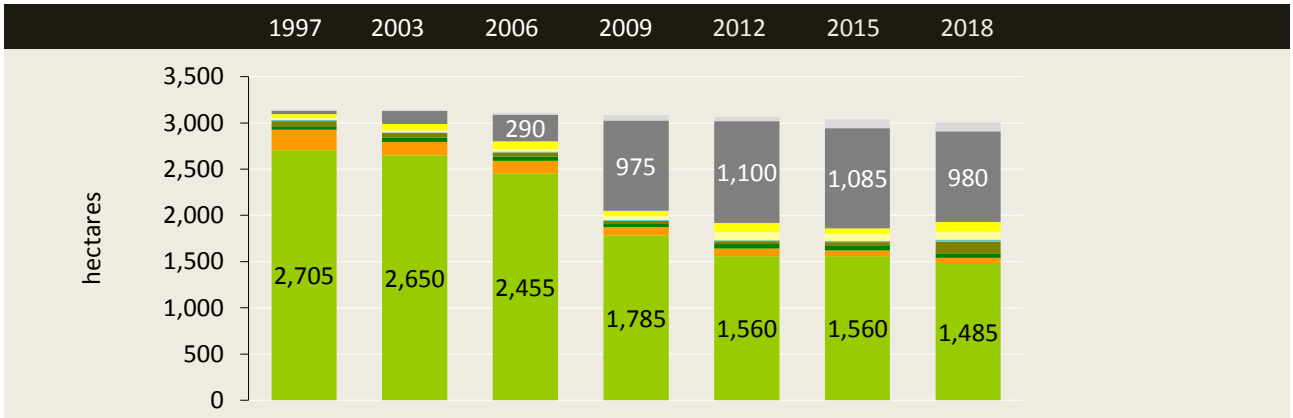
Map 10: Merbein irrigation district showing 2018 crop types

2.6.2 Merbein irrigation district - crop types from 1997 to 2018

Figure 47 summarises crop types in the Merbein irrigation district from 1997 to 2018.

- Dominant plantings in 2018 were:
    1. dried grape plantings, 635 ha (21% of the irrigable area);
    2. table grapes, 550 ha (18% of the irrigable area); and
    3. wine grapes, 300 ha (10% of the irrigable area).

- Dried grape plantings were the dominant crop from 1997 to 2018, except for in 2009 when wine grape plantings were dominant. Dried grape plantings decreased by 1,005 ha; a 61% decrease from 1,640 ha in 1997 to 635 ha in 2018.
- Of the irrigated crops, table grape plantings had the largest increase in area; a 267% increase from 150 ha in 1997 to 550 ha in 2018.



Crop type		1997	2003	2006	2009	2012	2015	2018	% of 2018 total	Change 1997-2018
Permanent	Grape Dried	1,640	1,295	1,115	730	715	710	635	21%	-1,005
	Grape Table	150	240	275	270	310	385	550	18%	+400
	Grape Wine	915	1,115	1,065	785	535	465	300	10%	-615
	Citrus	220	145	135	90	80	60	55	2%	-165
	Fruit Olive	5	10	10	10	15	15	15	0%	+10
	Fruit Other	35	35	35	30	35	35	35	1%	0
	Nut Almond	40	35	30	15	15	20	25	1%	-15
	Nut Other	15	15	15	10	15	20	100	3%	+85
	Other	15	10	10	10	10	15	25	1%	+10
Seasonal	Field Crop	20	20	30	45	90	80	85	3%	+65
	Veg. Carrot	-	-	-	-	-	-	-	-	-
	Veg. Potato	-	-	-	-	-	-	-	-	-
	Veg. Other	40	70	80	55	100	55	105	3%	+65
	Vacant P	40	140	290	975	1,100	1,085	980	33%	+940
	Vacant S	10	10	20	60	45	95	95	3%	+85
Total (ha)		3,145	3,140	3,110	3,085	3,065	3,040	3,005	100%	-140
Dominant		dried grape	dried grape	dried grape	wine grape	dried grape	dried grape	dried grape		

Figure 47: Merbein irrigation district - crop types from 1997 to 2018

2.6.3 Merbein irrigation district - development of permanent crops

Figure 48 shows the proportion of permanent crops planted or redeveloped in the previous three years in the Merbein irrigation district from 1997 to 2018.

The information provides an indication of development activity that is otherwise not evident in information on changes in areas and crop types, as it includes replanting and top working to different varieties. The figures are conservative, as top-worked plantings can be difficult to interpret from the three-yearly aerial imagery, particularly for grapevines.

- In 2018, at least 430 ha (25%) of permanent crops were planted or redeveloped in the previous three years. Development was predominantly:
    1. table grapes (200 ha);
    2. dried grapes (80 ha);
    3. pistachios (80 ha); and
    4. wine grapes (30 ha).

- The area of new or redeveloped permanent plantings was highest in 1997 with 520 ha (17%) planted in the previous three years.

- New and redeveloped permanent plantings were lowest in 2009 with 135 ha (7%) planted in the previous three years.

Permanent plantings	1997	2003	2006	2009	2012	2015	2018	% of 2018 total
≤3yr old plantings	520	390	270	135	235	225	430	25%
>3yr old plantings	2,515	2,510	2,420	1,815	1,495	1,500	1,310	75%
Total (ha)	3,035	2,900	2,690	1,950	1,730	1,725	1,740	100%
% 3year development	17%	13%	10%	7%	14%	13%	25%	

Figure 48: Merbein irrigation district - development of permanent crops from 1997 to 2018

2.6.4 Merbein irrigation district - planting trends

Figure 49 summarises planting trends in the Merbein irrigation district from 1997 to 2018.

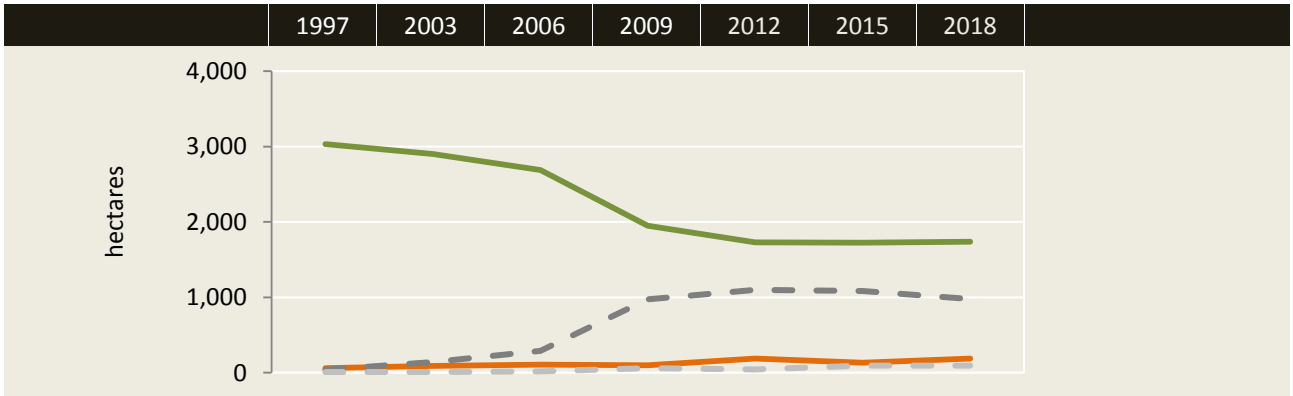
In 2018, the irrigable area of 3,005 ha comprised:

- 58% (1,740 ha) irrigated permanent plantings;
- 6% (190 ha) irrigated seasonal crops; and
- 36% (1,075 ha) vacant or not irrigated.

The proportion of permanent plantings, seasonal cropping and vacant areas changed from:

- 97% permanent, 2% seasonal and 1% vacant in 1997; to
- 58% permanent, 6% seasonal and 36% vacant in 2018.

- From 1997 to 2018:
  - irrigated permanent crops decreased by 1,295 ha;
  - irrigated seasonal crops increased by 130 ha;
  - vacant, not irrigated areas increased by 1,025 ha; and
  - the irrigable area decreased by 140 ha due to retirement of land for other land use purposes.



	1997	2003	2006	2009	2012	2015	2018	% of 2018 total	Change 1997-2018
Permanent - irrigated	3,035	2,900	2,690	1,950	1,730	1,725	1,740	58%	-1,295
Seasonal - irrigated	60	90	110	100	190	135	190	6%	+130
Vacant - permanent	40	140	290	975	1,100	1,085	980	33%	+940
Vacant - seasonal	10	10	20	60	45	95	95	3%	+85
Total (ha)	3,145	3,140	3,110	3,085	3,065	3,040	3,005	100%	-140
% Permanent	97%	92%	86%	63%	56%	57%	58%		
% Seasonal	2%	3%	4%	3%	6%	4%	6%		
% Vacant	1%	5%	10%	34%	37%	39%	36%		

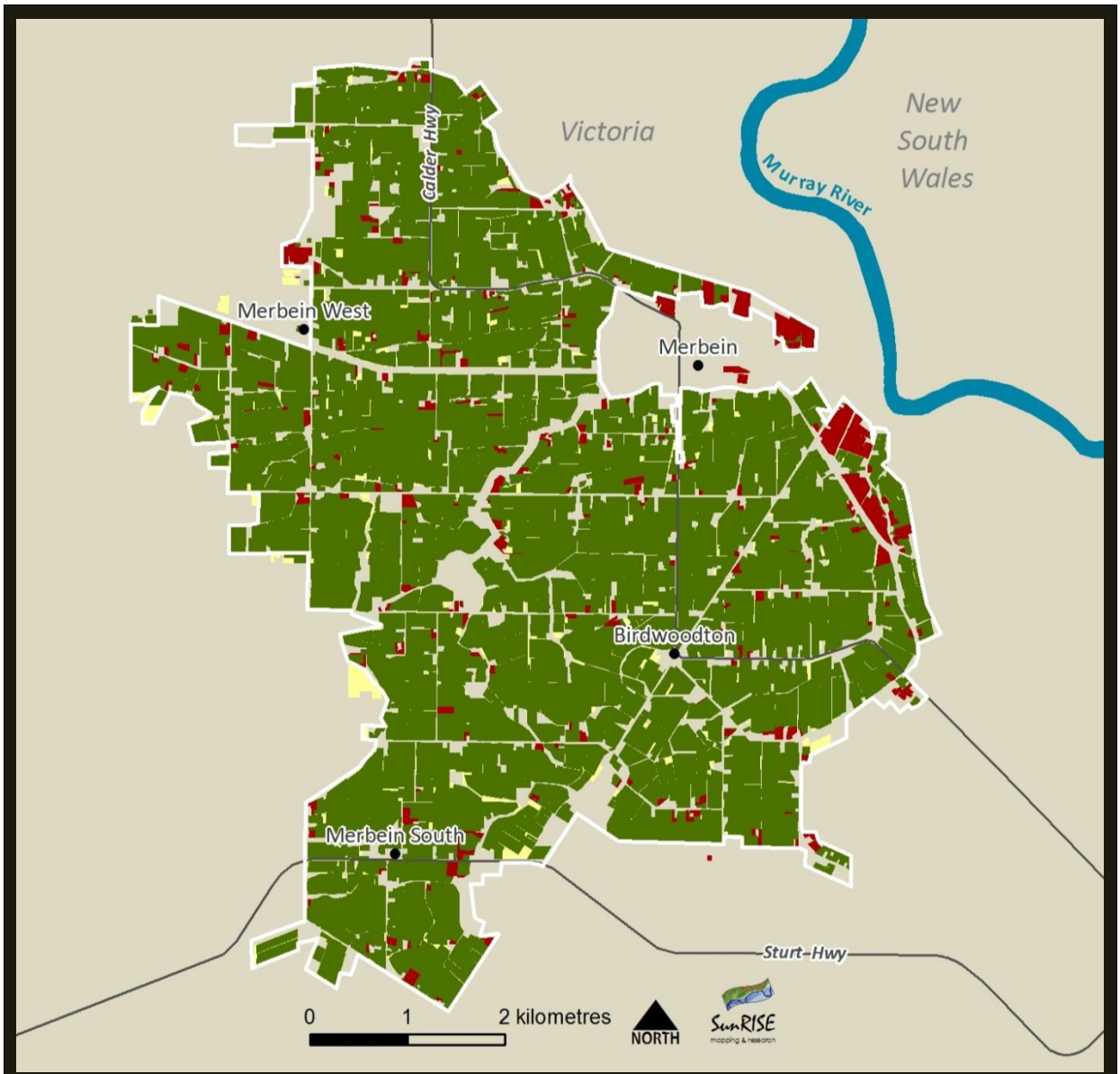
Figure 49: Merbein irrigation district - planting trends from 1997 to 2018

2.6.5 Merbein irrigation district - irrigation development

Map 11 shows irrigation development from 1997 to 2018 in the Merbein irrigation district with respect to new development (expansion) and areas retired[21] from irrigation.

- The irrigable area decreased by 140 ha, a 4% decrease from 3,145 ha in 1997 to 3,005 ha in 2018.
- The decrease of 140 ha was land retired from irrigation.

Map 11: Merbein irrigation district - irrigation development from 1997 to 2018



	Hectares		% of 1997
Irrigation areas in 1997 (1996-97 season)	3,145		
Retired between 1997 and 2018	-140		-4%
Expansion between 1997 and 2018	0		0%
Irrigation areas in 2018 (2017-18 season)	3,005		

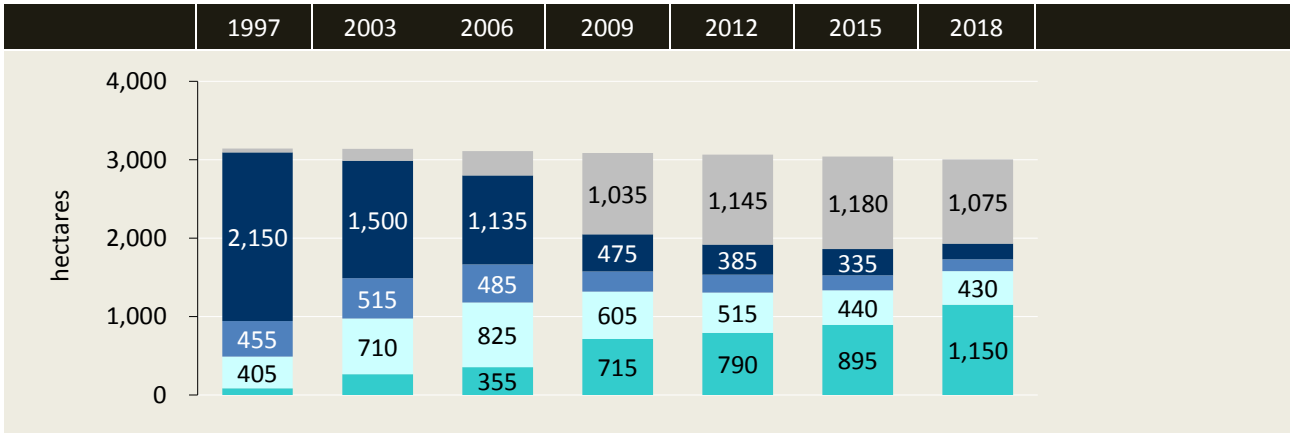
[21] Retired areas were previously irrigated but have undergone a change in land use that precludes use for irrigation e.g. urban development, housing, sheds, dams and land set aside for conservation purposes.

2.6.6 Merbein irrigation district - irrigation methods

Figure 50 summarises irrigation methods in the Merbein irrigation district from 1997 to 2018.

- In 2018, the irrigable area of 3,005 ha comprised:
  - 38% (1,150 ha) drip irrigation;
  - 14% (430 ha) lowlevel irrigation;
  - 5% (150 ha) overhead sprinklers;
  - 7% (200 ha) furrow irrigation; and
  - 36% (1,075 ha) not irrigated.

- Drip irrigation increased by 1,065 ha, a 1,253% increase from 85 ha in 1997 to 1,150 ha in 2018.
  - Drip irrigation was the dominant irrigation method from 2009 to 2018.
- Lowlevel irrigation increased by 25 ha, a 6% increase from 405 ha in 1997 to 430 ha in 2018.
- Overhead irrigation decreased by 305 ha, a 67% decrease from 455 ha in 1997 to 150 ha in 2018.
- Furrow irrigation decreased by 1,950 ha, a 91% decrease from 2,150 ha in 1997 to 200 ha in 2018.
  - Furrow irrigation was the dominant irrigation method from 1997 to 2006.



Irrigation method[22]	1997	2003	2006	2009	2012	2015	2018	% of 2018 total	Change 1997-2018
Drip	85	265	355	715	790	895	1,150	38%	+1,065
Lowlevel	405	710	825	605	515	440	430	14%	+25
Overhead	455	515	485	255	230	190	150	5%	-305
Furrow	2,150	1,500	1,135	475	385	335	200	7%	-1,950
Vacant	50	150	310	1,035	1,145	1,180	1,075	36%	+1,025
Total (ha)	3,145	3,140	3,110	3,085	3,065	3,040	3,005	100%	-140
Dominant	furrow	furrow	furrow	drip	drip	drip	drip		

Figure 50: Merbein irrigation district - irrigation methods from 1997 to 2018

[22] Overhead irrigation includes pivots and lateral move systems. Furrow includes flood irrigation. (Table 5)

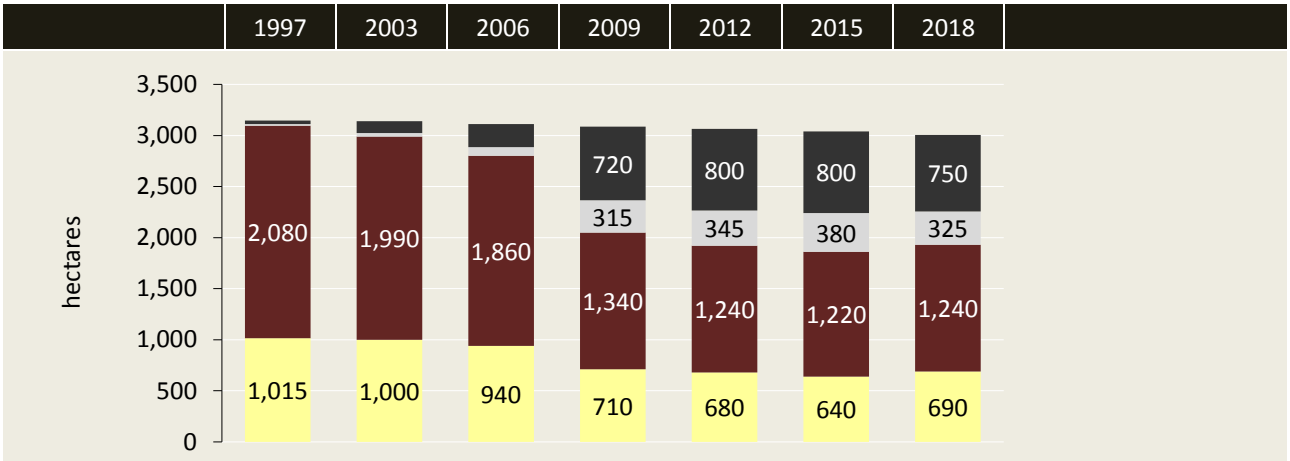
2.6.7 Merbein irrigation district - salinity impact zones

Figure 51 summarises river salinity impact zones of irrigated areas in the Merbein irrigation district from 1997 to 2018. The Merbein district is in the lowest salinity impact zone, L1 and the high salinity impact zone, HIZ.

- In 2018, the irrigable area of 3,005 ha comprised:
  - 34% (1,015 ha) in L1; and
  - 66% (1,990 ha) in the HIZ.

- The area irrigated in:
  - L1 decreased by 325 ha, a 32% decrease from 1,015 ha in 1997 to 690 ha in 2018; and
  - HIZ decreased by 840 ha, a 40% decrease from 2,080 ha in 1997 to 1,240 ha in 2018.

- The irrigable area in:
  - L1 decreased by 15 ha, a 1% decrease from 1,030 ha in 1997 to 1,015 ha in 2018; and
  - HIZ decreased by 125 ha, a 6% decrease from 2,115 ha in 1997 to 1,990 ha in 2018.



Salinity impact zone		1997	2003	2006	2009	2012	2015	2018	% of 2018 total	Change (ha) 1997-2018
Irrigated	L1	1,015	1,000	940	710	680	640	690	23%	-325
	L2	-	-	-	-	-	-	-	-	-
	L3	-	-	-	-	-	-	-	-	-
	L4	-	-	-	-	-	-	-	-	-
	HIZ	2,080	1,990	1,860	1,340	1,240	1,220	1,240	41%	-840
Not Irrigated	L1	15	35	85	315	345	380	325	11%	+310
	L2	-	-	-	-	-	-	-	-	-
	L3	-	-	-	-	-	-	-	-	-
	L4	-	-	-	-	-	-	-	-	-
	HIZ	35	115	225	720	800	800	750	25%	+715
Total (ha)		3,145	3,140	3,110	3,085	3,065	3,040	3,005	100%	-140
Dominant zone		HIZ	HIZ	HIZ	HIZ	HIZ	HIZ	HIZ		

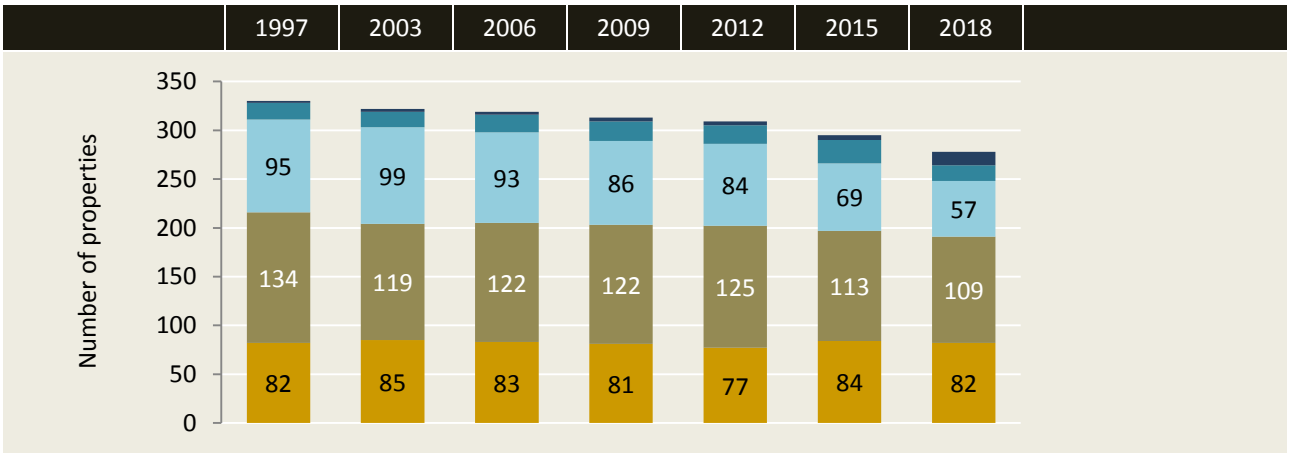
Figure 51: Merbein irrigation district - irrigable area in each salinity impact zone from 1997 to 2018

2.6.8 Merbein irrigation district - property change

Figure 52 provides estimates of property numbers and average property size (irrigable area) in the Merbein irrigation district from 1997 to 2018.

- In 2018:
  - there were approximately 278 irrigation properties; and
  - most properties (90%) had an irrigable area less than 20 ha.

- From 1997 to 2018:
  - the number of properties decreased by 52; a 16% decrease from 330 properties in 1997 to 278 in 2018;
  - properties with an irrigable area less than 20 ha decreased by 63, while the number over 20 ha increased by 11; and
  - average property size (irrigable area) increased from 10 ha in 1997 to 11 ha in 2018.



Property size (irrigable area)	1997	2003	2006	2009	2012	2015	2018	% of 2018 total	Change 1997-2018
1 to 5 ha	82	85	83	81	77	84	82	28%	0
5 to 10 ha	134	119	122	122	125	113	109	38%	-25
10 to 20 ha	95	99	93	86	84	69	57	23%	-38
20 to 40 ha	17	16	18	20	19	24	16	8%	-1
40 to 100 ha	2	3	3	4	4	5	14	2%	+12
100 to 500 ha	-	-	-	-	-	-	-	-	-
> 500 ha	-	-	-	-	-	-	-	-	-
Total properties	330	322	319	313	309	295	278	100%	-52
Average size (ha)	10	10	10	10	10	10	11		

Figure 52: Merbein irrigation district - property numbers and sizes from 1997 to 2018

3. Private diverters

3.1 Private diverters summary

In summary for private diverters, Nyah to South Australia

Crop types in 2018

Dominant plantings in the private diverter river reaches in 2018 were:

1. almonds; 24,295 ha (39% of the irrigable area);
2. wine grapes; 5,170 ha (8% of the irrigable area);
3. field crops; 4,455 ha (7% of the irrigable area);
4. citrus; 3,850 ha (6% of the irrigable area);
5. olives; 3,665 ha (6% of the irrigable area); and
6. table grapes; 3,375 ha (5% of the irrigable area).

Crop types 1997 to 2018

Almonds were the dominant crop from 2009 to 2018, whereas wine grapes were dominant from 2003 to 2006 and field crops were dominant in 1997.

The main changes in crops from 1997 to 2018 were:

- almonds increased by 22,665 ha; a 1,390% increase from 1,630 ha to 24,295 ha;
- olives increased by 3,600 ha; a 5,538% increase from 65 ha to 3,665 ha;
- table grape plantings increased by 2,265 ha; a 204% increase from 1,110 ha to 3,375 ha;
- field crops decreased by 1,520 ha; a 25% decrease from 5,975 ha to 4,455 ha;
- vegetables other than potatoes and carrots[23] increased by 1,215 ha; a 157% increase from 775 ha to 1,990 ha;
- wine grape plantings increased by 1,085 ha; a 27% increase from 4,085 ha to 5,170 ha; and
- dried grape plantings increased by 910 ha; a 246% increase from 370 ha to 1,280 ha.

[23] Potatoes and carrots are significant crops in the Mallee catchment and have separate reporting to 'other vegetables' (Table 9).

In summary for private diverters, Nyah to South Australia

Development of permanent plantings (new or redeveloped in the previous three years)

Development activity with respect to permanent plantings continued to increase from 1997 to 2009; 24% of plantings were new or redeveloped[24] in 1997 and 38% in 2009. Development fell to 8% in 2012 and 9% in 2015, but by 2018, activity was again on the increase with at least 17% (7,390 ha) of new plantings.

In 2018, the 7,390 ha (17%) of permanent crops planted or redeveloped in the previous three years were predominantly:

1. almonds (4,050 ha);
2. table grapes (1,010 ha);
3. olives (610 ha);
4. citrus (575 ha);
5. dried grapes (380 ha);
6. wine grapes (230 ha);
7. stone fruit (180 ha);
8. avocados (155 ha); and
9. pistachios (120 ha).

Planting trends - permanent plantings, seasonal crops and vacant areas

In 2018, the irrigable area of 61,510 ha comprised:

- 71% (43,825 ha) irrigated permanent plantings;
- 16% (9,700 ha) irrigated seasonal crops; and
- 13% (7,985 ha) vacant, not irrigated areas.

From 1997 to 2018:

- permanent plantings increased from 53% to 71% of the irrigable area;
- seasonal crops decreased from 43% to 16% of the irrigable area; and
- vacant, not irrigated areas increased from 4% to 13% of the irrigable area.

Irrigation development - expansion and retired areas

Across the private diverter river reaches, the irrigable area increased by 39,255 ha, a 176% increase from 22,255 ha in 1997 to 61,510 ha in 2018

The net increase of 39,255 ha was the balance of 39,940 ha expansion and 685 ha retired from irrigation.

Expansion occurred in all of the six river reaches between 1997 and 2018. The largest growth areas were:

- the Boundary Bend river reach with a net increase in the irrigable area of 16,550 ha (+308%); and
- the Wemen river reach with a net increase in the irrigable area of 10,550 ha (+491%).

[24] New or redeveloped within the previous three years

In summary for private diverters, Nyah to South Australia

Irrigation methods

Drip irrigation was the dominant irrigation method in the private diverter areas from 2003 to 2018, whereas overhead sprinklers were dominant in 1997.

In 2018, the irrigable area of 61,510 ha comprised:

- 65% (39,915 ha) drip irrigation;
- 8% (4,655 ha) lowlevel irrigation;
- 12% (7,185 ha) overhead sprinklers;
- 3% (1,770 ha) furrow irrigation; and
- 13% (7,985 ha) not irrigated.

From 1997 to 2018:

- drip irrigation increased by 36,755 ha; a 1,163% increase from 3,160 ha to 39,915 ha;
- lowlevel irrigation increased by 1,440 ha; a 45% increase from 3,215 ha to 4,655 ha;
- overhead irrigation decreased by 1,975 ha; a 22% decrease from 9,160 ha to 7,185 ha; and
- furrow irrigation decreased by 4,095 ha; a 70% decrease from 5,865 ha to 1,770 ha.

Salinity impact zones

Irrigable areas in the private diverter river reaches were predominantly in the lowest salinity impact zone, L1 from 2003 to 2018, whereas in 1997 they were predominantly in L2.

In 2018, the irrigable area of 61,510 ha comprised:

- 56% (34,515 ha) in the lowest salinity impact zone, L1;
- 21% (12,875 ha) in L2;
- 4% (2,455 ha) in L3;
- 14% (8,685 ha) in L4; and
- 5% (2,980 ha) in the high salinity impact zone, HIZ.

From 1997 to 2018 the irrigable area in:

- L1 to L4 increased by 39,210 ha, a 203% increase from 19,320 ha to 58,530 ha;
- HIZ increased by 45 ha, a 2% increase from 2,935 ha to 2,980 ha.

Irrigation properties

In 2018, there were approximately 430 irrigation properties with an average irrigable area of 143 ha.

From 1997 to 2018:

- the number of properties decreased by 70; a 14% decrease from 500 to 430 properties;
- properties with an irrigable area less than 20 ha decreased by 79, while the number over 20 ha increased by 9; and
- average property size (irrigable area) increased from 45 ha to 143 ha.

3.1.1 Private diverters summary - crop types in 2018

Table 9 lists horticultural crops in the private diverter river reaches in 2018.

- Dominant plantings were:
    1. almonds; 24,295 ha (39% of the irrigable area);
    2. wine grapes; 5,170 ha (8% of the irrigable area);
    3. field crops; 4,455 ha (7% of the irrigable area);
    4. citrus; 3,850 ha (6% of the irrigable area);
    5. olives; 3,665 ha (6% of the irrigable area); and
    6. table grapes; 3,375 ha (5% of the irrigable area).

Table 9: Private diverters - irrigated crops in 2018

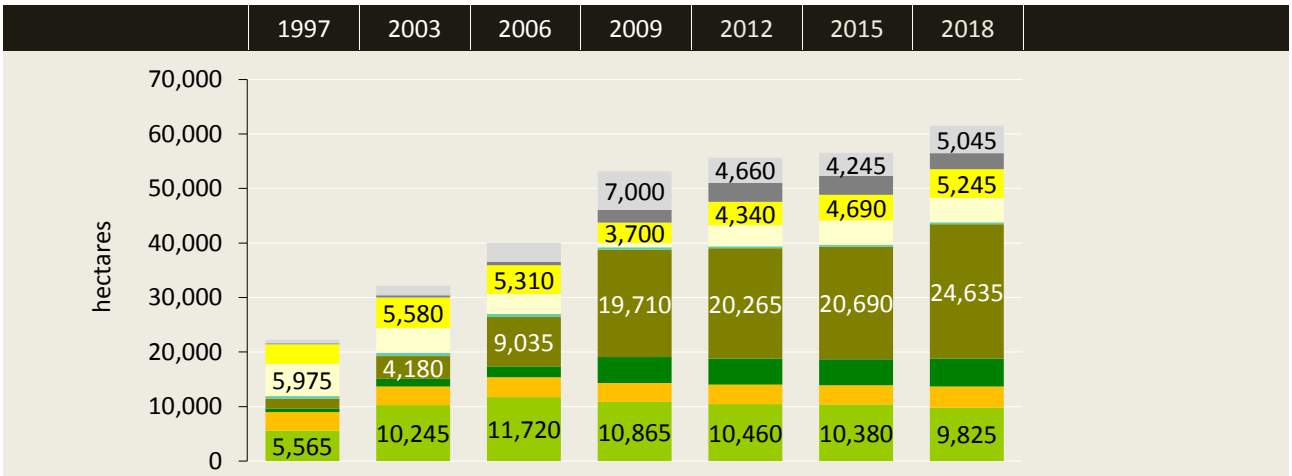
	Crop type	Category	2018 (ha)	2018 %	Description
Permanent plantings	Grapevine	Dried	1,280	2%	Includes a very small proportion of juiced grapes
		Table	3,375	5%	
		Wine	5,170	8%	
	Citrus		3,850	6%	Grapefruit, lemon, lime, mandarin, navel, blood orange, other orange, pummelo, tangelo, valencia
	Fruit tree	Olive	3,665	6%	
		Other	1,465	2%	Avocado, date palm, fig, jujube, mango, persimmon, pome fruit, pomegranate, stone fruit
	Nut tree	Almond	24,295	39%	
		Other nuts	340	1%	Pistachio, walnut
	Other	Miscellaneous	385	1%	Aquaculture, berry, fresh flowers, herbs, native plants, nursery, tree plantation
	Permanent crops (sub-total)		43,825	71%	
Seasonal crops	Field crop		4,455	7%	Canola, cereal, cover crop, lucerne, lupin, maize, pasture, turf
	Vegetable	Carrot	1,515	2%	
		Potato	1,740	3%	
		Other	1,990	3%	Asparagus, bean, beetroot, broccoli, cabbage, capsicum, cauliflower, chili, cucumber, eggplant, garlic, lettuce, melon, onion, pumpkin, salad greens, sweet corn, tomato, zucchini
	Seasonal crops (sub-total)		9,700	16%	
Vacant	Vacant P		2,940	5%	Vacant (not irrigated), previously an irrigated permanent crop
	Vacant S		5,045	8%	Vacant (not irrigated), previously an irrigated seasonal crop
	Total all crop areas		61,510	100%	

3.1.2 Private diverters summary - crop types from 1997 to 2018

Figure 53 summarises crop types across the six private diverter river reaches from 1997 to 2018.

- The dominant crop changed from:
  - field crops in 1997; to
  - wine grapes from 2003 to 2006; and
  - almonds from 2009 to 2018.

- Almond trees increased by 22,665 ha, a 1,390% increase from 1,630 ha in 1997 to 24,295 ha in 2018.
- The second highest increase in plantings was 3,600 ha of olive trees; a 5,538% increase from 65 ha in 1997 to 3,665 ha in 2018.



Crop type		1997	2003	2006	2009	2012	2015	2018	% of 2018 total	Change 1997-2018
Permanent	Grape Dried	370	790	820	735	835	955	1,280	2%	+910
	Grape Table	1,110	1,830	1,915	1,795	2,165	2,545	3,375	5%	+2,265
	Grape Wine	4,085	7,625	8,985	8,335	7,460	6,880	5,170	8%	+1,085
	Citrus	3,435	3,435	3,645	3,445	3,560	3,520	3,850	6%	+415
	Fruit Olive	65	630	1,170	3,945	3,645	3,510	3,665	6%	+3,600
	Fruit Other	580	760	840	800	1,090	1,245	1,465	2%	+885
	Nut Almond	1,630	4,015	8,870	19,520	20,045	20,455	24,295	39%	+22,665
	Nut Other	150	165	165	190	220	235	340	1%	+190
	Other	470	570	605	470	355	370	385	1%	-85
Seasonal	Field Crop	5,975	4,585	3,605	820	3,870	4,420	4,455	7%	-1,520
	Veg. Carrot	1,565	2,580	2,510	2,460	2,370	2,345	1,515	2%	-50
	Veg. Potato	1,190	1,715	1,520	610	875	905	1,740	3%	+550
	Veg. Other	775	1,285	1,280	630	1,095	1,440	1,990	3%	+1,215
	Vacant P	180	420	565	2,355	3,430	3,480	2,940	5%	+2,760
	Vacant S	675	1,755	3,530	7,000	4,660	4,245	5,045	8%	+4,370
Total (ha)		22,255	32,160	40,025	53,110	55,675	56,550	61,510	100%	+39,255
Dominant		field crop	wine grape	wine grape	almond	almond	almond	almond		

Figure 53: Private diverters - crop types from 1997 to 2018

3.1.3 Private diverters summary - development of permanent crops

Figure 54 summarises development activity of permanent crops planted or redeveloped by private diverters in the previous three years from 1997 to 2018.

The information provides an indication of development activity that is otherwise not evident in information on changes in areas and crop types, as it includes replanting and top working to different varieties. The figures are conservative, as top-worked plantings can be difficult to interpret from the three-yearly aerial imagery, particularly for grapevines.

- In 2018, at least 7,390 ha (17%) of permanent crops were planted or redeveloped in the previous three years. Development was predominantly:
    1. almonds (4,050 ha);
    2. table grapes (1,010 ha);
    3. olives (610 ha);
    4. citrus (580 ha);
    5. dried grapes (380 ha);
    6. wine grapes (230 ha);
    7. stone fruit (180 ha);
    8. avocados (150 ha); and
    9. pistachios (115 ha).

- The area of new or redeveloped permanent plantings was highest in 2009 with 15,035 ha (38%) planted in the previous three years.

- Development activity ranged from 8% of permanent plantings in 2012 to 38% of plantings in 2009.

Permanent plantings	1997	2003	2006	2009	2012	2015	2018	% of 2018 total
≤3yr old plantings	2,865	6,260	8,520	15,035	3,050	3,590	7,390	17%
>3yr old plantings	9,030	13,560	18,495	24,200	36,325	36,125	36,435	83%
Total (ha)	11,895	19,820	27,015	39,235	39,375	39,715	43,825	100%
% 3year development	24%	32%	32%	38%	8%	9%	17%	

Figure 54: Private diverters - development of permanent crops from 1997 to 2018

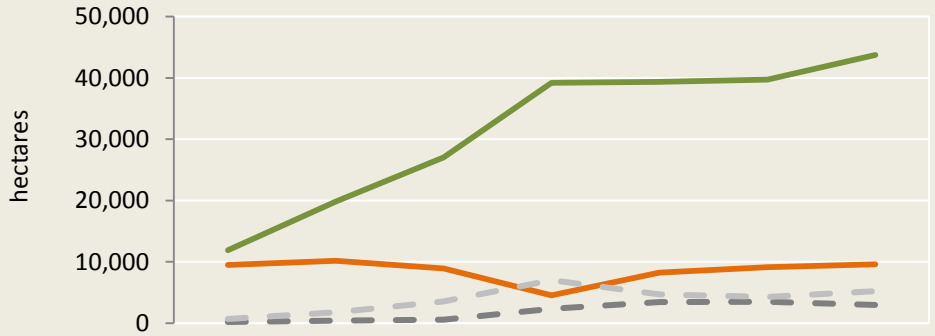
3.1.4 Private diverters summary - planting trends

Figure 55 summarises planting trends of private diverters 1997 to 2018.

- In 2018, the irrigable area of 61,510 ha comprised:
  - 71% (43,825 ha) irrigated permanent plantings;
  - 16% (9,700 ha) irrigated seasonal crops; and
  - 13% (7,985 ha) vacant, not irrigated areas.

The proportion of permanent plantings, seasonal cropping and vacant areas changed from:
  - 53% permanent, 43% seasonal and 4% vacant in 1997; to
  - 71% permanent, 16% seasonal and 13% vacant in 2018.

- From 1997 to 2018:
  - irrigated permanent crops increased by 31,930 ha;
  - irrigated seasonal crops increased by 195 ha;
  - vacant, not irrigated areas increased by 7,130 ha; and
  - the irrigable area increased by 39,255 ha; a 176% increase from 22,255 ha to 61,510 ha.



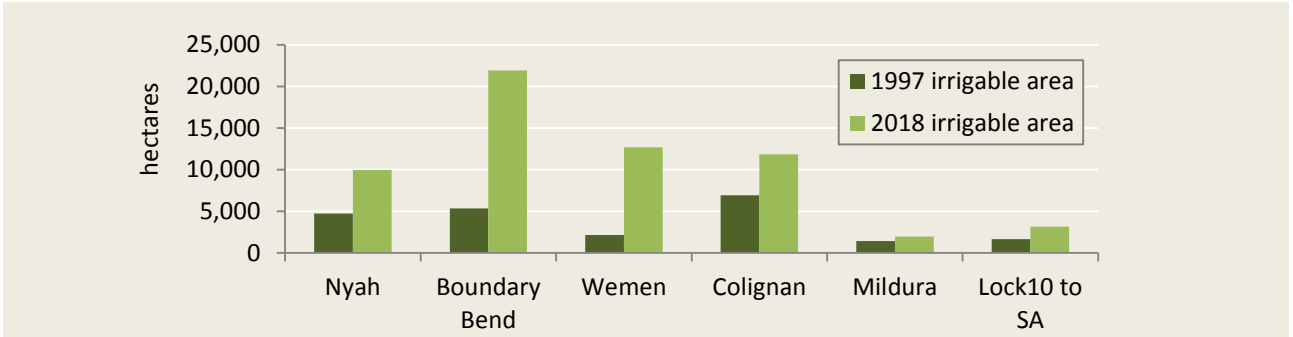
	1997	2003	2006	2009	2012	2015	2018	% of 2018 total	Change 1997-2018
Permanent - irrigated	11,895	19,820	27,015	39,235	39,375	39,715	43,780	71%	+31,885
Seasonal - irrigated	9,505	10,165	8,915	4,520	8,210	9,110	9,595	16%	+90
Vacant - permanent	180	420	565	2,355	3,430	3,480	2,950	5%	+2,770
Vacant - seasonal	675	1,755	3,530	7,000	4,660	4,245	5,185	8%	+4,510
Total (ha)	22,255	32,160	40,025	53,110	55,675	56,550	61,510	100%	+39,255
% Permanent	53%	62%	67%	74%	71%	70%	71%		
% Seasonal	43%	32%	22%	9%	15%	16%	16%		
% Vacant	4%	7%	10%	18%	15%	14%	13%		

Figure 55: Private diverters - planting trends from 1997 to 2018

3.1.5 Private diverters summary - irrigation development

Figure 56 summarises irrigation development with respect to new development (expansion) and areas retired[25] from irrigation in the private diverter river reaches from 1997 to 2018.

- The irrigable area increased by 39,255 ha, a 176% increase from 22,255 ha in 1997 to 61,510 ha in 2018.
- The net increase of 39,255 ha was the balance of 39,940 ha of expansion and 685 ha retired from irrigation.
- Expansion occurred in all six river reaches. The largest growth areas from 1997 to 2018 were:
  - the Boundary Bend river reach with a net increase in the irrigable area of 16,550 ha; and
  - the Wemen river reach with a net increase in the irrigable area of 10,550 ha.



River reach	1997 (ha)	1997 to 2018		2018 (ha)	Change 1997-2018	Growth 1997-2018
		Retired	New			
Nyah	4,730	-45	+5,260	9,945	+5,215	+110%
Boundary Bend	5,365	-230	+16,780	21,915	+16,550	+308%
Wemen	2,150	-50	+10,600	12,700	+10,550	+491%
Colignan	6,925	-75	+4,975	11,825	+4,900	+71%
Mildura	1,445	-65	+590	1,970	+525	+36%
Lock10 to Sth Aus.	1,640	-220	+1,735	3,155	+1,515	+92%
Total	22,255	-685	+39,940	61,510	+39,255	+176%

Figure 56: Private diverters - irrigation development from 1997 to 2018

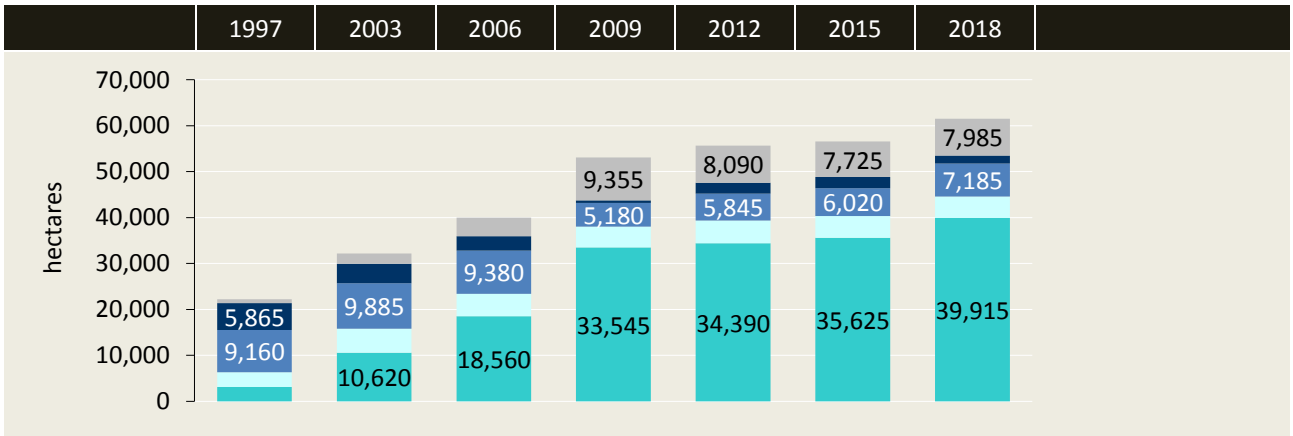
[25] Retired areas were previously irrigated but have undergone a change in land use that precludes use for irrigation e.g. urban development, housing, sheds, dams and land set aside for conservation purposes.

3.1.6 Private diverters summary - irrigation methods

Figure 57 summarises irrigation methods for Murray River private diverters in the Mallee catchment from 1997 to 2018.

- In 2018, the irrigable area of 61,510 ha comprised:
  - 65% (39,915 ha) drip irrigation;
  - 8% (4,655 ha) lowlevel irrigation;
  - 12% (7,185 ha) overhead sprinklers;
  - 3% (1,770 ha) furrow irrigation; and
  - 13% (7,985 ha) vacant, not irrigated.

- Drip irrigation increased by 36,755 ha, an 1,163% increase from 3,160 ha in 1997 to 39,915 ha in 2018.
  - Drip irrigation was the dominant irrigation method from 2003 to 2018.
- Lowlevel irrigation increased by 1,440 ha, a 45% increase from 3,215 ha in 1997 to 4,655 ha in 2018.
- Overhead irrigation decreased by 1,975 ha, a 22% decrease from 9,160 ha in 1997 to 7,185 ha in 2018.
  - Overheads and pivots were the dominant irrigation method in 1997.
- Furrow irrigation decreased by 4,095 ha, a 70% decrease from 5,865 ha in 1997 to 1,770 ha in 2018.



Irrigation method[26]	1997	2003	2006	2009	2012	2015	2018	% of 2018 total	Change 1997-2018
Drip	3,160	10,620	18,560	33,545	34,390	35,625	39,915	65%	+36,755
Lowlevel	3,215	5,230	4,860	4,480	5,000	4,745	4,655	8%	+1,440
Overhead	9,160	9,885	9,380	5,180	5,845	6,020	7,185	12%	-1,975
Furrow	5,865	4,250	3,130	550	2,350	2,435	1,770	3%	-4,095
Vacant	855	2,175	4,095	9,355	8,090	7,725	7,985	13%	+7,130
Total (ha)	22,255	32,160	40,025	53,110	55,675	56,550	61,510	100%	+39,255
Dominant	overhead	drip	drip	drip	drip	drip	drip		

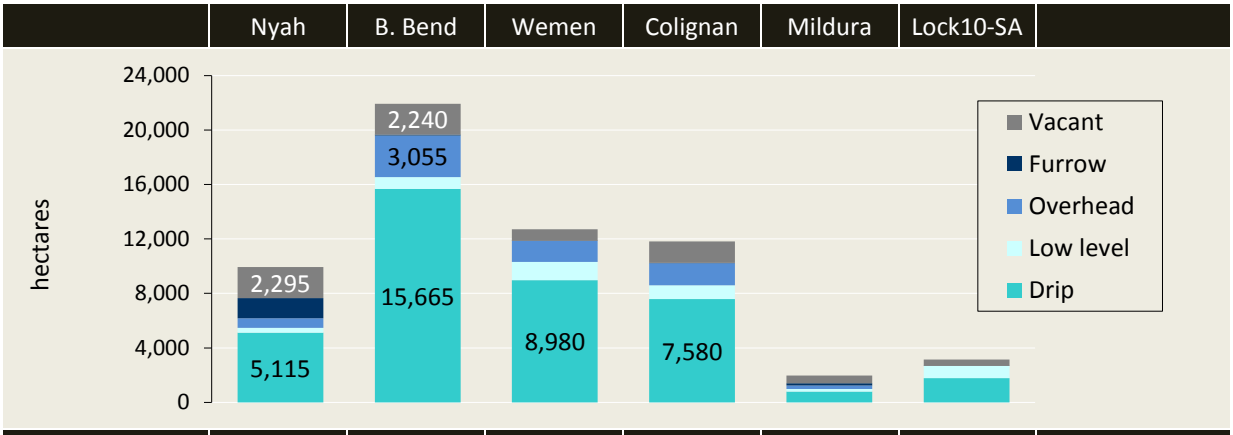
Figure 57: Private diverters - irrigation methods from 1997 to 2018

[26] Overhead irrigation includes pivots and lateral move systems. Furrow includes flood irrigation. (Table 5)

Irrigation methods in the private diverter areas

Figure 58 compares irrigation methods in each of the private diverter river reaches in 2018.

- Drip irrigation was the dominant method in each of the private diverter river reaches in 2018.



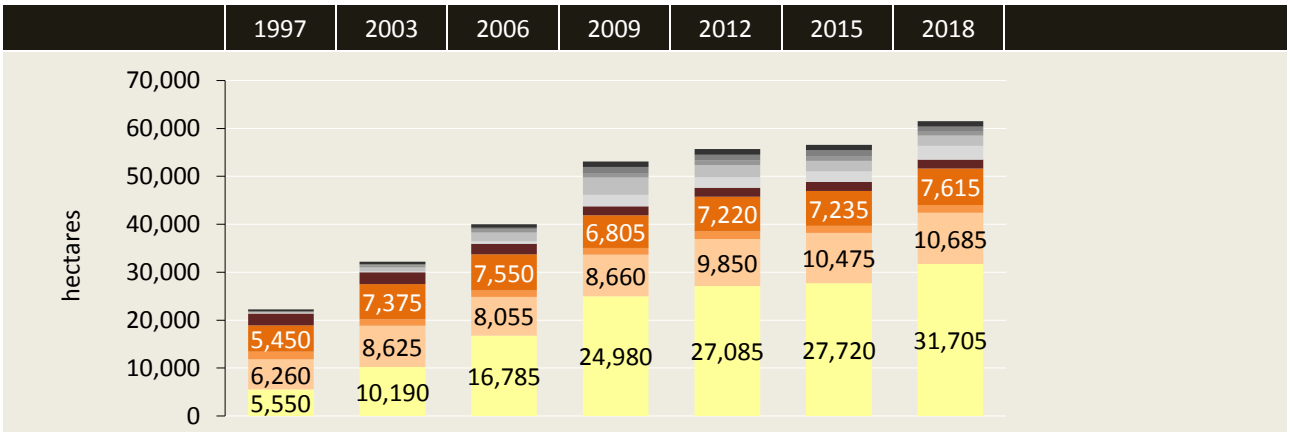
	Nyah	B. Bend	Wemen	Colignan	Mildura	Lock10-SA	2018 total
2018 hectares	9,945	21,915	12,700	11,825	1,970	3,155	61,510
% of 2018 total	16%	36%	21%	19%	3%	5%	100%
Dominant	drip	drip	drip	drip	drip	drip	drip

Figure 58: Private diverters - irrigation methods in each river reach in 2018

3.1.7 Private diverters summary - salinity impact zones

Figure 59 summarises river salinity impact zones of irrigated areas in the private diverter river reaches from 1997 to 2018.

- Irrigation development was predominantly in the lowest salinity impact zone, L1, from 1997 to 2018. The dominant zone changed from L2 to L1 between 1997 and 2003.
- In 2018, the irrigable area of 61,510 ha comprised:
  - 56% (34,515 ha) in the lowest salinity impact zone, L1;
  - 21% (12,875 ha) in L2;
  - 4% (2,455 ha) in L3;
  - 14% (8,685 ha) in L4; and
  - 5% (2,980 ha) in the high salinity impact zone, HIZ.
- The area irrigated in:
  - L1 to L4 increased by 32,760 ha, a 173% increase from 18,895 ha in 1997 to 51,655 ha in 2018;
  - HIZ decreased by 635 ha, a 25% decrease from 2,505 ha in 1997 to 1,870 ha in 2018.
- The irrigable area in:
  - L1 to L4 increased by 39,210 ha, a 203% increase from 19,320 ha in 1997 to 58,530 ha in 2018;
  - HIZ increased by 45 ha, a 2% increase from 2,935 ha in 1997 to 2,980 ha in 2018.



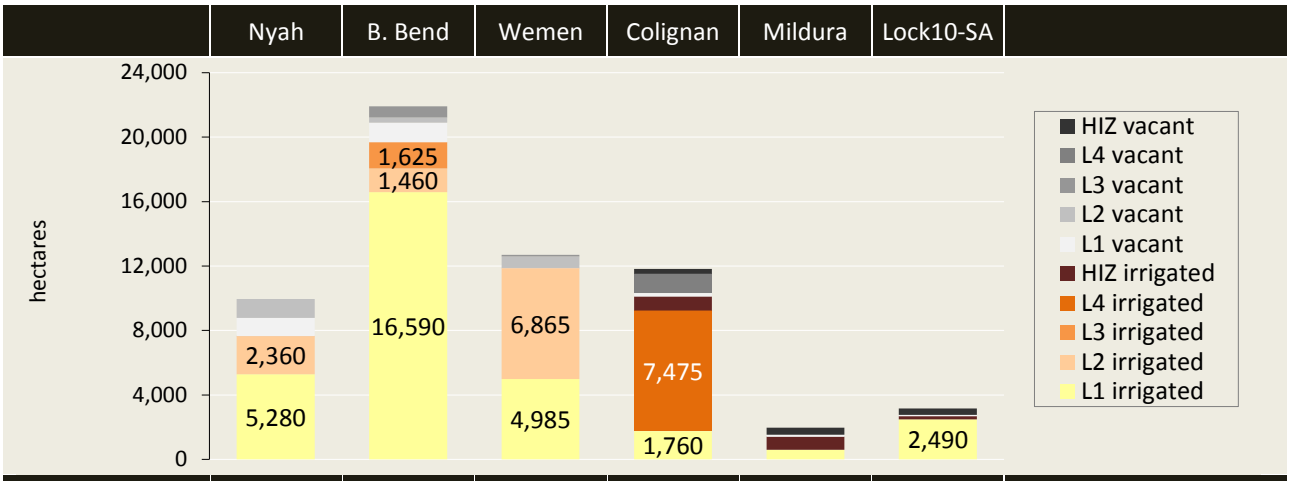
Salinity impact zone		1997	2003	2006	2009	2012	2015	2018	% of 2018 total	Change (ha) 1997-2018
Irrigated	L1	5,550	10,190	16,785	24,980	27,085	27,720	31,705	52%	+26,155
	L2	6,260	8,625	8,055	8,660	9,850	10,475	10,685	17%	+4,425
	L3	1,635	1,350	1,320	1,435	1,590	1,495	1,650	3%	+15
	L4	5,450	7,375	7,550	6,805	7,220	7,235	7,615	12%	+2,165
	HIZ	2,505	2,445	2,220	1,875	1,840	1,900	1,870	3%	-635
Not Irrigated	L1	20	220	510	2,390	2,220	2,210	2,810	5%	+2,790
	L2	205	765	1,810	3,620	2,585	2,200	2,190	4%	+1,985
	L3	55	390	635	915	905	960	805	1%	+750
	L4	145	285	400	1,265	1,170	1,205	1,070	2%	+925
	HIZ	430	515	740	1,165	1,210	1,150	1,110	2%	+680
Total (ha)		22,255	32,160	40,025	53,110	55,675	56,550	61,510	100%	+39,255
Dominant zone		L2	L1	L1	L1	L1	L1	L1		

Figure 59: Private diverters - irrigable area in each salinity impact zone from 1997 to 2018

Salinity zones in each of the private diverter river reaches

Figure 60 compares salinity impact zones in each of the private diverter river reaches in 2018.

- The irrigable area in each of the private diverter river reaches was predominantly in low salinity impact zones L1, L2 and L4, except for the Mildura river reach, which was predominantly in the HIZ.



Private diverters	Nyah	B. Bend	Wemen	Colignan	Mildura	Lock10-SA	2018 total
2018 HIZ (ha)	-	-	-	1,175	1,235	570	2,980
% of HIZ total	-	-	-	39%	42%	19%	100%
Dominant zone	L1	L1	L2	L4	HIZ	L1	L1

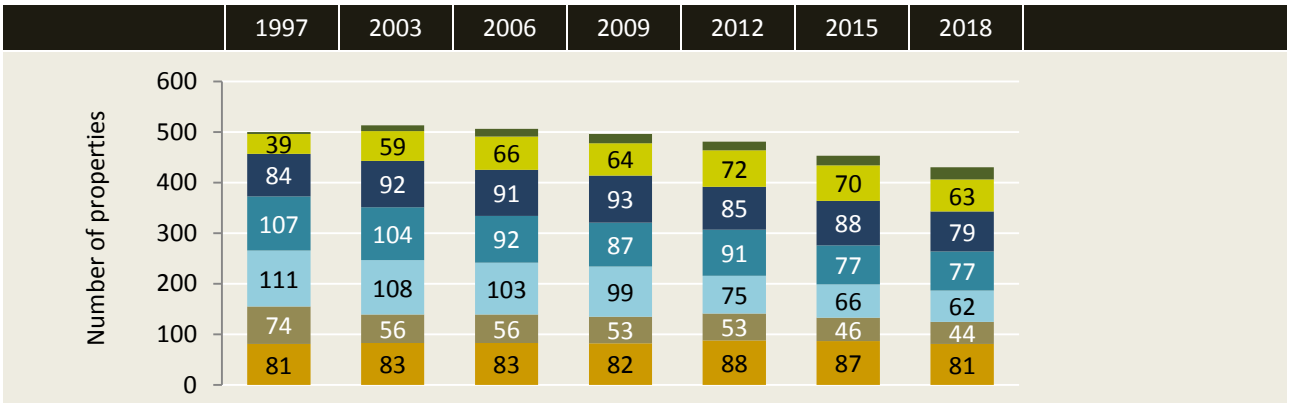
Figure 60: Private diverters - salinity impact zones in each river reach in 2018

3.1.8 Private diverters summary - property change

Figure 61 provides an estimate of property numbers and average property size (irrigable area) in the private diverter river reaches from 1997 to 2018.

- In 2018:
  - there were approximately 430 irrigation properties; and
  - most properties (57%) had an irrigable area over 20 ha.

- From 1997 to 2018:
  - the number of properties decreased by 70; a 14% decrease from 500 to 430 properties;
  - properties with an irrigable area less than 20 ha decreased by 79, while the number over 20 ha increased by 9; and
  - average property size (irrigable area) increased from 45 ha in 1997 to 143 ha in 2018.



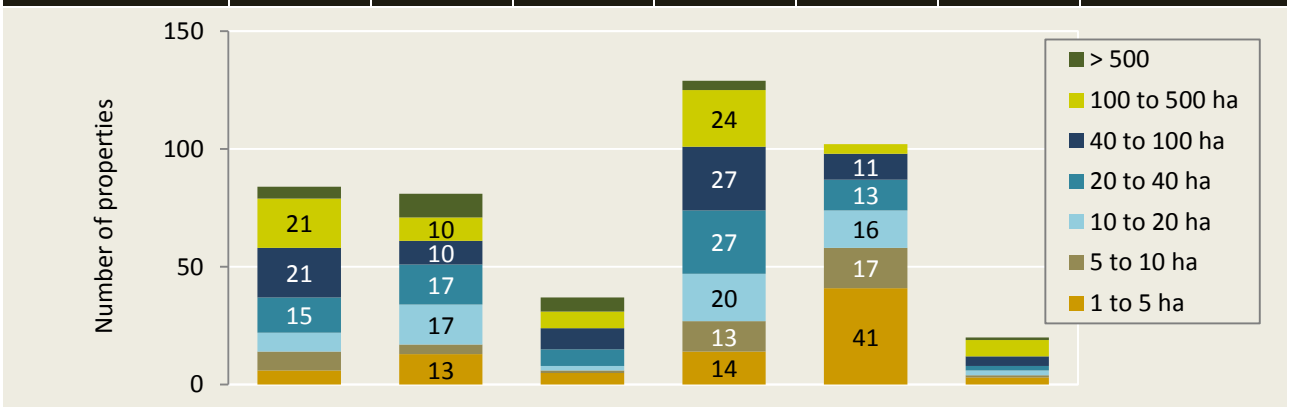
Property size (irrigable area)	1997	2003	2006	2009	2012	2015	2018	% of 2018 total	Change 1997-2018
1 to 5 ha	81	83	83	82	88	87	81	19%	0
5 to 10 ha	74	56	56	53	53	46	44	10%	-30
10 to 20 ha	111	108	103	99	75	66	62	14%	-49
20 to 40 ha	107	104	92	87	91	77	77	18%	-30
40 to 100 ha	84	92	91	93	85	88	79	18%	-5
100 to 500 ha	39	59	66	64	72	70	63	15%	+24
> 500 ha	4	11	15	18	17	19	24	6%	+20
Total properties	500	513	506	496	481	453	430	100%	-70
Average size (ha)	45	63	79	107	116	125	143		

Figure 61: Private diverters - property numbers and sizes from 1997 to 2018

Irrigation properties in each of the private diverter areas

Figure 62 provides an estimate of property numbers and average property size (irrigable area) in each of the private diverter river reaches in 2018.

- In 2018:
  - the Colignan river reach had the highest number of private diverters (129 properties);
  - the Wemen river reach had the highest average property size (irrigable area of 343 ha); and
  - Boundary Bend, Wemen and Lock 10 to South Australia river reaches had average property sizes greater than the regional average for private diverters of 143 ha.



River reach	Nyah	B. Bend	Wemen	Colignan	Mildura	Lock10-SA	2018 total
Total properties	84	81	37	129	102	20	453/430[27]
% of 2018 total	19%	18%	8%	29%	22%	4%	100%
Average size irrigable area (ha)	118	271	343	92	19	158	

Figure 62: Private diverters - property numbers and average size in each river reach in 2018

[27] The total number of private diverters in each river reach (453 properties, Figure 62) is greater than the total across the private diverter areas (430 properties, Figure 61) as some properties irrigate in more than one river reach.

3.2 Nyah river reach (Woorinen South to the Wakool junction)

In summary for the Nyah river reach[28]

Crop types in 2018

Dominant plantings in the Nyah river reach in 2018 were:

1. almond trees; 2,935 ha (30% of the irrigable area);
2. field crops; 2,360 ha (24% of the irrigable area); and
3. wine grapes; 885 ha (9% of the irrigable area).

Crop types 1997 to 2018

Almonds were the dominant crop in 2018 and temporarily dominant in 2009 when irrigating of field crops declined due to drought conditions and low water allocations. Field crops were dominant from 1997 to 2006 and again from 2012 to 2015.

The main changes in crops from 1997 to 2018 were:

- almonds increased by 2,935 ha; an increase from 0 ha to 2,935 ha;
- field crops decreased by 1,335 ha; a 36% decrease from 3,695 ha to 2,360 ha;
- wine grape plantings increased by 760 ha; a 608% increase from 125 ha to 885 ha; and
- fruit trees, mostly stone fruit, increased by 620 ha; a 376% increase from 165 ha to 785 ha.

Development of permanent plantings (new or redeveloped in the previous three years)

In 2018, at least 925 ha (19%) of permanent crops were planted or redeveloped in the previous three years, predominantly:

1. almonds (695 ha);
2. stone fruit (120 ha);
3. avocados (45 ha);
4. wine grapes (35 ha); and
5. table grapes (20 ha).

Development activity ranged from 7% of permanent plantings in 2015 to 54% in 2009.

Planting trends - permanent plantings, seasonal crops and vacant areas

In 2018, the irrigable area of 9,945 ha comprised:

- 50% (4,955 ha) irrigated permanent plantings;
- 27% (2,695 ha) irrigated seasonal crops; and
- 23% (2,295 ha) vacant, not irrigated areas.

From 1997 to 2018:

- permanent plantings increased from 12% to 50% of the irrigable area;
- seasonal crops decreased from 85% to 27% of the irrigable area; and
- vacant, not irrigated areas increased from 3% to 23% of the irrigable area.

[28] The Nyah river reach was amended to include irrigation at Woorinen South that has expanded west into the Mallee catchment. Hence, areas for the Nyah river reach are greater in this 2018 report than in earlier reports.

In summary for the Nyah river reach

Irrigation development - new and retired areas

The irrigable area in the Nyah river reach increased by 5,215 ha; a 110% increase from 4,730 ha in 1997 to 9,945 ha in 2018.

The net increase of 5,215 ha was the balance of 5,260 ha expansion and 45 ha retired from irrigation.

Irrigation methods

Drip irrigation was the dominant irrigation method in the Nyah river reach from 2009 to 2018, whereas furrow irrigation was dominant from 1997 to 2006.

In 2018, the irrigable area of 9,945 ha comprised:

- 51% (5,115 ha) drip irrigation;
- 3% (345 ha) lowlevel irrigation;
- 7% (705 ha) overhead sprinklers;
- 15% (1,485 ha) furrow irrigation; and
- 23% (2,295 ha) not irrigated.

Salinity impact zones

The Nyah river reach is in the low salinity impact zones: L1, L2 and L3.

In 2018, the irrigable area of 9,945 ha comprised:

- 64% (6,405 ha) in the lowest salinity impact zone, L1;
- 35% (3,530 ha) in L2; and
- <1% (10 ha) in L3.

From 1997 to 2018 the irrigable area in:

- L1 increased by 4,790 ha, a 297% increase from 1,615 ha to 6,405 ha;
- L2 increased by 425 ha, a 14% increase from 3,105 ha to 3,530 ha; and
- L3 was 10 ha in 1997 and 2018.

Irrigation properties

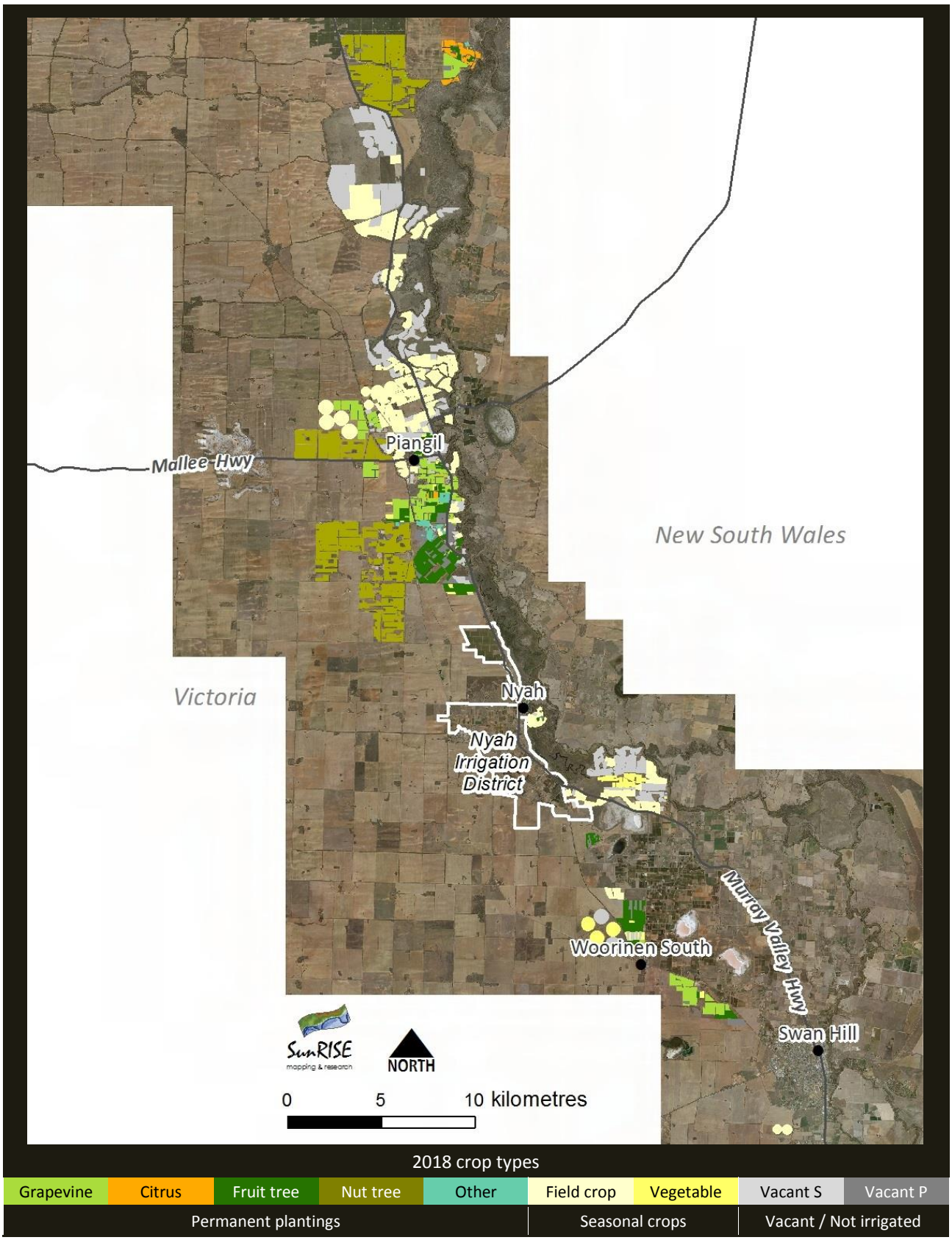
In 2018, there were approximately 84 irrigation properties with an average irrigable area of 118 ha.

From 1997 to 2018:

- the number of properties decreased by 1; a 1% decrease from 85 to 84 properties;
- properties with an irrigable area less than 20 ha decreased by 11, while the number over 20 ha increased by 10; and
- average property size (irrigable area) increased from 56 ha to 118 ha.

3.2.1 Nyah river reach - crop types in 2018

Map 12 shows the Nyah river reach and crop types in 2018.



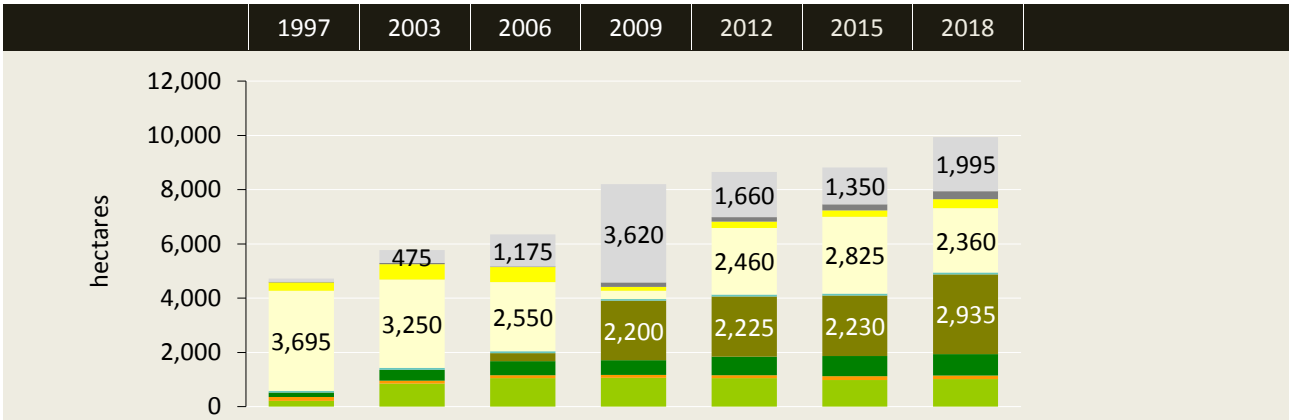
Map 12: Nyah river reach showing 2018 crop types

3.2.2 Nyah river reach - crop types from 1997 to 2018

Figure 63 summarises crop types in the Nyah river reach from 1997 to 2018.

- Dominant plantings in 2018 were:
    1. almond trees; 2,935 ha (30% of the irrigable area);
    2. field crops; 2,360 ha (24% of the irrigable area); and
    3. wine grapes; 885 ha (9% of the irrigable area).

- Field crops were the dominant crop from 1997 to 2015, except for in 2009 due to drought and low water allocations.
- Almonds were temporarily the dominant crop in 2009 and were dominant again in 2018.
- Between 1997 and 2018, the area of irrigated field crops decreased by 1,335 ha, while the area of almond plantings increased by 2,935 ha.



Crop type		1997	2003	2006	2009	2012	2015	2018	% of 2018 total	Change 1997-2018
Permanent	Grape Dried	5	0	0	0	0	0	0	0%	-5
	Grape Table	90	140	125	120	120	120	135	1%	+45
	Grape Wine	125	710	930	945	930	865	885	9%	+760
	Citrus	140	115	110	110	115	140	135	1%	-5
	Fruit Olive	5	5	5	5	5	5	5	<1%	0
	Fruit Other	165	395	510	535	675	735	785	8%	+620
	Nut Almond	0	0	295	2,200	2,225	2,230	2,935	30%	+2,935
	Nut Other	-	-	-	-	-	-	-	-	-
	Other	55	70	75	60	65	80	75	1%	+20
Seasonal	Field Crop	3,695	3,250	2,550	300	2,460	2,825	2,360	24%	-1,335
	Veg. Carrot	100	190	190	60	80	85	100	1%	0
	Veg. Potato	120	240	240	0	0	0	0	0%	-120
	Veg. Other	85	145	115	85	145	150	235	2%	+150
	Vacant P	20	40	30	160	175	230	300	3%	+280
	Vacant S	125	475	1,175	3,620	1,660	1,350	1,995	20%	+1,870
Total (ha)		4,730	5,775	6,350	8,200	8,655	8,815	9,945	100%	+5,215
Dominant		field crop	field crop	field crop	almond	field crop	field crop	almond		

Figure 63: Nyah river reach - crop types from 1997 to 2018

3.2.3 Nyah river reach - development of permanent crops

Figure 64 shows the proportion of permanent crops planted or redeveloped in the previous three years in the Nyah river reach from 1997 to 2018.

The information provides an indication of development activity that is otherwise not evident in information on changes in areas and crop types, as it includes replanting and top working to different varieties. The figures are conservative, as top-worked plantings can be difficult to interpret from the three-yearly aerial imagery, particularly for grapevines.

- In 2018, at least 925 ha (19%) of permanent crops were planted or redeveloped in the previous three years. Development was predominantly:
    1. almonds (695 ha);
    2. stone fruit (120 ha);
    3. avocados (45 ha);
    4. wine grapes (35 ha); and
    5. table grapes (20 ha).

- The area of new or redeveloped permanent plantings was highest in 2009 with 2,150 ha (54%) planted in the previous three years.

- Development activity ranged from 7% of permanent plantings in 2015 to 54% in 2009.

Permanent plantings	1997	2003	2006	2009	2012	2015	2018	% of 2018 total
≤3yr old plantings	130	590	755	2,150	340	305	925	19%
>3yr old plantings	455	845	1,295	1,825	3,795	3,870	4,030	81%
Total (ha)	585	1,435	2,050	3,975	4,135	4,175	4,955	100%
% 3year development	22%	41%	37%	54%	8%	7%	19%	

Figure 64: Nyah river reach - development of permanent crops from 1997 to 2018

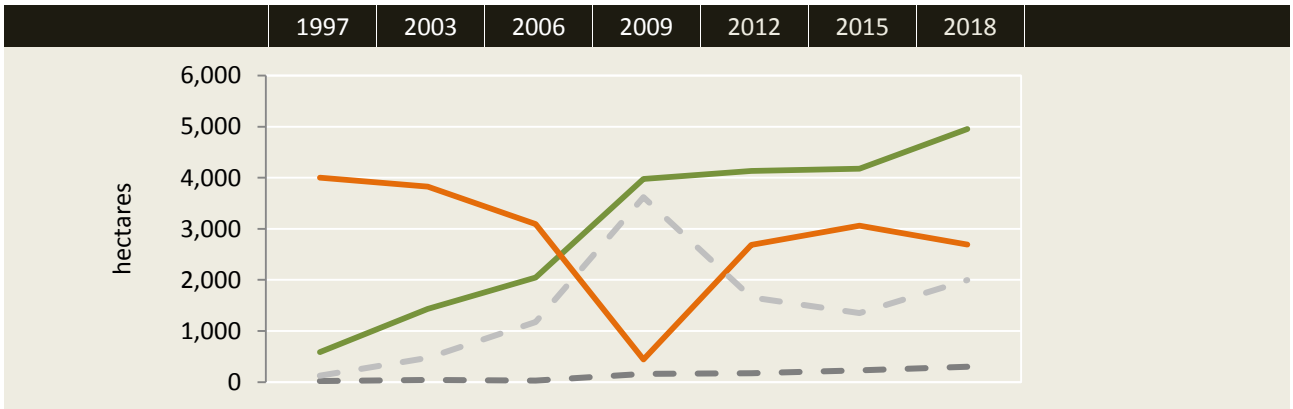
3.2.4 Nyah river reach - planting trends

Figure 65 summarises planting trends in the Nyah river reach from 1997 to 2018.

- In 2018, the irrigable area of 9,945 ha comprised:
  - 50% (4,955 ha) irrigated permanent plantings;
  - 27% (2,695 ha) irrigated seasonal crops; and
  - 23% (2,295 ha) vacant, not irrigated areas.

The proportion of permanent plantings, seasonal cropping and vacant areas changed from:
  - 12% permanent, 85% seasonal and 3% vacant in 1997; to
  - 50% permanent, 27% seasonal and 23% vacant in 2018.

- From 1997 to 2018:
  - irrigated permanent crops increased by 4,370 ha;
  - irrigated seasonal crops decreased by 1,305 ha;
  - vacant, not irrigated areas increased by 2,150 ha; and
  - the irrigable area increased by 5,215 ha; a 110% increase from 4,730 ha to 9,945 ha.



	1997	2003	2006	2009	2012	2015	2018	% of 2018 total	Change 1997-2018
Permanent - irrigated	585	1,435	2,050	3,975	4,135	4,175	4,955	50%	+4,370
Seasonal - irrigated	4,000	3,825	3,095	445	2,685	3,060	2,695	27%	-1,305
Vacant - permanent	20	40	30	160	175	230	300	3%	+280
Vacant - seasonal	125	475	1,175	3,620	1,660	1,350	1,995	20%	+1,870
Total (ha)	4,730	5,775	6,350	8,200	8,655	8,815	9,945	100%	+5,215
% Permanent	12%	25%	32%	48%	48%	47%	50%		
% Seasonal	85%	66%	49%	5%	31%	35%	27%		
% Vacant	3%	9%	19%	46%	21%	18%	23%		

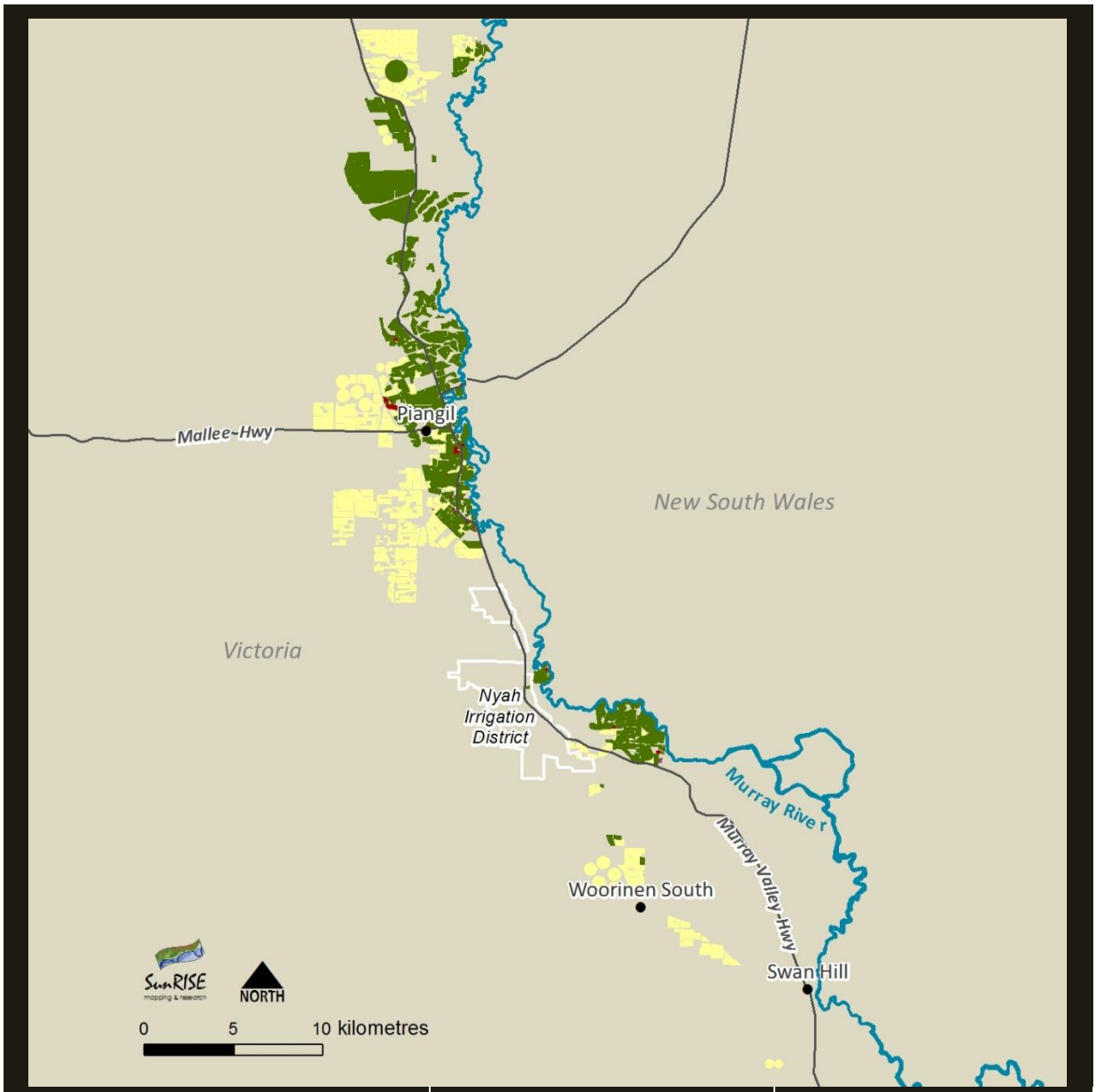
Figure 65: Nyah river reach - planting trends from 1997 to 2018

3.2.5 Nyah river reach - irrigation development

Map 13 shows irrigation development, from 1997 to 2018, in the Nyah river reach with respect to new development (expansion) and areas retired[29] from irrigation.

- The irrigable area increased by 5,215 ha; a 110% increase from 4,730 ha in 1997 to 9,945 ha in 2018.
- The net increase of 5,215 ha comprised 45 ha retired from irrigation and 5,260 ha of expansion.

Map 13: Nyah river reach - irrigation development from 1997 to 2018



	Hectares		% of 1997
Irrigation areas in 1997 (1996-97 season)	4,730		
Retired between 1997 and 2018	-45		-1%
Expansion between 1997 and 2018	+5,260		+111%
Irrigation areas in 2018 (2017-18 season)	9,945		

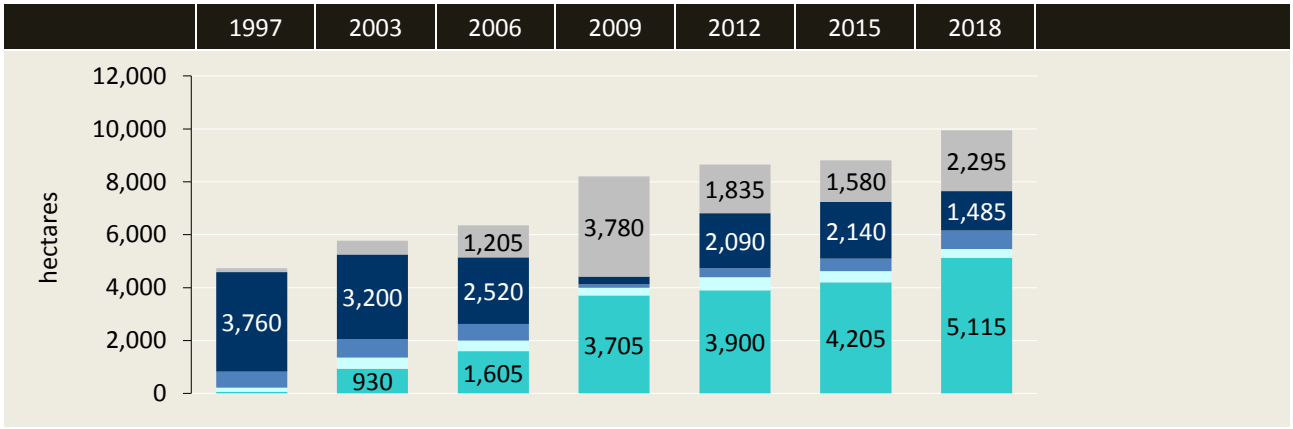
[29] Retired areas were previously irrigated but have undergone a change in land use that precludes use for irrigation e.g. urban development, housing, sheds, dams and land set aside for conservation purposes.

3.2.6 Nyah river reach - irrigation methods

Figure 66 summarises irrigation methods in the Nyah river reach from 1997 to 2018.

- In 2018, the irrigable area of 9,945 ha comprised:
  - 51% (5,115 ha) drip irrigation;
  - 3% (345 ha) lowlevel irrigation;
  - 7% (705 ha) overhead sprinklers;
  - 15% (1,485 ha) furrow irrigation; and
  - 23% (2,295 ha) not irrigated.

- Drip irrigation increased by 5,050 ha, a 7769% increase from 65 ha in 1997 to 5,115 ha in 2018.
  - Drip irrigation was the dominant irrigation method from 2009 to 2018.
- Lowlevel irrigation increased by 185 ha, a 116% increase from 160 ha in 1997 to 345 ha in 2018.
- Overhead irrigation increased by 105 ha, an 18% increase from 600 ha in 1997 to 705 ha in 2018.
- Furrow irrigation decreased by 2,275 ha, a 61% decrease from 3,760 ha in 1997 to 1,485 ha in 2018.
  - Furrow irrigation was the dominant irrigation method from 1997 to 2006.



Irrigation method[30]	1997	2003	2006	2009	2012	2015	2018	% of 2018 total	Change 1997-2018
Drip	65	930	1,605	3,705	3,900	4,205	5,115	51%	+5,050
Lowlevel	160	430	395	290	500	415	345	3%	+185
Overhead	600	700	625	135	330	475	705	7%	+105
Furrow	3,760	3,200	2,520	290	2,090	2,140	1,485	15%	-2,275
Vacant	145	515	1,205	3,780	1,835	1,580	2,295	23%	+2,150
Total (ha)	4,730	5,775	6,350	8,200	8,655	8,815	9,945	100%	+5,215
Dominant	furrow	furrow	furrow	drip	drip	drip	drip		

Figure 66: Nyah river reach - irrigation methods from 1997 to 2018

[30] Overhead irrigation includes pivots and lateral move systems. Furrow includes flood irrigation. (Table 5)

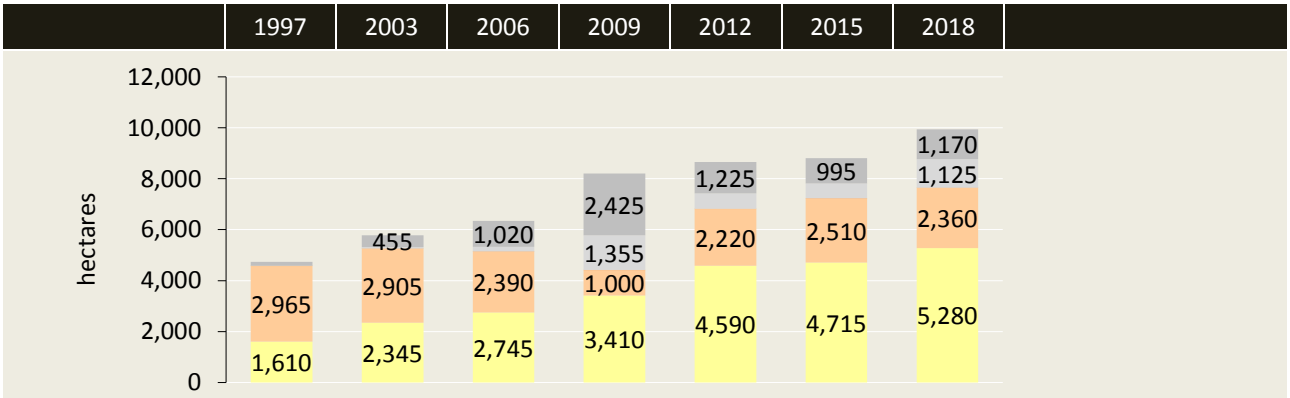
3.2.7 Nyah river reach - salinity impact zones

Figure 67 summarises river salinity impact zones of irrigated areas in the Nyah river reach from 1997 to 2018. Nyah private diverters are in low salinity impact zones L1, L2 and L3. There are no high salinity impact zones.

- In 2018, the irrigable area of 9,945 ha comprised:
  - 64% (6,405 ha) in the lowest salinity impact zone, L1;
  - 35% (3,530 ha) in L2; and
  - <1% (10 ha) in L3.

- The area irrigated in:
  - L1 increased by 3,670 ha, a 228% increase from 1,610 ha in 1997 to 5,280 ha in 2018;
  - L2 decreased by 605 ha, a 20% decrease from 2,965 ha in 1997 to 2,360 ha in 2018; and
  - L3 was 10 ha in 1997 and 2018.
- The irrigable area in:
  - L1 increased by 4,790 ha, a 297% increase from 1,615 ha in 1997 to 6,405 ha in 2018;
  - L2 increased by 425 ha, a 14% increase from 3,105 ha in 1997 to 3,530 ha in 2018; and
  - L3 was 10 ha in 1997 and 2018.

- Irrigation development from 1997 to 2018 occurred predominantly in L1.



Salinity impact zone		1997	2003	2006	2009	2012	2015	2018	% of 2018 total	Change (ha) 1997-2018
Irrigated	L1	1,610	2,345	2,745	3,410	4,590	4,715	5,280	53%	+3,670
	L2	2,965	2,905	2,390	1,000	2,220	2,510	2,360	24%	-605
	L3	10	10	10	10	10	10	10	<1%	0
	L4	-	-	-	-	-	-	-	-	-
	HIZ	-	-	-	-	-	-	-	-	-
Not Irrigated	L1	5	60	185	1,355	610	585	1,125	11%	+1,120
	L2	140	455	1,020	2,425	1,225	995	1,170	12%	+1,030
	L3	-	-	-	-	-	-	-	-	-
	L4	-	-	-	-	-	-	-	-	-
	HIZ	-	-	-	-	-	-	-	-	-
Total (ha)		4,730	5,775	6,350	8,200	8,655	8,815	9,945	100%	+5,215
Dominant zone		L2	L2	L2	L1	L1	L1	L1		

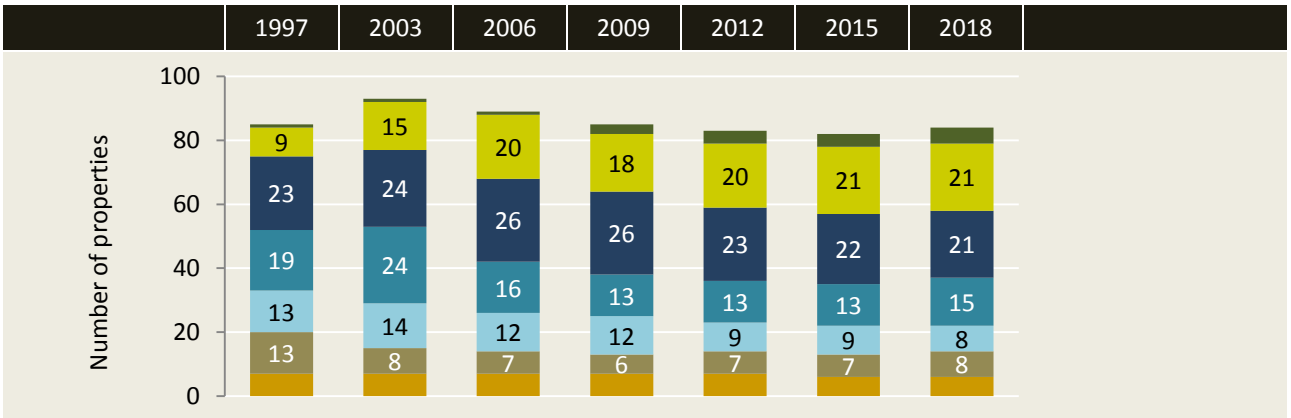
Figure 67: Nyah river reach - irrigable area in each salinity impact zone from 1997 to 2018

3.2.8 Nyah river reach - property change

Figure 68 provides estimates of property numbers and average property size (irrigable area) in the Nyah river reach from 1997 to 2018.

- In 2018:
  - There were approximately 84 irrigation properties; and
  - Most properties (74%) had an irrigable area over 20 ha.

- From 1997 to 2018:
  - The number of properties decreased by 1; a 1% decrease from 85 properties in 1997 to 84 in 2018;
  - Properties with an irrigable area less than 20 ha decreased by 11, while the number over 20 ha increased by 10; and
  - Average property size (irrigable area) increased from 56 ha in 1997 to 118 ha in 2018.



Property size (irrigable area)	1997	2003	2006	2009	2012	2015	2018	% of 2018 total	Change 1997-2018
1 to 5 ha	7	7	7	7	7	6	6	7%	-1
5 to 10 ha	13	8	7	6	7	7	8	10%	-5
10 to 20 ha	13	14	12	12	9	9	8	10%	-5
20 to 40 ha	19	24	16	13	13	13	15	18%	-4
40 to 100 ha	23	24	26	26	23	22	21	25%	-2
100 to 500 ha	9	15	20	18	20	21	21	25%	+12
> 500 ha	1	1	1	3	4	4	5	6%	+4
Total properties	85	93	89	85	83	82	84	100%	-1
Average size (ha)	56	62	71	96	104	108	118		

Figure 68: Nyah river reach - property numbers and sizes from 1997 to 2018

3.3 Boundary Bend river reach (*Wakool to Euston weir*)

In summary for the Boundary Bend river reach

Crop types in 2018

Dominant plantings in the Boundary Bend river reach in 2018 were:

1. almond trees; 11,040 ha (50% of the irrigable area);
2. olive trees; 2,785 ha (13% of the irrigable area);
3. potatoes; 1,740 ha (8% of the irrigable area); and
4. table grapes; 1,605 ha (7% of the irrigable area).

Crop types 1997 to 2018

Almonds were the dominant crop from 2006 to 2018, whereas potatoes were dominant in 2003 and field crops in 1997.

The main changes in crops from 1997 to 2018 were:

- almonds increased by 10,415 ha; a 1666% increase from 625 ha to 11,040 ha;
- olives increased by 2,735 ha; a 5470% increase from 50 ha to 2,785 ha;
- table grape plantings increased by 1,060 ha; a 194% increase from 545 ha to 1,605 ha; and
- potatoes increased by 670 ha; a 63% increase from 1,070 ha to 1,740 ha.

Development of permanent plantings (new or redeveloped in the previous three years)

In 2018, at least 2,100 ha (13%) of permanent crops were planted or redeveloped in the previous three years, predominantly:

1. almonds (800 ha);
2. olives (610 ha);
3. table grapes (420 ha);
4. pistachios (100 ha);
5. citrus (70 ha); and
6. avocados (70 ha).

Development activity ranged from 6% of permanent plantings in 2012 to 63% in 2006.

Planting trends - permanent plantings, seasonal crops and vacant areas

In 2018, the irrigable area of 21,915 ha comprised:

- 76% (16,635 ha) irrigated permanent plantings;
- 14% (3,040 ha) irrigated seasonal crops; and
- 10% (2,240 ha) vacant, not irrigated areas.

From 1997 to 2018:

- permanent plantings increased from 45% to 76% of the irrigable area;
- seasonal crops decreased from 53% to 14% of the irrigable area; and
- vacant, not irrigated areas increased from 2% to 10% of the irrigable area.

In summary for the Boundary Bend river reach

Irrigation development - new and retired areas

The irrigable area in the Boundary Bend river reach increased by 16,550 ha, a 308% increase from 5,365 ha in 1997 to 21,915 ha in 2018.

The net increase of 16,550 ha was the balance of 16,780 ha expansion and 230 ha retired from irrigation.

Irrigation methods

Drip irrigation was the dominant irrigation method in the Boundary Bend river reach from 2006 to 2018, whereas overhead sprinklers were dominant from 1997 to 2003.

In 2018, the irrigable area of 21,915 ha comprised:

- 71% (15,665 ha) drip irrigation;
- 4% (880 ha) lowlevel irrigation;
- 14% (3,055 ha) overhead sprinklers;
- < 1% (75 ha) furrow irrigation; and
- 10% (2,240 ha) not irrigated.

Salinity impact zones

The Boundary Bend river reach is in the low salinity impact zones: L1, L2 and L3.

In 2018, the irrigable area of 21,915 ha comprised:

- 81% (17,820 ha) in the lowest salinity impact zone, L1;
- 8% (1,775 ha) in L2; and
- 11% (2,320 ha) in L3.

From 1997 to 2018 the irrigable area in:

- L1 increased by 15,520 ha, a 675% increase from 2,300 ha to 17,820 ha;
- L2 increased by 270 ha, an 18% increase from 1,505 ha to 1,775 ha; and
- L3 increased by 760 ha, a 49% increase from 1,560 ha to 2,320 ha.

Irrigation properties

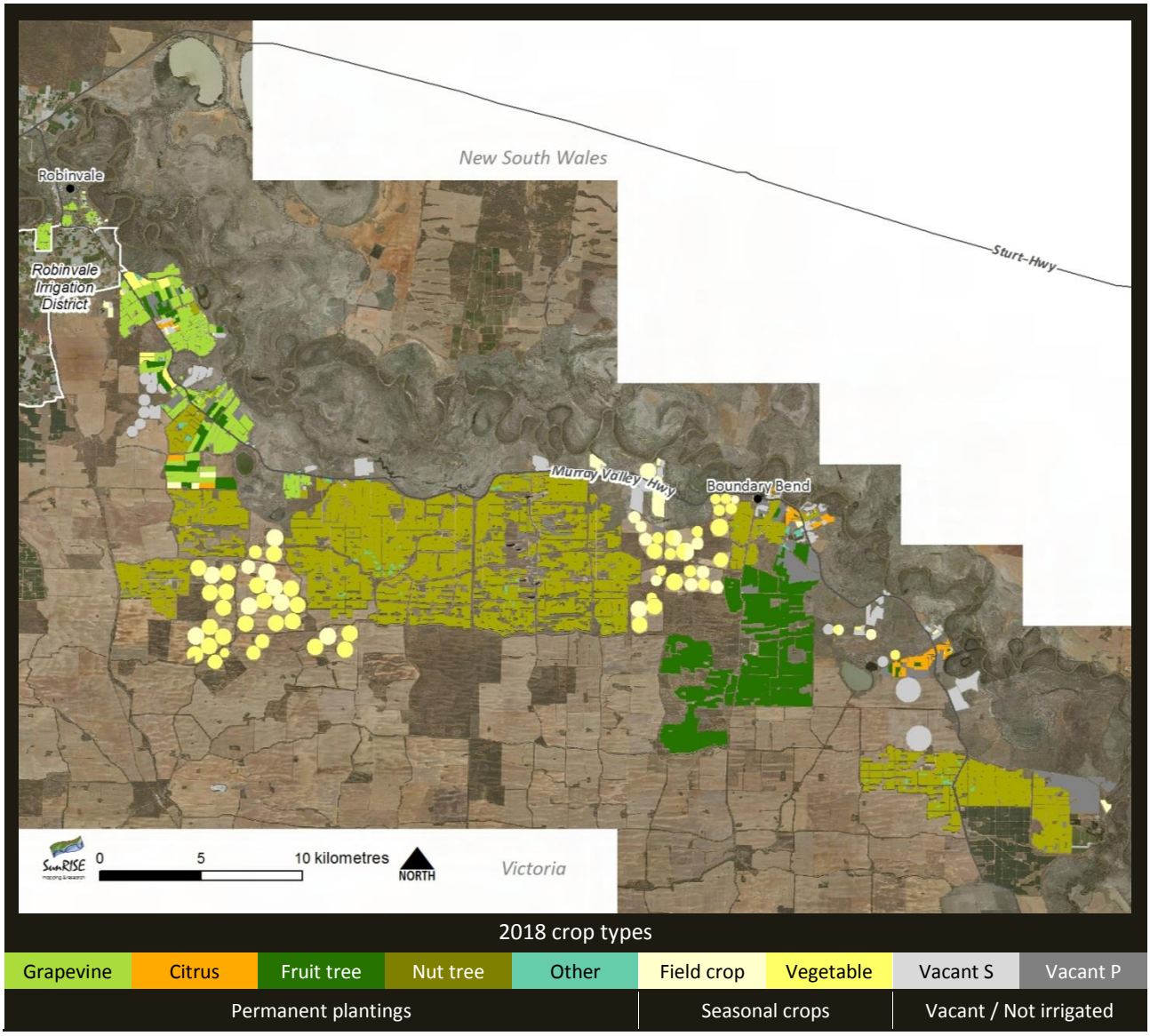
In 2018, there were approximately 81 irrigation properties with an average irrigable area of 271 ha.

From 1997 to 2018:

- the number of properties decreased by 30; a 27% decrease from 111 to 81 properties;
- properties with an irrigable area less than 20 ha decreased by 27
- properties with an irrigable area over 20 ha decreased by 3; and
- average property size (irrigable area) increased from 48 ha to 271 ha.

3.3.1 Boundary Bend river reach - crop types in 2018

Map 14 shows the Boundary Bend river reach and crop types in 2018.



Map 14: Boundary Bend river reach showing 2018 crop types

3.3.2 Boundary Bend river reach - crop types from 1997 to 2018

Figure 69 summarises crop types in the Boundary Bend river reach from 1997 to 2018.

- Dominant plantings in 2018 were:
    1. almond trees; 11,040 ha (50% of the irrigable area);
    2. olive trees; 2,785 ha (13% of the irrigable area); and
    3. potatoes; 1,740 ha (8% of the irrigable area).

- The dominant irrigated crop changed from field crops in 1997 to potatoes in 2003 then almonds from 2006 to 2018.
- Almond trees increased by 10,415 ha; a 1,666% increase from 625 ha in 1997 to 11,040 ha in 2018.
- The second highest increase in plantings was 2,735 ha of olive trees; a 5,470% increase from 50 ha in 1997 to 2,785 ha in 2018.

Crop type		1997	2003	2006	2009	2012	2015	2018	% of 2018 total	Change 1997-2018
Permanent	Grape Dried	45	10	10	10	0	0	0	0%	-45
	Grape Table	545	810	820	795	1,010	1,265	1,605	7%	+1,060
	Grape Wine	375	965	1,685	1,530	1,460	1,245	190	1%	-185
	Citrus	475	415	380	305	275	275	305	1%	-170
	Fruit Olive	50	610	1,145	3,065	2,765	2,630	2,785	13%	+2,735
	Fruit Other	130	95	85	70	175	255	325	1%	+195
	Nut Almond	625	620	5,040	10,190	10,290	10,370	11,040	50%	+10,415
	Nut Other	130	140	140	140	165	205	295	1%	+165
	Other	35	30	50	50	45	75	90	0%	+55
Seasonal	Field Crop	1,240	745	660	280	790	640	1,090	5%	-150
	Veg. Carrot	370	280	260	380	320	260	65	0%	-305
	Veg. Potato	1,070	1,440	1,280	610	820	905	1,740	8%	+670
	Veg. Other	165	180	270	90	170	140	145	1%	-20
	Vacant P	50	230	160	440	990	1,105	1,090	5%	+1,040
	Vacant S	60	395	830	1,280	1,050	1,170	1,150	5%	+1,090
Total (ha)		5,365	6,965	12,815	19,235	20,325	20,540	21,915	100%	+16,550
Dominant		field crop	potato	almond	almond	almond	almond	almond		

Figure 69: Boundary Bend river reach - crop types from 1997 to 2018

3.3.3 Boundary Bend river reach - development of permanent crops

Figure 70 shows the proportion of permanent crops planted or redeveloped in the previous three years in the Boundary Bend river reach from 1997 to 2018.

The information provides an indication of development activity that is otherwise not evident in information on changes in areas and crop types, as it includes replanting and top working to different varieties. The figures are conservative, as top-worked plantings can be difficult to interpret from the three-yearly aerial imagery, particularly for grapevines.

- In 2018, at least 2,100 ha (13%) of permanent crops were planted or redeveloped in the previous three years. Development was predominantly:
    1. almonds (800 ha);
    2. olives (610 ha);
    3. table grapes (420 ha);
    4. pistachios (100 ha);
    5. citrus (70 ha); and
    6. avocados (70 ha).

- The area of new or redeveloped permanent plantings was highest in 2009 with 7,265 ha (45%) planted in the previous three years.

- Development activity ranged from 6% in 2012 to 63% in 2006.

Permanent plantings	1997	2003	2006	2009	2012	2015	2018	% of 2018 total
≤3yr old plantings	260	1,110	5,905	7,265	1,000	1,860	2,100	13%
>3yr old plantings	2,150	2,585	3,450	8,890	15,185	14,460	14,535	87%
Total (ha)	2,410	3,695	9,355	16,155	16,185	16,320	16,635	100%
% 3year development	11%	30%	63%	45%	6%	11%	13%	

Figure 70: Boundary Bend river reach - development of permanent crops from 1997 to 2018

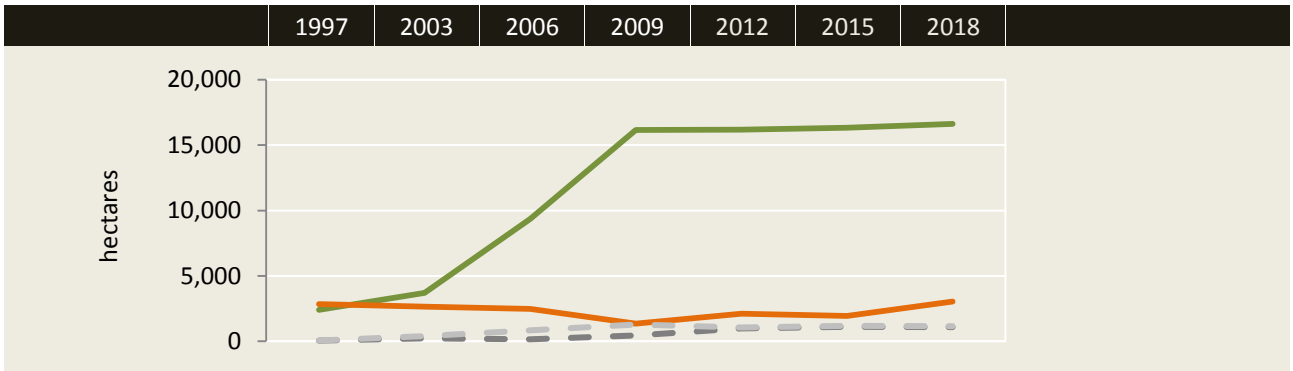
3.3.4 Boundary Bend river reach - planting trends

Figure 71 summarises planting trends in the Boundary Bend river reach from 1997 to 2018.

- In 2018, the irrigable area of 21,915 ha comprised:
  - 76% (16,635 ha) irrigated permanent plantings;
  - 14% (3,040 ha) irrigated seasonal crops; and
  - 10% (2,240 ha) vacant, not irrigated areas.

The proportion of permanent plantings, seasonal cropping and vacant areas changed from:
  - 45% permanent, 53% seasonal and 2% vacant in 1997; to
  - 76% permanent, 14% seasonal and 10% vacant in 2018.

- From 1997 to 2018:
  - irrigated permanent crops increased by 14,225 ha;
  - irrigated seasonal crops increased by 195 ha;
  - vacant, not irrigated areas increased by 2,130 ha; and
  - the irrigable area increased by 16,550 ha; a 308% increase from 5,365 ha to 21,915 ha.



	1997	2003	2006	2009	2012	2015	2018	% of 2018 total	Change 1997-2018
Permanent - irrigated	2,410	3,695	9,355	16,155	16,185	16,320	16,635	76%	+14,225
Seasonal - irrigated	2,845	2,645	2,470	1,360	2,100	1,945	3,040	14%	+195
Vacant - permanent	50	230	160	440	990	1,105	1,090	5%	+1,040
Vacant - seasonal	60	395	830	1,280	1,050	1,170	1,150	5%	+1,090
Total (ha)	5,365	6,965	12,815	19,235	20,325	20,540	21,915	100%	+16,550
% Permanent	45%	53%	73%	84%	80%	79%	76%		
% Seasonal	53%	38%	19%	7%	10%	9%	14%		
% Vacant	2%	9%	8%	9%	10%	11%	10%		

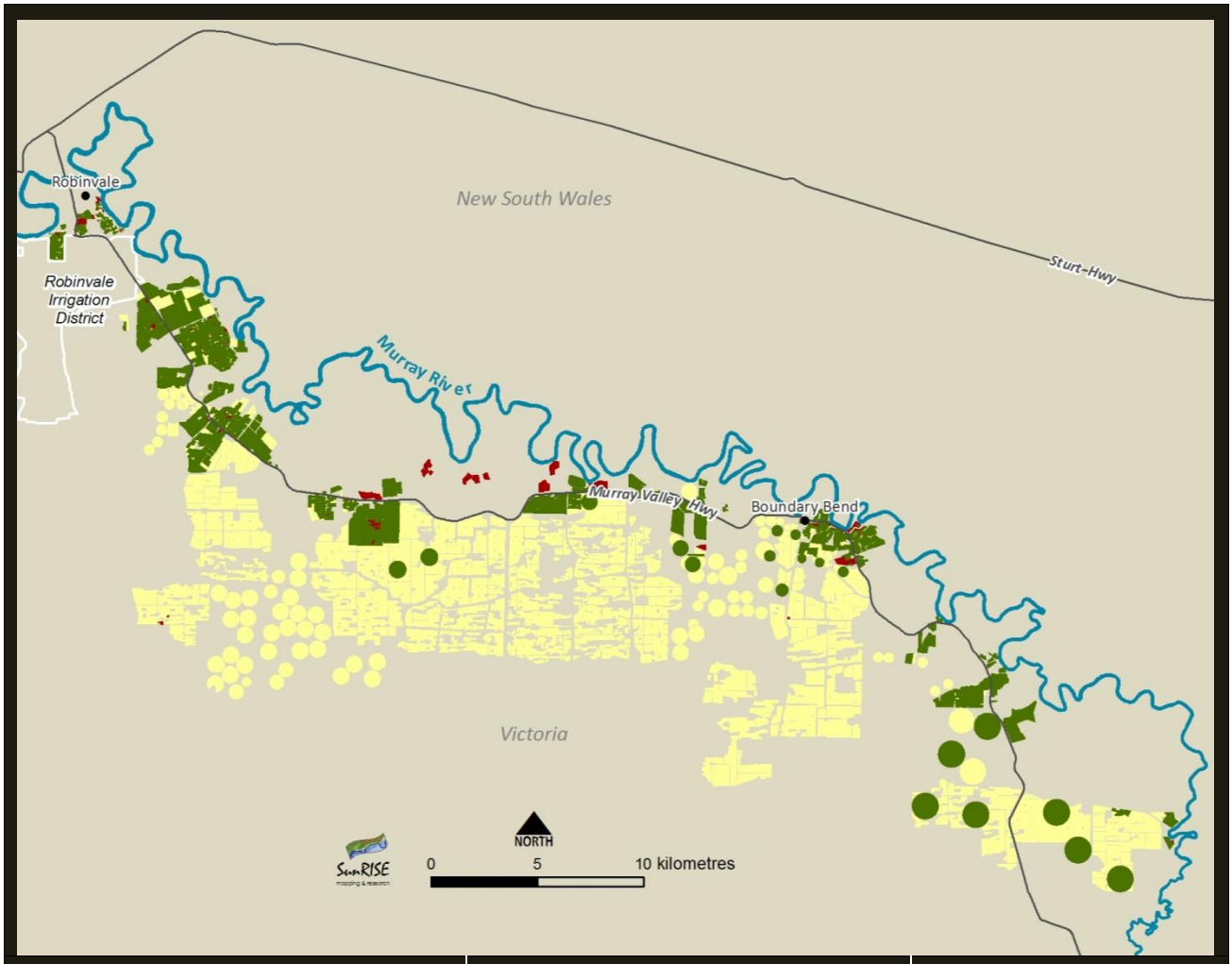
Figure 71: Boundary Bend river reach - planting trends from 1997 to 2018

3.3.5 Boundary Bend river reach - irrigation development

Map 15 shows irrigation development from 1997 to 2018 in the Boundary Bend river reach with respect to new development (expansion) and areas retired[31] from irrigation.

- The irrigable area increased by 16,550 ha, a 308% increase from 5,365 ha in 1997 to 21,915 ha in 2018.
- The net increase of 16,550 ha comprised 230 ha retired from irrigation and 16,780 ha of expansion.

Map 15: Boundary Bend river reach - irrigation development from 1997 to 2018



	Hectares		% of 1997
Irrigation areas in 1997 (1996-97 season)	5,365		
Retired between 1997 and 2018	-230		-4%
Expansion between 1997 and 2018	+16,780		+313%
Irrigation areas in 2018 (2017-18 season)	21,915		

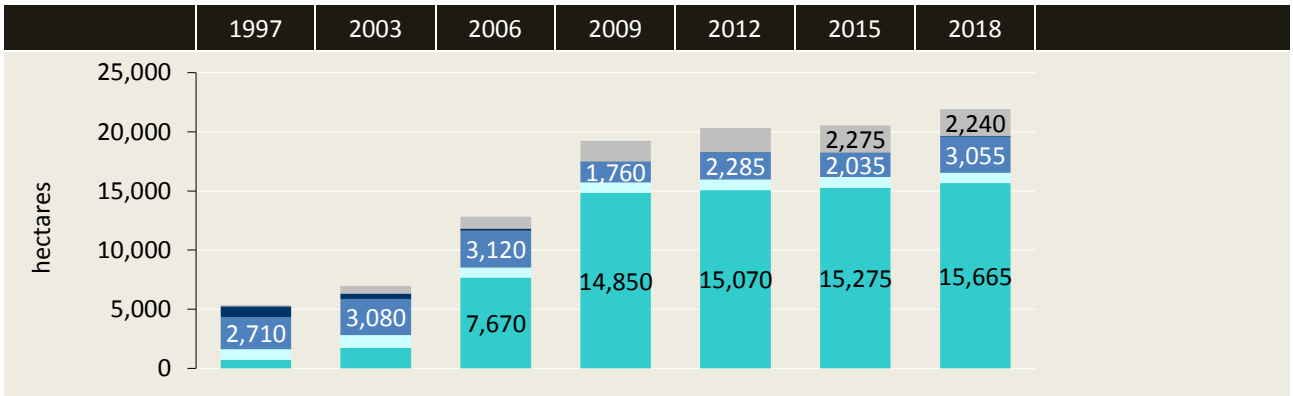
[31] Retired areas were previously irrigated but have undergone a change in land use that precludes use for irrigation e.g. urban development, housing, sheds, dams and land set aside for conservation purposes.

3.3.6 Boundary Bend river reach - irrigation methods

Figure 72 summarises irrigation methods in the Boundary Bend river reach from 1997 to 2018.

- In 2018, the irrigable area of 21,915 ha comprised:
  - 71% (15,665 ha) drip irrigation;
  - 4% (880 ha) lowlevel irrigation;
  - 14% (3,055 ha) overhead sprinklers;
  - < 1% (75 ha) furrow irrigation; and
  - 10% (2,240 ha) not irrigated.

- Drip irrigation increased by 14,940 ha, a 2,061% increase from 725 ha in 1997 to 15,665 ha in 2018.
  - Drip irrigation was the dominant irrigation method from 2006 to 2018.
- Lowlevel irrigation decreased by 5 ha, a 1% decrease from 885 ha in 1997 to 880 ha in 2018.
- Overhead irrigation increased by 345 ha, a 13% increase from 2,710 ha in 1997 to 3,055 ha in 2018.
  - Overhead irrigation was the dominant method from 1997 to 2003.
- Furrow irrigation decreased by 860 ha, a 92% decrease from 935 ha in 1997 to 75 ha in 2018.



Irrigation method[32]	1997	2003	2006	2009	2012	2015	2018	% of 2018 total	Change 1997-2018
Drip	725	1,720	7,670	14,850	15,070	15,275	15,665	71%	+14,940
Lowlevel	885	1,080	850	870	900	920	880	4%	-5
Overhead	2,710	3,080	3,120	1,760	2,285	2,035	3,055	14%	+345
Furrow	935	460	185	35	30	35	75	<1%	-860
Vacant	110	625	990	1,720	2,040	2,275	2,240	10%	+2,130
Total (ha)	5,365	6,965	12,815	19,235	20,325	20,540	21,915	100%	+16,550
Dominant	overhead	overhead	drip	drip	drip	drip	drip		

Figure 72: Boundary Bend river reach - irrigation methods from 1997 to 2018

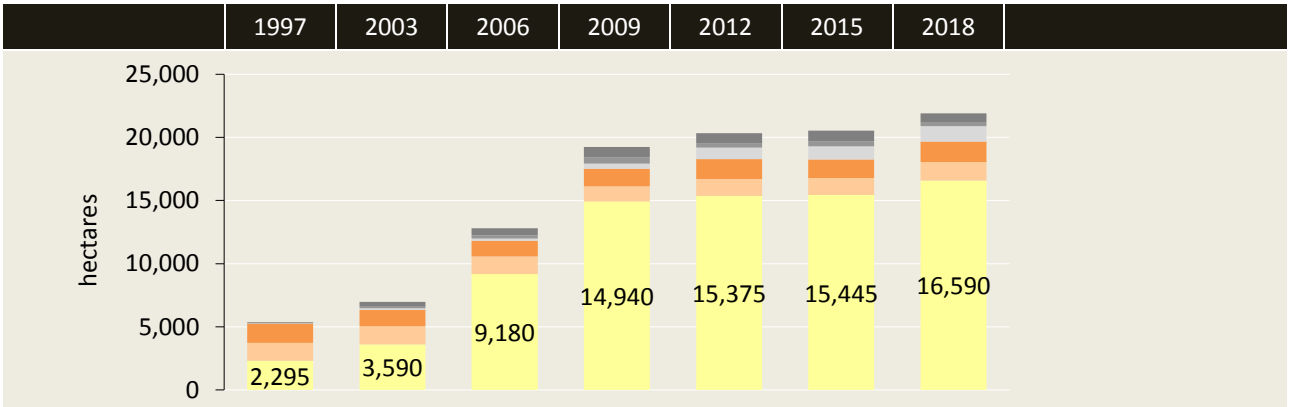
[32] Overhead irrigation includes pivots and lateral move systems. Furrow includes flood irrigation. (Table 5)

3.3.7 Boundary Bend river reach - salinity impact zones

Figure 73 summarises river salinity impact zones of irrigated areas in the Boundary Bend river reach from 1997 to 2018. Boundary Bend private diverters are in low salinity impact zones L1, L2 and L3. There are no high salinity impact zones.

- In 2018, the irrigable area of 21,915 ha comprised:
  - 81% (17,820 ha) in the lowest salinity impact zone, L1;
  - 8% (1,775 ha) in L2; and
  - 11% (2,320 ha) in L3.

- The area irrigated in:
  - L1 increased by 14,295 ha, a 623% increase from 2,295 ha in 1997 to 16,590 ha in 2018;
  - L2 increased by 20 ha, a 1% increase from 1,440 ha in 1997 to 1,460 ha in 2018; and
  - L3 increased by 105 ha, a 7% increase from 1,520 ha in 1997 to 1,625 ha in 2018.
- The irrigable area in:
  - L1 increased by 15,520 ha, a 675% increase from 2,300 ha in 1997 to 17,820 ha in 2018;
  - L2 increased by 270 ha, an 18% increase from 1,505 ha in 1997 to 1,775 ha in 2018; and
  - L3 increased by 760 ha, a 49% increase from 1,560 ha in 1997 to 2,320 ha in 2018.
- Irrigation development from 1997 to 2018 occurred predominantly in L1.



Salinity impact zone		1997	2003	2006	2009	2012	2015	2018	% of 2018 total	Change (ha) 1997-2018
Irrigated	L1	2,295	3,590	9,180	14,940	15,375	15,445	16,590	76%	+14,295
	L2	1,440	1,455	1,400	1,190	1,330	1,350	1,460	7%	+20
	L3	1,520	1,295	1,245	1,385	1,580	1,470	1,625	7%	+105
	L4	-	-	-	-	-	-	-	-	-
	HIZ	-	-	-	-	-	-	-	-	-
Not Irrigated	L1	5	120	175	415	900	1,030	1,230	6%	+1,225
	L2	65	190	245	475	360	395	315	1%	+250
	L3	40	315	570	830	780	850	695	3%	+655
	L4	-	-	-	-	-	-	-	-	-
	HIZ	-	-	-	-	-	-	-	-	-
Total (ha)		5,365	6,965	12,815	19,235	20,325	20,540	21,915	100%	+16,550
Dominant zone		L1	L1	L1	L1	L1	L1	L1		

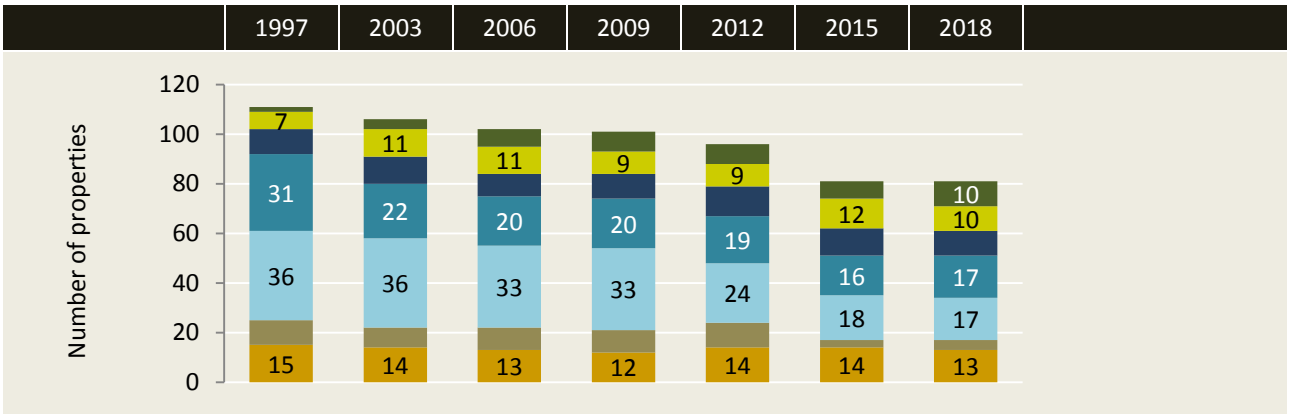
Figure 73: Boundary Bend river reach - irrigable area in each salinity impact zone from 1997 to 2018

3.3.8 Boundary Bend - property change

Figure 74 provides estimates of property numbers and average property size (irrigable area) in the Boundary Bend river reach from 1997 to 2018.

- In 2018:
  - There were approximately 81 irrigation properties; and
  - Most properties (58%) had an irrigable area over 20 ha.

- From 1997 to 2018:
  - The number of properties decreased by 30; a 27% decrease from 111 properties in 1997 to 81 in 2018;
  - Properties with an irrigable area less than 20 ha decreased by 27, and the number over 20 ha decreased by 3; and
  - Average property size (irrigable area) increased from 48 ha in 1997 to 271 ha in 2018.



Property size (irrigable area)	1997	2003	2006	2009	2012	2015	2018	% of 2018 total	Change 1997-2018
1 to 5 ha	15	14	13	12	14	14	13	16%	-2
5 to 10 ha	10	8	9	9	10	3	4	5%	-6
10 to 20 ha	36	36	33	33	24	18	17	21%	-19
20 to 40 ha	31	22	20	20	19	16	17	21%	-14
40 to 100 ha	10	11	9	10	12	11	10	12%	0
100 to 500 ha	7	11	11	9	9	12	10	12%	+3
> 500 ha	2	4	7	8	8	7	10	12%	+8
Total properties	111	106	102	101	96	81	81	100%	-30
Average size (ha)	48	66	126	190	212	254	271		

Figure 74: Boundary Bend river reach - property numbers and sizes from 1997 to 2018

3.4 Wemen river reach (Euston weir to Liparoo)

In summary for the Wemen river reach

Crop types in 2018

Dominant plantings in the Wemen river reach in 2018 were:

1. almond trees; 7,475 ha (59% of the irrigable area);
2. carrots; 1,350 ha (11% of the irrigable area); and
3. vegetables other than carrots and potatoes[33]; 1,130 ha (9% of the irrigable area).

Crop types 1997 to 2018

Almonds were the dominant crop from 2003 to 2018, whereas carrots were dominant in 1997.

The main changes in crops from 1997 to 2018 were:

- almonds increased by 7,305 ha; a 4,297% increase from 170 ha to 7,475 ha;
- vegetables other than carrots and potatoes increased by 875 ha; a 343% increase from 255 ha to 1,130 ha;
- olives increased by 855 ha; an increase from 0 ha to 855 ha; and
- carrots increased by 495 ha; a 58% increase from 855 ha to 1,350 ha.

Development of permanent plantings (new or redeveloped in the previous three years)

In 2018, at least 2,240 ha (24%) of permanent crops were planted or redeveloped in the previous three years, predominantly:

1. almonds (1,975 ha);
2. table grapes (140 ha);
3. dried grapes (35 ha);
4. wine grapes (30 ha);
5. avocados (25 ha); and
6. pistachios (15 ha).

Development activity ranged from 3% of permanent plantings in 2012 to 66% in 2003.

Planting trends - permanent plantings, seasonal crops and vacant areas

In 2018, the irrigable area of 12,700 ha comprised:

- 74% (9,365 ha) irrigated permanent plantings;
- 20% (2,500 ha) irrigated seasonal crops; and
- 7% (835 ha) vacant, not irrigated areas.

From 1997 to 2018:

- permanent plantings increased from 39% to 74% of the irrigable area;
- seasonal crops decreased from 60% to 20% of the irrigable area; and
- vacant, not irrigated areas increased from 1% to 7% of the irrigable area.

[33] Carrots and potatoes are significant crops in the Mallee catchment and are reported on separately

In summary for the Wemen river reach

Irrigation development - new and retired areas

The irrigable area in the Wemen river reach increased by 10,550 ha, a 491% increase from 2,150 ha in 1997 to 12,700 ha in 2018.

The net increase of 10,550 ha was the balance of 10,600 ha expansion and 50 ha retired from irrigation.

Irrigation methods

Drip irrigation was the dominant irrigation method in the Wemen river reach from 2003 to 2018, whereas overhead sprinklers were dominant 1997.

In 2018, the irrigable area of 12,700 ha comprised:

- 71% (8,980 ha) drip irrigation;
- 11% (1,345 ha) lowlevel irrigation;
- 12% (1,535 ha) overhead sprinklers;
- < 1% (5 ha) furrow irrigation; and
- 7% (835 ha) not irrigated.

Salinity impact zones

The Wemen river reach is in the low salinity impact zones: L1, L2 and L3. Irrigation development from 1997 to 2018 occurred predominantly in L2.

In 2018, the irrigable area of 12,700 ha comprised:

- 39% (5,005 ha) in the lowest salinity impact zone, L1;
- 60% (7,570 ha) in L2; and
- 1% (125 ha) in L3.

From 1997 to 2018 the irrigable area in:

- L1 increased by 4,830 ha, a 2760% increase from 175 ha to 5,005 ha;
- L2 increased by 5,715 ha, a 308% increase from 1,855 ha to 7,570 ha; and
- L3 increased by 5 ha, a 4% increase from 120 ha to 125 ha.

Irrigation properties

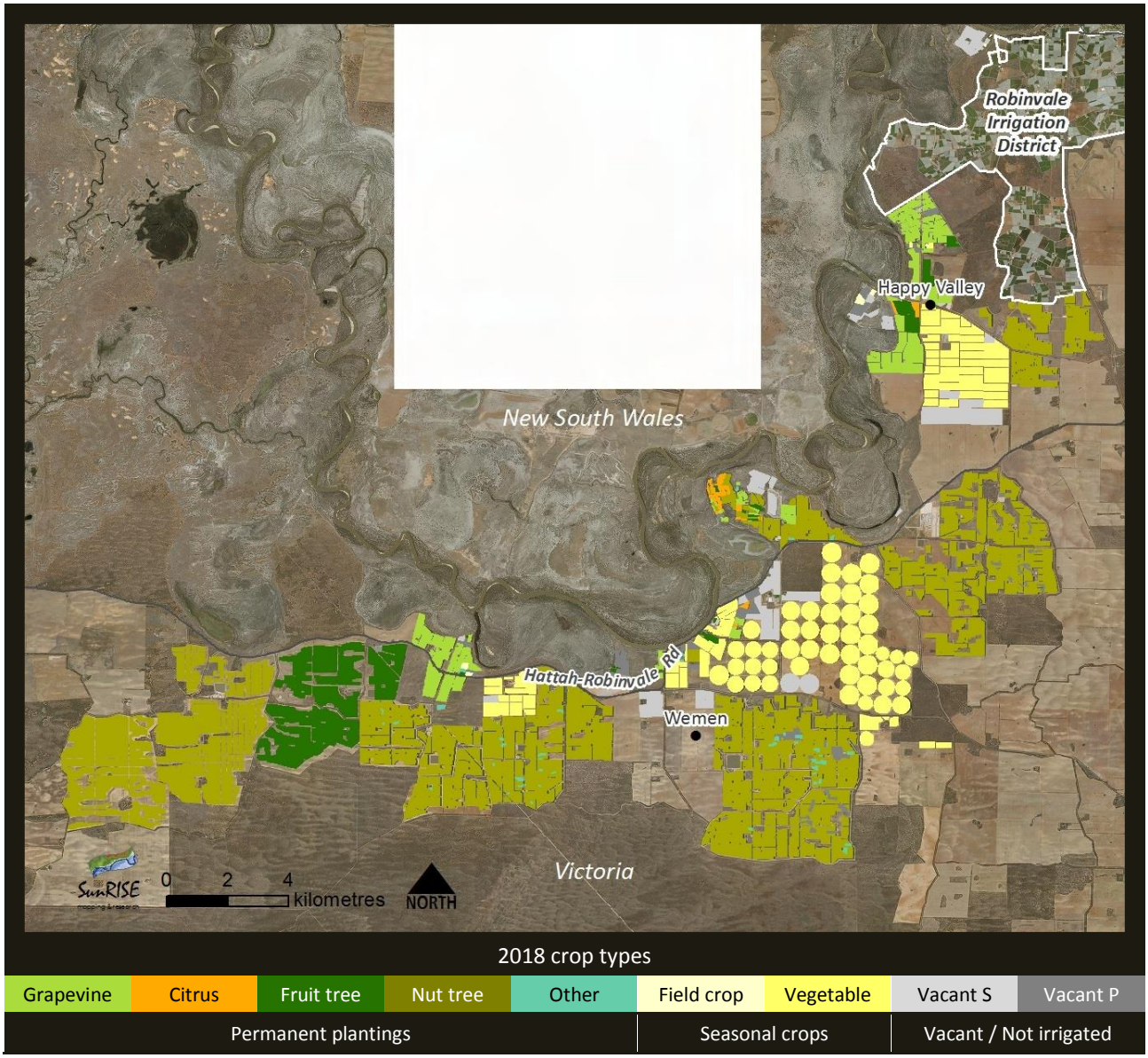
In 2018, there were approximately 37 irrigation properties with an average irrigable area of 343 ha.

From 1997 to 2018:

- the number of properties decreased by 3; an 8% decrease from 40 to 37 properties;
- properties with an irrigable area less than 20 ha decreased by 11, while the number over 20 ha increased by 8; and
- average property size (irrigable area) increased from 54 ha to 343 ha.

3.4.1 Wemen river reach - crop types in 2018

Map 16 shows the Wemen river reach with crop types in 2018.



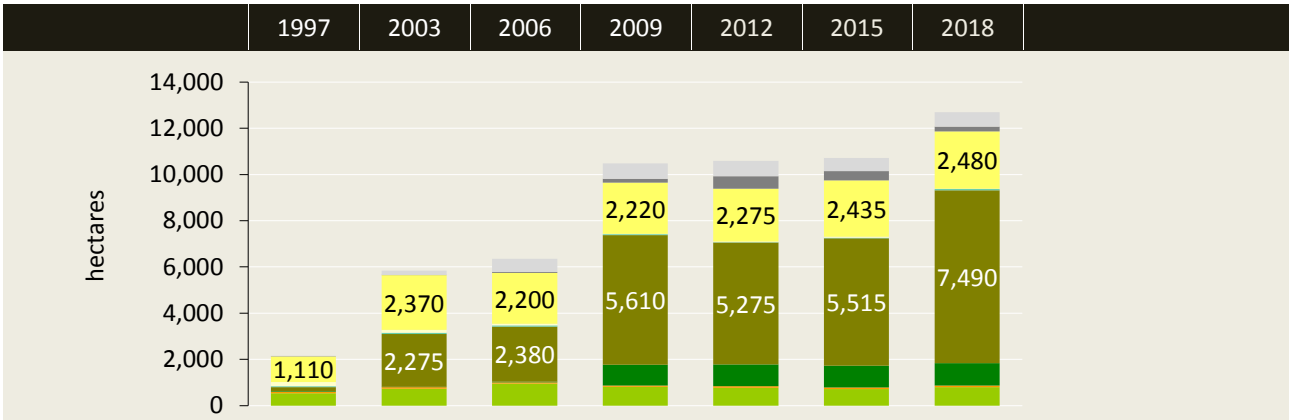
Map 16: Wemen river reach showing 2018 crop types

3.4.2 Wemen river reach - crop types from 1997 to 2018

Figure 75 summarises crop types in the Wemen river reach from 1997 to 2018.

- Dominant plantings in 2018 were:
    1. almond trees; 7,475 ha (59% of the irrigable area);
    2. carrots; 1,350 ha (11% of the irrigable area); and
    3. other vegetables; 1,130 ha (9% of the irrigable area).

- The dominant irrigated crop changed from carrots in 1997 to almonds from 2003 to 2018.
- Almond trees increased by 7,305 ha; a 4,297% increase from 170 ha in 1997 to 7,475 ha in 2018.
- The second highest increase in plantings was 855 ha of olive trees, an increase from no plantings in 1997 to 855 ha in 2018.



Crop type		1997	2003	2006	2009	2012	2015	2018	% of 2018 total	Change 1997-2018
Permanent	Grape Dried	30	80	95	90	90	95	120	1%	+90
	Grape Table	235	270	250	185	190	195	320	3%	+85
	Grape Wine	275	380	605	540	485	420	360	3%	+85
	Citrus	65	60	55	55	80	75	70	1%	+5
	Fruit Olive	0	0	0	855	855	855	855	7%	+855
	Fruit Other	25	25	25	45	85	80	105	1%	+80
	Nut Almond	170	2,275	2,380	5,595	5,260	5,515	7,475	59%	+7,305
	Nut Other	0	0	0	15	15	0	15	0%	+15
	Other	40	60	60	35	15	30	45	0%	+5
Seasonal	Field Crop	180	125	70	10	30	40	20	0%	-160
	Veg. Carrot	855	1,870	1,830	1,845	1,880	2,000	1,350	11%	+495
	Veg. Potato	-	-	-	-	-	-	-	-	-
	Veg. Other	255	500	370	375	395	435	1,130	9%	+875
	Vacant P	5	20	45	165	545	405	205	2%	+200
	Vacant S	15	175	565	665	660	565	630	5%	+615
Total (ha)		2,150	5,840	6,350	10,475	10,585	10,710	12,700	100%	+10,550
Dominant		carrot	almond	almond	almond	almond	almond	almond		

Figure 75: Wemen river reach - crop types from 1997 to 2018

3.4.3 Wemen river reach - development of permanent crops

Figure 76 shows the proportion of permanent crops planted or redeveloped in the previous three years in the Wemen river reach from 1997 to 2018.

The information provides an indication of development activity that is otherwise not evident in information on changes in areas and crop types, as it includes replanting and top working to different varieties. The figures are conservative, as top-worked plantings can be difficult to interpret from the three-yearly aerial imagery, particularly for grapevines.

- In 2018, at least 2,240 ha (24%) of permanent crops were planted or redeveloped in the previous three years. Development was predominantly:
    1. almonds (1,975 ha);
    2. table grapes (140 ha);
    3. dried grapes (35 ha);
    4. wine grapes (30 ha);
    5. avocados (25 ha); and
    6. pistachios (15 ha).

- Development of permanent crops was highest in 2009, with 4,145 ha planted in the previous three years.

- New or redeveloped permanent plantings were low in 1997 with 80 ha (10%) planted in the previous three years and in 2012 with 180 ha (3%) planted in the previous three years.

Permanent plantings	1997	2003	2006	2009	2012	2015	2018	% of 2018 total
≤3yr old plantings	80	2,075	405	4,145	180	340	2,240	24%
>3yr old plantings	760	1,075	3,065	3,270	6,895	6,925	7,125	76%
Total (ha)	840	3,150	3,470	7,415	7,075	7,265	9,365	100%
% 3year development	10%	66%	12%	56%	3%	5%	24%	

Figure 76: Wemen river reach - development of permanent crops from 1997 to 2018

3.4.4 Wemen river reach - planting trends

Figure 77 summarises planting trends in the Wemen river reach from 1997 to 2018.

- In 2018, the irrigable area of 12,700 ha comprised:
  - 74% (9,365 ha) irrigated permanent plantings;
  - 20% (2,500 ha) irrigated seasonal crops; and
  - 7% (835 ha) vacant, not irrigated areas.

The proportion of permanent plantings, seasonal cropping and vacant areas changed from:
  - 39% permanent, 60% seasonal and 1% vacant in 1997; to
  - 74% permanent, 20% seasonal and 7% vacant in 2018.

- From 1997 to 2018:
  - irrigated permanent crops increased by 8,525 ha;
  - irrigated seasonal crops increased by 1,210 ha;
  - vacant, not irrigated areas increased by 815 ha; and
  - the irrigable area increased by 10,550 ha; a 491% increase from 2,150 ha to 12,700 ha.

	1997	2003	2006	2009	2012	2015	2018	% of 2018 total	Change 1997-2018
Permanent - irrigated	840	3,150	3,470	7,415	7,075	7,265	9,365	74%	+8,525
Seasonal - irrigated	1,290	2,495	2,270	2,230	2,305	2,475	2,500	20%	+1,210
Vacant - permanent	5	20	45	165	545	405	205	2%	+200
Vacant - seasonal	15	175	565	665	660	565	630	5%	+615
Total (ha)	2,150	5,840	6,350	10,475	10,585	10,710	12,700	100%	+10,550
% Permanent	39%	54%	55%	71%	67%	68%	74%		
% Seasonal	60%	43%	36%	21%	22%	23%	20%		
% Vacant	1%	3%	10%	8%	11%	9%	7%		

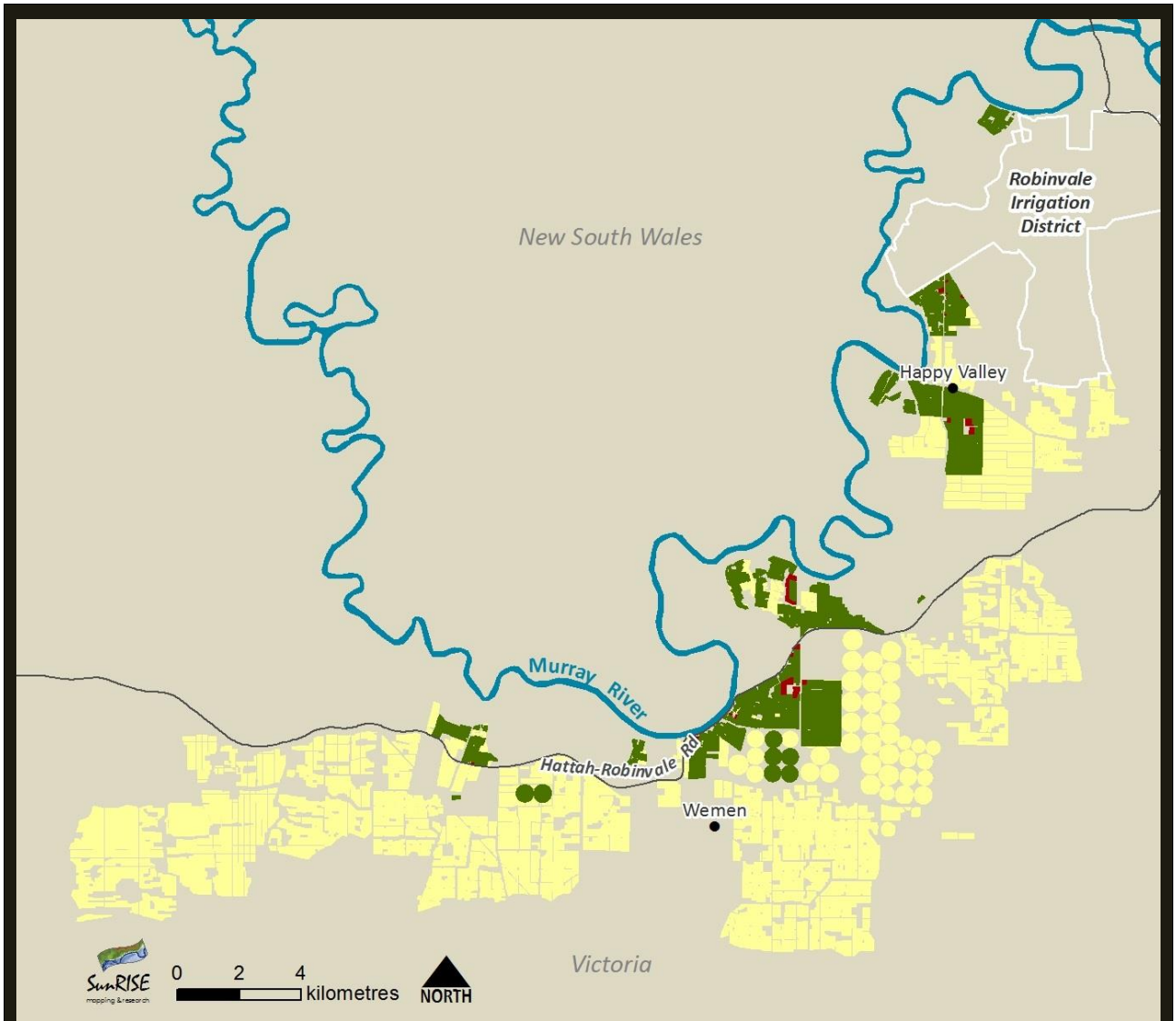
Figure 77: Wemen river reach - planting trends from 1997 to 2018

3.4.5 Wemen river reach - irrigation development

Map 17 shows irrigation development from 1997 to 2018 in the Wemen river reach with respect to new development (expansion) and areas retired[34] from irrigation.

- The irrigable area increased by 10,550 ha, a 491% increase from 2,150 ha in 1997 to 12,700 ha in 2018.
- The net increase of 10,550 ha comprised 50 ha retired from irrigation and 10,600 ha of expansion.

Map 17: Wemen river reach - irrigation development from 1997 to 2018



	Hectares		% of 1997
Irrigation areas in 1997 (1996-97 season)	2,150		
Retired between 1997 and 2018	-50		-2%
Expansion between 1997 and 2018	+10,600		+493%
Irrigation areas in 2018 (2017-18 season)	12,700		

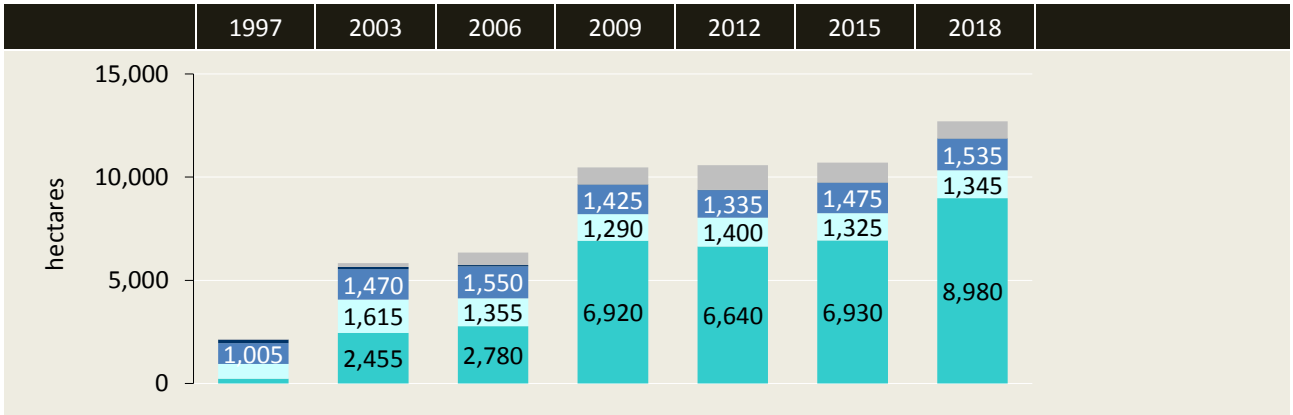
[34] Retired areas were previously irrigated but have undergone a change in land use that precludes use for irrigation e.g. urban development, housing, sheds, dams and land set aside for conservation purposes.

3.4.6 Wemen river reach - irrigation methods

Figure 78 summarises irrigation methods in the Wemen river reach from 1997 to 2018.

- In 2018, the irrigable area of 12,700 ha comprised:
  - 71% (8,980 ha) drip irrigation;
  - 11% (1,345 ha) lowlevel irrigation;
  - 12% (1,535 ha) overhead sprinklers;
  - < 1% (5 ha) furrow irrigation; and
  - 7% (835 ha) not irrigated.

- Drip irrigation increased by 8,750 ha, a 3804% increase from 230 ha in 1997 to 8,980 ha in 2018.
  - Drip irrigation was the dominant irrigation method from 2003 to 2018.
- Lowlevel irrigation increased by 625 ha, an 87% increase from 720 ha in 1997 to 1,345 ha in 2018.
- Overhead irrigation increased by 530 ha, a 53% increase from 1,005 ha in 1997 to 1,535 ha in 2018.
  - Overhead irrigation was the dominant method in 1997.
- Furrow irrigation decreased by 170 ha, a 97% decrease from 175 ha in 1997 to 5 ha in 2018.



Irrigation method[35]	1997	2003	2006	2009	2012	2015	2018	% of 2018 total	Change 1997-2018
Drip	230	2,455	2,780	6,920	6,640	6,930	8,980	71%	+8,750
Lowlevel	720	1,615	1,355	1,290	1,400	1,325	1,345	11%	+625
Overhead	1,005	1,470	1,550	1,425	1,335	1,475	1,535	12%	+530
Furrow	175	105	55	10	5	10	5	<1%	-170
Vacant	20	195	610	830	1,205	970	835	7%	+815
Total (ha)	2,150	5,840	6,350	10,475	10,585	10,710	12,700	100%	+10,550
Dominant	overhead	drip	drip	drip	drip	drip	drip		

Figure 78: Wemen river reach - irrigation methods from 1997 to 2018

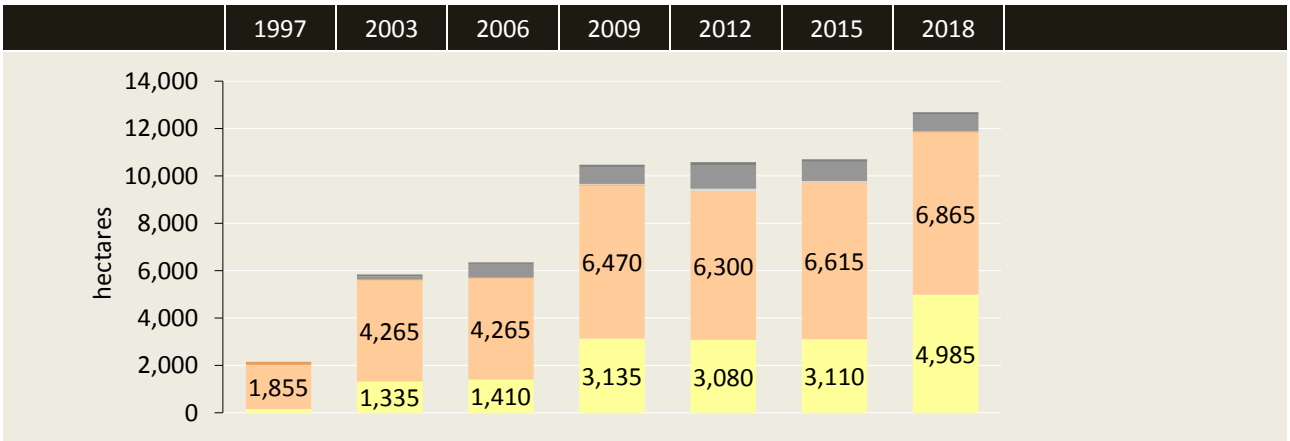
[35] Overhead irrigation includes pivots and lateral move systems. Furrow includes flood irrigation. (Table 5)

3.4.7 Wemen river reach - salinity impact zones

Figure 79 summarises river salinity impact zones of irrigated areas in the Wemen river reach from 1997 to 2018. Wemen private diverters are in low salinity impact zones L1, L2 and L3. There are no high salinity impact zones.

- In 2018, the irrigable area of 12,700 ha comprised:
  - 39% (5,005 ha) in the lowest salinity impact zone, L1;
  - 60% (7,570 ha) in L2; and
  - 1% (125 ha) in L3.

- The area irrigated in:
  - L1 increased by 4,815 ha, a 2832% increase from 170 ha in 1997 to 4,985 ha in 2018;
  - L2 increased by 5,010 ha, a 270% increase from 1,855 ha in 1997 to 6,865 ha in 2018; and
  - L3 decreased by 90 ha, an 86% decrease from 105 ha in 1997 to 15 ha in 2018.
- The irrigable area in:
  - L1 increased by 4,830 ha, a 2760% increase from 175 ha in 1997 to 5,005 ha in 2018;
  - L2 increased by 5,715 ha, a 308% increase from 1,855 ha in 1997 to 7,570 ha in 2018; and
  - L3 increased by 5 ha, a 4% increase from 120 ha in 1997 to 125 ha in 2018.
- Irrigation development from 1997 to 2018 occurred predominantly in L2.



Salinity impact zone		1997	2003	2006	2009	2012	2015	2018	% of 2018 total	Change (ha) 1997-2018
Irrigated	L1	170	1,335	1,410	3,135	3,080	3,110	4,985	39%	+4,815
	L2	1,855	4,265	4,265	6,470	6,300	6,615	6,865	54%	+5,010
	L3	105	45	65	40	0	15	15	<1%	-90
	L4	-	-	-	-	-	-	-	-	-
	HIZ	-	-	-	-	-	-	-	-	-
Not Irrigated	L1	5	0	0	25	80	50	20	<1%	+15
	L2	0	120	545	720	1,000	810	705	6%	+705
	L3	15	75	65	85	125	110	110	1%	+95
	L4	-	-	-	-	-	-	-	-	-
	HIZ	-	-	-	-	-	-	-	-	-
Total (ha)		2,150	5,840	6,350	10,475	10,585	10,710	12,700	100%	+10,550
Dominant zone		L2	L2	L2	L2	L2	L2	L2		

Figure 79: Wemen river reach - irrigable area in each salinity impact zone from 1997 to 2018

3.4.8 Wemen river reach - property change

Figure 80 provides estimates of property numbers and average property size (irrigable area) in the Wemen river reach from 1997 to 2018.

- In 2018:
  - There were approximately 37 irrigation properties; and
  - Most properties (78%) had an irrigable area over 20 ha.

- From 1997 to 2018:
  - The number of properties decreased by 3; an 8% decrease from 40 properties in 1997 to 37 in 2018;
  - Properties with an irrigable area less than 20 ha decreased by 11, while the number over 20 ha increased by 8; and
  - Average property size (irrigable area) increased from 54 ha in 1997 to 343 ha in 2018.

Property size (irrigable area)	1997	2003	2006	2009	2012	2015	2018	% of 2018 total	Change 1997-2018
1 to 5 ha	6	6	7	5	5	6	5	14%	-1
5 to 10 ha	4	3	3	3	3	2	1	3%	-3
10 to 20 ha	9	5	5	5	3	3	2	5%	-7
20 to 40 ha	7	7	7	8	9	7	7	19%	0
40 to 100 ha	10	10	9	8	7	9	9	24%	-1
100 to 500 ha	3	4	5	6	6	6	7	19%	+4
> 500 ha	1	3	3	5	5	5	6	16%	+5
Total properties	40	38	39	40	38	38	37	100%	-3
Average size (ha)	54	154	163	262	279	282	343		

Figure 80: Wemen river reach - property numbers and sizes from 1997 to 2018

3.5 Colignan river reach (*Colignan to Yatpool*)

In summary for the Colignan river reach

Crop types in 2018

Dominant plantings in the Colignan river reach in 2018 were:

1. citrus; 3,125 ha (26% of the irrigable area);
2. wine grapes; 2,765 ha (23% of the irrigable area);
3. dried grapes; 1,035 ha (9% of the irrigable area); and
4. almonds; 1,000 ha (8% of the irrigable area).

Crop types 1997 to 2018

Citrus was the dominant crop in 2018, whereas wine grapes were dominant from 1997 to 2015.

The main changes in crops from 1997 to 2018 were:

- dried grapes increased by 990 ha; a 2200% increase from 45 ha to 1,035 ha;
- almonds increased by 815 ha; a 441% increase from 185 ha to 1,000 ha;
- table grapes increased by 700 ha; a 400% increase from 175 ha to 700 ha; and
- citrus increased by 590 ha; a 23% increase from 2,535 ha to 3,125 ha.

Development of permanent plantings (new or redeveloped in the previous three years)

In 2018, at least 1,395 ha (15%) of permanent crops were planted or redeveloped in the previous three years, predominantly:

1. citrus (445 ha);
2. dried grapes (345 ha);
3. table grapes (225 ha);
4. almonds (195 ha);
5. wine grapes (75 ha); and
6. fruit trees (75 ha, mostly stone fruit and avocados).

Development activity ranged from 7% of permanent plantings in 2015 to 30% in 1997.

Planting trends - permanent plantings, seasonal crops and vacant areas

In 2018, the irrigable area of 11,825 ha comprised:

- 77% (9,145 ha) irrigated permanent plantings;
- 9% (1,105 ha) irrigated seasonal crops; and
- 13% (1,575 ha) vacant, not irrigated areas.

From 1997 to 2018:

- permanent plantings decreased from 87% to 77% of the irrigable area;
- seasonal crops decreased from 10% to 9% of the irrigable area; and
- vacant, not irrigated areas increased from 3% to 13% of the irrigable area.

In summary for the Colignan river reach

Irrigation development - new and retired areas

The irrigable area in the Colignan river reach increased by 4,900 ha, a 71% increase from 6,925 ha in 1997 to 11,825 ha in 2018.

The net increase of 4,900 ha was the balance of 4,975 ha expansion and 75 ha retired from irrigation.

Irrigation methods

Drip irrigation was the dominant irrigation method in the Colignan river reach from 2003 to 2018, whereas overhead sprinklers were dominant in 1997.

In 2018, the irrigable area of 11,825 ha comprised:

- 64% (7,580 ha) drip irrigation;
- 9% (1,020 ha) lowlevel irrigation;
- 14% (1,620 ha) overhead sprinklers;
- < 1% (30 ha) furrow irrigation; and
- 13% (1,575 ha) not irrigated.

Salinity impact zones

The Colignan river reach is in the low salinity impact zones, L1 and L4, and in the high impact zone, HIZ. Irrigation development from 1997 to 2018 occurred predominantly in L4.

In 2018, the irrigable area of 11,825 ha comprised:

- 17% (1,965 ha) in the lowest salinity impact zone, L1;
- 73% (8,685 ha) in L4; and
- 10% (1,175 ha) in the high salinity impact zone, HIZ.

From 1997 to 2018 the irrigable area in:

- L1 increased by 1,670 ha, a 566% increase from 295 ha to 1,965 ha;
- L4 increased by 3,090 ha, a 55% increase from 5,595 ha to 8,685 ha; and
- HIZ increased by 140 ha, a 14% increase from 1,035 ha to 1,175 ha.

Irrigation properties

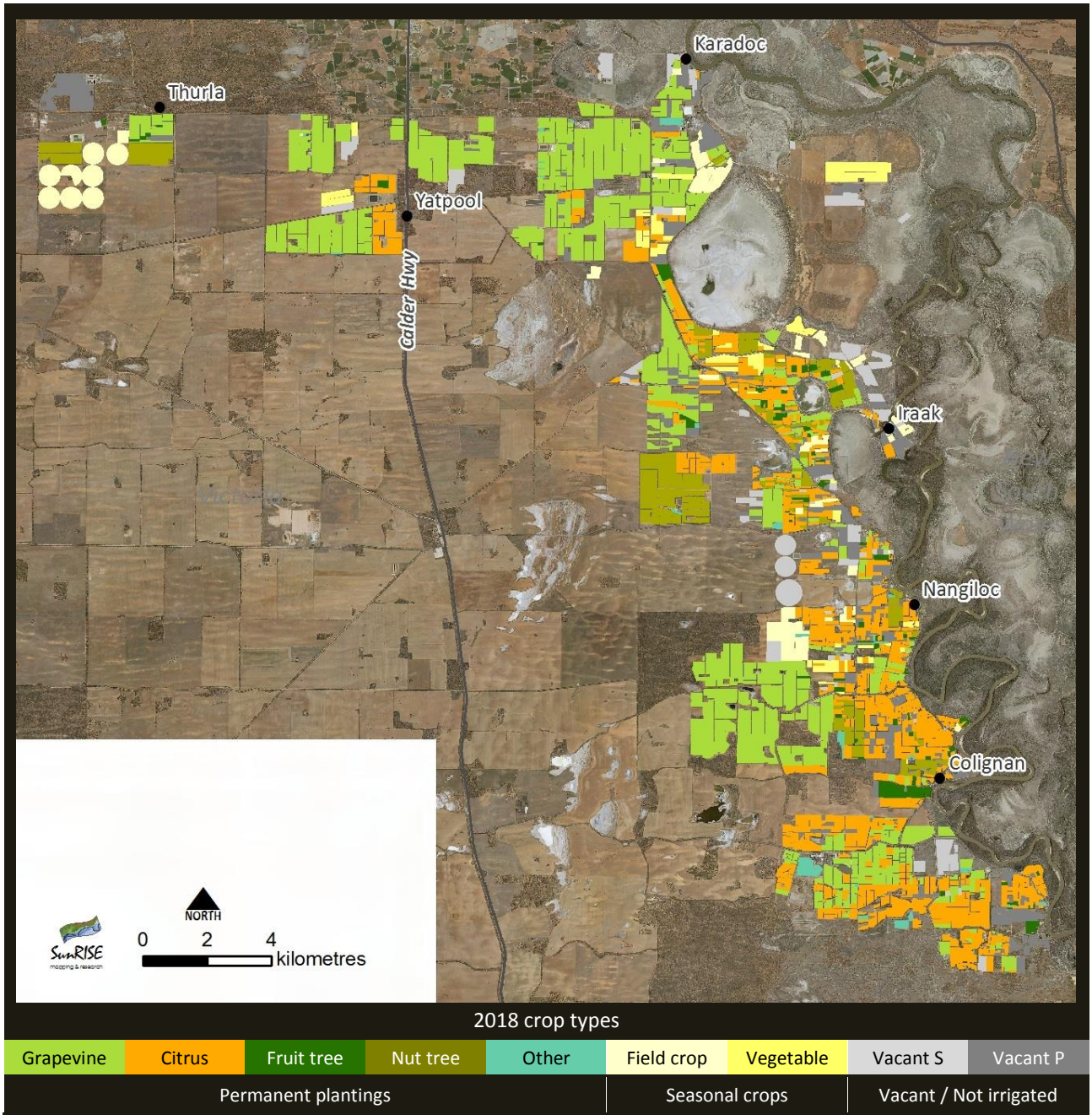
In 2018, there were approximately 129 irrigation properties with an average irrigable area of 92 ha.

From 1997 to 2018:

- the number of properties decreased by 16; an 11% decrease from 145 to 129 properties;
- properties with an irrigable area less than 20 ha decreased by 17, while the number over 20 ha increased by 1; and
- average property size (irrigable area) increased from 48 ha to 92 ha.

3.5.1 Colignan river reach - crop types in 2018

Map 18 shows the Colignan river reach with crop types in 2018.



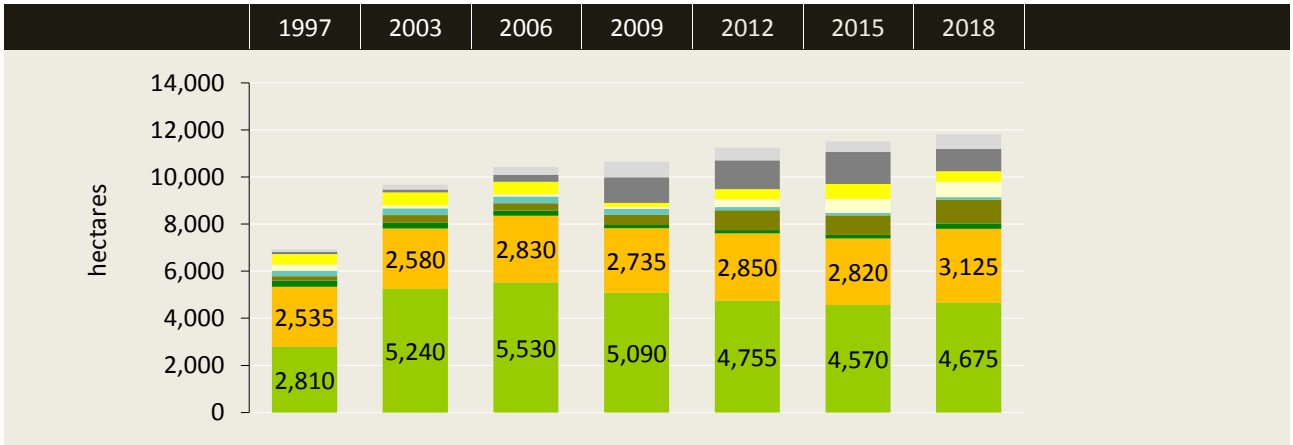
Map 18: Colignan river reach showing 2018 crop types

3.5.2 Colignan river reach - crop types from 1997 to 2018

Figure 81 summarises crop types in the Colignan river reach from 1997 to 2018.

- Dominant plantings in 2018 were:
    1. citrus; 3,125 ha (26% of the irrigable area);
    2. wine grapes; 2,765 ha (23% of the irrigable area); and
    3. dried grapes; 1,035 ha (9% of the irrigable area).

- Citrus was the dominant crop in 2018, whereas wine grape plantings were dominant from 1997 to 2015.
- From 1997 to 2018, the largest increases in plantings were:
    - 990 ha of dried grapes; from 45 ha to 1,035;
    - 815 ha of almonds; from 185 ha to 1,000 ha;
    - 700 ha of table grapes; from 175 ha to 875 ha; and
    - 590 ha of citrus; from 2,535 ha to 3,125 ha.



Crop type		1997	2003	2006	2009	2012	2015	2018	% of 2018 total	Change 1997-2018
Permanent	Grape Dried	45	530	525	525	615	725	1,035	9%	+990
	Grape Table	175	460	560	535	635	675	875	7%	+700
	Grape Wine	2,590	4,250	4,445	4,030	3,505	3,170	2,765	23%	+175
	Citrus	2,535	2,580	2,830	2,735	2,850	2,820	3,125	26%	+590
	Fruit Olive	5	5	5	5	5	5	5	<1%	0
	Fruit Other	245	230	205	130	135	150	225	2%	-20
	Nut Almond	185	320	310	420	815	805	1,000	8%	+815
	Nut Other	5	10	10	20	25	15	10	<1%	+5
	Other	240	280	290	245	140	110	105	1%	-135
Seasonal	Field Crop	250	125	95	85	330	595	660	6%	+410
	Veg. Carrot	240	240	230	175	90	0	0	0%	-240
	Veg. Potato	0	35	0	0	35	0	0	0%	0
	Veg. Other	210	285	300	0	300	635	445	4%	+235
	Vacant P	95	120	290	1,080	1,225	1,355	950	8%	+855
	Vacant S	105	200	325	665	550	450	625	5%	+520
Total (ha)		6,925	9,670	10,420	10,650	11,255	11,510	11,825	100%	+4,900
Dominant		wine grape	wine grape	wine grape	wine grape	wine grape	wine grape	citrus		

Figure 81: Colignan river reach - crop types from 1997 to 2018

3.5.3 Colignan river reach - development of permanent crops

Figure 82 shows the proportion of permanent crops planted or redeveloped in the previous three years in the Colignan river reach from 1997 to 2018.

The information provides an indication of development activity that is otherwise not evident in information on changes in areas and crop types, as it includes replanting and top working to different varieties. The figures are conservative, as top-worked plantings can be difficult to interpret from the three-yearly aerial imagery, particularly for grapevines.

- In 2018, at least 1,395 ha (15%) of permanent crops were planted or redeveloped in the previous three years. Development was predominantly:
    1. citrus (460 ha);
    2. dried grapes (345 ha);
    3. table grapes (230 ha);
    4. almonds (200 ha);
    5. fruit trees (75 ha, mostly stone fruit and avocados); and
    6. wine grapes (65 ha).

- The area of new or redeveloped permanent plantings was highest in 2003 with 2,005 ha planted in the previous three years; predominantly wine grape development.

- New or redeveloped permanent plantings were lowest in 2015 at 7% of plantings (600 ha); however development activity increased to 15% by 2018 with at least 1,395 ha of new permanent plantings.

Permanent plantings	1997	2003	2006	2009	2012	2015	2018	% of 2018 total
≤3yr old plantings	1,810	2,005	1,145	690	990	600	1,395	15%
>3yr old plantings	4,215	6,660	8,035	7,955	7,735	7,875	7,750	85%
Total (ha)	6,025	8,665	9,180	8,645	8,725	8,475	9,145	100%
% 3year development	30%	23%	12%	8%	11%	7%	15%	

Figure 82: Colignan river reach - development of permanent crops from 1997 to 2018

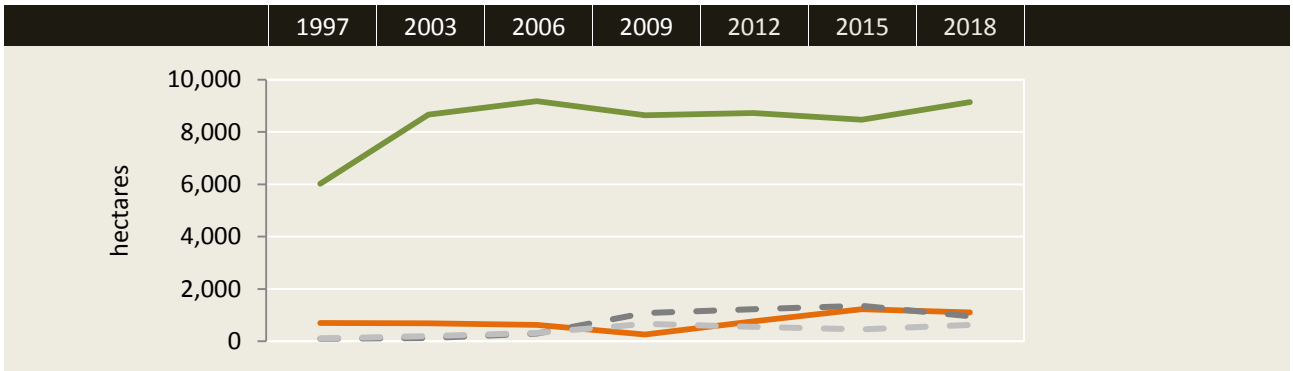
3.5.4 Colignan river reach - planting trends

Figure 83 summarises planting trends in the Colignan river reach from 1997 to 2018.

- In 2018, the irrigable area of 11,825 ha comprised:
  - 77% (9,145 ha) irrigated permanent plantings;
  - 9% (1,105 ha) irrigated seasonal crops; and
  - 13% (1,575 ha) vacant, not irrigated areas.

The proportion of permanent plantings, seasonal cropping and vacant areas changed from:
  - 87% permanent, 10% seasonal and 3% vacant in 1997; to
  - 77% permanent, 9% seasonal and 13% vacant in 2018.

- From 1997 to 2018:
  - irrigated permanent crops increased by 3,120 ha;
  - irrigated seasonal crops increased by 405 ha;
  - vacant, not irrigated areas increased by 1,375 ha; and
  - the irrigable area increased by 4,900 ha; a 71% increase from 6,925 ha to 11,825 ha.



	1997	2003	2006	2009	2012	2015	2018	% of 2018 total	Change 1997-2018
Permanent - irrigated	6,025	8,665	9,180	8,645	8,725	8,475	9,145	77%	+3,120
Seasonal - irrigated	700	685	625	260	755	1,230	1,105	9%	+405
Vacant - permanent	95	120	290	1,080	1,225	1,355	950	8%	+855
Vacant - seasonal	105	200	325	665	550	450	625	5%	+520
Total (ha)	6,925	9,670	10,420	10,650	11,255	11,510	11,825	100%	+4,900
% Permanent	87%	90%	88%	81%	78%	74%	77%		
% Seasonal	10%	7%	6%	2%	7%	11%	9%		
% Vacant	3%	3%	6%	16%	16%	16%	13%		

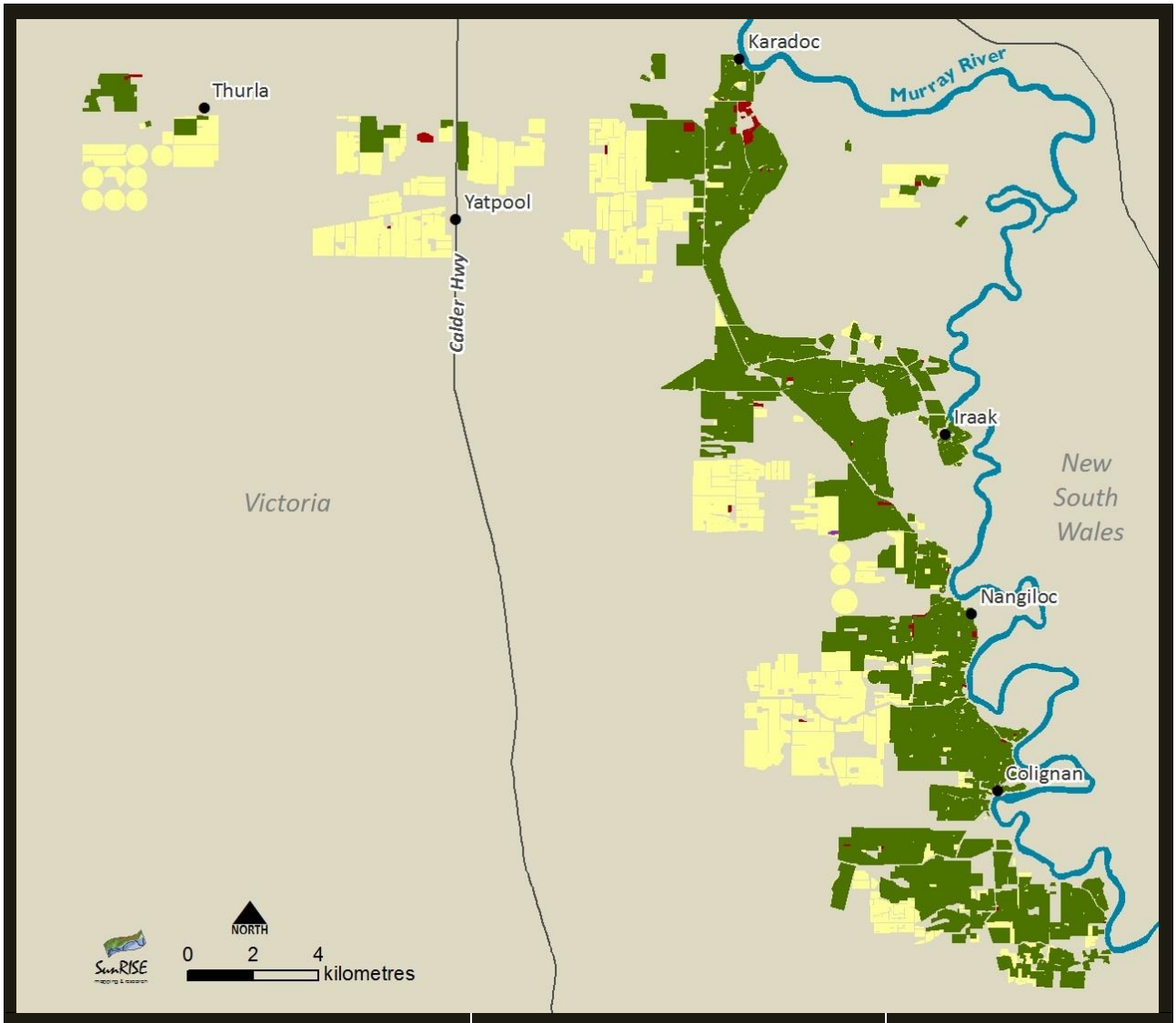
Figure 83: Colignan river reach - planting trends from 1997 to 2018

3.5.5 Colignan river reach - irrigation development

Map 19 shows irrigation development from 1997 to 2018 in the Colignan river reach with respect to new development (expansion) and areas retired[36] from irrigation.

- The irrigable area increased by 4,900 ha, a 71% increase from 6,925 ha in 1997 to 11,825 ha in 2018.
- The net increase of 4,900 ha comprised 75 ha retired from irrigation and 4,975 ha of expansion.

Map 19: Colignan river reach - irrigation development from 1997 to 2018



	Hectares		% of 1997
Irrigation areas in 1997 (1996-97 season)	6,925		
Retired between 1997 and 2018	-75		-1%
Expansion between 1997 and 2018	+4,975		+72%
Irrigation areas in 2018 (2017-18 season)	11,825		

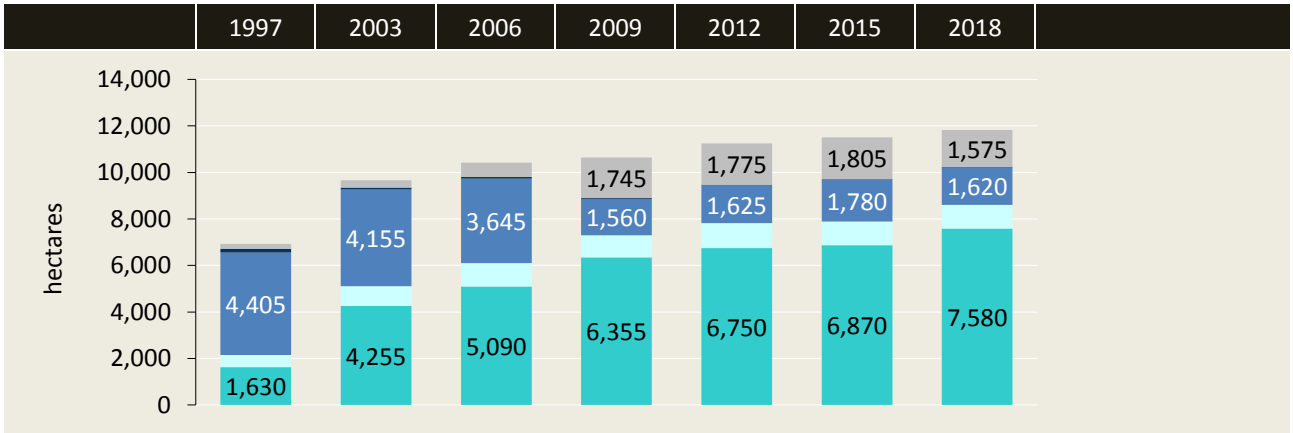
[36] Retired areas were previously irrigated but have undergone a change in land use that precludes use for irrigation e.g. urban development, housing, sheds, dams and land set aside for conservation purposes.

3.5.6 Colignan river reach - irrigation methods

Figure 84 summarises irrigation methods in the Colignan river reach from 1997 to 2018.

- In 2018, the irrigable area of 11,825 ha comprised:
  - 64% (7,580 ha) drip irrigation;
  - 9% (1,020 ha) lowlevel irrigation;
  - 14% (1,620 ha) overhead sprinklers;
  - < 1% (30 ha) furrow irrigation; and
  - 13% (1,575 ha) vacant, not irrigated.

- Drip irrigation increased by 5,950 ha, a 365% increase from 1,630 ha in 1997 to 7,580 ha in 2018.
  - Drip irrigation was the dominant irrigation method from 2003 to 2018.
- Lowlevel irrigation increased by 505 ha, a 98% increase from 515 ha in 1997 to 1,020 ha in 2018.
- Overhead irrigation decreased by 2,785 ha, a 63% decrease from 4,405 ha in 1997 to 1,620 ha in 2018.
  - Overhead irrigation was the dominant method in 1997.
- Furrow irrigation decreased by 145 ha, an 83% decrease from 175 ha in 1997 to 30 ha in 2018.



Irrigation method[37]	1997	2003	2006	2009	2012	2015	2018	% of 2018 total	Change 1997-2018
Drip	1,630	4,255	5,090	6,355	6,750	6,870	7,580	64%	+5,950
Lowlevel	515	860	1,005	950	1,065	1,025	1,020	9%	+505
Overhead	4,405	4,155	3,645	1,560	1,625	1,780	1,620	14%	-2,785
Furrow	175	80	65	40	40	30	30	<1%	-145
Vacant	200	320	615	1,745	1,775	1,805	1,575	13%	+1,375
Total (ha)	6,925	9,670	10,420	10,650	11,255	11,510	11,825	100%	+4,900
Dominant	overhead	drip	drip	drip	drip	drip	drip		

Figure 84: Colignan river reach - irrigation methods from 1997 to 2018

[37] Overhead irrigation includes pivots and lateral move systems. Furrow includes flood irrigation. (Table 5)

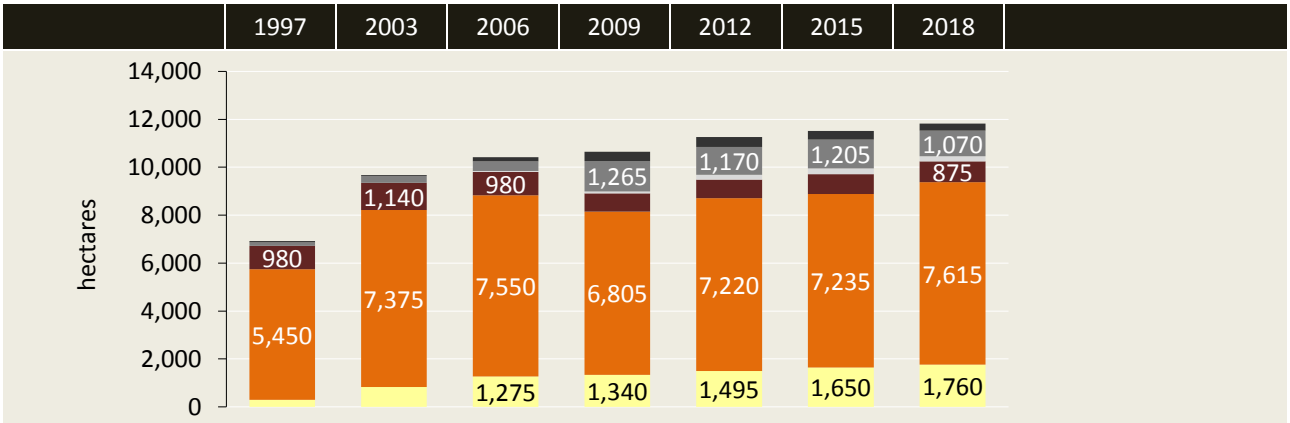
3.5.7 Colignan river reach - salinity impact zones

Figure 85 summarises river salinity impact zones of irrigated areas in the Colignan river reach from 1997 to 2018. Colignan private diverters are in low salinity impact zones L1 and L4, and the high salinity impact zone, HIZ.

- In 2018, the irrigable area of 11,825 ha comprised:
  - 17% (1,965 ha) in the lowest salinity impact zone, L1;
  - 73% (8,685 ha) in L4; and
  - 10% (1,175 ha) in the high salinity impact zone, HIZ.

- The area irrigated in:
  - L1 increased by 1,465 ha, a 497% increase from 295 ha in 1997 to 1,760 ha in 2018;
  - L4 increased by 2,165 ha, a 40% increase from 5,450 ha in 1997 to 7,615 ha in 2018; and
  - HIZ decreased by 105 ha, an 11% decrease from 980 ha in 1997 to 875 ha in 2018.
- The irrigable area in:
  - L1 increased by 1,670 ha, a 566% increase from 295 ha in 1997 to 1,965 ha in 2018;
  - L4 increased by 3,090 ha, a 55% increase from 5,595 ha in 1997 to 8,685 ha in 2018; and
  - HIZ increased by 140 ha, a 14% increase from 1,035 ha in 1997 to 1,175 ha in 2018.

- Irrigation development from 1997 to 2018 predominantly occurred in L4.



Salinity impact zone		1997	2003	2006	2009	2012	2015	2018	% of 2018 total	Change (ha) 1997-2018
Irrigated	L1	295	835	1,275	1,340	1,495	1,650	1,760	15%	+1,465
	L2	-	-	-	-	-	-	-	-	-
	L3	-	-	-	-	-	-	-	-	-
	L4	5,450	7,375	7,550	6,805	7,220	7,235	7,615	64%	+2,165
	HIZ	980	1,140	980	760	765	820	875	7%	-105
Not Irrigated	L1	0	0	35	90	200	250	205	2%	+205
	L2	-	-	-	-	-	-	-	-	-
	L3	-	-	-	-	-	-	-	-	-
	L4	145	285	400	1,265	1,170	1,205	1,070	9%	+925
	HIZ	55	35	180	390	405	350	300	3%	+245
Total (ha)		6,925	9,670	10,420	10,650	11,255	11,510	11,825	100%	+4,900
Dominant zone		L4	L4	L4	L4	L4	L4	L4		

Figure 85: Colignan river reach - irrigable area in each salinity impact zone from 1997 to 2018

3.5.8 Colignan river reach - property change

Figure 86 provides estimates of property numbers and average property size (irrigable area) in the Colignan river reach from 1997 to 2018.

- In 2018:
  - There were approximately 129 irrigation properties; and
  - Most properties (64%) had an irrigable area over 20 ha.

- From 1997 to 2018:
  - The number of properties decreased by 16; an 11% decrease from 145 to 129 properties;
  - Properties with an irrigable area less than 20 ha decreased by 17, while the number over 20 ha increased by 1; and
  - Average property size (irrigable area) increased from 48 ha in 1997 to 92 ha in 2018.

Property size (irrigable area)	1997	2003	2006	2009	2012	2015	2018	% of 2018 total	Change 1997-2018
1 to 5 ha	15	19	18	16	20	17	14	11%	-1
5 to 10 ha	15	12	13	14	14	14	13	10%	-2
10 to 20 ha	34	31	31	30	23	23	20	16%	-14
20 to 40 ha	33	32	34	34	34	28	27	21%	-6
40 to 100 ha	30	33	33	32	27	31	27	21%	-3
100 to 500 ha	18	25	26	25	30	29	24	19%	+6
> 500 ha	0	2	3	4	3	4	4	3%	+4
Total properties	145	154	158	155	151	146	129	100%	-16
Average size (ha)	48	63	66	69	75	79	92		

Figure 86: Colignan river reach - property numbers and sizes from 1997 to 2018

3.6 Mildura river reach (*Mildura to Lock 10*)

In summary for the Mildura river reach

Crop types in 2018

Dominant plantings in the Mildura river reach in 2018 were:

1. table grapes; 440 ha (22% of the irrigable area);
2. field crops; 320 ha (16% of the irrigable area);
3. wine grapes; 300 ha (15% of the irrigable area); and
4. dried grapes; 110 ha (6% of the irrigable area).

Crop types 1997 to 2018

Table grapes were the dominant crop in 2018, whereas wine grapes were dominant from 1997 to 2015.

The main changes in crops from 1997 to 2018 were:

- table grapes increased by 375 ha; a 577% increase from 65 ha to 440 ha;
- wine grapes decreased by 130 ha; a 30% decrease from 430 ha to 300 ha; and
- dried grapes decreased by 130 ha; a 54% decrease from 240 ha to 110 ha.

Development of permanent plantings (new or redeveloped in the previous three years)

In 2018, at least 260 ha (25%) of permanent crops were planted or redeveloped in the previous three years, predominantly:

1. table grapes (195 ha);
2. wine grapes (25 ha);
3. citrus (20 ha); and
4. walnuts (5 ha).

Development activity ranged from 10% of permanent plantings in 2009 to 25% in 2018 and 26% in 1997.

Planting trends - permanent plantings, seasonal crops and vacant areas

In 2018, the irrigable area of 1,970 ha comprised:

- 54% (1,060 ha) irrigated permanent plantings;
- 18% (350 ha) irrigated seasonal crops; and
- 28% (560 ha) vacant, not irrigated areas.

From 1997 to 2018:

- permanent plantings decreased from 66% to 54% of the irrigable area;
- seasonal crops decreased from 30% to 18% of the irrigable area; and
- vacant, not irrigated areas increased from 4% to 28% of the irrigable area.

In summary for the Mildura river reach

Irrigation development - new and retired areas

The irrigable area in the Mildura river reach increased by 525 ha, a 36% increase from 1,445 ha in 1997 to 1,970 ha in 2018.

The net increase of 525 ha was the balance of 590 ha expansion and 65 ha retired from irrigation.

Irrigation methods

Drip irrigation was the dominant irrigation method in the Mildura river reach from 2006 to 2018, whereas overhead sprinklers were dominant in 2003 and furrows in 1997.

In 2018, the irrigable area of 1,970 ha comprised:

- 41% (800 ha) drip irrigation;
- 9% (170 ha) lowlevel irrigation;
- 13% (265 ha) overhead sprinklers;
- 9% (175 ha) furrow irrigation; and
- 28% (560 ha) not irrigated.

Salinity impact zones

The Mildura river reach is in the lowest salinity impact zone, L1 and the high impact zone, HIZ. Irrigation development from 1997 to 2018 occurred predominantly in L1.

In 2018, the irrigable area of 1,970 ha comprised:

- 37% (735 ha) in L1; and
- 63% (1,235 ha) in HIZ.

From 1997 to 2018 the irrigable area in:

- L1 increased by 555 ha, a 308% increase from 180 ha to 735 ha; and
- HIZ decreased by 30 ha, a 2% decrease from 1,265 ha to 1,235 ha. The decrease was predominantly areas retired from irrigation for urban development.

Irrigation properties

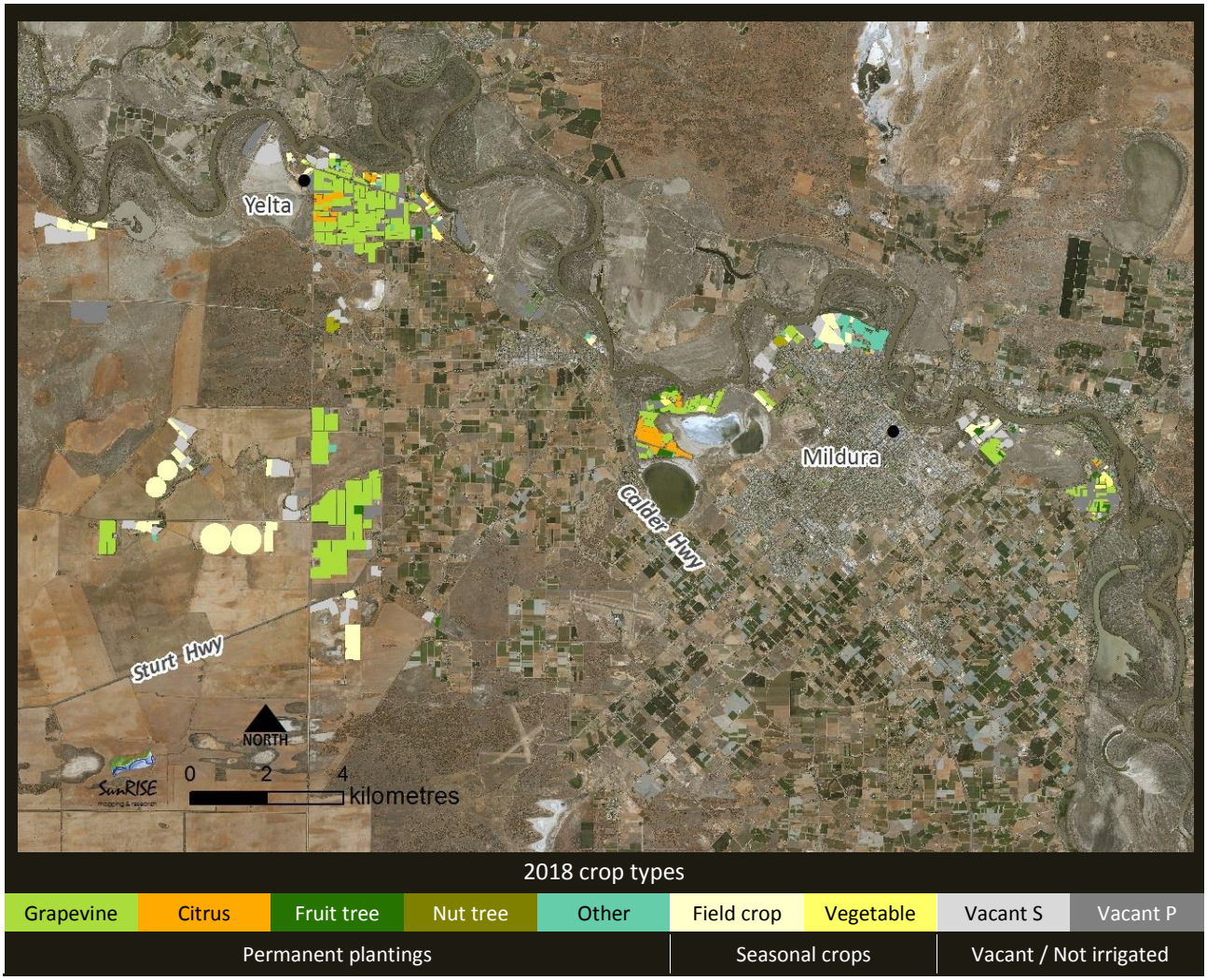
In 2018, there were approximately 102 irrigation properties with an average irrigable area of 19 ha.

From 1997 to 2018:

- the number of properties decreased by 10; a 9% decrease from 112 to 102 properties;
- properties with an irrigable area less than 20 ha decreased by 15, while the number over 20 ha increased by 5; and
- average property size (irrigable area) increased from 13 ha to 19 ha.

3.6.1 Mildura river reach - crop types in 2018

Map 20 shows the Mildura river reach with crop types in in 2018.



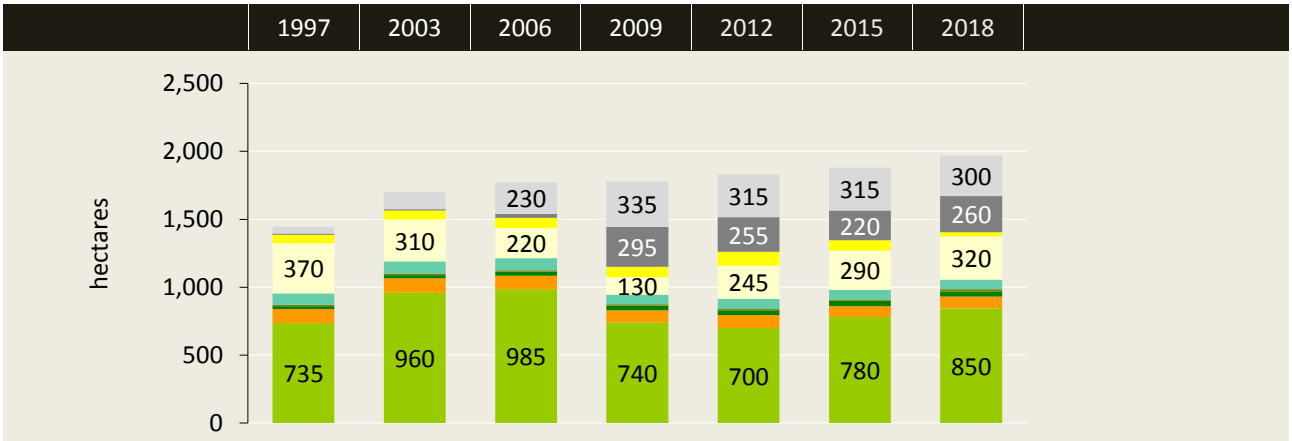
Map 20: Mildura river reach showing 2018 crop types

3.6.2 Mildura river reach - crop types from 1997 to 2018

Figure 87 summarises crop types in the Mildura river reach from 1997 to 2018.

- Dominant plantings in 2018 were:
    1. table grapes; 440 ha (22% of the irrigable area);
    2. field crops; 320 ha (16% of the irrigable area);
    3. wine grapes; 300 ha (15% of the irrigable area); and
    4. dried grapes; 110 ha (6% of the irrigable area).

- Table grapes were the dominant crop in 2018, while wine grapes were dominant from 1997 to 2015.
- Table grape plantings increased by 375 ha; a 577% increase from 65 ha in 1997 to 440 ha in 2018.
- Dried and wine grape plantings both decreased by 130 ha between 1997 and 2018.



Crop type		1997	2003	2006	2009	2012	2015	2018	% of 2018 total	Change 1997-2018
Permanent	Grape Dried	240	170	185	110	115	115	110	6%	-130
	Grape Table	65	150	160	160	210	290	440	22%	+375
	Grape Wine	430	640	640	470	375	375	300	15%	-130
	Citrus	105	105	100	90	95	80	90	5%	-15
	Fruit Olive	5	10	15	15	15	15	15	1%	+10
	Fruit Other	15	15	15	20	20	25	25	1%	+10
	Nut Almond	0	0	0	0	0	0	0	0%	0
	Nut Other	10	10	10	10	10	10	15	1%	+5
	Other	85	90	90	70	75	70	65	3%	-20
Seasonal	Field Crop	370	310	220	130	245	290	320	16%	-50
	Veg. Carrot	-	-	-	-	-	-	-	-	-
	Veg. Potato	0	0	0	0	20	0	0	0%	0
	Veg. Other	60	65	75	75	80	75	30	2%	-30
	Vacant P	10	10	30	295	255	220	260	13%	+250
	Vacant S	50	125	230	335	315	315	300	15%	+250
Total (ha)		1,445	1,700	1,770	1,780	1,830	1,880	1,970	100%	+525
Dominant		wine grape	wine grape	wine grape	wine grape	wine grape	wine grape	table grape		

Figure 87: Mildura river reach - crop types from 1997 to 2018

3.6.3 Mildura river reach - development of permanent crops

Figure 88 shows the proportion of permanent crops planted or redeveloped in the previous three years in the Mildura river reach from 1997 to 2018.

The information provides an indication of development activity that is otherwise not evident in information on changes in areas and crop types, as it includes replanting and top working to different varieties. The figures are conservative, as top-worked plantings can be difficult to interpret from the three-yearly aerial imagery, particularly for grapevines.

- In 2018, at least 260 ha (25%) of permanent crops were planted or redeveloped in the previous three years. Development was predominantly:
    1. table grapes (195 ha);
    2. wine grapes (25 ha);
    3. citrus (20 ha); and
    4. walnuts (5 ha).

- New or redeveloped permanent plantings were lowest in 2009 with 90 ha (10%) planted in the previous three years.

Permanent plantings	1997	2003	2006	2009	2012	2015	2018	% of 2018 total
≤3yr old plantings	245	245	140	90	115	150	260	25%
>3yr old plantings	710	945	1,075	855	800	830	800	75%
Total (ha)	955	1,190	1,215	945	915	980	1,060	100%
% 3year development	26%	21%	12%	10%	13%	15%	25%	

Figure 88: Mildura river reach - development of permanent crops from 1997 to 2018

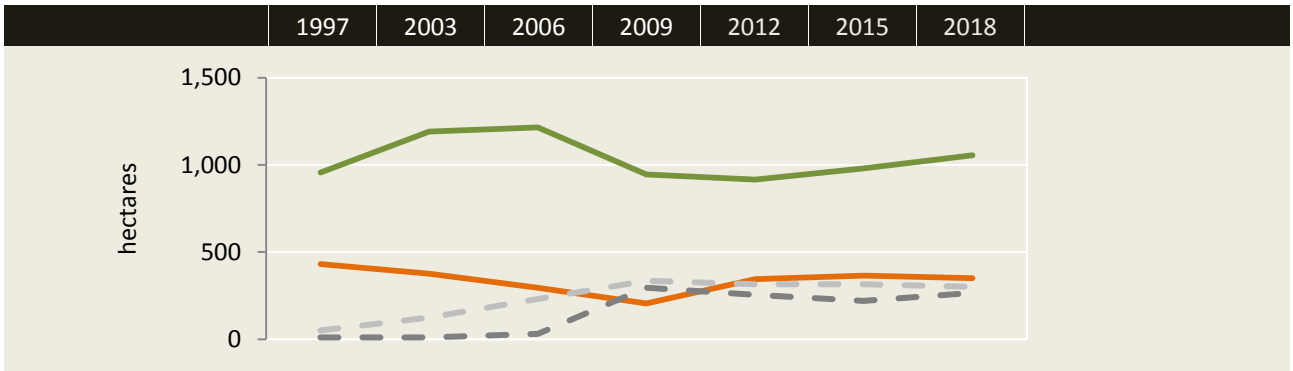
3.6.4 Mildura river reach - planting trends

Figure 89 summarises planting trends in the Mildura river reach from 1997 to 2018.

- In 2018, the irrigable area of 1,970 ha comprised:
  - 54% (1,060 ha) irrigated permanent plantings;
  - 18% (350 ha) irrigated seasonal crops; and
  - 28% (560 ha) vacant, not irrigated areas.

The proportion of permanent plantings, seasonal cropping and vacant areas changed from:
  - 66% permanent, 30% seasonal and 4% vacant in 1997; to
  - 54% permanent, 18% seasonal and 28% vacant in 2018.

- From 1997 to 2018:
  - irrigated permanent crops increased by 105 ha;
  - irrigated seasonal crops decreased by 80 ha;
  - vacant, not irrigated areas increased by 500 ha; and
  - the irrigable area increased by 525 ha; a 36% increase from 1,445 ha to 1,970 ha.



	1997	2003	2006	2009	2012	2015	2018	% of 2018 total	Change 1997-2018
Permanent - irrigated	955	1,190	1,215	945	915	980	1,060	54%	+105
Seasonal - irrigated	430	375	295	205	345	365	350	18%	-80
Vacant - permanent	10	10	30	295	255	220	260	13%	+250
Vacant - seasonal	50	125	230	335	315	315	300	15%	+250
Total (ha)	1,445	1,700	1,770	1,780	1,830	1,880	1,970	100%	+525
% Permanent	66%	70%	69%	53%	50%	52%	54%		
% Seasonal	30%	22%	17%	12%	19%	19%	18%		
% Vacant	4%	8%	15%	35%	31%	28%	28%		

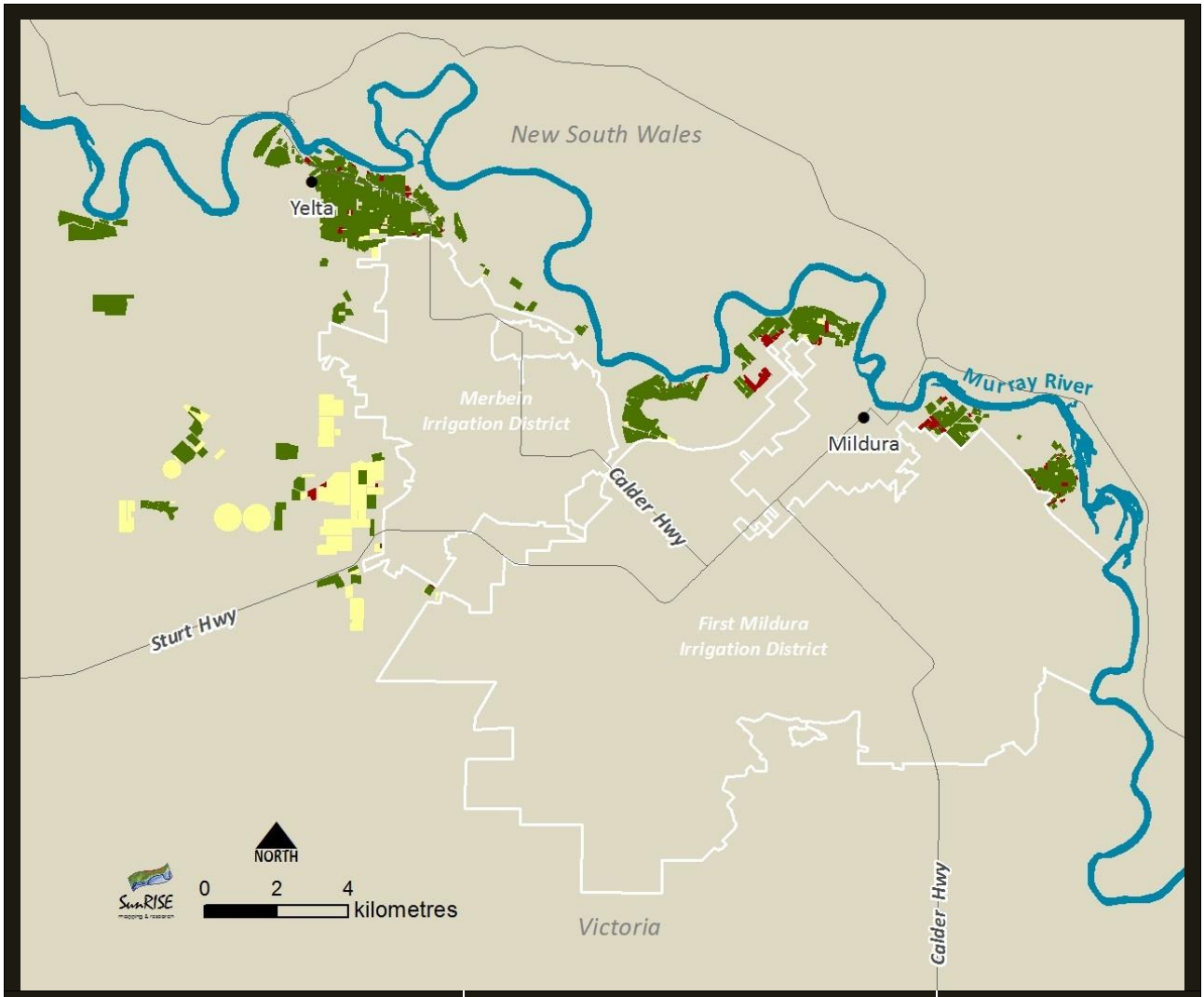
Figure 89: Mildura river reach - planting trends from 1997 to 2018

3.6.5 Mildura river reach - irrigation development

Map 21 shows irrigation development from 1997 to 2018 in the Mildura river reach with respect to new development (expansion) and areas retired[38] from irrigation.

- The irrigable area increased by 525 ha, a 36% increase from 1,445 ha in 1997 to 1,970 ha in 2018.
- The net increase of 525 ha comprised 65 ha retired from irrigation and 590 ha of expansion.

Map 21: Mildura river reach - irrigation development from 1997 to 2018



	Hectares		% of 1997
Irrigation areas in 1997 (1996-97 season)	1,445		
Retired between 1997 and 2018	-65		-4%
Expansion between 1997 and 2018	+590		+41%
Irrigation areas in 2018 (2017-18 season)	1,970		

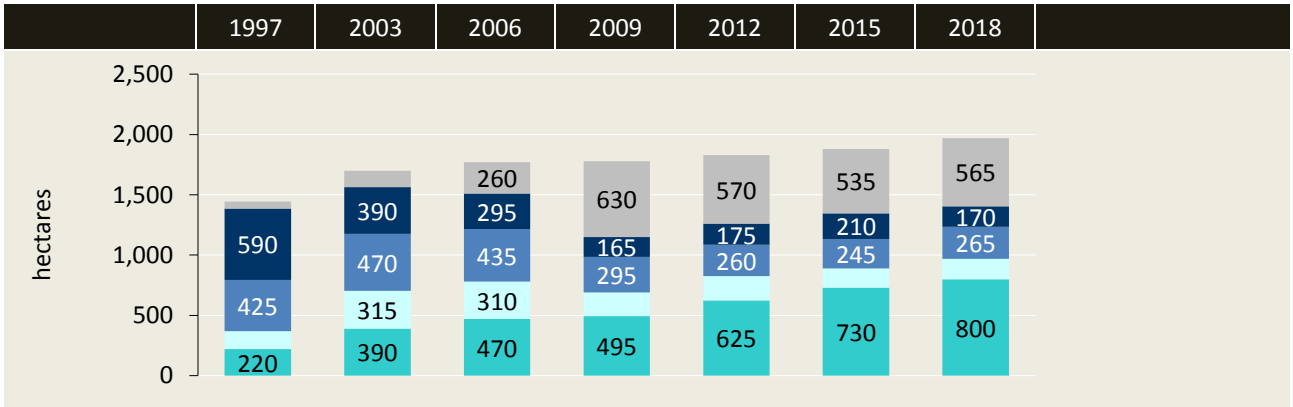
[38] Retired areas were previously irrigated but have undergone a change in land use that precludes use for irrigation e.g. urban development, housing, sheds, dams and land set aside for conservation purposes.

3.6.6 Mildura river reach - irrigation methods

Figure 90 summarises irrigation methods in the Mildura river reach from 1997 to 2018.

- In 2018, the irrigable area of 1,970 ha comprised:
  - 41% (800 ha) drip irrigation;
  - 9% (170 ha) lowlevel irrigation;
  - 13% (265 ha) overhead sprinklers;
  - 9% (175 ha) furrow irrigation; and
  - 28% (560 ha) vacant, not irrigated.

- Drip irrigation increased by 580 ha, a 264% increase from 220 ha in 1997 to 800 ha in 2018.
  - Drip irrigation was the dominant irrigation method from 2006 to 2018.
- Lowlevel irrigation increased by 20 ha, a 13% increase from 150 ha in 1997 to 170 ha in 2018.
- Overhead irrigation decreased by 160 ha, a 38% decrease from 425 ha in 1997 to 265 ha in 2018.
  - Overhead irrigation was the dominant method in 2003.
- Furrow irrigation decreased by 415 ha, a 70% decrease from 590 ha in 1997 to 175 ha in 2018.
  - Furrow, including flood, irrigation was the dominant method in 1997.



Irrigation method[39]	1997	2003	2006	2009	2012	2015	2018	% of 2018 total	Change 1997-2018
Drip	220	390	470	495	625	730	800	41%	+580
Lowlevel	150	315	310	195	200	160	170	9%	+20
Overhead	425	470	435	295	260	245	265	13%	-160
Furrow	590	390	295	165	175	210	175	9%	-415
Vacant	60	135	260	630	570	535	560	28%	+500
Total (ha)	1,445	1,700	1,770	1,780	1,830	1,880	1,970	100%	+525
Dominant	furrow	overhead	drip	drip	drip	drip	drip		

Figure 90: Mildura river reach - irrigation methods from 1997 to 2018

[39] Overhead irrigation includes pivots and lateral move systems. Furrow includes flood irrigation. (Table 5)

3.6.7 Mildura river reach - salinity impact zones

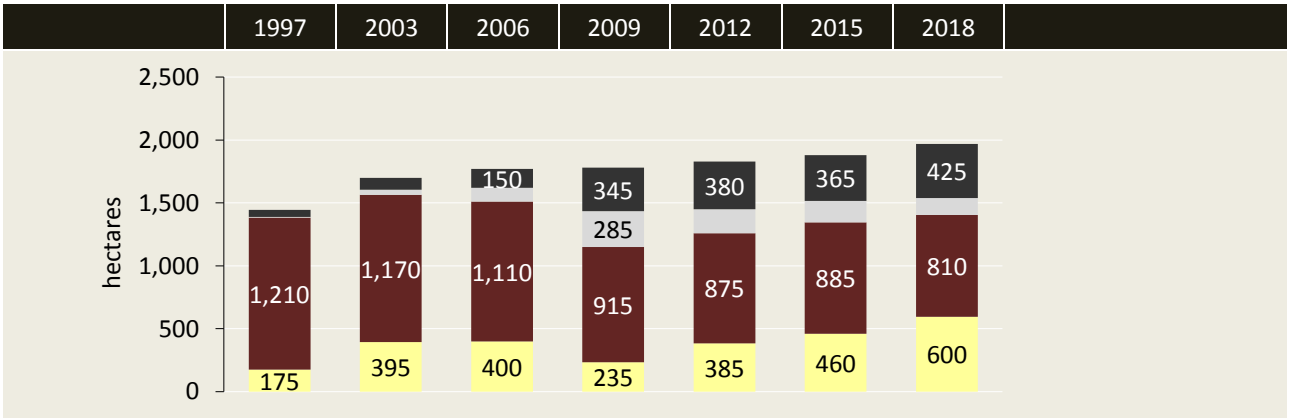
Figure 91 summarises river salinity impact zones of irrigated areas in the Mildura river reach from 1997 to 2018. Mildura private diverters are in the lowest salinity impact zone, L1 and the high salinity impact zone, HIZ.

- In 2018, the irrigable area of 1,970 ha comprised:
  - 37% (735 ha) in the lowest salinity impact zone, L1; and
  - 63% (1,235 ha) in the high salinity impact zone, HIZ.

- The area irrigated in:
  - L1 increased by 425 ha, a 243% increase from 175 ha in 1997 to 600 ha in 2018; and
  - HIZ decreased by 400 ha, a 33% decrease from 1,210 ha in 1997 to 810 ha in 2018.

- The irrigable area in:
  - L1 increased by 555 ha, a 308% increase from 180 ha in 1997 to 735 ha in 2018; and
  - HIZ decreased by 30 ha, a 2% decrease from 1,265 ha in 1997 to 1,235 ha in 2018. The decrease was predominantly due to areas retired from irrigation for urban development.

- Irrigation development from 1997 to 2018 predominantly occurred in L1.



Salinity impact zone		1997	2003	2006	2009	2012	2015	2018	% of 2018 total	Change (ha) 1997-2018
Irrigated	L1	175	395	400	235	385	460	600	30%	+425
	L2	-	-	-	-	-	-	-	-	-
	L3	-	-	-	-	-	-	-	-	-
	L4	-	-	-	-	-	-	-	-	-
	HIZ	1,210	1,170	1,110	915	875	885	810	41%	-400
Not Irrigated	L1	5	40	110	285	190	170	135	7%	+130
	L2	-	-	-	-	-	-	-	-	-
	L3	-	-	-	-	-	-	-	-	-
	L4	-	-	-	-	-	-	-	-	-
	HIZ	55	95	150	345	380	365	425	22%	+370
Total (ha)		1,445	1,700	1,770	1,780	1,830	1,880	1,970	100%	+525
Dominant zone		HIZ	HIZ	HIZ	HIZ	HIZ	HIZ	HIZ		

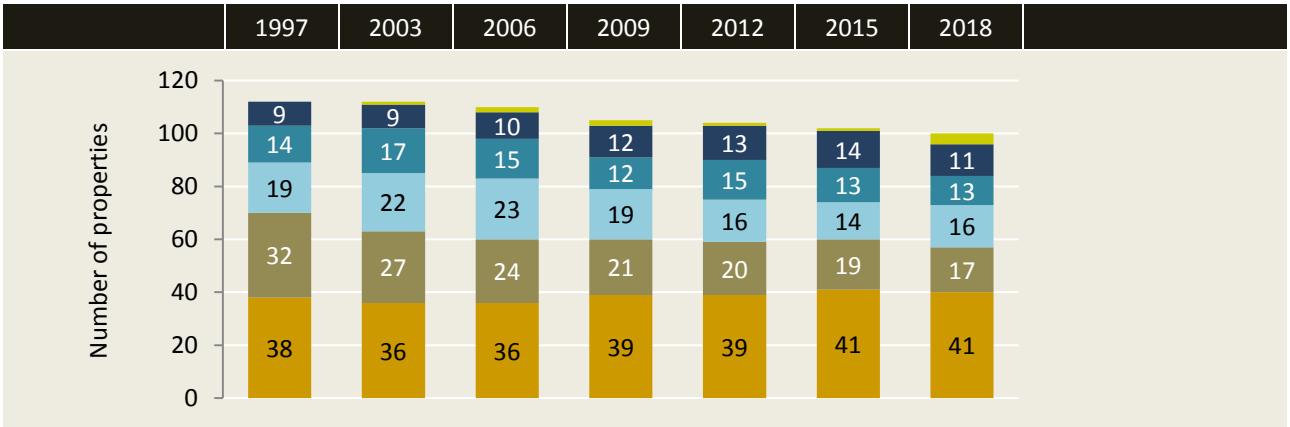
Figure 91: Mildura river reach - irrigable area in each salinity impact zone from 1997 to 2018

3.6.8 Mildura river reach - property change

Figure 92 provides estimates of property numbers and average property size (irrigable area) in the Mildura river reach from 1997 to 2018.

- In 2018:
  - There were approximately 102 irrigation properties; and
  - Most properties (73%) had an irrigable area less than 20 ha.

- From 1997 to 2018:
  - The number of properties decreased by 10; a 9% decrease from 112 to 102 properties;
  - Properties with an irrigable area less than 20 ha decreased by 15, while the number over 20 ha increased by 5; and
  - Average property size (irrigable area) increased from 13 ha in 1997 to 19 ha in 2018.



Property size (irrigable area)	1997	2003	2006	2009	2012	2015	2018	% of 2018 total	Change 1997-2018
1 to 5 ha	38	36	36	39	39	41	41	40%	+3
5 to 10 ha	32	27	24	21	20	19	17	19%	-15
10 to 20 ha	19	22	23	19	16	14	16	14%	-3
20 to 40 ha	14	17	15	12	15	13	13	13%	-1
40 to 100 ha	9	9	10	12	13	14	11	14%	+2
100 to 500 ha	0	1	2	2	1	1	4	1%	+4
> 500 ha	-	-	-	-	-	-	-	-	-
Total properties	112	112	110	105	104	102	102	100%	-10
Average size (ha)	13	15	16	17	18	18	19		

Figure 92: Mildura river reach - property numbers and sizes from 1997 to 2018

3.7 Lock 10 to the South Australian Border

In summary for the Lock 10 to South Australia river reach

Crop types in 2018

Dominant plantings in the Lock 10 to SA river reach in 2018 were:

1. almond trees; 1,845 ha (58% of the irrigable area);
2. wine grapes; 670 ha (21% of the irrigable area); and
3. citrus; 125 ha (4% of the irrigable area).

Crop types 1997 to 2018

Almonds were the dominant crop from 1997 to 2018.

The main changes in crops from 1997 to 2018 were:

- almonds increased by 1,195 ha; a 184% increase from 650 ha to 1,845 ha;
- wine grapes increased by 380 ha; a 131% increase from 290 ha to 670 ha; and
- field crops decreased by 235 ha; a 98% decrease from 240 ha to 5 ha.

Development of permanent plantings (new or redeveloped in the previous three years)

In 2018, at least 470 ha (18%) of permanent crops were planted or redeveloped in the previous three years, predominantly:

1. almonds (385 ha);
2. wine grapes (75 ha); and
3. citrus (10 ha).

Development activity ranged from 10% of permanent plantings in 2006 to 33% in 2009.

Planting trends - permanent plantings, seasonal crops and vacant areas

In 2018, the irrigable area of 3,155 ha comprised:

- 84% (2,665 ha) irrigated permanent plantings;
- <1% (10 ha) irrigated seasonal crops; and
- 15% (480 ha) vacant, not irrigated areas.

From 1997 to 2018:

- permanent plantings increased from 66% to 84% of the irrigable area;
- seasonal crops decreased from 15% to <1% of the irrigable area; and
- vacant, not irrigated areas decreased from 20% to 15% of the irrigable area.

In summary for the Lock 10 to South Australia river reach

Irrigation development - new and retired areas

The irrigable area in the Lock 10 to SA river reach increased by 1,515 ha, a 92% increase from 1,640 ha in 1997 to 3,155 ha in 2018.

The net increase of 1,515 ha was the balance of 1,735 ha expansion and 220 ha retired from irrigation.

Irrigation methods

Drip irrigation was the dominant irrigation method in the Lock 10 to South Australia river reach from 2009 to 2018. Prior to 2009, lowlevel sprinklers were dominant from 1997 to 2003, and were equally dominant with drippers in 2006.

In 2018, the irrigable area of 3,155 ha comprised:

- 56% (1,775 ha) drip irrigation;
- 28% (895 ha) lowlevel irrigation;
- < 1% (5 ha) overhead sprinklers; and
- 15% (480 ha) not irrigated.

Salinity impact zones

The Lock 10 to South Australia river reach is in the lowest salinity impact zone, L1 and in the high salinity impact zone, HIZ. Irrigation development from 1997 to 2018 occurred predominantly in L1.

In 2018, the irrigable area of 3,155 ha comprised:

- 82% (2,585 ha) in L1; and
- 18% (570 ha) in HIZ.

From 1997 to 2018 the irrigable area in:

- L1 increased by 1,580 ha, a 157% increase from 1,005 ha to 2,585 ha; and
- HIZ decreased by 65 ha, a 10% decrease from 635 ha to 570 ha.

Irrigation properties

In 2018, there were approximately 20 irrigation properties with an average irrigable area of 158 ha.

From 1997 to 2018:

- the number of properties increased by 3; an 18% increase from 17 to 20 properties;
- properties with an irrigable area less than 20 ha decreased by 1, while the number over 20 ha increased by 4; and
- average property size (irrigable area) increased from 96 ha to 158 ha.

3.7.1 Lock 10 to South Australia - crop types in 2018

Map 22 shows the Lock 10 to South Australia river reach with crop types in in 2018.

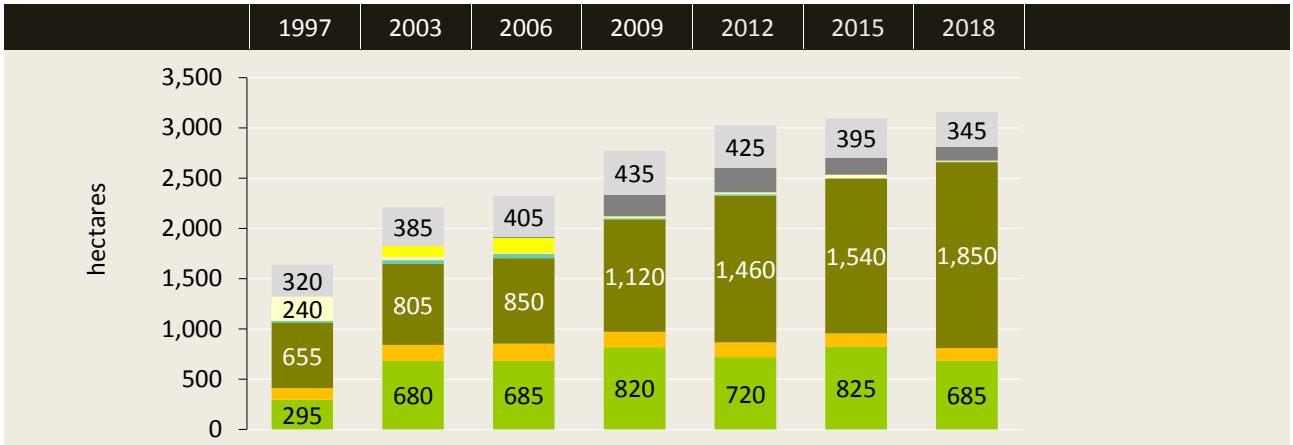
Map 22: Lock 10 to South Australia showing 2018 crop types

3.7.2 Lock 10 to South Australia - crop types from 1997 to 2018

Figure 93 summarises crop types in the Lock 10 to South Australia river reach from 1997 to 2018.

- Dominant plantings in 2018 were:
    1. almond trees; 1,845 ha (58% of the irrigable area);
    2. wine grapes; 670 ha (21% of the irrigable area); and
    3. citrus; 125 ha (4% of the irrigable area).

- Almond trees were the dominant crop from 1997 to 2018. Plantings increased by 1,195 ha; a 184% increase from 650 ha in 1997 to 1,845 ha in 2018.
- The second highest increase in plantings was 380 ha of wine grapes; a 131% increase from 290 ha in 1997 to 670 ha in 2018.



Crop type		1997	2003	2006	2009	2012	2015	2018	% of 2018 total	Change 1997-2018
Permanent	Grape Dried	5	0	5	0	15	20	15	<1%	+10
	Grape Table	-	-	-	-	-	-	-	-	-
	Grape Wine	290	680	680	820	705	805	670	21%	+380
	Citrus	115	160	170	150	145	130	125	4%	+10
	Fruit Olive	-	-	-	-	-	-	-	-	-
	Fruit Other	-	-	-	-	-	-	-	-	-
	Nut Almond	650	800	845	1,115	1,455	1,535	1,845	58%	+1,195
	Nut Other	5	5	5	5	5	5	5	<1%	0
	Other	15	40	40	10	15	5	5	<1%	-10
Seasonal	Field Crop	240	30	10	15	15	30	5	<1%	-235
	Veg. Carrot	-	-	-	-	-	-	-	-	-
	Veg. Potato	-	-	-	-	-	-	-	-	-
	Veg. Other	0	110	150	5	5	5	5	<1%	+5
	Vacant P	0	0	10	215	240	165	135	4%	+135
	Vacant S	320	385	405	435	425	395	345	11%	+25
Total (ha)		1,640	2,210	2,320	2,770	3,025	3,095	3,155	100%	+1,515
Dominant		almond	almond	almond	almond	almond	almond	almond		

Figure 93: Lock 10 to South Australia - crop types from 1997 to 2018

3.7.3 Lock 10 to South Australia - development of permanent crops

Figure 94 shows the proportion of permanent crops planted or redeveloped, in the previous three years, in the Lock 10 to South Australia river reach from 1997 to 2018.

The information provides an indication of development activity that is otherwise not evident in information on changes in areas and crop types, as it includes replanting and top working to different varieties. The figures are conservative, as top-worked plantings can be difficult to interpret from the three-yearly aerial imagery, particularly for grapevines.

- In 2018, at least 470 ha (18%) of permanent crops were planted or redeveloped in the previous three years:
    1. almonds (385 ha);
    2. wine grapes (75 ha); and
    3. citrus (10 ha).

- The area of new or redeveloped permanent plantings was highest in 2009 with 695 ha (33%) planted in the previous three years (predominantly almond trees).

- New or redeveloped permanent plantings were lowest in 2006 with 170 ha (10%) planted in the previous three years.

Permanent plantings	1997	2003	2006	2009	2012	2015	2018	% of 2018 total
≤3yr old plantings	340	235	170	695	425	335	470	18%
>3yr old plantings	740	1,450	1,575	1,405	1,915	2,165	2,195	82%
Total (ha)	1,080	1,685	1,745	2,100	2,340	2,500	2,665	100%
% 3year development	31%	14%	10%	33%	18%	13%	18%	

Figure 94: Lock 10 to South Australia river reach - development of permanent crops 1997 to 2018

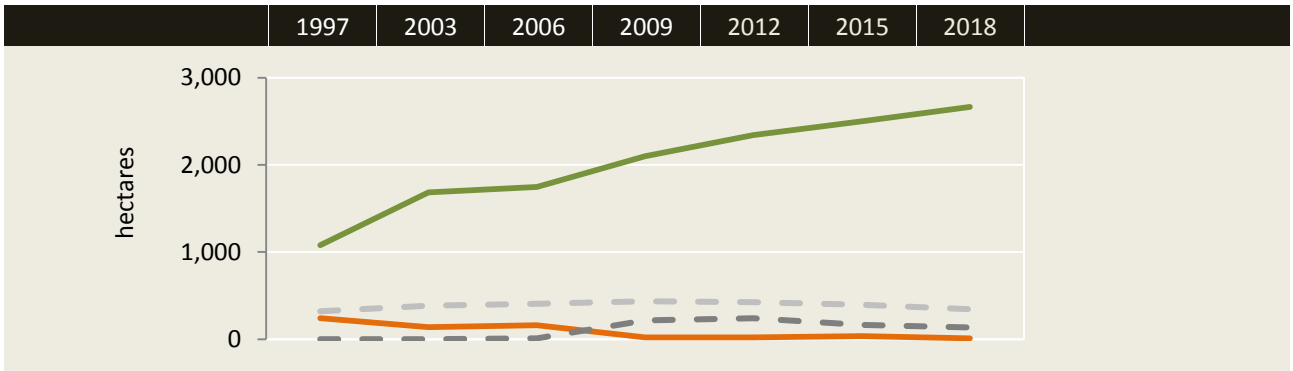
3.7.4 Lock 10 to South Australia - planting trends

Figure 95 summarises planting trends in the Lock 10 to South Australia river reach from 1997 to 2018.

- In 2018, the irrigable area of 3,155 ha comprised:
  - 84% (2,665 ha) irrigated permanent plantings;
  - <1% (10 ha) irrigated seasonal crops; and
  - 15% (480 ha) vacant, not irrigated areas.

The proportion of permanent plantings, seasonal cropping and vacant areas changed from:
  - 66% permanent, 15% seasonal and 20% vacant in 1997; to
  - 84% permanent, <1% seasonal and 15% vacant in 2018.

- From 1997 to 2018:
  - irrigated permanent crops increased by 1,585 ha;
  - irrigated seasonal crops decreased by 230 ha;
  - vacant, not irrigated areas increased by 160 ha; and
  - the irrigable area increased by 1,515 ha a 92% increase from 1,640 ha to 3,155 ha.



	1997	2003	2006	2009	2012	2015	2018	% of 2018 total	Change 1997-2018
Permanent - irrigated	1,080	1,685	1,745	2,100	2,340	2,500	2,665	84%	+1,585
Seasonal - irrigated	240	140	160	20	20	35	10	<1%	-230
Vacant - permanent	0	0	10	215	240	165	135	4%	+135
Vacant - seasonal	320	385	405	435	425	395	345	11%	+25
Total (ha)	1,640	2,210	2,320	2,770	3,025	3,095	3,155	100%	+1,515
% Permanent	66%	76%	75%	76%	77%	81%	84%		
% Seasonal	15%	6%	7%	1%	1%	1%	<1%		
% Vacant	20%	17%	18%	23%	22%	18%	15%		

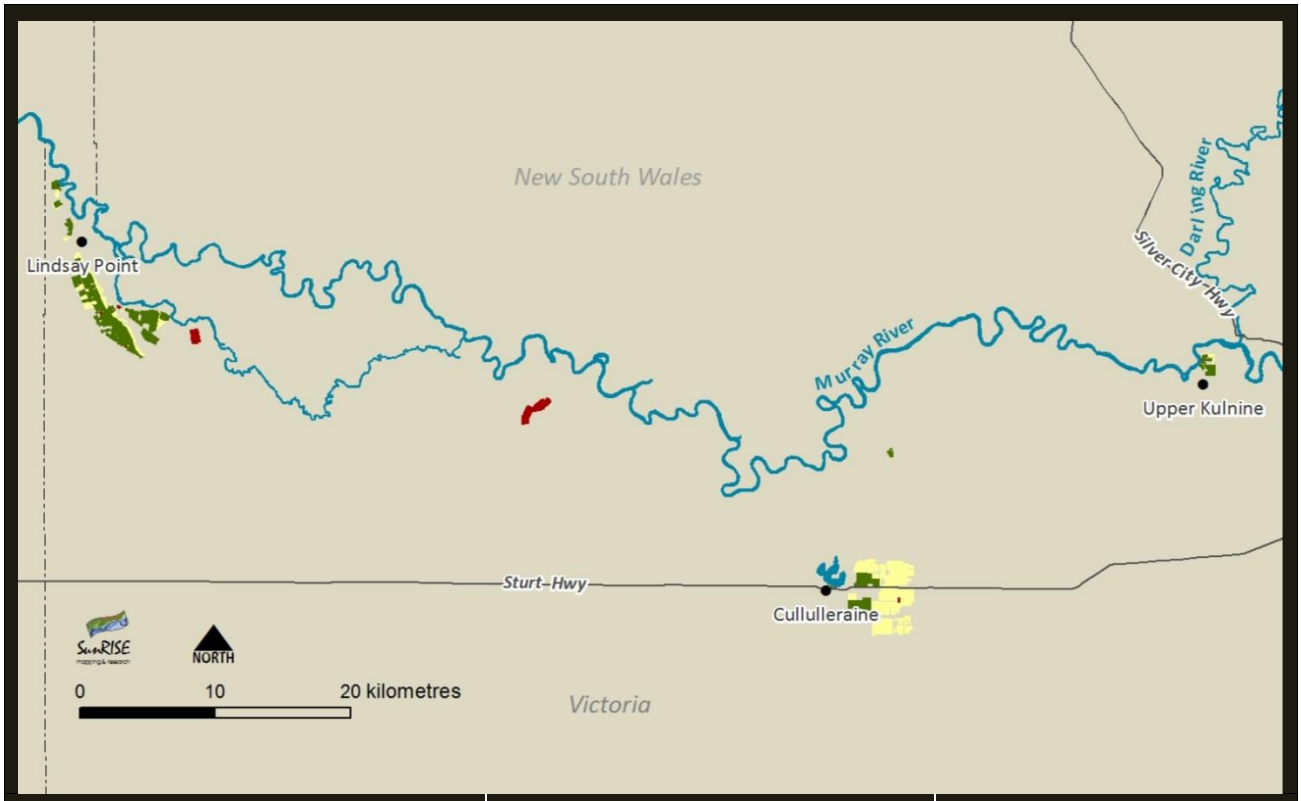
Figure 95: Lock 10 to South Australia river reach - planting trends from 1997 to 2018

3.7.5 Lock 10 to South Australia - irrigation development

Map 23 shows irrigation development in the Lock 10 to South Australia river reach with respect to new development (expansion) and areas retired[40] from irrigation from 1997 to 2018.

- The irrigable area increased by 1,515 ha, a 92% increase from 1,640 ha in 1997 to 3,155 ha in 2018.
- The net increase of 1,515 ha comprised 220 ha retired from irrigation and 1,735 ha of expansion.

Map 23: Lock 10 to South Australia - irrigation development from 1997 to 2018



	Hectares		% of 1997
Irrigation areas in 1997 (1996-97 season)	1,640		
Retired between 1997 and 2018	-220		-13%
Expansion between 1997 and 2018	+1,735		+106%
Irrigation areas in 2018 (2017-18 season)	3,155		

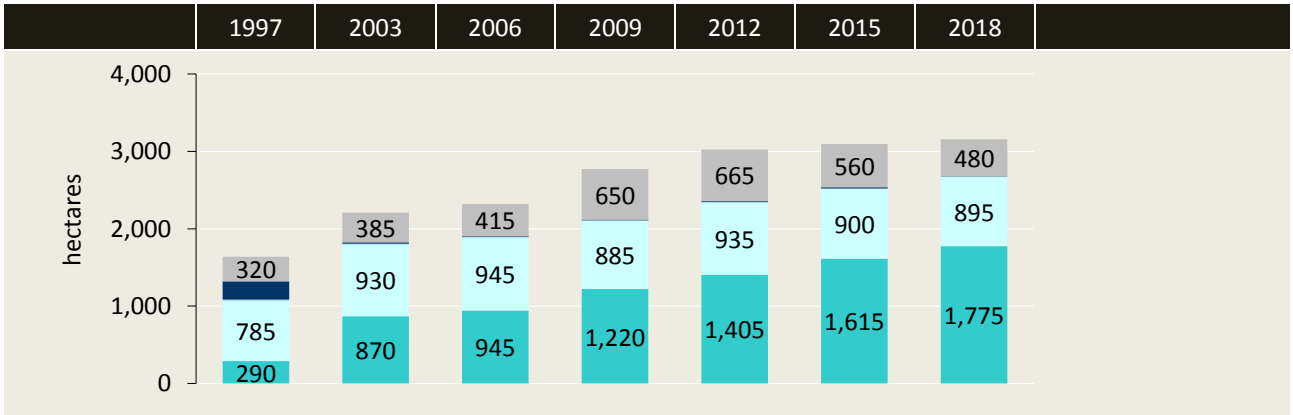
[40] Retired areas were previously irrigated but have undergone a change in land use that precludes use for irrigation e.g. urban development, housing, sheds, dams and land set aside for conservation purposes.

3.7.6 Lock 10 to South Australia - irrigation methods

Figure 96 summarises irrigation methods in the Lock 10 to South Australia river reach from 1997 to 2018.

- In 2018, the irrigable area of 3,155 ha comprised:
  - 56% (1,775 ha) drip irrigation;
  - 28% (895 ha) lowlevel irrigation;
  - < 1% (5 ha) overhead sprinklers; and
  - 15% (480 ha) not irrigated.

- Drip irrigation increased by 1,485 ha, a 512% increase from 290 ha in 1997 to 1,775 ha in 2018.
  - Drip irrigation was the dominant irrigation method from 2009 to 2018.
  - Drip and lowlevel irrigation were the dominant methods in 2006.
- Lowlevel irrigation increased by 110 ha, a 14% increase from 785 ha in 1997 to 895 ha in 2018.
  - Lowlevel irrigation was the dominant method from 1997 to 2003.
- Overhead irrigation decreased by 10 ha, a 67% decrease from 15 ha in 1997 to 5 ha in 2018.
- Furrow irrigation decreased by 230 ha, a 100% decrease from 230 ha in 1997 to 0 ha in 2018.



Irrigation method[41]	1997	2003	2006	2009	2012	2015	2018	% of 2018 total	Change 1997-2018
Drip	290	870	945	1,220	1,405	1,615	1,775	56%	+1,485
Lowlevel	785	930	945	885	935	900	895	28%	+110
Overhead	15	10	5	5	10	10	5	<1%	-10
Furrow	230	15	10	10	10	10	0	0%	-230
Vacant	320	385	415	650	665	560	480	15%	+160
Total (ha)	1,640	2,210	2,320	2,770	3,025	3,095	3,155	100%	+1,515
Dominant	lowlevel	lowlevel	lowlevel & drip	drip	drip	drip	drip		

Figure 96: Lock 10 to South Australia - irrigation methods from 1997 to 2018

[41] Overhead irrigation includes pivots and lateral move systems. Furrow includes flood irrigation. (Table 5)

3.7.7 Lock 10 to South Australia - salinity impact zones

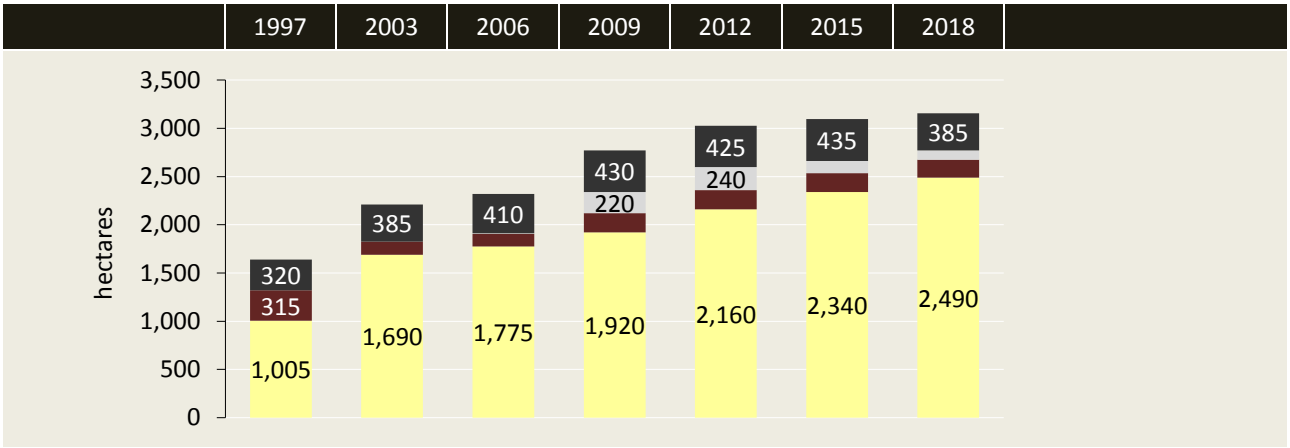
Figure 97 summarises river salinity impact zones of irrigated areas in the Lock 10 to South Australia river reach from 1997 to 2018.

- In 2018, the irrigable area of 3,155 ha comprised:
  - 82% (2,585 ha) in the lowest salinity impact zone, L1; and
  - 18% (570 ha) in the high salinity impact zone, HIZ.

- The area irrigated in:
  - L1 increased by 1,485 ha, a 148% increase from 1,005 ha in 1997 to 2,490 ha in 2018; and
  - HIZ decreased by 130 ha, a 41% decrease from 315 ha in 1997 to 185 ha in 2018.

- The irrigable area in:
  - L1 increased by 1,580 ha, a 157% increase from 1,005 ha in 1997 to 2,585 ha in 2018; and
  - HIZ decreased by 65 ha, a 10% decrease from 635 ha in 1997 to 570 ha in 2018.

- Irrigation development from 1997 to 2018 predominantly occurred in L1.



Salinity impact zone		1997	2003	2006	2009	2012	2015	2018	% of 2018 total	Change (ha) 1997-2018
Irrigated	L1	1,005	1,690	1,775	1,920	2,160	2,340	2,490	79%	+1,485
	L2	-	-	-	-	-	-	-	-	-
	L3	-	-	-	-	-	-	-	-	-
	L4	-	-	-	-	-	-	-	-	-
	HIZ	315	135	130	200	200	195	185	6%	-130
Not Irrigated	L1	0	0	5	220	240	125	95	3%	+95
	L2	-	-	-	-	-	-	-	-	-
	L3	-	-	-	-	-	-	-	-	-
	L4	-	-	-	-	-	-	-	-	-
	HIZ	320	385	410	430	425	435	385	12%	+65
Total (ha)		1,640	2,210	2,320	2,770	3,025	3,095	3,155	100%	+1,515
Dominant zone		L1	L1	L1	L1	L1	L1	L1		

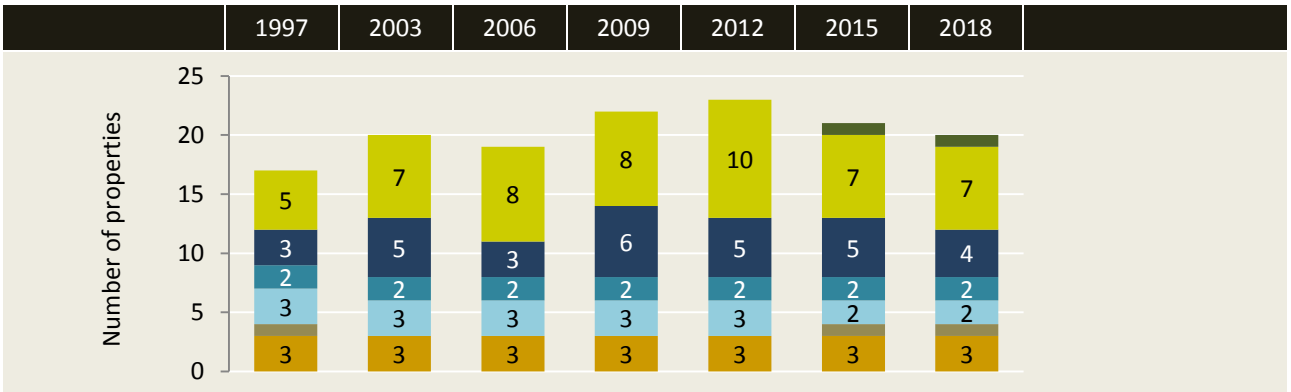
Figure 97: Lock 10 to South Australia - irrigable area in each salinity impact zone from 1997 to 2018

3.7.8 Lock 10 to South Australia - property change

Figure 98 provides estimates of property numbers and average property size (irrigable area) in the Lock 10 to South Australia river reach from 1997 to 2018.

- In 2018:
  - there were approximately 20 irrigation properties; and
  - most properties (70%) had an irrigable area over 20 ha.

- From 1997 to 2018:
  - the number of properties increased by 3; an 18% increase from 17 properties in 1997 to 20 in 2018;
  - properties with an irrigable area less than 20 ha decreased by 1, while the number over 20 ha increased by 4; and
  - average property size (irrigable area) increased from 96 ha in 1997 to 158 ha in 2018.



Property size (irrigable area)	1997	2003	2006	2009	2012	2015	2018	% of 2018 total	Change 1997-2018
1 to 5 ha	3	3	3	3	3	3	3	15%	0
5 to 10 ha	1	0	0	0	0	1	1	5%	0
10 to 20 ha	3	3	3	3	3	2	2	10%	-1
20 to 40 ha	2	2	2	2	2	2	2	10%	0
40 to 100 ha	3	5	3	6	5	5	4	20%	+1
100 to 500 ha	5	7	8	8	10	7	7	35%	+2
> 500 ha	0	0	0	0	0	1	1	5%	+1
Total properties	17	20	19	22	23	21	20	100%	+3
Average size (ha)	96	111	122	126	132	147	158		

Figure 98: Lock 10 to South Australia - property numbers and sizes from 1997 to 2018

4. Murrayville GMA

In summary for the Murrayville Groundwater Management Area

Limitations of the information

Irrigated crops in the Murrayville GMA were mapped from a limited series of aerial imagery and information in this section should be treated as estimates only.

Unlike permanent plantings, it is difficult to accurately determine irrigation activity for seasonal crops, such as potatoes and cereal crops, from aerial imagery with only one snapshot of the season. As 98% of irrigated crops in the Murrayville Groundwater Management Area (GMA) were seasonal, accuracy of the information is limited.

No imagery was available for 1997; however, information from the *Murrayville Area Groundwater Management Plan 2001* assisted with estimates.

Crop types

Potatoes were the dominant irrigated crop in the Murrayville GMA from 1997 to 2018.

Dominant plantings in 2018 were:

1. potatoes; 1,670 ha (70% of the irrigable area);
2. field crops; 660 ha (28% of the irrigable area); and
3. olives; 45 ha (2% of the irrigable area).

The main changes in crops from 1997 to 2018 were:

- potatoes increased by 1,155 ha; a 224% increase from 515 ha to 1,670 ha; and
- olives increased by 15 ha; a 50% increase from 30 ha to 45 ha.

Irrigation methods

Pivots were the dominant irrigation method from 1997 to 2018.

In 2018, the irrigated area of 2,375 ha comprised:

- 2% (45 ha) drip irrigation; and
- 98% (2,330 ha) pivot irrigation.

Irrigation properties

In 2018, there were approximately 13 irrigation properties with an average irrigable area of 183 ha.

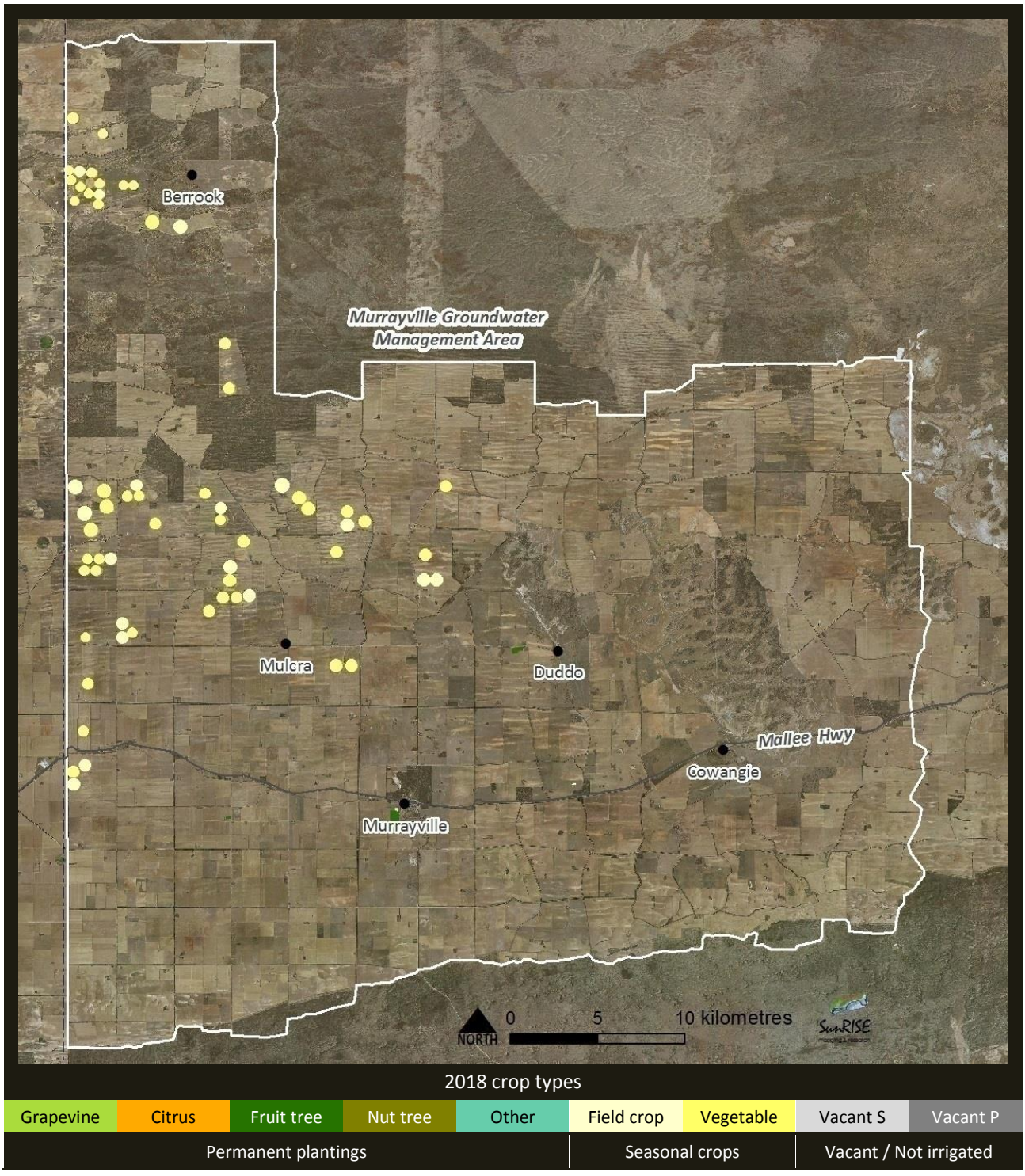
Estimates from 1997 to 2018:

- the number of properties increased by 6; an 86% increase from 7 to 13 properties;
- properties with an irrigable area less than 20 ha increased by 1, while the number over 20 ha increased by 5; and
- average property size (irrigable area) increased from 84 ha to 183 ha.

4.1.1 Murrayville GMA - crop types in 2018

Map 24 shows the Murrayville Groundwater Management Area (GMA) with crop types in in 2018.

- In 2018, the irrigable area of 2,375 ha comprised:
  - 2% (45 ha) irrigated permanent plantings; and
  - 98% (2,330 ha) irrigated seasonal crops.



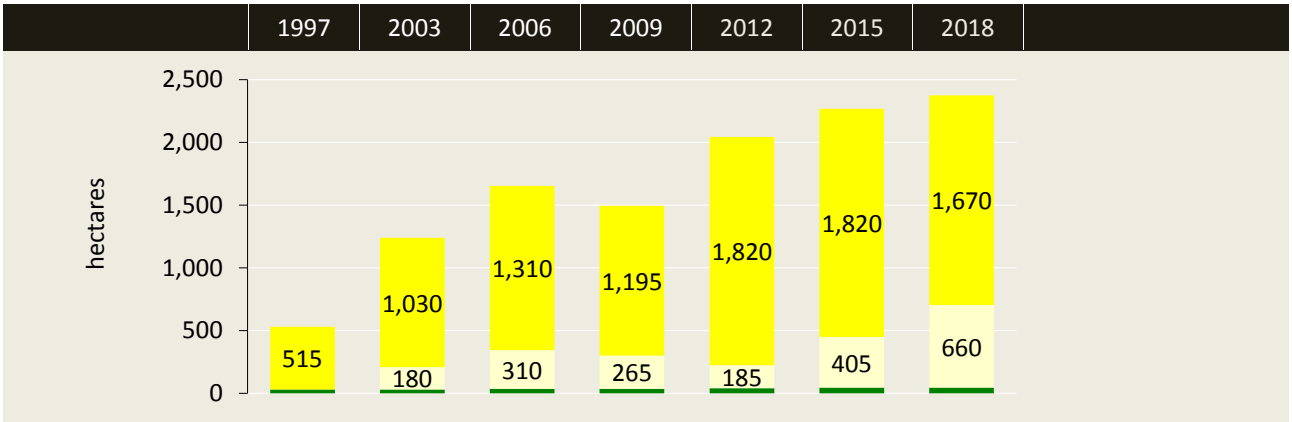
Map 24: Murrayville GMA showing 2018 crop types

4.1.2 Murrayville GMA - crop types from 1997 to 2018

Figure 99 summarises crop types in the Murrayville GMA from 1997 to 2018.

- Plantings in 2018 were:
  - potatoes: 1,670 ha (70% of the irrigable area);
  - field crops: 660 ha (28% of the irrigable area); and
  - olive trees: 45 ha (2% of the irrigable area).

- Potatoes were the dominant crop from 1997 to 2018. Plantings increased by 1,155 ha, a 224% increase from 515 ha in 1997 to 1,670 ha in 2018.



Crop type		1997	2003	2006	2009	2012	2015	2018	% of 2018 total	Change 1997-2018
Permanent	Grape Dried	-	-	-	-	-	-	-	-	-
	Grape Table	-	-	-	-	-	-	-	-	-
	Grape Wine	-	-	-	-	-	-	-	-	-
	Citrus	-	-	-	-	-	-	-	-	-
	Fruit Olive	30	30	35	35	40	45	45	2%	+15
	Fruit Other	-	-	-	-	-	-	-	-	-
	Nut Almond	-	-	-	-	-	-	-	-	-
	Nut Other	-	-	-	-	-	-	-	-	-
	Other	-	-	-	-	-	-	-	-	-
Seasonal	Field Crop	40	180	310	265	185	405	660	28%	+620
	Veg. Carrot	-	-	-	-	-	-	-	-	-
	Veg. Potato	515	1,030	1,310	1,195	1,820	1,820	1,670	70%	+1,155
	Veg. Other	-	-	-	-	-	-	-	-	-
	Vacant P	-	-	-	-	-	-	-	-	-
	Vacant S	-	-	-	-	-	-	-	-	-
Total (ha)		585	1,240	1,655	1,495	2,045	2,270	2,375	100%	+1,790
Dominant		potato	potato	potato	potato	potato	potato	potato		

Figure 99: Murrayville GMA - crop types from 1997 to 2018

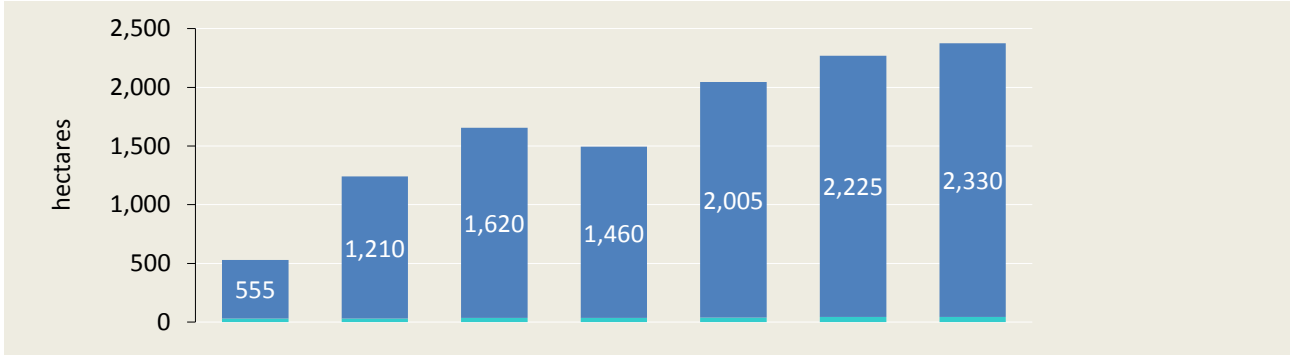
4.1.3 Murrayville GMA - irrigation methods

Figure 100 summarises irrigation methods in the Murrayville GMA from 1997 to 2018.

- In 2018, the irrigated area of 2,375 ha comprised:
  - 2% (45 ha) drip irrigation; and
  - 98% (2,330 ha) pivot irrigation.

- Drip irrigation increased by 15 ha, a 50% increase from 30 ha in 1997 to 45 ha in 2018.

- Pivot irrigation increased by 1,775 ha, a 320% increase from 555 ha in 1997 to 2,330 ha in 2018.
  - Pivot irrigation was the dominant irrigation method from 1997 to 2018.



Irrigation method[42]	1997	2003	2006	2009	2012	2015	2018	% of 2018 total	Change 1997-2018
Drip	30	30	35	35	40	45	45	2%	+15
Lowlevel	-	-	-	-	-	-	-	-	-
Overhead	555	1,210	1,620	1,460	2,005	2,225	2,330	98%	+1,775
Furrow	-	-	-	-	-	-	-	-	-
Vacant	-	-	-	-	-	-	-	-	-
Total (ha)	585	1,240	1,655	1,495	2,045	2,270	2,375	100%	+1,790
Dominant	pivot	pivot	pivot	pivot	pivot	pivot	pivot		

Figure 100: Murrayville GMA - irrigation methods from 1997 to 2018

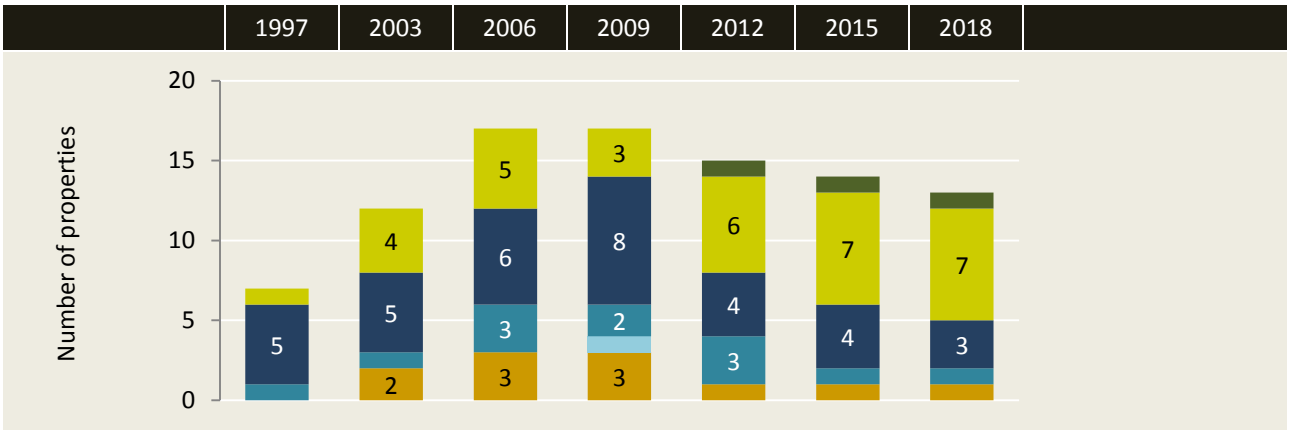
[42] Overhead irrigation includes pivots and lateral move systems. Furrow includes flood irrigation. (Table 5)

4.1.4 Murrayville GMA - property change

Figure 101 provides estimates of property numbers and average property size (irrigable area) in the Murrayville GMA from 1997 to 2018.

- In 2018:
  - there were approximately 13 irrigation properties; and
  - most properties (92%) had an irrigable area greater than 20 ha.

- From 1997 to 2018:
  - the number of properties increased by 6; from 7 properties in 1997 to 13 in 2018;
  - properties with an irrigable area less than 20 ha increased by 1, while the number over 20 ha increased by 5; and
  - average property size (irrigable area) increased from 84 ha in 1997 to 183 ha in 2018.



Property size (irrigable area)	1997	2003	2006	2009	2012	2015	2018	% of 2018 total	Change 1997-2018
1 to 5 ha	0	2	3	3	1	1	1	8%	+1
5 to 10 ha	-	-	-	-	-	-	-	-	-
10 to 20 ha	0	0	0	1	0	0	0	0%	0
20 to 40 ha	1	1	3	2	3	1	1	8%	0
40 to 100 ha	5	5	6	8	4	4	3	23%	-2
100 to 500 ha	1	4	5	3	6	7	7	54%	+6
> 500 ha	0	0	0	0	1	1	1	8%	+1
Total properties	7	12	17	17	15	14	13	100%	+6
Average size (ha)	84	103	97	88	136	162	183		

Figure 101: Murrayville GMA – estimate of property numbers and sizes from 1997 to 2018

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SunRISE Mapping and Research have prepared this report in consultation with individuals and regional organisations. Information contained herein is based on data and information from a range of sources. Whilst SunRISE Mapping and Research has endeavoured to correctly interpret, analyse and present the information, SunRISE Mapping and Research does not warrant that this report is definitive nor free of error and does not accept liability for any loss caused or arising from use of or reliance upon information contained herein.

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