Hydrological and nutrient modelling of the Peel–Harvey estuary catchment

Appendices (A–F)

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Appendix A: Hydrological calibration

A.1 Testing different hydrological models

We tested the following hydrological models in this project:

- GR4J (Perrin et al. 2003)
- LASCAM (Large Scale Catchment Model, Viney et al 2000)
- IHACRES (Jakeman et al. 1990)
- SYMHYD with routing (Chiew et al. 2002)

We tested these models for the period of 2000 to 2015 in cleared catchments in the Peel-Harvey catchment and the urban Bartram Road catchment (north of the model domain). We selected models with the best calibration performance (see Section 4.1 for calibration criteria) relative to their model run-times.

See Table A.1 for the calibration statistics for the models that we tested. Models with the best calibration statistics at each gauge are bold in this table. The GR4J model performed the best in most cleared catchments and was selected to represent cleared functional units. SYMHYD with routing was slightly better than GR4J in the urban catchment that was tested and was selected to represent urban functional units. GR4J was selected to represent vegetated functional units given its good performance in all other model testing.

Table A.1: Calibration result from hydrological model testing

Hydrology functional unit	Gauge	Model name	Daily NSE	Monthly NSE	Annual NSE	Mass balance error
Cleared	Dog Hill (614030)	GR4J	**0.90**	**0.93**	**0.92**	**4%**
		LASCAM	0.83	0.92	0.74	-8%
		IHACRES	0.85	0.91	0.76	-8%
	Yangedi Swamp (614094)	GR4J	**0.84**	0.83	0.55	**-4%**
		LASCAM	0.82	**0.87**	**0.64**	**-4%**
		IHACRES	0.78	0.85	0.58	-3%
	Lowlands (614114)	GR4J	**0.84**	**0.91**	0.79	**0%**
		LASCAM	0.81	0.88	0.81	-4%
		IHACRES	0.78	0.90	**0.82**	-7%
	Kielman (614063)	GR4J	**0.87**	**0.94**	**0.94**	7%
		LASCAM	0.77	0.88	0.79	**-3%**
		IHACRES	0.75	0.86	0.78	-4%
Urban	Bartram road (614083)	SYMHYD with routing	**0.84**	**0.88**	**0.80**	**0%**
		GR4J	0.83	0.87	0.71	4%

A.2 Overall performance of the catchment model

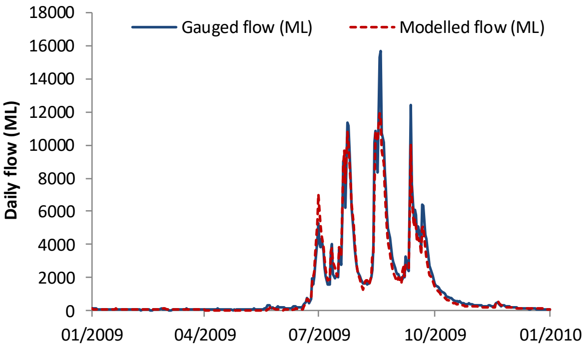
We have summarised the overall performance of the catchment model by summing the following end-of-catchment measured and modelled flows: 614030, 614121, 614094, 614120, 614063, 614065, 613027, 613031, 613052. For the days with without measured flow at a gauge we excluded modelled flows at the same gauge.

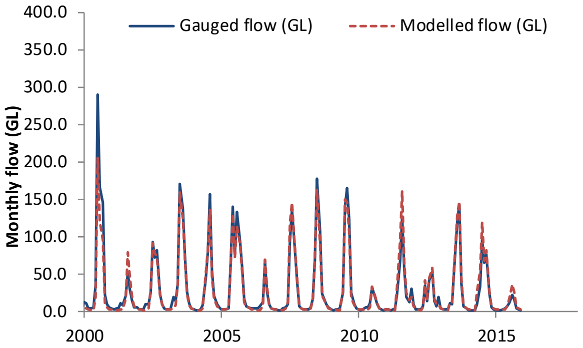
Figure A.1: Flow measurement sites used to summarise the overall performance of the hydrological model

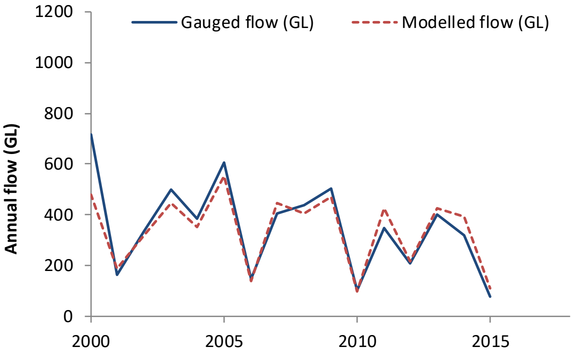
Sum of flow sites at the end of estuary catchments

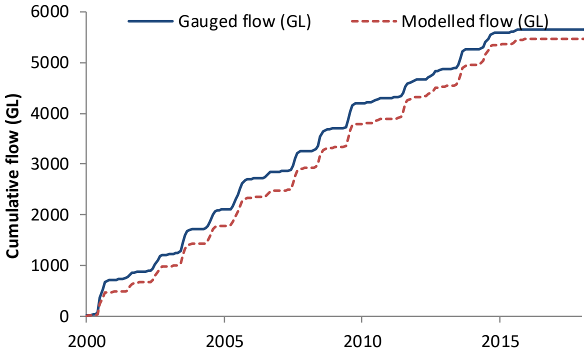
Statistic	Calibration	Validation
	2000–15	*0*
Daily NSE	0.93	0.88
Monthly NSE	0.95	0.89
Annual NSE	0.84	0.70
Mass balance error	-4%	-29%

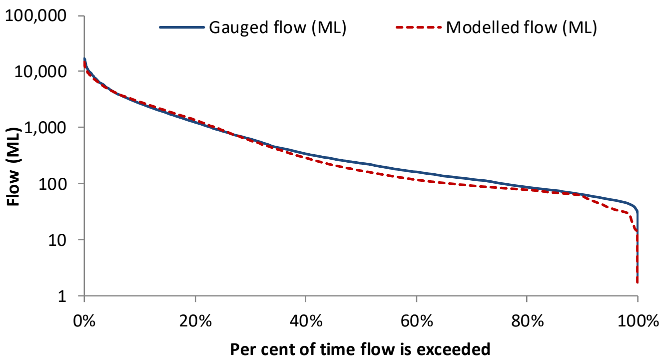
Daily flow statistic	Calibration Gauged (ML)	Calibration Modelled (ML)	Validation Gauged (ML)	Validation Modelled (ML)
Min	28	14	0	1
Percentile:				
5th	52	37	10	5
10th	64	60	37	18
20th	86	77	67	45
50th	231	170	175	110
75th	864	903	916	596
Max	17 222	14 173	30 832	21 330











A.3 Urban catchments source model

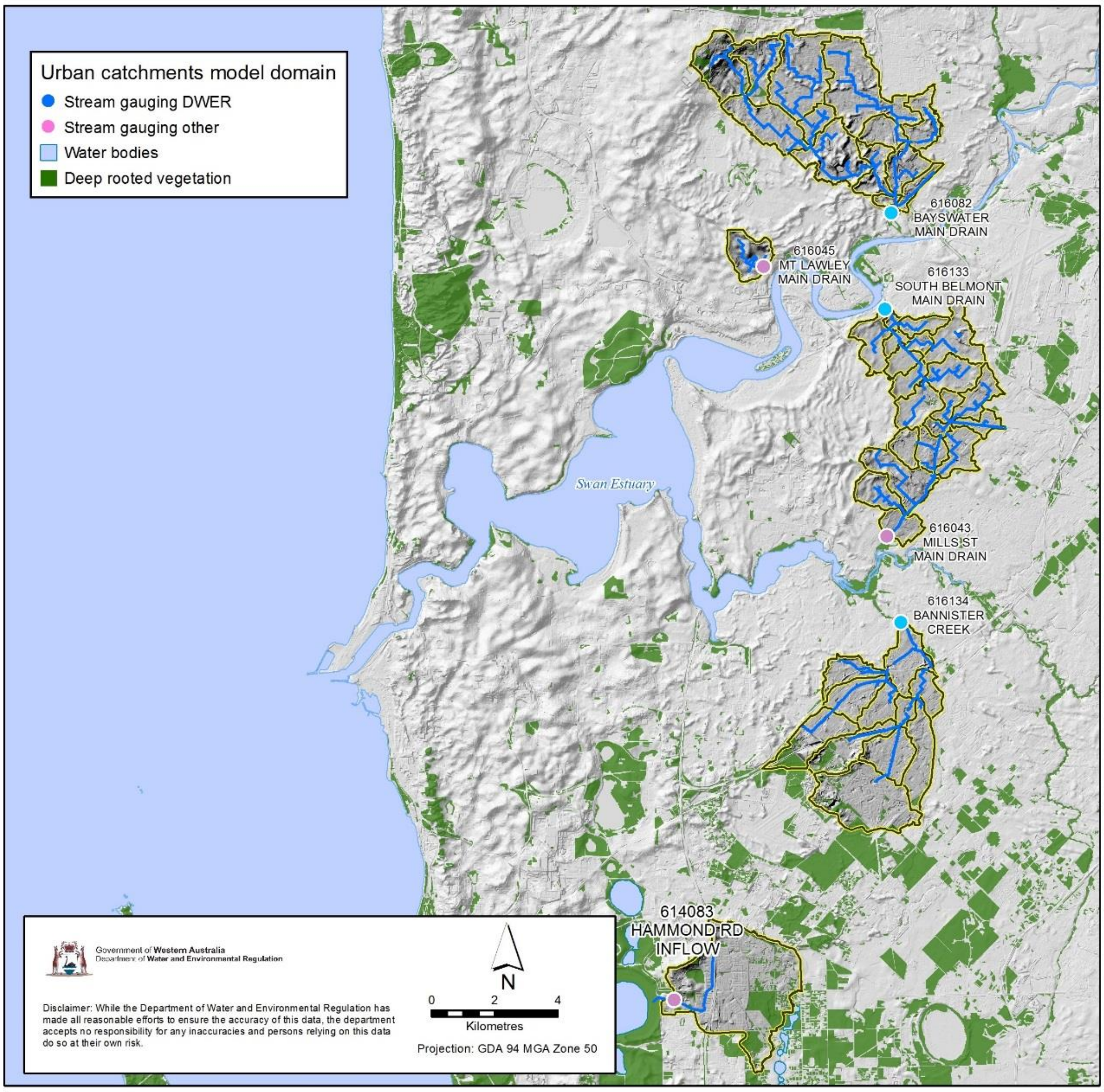


Table A.2: Urban model catchments and flow calibration gauges

Source version and plugins: Public 3.7.1 No plugins

Rainfall-runoff model: SYMHYD with routing

Link model: Straight through routing

Climate data: Daily AWAP rainfall and FAO56 PET (derived from AWAP data) at catchment centroids

Additional boundaries: None

Calibration period: 1985 to 2015

Validation period: No validation

Objective function: Daily NSE with bias penalty

Calibration description: All catchments were assumed to be 100% urban with a single functional unit. Unique SYMHYD parameters were calibrated for each gauge. Runoff coefficients for the urban catchments range from 22 to 40%. The Bannister Creek catchment achieved the highest NSE and exhibits typical hydrograph behaviour for urban catchments on the Swan Coastal Plain, with responsive peaks from individual rainfall events, a baseflow contribution from groundwater, and a runoff coefficient of 35%. Calibrated parameters from Bannister Creek were assigned to urban functional units in the Peel Harvey model domain. Note that the gauge used in the Bartram Road catchment (614083) was only used for model testing and was not considered when selecting urban model parameters.

Rainfall-runoff parameters:

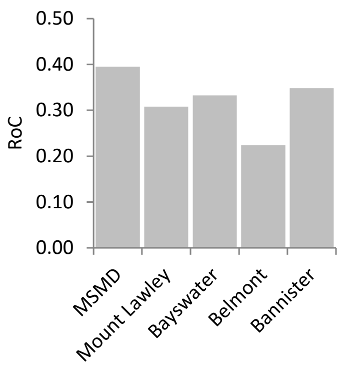
Simhyd with routing

Subcatchment	Function unit	Impervious Threshold (mm)	RISC (mm)	Perv. Fraction	SMSC (mm)	Infiltration shape	Infiltration Coeff.	Interflow Coeff.	Recharge coefficient	Baseflow coeff.
South Belmont	Urban	2.308	3.641	0.872	499.997	3.591	300.963	0.101	0.661	0.020
Mill Street	Urban	0.043	3.252	0.798	375.216	1862	304.439	0.140	0.988	0.021
Bannister	Urban	0.120	2.268	0.816	494.089	1762	359.193	0.070	0.995	0.025
Bayswater	Urban	1442	0.500	0.913	305.585	1209	311649	0.082	1000	0.011
Mount Lawley	Urban	0.003	3.562	0.893	286.184	1478	192.017	0.003	0.830	0.003

Link parameters: None

Runoff coefficients: Modelled runoff coefficients for model domain

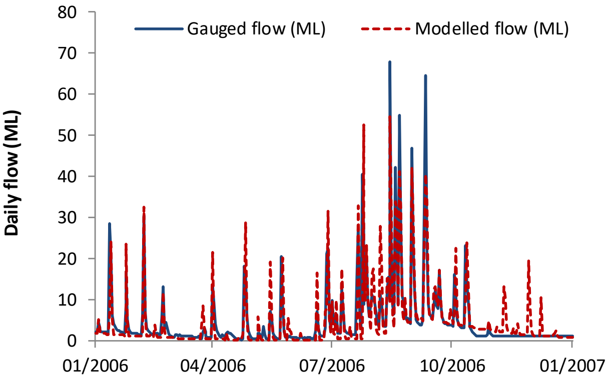
Catchment	MSMD	Mount Lawley	Bayswater	Belmont	Bannister
Period	Urban	Urban	Urban	Urban	Urban
All years	0.41	0.33	0.35	0.24	0.36
1980-1999	0.42	0.34	0.37	0.24	0.38
2000-2015	0.40	0.31	0.33	0.22	0.35

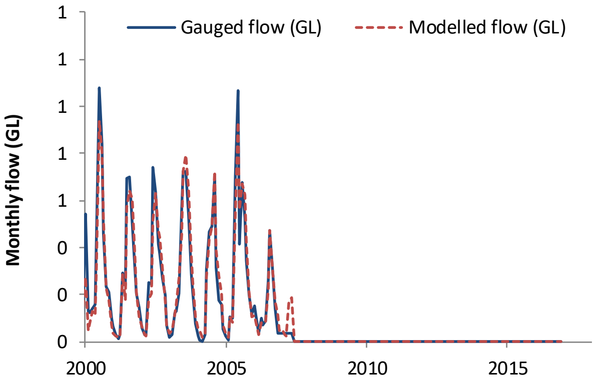


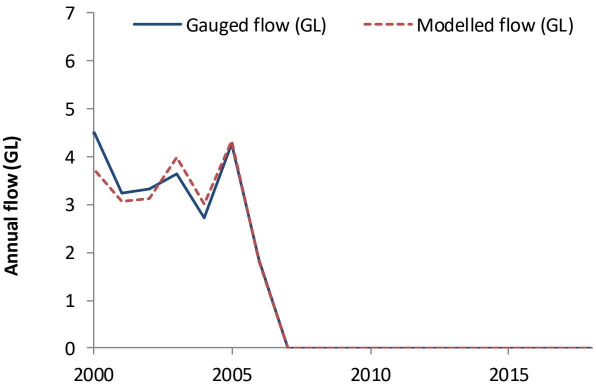
Mills Street Main Drain – Palm Place - 616043

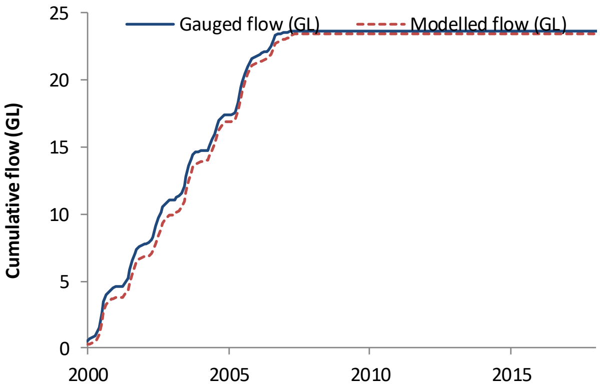
Statistic	Calibration *2000–06*	Validation *1984–99*
Daily NSE	0.79	0.79
Monthly NSE	0.93	0.88
Annual NSE	0.89	0.31
Mass balance error	-2%	-14%

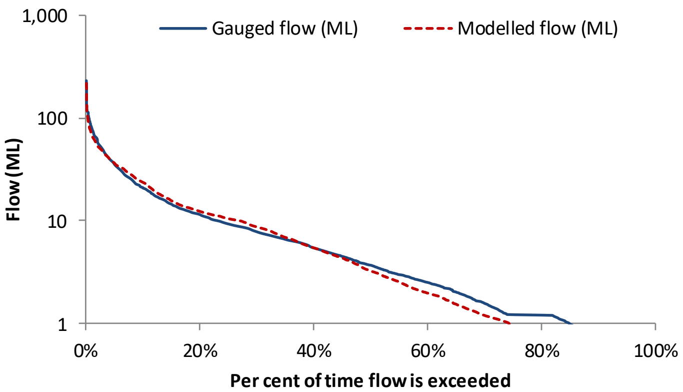
Daily flow statistic	Calibration Gauged (ML)	Calibration Modelled (ML)	Validation Gauged (ML)	Validation Modelled (ML)
Min	0	0	0	0
Percentile:				
5th	0	0	2	0
10th	1	0	2	0
20th	1	1	3	1
50th	4	3	7	5
75th	9	10	14	13
Max	229	200	235	223







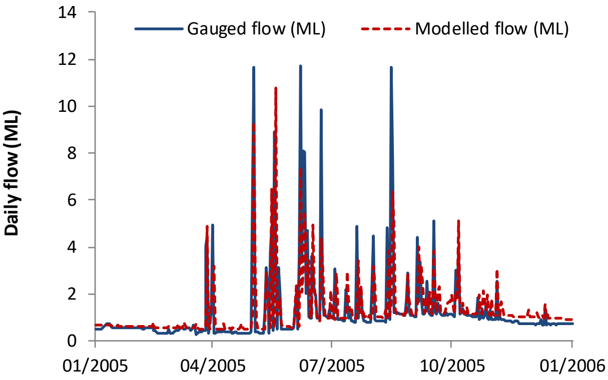


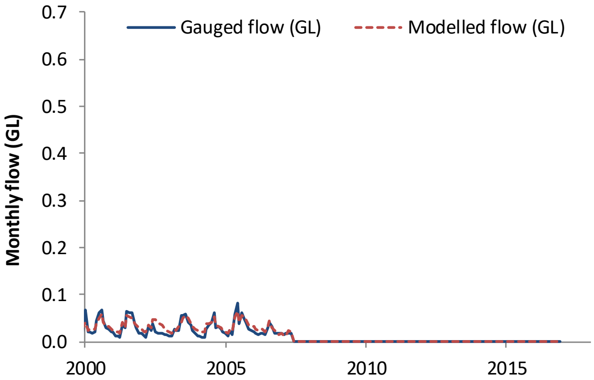


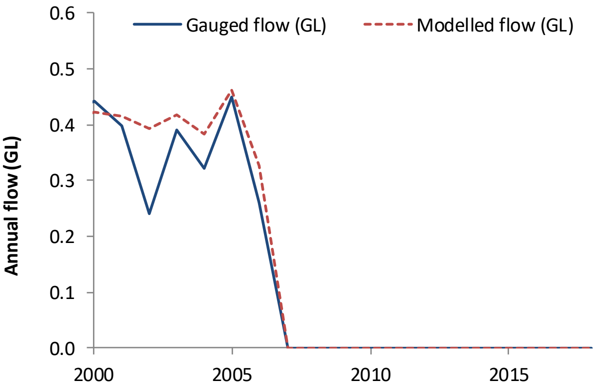
Mount Lawley Main Drain – Mount Lawley - 616045

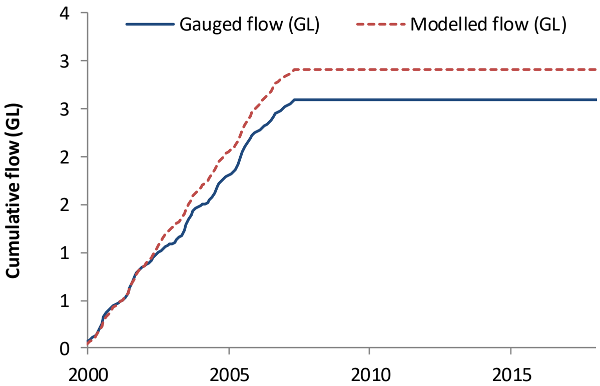
Statistic	Calibration *2000–06*	Validation *1985–99*
Daily NSE	0.29	0.14
Monthly NSE	0.76	0.09
Annual NSE	0.37	-0.39
Mass balance error	13%	5%

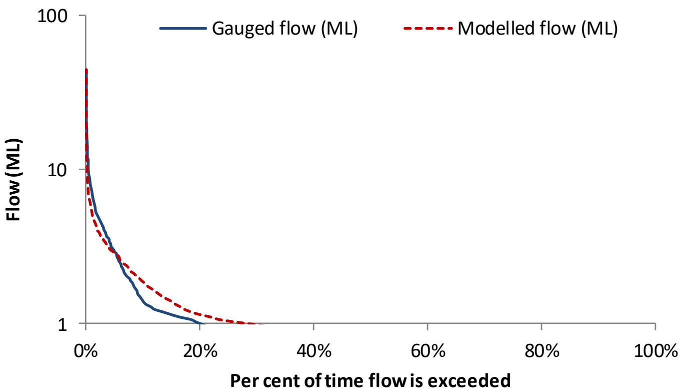
Daily flow statistic	Calibration Gauged (ML)	Calibration Modelled (ML)	Validation Gauged (ML)	Validation Modelled (ML)
Min	0	0	0	0
Percentile:				
5th	0	0	0	1
10th	0	1	0	1
20th	0	1	0	1
50th	1	1	1	1
75th	1	1	1	1
Max	45	17	57	21







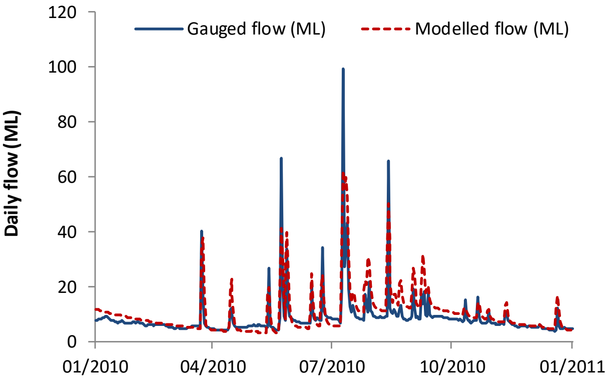


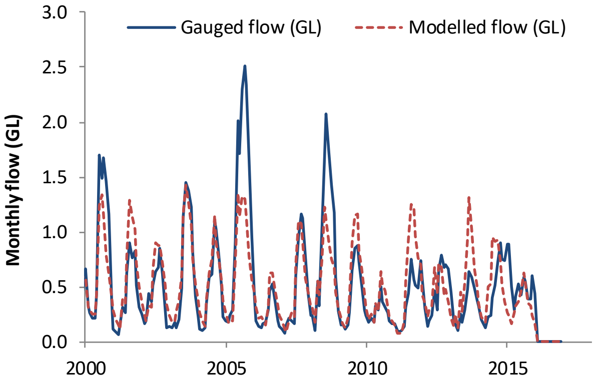


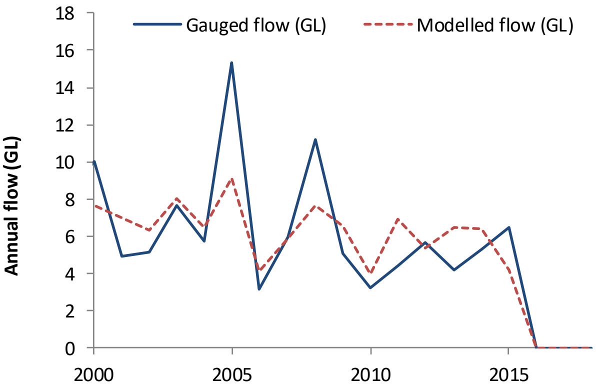
Bayswater Main Drain – Slade Street – 616082

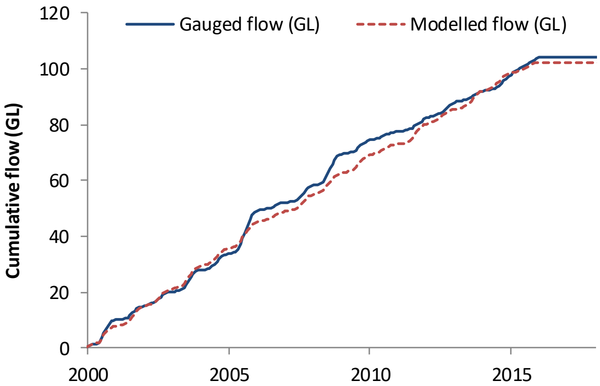
Statistic	Calibration *2000–15*	Validation *1988–99*
Daily NSE	0.61	0.65
Monthly NSE	0.64	0.75
Annual NSE	0.48	0.41
Mass balance error	-1%	0%

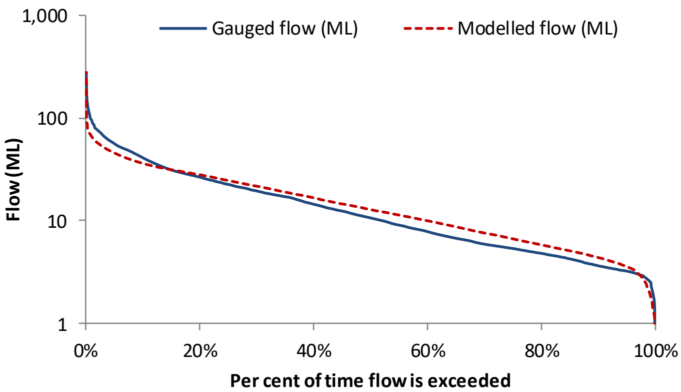
Daily flow statistic	Calibration		Validation	
	Gauged (ML)	Modelled (ML)	Gauged (ML)	Modelled (ML)
Min	1	1	1	3
Percentile:				
5th	3	4	3	4
10th	4	4	4	5
20th	5	6	5	7
50th	11	13	15	18
75th	23	25	32	33
Max	279	150	211	131







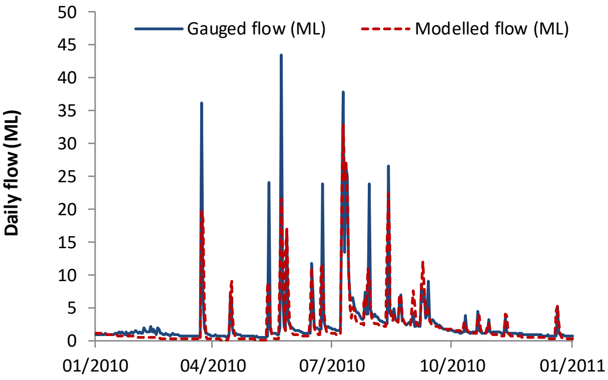


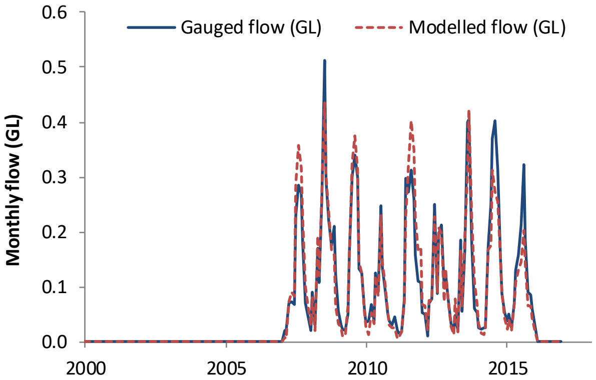


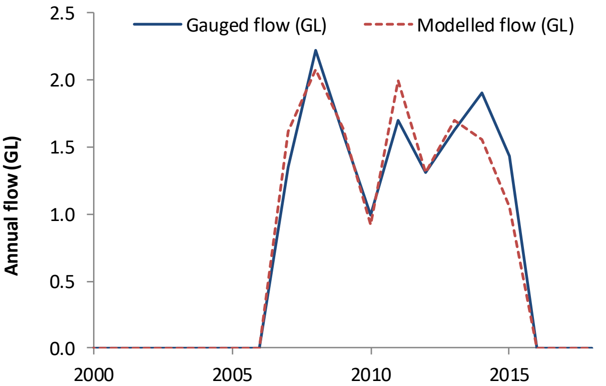
South Belmont Main Drain – Cleaver Terrace – 616134

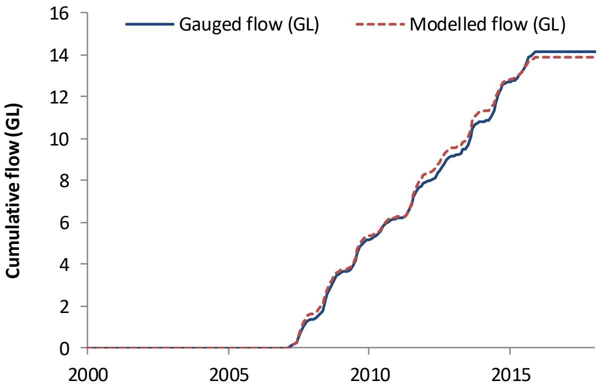
Statistic	Calibration	Validation
	2007–15	-
Daily NSE	0.73	-
Monthly NSE	0.89	-
Annual NSE	0.56	-
Mass balance error	-2%	-

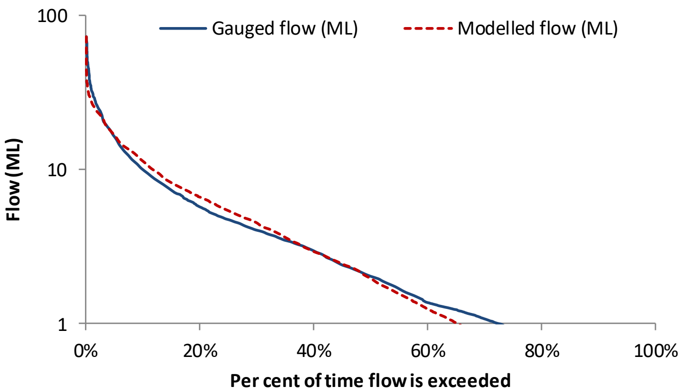
Daily flow statistic	Calibration Gauged (ML)	Calibration Modelled (ML)	Validation Gauged (ML)	Validation Modelled (ML)
Min	0	0	-	-
Percentile:				
5th	1	0	-	-
10th	1	0	-	-
20th	1	0	-	-
50th	2	2	-	-
75th	5	5	-	-
Max	73	43	-	-







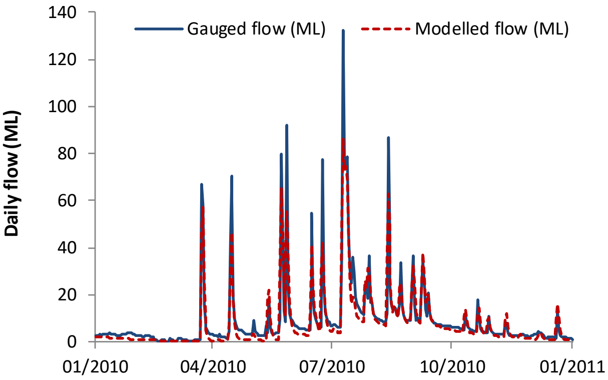


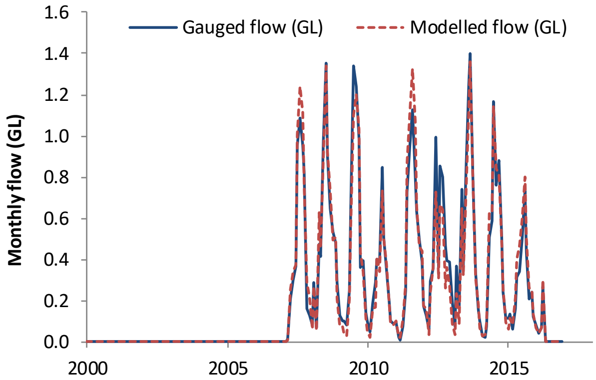


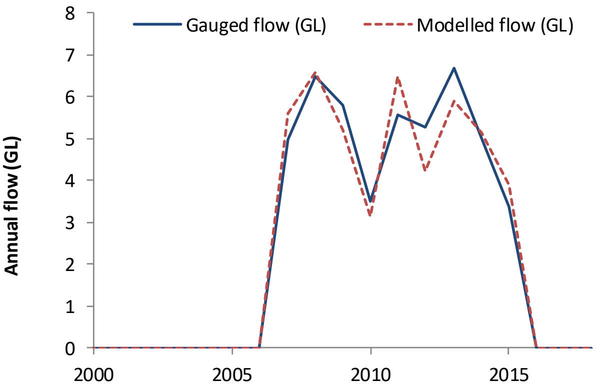
Bannister Creek - Acacia Place - 616134

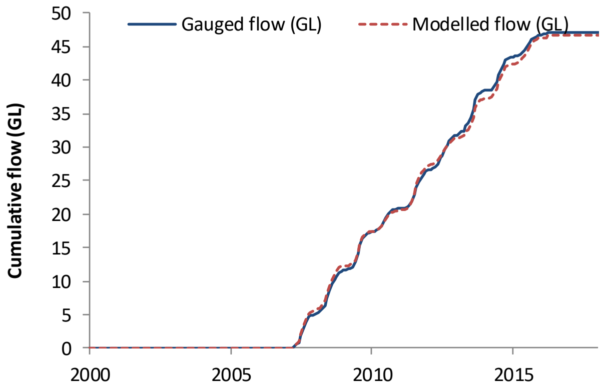
Statistic	Calibration	Validation
	2007–15	-
Daily NSE	0.84	-
Monthly NSE	0.94	-
Annual NSE	0.66	-
Mass balance error	-1%	-

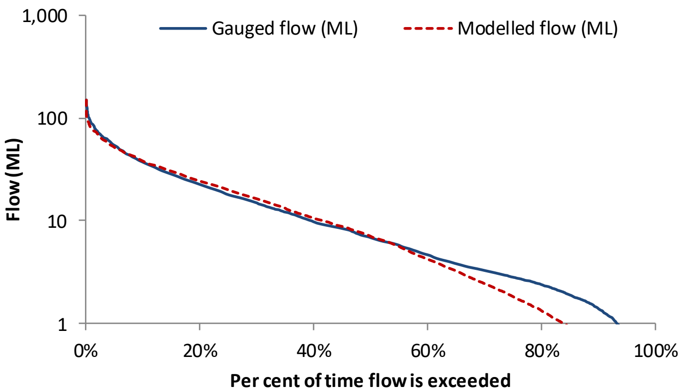
Daily flow statistic	Calibration Gauged (ML)	Calibration Modelled (ML)	Validation Gauged (ML)	Validation Modelled (ML)
Min	0	0	-	-
Percentile:				
5th	1	0	-	-
10th	2	1	-	-
20th	3	1	-	-
50th	7	7	-	-
75th	19	20	-	-
Max	148	106	-	-











A.4 Dam catchments source model

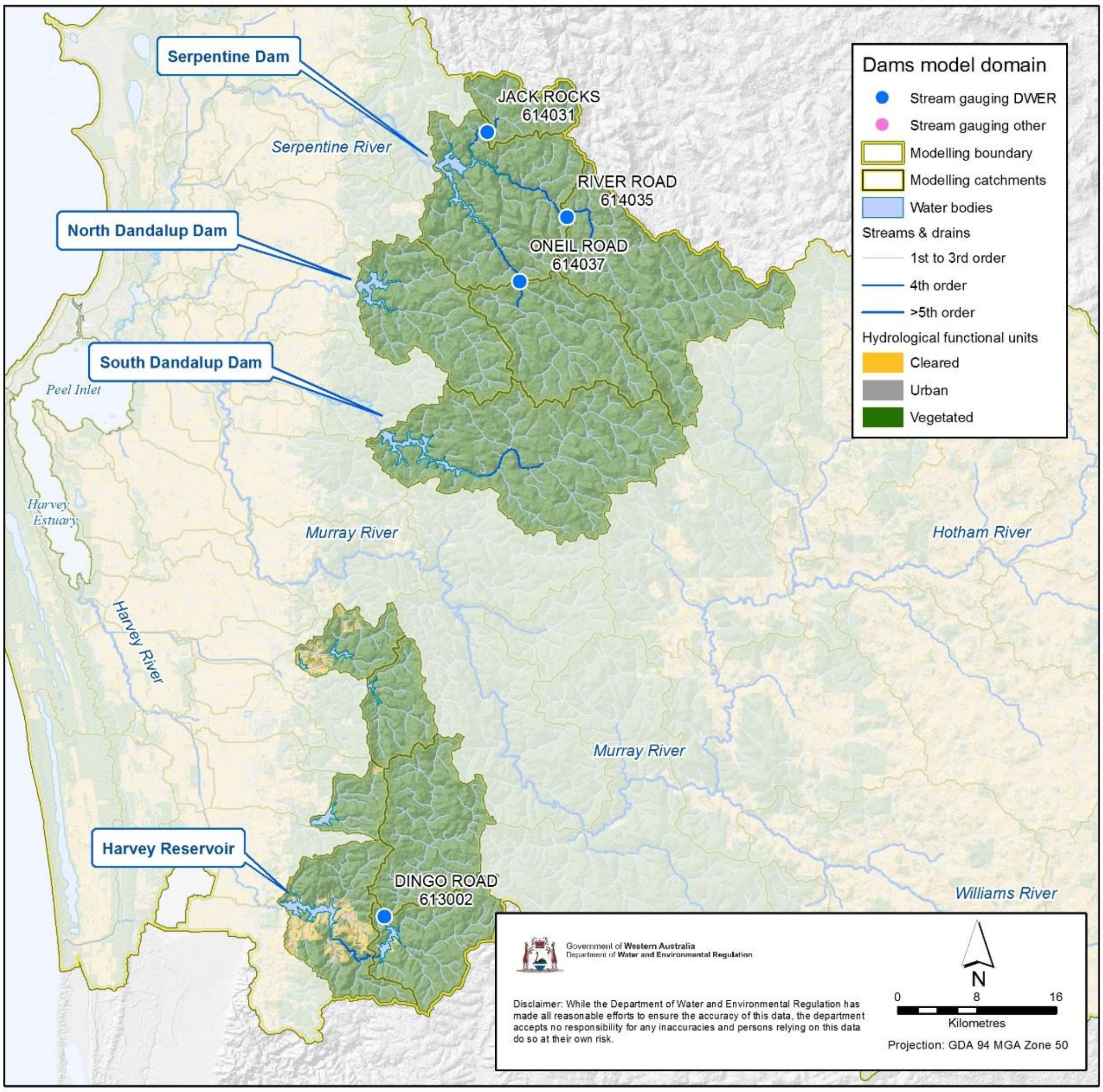


Figure A.2: Dam catchments and flow calibration gauges

Source version and plugins: Public 3.7.1 No plugins

Rainfall-runoff model: GR4J, SYMHYD with routing

Link model: Straight-through flow routing

Climate data: Daily AWAP rainfall and FAO56 PET (derived from AWAP data) at catchment centroids

Additional boundaries: None

Calibration period: 1990 to 2015

Validation period: None

Objective function: Daily NSE with bias penalty

Calibration description: Unique parameters for the vegetated functional units were calibrated for areas upstream of each gauge. For ungauged catchments parameters were transferred from a similar catchment. Runoff coefficients were low for all gauges except Dingo Road which is influenced by a large base flow component.

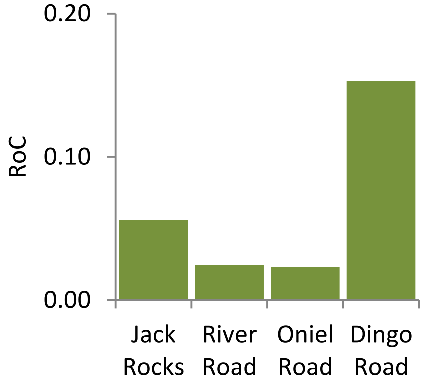
Rainfall-runoff parameters:

Subcatchment	Functional Unit	Model	GR4J-x1 (mm)	GR4J-x2 (mm)	GR4J-x3 (mm)	GR4J-x4 (d)
SC #19	Vegetated	GR4J	917.186	-9.986	32.757	1.212
SC #21	Vegetated	GR4J	917.186	-9.986	32.757	1.212
SC #24	Vegetated	GR4J	917.186	-9.986	32.757	1.212
SC #89	Vegetated	GR4J	1496.777	-0.295	45.846	2.409
SC #90	Vegetated	GR4J	1496.777	-0.295	45.846	2.409
SC #91	Vegetated	GR4J	1496.777	-0.295	45.846	2.409
SC #92	Vegetated	GR4J	917.186	-9.986	32.757	1.212
SC #93	Vegetated	GR4J	917.186	-9.986	32.757	1.212
SC #94	Vegetated	GR4J	808.116	-9.994	48.588	1.779
SC #95	Vegetated	GR4J	918.670	-10.000	19.934	3.300
SC #96	Vegetated	GR4J	917.186	-9.986	32.757	1.212
SC #97	Vegetated	GR4J	1279.658	-7.110	2.373	2.975

Link parameters: None

Runoff coefficients: Average annual modelled runoff coefficients for all areas in the Dams model domain

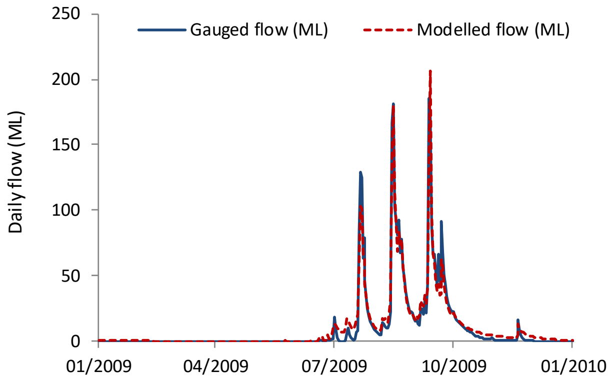
Period	Total RoC	Cleared RoC	Urban RoC	Vegetated RoC
All years	0.07	0.19	0.00	0.06
1980–99	0.07	0.20	0.00	0.07
2000–15	0.06	0.17	0.00	0.06

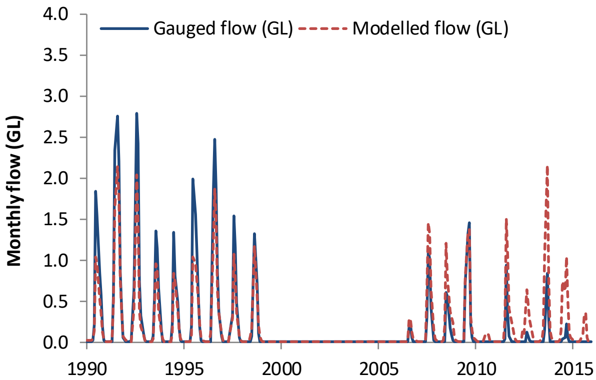


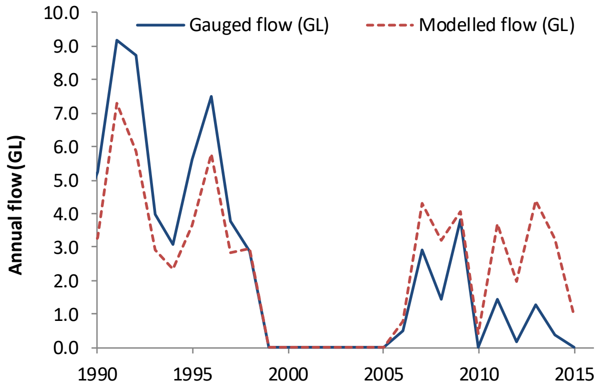
39 Mile Brook - Jack Rocks -614031

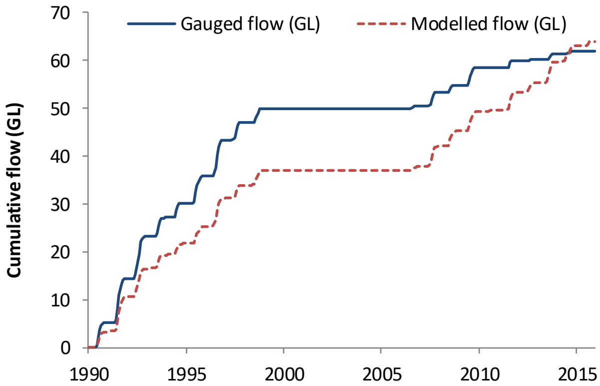
Statistic	**Calibration** *1990–15*
Daily NSE	0.79
Monthly NSE	0.79
Annual NSE	0.64
Mass balance error	3%

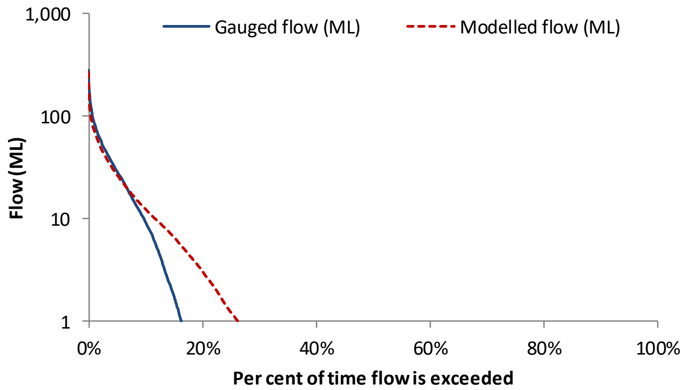
Daily flow statistic	**Calibration**		**Validation**	
	Gauged (ML)	**Modelled** (ML)	**Gauged** (ML)	**Modelled** (ML)
Min	0	0	-	-
Percentile:				
5th	0	0	-	-
10th	0	0	-	-
20th	0	0	-	-
50th	0	1	-	-
75th	4	9	-	-
Max	278	284	-	-







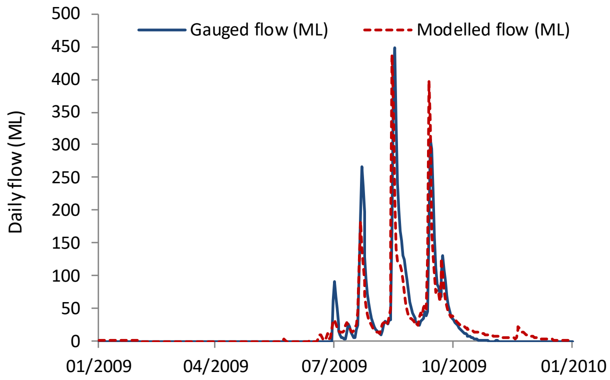


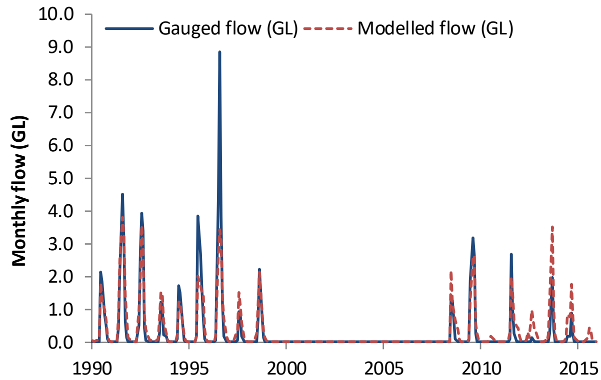


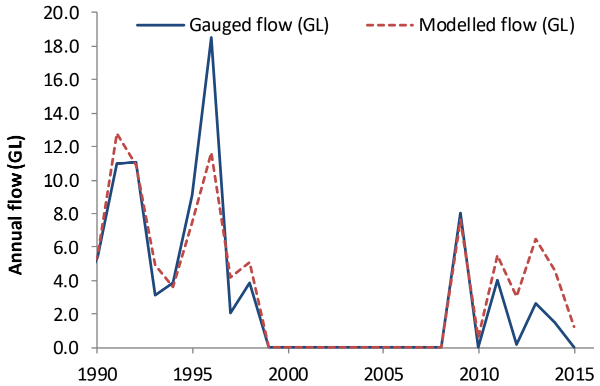
Serpentine River – River Road – 614035

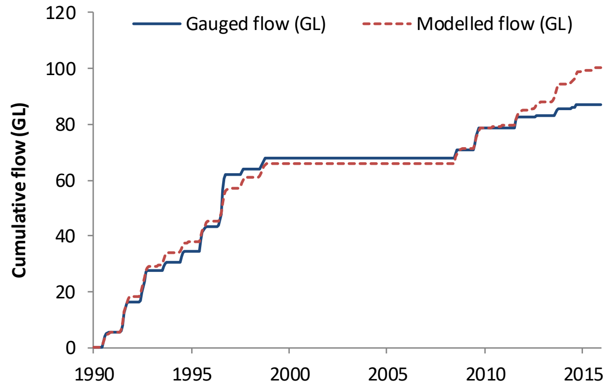
Statistic	Calibration
	1990–15
Daily NSE	0.61
Monthly NSE	0.76
Annual NSE	0.74
Mass balance error	13%

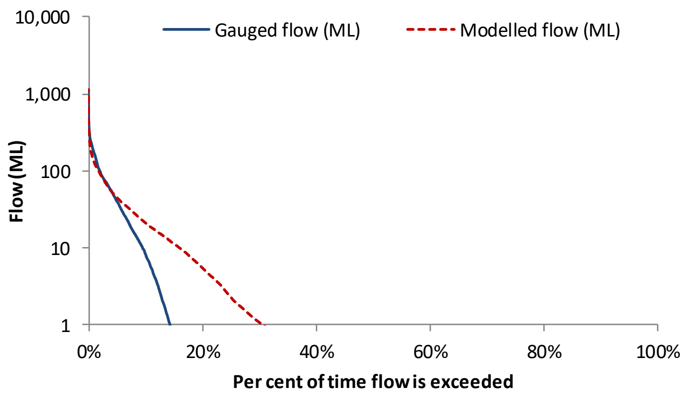
Daily flow statistic	Calibration		Validation	
	Gauged (ML)	Modelled (ML)	Gauged (ML)	Modelled (ML)
Min	0	0	-	-
Percentile:				
5th	0	0	-	-
10th	0	0	-	-
20th	0	0	-	-
50th	0	2	-	-
75th	3	15	-	-
Max	1 134	552	-	-







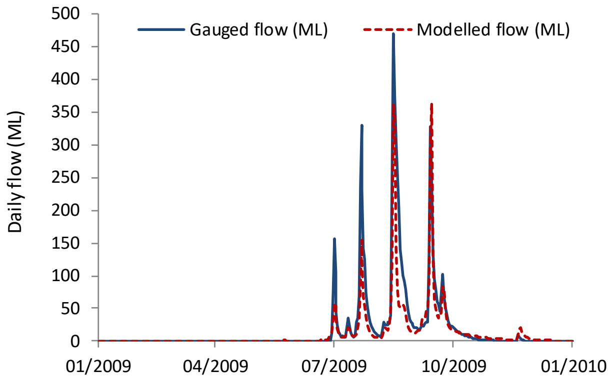


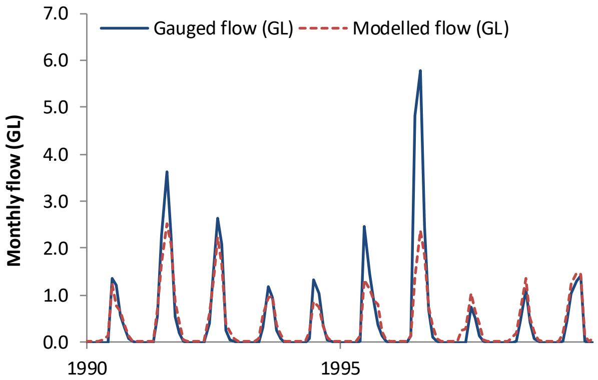


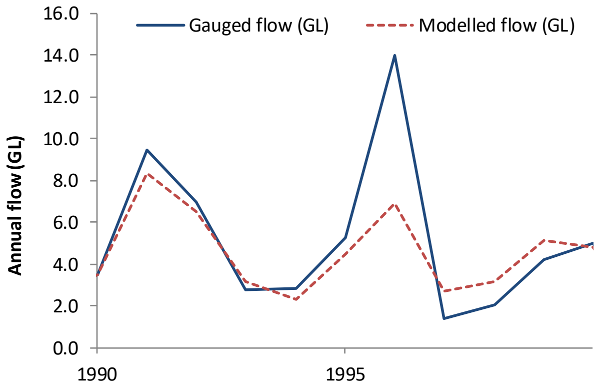
Big Brook – Oniel Road – 614037

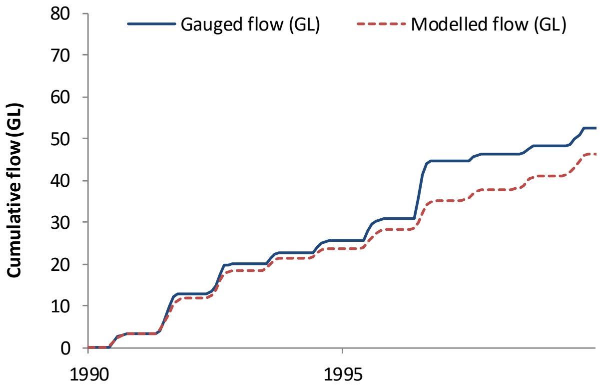
Statistic	Calibration *1990–15*
Daily NSE	0.64
Monthly NSE	0.73
Annual NSE	0.65
Mass balance error	7%

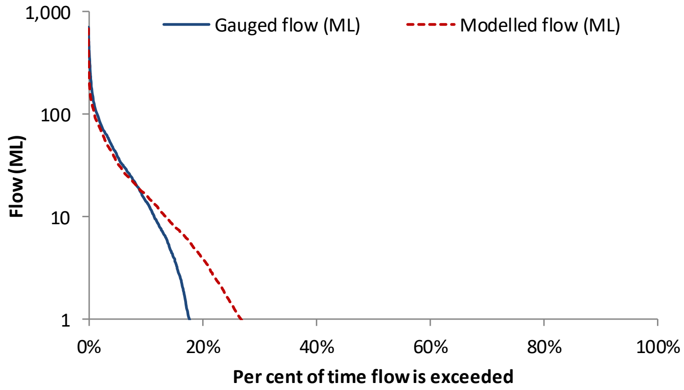
Daily flow statistic	Calibration Gauged (ML)	Calibration Modelled (ML)	Validation Gauged (ML)	Validation Modelled (ML)
Min	0	0	-	-
Percentile:				
5th	0	0	-	-
10th	0	0	-	-
20th	0	0	-	-
50th	0	1	-	-
75th	8	12	-	-
Max	717	411	-	-







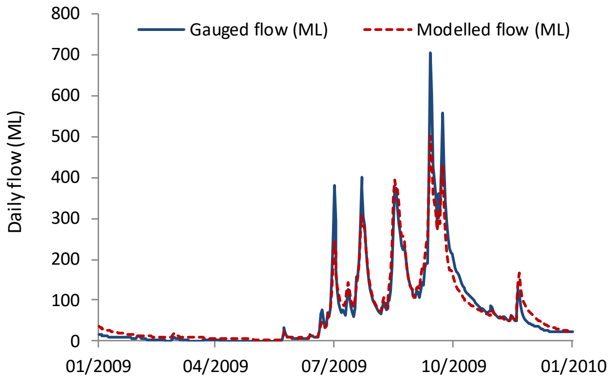


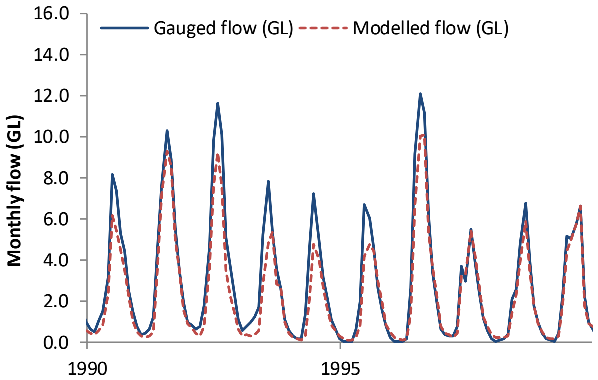


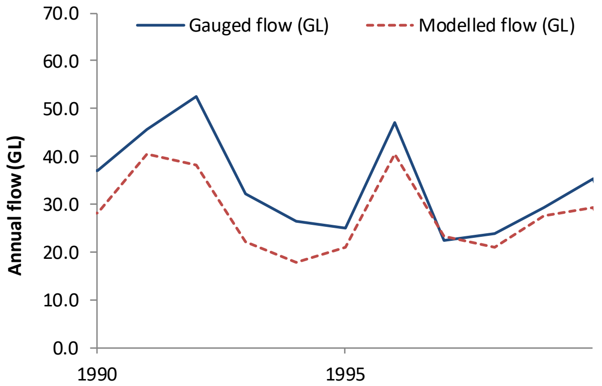
Harvey River – Dingo Road – 613002

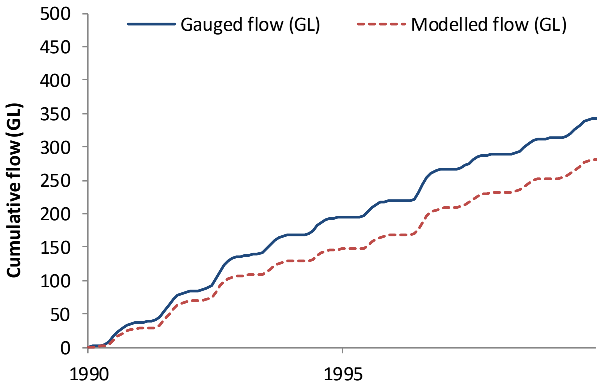
Statistic	Calibration *1990–15*
Daily NSE	0.87
Monthly NSE	0.91
Annual NSE	0.63
Mass balance error	1%

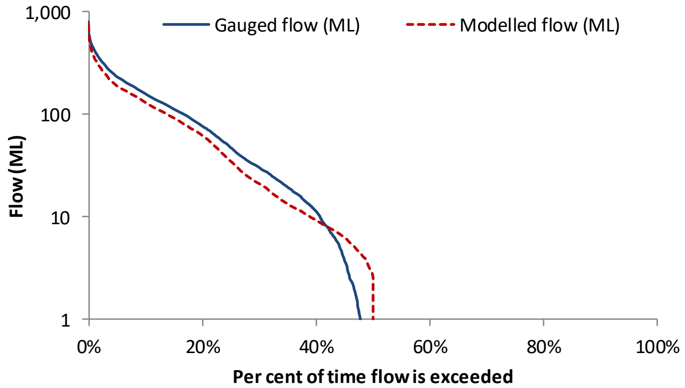
Daily flow statistic	Calibration Gauged (ML)	Calibration Modelled (ML)	Validation Gauged (ML)	Validation Modelled (ML)
Min	0	3	-	-
Percentile:				
5th	1	5	-	-
10th	4	6	-	-
20th	12	9	-	-
50th	48	35	-	-
75th	136	111	-	-
Max	815	721	-	-











A.5 Serpentine source model

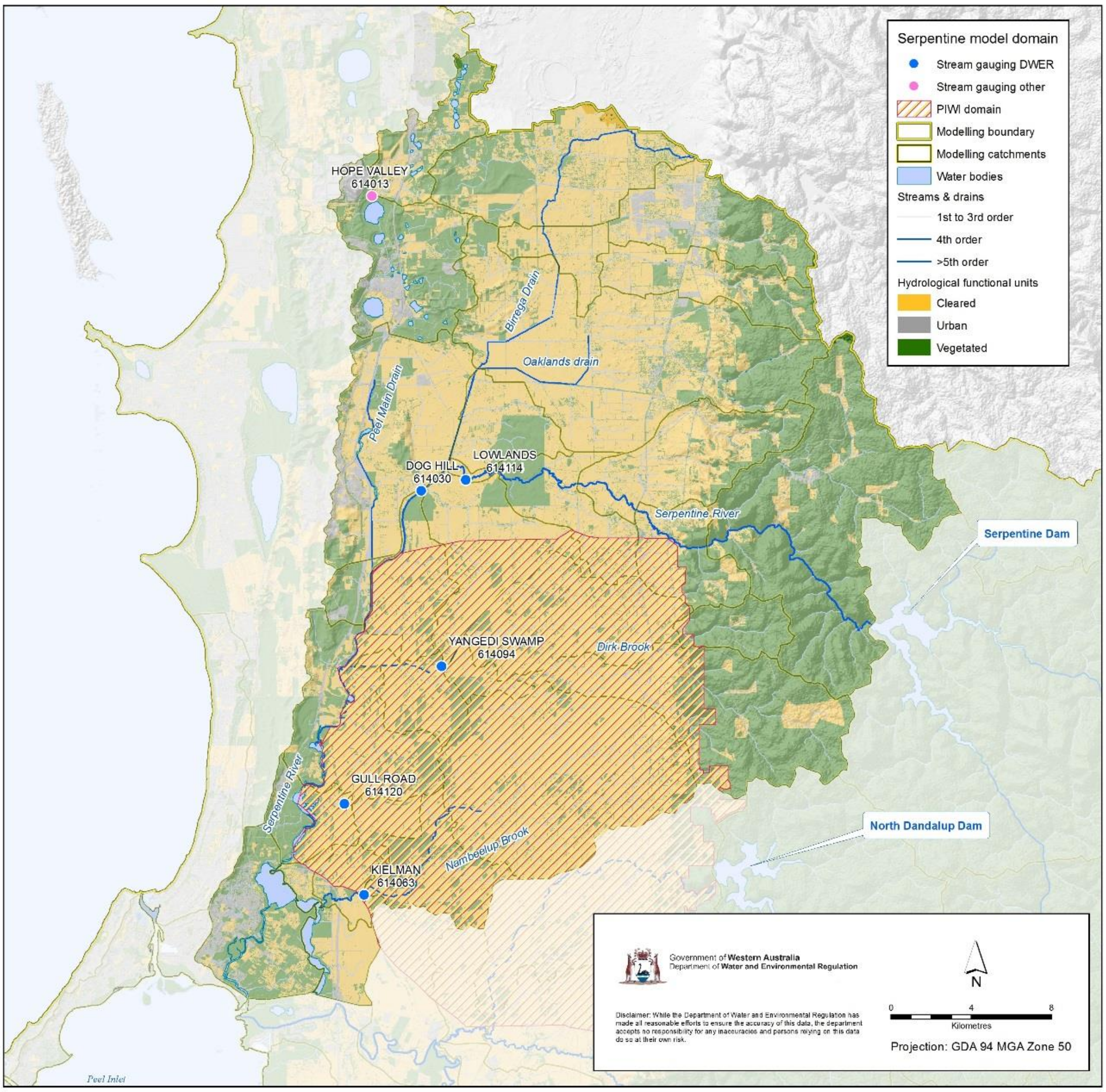


Figure A.3: Serpentine model domain, catchments and flow calibration sites

Source version and plugins: Public 3.7.1 No plugins

Rainfall-runoff model: GR4J, SYMHYD with routing

Link model: Straight-through flow routing

Climate data: Daily AWAP rainfall and FAO56 PET (derived from AWAP data) at catchment centroids

Additional boundaries: None

Calibration period: 2000 to 2015

Validation period: 1980 to 1999

Objective function: Daily NSE with bias penalty

Calibration description: The catchment was split into vegetated, cleared and urban functional units based on 2016 land use mapping. Model parameters for vegetated functional units were calibrated for the fully vegetated catchment of the River Road (614035) gauge and these parameters were used for all vegetated land uses throughout the catchment. SYMHYD parameters for urban areas were sourced from Bannister Creek. Unique parameters for the cleared functional units were calibrated for areas upstream of each gauge. For ungauged catchments, cleared parameters were transferred from a similar catchment. Catchments upstream of the Serpentine Dam were excluded from the model domain and it was assumed that the dam contributes no downstream flow.

Rainfall-runoff parameters:

Subcatchment	Functional Unit	Model	GR4J-x1 (mm)	GR4J-x2 (mm)	GR4J-x3 (mm)	GR4J-x4 (d)
All	Vegetated	GR4J	917.186	-9.986	32.757	1.212
SC #12	Cleared	GR4J	327.033	-1.253	31.981	0.768
SC #13	Cleared	GR4J	327.033	-1.253	31.981	0.768
SC #14	Cleared	GR4J	327.033	-1.253	31.981	0.768
SC #31	Cleared	GR4J	306.789	-3.371	23.207	1.188
SC #32	Cleared	GR4J	306.789	-3.371	23.207	1.188
SC #33	Cleared	GR4J	306.789	-3.371	23.207	1.188
SC #50	Cleared	GR4J	306.789	-3.371	23.207	1.188
SC #51	Cleared	GR4J	306.789	-3.371	23.207	1.188
SC #52	Cleared	GR4J	306.789	-3.371	23.207	1.188
SC #53	Cleared	GR4J	306.789	-3.371	23.207	1.188
SC #54	Cleared	GR4J	320.014	-9.972	25.607	3.279
SC #55	Cleared	GR4J	320.014	-9.972	25.607	3.279
SC #56	Cleared	GR4J	1500.000	-0.167	9.063	0.500
SC #57	Cleared	GR4J	306.789	-3.371	23.207	1.188
SC #76	Cleared	GR4J	244.061	-4.024	12.664	1.101
SC #77	Cleared	GR4J	292.538	-3.261	38.212	1.001
SC #78	Cleared	GR4J	244.061	-4.024	12.664	1.101
SC #79	Cleared	GR4J	292.538	-3.261	38.212	1.001
SC #80	Cleared	GR4J	292.538	-3.261	38.212	1.001
SC #81	Cleared	GR4J	244.061	-4.024	12.664	1.101
SC #82	Cleared	GR4J	244.061	-4.024	12.664	1.101
SC #83	Cleared	GR4J	244.061	-4.024	12.664	1.101
SC #84	Cleared	GR4J	244.061	-4.024	12.664	1.101
SC #85	Cleared	GR4J	244.061	-4.024	12.664	1.101
SC #86	Cleared	GR4J	292.538	-3.261	38.212	1.001
SC #87	Cleared	GR4J	306.789	-3.371	23.207	1.188
SC #88	Cleared	GR4J	306.789	-3.371	23.207	1.188
SC #99	Cleared	GR4J	348.895	-9.945	55.890	1.012
SC #100	Cleared	GR4J	306.789	-3.371	23.207	1.188

Simhyd with routing

Subcatchment	Function unit	Impervious Threshold (mm)	RISC (mm)	Perv. Fraction	SMSC (mm)	Infiltration shape	Infiltration Coeff.	Interflow Coeff.	Recharge coefficient	Baseflow coeff.
All	Urban	0.120	2.268	0.816	494.089	1.762	359.193	0.070	0.995	0.025

Link parameters: None

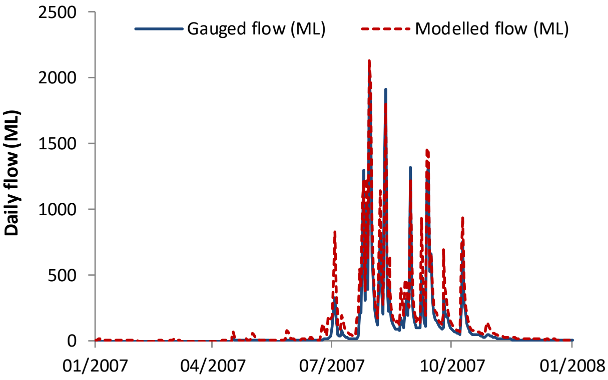
Runoff coefficients: Average annual modelled runoff coefficients for all areas in the Serpentine model domain. Flow from inflow nodes have been excluded.

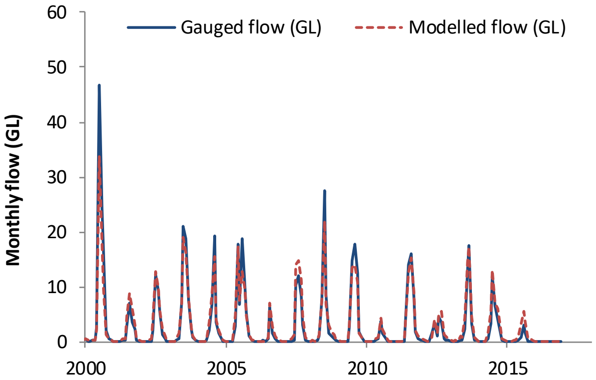
Period	Total RoC	Cleared RoC	Urban RoC	Vegetated RoC
All years	0.11	0.15	0.26	0.03
1980–99	0.12	0.17	0.28	0.04
2000–15	0.10	0.14	0.23	0.03

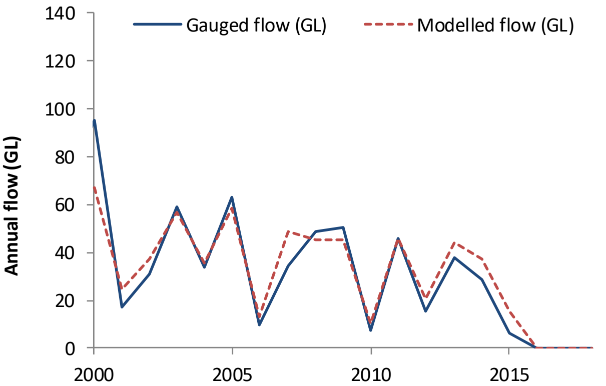
Serpentine Drain – Dog Hill – 614030

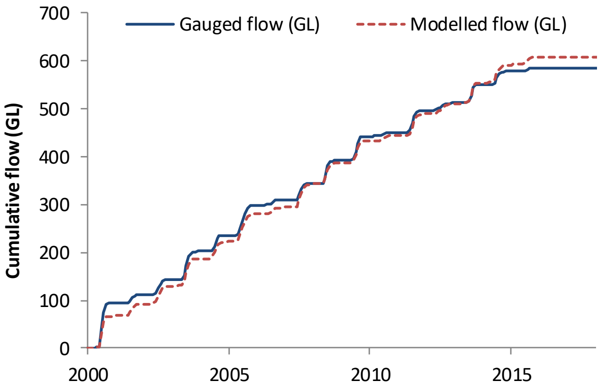
Statistic	Calibration *2000–15*	Validation *1980–99*
Daily NSE	0.91	0.76
Monthly NSE	0.94	0.74
Annual NSE	0.92	-0.20
Mass balance error	4%	-40%

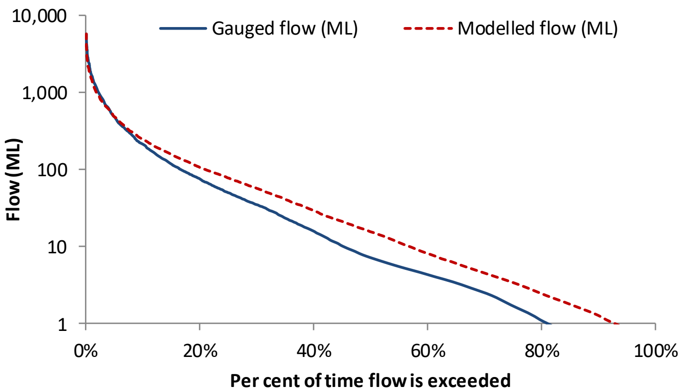
Daily flow statistic	Calibration Gauged (ML)	Calibration Modelled (ML)	Validation Gauged (ML)	Validation Modelled (ML)
Min	0	0	0	0
Percentile:				
5th	0	1	3	1
10th	0	1	6	2
20th	1	3	9	3
50th	8	17	38	22
75th	51	80	174	114
Max	5 749	3 883	9 744	10 036







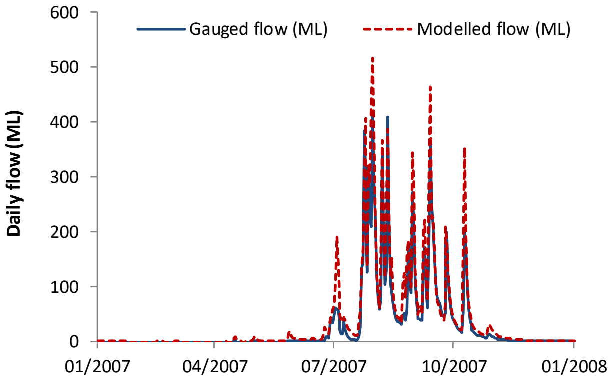


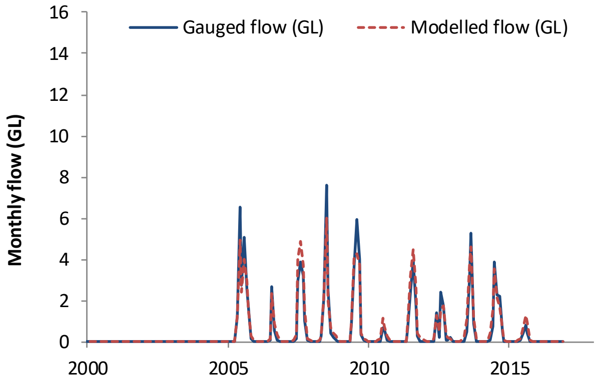


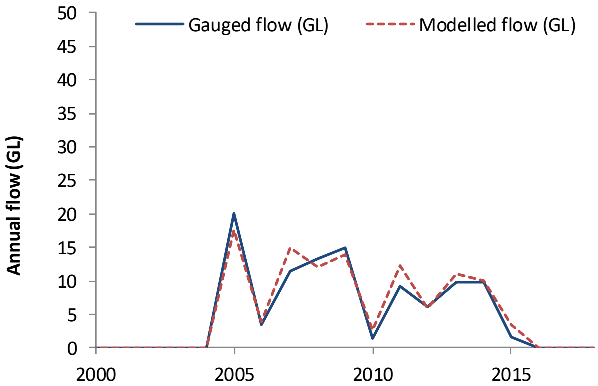
Nambeelup Brook – Kielman – 614063

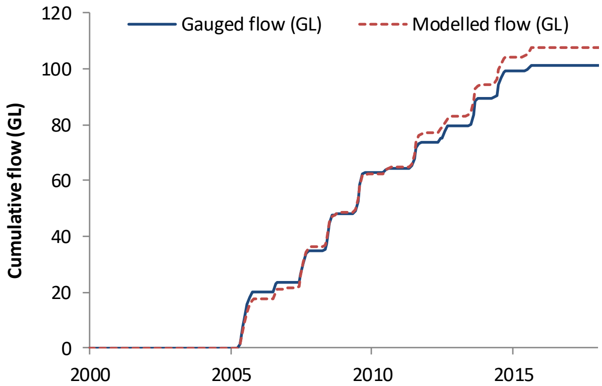
Statistic	Calibration	Validation
	2005–15	*1990–98*
Daily NSE	0.88	0.68
Monthly NSE	0.94	0.75
Annual NSE	0.94	0.48
Mass balance error	7%	-32%

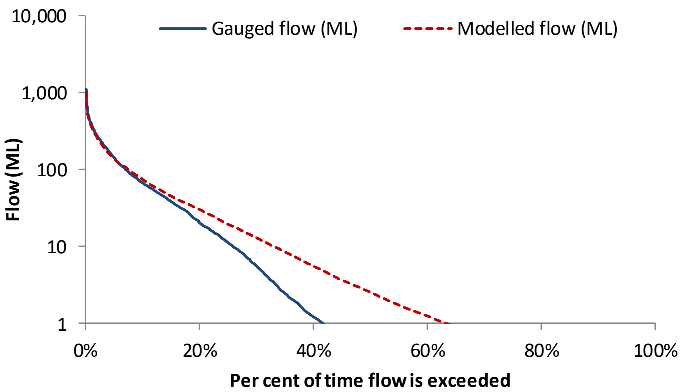
Daily flow statistic	Calibration		Validation	
	Gauged (ML)	Modelled (ML)	Gauged (ML)	Modelled (ML)
Min	0	0	0	0
Percentile:				
5th	0	0	0	0
10th	0	0	0	0
20th	0	0	0	0
50th	0	3	1	4
75th	12	20	48	39
Max	1 110	948	1 719	1 114







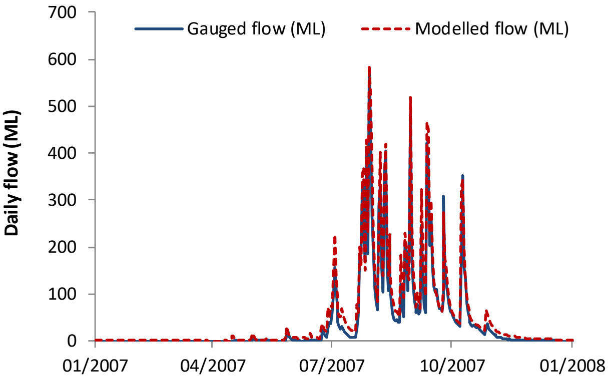


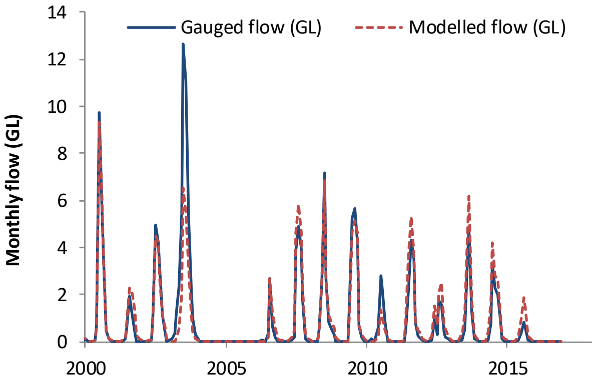


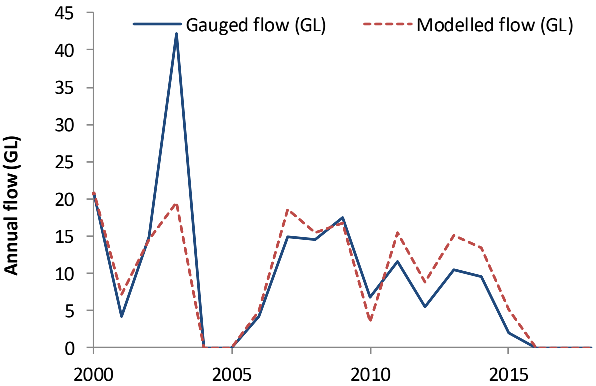
Dirk Brook & Punrack Drain – Yangedi Swamp – 614094

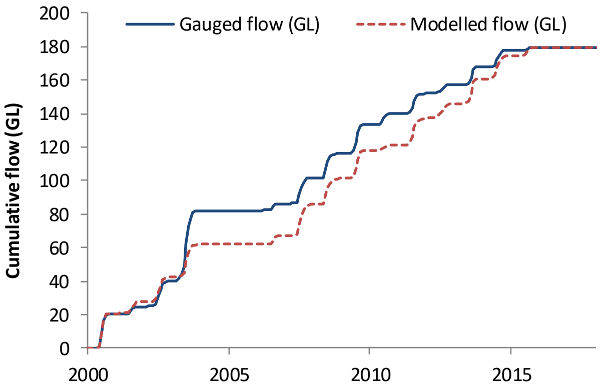
Statistic	Calibration *2000–15*	Validation *1995–99*
Daily NSE	0.84	0.84
Monthly NSE	0.83	0.92
Annual NSE	0.55	0.75
Mass balance error	0%	-14%

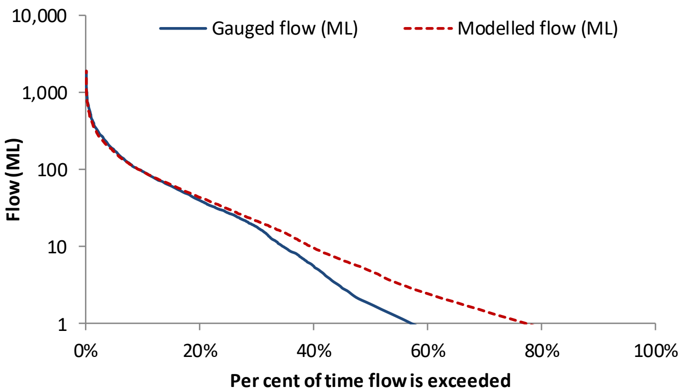
Daily flow statistic	Calibration Gauged (ML)	Calibration Modelled (ML)	Validation Gauged (ML)	Validation Modelled (ML)
Min	0	0	0	0
Percentile:				
5th	0	0	0	1
10th	0	1	0	1
20th	0	1	0	1
50th	2	5	12	10
75th	28	31	65	62
Max	1 912	1 086	1 823	1 153







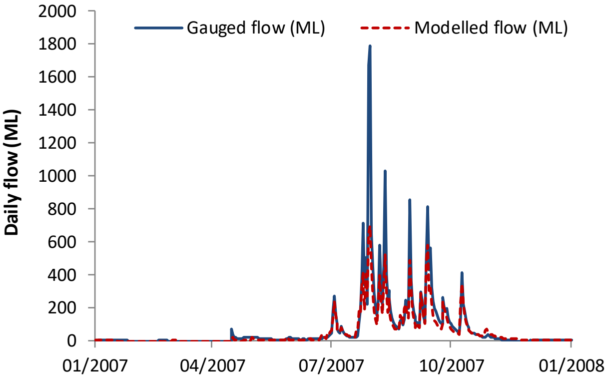


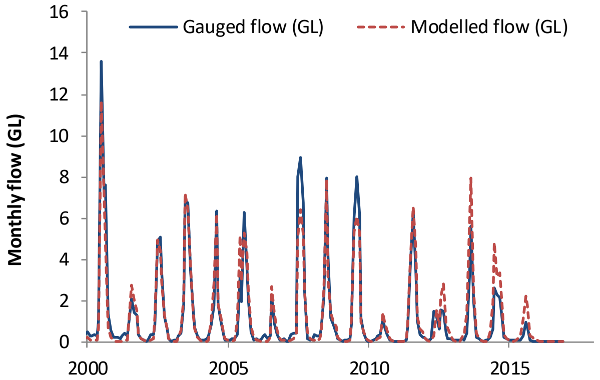


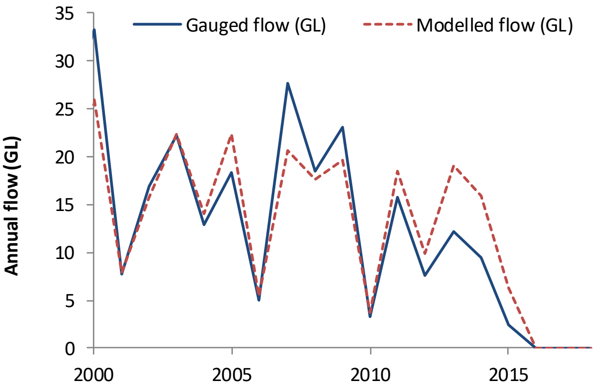
Serpentine River – Lowlands – 614114

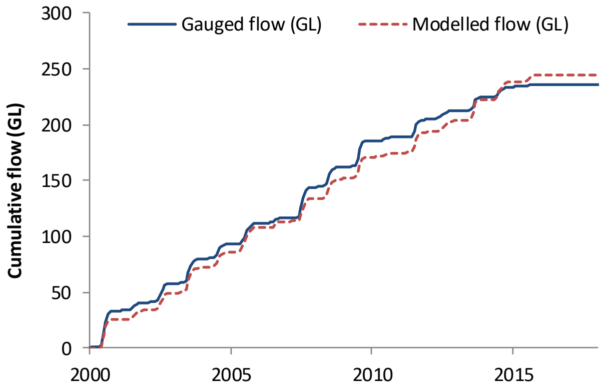
Statistic	Calibration *2000–15*	Validation *1998–99*
Daily NSE	0.85	0.83
Monthly NSE	0.91	0.95
Annual NSE	0.79	0.82
Mass balance error	3%	-9%

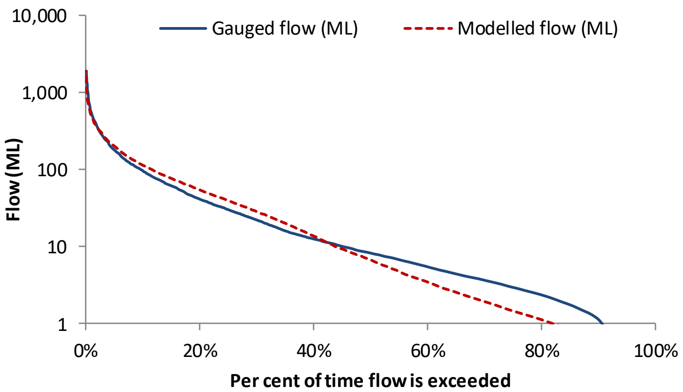
Daily flow statistic	Calibration Gauged (ML)	Calibration Modelled (ML)	Validation Gauged (ML)	Validation Modelled (ML)
Min	0	0	4	0
Percentile:				
5th	0	0	9	1
10th	1	1	10	1
20th	2	1	11	3
50th	8	7	28	22
75th	30	40	86	81
Max	1 888	1 157	754	684







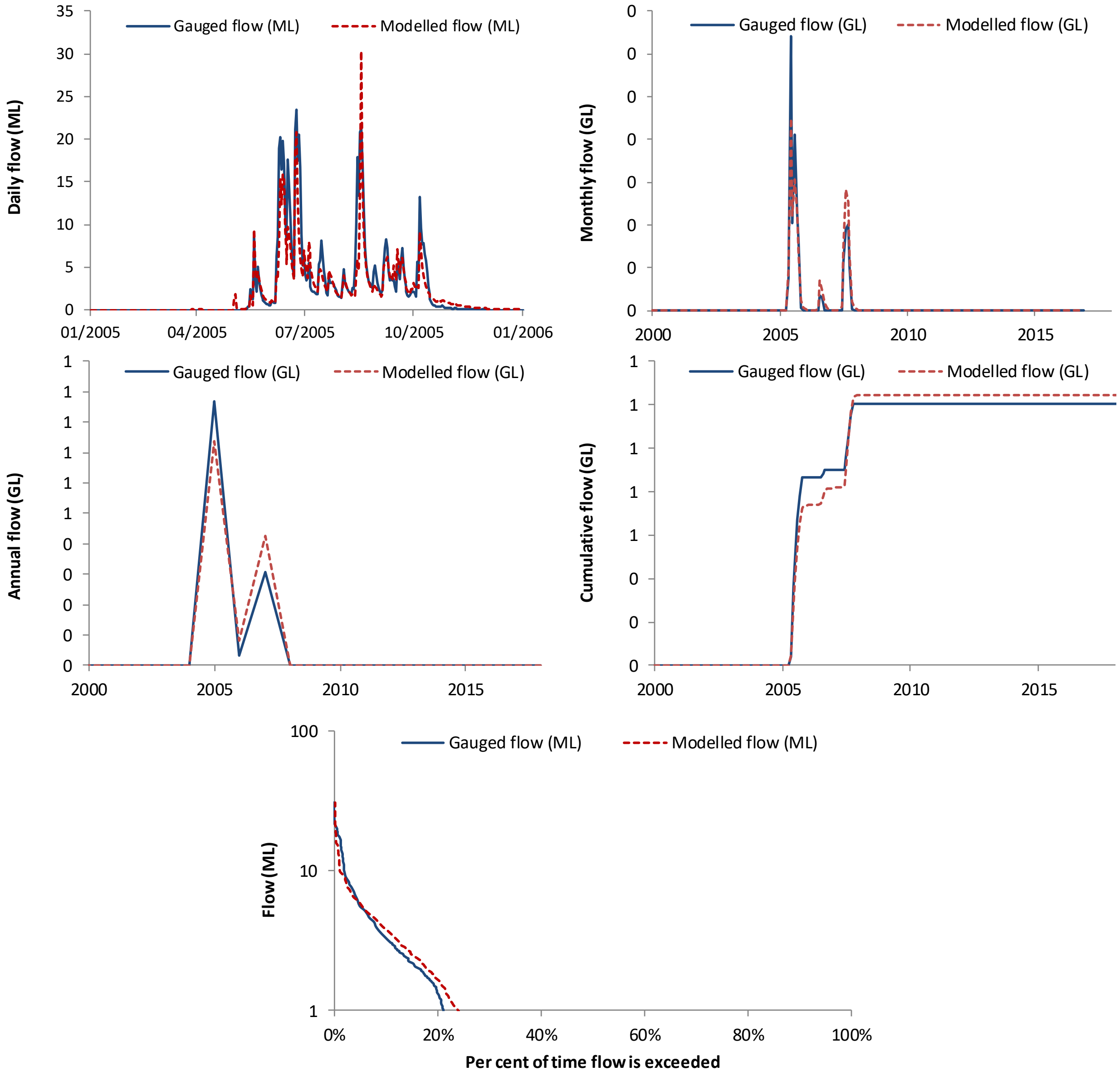




Gull Road Drain - Gull Road - 614120

Statistic	Calibration	Validation
	2005–07	-
Daily NSE	0.82	-
Monthly NSE	0.90	-
Annual NSE	0.91	-
Mass balance error	3%	-

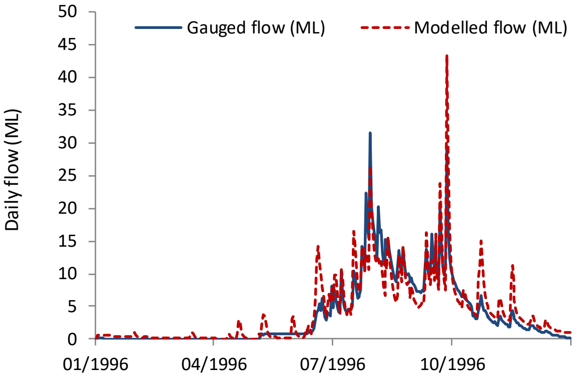
Daily flow statistic	Calibration		Validation	
	Gauged (ML)	Modelled (ML)	Gauged (ML)	Modelled (ML)
Min	0	0	-	-
Percentile:				
5th	0	0	-	-
10th	0	0	-	-
20th	0	0	-	-
50th	0	0	-	-
75th	0	1	-	-
Max	23	30	-	-

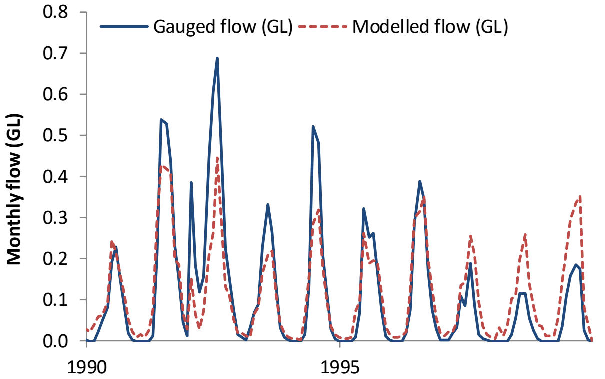


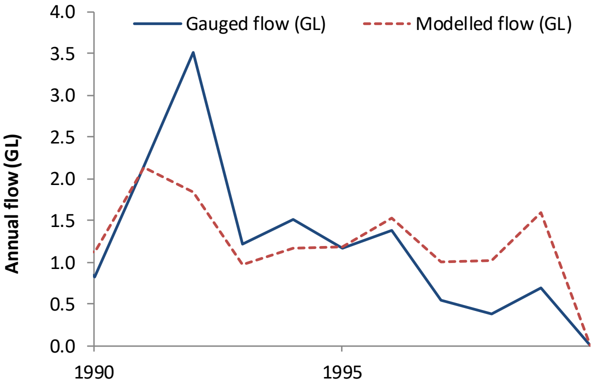
Peel Main Drain – Hope Valley – 614013

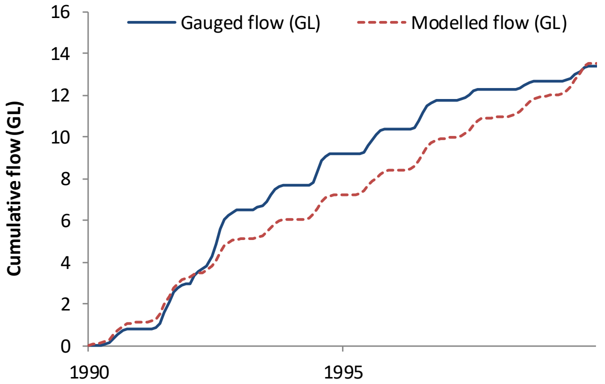
Statistic	Calibration *1990–99*
Daily NSE	0.67
Monthly NSE	0.73
Annual NSE	0.43
Mass balance error	1%

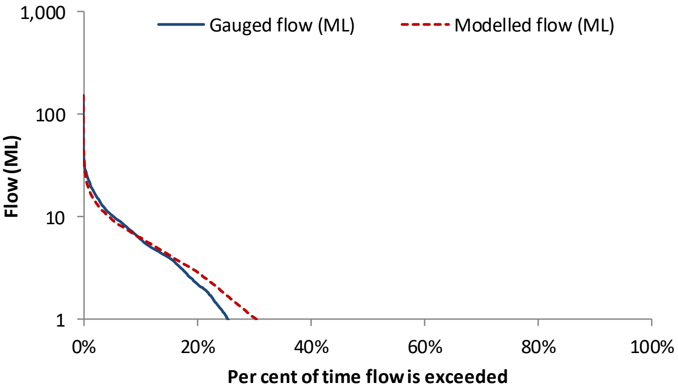
Daily flow statistic	Calibration Gauged (ML)	Calibration Modelled (ML)	Validation Gauged (ML)	Validation Modelled (ML)
Min	0	0	-	-
Percentile:				
5th	0	0	-	-
10th	0	0	-	-
20th	0	0	-	-
50th	1	2	-	-
75th	5	5	-	-
Max	153	54	-	-







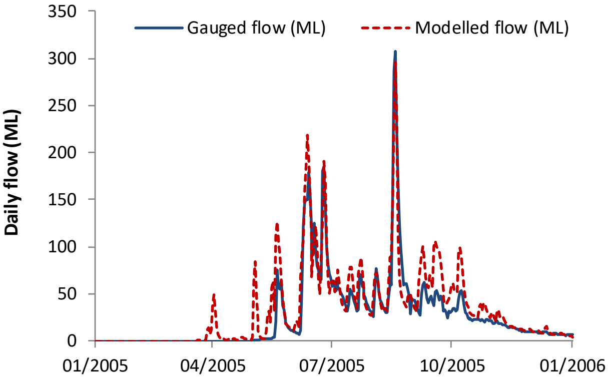


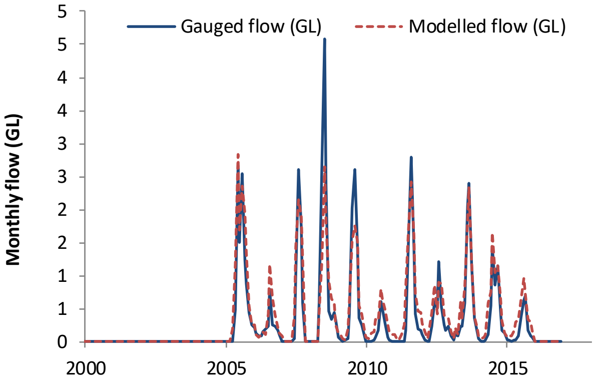


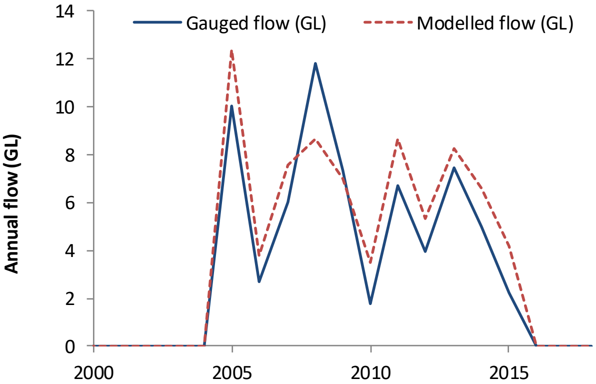
Peel Main Drain - Karnup Road - 614121

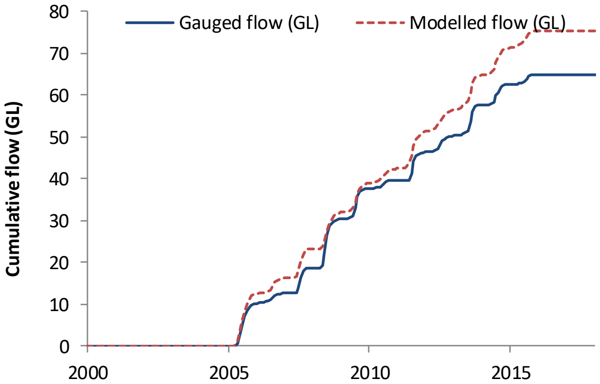
Statistic	Calibration	Validation
	2005–15	-
Daily NSE	0.73	-
Monthly NSE	0.83	-
Annual NSE	0.66	-
Mass balance error	17%	-

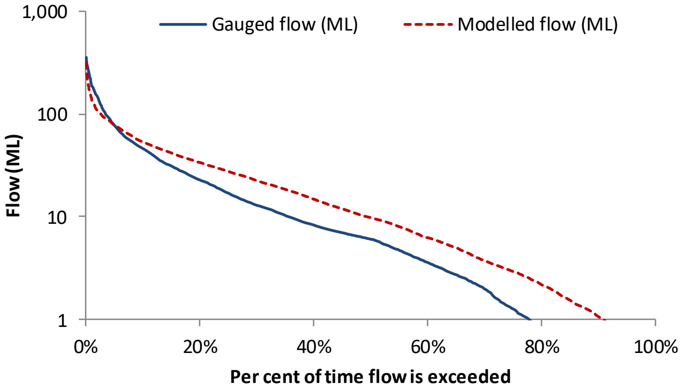
Daily flow statistic	Calibration		Validation	
	Gauged (ML)	Modelled (ML)	Gauged (ML)	Modelled (ML)
Min	0	0	-	-
Percentile:				
5th	0	1	-	-
10th	0	1	-	-
20th	1	2	-	-
50th	6	10	-	-
75th	17	28	-	-
Max	352	295	-	-











A.6 Murray source model

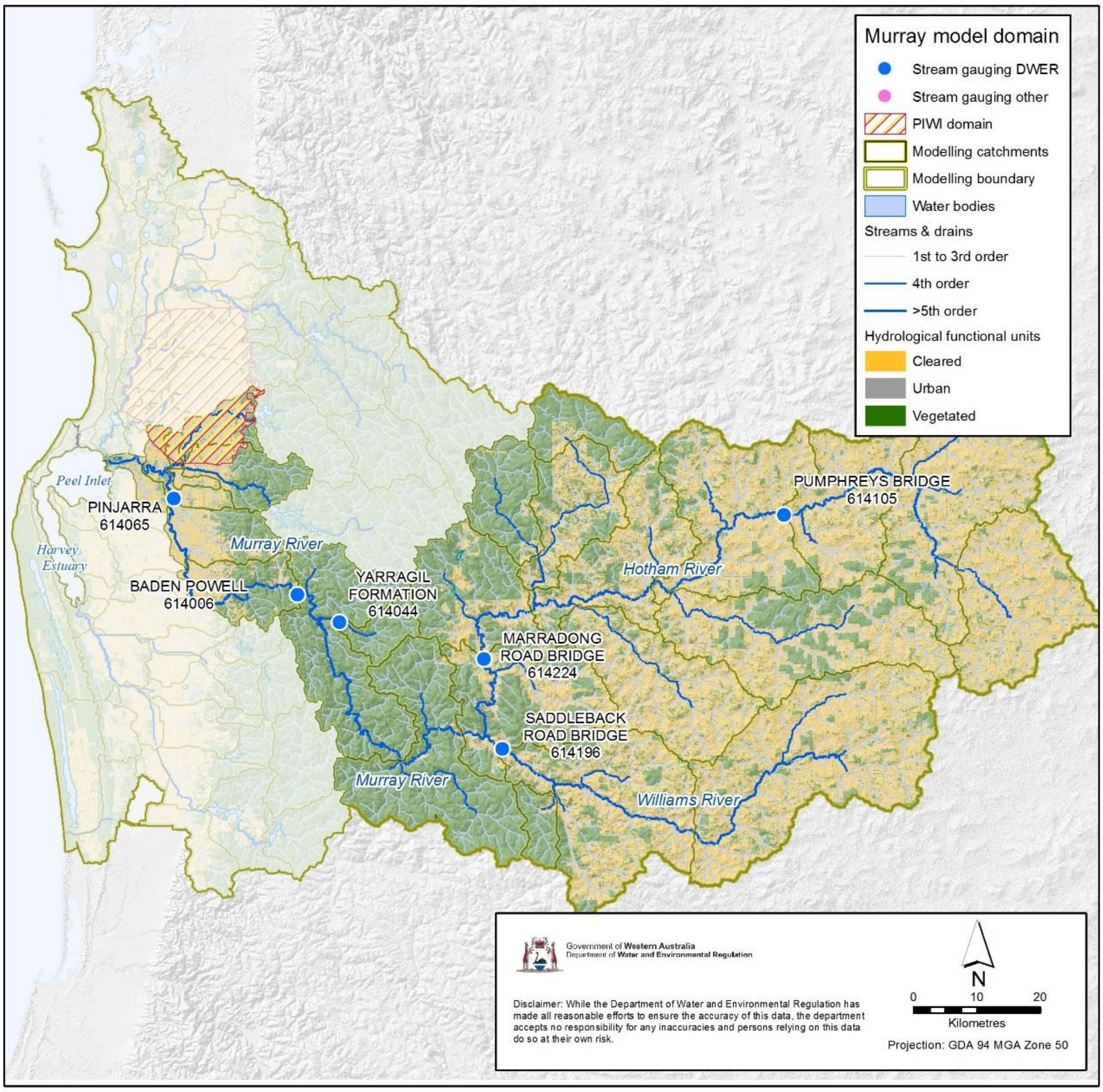


Figure A.4: Murray model domain, catchments and flow calibration sites

Source version and plugins: Public 3.7.1 No plugins

Rainfall-runoff model: GR4J, SYMHYD with routing

Link model: Storage routing

Climate data: Daily AWAP rainfall and FAO56 PET (derived from AWAP data) at catchment centroids

Additional boundaries: None

Calibration period: 2000 to 2015

Validation period: 1980 to 1999

Objective function: Daily NSE with bias penalty

Calibration description: The catchment was split into vegetated, cleared and urban functional units based on 2016 land use mapping. Model parameters for the vegetated functional unit were calibrated to the Yarragil Formation gauge which is fully vegetated. SYMHYD parameters for Urban areas were sourced from Bannister Creek. Cleared functional units were calibrated for the upstream catchment of each gauge, and a single set of storage routing parameters were calibrated for all gauges. For ungauged catchments downstream of Baden Powell Water Spout, cleared parameters were transferred from the Nambeelup Brook catchment (Serpentine model) which better represents hydrological response on the coastal plain.

Rainfall-runoff parameters:

Subcatchment	Functional Unit	Model	GR4J-x1 (mm)	GR4J-x2 (mm)	GR4J-x3 (mm)	GR4J-x4 (d)
All	Vegetated	GR4J	1500.000	-10.000	13.287	1.174
SC #42	Cleared	GR4J	256.779	-3.691	21.586	1.019
SC #43	Cleared	GR4J	170.137	-5.493	38.046	0.500
SC #44	Cleared	GR4J	256.779	-3.691	21.586	1.019
SC #45	Cleared	GR4J	170.137	-5.493	38.046	0.500
SC #46	Cleared	GR4J	256.779	-3.691	21.586	1.019
SC #47	Cleared	GR4J	256.779	-3.691	21.586	1.019
SC #48	Cleared	GR4J	256.779	-3.691	21.586	1.019
SC #49	Cleared	GR4J	256.779	-3.691	21.586	1.019
SC #58	Cleared	GR4J	170.137	-5.493	38.046	0.500
SC #59	Cleared	GR4J	170.137	-5.493	38.046	0.500
SC #60	Cleared	GR4J	170.137	-5.493	38.046	0.500
SC #61	Cleared	GR4J	218.503	-2.606	17.849	1.198
SC #62	Cleared	GR4J	113.827	-9.990	37.184	0.512
SC #63	Cleared	GR4J	218.503	-2.606	17.849	1.198
SC #64	Cleared	GR4J	218.503	-2.606	17.849	1.198
SC #65	Cleared	GR4J	218.503	-2.606	17.849	1.198
SC #66	Cleared	GR4J	218.503	-2.606	17.849	1.198
SC #67	Cleared	GR4J	113.827	-9.990	37.184	0.512
SC #68	Cleared	GR4J	218.503	-2.606	17.849	1.198
SC #69	Cleared	GR4J	113.827	-9.990	37.184	0.512
SC #70	Cleared	GR4J	170.137	-5.493	38.046	0.500
SC #71	Cleared	GR4J	218.503	-2.606	17.849	1.198
SC #72	Cleared	GR4J	150.188	-6.020	57.695	0.507
SC #73	Cleared	GR4J	150.188	-6.020	57.695	0.507
SC #74	Cleared	GR4J	150.188	-6.020	57.695	0.507
SC #75	Cleared	GR4J	218.503	-2.606	17.849	1.198

Simhyd with routing

Subcatchment	Function unit	Impervious Threshold (mm)	RISC (mm)	Perv. Fraction	SMSC (mm)	Infiltration shape	Infiltration Coeff.	Interflow Coeff.	Recharge coefficient	Baseflow coeff.
All	Urban	0.120	2.268	0.816	494.089	1.762	359.193	0.070	0.995	0.025

Runoff coefficients: Average annual modelled runoff coefficients for all areas in the Murray model domain. Flow from inflow nodes have been excluded.

Period	Total RoC	Cleared RoC	Urban RoC	Vegetated RoC
All years	0.05	0.09	0.11	0.01
1980–99	0.06	0.10	0.12	0.01
2000–15	0.05	0.08	0.10	0.01

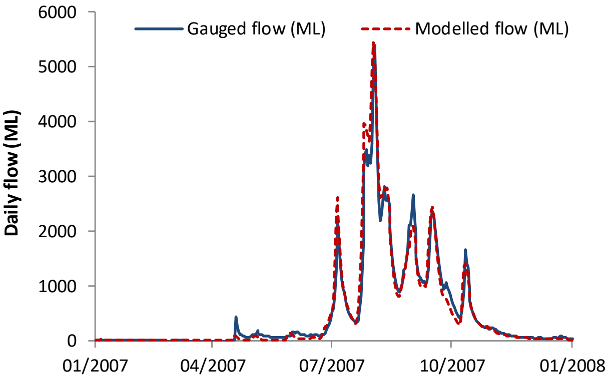
Storage routing parameters:

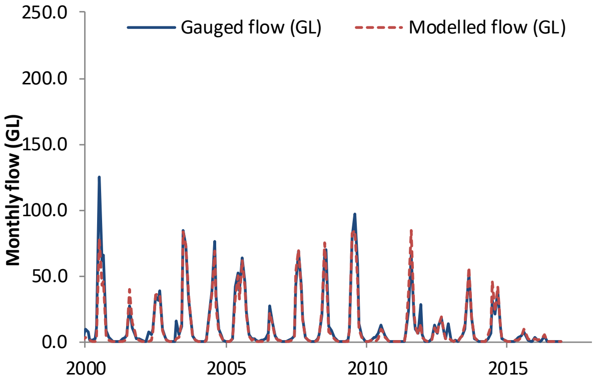
Link name	Routing Exponent (m)	Routing Constant (k)
link for catchment SC #62	0.9753	50697
link for catchment SC #69	0.9753	50697
link for catchment SC #67	0.9753	50697
link for catchment SC #68	0.9753	50697
link for catchment SC #65	0.9753	50697
link for catchment SC #75	0.9753	50697
link for catchment SC #71	0.9753	50697
link for catchment SC #66	0.9753	50697
link for catchment SC #63	0.9753	50697
link for catchment SC #64	0.9753	50697
link for catchment SC #72	0.9753	50697
link for catchment SC #73	0.9753	50697
link for catchment SC #74	0.9753	50697
link for catchment SC #61	0.9753	50697
link for catchment SC #60	0.9753	50697
link for catchment SC #70	0.9753	50697
link for catchment SC #58	0.9753	50697
link for catchment SC #59	0.9753	50697
link for catchment SC #43	0.9753	50697
link for catchment SC #45	0.9753	50697
link for catchment SC #47	0.9982	46032
link for catchment SC #46	0.9982	46032
link for catchment SC #48	0.9982	46032
link for catchment SC #44	0.9982	46032
link for catchment SC #42	0.9982	46032
link for catchment SC #49	0.9982	46032
Other Parameters		
Reach Length	25000	
Average Regulated Flow	0	
No. Divs.	1	
Inflow Bias	0.5	

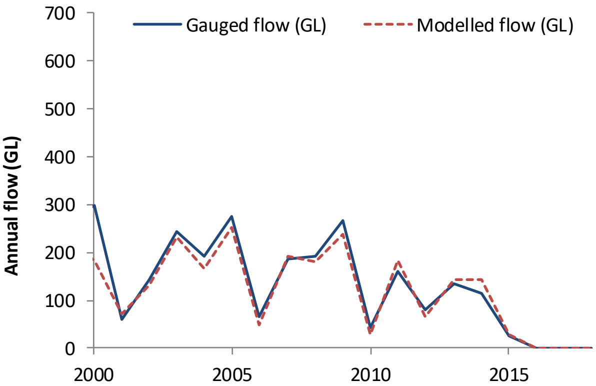
Murray River - Baden Powell – 614030

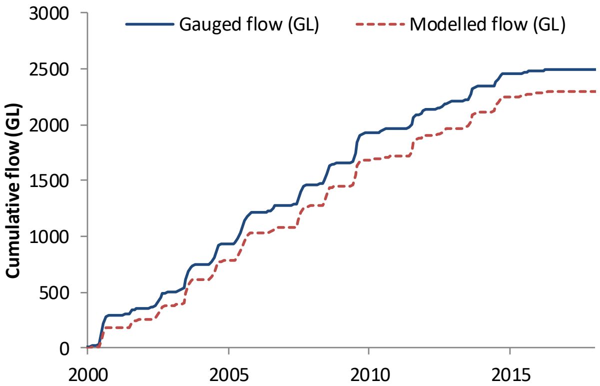
Statistic	Calibration *2000–15*	Validation *1980–99*
Daily NSE	0.89	0.85
Monthly NSE	0.94	0.89
Annual NSE	0.89	0.68
Mass balance error	-8%	-25%

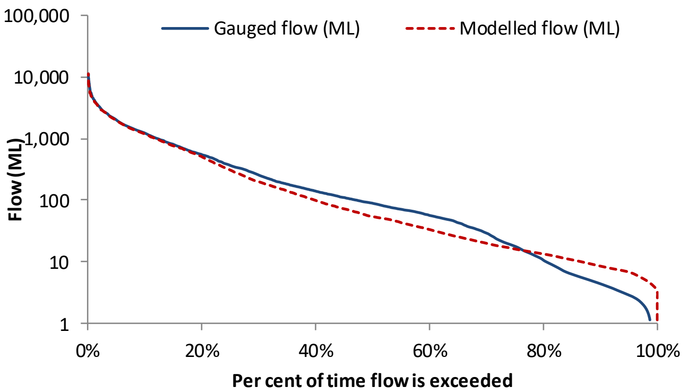
Daily flow statistic	Calibration Gauged (ML)	Calibration Modelled (ML)	Validation Gauged (ML)	Validation Modelled (ML)
Min	0	3	2	4
Percentile:				
5th	3	7	4	7
10th	5	8	9	9
20th	11	13	23	14
50th	93	53	130	69
75th	384	322	663	501
Max	11 383	8 994	26 642	16 837







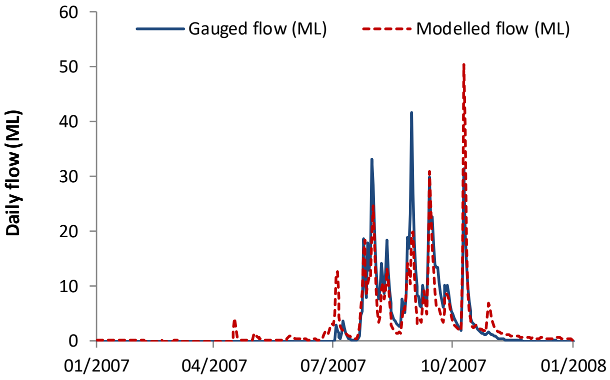


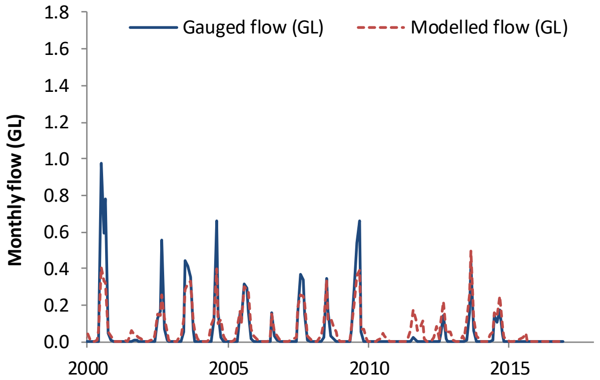


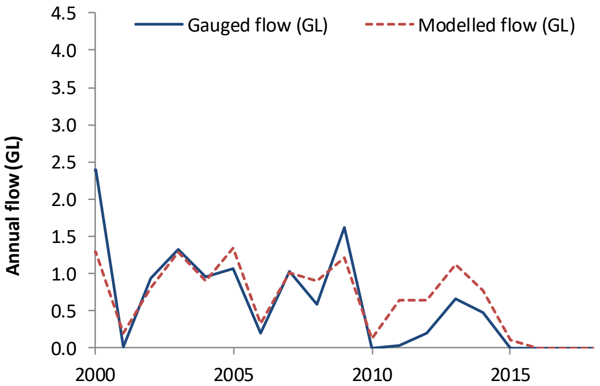
Yarragil Brook - Yarragil Formation – 614044

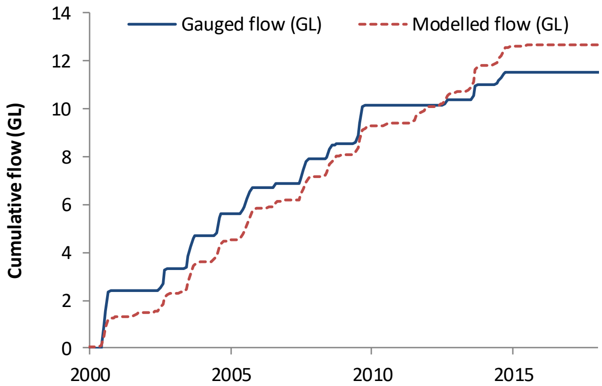
Statistic	**Calibration** *2000–15*	**Validation** *1980–99*
Daily NSE	0.69	0.49
Monthly NSE	0.76	0.54
Annual NSE	0.80	0.24
Mass balance error	10%	-41%

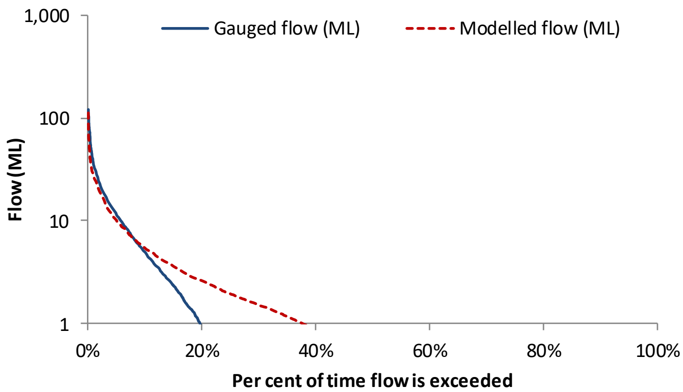
Daily flow statistic	**Calibration** **Gauged** (ML)	**Modelled** (ML)	**Validation** **Gauged** (ML)	**Modelled** (ML)
Min	0	0	0	0
Percentile:				
5th	0	0	0	0
10th	0	0	0	0
20th	0	0	0	0
50th	0	0	0	1
75th	0	2	4	3
Max	121	86	295	221







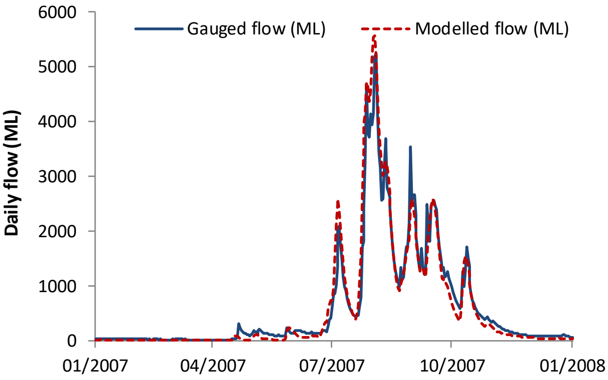


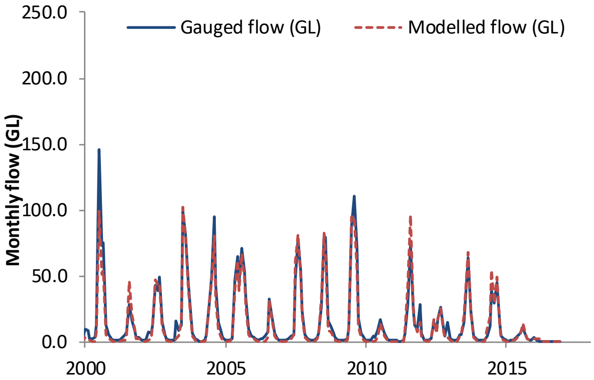


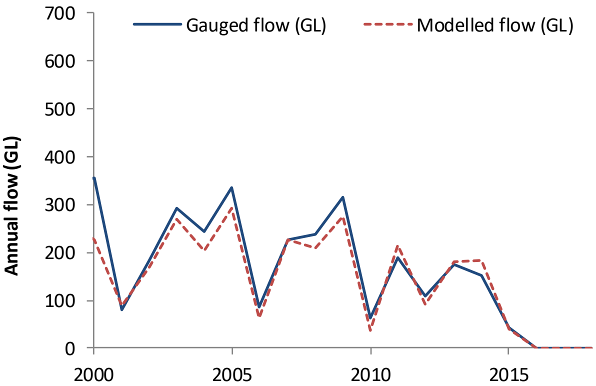
Murray River - Pinjarra - 614065

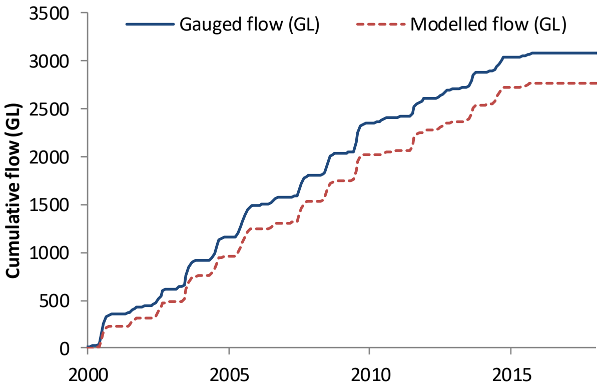
Statistic	Calibration *2000–15*	Validation *1992–99*
Daily NSE	0.90	0.88
Monthly NSE	0.94	0.90
Annual NSE	0.86	0.63
Mass balance error	-10%	-25%

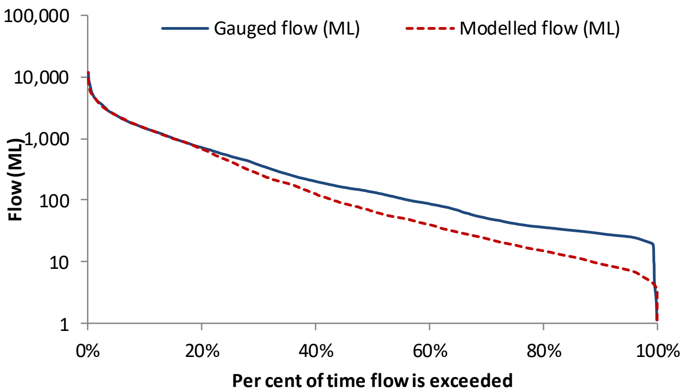
Daily flow statistic	Calibration Gauged (ML)	Calibration Modelled (ML)	Validation Gauged (ML)	Validation Modelled (ML)
Min	2	4	14	4
Percentile:				
5th	27	7	28	7
10th	30	9	32	10
20th	38	15	47	16
50th	141	68	266	121
75th	535	446	1 166	972
Max	11 800	8 849	25 031	16 542







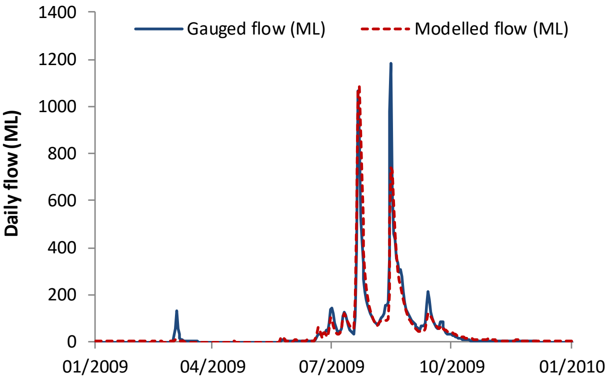


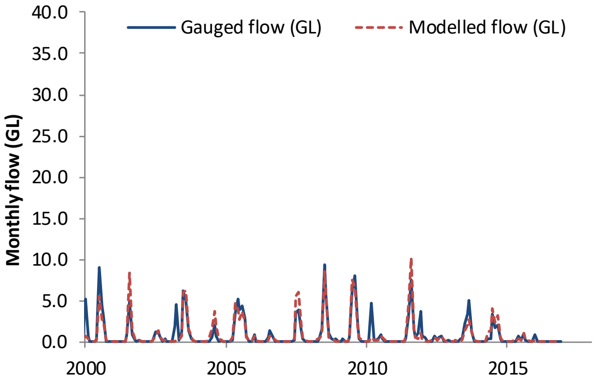


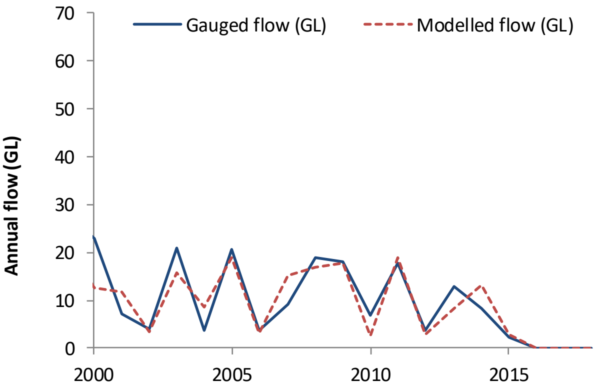
Hotham River – Pumphrey's Bridge – 614105

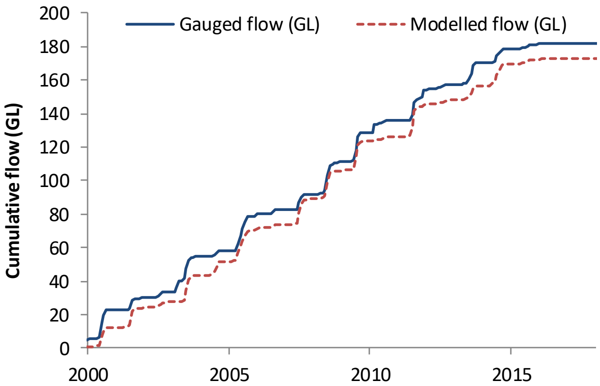
Statistic	Calibration *2000–15*	Validation *1996–99*
Daily NSE	0.57	0.71
Monthly NSE	0.77	0.77
Annual NSE	0.73	0.66
Mass balance error	-5%	-30%

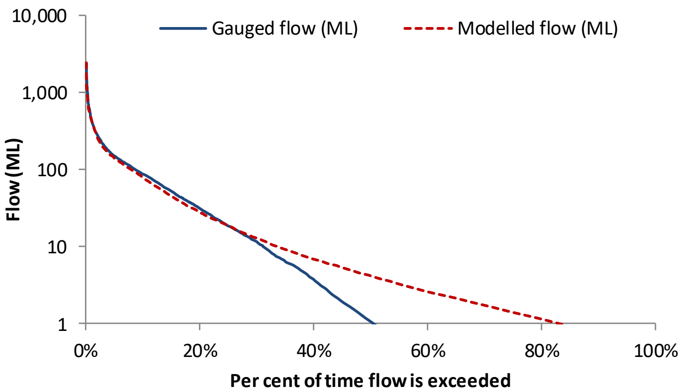
Daily flow statistic	Calibration Gauged (ML)	Calibration Modelled (ML)	Validation Gauged (ML)	Validation Modelled (ML)
Min	0	0	0	0
Percentile:				
5th	0	1	0	1
10th	0	1	0	1
20th	0	1	0	1
50th	1	4	1	8
75th	19	19	87	45
Max	2 374	1 358	8 781	3 444







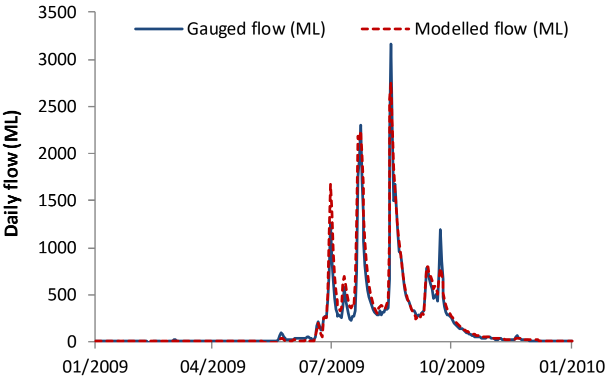


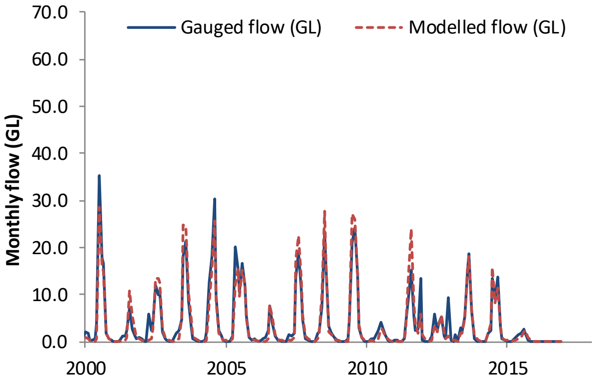


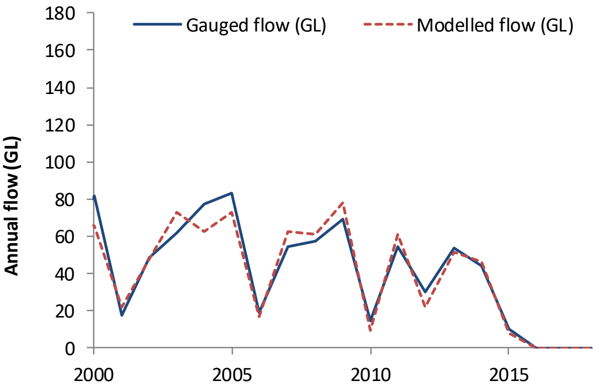
Williams River – Saddleback Road Bridge – 614196

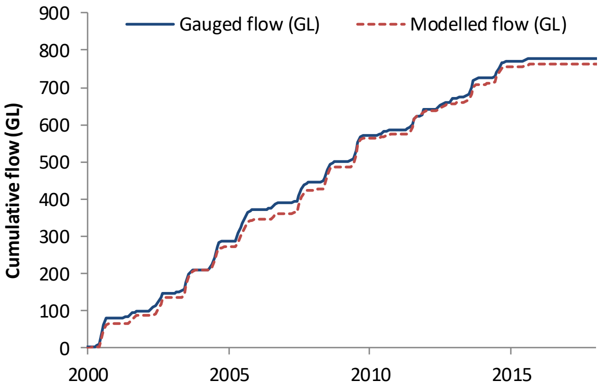
Statistic	Calibration	Validation
	2000–15	*1980–99*
Daily NSE	0.78	0.87
Monthly NSE	0.91	0.96
Annual NSE	0.90	0.90
Mass balance error	-2%	-5%

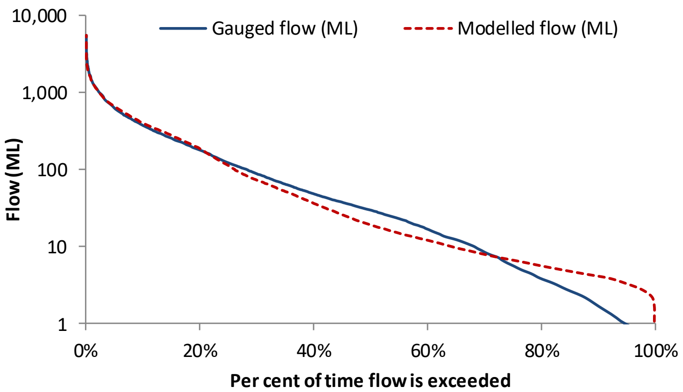
Daily flow statistic	Calibration Gauged (ML)	Calibration Modelled (ML)	Validation Gauged (ML)	Validation Modelled (ML)
Min	0	2	0	2
Percentile:				
5th	1	3	0	4
10th	2	4	1	4
20th	4	6	2	6
50th	30	19	29	24
75th	122	112	151	158
Max	5 529	2 761	19 735	11 554







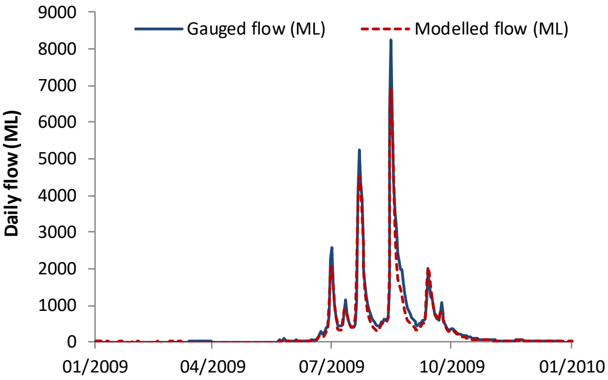


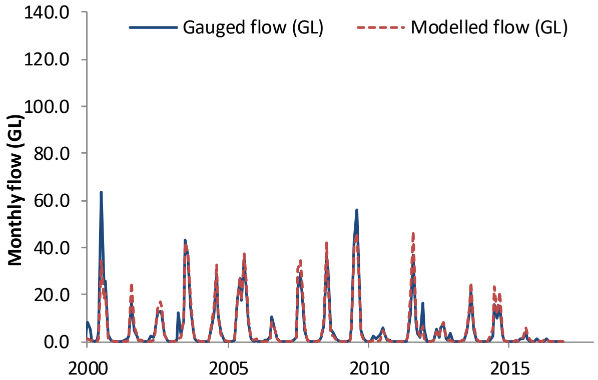


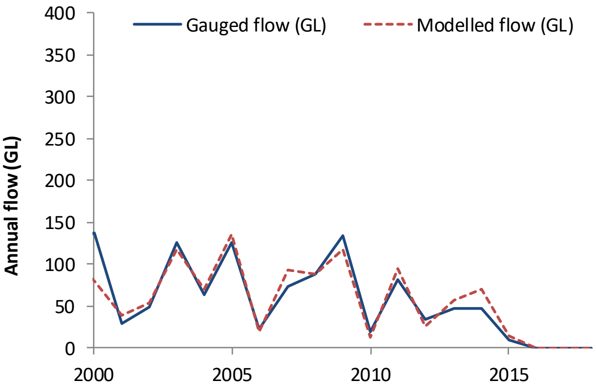
Hotham River – Marradong Road Bridge – 614224

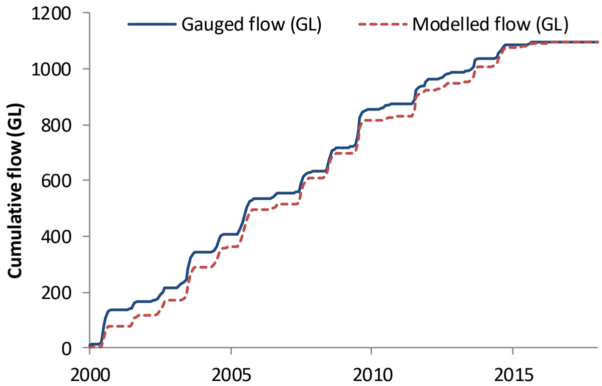
Statistic	Calibration	Validation
	2000–15	*1980–99*
Daily NSE	0.86	0.84
Monthly NSE	0.90	0.91
Annual NSE	0.87	0.79
Mass balance error	0%	-18%

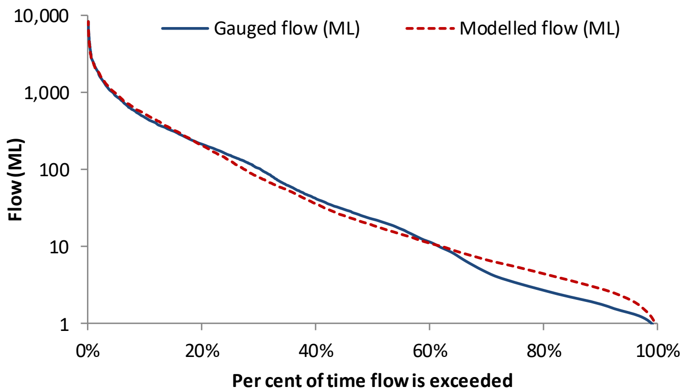
Daily flow statistic	Calibration		Validation	
	Gauged (ML)	Modelled (ML)	Gauged (ML)	Modelled (ML)
Min	1	1	0	1
Percentile:				
5th	1	2	2	2
10th	2	3	3	3
20th	3	5	4	5
50th	24	20	36	26
75th	158	137	249	206
Max	8 231	6 888	21 153	11 835











A.7 Harvey source model

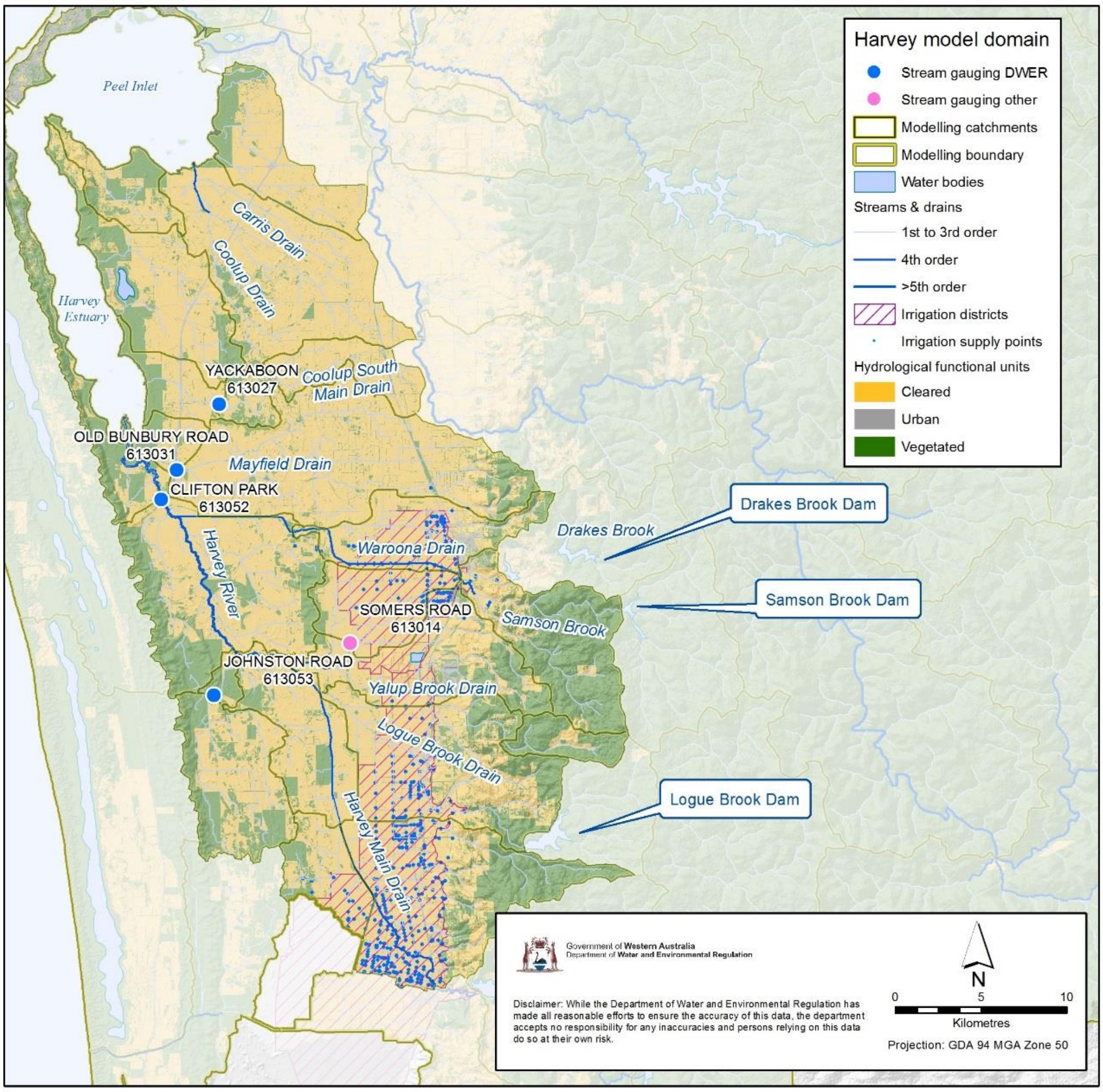


Figure A.5: Harvey model domain, catchments and flow calibration sites

Source version and plugins: Public 3.7.1 No plugins

Rainfall-runoff model: GR4J, SYMHYD with routing

Link model: Straight through routing

Climate data: Daily AWAP rainfall and FAO56 PET (derived from AWAP data) at catchment centroids

Additional boundaries: Inflow node model boundaries for irrigation supply in Waroona and Harvey irrigation districts with 45% return flows assumed based on average seasonal supply. Average Harvey Water supply point data from 1998 to 2008 was used to estimate irrigation supply.

Calibration period: 2000 to 2015

Validation period: 1980 to 1999

Objective function: Daily NSE with bias penalty

Calibration description: The catchment was split into vegetated, cleared and urban functional units based on 2016 land use mapping. Model parameters for the vegetated functional unit were calibrated to the River Road (614035) gauge which is fully vegetated. Cleared functional units were calibrated for the upstream catchment of each gauge. Cleared functional units in ungauged catchments were assigned parameters calibrated to the Yackaboon (613027) gauge. Mining areas in catchment #17 were assigned 'cleared' GR4J parameter set.

Rainfall-runoff parameters:

Subcatchment	Functional Unit	Model	GR4J-x1 (mm)	GR4J-x2 (mm)	GR4J-x3 (mm)	GR4J-x4 (d)
All	Vegetated	GR4J	917.186	-9.986	32.757	1.212
SC #6	Cleared	GR4J	340.076	-3.856	32.228	1.076
SC #7	Cleared	GR4J	340.076	-3.856	32.228	1.076
SC #8	Cleared	GR4J	340.076	-3.856	32.228	1.076
SC #9	Cleared	GR4J	340.076	-3.856	32.228	1.076
SC #10	Cleared	GR4J	340.076	-3.856	32.228	1.076
SC #11	Cleared	GR4J	340.076	-3.856	32.228	1.076
SC #15	Cleared	GR4J	251.596	-1.134	23.692	1.259
SC #16	Cleared	GR4J	251.596	-1.134	23.692	1.259
SC #17	Cleared	GR4J	251.596	-1.134	23.692	1.259
SC #18	Cleared	GR4J	251.596	-1.134	23.692	1.259
SC #20	Cleared	GR4J	251.596	-1.134	23.692	1.259
SC #22	Cleared	GR4J	251.596	-1.134	23.692	1.259
SC #23	Cleared	GR4J	251.596	-1.134	23.692	1.259
SC #25	Cleared	GR4J	251.596	-1.134	23.692	1.259
SC #26	Cleared	GR4J	251.596	-1.134	23.692	1.259
SC #27	Cleared	GR4J	251.596	-1.134	23.692	1.259
SC #28	Cleared	GR4J	286.247	-2.813	19.338	0.928
SC #34	Cleared	GR4J	340.076	-3.856	32.228	1.076
SC #35	Cleared	GR4J	231.025	-2.684	28.242	0.960
SC #36	Cleared	GR4J	231.025	-2.684	28.242	0.960
SC #37	Cleared	GR4J	486.125	-9.956	87.261	1.045
SC #38	Cleared	GR4J	243.655	-1.839	26.819	1.245

Simhyd with routing

Subcatchment	Function unit	Impervious Threshold (mm)	RISC (mm)	Perv. Fraction	SMSC (mm)	Infiltration shape	Infiltration Coeff.	Interflow Coeff.	Recharge coefficient	Baseflow coeff.
All	Urban	0.120	2.268	0.816	494.089	1.762	359.193	0.070	0.995	0.025

Link parameters: None

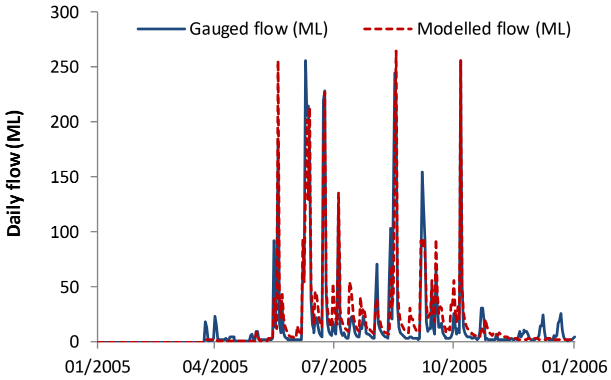
Runoff coefficients: Average annual modelled runoff coefficients for all areas in the Murray model domain. Flow from inflow nodes have been excluded.

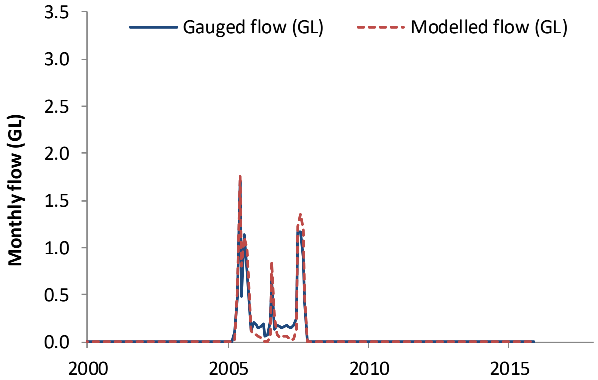
Period	Total RoC	Cleared RoC	Urban RoC	Vegetated RoC
All years	0.17	0.23	0.18	0.04
1980–99	0.18	0.25	0.19	0.04
2000–15	0.15	0.21	0.16	0.03

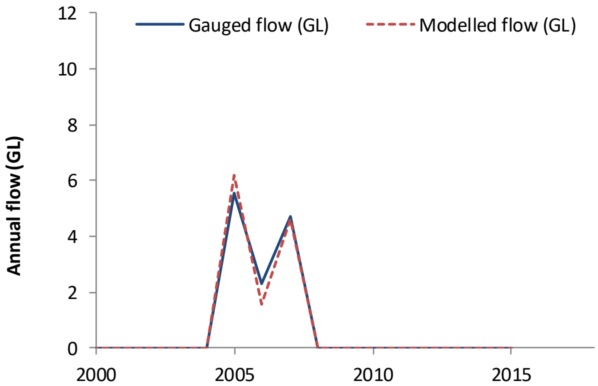
Samson North Drain - Somers Road - 613014

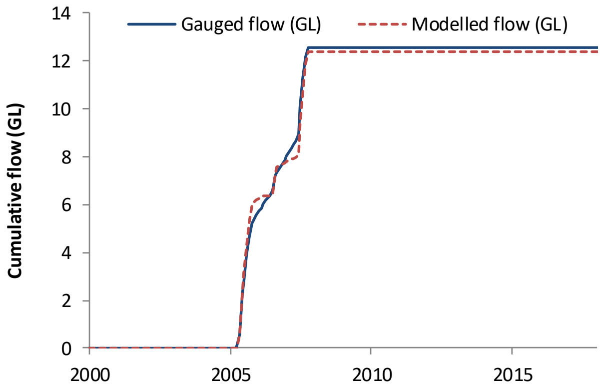
Statistic	Calibration	Validation
	2005–2007	*1980–99*
Daily NSE	0.82	0.67
Monthly NSE	0.90	0.71
Annual NSE	0.97	-0.22
Mass balance error	-2%	-20%

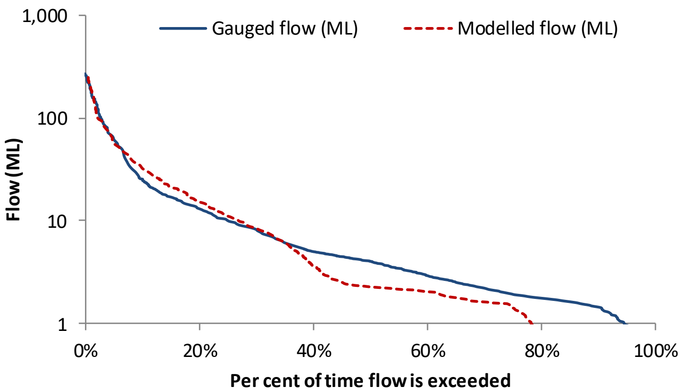
Daily flow statistic	Calibration		Validation	
	Gauged (ML)	Modelled (ML)	Gauged (ML)	Modelled (ML)
Min	0	0	0	0
Percentile:				
5th	1	0	1	0
10th	1	0	2	1
20th	2	1	3	2
50th	4	2	9	2
75th	10	11	16	12
Max	256	265	476	850







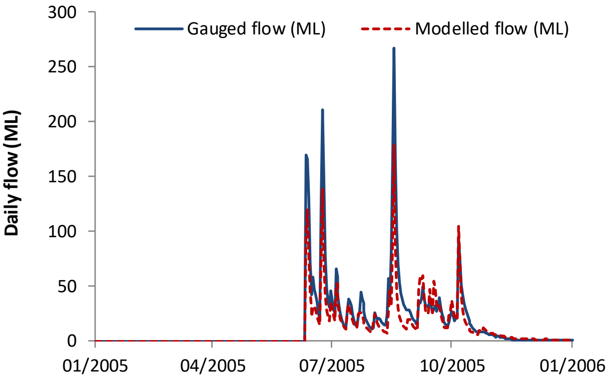


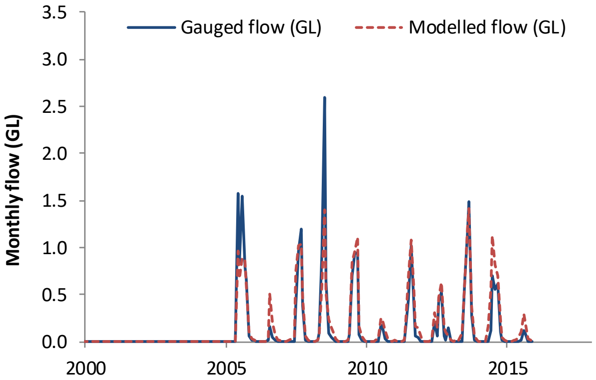


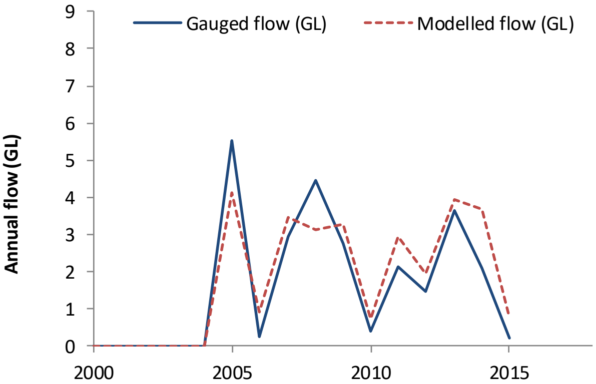
South Coolup Drain – Yackaboon – 613027

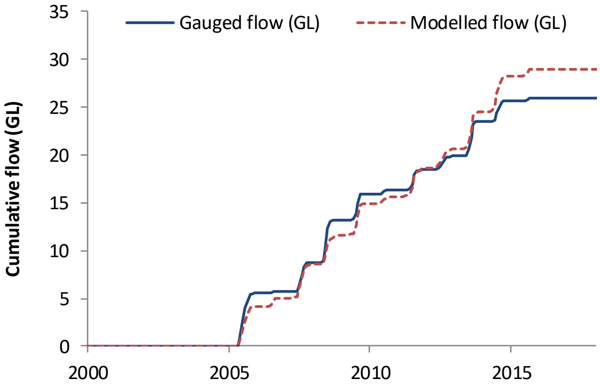
Statistic	Calibration *2005–15*	Validation *1990–98*
Daily NSE	0.82	0.78
Monthly NSE	0.85	0.90
Annual NSE	0.82	0.83
Mass balance error	12%	-9%

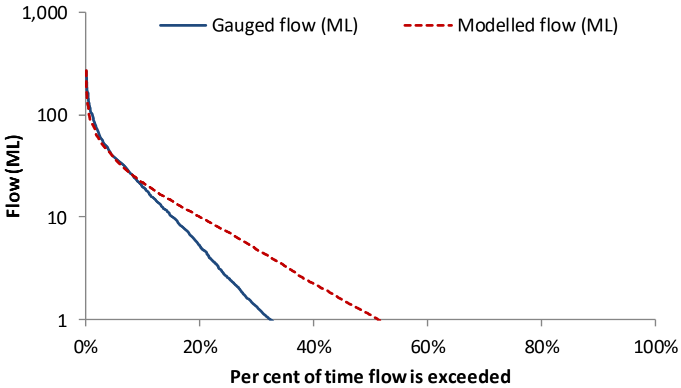
Daily flow statistic	Calibration Gauged (ML)	Calibration Modelled (ML)	Validation Gauged (ML)	Validation Modelled (ML)
Min	0	0	0	0
Percentile:				
5th	0	0	0	0
10th	0	0	0	0
20th	0	0	0	0
50th	0	1	0	2
75th	3	7	10	13
Max	270	179	420	501







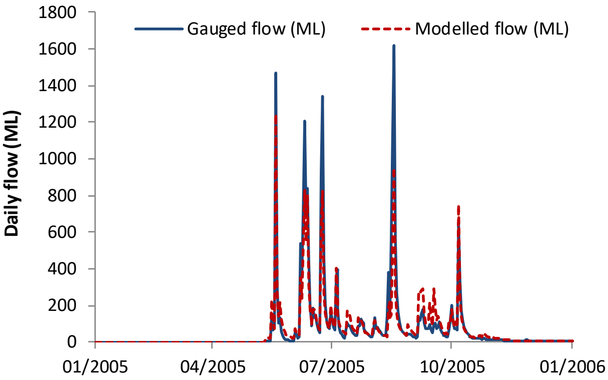


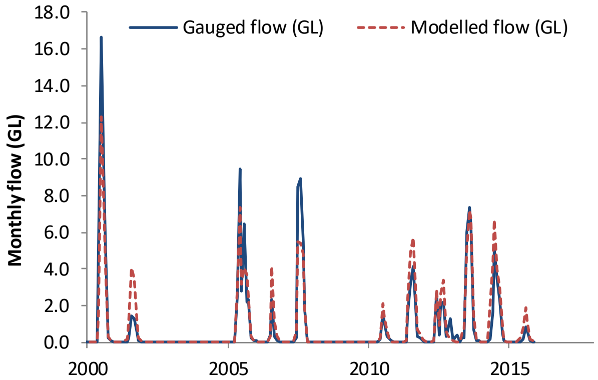


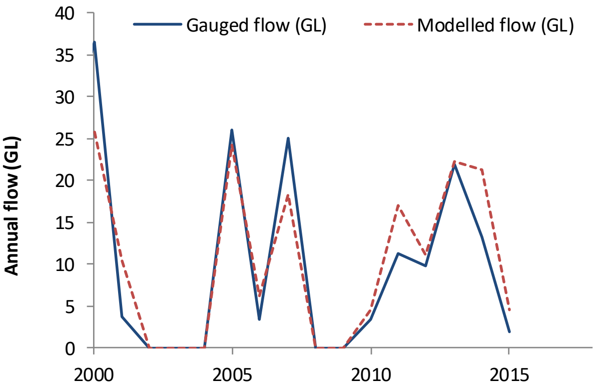
Mayfield Drain – Old Bunbury Road – 613031

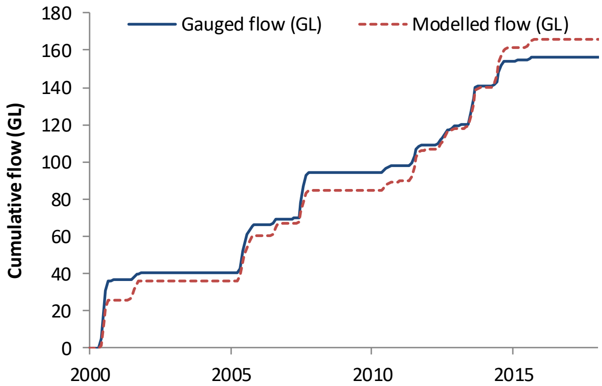
Statistic	Calibration *2000–15*	Validation *1991–99*
Daily NSE	0.77	0.82
Monthly NSE	0.86	0.93
Annual NSE	0.80	0.87
Mass balance error	6%	1%

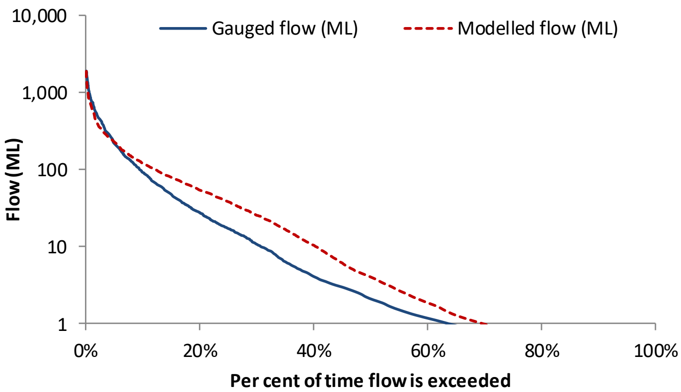
Daily flow statistic	Calibration Gauged (ML)	Calibration Modelled (ML)	Validation Gauged (ML)	Validation Modelled (ML)
Min	0	0	0	0
Percentile:				
5th	0	0	0	0
10th	0	0	0	0
20th	1	1	1	1
50th	2	4	3	5
75th	17	37	33	62
Max	1 841	1 528	2 253	2 936







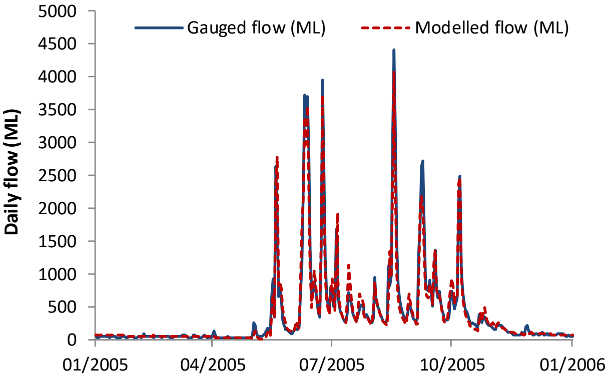


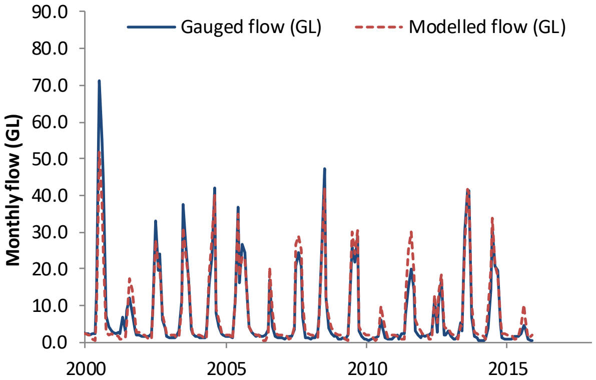


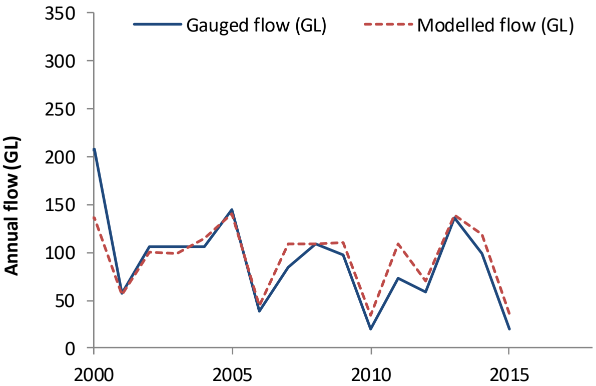
Harvey River – Clifton Park – 613052

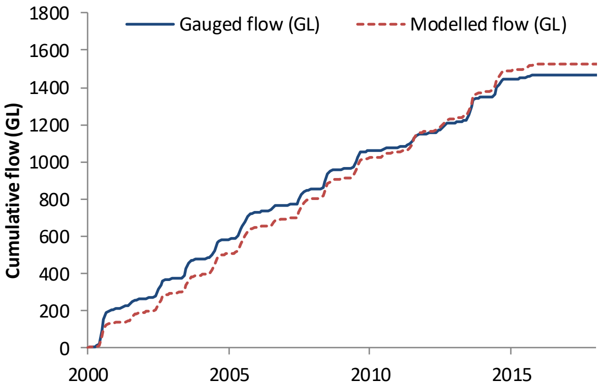
Statistic	Calibration	Validation
	2000–15	*1982–99*
Daily NSE	0.87	0.80
Monthly NSE	0.92	0.81
Annual NSE	0.86	0.22
Mass balance error	4%	-29%

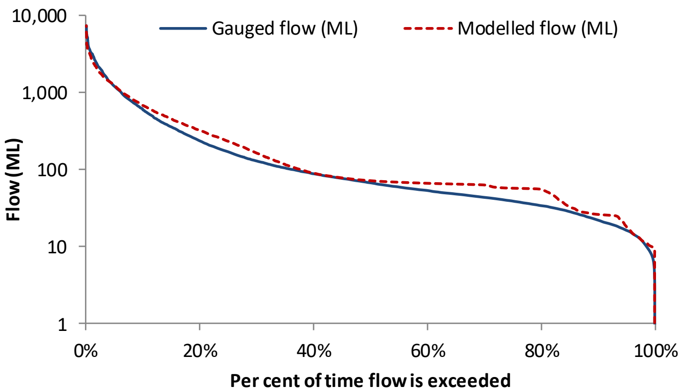
Daily flow statistic	Calibration		Validation	
	Gauged (ML)	Modelled (ML)	Gauged (ML)	Modelled (ML)
Min	4	9	6	9
Percentile:				
5th	16	18	29	19
10th	22	26	35	27
20th	34	55	47	57
50th	67	71	106	80
75th	169	231	497	349
Max	7 350	6 019	10 465	9 398







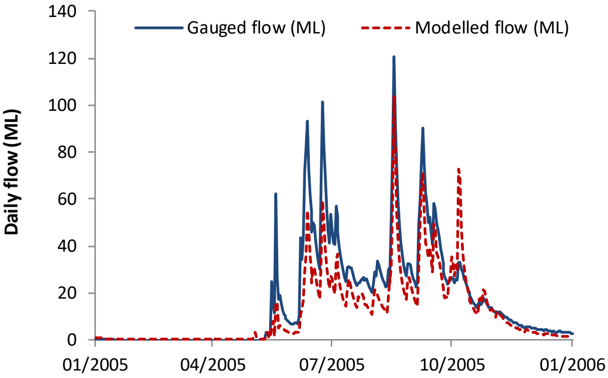


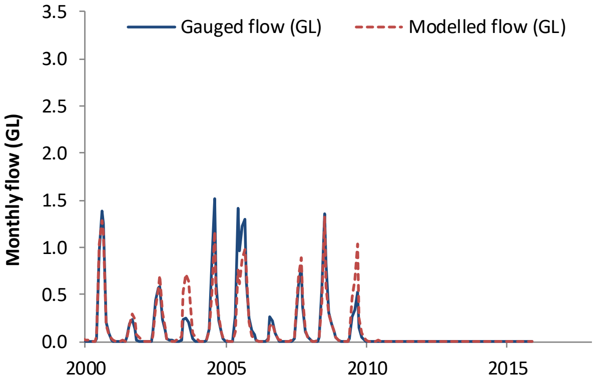


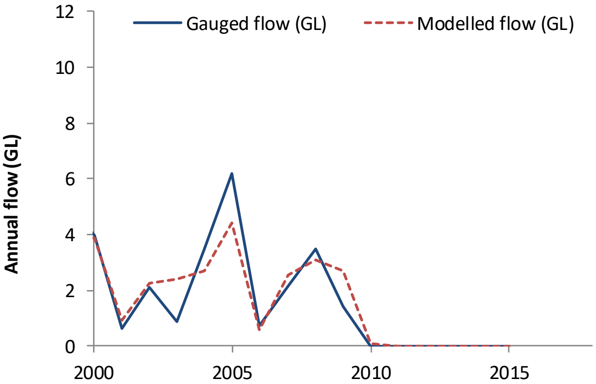
Meredith Drain - Johnston Road - 613053

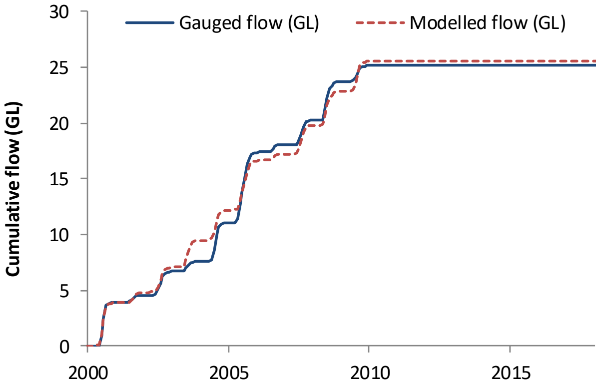
Statistic	Calibration	Validation
	2000–10	*1982–99*
Daily NSE	0.85	0.75
Monthly NSE	0.88	0.75
Annual NSE	0.89	0.16
Mass balance error	2%	-37%

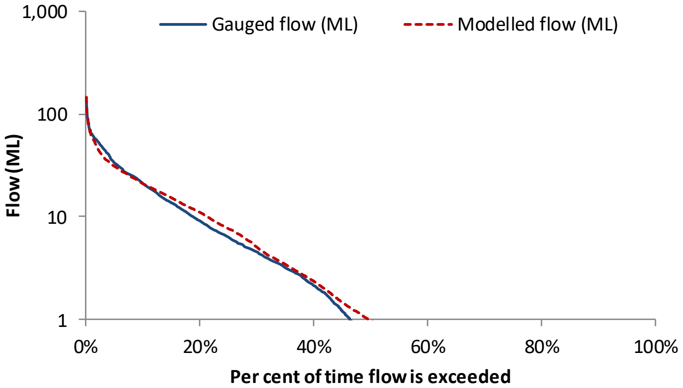
Daily flow statistic	Calibration Gauged (ML)	Calibration Modelled (ML)	Validation Gauged (ML)	Validation Modelled (ML)
Min	0	0	0	0
Percentile:				
5th	0	0	0	0
10th	0	0	0	0
20th	0	0	0	0
50th	1	1	4	2
75th	6	8	18	12
Max	145	132	345	255











A.8 Coastal south source model

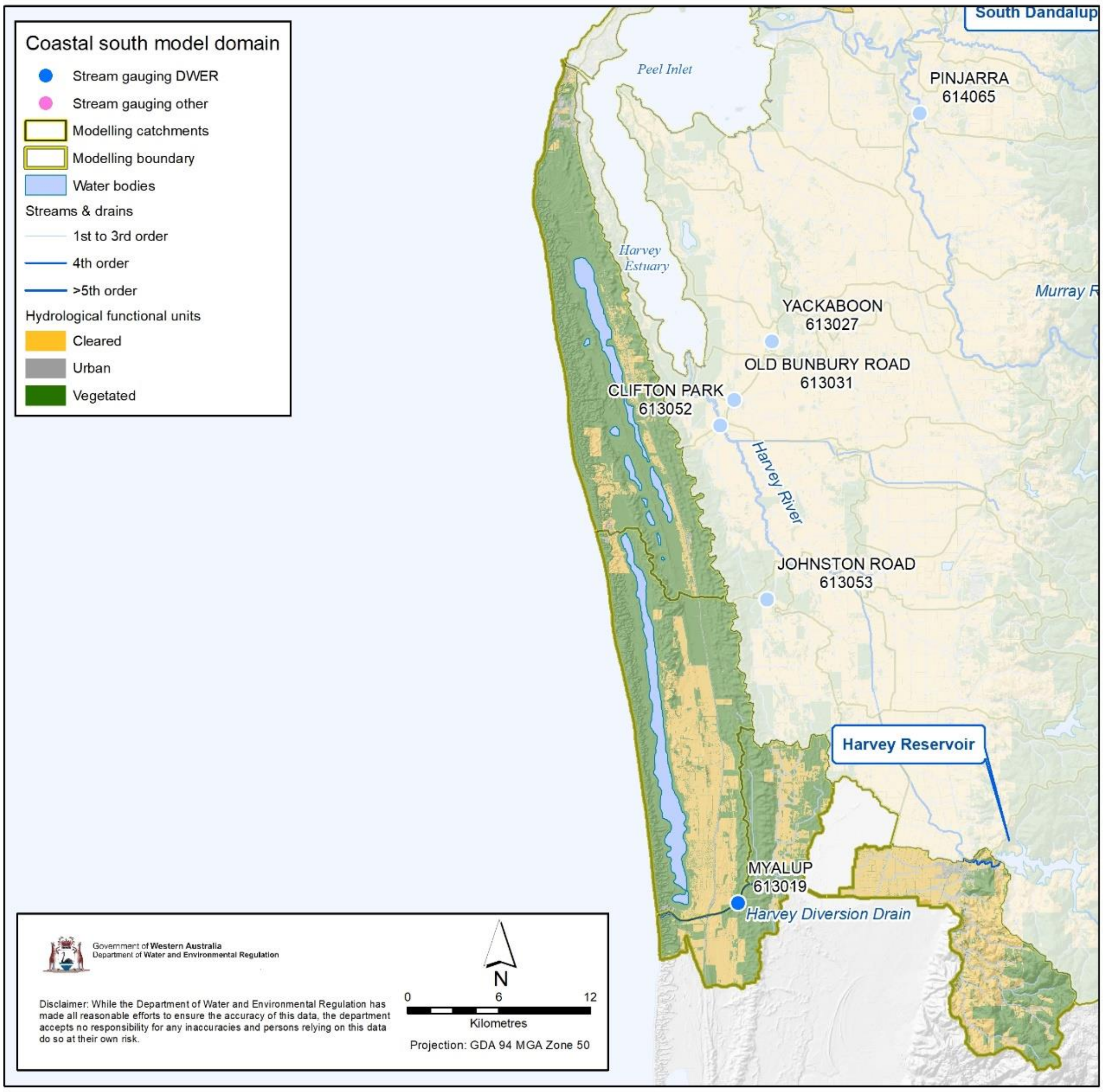


Figure A.6: Coastal south catchments and flow calibration sites

Source version and plugins: Public 3.7.1 No plugins

Rainfall-runoff model: GR4J, SYMHYD with routing

Link model: Straight through routing

Climate data: Daily AWAP rainfall and FAO56 PET (derived from AWAP data) at catchment centroids

Additional boundaries: Inflow node model boundaries for irrigation supply in Harvey irrigation district with 45% return flows assumed based on average seasonal supply. Average Harvey Water supply point data from 1998 to 2008 was used to estimate irrigation supply.

Calibration period: 2000 to 2015

Validation period: 1980 to 1999

Objective function: Daily NSE with bias penalty

Calibration description: The catchment was split into vegetated, cleared and urban functional units based on 2016 land use mapping. Model parameters for the cleared catchment areas were calibrated to the Myalup Gauge for the years 2014 and 2015 only. Cleared catchment parameters for the coastal strip were sourced from the Johnston Road catchment (SC37) in the Harvey Model.

Rainfall-runoff parameters:

Subcatchment	Functional Unit	Model	GR4J-x1 (mm)	GR4J-x2 (mm)	GR4J-x3 (mm)	GR4J-x4 (d)
All	Vegetated	GR4J	917.186	-9.986	32.757	1.212
SC #4	Cleared	GR4J	486.125	-9.956	87.261	1.045
SC #5	Cleared	GR4J	486.125	-9.956	87.261	1.045
SC #29	Cleared	GR4J	412.681	-3.105	13.187	2.181
SC #30	Cleared	GR4J	412.681	-3.105	13.187	2.181

Simhyd with routing

Subcatchment	Function unit	Impervious Threshold (mm)	RISC (mm)	Perv. Fraction	SMSC (mm)	Infiltration shape	Infiltration Coeff.	Interflow Coeff.	Recharge coefficient	Baseflow coeff.
All	Urban	0.120	2.268	0.816	494.089	1.762	359.193	0.070	0.995	0.025

Link parameters: None

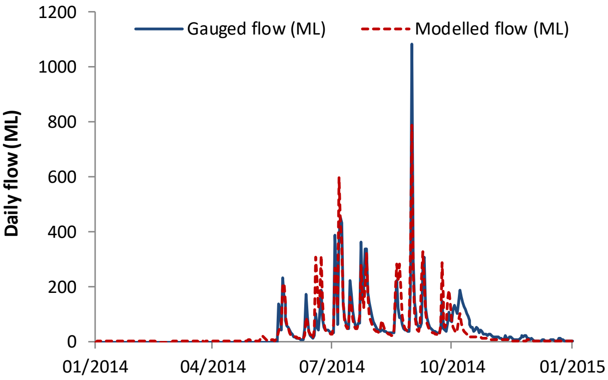
Runoff coefficients: Average annual modelled runoff coefficients for all areas in the Coastal South model domain. Flow from inflow nodes have been excluded.

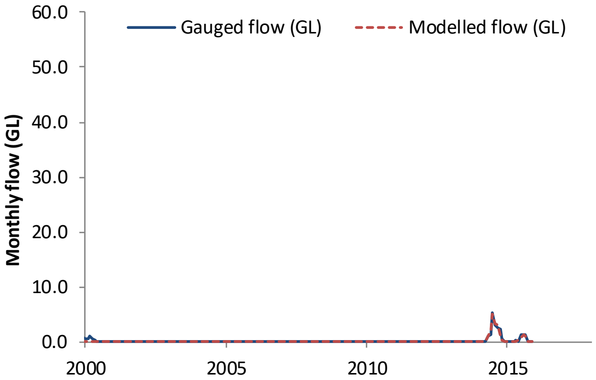
Period	Total RoC	Cleared RoC	Urban RoC	Vegetated RoC
All years	0.06	0.14	0.20	0.02
1980–99	0.07	0.16	0.22	0.03
2000–15	0.05	0.13	0.18	0.02

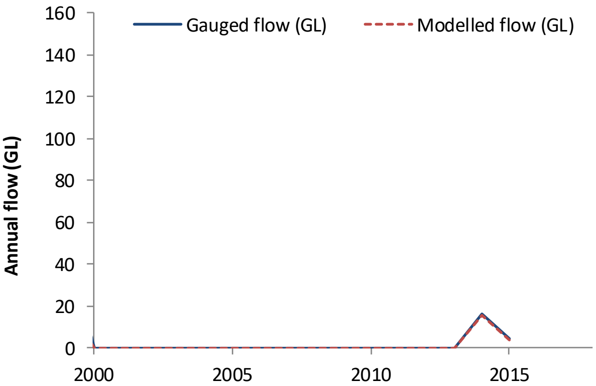
Harvey Diversion Drain – Myalup – 613019

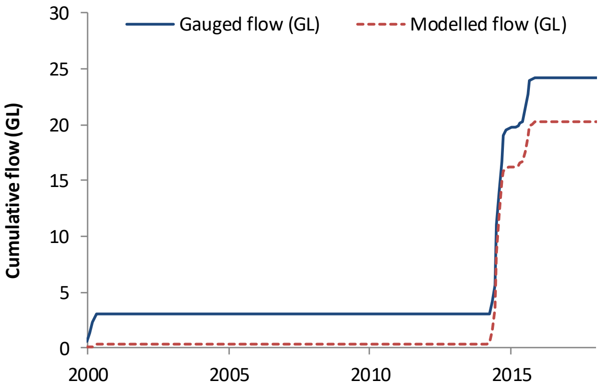
Statistic	Calibration	Validation
	2014–15	-
Daily NSE	0.96	0.23
Monthly NSE	0.99	0.09
Annual NSE	1.00	-2.48
Mass balance error	-5%	-76%

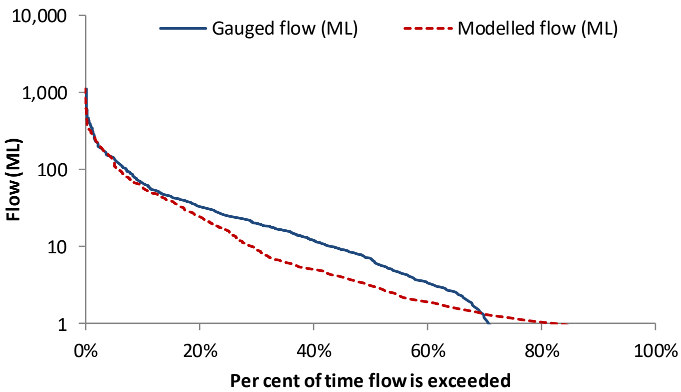
Daily flow statistic	Calibration		Validation	
	Gauged (ML)	Modelled (ML)	Gauged (ML)	Modelled (ML)
Min	0	1	0	0
Percentile:				
5th	0	1	7	1
10th	0	1	11	1
20th	0	1	19	1
50th	7	3	43	8
75th	25	16	227	44
Max	1 083	788	4 581	1 932











A.9 Coastal north and central source models

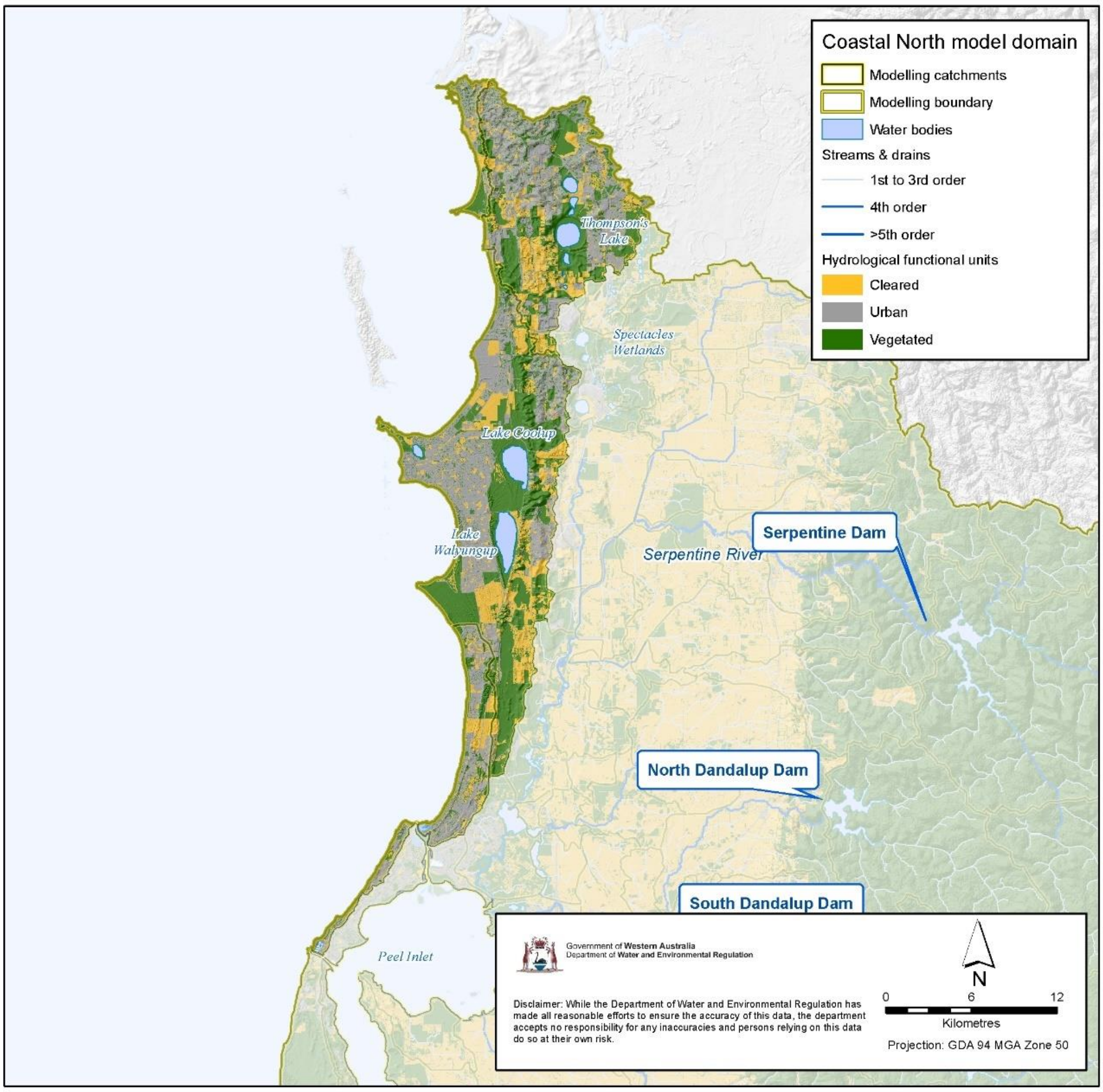


Figure A.7: Coastal north and central catchments

Source version and plugins: *Public 3.7.1* *No plugins*

Rainfall-runoff model: GR4J, SYMHYD with routing

Link model: Straight through routing

Climate data: Daily AWAP rainfall and FAO56 PET (derived from AWAP data) at catchment centroids

Additional boundaries: None

Calibration period: NA

Validation period: NA

Objective function: MA

Calibration description: The catchment was split into vegetated, cleared and urban functional units based on 2016 land use mapping. Urban model parameters were sourced from Bannister Creek. Cleared parameters were sourced from the Hope Valley catchment in the Serpentine model. Vegetated parameters were sourced from the River Road catchment.

Rainfall-runoff parameters:

Subcatchment	Functional Unit	Model	GR4J-x1 (mm)	GR4J-x2 (mm)	GR4J-x3 (mm)	GR4J-x4 (d)
All	Vegetated	GR4J	917.186	-9.986	32.757	1.212
SC #1	Cleared	GR4J	1499.950	-0.556	8.596	0.509
SC #2	Cleared	GR4J	1499.950	-0.556	8.596	0.509
SC #3	Cleared	GR4J	1499.950	-0.556	8.596	0.509
SC #98	Cleared	GR4J	1499.950	-0.556	8.596	0.509

Simhyd with routing

Subcatchment	Function unit	Impervious Threshold (mm)	RISC (mm)	Perv. Fraction	SMSC (mm)	Infiltration shape	Infiltration Coeff.	Interflow Coeff.	Recharge coefficient	Baseflow coeff.
All	Urban	0.120	2.268	0.816	494.089	1.762	359.193	0.070	0.995	0.025

Link parameters: None

Runoff coefficients: Average annual modelled runoff coefficients for all areas in the Coastal North model domain. Flow from inflow nodes have been excluded.

Period	**Total RoC**	**Cleared RoC**	**Urban RoC**	**Vegetated RoC**
All years	0.16	0.45	0.15	0.02
1980–99	0.17	0.47	0.16	0.02
2000–15	0.15	0.42	0.14	0.01

Appendix B: Nutrient calibration

B.1 Statistics from measured data

B.1.1 Nutrient status

Nutrient status is a method for classifying and reporting total nitrogen (TN) and total phosphorus (TP) concentrations. Nutrient status is a three-year median of consecutive years of water quality data and includes statistical measures to account for inter-annual variation. A full description of the calculation of nutrient status is given here[1].

The nutrient status classifications that we used are given in Table B.1 and the calculated nutrient status for all monitored sites is given in Table B.2 for the period of 2013–15.

Table B.1: Classifications used to assess the status of TN and TP concentrations

Status		Total nitrogen (mg/L)	Total phosphorus (mg/L)
Very high	🔴	> 2.0	> 0.2
High	🟡	1.2–2.0	0.08–0.2
Moderate	🟢	0.75–1.2	0.02–0.08
Low	🔵	< 0.75	< 0.02

Table B.2: Three-year median concentrations for the period of 2013–15

AWRC Ref	Site context	River name	TN (mg/L)	TN Status	TP (mg/L)	TP Status
613014	Somers Road	Samson North Drain	1.60	🟡	0.200	🟡
613027	Yackaboon	South Coolup Main Drain	2.15	🔴	0.285	🔴
613031	Old Bunbury Road	Mayfield Drain	0.54	🔵	0.031	🟢
613052	Clifton Park	Harvey River	1.40	🟡	0.150	🟡
613053	Johnston Road	Meredith Drain	2.40	🔴	0.260	🔴
614030	Dog Hill	Serpentine Drain	0.91	🟢	0.110	🟡
614063	Kielman	Nambeelup Brook	3.65	🔴	0.600	🔴
614065	Pinjarra	Murray River	0.56	🔵	0.013	🔵
614094	Yangedi Swamp	Punrack Drain	2.40	🔴	0.190	🟡
614120	Gull Road	Gull Road Drain	4.60	🔴	0.910	🔴
614121	Karnup Road	Peel Main Drain	1.40	🟡	0.235	🔴
6131335	Drakesbrook Drain	Harvey Catchment	1.05	🟢	0.062	🟢
6142623	Patterson Rd	South Dandalup River	0.80	🟢	0.095	🟡

B.1.2 Trends

Surface water nutrient concentrations are inherently variable. Changes brought about by human activity will usually be superimposed on natural sources of variation as well as the effect of climate. We examined the influences of flow and seasonal variation and applied

[1] https://www.water.wa.gov.au/water-topics/waterways/assessing-waterway-health/catchment-nutirent-reports

corrections before trend analysis. Thus, the observed trends in nutrient concentrations are likely to be linked to human intervention or other changes within the catchment.

Non-parametric tests are used to identify statistically significant trends in the nutrient data; they are used because they are not affected by non-normal data distribution, are not sensitive to outliers and are not affected by missing or censored data (Loftis et al. 1991). An assumption of the non-parametric (Mann-Kendall) trend tests is that the trends are monotonically increasing or decreasing (Helshel & Hirsch 1992). Refer to the department's website[2] for more information about this statistical technique.

To detect a statistically significant trend the *p-value* must be below 0.05, and the number of independent samples (n^*) must be larger than the number of independent samples required to detect a trend ($n^\#$). That is, if $p < 0.05$ and $n^* > n^\#$, then there is a statistically significant trend. If $p < 0.05$ and $n^* < n^\#$, then it is likely that a trend will emerge if more samples are collected.

Table B.3 and Table B.4 give the medium term (2010–14) trends in TN and TP concentrations respectively. We found increasing TN trends at Meredith Drain and Peel Main Drain, increasing TP trends at Harvey River and Nambeelup Brook and decreasing TP trends at Gull Road drain and the Murray River.

Table B.3: Medium term (2010–14) total nitrogen trends

AWRC ref	River name	Flow adjusted	Test	p	n*	n#	Trend (mg/L/yr)	Trend
613053	Meredith Drain	No	S	0.001	58	22	0.30	Increasing trend
614121	Peel Main Drain	No	S	0.049	44	29	0.15	Increasing trend
614121	Peel Main Drain	Yes	S	0.023	73	70	0.07	Increasing trend

S = Seasonal Kendall, MK = Mann-Kendall

Table B.4: Medium-term (2010–14) total phosphorus trends

AWRC ref	River name	Flow adjusted	Test	p	n*	n#	Trend (mg/L/yr)	Trend
613052	Harvey River	No	S	0	85	27	0.02	Increasing trend
614063	Nambeelup Brook	No	S	0.016	58	44	0.05	Increasing trend
614065	Murray River	Yes	S	0.003	84	47	0.00	Decreasing trend
614120	Gull Road Drain	No	S	0	43	8	-0.17	Decreasing trend

S = Seasonal Kendall, MK = Mann-Kendall

[2] https://www.water.wa.gov.au/water-topics/waterways/assessing-waterway-health/catchment-nutirent-reports

B.2 Nutrient model parameters and daily data

Table B.5: Hydrological and nutrient model parameters used by reporting catchment

Reporting catchment	**Hydrological model**	**Nutrient model**
Coastal Central	North Coastal	Peel Main Drain
Coastal North	North Coastal	Peel Main Drain
Coastal South	South Coastal	Peel Main Drain
Coolup (Harvey)	Harvey	Coolup (Harvey)
Coolup (Peel)	Harvey	Coolup (Peel) ungauged
Dirk Brook	Lower Serpentine	Dirk Brook
Harvey	Harvey	Harvey
Harvey Diversion Drain	South Coastal	Harvey Diversion Drain ungauged
Lower Serpentine	Lower Serpentine	Upper Serpentine
Mandurah	Harvey	Peel Main Drain
Mayfield Drain	Harvey	Mayfield
Meredith Drain	Harvey	Meredith
Murray	Murray	Murray ungauged
Nambeelup	Lower Serpentine	Nambeelup
Peel Main Drain	Lower Serpentine	Peel Main Drain
Upper Murray	Murray	Upper Murray
Upper Serpentine	Lower Serpentine	Upper Serpentine
Upstream Harvey Reservoir	Dams	Dams
Upstream North Dandalup Dam	Dams	Dams
Upstream Serpentine Dam	Dams	Dams
Upstream South Dandalup Dam	Dams	Dams

Table B.6: Nitrogen model parameters

Modelling land use	Dirk Brook		Nambeelup		Peel Main Drain		Upper Serpentine		Gull Road		Upper Murray		Murray		Harvey		Samson		Drakesbrook		Meredith		Mayfield		Coolup (Harvey)		Dams		Coolup (Peel) ungauged		Murray ungauged		Harvey Diversion Drain ungauged	
	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b
Bare soil & other (high PRI)	0.14	0.16	0.25	0.03	0.31	0.10	0.15	0.25	0.15	-0.10	0.13	0.20	0.10	0.38	0.15	0.29	0.14	0.20	0.14	0.20	0.24	0.18	0.12	0.26	0.15	0.05	0.21	-0.20	0.15	0.05	0.10	0.38	0.31	0.10
Bare soil & other (low PRI)	0.14	0.16	0.25	0.03	0.31	0.10	0.15	0.25	0.15	-0.10	0.13	0.20	0.10	0.38	0.15	0.29	0.14	0.20	0.14	0.20	0.24	0.18	0.12	0.26	0.15	0.05	0.21	-0.20	0.15	0.05	0.10	0.38	0.31	0.10
Beef (high PRI)	2.43	0.16	4.28	0.03	5.16	0.10	2.58	0.25	2.52	-0.10	2.12	0.20	1.69	0.38	2.56	0.29	2.30	0.20	2.41	0.20	4.10	0.18	2.04	0.26	2.57	0.05	0.21	-0.20	2.57	0.05	1.69	0.38	5.16	0.10
Beef (low PRI)	2.43	0.16	4.28	0.03	5.16	0.10	2.58	0.25	2.52	-0.10	2.12	0.20	1.69	0.38	2.56	0.29	2.30	0.20	2.41	0.20	4.10	0.18	2.04	0.26	2.57	0.05	0.21	-0.20	2.57	0.05	1.69	0.38	5.16	0.10
Cropping (high PRI)	1.11	0.16	1.96	0.03	2.36	0.10	1.18	0.25	1.15	-0.10	0.97	0.20	0.77	0.38	1.17	0.29	1.05	0.20	1.10	0.20	1.87	0.18	0.93	0.26	1.18	0.05	0.21	-0.20	1.18	0.05	0.77	0.38	2.36	0.10
Cropping (low PRI)	1.11	0.16	1.96	0.03	2.36	0.10	1.18	0.25	1.15	-0.10	0.97	0.20	0.77	0.38	1.17	0.29	1.05	0.20	1.10	0.20	1.87	0.18	0.93	0.26	1.18	0.05	0.21	-0.20	1.18	0.05	0.77	0.38	2.36	0.10
Dairy (high PRI)	3.82	0.16	7.90	0.03	7.97	0.10	4.29	0.25	3.89	-0.10	3.27	0.20	2.92	0.38	4.02	0.29	4.61	0.20	3.55	0.20	6.33	0.18	2.96	0.26	3.79	0.05	0.21	-0.20	6.37	0.05	3.13	0.38	3.98	0.10
Dairy (low PRI)	3.75	0.16	6.72	0.03	7.97	0.10	5.99	0.25	3.89	-0.10	3.27	0.20	2.60	0.38	1.61	0.29	3.54	0.20	4.75	0.20	6.33	0.18	4.22	0.26	5.94	0.05	0.21	-0.20	3.74	0.05	5.85	0.38	3.98	0.10
Feedlots & stockyards (high PRI)	18.19	0.16	32.08	0.03	38.70	0.10	19.36	0.25	18.90	-0.10	15.89	0.20	12.64	0.38	19.16	0.29	17.20	0.20	18.02	0.20	30.73	0.18	15.30	0.26	19.28	0.05	0.21	-0.20	19.28	0.05	12.64	0.38	38.70	0.10
Feedlots & stockyards (low PRI)	18.19	0.16	32.08	0.03	38.70	0.10	19.36	0.25	18.90	-0.10	15.89	0.20	12.64	0.38	19.16	0.29	17.20	0.20	18.02	0.20	30.73	0.18	15.30	0.26	19.28	0.05	0.21	-0.20	19.28	0.05	12.64	0.38	38.70	0.10
Horses (high PRI)	1.94	0.16	3.42	0.03	4.12	0.10	2.06	0.25	2.01	-0.10	1.69	0.20	1.35	0.38	2.04	0.29	1.83	0.20	1.92	0.20	3.27	0.18	1.63	0.26	2.05	0.05	0.21	-0.20	2.05	0.05	1.35	0.38	4.12	0.10
Horses (low PRI)	1.94	0.16	3.42	0.03	4.12	0.10	2.06	0.25	2.01	-0.10	1.69	0.20	1.35	0.38	2.04	0.29	1.83	0.20	1.92	0.20	3.27	0.18	1.63	0.26	2.05	0.05	0.21	-0.20	2.05	0.05	1.35	0.38	4.12	0.10
Horticulture (high PRI)	1.41	0.16	2.49	0.03	3.00	0.10	1.50	0.25	1.47	-0.10	1.23	0.20	0.98	0.38	1.49	0.29	1.33	0.20	1.40	0.20	2.38	0.18	1.19	0.26	1.50	0.05	0.21	-0.20	1.50	0.05	0.98	0.38	3.00	0.10
Horticulture (low PRI)	1.41	0.16	2.49	0.03	3.00	0.10	1.50	0.25	1.47	-0.10	1.23	0.20	0.98	0.38	1.49	0.29	1.33	0.20	1.40	0.20	2.38	0.18	1.19	0.26	1.50	0.05	0.21	-0.20	1.50	0.05	0.98	0.38	3.00	0.10
Industry, manufacturing & transport (high PRI)	0.10	0.16	0.11	0.03	0.05	0.10	0.06	0.25	0.03	-0.10	0.03	0.20	0.06	0.38	0.13	0.29	0.08	0.20	0.13	0.20	0.07	0.18	0.08	0.26	0.07	0.05	0.21	-0.20	0.07	0.05	0.06	0.38	0.05	0.10
Industry, manufacturing & transport (low PRI)	0.10	0.16	0.11	0.03	0.05	0.10	0.06	0.25	0.03	-0.10	0.03	0.20	0.06	0.38	0.13	0.29	0.08	0.20	0.13	0.20	0.07	0.18	0.08	0.26	0.07	0.05	0.21	-0.20	0.07	0.05	0.06	0.38	0.05	0.10
Lifestyle block (high PRI)	1.52	0.16	2.67	0.03	3.22	0.10	1.61	0.25	1.58	-0.10	1.32	0.20	1.05	0.38	1.60	0.29	1.43	0.20	1.50	0.20	2.56	0.18	1.28	0.26	1.61	0.05	0.21	-0.20	1.61	0.05	1.05	0.38	3.22	0.10
Lifestyle block (low PRI)	1.52	0.16	2.67	0.03	3.22	0.10	1.61	0.25	1.58	-0.10	1.32	0.20	1.05	0.38	1.60	0.29	1.43	0.20	1.50	0.20	2.56	0.18	1.28	0.26	1.61	0.05	0.21	-0.20	1.61	0.05	1.05	0.38	3.22	0.10
Mixed grazing (high PRI)	1.90	0.16	3.35	0.03	4.04	0.10	2.02	0.25	1.97	-0.10	1.66	0.20	1.32	0.38	2.00	0.29	1.79	0.20	1.88	0.20	3.21	0.18	1.60	0.26	2.01	0.05	0.21	-0.20	2.01	0.05	1.32	0.38	4.04	0.10
Mixed grazing (low PRI)	1.90	0.16	3.35	0.03	4.04	0.10	2.02	0.25	1.97	-0.10	1.66	0.20	1.32	0.38	2.00	0.29	1.79	0.20	1.88	0.20	3.21	0.18	1.60	0.26	2.01	0.05	0.21	-0.20	2.01	0.05	1.32	0.38	4.04	0.10
Native vegetation (high PRI)	0.08	0.16	0.22	0.03	0.12	0.10	0.11	0.25	0.08	-0.10	0.11	0.20	0.12	0.38	0.08	0.29	0.10	0.20	0.05	0.20	0.08	0.18	0.11	0.26	0.11	0.05	0.21	-0.20	0.11	0.05	0.12	0.38	0.12	0.10
Native vegetation (low PRI)	0.08	0.16	0.22	0.03	0.12	0.10	0.11	0.25	0.08	-0.10	0.11	0.20	0.12	0.38	0.08	0.29	0.10	0.20	0.05	0.20	0.08	0.18	0.11	0.26	0.11	0.05	0.21	-0.20	0.11	0.05	0.12	0.38	0.12	0.10
Offices, commercial & education (high PRI)	1.93	0.16	2.27	0.03	0.93	0.10	1.31	0.25	0.62	-0.10	0.69	0.20	1.14	0.38	2.69	0.29	1.56	0.20	2.61	0.20	1.34	0.18	1.65	0.26	1.35	0.05	0.21	-0.20	1.35	0.05	1.14	0.38	0.93	0.10
Offices, commercial & education (low PRI)	1.93	0.16	2.27	0.03	0.93	0.10	1.31	0.25	0.62	-0.10	0.69	0.20	1.14	0.38	2.69	0.29	1.56	0.20	2.61	0.20	1.34	0.18	1.65	0.26	1.35	0.05	0.21	-0.20	1.35	0.05	1.14	0.38	0.93	0.10
Orchard (high PRI)	0.26	0.16	0.46	0.03	0.55	0.10	0.28	0.25	0.27	-0.10	0.23	0.20	0.18	0.38	0.27	0.29	0.25	0.20	0.26	0.20	0.44	0.18	0.22	0.26	0.27	0.05	0.21	-0.20	0.27	0.05	0.18	0.38	0.55	0.10
Orchard (low PRI)	0.26	0.16	0.46	0.03	0.55	0.10	0.28	0.25	0.27	-0.10	0.23	0.20	0.18	0.38	0.27	0.29	0.25	0.20	0.26	0.20	0.44	0.18	0.22	0.26	0.27	0.05	0.21	-0.20	0.27	0.05	0.18	0.38	0.55	0.10
Piggeries & abattoirs (high PRI)	8.71	0.16	15.37	0.03	18.54	0.10	9.28	0.25	9.06	-0.10	7.61	0.20	6.06	0.38	9.18	0.29	8.24	0.20	8.63	0.20	14.72	0.18	7.33	0.26	9.23	0.05	0.21	-0.20	9.23	0.05	6.06	0.38	18.54	0.10
Piggeries & abattoirs (low PRI)	8.71	0.16	15.37	0.03	18.54	0.10	9.28	0.25	9.06	-0.10	7.61	0.20	6.06	0.38	9.18	0.29	8.24	0.20	8.63	0.20	14.72	0.18	7.33	0.26	9.23	0.05	0.21	-0.20	9.23	0.05	6.06	0.38	18.54	0.10
Plantation (high PRI)	1.71	0.16	4.55	0.03	2.42	0.10	2.36	0.25	1.73	-0.10	2.26	0.20	2.49	0.38	1.65	0.29	2.02	0.20	0.97	0.20	1.72	0.18	2.34	0.26	2.16	0.05	0.21	-0.20	2.16	0.05	2.49	0.38	2.42	0.10
Plantation (low PRI)	1.71	0.16	4.55	0.03	2.42	0.10	2.36	0.25	1.73	-0.10	2.26	0.20	2.49	0.38	1.65	0.29	2.02	0.20	0.97	0.20	1.72	0.18	2.34	0.26	2.16	0.05	0.21	-0.20	2.16	0.05	2.49	0.38	2.42	0.10
Point source (high PRI)	0.14	0.16	0.25	0.03	0.31	0.10	0.15	0.25	0.15	-0.10	0.13	0.20	0.10	0.38	0.15	0.29	0.14	0.20	0.14	0.20	0.24	0.18	0.12	0.26	0.15	0.05	0.21	-0.20	0.15	0.05	0.10	0.38	0.31	0.10
Point source (low PRI)	0.14	0.16	0.25	0.03	0.31	0.10	0.15	0.25	0.15	-0.10	0.13	0.20	0.10	0.38	0.15	0.29	0.14	0.20	0.14	0.20	0.24	0.18	0.12	0.26	0.15	0.05	0.21	-0.20	0.15	0.05	0.10	0.38	0.31	0.10
Poultry (high PRI)	37.71	0.16	66.51	0.03	80.23	0.10	40.15	0.25	39.19	-0.10	32.94	0.20	26.21	0.38	39.73	0.29	35.66	0.20	37.37	0.20	63.71	0.18	31.72	0.26	39.96	0.05	0.21	-0.20	39.96	0.05	26.21	0.38	80.23	0.10
Poultry (low PRI)	37.71	0.16	66.51	0.03	80.23	0.10	40.15	0.25	39.19	-0.10	32.94	0.20	26.21	0.38	39.73	0.29	35.66	0.20	37.37	0.20	63.71	0.18	31.72	0.26	39.96	0.05	0.21	-0.20	39.96	0.05	26.21	0.38	80.23	0.10
Recreation (high PRI)	1.97	0.16	3.48	0.03	4.20	0.10	2.10	0.25	2.05	-0.10	1.72	0.20	1.37	0.38	2.08	0.29	1.87	0.20	1.96	0.20	3.33	0.18	1.66	0.26	2.09	0.05	0.21	-0.20	2.09	0.05	1.37	0.38	4.20	0.10
Recreation (low PRI)	1.97	0.16	3.48	0.03	4.20	0.10	2.10	0.25	2.05	-0.10	1.72	0.20	1.37	0.38	2.08	0.29	1.87	0.20	1.96	0.20	3.33	0.18	1.66	0.26	2.09	0.05	0.21	-0.20	2.09	0.05	1.37	0.38	4.20	0.10
Rural living (bush block) (high PRI)	1.49	0.16	3.96	0.03	2.11	0.10	2.06	0.25	1.51	-0.10	1.97	0.20	2.17	0.38	1.44	0.29	1.76	0.20	0.84	0.20	1.50	0.18	2.04	0.26	1.88	0.05	0.21	-0.20	1.88	0.05	2.17	0.38	2.11	0.10
Rural living (bush block) (low PRI)	1.49	0.16	3.96	0.03	2.11	0.10	2.06	0.25	1.51	-0.10	1.97	0.20	2.17	0.38	1.44	0.29	1.76	0.20	0.84	0.20	1.50	0.18	2.04	0.26	1.88	0.05	0.21	-0.20	1.88	0.05	2.17	0.38	2.11	0.10
Turf farm (high PRI)	2.77	0.16	4.89	0.03	5.90	0.10	2.95	0.25	2.88	-0.10	2.42	0.20	1.93	0.38	2.92	0.29	2.62	0.20	2.75	0.20	4.68	0.18	2.33	0.26	2.94	0.05	0.21	-0.20	2.94	0.05	1.93	0.38	5.90	0.10
Turf farm (low PRI)	2.77	0.16	4.89	0.03	5.90	0.10	2.95	0.25	2.88	-0.10	2.42	0.20	1.93	0.38	2.92	0.29	2.62	0.20	2.75	0.20	4.68	0.18	2.33	0.26	2.94	0.05	0.21	-0.20	2.94	0.05	1.93	0.38	5.90	0.10
Urban residential (high PRI)	1.63	0.16	1.92	0.03	0.78	0.10	1.11	0.25	0.52	-0.10	0.58	0.20	0.96	0.38	2.27	0.29	1.32	0.20	2.21	0.20	1.13	0.18	1.40	0.26	1.14	0.05	0.21	-0.20	1.14	0.05	0.96	0.38	0.78	0.10
Urban residential (low PRI)	1.63	0.16	1.92	0.03	0.78	0.10	1.11	0.25	0.52	-0.10	0.58	0.20	0.96	0.38	2.27	0.29	1.32	0.20	2.21	0.20	1.13	0.18	1.40	0.26	1.14	0.05	0.21	-0.20	1.14	0.05	0.96	0.38	0.78	0.10
Urban residential (very small) (high PRI)	0.52	0.16	0.61	0.03	0.25	0.10	0.35	0.25	0.17	-0.10	0.19	0.20	0.31	0.38	0.73	0.29	0.42	0.20	0.70	0.20	0.36	0.18	0.45	0.26	0.36	0.05	0.21	-0.20	0.36	0.05	0.31	0.38	0.25	0.10
Urban residential (very small) (low PRI)	0.52	0.16	0.61	0.03	0.25	0.10	0.35	0.25	0.17	-0.10	0.19	0.20	0.31	0.38	0.73	0.29	0.42	0.20	0.70	0.20	0.36	0.18	0.45	0.26	0.36	0.05	0.21	-0.20	0.36	0.05	0.31	0.38	0.25	0.10
Viticulture (high PRI)	1.45	0.16	2.56	0.03	3.09	0.10	1.54	0.25	1.51	-0.10	1.27	0.20	1.01	0.38	1.53	0.29	1.37	0.20	1.44	0.20	2.45	0.18	1.22	0.26	1.54	0.05	0.21	-0.20	1.54	0.05	1.01	0.38	3.09	0.10
Viticulture (low PRI)	1.45	0.16	2.56	0.03	3.09	0.10	1.54	0.25	1.51	-0.10	1.27	0.20	1.01	0.38	1.53	0.29	1.37	0.20	1.44	0.20	2.45	0.18	1.22	0.26	1.54	0.05	0.21	-0.20	1.54	0.05	1.01	0.38	3.09	0.10
Total	**2.26**	**0.16**	**4.15**	**0.03**	**1.79**	**0.10**	**2.45**	**0.25**	**4.28**	**-0.10**	**0.92**	**0.20**	**1.46**	**0.38**	**2.17**	**0.29**	**2.15**	**0.20**	**1.80**	**0.20**	**3.50**	**0.18**	**1.91**	**0.26**	**2.50**	**0.05**	**0.21**	**-0.20**	**2.50**	**0.05**	**1.46**	**0.38**	**1.79**	**0.10**

Table B.7: Phosphorus model parameters

Modelling land use	Dirk Brook		Nambeelup		Peel Main Drain		Upper Serpentine		Gull Road		Upper Murray		Murray		Harvey		Samson		Drakesbrook		Meredith		Mayfield		Coolup (Harvey)		Dams		Coolup (Peel) ungauged		Murray ungauged		Harvey Diversion Drain ungauged	
	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b
Bare soil & other (high PRI)	0.001	0.08	0.002	0.05	0.002	0.10	0.001	0.20	0.001	-0.10	0.000	0.20	0.001	0.36	0.001	0.34	0.002	0.25	0.001	0.60	0.001	0.25	0.001	0.35	0.001	0.03	0.003	-0.20	0.001	0.03	0.001	0.36	0.002	0.10
Bare soil & other (low PRI)	0.007	0.08	0.012	0.05	0.016	0.10	0.011	0.20	0.006	-0.10	0.003	0.20	0.004	0.36	0.010	0.34	0.013	0.25	0.004	0.60	0.009	0.25	0.007	0.35	0.010	0.03	0.003	-0.20	0.010	0.03	0.004	0.36	0.016	0.10
Beef (high PRI)	0.053	0.08	0.096	0.05	0.127	0.10	0.088	0.20	0.045	-0.10	0.026	0.20	0.032	0.36	0.080	0.34	0.104	0.25	0.030	0.60	0.071	0.25	0.057	0.35	0.074	0.03	0.003	-0.20	0.074	0.03	0.032	0.36	0.127	0.10
Beef (low PRI)	0.425	0.08	0.768	0.05	1.013	0.10	0.704	0.20	0.361	-0.10	0.211	0.20	0.253	0.36	0.640	0.34	0.830	0.25	0.237	0.60	0.571	0.25	0.455	0.35	0.595	0.03	0.003	-0.20	0.595	0.03	0.253	0.36	1.013	0.10
Cropping (high PRI)	0.019	0.08	0.034	0.05	0.045	0.10	0.031	0.20	0.016	-0.10	0.009	0.20	0.011	0.36	0.028	0.34	0.037	0.25	0.011	0.60	0.025	0.25	0.020	0.35	0.026	0.03	0.003	-0.20	0.026	0.03	0.011	0.36	0.045	0.10
Cropping (low PRI)	0.150	0.08	0.272	0.05	0.359	0.10	0.249	0.20	0.128	-0.10	0.075	0.20	0.090	0.36	0.227	0.34	0.294	0.25	0.084	0.60	0.202	0.25	0.161	0.35	0.211	0.03	0.003	-0.20	0.211	0.03	0.090	0.36	0.359	0.10
Dairy (high PRI)	0.136	0.08	0.504	0.05	0.225	0.10	0.396	0.20	0.080	-0.10	0.047	0.20	0.183	0.36	0.288	0.34	1.514	0.25	0.050	0.60	0.127	0.25	0.094	0.35	0.125	0.03	0.003	-0.20	0.936	0.03	0.072	0.36	0.137	0.10
Dairy (low PRI)	0.755	0.08	1.378	0.05	1.802	0.10	1.914	0.20	0.642	-0.10	0.376	0.20	0.450	0.36	0.324	0.34	1.477	0.25	1.064	0.60	1.017	0.25	1.226	0.35	1.713	0.03	0.003	-0.20	0.919	0.03	1.574	0.36	0.137	0.10
Feedlots & stockyards (high PRI)	0.213	0.08	0.386	0.05	0.509	0.10	0.354	0.20	0.181	-0.10	0.106	0.20	0.127	0.36	0.321	0.34	0.417	0.25	0.119	0.60	0.287	0.25	0.229	0.35	0.299	0.03	0.003	-0.20	0.299	0.03	0.127	0.36	0.509	0.10
Feedlots & stockyards (low PRI)	1.706	0.08	3.086	0.05	4.071	0.10	2.830	0.20	1.450	-0.10	0.849	0.20	1.016	0.36	2.570	0.34	3.336	0.25	0.950	0.60	2.296	0.25	1.828	0.35	2.389	0.03	0.003	-0.20	2.389	0.03	1.016	0.36	4.071	0.10
Horses (high PRI)	0.062	0.08	0.112	0.05	0.148	0.10	0.103	0.20	0.053	-0.10	0.031	0.20	0.037	0.36	0.093	0.34	0.121	0.25	0.035	0.60	0.083	0.25	0.066	0.35	0.087	0.03	0.003	-0.20	0.087	0.03	0.037	0.36	0.148	0.10
Horses (low PRI)	0.496	0.08	0.897	0.05	1.184	0.10	0.823	0.20	0.422	-0.10	0.247	0.20	0.295	0.36	0.747	0.34	0.970	0.25	0.276	0.60	0.668	0.25	0.531	0.35	0.695	0.03	0.003	-0.20	0.695	0.03	0.295	0.36	1.184	0.10
Horticulture (high PRI)	0.546	0.08	0.987	0.05	1.303	0.10	0.905	0.20	0.464	-0.10	0.272	0.20	0.325	0.36	0.822	0.34	1.067	0.25	0.304	0.60	0.735	0.25	0.585	0.35	0.764	0.03	0.003	-0.20	0.764	0.03	0.325	0.36	1.303	0.10
Horticulture (low PRI)	4.365	0.08	7.898	0.05	10.42	0.10	7.243	0.20	3.710	-0.10	2.173	0.20	2.600	0.36	6.578	0.34	8.537	0.25	2.432	0.60	5.876	0.25	4.678	0.35	6.114	0.03	0.003	-0.20	6.114	0.03	2.600	0.36	10.42	0.10
Industry, manufacturing & transport (high PRI)	0.001	0.08	0.001	0.05	0.000	0.10	0.001	0.20	0.000	-0.10	0.000	0.20	0.000	0.36	0.001	0.34	0.001	0.25	0.000	0.60	0.000	0.25	0.001	0.35	0.001	0.03	0.003	-0.20	0.001	0.03	0.000	0.36	0.000	0.10
Industry, manufacturing & transport (low PRI)	0.004	0.08	0.005	0.05	0.002	0.10	0.005	0.20	0.001	-0.10	0.001	0.20	0.002	0.36	0.009	0.34	0.007	0.25	0.003	0.60	0.003	0.25	0.005	0.35	0.004	0.03	0.003	-0.20	0.004	0.03	0.002	0.36	0.002	0.10
Lifestyle block (high PRI)	0.011	0.08	0.020	0.05	0.027	0.10	0.019	0.20	0.010	-0.10	0.006	0.20	0.007	0.36	0.017	0.34	0.022	0.25	0.006	0.60	0.015	0.25	0.012	0.35	0.016	0.03	0.003	-0.20	0.016	0.03	0.007	0.36	0.027	0.10
Lifestyle block (low PRI)	0.090	0.08	0.163	0.05	0.215	0.10	0.150	0.20	0.077	-0.10	0.045	0.20	0.054	0.36	0.136	0.34	0.176	0.25	0.050	0.60	0.121	0.25	0.097	0.35	0.126	0.03	0.003	-0.20	0.126	0.03	0.054	0.36	0.215	0.10
Mixed grazing (high PRI)	0.036	0.08	0.065	0.05	0.086	0.10	0.060	0.20	0.031	-0.10	0.018	0.20	0.022	0.36	0.055	0.34	0.071	0.25	0.020	0.60	0.049	0.25	0.039	0.35	0.051	0.03	0.003	-0.20	0.051	0.03	0.022	0.36	0.086	0.10
Mixed grazing (low PRI)	0.289	0.08	0.523	0.05	0.691	0.10	0.480	0.20	0.246	-0.10	0.144	0.20	0.172	0.36	0.436	0.34	0.566	0.25	0.161	0.60	0.389	0.25	0.310	0.35	0.405	0.03	0.003	-0.20	0.405	0.03	0.172	0.36	0.691	0.10
Native vegetation (high PRI)	0.000	0.08	0.001	0.05	0.000	0.10	0.001	0.20	0.000	-0.10	0.000	0.20	0.000	0.36	0.000	0.34	0.001	0.25	0.000	0.60	0.000	0.25	0.001	0.35	0.001	0.03	0.003	-0.20	0.001	0.03	0.000	0.36	0.000	0.10
Native vegetation (low PRI)	0.002	0.08	0.006	0.05	0.004	0.10	0.005	0.20	0.002	-0.10	0.002	0.20	0.003	0.36	0.003	0.34	0.005	0.25	0.001	0.60	0.002	0.25	0.004	0.35	0.004	0.03	0.003	-0.20	0.004	0.03	0.003	0.36	0.004	0.10
Offices, commercial & education (high PRI)	0.056	0.08	0.068	0.05	0.030	0.10	0.060	0.20	0.015	-0.10	0.011	0.20	0.029	0.36	0.112	0.34	0.094	0.25	0.043	0.60	0.031	0.25	0.061	0.35	0.052	0.03	0.003	-0.20	0.052	0.03	0.029	0.36	0.030	0.10
Offices, commercial & education (low PRI)	0.451	0.08	0.544	0.05	0.242	0.10	0.478	0.20	0.118	-0.10	0.091	0.20	0.228	0.36	0.898	0.34	0.753	0.25	0.342	0.60	0.249	0.25	0.491	0.35	0.417	0.03	0.003	-0.20	0.417	0.03	0.228	0.36	0.242	0.10
Orchard (high PRI)	0.029	0.08	0.053	0.05	0.070	0.10	0.048	0.20	0.025	-0.10	0.015	0.20	0.017	0.36	0.044	0.34	0.057	0.25	0.016	0.60	0.039	0.25	0.031	0.35	0.041	0.03	0.003	-0.20	0.041	0.03	0.017	0.36	0.070	0.10
Orchard (low PRI)	0.233	0.08	0.421	0.05	0.556	0.10	0.387	0.20	0.198	-0.10	0.116	0.20	0.139	0.36	0.351	0.34	0.456	0.25	0.130	0.60	0.314	0.25	0.250	0.35	0.326	0.03	0.003	-0.20	0.326	0.03	0.139	0.36	0.556	0.10
Piggeries & abattoirs (high PRI)	0.317	0.08	0.573	0.05	0.756	0.10	0.525	0.20	0.269	-0.10	0.158	0.20	0.189	0.36	0.477	0.34	0.619	0.25	0.176	0.60	0.426	0.25	0.339	0.35	0.443	0.03	0.003	-0.20	0.443	0.03	0.189	0.36	0.756	0.10
Piggeries & abattoirs (low PRI)	2.532	0.08	4.581	0.05	6.044	0.10	4.201	0.20	2.152	-0.10	1.260	0.20	1.508	0.36	3.816	0.34	4.952	0.25	1.411	0.60	3.409	0.25	2.713	0.35	3.546	0.03	0.003	-0.20	3.546	0.03	1.508	0.36	6.044	0.10
Plantation (high PRI)	0.170	0.08	0.464	0.05	0.270	0.10	0.366	0.20	0.141	-0.10	0.128	0.20	0.213	0.36	0.235	0.34	0.416	0.25	0.054	0.60	0.136	0.25	0.296	0.35	0.284	0.03	0.003	-0.20	0.284	0.03	0.213	0.36	0.270	0.10
Plantation (low PRI)	1.359	0.08	3.713	0.05	2.163	0.10	2.926	0.20	1.129	-0.10	1.023	0.20	1.700	0.36	1.881	0.34	3.328	0.25	0.433	0.60	1.092	0.25	2.369	0.35	2.275	0.03	0.003	-0.20	2.275	0.03	1.700	0.36	2.163	0.10
Point source (high PRI)	0.001	0.08	0.002	0.05	0.002	0.10	0.001	0.20	0.001	-0.10	0.000	0.20	0.001	0.36	0.001	0.34	0.002	0.25	0.001	0.60	0.001	0.25	0.001	0.35	0.001	0.03	0.003	-0.20	0.001	0.03	0.001	0.36	0.002	0.10
Point source (low PRI)	0.007	0.08	0.012	0.05	0.016	0.10	0.011	0.20	0.006	-0.10	0.003	0.20	0.004	0.36	0.010	0.34	0.013	0.25	0.004	0.60	0.009	0.25	0.007	0.35	0.010	0.03	0.003	-0.20	0.010	0.03	0.004	0.36	0.016	0.10
Poultry (high PRI)	0.102	0.08	0.184	0.05	0.243	0.10	0.169	0.20	0.087	-0.10	0.051	0.20	0.061	0.36	0.154	0.34	0.199	0.25	0.057	0.60	0.137	0.25	0.109	0.35	0.143	0.03	0.003	-0.20	0.143	0.03	0.061	0.36	0.243	0.10
Poultry (low PRI)	0.815	0.08	1.475	0.05	1.946	0.10	1.353	0.20	0.693	-0.10	0.406	0.20	0.486	0.36	1.229	0.34	1.594	0.25	0.454	0.60	1.097	0.25	0.874	0.35	1.142	0.03	0.003	-0.20	1.142	0.03	0.486	0.36	1.946	0.10
Recreation (high PRI)	0.009	0.08	0.017	0.05	0.022	0.10	0.015	0.20	0.008	-0.10	0.005	0.20	0.006	0.36	0.014	0.34	0.018	0.25	0.005	0.60	0.013	0.25	0.010	0.35	0.013	0.03	0.003	-0.20	0.013	0.03	0.006	0.36	0.022	0.10
Recreation (low PRI)	0.074	0.08	0.135	0.05	0.178	0.10	0.123	0.20	0.063	-0.10	0.037	0.20	0.044	0.36	0.112	0.34	0.146	0.25	0.041	0.60	0.100	0.25	0.080	0.35	0.104	0.03	0.003	-0.20	0.104	0.03	0.044	0.36	0.178	0.10
Rural living (bush block) (high PRI)	0.005	0.08	0.014	0.05	0.008	0.10	0.011	0.20	0.004	-0.10	0.004	0.20	0.006	0.36	0.007	0.34	0.012	0.25	0.002	0.60	0.004	0.25	0.009	0.35	0.008	0.03	0.003	-0.20	0.008	0.03	0.006	0.36	0.008	0.10
Rural living (bush block) (low PRI)	0.040	0.08	0.108	0.05	0.063	0.10	0.085	0.20	0.033	-0.10	0.030	0.20	0.049	0.36	0.055	0.34	0.097	0.25	0.013	0.60	0.032	0.25	0.069	0.35	0.066	0.03	0.003	-0.20	0.066	0.03	0.049	0.36	0.063	0.10
Turf farm (high PRI)	0.125	0.08	0.226	0.05	0.298	0.10	0.207	0.20	0.106	-0.10	0.062	0.20	0.074	0.36	0.188	0.34	0.244	0.25	0.070	0.60	0.168	0.25	0.134	0.35	0.175	0.03	0.003	-0.20	0.175	0.03	0.074	0.36	0.298	0.10
Turf farm (low PRI)	0.999	0.08	1.808	0.05	2.385	0.10	1.658	0.20	0.849	-0.10	0.497	0.20	0.595	0.36	1.506	0.34	1.954	0.25	0.557	0.60	1.345	0.25	1.071	0.35	1.400	0.03	0.003	-0.20	1.400	0.03	0.595	0.36	2.385	0.10
Urban residential (high PRI)	0.049	0.08	0.059	0.05	0.027	0.10	0.052	0.20	0.013	-0.10	0.010	0.20	0.025	0.36	0.098	0.34	0.082	0.25	0.037	0.60	0.027	0.25	0.054	0.35	0.046	0.03	0.003	-0.20	0.046	0.03	0.025	0.36	0.027	0.10
Urban residential (low PRI)	0.394	0.08	0.476	0.05	0.212	0.10	0.418	0.20	0.103	-0.10	0.080	0.20	0.199	0.36	0.785	0.34	0.659	0.25	0.300	0.60	0.218	0.25	0.429	0.35	0.365	0.03	0.003	-0.20	0.365	0.03	0.199	0.36	0.212	0.10
Urban residential (very small) (high PRI)	0.020	0.08	0.024	0.05	0.011	0.10	0.021	0.20	0.005	-0.10	0.004	0.20	0.010	0.36	0.039	0.34	0.033	0.25	0.015	0.60	0.011	0.25	0.021	0.35	0.018	0.03	0.003	-0.20	0.018	0.03	0.010	0.36	0.011	0.10
Urban residential (very small) (low PRI)	0.158	0.08	0.190	0.05	0.085	0.10	0.167	0.20	0.041	-0.10	0.032	0.20	0.080	0.36	0.314	0.34	0.263	0.25	0.120	0.60	0.087	0.25	0.172	0.35	0.146	0.03	0.003	-0.20	0.146	0.03	0.080	0.36	0.085	0.10
Viticulture (high PRI)	0.063	0.08	0.115	0.05	0.151	0.10	0.105	0.20	0.054	-0.10	0.032	0.20	0.038	0.36	0.096	0.34	0.124	0.25	0.035	0.60	0.085	0.25	0.068	0.35	0.089	0.03	0.003	-0.20	0.089	0.03	0.038	0.36	0.151	0.10
Viticulture (low PRI)	0.507	0.08	0.918	0.05	1.211	0.10	0.842	0.20	0.431	-0.10	0.252	0.20	0.302	0.36	0.764	0.34	0.992	0.25	0.283	0.60	0.683	0.25	0.544	0.35	0.710	0.03	0.003	-0.20	0.710	0.03	0.302	0.36	1.211	0.10
Total	**0.304**	**0.08**	**1.322**	**0.05**	**0.223**	**0.10**	**0.294**	**0.20**	**2.470**	**-0.10**	**0.007**	**0.20**	**0.207**	**0.36**	**0.371**	**0.34**	**0.118**	**0.25**	**0.112**	**0.60**	**1.048**	**0.25**	**0.236**	**0.35**	**0.359**	**0.03**	**0.014**	**-0.20**	**0.359**	**0.03**	**0.207**	**0.36**	**0.223**	**0.10**

Table B.8: Riparian zone vegetation parameters derived from model calibration

Catchment ID	Reporting catchment	Location	Max N reduction (%)	Max P reduction (%)	Vegetated (%)	N reduction (%)	P reduction (%)
2	Coastal North	SCP	12	2.5	28	3.4	0.7
3	Coastal North	SCP	12	2.5	55	6.7	1.4
5	Coastal South	SCP	12	2.5	68	8.2	1.7
6	Coolup (Harvey)	SCP	12	2.5	12	1.5	0.3
7	Coolup (Harvey)	SCP	12	2.5	21	2.6	0.5
8	Coolup (Harvey)	SCP	12	2.5	31	3.7	0.8
9	Coolup (Peel)	SCP	12	2.5	16	1.9	0.4
10	Coolup (Peel)	SCP	12	2.5	40	4.8	1.0
11	Coolup (Peel)	SCP	12	2.5	32	3.9	0.8
12	Dirk Brook	SCP	12	2.5	83	10.0	2.1
13	Dirk Brook	SCP	12	2.5	57	6.8	1.4
14	Dirk Brook	SCP	12	2.5	29	3.5	0.7
15	Harvey	Upland	40	15.0	71	28.6	10.7
16	Harvey	SCP	12	2.5	23	2.8	0.6
17	Harvey	SCP	12	2.5	30	3.7	0.8
18	Harvey	SCP	12	2.5	44	5.3	1.1
19	Drakesbrook & Waroona Dams	Upland	40	15.0	87	34.7	13.0
20	Harvey	SCP	12	2.5	57	6.9	1.4
21	Logue Brook Dam	Upland	40	15.0	94	37.5	14.1
22	Harvey	SCP	12	2.5	37	4.4	0.9
23	Harvey	Upland	40	15.0	65	25.8	9.7
24	Samson Brook Dam	Upland	40	15.0	100	40.0	15.0
25	Harvey	SCP	12	2.5	15	1.8	0.4
26	Harvey	SCP	12	2.5	19	2.3	0.5
27	Harvey	SCP	12	2.5	23	2.7	0.6
28	Harvey	SCP	12	2.5	12	1.4	0.3
29	Harvey Diversion Drain	SCP	12	2.5	36	4.3	0.9
30	Harvey Diversion Drain	SCP	12	2.5	25	3.0	0.6
31	Lower Serpentine	SCP	12	2.5	60	7.2	1.5
32	Lower Serpentine	SCP	12	2.5	81	9.8	2.0
33	Lower Serpentine	SCP	12	2.5	49	5.8	1.2
35	Mayfield Drain	SCP	12	2.5	23	2.7	0.6
36	Mayfield Drain	SCP	12	2.5	54	6.5	1.4
37	Meredith Drain	SCP	12	2.5	24	2.9	0.6
38	Meredith Drain	SCP	12	2.5	10	1.2	0.3
42	Lower Murray	SCP	12	2.5	60	7.2	1.5
43	Lower Murray	SCP	12	2.5	79	9.5	2.0
44	Lower Murray	SCP	12	2.5	54	6.4	1.3
45	Lower Murray	SCP	12	2.5	58	7.0	1.4
46	Lower Murray	SCP	12	2.5	80	9.6	2.0
47	Lower Murray	SCP	12	2.5	55	6.6	1.4
48	Lower Murray	SCP	12	2.5	39	4.6	1.0
49	Lower Murray	SCP	12	2.5	40	4.9	1.0
50	Nambeelup	SCP	12	2.5	63	7.5	1.6
51	Nambeelup	SCP	12	2.5	68	8.1	1.7
52	Nambeelup	SCP	12	2.5	15	1.8	0.4
53	Nambeelup	SCP	12	2.5	46	5.5	1.1
54	Peel Main Drain	SCP	12	2.5	32	3.9	0.8
55	Peel Main Drain	SCP	12	2.5	64	7.6	1.6
56	Peel Main Drain	SCP	12	2.5	43	5.1	1.1
57	Dirk Brook	SCP	12	2.5	17	2.0	0.4
58	Upper Murray	Upland	40	15.0	100	40.0	15.0
59	Upper Murray	Upland	40	15.0	93	37.1	13.9
60	Upper Murray	Upland	40	15.0	54	21.7	8.1
61	Upper Murray	Upland	40	15.0	77	30.6	11.5

Catchment ID	Reporting catchment	Location	Max N reduction (%)	Max P reduction (%)	Vegetated (%)	N reduction (%)	P reduction (%)
62	Upper Murray	Upland	40	15.0	27	10.9	4.1
63	Upper Murray	Upland	40	15.0	35	14.1	5.3
64	Upper Murray	Upland	40	15.0	28	11.2	4.2
65	Upper Murray	Upland	40	15.0	46	18.6	7.0
66	Upper Murray	Upland	40	15.0	59	23.6	8.8
67	Upper Murray	Upland	40	15.0	29	11.8	4.4
68	Upper Murray	Upland	40	15.0	39	15.8	5.9
69	Upper Murray	Upland	40	15.0	28	11.0	4.1
70	Upper Murray	Upland	40	15.0	99	39.5	14.8
71	Upper Murray	Upland	40	15.0	65	25.9	9.7
72	Upper Murray	Upland	40	15.0	37	14.7	5.5
73	Upper Murray	Upland	40	15.0	41	16.2	6.1
74	Upper Murray	Upland	40	15.0	70	28.1	10.5
75	Upper Murray	Upland	40	15.0	88	35.2	13.2
76	Upper Serpentine	SCP	12	2.5	31	3.7	0.8
77	Upper Serpentine	Upland	40	15.0	85	33.8	12.7
78	Upper Serpentine	SCP	12	2.5	22	2.7	0.6
79	Upper Serpentine	SCP	12	2.5	61	7.3	1.5
80	Upper Serpentine	SCP	12	2.5	51	6.1	1.3
81	Upper Serpentine	SCP	12	2.5	23	2.7	0.6
82	Upper Serpentine	SCP	12	2.5	22	2.6	0.5
83	Upper Serpentine	SCP	12	2.5	11	1.4	0.3
84	Upper Serpentine	SCP	12	2.5	44	5.3	1.1
85	Upper Serpentine	SCP	12	2.5	34	4.1	0.8
86	Upper Serpentine	SCP	12	2.5	47	5.7	1.2
87	Peel Main Drain	SCP	12	2.5	33	4.0	0.8
88	Upper Serpentine	SCP	12	2.5	36	4.3	0.9
89	Harvey Reservoir & Stirling Dam	Upland	40	15.0	81	32.3	12.1
90	Harvey Reservoir & Stirling Dam	Upland	40	15.0	58	23.0	8.6
91	Harvey Reservoir & Stirling Dam	Upland	40	15.0	99	39.4	14.8
92	North Dandalup Dam	Upland	40	15.0	100	40.0	15.0
93	Serpentine Dam	Upland	40	15.0	100	40.0	15.0
94	Serpentine Dam	Upland	40	15.0	98	39.4	14.8
95	Serpentine Dam	Upland	40	15.0	100	40.0	15.0
96	Serpentine Dam	Upland	40	15.0	100	39.9	15.0
97	South Dandalup Dam	Upland	40	15.0	100	40.0	15.0

B.3 Daily modelled and measured nutrient concentrations

B.3.1 Samson North Drain, Sommers Road (AWRC ref - 613014).

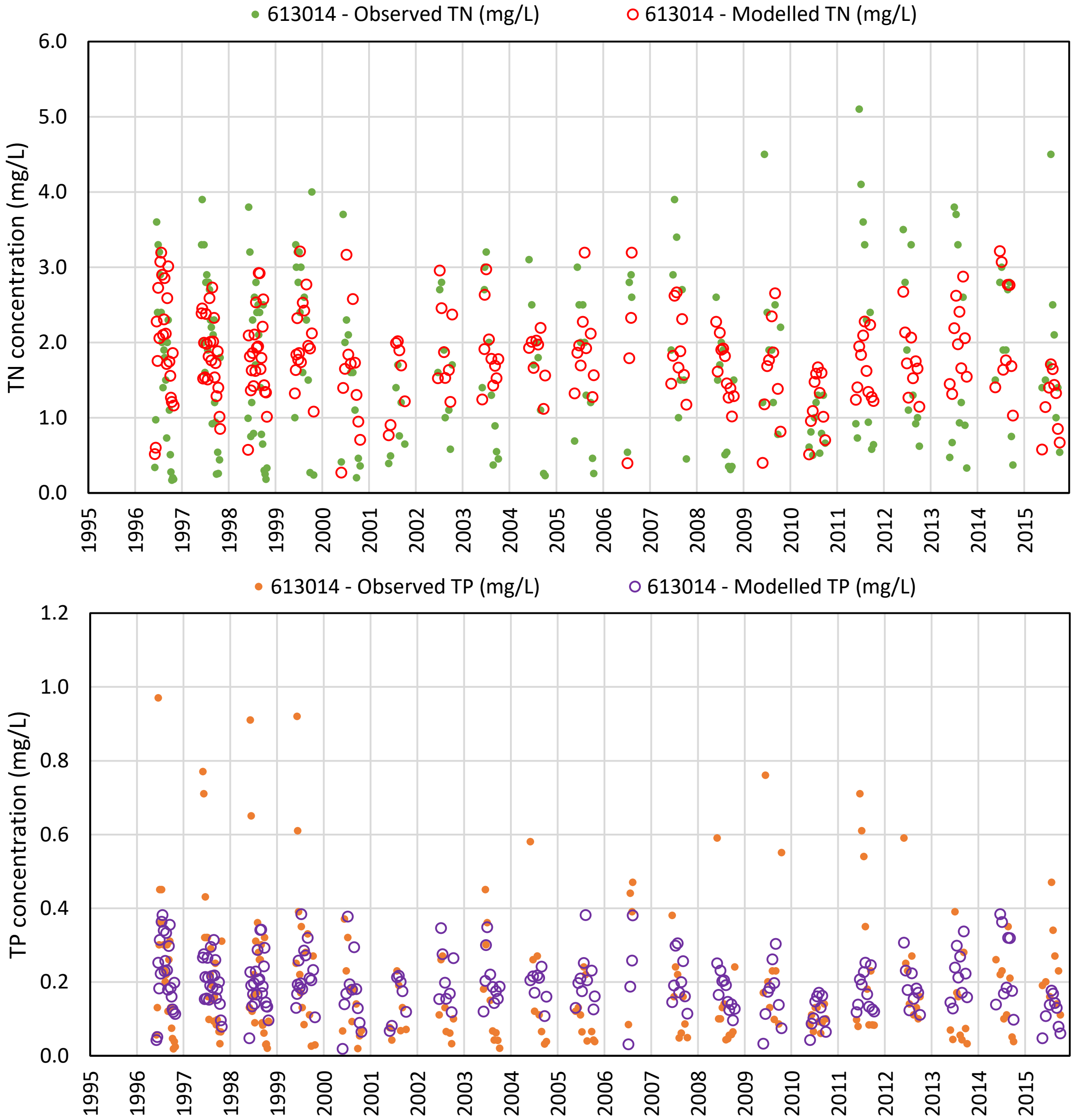


Figure B.1: Measured and modelled total nitrogen (TN, top graph) and total phosphorus (TP, bottom graph) at Sommers Road (Samson North Drain, AWRC Ref 613014)

B.3.2 South Coolup Main Drain, Yackaboon (AWRC ref - 613027).

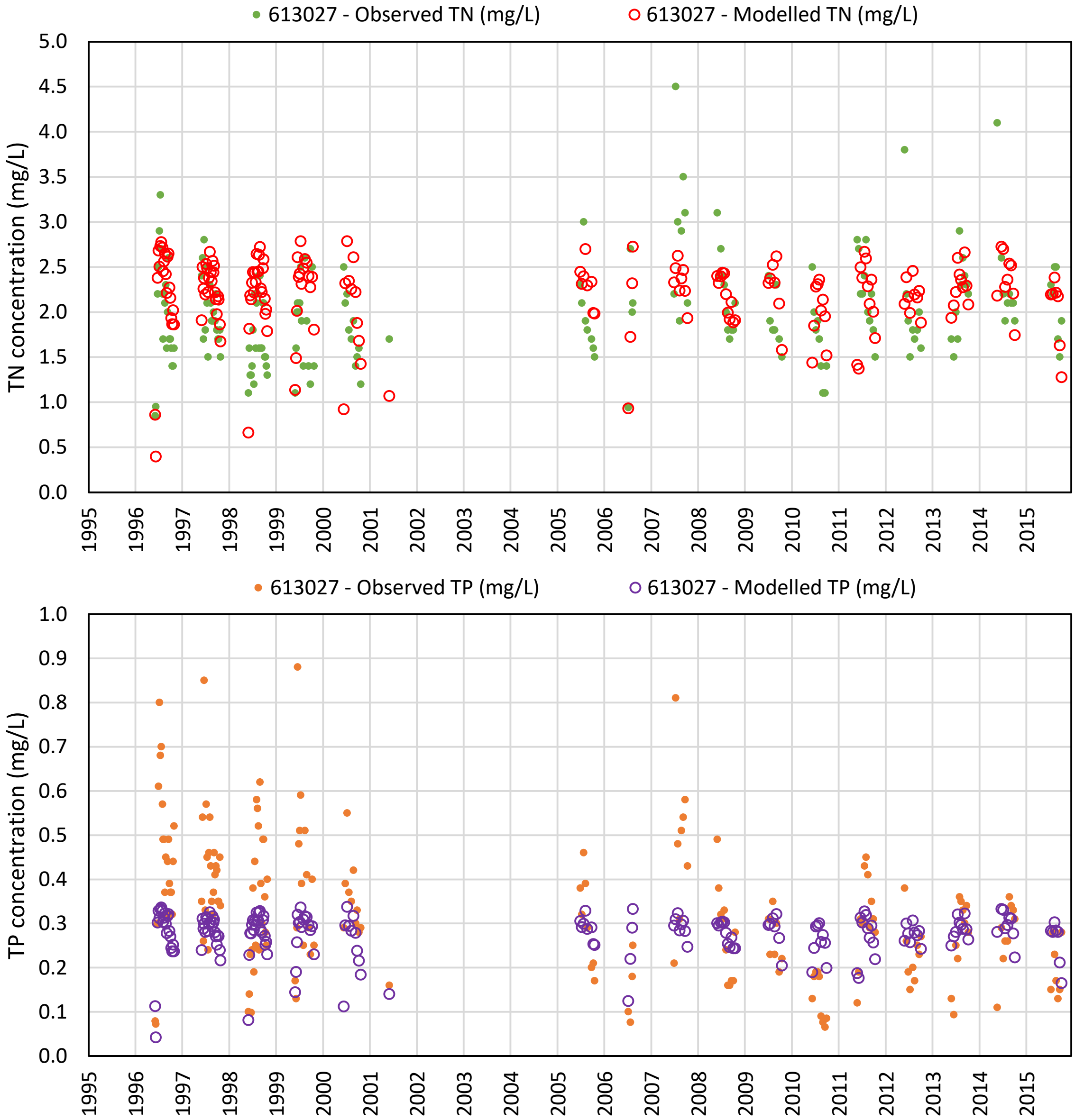
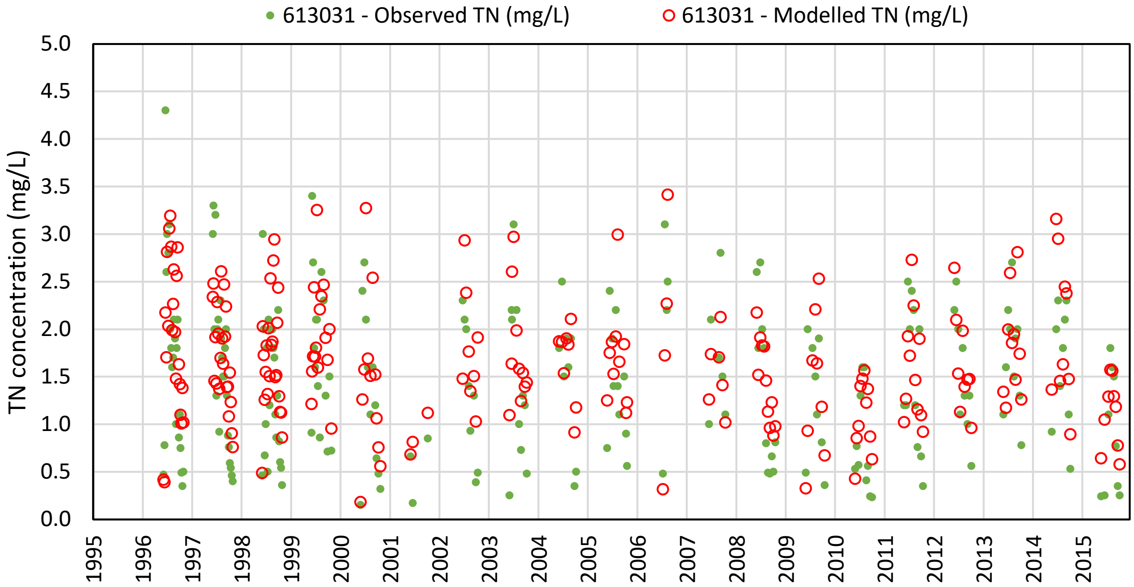


Figure B.2: Measured and modelled total nitrogen (TN, top graph) and total phosphorus (TP, bottom graph) at Yackaboon (South Coolup Main Drain, AWRC Ref 613027)

B.3.3 Mayfield Drain, Old Bunbury Road (AWRC ref - 613031).



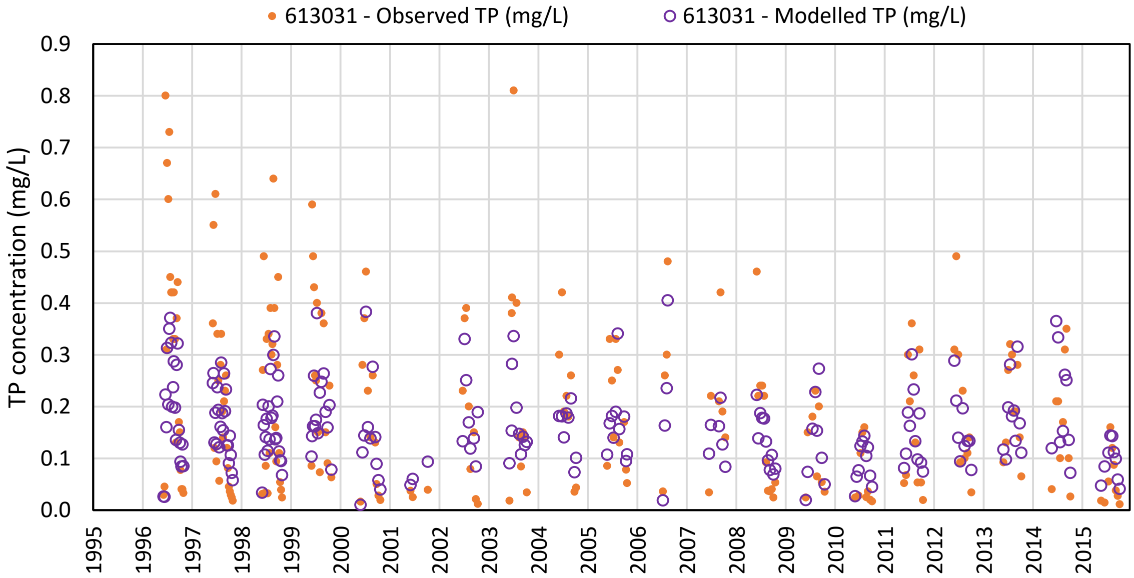


Figure B.3: Measured and modelled total nitrogen (TN, top graph) and total phosphorus (TP, bottom graph) at Old Bunbury Road (Mayfield Drain, AWRC Ref 613031)

B.3.4 Harvey River, Clifton Park (AWRC ref - 613052).

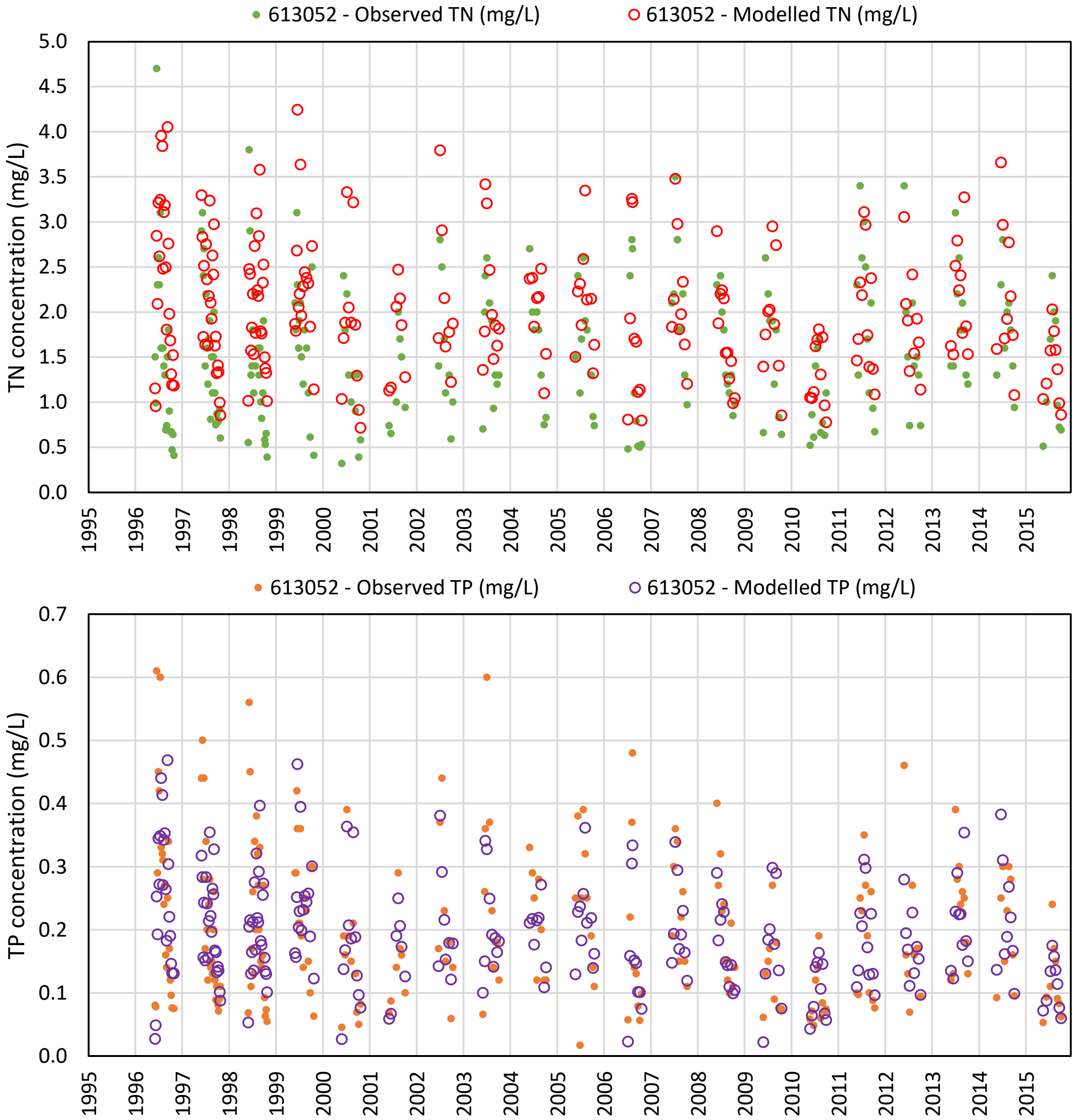


Figure B.4: Measured and modelled total nitrogen (TN, top graph) and total phosphorus (TP, bottom graph) at Clifton Park (Harvey River, AWRC Ref 613052)

B.3.5 Meredith Drain, Johnston Road (AWRC ref - 613053).

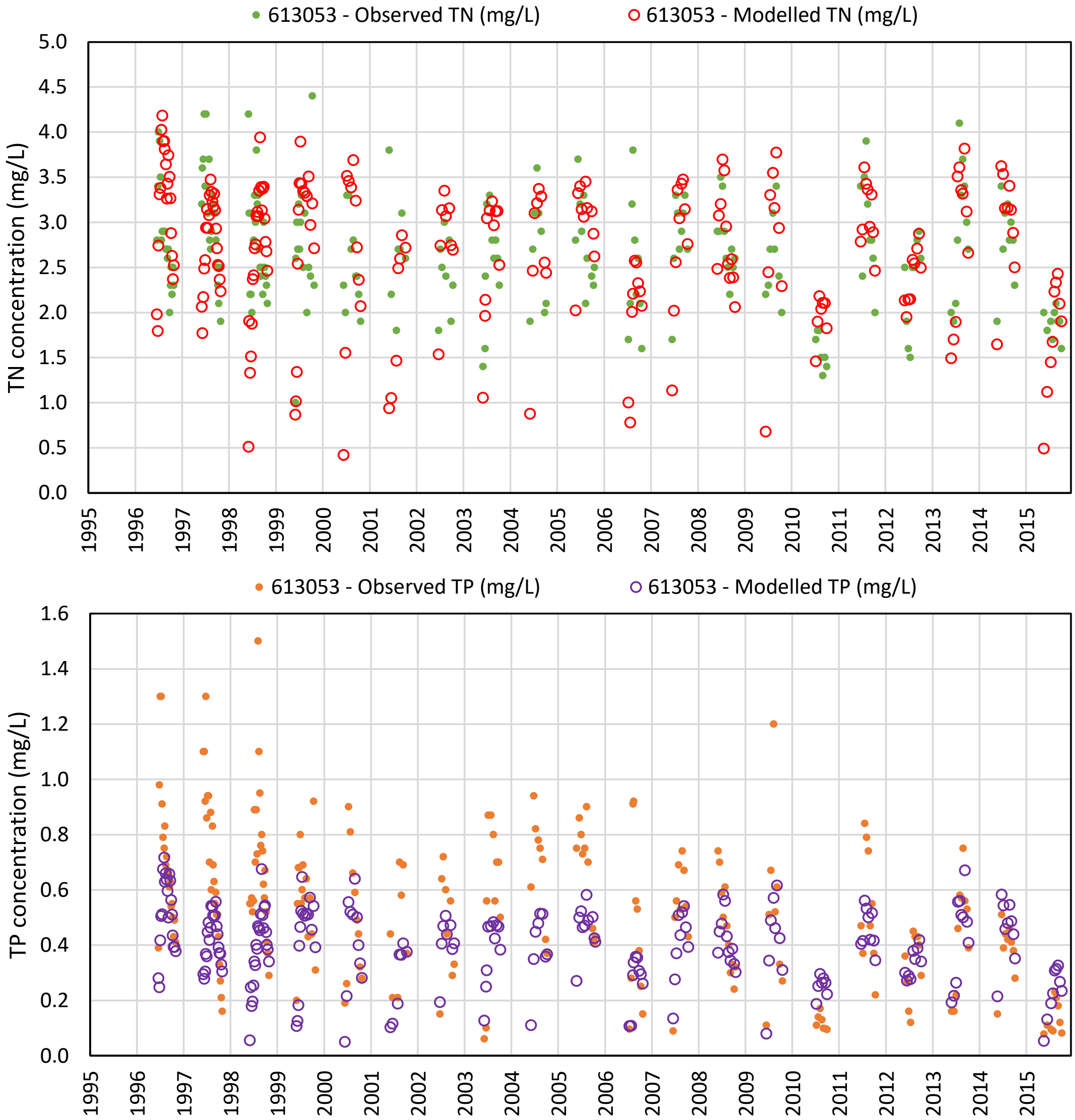
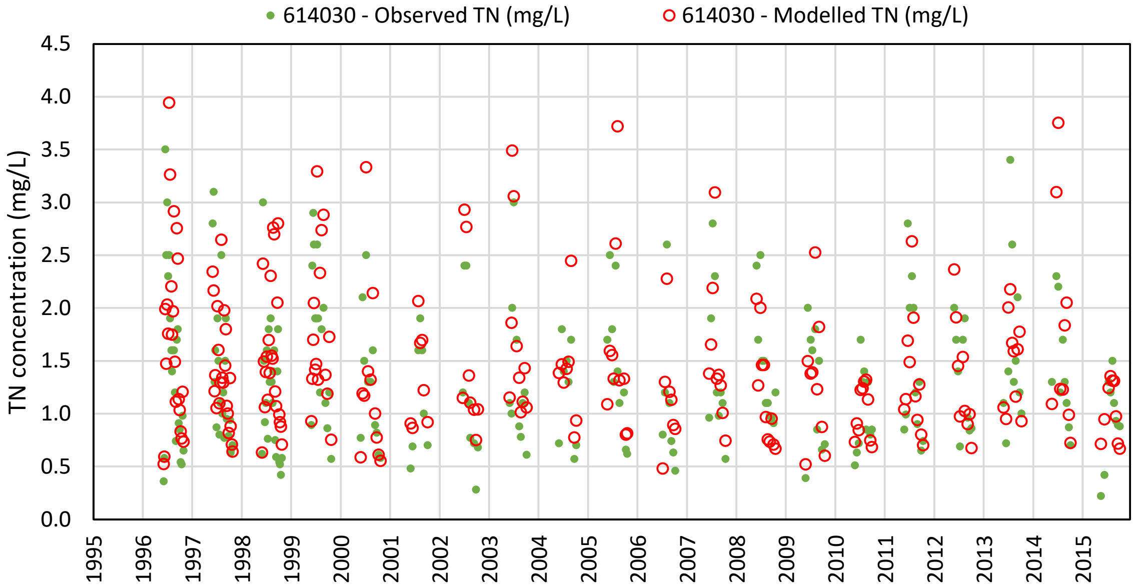


Figure B.5: Measured and modelled total nitrogen (TN, top graph) and total phosphorus (TP, bottom graph) at Johnston Road (Meredith Drain, AWRC Ref 613053)

B.3.6 Serpentine Drain, Dog Hill (AWRC ref - 614030).



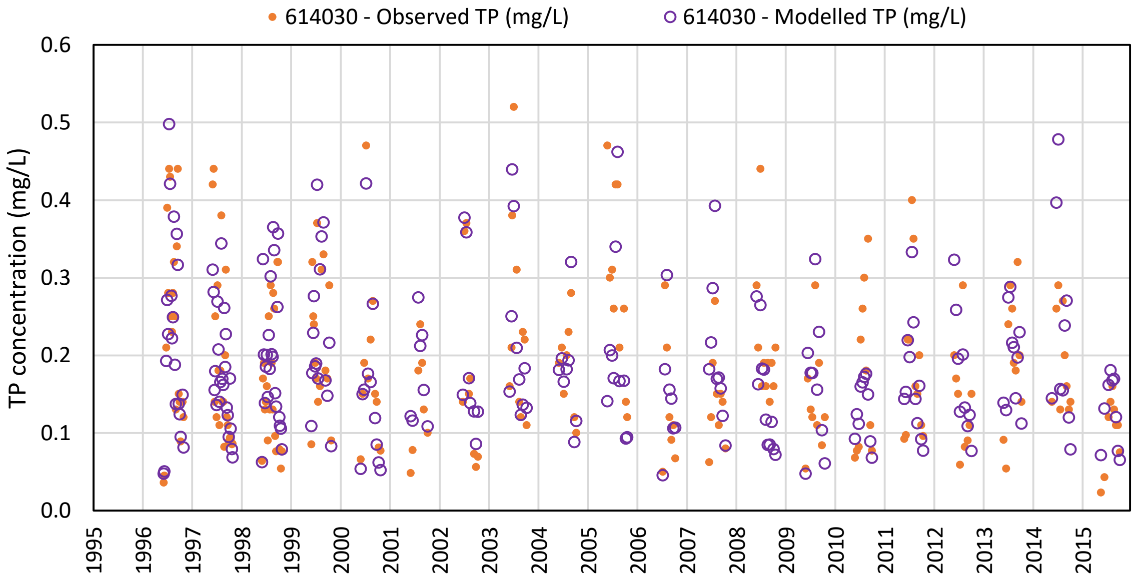


Figure B.6: Measured and modelled total nitrogen (TN, top graph) and total phosphorus (TP, bottom graph) at Dog Hill (Serpentine Drain, AWRC Ref 614030)

B.3.7 Nambeelup Brook, Kielman (AWRC ref - 614063).

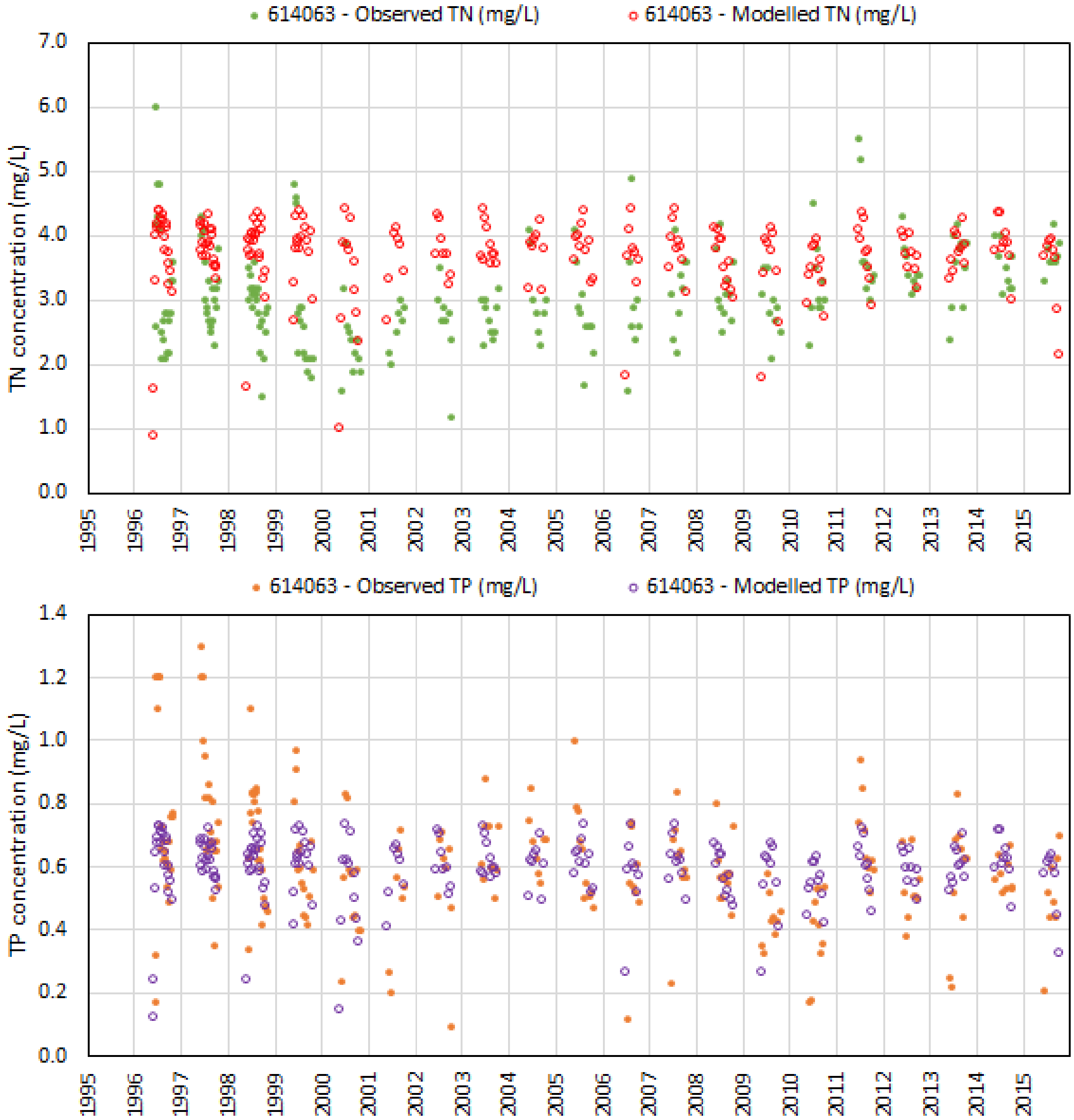


Figure B.7: Measured and modelled total nitrogen (TN, top graph) and total phosphorus (TP, bottom graph) at Kielman (Nambeelup Brook, AWRC Ref 614063)

B.3.8 Murray River, Pinjarra (AWRC ref - 614065).

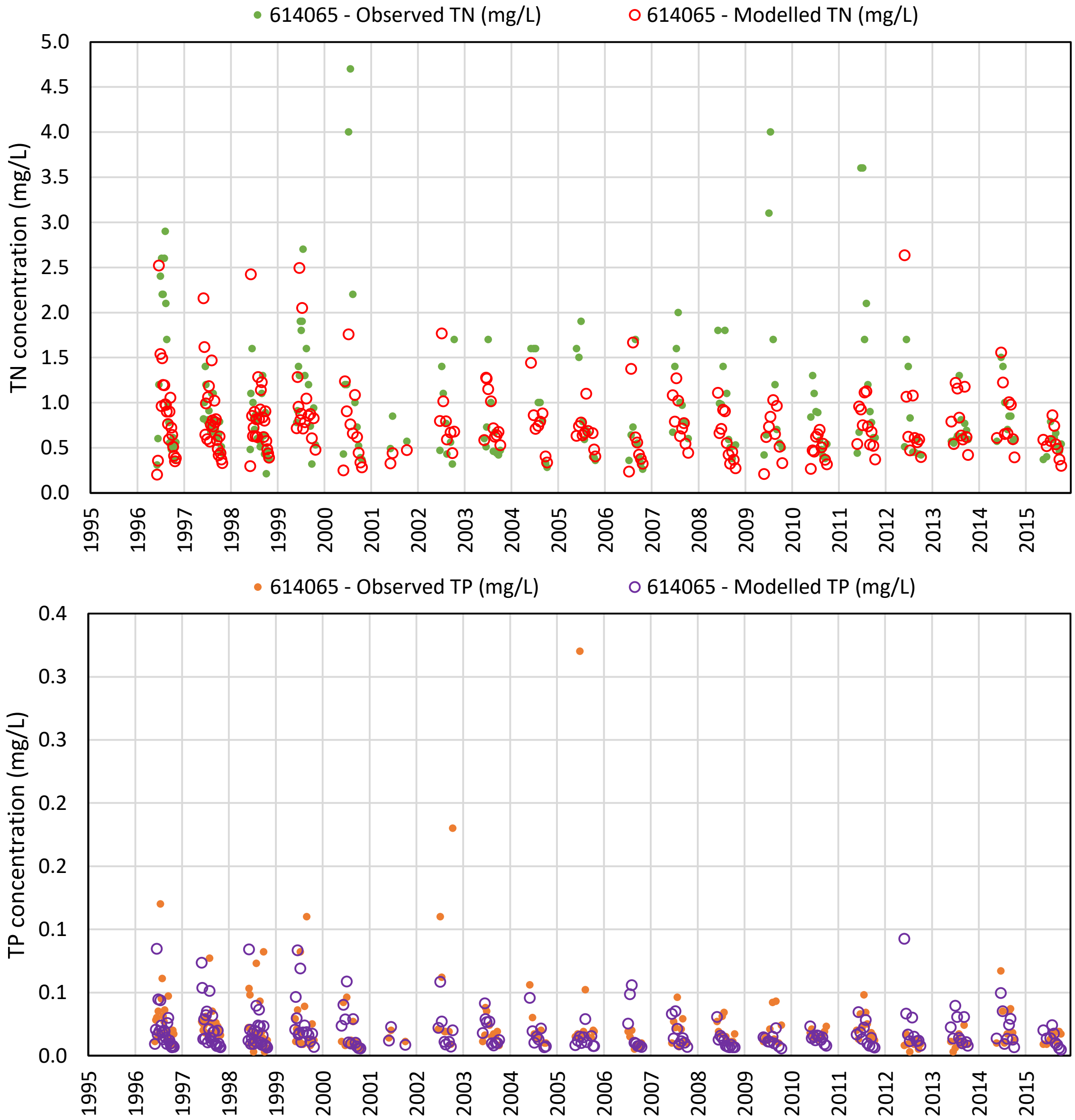


Figure B.8: Measured and modelled total nitrogen (TN, top graph) and total phosphorus (TP, bottom graph) at Pinjarra (Murray River, AWRC Ref 614065)

B.3.9 Punrak Drain, Yangedi Swamp (AWRC ref - 614094).

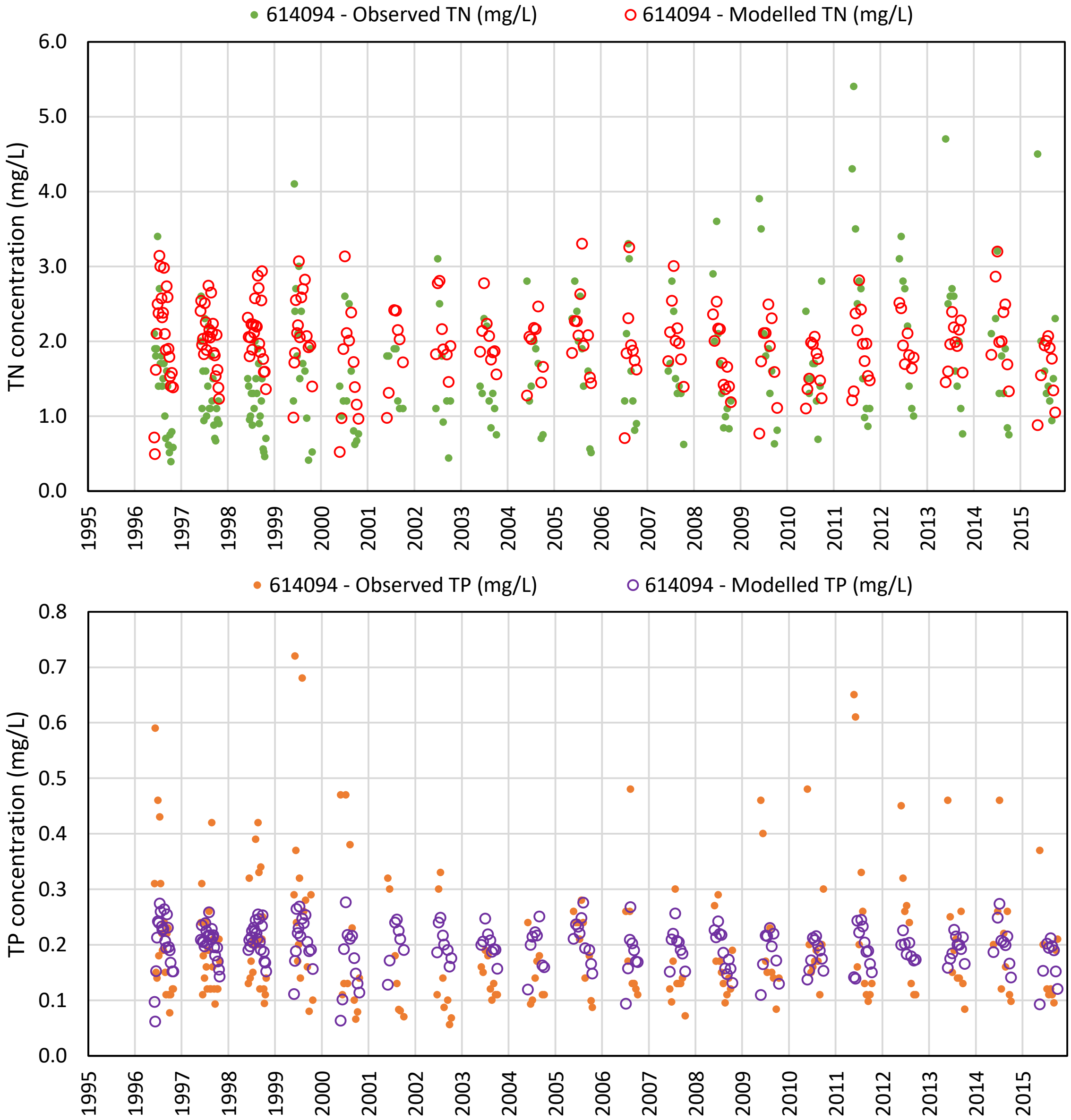


Figure B.9: Measured and modelled total nitrogen (TN, top graph) and total phosphorus (TP, bottom graph) at Yangedi Swamp (Punrack Drain, AWRC Ref 614094)

B.3.10 Gull Road Drain, Gull Road (AWRC ref - 614120).

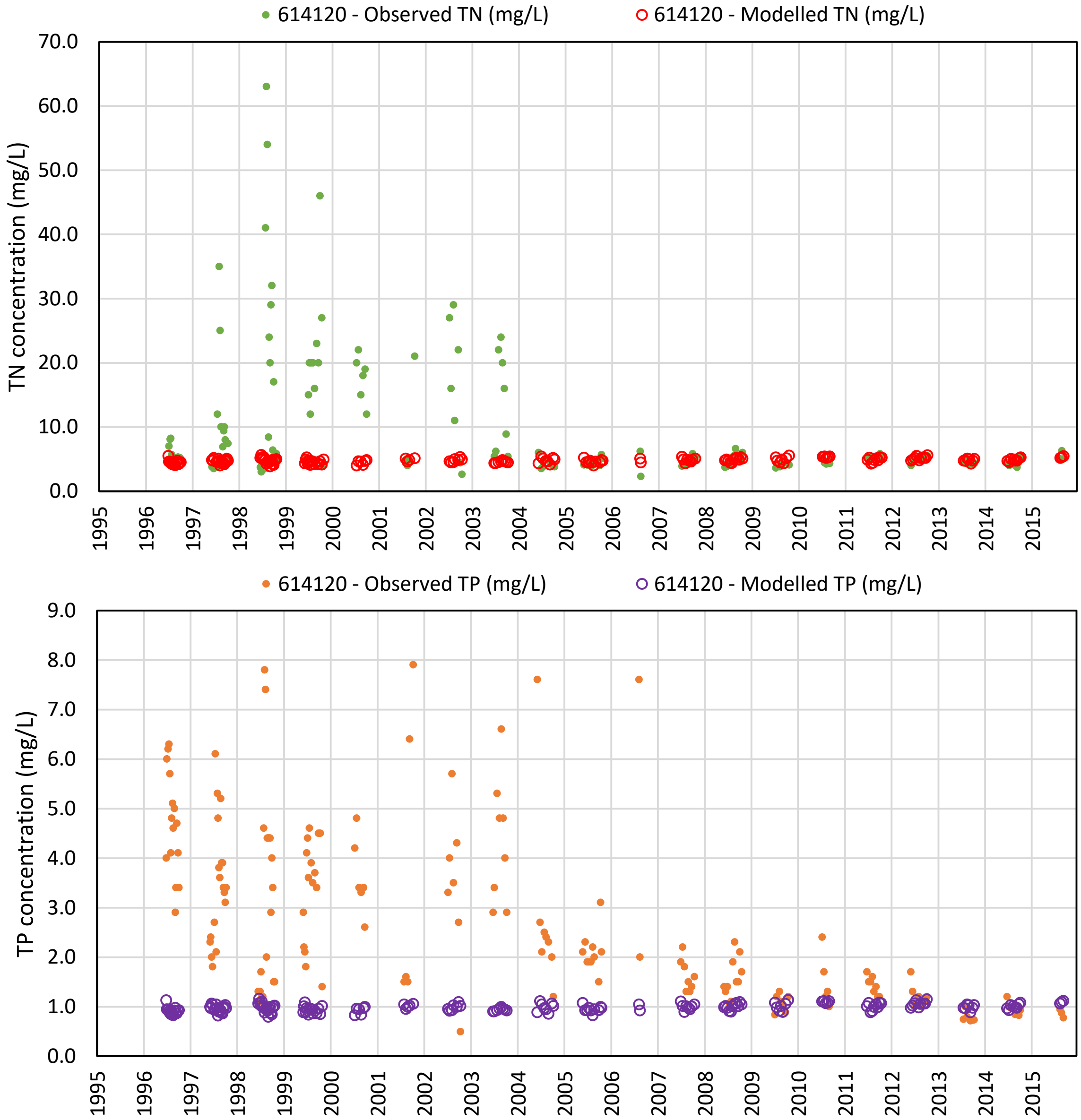
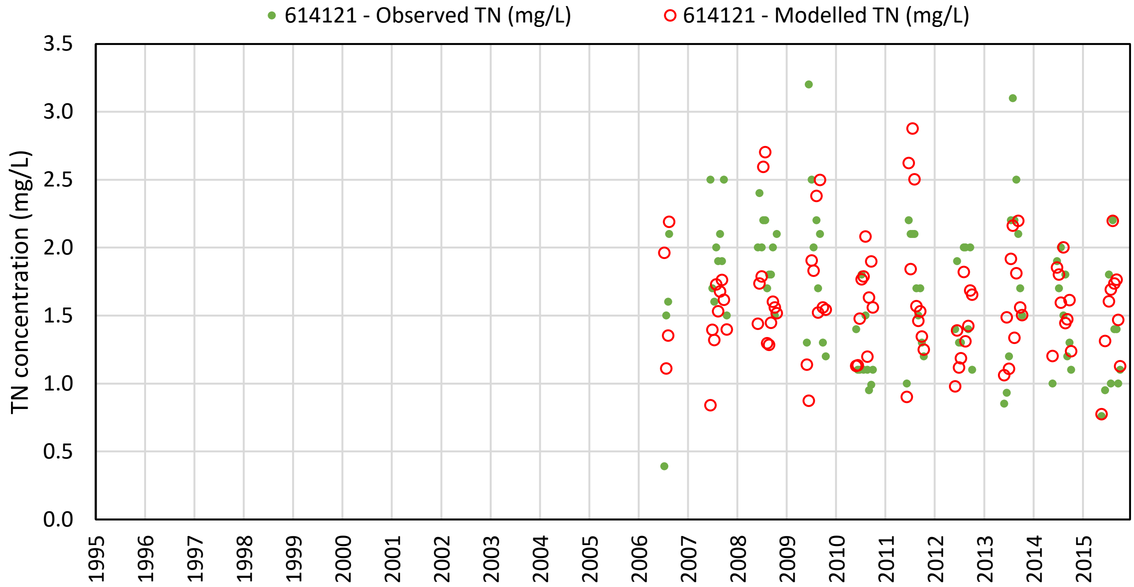


Figure B.10: Measured and modelled total nitrogen (TN, top graph) and total phosphorus (TP, bottom graph) at Gull Road (Gull Road Drain, AWRC Ref 614120)

B.3.11 Peel Main Drain, Karnup Road (AWRC ref - 614121).



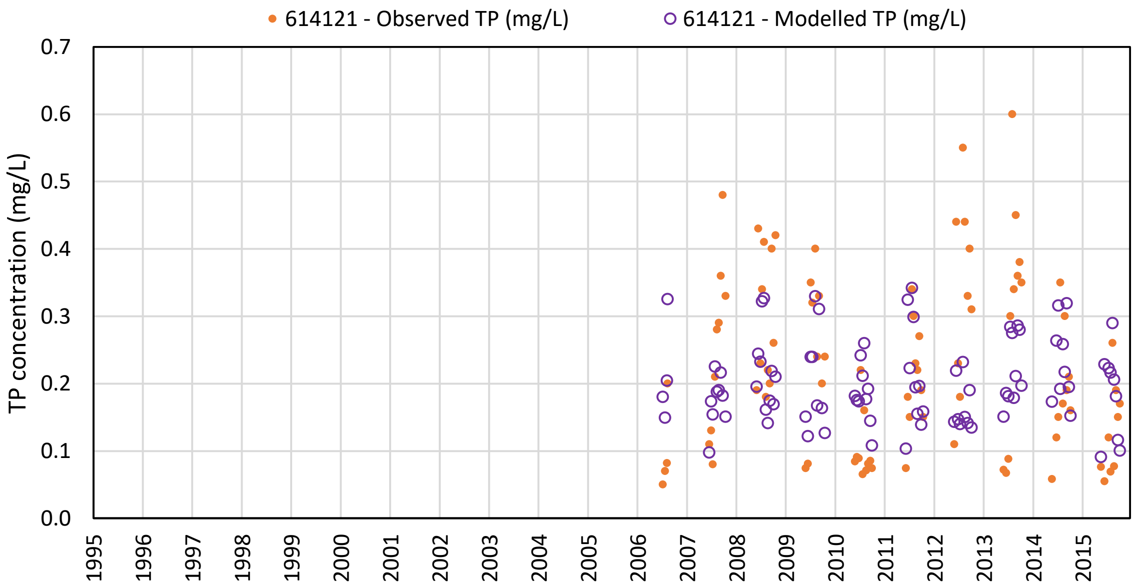


Figure B.11: Measured and modelled total nitrogen (TN, top graph) and total phosphorus (TP, bottom graph) at Karnup Road (Peel Main Drain, AWRC Ref 614121)

B.3.12 Harvey Catchment, Drakesbrook Drain (AWRC ref - 6131335).

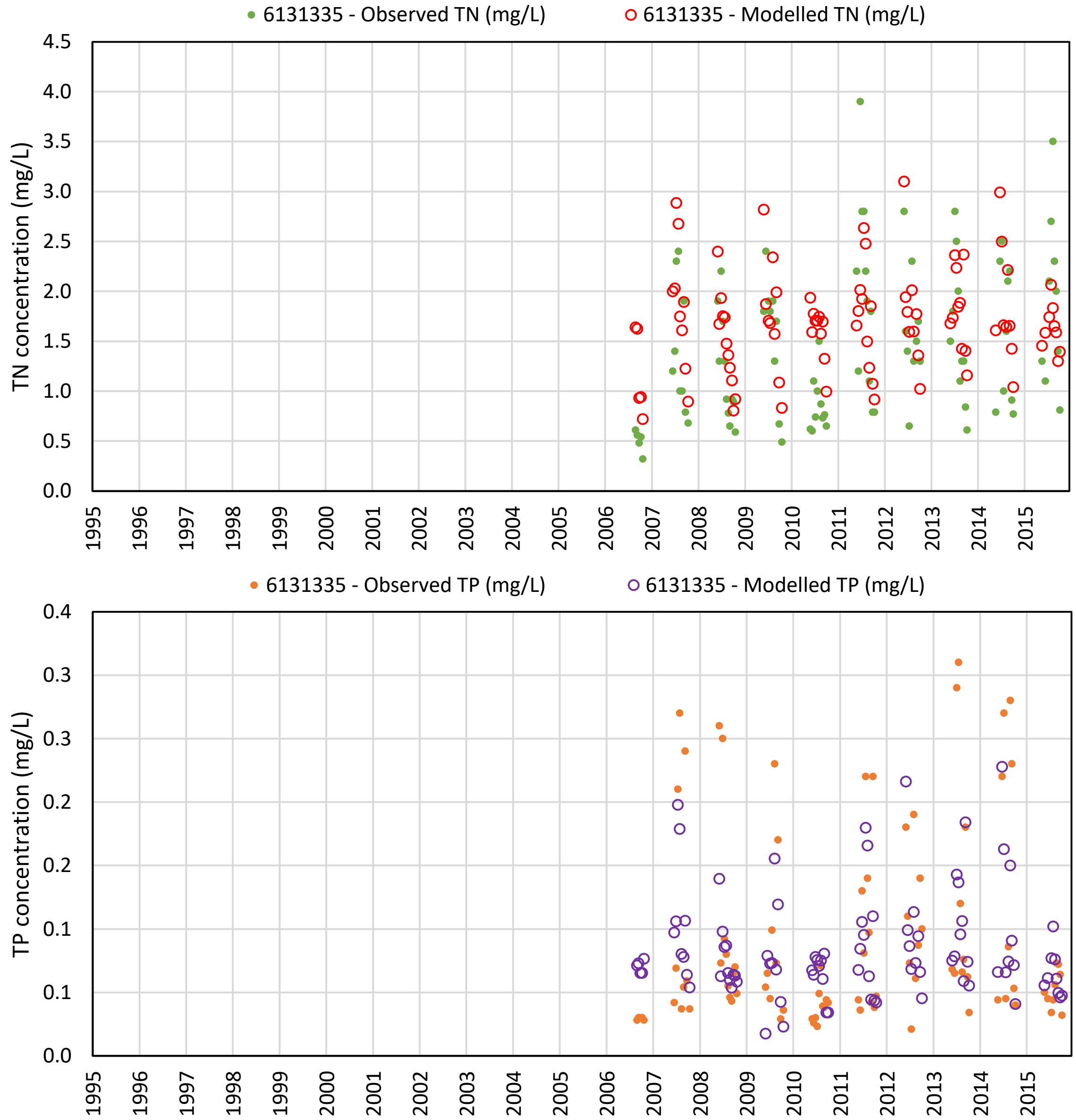
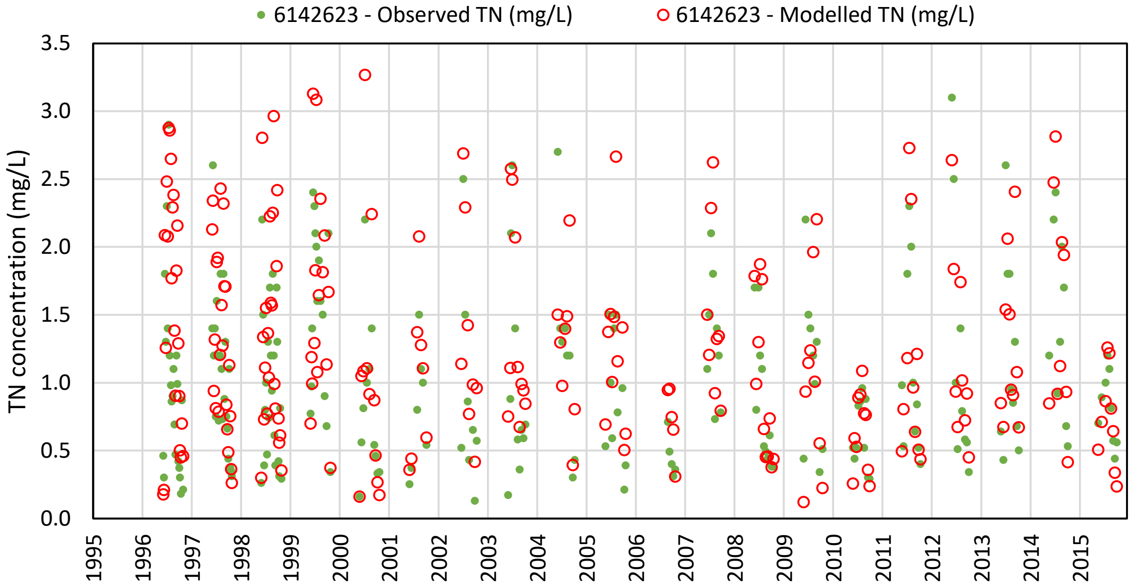


Figure B.12: Measured and modelled total nitrogen (TN, top graph) and total phosphorus (TP, bottom graph) at Drakesbrook Drain (Harvey Catchment, AWRC Ref 6131335)

B.3.13 South Dandalup River, Patterson Rd (AWRC ref - 6142623).



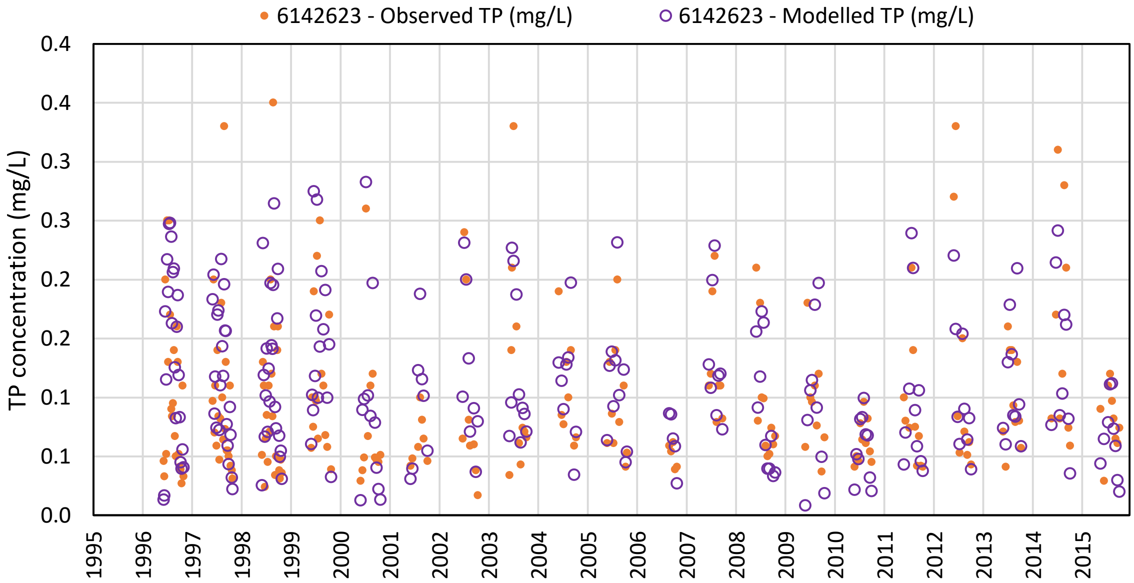
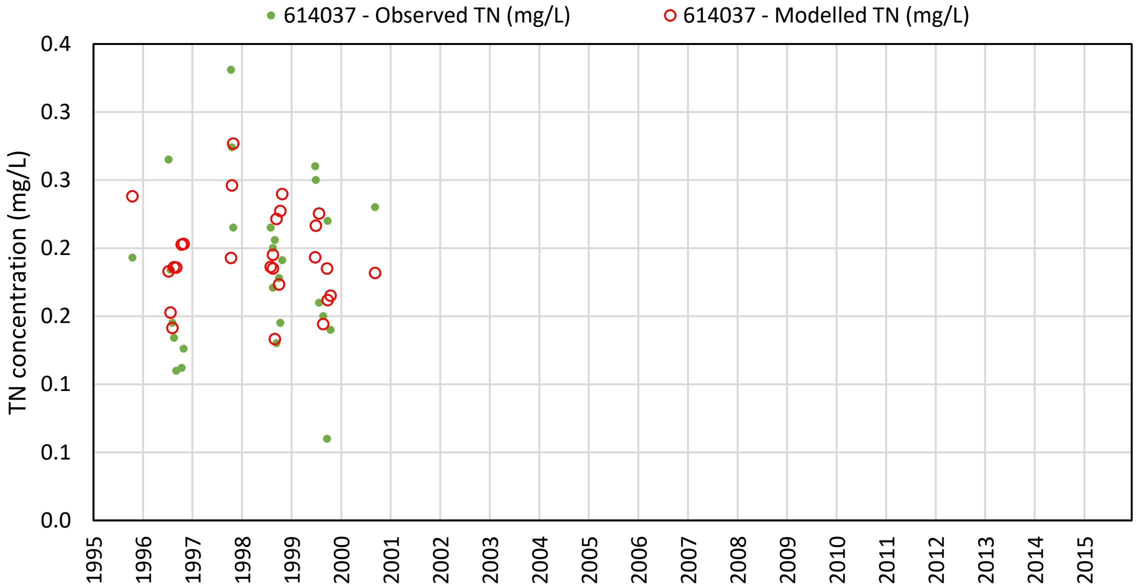


Figure B.13: Measured and modelled total nitrogen (TN, top graph) and total phosphorus (TP, bottom graph) at Patterson Rd (South Dandalup River, AWRC Ref 6142623)

B.3.14 Big Brook, Oneil Road (AWRC ref - 614037).



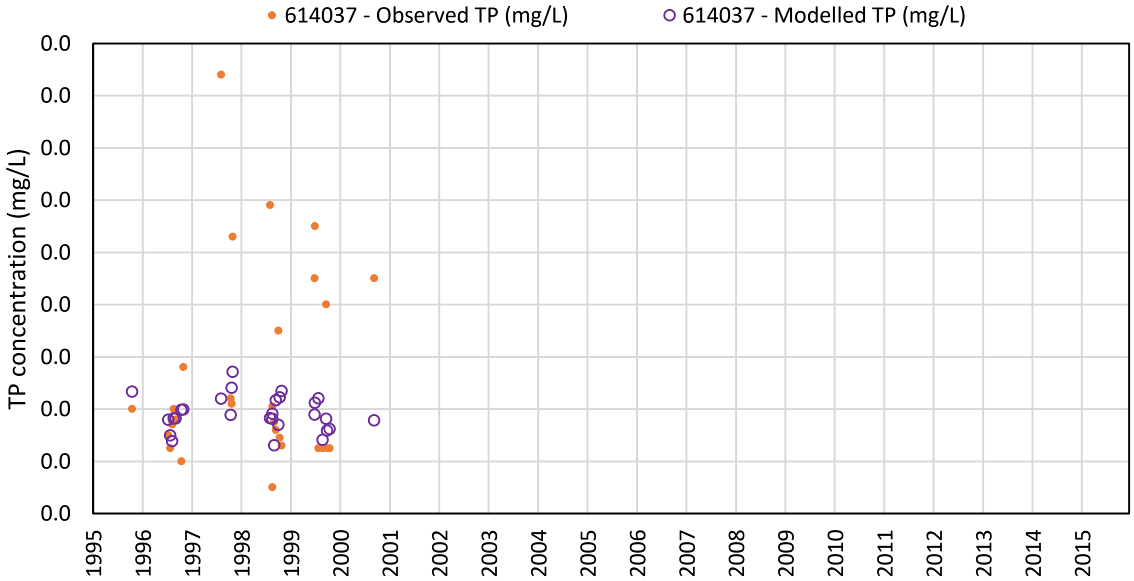


Figure B.14: Measured and modelled total nitrogen (TN, top graph) and total phosphorus (TP, bottom graph) at Oneil Road (Big Brook, AWRC Ref 614037)

Appendix C: Point sources and septic tanks

C.1 Point sources of nutrient pollution

Here we discuss the point sources of pollution that we identified in this project and the rational for their inclusion (or exclusion) in the catchment model. We identified point sources through the land-use mapping process, the state cadastre, the National Pollutant Inventory database, and the department's (formally the Department of Environment Regulation) licences and works approvals database. Excluding landfill sites, there were 84 point sources that were identified in this project (Table C.1). Of these, 64 were included in the model with 54 being in catchments that drain to the Peel-Harvey estuary.

Table C.1: Point sources identified in this modelling

	Abattoir		Beverage & brewing		Composting		Feedlot		Industrial		Piggery		Poultry		Stockyard or saleyard		Sawmill		WWTP		**Total**	
Reporting catchment	Included	Excluded	Included	Excluded	Included	Excluded	Included	Excluded	Included	Excluded	Included	Excluded	Included	Excluded	Included	Excluded	Included	Excluded	Included	Excluded	**Included**	**Excluded**
Coastal North									3	7			4							4	**7**	**11**
Coastal Central																				1		**1**
Coastal South							1													1	**1**	**1**
Peel Main Drain													3		1				1		**5**	
Upper Serpentine					1		1				1		13		3						**19**	
Dirk Brook							1				1		3								**5**	
Nambeelup							1														**1**	
Lower Serpentine											1		3								**4**	
Upper Murray							3				3		1						2	1	**9**	**1**
Lower Murray							1			1			2							1	**3**	**2**
Coolup (Peel)							1				1									1	**2**	**1**
Coolup (Harvey)											1										**1**	
Mayfield Drain							1														**1**	
Harvey			1				1			1								1	1		**3**	**2**
Meredith Drain											1										**1**	
Harvey Diversion Drain	1																		1	1	**2**	**1**
Peel-Harvey estuary	**0**		**1**		**1**		**10**			**2**	**9**		**25**		**4**			**1**	**4**	**3**	**54**	**6**
Total	**1**		**1**		**1**		**11**		**3**	**9**	**9**		**29**		**4**			**1**	**5**	**10**	**64**	**20**

Intensive animal uses

We modelled intensive animal land uses (Piggeries & abattoirs, Feedlots & stockyards, Poultry) using the diffuse model described Section 3.1.2 of the main body of the report.

Industrial sites and other point sources

The NPI database contains several facilities that emit nitrogen and/or phosphorus to the environment. Facilities that emitted nutrients to land or water were included in the model and were all located in the Kwinana Industrial area (see Table C.2). Emissions were converted from financial year to calendar year and converted to a daily timestep.

Although emissions of nitrous oxides and/or ammonia to air were the most common form of nutrient emission in the NPI database, these sources were not included in the model. This was due to the lack of a suitable approach for including atmospheric emissions into the model. Note that average annual atmospheric deposition of nutrients is included as a model input and are based on local measurements.

Table C.2: Industrial emissions to land and water

Reporting	Coastal North		Coastal North		Coastal North		Coastal North	
Subcat of discharge	3		3		3		3	
Subcat of site	3		3		3		3	
Model method	Source node		Source node		Source node		Not inluded in model	
Point source type	Industry & chemical		Industry & chemical		Industry & chemical		Industry & chemical	
Facility name	BP Refinery (Kwinana) Pty Ltd		CSBP Kwinana Operations		Kwinana Power Station		Kwinana Nickel Refinery	
Data source	NPI		NPI		NPI		NPI	
Discharge to land/water	Water		Water		Water		Land	
Year	**N (t/yr)**	**P (t/yr)**	**N (t/yr)**	**P (t/yr)**	**N (t/yr)**	**P (t/yr)**	**N (t/yr)**	**P (t/yr)**
2006	8.5	1.5	27.5	5.0				
2007	7.7	1.1	35.0	5.2				
2008	5.2	1.2	40.0	4.4			353.6	
2009	3.5	1.6	41.5	2.6			398.9	
2010	4.8	1.9	49.5	2.0			82.7	
2011	5.3	1.8	43.5	3.0			60.4	
2012	6.3	1.5	31.5	4.5			50.6	
2013	7.7	1.5	32.5	4.6	3.2	0.1	55.1	
2014	7.5	2.3	34.0	3.9	5.4	0.1	51.4	
2015	4.1	1.5	16.5	2.1	2.2	0.0	23.9	
Average	**6.0**	**1.6**	**35.2**	**3.7**	**3.6**	**0.1**	**134.6**	

We included a composting facility in the catchment model by assuming modelled surface water concentrations of 62 mg/L TN and 8.6 mg/L TP. These concentrations were based on measurements taken adjacent to the site. We derived modelled surface water volumes from the ‘cleared’ hydrological model in modelling catchment 83. We estimated that this 7.1-hectare site had average annual (2006–15) nutrient exports of 48 kg N/ha/yr and 6.7 kg P/ha/yr.

We identified a beverage and brewing site using the departments licences and works approval database (L4404/1991/15). This 116-hectare site irrigates pastures and orchards with treated wastewater. We classified as ‘horticulture’ in the land use mapping and modelled nutrient export using the diffuse model. As such the nutrient emissions of this site are lumped with all horticultural land uses in the Harvey reporting catchment source separation. We estimated that this site had average annual (2006–15) nutrient exports of 5.2 kg N/ha/yr and 4.5 kg P/ha/yr.

Wastewater treatment plants

We identified 12 operating and 3 decommissioned wastewater treatment plants (WWTP) in the model domain as of 2015 (Table C.3). The East Rockingham WWTP became operational in 2016 (Coastal North catchment) and was not considered in this modelling as it was not operational during the modelling period (up to 2015).

We included four WWTPs (Waroona, Harvey, Williams and Kwinana) in the catchment model:

- Treated wastewater discharge from the Waroona WWTP uses monthly compliance data from the proponent for 2006–15. We infilled missing data using the values from the previous year. In 2014 a nutrient stripping swale was created to further remove nutrients from treated wastewater discharge prior to entering Drakesbrook Drain (Harvey reporting catchment).

- We estimated treated wastewater discharge from the old Williams WWTP using a monthly water balance (see Table C.4) that was disaggregated into daily data. We assume discharge concentrations of 28 mg/L TN and 8 mg/L TP. The old Williams WWTP was Shire run and was decommissioned in 2012 after the construction of the new Williams WWTP which is operated by the Water Corporation. This new plant detains treated wastewater and has been used to irrigate the town oval (3.56 ha) from 2014 and the hocky oval (1.40 ha) from 2015. The model does not explicitly account for the nutrient inputs from treated wastewater reuse. These WWTPs are in the Upper Murray reporting catchment.
- The Kwinana WWTP infiltrates treated wastewater adjacent to the Spectacle Wetlands. The work of Shams (2000) and McFarlane et al. (2015) suggest that some of the infiltrated wastewater reaches the wetland. McFarlane et al. (2015) only estimated the spatial extent of infiltrated treated wastewater. Shams (2000) estimated the net annual contribution from the WWTP to the lakes to be 0.36 GL/yr, 1.4 tonnes of nitrogen and 0.033 tonnes of phosphorus. We used estimates from Shams (2000) which we disaggregated into daily data using the monthly scaling factors given in Table C.5 and included this contribution in the Peel Main Drain catchment.
- We used 2013-14 compliance data from the proponent (disaggregated using Table C.5) to represent the treated wastewater discharge from the Harvey WWTP, which discharges to the Harvey Diversion Drain.

WWTPs that were not explicitly included in the model are detailed below:

- We didn’t include the Woodman Point and Point Perron WWTPs in the model as treated wastewater is discharged via an ocean outlet into the Sepia Depression.
- The Halls Head and Caddadup WWTPs infiltrate treated wastewater onsite and groundwater flows to a well-mixed ocean.
- The Gordon Road WWTP infiltrates treated wastewater onsite, which would predominantly flow west to the Indian Ocean. However, some infiltrated wastewater could flow east and express in Goegrup Lake (Serpentine River). Pavlov (2015) found that infiltrated treated wastewater from the Gordon Road WWTP was moving east but could not conclusively demonstrate any discharge into Goegrup Lake. No published reports that quantified the amount of nutrient discharge from this WWTP to Goegrup Lake were found when developing this model and therefore the WWTP was excluded.
- The Pinjarra and Boddington WWTPs provide all treated wastewater for industrial reuse. Prior to industrial reuse, it is understood that the Pinjarra WWTP discharged treated wastewater to the Murray River catchment (Bradby 1997) and the Boddington WWTP irrigated kikuyu pastures (4.4 ha). The nutrient contributions of these WWTPs have not been included in the model.
- Decommissioned WWTPs (Yunderup and Port Kennedy) were not included in the model due to a lack of data.

Table C.3: All WWTPs within the Peel-Harvey catchment model domain

Facility name		Effluent disposal	Start (yr)	End (yr)	Volume (ML/yr)	Nitrogen (kg/yr)	Phosphorus (kg/yr)
Caddadup	1, 6	Infiltration (ocean discharge)	-	Current	560	1 014	-
Halls Head	1, 6	Infiltration (ocean discharge)	-	Current	1 100	1 974	-
Kwinana	2	Infiltration (Spectacle Wetlands net discharge)	-	Current	360	1 400	33
Gordon Road	1, 7	Infiltration	-	Current	3 500	17 500	17 500
Point Peron	6	Ocean outfall	-	Current	7 300	292 000	59 750
Woodman Point	6	Ocean outfall	-	Current	51 100	712 000	260 500
Waroona	8	Surface waters	-	Current	86	2 740	140
Harvey	8	Surface waters	-	Current	303	7 900	280
Binningup		Infiltration	-	Current	-	-	-
Williams (old)	3, 7	Surface waters (decommissioned)	-	2012	7	204	58
Williams (new)		Detention/reuse (POS)	2014	Current	-	-	-
Boddington	3	Reuse (industrial)	2007	Current	183	5 100	1 500
Pinjarra	5	Reuse (industrial)	1998/9	Current	-	-	-
Yunderup	5	Decommissioned	-	1997	-	-	-
Port Kennedy	5	Decommissioned	-	1997	-	-	-

Note:

SBR = Sequencing batch reactor

Port Kennedy WWTP was decommissioned between 1995 and 2000

Data sources:

1. Volume of discharge as reported in McFarlane 2015
2. Shams 2000
3. Department of Water and Environmental Regulation (formally the Department of Environment Regulation) licence data. Accessed 2015/16
4. Assumed water balance
5. Kelsey et al. 2011
6. NPI data
7. Assumed nutrient effluent concentrations
8. 2013-14 data

Table C.4: Water balance of the old Williams WWTP

	Inputs			Outputs		
Month	**Wastewater inflows** (ML/month)	**Rainfall** (ML/month)	**Total inputs** (ML/month)	**Evaporation** (ML/month)	**Discharge to Williams River** (ML/month)	**Total outputs** (ML/month)
Jan	1.0	0.1	1.1	1.0	0.1	1.1
Feb	0.9	0.0	0.9	0.8	0.1	0.9
Mar	1.0	0.1	1.1	0.7	0.4	1.1
Apr	1.0	0.1	1.1	0.4	0.6	1.1
May	1.0	0.2	1.2	0.3	1.0	1.2
Jun	1.0	0.3	1.2	0.2	1.0	1.2
Jul	1.0	0.4	1.4	0.2	1.2	1.4
Aug	1.0	0.3	1.3	0.3	1.1	1.3
Sep	1.0	0.2	1.2	0.4	0.8	1.2
Oct	1.0	0.1	1.1	0.6	0.5	1.1
Nov	1.0	0.1	1.1	0.8	0.3	1.1
Dec	1.0	0.1	1.1	0.9	0.2	1.1
Total	**11.7**	**2.1**	**13.8**	**6.5**	**7.3**	**13.8**

Note:
Daily wastewater inflow = 0.032 ML/day
(https://www.watercorporation.com.au/about-us/media/media-releases/media-release/$12m-upgrade-to-williams-wastewater-scheme)
Measured pond area = 4740 m2, assumed pond depth = 2 m, assumed pond volume = 9.48 ML
Climate data taken as the 2000–15 monthly average of subcatchment 72
Assumes initial volume to be full

Table C.5: Monthly scaling of annual treated wastewater discharge data

	Percent of annual discharge	
Month	**Harvey**	**Kwinana**
Jan	2%	6%
Feb	2%	4%
Mar	5%	2%
Apr	9%	1%
May	13%	1%
Jun	14%	1%
Jul	16%	5%
Aug	15%	10%
Sep	11%	20%
Oct	7%	22%
Nov	4%	16%
Dec	2%	12%
Total	**100%**	**100%**

Rubbish tips and septage disposal sites

There are 34 rubbish tips and septage disposal sites in the catchment which may be contributing nitrogen and phosphorus to groundwater which are listed in Table C.6.The landfill class definitions are:

Class I - unlined, not located near sensitive environments;

Class II - appropriately located, may have lining and leachate collection;

Class III - lined with leachate collection; and

Class IV - double lined with leachate collection or alternative measures as appropriate.

The quantities of rubbish or septage deposited per year are taken from APrince Consulting (2006) and Hirschberg (1992) suggested that ammonium levels in groundwater adjacent to rubbish tips greater than 0.5 mg/l indicates that the site is polluting. He identified four such sites in the Peel-Harvey catchment, which are highlighted in Table C.6. We did not include the discharge from these sites into the catchment model due to the difficulty in estimating groundwater-surface water nutrient exports, as well as there being limited data at the time of constructing this model.

C.2 Septic tanks

Septic tank inputs

We identified unsewered properties using the Water Corporation's sewerage coverage dataset (2016) and the land-use mapping used in this project. We assumed that all unsewered areas used septic tanks which discharged 5.5 kg/person/yr of nitrogen and 1.1 kg/person/yr of phosphorus (Whelan et al. 1981). Each residential septic tank was assumed to service a house with 2.4 people per dwelling (Mandurah statistical area ABS 2011[3]) or as specified in Table C.7.

Table C.8 gives the nutrient load from septic tank discharge prior to catchment assimilation. We did not include the nutrient contribution of septic tanks in dam catchments or the Upper Murray in the catchment model.

Septic tank exports

Here we describe how we estimated septic tank nutrient loss to surface water after catchment assimilation. We modelled the proportion of septic tank effluent that reached surface waters using an export rate derived from Kelsey et al. (2011) (see Table C.9) and a daily subcatchment outflow modifier. This daily subcatchment outflow modifier scales the daily septic tank export using the ratio of daily subcatchment flow to the average daily flow between 1960–2015. This modifier was necessary to prevent the discharge of highly concentrated nutrients when there is little to no surface flow. We also increased septic tank exports by a factor of 1.4 so that nutrient export load was close to those given Kelsey et al. 2011. The resulting septic tank exports are given in Table C.10.

[3] https://quickstats.censusdata.abs.gov.au/census_services/getproduct/census/2011/quickstat/0

Table C.6: Rubbish tips and septage disposal sites in the Peel-Harvey catchment (Kelsey et al. 2011)

Operator or Locality	**Activity / Description**	**Comments**
Armadale	Class II or III putrescible landfill site. Natural clay liner. 32,000 T/yr	NH4-N > 0.5 mg/l (1)
Boddington	Putrescible landfill site 3,000 T/yr	
Bibra Lake	Abandoned Landfill	Abandoned, but most likely still leaking waste.
Henderson Landfill, Henderson	Class I inert landfill site, 2nd licence - Class II or III putrescible landfill. Clay, HDPE liner. 20,000T/yr	NPI 2005: emits 1,671kg of ammonia to land
Henderson	Class I Inert Landfill Site 2nd licence - Compost manufacturing and soil blending	
Amcor Packaging Australasia (Spearwood) Cockburn	Class II or III putrescible landfill site, 2nd licence - Pulp, paper or paperboard manufacturing, 3rd licence- Solid waste depot, transfer station, 4th licence- Class I inert landfill site.	
Cuballing	Putrescible landfill and sewage disposal. 500 T/yr	
Popanyinning	Putrescible landfill site – 400 T/yr	
Fremantle cnr Douro Rd and Hampton Rd	Abandoned landfill	Now a shopping centre. NH4-N >10 mg/l (1)
Fremantle Lefroy Rd Quarry	Class I inert landfill site	Not polluting - inert land fill
Harvey	Class II or III putrescible landfill site. 5,000T/yr	
Australind	Closed Landfill	Closed in 1999
Harvey	Septage Disposal Site 680 KL/yr	
Kwinana	Solid Waste Landfill	
Kwinana	Class I inert landfill site, 2nd licence - Class II or Class III putrescible land fill, 3rd licence - Solid waste depot, transfer station	Putrescibles closed in 1995. Still operating as an inert land fill. Big and most likely polluting.
Wellard	Class 1 Inert Landfill, 2nd licence - solid waste depot, transfer station	Not polluting - inert land fill and transfer station
Kwinana	Waste Disposal Site - bauxite processing residues. Lined but type unknown	
Herron	Waste Disposal Site	Getting landfill gas from site
Caddadup	Closed landfill & liquid disposal	Most of the pollution going west to ocean, only a small amount going to Harvey Inlet.
Dawesville	Liquid waste facility Waste Disposal Site	
Pinjarra	Landfill & septics Class I inert landfill site 2nd licence - Used tyre storage	
Pinjarra	Waste Disposal Site Class II or III putrescible waste, Bauxite refining residues	
Pingelly	Class II or III putrescible landfill. Natural clay liner.	
Rockingham	Closed landfill	NH4-N > 10 mg/l (1)
Baldivis	Class II or III putrescible landfill site, Solid waste landfill	Big tip with liquid waste disposal ponds
Byford	Landfill	
Keysbrook	Landfill	NH4-N 0.5 to 3 mg/l (1)
Serpentine - Jarrahdale	Landfill	
Serpentine-Jarrahdale South Cardup Landfill	Class II or III putrescible landfill site, Multilayer clay liner. 12,000T/yr	Big Site. Liquid waste pond
Wandering	Class II or III putrescible landfill site -40T/yr	
Waroona	Landfill & septics Class II or III putrescible landfill site 3,500T/yr	Liquid waste ponds
Waroona	Class II or III putrescible waste	
Williams	Putrescible landfill site – 500T/yr	
Williams	Sewage disposal	

1. Hirschberg (1992)

Table C.7: The assumed number of people per septic tank for land uses other than urban residential.

Landuse category	People per septic tank
Residential - single/duplex dwelling	2.4
Residential - multiple dwelling	2.4
Residential - aged person	2.4
Residential - temporary accommodation	71.1
Caravan park	71.1
Manufacturing / processing	19.9
Storage / distribution	19.9
Commercial / service - centre	10.1
Commercial / service - residential	5.5
Office - without parkland	7.4
Office - with parkland	7.4
Garden centre / nursery	2.4
Community facility - education	246.2
Community facility - non-education	11.9
Recreation - turf	11.9

Table C.8: Septic tank inputs by reporting catchment

Reporting catchment	Total people	Total septics	Input Volume (ML/yr)	Input Nitrogen (kg/yr)	Input Phosphorus (kg/yr)
Coastal Central	1 795	744	102	9 873	1 975
Coastal North	22 669	4 838	1 283	124 678	24 936
Coastal South	3 775	1 340	214	20 764	4 153
Coolup (Harvey)	284	115	16	1 560	312
Coolup (Peel)	238	99	13	1 307	261
Dirkbrook	430	175	24	2 362	472
Harvey	6 275	2 229	355	34 510	6 902
Harvey Diversion Drain	805	234	46	4 430	886
Lower Serpentine	3 492	1 206	198	19 208	3 842
Mandurah	1 850	746	105	10 173	2 035
Mayfield Drain	151	63	9	832	166
Meredith Drain	29	12	2	158	32
Murray	4 670	1 172	264	25 683	5 137
Nambeelup	758	316	43	4 171	834
Peel Main Drain	4 267	1 632	241	23 467	4 693
Upper Murray	3 738	781	212	20 558	4 112
Upper Serpentine	11 079	4 187	627	60 936	12 187
Upstream Harvey Reservoir	5	2	0	26	5

Table C.9: Initial septic tank export rates

Reporting catchment	Volume (%)	Nitrogen (%)	Phosphorus (%)
Coastal Central	51	51	17
Coastal North	51	51	17
Coastal South	11	11	1.3
Coolup (Harvey)	5.2	5.2	0.5
Coolup (Peel)	5.2	5.2	0.5
Dirkbrook	14	14	3.4
Harvey	6.1	6.1	9.1
Harvey Diversion Drain	21	21	7.8
Lower Serpentine	24	24	3.6
Mandurah	33	33	8.2
Mayfield Drain	6.1	6.1	9.1
Meredith Drain	6.1	6.1	9.1
Murray	15	15	1.2
Nambeelup	2.8	2.8	3.5
Peel Main Drain	14	14	5.2
Upper Serpentine	14	14	3.4

Note: The Dirkbrook catchment was assigned the export rates of the Upper Serpentine catchment and the Mayfield and Meredith catchments were assigned the export rates of the Harvey catchment

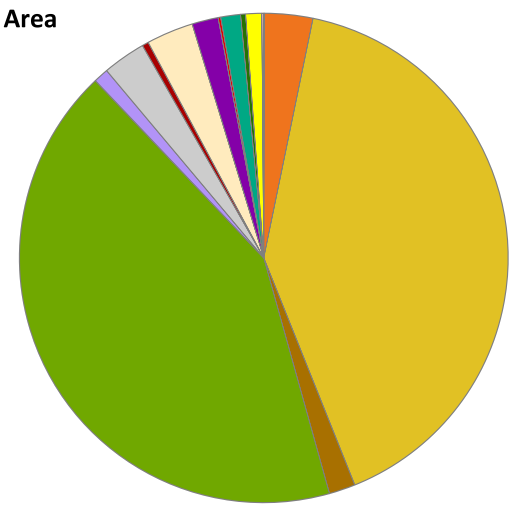
Table C.10: Average annual (2006–15) modelled septic tank exports

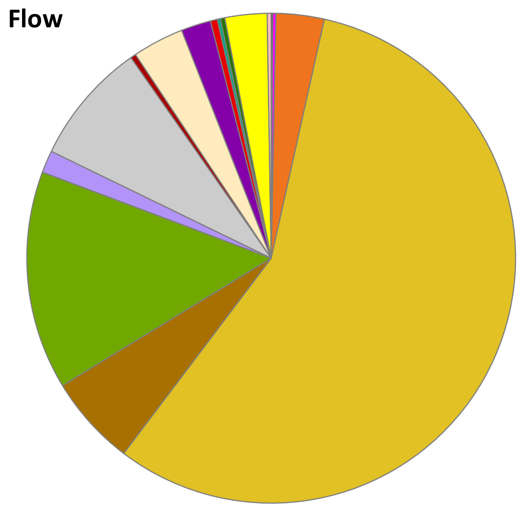
Reporting catchment	Volume (ML/yr)	Export (%)	Nitrogen (kg/yr)	Export (%)	Phosphorus (kg/yr)	Export (%)
Coastal Central	49	49	4 790	49	325	16
Coastal North	661	52	64 268	52	4 359	17
Coastal South	17	8.2	1 698	8.2	38	0.9
Coolup (Harvey)	1	4.1	63	4.1	1	0.4
Coolup (Peel)	0	3.7	48	3.7	1	0.4
Dirkbrook	3	12	296	13	15	3.1
Harvey	21	5.8	2 012	5.8	605	8.8
Harvey Diversion Drain	9	21	919	21	68	7.7
Lower Serpentine	38	19	3 728	19	110	2.9
Mandurah	32	30	3 064	30	150	7.4
Mayfield Drain	0	5.5	46	5.5	14	8.3
Meredith Drain	0	5.1	8	5.1	2	7.7
Murray	32	12	3 111	12	51	1.0
Nambeelup	1	2.0	91	2.2	23	2.8
Peel Main Drain	31	13	3 019	13	218	4.7
Upper Serpentine	78	12	7 585	12	376	3.1

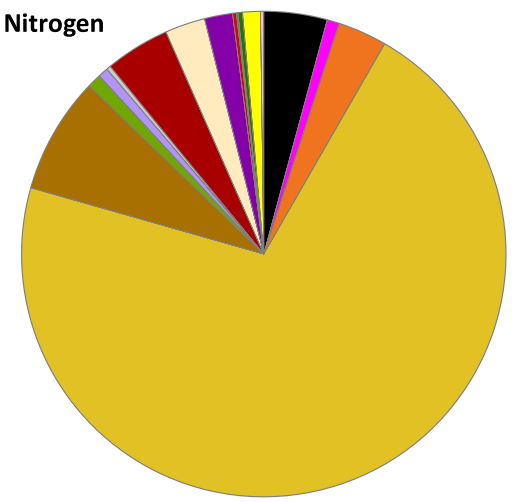
Appendix D: Source separation

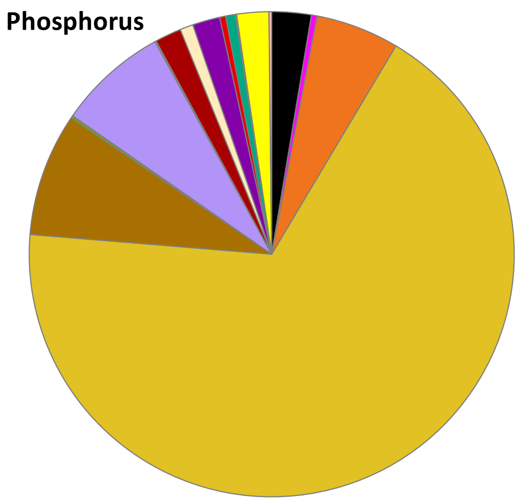
D.1 Peel-Harvey coastal plain catchments

Land use	Colour	Area		Flow		Nitrogen		Phosphorus	
		(km^2)	(%)	(GL)	(%)	(tonnes)	(%)	(tonnes)	(%)
Septic (#)			-	0.2	0.1	23.3	4.2	1.6	2.6
Point sources		1.1	0.0	0.5	0.2	4.5	0.8	0.2	0.4
Horses		84.1	3.2	7.7	3.2	18.1	3.3	3.3	5.6
Beef		1072.4	40.7	138.5	56.8	392.7	71.1	40.1	67.7
Dairy		45.9	1.7	14.6	6.0	43.0	7.8	4.9	8.2
Native vegetation		1112.9	42.2	35.1	14.4	5.1	0.9	0.1	0.2
Cropping		0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Horticulture		25.9	1.0	3.6	1.5	3.7	0.7	4.3	7.3
Industry, manufacturing & transport		75.2	2.9	19.7	8.1	1.5	0.3	0.1	0.1
Intensive animal use		11.1	0.4	0.9	0.4	23.8	4.3	1.0	1.8
Lifestyle block		82.0	3.1	8.3	3.4	14.8	2.7	0.5	0.9
Mixed grazing		45.8	1.7	4.8	2.0	10.3	1.9	1.1	1.8
Offices, commercial & education		4.5	0.2	1.1	0.5	1.4	0.3	0.2	0.4
Plantation		34.5	1.3	0.5	0.2	0.6	0.1	0.4	0.7
Recreation		8.6	0.3	0.7	0.3	1.7	0.3	0.0	0.1
Residential		27.9	1.1	6.8	2.8	6.5	1.2	1.3	2.1
Viticulture		3.4	0.1	0.6	0.3	1.2	0.2	0.1	0.2
Total		**2635.5**		**243.8**		**552.4**		**59.3**	









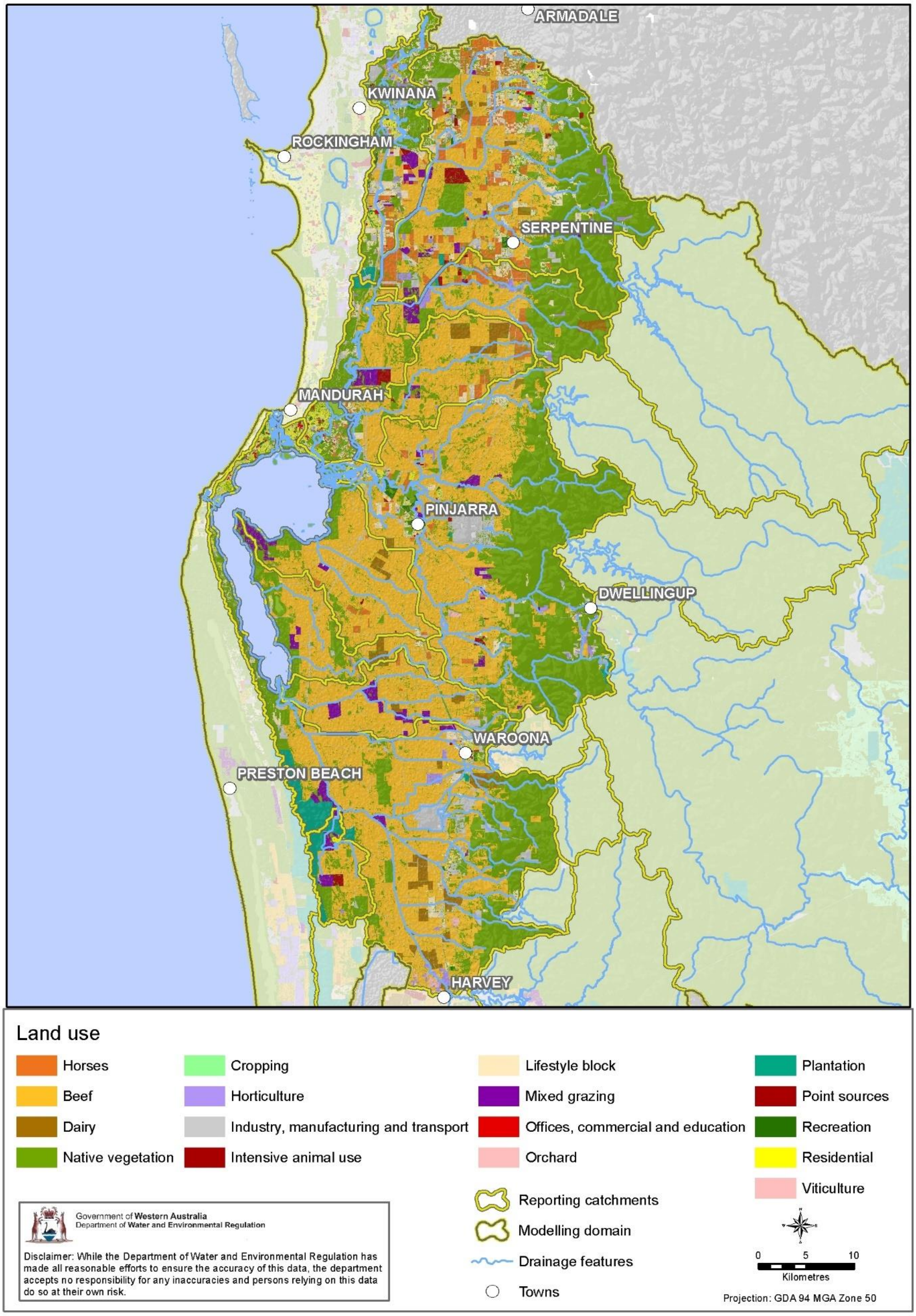
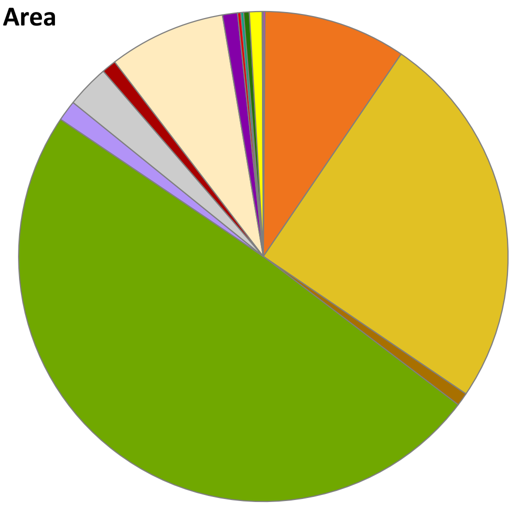
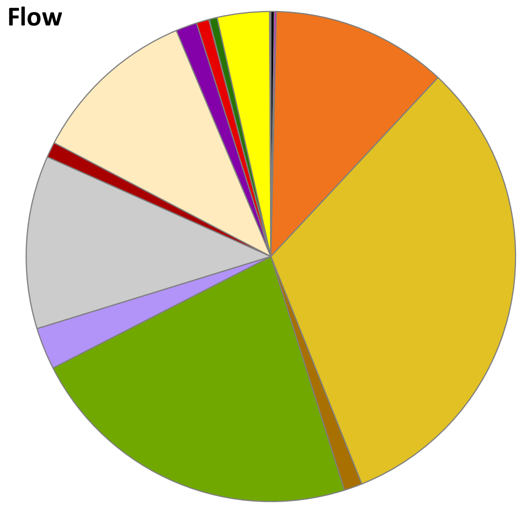


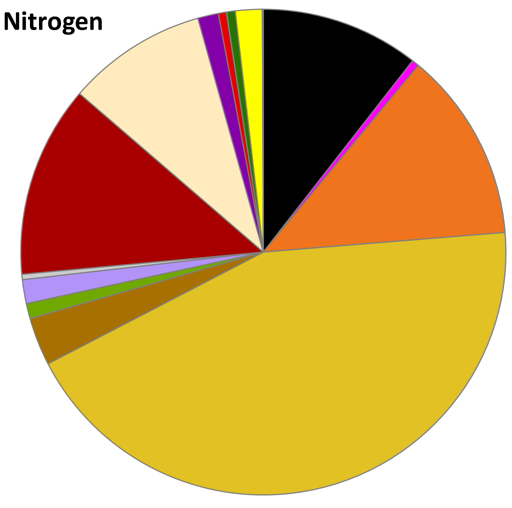
Figure D.1: Peel-Harvey coastal plain catchment land use

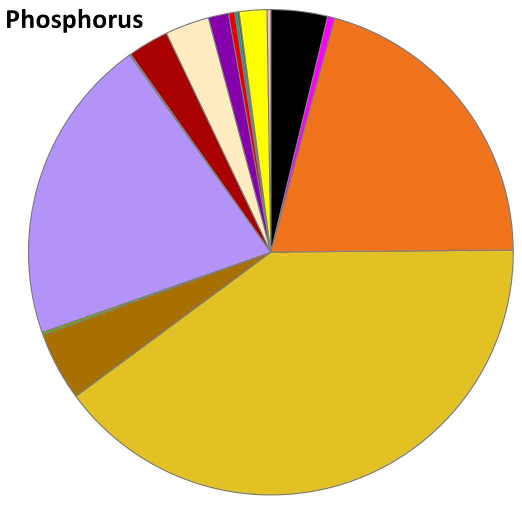
D.2 Upper Serpentine

Land use	Colour	Area		Flow		Nitrogen		Phosphorus	
		(km^2)	(%)	(GL)	(%)	(tonnes)	(%)	(tonnes)	(%)
Septic (#)		4187.0	-	0.1	0.2	7.6	10.6	0.38	3.8
Point sources		0.6	0.1	0.0	0.1	0.3	0.5	0.05	0.5
Horses		46.1	9.4	3.9	11.6	9.1	12.7	2.06	20.6
Beef		122.4	25.0	10.9	32.0	31.4	43.7	3.99	40.0
Dairy		4.2	0.9	0.4	1.2	2.3	3.2	0.46	4.6
Native vegetation		240.8	49.1	7.6	22.3	0.7	1.0	0.02	0.2
Cropping		0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.0
Horticulture		6.7	1.4	0.9	2.8	1.1	1.6	2.04	20.5
Industry, manufacturing & transport		13.9	2.8	3.9	11.4	0.3	0.4	0.01	0.1
Intensive animal use		4.7	0.9	0.3	1.0	9.2	12.8	0.27	2.7
Lifestyle block		37.9	7.7	3.7	11.0	6.7	9.3	0.29	2.9
Mixed grazing		4.9	1.0	0.5	1.4	1.0	1.4	0.13	1.3
Offices, commercial & education		1.0	0.2	0.3	0.8	0.4	0.5	0.04	0.4
Plantation		0.9	0.2	0.0	0.0	0.0	0.0	0.02	0.2
Recreation		1.8	0.4	0.2	0.5	0.4	0.6	0.01	0.1
Residential		4.1	0.8	1.2	3.5	1.3	1.8	0.18	1.8
Viticulture		0.3	0.1	0.0	0.1	0.0	0.1	0.02	0.2
Total		**490.4**		**33.9**		**71.8**		**9.97**	









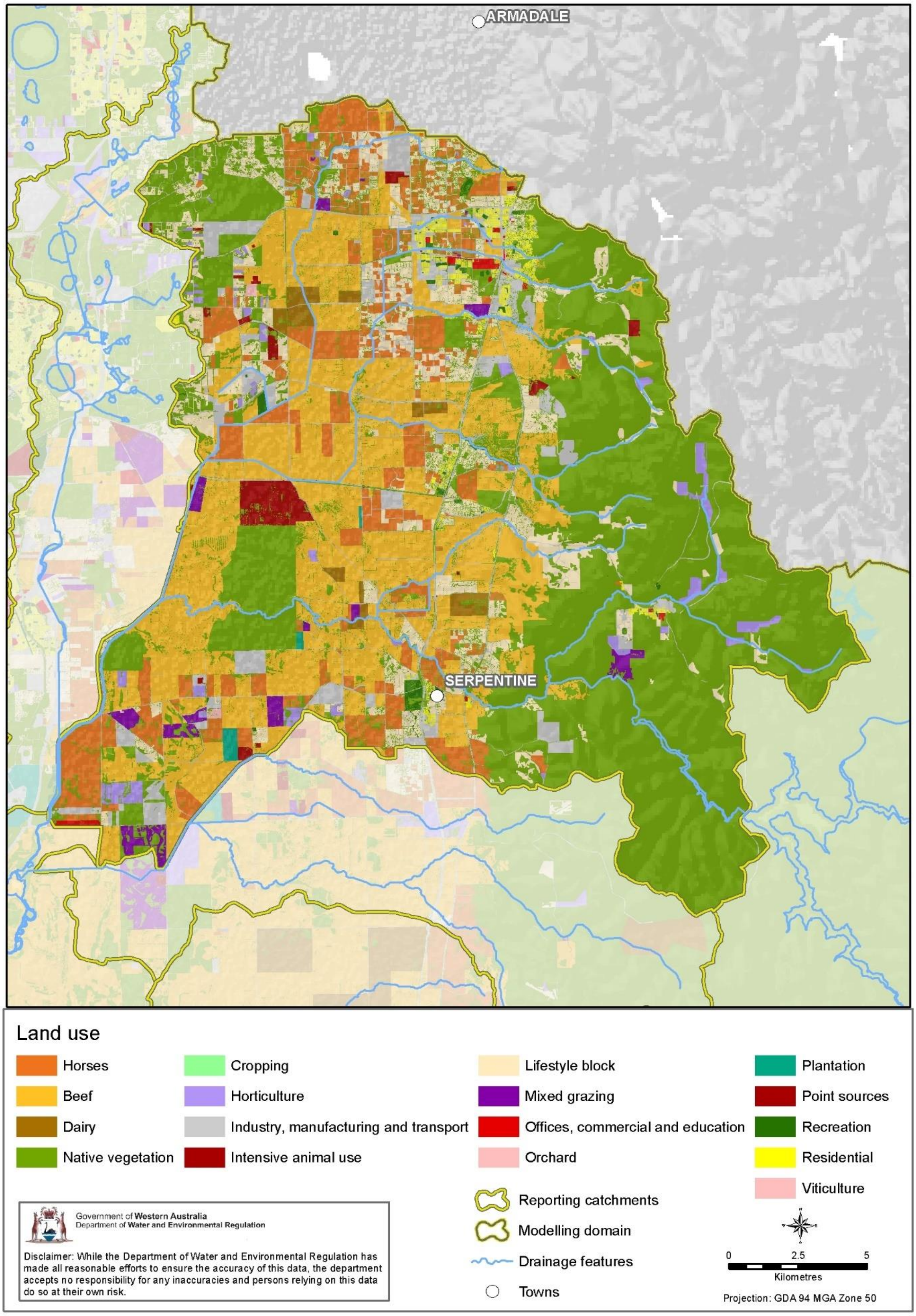
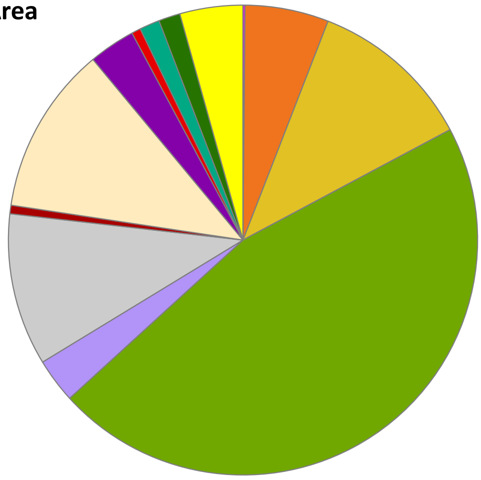


Figure D.2:Land-use of the Upper Serpentine reporting catchment

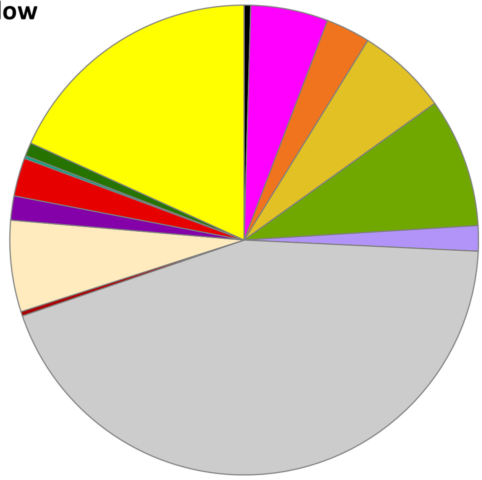
D.3 Peel Main Drain

Land use	Colour	Area		Flow		Nitrogen		Phosphorus	
		(km^2)	(%)	(GL)	(%)	(tonnes)	(%)	(tonnes)	(%)
Septic (#)		1632.0	-	0.0	0.5	3.0	26.1	0.22	15.4
Point sources		0.2	0.1	0.4	5.3	1.4	12.1	0.03	2.3
Horses		7.2	5.8	0.2	3.1	0.8	6.6	0.09	6.4
Beef		14.1	11.3	0.4	6.3	2.0	17.2	0.10	7.1
Dairy		0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.0
Native vegetation		57.5	46.0	0.6	8.9	0.2	2.0	0.01	0.4
Cropping		0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.0
Horticulture		3.8	3.1	0.1	1.7	0.3	2.3	0.69	48.4
Industry, manufacturing & transport		13.1	10.5	3.0	44.0	0.1	1.1	0.00	0.3
Intensive animal use		0.7	0.6	0.0	0.3	0.9	7.8	0.03	1.8
Lifestyle block		14.5	11.6	0.4	6.3	1.2	10.5	0.04	3.1
Mixed grazing		4.0	3.2	0.1	1.7	0.4	3.6	0.02	1.3
Offices, commercial & education		0.8	0.6	0.2	2.6	0.2	1.4	0.02	1.1
Plantation		1.7	1.4	0.0	0.2	0.0	0.2	0.01	1.0
Recreation		1.9	1.5	0.1	0.9	0.2	2.1	0.00	0.3
Residential		5.4	4.3	1.3	18.2	0.8	7.1	0.16	11.0
Viticulture		0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.0
Total		**124.9**		**6.9**		**11.6**		**1.42**	

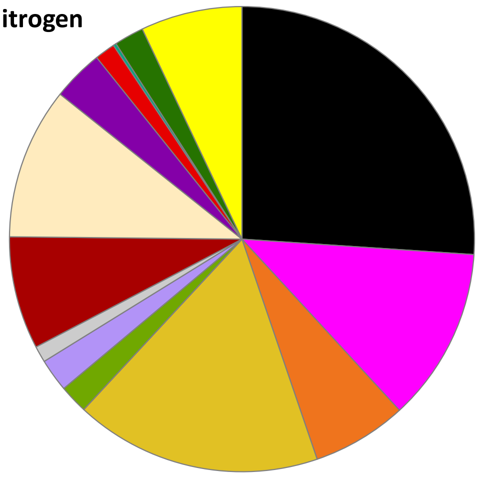
Area



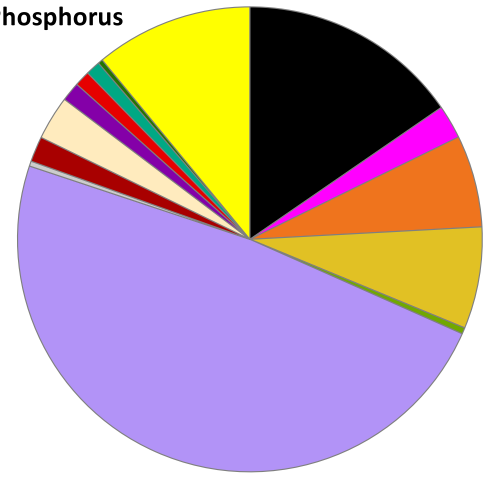
Flow



Nitrogen



Phosphorus



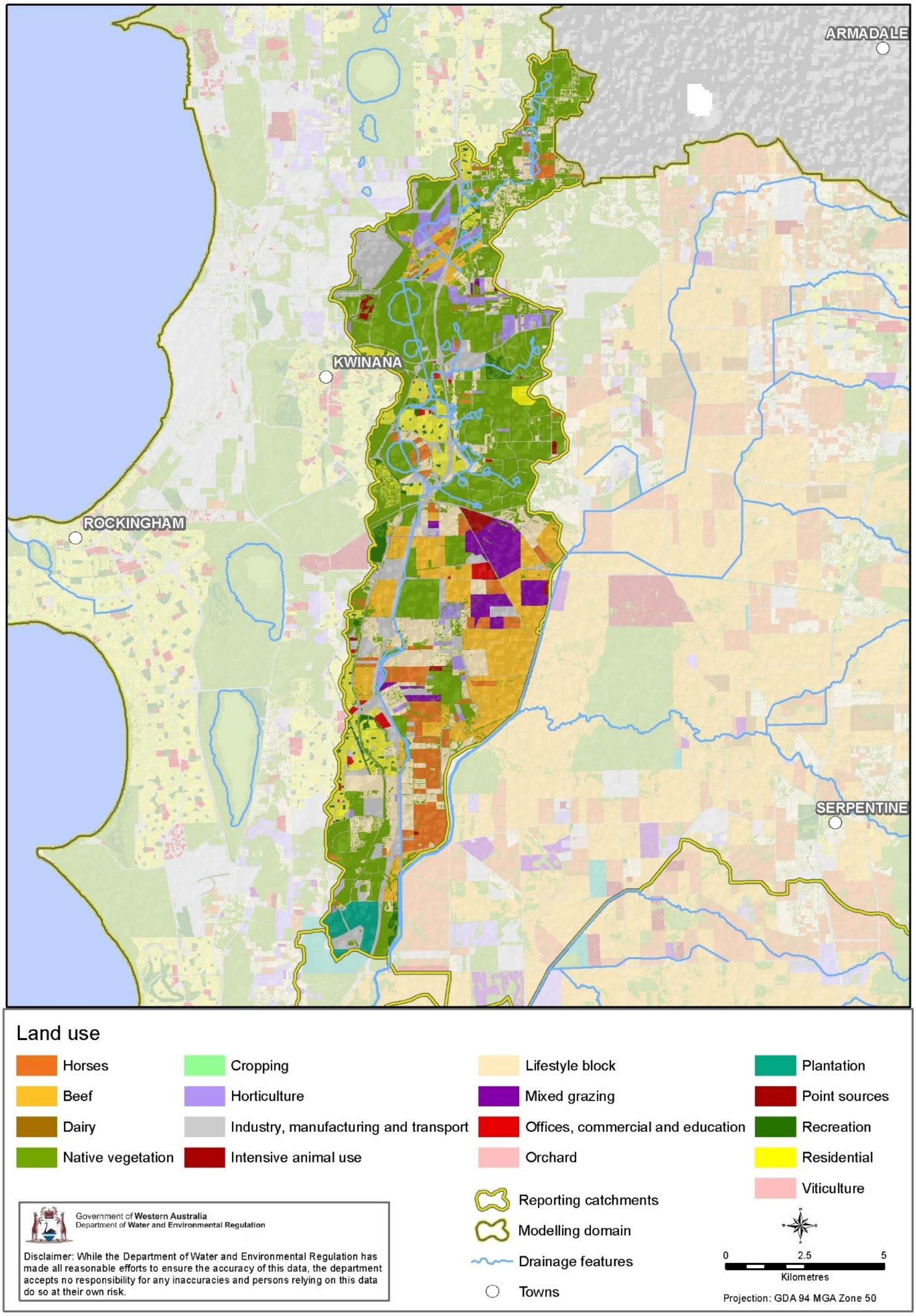
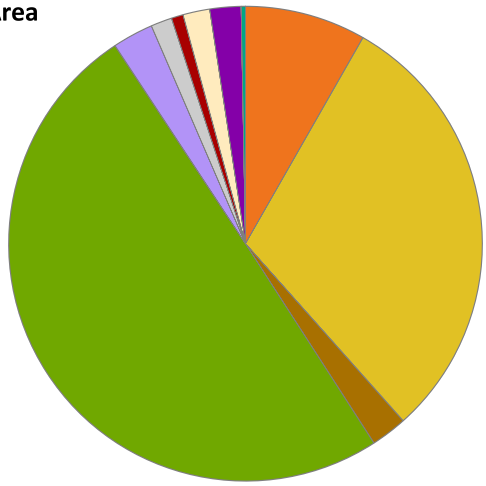


Figure D.3: Land-use of the Peel Main Drain reporting catchment

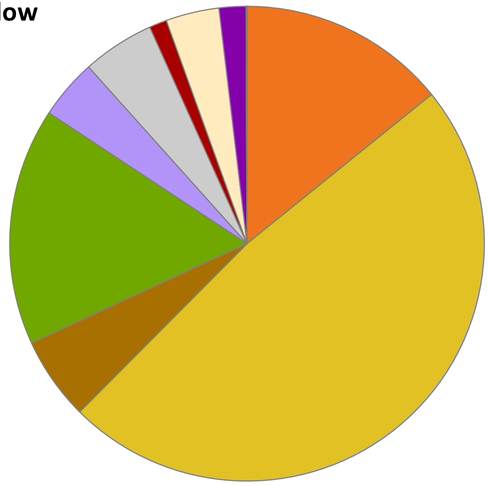
D.4 Dirk Brook

Land use	Colour	Area		Flow		Nitrogen		Phosphorus	
		(km^2)	(%)	(GL)	(%)	(tonnes)	(%)	(tonnes)	(%)
Septic (#)		175.0	-	0.0	0.0	0.3	1.0	0.01	0.5
Point sources		0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.0
Horses		11.5	8.3	1.8	14.2	3.6	12.7	0.44	15.7
Beef		42.0	30.1	6.1	48.3	15.5	54.0	1.62	58.4
Dairy		3.4	2.5	0.7	5.6	2.9	10.2	0.10	3.7
Native vegetation		69.5	49.8	2.0	16.2	0.1	0.5	0.00	0.0
Cropping		0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.0
Horticulture		3.9	2.8	0.5	4.1	0.6	2.2	0.31	11.1
Industry, manufacturing & transport		2.0	1.4	0.6	4.9	0.1	0.2	0.00	0.0
Intensive animal use		1.1	0.8	0.1	1.2	4.3	15.1	0.22	7.8
Lifestyle block		2.5	1.8	0.5	3.6	0.7	2.6	0.01	0.4
Mixed grazing		3.0	2.1	0.2	1.8	0.4	1.5	0.06	2.1
Offices, commercial & education		0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.0
Plantation		0.4	0.3	0.0	0.0	0.0	0.0	0.01	0.2
Recreation		0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.0
Residential		0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.0
Viticulture		0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.0
Total		**139.5**		**12.6**		**28.7**		**2.78**	

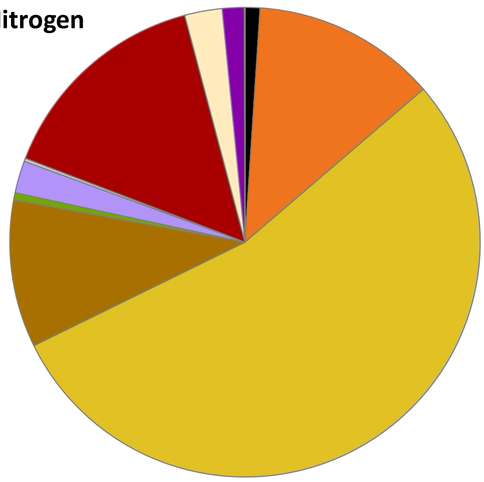
Area



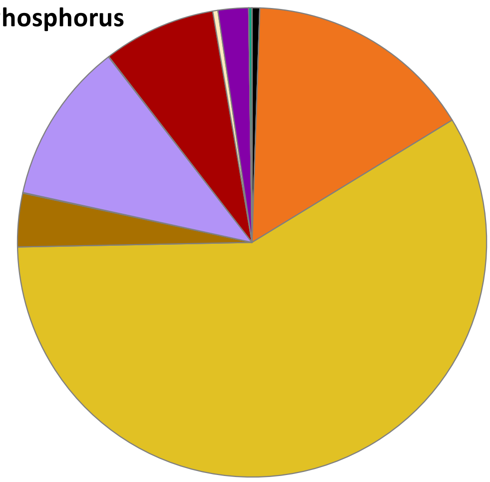
Flow



Nitrogen



Phosphorus



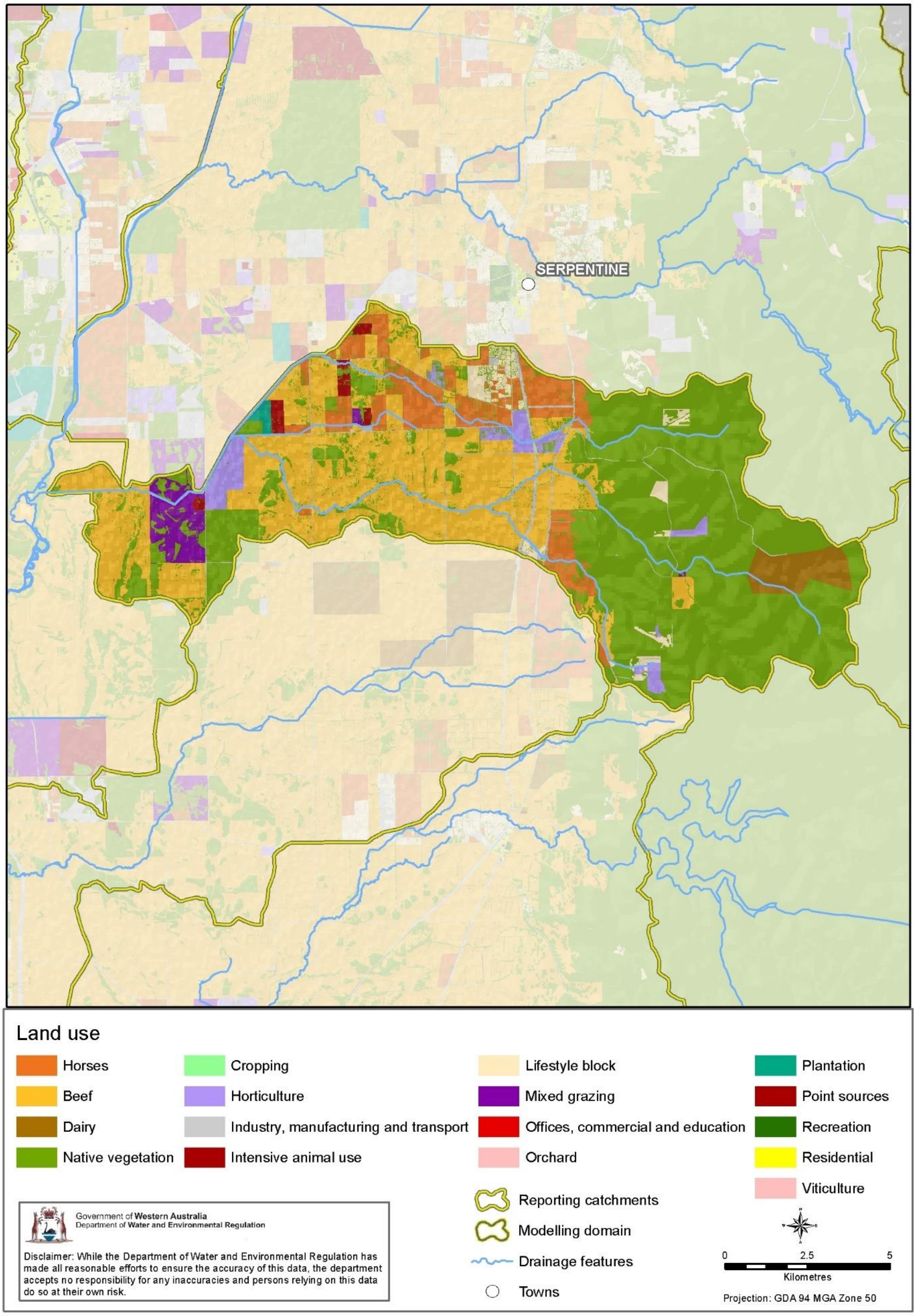
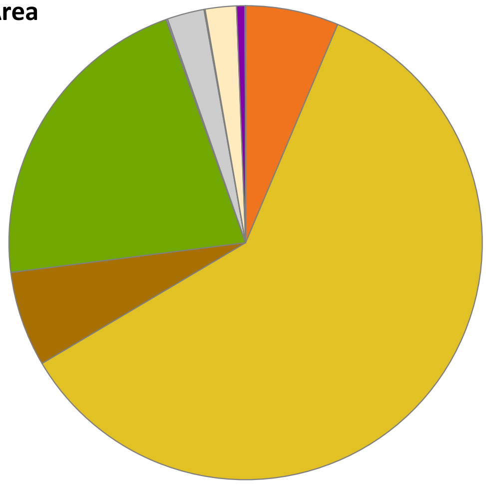


Figure D.4: Land-use of the Dirk Brook reporting catchment

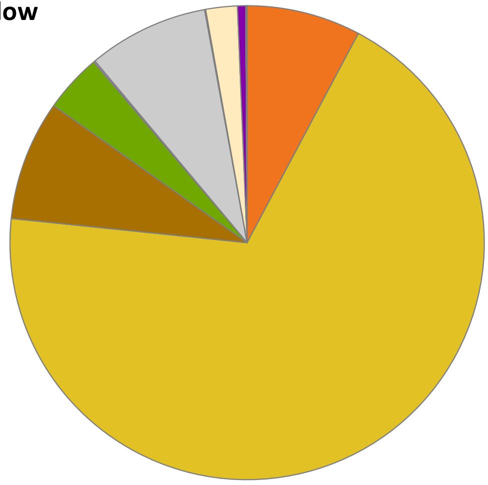
D.5 Nambeelup

Land use	Colour	Area		Flow		Nitrogen		Phosphorus	
		(km^2)	(%)	(GL)	(%)	(tonnes)	(%)	(tonnes)	(%)
Septic (#)		316.0	-	0.0	0.0	0.1	0.2	0.02	0.3
Point sources		0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.0
Horses		8.8	6.4	0.8	7.8	2.8	6.9	0.36	5.3
Beef		83.4	60.1	7.3	68.9	30.4	75.3	5.08	76.2
Dairy		9.0	6.5	0.9	8.2	5.9	14.7	1.09	16.3
Native vegetation		29.9	21.6	0.4	4.0	0.1	0.2	0.00	0.0
Cropping		0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.0
Horticulture		0.1	0.1	0.0	0.1	0.0	0.0	0.03	0.4
Industry, manufacturing & transport		3.5	2.5	0.9	8.2	0.1	0.2	0.00	0.1
Intensive animal use		0.1	0.1	0.0	0.1	0.2	0.5	0.02	0.4
Lifestyle block		3.0	2.1	0.2	2.2	0.6	1.4	0.03	0.5
Mixed grazing		0.8	0.6	0.1	0.6	0.2	0.5	0.03	0.5
Offices, commercial & education		0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.0
Plantation		0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.0
Recreation		0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.0
Residential		0.0	0.0	0.0	0.1	0.0	0.0	0.00	0.0
Viticulture		0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.0
Total		**138.7**		**10.6**		**40.3**		**6.66**	

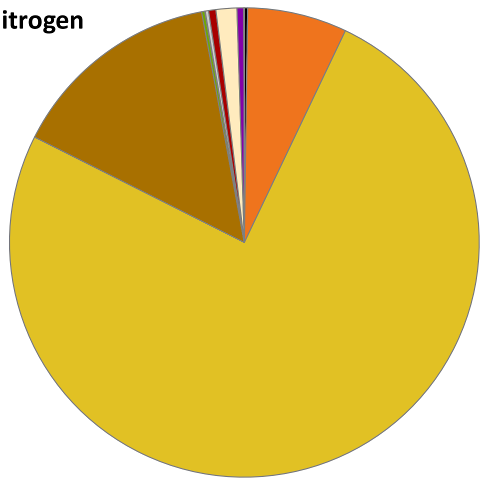
Area



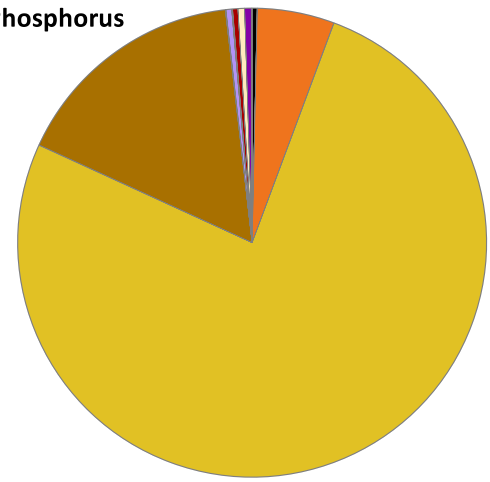
Flow



Nitrogen



Phosphorus



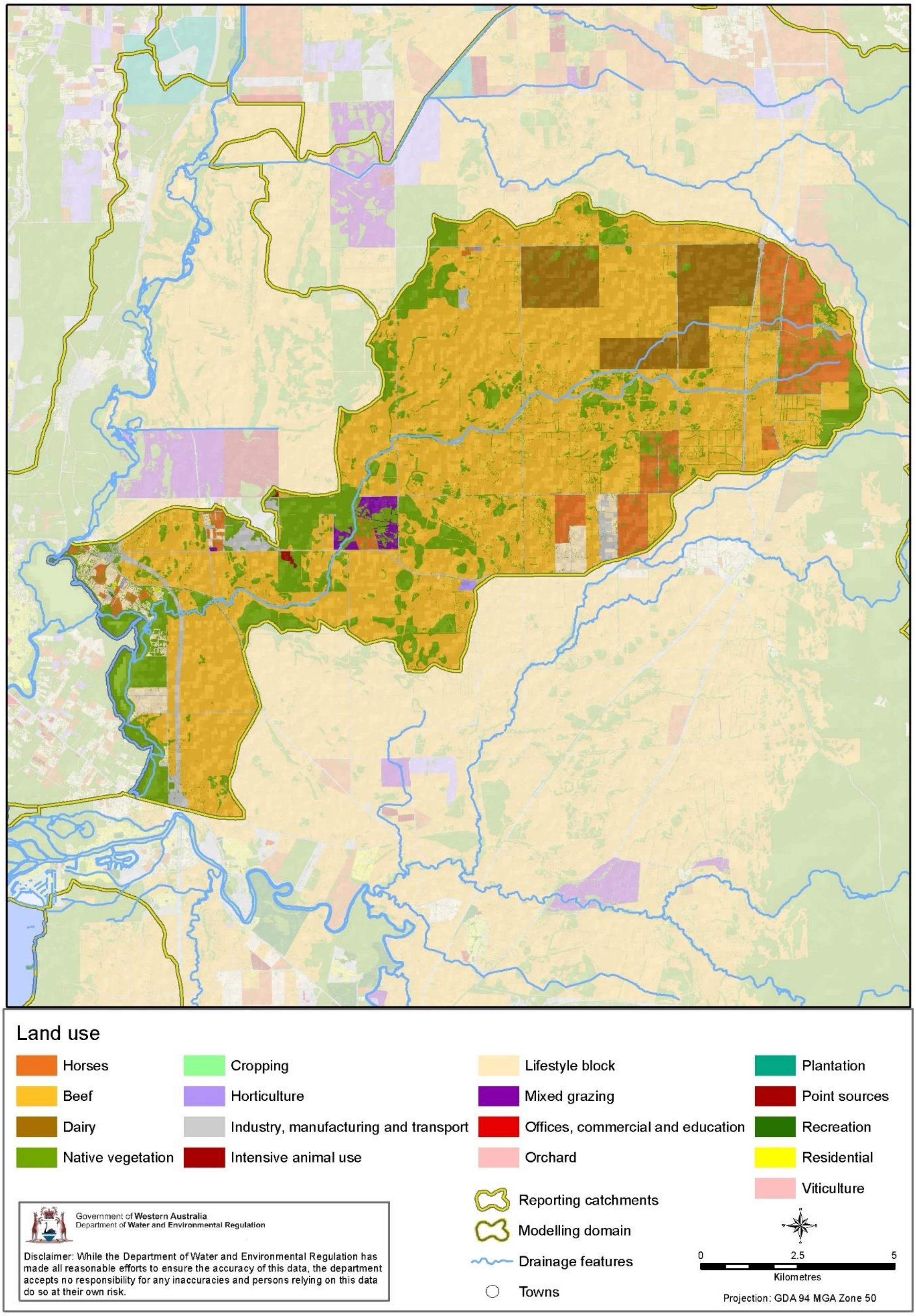
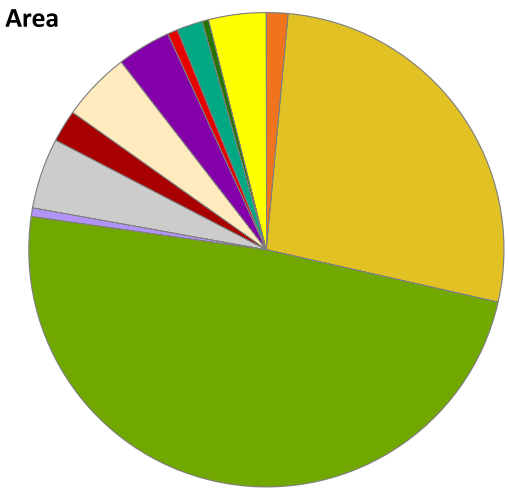
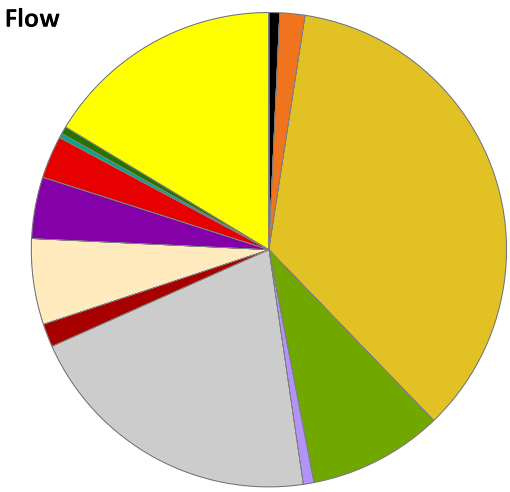


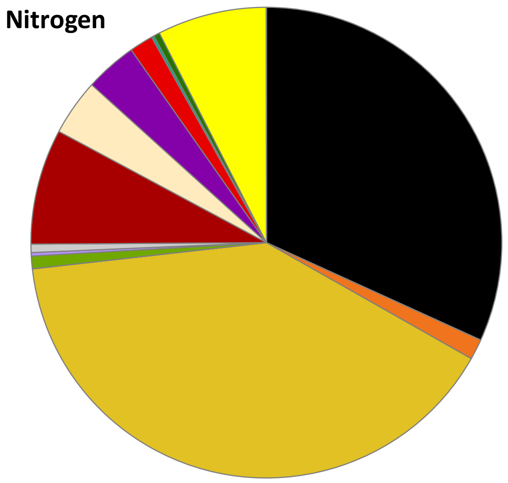
Figure D.5: Land-use of the Nambeelup reporting catchment

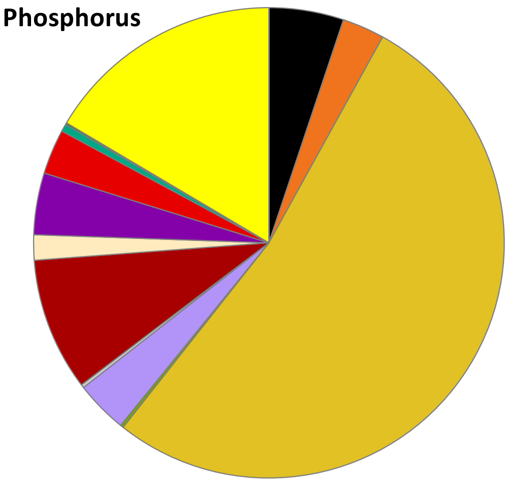
D.6 Lower Serpentine

Land use	Colour	Area		Flow		Nitrogen		Phosphorus	
		(km^2)	(%)	(GL)	(%)	(tonnes)	(%)	(tonnes)	(%)
Septic (#)		1206.0	-	0.0	0.7	3.7	31.8	0.11	5.1
Point sources		0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.0
Horses		1.5	1.5	0.1	1.7	0.2	1.4	0.06	2.9
Beef		27.1	27.1	1.9	35.4	4.7	40.0	1.13	52.6
Dairy		0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.0
Native vegetation		48.7	48.7	0.5	9.2	0.1	0.9	0.00	0.2
Cropping		0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.0
Horticulture		0.6	0.6	0.0	0.7	0.0	0.2	0.08	3.6
Industry, manufacturing & transport		4.8	4.8	1.1	20.6	0.1	0.6	0.00	0.2
Intensive animal use		2.2	2.2	0.1	1.6	0.9	7.9	0.20	9.1
Lifestyle block		4.7	4.7	0.3	5.8	0.5	3.9	0.04	1.7
Mixed grazing		3.7	3.7	0.2	4.2	0.4	3.6	0.09	4.2
Offices, commercial & education		0.7	0.7	0.2	2.9	0.2	1.6	0.07	3.1
Plantation		1.8	1.8	0.0	0.3	0.0	0.2	0.01	0.5
Recreation		0.4	0.4	0.0	0.5	0.0	0.4	0.00	0.1
Residential		3.9	3.9	0.9	16.3	0.9	7.5	0.35	16.5
Viticulture		0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.0
Total		**100.0**		**5.3**		**11.7**		**2.14**	









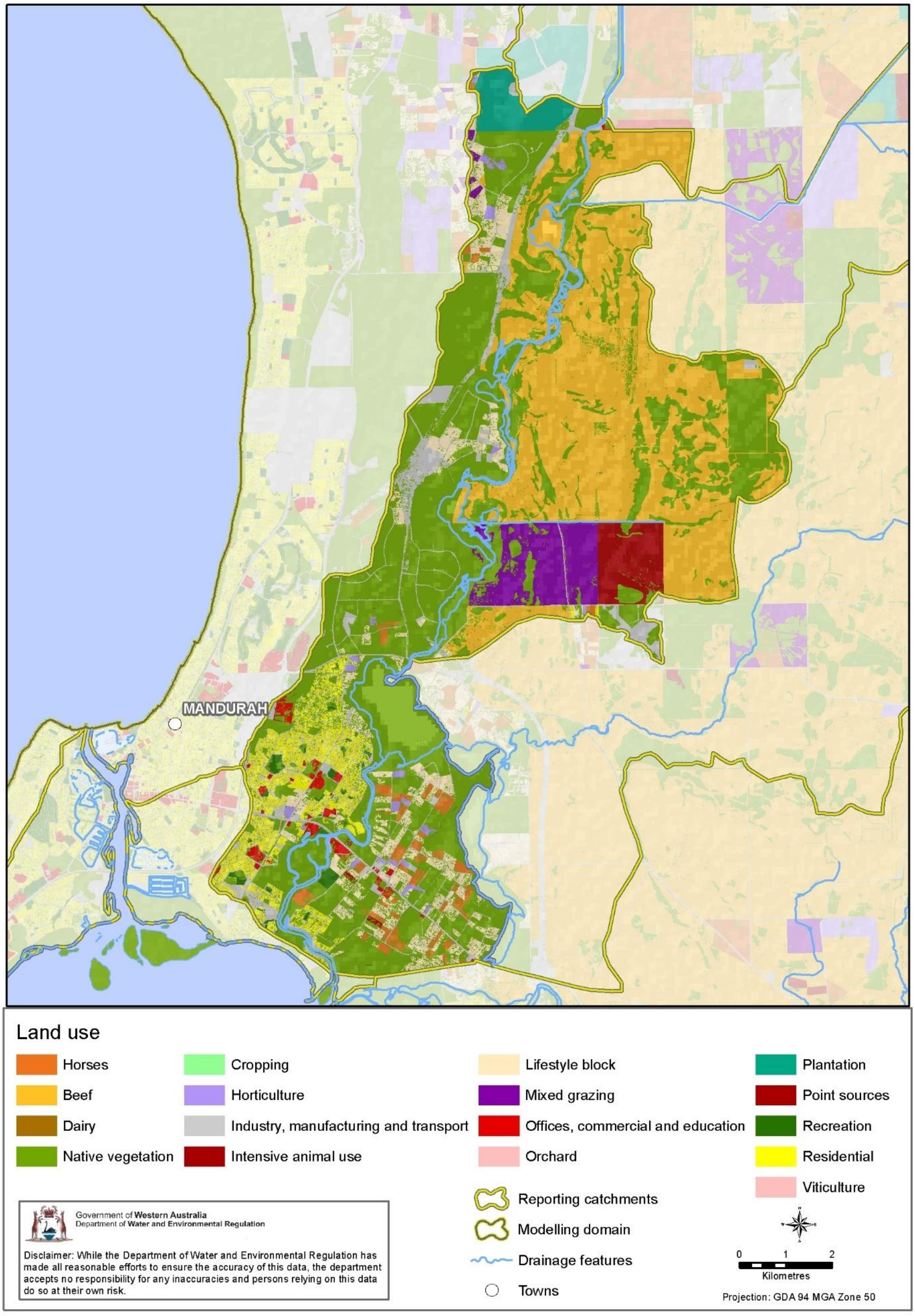
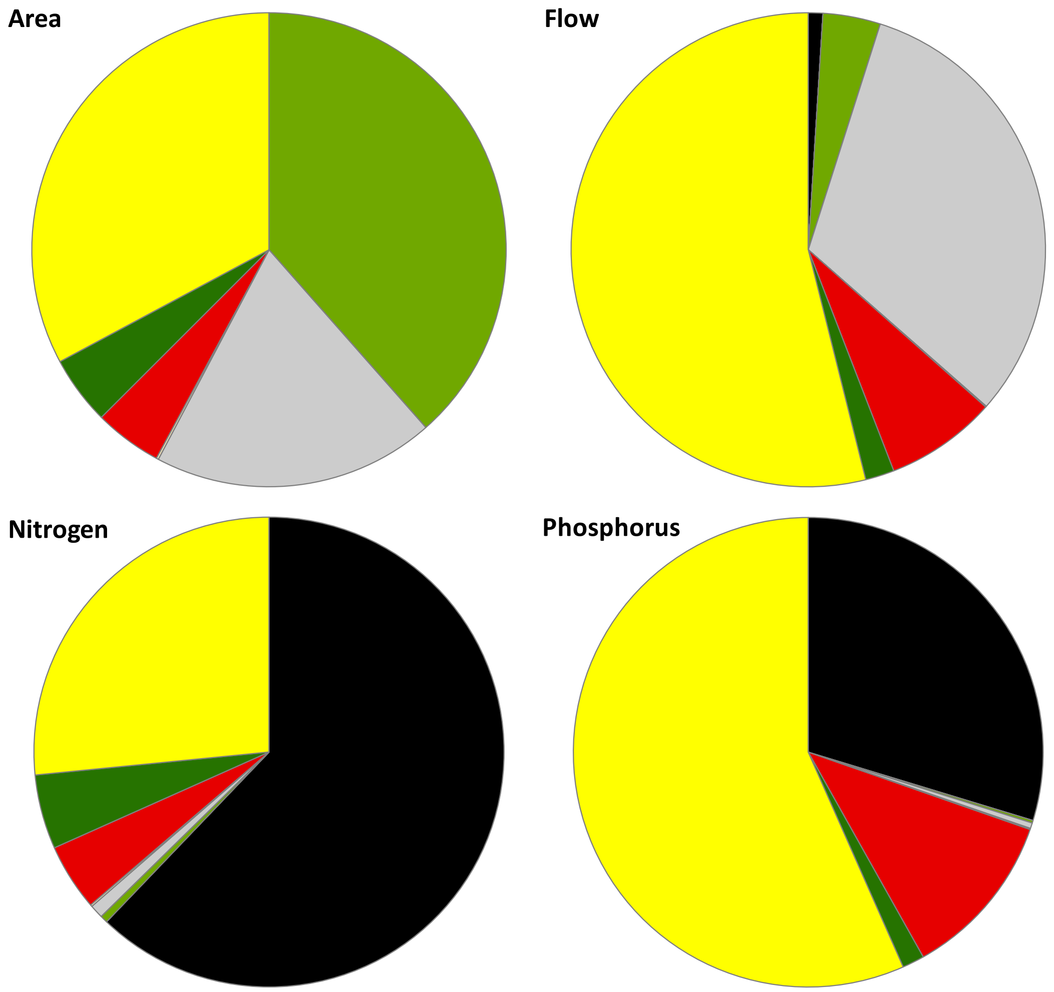


Figure D.6: Land-use of the Lower Serpentine reporting catchment

D.7 Mandurah

Land use	Colour	Area		Flow		Nitrogen		Phosphorus	
		(km^2)	(%)	(GL)	(%)	(tonnes)	(%)	(tonnes)	(%)
Septic (#)		746.0	-	0.0	1.0	3.1	62.1	0.15	29.7
Point sources		0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.0
Horses		0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.0
Beef		0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.0
Dairy		0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.0
Native vegetation		9.3	38.5	0.1	3.9	0.0	0.5	0.00	0.2
Cropping		0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.0
Horticulture		0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.0
Industry, manufacturing & transport		4.7	19.2	1.0	31.6	0.0	0.9	0.00	0.4
Intensive animal use		0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.0
Lifestyle block		0.0	0.1	0.0	0.1	0.0	0.1	0.00	0.1
Mixed grazing		0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.0
Offices, commercial & education		1.1	4.6	0.2	7.6	0.2	4.6	0.06	11.5
Plantation		0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.0
Recreation		1.1	4.7	0.1	2.0	0.3	5.1	0.01	1.5
Residential		7.9	32.8	1.7	53.9	1.3	26.6	0.29	56.6
Viticulture		0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.0
Total		**24.2**		**3.2**		**5.0**		**0.51**	



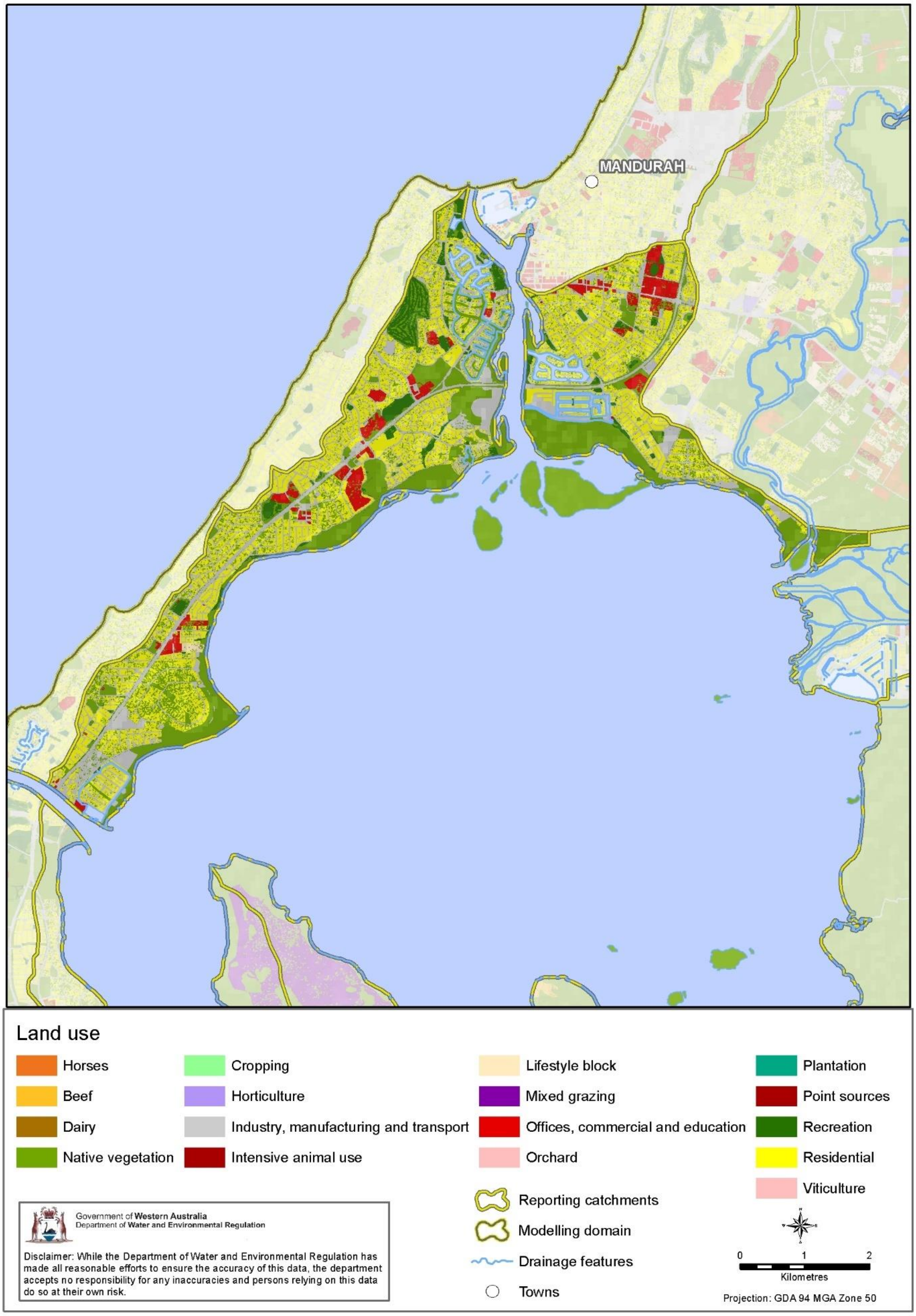
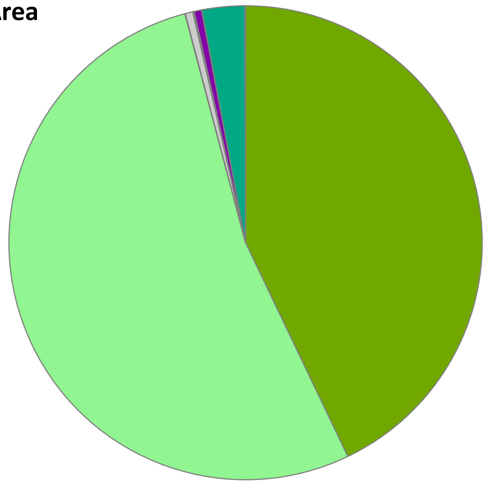


Figure D.7: Land-use of the Mandurah reporting catchment

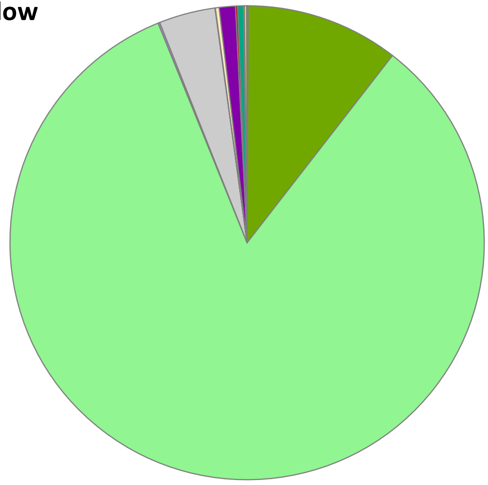
D.8 Upper Murray

Land use	Colour	Area		Flow		Nitrogen		Phosphorus	
		(km^2)	(%)	(GL)	(%)	(tonnes)	(%)	(tonnes)	(%)
Septic (#)		781.0	-						
Point sources		0.1	0.0	0.0	0.0	0.1	0.2	0.04	4.3
Horses		0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.0
Beef		0.4	0.0	0.1	0.1	0.1	0.2	0.00	0.2
Dairy		0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.0
Native vegetation		2895.6	42.9	13.0	10.4	0.7	0.9	0.00	0.2
Cropping		3577.1	53.0	104.0	83.4	76.0	94.7	0.83	86.6
Horticulture		2.0	0.0	0.1	0.1	0.1	0.1	0.02	2.1
Industry, manufacturing & transport		35.2	0.5	4.8	3.8	0.1	0.2	0.00	0.0
Intensive animal use		2.2	0.0	0.0	0.0	0.2	0.3	0.00	0.3
Lifestyle block		4.5	0.1	0.3	0.3	0.3	0.4	0.00	0.2
Mixed grazing		33.9	0.5	1.4	1.1	1.7	2.1	0.02	2.3
Offices, commercial & education		1.4	0.0	0.2	0.1	0.1	0.1	0.00	0.2
Plantation		196.8	2.9	0.5	0.4	0.4	0.5	0.03	3.2
Recreation		1.1	0.0	0.1	0.1	0.1	0.1	0.00	0.0
Residential		1.1	0.0	0.2	0.1	0.1	0.1	0.00	0.2
Viticulture		1.1	0.0	0.0	0.0	0.0	0.1	0.00	0.1
Total		**6752.3**		**124.8**		**80.2**		**0.96**	

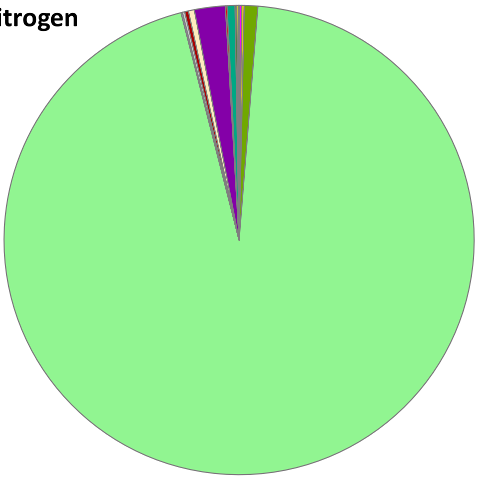
Area



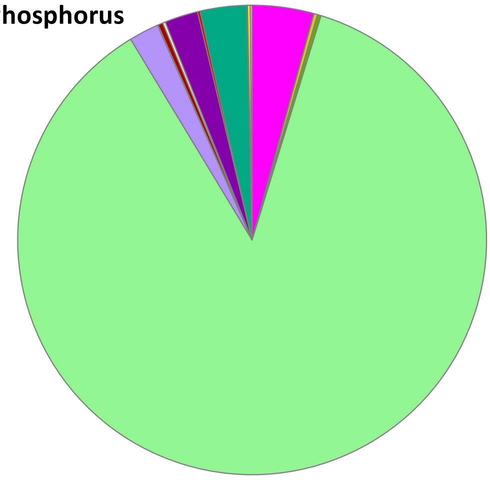
Flow



Nitrogen



Phosphorus



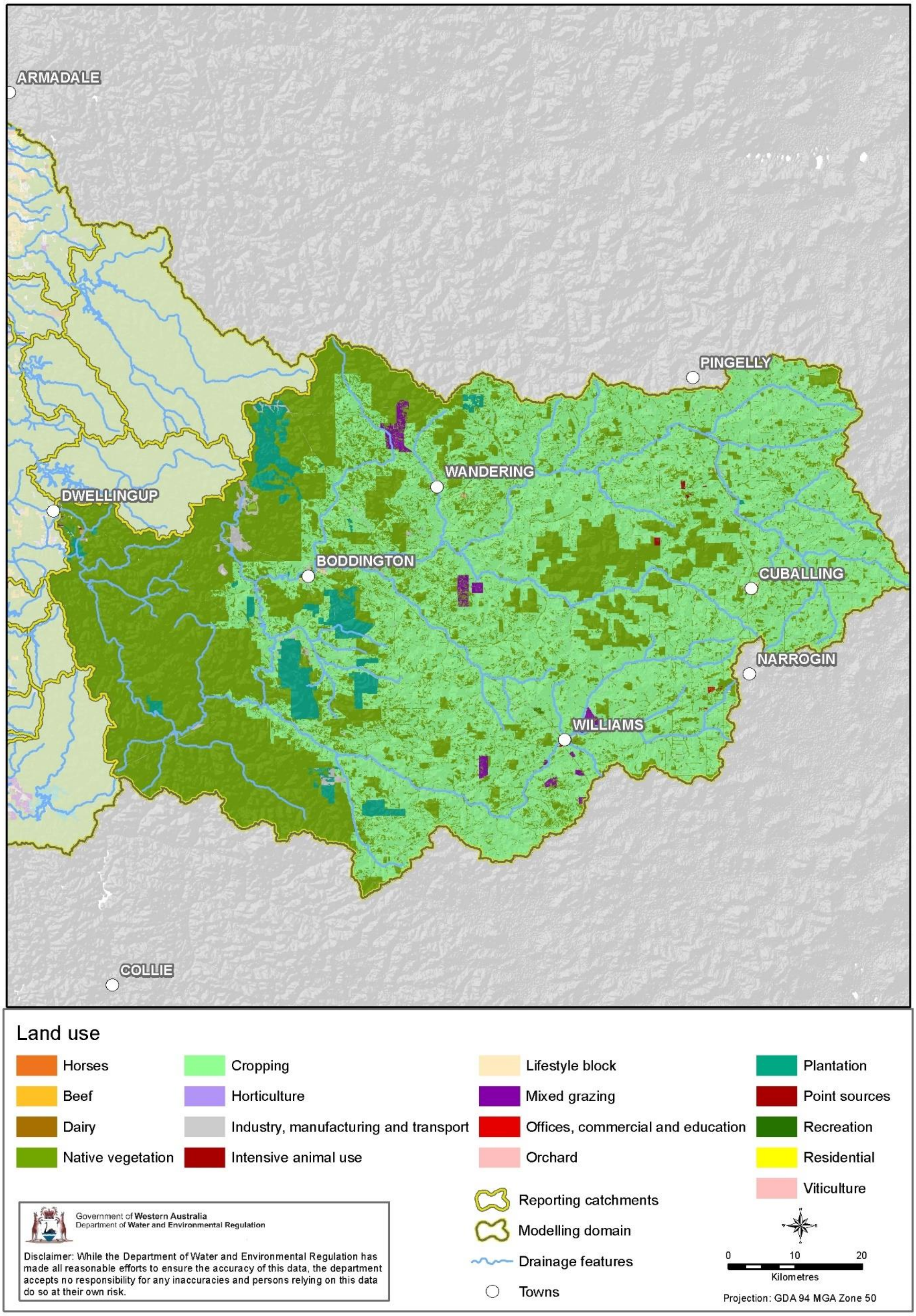
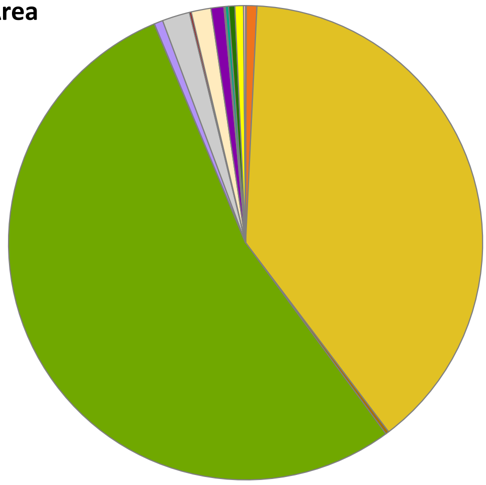


Figure D.8: Land-use of the Upper Murray reporting catchment

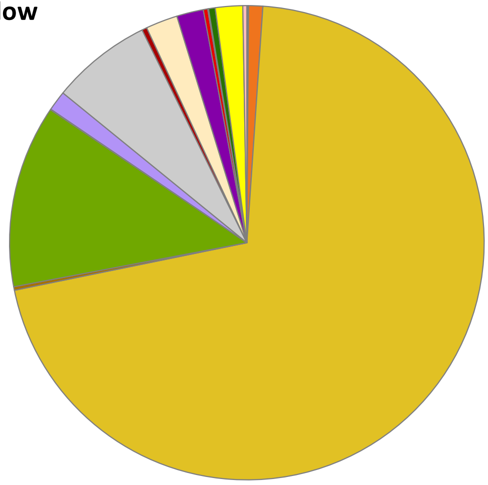
D.9 Lower Murray

Land use	Colour	Area		Flow		Nitrogen		Phosphorus	
		(km^2)	(%)	(GL)	(%)	(tonnes)	(%)	(tonnes)	(%)
Septic (#)		1172.0	-	0.0	0.1	3.4	3.3	0.06	0.9
Point sources		0.3	0.0	0.0	0.0	0.0	0.0	0.00	0.0
Horses		4.6	0.7	0.5	1.0	0.8	0.8	0.12	1.9
Beef		247.6	38.9	36.1	70.7	85.6	82.8	5.38	86.6
Dairy		1.4	0.2	0.1	0.2	0.5	0.4	0.04	0.6
Native vegetation		342.1	53.8	6.4	12.5	0.6	0.6	0.01	0.1
Cropping		0.1	0.0	0.0	0.0	0.0	0.0	0.00	0.0
Horticulture		3.8	0.6	0.7	1.4	0.3	0.3	0.22	3.5
Industry, manufacturing & transport		12.0	1.9	3.5	6.8	0.2	0.2	0.00	0.1
Intensive animal use		0.8	0.1	0.2	0.3	6.9	6.7	0.06	0.9
Lifestyle block		8.5	1.3	1.1	2.2	1.6	1.6	0.03	0.4
Mixed grazing		5.6	0.9	0.9	1.8	1.8	1.7	0.11	1.7
Offices, commercial & education		0.6	0.1	0.2	0.3	0.2	0.2	0.03	0.5
Plantation		1.5	0.2	0.0	0.1	0.0	0.0	0.00	0.1
Recreation		2.7	0.4	0.2	0.5	0.4	0.4	0.01	0.1
Residential		3.7	0.6	0.9	1.9	0.9	0.9	0.15	2.4
Viticulture		0.9	0.1	0.1	0.3	0.2	0.2	0.02	0.2
Total		**636.1**		**51.0**		**103.4**		**6.21**	

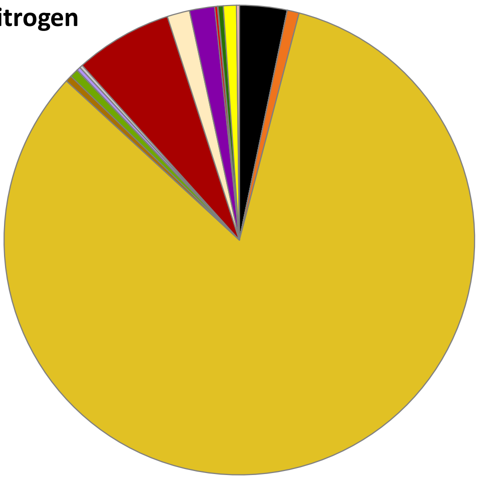
Area



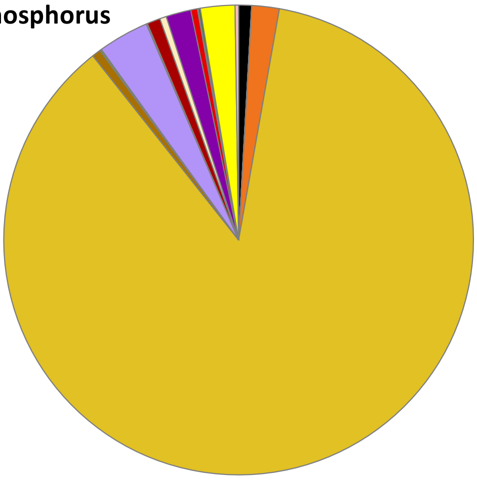
Flow



Nitrogen



Phosphorus



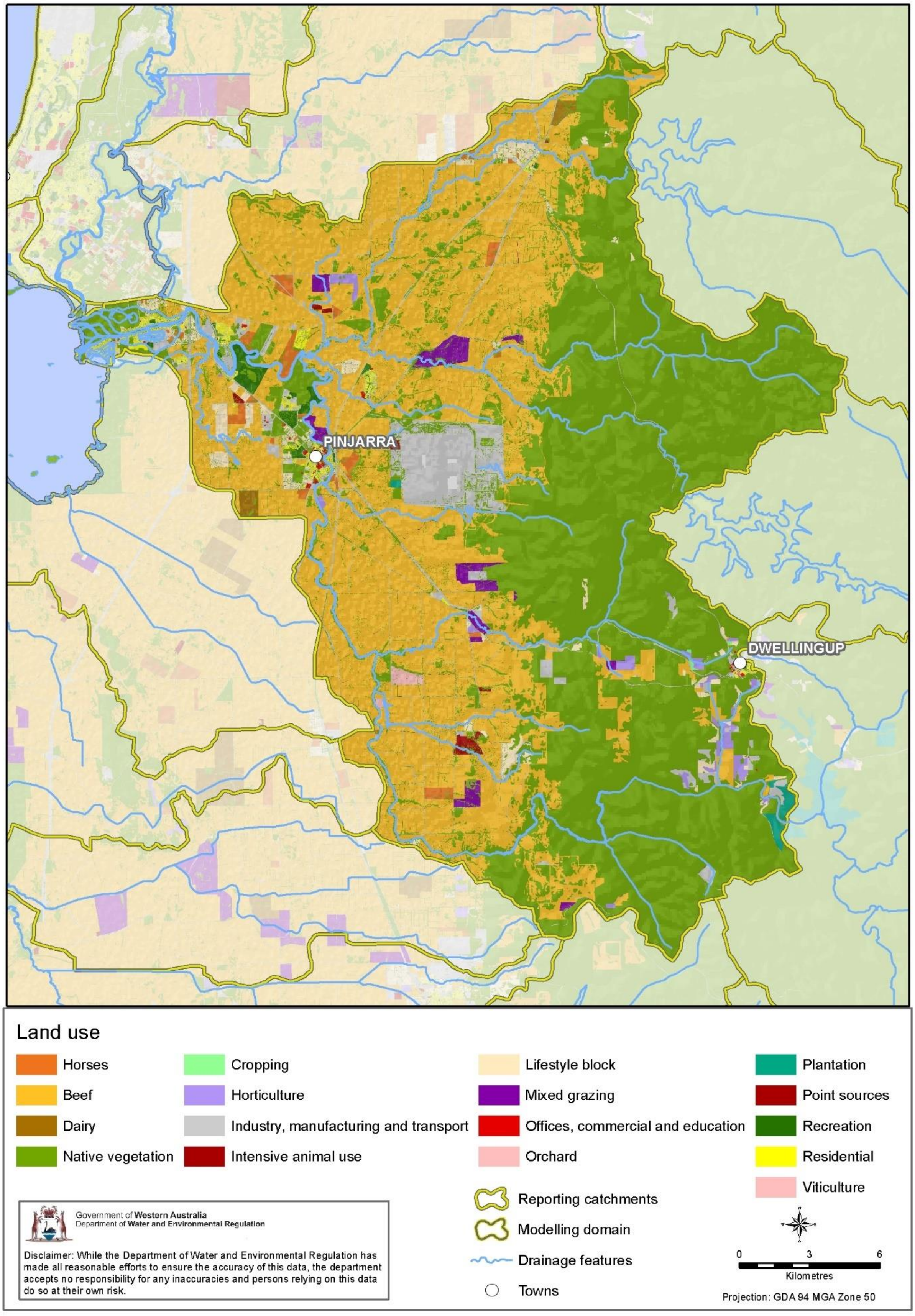
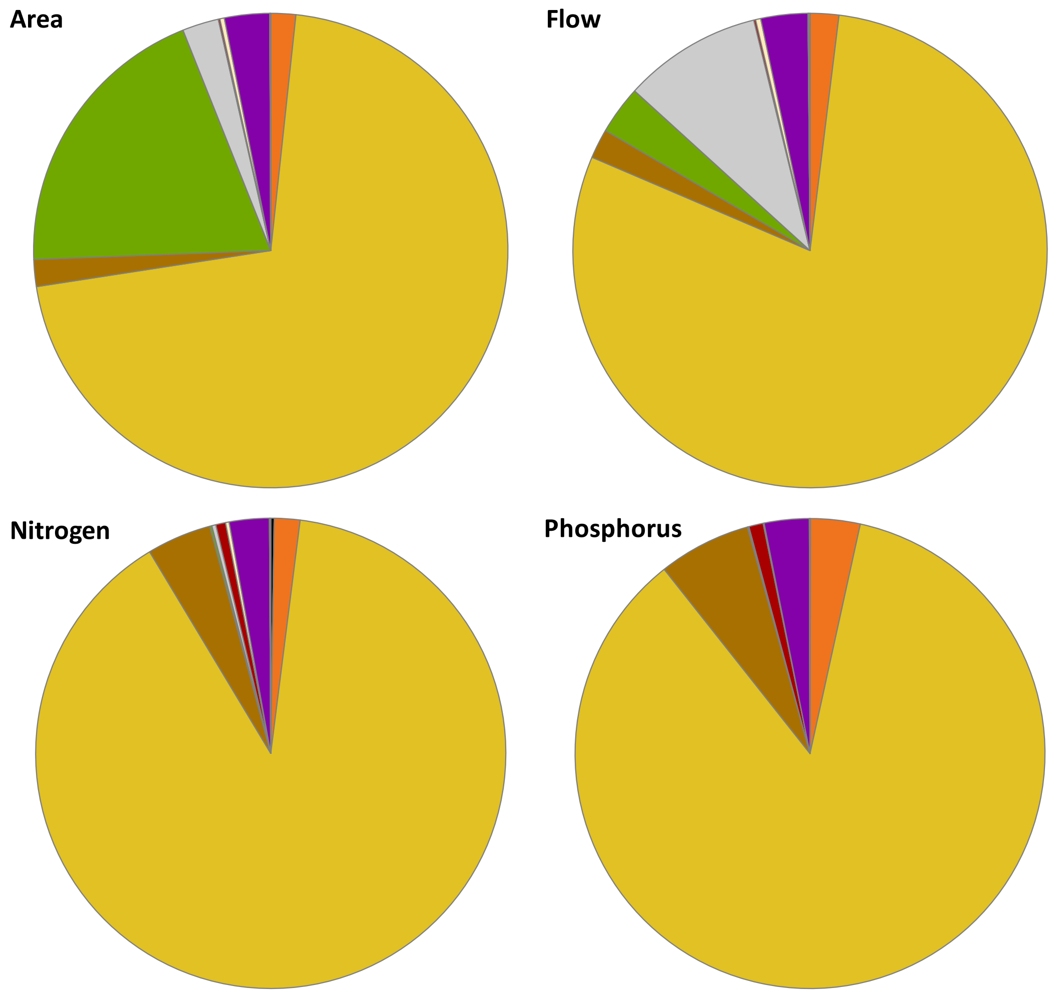


Figure D.9: Land-use of the Lower Murray reporting catchment

D.10 Coolup (Peel)

Land use	Colour	Area		Flow		Nitrogen		Phosphorus	
		(km^2)	(%)	(GL)	(%)	(tonnes)	(%)	(tonnes)	(%)
Septic (#)		99.0	-	0.0	0.0	0.0	0.2	0.00	0.0
Point sources		0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.0
Horses		2.5	1.7	0.2	2.0	0.4	1.8	0.09	3.4
Beef		106.4	70.9	7.6	79.5	18.8	89.4	2.36	85.9
Dairy		2.7	1.8	0.2	2.0	0.9	4.4	0.17	6.4
Native vegetation		29.4	19.6	0.3	3.3	0.0	0.1	0.00	0.0
Cropping		0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.0
Horticulture		0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.0
Industry, manufacturing & transport		3.7	2.5	0.9	9.4	0.1	0.3	0.00	0.1
Intensive animal use		0.2	0.1	0.0	0.1	0.1	0.7	0.03	1.0
Lifestyle block		0.5	0.3	0.0	0.3	0.1	0.2	0.00	0.1
Mixed grazing		4.6	3.1	0.3	3.2	0.6	2.8	0.08	3.1
Offices, commercial & education		0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.0
Plantation		0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.0
Recreation		0.1	0.0	0.0	0.0	0.0	0.0	0.00	0.0
Residential		0.0	0.0	0.0	0.1	0.0	0.0	0.00	0.0
Viticulture		0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.0
Total		**150.2**		**9.5**		**21.0**		**2.75**	



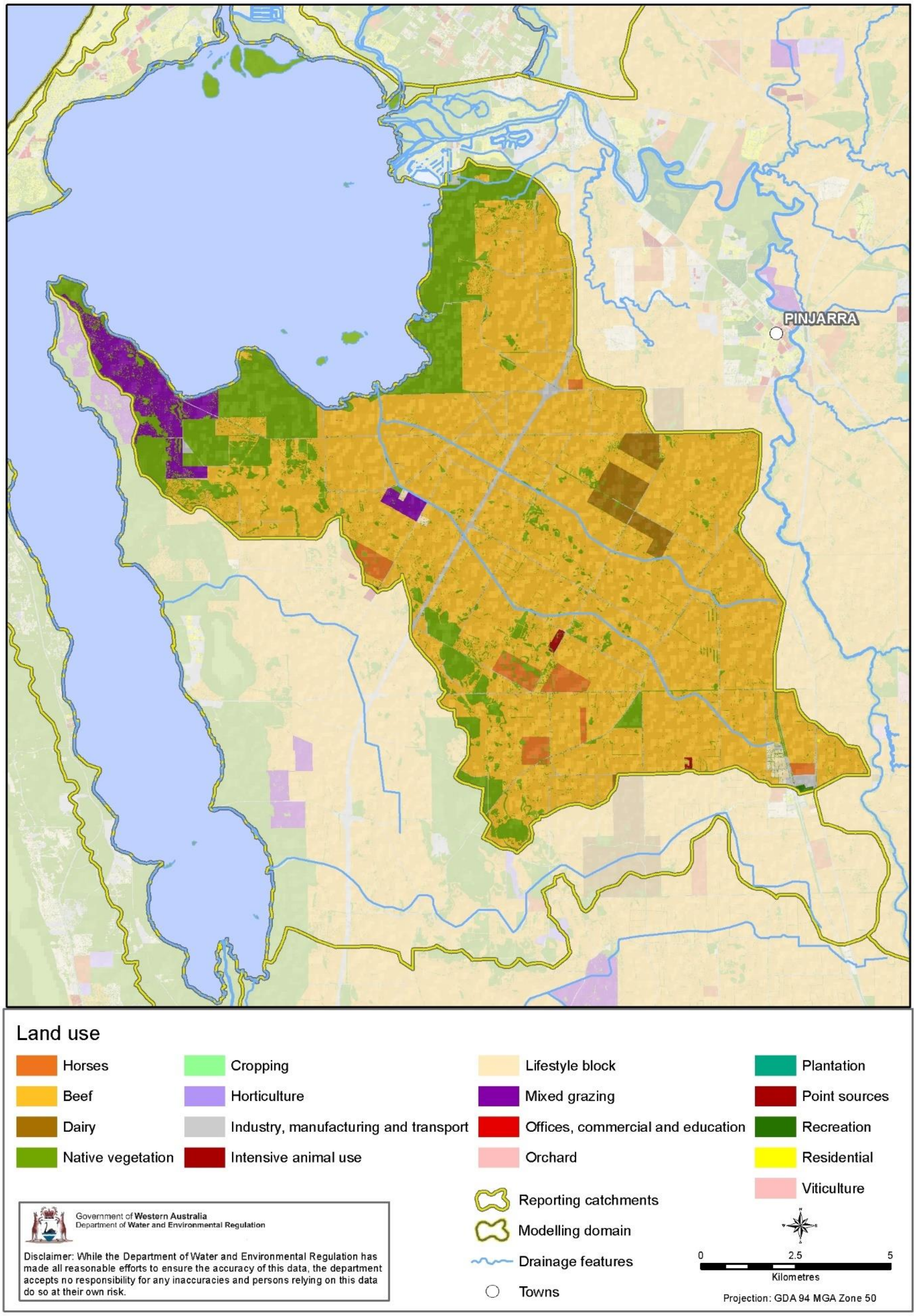
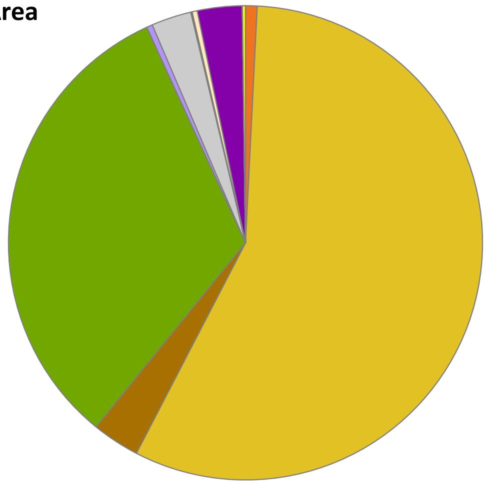


Figure D.10: Land-use of the Coolup (Peel) reporting catchment

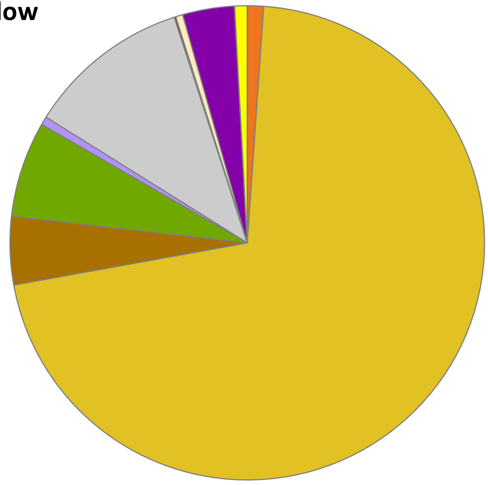
D.11 Coolup (Harvey)

Land use	Colour	Area		Flow		Nitrogen		Phosphorus	
		(km^2)	(%)	(GL)	(%)	(tonnes)	(%)	(tonnes)	(%)
Septic (#)		115.0	-	0.0	0.0	0.1	0.5	0.00	0.1
Point sources		0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.0
Horses		0.8	0.8	0.1	1.1	0.1	1.0	0.02	0.8
Beef		58.8	56.8	4.5	71.0	11.1	83.4	1.68	81.7
Dairy		3.4	3.2	0.3	4.6	1.3	9.4	0.17	8.1
Native vegetation		33.4	32.3	0.4	6.5	0.0	0.3	0.00	0.1
Cropping		0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.0
Horticulture		0.4	0.4	0.0	0.6	0.1	0.6	0.09	4.3
Industry, manufacturing & transport		2.8	2.7	0.7	11.1	0.0	0.3	0.00	0.1
Intensive animal use		0.1	0.1	0.0	0.1	0.1	0.4	0.02	1.1
Lifestyle block		0.4	0.3	0.0	0.5	0.0	0.4	0.00	0.1
Mixed grazing		3.2	3.1	0.2	3.5	0.4	3.2	0.06	3.0
Offices, commercial & education		0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.0
Plantation		0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.0
Recreation		0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.0
Residential		0.2	0.2	0.1	0.9	0.1	0.4	0.02	0.7
Viticulture		0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.0
Total		**103.4**		**6.3**		**13.3**		**2.05**	

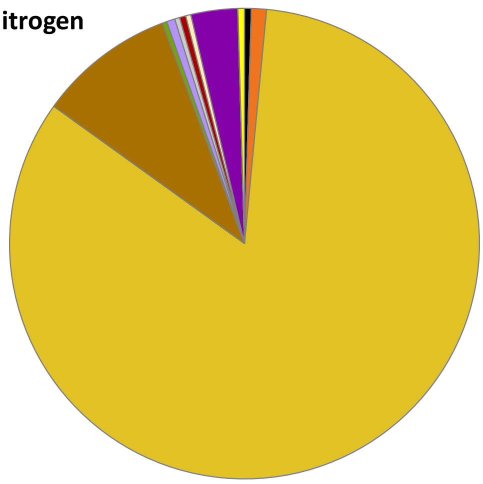
Area



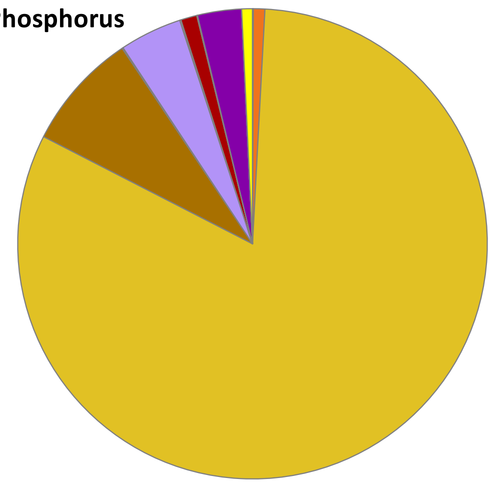
Flow



Nitrogen



Phosphorus



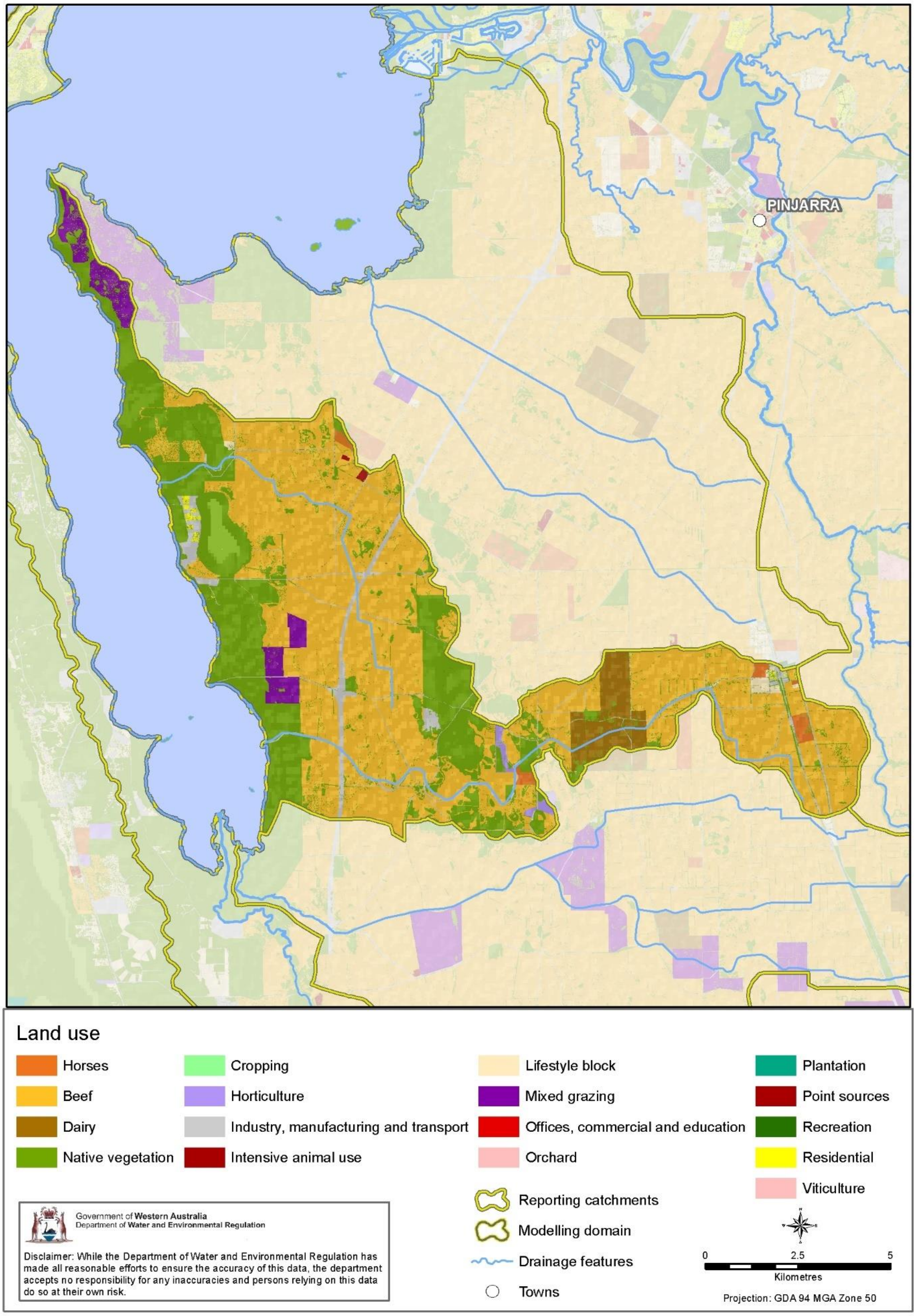
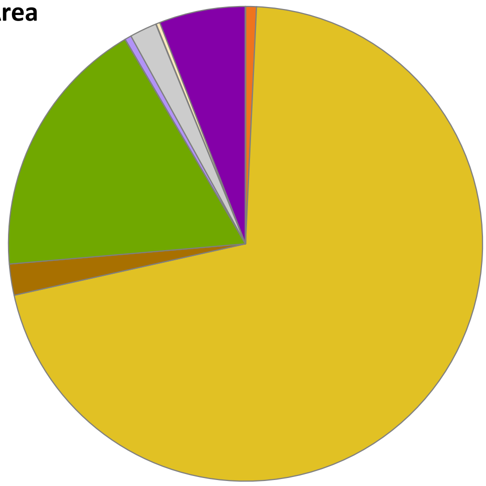


Figure D.11: Land-use of the Coolup (Harvey) reporting catchment

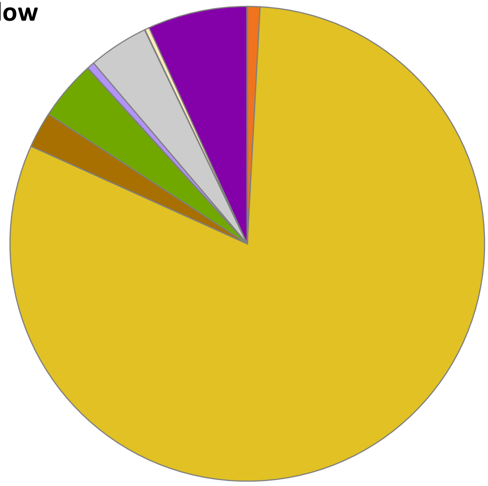
D.12 Mayfield Drain

Land use	Colour	Area		Flow		Nitrogen		Phosphorus	
		(km^2)	(%)	(GL)	(%)	(tonnes)	(%)	(tonnes)	(%)
Septic (#)		63.0	-	0.0	0.0	0.0	0.1	0.01	0.4
Point sources		0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.0
Horses		0.9	0.7	0.1	0.9	0.2	0.7	0.06	1.6
Beef		86.4	70.8	12.1	80.9	29.3	88.0	3.09	85.3
Dairy		2.6	2.1	0.4	2.4	1.5	4.4	0.21	5.8
Native vegetation		21.8	17.9	0.6	4.1	0.1	0.2	0.00	0.0
Cropping		0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.0
Horticulture		0.5	0.4	0.1	0.5	0.0	0.1	0.09	2.4
Industry, manufacturing & transport		2.3	1.9	0.6	4.1	0.1	0.2	0.00	0.1
Intensive animal use		0.0	0.0	0.0	0.0	0.1	0.2	0.00	0.0
Lifestyle block		0.3	0.3	0.0	0.3	0.1	0.2	0.00	0.0
Mixed grazing		7.2	5.9	1.0	6.8	1.9	5.8	0.16	4.4
Offices, commercial & education		0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.0
Plantation		0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.0
Recreation		0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.0
Residential		0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.0
Viticulture		0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.0
Total		**122.1**		**15.0**		**33.3**		**3.62**	

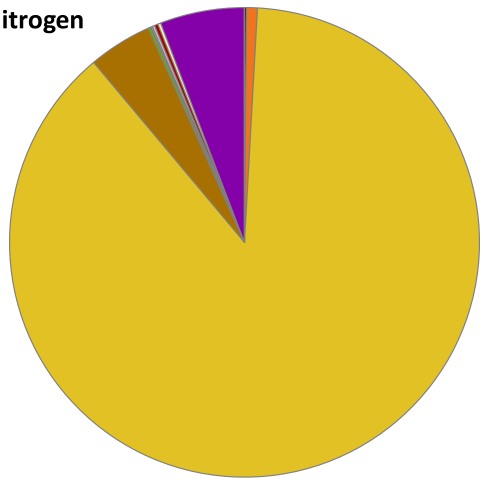
Area



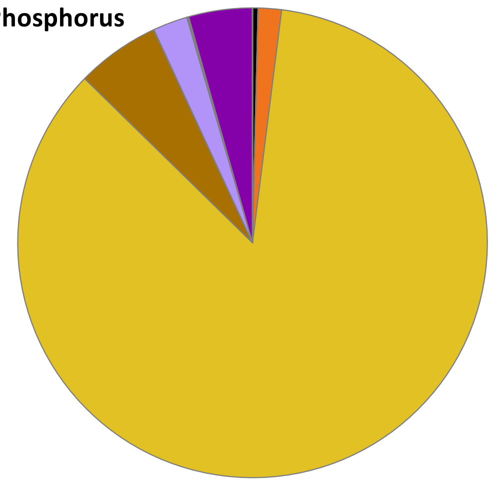
Flow



Nitrogen



Phosphorus



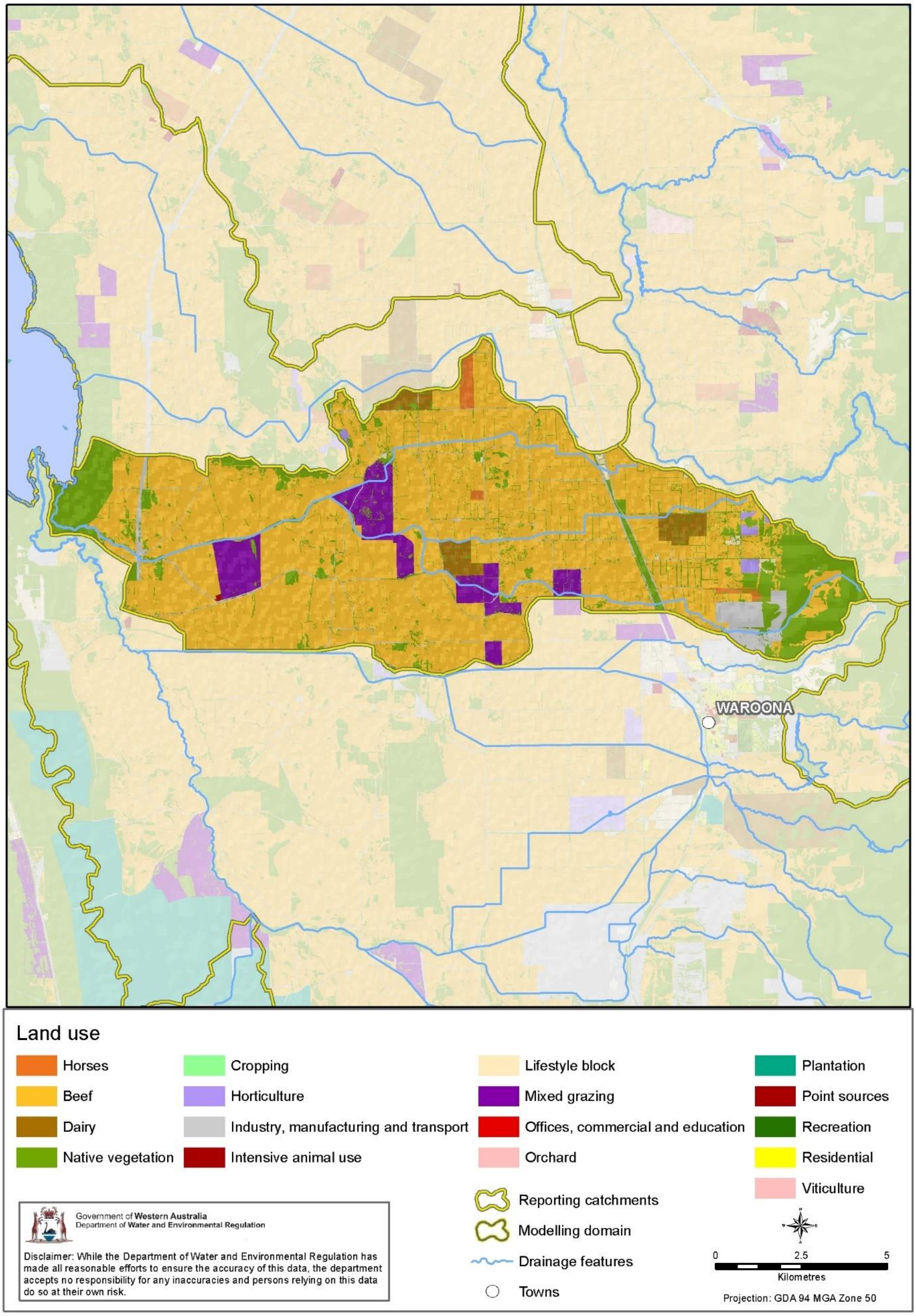
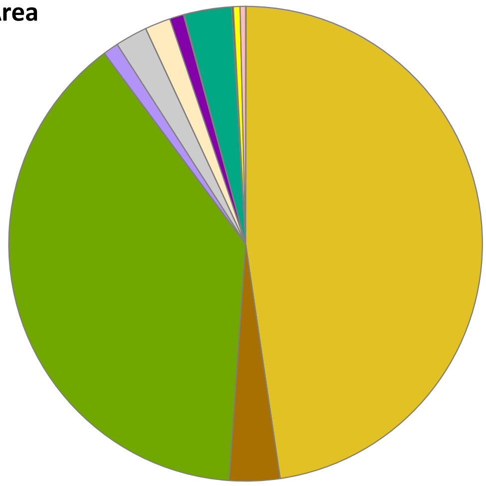


Figure D.12: Land-use of the Mayfield Drain reporting catchment

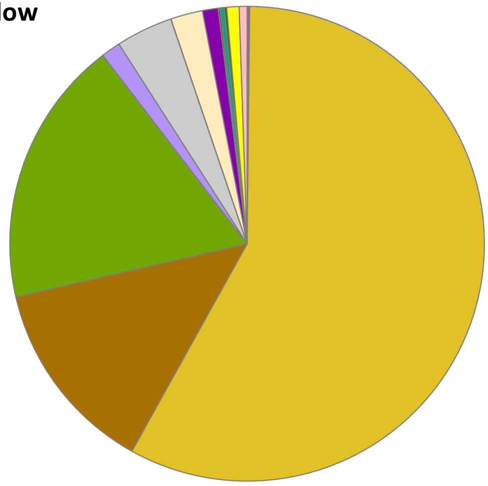
D.13 Harvey

Land use	Colour	Area		Flow		Nitrogen		Phosphorus	
		(km^2)	(%)	(GL)	(%)	(tonnes)	(%)	(tonnes)	(%)
Septic (#)		2229.0	-	0.0	0.0	2.0	1.0	0.59	2.9
Point sources		0.1	0.0	0.1	0.1	2.8	1.3	0.14	0.7
Horses		0.1	0.0	0.0	0.0	0.1	0.0	0.01	0.1
Beef		263.4	47.6	50.5	57.9	159.3	77.6	15.12	75.2
Dairy		19.1	3.4	11.6	13.3	27.8	13.5	2.62	13.1
Native vegetation		214.1	38.7	15.9	18.2	3.0	1.5	0.05	0.3
Cropping		0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.0
Horticulture		5.8	1.0	1.1	1.3	1.2	0.6	0.78	3.9
Industry, manufacturing & transport		12.1	2.2	3.4	3.9	0.5	0.2	0.01	0.1
Intensive animal use		0.1	0.0	0.0	0.0	0.2	0.1	0.03	0.1
Lifestyle block		9.6	1.7	1.9	2.2	3.3	1.6	0.07	0.4
Mixed grazing		5.3	1.0	0.9	1.1	2.2	1.1	0.22	1.1
Offices, commercial & education		0.3	0.1	0.1	0.1	0.3	0.1	0.02	0.1
Plantation		17.8	3.2	0.3	0.3	0.2	0.1	0.23	1.2
Recreation		0.6	0.1	0.1	0.2	0.3	0.2	0.01	0.0
Residential		2.5	0.5	0.7	0.8	1.2	0.6	0.12	0.6
Viticulture		2.1	0.4	0.5	0.5	0.9	0.5	0.07	0.3
Total		**553.0**		**87.2**		**205.5**		**20.11**	

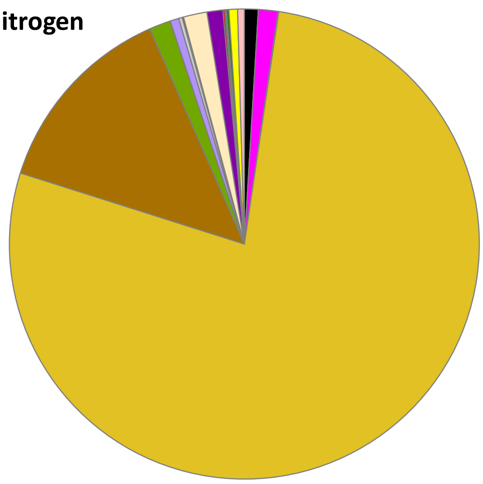
Area



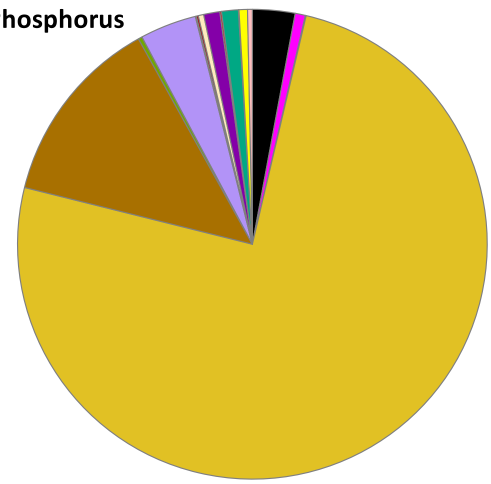
Flow



Nitrogen



Phosphorus



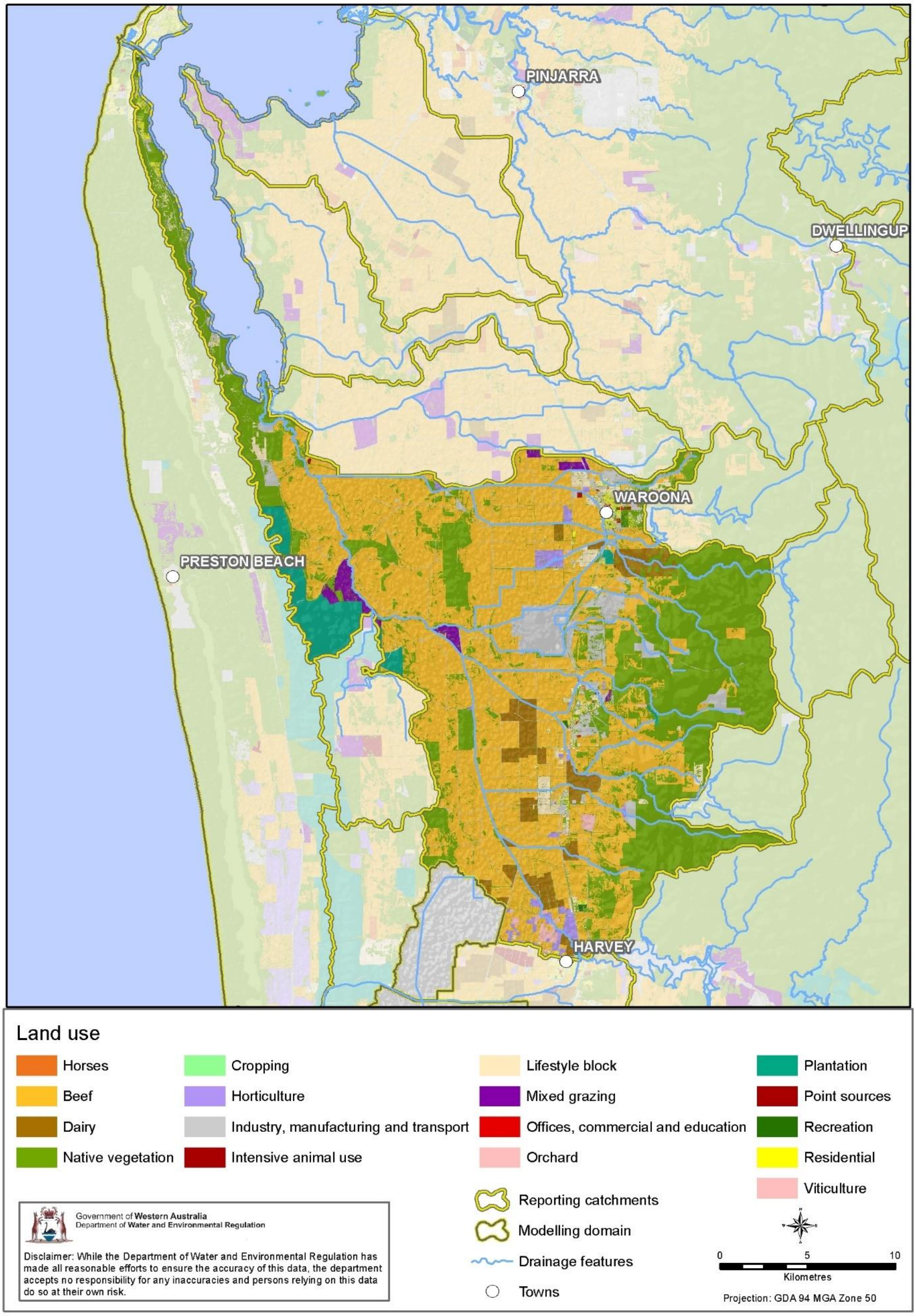
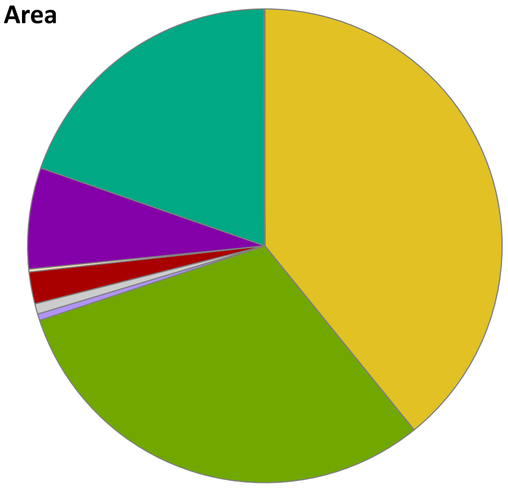
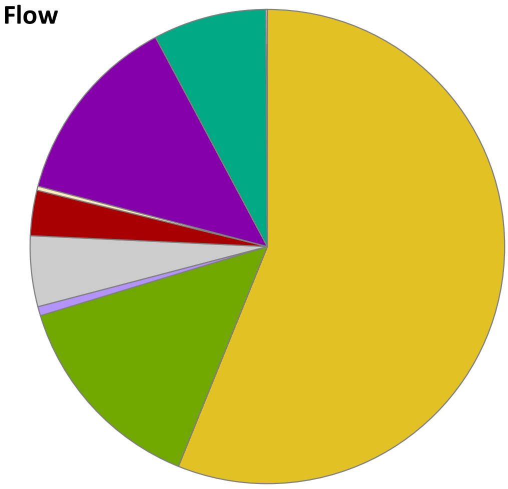


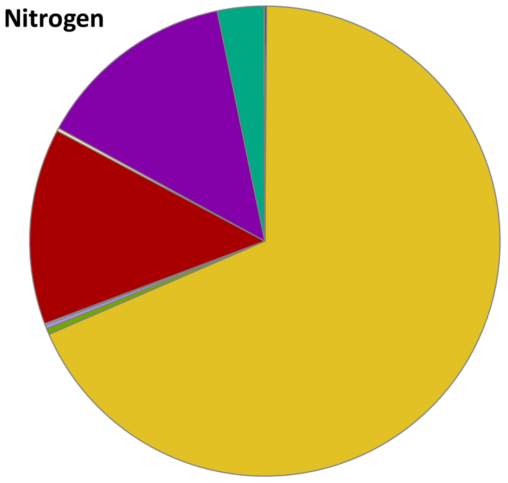
Figure D.13: Land-use of the Harvey reporting catchment

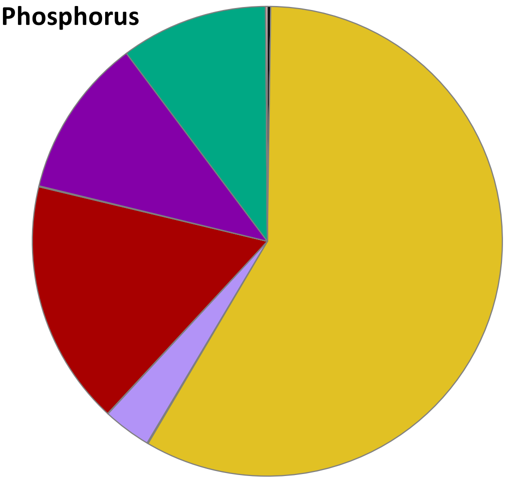
D.14 Meredith Drain

Land use	Colour	Area		Flow		Nitrogen		Phosphorus	
		(km^2)	(%)	(GL)	(%)	(tonnes)	(%)	(tonnes)	(%)
Septic (#)		12.0	-	0.0	0.0	0.0	0.1	0.00	0.2
Point sources		0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.0
Horses		0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.0
Beef		20.8	39.2	1.3	56.1	4.6	68.4	0.61	58.3
Dairy		0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.0
Native vegetation		16.3	30.7	0.3	14.2	0.0	0.4	0.00	0.1
Cropping		0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.0
Horticulture		0.2	0.4	0.0	0.6	0.0	0.2	0.03	3.3
Industry, manufacturing & transport		0.4	0.7	0.1	4.8	0.0	0.1	0.00	0.0
Intensive animal use		1.2	2.2	0.1	3.1	0.9	13.5	0.18	16.8
Lifestyle block		0.1	0.2	0.0	0.3	0.0	0.2	0.00	0.1
Mixed grazing		3.7	6.9	0.3	13.1	0.9	13.8	0.11	11.0
Offices, commercial & education		0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.0
Plantation		10.4	19.6	0.2	7.7	0.2	3.2	0.11	10.1
Recreation		0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.0
Residential		0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.0
Viticulture		0.0	0.1	0.0	0.1	0.0	0.1	0.00	0.1
Total		**53.1**		**2.3**		**6.7**		**1.04**	









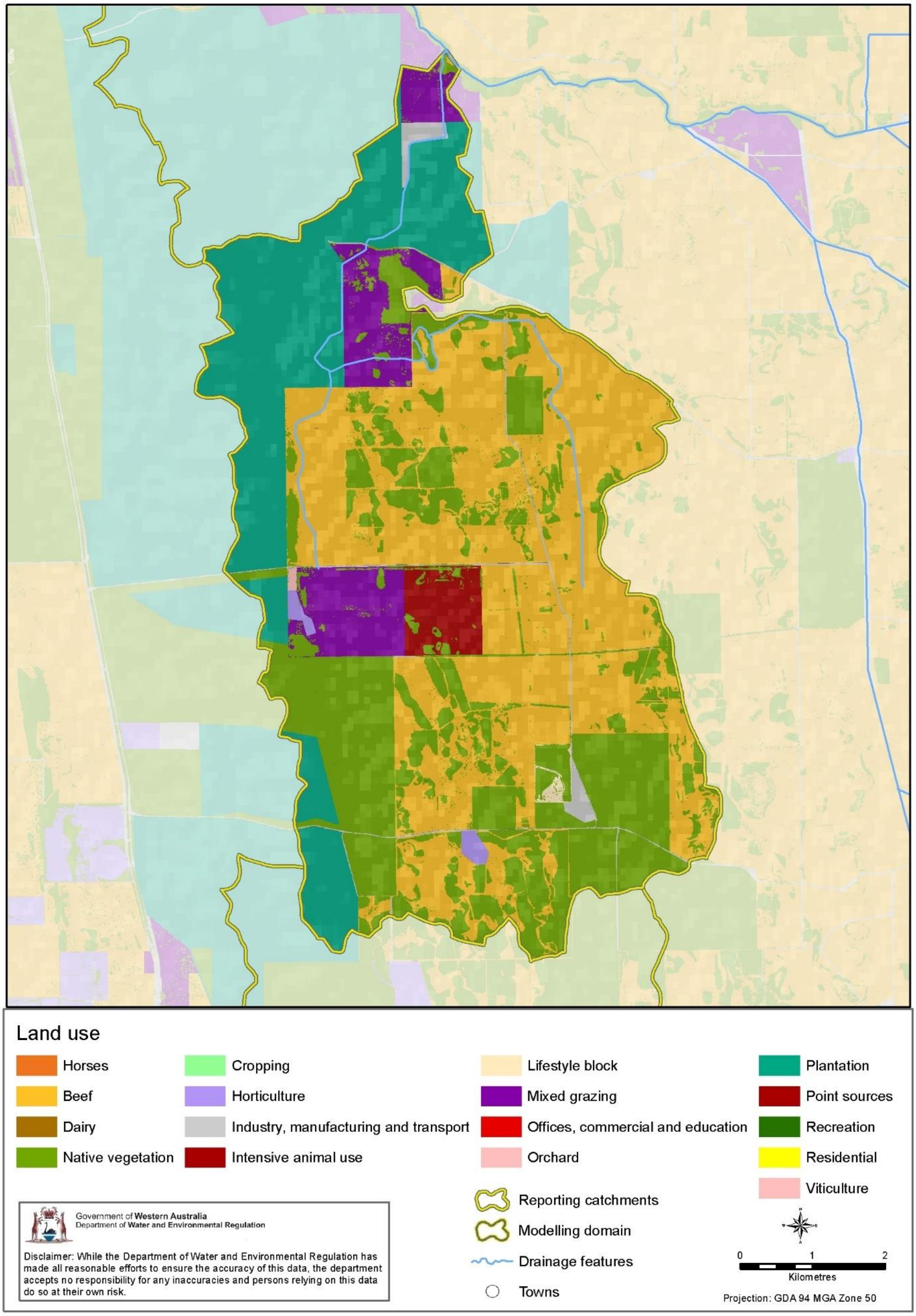
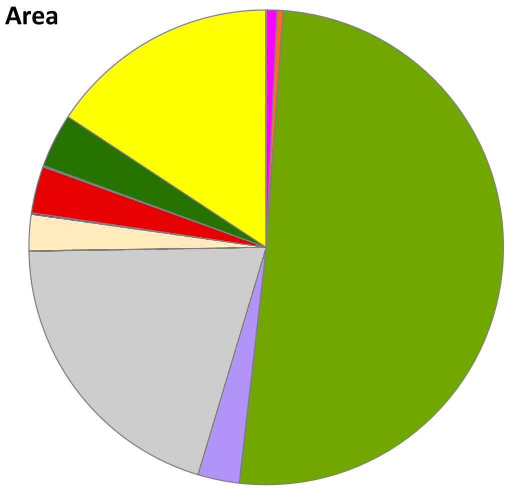
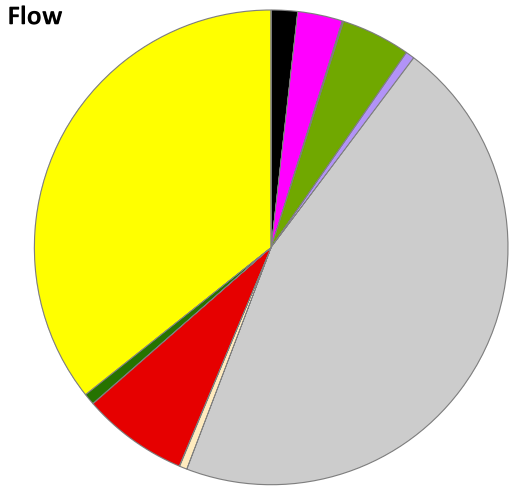


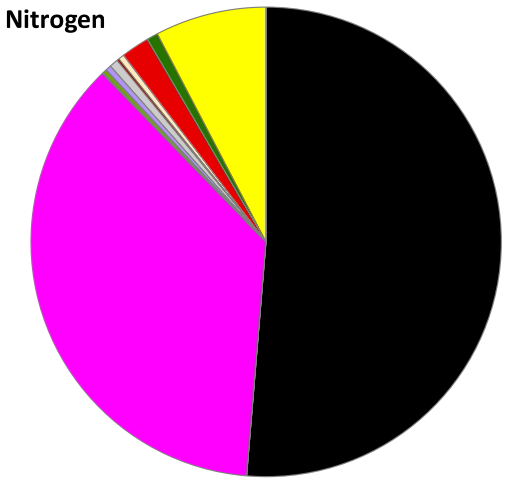
Figure D.14: Land-use of the Meredith Drain reporting catchment

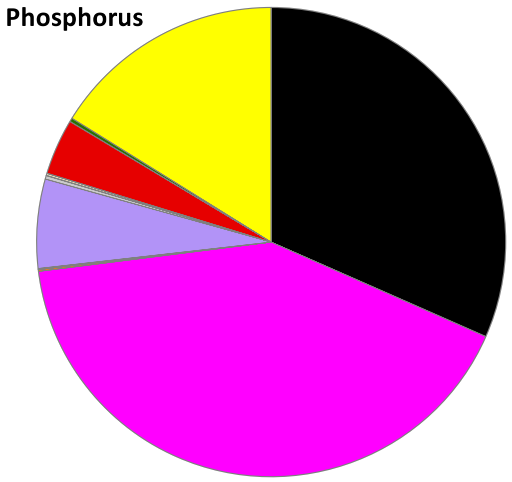
D.15 Coastal North

Land use	Colour	Area		Flow		Nitrogen		Phosphorus	
		(km^2)	(%)	(GL)	(%)	(tonnes)	(%)	(tonnes)	(%)
Septic (#)		4838.0	-	0.6	1.8	59.6	51.3	4.04	31.6
Point sources		2.7	0.7	1.1	3.1	42.3	36.4	5.30	41.4
Horses		1.6	0.4	0.0	0.1	0.1	0.1	0.02	0.1
Beef		0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.0
Dairy		0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.0
Native vegetation		185.6	50.6	1.6	4.7	0.3	0.3	0.01	0.1
Cropping		0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.0
Horticulture		10.4	2.8	0.2	0.6	0.4	0.4	0.78	6.1
Industry, manufacturing & transport		73.6	20.1	15.6	45.5	0.7	0.6	0.03	0.2
Intensive animal use		0.2	0.0	0.0	0.0	0.2	0.2	0.00	0.0
Lifestyle block		9.0	2.4	0.2	0.5	0.5	0.4	0.02	0.1
Mixed grazing		0.4	0.1	0.0	0.0	0.0	0.0	0.00	0.0
Offices, commercial & education		11.6	3.2	2.5	7.2	2.2	1.9	0.49	3.9
Plantation		0.4	0.1	0.0	0.0	0.0	0.0	0.00	0.0
Recreation		13.4	3.7	0.3	0.8	0.9	0.8	0.03	0.3
Residential		57.6	15.7	12.2	35.7	8.9	7.7	2.07	16.2
Viticulture		0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.0
Total		**366.4**		**34.3**		**116.1**		**12.79**	









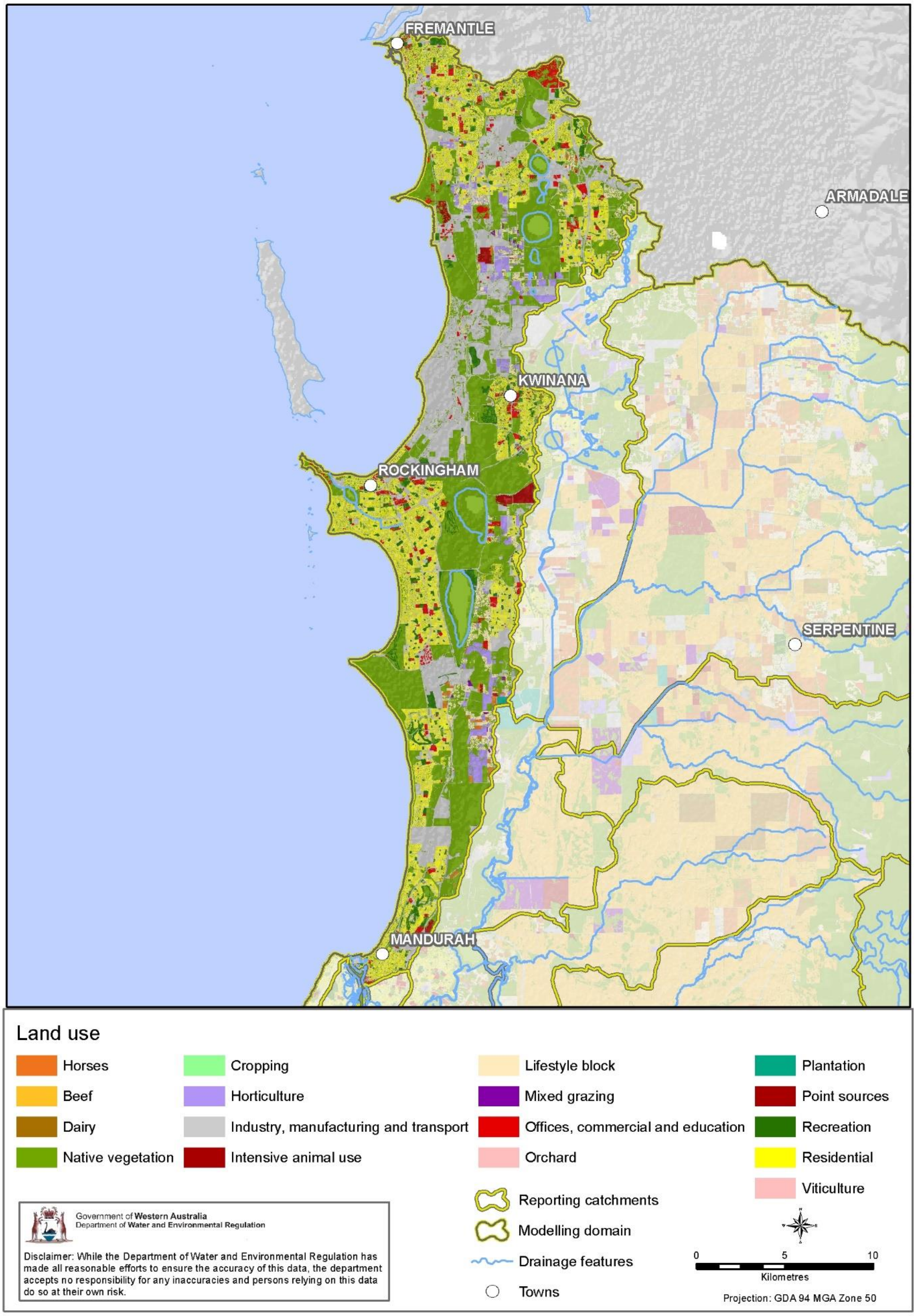
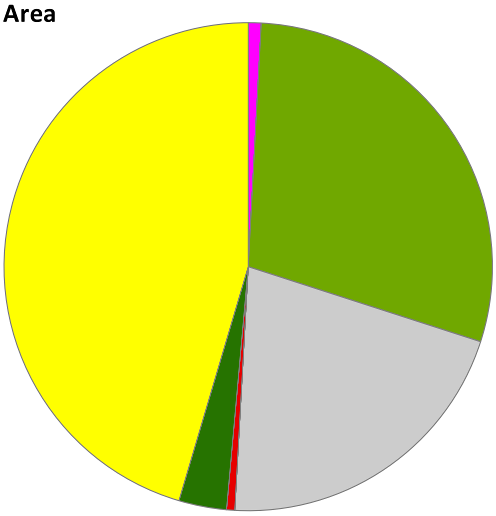


Figure D.15: Land-use of the Coastal North reporting catchment

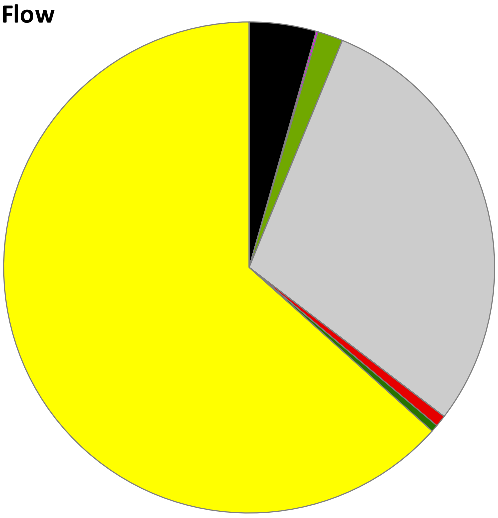
D.16 Coastal Central

Land use	Colour	Area		Flow		Nitrogen		Phosphorus	
		(km^2)	(%)	(GL)	(%)	(tonnes)	(%)	(tonnes)	(%)
Septic (#)		744.0	-	0.0	4.4	4.8	89.0	0.32	75.2
Point sources		0.1	0.9	0.0	0.1	0.0	0.0	0.00	0.0
Horses		0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.0
Beef		0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.0
Dairy		0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.0
Native vegetation		2.0	29.1	0.0	1.7	0.0	0.0	0.00	0.0
Cropping		0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.0
Horticulture		0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.0
Industry, manufacturing & transport		1.5	20.9	0.3	29.2	0.0	0.3	0.00	0.1
Intensive animal use		0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.0
Lifestyle block		0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.0
Mixed grazing		0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.0
Offices, commercial & education		0.0	0.5	0.0	0.8	0.0	0.1	0.00	0.5
Plantation		0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.0
Recreation		0.2	3.2	0.0	0.5	0.0	0.3	0.00	0.2
Residential		3.2	45.4	0.7	63.4	0.6	10.2	0.10	24.0
Viticulture		0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.0
Total		**7.0**		**1.1**		**5.4**		**0.43**	

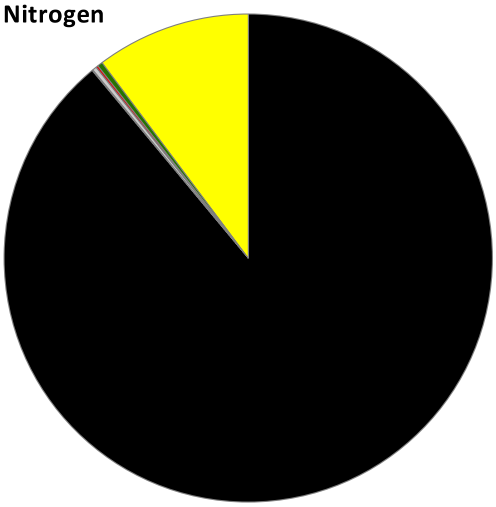
Area



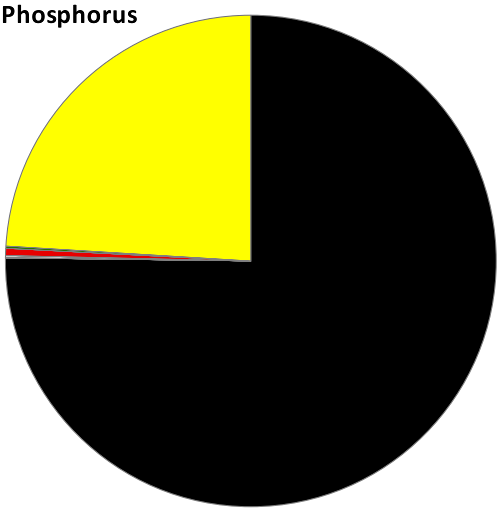
Flow



Nitrogen



Phosphorus



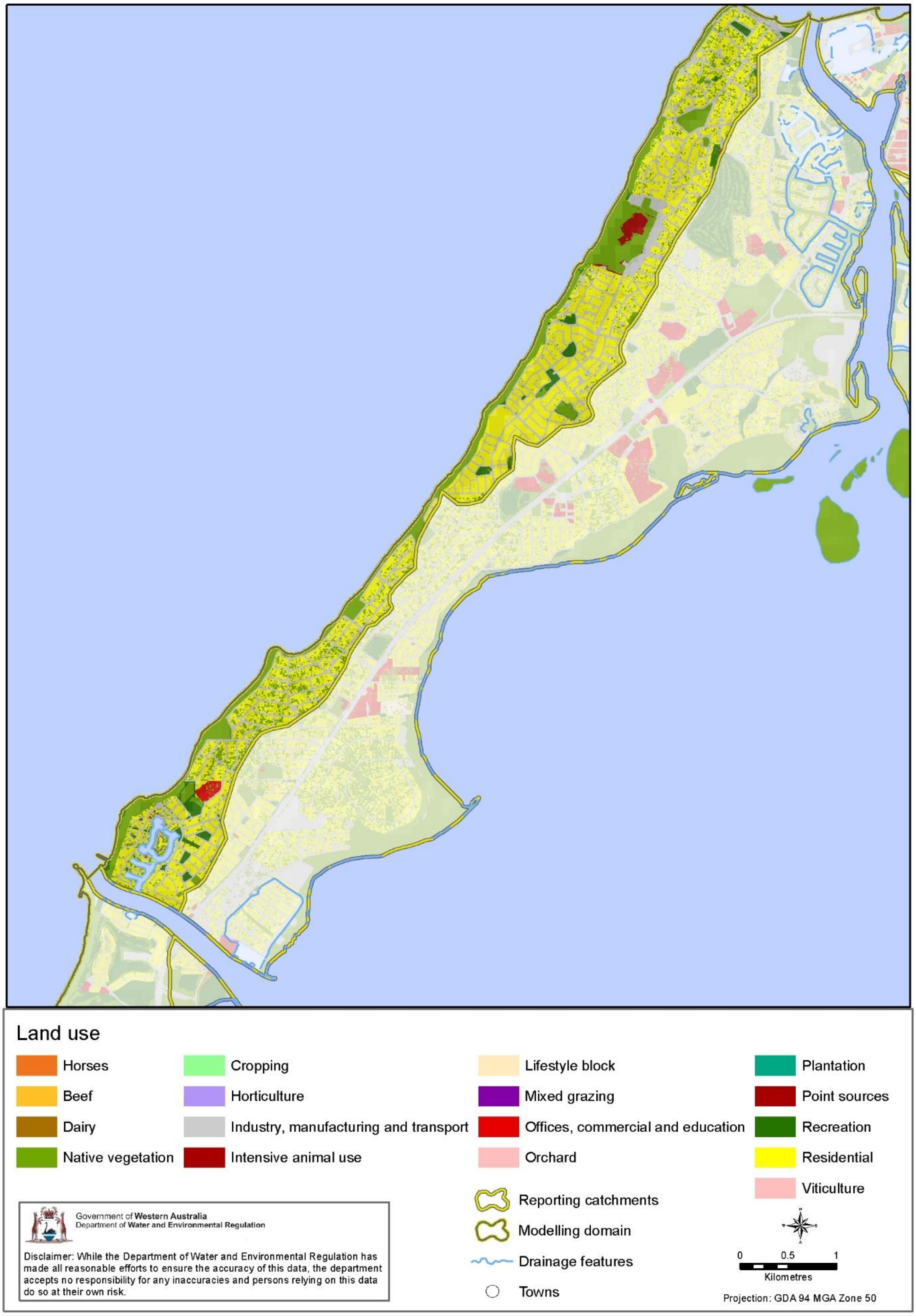
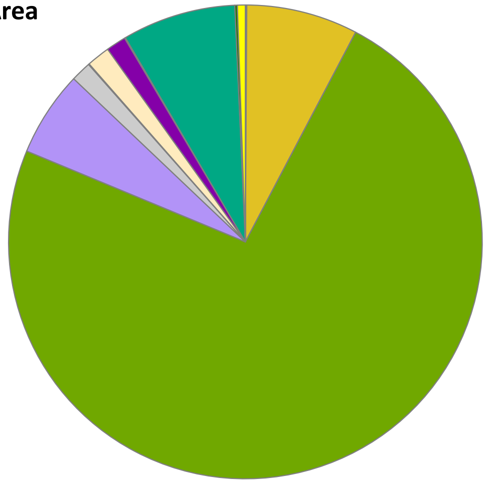


Figure D.16: Land-use of the coastal central reporting catchment

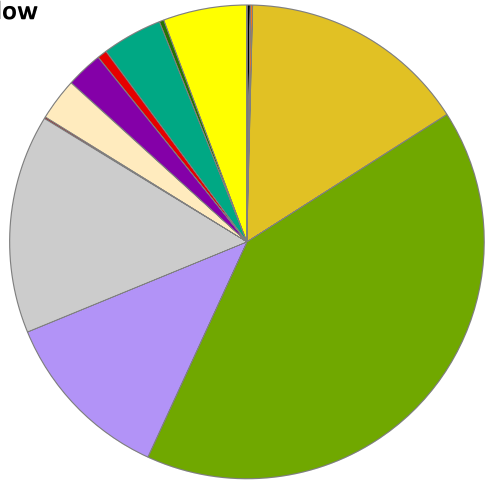
D.17 Coastal south

Land use	Colour	Area		Flow		Nitrogen		Phosphorus	
		(km^2)	(%)	(GL)	(%)	(tonnes)	(%)	(tonnes)	(%)
Septic (#)		1340.0	-	0.0	0.2	1.7	13.4	0.04	0.4
Point sources		0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.0
Horses		0.3	0.1	0.0	0.1	0.0	0.3	0.01	0.1
Beef		24.8	7.6	1.2	15.6	5.3	42.2	0.76	8.6
Dairy		0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.0
Native vegetation		239.7	73.6	3.2	40.9	0.4	3.5	0.01	0.1
Cropping		0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.0
Horticulture		19.0	5.8	0.9	11.9	2.4	18.6	7.51	84.5
Industry, manufacturing & transport		4.5	1.4	1.2	14.9	0.1	0.4	0.00	0.0
Intensive animal use		0.2	0.1	0.0	0.1	0.3	2.2	0.03	0.3
Lifestyle block		5.2	1.6	0.2	2.9	0.7	5.2	0.03	0.4
Mixed grazing		4.5	1.4	0.2	2.5	0.7	5.6	0.09	1.0
Offices, commercial & education		0.2	0.1	0.1	0.7	0.0	0.4	0.01	0.1
Plantation		25.2	7.7	0.3	4.1	0.6	4.7	0.35	4.0
Recreation		0.6	0.2	0.0	0.3	0.1	0.7	0.00	0.0
Residential		1.8	0.5	0.4	5.7	0.3	2.7	0.04	0.5
Viticulture		0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.0
Total		**325.9**		**7.8**		**12.6**		**8.89**	

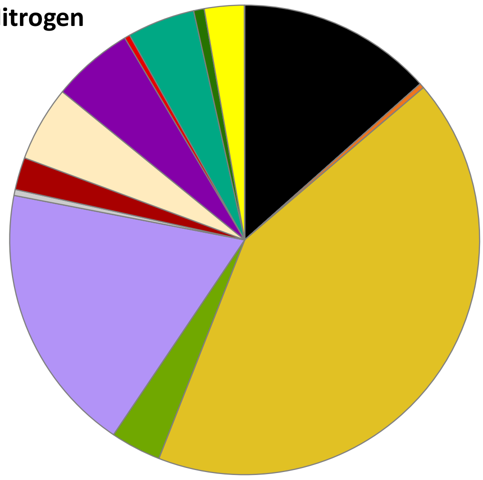
Area



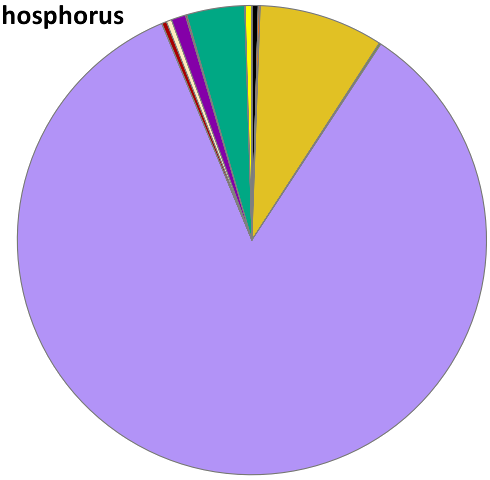
Flow



Nitrogen



Phosphorus



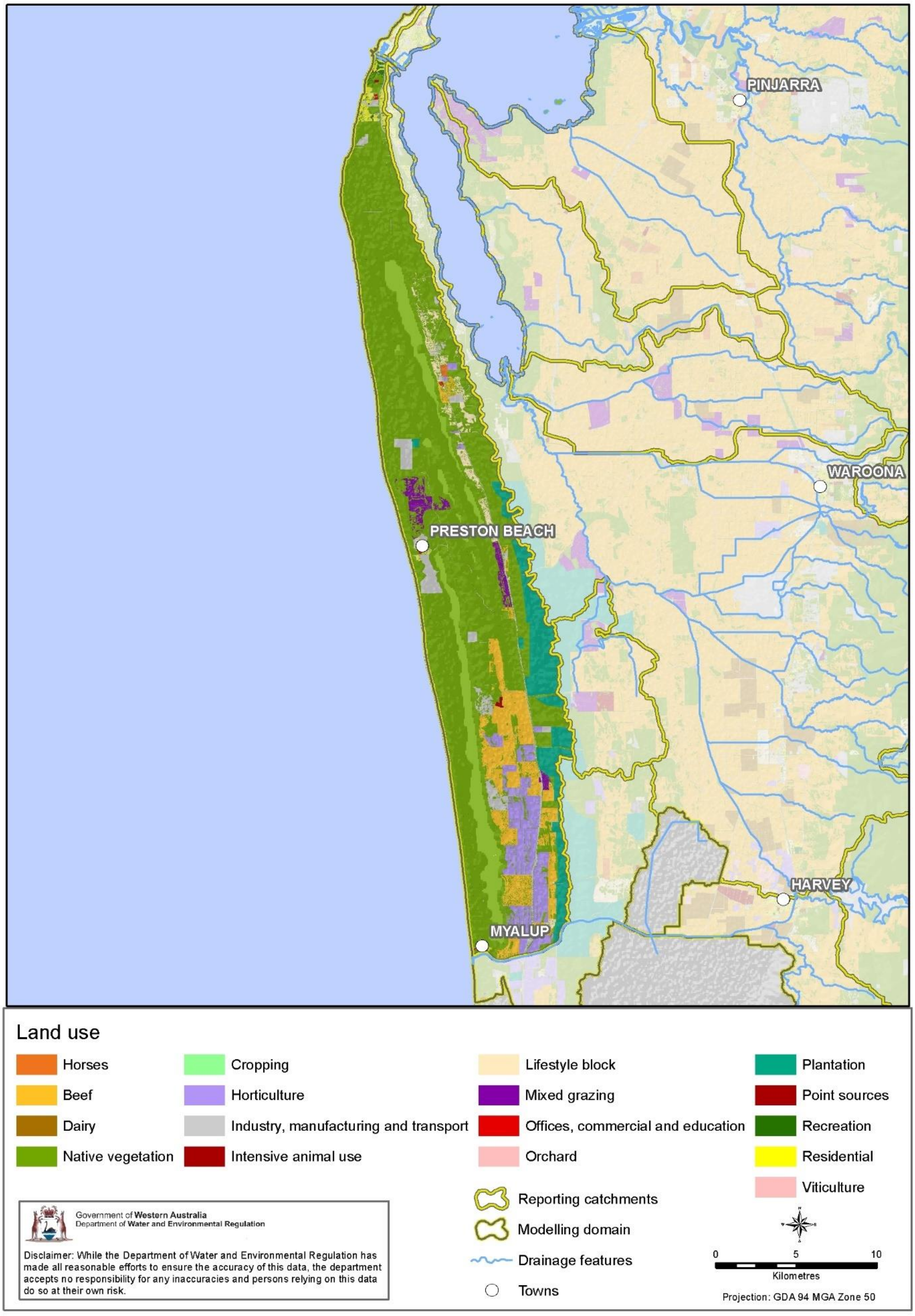
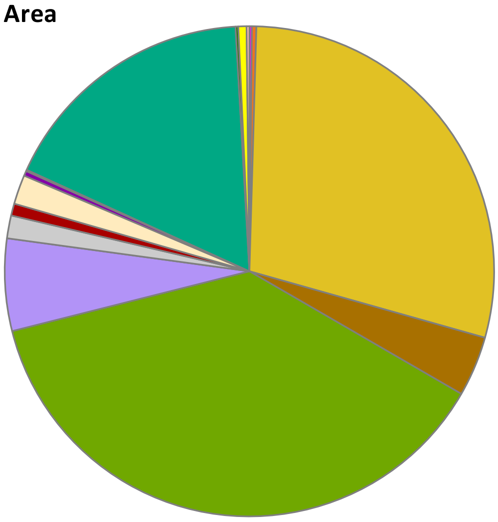


Figure D.17: Land-use of the coastal south reporting catchment

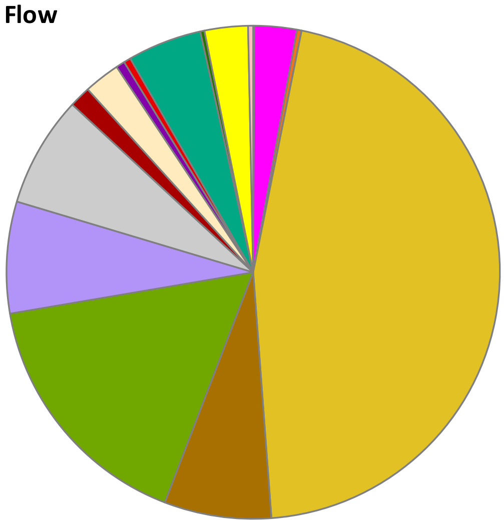
D.18 Harvey Diversion Drain

Land use	Colour	Area		Runoff		Nitrogen		Phosphorus	
		(km^2)	(%)	(GL)	(%)	(tonnes)	(%)	(tonnes)	(%)
Septic (#)		234.0	-	0.0	0.1	0.9	1.9	0.07	0.9
Point sources		0.3	0.2	0.3	2.8	7.9	16.1	0.28	3.8
Horses		0.5	0.3	0.0	0.3	0.1	0.3	0.04	0.5
Beef		49.6	28.9	5.4	45.7	28.5	58.1	1.35	17.8
Dairy		6.8	4.0	0.8	7.0	3.4	6.9	0.12	1.6
Native vegetation		64.8	37.7	2.0	16.5	0.3	0.6	0.00	0.1
Cropping		0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.0
Horticulture		10.4	6.1	0.9	7.3	1.8	3.7	4.85	64.1
Industry, manufacturing & transport		2.6	1.5	0.9	7.3	0.0	0.1	0.00	0.0
Intensive animal use		1.4	0.8	0.2	1.4	3.2	6.4	0.13	1.8
Lifestyle block		3.3	1.9	0.3	2.4	0.9	1.8	0.04	0.5
Mixed grazing		0.6	0.3	0.1	0.6	0.3	0.6	0.01	0.1
Offices, commercial & education		0.2	0.1	0.1	0.5	0.1	0.1	0.00	0.0
Plantation		29.7	17.3	0.6	4.9	1.2	2.4	0.66	8.7
Recreation		0.3	0.2	0.0	0.3	0.1	0.3	0.00	0.0
Residential		0.9	0.5	0.3	2.8	0.3	0.5	0.01	0.1
Viticulture		0.3	0.2	0.0	0.3	0.1	0.3	0.01	0.1
Total		**171.7**		**11.9**		**49.1**		**7.57**	

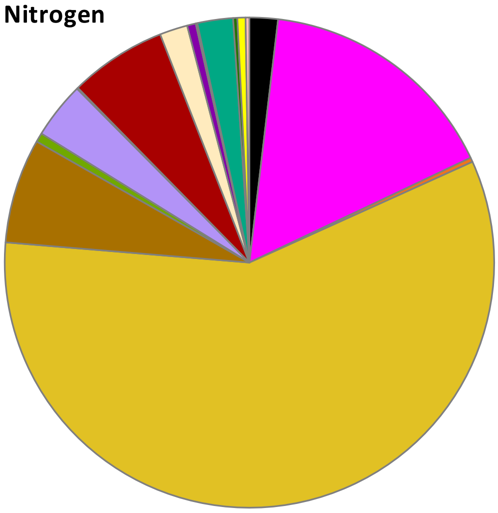
Area



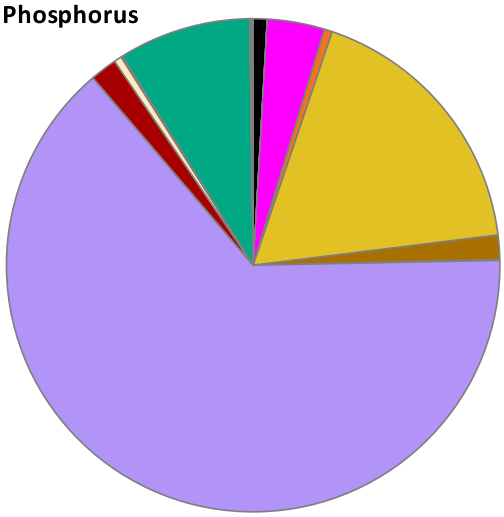
Flow



Nitrogen



Phosphorus



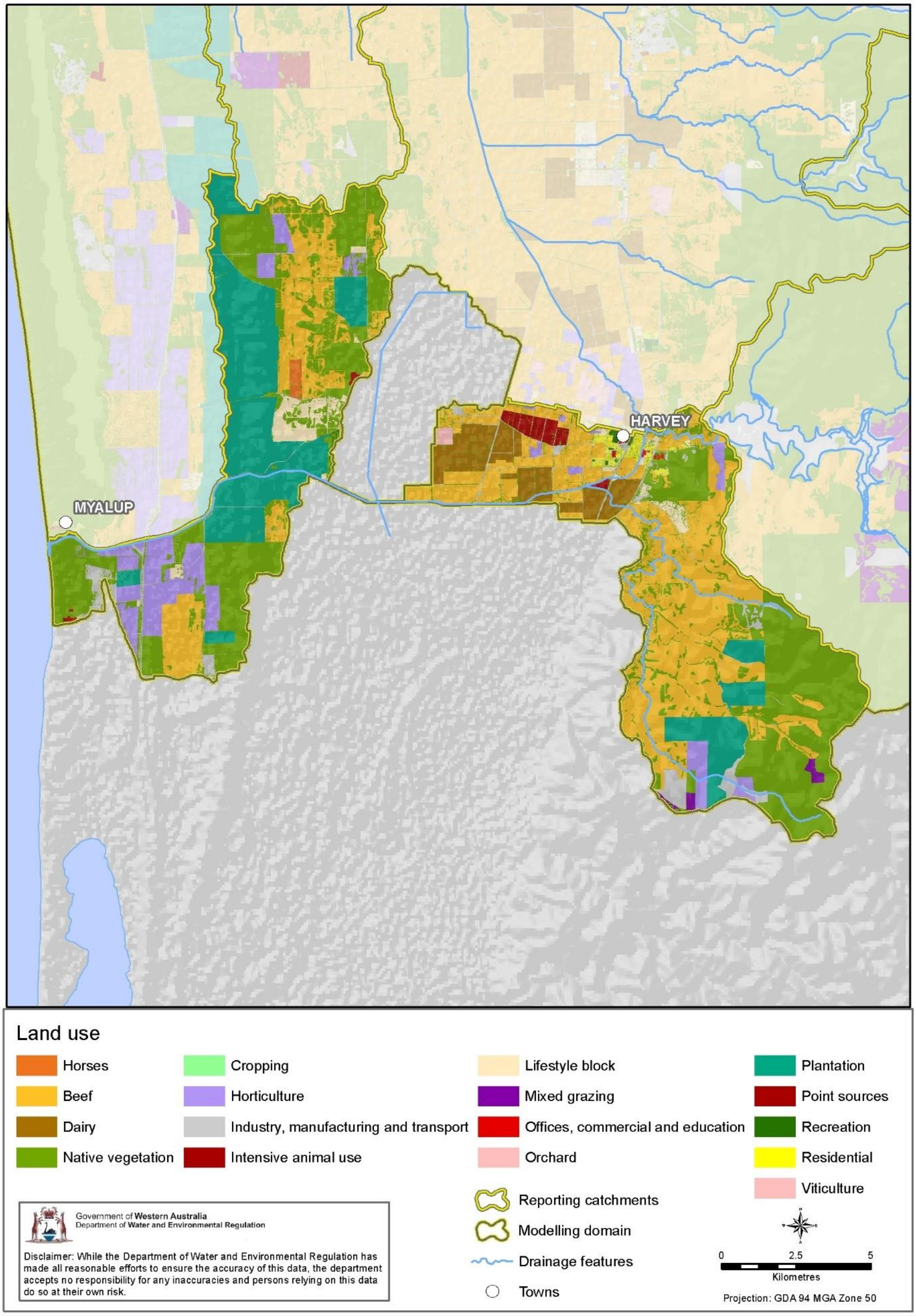


Figure D.18: Land-use of the Harvey Diversion Drain reporting catchment

Appendix E: Catchment targets

E.1 Summary of catchment targets for Western Australian estuaries

Table E.1: Summary of catchment water quality targets in Western Australia

System	Nitrogen target	Phosphorus target	Publication
Swan-Canning	Long-term 2.0 mg/L TN Short-term 1.0 mg/L TN	Long-term 0.2 mg/L TP Short-term 0.1 mg/L TP	SRT, 2008
	0.5–1.0 mg/L TN depending on flow yield	0.05–0.1 mg/L TP depending on flow yield	Kelsey et al. 2010a SRT 2009
Peel-Harvey	-	10-year median phosphorus load of 75 tonnes	EPA 1992
	-	0.1 mg/L TP	EPA 2008
	1.2 mg/L TN	Median phosphorus load of 75 tonnes	Kelsey et al. 2011
Leschenault	1.0 mg/L TN for lowland catchments 0.45 mg/L TN for upland catchments	0.1 mg/L TP for lowland catchments 0.02 mg/L TP for upland catchments	Hugues-dit-Ciles et al. 2012
Geographe Bay	1.0 mg/L TN	0.1 mg/L TP	Hall, 2009
Hardy - Scott River	1.0 mg/L TN (based on recent data)	0.1 mg/L TP (based on historic data at 609002 before Lyngbya blooms manifested)	White 2012

E.2 The EPP phosphorus targets

The statutory Environmental Protection Policy (EPP) (EPA 1992) sets out environmental quality objectives for the protection of the Peel-Harvey estuary. These are stated in the EPP in Part 2 Clause 7 as:

> The environmental quality objectives to be achieved and maintained in respect of the Estuary are a median annual load (mass) of phosphorus flowing into the estuary of less than 75 tonnes with −
>
> a) the median load (mass) of total phosphorus flowing into the Estuary from the Serpentine River being less than 21 tonnes;
>
> b) the median load (mass) of total phosphorus flowing into the Estuary from the Murray River being less than 16 tonnes; and
>
> c) the median load (mass) of total phosphorus flowing into the Estuary from the Harvey River being less than 38 tonnes.

The EPP also stated in Clause 8(2):

> The environmental quality objectives are to be achieved and maintained through —

a) implementation of the Planning Policy by local authorities through their relevant town planning schemes, and by the State Planning Commission through the Metropolitan Region Scheme;

b) appropriate land management by landholders and management authorities in the policy area;

c) government extension services including the provision of advice to land holders in the policy area; and

d) local authorities and the State ensuring that decisions and actions are compatible with the achievement and maintenance of the environmental quality objectives.

That is, all government and private activities in the catchment must contribute to reaching these targets.

The EPP targets were derived by considering limitation to Nodularia spumigena growth in the estuary prior to the Dawesville Channel, and thus have an ecological basis (EPA 1992; Kinhill Engineers 1988). Even though Nodularia no longer blooms in the estuary because of its sensitivity to salinity, it still blooms in the estuarine reaches of the rivers.

We used our catchment model to assess against the EPP phosphorus targets using modelled 10-year median phosphorus loads from 2006 to 2015:

Serpentine River: 28 tonnes (target of 21 tonnes)

Murray River: 13 tonnes (target of 16 tonnes)

Harvey River: 34 tonnes (target of 38 tonnes)

Peel-Harvey estuary: 74.6 tonnes (target of 75 tonnes)

The EPP does not specify if the Peel-Harvey estuary target is to be calculated as a 10-year median from the total annual river catchment time-series or the summation of the 10-year median calculated for each individual river catchment (

Table E.2). This is evidently important as these two calculation methods either result in an estuary target failure (79 tonnes calculated from total annual time-series) or the estuary target is marginally met (74.6 tonnes summation of river catchment median).

E.3 The Peel Harvey water quality improvement plan

The *Water quality improvement plan for the rivers and estuaries of the Peel-Harvey system – phosphorus management* (PHWQIP) (EPA 2008) used a winter median phosphorus concentration target of 0.1 mg/L derived for the Swan and Canning streams (SRT 1999; SRT 2007). The LASCAM modelling that was used to support the PHWQIP (Zammit et al. 2006) used this concentration target method to derive winter median load targets and load reduction targets for individual catchments. Winter was defined as 1 June to 31 October. Figure E.1 gives the modelled winter median concentrations by reporting catchment from our model for the period of 2006 to 2015.

Table E.2: Annual modelled phosphorus loads from the Serpentine (include Mandurah), Murray (includes Coolup (Peel)) and Harvey (includes Mayfield and Coolup (Harvey)) river catchments and comparison to the EPP phosphorus targets.

Year	Serpentine River catchment (tonnes)	Murray River catchment (tonnes)	Harvey River catchment (tonnes)	Total (Peel-Harvey estuary) (tonnes)
2006	8.8	4.3	10	23
2007	38	15	35	87
2008	35	13.2	37	85
2009	35	16	37	88
2010	6.6	2.5	6.0	15
2011	34	12.5	34	80
2012	13	6.5	17	36
2013	30	13.4	48	92
2014	25	12.7	39	77
2015	8.9	2.6	6.1	18
Median of timeseries	**28**	**13**	**34**	79
Sum of catchment medians	**-**	**-**	**-**	**74.6**
EPP target	**21**	**16**	**38**	**75**

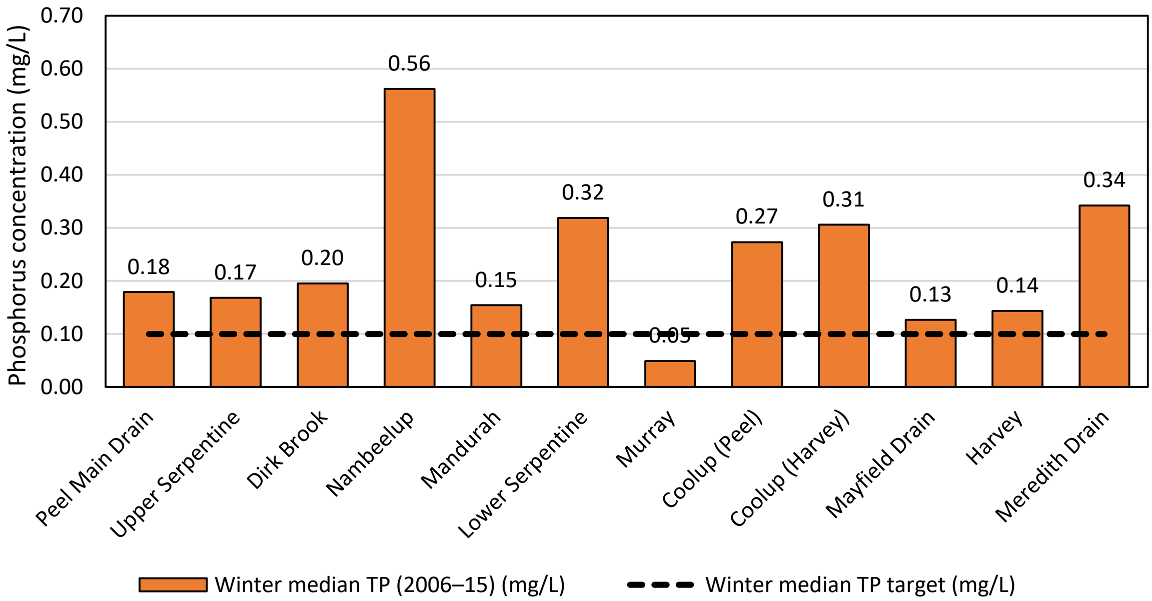


Figure E.1: Modelled reporting catchment winter median total phosphorus concentrations and the PHWQIP concentration target for the period of 2006–15

Appendix F: Supporting information for the management scenario modelling

F.1 Overseer modelling

We used the Overseer lot-scale model to estimate the reduction in phosphorus export from beef and dairy farms from various scenarios. Four Overseer models were developed (beef low PRI, beef high PRI, dairy low PRI, dairy high PRI) and were run for the following:

- **Current management (basecase).** Highly soluble phosphorus fertilisers are applied at ‘typical’ rates and soil phosphorus content is based on average soil measurements from the Peel-Harvey catchment. Livestock are assumed to have access to waterways.
- **Best-practice fertiliser management using traditional fertilisers**. Farms utilise excess soil phosphorus until concentrations are at an optimum for growing profitable pastures. Soluble phosphorus fertilisers are then applied to maintain optimum soil phosphorus concentrations.
    - **Best-practice fertiliser management using low-water-soluble phosphorus fertilisers**. We modelled the same scenario described above but used low-water-soluble phosphorus fertilisers rather than highly soluble phosphorus fertilisers.
- **Stock exclusion**: We modified the basecase model to exclude livestock from waterways to simulate waterway fencing.
- **Soil amendment**: We increased the phosphorus retention of low-PRI soils in the basecase model to represent soil amendments.

For all Overseer modelling we used a web-based tool that was last accessed in December 2018. In 2019 the version of Overseer that we used was replaced by OverseerFM, which is a more streamlined tool for farm managers but without some of the functionality used in our modelling. OverseerSci currently has the same functionality as the version that was used in this modelling.

F.1.1 Whole-farm nutrient mapping dataset

The DPIRD whole-farm nutrient mapping dataset contains the soil test results of farms that were part of programs from 2009 to 2020 to improve fertiliser use and agricultural productivity in sensitive estuary catchments, such as the Peel-Harvey estuary. This dataset includes soil testing funded by the Western Australian state governments Regional Estuaries Initiative (REI) which operated from 2016 to 2020. We used the whole-farm nutrient mapping dataset in two different ways in this modelling project:

1. Parameterising the soil phosphorus content and phosphorus retention properties of beef and dairy farms in Overseer. We used a subset of the dataset (2009–18) as not all of the REI funded soil testing data had been collected when undertaking this modelling. Paddocks that were sampled in multiple years were retained in the analysis. We used data from paddocks in estuary catchments on the coastal plain

and the Harvey Diversion Drain catchment. We describe this parameterisation in Section F.1.2.

2. Estimating the long-term phosphorus load reduction from government-funded soil-testing programs in the Peel-Harvey catchment. We calculated the area of farmers engaged in soil-testing programs for all estuary catchments on the coastal plain (excludes the Upper Murray and the Harvey Diversion Drain). Areas were given by funding program: Regional Estuaries Initiative (REI) funded soil testing (2016–20) and all programs including the REI (2009–2020). We retained the most recent soil testing data of paddocks that were sampled in multiple years.

Note that the updated DPIRD dataset (2009–20) had less than a ±5% difference in the soil test values that we used to parameterise the Overseer model.

F.1.2 Model setup for the basecase Overseer farm models (current management)

We first describe the overarching design of beef and dairy models. We gave these models uniform soil properties typical of either low or high PRI soils in the Peel-Harvey catchment, which is described separately.

Beef farm models

We modelled beef farms in Overseer to have a farm area of 120 ha and were stocked with black angus cattle (0.86 head/ha). Livestock were populated using the Overseer breeding stock tool using a breeding stock of 40. The pasture used was a mix of clover and ryegrass with medium levels of clover. No feed was imported or exported from the farm and there was no irrigation. All stock had access to waterways.

We based nutrient inputs (e.g. feed, fertiliser) on local farm-gate nutrient budget survey data (Ovens et al. 2008; Weaver et al. 2008). Beef farms were fertilised using 13 kg P/ha/yr of soluble phosphorus and nitrogen inputs were from clover fixation (43 kg N/ha/yr) and atmospheric deposition (2 kg N/ha/yr). The resulting farm-gate nutrient budget of the Overseer beef model was similar to local studies for phosphorus. However, for nitrogen, the Overseer beef model tended to have lower inputs (less fixation) and outputs than local studies (see Table F.1).

Dairy farm models

We modelled dairy farms in Overseer to have a farm area of 165 ha and were stocked with 230 Friesian milking cows (1.4 head per hectare). This 165-hectare farm consisted of a 163-hectare non-dairy effluent block (traditionally fertilised and used for pasture production) and a 2-hectare effluent block. We used default Overseer milk production values and a lactation length of 335 days per year.

We assumed that dairy effluent was managed using a holding pond with ‘regular spray irrigation’ and ‘annual solid spreading’ onto the effluent block. Overseer assumes best-practice effluent management and does not estimate the nutrient loss resulting from poorly constructed or managed dairy effluent systems.

All stock had access to waterways and thus directly deposited 0.1 kg/ha/yr of phosphorus.

We based fertiliser and feed inputs on local farm-gate nutrient budget survey data. These were generally comparable in terms of total inputs and outputs (see Table F.1). Total nutrient inputs in the model were 147 kg N/ha/yr and 29 kg P/ha/yr, which was comprised of:

- **Fertiliser:** 25 kg N/ha/yr and 23 kg P/ha/yr on non-effluent blocks and 8 kg P/ha/yr on effluent blocks.
- **Feed inputs:** Feed inputs to the entire farm (effluent and non-effluent blocks) were 34 kg N/ha/yr and 5 kg P/ha/yr from 'Grains and oats' (150 tonnes dry matter) and 'silage' (150 tonnes dry matter).
- **Atmospheric inputs**: 2 kg N/ha/yr (Overseer default).
- **Pasture fixation:** 59 kg N/ha/yr on the non-effluent block and 12 kg N/ha/yr on the effluent block.
- **Irrigation:** Inputs of 28 kg N/ha/yr and 1 kg P/ha/yr on all farm areas from 'boarder dyke' irrigation and default inflow concentrations (2.5 mg/L TN and 0.1 mg/L TP). Rivers (2012) measured local irrigation inflow concentrations, which were similar to the Overseer default values.

Table F.1: Farm-gate nutrient budgets of beef and dairy farms that were modelled in Overseer and from local surveys (Ovens et al. 2008; Weaver et al. 2008)

Farm budget	Category	Dairy				Beef			
		Nitrogen (kg/ha/yr)		Phosphorus (kg/ha/yr)		Nitrogen (kg/ha/yr)		Phosphorus (kg/ha/yr)	
		WA surveys	Overseer modelling	WA surveys	Overseer modelling	WA surveys	Overseer modelling	WA surveys	Overseer modelling
Input	Livestock	0.1	-	0.04	-	0.7	0.0	0.26	0.00
	Feed	54	34	9.1	5.0	0.3	-	0.1	-
	Fertiliser	**25**	**25**	**15.9**	**23.0**	**1.7**	**0.0**	**12.3**	**13.0**
	Pasture	65	58	-	0	83.6	43.0	-	0
	Other	0.4	30	0.4	1.0	0.0	2.0	0.1	0.0
	Total	**145**	**147**	**25.5**	**29.0**	**86.4**	**45.0**	**12.7**	**13.0**
Output	Livestock & milk	23	31	5.4	5.0	7.5	4.0	1.4	1.0
	Feed	0.1	0.0	0.01	-	0.1	-	0.01	-
	Total	**24**	**31**	**5.4**	**5.0**	**7.6**	**4.0**	**1.4**	**1.0**
Surplus	**Total**	**122**	**116**	**20.1**	**24.0**	**78.8**	**41.0**	**11.3**	**12.0**

Soil phosphorus parameterisation

We parameterised Overseer using soil testing data (2009–18) in coastal catchments that drain to the Peel-Harvey estuary and the Harvey Diversion Drain catchment. We calculated the average soil test values[4] of beef and dairy farms on low and high PRI soils using the modelling land use spatial dataset. Overseer uses Olsen P rather than Colwell P which predominantly used in the southwest of Western Australia. We converted Colwell P to Olsen P using a relationship for various PBI ranges that was developed by the DPIRD (see Table

[4] Colwell P, phosphorus buffering index (PBI) and fertility index values (85% and 95%)

F.2). Table F.3 gives the soil properties that were derived from the DPIRD database (2009–18) and were used in the Overseer models of beef and dairy farms for low and high PRI soils.

Low-PRI soils of beef and dairy farm models used ‘sandy high P export’ soils. The phosphorus retention (anion storage capacity) of low PRI beef and dairy was 1 % and 2% respectively. High-PRI soils of beef and dairy models used ‘sedimentary’ soils with a phosphorus retention of 20. All Overseer farm models use were assumed to have the phosphorus maintenance fertiliser rates derived from ‘sedimentary’ soils.

Table F.2: The conversion of Colwell P to Olsen P (derived by DPIRD)

PBI class	Equation
<35	$10^{0.882 * \log(\text{Colwell P}) - 0.155)}$
35–139	$10^{0.874 * \log(\text{Colwell P}) - 0.23)}$
140–279	$10^{0.89 * \log(\text{Colwell P}) - 0.32)}$
>280	$10^{0.89 * \log(\text{Colwell P}) - 0.38)}$

Table F.3: Assumed soil properties of beef and dairy farms that were derived from the DPIRD whole-farm nutrient mapping dataset (2009–18)

Farm model	Area (ha)	PBI	Current colwell P (mg/kg)	Current Olsen P (mg/kg)	Fertility index	Target Colwell P (mg/kg)	Target Olsen P (mg/kg)
Beef (low PRI)*	**7 092**	**45**	**29**	**11**	**1.8**	**16**	**7**
Beef (high PRI)*	**11 080**	**126**	**53**	**19**	**2.5**	**21**	**8**
Dairy (low PRI)¥	**730**	**53**	**56**	**20**	**2.0**	**27**	**10**
Dairy (high PRI)¥	**1 934**	**204**	**81**	**24**	**2.2**	**37**	**12**

* Fertility index for 85% of maximum productivity

¥ Fertility index for 95% of maximum productivity

F.1.3 Model setup for the Overseer scenarios

Best-practice fertiliser management using traditional fertilisers

In this scenario we assume that beef and dairy farms rundown their available soil phosphorus content to critical values (fertility index of 1) by applying lower (or no) phosphorus fertilisers. We represented this by modifying the soil Olsen P content to target concentrations (see Table F.3). We then ran the model with single superphosphate being applied at Overseer maintenance rates for sedimentary soils, which were:

- **Beef** maintenance phosphorus: **6 kg P/ha/yr** as single super phosphate.
- **Dairy** maintenance phosphorus: **12 kg P/ha/yr** as single super phosphate (feed and irrigation inputs were unchanged in this scenario and amounted to 7 kg P/ha/yr.

All other model parameters were the same as the basecase farm models including feed inputs and dairy effluent management.

Best-practice fertiliser management using low-water-soluble phosphorus fertilisers.

This scenario is identical to the scenario above with the exception that low-water-soluble phosphorus (LWSP) fertilisers are used in place of single superphosphate. Overseer allows users to input multiple fertiliser sources, including reactive phosphate rock which has a very low solubility and is the only fertiliser type that reduces phosphorus export in Overseer. An approximate blend of **60% reactive phosphate rock** (as elemental phosphorus) and **40% highly soluble phosphorus** was used to represent low-water-soluble phosphorus fertilisers.

Thus, the application of phosphorus fertilisers in this scenario were:

- **Beef** maintenance phosphorus: **6 kg P/ha/yr** as low-water-soluble phosphorus fertiliser.
- **Dairy** maintenance phosphorus: **12 kg P/ha/yr** as low-water-soluble phosphorus fertiliser (feed and irrigation inputs were unchanged in this scenario and amounted to 7 kg P/ha/yr)

Stock exclusion

Here we estimate the benefit of excluding stock access to waterways to prevent the direct deposition of nutrients from urine and faeces and bank erosion. This scenario used the same parameterisation of the basecase scenario with the exception that stock access to streams was unchecked. Stock exclusion reduced nutrient exports by:

- Beef: **0 kg N/ha/yr (0% reduction)** and **0.1 kg P/ha/yr (11% to 50% reduction)**
- Dairy: **1 kg N/ha/yr (1 to 2% reduction)** and **0.1 kg P/ha/yr (1 to 2% reduction)**

Soil amendments

We modelled soil amendments in Overseer by modifying the phosphorus retention parameter in low PRI beef and dairy farm models. The effect of a 20 tonne per hectare soil amendment was assumed to increase soil phosphorus retention by 3% compared to the basecase. Phosphorus retention was increased from 1% to 4% for beef and from 2% to 5% for dairy. The modelled reduction in phosphorus export was:

- Beef: **56%** reduction in phosphorus export
- Dairy: **30%** reduction in phosphorus export

F.1.4 Overseer parameter and result summaries

Table F.4: Overseer beef (low PRI) basecase and scenario model parameterisation and results

		Basecase		Fertiliser management		Low water soluble phosphorus fertilisers		Soil amendment	
Variable	**Units**	**Farm total**		**Farm total**		**Farm total**		**Farm total**	
Area	ha	120		120		120		120	
Number of cows		104		104		104		104	
Climate	-	Average annual (1900-2017) at Pinjarra met site		Average annual (1900-2017) at Pinjarra met site		Average annual (1900-2017) at Pinjarra met site		Average annual (1900-2017) at Pinjarra met site	
Irrigation method		No irrigation		No irrigation		No irrigation		No irrigation	
Do animals have access to streams?	Yes/no	Yes		Yes		Yes		Yes	
Pasture and clover levels		Very high		Very high		Very high		Very high	
Maximum pasture yield	t DM/ha/yr	4.1		4.1		4.1		4.1	
Supplements made	t DM/yr	Silage 12 tonnes (used on farm)		Silage 12 tonnes (used on farm)		Silage 12 tonnes (used on farm)		Silage 12 tonnes (used on farm)	
Soils & drainage									
Soil description	-	Sand (high P export)		Sand (high P export)		Sand (high P export)		Sand (high P export)	
Soil drainage class and characteristics	-	Moderately well - Drainage always soaks in		Moderately well - Drainage always soaks in		Moderately well - Drainage always soaks in		Moderately well - Drainage always soaks in	
Top soil texture	-	Sand		Sand		Sand		Sand	
Maximum rooting depth	cm	20		20		20		20	
Soil phosphate retention (PR)	Percent	1		1		1		**4**	
PBI		45		45		45		45	
Colwell P	mg/kg	29		16		16		29	
Fertiliser index (85% productivity)	Fraction	1.8		1		1.8		1.8	
Olsen P	mg/kg	**11**		**7**		**7**		**11**	
Maintenance P (P required to maintain Olsen P content)	kg/ha/yr	22 (assumed 12 based on sedimentary soils)		15 (assumed 6 based on sedimentary soils)		15 (assumed 6 based on sedimentary soils)		21 (assumed 12 based on sedimentary soils)	
Proportion of maximum pasture yield with maintenance P	% of max	91 (Assumed to be~97)		81 (Assumed to be~85)		81 (Assumed to be~85)		91 (Assumed to be~97)	
Proportion of maximum pasture yield current P input	% of max	90 (Assumed to be~97)		79 (Assumed to be~85)		79 (Assumed to be~85)		90 (Assumed to be~97)	
Farm nutrient budget		**Nitrogen**	**Phosphorus**	**Nitrogen**	**Phosphorus**	**Nitrogen**	**Phosphorus**	**Nitrogen**	**Phosphorus**
Timing and amount of fertilisation (SSP or RPR)	Apr (kg/ha/yr)	0	13 (SSP)	0	6 (SSP)	0	1 (SSP) 4 (RPR)	0	13 (SSP)
Nutrient inputs									
Fertiliser	Kg/ha/yr	0	13	0	6	0	6	0	13
Rain	Kg/ha/yr	2	0	2	0	2	0	2	0
Pasture nitrogen fixation	Kg/ha/yr	43	0	43	0	43	0	43	0
Nutrient outputs									
Farm produce (animals, milk etc.)	Kg/ha/yr	4	1	4	1	4	1	4	1
Exported effluent	Kg/ha/yr	0	0	0	0	0	0	0	0
Supplements or crop outputs	Kg/ha/yr	0	0	0	0	0	0	0	0
To atmosphere	Kg/ha/yr	24	0	23	0	23	0	23	0
To water	**Kg/ha/yr**	**18**	**0.9**	**18**	**0.5**	**18**	**0.4**	**18**	**0.4**
leaching - Urine patches	Kg/ha/yr	8	0.0	8	0.0	8	0.0	8	0.0
Leaching - other	Kg/ha/yr	10	0.0	10	0.0	10	0.0	10	0.0
Runoff	Kg/ha/yr	0	0.8	0	0.4	0	0.3	0	0.3
Animal contact with streams	Kg/ha/yr	0	0.1	0	0.1	0	0.1	0	0.1
Direct pond discharge	Kg/ha/yr	0	0.0	0	0.0	0	0.0	0	0.0
Boarder dyke outwash	Kg/ha/yr	0	0.0	0	0.0	0	0.0	0	0.0
Septic tank outflow	Kg/ha/yr	0	0.0	0	0.0	0	0.0	0	0.0
Change in plant and soil stores									
Plant material	Kg/ha/yr	0	0	0	0	0	0	0	0
Organic pool	Kg/ha/yr	-1	21	-1	15	-1	15	0	21
Inorganic mineral	Kg/ha/yr	0	-3	0	-3	0	-3	0	-3
Inorganic soil pool	Kg/ha/yr	0	-8	0	-8	0	-8	0	-7

Table F.5: Overseer beef (high PRI) basecase and scenario model parameterisation and results

		Basecase		Fertiliser management	
Variable	**Units**	**Farm total**		**Farm total**	
Area	ha	120		120	
Number of cows		104		104	
Climate	-	Average annual (1900-2017) at Pinjarra met site		Average annual (1900-2017) at Pinjarra met site	
Irrigation method		No irrigation		No irrigation	
Do animals have access to streams?	Yes/no	Yes		Yes	
Pasture and clover levels		Very high		Very high	
Maximum pasture yield	tonnes dry matter/	4.1		4.1	
Supplements made	tonnes dry matter	Silage 50 tonnes (used on farm)		Silage 50 tonnes (used on farm)	
Soils & drainage					
Soil description	-	Sedimentary		Sedimentary	
Soil drainage class and characteristics	-	Poor (default with naturally high groundwater)		Poor (default with naturally high groundwater)	
Top soil texture	-	Clay loam (heavy)		Clay loam (heavy)	
Maximum rooting depth	cm	20		20	
Soil phosphate retention (PR)	Percent	20		20	
PBI		125		125	
Colwell P	mg/kg	53		21	
Fertiliser index (85% productivity)	Fraction	2.5		1	
Olsen P	mg/kg	**19**		**8**	
Maintenance P (P required to maintain Olsen P content)	kg/ha/yr	12		12	
Proportion of maximum pasture yield with maintenance P	% of max	96		96	
Proportion of maximum pasture yield current P input	% of max	96		96	
Farm nutrient budget		**Nitrogen**	**Phosphorus**	**Nitrogen**	**Phosphorus**
Timing and amount of fertilisation (SSP or RPR)	Apr (kg/ha/yr)	0	13 (SSP)	0	6 (SSP)
Nutrient inputs					
Fertiliser	Kg/ha/yr	0	13	0	6
Rain	Kg/ha/yr	2	0	2	0
Pasture nitrogen fixation	Kg/ha/yr	44	0	44	0
Nutrient outputs					
Farm produce (animals, milk etc.)	Kg/ha/yr	4	1	4	1
Exported effluent	Kg/ha/yr	0	0	0	0
Supplements or crop outputs	Kg/ha/yr	0	0	0	0
To atmosphere	Kg/ha/yr	26	0	26	0
To water	**Kg/ha/yr**	**17**	**0.2**	**17**	**0.1**
leaching - Urine patches	Kg/ha/yr	7	0.0	7	0.0
Leaching - other	Kg/ha/yr	10	0.0	10	0.0
Runoff	Kg/ha/yr	0	0.1	0	0.1
Animal contact with streams	Kg/ha/yr	0	0.1	0	0.1
Direct pond discharge	Kg/ha/yr	0	0.0	0	0.0
Boarder dyke outwash	Kg/ha/yr	0	0.0	0	0.0
Septic tank outflow	Kg/ha/yr	0	0.0	0	0.0
Change in plant and soil stores					
Plant material	Kg/ha/yr	0	0	0	0
Organic pool	Kg/ha/yr	-1	11	-1	6
Inorganic mineral	Kg/ha/yr	0	0	0	-1
Inorganic soil pool	Kg/ha/yr	0	1	0	0

Table F.6: Overseer dairy (low PRI) basecase and scenario model parameterisation and results

		Basecase						Fertiliser management						Low water soluble phosphorus fertilisers						Soil amendment					
Variable	**Units**	**Non-effluent block**		**Effluent block**		**Farm total**		**Non-effluent block**		**Effluent block**		**Farm total**		**Non-effluent block**		**Effluent block**		**Farm total**		**Non-effluent block**		**Effluent block**		**Farm total**	
Area	ha	163		2		165		163		2		165		163		2		165		163		2		165	
Number of milking cows and type		230 milking cows (Friesian)						230 milking cows (Friesian)						230 milking cows (Friesian)						230 milking cows (Friesian)					
Climate	-	Average annual (1900-2017) at Pinjarra met site						Average annual (1900-2017) at Pinjarra met site						Average annual (1900-2017) at Pinjarra met site						Average annual (1900-2017) at Pinjarra met site					
Effluent management	-	Holding pond: Irrigation and spreading of solids to effluent block in April each year						Holding pond: Irrigation and spreading of solids to effluent block in April each year						Holding pond: Irrigation and spreading of solids to effluent block in April each year						Holding pond: Irrigation and spreading of solids to effluent block in April each year					
Effluent irrigation	mm per milking day	None		>24 mm				None		>24 mm				None		>24 mm				None		>24 mm			
Irrigation method		Boarder dyke: default nutrient concentrations						Boarder dyke: default nutrient concentrations						Boarder dyke: default nutrient concentrations						Boarder dyke: default nutrient concentrations					
Months irrigated and amount	mm/month	Nov–March (227 mm/month)						Nov–March (227 mm/month)						Nov–March (227 mm/month)						Nov–March (227 mm/month)					
Do animals have access to streams?	Yes/no	Yes						Yes						Yes						Yes					
Pasture and clover levels		Ryegrass/white clover with low clover levels						Ryegrass/white clover with low clover levels						Ryegrass/white clover with low clover levels						Ryegrass/white clover with low clover levels					
Maximum pasture yield	tonnes dry matter/ha/yr	6.3		6.3		6.3		6.3		6.3		6.3		6.3		6.3		6.3		6.3		6.3		6.3	
Soils & drainage																									
Soil description	-	Sand (high P export)						Sand (high P export)						Sand (high P export)						Sand (high P export)					
Soil drainage class and characteristics	-	Moderately well - Drainage always soaks in						Moderately well - Drainage always soaks in						Moderately well - Drainage always soaks in						Moderately well - Drainage always soaks in					
Top soil texture	-	Sand						Sand						Sand						Sand					
Maximum rooting depth	cm	20						20						20						20					
Soil phosphate retention (PR)	Percent	**2**						**2**						**2**						**5**					
PBI		53						53						53						53					
Colwell P	mg/kg	56						27						27						56					
Fertiliser index (85% productivity)	Fraction	2						1						1						2					
Olsen P	mg/kg	**20**						**10**						**10**						**20**					
Maintenance P (P required to maintain Olsen P content)	kg/ha/yr	43 (assume 19)		Not given by model				25 (assume 12)		Not given by model				25 (assume 12)		Not given by model				12 (assume 19)		Not given by model			
Proportion of maximum pasture yield with maintenance P	% of max	98		Not given by model				89 (assume 95)		Not given by model				89 (assume 95)		Not given by model				98		Not given by model			
Proportion of maximum pasture yield current P input	% of max	97		97		97		89 (assume 95)		97		97		89 (assume 95)						97		97		97	
Farm nutrient budget		**N**	**P**	**N**	**P**	**N**	**P**	**N**	**P**	**N**	**P**	**N**	**P**	**N**	**P**	**N**	**P**	**N**	**P**	**N**	**P**	**N**	**P**	**N**	**P**
Timing and amount of fertilisation (SSP or RPR)	Apr (kg/ha/yr)	25	15 (SSP)	0	0			0	6 (SSP)	0	0			0	2 (SSP) 4 (RPR)	0	0			25	15 (SSP)	0	0		
	September (kg/ha/yr)	0	8 (SSP)	0	8			0	6 (SSP)	0	0			0	2 (SSP) 4 (RPR)	0	0			0	8 (SSP)	0	8		
Nutrient inputs																									
Fertiliser	Kg/ha/yr	25	23	0	8	25	23	0	12	0	0	0	12	0	12	0	0	0	12	25	23	0	8	25	23
Rain	Kg/ha/yr	2	0	2	0	2	0	2	0	2	0	2	0	2	0	2	0	2	0	2	0	2	0	2	0
Pasture nitrogen fixation	Kg/ha/yr	59	0	12	0	58	0	67	0	7	0	66	0	67	0	7	0	66	0	59	0	12	0	58	0
Irrigation	Kg/ha/yr	28	1	28	1	28	1	28	1	28	1	28	1	28	1	28	1	28	1	28	1	28	1	28	1
Effluent	Kg/ha/yr	0	0	845	120	NA	NA	0	0	717	72	0	0	0	0	717	72	0	0	0	0	845	120	NA	NA
Supplements	Kg/ha/yr	34	5	34	5	34	5	34	5	34	5	34	5	34	5	34	5	34	5	34	5	34	5	34	5
Nutrient outputs																									
Farm produce (animals, milk etc.)	Kg/ha/yr	31	5	31	5	31	5	31	5	31	5	31	5	31	5	31	5	31	5	31	5	31	5	31	5
Exported effluent	Kg/ha/yr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Supplements or crop outputs	Kg/ha/yr	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
To atmosphere	Kg/ha/yr	57	0	117	0	60	0	53	0	105	0	57	0	53	0	105	0	57	0	57	0	117	0	60	0
To water	**Kg/ha/yr**	**66**	**9.9**	**401**	**11.4**	**70**	**10.1**	**64**	**6.3**	**332**	**7.3**	**68**	**6.5**	**64**	**5.8**	**332**	**7.3**	**68**	**6.0**	**66**	**7.4**	**401**	**9.7**	**70**	**7.1**
leaching - Urine patches	Kg/ha/yr	29	0.0	57	0.0	29	0.0	29	0.0	52	0.0	29	0.0	29	0.0	52	0.0	29	0.0	29	0.0	57	0.0	29	0.0
Leaching - other	Kg/ha/yr	20	0.0	298	0.0	23	0.2	18	0.0	240	0.0	21	0.2	18	0.0	240	0.0	21	0.2	20	0.0	298	0.0	23	0.2
Runoff	Kg/ha/yr	0	6.5	29	8.0	0	6.5	0	3.0	22	4.0	0	3.0	0	2.5	22	4.0	0	2.5	0	4.0	29	6.3	0	3.5
Animal contact with streams	Kg/ha/yr	1	0.2	1	0.2	1	0.2	1	0.1	1	0.1	1	0.1	1	0.1	1	0.1	1	0.1	1	0.2	1	0.2	1	0.2
Direct pond discharge	Kg/ha/yr	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
Boarder dyke outwash	Kg/ha/yr	16	3.1	16	3.1	16	3.1	16	3.1	16	3.1	16	3.1	16	3.1	16	3.1	16	3.1	16	3.1	16	3.1	16	3.1
Septic tank outflow	Kg/ha/yr	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
Change in plant and soil stores																									
Plant material	Kg/ha/yr	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0
Organic pool	Kg/ha/yr	-24	35	351	21	-10	36	-35	21	303	12	-21	22	-35	21	303	12	-21	22	-24	35	351	35	-10	36
Inorganic mineral	Kg/ha/yr	0	-3	0	-3	0	-3	0	-3	0	-3	0	-3	0	-3	0	-3	0	-3	0	-2	0	-2	0	-2
Inorganic soil pool	Kg/ha/yr	0	-20	0	27	0	-19	0	-12	0	47	0	-12	0	-12	0	47	0	-11	0	-18	0	85	0	-16

Table F.7: Overseer dairy (high PRI) basecase and scenario model parameterisation and results

		Basecase						Fertiliser management					
Variable	**Units**	**Non-effluent block**		**Effluent block**		**Farm total**		**Non-effluent block**		**Effluent block**		**Farm total**	
Area	ha	163		2		165		163		2		165	
Number of milking cows and type		230 milking cows (Friesian)						230 milking cows (Friesian)					
Climate	-	Average annual (1900-2017) at Pinjarra met site						Average annual (1900-2017) at Pinjarra met site					
Effluent management	-	Holding pond: Irrigation and spreading of solids to effluent block in April each year						Holding pond: Irrigation and spreading of solids to effluent block in April each year					
Effluent irrigation	mm per milking day	None		>24 mm				None		>24 mm			
Irrigation method		Boarder dyke: default nutrient concentrations						Boarder dyke: default nutrient concentrations					
Months irrigated and amount	mm/month	Nov–March (227 mm/month)						Nov–March (227 mm/month)					
Do animals have access to streams?	Yes/no	Yes						Yes					
Pasture and clover levels		Ryegrass/white clover with low clover levels						Ryegrass/white clover with low clover levels					
Maximum pasture yield	tonnes dry matter/ha/yr	6.3		6.3		6.3		6.3		6.3		6.3	
Soils & drainage													
Soil description	-	Sedimentary						Sedimentary					
Soil drainage class and characteristics	-	Poor - Rainfall mostly runs off						Poor - Rainfall mostly runs off					
Top soil texture	-	Clay loam - Heavy texture						Clay loam - Heavy texture					
Maximum rooting depth	cm	20						20					
Soil phosphate retention (PR)	Percent	**20**						**20**					
PBI		204						204					
Colwell P	mg/kg	81						37					
Fertiliser index (85% productivity)	Fraction	2.2						1					
Olsen P	mg/kg	**24**						**12**					
Maintenance P (P required to maintain Olsen P content)	kg/ha/yr	19		Not given by model				12		Not given		12	
Proportion of maximum pasture yield with maintenance P	% of max	98		Not given by model				92		91		~91	
Proportion of maximum pasture yield current P input	% of max	98		98		98		92		91		91	
Farm nutrient budget		**N**	**P**	**N**	**P**	**N**	**P**	**N**	**P**	**N**	**P**	**N**	**P**
Timing and amount of fertilisation (SSP or RPR)	Apr (kg/ha/yr)	25	15 (SSP)	0	0			0	6 (SSP)	0	0		
	September (kg/ha/yr)	0	8 (SSP)	0	8			0	6 (SSP)	0	0		
Nutrient inputs													
Fertiliser	Kg/ha/yr	25	23	0	8	25	23	0	12	0	0	0	12
Rain	Kg/ha/yr	2	0	2	0	2	0	2	0	2	0	2	0
Pasture nitrogen fixation	Kg/ha/yr	58	0	1	0	58	0	66	0	1	0	66	0
Irrigation	Kg/ha/yr	28	1	28	1	28	0	28	1	28	1	28	0
Effluent	Kg/ha/yr			845	124	0	1			838	100	0	1
Supplements	Kg/ha/yr	34	5	34	5	34	5	34	5	34	5	34	5
Nutrient outputs													
Farm produce (animals, milk etc.)	Kg/ha/yr	31	5	31	5	31	5	31	5	31	5	31	5
Exported effluent	Kg/ha/yr	0	0	0	0	0	0	0	0	0	0	0	0
Supplements or crop outputs	Kg/ha/yr	0	0	0	0	0	0	0	0		0	0	0
To atmosphere	Kg/ha/yr	65	0	20	0	70	0	67	0	127	0	67	0
To water	**Kg/ha/yr**	**56**	**5.8**	**369**	**6.3**	**60**	**6.0**	**58**	**4.6**	**364**	**5.0**	**58**	**4.6**
leaching - Urine patches	Kg/ha/yr	19	0.0	45	0.0	19	0.0	19	0.0	44	0.0	19	0.0
Leaching - other	Kg/ha/yr	20	0.0	297	0.0	23	0.2	22	0.2	293	0.0	22	0.2
Runoff	Kg/ha/yr	0	2.4	10	2.9	0	2.4	0	1.1	10	1.7	0	1.1
Animal contact with streams	Kg/ha/yr	1	0.2	1	0.2	1	0.2	1	0.1	1	0.1	1	0.1
Direct pond discharge	Kg/ha/yr	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
Boarder dyke outwash	Kg/ha/yr	16	3.1	16	3.1	16	3.1	16	3.1	16	3.1	16	3.1
Septic tank outflow	Kg/ha/yr	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
Change in plant and soil stores													
Plant material	Kg/ha/yr	0	0	0	0	0	0	0	0	0	0	0	0
Organic pool	Kg/ha/yr	-26	15	361	15	-11	16	-21	11	360	10	-21	11
Inorganic mineral	Kg/ha/yr	0	-3	0	-3	0	-3	0	-3	0	-3	0	-3
Inorganic soil pool	Kg/ha/yr	0	4	0	112	0	5	0	1	0	87	0	1

F.2 Low-water-soluble phosphorus fertilisers: Literature review

Here we summarise relevant literature on the effect of low-water-soluble phosphorus fertiliser use on phosphorus export. We have mainly focused on local studies, with most being undertaken in the Peel-Harvey catchment.

Context and a list of cited literature

In 1976 the Western Australian state government launched a government funded investigation into the problematic algal growth in the Peel-Harvey. The use of highly soluble phosphorus fertilisers (typically > 77% soluble) was identified as a potential cause and required further investigation. This initiated a series of studies on lower soluble phosphorus fertilisers:

- A commercial low-water-soluble phosphorus fertiliser called ‘coastal super’ was developed. This fertiliser had a solubility of <27% and was made from a blend of ordinary single superphosphate, phosphate rock and elemental sulphur.
- Ritchie et al. (1985) tested the phosphorus leaching from single superphosphate and coastal superphosphate using unvegetated column trials over a simulated 10-year period. Rates of nutrient rundown and fertiliser management advice were derived from this work.
- Plot and small catchment field trials by Schofield et al. (1985a) and Silberstein & Schofield (1990) measured pasture yield, runoff and phosphorus export from the use of response to single superphosphate, coastal super and no fertiliser application.
- Pasture yield field trials by Bolland et al. (1995) using single superphosphate, coastal super, rock phosphate and calcium phosphate.

In later years, more local studies were initiated:

- Column and field trials of RedCoat (single superphosphate coated with bauxite residue) (Summers et al. 2000). Phosphorus leaching was measured in column trials and pasture yield was measured in plot-scale field trials.
- Column and plot-scale field trials of a newer low-water-soluble phosphorus product by Maddern (2016). Column trials of phosphorus leaching were attempted using unvegetated perlite and a combination of vegetated and unvegetated soils from the Peel-Harvey catchment. Field trials measured pasture yield and tissue phosphorus content.

Other cited literature:

- Nguyen et al. (2002) was a New Zealand column trial study that tested reactive phosphate rock and single superphosphate. This study informed the efficacy of reactive phosphate rock fertilisers in the Overseer phosphorus model (McDowell 2005).

Ritchie & Weaver column trials

The column trial work by Ritchie et al. (1985) was subsequently published in Weaver et al. (1988 a & b) and Ritchie & Weaver (1993). This collective body of work demonstrated that in bare sand columns, coastal super reduced phosphorus leaching by 50% initially. However, after 10 years of simulated climate and fixed fertiliser applications (10 kg P/ha/yr), coastal super had phosphorus leaching that was approaching that of single superphosphate. This finding, in conjunction with other related experiments lead the authors to conclude:

- Coastal super has the potential to build up in the soil and could result in similar rates of leaching as ordinary single superphosphate after 10-15 years of excessive application. Thus, coastal super may not be required every year.
- Phosphorus fertilisation is only required if soil bicarbonate levels are less than:
    - < 12 ppm for Bassendean sands
    - <18 ppm for sandy duplex soils
- Phosphorus rundown of soils with excessive soil bicarbonate phosphorus concentrations may take 2-5.5 years for Bassendean sands and more than 7 years for sandy duplex soils.

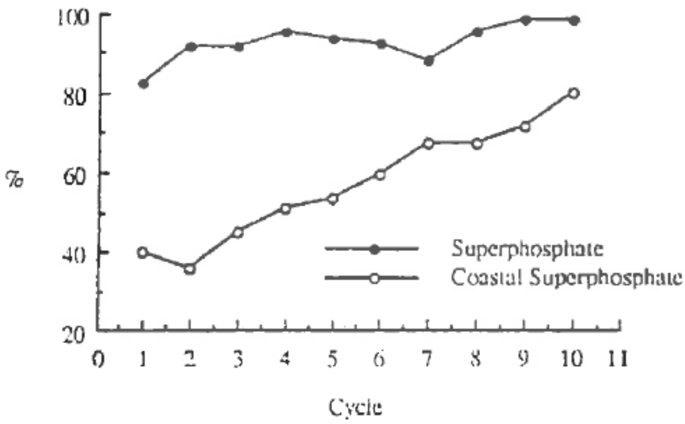


Fig. 7. Cumulative fertilizer P lost as a percentage of the cumulative fertilizer P added continuously at 10 kg P ha^{-1} as superphosphate (●) or coastal superphosphate (○). (Modified from [9].)

Plot and small catchment studies

A series of plot and small catchment studies were undertaken by Schofield et al. (1985a) and Silberstein & Schofield (1990). They measured pasture yield, runoff and phosphorus export in response to applications of fertiliser or no fertiliser at the following trial sites:

- **Caratti catchment:** Three five-hectare catchments were monitored in 1984 in response to applications of ordinary single superphosphate, new coastal superphosphate and no fertiliser application. A detailed write-up of the methods and results of these sites has not been found, apart from a brief description of the experimental site and results given in Schofield et al. (1985a).
- **Hodgson and Jenkins experiments:** Two sets of four 200 m^2 plots testing the effect of no fertiliser, single superphosphate, lime and lime + superphosphate**.** A detailed write-up of the methods and results of these sites has not been found, apart from a brief description of the experimental sites in Schofield et al. (1985a).

- **The paired Talbot catchments (traditional fertilisers only):** The catchment-scale (~62.3 ha) response to single superphosphate application and no fertiliser application for 1983–84 (Schofield et al. 1985b).
- **The Stacey experiment** is discussed below.

A study site called the 'Stacey experiment' was located in the Coolup catchment which had sandy duplex soils. The study measured pasture response and surface water from plots of pasture that were treated with single superphosphate (plot 1), coastal super (plot 2) and no fertiliser (plot 3) (Silberstein & Schofield 1990). The experiment ran for four years (1983–86) and fertiliser was applied at 18 kg P/ha/yr. Potassium and sulphur were applied annually to all plots. Flow-weighted phosphorus concentrations of surface water and pasture yield tended to be the greatest from the coastal super plots. Silberstein & Schofield (1990) could not explain this result.

However, it appears that coastal super was not used according to what would later be defined as best-practice fertiliser management. It seems likely that no fertiliser was required for the duration of the experiment Stacey experiment. The bicarbonate extractable phosphorus of the soils were >29 ppm for all plots at the start of and end of the experiment. Using the recommendations of Ritchie et al. (1985), no fertiliser should have been applied to these soils until bicarbonate extractable phosphorus was 18 ppm. Also, Ritchie stated that soil phosphorus rundown could take more than 7 years, which is also consistent with the findings from the unfertilised plots.

Despite these possible experimental flaws, the Stacy experiment helped to understand the effect of zero phosphorus fertiliser application on phosphorus export and pasture yield. After four years without fertiliser application, phosphorus export (flow-weighted phosphorus concentration) was 61% lower than exports from the single superphosphate plots while pasture yield was 90% of the single superphosphate plots. Additionally, pasture tissue phosphorus content (0.34%) did not fall below the minimum recommended values for clover (0.3%) or ryegrass (0.24%) (DPIRD 2018).

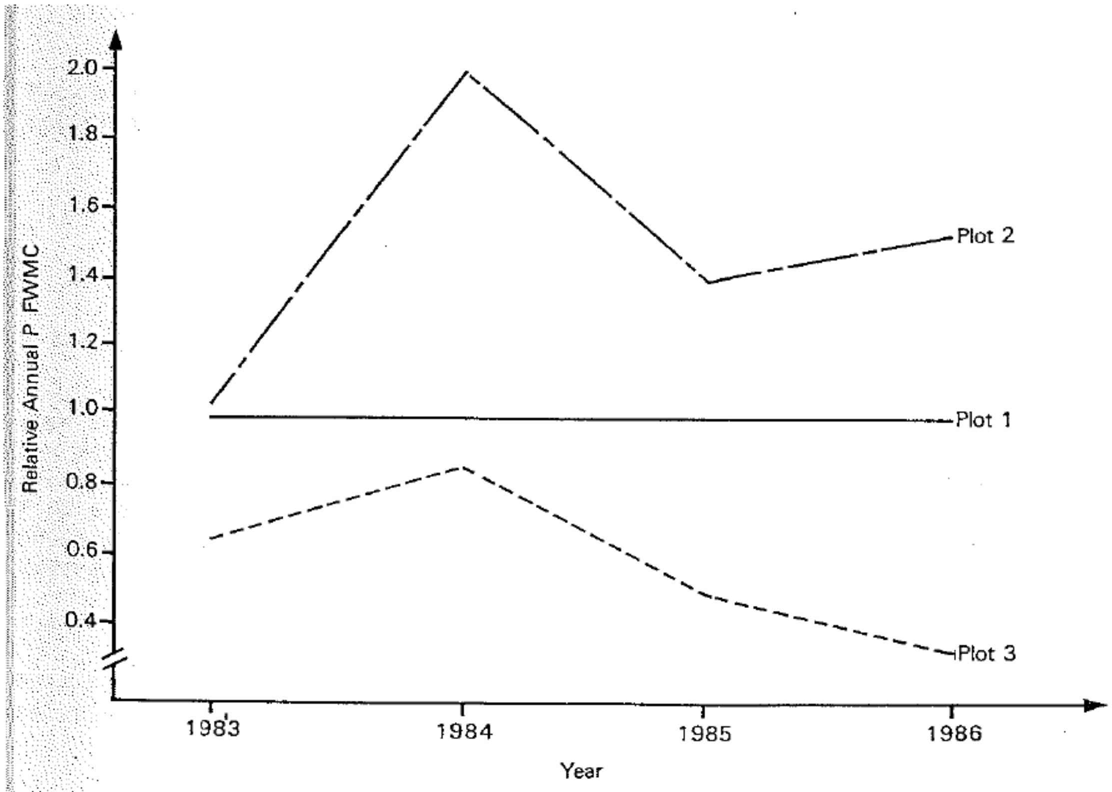


Figure 6. Relative annual flow weighted mean concentration (FWMC) of phosphorus for plot 2 (NCS) and plot 3 (Nil P) relative to plot 1.

Figure 7. Relative annual pasture yield of plots 2 (NCS) and plot 3(Nil P) relative to plot 1.

Plot Treatment: Plot 1 – Superphosphate (18kg P/ha). Plot 2 – Slow-P-release NCS (18kg P/ha). Plot 3 – No P.

	1983			1984			1985			1986			mean		
PLOT	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
Pre-treatment															
Rain(mm)	321			460			358			407			386		
Runoff(m^3)	330	350	470	730	460	600	430	300	580	130	180	200	400	360	460
P load(g)	150	220	200	270	480	200	490	410	340	110	200	70	260	330	200
F.W.$\bar{X}$ P conc. (mg/L)	.44	.63	.42	.37	1.05	.34	1.15	1.38	.59	.83	.10	.12	.70	1.04	.42
Post-treatment															
Rain	412			238			248			218			279		
Runoff(m^3)	1020	1370	2160	530	440	500	600	500	1600	580	420	1310	680	680	1390
P load(g)	640	800	760	240	240	170	410	640	660	410	470	350	420	540	480
F.W.$\bar{X}$ P conc. (mg/L)	.63	.58	.35	.46	.55	.33	.68	1.26	.41	.70	1.14	.27	.62	.88	.34
Total Period															
Rain(mm)	733			763			606			625			682		
Runoff(m^3)	1350	1760	2630	1260	910	1100	1080	800	2180	710	590	1520	1100	1020	1860
P load(g)	790	1020	960	510	730	370	980	1040	1000	520	670	420	700	860	690
F.W.$\bar{X}$ P conc. (mg/L)	.58	.59	.36	.40	.80	.34	.91	1.31	.46	.72	1.13	.28	.65	.96	.36
Pasture Yield (t/ha)	3.8	3.5	3.4	4.6	5.1	3.9	7.8	8.0	7.1	6.3	7.4	5.7	5.6	6.0	5.0
Tissue P%	.31	.38	.34	.42	.46	.38	.40	.37	.34	.36	.38	.31	.37	.40	.34
Soil Bic. P(µg/g)	31	29	30	34	34	30	38	37	31	39	41	35	36	35	32

Bolland et al. (1995) pasture yield field trials

Bolland et al. (1995) measured the pasture yield in response to 0-100 kg P/ha/yr applications of the following fertilisers

- Single superphosphate (80% water soluble),
- Coastal superphosphate (27% water soluble),
- Island rock phosphate (<1% water soluble). This was a 50% mixture of apatite from Nauru and the Christmas Islands.
- Calciphos 'rock phosphate' (<1% water soluble). This was produced by heating phosphate rock (C grade ore) from the Christmas Islands.

These pasture yield trials were undertaken from 1985 to 1991 at three sites (Denmark, west Harvey and Cookernup which is north of Harvey). All sites had sandy acidic peaty soils with negative PRI values (-1.8 to -0.4) and low Colwell P content (2–5 ppm).

The authors used the relative effectiveness (RE) statistic to compare the pasture yield of single superphosphate with the pasture yield resulting from low-water-soluble phosphorus fertilisers. A relative effectiveness score of 1 means that a low-water-soluble phosphorus fertiliser produced the same yield as single superphosphate for that time period. Values greater than 1 mean that the low-water-soluble phosphorus fertiliser had greater pasture yields than single superphosphate.

Coastal Super generally resulted in the greatest pasture yield of the fertilisers that were tested, regardless of site. Island rock phosphate and Calciphos were more effective than single superphosphate at West Harvey and Denmark.

Table 5. Relative effectiveness (RE) values for the Type 1 experiments, in which P was applied annually, when RE was measured more than once in any one year. RE was calculated from Mitscherlich equation (1) fitted to the relationship between yield (kg ha^{-1}) and the level of P applied annually (kg P ha^{-1}), by dividing the initial slope (*bc*) for each P fertilizer by *bc* for single superphosphate (see Analysis of data section for details). Thus the RE for single superphosphate is always 1.00

Year	Denmark				West Harvey				Cookernup		
	Date[a]	CSP[b]	IRP	Cal	Date[a]	CSP[b]	IRP	Cal	Date[a]	CSP[b]	IRP
1985					6 Aug	0.15	0.33				
					10 Oct	1.94	1.16				
1986					4 Sept	0.28	0.62	0.07			
					1 Oct	1.09	0.67	1.25			
1988	15 Aug	1.11	0.61	0.53	29 Aug	1.24	1.05	0.96	25 Aug	1.76	0.84
	11 Oct	2.17	0.67	0.91	17 Oct	1.39	1.15	1.10	13 Oct	2.85	2.02
1989	10 July	1.06	0.36	0.58							
	25 Oct	1.82	0.97	1.20							
1990	28 June	6.03	0.82	0.83	30 July	2.08	3.21	9.23	26 July	0.58	0.48
	4 Oct	7.21	0.77	1.65	18 Sept	0.74	0.93	4.81	17 Sept	1.31	0.75
					16 Oct	1.55	1.24	3.10	16 Oct	1.06	0.92
1991	6 Aug	8.79	1.33	1.76	12 Aug	0.59	1.15	0.59			
	11 Oct.	5.23	1.00	1.49	25 Sept	1.12	1.24	1.77			
Percentage of observations when RE > 1.00[c]		100	20	50		62	62	55		88	25

[a]Date yields measured in the years listed;
[b]CSP, coastal superphosphate; IRP, Island rock phosphate; Cal, Calciphos;
[c]This is for all data in all years, and is a measure of when the fertilizers were more effective than single superphosphate, because RE of all fertilizers was calculated relative to single superphosphate so that the RE of single superphosphate is always 1.00.

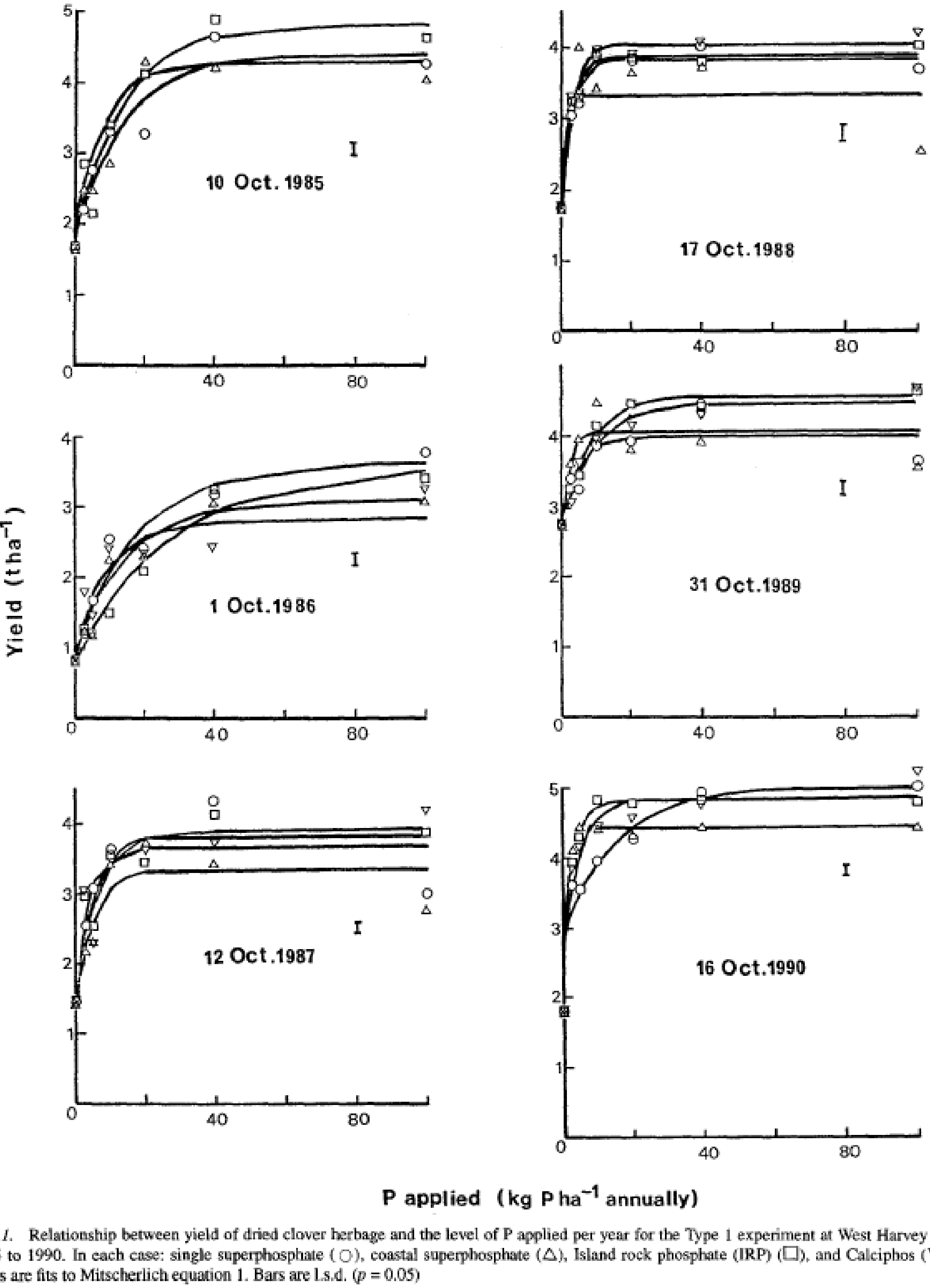


Fig. 1. Relationship between yield of dried clover herbage and the level of P applied per year for the Type 1 experiment at West Harvey for 1985 to 1990. In each case: single superphosphate (○), coastal superphosphate (△), Island rock phosphate (IRP) (□), and Calciphos (▽). Lines are fits to Mitscherlich equation 1. Bars are l.s.d. ($p = 0.05$)

RedCoat (Summers et al. 2000)

Summers et al. (2000) investigated the leaching and pasture response to ordinary single superphosphate and single superphosphate that was coated with bauxite residue. Two types of studies were undertaken:

- **Glasshouse trials:** The mass of phosphorus leaching and clover yield were measured in columns filled with sandy acidic soils. This study compared the effect of ordinary and coated (5-40% by weight) single superphosphate fertilisers applied at 20 and 40 kg/ha/yr of phosphorus. A 20 t/ha top dress amendment of bauxite residue using ordinary single superphosphate was also investigated. A total of 1200 mm of water was applied to the columns over the 8-week study.
- **Field trials:** Field trials measuring clover yields were undertaken in Denmark (WA) which had humic sandy soils (PRI not specified). Ordinary and coated (25% by weight) single superphosphate were compared at applications of 0-80 kg/ha/yr of phosphorus. The trial was conducted for three years.

From these trials single superphosphate coated with 25–30% bauxite residue (by weight) was found to:

- Reduce leaching of phosphorus by ~**50%** compared to ordinary single superphosphate. This coated fertiliser was as effective as a 20 t/ha bauxite residue amendment using traditional single superphosphate fertiliser.
- Resulted in greater phosphorus uptake and pasture yield than ordinary single superphosphate in the second and third year of the study

This led to the development of the RedCoat product, which was considered as a low-water-soluble phosphorus fertiliser in the Fertiliser action Plan and had a water-soluble phosphorus content of 39%.

Maddern (2016): Low-water-soluble superphosphate fertiliser

Maddern (2016) investigated the phosphorus leaching and pasture yield of a low-water-soluble superphosphate product (termed LWSSP here). This LWSSP product was a blend of the following fertiliser components:

- Monobasic calcium phosphate (MCP) which is 99.9% water soluble
- Dibasic calcium phosphate (DCP, also called Dicalc phosphate) which is 36.2% water soluble.
- Tribasic calcium phosphate (TCP) which is 0.01% water soluble.

This LWSSP blend had a calculated water solubility of 51.3%.

Table 3.10 Total predicted solubility of each treatment applied to glasshouse experiment 1.

Fertiliser	MCP (%)	DCP (%)	TCP (%)	Total calculated solubility (%)
MCP	100	0	0	99.9
DCP	0	100	0	36.2
TCP	0	0	100	0.01
SSP	86	9	5	89.2
LWSSP	35	45	20	51.3

Monobasic calcium phosphate (MCP), dibasic calcium phosphate (DCP), tribasic calcium phosphate (TCP), single superphosphate (SSP) and low water-soluble superphosphate (LWSSP). Calculations used to determine total calculated solubility are based on 40 L of water outlined in Appendix 9.3.2.3 (Kotz *et al.* 2003).

Four main experiments were undertaken where plant yield or phosphorus leachate were measured in response to single superphosphate, LWSSP and the three previously mentioned fertiliser components. These four experiments were:

1. Hydroponic plant yields trials
2. Unvegetated perlite column leaching
3. Vegetated column leaching using three soil types that are common to the Peel-Harvey catchment
4. Field pasture yield trials and an unvegetated sand leaching column.

The unvegetated leaching experiments 2 and 4 showed that LWSSP fertiliser leached half as much phosphorus as single superphosphate.

Experiment 3 had results that were unusual. The unfertilised heavy soil column had the largest cumulative phosphorus leachate, which was mainly caused by leaching in the first three measurements. It is not clear if leachate was filtered prior to chemical analysis or if an inert filter media was used at the base of columns to prevent particulate leaching. Thus, it is possible that particulate phosphorus was collect and measured, which would overstate phosphorus leachate mass of this experiment. The results from experiment 3 are not discussed further here due to this possible issue,

The pasture yield experiments (equal portions of ryegrass and clover) of experiment 4 found that there was little difference in fertiliser type or application rate for both sites over the three-year period. This indicates that these LWSSP blends were as effective as single superphosphate.

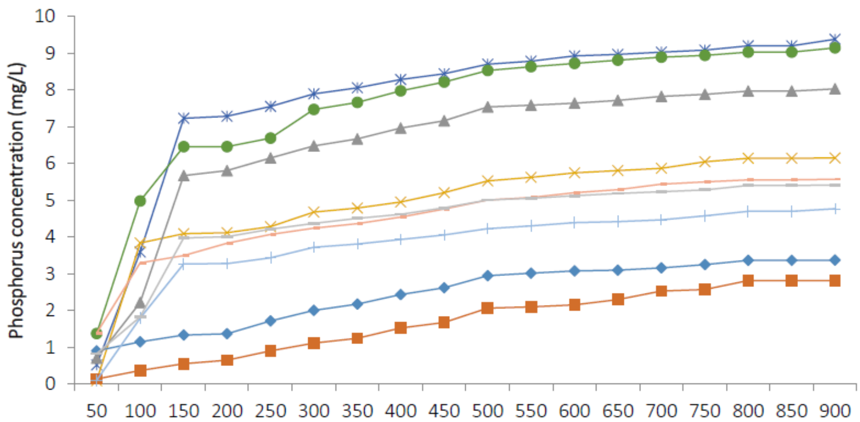


Figure 5.6 Cumulative totals of phosphorus in leachate from the heavy soil, rainfall is displayed along the X axis. * nil (nil-P), × nil (low water-soluble superphosphate), ● nil (single superphosphate), □ clover (nil-P), ◊ clover (low water-soluble superphosphate), Δ clover (single superphosphate), ○ ryegrass (nil-P), + ryegrass (low water-soluble superphosphate), — ryegrass (SSP). The least significant difference for comparing phosphate forms between treatments (lsd = 1.1).

Overseer and Nguyen et al. (2002)

Reactive phosphate rock (RPR) fertilisers are the only fertiliser type that had lower phosphorus export in Overseer. These RPR fertilisers are intended to be used in acidic sandy soils or areas with high phosphorus export risk, such as inundated areas. The Overseer phosphorus model (McDowell et al. 2005), references the work of the work of Nguyen et al. (2002) when discussing reactive phosphate rock.

This New Zealand study used columns of bare silt loam soils from an experimental dairy to measure the nutrient exports from superphosphate or reactive phosphate rock applied at 35 kg/ha. The study used simulated rainfall events of 50 mm over an hour at days 3,10 and 32 after fertilisation. The study measured soluble and particulate P in runoff and drainage. The main findings were:

- **Phosphorus mass in surface runoff**: Reactive phosphate rock exported 61% less P (soluble + particulate phosphorus) than superphosphate (cumulative export from days 3–32). Note that this data was not explicitly given by Nguyen et al. (2002) and was calculated from using the results for soluble and particulate P in runoff (Tables 4 & 6 in Nguyen et al. 2002). The sum of soluble and particulate data was assumed to constitute all surface runoff phosphorus losses. Table F.8 gives this annotated and calculated data.
    - **Soluble P mass in surface runoff**: Reactive phosphate rock exported 96% less soluble P than superphosphate.
    - **Particulate P mass in surface runoff**: Reactive phosphate rock exported 40% less particulate P than superphosphate.
- **Phosphorus concentration in subsurface drainage**: Concentrations in drainage were about 39% lower when using reactive phosphate rock compared to single superphosphate. This was inferred from at day 32 in Figure 6B (Nguyen et al. 2002).

Table F.8: Cumulative surface runoff phosphorus export mass resulting from applications of single superphosphate (SSP) reactive phosphate rock (RPR) and no fertiliser application from Nguyen et al. (2002)

Soil/site	**Fertiliser**	**Soluble phosphorus export** (µg)	**Reduction from SSP** (%)	**Particulate phosphorus export** (µg)	**Reduction from SSP** (%)	**Total phosphorus export** (µg)	**Reduction from SSP** (%)
WM1/1	Control	343		22 415		22 758	
	SSP	20141		34 846		54 987	
	RPR	845	96%	21 611	38%	22 456	59%
S block	Control	466		20 309		20 775	
	SSP	22 516		36 114		58 630	
	RPR	914	96%	21 248	41%	22 162	62%
WM1/1	Control	383		19 847		20 230	
	SSP	21 047		33 432		54 479	
	RPR	806	96%	20 137	40%	20 943	62%
Organic	Control	453		19 533		19 986	
	SSP	21 395		34 026		55 421	
	RPR	858	96%	19 633	42%	20 491	63%
All sites	Average		96%		40%		61%
	Min		96%		38%		59%
	Max		96%		42%		63%

F.3 Dairy effluent management supporting information

Table F.9: Dairy survey criteria

On-site assessment checklist			
Insert farmer name:	**Date:**		
Water use efficiency	**Yes**	**No**	**Not assessed**
Water off roof diverted			
Platecooler water recycled			
Other water diverted away			
Water use audit done			
water use at or below industry median?			
Nozzle types high vol/low pressure			
Result: meets industry standards			
Result: partially meets industry standards			
Result: does not meet industry standards			
Effluent containment			
Solids trap/sump or collection ditch			
Hold 2-3 days effluent			
Result:			
Storage of effluent			
Lined			
Sufficent winter capacity			
Result:			
Effluent application system			
Infrastructure in place eg pump, main line, irrigator			
Equipment operational/commissioned			
Waterways > 100m from application areas			
Application area adequate (liquids)			
Area soil tested			
Fertiliser adjusted			
Solids spread away from shed			
Result:			
Management & Maintenance			
Equipment serviced /maintained			
Trap cleaned on regular basis (not as needed)			
Pond emptied before winter			
Pond desludged periodically			
Solids stockpiled on pad			
Irrigator shifted regularly			
Current Eff Mngt Plan			
Result:			
Effluent prevented from entering surface or groundwater			
Is there an overall risk based on above; insert comment			

Dairy effluent management: Literature review

Here we summarise the available literature on the effect of dairy effluent management on P export that was used to inform the dairy effluent management scenario. Ideally, Overseer or other suitable models would be used to model the effect of improving dairy effluent management practices. However, Overseer assumes that dairy effluent management is undertaken according to best practice and does not model: dairy effluent being discharged directly to streams, ineffective or leaking wastewater ponds or the over irrigation of nutrient rich wastewater.

A literature review undertaken by Ecotones & Associates (2005) for the Peel-Harvey SSPRED model cited nutrient load reductions of 4-95% based on various animal industry wastewater pond intervention studies.

The Leschenault WQIP estimated that best practice effluent management would reduce nutrient exports from dairy sheds by 60% (Hugues-dit-Ciles et al. 2012).

A literature review undertaken by Haine et al. (2011) found that effluent treatment ponds resulted in nutrient reductions of 0-73% for nitrogen and 14% for phosphorus. However, when coupled with land application, dairy effluent loads could be reduced by 90% for nitrogen and 98% for phosphorus.

Given the above and the generally low standard of dairy effluent management in the Peel-Harvey catchment, best-practice dairy shed effluent management was assumed to reduce the nitrogen and phosphorus exports of dairy sheds by 60%. Dairy sheds contribute 10% of dairy farm (shed + paddock) nitrogen exports and 40% of phosphorus exports. The nutrient export from dairy paddocks was unchanged by this scenario.

F.4 Summary of the catchment model management scenario results

Table F.10: Nitrogen load removal from all individual and combined management scenarios

Reporting catchment	Basecase	Load reduction target		Catchment revegetation				Dairy effluent management		Intensive sources						WWTP management		Septic tank removal							
				Native vegetation		Plantations				Intensive animal industries		Intensive horticulture		All intensive sources				Scenario 1: Targeted septic tank removal		Scenario 2: Small lots close to waterways		Scenario 3: Lots less than 1 ha		Scenario 4: Remove all septic tanks	
	Load to estuary	Load reduction		Load removed		Load removed		Load removed		Load removed		Load removed		Load removed		Load removed		Load removed		Load removed		Load removed		Load removed	
	(kg)	(kg)	(%)	(kg)	(%)	(kg)	(%)	(kg)	(%)	(kg)	(%)	(kg)	(%)	(kg)	(%)	(kg)	(%)	(kg)	(%)	(kg)	(%)	(kg)	(%)	(kg)	(%)
Peel Main Drain	11 586	3 306	29	1 283	11	1 160	10	0	-	863	7.4	242	2.1	1 105	10	0	-	0	-	548	4.7	577	5.0	3 019	26
Upper Serpentine	71 844	31 125	43	5 325	7.4	5 025	7.0	429	0.6	8 719	12	1 037	1.4	10 080	14	0	-	0	-	5	<0.1	2 105	2.9	7 585	11
Dirk Brook	28 748	13 667	48	0	-	0	-	51	0.2	4 111	14	541	1.9	4 653	16	0	-	0	-	0	-	0	-	296	1.0
Nambeelup	40 302	27 616	69	14 638	36	14 724	37	270	0.7	192	0.5	7	<0.1	199	0.5	0	-	0	-	0	-	0	-	91	0.2
Mandurah	5 007	1 129	23	0	-	0	-	0	-	0	-	0	-	0	-	0	-	3 011	60	3 024	60	3 099	62	3 111	62
Lower Serpentine	11 724	5 396	46	182	1.6	170	1.5	0	-	884	7.5	21	0.2	904	7.7	0	-	380	3.2	1 048	8.9	1 054	9.0	3 728	32
Upper Murray	80 210	24 069	30	6 674	8.3	6 016	7.5	0	-	197	0.2	61	<0.1	257	0.3	143	0.2	0	-	0	-	0	-	0	-
Lower Murray	103 388	42 137	41	0	-	0	-	42	<0.1	6 572	6.4	84	<0.1	6 657	6.4	0	-	0	-	0	-	1 012	1.0	3 380	3.3
Coolup (Peel)	20 999	9 567	46	8 125	39	8 163	39	146	0.7	134	0.6	0	-	134	0.6	0	-	0	-	0	-	0	-	50	0.2
Coolup (Harvey)	13 349	5 763	43	3 532	26	3 549	27	116	0.9	54	0.4	71	0.5	125	0.9	0	-	0	-	0	-	0	-	63	0.5
Mayfield Drain	33 299	15 294	46	13 840	42	13 879	42	117	0.4	77	0.2	18	<0.1	95	0.3	0	-	0	-	0	-	0	-	45	0.1
Harvey	205 464	100 840	49	37 530	18	36 740	18	1 116	0.5	176	<0.1	420	0.2	1 166	0.6	830	0.4	201	<0.1	494	0.2	817	0.4	1 957	1.0
Meredith Drain	6 739	4 030	60	0	-	0	-	0	-	863	13	13	0.2	876	13	0	-	0	-	0	-	0	-	8	0.1
Estuary (coastal plain)	552 447	259 869	47	84 455	15	83 409	15	2 288	0.4	22 646	4.1	2 454	0.4	25 994	4.7	830	0.2	3 593	0.7	5 119	0.9	8 665	1.6	23 334	4.2
Estuary (total)	632 657	283 938	45	91 129	14	89 425	14	2 288	0.4	22 842	3.6	2 514	0.4	26 251	4.1	973	0.2	3 593	0.6	5 119	0.8	8 665	1.4	23 334	3.7

Reporting catchment	Basecase	Load reduction target		WSUD in existing urban areas		Constructed wetlands		Riparian zone management				Combined scenarios					
								Stock exclusion (fencing only)		Fencing and revegetation		Best-practice agriculture		Non-agricultural actions		All actions (agricultural & non-agricultural)	
	Load to estuary	Load reduction		Load removed		Load removed		Load removed		Load removed		Load removed		Load removed		Load removed	
	(kg)	(kg)	(%)	(kg)	(%)	(kg)	(%)	(kg)	(%)	(kg)	(%)	(kg)	(%)	(kg)	(%)	(kg)	(%)
Peel Main Drain	11 586	3 306	29	549	4.7	3 476	30	1 017	8.8	1 913	17	863	7.4	3 443	30	4 163	36
Upper Serpentine	71 844	31 125	43	933	1.3	21 553	30	5 020	7.0	14 203	20	9 147	13	19 224	27	26 563	37
Dirk Brook	28 748	13 667	48	1	<0.1	8 624	30	1 935	6.7	5 021	17	4 163	14	5 022	17	8 457	29
Nambeelup	40 302	27 616	69	5	<0.1	12 091	30	3 488	8.7	9 265	23	462	1.1	20 542	51	20 898	52
Mandurah	5 007	1 129	23	817	16	0	-	0	-	0	-	0	-	3 829	76	3 829	76
Lower Serpentine	11 724	5 396	46	504	4.3	0	-	641	5.5	1 127	10	884	7.5	2 090	18	2 889	25
Upper Murray	80 210	24 069	30	120	0.1	0	-	7 046	8.8	13 150	16	0	-	0	-	0	-
Lower Murray	103 388	42 137	41	674	0.7	0	-	4 130	4.0	9 812	9.5	6 614	6.4	10 422	10	16 409	16
Coolup (Peel)	20 999	9 567	46	8	<0.1	0	-	1 704	8.1	4 940	24	280	1.3	11 160	53	11 375	54
Coolup (Harvey)	13 349	5 763	43	27	0.2	0	-	1 040	7.8	3 034	23	171	1.3	5 784	43	5 916	44
Mayfield Drain	33 299	15 294	46	1	<0.1	9 990	30	1 070	3.2	7 570	23	193	0.6	18 265	55	18 414	55
Harvey	205 464	100 840	49	818	0.4	61 639	30	18 097	8.8	41 390	20	1 292	0.6	72 173	35	73 205	36
Meredith Drain	6 739	4 030	60	0	-	2 022	30	584	8.7	1 558	23	863	13	1 558	23	2 222	33
Estuary (coastal plain)	552 447	259 869	47	4 337	0.8	119 394	22	38 726	7.0	99 834	18	24 933	4.5	173 512	31	194 339	35
Estuary (total)	632 657	283 938	45	4 457	0.7	119 394	19	45 772	7.2	112 984	18	24 933	3.9	173 512	27	194 339	31

Table F.11: Phosphorus load removal from all individual and combined management scenarios

Reporting catchment	Basecase	Load reduction target		Catchment revegetation				Fertiliser management		Fertiliser management with LWSP fertilisers		Dairy effluent management		Soil amendment		Intensive sources						WWTP management	
				Native vegetation		Plantations										Intensive animal industries		Intensive horticulture		All intensive sources			
	Load to estuary	Load reduction		Load removed		Load removed		Load removed		Load removed		Load removed		Load removed		Load removed		Load removed		Load removed		Load removed	
	(kg)	(kg)	(%)	(kg)	(%)	(kg)	(%)	(kg)	(%)	(kg)	(%)	(kg)	(%)	(kg)	(%)	(kg)	(%)	(kg)	(%)	(kg)	(%)	(kg)	(%)
Peel Main Drain	1 418	728	51	83	5.8	45	3.2	47	3.3	54	3.8	0	-	34	2.4	24	1.7	649	46	672	47	0	-
Upper Serpentine	9 975	6 581	66	1 444	14	997	10	1 945	20	2 364	24	136	1.4	2 215	22	258	2.6	1 911	19	2 214	22	0	-
Dirk Brook	2 777	1 520	55	0	<0.1	0	<0.1	746	27	923	33	19	0.7	883	32	205	7.4	286	10	491	18	0	-
Nambeelup	6 664	5 607	84	2 714	41	2 716	41	2 621	39	3 272	49	53	0.8	3 614	54	23	0.3	22	0.3	45	0.7	0	-
Mandurah	514	190	37	0	-	0	-	0	-	0	-	0	-	0	-	0	-	0	-	0	-	0	-
Lower Serpentine	2 139	1 611	75	49	2.3	32	1.5	496	23	629	29	0	-	662	31	186	8.7	66	3.1	252	12	0	-
Upper Murray	960	0	0	73	7.6	24	2.5	1	0.1	1	0.1	0	-	0	-	3	0.3	18	1.8	21	2.2	41	4.3
Lower Murray	6 212	1 108	18	0	-	0	-	2 445	39	2 955	48	14	0.2	2 555	41	54	0.9	190	3.1	244	3.9	0	-
Coolup (Peel)	2 747	1 795	65	1 934	70	1 935	70	1 108	40	1 359	49	47	1.7	1 288	47	26	0.9	0	-	26	0.9	0	-
Coolup (Harvey)	2 053	1 421	69	843	41	844	41	803	39	994	48	39	1.9	1 007	49	22	1.1	82	4.0	104	5.1	0	-
Mayfield Drain	3 619	2 119	59	2 607	72	2 607	72	1 466	41	1 773	49	48	1.3	1 597	44	1	0.0	79	2.2	80	2.2	0	-
Harvey	20 109	11 391	57	9 942	49	9 000	45	7 387	37	8 724	43	669	3.3	6 728	33	25	0.1	204	1.0	723	3.6	71	0.4
Meredith Drain	1 045	819	78	0	-	0	-	268	26	340	33	0	-	362	35	167	16	31	3.0	198	19	0	-
Estuary (coastal plain)	59 272	34 890	59	19 615	33	18 176	31	19 332	33	23 387	39	1 027	1.7	20 945	35	990	1.7	3 521	5.9	5 050	8.5	71	0.1
Estuary (total)	60 231	34 890	58	19 689	33	18 200	30	19 333	32	23 388	39	1 027	1.7	20 945	35	993	1.6	3 538	5.9	5 070	8.4	112	0.2

Reporting catchment	Basecase	Load reduction target		Septic tank removal								WSUD in existing urban areas		Constructed wetlands		Riparian zone management				Combined scenarios					
				Scenario 1: Targeted septic tank removal		Scenario 2: Small lots close to waterways		Scenario 3: Lots less than 1 ha		Scenario 4: Remove all septic tanks						Stock exclusion (fencing only)		Fencing and revegetation		Best-practice agriculture		Non-agricultural actions		All actions (agricultural & non-agricultural)	
	Load to estuary	Load reduction		Load removed		Load removed		Load removed		Load removed		Load removed		Load removed		Load removed		Load removed		Load removed		Load removed		Load removed	
	(kg)	(kg)	(%)	(kg)	(%)	(kg)	(%)	(kg)	(%)	(kg)	(%)	(kg)	(%)	(kg)	(%)	(kg)	(%)	(kg)	(%)	(kg)	(%)	(kg)	(%)	(kg)	(%)
Peel Main Drain	1 418	728	51	0	-	40	2.8	42	2.9	218	15	79	5.6	709	50	39	2.7	37	2.6	93	6.5	194	14	226	16
Upper Serpentine	9 975	6 581	66	0	-	0	0.0	104	1.0	376	3.8	107	1.1	4 987	50	262	2.6	353	3.5	3 677	37	1 849	19	4 248	43
Dirk Brook	2 777	1 520	55	0	-	0	-	0	-	15	0.5	0	0.0	1 388	50	65	2.3	85	3.1	1 531	55	85	3	1 569	57
Nambeelup	6 664	5 607	84	0	-	0	-	0	-	23	0.3	1	0.0	3 332	50	191	2.9	253	3.8	4 992	75	2 865	43	5 514	83
Mandurah	514	190	37	148	29	148	29	152	30	153	30	161	31	0	-	0	-	0	-	0	-	309	60	309	60
Lower Serpentine	2 139	1 611	75	11	0.5	31	1.4	31	1.5	110	5.1	189	8.9	0	-	41	1.9	37	1.7	1 106	52	283	13	1 329	62
Upper Murray	960	0	0	0	-	0	-	0	-	0	-	2	0.2	0	-	82	8.5	153	16	0	-	0	-	0	-
Lower Murray	6 212	1 108	18	0	-	0	-	17	0.3	55	0.9	83	1.3	0	-	90	1.4	111	1.8	4 142	67	192	3	4 260	69
Coolup (Peel)	2 747	1 795	65	0	-	0	-	0	-	1	0.0	1	0.0	0	-	74	2.7	107	3.9	1 984	72	1 966	72	2 340	85
Coolup (Harvey)	2 053	1 421	69	0	-	0	-	0	-	1	0.1	7	0.3	0	-	55	2.7	77	3.7	1 484	72	895	44	1 655	81
Mayfield Drain	3 619	2 119	59	0	-	0	-	0	-	14	0.4	0	0.0	1 810	50	40	1.1	136	3.8	2 508	69	2 645	73	3 029	84
Harvey	20 109	11 391	57	60	0.3	149	0.7	246	1.2	588	2.9	66	0.3	10 055	50	649	3.2	773	3.8	12 214	61	10 455	52	14 320	71
Meredith Drain	1 045	819	78	0	-	0	-	0	-	2	0.2	0	-	522	50	30	2.9	40	3.9	667	64	40	4	682	65
Estuary (coastal plain)	59 272	34 890	59	219	0.4	367	0.6	591	1.0	1 557	2.6	694	1.2	22 803	38	1 536	2.6	2 009	3.4	34 397	58	21 778	37	39 480	67
Estuary (total)	60 231	34 890	58	219	0.4	367	0.6	591	1.0	1 557	2.6	696	1.2	22 803	38	1 618	2.7	2 162	3.6	34 397	57	21 778	36	39 480	66