4. Effects Associated with Changes in Baseline Groundwater Levels

As detailed in the previous section, development of the CPWL scheme will result in a net increase in the overall water budget of the Central Plains area. This situation will arise due to a combination of

- The transfer of surface water via CPWL infrastructure into the Central Plains area;
- Increased land surface recharge on approximately 30,000 ha of additional irrigated land[8];
- Decreased groundwater abstraction as a portion of existing groundwater takes are replaced by surface water drawn from the CPWL reticulation.

The net result of these changes will be a rise in the water table in the area underlying the CPWL scheme. Due to the depth of the water table across a majority of the Central Plains this groundwater mounding is unlikely to result in significant adverse effects and may provide positive benefits due to improved reliability of supply and reduced pumping lift from groundwater users and a reduced frequency of flow loss across middle reaches of the Selwyn River. However, the increased groundwater flux resulting from CPWL development will also result in an increase in groundwater levels in lowland areas of the Central Plains as groundwater flows toward coastal discharge areas (lowland streams, indirect seepage to Te Waihora/Lake Ellesmere and offshore areas).

While the projected magnitude of changes to existing groundwater levels in lowland areas are relatively minor, the shallow water table and natural interaction between groundwater and the surface environment mean these areas are sensitive to relatively minor changes in existing groundwater levels. Potential effects associated with potential changes to groundwater levels in lowland areas (both positive and negative) include:

- Effects on existing wastewater infrastructure due to increased inflows of groundwater via leaking pipes in older parts of the reticulation,
- Decreased treatment efficiency and/or capacity for wastewater and stormwater discharges to land;
- Increased inundation of low-lying land around the margins of Te Waihora/Lake Ellesmere resulting in a decrease in agricultural productivity;
- Increased flows in lowland drainage schemes;
- Increased baseflows in lowland streams.

It is noted that under existing conditions, many lowland areas currently experience issues (particularly in terms of land drainage) during periods of naturally high groundwater levels. Development of the CPWL scheme has the potential to exacerbate the extent and magnitude of such conditions.

Due to the heterogeneity of the geological environment and regional-scale utilised for modelling of cumulative effects associated with development of the CPWL scheme, limited local scale assessment of

[8] Recharge modelling data provided by Environment Canterbury indicate that land surface recharge increases from approximately 30 percent of rainfall under dryland conditions (typically 200-300mm/year) to around 55% of rainfall under irrigated conditions (typically 400-500 mm/*year)*.

potential effects was undertaken for the CPWL resource consent process. Rather, an 'adaptive management' approach was adopted whereby adverse effects associated with elevated groundwater levels would be addressed on a case-by-case basis as and when they arose.

The following section provides a brief overview of potential effects associated with increased groundwater levels in lowland areas resulting from the operation of the CPWL scheme. Information presented is largely derived from evidence presented at the CPWL resource consent hearing supplemented by analysis of the relationship between groundwater levels and flows in lowland streams.

4.1. Community Water Services

The Selwyn District Council (SDC) operate an extensive water supply, wastewater and stormwater network servicing communities to the east (i.e. down gradient) of the CPWL command area. This network services Rolleston, Prebbleton, Lincoln, Leeston and Southbridge along with a number of smaller townships and consists of reticulation networks, supply wells, pumping stations, treatment systems and infrastructure associated with disposal of treated water to land.

As illustrated in **Figure 38**, much of the current District Council water infrastructure is located within areas where the seasonal water table currently occurs at shallow depths (<1 metre below ground) or, as in the case of Rolleston, where groundwater modelling indicates groundwater levels are likely to rise within 1 metre of the land surface as a result of CPWL operation[9]. As illustrated in **Figure 39,** operation of the CPWL scheme is likely to increase the duration over which groundwater levels occur at shallow depths. In the example shown, modelling results indicate that the percentage of time groundwater levels are within 0.5 metres of the land surface at Lincoln increase from approximately 29 percent of the time currently to around 40 percent of the time following CPWL development.

In addition to issues associated with physical construction of the CPWL scheme, Blake-Manson (2008) identified the following potential issues associated with SDC water infrastructure as a result of CPWL operation:

- Increased pumping costs associated with increased groundwater inflows to the wastewater and stormwater reticulation;
- Reduction in treatment system capacity in situations where a shallow water table reduces infiltration capacity or treatment efficiency;
- An increased risk of non-compliance with resource consent conditions related to system operation;
- Increased costs for the community associated with replacement/upgrading of existing infrastructure and development of additional treatment capacity.

These issues are summarised in **Table 1** below.

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[9] Although it is noted that the distribution of areas currently experiencing potential minimum water table depths within 1 m and 5 m of the land surface respectively shown in Figure 37 (from modelling undertaken by Aqualinc for the CPWL application) differ from those interpolated for this report (illustrated on Figure 19 above). However, notwithstanding these differences, both estimates indicate a significant proportion of SDC water supply, wastewater and stormwater reticulation to the east of SH1 occurs in areas with a shallow water table which is likely to increase in response to the CPWL scheme.

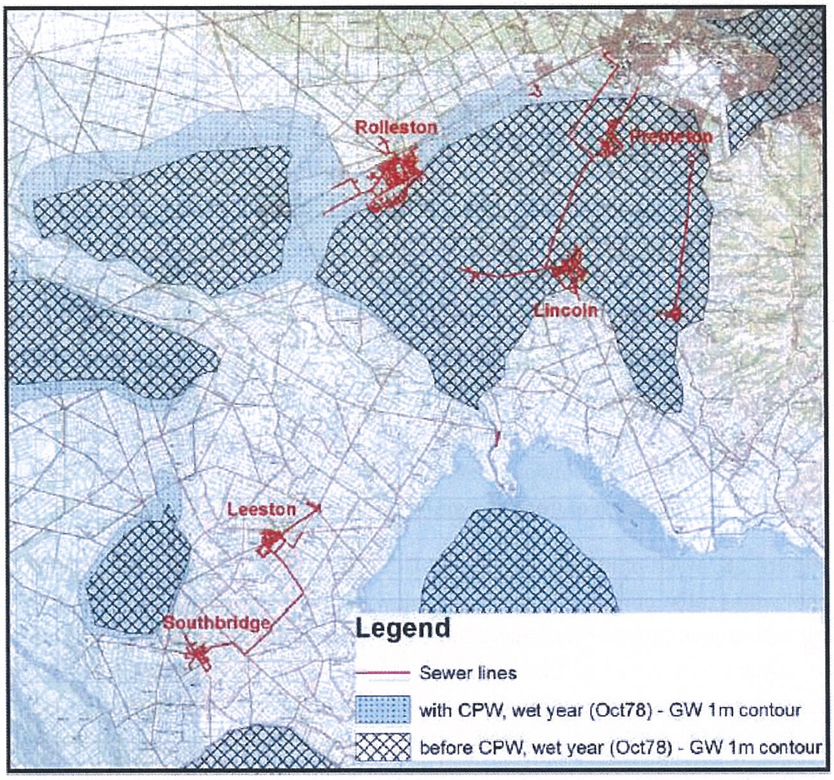

Figure 38. Map of SDC reticulated wastewater schemes in the lower Central Plains area showing the modelled extent of areas experiencing water tables <1 m below ground prior to and following operation of the CPWL scheme (reproduced from Lewthwaite (2008))

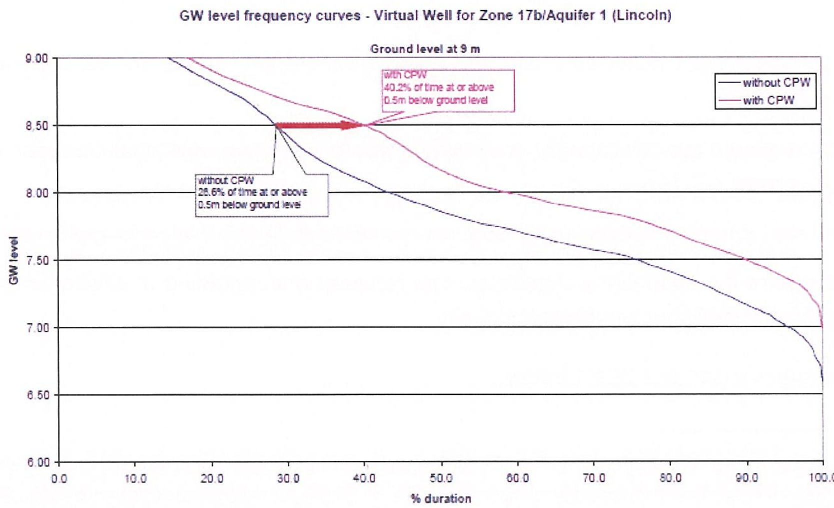

Figure 39. Potential effect of CPWL operation on the frequency of groundwater levels within 0.5 m of the land surface at Lincoln (reproduced from Lewthwaite (2008))

Table 1. Potential issues for operation of SDC water infrastructure associated with development of the CPWL scheme (reproduced from Blake-Manson, 2008)

Utility	Issue	Effect	Most Effected
Community Water Supply	Disruption (breakages, rerouting etc during construction	▪ Water outages ▪ Cost to community ▪ LOS failed ▪ Ingress of contaminated water	Rural water supplies
	Water mains under CPWL structures	▪ Cost to repair ▪ Difficult to ascertain failure	▪ Rural water supplies ▪ Critical rising mains
	Effect on overall groundwater quality	▪ Elevated health risks	▪ Individual well users
	Groundwater quality in SDC supply wells	Non-compliance with NZDWS 2005	Reticulated areas
Wastewater	Increased infiltration into wastewater system	▪ Increased pumping and maintenance costs ▪ Reduction in treatment system capacity ▪ Increased risk of non-compliance	Upper Selwyn Huts, Springston, Lincoln, Leeston and Prebbleton
	Disposal systems compromised	Reduced ability for land disposal systems to operate to design capacity Population growth and/or development may be constrained by capacity issues	Rolleston and Leeston
Storm water	Increased groundwater levels	Reduction in the ability of existing systems to treat and dispose stormwater via infiltration	Lincoln, Leeston, Springston, Tai Tapu and Southbridge

4.2. Wastewater and Stormwater Discharges

In addition to community schemes operated by SDC, a significant number of wastewater and stormwater discharges to land are located in the lower Central Plains area. These discharges include a large number of individual on-site wastewater and stormwater systems as well as agricultural and various miscellaneous discharges (e.g. leachate, contaminated water, cooling water, swimming pool water).

Figure 40 shows a plot of data from the Environment Canterbury Consents database showing the location of currently active resource consents for land discharge down gradient of the CPWL scheme. The data show a total of approximately 1,650 individual discharges including 1,228 on-site wastewater disposal systems (human effluent), 201 agricultural discharges (animal effluent) and 181 stormwater discharges. In addition there are potentially a significant number of additional discharges operating in this area which do not currently have resource consents. Such discharges may include historical

discharges which predate introduction of current legislative requirements, discharges operating under permitted activity rules and unauthorised discharges.

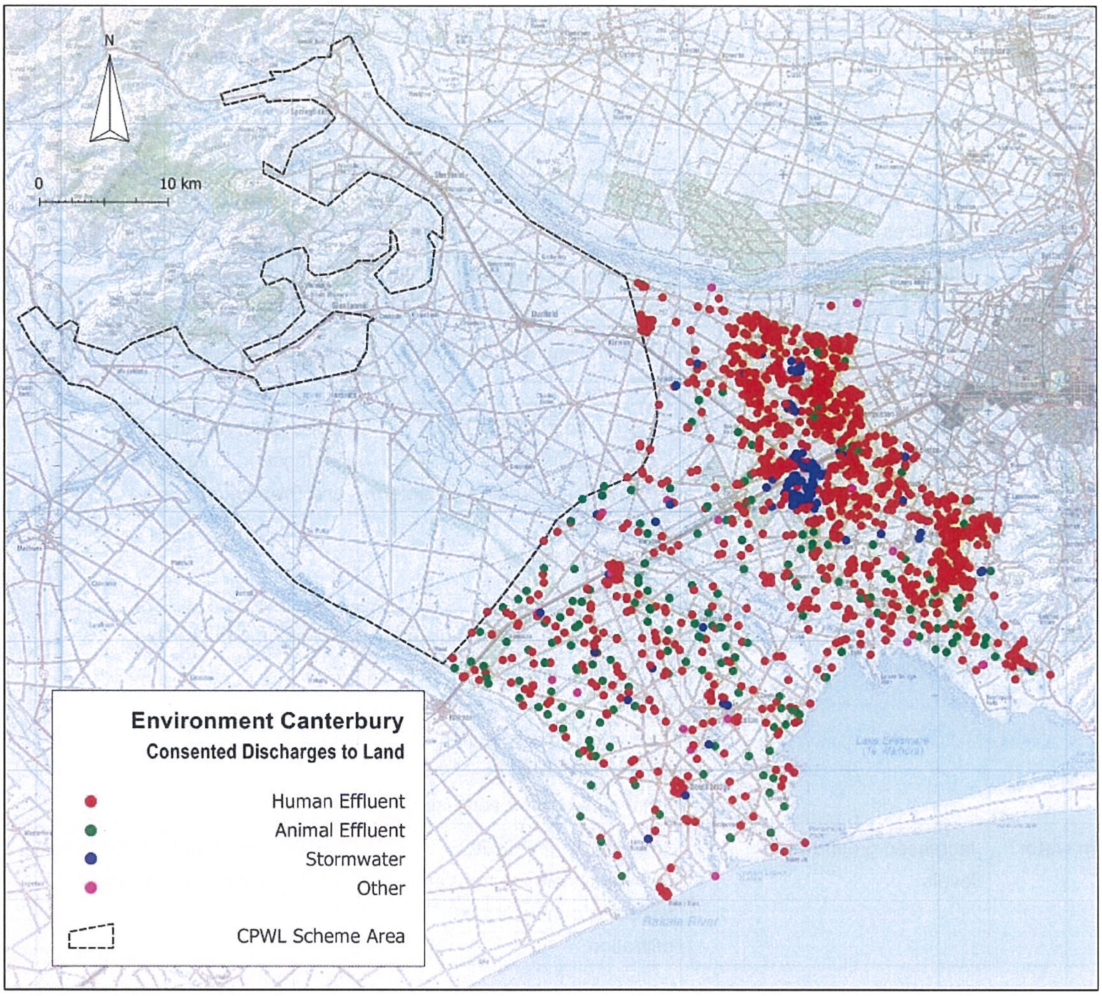

Figure 40. Location and type of current resource consents for land discharge downgradient of the CPWL scheme (data sourced from ECan GIS)

Like District Council infrastructure, many on-site wastewater and stormwater discharges in the Central Plains area have the potential to be adversely affected during periods of high groundwater levels, particularly if the magnitude and duration of peak groundwater levels increases due to operation of the CPWL scheme.

While the potential for localised effects on existing discharges was acknowledged during the consent process, it was considered unrealistic to provide an assessment of the potential effects of CPWL

operation on individual disposal systems[10]. Instead it was accepted that an 'adaptive management' approach would be a necessary feature of future management of groundwater mounding whereby solutions would be developed and implemented to address adverse effects as and where they occur (where such effects can be attributed to operation of the CPWL scheme). To this end, the final conditions for the CPWL scheme specify a requirement to:

26. Lowland Drainage

Prior to the finalisation of the Ground and Surface Water Plan: Part 2, the consent holder shall:

(a) undertake a baseline survey of the lowland drainage systems of the Central Plains taking into consideration historical data. The survey shall build on existing data, and include:

(i) An evaluation of the current cultural health and identification of the mahinga kai values of these waterways;

(ii) An inventory of drains and streams, their location, size and capacity,

(iii) An inventory of sewerage systems (reticulated and individual septic tanks),

(iv) The conditions of these facilities, their capacities, maintenance activities, dates of installation, histories of water-level related issues,

(v) Records of stream and drain flows and groundwater levels,

(vi) Existing management and administration arrangements for the drainage schemes,

(vii) Current costs of maintenance and operation of the drainage schemes.

(b) Identify groundwater levels that would trigger the implementation of mitigation measures as specified in condition 21(a). The baseline survey and trigger levels shall be incorporated into the Ground and Surface Water Plan.

Condition 31 (c) requires CPWL to undertake the initiate the following actions should a groundwater level trigger defined in the Ground and Surface Water Plan:

c) In the event that the groundwater trigger levels specified in the Ground and Surface Water Plan are reached, the consent holder shall undertake measures to avoid, mitigate or remedy any adverse effects related to groundwater levels that may arise as a result of exercising this consent. Mitigation measures may include but not be limited to;

i. additional monitoring;

ii. restricting the use of water for irrigation;

iii. the widening and/or deepening of drains to increase their capacity;

iv. the installation of more drains;

v. providing pumped drainage for affected properties or facilities;

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10 Due to the uncertainty inherent in the application of regional-scale numerical models to predict effects at a local scale as well as the availability of data to characterise the location, condition and operation of individual discharges across the potentially affected area.

vi. *upgrading sewerage reticulation systems to reduce groundwater infiltration into pipes;*

vii. *more frequent maintenance of existing drains, including cleaning;*

viii. *financial compensation in lieu of remedial works; and*

ix. *complementary enhancement measures which may include but are not limited to the construction of wetlands.*

Condition 32 also establishes a process for response to 'complaints' regarding groundwater levels and quality whereby CPWL is required to investigate and, if appropriate, mitigate potential adverse effects associated with operation of the CPWL scheme. Part of the role of the GSWERP is to adjudicate on any such complaints.

4.3. Effects on Lowland Drainage

SDC currently operates 10 land drainage schemes in the Central Plains area. Basic details of these schemes are outlined in **Table 2** and the spatial extent of the 9 schemes around the margins of Te Waihora/Lake Ellesmere is shown in **Figure 41** below[11].

Table 2. SDC drainage schemes in the Central Plains area

Scheme	Length of drain/river (km)	Area serviced (Ha)	Properties serviced
Taumutu	8.2	500	14
Taumutu Culverts	4 culverts	1,000	200
Leeston	207.9	12,847	393
Leeston Township	3.9	89.9	640
Ellesmere	25.7	1,329	74
LII	64.6	5,068	1,055
Greenpark	21.2	2,433	90
Osbornes	9.5	1,256	49
Hororata	5.5	677	15
Halswell	156	11,700	n.a
Total	**502.5**	**36,900**	**2,530**

[11] The remaining scheme (Hororata) is located south-west of Glentunnel

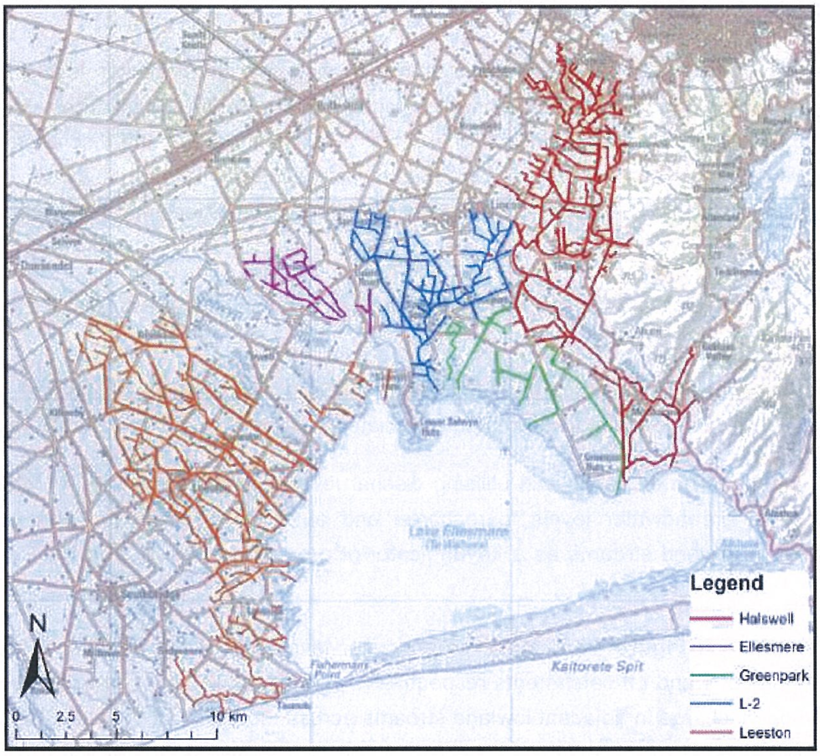

Figure 41. Spatial extent of SDC drainage schemes in the vicinity of Te Waihora/Lake Ellesmere (reproduced from Lewthwaite (2008))

The increase in groundwater levels in lowland areas resulting from operation of the CPWL scheme has the potential to result in a range of effects in terms of land drainage including:

- An increase in the extent and duration of land experiencing surface flooding;
- Increased waterlogging of soils (due to groundwater levels remaining higher for longer) resulting in a decline in agricultural productivity;
- Increased requirements for drain cleaning and other maintenance works to maintain channel capacity
- Capacity issues with the existing drainage network requiring construction of additional drains or pumping.

Potential issues arising from CPWL development on land drainage were canvassed relatively extensively during the resource consent hearing process. However, similar to potential effects on wastewater and stormwater infrastructure, it was again acknowledged that assessment of the magnitude and extent of effects could not be realistically achieved using available assessment methods. As a result, a requirement for 'adaptive management' of land drainage issues was established through the resource consent conditions.

4.4. Effects on Lowland Streams

Williams and Aitchison-Earl (2006) assessed relationships between groundwater levels and flow in lowland streams in the Te Waihora/Lake Ellesmere catchment. The report identified a relatively strong correlation (R^2 >0.65) between local groundwater levels at a range of depths and discharge in adjacent surface waterways, although the nature of the observed relationships differed between catchments reflecting local hydrogeological conditions. Based on the observed relationships the report concluded that:

- Flows in lowland streams provide an indicator of general groundwater pressures in the catchment adjacent to Te Waihora/Lake Ellesmere
- A threshold groundwater pressure in individual monitoring wells could be utilised to manage groundwater abstraction to maintain flows and associated in-stream values in adjacent waterways.

Williams (2011) expanded on this approach utilising discharge in lowland streams as an input to model temporal response of groundwater levels to recharge and abstractive pressure. Again, this report identified discharge in lowland streams as a key indicator of groundwater storage in the Central Plains area.

Figure 42, **Figure 43** and **Figure 44** illustrate groundwater level/stream discharge correlations in the Selwyn River, Harts Creek and LII catchments respectively. Similar relationships are observed between monitoring wells and discharge in adjacent lowland streams across the wider Te Waihora/Lake Ellesmere catchment. However, it is noted that the quality of observed correlations are affected by drawdown occurring in response to abstraction during the summer months, particularly in deeper semi-confined aquifers (see **Figure 12** for an illustration of relative groundwater level variations between different water-bearing layers).

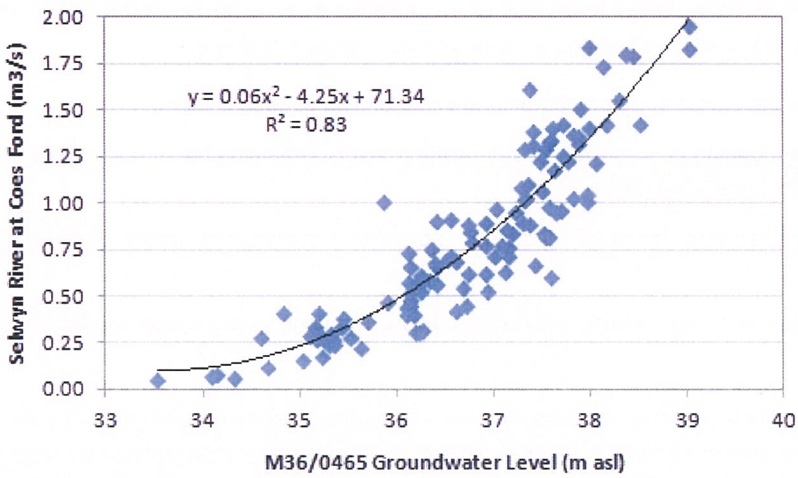

Figure 42. Correlation between groundwater levels in M36/0465 and discharge in the Selwyn River at Coes Ford

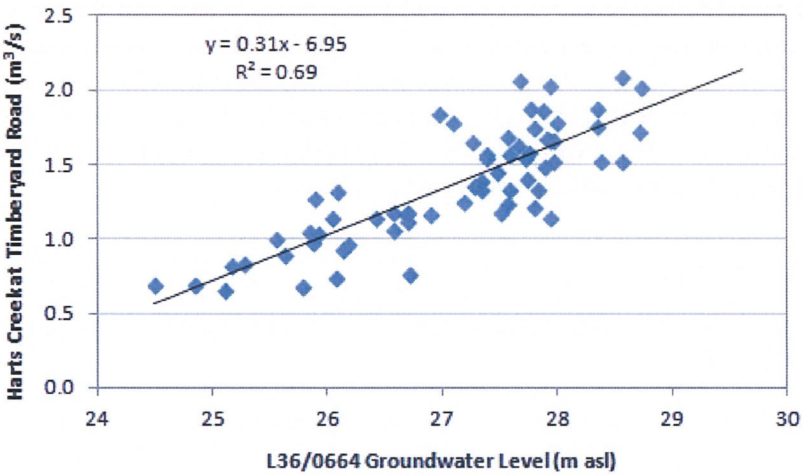

Figure 43. Correlation between groundwater levels in L36/0664 and discharge in Harts Creek at Timberyard Road

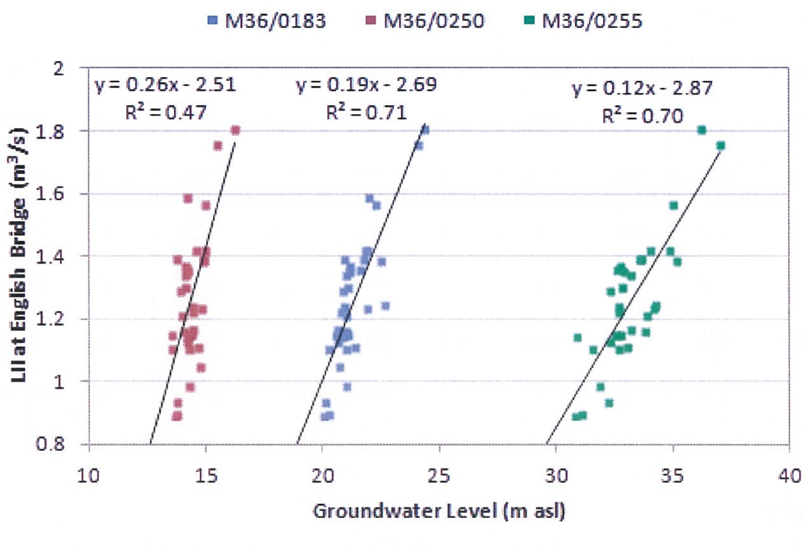

Figure 44. Correlation between groundwater levels and discharge in the LII catchment

Based on observed relationships between groundwater levels and lowland stream discharge it is clear that increases in groundwater levels associated with operation of the CPWL scheme are likely to result in increased discharge in a majority of catchments draining into Te Waihora/Lake Ellesmere. Such increases are likely to be particularly evident during low flow periods when groundwater discharge (as opposed surface runoff or interflow occurring following rainfall events) is the predominant source of flow.

In terms of potential cumulative effects of CPWL development on lowland stream discharge, Clarke (2013) provided an analysis of various land use scenarios on water quantity across the wider Te Waihora/Lake Ellesmere catchment. **Table 3** compares results of this assessment for two of the land use change scenarios modelled; Scenario 1 (essentially status quo land use) and Scenario 2 (CPWL development). The figures include a range of flow statistics and show an appreciable increase in median and low flow discharge in a majority of lowland catchments as a result of CPWL development. For example, once the CPWL scheme is operational 7-day mean annual low flow (MALF) in the lower Selwyn River (the largest surface waterway draining into Te Waihora/Lake Ellesmere) is projected to increase by approximately 210 percent with median flow increasing by 43 percent.

Table 3. Comparison of calculated flow statistics for lowland streams in the Te Waihora/Lake Ellesmere catchment between Scenario 1 (status quo) and Scenario 2 (CPWL development) undertaken for the Selwyn/Waihora limit setting process. Reproduced from Clarke (2013)

River	7D MALF (l/s)		Mean Flow (l/s)		Annual Volume (Mm^3)		Median Flow (l/s)		Flow Permanence (%)	
Scenario	1	2	1	2	1	2	1	2	1	2
Selwyn	289	905	2976	4279	93.9	135	963	1959	99.5	99.9
Halswell	500	570	1186	1277	37.4	40.2	1034	1116	99.7	99.7
L-2	1050	1370	2307	2645	72.8	83.4	2170	2506	99.8	100
Irwell	1.7	5.9	400	482	12.6	15.2	152	216	84.7	86.4
Hanmer	3.6	4.2	216	230	6.8	7.3	95.7	100	75.0	75.9
Boggy	0.3	0.5	188	199	5.9	6.3	109	125	79.4	77.5
Doyleston	0.0	0.0	158	200	5.0	6.3	22.0	57.0	65.6	70.7
Harts	560	842	1696	1889	53.5	59.6	1191	1368	100	100
Waikekewai	3.7	6.9	111	133	3.5	4.2	43.7	60.5	92.9	96.3

4.5. Summary

Development of the CPWL scheme will alter the existing water balance of the Central Plains area due to a combination of increased land surface recharge and decreased groundwater abstraction. This will result in mounding of the water table underlying the CPWL command area and an accompanying increase in groundwater levels in lowland areas as the increased recharge flux moves through the aquifer system to natural discharge areas along the coastal margin.

Increased groundwater levels in lowland areas have the potential to result in both negative and positive effects on the environment. Potential adverse effects associated with increased groundwater levels in

lowland areas include deleterious impacts on the capacity and efficacy of wastewater, stormwater and water supply reticulation and/or treatment infrastructure as well as land drainage issues associated with increased waterlogging of agricultural soils and capacity issues in the existing drainage network. However, due to the interconnection between groundwater and lowland streams, increased groundwater levels have the potential to increase discharge in many of the catchments draining to Te Waihora/Lake Ellesmere, particularly during low flow periods.

While increased groundwater levels in lowland areas were largely considered to be a negative outcome during the CPWL resource consent hearing process, potential benefits in terms of lowland stream flows are now recognised thorough the CWMS Selwyn-Waihora limit setting process. For example, a requirement to increase existing minimum flows in lowland streams through a combination of managing cumulative allocation, additional CPWL recharge and potentially augmentation (either directly or via managed aquifer recharge) is detailed in the zone implementation plan (ZIP) and ZIP addendum[12]. As a consequence, management of potential effects of increased groundwater levels in lowland areas may ultimately require development of a management approach which provides the anticipated environmental benefits while minimising adverse effects on the operation of existing water and land drainage infrastructure.

Combined with groundwater level monitoring, identification of temporal changes in the rate of groundwater infiltration into sewage or stormwater networks, the rate of outflow in drainage schemes and the extent of surface inundation of agricultural land are likely to be key metrics for identifying the significance of changes in baseline groundwater levels on existing infrastructure and services. Provision for the recording of such data should be a primary consideration for the establishment of environmental monitoring for the CPWL scheme.

[12] http://ecan.govt.nz/get-involved/canterburywater/committees/selwyn-waihora/Pages/selwyn-waihora-zip.aspx