Water Availability in the Campaspe
Summary of a report to the Australian Government from the CSIRO Murray-Darling Basin Sustainable Yields Project

May 2008
Project framework

The project framework begins with definition of subcatchments for modelling and regions for reporting, and with definition of the climate and development scenarios to be assessed (including generation of the time series of climate data that describe these scenarios). The climate data form inputs to spatio-temporal modelling of the implications of these climate scenarios for catchment runoff and groundwater recharge. The catchment development scenarios (farm dams and commercial plantation forestry) are modifiers of the resulting modelled runoff time series. The runoff implications are then propagated through existing river system models. The recharge implications are propagated through groundwater models – for the major groundwater resources – or considered in simpler assessments for the minor groundwater resources. The connectivity of surface and groundwater is assessed and the actual exchange volumes under current and likely future groundwater extraction are quantified. Monthly water balances for the last 10 to 20 years are analysed using all relevant existing data and remotely-sensed measures of irrigation and floodplain evapotranspiration, and are compared to the river modelling results. The implications of the scenarios for water availability and water use under current water sharing arrangements are then assessed and synthesised.

The uncertainty in the assessments is considered from the perspective of ‘IF this future’ (of climate and development) ‘THEN these hydrologic implications’. There is uncertainty in both the ‘IF’ and the ‘THEN’. The uncertainty in the IF is typically large, since the degree of future global warming cannot be accurately predicted. Additionally, there is still considerable uncertainty in predictions of rainfall change resulting from global warming. The uncertainty in the THEN stems from the adequacy of hydrologic and meteorologic data and the imperfect predictions of hydrologic response to climate change given current understanding. The implications of the uncertainty assessments are summarised under Limitations (page 5) to advise users of the reliability of the assessments with respect to the terms of reference of the project.

Scenarios assessed

The assessments of current and potential future water availability have been undertaken by considering four scenarios of historical, recent and future climate and current and future development. All scenarios are defined by daily time series of climate variables based on different scalings of the 1895–2006 climate. The first scenario is for historical climate and current development and is used as a baseline against which other scenarios are compared. The second scenario is for recent climate and current development and is intended as a basis for assessing future water availability should the climate in the future prove to be similar to that of the last ten years. The third scenario is for future climate and current development and evaluates three global warming scenarios using 15 global climate models to provide a spectrum of possible climates for 2030. From this spectrum three variants are reported: a median or best estimate, a wet variant and a dry variant. The fourth scenario is for future climate and future development and considers the effects of both a 2030 climate and the expansions in farm dams and commercial plantation forestry expected under current policy, and the changes in groundwater extractions anticipated under existing groundwater plans. All scenarios assume current water sharing arrangements and do not attempt to include possible management responses to changes in climate, water availability or development.

Acknowledgments
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Cover: Campaspe River at the confluence with the Murray River at Echuca, Vic (North Central CMA)
The Campaspe region is in northern Victoria and covers 0.4 percent of the total area of the Murray-Darling Basin (MDB). The region is based around the Campaspe River. The population is 42,000 or 2 percent of the MDB total, concentrated in the centres of Echuca, Rochester, Elmore, Heathcote and Kyneton. Over 75 percent of the region is used for dryland agriculture, primarily beef and sheep grazing. Extensive irrigation is undertaken on the riverine plain from south of Rochester to the Murray River and dairying predominates. Approximately 32,500 ha were irrigated in 2000 including 30,700 ha of pasture and hay production and 1400 ha of cereal crops. There are no nationally important wetlands in the region. However, several reaches of the Campaspe River have significant environmental value. The region uses 0.2 percent of the surface water diverted for irrigation in the MDB and 1.7 percent of the total groundwater used in the MDB. Water supply to the Campaspe Irrigation Area is supplemented by water from the Goulburn River system.

**Broad land use in the year 2000**

<table>
<thead>
<tr>
<th>Land use</th>
<th>Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>percent</td>
<td>ha</td>
</tr>
<tr>
<td>Dryland crops</td>
<td>6.2%</td>
</tr>
<tr>
<td>Dryland pasture</td>
<td>69.3%</td>
</tr>
<tr>
<td>Irrigated crops</td>
<td>8.2%</td>
</tr>
<tr>
<td>Cereals</td>
<td>4.3%</td>
</tr>
<tr>
<td>Horticulture</td>
<td>0.3%</td>
</tr>
<tr>
<td>Orchards</td>
<td>0.9%</td>
</tr>
<tr>
<td>Pasture and hay</td>
<td>94.5%</td>
</tr>
<tr>
<td>Native vegetation</td>
<td>14.2%</td>
</tr>
<tr>
<td>Plantation forests</td>
<td>0.4%</td>
</tr>
<tr>
<td>Urban</td>
<td>0.9%</td>
</tr>
<tr>
<td>Water</td>
<td>0.8%</td>
</tr>
<tr>
<td>Total</td>
<td>100.0%</td>
</tr>
</tbody>
</table>

Source: Bureau of Rural Sciences, 2005

**Share of MDB runoff**

0.9%

**Share of total MDB groundwater use (excluding confined aquifers of the Great Artesian Basin)**

1.7%
Key findings

• Average surface water availability under the historical climate is 275 GL/year and under current development 36 percent of this is diverted for use. This is a high level of use. Current groundwater use is about 29 GL/year or 9 percent of total water use.

• If the recent climate (1997 to 2006) were to continue, average surface water availability would be reduced by 54 percent and the volume of water diverted for use within the region would be reduced by 26 percent.

• The best estimate of climate change by 2030 would reduce average surface water availability by 16 percent and would reduce the volume of water diverted for use within the region by 5 percent.

• Future development of farm dams would reduce average annual runoff by 1.5 percent. Groundwater extraction is expected to increase to 33 GL/year by 2030.

For historical climate and current development

The annual rainfall and modelled annual runoff averaged over the region are 594 mm and 69 mm, respectively. The Campaspe region generates about 0.9 percent of the total runoff in the MDB. Current average surface water availability is 275 GL/year — this is water generated from runoff within the region. On average, 342 GL/year are diverted for use in the region (including channel and pipe losses). Around 99 GL/year of this diverted volume is sourced within the region, thus the level of surface water use is 36 percent. This is a high level of development. The other 243 GL/year that is diverted for use is supported by the 507 GL/year transferred from the Goulburn-Broken region via the Waranga Western Channel. This water use (and the associated water availability) is accounted at the point of diversion (in the Goulburn-Broken region) not at the points of use (in the Campaspe and other regions). On average, 264 GL/year in the Waranga Western Channel passes through the Campaspe region to the Loddon-Avoca region.

Groundwater extraction for 2004/05 is estimated at 29 GL and about 88 percent came from the Campaspe Deep Lead Groundwater Management Unit (GMU). This level of groundwater use is 9 percent of current total water use on average and 12 percent of total use in years of lowest flow. Historical groundwater extraction has and will continue to impact on Campaspe River flow and the eventual impact will be a loss to groundwater of 3 GL/year. However, this value is highly uncertain because of large lateral inflows in the groundwater balance. Groundwater extraction in the Campaspe Deep Lead GMU is moderate (extraction is 47 percent of recharge) and low (7 percent of recharge) in the Ellesmere GMU.

Water resource development has led to substantial changes in the winter–spring bankfull flows in the lower Campaspe River which are important for several ecological process and aquatic species. The period between bankfull flow events has increased and the size of these events has been reduced. These changes are likely to have had adverse environmental affects.

For recent climate and current development

The average annual rainfall and runoff over the past ten years (1997 to 2006) were 13 percent and 50 percent lower respectively than the long-term (1895 to 2006) average values. If the climate of the last ten years were to continue, average surface water availability would be reduced by 54 percent and end-of-system flows of the Campaspe River at Echuca would be reduced by 76 percent. The volume of water diverted for use within the region would be reduced by 26 percent. Transfers from the Goulburn-Broken region via the Waranga Western Channel would be reduced by 25 percent. The relative level of surface water use would rise to an extremely high 60 percent.

Rainfall recharge to groundwater would be reduced by 25 percent but current groundwater extraction could be maintained due increases in lateral flows into the groundwater systems.

If the recent climate were to continue, the average period between environmentally beneficial winter–spring bankfull flows in the lower Campaspe River would be eight times longer (or 14 years) and the maximum period between these events would be four times longer (or nearly 30 years). The overbank flood volume per event would be reduced by 43 percent causing a 94 percent reduction in the average annual overbank flood volume. These dramatic changes would have severe impacts on the ecology of the Campaspe River.

For future climate and current development

Rainfall-runoff modelling with climate change projections from global climate models indicates that future runoff in the region will decrease significantly by 2030. Under the best estimate 2030 climate average annual runoff would be reduced by 16 percent. The extreme estimates from the high global warming scenario range from a 46 to a 4 percent reduction in average annual runoff.

Under the best estimate 2030 climate, average surface water availability would be reduced by 16 percent and end-of-system flows at Echuca would be reduced by 27 percent. The volume of water diverted for use within the region would be reduced by 5 percent. Transfers from the Goulburn-Broken region via the Waranga Western Channel would be reduced by 5 percent. The level of surface water use would be 42 percent.

Under the wet 2030 climate extreme, average surface water availability would be reduced by 4 percent and end-of-system flows at Echuca would be reduced by 10 percent. There would be no change in the volumes of surface water diverted for use within the region and no significant change in transfers from the Goulburn-Broken region via the Waranga Western Channel. Under the dry 2030 climate extreme, average surface water availability would be reduced by 46 percent and end-of-system flows at Echuca would be reduced by 69 percent. The volume of water diverted for use within the region would be reduced by 28 percent. Transfers into the region from the Goulburn-Broken region via the Waranga Western Channel would be reduced by 32 percent. The
level of surface water use would then be 57 percent.

By 2030, substantial changes are likely in rainfall recharge to groundwater – between a 34 percent reduction and a 14 percent increase. However, current extraction could be maintained due to changes in lateral groundwater flows.

Under the best estimate 2030 climate, the average period between winter–spring bankfull flows in the lower Campaspe River would increase by nearly one year (44 percent) and the maximum period between these events would increase by about two years (21 percent). The average overbank volume per event would be reduced by 11 percent, and the average annual overbank volume would be reduced by 37 percent. These changes would be likely to have substantial ecological consequences. Under the wet 2030 climate extreme, the average and maximum period between winter–spring high bankfull flows would be increased and overbank flood volumes would be reduced. The dry 2030 climate extreme would lead to changes in environmentally important flows that would be very similar to under a continuation of the recent climate.

**For future climate and future development**

Projected growth in commercial forestry plantations in the region is negligible. Total farm dam storage capacity is projected to increase by 8 percent by 2030 which would reduce average annual runoff by about 1.5 percent. Groundwater extraction is projected to grow to 33 GL/year by 2030. This would cause an average streamflow reduction of about 6 GL/year. In aggregate, future farm dams and the projected additional groundwater extraction would have minor impacts on streamflow and on surface water use.

The runoff estimates for the region are relatively good because there are many gauged catchments from which to estimate the model parameter values.

The largest source of uncertainty in the future climate results is from the global warming projections and the modelled implications of global warming on local rainfall. The uncertainty in the rainfall-runoff modelling of climate change impact on runoff is small compared to the climate change projections. The project takes into account the current uncertainty in climate change projections explicitly by considering results from 15 global climate models and three global warming scenarios based on the Intergovernmental Panel on Climate Change Fourth Assessment Report.

There are also considerable uncertainties associated with the projections of future increases in commercial forestry plantations and farm dam development and the impact of these developments on runoff. The increase in farm dams is estimated based on the current policy controls in Victoria that limit further farm dam development to stock and domestic dams and an assumption that growth in stock and domestic dam storage will be proportional to the rate of rural population growth.

There is uncertainty both as to how landholders will respond to these policies and how governments may set policies in the future.

The river model for the Campaspe River is well suited for the purposes of this project – assessments of total water availability and use. However, some caution is required in interpreting the absolute values of projected changes in low flows, particularly during dry periods. The river model reproduces observed streamflow patterns very well and produces estimates of water balance terms that agree well with separate water balance accounts for the three reaches assessed. The projected changes in flows due to climate change were greater than model uncertainty under the dry 2030 climate extreme and the best estimate 2030 climate, but projected changes were small and within model uncertainty for the wet 2030 climate extreme. The model provides strong evidence of changes in flow pattern due to prior development, but projected changes due to future development are very small for the river reaches considered.

The groundwater assessments made for the Campaspe region applied a model constructed specifically for this project and subjected to rigorous internal review. However, only as it is used more widely, will it receive more thorough external peer review. Monitoring and extraction data are not as good as for some other regions such as the Namoi. The model is adequate for providing information on water availability in the context of this project, but less reliable for local management requirements. The model reached a dynamic equilibrium under both current and future extraction rates.

The environmental assessments of this project only consider a subset of the important assets for this region and are based on limited hydrology parameters with no direct quantitative relationships for environmental responses. Considerably more detailed investigation is required to provide the necessary information for informed management of the environmental assets of the region.
The annual rainfall and modelled runoff averaged over the region are 594 mm and 69 mm, respectively. Rainfall is generally higher in the winter half of the year and most of the runoff occurs in winter and early spring. The region covers 0.4 percent of the MDB and contributes about 0.9 percent of the total runoff.

The average annual rainfall and runoff over the ten-year period 1997 to 2006 are 13 percent and 50 percent lower respectively than the long-term (1895 to 2006) average values. The recent values are statistically significantly different to the long-term averages.

Rainfall-runoff modelling with climate change projections from global climate models (GCMs) indicates that future runoff in the region will decrease significantly. All the modelling results using climate projections from different GCMs show a decrease in runoff. Under the best estimate 2030 climate the average annual runoff would be reduced by 16 percent. The extreme estimates from the high global warming scenario range from a 46 to a 4 percent reduction in average annual runoff. The range from the low global warming scenario is a 14 to a 1 percent reduction in average annual runoff.

Projected growth in commercial forestry plantations in the region is negligible. The total farm dam storage volume is projected to increase by 2750 ML (8 percent) by 2030. This projected increase in farm dams will reduce average annual runoff by about 1.5 percent, relatively small compared to the climate change impact on runoff. The best estimate of the combined impact of 2030 climate and farm dam development would be an 18 percent reduction in average annual runoff. Extreme estimates range from a 47 to a 6 percent reduction.

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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Historical</td>
<td>Rainfall</td>
<td>594</td>
<td>517</td>
<td>-18%</td>
<td>-4%</td>
<td>-1%</td>
<td>-18%</td>
<td>-4%</td>
</tr>
<tr>
<td></td>
<td>Runoff</td>
<td>69</td>
<td>34</td>
<td>-46%</td>
<td>-16%</td>
<td>-4%</td>
<td>-47%</td>
<td>-18%</td>
</tr>
<tr>
<td></td>
<td>Evapotranspiration</td>
<td>525</td>
<td>483</td>
<td>-14%</td>
<td>-2%</td>
<td>0%</td>
<td>-14%</td>
<td>-2%</td>
</tr>
</tbody>
</table>
Rainfall

Annual rainfall (1895–2006) spatially averaged across the region (based on SILO data) with low-frequency smoothed line shown to indicate longer-term variations.

Average (1895–2006) monthly rainfall averaged across the region and range (shaded) of potential changes in mean monthly rainfall due to climate change by 2030.

Runoff

Annual runoff (1895–2006) spatially averaged across the region (based on daily runoff modelling) with low-frequency smoothed line shown to indicate longer-term variations.

Average (1895–2006) monthly runoff averaged across the region and range (shaded) of potential changes in mean monthly runoff due to climate change by 2030.
Surface water

Current average surface water availability for the Campaspe region is 275 GL/year – this is water generated from runoff within the region. On average, 342 GL/year are diverted for use in the region (including channel and pipe losses). Around 99 GL/year of this diverted volume is sourced within the region, thus the level of surface water use is 36 percent. This is a high level of development. The other 243 GL/year that is diverted for use is supported by the 507 GL/year transferred from the Goulburn-Broken region via the Waranga Western Channel. This water use (and the associated water availability) is accounted at the point of diversion (in the Goulburn-Broken region) not at the points of use (in the Campaspe and other regions). On average, 264 GL/year in the Waranga Western Channel passes through the Campaspe region to the Loddon-Avoca region.

Reliability of supply is determined separately for high reliability water shares (HRWS) and low reliability water shares (LRWS) and is reported for allocations in February. In the Campaspe system, a 100 percent HRWS allocation occurs in 99 percent of years and the minimum HRWS allocation is 76 percent. However, these HRWS reliability results are overestimates because the current model configuration does not properly reflect the low allocations of recent years. A 100 percent LRWS allocation occurs in 74 percent of years and a zero LRWS allocation occurs in 10 percent of years. Annual reliability of supply for urban users in the Coliban system is 95 percent and meets Coliban Water’s ‘level of service’ objective.

If the climate of the last ten years were to continue, average surface water availability would be reduced by 54 percent and end-of-system flows of the Campaspe River at Echuca would be reduced by 76 percent. The volume of water diverted for use within the region would be reduced by 26 percent. A 100 percent HRWS allocation would occur in 77 percent of years and the minimum HRWS allocation would be 8 percent. A 100 percent LRWS allocation would occur in 24 percent of years and a zero LRWS allocation would occur in 46 percent of years. Annual reliability of supply for urban users in the Coliban system would drop to 63 percent and breach Coliban Water’s ‘level of service’ objective if there were no intervention. Transfers from the Goulburn-Broken region via the Waranga Western Channel would be reduced by 25 percent. The relative level of surface water use would rise to an extremely high 60 percent.

Under the best estimate 2030 climate, average surface water availability would be reduced by 16 percent and end-of-system flows at Echuca would be reduced by 27 percent. The volume of water diverted for use within the region would be reduced by 5 percent. A 100 percent HRWS allocation would occur in 97 percent of years and the minimum HRWS allocation would be 33 percent. A 100 percent LRWS allocation would occur in 67 percent of years and a zero LRWS allocation would occur in 17 percent of years. Annual reliability of supply for urban users in the Coliban system would drop to 82 percent.

> Campaspe River near Goornong, Vic (North Central CMA)
and breach Coliban Water’s ‘level of service’ objective if there was no intervention. Transfers from the Goulburn-Broken region via the Waranga Western Channel would be reduced by 5 percent. The level of surface water use would be 42 percent.

Under the wet 2030 climate extreme, average surface water availability would be reduced by 4 percent and end-of-system flows at Echuca would be reduced by 10 percent. There would be no change in the volumes of surface water diverted for use within the region and no significant change in transfers from the Goulburn-Broken region via the Waranga Western Channel. There would be negligible change to the reliability of surface water supply. Under the dry 2030 climate extreme, average surface water availability would be reduced by 46 percent and end-of-system flows at Echuca would be reduced by 69 percent. The volume of water diverted for use within the region would be reduced by 28 percent. The reliability of supply would be broadly similar to that under a continuation of the recent climate. Transfers into the region from the Goulburn-Broken region via the Waranga Western Channel would be reduced by 32 percent. The level of surface water use would then be 57 percent.

Projected future development of small farm dams and increases in groundwater extraction would have minor impacts on streamflow and surface water use.

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</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>GL/y</td>
<td></td>
<td>Dry</td>
<td>Best estimate</td>
<td>Wet</td>
</tr>
<tr>
<td>Total inflows</td>
<td>–</td>
<td>-35%</td>
<td>-37%</td>
<td>-9%</td>
<td>-2%</td>
</tr>
<tr>
<td>Total surface water availability</td>
<td>274.8</td>
<td>-54%</td>
<td>-46%</td>
<td>-16%</td>
<td>-4%</td>
</tr>
<tr>
<td>End-of-system flow at Echuca to Murray</td>
<td>154.5</td>
<td>-76%</td>
<td>-69%</td>
<td>-27%</td>
<td>-10%</td>
</tr>
</tbody>
</table>

**Water use**

- **Lowest 1-year period**: 214.7 GL, -77% from historical, -80%, -43%, -19%, -81%, -44%, -21%
- **Lowest 3-year period**: 239.3 GL, -56% from historical, -59%, -19%, -8%, -61%, -20%, -9%
- **Lowest 5-year period**: 243.9 GL, -54% from historical, -58%, -17%, -5%, -59%, -18%, -6%
- **Average**: 306.9 GL, -26% from historical, -28%, -5%, 0%, -29%, -5%, 0%

**Non-diverted water**

- **Non-diverted water as a percentage of total available water**: 64%, 40%, 43%, 58%, 62%, 44%, 58%, 62%
- **Non-diverted share relative to historical non-diverted share**: 100%, 29%, 36%, 76%, 92%, 37%, 76%, 92%

Note: an additional 507 GL/year is transferred into the region from the Goulburn-Broken region via the Waranga Western Channel and of this, 264 GL/year passes through to the Loddon-Avoca region.
Groundwater

Groundwater extraction in the Campaspe region in 2004/05 is estimated to be 29 GL. This represents 1.7 percent of groundwater use in the MDB. About 88 percent of this extraction came from the Campaspe Deep Lead GMU. This level of groundwater use represents 9 percent of current total water use on average and 12 percent of total water use in years of lowest surface water use.

Surface–groundwater connectivity mapping shows the Campaspe River is losing water to the aquifer between Campaspe Weir and Lake Eppalock and is gaining water downstream of the weir. The river is likely to be gaining upstream of Lake Eppalock, although there are no bore data from this area to confirm this.

Modelling shows that historical groundwater extraction has and will continue to impact on streamflow in the Campaspe River. The eventual impact on streamflow will be a loss to groundwater of 3 GL/year compared to that included in the current river planning models. However, this value is highly uncertain because of large lateral inflows in the modelled groundwater balance.

Groundwater levels within the Renmark and Calivil Formation have fallen by 5 to 10 m since the early 1990s due to increases in groundwater extraction. Levels stabilised subsequently due to management intervention. Groundwater extraction in the Campaspe Deep Lead GMU is at a moderate (extraction is 47 percent of recharge) level of development while extraction from the Ellesmere GMU is low (extraction is 7 percent of recharge).

Either a continuation of the climate of the last ten years or the estimates of climate changes by 2030 would lead to substantial reductions (up to 34 percent) in rainfall recharge to groundwater in the Campaspe region. However, current extraction levels could be maintained due to increases in lateral flows into the groundwater systems despite these reductions in rainfall recharge.

Projected groundwater extraction by 2030 is 33 GL/year. The total eventual impact of groundwater extraction at projected 2030 levels would be an average streamflow reduction of about 6 GL/year.

<table>
<thead>
<tr>
<th>Code</th>
<th>Name</th>
<th>Priority</th>
<th>Licensed entitlement</th>
<th>Current extraction* (2004/05)</th>
<th>Permissible consumptive volume</th>
<th>Recharge**</th>
</tr>
</thead>
<tbody>
<tr>
<td>V42</td>
<td>Campaspe Deep Lead WSPA</td>
<td>low</td>
<td>46.04</td>
<td>26.09</td>
<td>46.04</td>
<td>34.37</td>
</tr>
<tr>
<td>V44</td>
<td>Ellesmere GMA</td>
<td>low</td>
<td>2.28</td>
<td>0.83</td>
<td>1.9</td>
<td>42.19</td>
</tr>
<tr>
<td>na</td>
<td>Unincorporated areas***</td>
<td>na</td>
<td>2.46</td>
<td>1.90</td>
<td>NA</td>
<td>50.15</td>
</tr>
</tbody>
</table>

Note: The Campaspe Deep Lead Water Supply Protection Area (WSPA) and the Ellesmere Groundwater Management Area (GMA) are referred to as the Campaspe Deep Lead GMU and the Ellesmere GMU in the text.

* Source: Department of Sustainability and Environment, Victoria. These volumes include estimates of stock and domestic use of: 0.38 GL/year for the Campaspe Deep Lead WSPA, 0.03 GL/year for the Ellesmere GMA and 0.80 GL/year for the unincorporated areas.

** Includes only rainfall recharge in non-modelled areas and all forms of recharge in modelled areas.

*** Unincorporated areas of the region represents those water resources outside the GMUs where groundwater salinity is less than 1500 mg/L total dissolved solids.

na not applicable
NA not available
Environment

Water resource development has had only minor impact on the summer–autumn freshes that are important for instream ecosystems in the Campaspe River, and neither climate change nor increases in farm dams and groundwater extraction are expected to have greatly affected these flows. However, water resource development has led to substantial changes in winter–spring bankfull flows, both increasing the period between these events and reducing their size. These changes are likely to have adversely affected a range of aquatic species and geomorphic processes.

Under a long-term continuation of the 1997 to 2006 climate the average period between winter–spring bankfull flows would be eight times (or 14 years) longer and the maximum period between these events would be four times (or nearly 30 years) longer. The overbank flood volume per event would be reduced by 43 percent meaning the average annual overbank flood volume would be reduced by 94 percent. These dramatic changes in bankfull events would have severe impacts on the ecology of the Campaspe River.

Under the best estimate 2030 climate the average period between winter–spring bankfull flows would increase by nearly a year (a 44 percent increase) and the maximum period between these events would increase by about two years (a 21 percent increase). The average overbank flooding volume per event would be reduced by 11 percent, meaning that the average annual overbank volume would be reduced by 37 percent. It is likely these changes in bankfull events would have substantial ecological consequences.

Under the wet extreme 2030 climate, the average and maximum period between winter–spring high bankfull flows would increase further, and overbank flood volumes would reduce further compared to current conditions. The changes that would occur under the dry extreme 2030 climate would be very similar to those under a long-term continuation of the recent climate.

The small projected increases in farm dams and groundwater development would have a minimal additional impact on the frequencies and volumes of bankfull events.

There are no wetlands in the Campaspe region that are recognised as being either nationally or internationally important. Therefore the instream environment of the lower Campaspe River was considered in the environmental assessments. Investigations related to environmental flows and native fish recruitment have recently been undertaken, however, these studies did not specify environmental water requirements. However, it is thought that both summer and autumn freshes and summer low flows are important for the instream environment of the lower Campaspe River.

Summer and autumn freshes wet the stream channel and the within channel benches that are important for maintaining species diversity. Instream vegetation benefits from this wetting and movement of fish and other aquatic fauna is enhanced. The brief flow increases also improve water quality in remnant pools.

Winter–spring high flows (June to November) provide ecological and geomorphologic disturbances that are important stimuli in the life cycles of a wide range of aquatic plants and animals. These high flows provide an injection of organic matter to the instream ecosystem from material which has accumulated on channel benches.

> Coliban River near Redesdale, Vic (North Central CMA)

<table>
<thead>
<tr>
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</thead>
<tbody>
<tr>
<td><strong>Dry</strong></td>
<td><strong>Best estimate</strong></td>
<td><strong>Wet</strong></td>
</tr>
<tr>
<td>Average period without summer–autumn freshes*</td>
<td>0.41</td>
<td>0.46</td>
</tr>
<tr>
<td>Maximum period without summer–autumn freshes*</td>
<td>1.00</td>
<td>0.67</td>
</tr>
<tr>
<td>Average period between winter–spring bankfull flows **</td>
<td>1.2</td>
<td>1.9</td>
</tr>
<tr>
<td>Maximum period between winter–spring bankfull flows**</td>
<td>3.8</td>
<td>9.1</td>
</tr>
<tr>
<td><strong>GL</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average excess volume per winter–spring bankfull event***</td>
<td>276</td>
<td>241</td>
</tr>
<tr>
<td>Average excess volume per winter–spring bankfull event****</td>
<td>194</td>
<td>106</td>
</tr>
</tbody>
</table>

* Where flows are less than 4.5 GL/month December–May at Campaspe Siphon.
** Period between events of 43 GL/month June–November at Campaspe Siphon.
*** Event above 43 GL/month June–November at Campaspe Siphon.
About the project

The CSIRO Murray-Darling Basin Sustainable Yields Project resulted from the Summit on the Southern Murray-Darling Basin, convened by the then Prime Minister on 7 November 2006. The project is providing governments with a robust estimate of water availability for the entire Murray-Darling Basin (MDB) on an individual catchment and aquifer basis taking into account climate change and other risks. The project will report progressively to mid-2008. The project will be the most comprehensive assessment of water availability for the MDB undertaken to-date. For the first time:

- daily rainfall-runoff modelling has been undertaken at high spatial resolution for a range of climate change and development scenarios in a consistent manner for the entire MDB
- the hydrologic subcatchments required for detailed modelling have been precisely defined across the entire MDB
- the hydrologic implications for water users and the environment by 2030 of the latest Intergovernmental Panel on Climate Change climate projections, the likely increases in farm dams and commercial forestry plantations and the expected increases in groundwater extraction have been assessed in detail
- the assessments have employed all existing river system and groundwater models as well as new models developed within the project
- the modelling has included full consideration of the downstream implications of upstream changes between multiple models and between different states, and quantification of the volumes of surface–groundwater exchange
- detailed analyses of monthly water balances for the last 10 to 20 years are being undertaken using available streamflow and diversion data together with additional modelling including estimates of wetland evapotranspiration and irrigation water use based on remote sensing imagery. These analyses provide an independent cross-check on the performance of river system models.

The assessments reported here have been reviewed by a Steering Committee and a Technical Reference Panel both with representation from Commonwealth and State governments and the Murray-Darling Basin Commission.

Information on how these results may be used in the development of a new sustainable diversion limit for the Murray-Darling Basin can be found at www.environment.gov.au/water/mdb/yields.html.

Enquiries

More information about the project can be found at www.csiro.au/mdbsy. This information includes the full terms of reference for the project, an overview of the project methods and the project reports that have been released to-date, including the full report for this region.