



Chapter 15. Measuring and monitoring



15. Measuring and monitoring

The Basin Plan requires Victoria's North and Murray Water Resource Plan to provide information about how Victoria measures and monitors water resources and what is done to ensure the measurements are maintained.

Part 10 of the Basin Plan requires:

- the best estimate of the total long-term annual average quantity of water taken that is measured
- how the quantity measured was calculated
- the proportion of that quantity that is measured in accordance with agreed metering standards
- the best estimate of the total long-term annual average quantity of water taken that is not measured and how that quantity was calculated
- actions and timeframes for actions for maintaining and, if practicable, improving:
 - the proportion of take that is measured
 - the standard to which the take is measured
- monitoring of water resources to fulfil the reporting obligations under section 13.14 of the Basin Plan

Appropriate measuring and monitoring is critical for sound water resource management. This informs policy, evidence-based decision making and managing the state's water resources to adapt to changing conditions. It supports a strong compliance and enforcement framework. Good measuring and monitoring means Victoria can protect the reliability of water for the environment and existing entitlement holders, and give water users and the community confidence that our water resources are well managed.

15.1 Victoria's regional water monitoring partnership

Victoria's Regional Water Monitoring Partnerships and State Observation Bore Network have been established to collect data on surface water and groundwater quantity and quality to meet legislative and regulatory compliance requirements and for performance monitoring, policy development and operational decisions.

Catchment management authorities, water corporations, local government and other agencies may also monitor water quality beyond these two key networks.

15.1.1 Surface water

The Regional Water Monitoring Partnership is made up of 40 partner organisations. It routinely monitors surface water and collects surface water data from around 780 monitoring sites across Victoria.

The data is collected to identify:

- how much water there is
- where the water is
- the water quality
- how much water is being used
- what the water is used for

15.1.2 Groundwater

The Groundwater Monitoring Partnership includes DELWP, Southern Rural Water, Grampians Wimmera Mallee Water, Central Highlands Water and Goulburn-Murray Water. These agencies routinely monitor groundwater and collect groundwater data from the 1,400 State Observation Bore Network (SOBN) bores. This also includes an annual spring sampling program to analyse groundwater quality parameters.

15.1.3 Water Management Information System (WMIS)

All surface water and groundwater data collected through the Regional Partnerships is stored and managed in the Water Management Information System (WMIS). WMIS is a publicly accessible web site and contains data on water levels (surface and ground water), surface water discharge and water quality (surface and groundwater). This includes all telemetered water data which is published within 1 hour of collection. Verified water data is published within 2 weeks of collection.

15.2 Victorian Water Accounts

The annual Victorian Water Accounts provide detailed information about water availability and use each water year. Accounts have been produced every year since the first accounts were put together for 2003–04.

Water accounts are produced for each of Victoria's 29 river basins and 20 groundwater catchments.

Producing the Victorian Water Accounts is an important process to demonstrate how Victoria's water resources are managed. The strength of the accounts is in the data and the process for reporting on that data. Victoria has an extensive network of monitoring sites that record information on rainfall, temperature, river quantity and quality, groundwater levels and quality and the production and quality of recycled water. The amount of water taken from rivers and groundwater is also monitored and use is metered wherever practical.

Data is collected from rural and urban water corporations, the Department of Environment, Land, Water and Planning (DELWP), the Australian Bureau of Meteorology, the Victorian Environmental Water Holder (VEWH), the Essential Services Commission, the Murray-Darling Basin Authority (MDBA), the Victorian Alpine Resort Commission, power companies and other major water users.

15.2.1 Surface water accounts

Surface water data in the water accounts aligns with river basin boundaries. For the purposes of the basin water accounts, water is accounted for at the point of diversion from the waterway and not the point of use.

The surface water accounts present the water balance for each basin. The water balance is made up of:

- change in the volume stored in the river basin
- inflows to the basin, such as catchment inflows, rainfall on major storages, transfers from other basins, return flows from irrigation and treated wastewater discharged back to rivers
- diversions such as urban diversions, irrigation district diversion, licensed diversions from regulated and unregulated streams, transfers to other basins, environmental water diversions and small catchment dams
- losses such as evaporation from major storages, losses from small catchment dams and instream infiltration to groundwater
- water passed at the basin outlet

Information for the surface water accounts is obtained from:

- the Victorian Water Register
- data from rural and urban water corporations, the VEWH, DELWP, the MDBA and other major water users
- water consumption and recycled water data collected from water corporations by the Essential Services Commission
- hydrological data for surface water monitoring sites is obtained from the Water Management Information System (WMIS)
- climate information from selected rainfall and evaporation monitoring sites provided by the Bureau of Meteorology and water corporations
- estimated relationships between water use and climate or hydrological data, which is produced by water supply system modelling

Details of the methodology used to quantify each component of the water balance are described in the Victorian Water Accounts (DELWP, Victorian Water Accounts: 2015-2016, 2017-18).

Victoria's North and Murray water resource plan area includes the Murray (Victoria), Kiewa, Ovens, Broken, Goulburn, Campaspe and Loddon basins and surface water accounts are prepared for these basins. Note the Murray basin and the Kiewa basin are amalgamated in the Victorian Water Accounts.

15.2.2 Groundwater accounts

Accounts are presented for each groundwater catchment. Boundaries of these catchments are determined by hydrogeological features and differ from surface water catchments. The groundwater accounts present data about:

- licensed groundwater volumes and use
- urban groundwater use, which is a sub-category of licensed use
- estimated number of groundwater bores and use for domestic and stock supplies

Information for the groundwater accounts is obtained from:

- the Victorian Water Register
- responses to requests for data to water corporations, DELWP and other major users of groundwater
- hydrogeological information for groundwater monitoring sites is obtained from the Water Management Information System (WMIS)
- estimated relationships between water use and hydrological data, which is produced by water supply system modelling
- water corporation groundwater statements and annual reports

Victoria's North and Murray water resource plan area includes the area covered by the Goulburn-Murray groundwater basin and incorporates groundwater data in the Upper Murray, Kiewa, Ovens, Goulburn, Broken, Campaspe and Loddon catchments.

15.2.3 Estimating evapotranspiration

Evapotranspiration estimates are provided as supplementary information in the accounts to estimate the use of water by commercial plantations. Data used in the accounts is estimated by the SoilFlux model as the sum of transpiration by plants, evaporation from soil and open water surfaces and evaporation from the wet surfaces of plants soon after rainfall.

SoilFlux is a one-dimensional water balance model. It requires many approximations and assumptions, which limit its accuracy. Major assumptions and limitations of this method include:

- not accounting for water applied by irrigation
- not allowing for changes in water storage, such as rises and falls in the water table and soil moisture, or lateral flow
- using land use information from 2009, which has been condensed from the Victorian Land Use Information System into 10 representative land use types, for water balance modelling
- using one kilometre gridded data for land use, geology, depth to groundwater and rainfall

15.2.4 Victorian Water Register

The Victorian Water Act requires records of all water entitlements to be recorded by the Victorian Water Register, which contains detailed water accounts. The register is the central source of information about water entitlements, trade and usage and contains information on:

- bulk and environmental entitlements
- water shares
- water-use licences and registrations
- take and use licences
- works licences

The register records details about:

- ownership
- changes in ownership through trade
- entitlement characteristics including maximum volume
- allocations to entitlements where relevant
- use
- carryover where relevant

The register's water entitlement records are reconciled quarterly and finalised at the end of each financial year.

15.3 Collecting data for the accounts

15.3.1 Bulk entitlements

The holder of each bulk entitlement must prepare and implement a metering plan that demonstrates how the entitlement holder collects and stores the data necessary to determine that the entitlement holder has complied with the bulk entitlement. The metering plans must be prepared in accordance with the *Minister's Guidelines for the Development of Bulk Entitlement Metering Programs* (Minister for Water, 2009), including meeting the relevant national standards.

Entitlement holders are also required to keep records collected from the metering program and provide reports to the Minister on request. Each year the Minister requests water corporations report on their take and use of water in their annual reports which are tabled in Parliament. Entitlement holders are also required to include details of any non-compliance with their bulk entitlement in these annual reports.

15.3.2 Environmental entitlements

Like bulk entitlement holders, the Victorian Environmental Water Holder (VEWH) has obligations to prepare metering programs to demonstrate how it complies with the requirements of its environmental entitlements. The Ministerial rules relating to the Victorian Environmental Water Holder (Minister for Water, 2014) require the VEWH to report each year on:

- the rights and entitlements in the water holdings at the end of the year
- water allocations made available
- changes in the water holdings
- the use of carryover
- water trading activity

The VEWH annual report is also tabled in Parliament and contains comprehensive information about the use of environmental holdings in response to these requirements. See for example, the Victorian Environmental Water Holder Annual Report 2017-18 (VEWH, 2018).

15.3.3 Take and use licences

Victoria's metering policy for non-urban water supplies (DEPI, 2014) includes:

Where a delegate issues, renews or approves the transfer of a licence to take water in a non-urban situation, the following conditions apply:

- a) *All new licences where the water taken under the licence is to be used for irrigation or commercial purposes must be metered*
- b) *Existing licensed extraction sites must be metered if the licensed volume is –*
 - i) *10 ML or greater, for surface water, or*
 - ii) *20 ML or greater, for groundwater*



- c) *The obligations in paragraph (a) and (b) do not apply if, in the view of the delegated authority, a meter would be impractical or can be exempted according to the following criteria:*
- i) *Cost of metering can be shown to significantly outweigh the benefits*
 - ii) *Resource management objectives can still be achieved without impacting negatively on the resource, the environment or other users*
 - iii) *An exemption exists according to the Victorian Water Act*
- d) *In these cases, the delegate must:*
- i) *Document clearly the reasons for its view, and*
 - ii) *Identify a substitute method for estimating the volume of water taken to meet state and federal water accounting and reporting requirements*

The above requirements do not preclude a delegate from requiring more extensive metering.

This policy is implemented through the Minister's Policies for Managing Take and Use Licences (Minister for Water, 2014). These policies require details of all take and use licences to be recorded on the Victorian Water Register. Metered use is also recorded on the Water Register.

Water corporations that provide non-urban supplies must prepare and implement metering action plans that comply with the Victorian implementation plan for the national metering standards for non-urban water meters. See clause 7.4 of the Statement of Obligations (DELWP, 2015).

15.3.4 Basic rights

15.3.4.1 Section 8 rights

The Victorian Water Accounts do not include estimates of the volume of water taken under the section 8 rights provisions of the Victorian Water Act, known as basic rights in the Basin Plan. The most significant use under this category is by stock drinking from unfenced waterways. The water taken under section 8 rights is relatively small and there is no practicable way of measuring the volume. For the purposes of determining permitted and actual take, an estimate has been made as described in [Appendix C](#).

Similarly, the use of groundwater from domestic and stock bores is not known with any precision. Records are kept of the works licences required to construct a domestic and stock bore. However, these bores are not metered and there is no record of which bores are actively used. The number of domestic and stock bores includes all bores on the groundwater management database that are not licensed bores and that are less than 30 years old. The volume of domestic and stock use is estimated by assuming each bore uses 2 ML per year as described in [Appendix C](#).

15.3.4.2 Section 8A rights

The Victorian Water Accounts do not include estimates of the volume of water taken under the section 8A rights provisions of the Victorian Water Act, known as basic rights in the Basin Plan. These rights for Traditional Owners to take water under section 8A are outlined in more detail in [section 7.1.1.2](#) of the Comprehensive Report. At the time of producing this report there are no circumstances of Traditional Owner groups exercising this right in Victoria's North and Murray water resource plan area. However, this may change as a result of the implementation of the Aboriginal Water policy outlined in *Water for Victoria* (DELWP, 2016). An estimate has been used for determining permitted and actual take as described in [Appendix C](#).

15.3.4.3 Farm dams

No cost-effective method is available to measure the volume of water diverted from farm dams. There is no practicable way of metering use from these dams, which is mainly for stock. The volume of water harvested by small dams is included in the Victorian Water Accounts as an estimate.

This estimate is based on spatial data compiled using aerial imagery from 2005-2010 and showing the location and surface area of all dams in Victoria. This data was combined with hydrologic modelling of the impact of small catchment dams on mean annual streamflow.

The estimated total water harvested by small catchment dams, or their total impact in a basin, is represented in the water balance as two separate components:

1. The estimated volume that owners extract from dams to supply their needs is accounted for as a diversion in the surface water balance.
2. The estimated volume of evaporation from small catchment dams is accounted for as a loss in the surface water balance.

The method used to estimate the number and capacity of dams uses outputs from aerial photography. This dataset was wholly based on the Murray-Darling Basin Authority's waterbodies data prepared by Geoscience Australia in 2010 using aerial imagery from around 2004-05. This data represents the best available information.

While the estimates of the number and locations of the dams are relatively accurate, it requires significant assumptions to convert this spatial data to estimates of take. These estimates are not sufficiently precise to provide accountable volumes of take (see [Chapter 11](#)).

15.4 Information related to take

The best estimates of the total long-term annual average quantity of surface water taken that is measured and not measured in the Victorian Murray water resource plan area, the Northern Victoria water resource plan area and the Goulburn-Murray water resource plan area are set out in [Table 15-1](#).

Measured take for bulk entitlements is determined in accordance with the metering plans prepared and implemented by bulk water entitlement holders. Measurement usually includes a combination of stream gauging and metering, depending on the physical water harvesting arrangements.

Water corporations are responsible for making sure meters comply with the requirements of the national metering standards for urban and non-urban water meters, and that stream gauges are read, calibrated and maintained in line with their metering programs.

Table 15-1: Volume and method used to quantify take in Victoria's North and Murray water resource plan area

Form of take	Estimated / Measured ^(a)	Annual Volume (ML) ^(b)
Victorian Murray water resource plan area		
Bulk entitlement ^(c)	Measured	1,915,739
Take and use licence ^(d)	Measured	32,028
Basic rights (regulated and unregulated streams)	Estimated	7,000
Farm dams - licence	Measured	9,362
Farm dams – basic rights	Estimated	11,285
Northern Victoria water resource plan area		
Bulk entitlement	Measured	2,199,715
Take and use licence	Measured	69,680
Basic rights (regulated and unregulated streams)	Estimated	13,100
Farm dams - licence	Measured	74,164
Farm dams – basic rights	Estimated	74,043
Goulburn-Murray water resource plan area (groundwater)		
Take and use licences	Measured	435,841
Basic rights	Estimated	16,400

a. For detail about how the data is estimated and measured refer to the [Appendix C – Methods Report](#)

b. The Annual Volumes are estimated at 30 June 2016 and were recorded in the Victorian Water Accounts 2015-16

c. Bulk entitlements include high-reliability water shares, low-reliability water shares, loss provisions, waterworks districts, provision for unlicensed domestic and stock use and urban water corporation bulk entitlements from regulated and unregulated parts of the system

d. Take and use licences are for the unregulated parts of the system.

e. Victoria will incorporate water resource plan reporting requirements about actual take of water into the existing processes to prepare the annual Victorian Water Accounts. In this way, data that is already collected and reported will be used for both purposes.

15.5 Improving measuring

Stream gauges are funded by water corporations and DELWP, with private contractors operating and maintaining these stream gauges in accordance with best practice. Non-urban water metering is being progressively upgraded consistent with the National Framework for Non-Urban Water Meters and Victoria's state-wide implementation plan.

The Victorian Government has made these commitments in *Water for Victoria* (actions 8.4 and 8.11) to improve water use information (DELWP, 2016) and to:

- *monitor and report on the impact of water use on other users and the environment, and report on significant uses of water in the annual Victorian Water Accounts*
- *periodically review the long-term risks to Victoria's water resources through mechanisms such as long-term water resource assessments and sustainable water strategies*
- *work with water corporations and catchment management authorities to:*
 - *continue to invest in ongoing statewide surface water and groundwater monitoring networks*
 - *improve the quality and accuracy of monitoring data through investment in infrastructure upgrades and new technologies to receive more timely data*
 - *strengthen water resource assessments and modelling by including up-to-date information on catchment characteristics to better understand water availability, use and climate change*

These actions are continuous and will be reported through *Water for Victoria* (DELWP, 2016) implementation progress reports.

The following is proposed accredited text for section 10.45(1) of the Basin Plan:

Victoria has committed to the following measures under Water for Victoria for maintaining and, where practicable, improving the proportion of take that is measured in the water resource plan area, and the standard to which take is measured by:

- a) Implementation Plan under the Basin Compliance Compact to improve metering against the National Standard for metering in accordance with the approved exemptions published in under Action 3.1 (including Actions 3.2--3.5) and supported by Actions VIC 3.1-3.7
- b) Maintenance of stream gauges by water corporations and DELWP according to national standards
- c) Installation and maintenance of meters by water corporations according to national standards
- d) Upgrades to non-urban metering according to the National Metering Standards for Non-Urban Water Meters consistent with the Victorian Policy for non-urban water metering and the state-wide implementation plan
- e) Continued investment in ongoing statewide surface water and groundwater monitoring networks
- f) Investment in infrastructure upgrades and new technologies to improve the quality, accuracy and timeliness of monitoring data; and
- g) Investigation into the introduction of a reasonable use limit for domestic and stock rights to improve monitoring and reporting of the quantity of water used under these rights

<<end of accredited text>>.

The following is proposed accredited text for section 10.45(2) of the Basin Plan:

These measures will be implemented over the next 10 years.

<<end of accredited text>>

15.6 Monitoring water resources

In relation to reporting obligations under section 13.14 of the Basin Plan, Schedule 12 lists 2 matters that Basin states, the MDBA, the Commonwealth Environmental Water Holder and the relevant Commonwealth department must report on, annually or five yearly. From this list, Basin states are required to report on 13 of the matters and monitoring of water resources is relevant to eight of these: 4, 8, 9, 10, 12, 14, 18 and 19.

15.6.1 Current monitoring to meet Basin Plan requirements

Table 15-2 shows the monitoring of water resources to be done to meet the accreditation requirements of the Basin Plan.

Four core matters require monitoring of water resources to report against them:

- Matter 8 – Achievement of environmental outcomes at an asset scale
- Matter 9 – Identification of environmental water and monitoring of its use
- Matter 12 – Progress towards water quality targets
- Matter 19 – Compliance with water resource plans

The following is proposed accredited text for section 10.46(1) of the Basin Plan

Table 15-2 of Victoria's North and Murray Comprehensive Report and Part 6 of Victoria's North and Murray Water Quality Management Plan sets out the monitoring of the water resources of Victoria's North and Murray water resource plan area that will be done to fulfil the reporting obligations under section 13.14 of the Basin Plan.

The remaining four matters will be informed by the monitoring conducted for the purposes of the matters listed above. These four matters relate to:

- a) Matter 4 – the effectiveness of the management of risks to Basin water resources (informed by monitoring of matters 8, 9 and 12)
- b) Matter 10 – implementation of the environmental management framework (informed by matter 8)
- c) Matter 14 – the implementation of the water quality and salinity management plan including to the extent to which regard is had to the targets in Chapter 9 when making flow management decisions (informed by matter 12)
- d) Matter 18 – the efficiency and the effectiveness of the operation of water resource plans, including in providing a robust framework under a changing climate (informed by matters 8, 9, 12 and 19)

Monitoring undertaken in accordance with approved Management Plans for declared water supply protection areas supports reporting requirements under section 13.14 to report on matters listed in Schedule 12.

<<end of accredited text>>

Table 15-2: Monitoring of water resources of Victoria’s North and Murray water resource plan area that will enable Victoria to fulfil its reporting obligations under section 13.14.

Matter	Relevant indicators	What will be reported	Monitoring to fulfil reporting obligations
8	Asset-scale indicators will be developed by Basin states following the development of objectives and targets for long-term watering plans and annual priorities using the Environmental Management Framework	Report on achievement of environmental outcomes at an asset scale as per indicators in the long-term watering plan	<p>Victoria undertakes the following monitoring to evaluate its long-term watering plan targets:</p> <ul style="list-style-type: none"> ecological monitoring of rivers through the Victorian Environmental Flows Monitoring and Assessment Program and the Native Fish Report Card ecological monitoring of wetlands through the Wetlands Monitoring and Assessment Program for environmental flows Victoria’s Regional Water Monitoring Partnerships programs (surface water and groundwater water quality and hydrology) and CMA monitoring related to long-term watering plan objectives <p>To report against Matter 8, Victoria will also use data from the following Commonwealth funded programs:</p> <ul style="list-style-type: none"> Murray-Darling Basin Fish Survey The Living Murray program and Long-term Intervention Monitoring (Goulburn River)

Matter	Relevant indicators	What will be reported	Monitoring to fulfil reporting obligations
9.1	Volume of Held Environmental Water (HEW) that is available for use.	<p>Volume of HEW entitlements by SDL resource unit</p> <p>Carryover and forfeiture of HEW by SDL resource unit</p> <p>Volume of HEW used by SDL resource unit</p>	<p>Allocation, use, carryover, spills and forfeiture of HEW is accounted for in the Victorian Water Register, and VEWH reports this annually in their Annual Report.</p> <p>The monitoring to ensure environmental water delivery occurs is described in the VEWH metering programs.</p>
9.2	Volume of planned environmental water (PEW) that was available	<p>There is a PEW reporting requirement for the Ovens and Broken basins. However due to the complex nature of minimum flow requirements, with different flow requirements at multiple sites along the system, only qualitative remarks can be made in the reporting.^(a)</p>	<p>There are PEW reporting requirement for the Ovens and Broken basins.</p> <p>Monitoring to fulfil reporting obligations occurs in accordance with the GMW bulk entitlement metering programs.</p>
9.3	Purpose and consequences of environmental water use	<p>This indicator has been excluded</p>	<p>Accounting for the use of held environmental water is managed through the Victorian Water Register.</p> <p>The monitoring arrangements to ensure environmental water delivery occurs is described in the VEWH metering programs</p> <p>Monitoring of the impact of use of held environmental water is managed through monitoring done for Matter 8 outlined previously in this table.</p>
12.1	Implementation of measures identified in Water Quality Management (WQM) plans (Basin Plan s10.33)	<p>A summary of the implementation of measures set out in the WQM plan in each water resource plan area</p>	<p>Monitoring to be undertaken is detailed in the Water Quality Management Plan (Appendix A) for both surface water and groundwater.</p>



Matter	Relevant indicators	What will be reported	Monitoring to fulfil reporting obligations
12.3	The number and severity of blue-green algae and blackwater events	An analysis of the frequency, duration and extent of blue-green algae and blackwater events	<p>Victoria and its regional agencies monitor blue-green algae through the steps outlined in the Blue-Green Algal Circular and emergency management documents</p> <p>Blue-green algae monitoring is undertaken by Goulburn-Murray Water and Lower Murray Water as regional coordinators and urban water corporations, CMAs, Parks Victoria, local government and DELWP where they act as local waterway manager.</p>
19	The MDBA does not propose reporting beyond the Statements of Assurance as agreed in the Implementation Agreement	Statement of Assurance	Monitoring to be undertaken is that required to measure compliance against the tasks under the Statement of Assurance. No additional monitoring is proposed

a. For more information about what is and is not considered planned environmental water and held environmental water please refer to [Chapter 12](#) of Victoria’s North and Murray Water Resource Plan

In Victoria the Victorian Environmental Water Holder (VEWH) reports on its environmental watering in its annual publication Reflections and in its annual report. These publications include the following information:

- carryover and trade that occurred during the year
- volume of water delivered by region and by site
- environmental outcomes resulting from the water delivered

The VEWH works with catchment management authorities to do monitoring, investigations and research projects that test assumptions and address knowledge gaps to improve on-ground adaptive management of environmental water. The VEWH’s investment generally focuses on short-term projects with a defined question of interest, for example projects to improve understanding of the volume, magnitude or timing of flows that will improve outcomes achievable with the environmental water that is available.

The VEWH’s contribution aims to complement investments in longer-term and broader-scale monitoring made by partner agencies such as DELWP, with the Victorian Environmental Flows Monitoring and Assessment Program and the Wetlands Monitoring and Assessment Program, and the Commonwealth Environmental Water Office’s Environmental Water Knowledge and Research project and Long-Term Intervention Monitoring project. The VEWH also invests in small-scale complementary works and measures to improve environmental water outcomes. See [Chapter 12](#) for more information.

In contributing to Victoria's Basin Plan obligations, the VEWH reports each year on water use and alignment of outcomes with the MDBA's annual watering priorities. The results of monitoring and investigations supported by VEWH and its partner organisations help to build a comprehensive picture of the ecological benefits of environmental watering and inform reporting towards Basin Plan outcomes.

The VEWH's publications are on its website.

15.6.2 Proposed improvements to monitoring

To further support reporting against Matter 8 of Schedule 12 of the Basin Plan, Victoria is currently working to develop:

- an approach for monitoring the hydrological, physical or ecological response to environmental watering in the Wetlands Monitoring and Assessment Program
- an Aboriginal Waterways Assessment tool that can assess the cultural health of waterways and the outcomes of environmental watering

