

Climate, weather and water: a water management perspective

Bruce Rhodes
Melbourne Water
PO Box 4342
Melbourne 3000

Introduction

A major factor underpinning water authority planning, management and operations is prevailing and anticipated climatic and meteorological conditions. As Melbourne Water (MW) has a major role in water management in the greater Melbourne area, we have an active interest in understanding and managing our key business risks and drivers. From a climate perspective, these can range from the short term impacts of daily rainfall events and the effects on streamflow, water quality and sewerage system flows to the long-term potential risks of climate change and the implications for water resources planning and management.

This paper and the corresponding presentation provides an overview of the framework for managing hydrometeorological risk being used in planning and managing Melbourne's water resources systems and highlights key climate and metrological information used to support planning and operations. The paper covers:

- Background to Melbourne's water resources systems and climate impacts on these systems
- Monitoring, management, data and decision support systems
- Strategies and long term planing
- Response plans
- Studies and implications
- Communication and awareness
- Research and development studies, including climate change

The purpose of the paper is to highlight how hydrometeorological information is used by water agencies, and provide an insight into areas where further understanding of climate issues on hydrological process may assist water agencies. While the views reflect Melbourne Water's experiences, and in particular in the management of the water supply system, many of the areas of discussion in the paper will be consistent with approaches used by other water agencies.

Background to Melbourne Water

Melbourne Water manages Melbourne's water supply catchments, removes and treats most of Melbourne's sewage at two major treatment plants, and manages rivers, creeks and major drainage systems in the Melbourne region. Our customers include the metropolitan retail water businesses, other water authorities, local councils and the land development industry.

Our vision is to work with the community and stakeholders to ensure a sustainable water future. Melbourne Water is owned by the Victorian Government with the responsible Minister being the Minister for Water. An independent Board of Directors is responsible for governance.

Melbourne Water is a significant business, managing \$7.9 billion of natural and built assets. Our organisational structure covers the range of functions required to ensure safe and

reliable water systems for Melbourne now and into the future. These functions include; corporate, strategy and planning, operations, catchment management, rivers and drainage, water and sewage treatment, research, water quality, regulation, finance, and asset management.

Water supply system

Melbourne Water provides water and sewerage services to three retail water companies: City West Water Ltd, South East Water Ltd, and Yarra Valley Water Ltd. Melbourne Water also provides water supplies to Gippsland Water, Southern Rural Water and Western Water. Water supplied supports a city of more than 3.5 Million people.

An extensive transfer system links Melbourne's storage reservoirs with the city's three retail water companies and their customers. The major storage reservoirs supply water via large transfer mains to the service reservoir sites that are located throughout the metropolitan area to meet consumption needs. The water is then transferred to the retail water companies, which operate the reticulation network across the Melbourne area.

The water supply system has developed since the first storages at Yan Yean and Toorourrong were constructed in mid to late 1800s. Development of the water supply system has occurred to the eastern ranges and Melbourne now draws and stores most of its water from streams and reservoirs in the Yarra Ranges and Mt Baw Baw areas to the north and east of Melbourne. These catchments, streams and reservoirs are mostly on the southern side of the Great Dividing Range and are heavily influenced by the climatic conditions and weather patterns around these areas. The history of development of the supply system has also been influenced by considerations of short and long term supply adequacy, particularly following major drought periods.

The largest reservoir in the system is Thomson Reservoir, which has a capacity of some 1,068,000 ML. This reservoir has a storage capacity equivalent to around four times the mean annual streamflow, meaning that storage volumes are heavily influenced by long term demand and inflows.

The major driver for management of the water supply system is both annual and seasonal climatic variability. Severe drought periods, or extended low streamflow conditions can result in significant draw on water storages over extended periods of time. Annual and seasonal variability influences system operations with water transferred between storages to reflect variability of rainfall and catchment conditions across the system and to manage seasonal variability of water demand.

Sewerage system

Melbourne Water operates the larger main and trunk sewers and treatment plants and the three retail water companies, City West Water, South East Water and Yarra Valley Water, manage customer relations and operate the reticulation system from individual properties and the branch sewers. This pipe network delivers flows to the transfer system and some small regional treatment plants. Approximately 92% of Melbourne's sewerage is transferred and treated at the Western Treatment Plant at Werribee and the Eastern Treatment Plant at Bangholme.

The transfer system incorporates underground pipelines, pumping stations, emergency relief structures and detention tanks. The sewers generally transfer flows by gravity. However, a number of major pumping stations, which are required to lift sewage and

enable continuous transfer in the system, are located at Hoppers Crossing, Brooklyn, Kew and North Road Caulfield.

Climate variability impacts on sewer flows as a result of infiltration and limited illegal connections. Wetter periods, coupled with intense storm events can also increase the risk of sewer overflows at relief structures throughout the system.

Drainage system

Melbourne Water is the drainage authority for the Greater Melbourne area and the Flood Plain Management Authority by delegation from the Minister responsible for the Water Act. MW is responsible for regional drainage management, including large drains, rivers and creeks, and works closely with local councils, who control local drainage systems, and with the Port Phillip and Westernport Catchment Management Authority. Melbourne Water is also a referral authority in the planning system and receives around 2000 applications per year for subdivisions and other developments from councils.

With the recent Government initiatives outline in *Our Water Our Future*, Melbourne Water will become responsible for drainage to Westernport and Port Phillip, excluding the greater Geelong area. This will increase the area of drainage responsibility by around 40%.

Melbourne Water also carries out a wide range of drainage and flood protection works including flood mapping, asset inspections and works on retarding basins and vulnerable properties.

Melbourne Water is responsible for a range of infrastructure assets that manage drainage, including 140 retarding basins, 193km of levee banks, four tidal gates and 1125km of underground stormwater drains and 4500km of natural waterways.

Climate and weather impacts on design of the systems and operationally on peak flows and flooding in the systems. Climate variability, along with consideration of catchment water uses and flows in Melbourne's streams also has significant implications for in stream environmental health.

Managing for climate variability and change

Planning and managing complex water systems to take account of potential climate variability and change and other uncertainties requires a complementary set of activities, including:

- Data Collection and Management
- Decision support system and modelling
- Long term planning strategies to address climate and other risks and uncertainties
- Short term response to climate events such as drought and flood events
- Communication on managing the water supply system
- Research and development

Data Collection and Management

Melbourne Water has a large data network that is used to assist operations and long term planning across the business. The data network area covers from near Mt Macedon in the west, Thomson in the east, Toorourrong in the North to Portsea in the South.

The data collection network, and the data bases comprising the data from these sites includes:

- 150 rainfall monitoring sites that have, in some cases, record lengths dating back to 1855 (Yan Yean Reservoir). This data comprises of pluviograph data and bulk rain gauges. Some of this data, eg O'Shannassy and Toorourrong is provided to the Bureau of Meteorology for inclusion in long term data sets.
- 20 meteorological stations including temperature and evaporation data.
- 175 streamflow sites that are used for water supply system operations, for the monitoring of rivers and streams within the catchments and flood warning purposes.
- 340 private rain gauge operators scattered throughout the metropolitan area that provide valuable data where telemetry sites are not available. In some cases the data extends back 30 to 40 years. These data sets tend to have lower reliability than the rainfall monitoring sites, and are used mainly for flood planning within the urban area, particularly where storm information is being interpreted at a local level
- 450 network flow monitoring sites that monitor flows throughout the water supply, sewerage and drainage distribution systems.
- 70 physical and chemical water quality monitoring sites

The data collected from these sites is stored in various formats ranging from spreadsheets to telemetry systems such as MOSAIC and HYDSYS. These systems provide an effective basis for storing and analysing rainfall and flow data for different time step resolution.

Presently, MW is processing paper record data comprising of meteorological observations, streamflow and operational observation that is not available in an electronic format. The information mostly covers the water supply system for the period 1860 to 1940 and has been located in old office files, and in the Public Record Office.

The information collected and stored represents a detailed climate history of Melbourne and forms a core element of the knowledge base for planning purposes and is used as the basis for analysis of the performance and adequacy of the water management systems for Melbourne.

Decision support systems

An extensive set of models have been developed and maintained to support planning and operational decisions that require high quality time series or event based hydro-climatic data. These models help assess behaviour of systems in a range of climate conditions against defined performance objectives and are central to maintaining safe and reliable, water sewerage and drainage systems.

The range of models include models covering water demand, major water supply and sewerage system behaviour, hydraulic conditions in major transfer assets, catchment rainfall runoff models, assessment of flooding at local levels, flood warning models, and wetland performance models.

In addition to these models, a range of hydrological techniques are used to infill or generate data sets based on observed data. These techniques include the use of stochastically generated streamflow data at major reservoir sites based on the statistical parameters of the observed data sets.

Long-term strategies and planning

Like most major cities, Melbourne has a long history of planning water resources systems to provide for the long-term water needs. Early planning decisions for Melbourne included the

catchments being set aside for the water supply purposes from the 1850s and the setting aside of land and the establishment of the Werribee Sewage Treatment plant in the 1890s.

Over the years Melbourne has seen a range of planning and operational strategies to plan for growing populations and changing water needs with the backdrop of Melbourne's variable climate. In recent decades these have included major water resources strategy assessments in the 1960s, 1980s, 1990s and the 2002 Water Resources Strategy for the Melbourne area. These strategies have evolved from being mainly focussed on servicing future water demands with additional supply side activities to increased consideration of whole of water cycle supply and demand management options within the context of variable climate and the potential for climate change. The long term water needs are currently being reassessed in the Water Supply Demand Strategy for Melbourne given the findings of the recent CSIRO and Melbourne Water climate change study (discussed below).

Drainage Planning for Melbourne has evolved from the focus of public health and risk, conveyancing and disposal to now one of consideration of the implications of flow and quality on flora, fauna and habitat and broader social, amenity values and sustainability and conservation issues including water sensitive urban design.

Sewerage strategies have been undertaken since the establishment of the sewerage systems for Melbourne in the 1890s as a result of public health concerns. Like water and drainage, through the years these have moved from consideration of waste conveyance and disposal to greater attention to source control, and recycling opportunities. Ensuring public health, as in water and drainage considerations remains a key consideration in the development of any planning initiatives.

Until the last decade, water, sewerage and drainage planning has tended to be considered independently. In recent years, as a result of a combination of increased awareness of water resources scarcity, greater awareness of sustainability principles and advances in technologies, greater attention is being directly to integrated whole of cycle water management. As systems and their operation become more integrated the demands for high quality data, decision models and the understanding of climate linkages to optimise system performance and infrastructure investments over a range of timescales is receiving greater attention.

Climate, particularly climate extremes, is a key variable in many planning studies for major infrastructure. These influences include:

- Drought severity, duration and frequency are the main drivers for assessing water supply yield and have implications for system operations and instream environmental health.
- Annual and seasonal climate variability impacts on catchment rainfall runoff rates
- Drought conditions can lead to higher risks of bushfires within catchment areas
- Variability in rainfall and streamflow has implications for water quality entering the water supply system
- Estimates of probable maximum rainfall influence design of major spillways
- Seasonal variability of temperature and rainfall influences streamflow variations at major harvesting sites and water demand and seasonal water transfers within the system
- Peak day temperatures influence design of assets for peak day water demands in water transfer studies
- Storm frequencies and intensities influence design of urban drainage infrastructure and the potential risk of sewer overflows
- Storm characteristics across Melbourne influence infiltration rates in sewers and operation of treatment processes

- Storm intensity, frequency and duration influence flood risk and water quality in the Yarra catchment

Information that provides further understanding of the conditions and risks of these events improves the provision of safe, reliable and sustainable water management systems.

Short-term response to climate events

While climate risks are addressed in the planning of resource management systems, systems are not designed to cover the full extent of potential climate variability. To address the risks of extreme events a range of response initiatives, contingency plans and actions have been developed. Those that have a connection to climate variability include:

- Drought Response Plans. These plans, which were developed by the metropolitan water companies, include consideration of drought severity, and storage volumes in the development of trigger volumes for water restrictions to reduce water use. The plan also includes obligations for monitoring hydro-meteorological conditions including Bureau of Meteorology Seasonal Climate Outlooks.
- Flood monitoring systems and response activities. Melbourne Water maintains an extensive data collection network comprising of rainfall and river levels throughout the area of responsibility. This data is provided to the Bureau of Meteorology, which then notifies the State Emergency Services, councils and the media.

Communications and awareness

The metropolitan water companies fund the Victorian Government's *Our Water Our Future* community information and education program. This program is aimed at fostering behavioural change in relation to the responsible use of drinking water. This program has been successful in increasing community awareness of water as a scarce resource, and building knowledge and awareness of how to save water as part of people's everyday lives.

These programs have also assisted in increasing awareness of the links between climate and weather impacts on managing water, sewerage and drainage systems. Examples of these activities, several implemented in collaboration with the Department of Sustainability and Environment and the retail water companies under the Victorian Government's *Our Water Our Future* (OWOF) program include:

- Providing information on:
 - Real time rainfall and streamflow information on Melbourne Water telemetered sites
 - Storage levels and water usage information for *OWOF* Billboards at Flinders Street and Punt Road
 - Daily updates of storage levels to Yellow Taxis through their internal messaging system
 - Information on ninemsn website and links from Melbourne Water's website to other sites such as Bureau of Meteorology
 - Distribution of a weekly water report that includes storage levels, consumption data, rainfall information.
 - Drought and water conservation dedicated websites
- Publications and online resources such as *The Source* magazine, which aims to increase awareness of water management issues to a broad audience. Recent articles on climate related issues have included information on the Melbourne Water climate change study and the Bureau of Meteorology publication *Drought, Dust and Deluge* (BOM 2004)
- Educational resources, including the Melbourne Water discovery centre which includes interactive displays on Melbourne's water, sewerage and drainage systems

and includes water cycle and sewer virtual tours, and online Educational material, online resources on water management and conservation including 'Rain, rain, don't go away', 'Every drop counts' and 'Rain Hail Shine'

- Partnerships with Government and water companies and other parties to promote sustainable water practices,

While the focus of the information is on water management, the information is aimed at increasing awareness of the implications and challenges of managing these systems for Melbourne's variable climate and the potential implications of climate change.

Research and climate change

A range of strategic research and development programs are undertaken in collaboration with research agencies, and other parties such as; Government agencies, academic institutions and consultants. This research is undertaken with the objectives of:

- Increasing efficiency and productivity
- Minimising exposure to environmental and public health risks
- Enhancing knowledge for strategic purposes, and
- Addressing potential changes in regulatory standards and practices.

The three major research areas are water quality, treatment & marine and waterways & wetlands that cover the traditional functions of "water, sewerage and drainage". There is also a major research effort on water recycling and water conservation.

As part of this research program studies into the implications of climate change and variability have been commissioned. A key recent study has been the CSIRO and Melbourne Water collaborative study on the implications of climate change for Melbourne's water resources. This report is available on the website www.melbournewater.com.au. Key findings from the study include:

- Increases in average annual temperature of 0.3 to 1.0°C in 2020 (mid range 0.5°C), and 0.6 to 2.5°C in 2050 (mid range 1.4°C).
- Changes in rainfall in Melbourne's catchments of between -5% and 0% (mid range -2%) in 2020 and between -13% to 1% in 2050 (mid range -4%)
- Potential for drier conditions with more hot, dry days, but increased rainfall intensity during storms.
- Potential for increases in water demand as a result of drier and hotter conditions.
- Reduction in average annual streamflow into Melbourne's main water reservoirs of between 3% and 11% by 2020 (mid range -7%) and between 7% and 35% by 2050 (mid range -18%). Streamflow reductions of this magnitude would reduce the average volumes available from the water supply system (or system yield) by 8% in 2020 and 20% by 2050.

In response to the potential water yield reductions Tarago Reservoir is to be reconnected by 2011 to help provide a buffer from the impact of climate change. Water supply projections also indicate that a number of actions in the Victorian Government *Our Water Our Future* (2004) may have to be brought forward. This will require further investigation of further water conservation, recycling and providing new or alternative water sources; including stormwater harvesting, desalination, aquifer storage and recovery and major recycling and water substitution opportunities from the main sewage treatment plants.

There are rigorous planning processes in place to address these yearly Water Supply-Demand Strategies, the State Water Report, and other Sustainable Water Strategies that will provide the framework for ensuring sustainable water supplies.

The climate change study took two years to complete and involved a large number of people in the supporting studies. This highlights the complexity involved in assessing local impacts of climate change on water systems and the need for collaborative approaches.

Melbourne Water is also completing research with the University of Melbourne in conjunction with water resources academics from California and South Africa on the potential implications of hydro-climatic variability on the water supply system and implications for variability in supply system yields in wetter and drier phases characterised by shifts in the Pacific Decadal Oscillation.

These studies have highlighted a number of areas where further climate based research would assist in identifying adaptation options for managing climate variability and change, including:

- Periodic review of climate change scenarios based on available climate change research.
- Development of a better understanding of climate variability, particularly decadal rainfall variability and how variability may interact with climate change.
- More site specific research into changes to rainfall totals, temporal patterns and intensities associated with storm events to assist local planning initiatives.

Review and development

The above initiatives are also subject to on going review and development to ensure business decisions are sound and risks are appropriately addressed. These periodic reviews build in any changes to underlying assumptions, including climate based assumptions.

Conclusion

Climate, and its variability over a range of timescales has significant implications for the planning and management of water, sewerage and drainage systems.

Melbourne Water maintains a series of on-going initiatives to collect, plan, respond and provide information on the range of climate influences on the management of water, sewerage and drainage systems. This paper has outlined the initiatives and some recent research on climate based studies.

Acknowledgments

This paper has been prepared with the assistance of many people in including: Chris Chesterfield, Paul Rassmussen, Salayana Williams, Peter Scott, Terry Scott, Udaya Kularathna, and Ian Watson.

References

Australian Bureau of Meteorology, 2004. *Drought, Dust and Deluge: A Century of Climate Extremes in Australia*, Australian Government.

CSIRO, 2005. “*Melbourne Water Climate Change Study, Implications of Potential Climate Change*”, Melbourne Water.

Victorian Government, 2004. *Our Water Our Future, Securing our Water Future Together, Victorian Government White Paper*, Victorian Government Department of Sustainability and Environment, Melbourne.