Government of South Australia
Department of Water, Land and Biodiversity Conservation

Review of Hydrological Monitoring and Operational Information for the Drains, Watercourses, Wetlands and Regulators in the Upper South East

Part Two: Hydrological Information




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This project is part of the Upper South East Drain and Watercourse Surface Water Modelling Project forming part of the Upper South East Dryland Salinity and Flood Management Program

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Cover Photographs (clockwise, starting top left)
Salt Creek flow and salinity monitoring site (Site A2390568), flow monitoring site on Bakers Range Watercourse (Site A2391001), taking a salinity reading on Ballater Main Drain (Site A2391054), flow and salinity monitoring site on Fairview Drain, (Site A2390569).

FOREWORD

South Australia's water resources are fundamental to the economic and social wellbeing of the State. Water resources are an integral part of our natural resources. In pristine or undeveloped situations, the condition of water resources reflects the equilibrium between rainfall, vegetation and other physical parameters. Development of surface and groundwater resources changes the natural balance and causes degradation. If degradation is small, and the resource retains its utility, the community may assess these changes as being acceptable. However, significant stress will impact on the ability of a resource to continue to meet the needs of users and the environment. Degradation may also be very gradual and take some years to become apparent, imparting a false sense of security.

Management of water resources requires a sound understanding of key factors such as physical extent (quantity), quality, availability, and constraints to development. The role of the Knowledge and Information Division of the Department of Water, Land and Biodiversity Conservation is to maintain an effective knowledge base on the State's water resources, including environmental and other factors likely to influence sustainable use and development, and to provide timely and relevant management advice.

Neil Power
Acting Director, Knowledge and Information Division
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EXECUTIVE SUMMARY

This report was prepared as part of the Drain and Watercourse Modelling Project that forms part of the Adaptive Management and Integrated Monitoring Sub-Program of the Upper South East Dryland Salinity and Flood Management Program. Other reports reviewing and documenting similar material relating to climatological information, in particular rainfall and evaporation, and drainage system operations, detailing regulator and weir structure specifications, together with this report form the first stage in the preparation of a drain and watercourse model.

In the process of collating and reviewing all the hydrological data for the USE area a number of disparate data sets were amalgamated into a single data system, Hydstra TS. A significant amount of additional new data and information was also collected during in-field visits to monitoring sites and this has also been added to the data system.

Weaknesses in the previous hydrological data sets were identified and overcome through the implementation of the Hydstra TS system. A number of strategies have been recommended to ensure that the data held in Hydstra TS system maintains its integrity and provides an effective and efficient data system that can be sustained into the future.

Management of ad hoc manual readings has been identified as an issue that is to be overcome through the development of a new Adaptive Management Geo-database.

This report also provides a review of current and past hydrological monitoring within the Upper South East Dryland Salinity and Flood Management Program area. Details of the characteristics of each individual monitoring site are provided together with summaries of data that has been collected either by continuous recording or by manual ad hoc readings.

A revised monitoring network is proposed that will provide the required level of data and information to enable dynamic operation of the complex system of drains, watercourses and wetlands within this area.

An increase in the number of continuous recording sites from 21 to 42 is recommended to provide the required level of data and information. An important feature of the proposed monitoring network is to employ telemetering facilities to enable data from monitoring sites to be made available to managers of the system in real time.

In making recommendations for the expanded monitoring network it is recognised that the most prominent risk to the monitoring program and thus to the adaptive management program is the lack of suitable human resources to manage and operate the existing and proposed network of sites. A review to determine the required level of resourcing is proposed.

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1. INTRODUCTION

1.1 Purpose

A comprehensive review of hydrological monitoring and operational information for the drains, watercourses, wetlands and regulators in the Upper South East (USE) has been undertaken as the first stage of a Drain and Watercourse Modelling Project within the USE Dryland Salinity and Drainage Program. From this review, technical reports that collate all currently available information and detail the methodology and results of this assessment will be produced. These will provide a fundamental basis for the development of a hydrological time-series model for the region and to determine additional monitoring requirements. This report forms part of this review, focusing on hydrological information.

1.2 Background

The Upper South East region of South Australia is approximately 17,000 km^2 and includes the rural towns of Keith, Padthaway, Naracoorte, Kingston SE, Lucindale, Salt Creek and Tintinara as shown in Figure 1. The topography comprises a series of remnant sand dune ranges aligned in a northwest to southeast direction and separated by inter-dunal flats with sandy-clay soils. The low surface relief ensured that extended periods of flooding were a common occurrence (NRCSA, 1993). For this reason, dryland salinisation is not a recent phenomenon in the USE and was naturally present in small areas before the land was first cleared. These historic saline areas occurred where shallow water tables existed and poorly developed natural drainage systems resulted in the evaporation of excess surface water.

Over the last 20 years there has been an acceleration in the rate of dryland salinisation experienced across the region. This is considered to be the result of a number of interacting factors (NRCSA, 1993). Land clearance dramatically increased in the late 1940s and 1950s, with the removal of native vegetation cover and the establishment of perennial lucerne. This was almost completely destroyed by the lucerne aphid in the late 1970s and since that time increased groundwater recharge has caused a rise in groundwater levels. In addition, altered drainage lines and extensive development of private drainage has increased water flows within the area. Native vegetation and wetlands have been adversely affected by salinisation and flooding to varying degrees, with some systems becoming waterlogged, some affected by salt accumulation and others being deprived of water by drainage systems.

The Upper South East Dryland Salinity and Flood Management Program (USE Program) was developed in the early 1990s to address community concerns about dryland salinisation, waterlogging and ecosystem fragmentation and degradation. One of the long-term objectives of the USE Program is to establish an adaptive management system for the whole region, designed to manage the available water for hydrological, environmental, and agricultural benefits within the catchment. In order to develop such a system, a complete understanding of water availability and how this water moves through the drains, watercourses and wetlands is essential. This has led to the Drain and Watercourse Modelling Study of which this report forms part of the first stage.

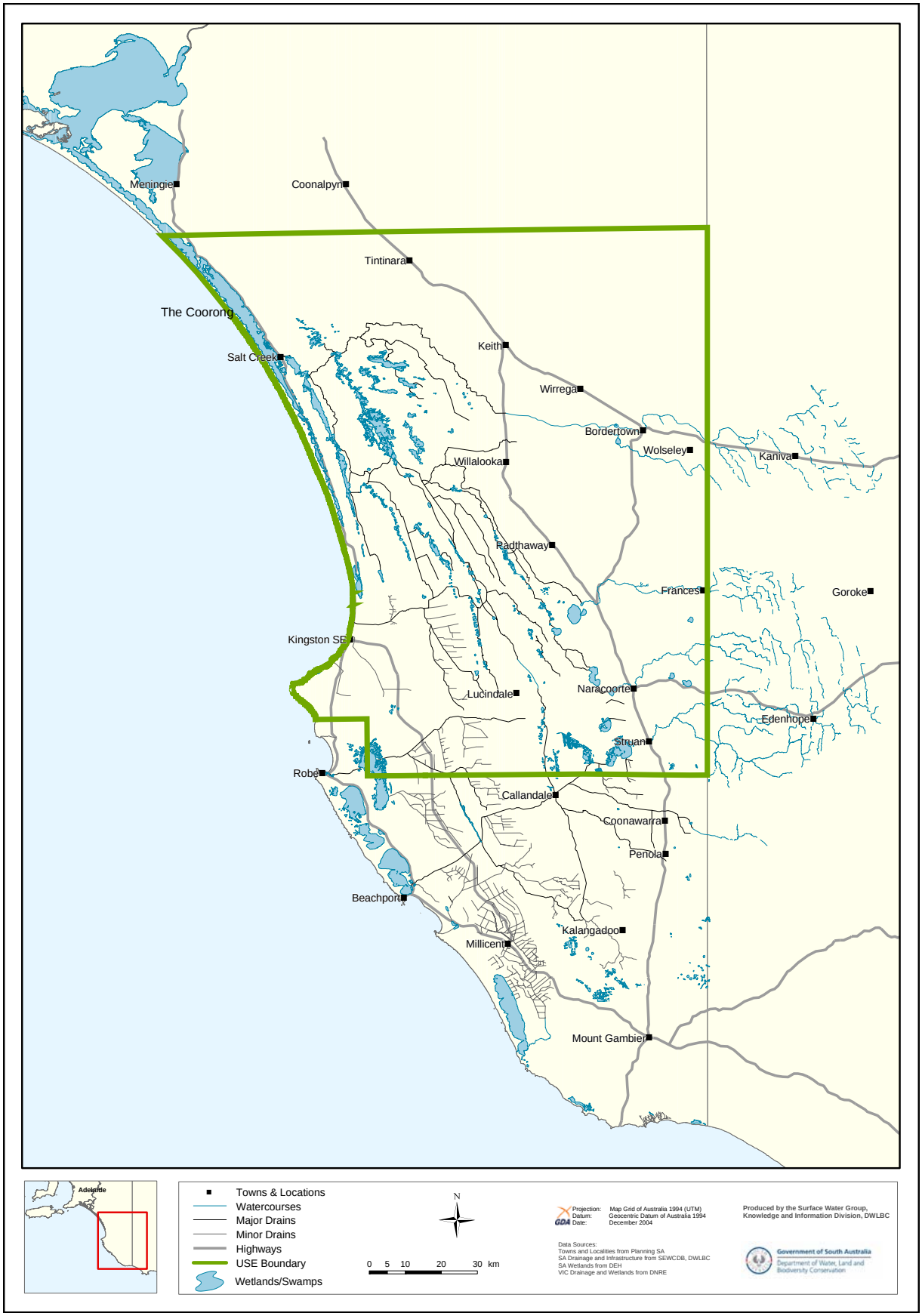

Figure 1 Locality Map.

1.3 Objectives and Methodology

The primary objective of the Drain and Watercourse Modelling Project is to develop a hydrological time-series model that describes the movement of water through the drains, watercourses, wetlands, swamps and regulatory structures in the Upper South East. Such models provide a technical foundation for the consideration of future management options and decisions.

It is intended that the hydrological model describe catchment rainfall-runoff processes while explicitly incorporating the spatial distribution of significant physical features that control or influence runoff and its movement through the region. This allows for a better understanding of the hydrological processes and subsequently offers the most flexible means to facilitate a meaningful assessment of various operating strategies. Such an assessment includes the identification and evaluation of potential impacts and risks to specific environmental assets due to varying diversion operations and storage management strategies. This allows comparisons between approaches to be made before physical trials are undertaken.

This Drain and Watercourse Modelling Study has been sub-divided into a number of stages that are briefly described in the following:

Stage One

- Monitoring Information (rainfall, evaporation, water level, flow, salinity)
  - Identification of monitoring locations and data availability;
  - Processing and statistical analysis of rainfall and evaporation data, including both short and long-term statistics and trends;
  - Collation, audit and review of water level, flow and salinity data quality; and
  - Recommendations to address additional monitoring requirements.
- System and Operational Information
  - Identification of drains, watercourses, wetlands and swamps, their physical characteristics and water flow paths within the system;
  - Identification of diversion/regulatory structures, their operational regimes and availability of operational data; and
  - Identification of gaps in existing information.

Stage Two

- Model Datasets
  - Preparation of rainfall and evaporation data files and quantification of rainfall spatial variability;
  - Revision of hydrological data (water level, flow) based on field investigations and preparation of data files; and
  - Revision of the physical characteristics and the development of surface area to volume relationships for wetlands and swamps based on field surveys.
- Model Construction
  - Definition of sub-catchments; and Development of system layout within modelling platform that describes the generation, storage and movement of water throughout the region.

Stage Three

- Model Calibration
  - Selection of a rainfall-runoff model for each sub-catchment; and
  - Calibration of parameters including assessment of parameter appropriateness.

Stage Four

- Model Scenario Evaluation
  - Quantification of the linkage between hydrology and ecology in the development of management rules and operational strategies that provide acceptable drainage and maintain wetlands and swamps;
  - Evaluation of these management rules and operational strategies to further environmental flow studies and so assist in the development of optimal environmental management plans; and
  - Identification and recommendation for additional requirements and improvements to regulatory infrastructure to meet the demands of future management regimes.

As described above, the first stage of this study is the collation of information required to construct and evaluate the hydrological model. This has been documented in a three part report, each focusing on a particular aspect of this stage. In particular:

Part One: Climatological Information

- availability and quality of climatological and hydrological data relating to rainfall and evaporation;
- an analysis of available rainfall and evaporation data at daily, monthly, annual and decadal timescales, including long-term trends; and
- consideration and recommendation of additional monitoring locations.

Part Two: Hydrological Information

- availability of monitoring data relating to water level, flow and salinity through drains and watercourses and water level and salinity within wetlands and swamps;
- data summary report for each monitoring location including site characteristics and instrumentation, type and quality of recorded data, proximity of any flow regulation structures and suitability of data for modelling; and
- consideration and recommendation of additional monitoring locations.

Part Three: System Operation

- an understanding of the drain and watercourse system including water flow paths and the location and operational regime of diversion/regulatory structures; and
- the identification of all storages (wetlands, swamps and runaway holes) and an understanding of their hydrological characteristics.

This report forms Part Two: Hydrological Information of Stage One of the Drain and Watercourse Modelling Project.

2. DRAINAGE SYSTEMS

The Upper South East Dryland Salinity and Flood Management Program area contains a number of interconnected drainage systems that form a network of drains and watercourses carrying either fresh surface water runoff or saline water emanating from the groundwater system or a mixture of both.

Since the commencement of European settlement of the South East of South Australia in the 1840s the low lying swampy nature of the area had been considered an impediment to development and as early as 1864 drainage channels were being constructed to alleviate flooding, make additional land available for agricultural use and improve roads that were frequently inundated (Turner & Derek 1989).

Construction of drainage works has continued since the late 1800s with significant construction programs undertaken following the Second World War. The majority of these drains were developed to drain areas south of Kingston and convey the excess surface water westward to the ocean rather than northward along historical drainage lines. To accomplish this, major channels were excavated through the dune ranges that run south-east to north-west across the region.

The Upper South East Dryland Salinity and Flood Management Program includes the construction of additional drainage systems in the area north and east of the original southern area serviced by drains constructed over the 120 years since the 1860s. The new drains in the USE area interconnect with a number of the pre-existing drains and natural watercourses and have been designed to perform a number of different functions to provide a integrated system that can assist in alleviating dryland salinity, reduce flooding and provide benefits to wetland systems.

Two different types of drainage channels have been excavated within the USE area. Drains primarily used to control groundwater levels, generally referred to as ‘deep drains’, have been excavated to a depth of greater than 2 m where they intercept saline ground water. Drains used primarily to collect surface water runoff, thus reducing surface inundation, are generally referred to a ‘shallow drains’ have been excavated to less than 2 m and do not intercept ground water. Construction of the USE drainage system commenced in 1995 and is still underway, with completion of the system planned for the end of 2006.

Information in this report has been divided into a number of drainage sub-systems that generally align with wetland and watercourse sub-catchments referred to in other components of the Adaptive Management and Integrated Monitoring Sub-Program. A brief description of each of the sub-systems follows and Figure 2 provides a simplified schematic diagram of these drainage sub-systems.

Tatiara Creek

The Tatiara Creek Sub-system includes the catchments of Tatiara Creek and Nalang Creek from their sources in western Victoria eastward to the Riddoch Highway in South Australia. The upper catchments of both Tatiara Creek and Nalang Creek are generally flat to slightly undulating with numerous small shallow channels that can be easily surcharged. As the small channels amass they form the more defined main streams of the Tatiara Creek and the north and south arms of Nalang Creek. Shortly after the confluence of Nalang Creek with Tatiara Creek near Cannawigara numerous karst features, known as runaway holes, enable surface water flows to pass into the upper aquifer of the regional groundwater system. In all but very high rainfall years these features absorb almost all surface water flow with no water passing further downstream towards the Mount Charles Drain.

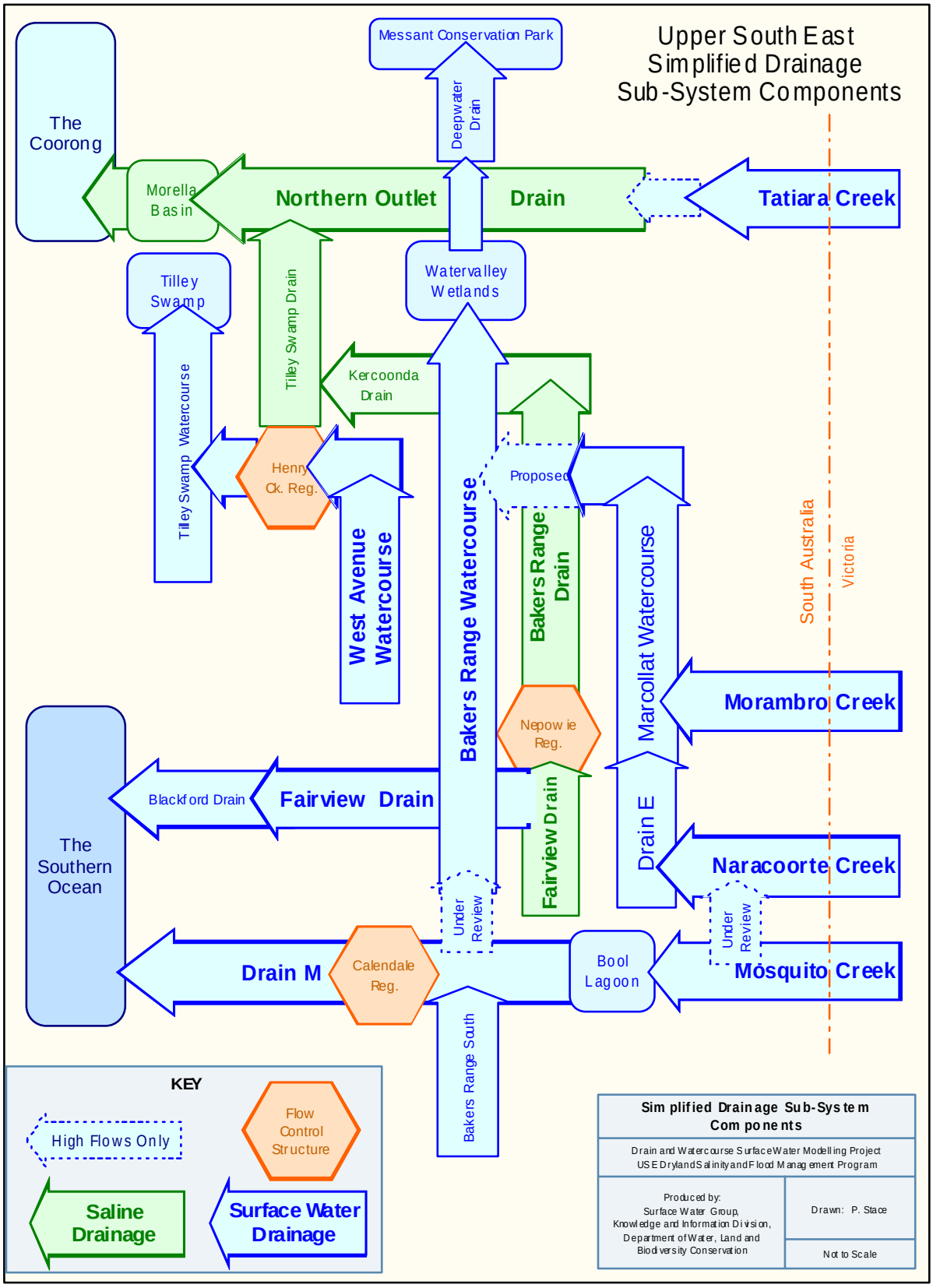

Figure 2 Drainage Sub-systems.

Morambro Creek-Marcollat Watercourse

The Morambro Creek–Marcollat Watercourse Sub-system includes the catchment of Morambro Creek commencing in western Victoria then eastward into South Australia flowing downstream to Cockatoo Lake. From Cockatoo Lake water passes down the excavated Nyroca Channel to the confluence with the Naracoorte-Drain E Sub-system. Further downstream the combined flow passes through numerous wetlands along the Marcollat Watercourse towards Jip Jip and finally to the confluence with Watervalley Drain being part of the Bakers Range Sub-system. Also included in this sub-system is the Didicoolum Drain an excavated deep drain that connects to the Watervalley Drain just downstream of the confluence of the Marcollat Watercourse. The Didicoolum Drain runs generally parallel to the Marcollat Watercourse and it is planed that it will be extended nearly 30 kms further to the southeast.

Naracoorte-Drain E

Commencing in western Victoria the catchment of Naracoorte Creek extends into South Australia with the natural surface water channel of Naracoorte Creek terminating at Lake Ormerod. Downstream of Lake Ormerod water passes along Drain E through numerous wetland systems to Jaffray Swamp. Just downstream of Jaffray Swamp Drain E is joined by the Nyroca Channel carrying flow from the Morambro Creek Sub-system with the combined waters entering The Muddies wetland and then continuing northward as the Marcollat Watercourse. Currently the Marcollat Watercourse intersects the Watervalley Drain (part of the Bakers Range Drain pathway) however a structure is planned to be constructed that will carry the Marcollat Watercourse flow over the Watervalley Drain to join the Bakers Range Watercourse.

Fairview Drain

The Fairview Drain commences as a deep drain collecting saline groundwater and connects to the Bakers Range Drain upstream of the Nepowie Regulator. At this point saline water may be allowed to pass into the Bakers Range Drain or, if of a suitably quality, water can be diverted along the lower segment of the Fairview Drain towards Blackford Drain, eventually being discharged to the ocean.

The Tressant Drain area is a closed system adjacent to the upstream end of the Fairview Drain and has been included within the Fairview Drain sub-system even though these two drains do not connect.

Bakers Range

The Bakers Range Sub-system forms the backbone of the south to north drainage scheme and is made up of two parallel channels.

The Bakers Range Watercourse, carries fresh surface water runoff northward via extensive interconnected wetland systems culminating at the Cattledam Stop Bank. Water from the Bakers Range Watercourse is able to continue further north passing over the Northern Outlet and flow as far as the Messant Conservation Park or depending on flow volume and salinity level may be diverted into the Northern Outlet Drain.

The Bakers Range Drain runs parallel to the watercourse and conveys saline groundwater from the Nepowie Regulator and from deep drains such as the Ballater Main Drain and Didicoolum Drain that flow into the Watervalley Drain forming a segment of the Bakers Range Drain pathway further north. The Watervalley Drain currently connects to the Bakers

Range Watercourse upstream of the Watervalley Wetlands however with the completion of the Kercoonda Interchange it will be possible to divert more saline water under the watercourse to join the Kercoonda Drain and eventually make its way to the Northern Outlet Drain via the Tilley Swamp Drain.

West Avenue – Tilley Swamp

This sub-system is also comprised of a freshwater system and a saline water system. The West Avenue Drain collects water, which if saline may be diverted via the Henry Creek Regulator to the Tilley Swamp Drain that in turn connects to the Northern Outlet Drain. If sufficiently fresh the water can alternatively be diverted at Henry Creek Regulator to Tilley Swamp Watercourse and then to Tilley Swamp. A number of drains are yet to be constructed in the sub-system including the Taratap Drain and a proposed connection between the Kercoonda Drain and the Tilley Swamp Drain that will prevent saline water from passing through the sensitive area of Henry Creek.

Northern Outlet

The Northern Outlet Drain Sub-system forms the northern connector for all the saline drainage to Morella Basin, the terminal storage area for the scheme, which is connected to The Coorong via Salt Creek. At present flows from the Tatiara Creek sub-system very rarely connect with the upper end of the Mount Charles Drain however the Brunbury and Taunta Drains connect to the Mount Charles Drain to form the Northern Outlet Drain. This system is almost entirely excavated deep channels.

Mosquito Creek

The Mosquito Creek Sub-system includes the catchment of Mosquito Creek within Victoria downstream to Hacks Lagoon and Bool Lagoon after which water passes into the Drain M sub-system.

Whilst the Mosquito Creek sub-system and the adjoining Drain M sub-system are at present not directly connected to the USE drainage system prior to the construction of drainage in this area flood flows did historically move northward from Mosquito Creek to what is now part of Drain E. The feasibility of re-establishing a flow path from Mosquito Creek to Naracoorte Ck is being investigated as part of the USE Program.

Drain M

Downstream of Bool Lagoon water from the Mosquito Creek sub-system is conveyed down Drain M and joined from the south by several drainage networks, including Bakers Range South Drain. Flows then pass through Callendale Regulator towards Lake George and then to the Southern Ocean.

Historically flow from the Bakers Range South catchment would have continued northward along the Bakers Range Watercourse however with the construction of Drain M this pathway was interrupted. During periods of very high flows in the Drain M and Bakers Range South Drains flow can still move northward into the Bakers Range Watercourse with flooding impacts. The feasibility of re-establishing a flow path from Drain M to the Bakers Range Watercourse is being investigated as part of the USE Program.

Whilst the Drain M sub-system and the upper portions of the Tatiara Creek, Morambro Creek, Naracoorte Creek and Mosquito Creek catchments within Victoria are outside of the formal USE Program area (See Figure 1) hydrological information for these areas is included in this project as this information forms an integral part of the drain and watercourse model.

3. HYDROLOGICAL DATA

Hydrological data is required to enable a drain and watercourse surface water model of the USE area to be developed. All available data needs to be collated and reviewed and then suitable data selected, revised and prepared for use in the model.

In addition to being used in the construction of the model, the process of collating and reviewing all available data provides the basis for a systematic review of current monitoring activities leading to the formulation of a revised monitoring program focusing on the needs of hydrological modelling and forming an integral part of the Adaptive Management System to be used for the future management of regional drainage and wetland systems.

3.1 Data Types

A wide range of data types fall into the general category of hydrological data however the most common data types collected for the purpose of hydrological analysis usually include water level (also referred to as stage), and salinity. In many cases flow (also referred to as discharge) is required and this can be derived from the water level data provide a relationship between water level and flow has been established. Sites where flow data is produced from water level data are commonly referred to as 'Gauging Stations' since the method used to establish the stage-discharge relationship involves numerous individual measurements of flow, known as flow gaugings, to be undertaken.

A wide variety of options exist for collecting water level and salinity data and for deriving flow volumes in streams. The equipment used and the scale of associated infrastructure has a significant influence in the accuracy and reliability of data collected. Data can be collected continuously using recording equipment such as data loggers that provide a unbroken time series representing actual events over time, or data can be collected as individual non-continuous data points that only represent the value at single point in time.

3.1.1 Continuous Data

In situations where long-term, accurate, reliable flow data is required a continuously recording 'Gauging Station' that includes a stable control weir would be used. Typically water level would be recorded using a data logger located above a stilling well that is connected to the stream by inlet pipes or alternatively water level could be measured using an electronic sensor placed in the stream and connected to the data logger via a cable. Over a period of time numerous individual flow gauging measurements would need to be conducted to establish the relationship between stage and discharge. Salinity could be recorded on the same data logger using an electrical conductivity (EC) sensor located in the stream. These sites require specific design criteria to be followed to ensure that a stable relationship between water level and flow is produced. Construction of the control weir is frequently a significant proportion of the establishment cost for these sites, particularly on large streams.

Alternatively similar water level and salinity instrumentation can be installed in an open channel on a stream without the construction of a control weir. This can provide accurate, reliable water level and salinity data but the relationship between water level and flow is more difficult to establish and is generally unstable over time. More frequent flow gauging measurements would be required over the entire life of the site to determine when changes in the stage-discharge relationship occur. Establishment cost of this type of site are significantly less than a site which includes a weir however there is a delay of possibly

several years before a stage-discharge relationship can be established and flow information produced. Due to the need for more frequent flow gaugings the ongoing operational cost can be higher than for a site with a stable control weir.

Another important hydrological condition that can also be continuously recorded is rainfall. Rainfall recording equipment typically consists of a tipping bucket pluviometer connected to a recording device such as a data logger. This equipment is sometimes located at a 'Gauging Station' and connected to the same recording equipment used for collecting the water level data. Alternatively a separate site may be established where only rainfall is recorded using a stand alone integrated pluviometer and data logger system.

At some sites where continuous recorded data is collected the option of making the data available to users without the need to visit the site may also be provided. The level of remote access to data can vary from interrogating the recording device using very specific technical software through to providing data via a Web site in interactive and highly graphical formats. In practice the level and type of data and information that can be provided remotely from a monitoring site is dependent on the capability of the recording device, the type and reliability of the communication system and the sophistication of the remote interface system. Due to the technical requirements and associated costs involved in telemetering of data this function is usually reserved for key locations where up to date critical information is required to assist in decision making processes, or at sites where a high degree of data reliability is required, such as primary sites used in a operational model.

Regardless of the existence of telemetering at a site or what type of data is continuously recorded all data is removed from the recording device by a technician on-site and then entered into the regional Hydstra time series system. Data from the regional Hydstra system is routinely uploaded to the central Hydstra system in Adelaide that forms the State Water Archive, the final permanent store for hydrological data.

3.1.2 Non-continuous Data

At less critical locations where continuous recorded data is not essential, but where a 'snap shot' indication of hydrological conditions is sufficient, non-continuous manual readings can provide an adequate low technology, low cost option.

Sites where non-continuous data collection takes place typically include a staff gauge that is used to provide a visual reading of water level. Salinity may be measured on-site using a portable EC meter or by taking a bottled sample that can later be tested off-site.

As with continuous recording monitoring sites a stable flow control structure may exist or the site may be an open channel. In either case, provided that a reliable stage-discharge relationship has been established, an instantaneous flow value can be determined from the water level reading.

Ad hoc manual readings have generally been noted down into diaries or field books on-site. Some of this data has been entered into some form of digital storage such as spreadsheets. Whilst there has been no single, standard data system for storing or managing this data in the past a new data system, the Adaptive Management Geo-Database, is being developed to accommodate ad hoc hydrological data together with wetland and system operation information.

Two ad hoc reading data sets do exist that are, in part, contained within digital data systems. A network of wetland monitoring sites was established in 1990 as part of the USE Program

with the data being entered into a database, (Giraudo, Monitoring Database 2002). These monitoring sites were located in wetlands within the USE area, with particular concentration around the central area (see Figure 3). The second ad hoc reading data set contains a mixture of ad hoc water level and salinity readings and weir operation information for locations of interest to the SEWCDB across the wider SE regional area. Details of the position of many of these sites are not available however data has been entered into a set of spreadsheets (Puddy, Spreadsheets 2002).

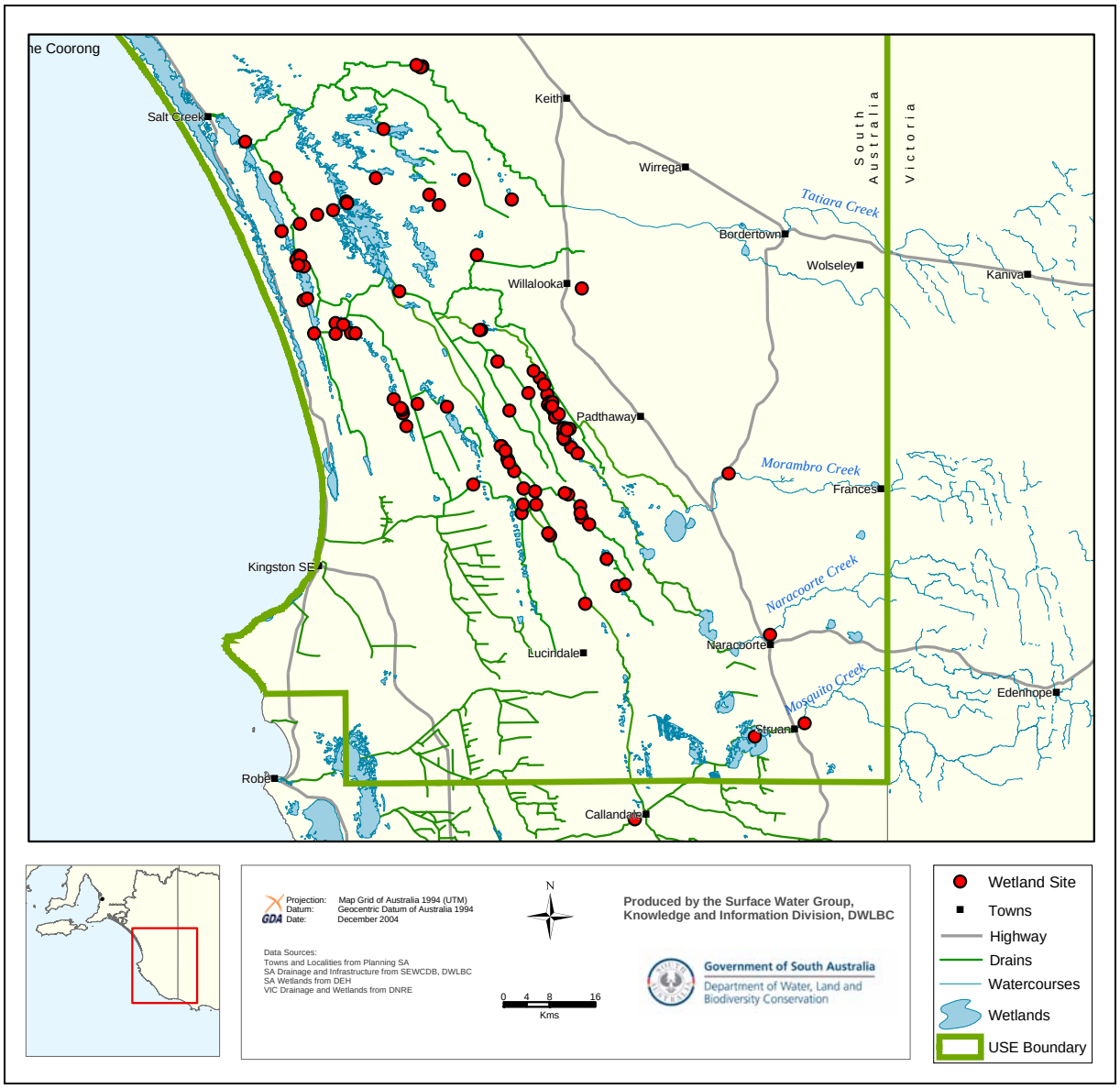

Figure 3 Wetland Monitoring Sites.

3.2 Site Classifications

Hydrological monitoring sites have been divided into four general categories defined by the type and quality of data required.

Category I

Category 1 sites are capable of providing the highest level of resolution, precision and reliability of continuous record over all ranges for an extended (indefinite) period.

These sites would be located at critical positions within the water system at major catchment or sub-catchment outflows, locations representing areas of significant interest or at locations where major operational decision-making information is required.

Recorded parameters may include:-

- Water Level
- Water Flow (using a stage-discharge or velocity-discharge relationship)
- Salinity (including water temperature)
- Rainfall
- Flow Control Condition (such as sluice gate position)

In most circumstances data will be available in real time or near real time using a telemetry systems that may also include remote data acquisition capability.

Monitoring equipment may be duplicated to ensure the highest reliability of continuous data.

Category 2

Category 2 sites are capable of providing accurate, reliable, continuous record over a specific range of conditions for a limited period (possibly many years).

These sites would be located at positions within the water system at major or minor sub-catchment outflows, locations representing areas of specific interest, locations where supplementary decision-making information is required or at locations where the effect of operational actions need to be continuously monitored.

Parameters recorded may include:-

- Water Level
- Water Flow (using a stage-discharge or velocity-discharge relationship)
- Salinity (including water temperature)
- Rainfall
- Flow Control Condition (such as sluice gate position)

In some circumstances data will be available in real time or near real time using a telemetry systems that may also include remote data acquisition capability.

Whilst a Category 1 site and a Category 2 site may initially appear very similar and may include identical infrastructure the difference is that the Category 1 site requires the highest level of reliability and accuracy and would be managed at a significantly higher level of priority. This may include the duplication of recording equipment and sensors to reduce the potential for lost record.

Category 3

Category 3 sites are capable of providing reliable, non-continuous ad hoc readings.

These sites are located at positions within the water system at minor sub-catchment outflows, locations representing less important areas of specific interest, locations where supplementary operational decision-making information is required or at locations where the effect of operational actions need to be observed.

Parameters observed may include:-

- Water Level (staff gauge reading)
- Water Flow (flow gauging)
- Salinity (on-site reading using a portable EC meter or off-site using a grab sample)
- Flow Control Condition (such as sluice gate position)

There is no continuous recording at these sites. Typically a staff gauge would be used to provide a stable reference for water level observations. If flow gaugings are required then suitable flow measurement sections would need to be maintained. All readings are 'single point' values and accurately represent the stream conditions at the time of the reading but do not necessarily form part of a time series.

Category 4

Category 4 sites are capable of providing a complete record of flow control operations.

These sites are located at water system control structures such as weirs or regulators.

Parameters observed may include:-

- Flow Control Condition (such as sluice gate position)
- Water Level (staff gauge reading)
- Water Flow (flow gauging)
- Salinity (on-site reading using a portable EC meter or off-site using a grab sample)

The principal purpose of this type of site is to provide a record of all control structure operations that take place. Each and every change made to a regulator/weir is to be manually recorded. This may be the number of standard sized stop logs moved, or the number remaining in the structure, or a measurement of the water depth over the weir, or the dimensions of the weir opening. The type of data required will vary from site to site dependant on the type of structure and its method of operation.

Generally there is no continuous recording at these sites and a staff gauge would be used to provide a stable reference for water level observations. If flow gaugings are required then suitable flow measurement sections would need to be maintained. All readings are 'single point' values and accurately represent the control structure and stream conditions at the time of the reading but do not necessarily form part of a time series.

In some cases flow control sites such as regulators or weirs may also be used as a continuous recording site, possibly including remote telemetry facilities. In these cases the requirements of both the Category 1 or Category 2 site coexist with the requirement of a Category 4 site.

4. MONITORING NETWORK

4.1 Regional History

A network of 'Gauging Stations' has existed in the South East Region since the early 1970s. These monitoring sites have been used principally to record continuous water level in drains and streams to enable continuous flow volume to be calculated. Many of the sites established in the early 1970s used existing weirs designed for flow management that provided a stable stage-discharge relationship but in many cases were not ideal for monitoring purposes and later needed to be modified to provide for the required level of resolution. The weir at site A2390519, Mosquito Creek @ Struan is a typical example of an existing flow management weir structure at which a monitoring site was established in 1971 (see Figure 4). The weir structure at this location consisted of a wide, broad crested rectangular weir incorporating four rectangular undershot openings along the weir base with rectangular dissipater blocks positioned on the downstream apron. This structure was insensitive for monitoring low flows and proved difficult to develop a reliable stage-discharge relationship. As a consequence modifications to the weir were made in 1976 by adding four concrete low profile "V' crump weirs along the upstream edge of the weir apron immediately in front of the four undershot openings. The result was an increase in sensitivity of the stage-discharge relationship at low flows however the compromise in using an existing structure that was not designed for flow measurement still presents difficulties and complexities in providing reliable flow data.

Figure 4 View of Downstream Side of Mosquito Creek Weir Structure.

These early monitoring sites were originally established by the Engineering and Water Supply Department (EWS) (now SA Water Corporation) however in the early 1990s the EWS ceased surface water monitoring activities in the SE Region and the responsibility for ongoing surface water monitoring fell to the South Eastern Water Conservation and Drainage Board (SEWCDB).

The current available surface water data and information for the SE Region is a product of the original monitoring network established by the EWS and later modified and added to by the SEWCDB. A few continuous recording sites and a number of non-continuous sites have also been established to monitor the USE drains and watercourses as they were constructed.

In addition to monitoring activities conducted by SEWCDB a number of other government agencies including DWLBC, Department of Environment and Heritage, Primary Industries and Research SA, undertake some regional monitoring activities at specific locations on a project basis. Other government agencies such as the EPA and SA Water also undertake monitoring at specific locations as part of broader state-wide programs. The South East Water Catchment Management Board also has a primary interest in the water resources of the region and is becoming directly involved in monitoring activities. No attempt has been made to include information about these monitoring programs within this project. Details in this report are limited to monitoring sites operated by SEWCDB that will become or are presently part of the USE Program.

A summary of available continuously recorded water level data for the whole South East Region, including the USE area, is provided in Appendix A. Most sites with continuous water level data would have a stage-discharge relationship enabling flow data to be produced.

Across the entire South East Region 135 monitoring sites have been registered in the Hydstra system (see Figure 5) however 63 of these are currently closed. Of the 135 sites that have existed, 54 sites, or 40%, have included continuous water level recording (see Appendix A) with 8 also having continuous EC recording and 5 including rainfall recorders. The remaining 81 sites, or 60%, have been non-continuous ad hoc reading sites.

The sites detailed in the following portion of this report include all site within the USE Program area (see Figure 1) in addition to sites that form parts of the drainage sub-systems that flow into, or connect to the USE area.

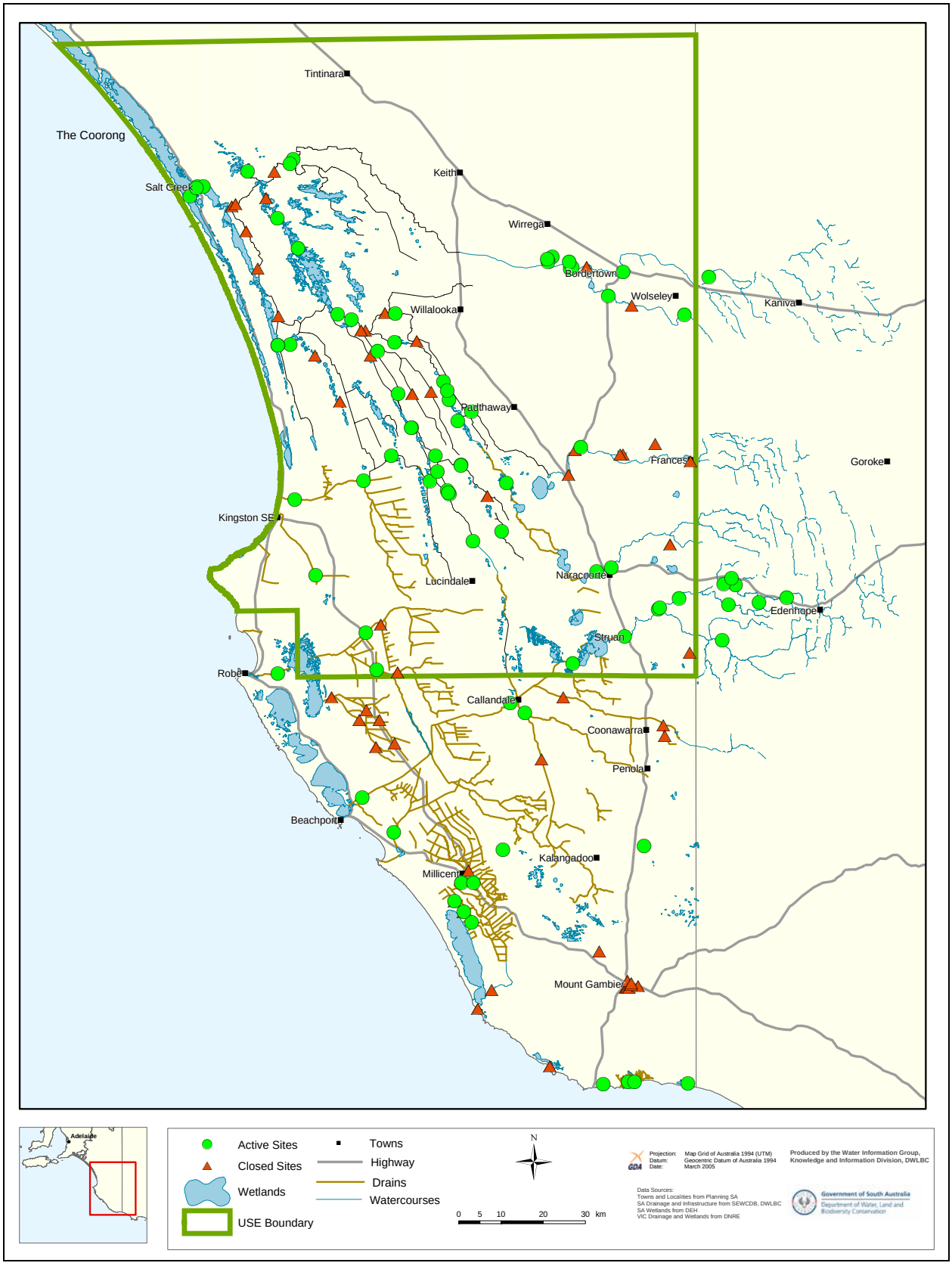

Figure 5 SE Region Hydrological Monitoring Sites

4.2 Current and Proposed USE Monitoring Network Summary

The current hydrological monitoring network for the USE area is to a large degree the product of historical state-wide and regional monitoring networks originally established by the EWS then operated by the SEWCDB and more recently augmented by the USE Program (see Figure 6).

Of the 105 sites that are located within or connected to the USE area 21 are currently closed whilst 84 are active, 21 being active continuous recording sites while 63 are non-recording sites, where ad hoc manual readings and observations are made.

Details of current and proposed monitoring are summarised for the entire USE area in Table 1 and are provided at the drainage sub-system and individual site level following in this report. Table 2 provides a summary of available data types that are currently being collected at active operating sites and data types for the proposed monitoring network.

The proposed monitoring network represents a shift towards more continuous monitoring of water level, flow and salinity with a doubling of the number of recording sites from 21 to 42, and significantly greater use of telemetering to provide real-time and near real-time information to assist in operational decision making.

Table 1 USE Area Current and Proposed Monitoring Network Site Category Summary.

Category	Category Description	Current	Proposed	Change
	Closed	21	33	12
1	Continuous recording, highest level of resolution and reliability	2	15	13
2	Continuous recording, secondary level of resolution and reliability	19	27	8
3	Non-continuous ad hoc readings	50	53	3
4	Flow control operation readings	13	15	2
	Total Operating	84	110	26

Figures include one new Category 1 site and one new Category 3 site to be established by SECWMB.
Figures include a number of Category 1 and Category 2 sites that are subject to connections being established between drainage sub-systems.

Table 2 USE Area Current and Proposed Data Types

Key	Description	Active	Proposed	Change
G	Occasional Flow **G**augings, Manual Water Level or Salinity Reading	55	61	6
O	Occasional Flow Control **O**perations (regulator/weir settings)	14	23	9
L	Continuous Water **L**evel Record	22	35	13
F	Continuous **F**low Data (Derived)	17	29	12
E	Continuous **E**C (Salinity) Recording	6	27	21
T	Data **T**elemetry	7	24	17
R	Continuous **R**ainfall Recording	2	8	6
W	Continuous **W**ind Velocity and Direction Recording	1	0	-1

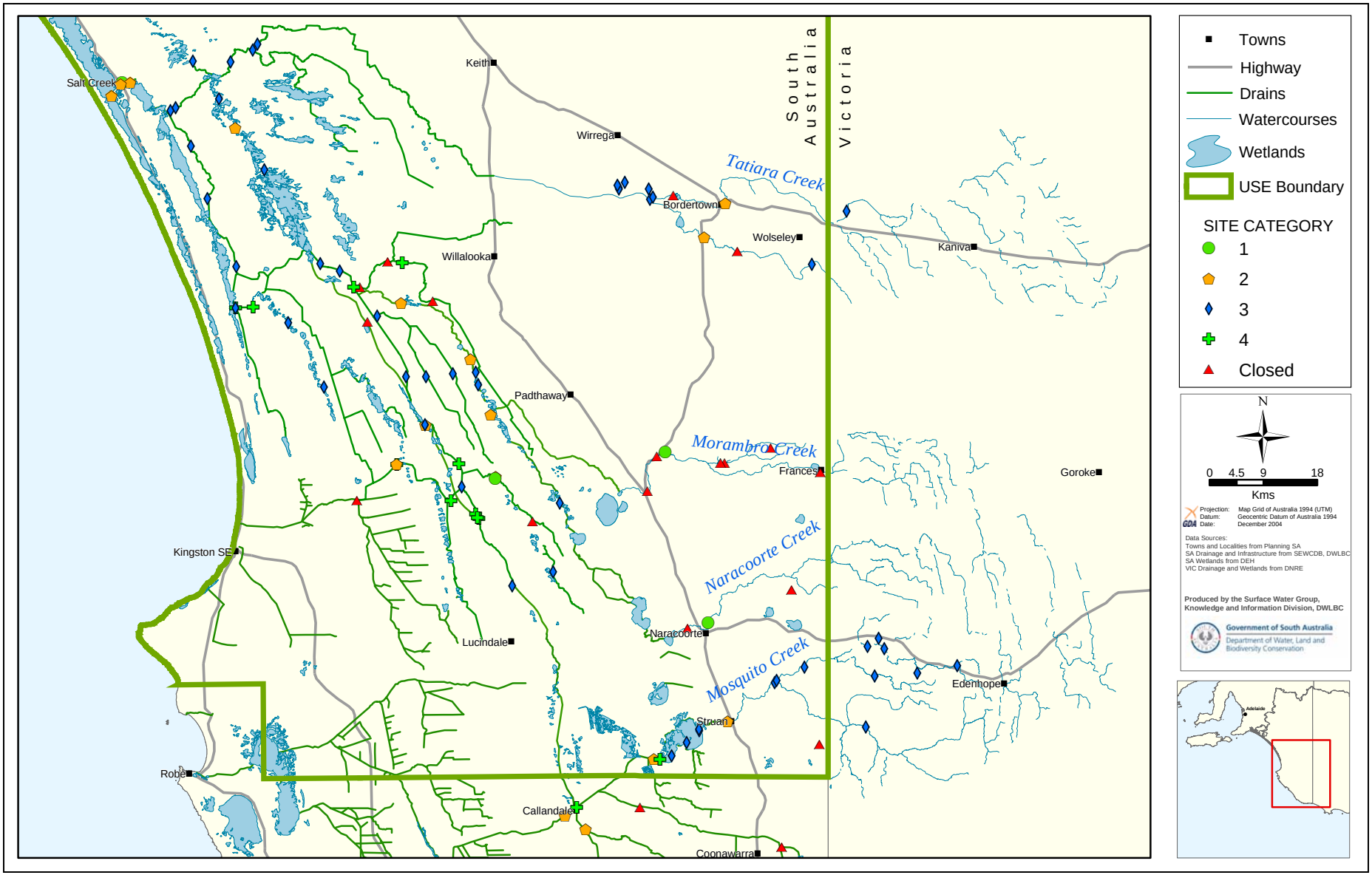

Figure 6 Current USE Hydrological Monitoring Sites

4.2.1 Monitoring Issues

There are two significant issues that need special consideration in the context of developing a revised hydrological monitoring program for the USE area. The first is the availability of suitable technical human resources to provide ongoing management of sites and the data produced and the second is the use of remote accessibility to data through telemetry systems that can provide increased effectiveness and efficiency.

Human Resources

At present one technical officer within the SEWCDB manages all the continuous recorder sites across the entire South East Region in addition to collecting data from a large number of ad hoc water level, flow gauging and salinity sampling sites. In addition to performing regional hydrological duties this officer has other significant SEWCDB responsibilities that take up approximately 50% of available time. Whilst some non-technical assistance is available from other staff within the SEWCDB and from the USE Program this officer is the only technical resource directly associated with hydrological data collection within the USE area and across the broader SE Region.

Table 3 provides a comparison of the number of hydrological sites operated within the SE Region by one technical officer at 50% of time against the number of recording sites operated by DWLBC hydrological personnel located in Adelaide at 100% of time.

Table 3 Current and Proposed SE Sites Operated and Adelaide Sites Operated

Region/Area	Comment	Number of Sites
SE Region	Current continuous recording sites	29
SE Region	Proposed continuous recording sites (+10 in USE area)	39
SE Region	Registered ad hoc reading sites (flow gaugings, sampling etc)	49
SE Region	Non-registered ad hoc reading wetland sites	50+
SE Region	Operational weirs and flow control structures	30+
Far North + Mid North	Large travel times	32
KI + Eyre Peninsula	Multi-parameter recorders	18
Mt Lofty Ranges	Environmental monitoring sites	25
R. Murray Lower Lakes	Significant telemetry	16
Adelaide Average		23

Whilst it is inappropriate to draw too many conclusions from Table 3, since site types, locations, instrumentation and technical requirements vary considerably over the range of sites represented, the figures do highlight the need for additional resources to manage the current and proposed hydrological workload within the SE Region.

It is also relevant to recognise that further additional regional hydrological workload may result from other agencies with interests in surface water data including SECWMB, DWLBC (SE), DEH, etc. To further compound this issue the level of instrumentation and other technical support for the SE Region from DWLBC, located in Adelaide, is limited and unlikely to be able to meet increasing regional demands.

Failure to provide adequate human resource to manage the proposed USE monitoring network creates a high risk to the implementation of the adaptive management Sub-program.

It is recommended that an assessment of the level of human resources required to adequately manage surface water data collection within the SE Region should be conducted. This assessment could be conducted as part of the Integrated Water Monitoring Review of the South East of South Australia project that is currently to being developed by the SECWMB.

Telemetering

To be able to manage the network of drains and control structures forming the USE drainage system it will be necessary to have available a range of data and information about the current and historical status of key sites. Data will need to be available in real-time or near real-time so that effective operational decisions can be made based on up to date knowledge. Telemetering of data can provide data from a remote site using a range of communication systems including telephone or radio. Many sites can be interrogated in a matter of minutes without the need for a person to visit the sites, thus saving considerable time. In addition telemetering systems provide the opportunity to maintain and manage on-site recording equipment remotely. This leads to an increase in data reliability and quality as errors and problems with the equipment can be detected and remedied as they occur. Without telemetry equipment errors resulting in data loss can go unnoticed for several months until the next routine site visit occurs.

Telemetering of key sites is a fundamental characteristic of the proposed USE monitoring network. Using this type of technology is essential to ensure that timely, sound decisions can be made to dynamically manage the drainage system.

A number of components are required to provide a telemetry system.

- On-site a data logger is used to record the parameters such as water level, salinity or temperature. The logger is connected to the communication system, generally a landline phone or mobile phone service or in some cases a radio system through an interface such as a modem.
- At a remote location, where the data is to be retrieved, equipment is required that can interface to the communication equipment and interpret the signal. Generally this would take the form of a computer containing specialised software connected to the phone system through a modem connection. The specialised software is the key to the system allowing the operator to schedule the frequency of interrogation and the method used to save and process the data.

Data can be downloaded automatically on a regular, frequent basis, say daily, and appended to previously downloaded data providing a continuous up to date data set rather than waiting several months for data to be collected by visiting the site and manually downloading data. The frequency and timing of data downloads can be altered to meet changing needs and if required data processed automatically to form a Web system that can be made available across an intranet or Internet system.

It is important to note however that all the data that is collected using telemetry is unverified. Data remains stored on the data logger on-site to be downloaded during a visit by an experienced technician. This data undergoes check processing and if necessary adjustment based on independent on-site measurements and observations and is then processed into the final archive. Telemetering systems provide up to date, but unverified data that may be out of calibration or contain errors and is only used as interim data until the verified data obtained from routine on-site visits is available.

4.3 Current and Proposed Sub-System Monitoring

4.3.1 Tatiara Creek

Currently there are eleven monitoring sites operating within this area (see Table 4 and Table 5). Of these only two are continuous recording sites with the remainder being ad hoc manual reading sites where opportunistic water level readings and salinity readings are taken when flow occurs. There is no rainfall recording within this area.

Table 4 Tatiara Creek Current and Proposed Data Types.

Site ID	Site Name	Previous + Current									Proposed								
		Cat	G	O	L	F	E	T	R	W	Cat	G	O	L	F	E	T	R	W
	TATIARA CREEK CATCHMENT PLUVIO										**2**						**1**	**1**	
A2391029	TATIARA CREEK @ Box Farm	3	1								3	1							
A2390534	TATIARA CREEK @ Bordertown	2			1	1		1			**1**			1	1	**1**	1		
A2390548	TATIARA CREEK @ Poocher Swamp Outlet	C			X						C			X					
A2391030	NALANG CREEK @ Choopawip Swamp	3	1								3	1							
A2390535	NALANG CREEK @ Olive Bank	C			X	X					C			X	X				
A2390562	NALANG CREEK @ Allendale	2			1	1					2			1[(1)]	1				
A2391031	TATIARA CREEK @ Scowans Runaway Hole	3	1								3	1							
A2391032	TATIARA CREEK @ Cannawigara Rd	3	1								3	1							
A2391033	TATIARA CREEK @ Thomas Runaway Hole	3	1								3	1							
A2391034	TATIARA CREEK @ Lampys Runaway Hole	3	1								3	1							
A2391035	TATIARA CREEK @ Sandy Joes Runaway	3	1								3	1							
A2391036	TATIARA CREEK @ Sandy Joes South Group	3	1								3	1							
A2391037	TATIARA CREEK @ Sandy Joes North Group	3	1								3	1							
	TATIARA CREEK @ U/S Riddoch Highway										**2**			**1**	**1**	**1**			
	Closed	*2*	*0*	*0*	*2*	*1*	*0*	*0*	*0*	*0*	*2*	*0*	*0*	*2*	*1*	*0*	*0*	*0*	*0*
	Operating	*11*	*9*	*0*	*2*	*2*	*0*	*1*	*0*	*0*	*13*	*9*	*0*	*3*	*3*	*2*	*2*	*1*	*0*

1. Replace chart recorder with data logger.

It is proposed that a new, telemetered rainfall recording site be established to represent the upper catchment of this system to provide data to assist in estimations of potential runoff. In addition it is proposed to upgrade the existing continuous recording water level and flow site at Bordertown (A2390534) from Category 2 to Category 1 and to add EC and temperature recording and telemetering capability. The other existing continuous recording water level and flow site at Allendale (A2390562) currently has a chart recorder that needs to be replaced by a data logger.

A new continuous recording water level, flow and salinity site is proposed to be located on Tatiara Creek downstream of the runaway hole area, but upstream of the Riddoch Highway and the commencement of the Mount Charles Drain. This site would provide a measurement of flow from the Tatiara catchment into the Mount Charles Drain and Northern Outlet sub-

system and an estimation of the volume taken up by the groundwater system and would be used for operational management of Croziers Wetland.

No changes are proposed at the nine ad hoc reading locations that form a network of sites generally visited at the commencement of the winter season to provide an advanced indication of potential flow within the system.

Table 5 Tatiara Creek Current and Proposed Site Category Summary.

Category	Category Description	Current	Proposed	Change
C	Closed	2	2	0
1	Continuous recording, highest level of resolution and reliability	0	1	1
2	Continuous recording, secondary level of resolution and reliability	2	3	1
3	Non-continuous ad hoc readings	9	9	0
4	Flow control operation readings	0	0	0
	Total Operating	11	13	2

Detailed Monitoring Site Summaries for all sites in the Tatiara Creek sub-system are available in Appendix C.

4.3.2 Morambro Creek-Marcollat Watercourse

This sub-system currently contains a total of six operating sites including three continuous recording sites and three ad hoc reading sites (see Table 6 and Table 7). A further nine sites have previously existed and have been closed. Three previous continuous recording water level and flow monitoring sites (A2390543, A2390544, A2390545) had been established as part of a project to determine runoff volumes to the upper aquifer and were closed when the project was completed. A further four continuously recording water level and flow monitoring sites (A2390517, A2390518, A2390529, A2390551) had existed for relatively short periods on the main streams of Morambro Creek and the Marcollat Watercourse but these sites had proven to be unsuitable and were closed. Additional water level recording sites had also been establish in North Swamp (A2391058) and South Reedy Swamp (A2391026) for a number of years to monitor water levels in these wetland systems. These recorders have been removed however the sites remain active as ad hoc water level reading sites.

Morambro Creek is a Prescribed Surface Water Area under the regulations of the Water Resources Act 1997 and as such is of particular interest to the SECWMB. Two new surface water monitoring sites have been proposed for the Morambro Creek and Nyrocha Channel by the SEWCMB including:-

- Morambro Creek @ Cockatoo Lake
- Nyrocha Channel @ Nyrocha Homestead

Whilst it is anticipated than these sites will be established as part of the monitoring program to manage the surface water resources of this area they would also provide flow data that would be of value to the USE Adaptive Management Project. Details of these sites may change in accordance with SEWCMB requirements.

As there is no rainfall recording site in this area it is proposed that a continuous recording rain gauge, including telemetry capability, be established to represent the upper Morambro Creek catchment.

In addition it is proposed to upgrade from Category 2 to Category 1 the existing water level, flow and salinity site on the Marcollat Watercourse at Ballater Road Jip Jip (A2391023) and to add telemetry capability. This site monitors the total outflow from the Morambro Creek catchment prior to the confluence with the Watervalley Drain (Bakers Range Sub-system) and is a critical model calibration location.

Table 6 Morambro Ck – Marcollat WC Current and Proposed Data Types.

Site ID	Site Name	Previous + Current									Proposed								
		Cat	G	O	L	F	E	T	R	W	Cat	G	O	L	F	E	T	R	W
	MORAMBRO CK CATCHMENT PLUVIO										**2**						**1**	**1**	
A2390529	MORAMBRO CK @ Frances (Rly Bridge)	C			X	X					C			X	X				
A2390545	CRINOGLE BORE @ near Woolshed	C			X	X					C			X	X				
A2390543	PRETTY GULLY CK @ U/S Runaway Hole	C			X	X					C			X	X				
A2390544	PRETTY GULLY CK @ D/S Runaway Hole	C			X	X					C			X	X				
A2390531	MORAMBRO CK @ Bordertn-Nar Rd Bridge	1			1	1		1			1			1	1	**1**	1		
A2390517	MORAMBRO CK @ The Gap	C			X	X					C			X	X				
A2390518	MORAMBRO CK @ Rangeview	C			X	X					C			X	X				
	MORAMBRO CK @ Cockatoo Lake [1]										**3**	**1**							
A2391027	NYROCA CHN @ Nyroca Homestead [1]										**1**			**1**	**1**	**1**	**1**		
A2391026	MARCOLLAT WC @ South Reedy Swamp	3	1		1						3	1							
A2391058	MARCOLLAT WC @ North Swamp	3	1		1						3	1							
A2390563	MARCOLLAT WC @ Rowney Rd	2			1	1					2			1	1				
A2390551	MARCOLLAT WC @ Jip Jip Regulator	4		1	1	1					4		1						
A2391023	MARCOLLAT WC @ Ballater Rd Jip Jip	2			1	1	1				**1**			1	1	1	**1**		
	DIDICOOLUM DRN @ D/S Didicoolum Ext										**2**			**1**	**1**	**1**			
A2391003	DIDICOOLUM DRN @ Didicoolum Station	C	X								C	X							
A2391002	DIDICOOLUM DRN @ Jack Camp	C	X								C	X							
	DIDICOOLUM DRN @ U/S Coola-C Offtake [2]										**1**		**1**	**1**	**1**	**1**	**1**		
A2391004	DIDICOOLUM DRN @ D/S Peacock Rng	C	X		X						C	X		X					
	Closed	*9*	*3*	*0*	*7*	*6*	*0*	*0*	*0*	*0*	*9*	*3*	*0*	*7*	*6*	*0*	*0*	*0*	*0*
	Operating	*6*	*2*	*1*	*6*	*4*	*1*	*1*	*0*	*0*	*12*	*2*	*2*	*8*	*7*	*5*	*6*	*2*	*0*

1. Site expected to be established by SECWMB.
2. Subject to connection between Didicoolum Drain and Coola Coola Swamp.

Didicoolum Drain

Three ad hoc reading sites (A2391002, A2391003, A2391004) had been established on the Didicoolum Drain following construction of the drainage channel to monitor initial flows and salinities. These sites are no longer required and it is proposed to establish a new continuous recording water level and flow site at the connection between the upper end of the existing Didicoolum Drain and the commencement of the proposed new drain extension, once this channel has been constructed. In addition should a connection from Didicoolum Drain be made to the Coola Coola Swamp system a further continuously recorded water level and flow monitoring site incorporating telemetry capability would need to be established near the diversion weir.

Table 7 Morambro Ck – Marcollat WC Current and Proposed Site Category Summary.

Category	Category Description	Current	Proposed	Change
C	Closed	9	9	0
1	Continuous recording, highest level of resolution and reliability	1	5(1) (2)	4
2	Continuous recording, secondary level of resolution and reliability	2	2	0
3	Non-continuous ad hoc readings	2	3(3)	1
4	Flow control operation readings	1	1	0
	Total Operating	6	11	5

1. Includes one new continuous recording site to be established by SECWMB.
2. Includes one new site subject to a connection between Didicoolum Drain and Coola Coola Swamp.
3. Includes one new ad hoc reading site to be established by SECWMB.

Detailed Monitoring Site Summaries for all sites in the Morambro Creek sub-system are available in Appendix D.

4.3.3 Naracoorte-Drain E

There are currently only three active sites within the Naracoorte Creek-Drain E Sub-system (see Table 8 and Table 9). Only one site (A2390542) provides continuous water level and flow record whilst water level only is recorded at Jaffray Swamp (A2391025) with the third site being an ad hoc water level reading site (A2391024) mid way along Drain E.

Two continuous water level and flow monitoring sites have previously existed and are now closed, one on the outflow of the Naracoorte Sewage Treatment Works (A2390557), and the other on a small, localised catchment leading to a drainage bore (A2390547).

There is no continuous rainfall recorder in this area and it is proposed that a rainfall recording site including telemetering capability be established to represent the upper catchment of the Naracoorte Creek upstream of the township of Naracoorte.

It is also proposed to upgrade the category of the flow monitoring site at Naracoorte (A2390542) from Category 2 to Category 1 and to add EC and temperature recording.

Four additional ad hoc gauge board water level and salinity reading sites are proposed for wetlands along the Drain E channel at:-

- Lake Wanwarrie
- Lake Omerod
- Garrie Swamp
- Locharbar Swamp

To enable flows to be monitored at the lower end of this system, prior to the confluence with the Nyroca Channel upstream of The Muddies, it is proposed to establish a new Category 1 site on the outflow channel leading from Jaffray Swamp. This site would include continuous water level, EC and temperature recording and telemetry capability. A new flow control, such as a small concrete crump weir, is proposed to ensure that reliable flow data can be produced. The existing water level recorder site located in Jaffray Swamp would be retained however the existing chart recorder needs to be replaced by a data logger.

Table 8 Naracoorte Ck Current and Proposed Data Types.

Site ID	Site Name	Previous + Current									Proposed								
		Cat	G	O	L	F	E	T	R	W	Cat	G	O	L	F	E	T	R	W
	NARACOORTE CK CMT PLUVIO @ ?										**2**						**1**	**1**	
A2390547	ATTYFORD CREEK @ Drainage Bore	C			X	X					C			X	X				
A2390542	NARACOORTE CREEK @ Naracoorte	2			1	1		1			1			1	1	**1**	1		
A2390557	NARACOORTE STW @ Naracoorte Outfall	C			X	X					C			X	X				
	DRAIN E @ Lake Wanwarrie										**3**	**1**							
	DRAIN E @ Lake Ormerod										**3**	**1**							
	DRAIN E @ Garrie Swamp										**3**	**1**							
	DRAIN E @ Locharbar Swamp										**3**	**1**							
A2391024	DRAIN E @ Harris's on Alaman Rd	3	1								3	1							
A2391025	DRAIN E @ Jaffray Swamp	2			1						2			1(1)					
	DRAIN E @ Jaffray Swamp Outlet Weir										**1**			**1**	**1**	**1**	**1**		
	Closed	*2*	*0*	*0*	*2*	*2*	*0*	*0*	*0*	*0*	*2*	*0*	*0*	*2*	*2*	*0*	*0*	*0*	*0*
	Operating	*3*	*1*	*0*	*2*	*1*	*0*	*1*	*0*	*0*	*9*	*5*	*0*	*3*	*2*	*2*	*3*	*1*	*0*

1. Replace chart recorder with data logger.

Table 9 Naracoorte Ck Current and Proposed Site Category Summary.

Category	Category Description	Current	Proposed	Change
C	Closed	2	2	0
1	Continuous recording, highest level of resolution and reliability	0	2	2
2	Continuous recording, secondary level of resolution and reliability	2	2	0
3	Non-continuous ad hoc readings	1	5	4
4	Flow control operation readings	0	0	0
	Total Operating	3	9	6

Detailed Monitoring Site Summaries for all sites in the Naracoorte Creek sub-system are available in Appendix E.

4.3.4 Fairview Drain

Of the seven currently active sites in this sub-system there is one Category 1 rainfall recording site (A2390567), two Category 2 continuously recording water level, flow and salinity sites and four ad hoc reading sites (see Table 10 and Table 11).

The Fairview Drain Sub-system includes a number of flow operation sites where water can be dammed-up or diverted. Many of these structures are used to raise water level in the drainage channel to induce flow into adjoining wetlands or to provide a pool from which pumps can be used to lift water to swamps. The Nepowie Regulator performs a critical function in diverting water either back along Fairview Drain towards Blackford Drain and the ocean or alternatively, when the regulator is open, water flows north along the Nepowie Offtake towards the Bakers Range Sub-system. The current monitoring sites at The Pitts (A2390565 and A2390567) provide information on water quality, flow and rainfall used to determine the operation of the Nepowie and James Road Regulators.

It is proposed that that the flow and salinity monitoring site at The Pitts (A2390562) be upgraded from Category 2 to Category 1 and telemetry capability added so that timely data can be available to assist in the operation of Nepowie and James Road Regulators. Telemetering of data from this site may also provide the opportunity to add telemetry capability to the adjacent rainfall recorder (A2390567) at little additional cost, thus providing real time rainfall data representing the southern mid segment of the USE area.

The Keilira Road flow and salinity monitoring site (A2390569) is currently the most downstream continuously recording site on this sub-system. This site was established in 2000 to replace the previous monitoring site (A2390564) that had been located just upstream of the Keilira Regulator. The original monitoring site had proven difficult to establish a reliable stage-discharge relationship due to operations of the regulator used to hold water at higher levels to inundate adjoining wetlands.

Should a connection be made from Fairview Drain northward to the West Avenue Drain then flow and salinity monitoring at Keilira Road would become important in determining the operation of any diversion structure. If this proposal goes ahead then A2390569 would need to be upgraded to Category 1 with telemetry capabilities.

East Avenue Drain

A number of additional flow regulator structures may be constructed in the upper segment of the East Avenue Drain to provide a possible connection to Jackie White Drain. It will be necessary to record all weir operations at these sites in addition to water level and salinity readings and occasional flow gauging measurements.

Tresant Drain

The Tresant Drain is a separate self-enclosed system that includes a number of small culvert weir structures used to divert drain flows into the adjoining wetland systems. Currently there is one ad hoc flow gauging and salinity reading site located on Locharber West Road (A2391051). There are also a number of unregistered water level observation sites that had been used in conjunction with wetland monitoring or investigations projects within the swamp systems including:-

- Tresant Drain Bloomfield Inlet Culvert No.1
- Tresant Drain Bloomfield Inlet Culvert No.2
- Tresant Drain Conservation Park Inlet
- Tresant Drain Kangoora Inlet
- Tresant Drain Bloomfield
- Bloomfield Wetland

If these sites are to continue to be used for occasional water level, flow gauging or salinity readings appropriate details need to be gathered and the sites registered.

In addition it is proposed that a new gauge board, ad hoc reading site, be established in Kangoora Lagoon, which currently does not have a monitoring site.

Table 10 Fairview Drain Current and Proposed Data Types.

Site ID	Site Name	Previous + Current									Proposed								
		Cat	G	O	L	F	E	T	R	W	Cat	G	O	L	F	E	T	R	W
A2391051	TRESANT DRN @ Lochaber West Rd	3	1								3	1							
	KANGOORA LAGOON										**3**	**1**							
A2390566	FAIRVIEW DRN @ Clothier	C			X	X	X				C			X	X	X			
A2390565	FAIRVIEW DRN @ Pitts	2			1	1	1				**1**(2)			1	1	1	**1**(2)		
A2390567	FAIRVIEW DRN PLUVIO @ Pitts	2							1		2						**1**(1)	1	
A2391047	FAIRVIEW OFFTAKE @ Nepowie Reg	4		1							4		1						
A2391046	FAIRVIEW DRN @ James Rd	4	1	1							4		1						
A2390564	FAIRVIEW DRN @ U/S Keilira Rd	4		1	X	X	X				4		1						
A2390569	FAIRVIEW DRN @ D/S of Keilira Rd	2			1	1	1				**1**			1	1	1	**1**		
A2391045	FAIRVIEW DRN @ Inlet to Blackford Drn	C	X								C	X							
	EAST AVENUE DRN @ Reg to S1272										**4**	**1**	**1**						
	EAST AVENUE DRN @ Samphire Swp Inl										**4**	**1**	**1**						
	EAST AVENUE DRN @ Philips Gap Reg										**4**	**1**	**1**						
	Closed	*2*	*1*	*0*	*2*	*2*	*2*	*0*	*0*	*0*	*2*	*1*	*0*	*1*	*1*	*1*	*0*	*0*	*0*
	Operating	*7*	*2*	*3*	*2*	*2*	*2*	*0*	*1*	*0*	*11*	*5*	*6*	*2*	*2*	*2*	*3*	*1*	*0*

1. Could be telemetered together with A2390565.
2. Telemetering and category upgrade subject to connection being made between Fairview Drain and West Avenue Drain.

Table 11 Fairview Drain Current and Proposed Site Category Summary.

Category	Category Description	Current	Proposed	Change
C	Closed	2	2	0
1	Continuous recording, highest level of resolution and reliability	0	2(1)	2
2	Continuous recording, secondary level of resolution and reliability	3	1	-2
3	Non-continuous ad hoc readings	1	2	1
4	Flow control operation readings	3	6	3
	Total Operating	7	11	4

1. Includes upgrade of one Cat 2 site to Cat 1 subject to connection between Fairview Drain and West Avenue Drain being made.

Detailed Monitoring Site Summaries for all sites in the Fairview Drain sub-system are available in Appendix F.

4.3.5 Bakers Range

The Bakers Range Sub-system forms the backbone of the USE drainage system providing the pathway for water to move from the south towards the north. Two parallel pathways are provided with the Bakers Range Watercourse conveying fresher runoff towards Messent Conservation Park via a series of wetland systems whist the Bakers Range Drain conveys more saline water to the Northern Outlet Drain, which in turn connects to the Morella Basin.

These two pathways are linked to each other in addition to being connected to the other major USE drainage sub-systems. Due to the complexity of this sub-system and the number of flow control structures that exist there is a need for a range of monitoring site types along the 150km length of the sub-system.

Currently there are eighteen active sites within this system only two of which provide continuous water level and flow monitoring (A2390556, A2391007), one of which also includes continuous EC recording (see Table 12 and Table 13). Both of the continuous recording sites are located on the Bakers Range Watercourse with no continuous recording sites existing along the Bakers Range Drain pathway. The remainder of the active sites are ad hoc water level, salinity sampling, flow gauging and operational flow control sites.

A number of new recording sites are proposed for this sub-system to provide information required to make operational decisions or to monitor the outcomes of operations.

- A Category 2 water level, flow and salinity recording site is required on the Bakers Range Watercourse upstream of Tatiara Swamp to monitor flows that could enter the swamp or alternatively be diverted via the Tatiara Bypass Regulator to Fairview Drain.
- A Category 1 water level, flow, salinity and rainfall recording site with telemetering capability is proposed on the Bakers Range Watercourse to monitor flows upstream of the Kercoonda Interchange structure (see Figure 7). Flow at this point may be diverted westward to the Kercoonda Drain or allowed to continue northward along the Bakers Range Watercourse. The Kercoonda Interchange will include a cross-over to allow flow from Watervalley Drain (part of the Bakers Range Drain pathway) to pass under the watercourse however this structure has not yet been constructed. There is currently no continuous rainfall recording site in the central segment of the USE drainage system and this location would provide a representation of rainfall for this area and assist in operational decisions.
- A Category 3 ad hoc water level and salinity reading and flow gauging site is proposed to be located on the Watervalley Drain just upstream of the Kercoonda Interchange structure (see Figure 7) to assist in estimating the proportion of flow volume, salinity and salt load being contributed by the Watervalley-Bakers Range Drain systems.
- A Category 2 water level, flow and salinity recording site is proposed for the Bakers Range Watercourse at the Mandina Marsh Outlet to monitor flow and water quality at the downstream end of this important wetland system.

- An additional Category 2 water level, flow and salinity recording site is proposed for the Bakers Range Watercourse at South Bonney's Camp in the channel connecting the first and second wetland downstream of the Well and Bridge crossing. This would replace the existing water level monitoring site A2391007 located in the first wetland after the Well and Bridge crossing. This existing site is not suitable for producing flow information and currently has a chart recorder. The new site would incorporate a low profile flow measurement weir to provide a stable stage-discharge relationship. This site is approximately 10 kms upstream from the Cattle Dam Stopbank and is the last continuously recording site on the Bakers Range Watercourse.

To increase the accuracy and resolution of low and medium flow information at the existing site on the Bakers Range Watercourse at G Cutting (A2390556) it is proposed that a more stable and sensitive control be constructed. Whilst details of the current channel geometry are not available it is envisaged that a low profile concrete sill could provide a low cost solution.

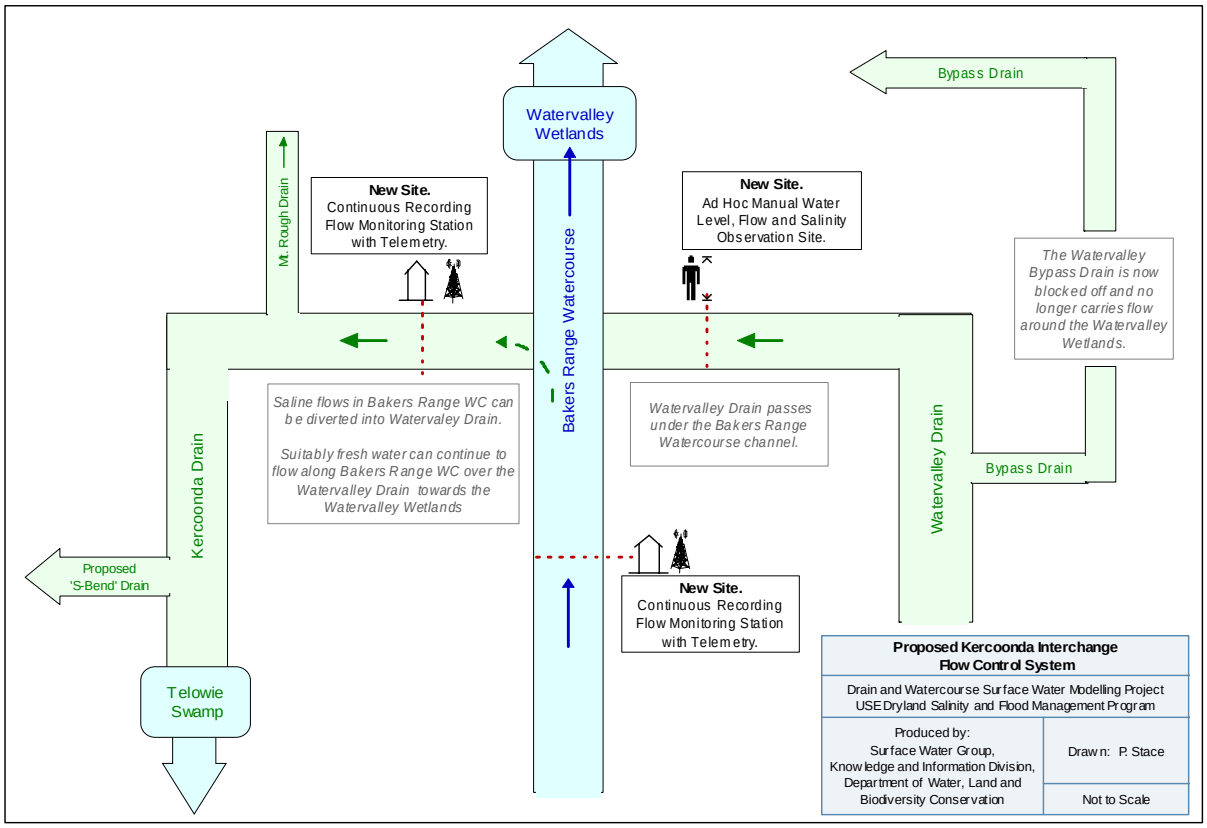

Figure 7 Proposed Kercoonda Interchange Monitoring System.

Three additional ad hoc reading sites are also proposed to supplement the monitoring network.

- A new gauge board water level and salinity reading site on Bakers Range Watercourse at Taunta Hut Road.
- A new water level and salinity reading and weir operations site Bakers Range Watercourse at the Cattle Dam Stopbank Regulator (under construction).

- A new gauge board water level and salinity reading site on Bakers Range Watercourse at the Northern Drain Overpass (under construction) (see Figure 8).

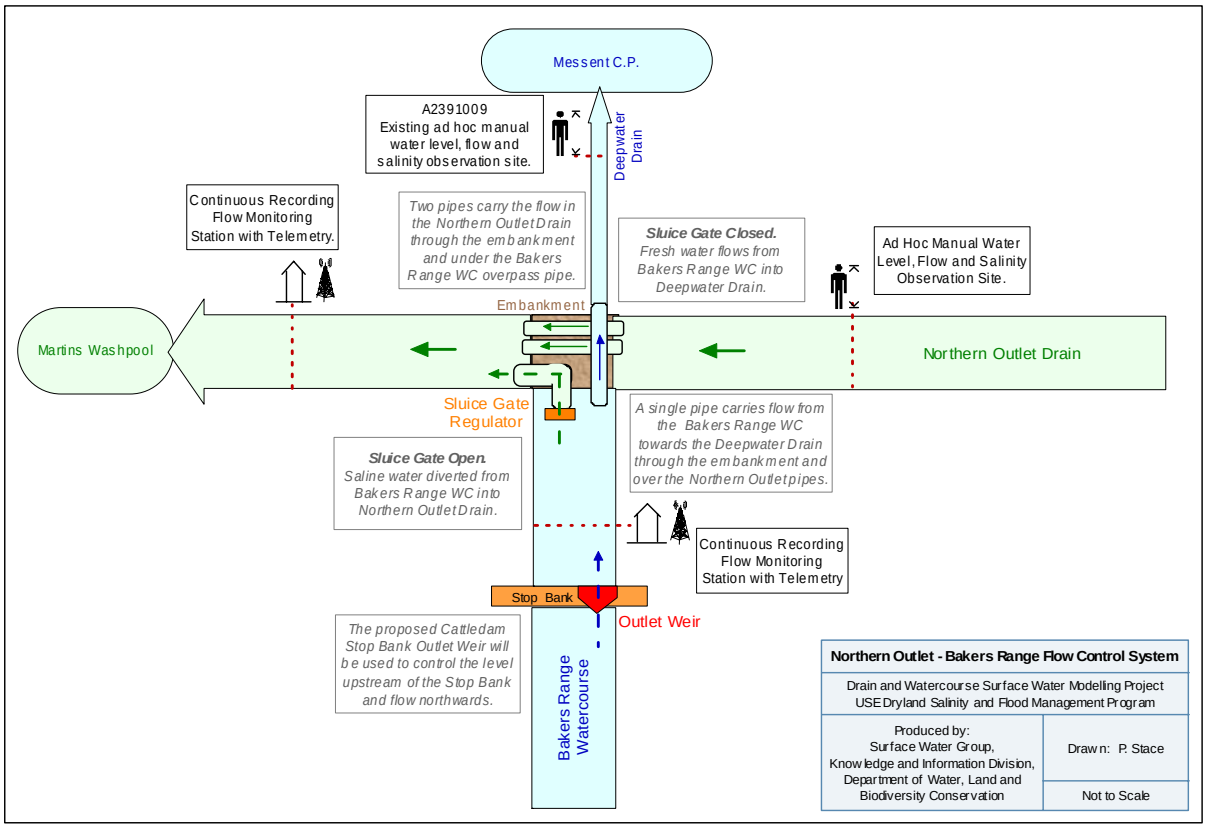

Figure 8 Proposed Northern Outlet Overpass Monitoring System.

A number of sites are no longer necessary and can be closed.

- The ad hoc reading sites on Ballater East Drain at Hanson-Tiver Track (A2391052) and Wongawilli Drain at Rowney Road (A2391053) are no longer required. The site on Ballater Main Drain upstream of Watervalley Drain (A231054) is adequate to monitor the Ballater Drain.
- The ad hoc weir operations site on Watervalley Main Drain at Watervalley Weir (A2391012) is no longer required as it is not expected that this weir will be operated in the future.
- The continuous water level recording site on Bakers Range Watercourse D/S Well & Bridge (A2391007) is proposed to be replaced by a new continuous flow monitoring site.
- The ad hoc reading site on Bakers Range Watercourse at Cattledam Road (A2391008) will be replaced by monitoring proposed at the Cattle Dam Stopbank.

The overall outcome of the proposed monitoring network is the addition of one Category 1 and two Category 2 sites and no change in the number of ad hoc reading site. Operational decision support is significantly improved with the addition of the proposed sites particularly the site at the Kercoonda Interchange which will become a critical operational location.

Table 12 Bakers Range Current and Proposed Data Types.

Site ID	Site Name	Previous + Current									Proposed								
		Cat	G	O	L	F	E	T	R	W	Cat	G	O	L	F	E	T	R	W
A2391050	BAKERS RNG WC @ Angels Rd	3	1								3	1							
	BAKERS RNG WC @ U/S Tatiara Swamp										**2**			**1**	**1**	**1**	**1**		
A2391057	BAKERS RNG DRN @ Tatiara Bypass Reg	4		1							4		1						
A2391062	BAKERS RNG WC @ Tatiara Swp Inlet	4		1							4		1						
A2391049	BAKERS RNG WC @ Tataira Swp Outlet	4	1	1							4	1	1						
A2391048	TATIARA BYPASS DRN @ U/S Fairview Drn	3	1								3	1							
A2391010	BAKERS RNG CATCH DRN @ G-Cutting	3	1								**2**			**1**	**1**	**1**			
A2390556	BAKERS RNG WC @ G Cutting	2			1	1	1				2			1	1	1			
A2391011	BAKERS RNG CATCH DRN @ Hirst S Track	3	1								3	1							
A2390550	BAKER RNG WC @ Hirst Summer Track	C			X	X					C			X	X				
	BAKER RNG WC @ U/S Kercoonda Interchange										**1**		**1**	**1**	**1**	**1**	**1**	**1**	
A2391052	BALLATER EAST DRN @ Hanson-Tiver Track	3	1								**C**	**x**							
A2391053	WONGAWILLI DRN @ Rowney Rd	3	1								**C**	**x**							
A2391054	BALLATER MAIN DRN @ U/S Watervalley Drn	3	1								3	1							
A2391012	WATERVALLEY MAIN DRN @ Waterval Weir	4	1	1							**C**	**x**	**x**						
	WATERVALLEY DRN @ U/S Kercoonda IC										**3**	**1**							
A2391013	WATERVALLEY MAIN DRN @ U/S Petherick Rd	3	1								3	1							
A2391005	BAKERS RNG WC @ Petherick Rd	3	1								3	1							
	BAKERS RNG WC @ Mandina Marshes Outlet										**2**		**1**	**1**		**1**			
A2391006	BAKERS RNG WC @ Log Crossing	3	1								3	1							
	BAKERS RNG WC @ Taunta Hut Rd										**3**	**1**							
A2391007	BAKERS RNG WC @ D/S Well & Bridge [1]	2			1	1					**C**			**x**	**x**				
	BAKERS RNG WC @ South Bonney's Camp										**2**			**1**	**1**	**1**			
A2391008	BAKERS RNG WC @ Cattledam Rd	3	1								**C**	**x**							
	BAKERS RNG WC @ Cattledam Bank Outlet										**4**	**1**	**1**						
	BAKERS RNG WC @ U/S Northern Drn Overpass										**1**			**1**	**1**	**1**	**1**		
A2391009	DEEPWATER DRN @ Deepwater Rd	3	1								3	1							
	Closed	*1*	*0*	*0*	*1*	*1*	*0*	*0*	*0*	*0*	*6*	*4*	*1*	*2*	*2*	*0*	*0*	*0*	*0*
	Operating	*18*	*14*	*4*	*2*	*2*	*1*	*0*	*0*	*0*	*21*	*12*	*6*	*7*	*6*	*7*	*3*	*1*	*0*

1. To be replaced by a new flow monitoring site in the channel D/S.

Table 13 Bakers Range Current and Proposed Site Category Summary.

Category	Category Description	Current	Proposed	Change
C	Closed	1	6	5
1	Continuous recording, highest level of resolution and reliability	0	2	2
2	Continuous recording, secondary level of resolution and reliability	2	5	3
3	Non-continuous ad hoc readings	12	10	-2
4	Flow control operation readings	4	4	0
	Total Operating	18	21	3

Detailed Monitoring Site Summaries for all sites in the Bakers Range sub-system are available in Appendix G.

4.3.6 West Avenue – Tilley Swamp

The West Avenue Sub-system includes a number of proposed drainage pathways that have yet to be constructed including the Winpinmerit Drain, the Bald Hill Drain and the Taratap Drain in addition to two important drainage system connectors, the proposed Kercoonda Interchange and the proposed 'S-Bend' connection (see figure 7). Currently there are no continuous recording monitoring sites in this area although there are nine ad hoc reading sites (see Table 14 and Table 15). The proposed monitoring network in this sub-system includes a new Category 1 continuous recording water level, flow and salinity telemetered site near the start of the Kercoonda Drain, downstream of the Kercoonda Interchange and upstream of the 'S-Bend' Drain and a new Category 2 continuous recording water level, flow and salinity site on the lower end of the Winpinmerit Drain, in the area of Landseer Park. A new ad hoc reading site to monitor and record operations at the Little Telowie Swamp inlet weir is also proposed. Six of the current ad hoc monitoring sites along the West Avenue and Tilley Swamp Drains that had been established to monitor flows and salinity in these drains are no longer required and should be closed.

Table 14 West Avenue Current and Proposed Data Types.

Site ID	Site Name	Previous + Current									Proposed								
		Cat	G	O	L	F	E	T	R	W	Cat	G	O	L	F	E	T	R	W
	WINPINMERIT DRN @ Landseer Park [1]										**2**			**1**	**1**	**1**			
A2391020	WEST AVENUE WC @ Robertson Rd	3	1								**C**	**x**							
A2391021	WEST AVENUE WC @ Westslopes	3	1								**C**	**x**							
	KERCOONDA DRN @ D/S Kercoonda IC [2]										**1**		**1**	**1**	**1**	**1**	**1**		
	WEST AVENUE WC @ Little Telowie Swp Inl										**4**	**1**	**1**						
A2391022	HENRY CREEK @ Litigation Lane Weir	4	1	1							4	1	1						
A2391055	TILLEY SWAMP BYPASS @ Henry Ck Reg	4	1	1							4	1	1						
A2391056	TILLEY SWAMP FLOODWAY @ Henry Ck Reg	3	1								3	1							
A2391018	TILLEY SWAMP BYPASS @ Petherick Rd	3	1								**C**	**x**							
A2391017	TILLEY SWAMP BYPASS @ Cantara Rd	3	1								**C**	**x**							
A2391016	TILLEY SWAMP BYPASS @ Safari Track	3	1								**C**	**x**							
A2391014	TILLEY SWAMP BYPASS @ U/S Nth Drn	3	1								**C**	**x**							
	Closed	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*6*	*6*	*0*	*0*	*0*	*0*	*0*	*0*	*0*
	Operating	*9*	*9*	*2*	*0*	*0*	*0*	*0*	*0*	*0*	*6*	*4*	*4*	*2*	*2*	*2*	*1*	*0*	*0*

1. Winpinmerit Drain has not yet been constructed.
2. Kercoonda Interchange has not yet been constructed.

Table 15 West Avenue Current and Proposed Site Category Summary.

Category	Category Description	Current	Proposed	Change
C	Closed	0	6	6
1	Continuous recording, highest level of resolution and reliability	0	1	1
2	Continuous recording, secondary level of resolution and reliability	0	1	1
3	Non-continuous ad hoc readings	7	1	-6
4	Flow control operation readings	2	3	1
	Total Operating	9	6	-3

Detailed Monitoring Site Summaries for all sites in the West Avenue sub-system are available in Appendix H.

4.3.7 Northern Outlet

The Northern Outlet Sub-system provides a link with the Tatiara Creek Sub-system, the Bakers Range Sub-system and the West Avenue Sub-system and connects these sub-systems to the terminal storage for saline water at Morella Basin. From Morella Basin water can, under certain conditions, be allowed to flow into the southern lagoon of The Coorong. In addition to providing for the conveyance of water from the other sub-systems the Northern

Outlet Sub-system also includes an area of drainage created by the Taunta Drain, Brunbury Drain and Mount Charles Drain.

Current monitoring of this sub-system includes a single Category 1 site on Salt Creek that monitors flow and salinity of any water passing to The Coorong (see Table 16 and Table 17). In association with this site a Category 2 water level and salinity recording site has been established in Morella Basin upstream of the outlet weir. Both these sites are telemetered to provide real-time information. In addition a meteorological site incorporating the recording of rainfall and wind direction and velocity is located adjacent to Salt Creek together with a water level and salinity recorder in The Coorong just south of the outlet from Salt Creek. This group of sites provide important information to assist in the operation of outflows to The Coorong and to monitor the effect of these outflows.

No change to the function of these sites is proposed except for termination of the wind direction and velocity recorder adjacent Salt Creek. A preliminary review of the data collected at this location indicates some significant errors and experience at other locations using the same equipment suggest that data may be unreliable. The rainfall recorder located at the same site would however be continued and it is proposed that this be added to the telemetry system.

A number of new monitoring sites are proposed for this sub-system:-

- A new continuous recording water level, flow and salinity site is proposed to monitor the Northern Outlet Drain downstream of the Bakers Range Watercourse overpass (see Figure 8).
- A new salinity recording site will be required on the Brunbury Drain upstream of Saunders Scrub Regulator together with a new water level recorder in Saunders Scrub to assist with the operation of the regulator and management of Saunders Scrub Swamp.
- A series of new gauge board ad hoc water level and salinity reading sites are proposed in the following wetlands subject to integration with the Ecological Monitoring Framework:
    - Bunbury Main Lagoon
    - Kendal Wetland
    - Croziers Swamp
    - Gum Waterhole
    - Bunburry Conservation Park regulator
- One existing ad hoc reading site (A2391015) is no longer required and may be closed.

Table 16 Northern Outlet Current and Proposed Data Types.

Site ID	Site Name	Previous + Current									Proposed								
		Cat	G	O	L	F	E	T	R	W	Cat	G	O	L	F	E	T	R	W
	BUNBURY MAIN LAGOON										**3**	**1**							
	KENDAL WETLAND										**3**	**1**							
	GUM WATERHOLE (Mt Charles Drain)										**3**	**1**							
	CROZIERS SWAMP (Mt Charles Drain)										**3**	**1**							
	GUM WATERHOLE (Mt Charles Drain)										**3**	**1**							
A2391059	MOUNT CHARLES DRN @ U/S Taunta Hut Rd	3	1								3	1							
	BUNBURY DRN @ U/S Saunders Scrub Reg										**2**					**1**			
	SAUNDERS SCRUB SWAMP										**2**			**1**					
	TAUNTA HUT DRN @ Bunbury CP Swamp Reg										**3**	**1**	**1**						
A2391060	BUNBURY DRN @ Upstream of Taunta Hut Rd	3	1								3	1							
A2391019	NTH OULET DRN @ 2Km D/S Ashby Drain	3	1								3	1							
	NTH OULET DRN @ D/S Bakers Rg Overpass										**2**			**1**	**1**	**1**			
A2391015	NTH OUTLET DRN @ U/S Tilley Swamp Bypass	3	1								**C**	**x**							
A2391061	MORELLA BASIN @ U/S of Outlet Regulator	2		1	1			1			2		1	1			1		
A2390568	SALT CREEK OUTLET @ Salt Creek	1			1	1	1	1			1			1	1	1	1		
AW426634	COORONG @ Sand Spit Point	2			1		1				2			1		1			
AW426646	COORONG AUTO WEATHER STN @ Salt Creek	2							1	1	2						1	1	**x**
	Closed	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*1*	*1*	*0*	*0*	*0*	*0*	*0*	*0*	*1*
	Operating	*8*	*4*	*1*	*3*	*1*	*2*	*2*	*1*	*1*	*16*	*9*	*2*	*5*	*2*	*4*	*3*	*1*	*0*

Table 17 Northern Outlet Current and Proposed Site Category Summary.

Category	Category Description	Current	Proposed	Change
C	Closed	0	1	1
1	Continuous recording, highest level of resolution and reliability	1	1	0
2	Continuous recording, secondary level of resolution and reliability	3	6	3
3	Non-continuous ad hoc readings	4	9	5
4	Flow control operation readings	0	0	0
	Total Operating	8	16	8

Detailed Monitoring Site Summaries for all sites in the Northern Outlet Drain sub-system are available in Appendix I.

4.3.8 Mosquito Creek

Within the Mosquito Creek Sub-system there are currently ten ad hoc water level and salinity monitoring sites located along the upper reaches of the catchment (see Table 18 and Table 19). These sites are generally visited during the commencement of the winter to determine the likely degree of runoff during that season. Only one continuously recording water level and flow site exists being located on Mosquito Creek at Struan. This site is effectively at the end of the natural stream channel where runoff is fed into the Hacks Lagoon – Bool Lagoon system. As such this site is important in the management of the Bool Lagoon complex in addition to flow management of the Drain M system and would provide primary information should water be transferred from the Mosquito Creek – Drain M systems north to Drain E or Bakers Range Drain.

The Struan site (A2390519) currently includes telemetry and it is proposed that salinity recording be added and the site upgraded to Category 1.

Table 18 Mosquito Creek Current and Proposed Data Types.

Site ID	Site Name	Previous + Current									Proposed								
		Cat	G	O	L	F	E	T	R	W	Cat	G	O	L	F	E	T	R	W
	MOSQUITO CREEK CATCHMENT PLUVIO @ ?										**2**						**1**	**1**	
A2391038	KOIJAK CREEK @ Wimmera Highway	3	1								3	1							
A2391040	KOIJAK CREEK @ Rainsford	3	1								3	1							
A2391039	KOIJAK CREEK @ Westons	3	1								3	1							
A2391065	KOIJACK CREEK @ Newland Lake	3	1								3	1							
A2391044	KOIJACK CREEK @ Newland Lake Outfall	3	1								3	1							
A2391043	YALLA CREEK @ Norilla	3	1								3	1							
A2391042	YELLOCK CREEK @ Omha	3	1								3	1							
A2391064	YELLOCH CREEK @ Naracoorte Langkoop Rd	3	1								3	1							
A2391041	MOSQUITO CREEK @ Langkoop	3	1								3	1							
A2390546	ATTADALE CREEK @ U/S Attadale Rway Hole	C			X	X					C			X	X				
A2391063	MOSQUITO CREEK @ Concrete Bridge Rd	3	1								3	1							
A2390519	MOSQUITO CREEK @ Struan	2			1	1		1			**1**			1	1	**1**	1		
A2391070	HACKS LAGOON @ Adjacent The Office	3	1								3	1							
A2391069	BOOL LAGOON @ The Office	3	1								3	1							
A2391068	BOOL LAGOON @ Big Hill	3	1								3	1							
A2391067	BOOL LAGOON @ The Yards	3	1								3	1							
A2391066	BOOL LAGOON OUTLET @ Outlet Reg	4		1							4		1						
	Closed	*1*	*0*	*0*	*1*	*1*	*0*	*0*	*0*	*0*	*1*	*0*	*0*	*1*	*1*	*0*	*0*	*0*	*0*
	Operating	*16*	*14*	*1*	*1*	*1*	*0*	*1*	*0*	*0*	*17*	*14*	*1*	*1*	*1*	*1*	*2*	*1*	*0*

There are four ad hoc water level reading site in the Hacks Lagoon-Bool Lagoon system used to monitor levels in the system an assist with operation of the Bool Lagoon Outlet Regulator that controls flow into the Drain M system. The Bool Lagoon Outlet is an operational site at which water level and gate setting information is recorded manually.

No rainfall recorder exists in this sub-system and it is proposed that a new continuous rainfall recorder including telemetry capability be established in the upper area of the catchment in the vicinity of Rainsford.

Table 19 Mosquito Creek Current and Proposed Site Category Summary.

Category	Category Description	Current	Proposed	Change
C	Closed	1	1	0
1	Continuous recording, highest level of resolution and reliability	0	1	1
2	Continuous recording, secondary level of resolution and reliability	1	1	0
3	Non-continuous ad hoc readings	14	14	0
4	Flow control operation readings	1	1	0
	Total Operating	16	17	1

Detailed Monitoring Site Summaries for all sites in the Mosquito Creek sub-system are available in Appendix J.

4.3.9 Drain M

Drain M conveys water from Bool Lagoon and the Mosquito Creek catchment downstream to Lake George and the ocean. It also collects flow from a number of drainage systems located on the southern side of Drain M including the Bakers Range South Drain. A significant feature of this system is the Callendale Regulator, which is located on Drain M just downstream of the confluence with Bakers Range South Drain. The Callendale Regulator is used to control flow so that the drain is not surcharged causing damage to infrastructure and adjacent land. The Callendale Regulator also provides the potential to divert Drain M and Bakers Range South Drain flows northward along the Bakers Range Watercourse and into the USE area.

Current monitoring in this sub-system includes three continuously recording water level and flow monitoring sites on Drain M, the first being downstream of the Bool Lagoon Outlet Regulator, the second downstream of Callendale Regulator and the last at Woakwine just upstream of the outfall into Lake George (see Table 20 and Table 21). Two of these sites (A2390541, A2390512) currently use chart recorders that should be replaced with more efficient data loggers.

To provide information to support the operation of Callendale Regulator and to assist with management of potential flows northward into the USE area it is proposed that a water level and salinity recording site including telemetry capability be established on the upstream side of the Callendale Regulator. No other salinity recording is available along Drain M and it can be expected that water quality would be an important factor in any decision to divert water north along Bakers Range Watercourse. This site would be used only for water level and salinity recording with flow monitoring continuing at the existing flow site (A2390514) downstream of the regulator.

Within the drainage areas that enter Drain M upstream of Callendale Regulator from the southern side a number of monitoring sites currently exist or have existed in the past. The site on Bakers Range South Drain at Phillips Road (A2391001) provides flow data representing the whole of the Bakers Range South Drain catchment and thus is important for the management of flows down Drain M and potential flows northward along Bakers Range Watercourse. This site currently has an open channel control that is insensitive and unstable and flow data could be significantly improved with the addition of a low profile weir positioned on the upstream apron of the road bridge. The Phillips Road site replaced a previous monitoring site on Bakers Range South Drain at the Robe-Penola Road (A2390515) closed in 1993 after operating for 21 years. Data from this site may be of use to extrapolate flow data at the new site located downstream at Philips Road.

A number of sites had also existed along Drain C, the other major drainage system on the southern side of Drain M, however all of these are now closed.

Currently outflow from the Drain M-Mosquito Creek catchment to the ocean via the Lake George Outlet Regulator is not recorded. To assist in the management of Lake George and management of potential flows from Drain M northward into the USE area it is proposed that a flow and salinity recording site be established on the Lake George outlet. Tide levels immediately downstream of the outlet regulator create a backwater effect that significantly influence flows from Lake George to the ocean. A standard stage-discharge relationship is not expected to be applicable at this site and it may be appropriate to consider the use of acoustic velocity sensors and the development of a velocity-discharge relationship.

Table 20 Drain M Current and Proposed Data Types.

Site ID	Site Name	Previous + Current									Proposed								
		Cat	G	O	L	F	E	T	R	W	Cat	G	O	L	F	E	T	R	W
A2390541	DRAIN M @ D/S Bool Lagoon Outlet	2			1	1					2			1[(1)]	1				
A2390536	DRAIN C @ U/S Coonawarra	C			X	X					C			X	X				
A2390537	DRAIN C2 @ U/S Rocky Point	C			X	X					C			X	X				
A2390516	DRAIN C @ Balma Carra	C			X	X					C			X	X				
A2390515	BAKERS RNG SOUTH DRN @ Robe-Penola Rd	C			X	X					C			X	X				
A2391001	BAKERS RNG SOUTH DRN @ Phillips Rd	2			1	1					2			1[(2)]	1				
A2391071	DRAIN M @ Callendale Regulator	4		1							**2**		**1**	**1**		**1**	**1**	**1**	
A2390514	DRAIN M @ D/S Callendale Regulator	2			1	1		1	X		2			1	1		1		
A2390512	DRAIN M @ Woakwine Amtd 5.1km	2			1	1			X		2			1[(1)]	1				
	DRAIN M @ Lake George Outlet Regulator	4		1							**2**		1	**1**	**1**	**1**			
	Closed	*4*	*0*	*0*	*4*	*4*	*0*	*0*	*2*	*0*	*4*	*0*	*0*	*4*	*4*	*0*	*0*	*0*	*0*
	Operating	*6*	*0*	*2*	*4*	*4*	*0*	*1*	*0*	*0*	*6*	*0*	*2*	*6*	*5*	*2*	*2*	*1*	*0*

1. Current chart recorder to be replaced by data logger.
2. New control weir proposed.

Table 21 Drain M Current and Proposed Site Category Summary.

Category	Category Description	Current	Proposed	Change
C	Closed	4	4	0
1	Continuous recording, highest level of resolution and reliability	0	0	0
2	Continuous recording, secondary level of resolution and reliability	4	6	2
3	Non-continuous ad hoc readings	0	0	0
4	Flow control operation readings	2	0	-2
	Total Operating	6	6	0

Detailed Monitoring Site Summaries for all sites in the Drain M sub-system are available in Appendix K.

5. MONITORING SITE INFORMATION

To enable informed decisions to be made regarding the suitability of data from existing sites to be of use for modelling purposes and more generally to determine the suitability of sites to match the requirements of the Adaptive Management and Integrated Monitoring Sub-Program a thorough process of collating, reviewing and summarising of site related information has been completed.

Collating information and data from numerous disparate systems has been the prime task within this process.

Prior to the commencement of this project all time series hydrological data was managed in the Adelaide based Hydstra system and no single integrated system was available within the SE Region. A Hydstra system was developed specifically for use in the SE Region that was populated with all available digital data that had been held in legacy systems that were no longer being supported. This data was imported into the regional Hydstra system and merged with the archived data that had been previously maintained in the Adelaide system. Additional site related information was also extracted from a variety of hard copy records including site history files, microfilm and miscellaneous reports. With assistance from local personnel, visits to sites were conducted to collect additional required site information such as position data, photos and details of site infrastructure and facilities. This information was entered into the SE Hydstra system that is now the primary system for storing regional hydrological data and information. Material held in the SE Hydstra system is transferred on a routine basis and merged into the central Adelaide Hydstra system that forms the State Water Archive.

5.1 Data Gaps and Information Quality Issues

During the process of collating hydrological monitoring site data and information a number of data gaps and information quality issues became apparent.

5.1.1 Site Details

Fundamental site information was missing for virtually all sites. Even basic information such as location details (Easting and Northing coordinates), operating periods and site purpose were initially unavailable. Some information was obtained from Site History Files but in many cases no file existed. Other information was sourced from SEWCDB staff but in many cases on-site inspections needed to be conducted to obtain the required information. Material gathered during this process was entered into Hydstra with most of the descriptive information being entered into the Site Related Tables – History Table that had initially been unused and now contains over 1400 records. Digital photos were taken at most sites and these form a photo library that is also attached to the Hydstra system. In addition, GPS readings were taken at most sites enabling accurate location details to be entered into Hydstra.

5.1.2 Drainage System

Another vital set of information that had not been available was a complete, accurate and detailed description of the existing and proposed drainage and watercourse system. Various reports, diagrams and spatial information system data sets contained this portions of this information however there was no single complete information set. To overcome this

deficiency a schematic diagram of the drainage system that brought all the different formats of information into a single layout was assembled. The schematic describes the connection between the hydrological monitoring network, the drains, watercourses and water bodies and the flow control structures for the entire USE area (see Figure 9). This plan can be produced in a large format (size A0) and has been very useful during the monitoring review and model conception processes.

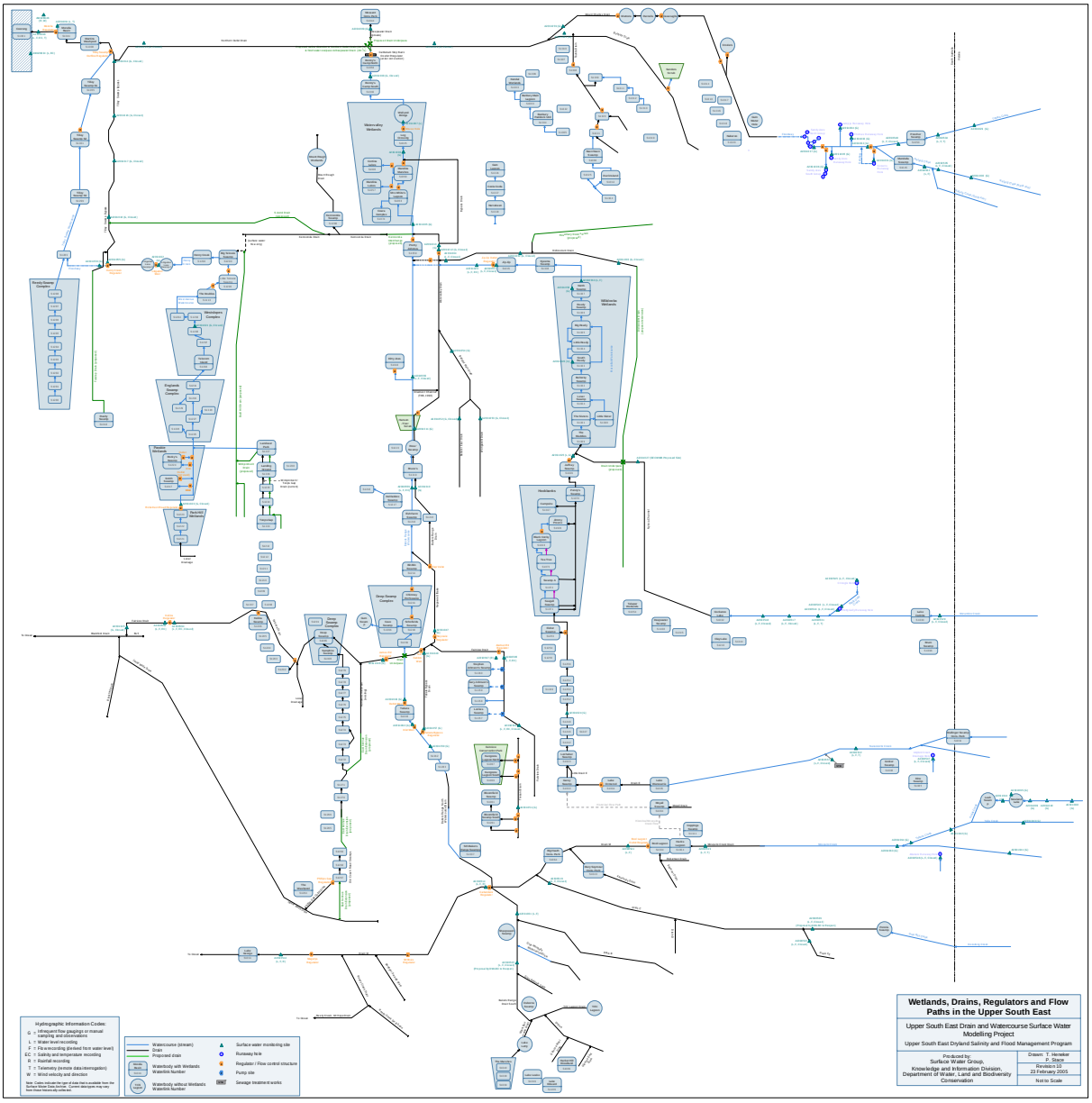

Figure 9 USE Wetlands, Drains, Regulators and Flow Paths Schematic

In addition more detailed schematics of each drainage sub-system hydrological monitoring network were produced together with a number of site sketches and flow control system diagrams for locations where the systems are particularly complex. These diagrams are provided in the Drainage Sub-System Monitoring Site Summaries forming Appendix C to Appendix K.

5.1.3 Catchment Areas

The surface area contributing to the runoff at a monitoring site is an important element used to develop an understanding of the hydrology of an area. Usually a catchment area is determined by delineating the catchment boundary using topographical features. In the case of the USE area this can be problematical due to the very flat, poorly defined topography and the modification to natural flow paths created by the constructed drainage systems. Whilst the catchment area for some monitoring sites had been documented in various sources the methods used have not been consistent and may represent different interpretations of the area contributing to runoff. For many sites catchment area values are not available. As part of the planned modelling process it will be necessary to develop a standard approach to the determination of catchment areas for key monitoring sites.

5.1.4 Unprocessed Recorded Data

Chart recorded water level data from a number of sites has not been digitised or has been digitised but not processed into Hydstra. Most of this data is for short periods of a year or two that had been collected in the initial period after a new drain had been constructed. In total there is 25 years of unprocessed record. Whilst the record from sites may be of limited value to the modelling project a process has commenced to enter the data into Hydstra so that it is available from the archive if required.

5.1.5 Non-Continuous Data

Hydstra Data

While the Hydstra system used within DWLBC is most commonly used to manage continuous recorded data it can also hold non-continuous data such as ad hoc water level or salinity readings. One specific set of ad hoc readings taken at monitoring sites across South Australia from the early 1970s to the early 1990s has been imported into Hydstra as point type data. Data stored as point type data is not treated as a time series with a connection between values but rather it is treated as an individual ‘spot reading’ unrelated to the previous or subsequent reading. This data set, which was originally collected as part of a national water quality assessment program, includes a mixture of parameters that can be the result of on-site readings and or results from laboratory test using a range of different methods from a sample taken during the on-site visit (see Table 22). Several on-site and laboratory results can be related to a single sample event, including different values for the same parameter resulting from different test methods. This set of data has been entered into Hydstra using different variable and sub-variable codes and quality codes to ensure that the different methods used to obtain each results can be identified.

Over 11,000 results were imported against 40 monitoring sites across the South East Region. This data underwent a basic data check to remove spurious data and sample times that had been missing from the original data set were added so that on-site and laboratory results can be matched with continuously recorded water level data and derived flow.

Table 22 Non-continuous Hydstra Data Types

Parameter	On-site (In Field)	Laboratory
Gauge Height	Staff gauge reading	No laboratory data, on-site reading only
Flow	Flow gauging result	No laboratory data, on-site reading only
Temperature	Water temperature reading	No laboratory data, on-site reading only
Total Dissolved Solids (TDS)	Calculated from on-site EC	Several different laboratory processes
PH	pH meter reading	Several different types of pH meter
Dissolved Oxygen (DO)	DO meter reading	Several different types of DO meter
Conductivity (EC)	EC meter reading	Several different types of EC meter

This data set ceases in early 1990 when responsibilities for water monitoring and water quality data management were restructured. Similar data collected at these sites since that time has not been entered into any data system. Details of this data for USE sites are included in the Monitoring Site Summaries provided in the appendices of this report.

Non-Hydstra Data

A significant amount of non-continuous water data has been collected at sites throughout the SE Region and the USE area that have not been entered into Hydstra. Various personnel from the SEWCDB and the USE Program currently note ad hoc water level and salinity readings or weir operations into diaries or field books on-site. In some cases these readings may later be entered into some form of digital storage, such as spreadsheets, however there has been no standard data system for storing or managing this data. It is planned that this type of data will be stored and managed in the Adaptive Management Geo-Database that is currently under development.

There are however two specific ad hoc reading data sets that are, in part, contained within digital data systems.

A network of wetland monitoring sites was established in 1990 as part of the USE Program with the data being entered into a Access database, (Giraudo, Monitoring Database 2002). These monitoring sites were mainly located in wetlands within the USE area, with particular concentration around the central area (see Figure 3).

The second ad hoc reading data set contains a mixture of water level and salinity readings and weir operation information for locations of interest to the SEWCDB. Details of the position of many of these sites are not available however some of this data has been entered into a set of spreadsheets (Puddy, Spreadsheets 2002).

These ad hoc readings and weir operation records form a vital part of the information describing the status of the drain, watercourse and wetland systems needed to provide a historical perspective of the outcomes of past actions. A USE Adaptive Management Geo-Database is currently being developed that is intended to manage this type of ad hoc data. Sourcing the historic hard copy records of this data and then entering it into the appropriate fields within the geo-database is expected to be a substantial task however in many cases this information provides the only available historical record of past events that can form the basis of future decision making.

5.1.6 Stage-Discharge Relationships

A stage-discharge relationship (rating) provides a means by which a water level value can be translated into a flow value. Whilst water level is a relatively simple parameter to record with good precession, translating this into continuous flow information relies entirely on the stage-discharge relationship, which if poorly developed will produce unreliable, inaccurate flow data. Ratings need to be kept under constant review as they can alter over time due to changes in conditions at the site such as seasonal weed growth in the channel.

A preliminary review of ratings for sites in the USE area has shown that virtually all existing ratings require a more thorough technical review and many will probably require revision or completely new ratings to be developed to cover new periods created by changing site conditions. Ratings for several sites are considered dubious and for three sites (A2390564, A2390551, A2390541) appeared to contain serious errors, which would have resulted in erroneous flow data being produced. Thorough rating reviews and revisions are being undertaken on a priority basis following on from the initial rating review as part of the second phase of the hydrological information project. Once the ratings have been formally reviewed and if necessary revised data files can be prepared for use in the modelling process.

Stage-discharge reviews are undertaken using applications available within the Hydstra system that provide graphical tools that assist in adjusting the rating curve to best fit the available flow gaugings using accepted international standard methods whilst taking into account cross sectional geometry and other hydrological factors. Various standard tests can be applied to the results to confirm the goodness of fit and the results saved within the system to then used for the derivation of flow.

The most important information used in the preparation of a stage-discharge relationship is the series of flow gaugings taken over a range of water level and flow conditions at the site.

Historically flow measurements have been made using mechanical current meter devices placed in the stream that have a propeller-like fan that is rotated by the movement of the passing water. The number of revolutions of the fan over a set time interval is directly related to the velocity of the water at that point. By counting the number of revolutions over a set time and using the meter's calibration information the velocity of the water at that point can be determined. Numerous individual velocity measurements across the entire width and depth of the cross section together with details of the stream cross sectional geometry are required to provide one measurement of flow.

Whilst this method has been used for many years it is generally accepted that there are a number of practical issues and shortcomings that that have been difficult to overcome because of the nature of the equipment used. Not the least of these is a range of safety issues due to the inherent need for operators to use boats with cross cables and cableway systems to hold the current meter in a fixed position in the stream. When conditions are suitable the operator may also enter the stream and wade across it holding the current meter on a rod system. The combination of working in the water, in boats, and the use of tightly drawn steel cables creates significant risks particularly at times of high water levels and strong flow. In addition mechanical current meters can be damaged by debris etc during use rendering them inaccurate. Many difficult to detect in-water phenomena can also affect the accuracy of current meter measurements.

During the last decade significant advances have occurred with the development of non-mechanical water velocity measuring equipment. Many different methods have been tested however the use of sound wave, or acoustic, systems appears to be the emerging direction.

The Acoustic Doppler Current Profiler (ADCP) is a spin-off from equipment used for decades in oceanography to measure ocean currents. A new scaled-down version of this equipment, a mini-ADCP, was tested in the SE Region during September 2004 and an evaluation report produced that recommended the purchase of a unit for use in the SE Region (Stace 2004). Subsequently a StreamPro mini-ADCP unit was purchased and it is expected that this unit will make future flow gauging safer and more efficient and enable more frequent gaugings to be completed. This will in turn provide the basis for more reliable and accurate stage-discharge relationships to be developed and thus better quality flow data to be produced.

At the commencement of this project only a few hundred flow gauging results were registered in the Hydstra system. The majority of gauging results had been stored in a stand-alone regional data system and needed to be transferred into Hydstra. A total of over 3200 gauging results are now available in Hydstra for sites within the SE Region with nearly 1800 of these being for sites within the USE area.

Over 50 cross section level surveys, that provide details of channel geometry used in rating development, have also been entered into Hydstra with an additional 25 being identified as needing to be surveyed. It is planned these surveys will be completed by SEWCDB personnel during routine visits to these sites.

5.1.7 Salinity Data

Salinity of streams frequently varies in relation to flow and in a typical natural stream situation salinity would generally decrease with increasing flow and visa versa. The situation in the USE area is however more complex due to the shallow nature of ground water, which is generally saline, and the presence of drains constructed to varying depths that intercept groundwater to varying degrees at varying times. The only method that can provide a reliable depiction of stream salinity over time, particularly in these more complex circumstances, is to continuously record salinity as electrical conductivity (EC).

Salinity is currently being continuously recorded at 6 flow monitoring sites enabling continuous salt load rates and total salt load volumes to be produced. Continuous monitoring of salinity is proposed at 27 additional sites, 4 at existing flow monitoring sites and the remaining 17 at proposed new sites. This additional continuous salinity monitoring is critical to assist in decision making and the effective management of this system.

At sites where there is no continuous salinity recording it is sometimes possible to derive a salinity-discharge relationship using ad hoc salinity sample results taken over a range of flow conditions. This is similar to the method used to derive a stage-discharge relationship but is generally much less precise as salinity is influenced by many other factors in addition to flow. Never the less a salinity-discharge relationship can be used to produce a representation of stream salinity over time.

To be able to produce a salinity-discharge relationship from non-continuous data it is critical the salinity readings are taken over a full range of flows. Generally this is not the case and most salinity results are typically taken at low flows with few results available to define the relationship at medium and high flows.

Figure 10 provides an example of a salinity-discharge relationship derived from grab sample and on-site testing results for site A2390531, Morambro Creek @ Bordertown-Naracoorte Road one of the existing sites where it is proposed to add a salinity sensor. The relationship produced is a line of best fit through 50 EC samples taken between 1979 and 1996.

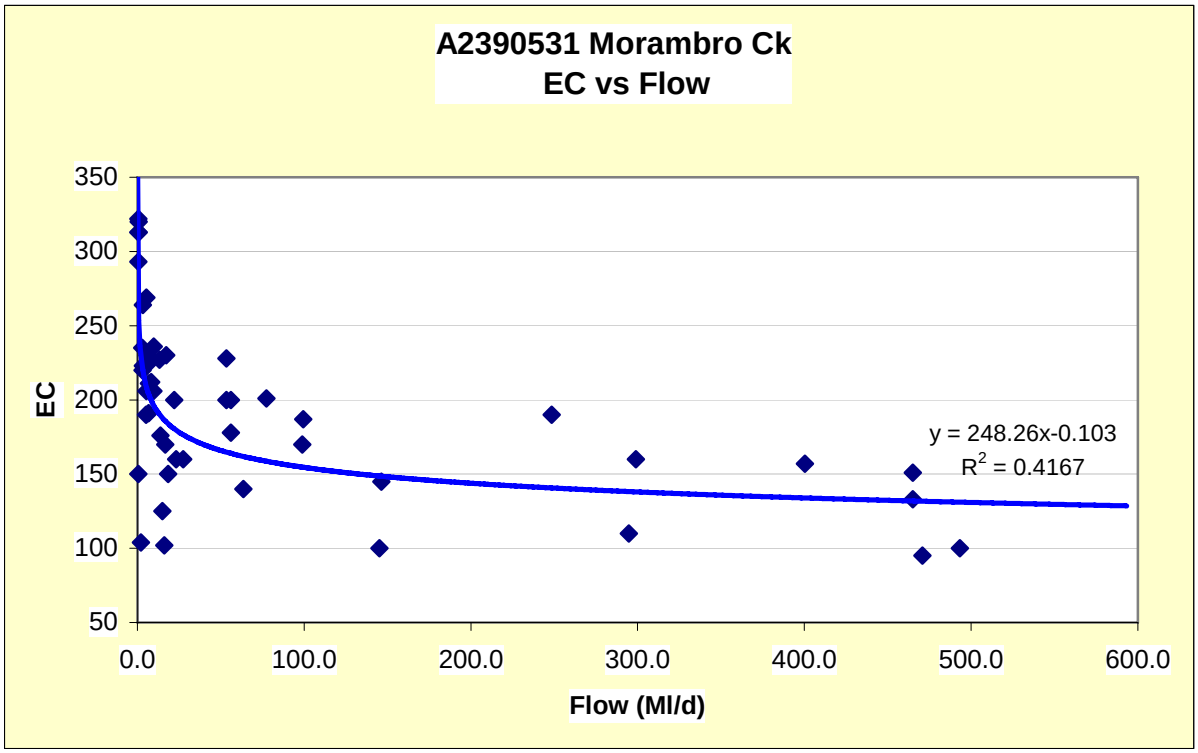

Figure 10 Salinity-Discharge Relationship at Site A2390531

It can bee seen in this example that there is significant scatter of EC results in low flows <100 Ml/d with few results above 100Ml/d to define the higher flow relationship. This is an example of one of the best available data sets with many sites having too few results to provide any relationship. In addition sites within areas of constructed drainage systems rather than the natural stream systems as in this case do not have a definable relationship between salinity and discharge due to the varying effects from groundwater interaction and flow control operations.

It is inappropriate to relying on ad hoc salinity readings to provide an ongoing time series of salinity or to use for salt load calculations and continuous recording of salinity provides the only viable option.

5.1.8 Rainfall Data

Rainfall data will be used as the primary input into the proposed USE model. Rainfall data can also provide an advanced indication of potential flows and by equipping rainfall recorders with telemetering capabilities operators of the flow control systems can make timely informed decisions. Currently there are two continuous recording rainfall sites operating within the USE area one at Salt Creek in the north and one near Fairview Drain in the southern central segment of the USE area. Neither of these sites includes telemetry.

It is proposed that a further six continuous recording rainfall sites be established, four in the upper catchments of the eastern streams (Tatiara, Morambro, Naracoorte and Mosquito Creeks) one in the southern area at Callendale Regulator and one in the central northern area at the Kercoonda Interchange. It is recommended that all rainfall recorders be telemetered.

5.1.9 Quality Assurance

During the process of developing the Hydstra system to be deployed in the SE Region all historical time series data was put through a range of check procedures to ensure the integrity of the data. These checks were made using a Hydstra tool, HyAudit, which can be customised to perform a wide range of tests on both time series data files and supporting data tables such as the Site Related Tables. The HyAudit processes were developed to be run on each occasion when new data is about to be added to the archive. Using HyAudit routinely in this way will assist the data entry person to identify errors prior to the data being archived and ensure the ongoing integrity of the system.

A standard work procedure 'SWD0010 - Auditing Time Series Data Prior to Archiving' has been developed that provides guidance in this task and instructions on the use of Hydstra HyAudit.

It is recommended that auditing of USE data be conducted prior to archiving as a standard practice in accordance with the standard work procedure SWD0010.

To provide further quality assurance it is also recommended that an annual check of all data and associated system tables be conducted. This would use an extended set of HyAudit tests that would need to be developed specifically for each site. By combining the annual data audit with a site audit including a level survey, commonly known as the Annual Check Survey, a clear indication of the performance of a site can be provided ensuring that management and operation of the site is refocused to effectively and efficiently meet the requirements of the site.

5.1.10 Data Reporting

A range of reporting mechanisms need to be developed to disseminate the information produced from the hydrological network. This could include routine summary reporting of annual drainage system flow volumes and salinities and information detailing the extent of water within the system. The exact nature and content of this type of information needs to be determined and will, to a great extent, depend upon the target audience.

In addition routine frequent detailed (daily) reporting of specific parameters from key telemetered sites could be made available using an automated Internet system. The need for this type of reporting needs to be carefully considered and if required the system should be produced with reliable, well tested technology that can be easily sustained into the future.

5.2 Monitoring Site Summary Information

Summary information has been prepared for each site within the USE area by combining information from various sources including a range of Hydstra reports and processes. Appendix B provides details of the sources of information used to produce the Hydrological Monitoring Site Summary Information Reports that are provided for each individual site within drainage sub-system groupings in Appendices C to K.

6. SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

This report summarises a project aimed at capturing and consolidating existing hydrological knowledge and information for monitoring sites the USE area.

The availability and reliability of hydrological data, including types of hydrological stations, their location, purposes and functions, and an assessment of the quality of data recorded at each monitoring site is detailed. The process formed the basis for an analysis of weaknesses in existing data sets and a review of the network of hydrological monitoring sites.

A preliminary review of water monitoring data has been completed and a number of data issues identified. Recommendations of this review include:-

- Site details need to be maintained more rigorously to support the data collected at these sites.
- Details of the layout of drains, watercourses, wetlands and flow control structures need to be maintained in a single data set.
- Continuous recording of data on chart recorders introduces inherent errors and is inefficient. All chart recorders should be replaced with data loggers and all outstanding chart record should be digitised and entered into the Hydstra system.
- Ad hoc manual readings of water level, salinity and weir operations etc should be recorded digitally in a single standard data system. The proposed Adaptive Management Geo-database should be designed to accommodate all of this type of data.
- Stage-discharge relationships should be kept under constant review. More frequent flow gaugings need to be undertaken to ensure that the stage-discharge relationships provide a reliable estimation of actual flow.
- Continuous recording of salinity should be included as a 'standard' parameter at all sites were salinity is critical to a decision.
- All time series data should routinely undergo a basic audit using the Hydstra HyAudit tool prior to the data being added to the archive.
- A comprehensive audit should be performed on all data and site related information on an annual basis. A physical audit of the site including a check level survey would be conducted as part of this annual audit process.
- The type of information required by stakeholders need to be identified so that standard data reporting mechanisms can be developed to meet these needs.

A review of the current monitoring network was conducted and a revised network proposed. The proposed monitoring network includes a doubling of the number of continuously recording monitoring sites, from 21 sites to 42 sites, and a relatively small overall increase in the number of ad hoc manual reading sites. It is recommended that twelve sites, most of which are ad hoc manual reading sites, be closed.

The main emphasis of the proposed monitoring network is to provide a level of data and information necessary to assist in the timely management of this complex drainage system utilising reliable technology.

The use of telemetering functionality to enable real-time data access and data acquisition is another feature of the proposed network. Utilising this technology provides timely data for operational decisions in addition to reducing the amount of data that may potentially be lost during recording equipment failures.

Recommendations for the proposed monitoring network include:-

- An increase of 21 continuous recording sites from 21 to 42 sites.
- An increase of 17 sites with telemetry capability from 7 to 24 sites.
- An increase of 21 sites with salinity recording from 6 to 27 sites.
- An increase of 6 sites with continuous rainfall recording from 2 to 8 sites.
- The closure of 12 existing sites.
- The replacement of all (6) existing chart recorders with data loggers.

Some of the USE drainage system is yet to be completed and refinements to the proposed monitoring network will be necessary later. The monitoring network needs to be constantly under review and able to adjust to meet the changing needs of the adaptive management process.

In the process of collating hydrological information for the USE area it became apparent that there are insufficient resources available to manage and operate the existing and proposed monitoring network to the required standards.

Recommendation to sustain monitoring activities into the future include:-

- A formal review be conducted to determine level of human resources necessary for existing and proposed monitoring.
- Where appropriate the use of more efficient equipment and techniques, such as the StreamPro mini-ADCP and telemetry, be actively perused.

The next phase is to complete a thorough revision of the available data, in particular stage-discharge relationships, so that the best possible flow data can be prepared for the modelling process.

7. GLOSSARY

Acoustic Doppler Current Profiler (ADCP)

Equipment that can be used for measuring the flow in a stream using ultrasonic technology. This equipment is operated by moving it slowly across the surface of the stream and provides detailed data of water velocity and direction through the stream profile in addition to streambed definition.

aquifer

An underground layer of rock or sediment that holds water and allows water to percolate through.

aquifer, confined

Aquifer in which the upper surface is impervious and the water is held at greater than atmospheric pressure. Water in a penetrating well will rise above the surface of the aquifer.

aquifer, unconfined

Aquifer in which the upper surface has free connection to the ground surface and the water surface is at atmospheric pressure.

baseflow

The water in a stream that results from groundwater discharge to the stream. (This discharge often maintains flows during seasonal dry periods and has important ecological functions.)

basin

The area drained by a major river and its tributaries.

catchment

A catchment is that area of land determined by topographic features within which rainfall will contribute to runoff at a particular point.

control

The control is the feature within a river reach that regulates flow for any given water level. Along any reach of river, the controlling feature may vary with changes in water level. Specially designed weirs and other structures are frequently used to create a controlling section at stream monitoring sites.

When the controlling feature causes a transition from subcritical to supercritical flow, immediately upstream of such a transition is a section where water level is uniquely related to flow. This is an ideal situation for establishing a stage-discharge relationship, because for any water level there is only one corresponding rate of flow.

Such a situation is referred to as section control. When the controlling feature does not cause a transition from sub-critical to super-critical flow, upstream or downstream conditions influence hydraulic gradient resulting in varying rates of flow for any given water level. Such conditions are referred to as channel control.

chart recorder

A mechanical device used to record data onto a paper chart medium. Chart recorders were used extensively in the hydrographic industry to record environmental parameters such as water level up to the 1980s when most chart recorders were replaced by data loggers.

current meter

An instrument used to measure water velocity. Typically this is a mechanical device that includes a propeller-like fan that is revolved by the movement of the passing water. The number of revolutions is counted for a set period of time and a calibration table used to provide water velocity.

CWMB

Catchment Water Management Board.

data logger

An instrument used to digitally record data. Data loggers are used in the hydrographic industry to record a wide range of environmental parameters such as water level or salinity. Data loggers need to be connected to a sensor that can measure the parameter and provide a signal that the data logger can interpreter and then store in digital memory.

discharge measurement

See flow gauging.

effluent

Domestic wastewater and industrial wastewater.

electrical conductivity (EC)

Water's ability to conduct electric current is directly related to the total dissolved solids (TDS) present in the water. Electrical conductivity, (generally abbreviated to EC) is widely used as an indicator of water salinity and is reported in µS/cm (micro-Siemens per centimetre). Electrical conductivity is temperature sensitive and increases with increasing temperature. Conductivity values are usually adjusted (often referred to as compensated) to the value that would occur if the water temperature was 25°C. By compensating to a standard temperature, comparisons between EC readings are possible.

1 EC unit = 1 micro-Siemen per centimetre (µS/cm) measured at 25 degrees Celsius.

ephemeral streams / wetlands

Those streams or wetlands that usually contain water only on an occasional basis after rainfall events. Many arid zone streams and wetlands are ephemeral.

erosion

Natural breakdown and movement of soil and rock by water, wind or ice. The process may be accelerated by human activities.

flow gauging

A measurement of flow made at a particular stage (water level) for purposes of establishing the relationship between water level and flow in a particular river reach. Flow gaugings are also referred to as discharge measurements.

gauging station

A gauging station is a specific type of monitoring site where stream flow is measured. At a gauging station a variety of other environmental parameters may also be measured however these sites will always include some form of flow monitoring. The data collected at a monitoring site may be individual readings taken at varying intervals or continuously recorded using a variety of instrumentation. Typically at a gauging station a stage-discharge relationship would be developed based on the flow control at the site by undertaking flow gaugings over a range of flow conditions. In some cases a gauging station may include water velocity measuring instruments, which together with stream cross-sectional area provide a measurement of water flow.

gigalitre (GL)

One thousand million litres (1 000 000 000).

GIS

Geographic Information System – Computer software allows for the linking of geographic data (for example land parcels) to textual data (soil type, land value, ownership). It allows for a range of features, from simple map production to complex data analysis.

GPS

Global Positioning System – A satellite-based global positioning and navigation system consisting of a network of earth orbiting satellites. Using a GPS receiver the position on the earth surface can be determined.

hydrogeology

The study of groundwater, which includes its occurrence, recharge and discharge processes and the properties of aquifers. (See: hydrology)

hydrography

The discipline related to the measurement and recording of parameters associated with the hydrological cycle, both historic and real time.

hydrology

The study of the characteristics, occurrence, movement and utilisation of water on and below the earth's surface and within its atmosphere.(See: hydrogeology)

hydrometric

Of or relating to the measurement of elements of the hydrological cycle.

Hydstra TS

Hydstra TS is a software product widely used to for the storage, analysis and presentation of hydrometric time series data. Hydstra products were previously known under the name HYDSYS.

lake

A natural lake, pond, lagoon, wetland or spring (whether modified or not) and includes: part of a lake; and a body of water declared by regulation to be a lake; a reference to a lake is a reference to either the bed, banks and shores of the lake or the water for the time being held by the bed, banks and shores of the lake, or both, depending on the context.

Megalitre (ML)

One million litres (1 000 000).

model

A conceptual or mathematical means of understanding elements of the real world, which allows for predictions of outcomes given certain conditions. Examples include estimating storm runoff, assessing the impacts of dams or predicting ecological response to environmental change.

monitoring site

A location at which one or many environmental parameters are measured. The data collected at a monitoring site may be individual readings taken at varying intervals or continuously recorded using a variety of instrumentation.

NLWRA

National Land and Water Resources Audit 2000. A National review of Australia's land and water resources under Environment Australia through the National Heritage Trust.

Ramsar

The Convention on Wetlands, signed in Ramsar, Iran, in 1971, is an intergovernmental treaty, which provides the framework for national action and international cooperation for the conservation and wise use of wetlands and their resources. There are presently 138 Contracting Parties to the Convention, with 1369 wetland sites, totalling 119.6 million hectares, designated for inclusion in the Ramsar List of Wetlands of International Importance (the Ramsar Convention Secretariat, 2004).

recharge area

The area of land from which water from the surface (rainfall, streamflow, irrigation, etc) infiltrates into an aquifer.

rating

See stage-discharge relationship.

reach

A relatively short section of a river. A reach usually describes a length of river having some related characteristic such as between two weirs or a length of stream having the same flow regime.

runaway hole

A geomorphic feature where surface water flows into the ground.

telemetry

A mechanism, usually using telephone or radio systems, that provides remote access to a equipment such as a data logger at a monitoring site enabling data to be viewed and or downloaded to the remote location.

time series

Time series data is a series of variable values recorded against time.

In the context of water resource monitoring, time-series data is records of water related environmental variables, such as water level or water salinity, recorded against the time the readings were taken. The time interval between recording can be seconds, hours, days or even longer, provided that the recorded values give a reliable representation of the actual changes in the variable at the required level of accuracy.

A wide range of variables can be recorded as a time series including any level or counter type data that varies with time. Examples include water level, flow rate, velocity, salinity, turbidity, temperature, wind speed, rainfall, wind direction, flow volume, battery voltage, gate opening, pump status, etc.

In cases where the variable does not change rapidly a time series can be made up from manual observations such as a manual reading of groundwater levels. In other situations where the variable changes rapidly very frequent readings are required and continuously recording devices are used to record the data.

total dissolved solids (TDS)

Total Dissolved Solids (TDS) is the quantity (by mass per unit volume) of residue left by evaporation, giving one of the best indications of the salinity of the water.

salt load

A rate at which salt (dissolved solids) passes a point on a river reach. Salt load is usually expressed in units of mass per unit time, such as tonnes per day.

seasonal watercourses / wetlands

Those watercourses and wetlands that contain water on a seasonal basis, usually over the winter/spring period, although there may be some flow or standing water at other times.

stage

The water level measured as a height above an arbitrary datum.

stage-discharge relationship

Also known as a rating curve, the stage-discharge relationship associates water level (stage) with flow (discharge) for a specific reach of river where a control feature is present. The relationship is often established over time by making flow gaugings at all ranges of water level when they occur. The relationship can also be based on adopted

hydraulic principals when a pre-calibrated gauging weir is used as the controlling feature.

State Water Plan (SWP)

A plan prepared by the Minister for Water resources under section 90 of the Water Resources Act 1997.

waterbody

Waterbodies include watercourses, riparian zones, floodplains, wetlands, estuaries, lakes and groundwater aquifers.

watercourse

A river, creek or other natural watercourse (whether modified or not) and includes: a dam or reservoir that collects water flowing in a watercourse; and a lake through which water flows; and a channel (but not a channel declared by regulation to be excluded from the this definition) into which the water of a watercourse has been diverted; and part of a watercourse.

8. SI UNITS COMMONLY USED WITHIN TEXT

Name of unit	Symbol	Definition in terms of other metric units	
Metre	m		length
Kilometre	km	10^3 m	length
Hectare	ha	10^4 m^2	area
Millilitre	mL	10^{-6} m^3	volume
Litre	L	10^{-3} m^3	volume
Kilolitre	kL	1 m^3	volume
Megalitre	ML	10^3 m^3	volume
Gigalitres	GL	10^6 m^3	volume
Milligram	mg	10^{-3} g	mass
Gram	g		mass

9. ABBREVIATIONS COMMONLY USED WITHIN TEXT

Abbreviation		Name	Units of measure
ADCP	=	Acoustic Doppler Current Profiles	
D/S	=	Downstream	
DWLBC	=	Department of Water Land and Biodiversity Conservation	
EC	=	Temperature adjusted Electrical Conductivity *(micro Siemens per centimetre at 25 degrees Centigrade)*	µS/cm @ 25^c
EWS		Engineering and Water Supply Department	
GPS	=	Global Positioning System	
NLWRA		National Land and Water Resource Audit	
PH	=	Relative strength of acidity/alkalinity measured as the negative logarithm of the hydrogen ion concentration in solution.	
SAW		South Australian Water Corporation	
SECWMB		South East Catchment Water Management Board	
SEWCDB	=	South Eastern Water Conservation and Drainage Board	
SWP		State Water Plan	
t/d	=	Tonnes per day. (*A measure of the mass of salt passing a point on a stream in one day*.)	tonnes/day
U/S	=	Upstream	
USE		Upper South East (*area*)	

10. REFERENCES

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