Managing Climate, Irrigation and Ground Water Interactions using a Numerical Model: A Case Study of the Murrumbidgee Irrigation Area

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Summary

This report describes the development of a surface-groundwater interaction model for the Murrumbidgee Irrigation Area. The US geological survey model MODFLOW coupled with the MT3D solute transport simulator under a PMWIN environment was used as the modeling framework. The spatial domain represented in the model consists of four layers each of 106 rows and 113 columns (750m x 750m cell size). A stress period length of 30-days was used to enable simulation of irrigation and on-irrigation seasons with a computational time step of one day. Initially the model parameters have been specified for the 1995 to 2000 period for calibration purposes. Extensive datasets on the aquifer lithology (structural contours, borelogs, aquifer properties), piezometric levels, groundwater salinity, aquifer abstractions, channel network, Murrumbidgee River and rice area locations have been collected and collated in ArcView GIS format. This work has provided an opportunity to consolidate a larger number of scattered databases into various formats for the MIA and in a form which can be readily used to carry out a range of environmental studies. Several customised programs have been written for the manipulation of the difficult data sets to incorporate them into MODFLOW-MT3D format for the 1995-2000 period. A working surface-groundwater interaction model of the MIA is now available. Detailed piezometric data and numerical model results have shown overall decline in the groundwater levels in the region. This decline is attributed to improved land and water management practices as well as relatively dry climate over the last decade. Some areas within the MIA e.g. Yenda, Murrumai and some parts of the Kooba and Benerembah areas have very limited groundwater outflow capacities. These areas are likely to result in shallow watertable and soil salinity problems if irrigation and winter cropping efficiency is not managed within the regional groundwater flow capacity.

This model has been calibrated and used to simulate possible management scenarios. As with any model there is a need to keep this model updated and use it with other tools such as SWAGMAN Farm to convey modeling results and help determine sustainable irrigation levels on a year to year basis.
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INTRODUCTION TO THE STUDY AREA

1.1 Geographical Location

This report describes the development of a surface-groundwater interaction model of the Murrumbidgee Irrigation Area (MIA), situated in central New South Wales in south-east Australia. The location of MIA in the Murray-Darling Basin and in the Murrumbidgee Catchment is shown in Figure 1.1. The MIA includes the cities of Griffith and Leeton and is about 600 km west of Sydney and 900 km east of Adelaide. The Murrumbidgee River, the third largest river in Australia (1,690 kms), flows to the south of the MIA. The geographic boundary of the study area is 375250E, 6150500N for the south-eastern corner and 460000E, 6230000N for the north-western corner.

Figure 1.1: Location of the study area (MIA) in relation to Australia and NSW irrigation areas.
1.2 Climate

The climate of Murrumbidgee Irrigation Area is classified as semi-arid, with an average annual rainfall ranging from 256 mm to 609 mm. The average monthly rainfall distribution at Griffith is given in Figure 1.2 and average monthly weather parameters such as wind, relatively humidity, temperature and potential evapotranspiration at Griffith are given in Figure 1.3 and Figure 1.4. Average rainfall gets close to average evapotranspiration rates during the winter months of June and July.

![Image of Monthly Average Rainfall](image-url)

Figure 1.2: Monthly average rainfall (mm) for Griffith, averaged between the years of 1962-2000.
Figure 1.3: Average wind (km/day) and average relative humidity (%) for years of 1962-2000 and 1983-2000 respectively, taken at Griffith.

Figure 1.4: Average temperature (°C) and average evapotranspiration (mm) from 1962-1999 taken at Griffith.
1.3 Geology of the Murrumbidgee Irrigation Area

The study area is the Murrumbidgee Irrigation Area on the northern side of a fluvial plain formed by the Murrumbidgee River. The majority of the MIA’s elevation is below 200m above sea level, although on the north-eastern flank of the study area there are low hilly outcrops that extend to 240m above sea level. The land surface generally slopes east to west with an average slope of 40 cm per km. The geology of the Murrumbidgee Irrigation Area is described by three major aquifer systems (Figure 1.5) i.e. Shepparton, Calivil and Renmark Formations (Brown & Stephenson 1991). The Shepparton formation were deposited during the late tertiary to the quaternary period and mainly consist of unconsolidated to poorly consolidated, mottled, variegated clays and silty clays with lenses of polymictic, coarse to fine sand and gravel, partly modified by pedogenesis. The Calivil formation belongs to the late Miocene to Pliocene period and mainly consists of poorly consolidated, pale grey, poorly sorted, coarse to granular quartz and conglomerate, with white kaolinitic matrix. The Renmark formation belongs to the Palaeocene to middle Miocene period overlies the basaltic bed rock from the Palaeocene to Miocene period. The Renmark formation is distinguished from the Calivil formation by the presence of grey, carbonaceous sand.
Figure 1.5: Geological Units in the MIA (Source: Wooley, 1991).
1.4 Soils

The soils (0-5 m depth) in the study area consist of more than 90 different soil types, and have been mapped in the Murrumbidgee Irrigation Area (MIA) (Hornbuckle and Christen, 1999; Stannard, 1970; Taylor and Hooper, 1938; van Dijk, 1958; 1961). These soils are generally grouped into five distinct groups due to similarity in hydraulic characteristics:

- **Clays** - self mulching and hard setting (non self mulching clays). These soils either consist of crumbly calcareous shallow horizons (self mulching) or hard setting non-calcareous surface soils (non self mulching clays). The hydraulic conductivity of top horizons of self mulching clays (up to 0.5 m depth) is normally high (around 30 mm/day) whereas the hydraulic conductivity for deeper horizons (1.5 to 3 m) is relatively low (0.5 to 1 mm/day). The reported hydraulic conductivity values for shallow non-self mulching clays are around 4 mm/day.

- **Red-Brown Earths** - this group of soils consists of loamy or sandy surface horizons of more than 0.1 m depth which abruptly change to clay subsoils. The reported hydraulic conductivity values for this soil group vary greatly between 58 mm/day to 1039 mm/day.

- **Transitional Red Brown Earths** – these soils have hydraulic characteristics of clays and red brown earths. The top clay layer is very shallow (0.08-0.1m). The deeper profiles contain lime and gypsum. The reported hydraulic conductivity of these soils in the 0.2-0.6 m depth ranges between 0.026 to 10 mm/day, with most values falling at the lower end of this range.

- **Sands over clay** – these soils mainly consist of sandy top soils (0.1 to 0.6 m) with a dense sub clay soils. The hydraulic conductivity of some of the soils of this group is greater than 100 mm/day.

- **Deep sandy soils** – these soils are of aeolian origin and contain coarse sands to a depth of 4 meters. The hydraulic conductivities for this soil group may be greater than 1000 mm/day.

Since the groundwater model extends to the bed rock the hydraulic properties for the individual layers were determined by using extensive borelog data sets and subsequently interpolating for the model area (refer to Chapter 5).
### 1.5 Irrigation History

Irrigation suitability studies were undertaken along the Murrumbidgee River in the 1890s, with development taking place in the MIA between 1906 and 1913. By 1914, there were 677 farms in the MIA. Water was supplied by the first major reservoir built for irrigation – Burrinjuck Dam, which was completed in 1924. Rice-growing started in the MIA in 1924, although rapid development of rice areas took off in the 1970s and 1980s.

### 1.6 Landuse

The total area for the MIA is 230,222 ha. Table 1.1 and Table 1.2 outline the different types of land uses and their respective areas in the MIA. Rice is the most dominant land use with more than 32,000 ha (14 percent of the total landscape) in 2000.

**Table 1.1: Land-use in the MIA, 1999-2000 (Source, Murrumbidgee Irrigation).**

<table>
<thead>
<tr>
<th>Land Use</th>
<th>ha</th>
</tr>
</thead>
<tbody>
<tr>
<td>Horticulture</td>
<td>21,931</td>
</tr>
<tr>
<td>Large Area Farms</td>
<td>148,500</td>
</tr>
<tr>
<td>Total Area under Rice</td>
<td>32,277</td>
</tr>
<tr>
<td>Other Lands</td>
<td>6,000</td>
</tr>
<tr>
<td>(including towns, Lake Wyangan and Warburn Swamp catchment)</td>
<td></td>
</tr>
<tr>
<td>Other (cereal)</td>
<td>21,514</td>
</tr>
<tr>
<td>Total Area for Murrumbidgee Irrigation</td>
<td>230,222</td>
</tr>
</tbody>
</table>

**Table 1.2: Area in the MIA for the major horticultural crops (source: MIA Council of Horticultural Association).**

<table>
<thead>
<tr>
<th></th>
<th>Mirrool</th>
<th>Yanco</th>
<th>Other</th>
<th>Total (ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grapes (ha)</td>
<td>10,127.53</td>
<td>1,376.81</td>
<td>821.89</td>
<td>12,326.23</td>
</tr>
<tr>
<td>Citrus (ha)</td>
<td>4,827.72</td>
<td>3,003.66</td>
<td>899.15</td>
<td>8,730.53</td>
</tr>
<tr>
<td>Prunes (ha)</td>
<td>432.75</td>
<td>28.56</td>
<td>149.14</td>
<td>610.45</td>
</tr>
<tr>
<td>Other (ha)</td>
<td>139.57</td>
<td>123.96</td>
<td>-</td>
<td>263.53</td>
</tr>
<tr>
<td>Total (ha)</td>
<td>15,527.57</td>
<td>4,532.99</td>
<td>1,870.18</td>
<td>21,930.74</td>
</tr>
</tbody>
</table>
The 1999 monthly irrigation flows for different enterprises is given in Table 1.3. Rice is grown under ponded conditions, and for this reason tends to use much larger volumes of water per hectare (~14 ML/ha) than other crop types (wheat 3.6 ML/ha, soybeans 9.5 ML/ha). Locations of rice paddocks during the 1999 summer are given in Figure 1.6.

<table>
<thead>
<tr>
<th>Month</th>
<th>Rice</th>
<th>Pasture</th>
<th>Cereal</th>
<th>Vegetables</th>
<th>Horticulture</th>
<th>Misc</th>
<th>Total</th>
<th>% of Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>August</td>
<td>2,184</td>
<td>6,307</td>
<td>14</td>
<td>8</td>
<td>1,204</td>
<td>9,717</td>
<td>1.2</td>
<td></td>
</tr>
<tr>
<td>September</td>
<td>801</td>
<td>1,755</td>
<td>3,140</td>
<td>19</td>
<td>365</td>
<td>1,205</td>
<td>7,285</td>
<td>0.9</td>
</tr>
<tr>
<td>October</td>
<td>77,758</td>
<td>2,030</td>
<td>8,925</td>
<td>1,629</td>
<td>5,370</td>
<td>2,937</td>
<td>98,649</td>
<td>12.0</td>
</tr>
<tr>
<td>November</td>
<td>73,339</td>
<td>4,251</td>
<td>8,882</td>
<td>3,108</td>
<td>13,187</td>
<td>4,223</td>
<td>106,990</td>
<td>13.0</td>
</tr>
<tr>
<td>December</td>
<td>109,170</td>
<td>6,259</td>
<td>9,605</td>
<td>5,457</td>
<td>24,829</td>
<td>6,623</td>
<td>161,943</td>
<td>19.6</td>
</tr>
<tr>
<td>January</td>
<td>126,336</td>
<td>6,270</td>
<td>11,769</td>
<td>6,539</td>
<td>23,089</td>
<td>5,835</td>
<td>179,838</td>
<td>21.8</td>
</tr>
<tr>
<td>February</td>
<td>75,530</td>
<td>11,148</td>
<td>8,160</td>
<td>4,790</td>
<td>20,360</td>
<td>4,866</td>
<td>124,854</td>
<td>15.1</td>
</tr>
<tr>
<td>March</td>
<td>14,517</td>
<td>37,279</td>
<td>3,836</td>
<td>2,039</td>
<td>10,215</td>
<td>13,011</td>
<td>80,897</td>
<td>9.8</td>
</tr>
<tr>
<td>April</td>
<td>23</td>
<td>9,209</td>
<td>1,203</td>
<td>237</td>
<td>3,300</td>
<td>6,059</td>
<td>20,031</td>
<td>2.4</td>
</tr>
<tr>
<td>May</td>
<td>89</td>
<td>15,209</td>
<td>2,678</td>
<td>1,005</td>
<td>3,891</td>
<td>3,003</td>
<td>25,875</td>
<td>3.1</td>
</tr>
<tr>
<td>June</td>
<td>-</td>
<td>6,197</td>
<td>726</td>
<td>130</td>
<td>908</td>
<td>1,350</td>
<td>9,311</td>
<td>1.1</td>
</tr>
<tr>
<td>Total</td>
<td>477,563</td>
<td>101,791</td>
<td>65,231</td>
<td>24,967</td>
<td>105,522</td>
<td>50,316</td>
<td>825,390</td>
<td>100</td>
</tr>
<tr>
<td>% of Total</td>
<td>57.9</td>
<td>12.3</td>
<td>7.9</td>
<td>3.0</td>
<td>12.8</td>
<td>6.1</td>
<td>100</td>
<td></td>
</tr>
</tbody>
</table>
Figure 1.6: Rice-growing farms in the MIA 1999-2000 growing season.
1.7 Number of Farms

In the year 1999-2000, there were 4,117 farms in the MIA (Figure 1.7). In the 1999-2000 season, rice was grown on 555 farms.

1.8 Water-logging Soil and Salinisation

Soil salinity surveys are available in the MIA for 1991, 1992, 1994 and 1998 (van der Lely, 1999) which show that percentage area of land with salinity (EC; 1:2) greater than 2 dS/m has increased from 53 percent (1991-94 average) to 70 percent (1998 average). Waterlogging appeared in the MIA soon after irrigation. During the winter of 1931, major waterlogging was caused on the horticultural farms of the Murrumbidgee Irrigation Area when 92 mm rainfall fell during June (Butler, 1971) and the perched watertables rose to the surface in many places. Figure 1.8 shows the water table fluctuations in the MIA, particularly in the South Benerembah area, where a rise of around 12m has occurred since the early 1970s.
Figure 1.9 shows average piezometric levels in the upper and lower Shepparton aquifers. Pre-irrigation soil salinity in the soils of MIA was caused by rainfall over thousands of years when rainfall magnitude was not enough to leach the salts to the deeper watertables. With the introduction of irrigation these salts were washed to the groundwater resulting in high groundwater salinity levels. Now, due to the presence of shallow watertables within 2 meters from the soil surface, the capillary upflows from highly saline watertable and evapotranspiration have caused soil salinisation in the root zone in the northern parts of the MIA, Benerembah and parts of Wah Wah irrigation district (van der Lely, 1998).

Figure 1.8: Average Pressure (m) in Aquifers 12-35 metres depth for different regions of the Murrumbidgee Irrigation Area.
In 1989 the MIA & Districts Community Land and Water Management Plan was initiated in response to widespread flood damage. The initial purpose was to assess drainage issues in the area, however it soon became clear that addressing drainage alone would not cover the MIA’s land and water management issues.

The main objective of the MIA LWMP is given as:

To maintain and enhance the sustainability and profitability of agriculture in the MIA & Districts.

The LWMP for the MIA was finalised in 1998. The document served to address the effects of the following on agriculture, infrastructure and overall economy:

- Excessive drainage and flooding
- Waterlogging and land salinity
- High watertables
- Reduction in asset values, income and business value
- Deterioration in water quality
- Decline in quality of natural resources

1.9.1 The LWMP options to address above issues include:

- Reduce seepage to the groundwater systems
- Reduce drainage volumes to acceptable levels
- Keep drainage water quality within agreed limits
- Manage drainage disposal to agreed standards
- To protect and enhance natural resources

1.9.2 MIA LWMP targets include:

- Increase productivity
- Reduce groundwater accessions by 25,000 ML
- Keep salinity to less than 20% of landscape
- Improvement of 100 EC at Mirrool Dam
- Reduce drainage volume by 36,000 ML/year
- Reduce flood frequency in Lower Mirrool Creek

1.9.3 Actions to achieve

- Best management practices
- On-farm activities
- Regional activities
- Regional activities

The final plan integrates upstream improvements (i.e. east of Barren Box Swamp), addressing drainage into Barren Box Swamp, and the water re-use in downstream areas (i.e. west of Barren Box Swamp).

1.10 Previous Groundwater Studies

A number of groundwater modelling studies has been previously carried out in the MIA. These studies were unable to provide insights into the spatial distribution of groundwater and soil salinity dynamics. The most notable of these studies are summarised below:
a) Murray Darling Basin Commission Simplified Shepparton Model (Merrilees, 1992)

This model used a simple lumped equation to define salinity trends using the irrigation and runoff volumes and salinities. This model resulted in very high salinity projections for the MIA (van der Lely, 1998).

b) SWAGSIM Model

Prathapar (1994) developed a two layer (Shepparton and Calivil formations) flow model using SWAGSIM covering an area of 3,750 ha near Griffith. This model assumed very high deep leakage rates to match the piezometric levels in shallow aquifers (deep leakage rate was about half the recharge rate). This model was used to compute the pumping rates for desired watertable targets and impact of different rice areas. The main limitation of this approach was the lack of representation of surface-groundwater interactions and dynamic representation of deep aquifer pressure changes over time.

c) Modelling Efforts by van der Lely

Van der Lely developed a number of models ranging from simple analytical solutions describing leakage from rice bays to lumped water and salinity balance models. The models relevant to this study include groundwater balance model (GWBM) and soil salinity assessment and prediction model (SSAPM) (van der Lely, 1998). Both of these models are based on empirical lumped water and salt balance relationships and therefore can not be used to determine spatial groundwater flow and salinity dynamics in the MIA.

d) Department of Land and Water Conservation Regional Groundwater Model

Punthakey et al. (1994) reported a groundwater model of the Lower Murrumbidgee River Basin (LMRB). This model was constructed as an initiative of the Murray Darling Basin Commission Groundwater Working Group. This initiative involved the development of five regional groundwater models covering the entire basin, which were to be integrated into a Murray Darling Basin model. The LMRB model is a three-layer MODFLOW based model. This model used a 7.5 km square mesh. The mesh size of this model provided a relatively coarse representation of the groundwater system and therefore the development of a more detailed sub-model of the MIA is necessary to evaluate land and water management plan options.
e) Preliminary MIA groundwater model by Gates

Professor Gates (Gates, 1997) of the Colorado State University on a sabbatical visit to CSU and CSIRO Land and Water, Griffith collected some data on soil properties and rice areas in the MIA. Using this data and some assumed parameters he developed a preliminary MODFLOW-MT3D model of the MIA. Due to lack of time he could not improve the model parameters or carry out any calibrations.
2 Objectives of Modelling Study

The main objectives of the modelling study described in this report are given below:

- To collect and collate hydrogeological databases characterising different aquifer systems, surface-groundwater interactions and groundwater abstractions in the MIA.
- To process the hydrogeological databases in a GIS environment for ready incorporation in a surface-groundwater interaction model.
- Development of a preliminary MODFLOW-MT3D flow and transport model.

The objectives of future work using the results of work presented in this report as listed below:

- To calibrate the groundwater flow and transport model to describe historic piezometric levels and surface-groundwater interactions in the MIA.
- To simulate different Land and Water Management Plan options to assess their effectiveness.
- To differentiate and quantify climatic and management impacts on shallow watertables and soil salinity.
- To develop a natural resource management tool/decision support system for the MIA.
3 CONCEPTUAL MODEL OF THE MURRUMBIDGEE IRRIGATION AREA

Figure 3.1 shows a schematic diagram of the conceptual model of the Murrumbidgee Irrigation Area. The model area extends beyond the MIA to include the Murrumbidgee River and surrounding areas. The following hydrogeological features are represented in this model:

- Lithology of Upper Shepparton, Lower Shepparton, Calivil and Renmark Formations-including top and bottom elevations and hydraulic characteristics (Figure 3.2)
- Vertical interactions (leakage) between the aquifers
- Recharge due to irrigation and rainfall
- Groundwater abstractions from different aquifer layers (Figure 3.3)
- Tile drainage from the horticultural farms (Figure 3.4)
- Leakage to and from the supply channels with the adjoining aquifers
- Leakage to and from the drainage channels
- Surface-groundwater interactions for the Murrumbidgee river
- Regional groundwater flow interactions for different aquifers at the boundaries of the model domain

For the model development, MODFLOW (McDonald and Harbaugh, 1988) and MT3D (Zheng, 1996) packages under the PMWIN (Chiang and Kinzelbach, 1998) environment were used.
Figure 3.1: Schematic of the conceptual model, illustrating the hydrological flows in, through and out of the model.
Figure 3.2: Cross-section of Easting 402625 through the lithology of the study area. Further examples of cross-sections through the model area are shown in Appendix A - Structure Contours.

Figure 3.3: Total abstraction volume per year for the different formations, Lower Shepparton, Calivil and Renmark from which pumping took place.
Figure 3.4: Tile drainage in the Murrumbidgee Irrigation Area.
4 DATA REQUIREMENTS

For the MODFLOW (McDonald and Harbaugh, 1988) model, the following data were required:

- Structure contour information to derive top and bottom elevations of formations for:
  - Upper Shepparton
  - Lower Shepparton
  - Calivil
  - Renmark
  - Bedrock
- Groundwater abstractions for each formation
- Piezometer readings – to define the initial conditions and compare model results with observations for each formation
- Horizontal and vertical hydraulic conductivity distributions for each of the formations
- Specific yield distribution for each of the formations
- Specific storage distribution for each of the formations
- Effective porosity for each of the formations
- Layout and cross-sections (bed elevation, width, depth etc) for the Murrumbidgee River and irrigation and drainage channel system
- Location and area of tile drained land and average depth of drains
5 PROCESSED DATABASES FOR THE GROUNDWATER MODEL

5.1 Data Formats

There was a variety of data formats between databases. In order to develop all databases into a consistent data format and type, a number of steps were required.

5.1.1 Drill Logs

Due to the general age of the drill logs, all drill logs had to be brought in a consistent digital format. Measurements were frequently recorded in imperial units and required conversion from feet to metres where applicable. Secondly, the majority of bore locations (i.e. easting and northing) were absent. To derive the easting and northing for each bore, a number of steps were required the bores needed to be located in a real-world co-ordinate system. This was achieved by consulting the original bore logs and identifying their locations on a paper map, then transferring the co-ordinates (easting and northing) into the ArcView database with the associated bore number. These details were then matched up with the drill logs in ArcView, to associate each drill log with its geographic location. It should be noted that the identification of the bore on the paper map was a ‘best estimate’ according to the sketch drawn by the original scribe.

5.1.2 Groundwater Elevations

Data for the piezometer readings obtained from DLWC at Leeton required a fair amount of processing. The following are the three major areas of data manipulation carried out.

a) The original piezometer readings required association with work details such as geographic location and completed bore depth. The piezometer readings and work details files were imported into ArcView and association was performed there through joining tables based on bore number.

b) The file format for piezometeric readings was not suitable for the modelling purposes. In certain cases a number of piezometers were nested with up to 5 measurement levels. The
format for the piezometer readings was in vertical columns, with one column comprising dates and one column showing bore numbers and one column for pipe level, rather than one column per month per piezometer. This required a large amount of data manipulation to extract the relevant data into a monthly format by piezometer. The piezometer number was concatenated with the pipe level to give a single column of piezometer number. The data were then run through the ‘PivotTable’ command in Excel to extend the readings into multiple date columns. The individual daily totals were then averaged per month to give a single monthly observation.

c) Groundwater elevations: Where elevation data were present in the work details file and not in the piezometer readings file, and vice versa, these details needed extraction and association with the bore number. Association was conducted in ArcView as previously outlined.

5.1.3 Groundwater Abstractions Data

Groundwater abstraction data obtained from DLWC at Leeton required a large amount of manipulation and processing. Many pieces of information required for the modelling purposes were in different files. These files required amalgamating. The following are the three major areas of data manipulation carried out.

a) License and Property numbers: The pumping data in original format did not contain a joined version of licence number and property number per abstraction volume. These needed to be combined first before any other processing, because various files contained different information, such as either the license numbers or the property numbers. To correlate the abstraction volume of a particular bore with its depth, location, property and subsequently aquifer, this information needed amalgamation. This process was achieved in ArcView by importing, joining tables and then exporting to Excel where further processing could be completed.

b) Cell assignment: Geographic location was assigned in ArcView by joining the amalgamated abstraction files in (a) above, with the respective eastings and northings from a file containing property numbers, license numbers and geographic locations. From the eastings and northings in the output file, the cell co-ordinate system used in MODFLOW could be calculated \((i,j)\).
c) Work details and bore numbers: The original abstraction readings required association with work details such as completed bore depth, and also respective bore number. The abstraction volumes, work details and bore number files were imported into ArcView and association was performed there through joining tables based on bore number.

d) Residuals: Residuals were obtained (refer to Section 5.9 for methodology) to identify the top of each formation, including top of Shepparton (surface), top of lower Shepparton, top of Calivil and top of Renmark. From these depths, aquifer delineation for each abstraction could be made.

e) Aquifer assignment: The individual abstractions were assigned to different aquifers by identifying the bore depth with respect to aquifer top and bottom. Where the bore depth was greater than the top of formation but less than the bottom of formation (or top of aquifer below), the bore was determined as belonging to that aquifer.

5.2 Spatial Discretisation of Aquifer Layers

The structure contour data for top of Calivil, top of Renmark and Bedrock, were obtained in a digital format in Australian Height Datum (AHD) from the Department of Land and Water Conservation (Parramatta, Sydney) in '.dxf' format. To associate the elevation for the top of each formation to the contours, the structure contours were digitised using Surfer software (Golden Software, 1999) from the original dxf files, to give a final file containing easting, northing and elevation data. The data were then interpolated in the Surfer environment using the Kriging method (refer to Section 5.13) to generate an elevation surface for each formation.

The top structural surface was generated by taking the initial point surface level (ISL) from all bores and piezometers with surface level data and the data kriged based on easting, northing and ISL. This layer was subsequently ‘top of Upper Shepparton’. To identify the ‘top of Lower Shepparton’, a uniform depth of 12m was subtracted from the ISL values at each bore and an elevation surface generated. Modifications were later made to the top of the Upper Shepparton layer in instances where the total thickness of the Shepparton formation is less than 12 m. All grids were generated based on a 500m x 500m cell. These grids were used to compute the depth of each formation at each piezometer, to assign piezometers to individual aquifers (refer to Section 5.9 for details).
5.3 Manipulation of Drill Logs

Drill log information was obtained in a digital form for the MIA from two sources, Department of Land and Water Conservation (DLWC) in Leeton and DLWC, Griffith. Data obtained from DLWC Griffith were largely shallow bores, while Leeton data were primarily the drill logs from deep exploration bores. For geographical location of drill logs from each source, refer to Appendix F - Drill Log locations, Section 17.

To increase the density of point soil information in the model, hard copy drill log data was obtained from Murrumbidgee Irrigation for the Mirrool and Yanco Irrigation Areas and entered manually into Excel spreadsheets. Drill logs were selected for digitisation based on their density and location in a 1 km x 1 km grid across the MIA. The number of original drill logs, obtained or entered, in digital form and their source are given in Table 5.1.

Table 5.1: Original Drill log information in digital form, and their respective source.

<table>
<thead>
<tr>
<th>Source</th>
<th>No. of Drill logs</th>
</tr>
</thead>
<tbody>
<tr>
<td>DLWC, Griffith</td>
<td>1436</td>
</tr>
<tr>
<td>DLWC, Leeton</td>
<td>440</td>
</tr>
<tr>
<td>Murrumbidgee Irrigation - Mirrool</td>
<td>680</td>
</tr>
<tr>
<td>Murrumbidgee Irrigation - Yanco</td>
<td>339</td>
</tr>
</tbody>
</table>

After assessment of the data (such as accuracy of location (easting and northing), complete coding of type of material at each depth, accuracy of depth and so on), the completeness of drill logs was reassessed. Final numbers of drill logs used in each subsequent process is illustrated in Table 5.2. The details available for each drill log included bore number, from depth (m), to depth (m), material type, and texture.

Table 5.2: Final number of drill logs used in subsequent database processing, and their respective source.

<table>
<thead>
<tr>
<th>Source</th>
<th>No. of Drill logs</th>
</tr>
</thead>
<tbody>
<tr>
<td>DLWC, Griffith</td>
<td>1424</td>
</tr>
<tr>
<td>DLWC, Leeton</td>
<td>440</td>
</tr>
<tr>
<td>Mirrool</td>
<td>672</td>
</tr>
<tr>
<td>Yanco</td>
<td>273</td>
</tr>
</tbody>
</table>
It is noted that as a result of the different sources of drill logs, different data entry methods have been used by many different workers depending on the objectives of data, therefore, the format for the drill logs from each source was quite different. Due to differences in format it was best to keep different data sources separate from each other. As a result, all subsequent processing was done on separate databases, although each database was maintained in a similar structure for the purpose of assimilation using custom developed FORTRAN programs.

### 5.4 Parameters for deriving hydraulic properties

Table 5.3 outlines the values attributed to each of the major categories of material type. \( K_s, S_y, n, \) \( M_e \) values are after the averages from Punthakey et al (1994). \( \beta_p \) values are derived by dividing 1 by \( M_e \). The derivation of \( S_s \) is depicted in Section 5.7 below.

### 5.5 Soil Types

To obtain a listing of the unique names for each of the material types within each database, FORTRAN programs were developed. These programs were used to extract each unique material coding from each database, for the unique names to be each manually assigned a hydraulic conductivity value. The resulting 2-column file, consisting of unique material types and hydraulic conductivities, was then run through another FORTRAN program for each of the material types at each of the depths to be associated with the hydraulic conductivity. The hydraulic conductivities (\( K_s \)) used for each of the material types is depicted in Table 5.3.

<table>
<thead>
<tr>
<th>Material Type</th>
<th>( K_s ) (m/day)</th>
<th>( S_y )</th>
<th>( n )</th>
<th>( M_e )</th>
<th>( \beta_p ) (m²/N)</th>
<th>( S_s ) (1/m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coal, lignite, wood, peat, charcoal</td>
<td>1.0E-04</td>
<td>0.050</td>
<td>0.160</td>
<td>4.0E+09</td>
<td>2.50E-10</td>
<td>6.8E-06</td>
</tr>
<tr>
<td>Clay, clay shale, marl, bentonite</td>
<td>9.0E-06</td>
<td>0.055</td>
<td>0.480</td>
<td>2.5E+07</td>
<td>4.00E-08</td>
<td>2.1E-04</td>
</tr>
<tr>
<td>Clay silty, clay sandy, kaolinite sandy</td>
<td>4.5E-05</td>
<td>0.100</td>
<td>0.450</td>
<td>5.5E+05</td>
<td>1.82E-06</td>
<td>9.8E-03</td>
</tr>
<tr>
<td>Gravel, cobble, pebble</td>
<td>9.5E+01</td>
<td>0.110</td>
<td>0.250</td>
<td>2.5E+09</td>
<td>4.00E-10</td>
<td>7.7E-06</td>
</tr>
<tr>
<td>Gravel with clay, rubble &amp; clay, pebble shale</td>
<td>1.0E-02</td>
<td>0.055</td>
<td>0.280</td>
<td>2.5E+07</td>
<td>4.00E-08</td>
<td>2.9E-04</td>
</tr>
<tr>
<td>Soil, topsoil, subsoil, humus</td>
<td>1.0E-02</td>
<td>0.210</td>
<td>0.520</td>
<td>1.5E+06</td>
<td>6.67E-07</td>
<td>3.1E-03</td>
</tr>
<tr>
<td>Loam, loamy soil, overburden sandy</td>
<td>3.0E-01</td>
<td>0.110</td>
<td>0.400</td>
<td>5.0E+06</td>
<td>2.00E-07</td>
<td>1.2E-03</td>
</tr>
<tr>
<td>Claystone, mudstone, silstone, mudrock</td>
<td>3.0E-07</td>
<td>0.030</td>
<td>0.200</td>
<td>3.8E+10</td>
<td>2.63E-11</td>
<td>4.9E-06</td>
</tr>
<tr>
<td>Granite, sandstone, ironstone, bedrock, quartz</td>
<td>1.0E-03</td>
<td>0.065</td>
<td>0.180</td>
<td>6.5E+09</td>
<td>1.54E-10</td>
<td>5.9E-06</td>
</tr>
<tr>
<td>Sandstone, limestone, gypsum, tuff, schist soft</td>
<td>3.0E-04</td>
<td>0.130</td>
<td>0.080</td>
<td>7.5E+09</td>
<td>1.33E-10</td>
<td>5.9E-06</td>
</tr>
<tr>
<td>Sand, sand &amp; gravel, wash, drift, quartz</td>
<td>3.2E+00</td>
<td>0.190</td>
<td>0.280</td>
<td>3.0E+09</td>
<td>3.33E-10</td>
<td>7.1E-06</td>
</tr>
<tr>
<td>Sand &amp; clay, silt, wash heavy clay</td>
<td>1.0E-03</td>
<td>0.060</td>
<td>0.480</td>
<td>7.5E+05</td>
<td>1.33E-06</td>
<td>6.8E-03</td>
</tr>
<tr>
<td>Shale, slate, mica, phyllite</td>
<td>4.0E-05</td>
<td>0.055</td>
<td>0.055</td>
<td>4.0E+09</td>
<td>2.50E-10</td>
<td>7.0E-06</td>
</tr>
</tbody>
</table>
5.6 Determination of $K_s$

FORTRAN programs were written to delineate the drill logs into their respective aquifer, and then aggregate the distance between the ‘from’ and ‘to’ depths per material type for Calivil, Renmark, Upper and Lower Shepparton aquifers. The program then multiplied the summed difference for each material type by the assigned hydraulic conductivity for that particular soil types for each of the aquifers represented by the borelog. This gave the transmissivity for that particular material of the each of the aquifers. The total summed $K$-value for each aquifer was then divided by the total summed depth of the aquifer to get the average hydraulic conductivity for that aquifer at that bore. These results were written to an output file with an averaged $K$-value per aquifer per bore.

The general statistics for each of the aquifers is illustrated in Table 5.4. Interpolated surfaces for hydraulic conductivity in each formation are depicted in Appendix B - Hydraulic Conductivity.

<table>
<thead>
<tr>
<th></th>
<th>Upper Shepparton</th>
<th>Lower Shepparton</th>
<th>Calivil</th>
<th>Renmark</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>5.22E-01</td>
<td>1.57E+00</td>
<td>3.60E+00</td>
<td>8.59E+00</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>1.16E+00</td>
<td>4.98E+00</td>
<td>1.05E+01</td>
<td>1.66E+01</td>
</tr>
<tr>
<td>Skewness</td>
<td>1.32E+01</td>
<td>8.84E+00</td>
<td>6.03E+00</td>
<td>2.81E+00</td>
</tr>
<tr>
<td>Range</td>
<td>3.02E+01</td>
<td>6.82E+01</td>
<td>9.50E+01</td>
<td>9.50E+01</td>
</tr>
<tr>
<td>Minimum</td>
<td>9.00E-06</td>
<td>3.78E-06</td>
<td>9.00E-06</td>
<td>9.00E-06</td>
</tr>
<tr>
<td>Maximum</td>
<td>3.02E+01</td>
<td>6.82E+01</td>
<td>9.50E+01</td>
<td>9.50E+01</td>
</tr>
<tr>
<td>Count</td>
<td>2.04E+03</td>
<td>1.02E+03</td>
<td>3.65E+02</td>
<td>1.31E+02</td>
</tr>
</tbody>
</table>

5.7 Determination of $S_s$

The equation for the derivation of specific storage ($S_s$) values for each soil type is illustrated in Equation, and input parameters and final values for $S_s$ in Table 5.3.

To derive specific storage values for each aquifer in the model area, a FORTRAN program was written. For each of the materials in the original input file of drill logs, the specific storage value was assigned to each material type. The individual material depths were multiplied by the
specific storage value for that particular material type for each bore. These lumped values were then divided by the total depth each aquifer for the corresponding bores to derive depth averaged specific storage values for each bore. Statistics of specific storage variation for each aquifer are given Table 5.5. Interpolated surfaces for specific storage throughout the model area for each formation are shown in Appendix C - Specific Storage.

Equation 5.1: Equation for specific storage:

\[ S_s = \rho_w g ((n-1)\beta_p + n\beta_w) \]

Where:

- \( \rho_w = 1000 \text{ kg/m}^3 \), Density or unit mass of water
- \( g = 9.81 \text{ m/sec}^2 \), acceleration due to gravity
- \( n = \) porosity (Refer to Table 5.3)
- \( \beta_p = \) The inverse of the modulus of elasticity (ME, refer to table 1.3), to give vertical compressibility
- \( \beta_w = 4.8 \times 10^{-10} \), bulk compressibility of water

Table 5.5: Statistics for \( S_s \) values for each of the aquifers. Values are in m/day.

<table>
<thead>
<tr>
<th></th>
<th>Upper Shepparton (m^3)</th>
<th>Lower Shepparton (m^3)</th>
<th>Calivil (m^3)</th>
<th>Renmark (m^3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>2.91E-03</td>
<td>1.91E-03</td>
<td>1.66E-03</td>
<td>8.88E-04</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>2.30E-03</td>
<td>2.07E-03</td>
<td>2.11E-03</td>
<td>1.60E-03</td>
</tr>
<tr>
<td>Skewness</td>
<td>7.63E-01</td>
<td>1.57E+00</td>
<td>2.01E+00</td>
<td>2.91E+00</td>
</tr>
<tr>
<td>Range</td>
<td>9.79E-03</td>
<td>9.79E-03</td>
<td>9.79E-03</td>
<td>9.79E-03</td>
</tr>
<tr>
<td>Minimum</td>
<td>5.90E-06</td>
<td>5.90E-06</td>
<td>5.90E-06</td>
<td>5.90E-06</td>
</tr>
<tr>
<td>Maximum</td>
<td>9.80E-03</td>
<td>9.80E-03</td>
<td>9.80E-03</td>
<td>9.80E-03</td>
</tr>
<tr>
<td>Count</td>
<td>2.04E+03</td>
<td>1.02E+03</td>
<td>3.65E+02</td>
<td>1.31E+02</td>
</tr>
</tbody>
</table>

### 5.8 Determination of \( S_y \)

Specific yield values were assigned for only two layers, up to 5m below the surface and then between 5 and 10m below the surface. This segregation is necessary to proper watertable
fluctuations for different depths. For this purpose, a FORTRAN program was developed. The differences in depth for each different soil type contained in borelogs were summed, and then the individual depths multiplied by the specific yield value for the corresponding soil type. These integrated values were then divided by the total depth (i.e. 0 to 5m or 5 to 10m). This gave an averaged specific yield for the 0-5 m and 5-10 m depths. Interpolated surfaces for each formation are illustrated in Appendix D - Specific Yield. Statistics for the specific yield distribution are given in Table 5.6.

Table 5.6: Statistics for $S_y$ values for each of the aquifers. Values are in m/day.

<table>
<thead>
<tr>
<th></th>
<th>$S_y \leq 5m$</th>
<th>$S_y &gt; 5m$ and $\leq 10m$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>8.55E-02</td>
<td>9.30E-02</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>3.44E-02</td>
<td>4.00E-02</td>
</tr>
<tr>
<td>Skewness</td>
<td>1.99E+00</td>
<td>1.14E+00</td>
</tr>
<tr>
<td>Range</td>
<td>1.55E-01</td>
<td>1.55E-01</td>
</tr>
<tr>
<td>Minimum</td>
<td>5.50E-02</td>
<td>5.50E-02</td>
</tr>
<tr>
<td>Maximum</td>
<td>2.10E-01</td>
<td>2.10E-01</td>
</tr>
<tr>
<td>Count</td>
<td>1.99E+03</td>
<td>1.44E+03</td>
</tr>
</tbody>
</table>

5.9 Groundwater Elevations

Piezometer data were obtained for the MIA from Department of Land and Water Conservation (DLWC), Griffith and Leeton. The data collected by DLWC in the Griffith region mainly belong to the Shepparton formation, with only a few observations for the Calivil formation. Leeton piezometric data were primarily for deep bores (in the Calivil and Renmark aquifers), with no readings from the Shepparton formation.

Because piezometer readings are noted as a depth from the ground surface rather than an elevation with reference to AHD, the elevation of the piezometer readings was calculated for each bore. However, not all piezometers had an associated elevation so those data sets without piezometric elevations were discarded. From the elevation of the top of the piezometer, the piezometer reading was subtracted to obtain the corresponding groundwater potential elevation.
To identify which piezometer readings were related to each aquifer, the depth *residuals* for each bore within each formation were obtained. To identify the tops of each formation (Upper Shepparton, Lower Shepparton, Calivil and Renmark) at each piezometer, the *Grid Residuals* function was used in Surfer (1999). This function involved three files; 1) the girded (kriged) tops of formation surfaces, 2) the point $x, y, z$ piezometer data, and 3) an output ASCII file. The input point file required a column with a value of zero attributed to each point, from which the difference between 0 and the girded file value (elevation in metres) could be calculated for each bore. The output file provided the depth of the top of each formation, according to the grid file, at each bore. To identify into which aquifer the piezometer penetrated, the depth of bore was subtracted from the ISL to calculate the elevation of the bore’s depth in AHD. From this delineation, the groundwater elevations for each formation could be interpolated. Initial conditions of the groundwater elevation for the model were taken from September, 1995 readings.

Refer to Section 5.1.2 for details on database processing to obtain elevations, geographic location and bore depth and Appendix E - Groundwater Elevation – Initial Conditions, Section 16 for surface interpolation.

The observation data for inclusion into MODFLOW were chosen for each formation based on a) their even spatial distribution throughout the model area within each formation, and b) their consistent piezometric data across the years 1995-2000 (refer to Appendix G - Well locations, Section 18).

### 5.10 Groundwater Abstractions

The groundwater abstraction data was collected from DLWC, Leeton, for the 1995-1999 period. Once again, a large amount of data manipulation was required for the data to be used in MODFLOW. For information on data processing, refer to Section 5.1.3.

It was assumed that the pumping volume per bore was pumped over a six-month period, rather than the full year. Hence, because the model has a time step of one day, to gain a per day pumping volume, only 182.5 days was used. In addition, the data received was in megalitres (ML), and therefore all pumping volumes needed to be converted into m$^3$/day for input into MODFLOW. The transformation calculation for the pumping data from ML into m$^3$/day is illustrated in Equation.
Equation 5.2: Transformation of pumping data from megalitres (ML) to metres cubed per day.

\[ Q(m^3/day) = Q(ML) \times \frac{1000}{182.5} = Q(ML) \times 5.48 \ m^3/day \]

The grid cells \( i \) and \( j \) values \((x, y)\) per well were calculated in Excel. The volume data for each well in each formation was then inserted into the 106 row x 113 column grids for input into MODFLOW via a FORTRAN program.

5.11 Channel Network

The irrigation and drainage network in the MIA consist of a series of interlinked channels, with the main source of irrigation water from the Murrumbidgee River. There are approximately 795 kilometres of supply and drainage channels in the defined MIA, whilst Mirrool Creek and the Murrumbidgee River cover a distance of the order of 255 kilometres (Fig. 5.2).

The primary water diversions take place at Berembed Weir and Gogeldrie Weir via the Main and Sturt Canals respectively. The factors which affect surface-groundwater interactions are hydraulic conductivity of the bed, depth to groundwater, size of the channel, and circumstantial features of the channel such as age and presence of weeds (Tiwari, 1995). Seepage losses from channels lead to loss of irrigation water for crops and rising water tables, whilst groundwater interception by drains causes saline water to enter the drain.

The Murrumbidgee River and associated irrigation network such as supply channels, creeks and drains were digitised into ArcView as separate themes. A 750×750 ASCII raster grid was generated and each cell given a grid-code with row and column number combined (that is, Grid-code = row×1000 + column, e.g. Gridcode 36072 = row 36, column 72) to enable later assimilation into MODFLOW format through a FORTRAN program.

The grid was overlaid onto the irrigation network. A buffer of 15m was generated around each feature to create a polyshape which was then intersected with the MIA grid to define the area of channel network within each grid. From the calculated area for each cell, the length of channel in each cell was calculated, as well as the conductance of the river (Equation 5.3).

Equation 5.3: Equation used to calculate conductance of river in each cell within the model.

\[ \text{Conductance} = \frac{k \ l \ w}{m} \]

where \( k \) = hydraulic conductivity

\( l \) = length of segment
\( w = \) width of segment

\( m = \) bank to bed height (for derivation of unit gradient \( m = HRIV - RBOT \); refer to Figure 5.1)

From field observations, the head of the channel (HRIV), and river bottom (RBOT) were determined for input into MODFLOW.

![Figure 5.1: Unit Hydraulic Gradient at a River (McDonald and Harbaugh, 1988)]

An estimate of the flow through the Murrumbidgee River was used to ensure that the derived river width was realistic. By use of Chezy’s equation (Equation 5.4 and Darcy’s Law (Equation 5.5), width of Murrumbidgee River was calculated to be 34.625m and 47.85m respectively.

**Equation 5.4: Chezy’s Equation**

\[
Q = A C \left( R S \right)^{1/2}
\]

where

\( Q = \) flow (m³/day)

\( A = \) area of cross-section of channel

\( R = \) hydraulic radius (area/wetted perimeter)

\( S = \) slope

**Equation 5.5: Manning’s Equation**

\[
Q = \frac{1}{n} R^{2/3} S^{1/2} A
\]

where

\( Q = \) flow (m³/day)

\( n = \) Manning value

\( R = \) hydraulic radius
\( S = \text{slope} \)
\( A = \text{area of cross-section of channel} \)

Comparison of flow calculated by multiplying the conductance by the difference between \( h_{\text{riv}} \) – \( h_{\text{aquifer}} \).
Figure 5.2: Channel, drainage, river network for the MIA, with weirs and regulators.
5.12 Spatial Distribution of Groundwater Salinity

Salinity data was acquired from Murrumbidgee Irrigation. Through identification of bore depth, the data was divided into aquifer through similar methods as groundwater elevation data (refer to Section 5.9). Interpolation of salinity contours for the initial conditions (1994) of salinity used in the model are illustrated in Appendix I – Salinity Distribution, Section 20. There were no bores deep enough to extend to the Renmark formation (Table 5.7). Salinity readings were only available for the top three formations of Upper Shepparton, Lower Shepparton and Calivil.

Table 5.7: Total number of piezometers in each formation used in the model for groundwater salinity.

<table>
<thead>
<tr>
<th>Formation</th>
<th>Number of bores 1994</th>
<th>Number of bores 1998</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upper Shepparton</td>
<td>129</td>
<td>213</td>
</tr>
<tr>
<td>Lower Shepparton</td>
<td>130</td>
<td>264</td>
</tr>
<tr>
<td>Calivil</td>
<td>96</td>
<td>101</td>
</tr>
</tbody>
</table>

It should be noted that for each point location there was one reading taken. As there is only one salinity value per cell for the thickness of the entire aquifer at that location, the salinity levels could vary both horizontally and vertically within the formation. This is due to the measurement depth not being consistent across the model area.

5.13 Interpolation

Kriging was chosen as the interpolation method for generation of spatial variation of data due to its ability to pick up trends in the data and reduce ‘bull’s eye’ effects. When creating surfaces from point data, particularly lithological data, it was necessary to pick out trends such as fault lines, rapid changes in elevation and so on. While inverse distance-weighted (IVD) methods have a similar ability to reduce ‘bull’s eye’ effect (refer to Figure 5.3), Kriging was found to be the more accurate method for surface generation from point data (refer to Figure 5.5). This accuracy was paramount when applying the ‘Residuals’ command in Surfer (Golden Software, 1999) to pick up the elevation at each bore, because the surface was more consistent with the input and continuous after Kriging, than was the IVD method.

Nearest neighbour method was not chosen because the nearest neighbour method does not interpolate data, but rather picks up the closest datum point and assigns that value to the grid.
This method is generally used when input data is sampled in a regular format, such as on a regularly spaced grid. In addition, the data were numerical in nature rather than categorical. Both the numerical and irregularly spaced nature of the data meant that interpolation of areas between the data points was necessary, rather than the generation of a categorical surface.

The disadvantage in using an interpolation method as opposed to categorical method such as nearest neighbour, is the lack of preservation of the original data limits. The interpolation techniques use each data point to generate the missing data values, and in doing so apply an averaging or co-variance factor that may increase or decrease the real-world elevation depending on the number and value of the data points. This is demonstrated in Table 5.8, where the nearest neighbour griding function preserves the data limits (minimum = 104, maximum = 183), while the kriging and IVD methods under-represent the true maximum values. This is largely due to the relatively fewer data points that hold the approximate maximum values (such as the area in the hills to the east of Griffith), and the greater number of points that represent the minimum values (the lower flat areas that cover the majority of the model area). Hence, the interpolation method reduces the maximum value for the more hilly areas of the model. As the model is a regional model on a 750m x 750m grid, this factor has not been deemed a major problem.

Table 5.8: Minimum and Maximum values for each griding method.

<table>
<thead>
<tr>
<th>Method</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nearest Neighbour</td>
<td>104</td>
<td>183</td>
</tr>
<tr>
<td>Kriging</td>
<td>104</td>
<td>164</td>
</tr>
<tr>
<td>Inverse Distance-Weighted</td>
<td>104</td>
<td>162</td>
</tr>
</tbody>
</table>
Figure 5.3: Interpolated surface of the initial surface level for the model area, using the inverse distance-weighted method.
Figure 5.4: Interpolated surface of the initial surface level for the model area, using the nearest neighbour method.
Figure 5.5: Interpolated surface of the initial surface level for the model area, using the kriging method.
6 DETAILS OF THE MURRUMBIDGEE GROUNDWATER MODEL

6.1 Model Properties

The model covers an area of 674 ha (Figure 6.1). The geographic boundaries of the model domain are given in UTM co-ordinates in Table 6.1. The spatial domain represented in the model consists of four layers of 106 rows and 113 columns (total of 47912 cells with 750m×750m square for each cell). A stress period length of 30-days was used to enable simulation of irrigation and non-irrigation seasons with a computational time step of one day. Initially the model parameters have been specified for 1995 to 2000 period for calibration purposes. Irrigation periods are specified over a 6-month period, from October through to March. The initial conditions for the model simulation are specified on 1 September, 1995. Figure 6.1 and Figure 6.2 show details about the model, such as columns and rows.

Figure 6.1: Model area showing inactive zones (grey) and drainage network.
About this model:

- Model: c:\murrumbidgee\nodes\new\nia.pm5
- Number of Rows: 106
- Number of Columns: 113
- Number of Layers: 4
- Number of Stress Periods: 60
- Simulation Flow Type: Transient
- Simulation Time Unit: days

Figure 6.2: About the MIA model; the screen from MODFLOW containing information on number of rows, columns, stress period and simulation details.

Table 6.1: Geographic limits for the model in MODFLOW.

<table>
<thead>
<tr>
<th>Easting Minimum</th>
<th>375250</th>
<th>Easting Maximum</th>
<th>460000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Northing Minimum</td>
<td>6150500</td>
<td>Northing Maximum</td>
<td>6230000</td>
</tr>
</tbody>
</table>

Figure 6.3 shows the model details for each aquifer and requirements for transmissivity and leakance.

<table>
<thead>
<tr>
<th>Layer</th>
<th>Type</th>
<th>Anisotropy Factor</th>
<th>Transmissivity</th>
<th>Leakance</th>
</tr>
</thead>
<tbody>
<tr>
<td>1:</td>
<td>Unconfined</td>
<td>1</td>
<td>Calculated</td>
<td>Calculated</td>
</tr>
<tr>
<td>2:</td>
<td>Confined</td>
<td>1</td>
<td>Calculated</td>
<td>Calculated</td>
</tr>
<tr>
<td>3:</td>
<td>Confined</td>
<td>1</td>
<td>Calculated</td>
<td>Calculated</td>
</tr>
<tr>
<td>4:</td>
<td>Confined</td>
<td>1</td>
<td>Calculated</td>
<td>Calculated</td>
</tr>
</tbody>
</table>

Figure 6.3: Layer Options in MODFLOW outlining which aquifers have been classified unconfined and which confined, and transmissivity and leakance requirement.
6.2 Zoning

The area east of the bedrock (Refer to Figure 6.1 was zoned as inactive cells in the model, as it represents the rocky outcrop of the Cocopara National Park.

6.3 Girding Data

The three-column files of easting, northing and z-value were interpolated in MODFLOW using the Field Interpolator. The search method was Octant, with 3 data per sector, and the girding method Shepard’s Inverse Distance with a weighting exponent of 2.

6.4 Vertical and Horizontal Hydraulic Conductivity

The same values were used for horizontal hydraulic conductivity as those calculated for vertical hydraulic conductivity (refer to Table 5.4)

6.5 Formations

In situations where the overall thickness of the Shepparton formation is greater than 12 m a 12 m depth was subtracted from ‘top of Upper Shepparton’ to generate the ‘top of Lower Shepparton’. This gave an elevation for each cell for the top of lower Shepparton, or bottom of upper Shepparton. In other situations the total depth of the Shepparton aquifer was divided into a larger upper aquifer and a 0.25 m minimum thickness for the Lower Shepparton aquifer.

Because MODFLOW requires a value greater than zero for the thickness of each cell, for any value less than 0.25, a value of 0.25 was substituted. Where a layer had an increase in thickness as a result of increasing values less than 0.25, the difference (0.25-original value) was subtracted from the bedrock top of layer, so that the original elevation of the top of the formation was not compromised. The thickness of the new layer was computed and added to the top of the lower layer to obtain the new top of layer, after subtracting the difference from the bottom of the lower formation. The formations were calculated from the bottom up to maintain original elevations. For thickness graphs for each formation, refer to Appendix H - Thickness of each formation in the model., Section 19.
6.6  **Groundwater Abstractions**

Table 6.2 shows the number of wells used per formation. The WELL package was used to represent abstractions in MODFLOW.

<table>
<thead>
<tr>
<th>Formation</th>
<th>Total number of wells</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upper Shepparton</td>
<td>30</td>
</tr>
<tr>
<td>Lower Shepparton</td>
<td>15</td>
</tr>
<tr>
<td>Calivil</td>
<td>19</td>
</tr>
<tr>
<td>Renmark</td>
<td>19</td>
</tr>
</tbody>
</table>

6.7  **Channel Network**

The stage and bed information of the supply network was used to simulate the operation of supply and drainage channels during the irrigation season (between September and March each year). The non-irrigation season for the rest of the year was accounted for by altering the head in the river to a level slightly greater than RBOT, providing minimal flow in channels (i.e. HRIV = RBOT + 0.1). The supply and the drainage network were represented using the RIVER package in MODFLOW.
7 Model Calibration

Model calibration is an iterative process through which model results (e.g., heads) are matched with the historic field-measured values by adjusting aquifer parameters, boundary conditions, and stresses within plausible ranges. This process is complicated by the number of input parameters that can be adjusted, the number of variables available for calibration targets, and the possibility of achieving non-unique model solutions. For multiple-layer models, vertical hydraulic gradients and vertical leakage add additional complexity. Consequently, it is not uncommon to make tens or hundreds of trial-and-error simulations before an acceptable match is achieved. An alternative procedure for model calibration includes use of inverse modelling techniques such as PEST and UCODE.

The first step in model calibration is the identification of the calibration targets. Observed water levels in the Murrumbidgee Irrigation Area (MIA) were used for calibration purpose. The second step consists of determining the acceptable range of errors between simulated and measured calibration targets. These errors, or differences in heads, are referred to as residuals. Residual heads are defined as the observed water levels minus the simulated water levels. As the third step, trial-and-error and inverse simulations are performed until simulated parameters are within the acceptable range of errors. For this study a combination of PEST and UCODE methods were used.

In the MIA model, there are 9905 active cells per model layer. There are 4 layers and the model inputs that could be altered include leakage between layers, storage, hydraulic conductivity and conductance of channels. This equates to a possible 118,860 input variables that can be altered to achieve the calibration target. During model calibration it is desirable to compare the calculated and observed head on original piezometer data rather than interpolated piezometer data because of the uncertainty involved in the interpolation process, however interpolated piezometer data has the advantage of being available in every model cell making it easier to judge the success or failure of every model cell to replicate observation. A set of 202 piezometer hydrographs was selected from the piezometer database for dynamic history matching.
7.1 Calibrated Aquifer Parameters

The calibrated spatial aquifer parameter data sets are shown in Figure 7.1 to Figure 7.12.

7.1.1 Horizontal Hydraulic Conductivity (Kh)

The results of the calibrated model indicate that the horizontal hydraulic conductivity of layer-1 ranges between 0.0025 –14 m/day (Fig.7.1). The twenty five percent of the area of this layer has a $K_h$ less than 0.16 m/day and another 25% has values of $K_h$ greater than 0.55 m/day. The $K_h$ values range between 0.16-0.55 m/day for the remaining 50% of the layer while the spatial average of the horizontal conductivity of the whole formation is 0.45 m/day.

![Figure 7.1: Calibrated Horizontal Hydraulic Conductivity (m/day) for Model Layer 1 (Upper Shepparton)](image)

The horizontal hydraulic conductivity of layer 2 ranges between 0.02–44 m/day (Fig.7.2). The twenty five percent of the area of this layer has $K_h < 0.11$ m/day and another 25% has values of $K_h$ greater than 1 m/day. The remaining 50% of the layer has a $K_h$ range between 0.11-1 m/day and the average horizontal conductivity of the whole formation is 0.7 m/day.
Figure 7.2 Calibrated Horizontal Hydraulic Conductivity (m/day) for Model Layer 2 (Lower Shepparton)

The horizontal hydraulic conductivities of layer 3 range between 0.075–77 m/day (Fig. 7.3). The twenty five percent of the area of this layer has $K_h < 1.7$ m/day and another 25% has $K_h > 7$ m/day. The $K_h$ range of 50% of the layer is 1.7-7 m/day and the average horizontal conductivity of layer 3 is 5.57 m/day.

The calibrated model results show that the horizontal hydraulic conductivities of layer 4 range between 0.4-75 m/day (Fig. 7.4). The value of $K_h$ is less than 7.5 m/day for around 25% area of the formation and values of $K_h$ is greater than 75 m/day for another 25% of the area. The remaining 50% of the layer has $K_h$ values between 7.5-75 m/day and the overall average horizontal conductivity of layer 4 is 13.5 m/day.
Figure 7.3 Calibrated Horizontal Hydraulic Conductivity (m/day) for Model Layer 3 (Calivil)

Figure 7.4 Calibrated Horizontal Hydraulic Conductivity (m/day) for Model Layer 4 (Renmark)
7.1.2 Vertical Hydraulic Conductivity (Kv)

The results of the calibrated model show that the vertical hydraulic conductivity of layer-1 ranges between 2.5E-06 and 1.4E-02 m/day (Fig. 7.5). The values of Kv are less than 1.5E-04 m/day for 25 percent area of the formation and another 25% of the layer has Kv values greater than 5.5E-04 m/day. The Kv values range between 1.5E-04 and 5.5E-04 m/day for the remaining 50% of the layer and the average vertical conductivity of layer-1 is 4.5E-04 m/day.

Figure 7.5 Calibrated Vertical Hydraulic Conductivity (m/day) for Model Layer 1 (Upper Shepparton)

The vertical hydraulic conductivities of the layer 2 are between 6.5E-06 –0.19 m/day (Fig. 7.6). The twenty five percent of the area of this layer has Kv < 1.6E-03 m/day and another 25% area has Kv > 1.5E-02 m/day. The Kv values range between 1.6E-03-1.5E-02 m/day for the remaining 50% of the layer and the average vertical conductivity of layers 2 is 1.0E-2 m/day.

The vertical hydraulic conductivity of the layer 3 ranges between 7.8E-04 -7.8E-01 m/day (Fig. 7.7). The 25% area of this layer has Kv < 1.8E-02 m/day and another 25% area has Kv > 7.1E-02 m/day. The Kv values range between 1.8E-02 and 7.1E-02 m/day for the remaining 50% of the layer and the average vertical conductivity of layer 3 is 5.67E-02 m/day.
Figure 7.6 Calibrated Vertical Hydraulic Conductivity (m/day) for Model Layer 2 (Lower Shepparton)

Figure 7.7 Calibrated Vertical Hydraulic Conductivity (m/day) for Model Layer 3 (Calivil)
The calibrated model results show that the vertical hydraulic conductivity of layer 4 ranges between 4.1E-03-7.5E-01 m/day (Fig. 7.8). The value of $K_v$ is less than 7.5E-02 m/day for 25% area of the formation and another 25% of area has $K_v$ values greater than 1.9E-01 m/day. The remaining 50% area of this layer has $K_v$ values between 7.5E-02 - 1.9E-01 m/day and the average vertical conductivity of layer 4 is 1.36E-01 m/day.

![Figure 7.8 Calibrated Vertical Hydraulic Conductivity (m/day) for Model Layer 4 (Renmark)](image)

### 7.1.3 Specific Storage ($S_s$)

Calibrated specific storage in the first layer of the model ranges between 3.4E-04 m$^{-1}$ – 6.3E-03 m$^{-1}$ (Fig 7.9). The twenty five percent of the area of this layer has $S_s$ values $< 1.9E-03$ m$^{-1}$ and another 25% area has $S_s$ values $>3.2E-03$ m$^{-1}$. The remaining 50% of the area of this layer has $S_s$ range between 1.9E-03 – 3.2E-03 m$^{-1}$ and the average specific storage of the whole formation is 2.6E-03 m$^{-1}$.

The calibrated model results show that the specific storage of layer 2 ranges between 2.5E-04 m$^{-1}$ to 9.2E-03 m$^{-1}$ (Fig.7.10). The twenty five percent of the area of this layer has $S_s < 1.1E-03$ m$^{-1}$ and another 25% area has values of $S_s >2.5E-03$. The remaining 50% of the layer has $S_s$ values range between 1.1E-03 and 2.5E-03 m$^{-1}$ and the average specific storage of the whole formation is 2.0E-03m$^{-1}$. 
Figure 7.9 Calibrated Specific Storage (m⁻¹) for Model Layer 1 (Upper Shepparton)

Figure 7.10 Calibrated Specific Storage (m⁻¹) for Model Layer 2 (Lower Shepparton)
The specific storage of layer 3 ranges between 1.4E-04 and 9.5E-03 m\(^{-1}\) (Fig. 7.11). The twenty five percent of the area of this layer has \(S_s < 1.1E-03\) m\(^{-1}\) and another 25% area has \(S_s > 2.3E-03\) m\(^{-1}\). The remaining 50% of the area of this layer has \(S_s\) range between 1.1E-03 and 2.3E-03 m\(^{-1}\) and the average specific storage of layers 3 is 1.9E-03 m\(^{-1}\).

![Figure 7.11 Calibrated Specific Storage (m\(^{-1}\)) for Model Layer 3 (Calivil)](image)

The model results show that the specific storage of the layer 4 ranges between 1.8E-05 m\(^{-1}\) to 4.5E-03 m\(^{-1}\) (Fig. 7.12). The value of \(S_s\) is less than 4.5E-04 m\(^{-1}\) for around 25% of the area of this formation and values of \(S_s\) is greater than 1.2E-03 m\(^{-1}\) for another 25% of area. The remaining half of the layer has \(S_s\) values between 4.5E-04 - 1.2E-03 m\(^{-1}\) and the overall average specific storage of layers 4 is 8.6E-04 m\(^{-1}\).
7.2 Calibration Results

7.2.1 Matching of Hydrograph History

To measure the performance of the model, calibrated water levels were compared with the observed water levels for 124 observation bores. The historic data for these wells (September-95 to August-00 period) was used for the calibration purposes. The hydraulic conductivity, specific yield, specific storage, vertical leakance and recharge and discharge values were adjusted until reasonable matches were obtained between the observed and simulated water levels for all observed hydrographs.

Two hydrographs for each irrigation district of MIA are discussed in the following section and a full set of calibrated and observed hydrographs is included in Appendix-K.
North Benerembah Region

The model output shows a good agreement between the observed and simulated heads. The overall trend of the observed groundwater hydrograph is closely followed by the modelled data (Figs. 7.13 and 7.14). The hydrograph of piezometer G1073 reflects a water level increase from March 98 to September 99 and a decrease in the groundwater level thereafter.

![Figure 7.13 Calculated and observed Hydrographs for G1073, North Benerembah](image1)

![Figure 7.14 Calculated and observed Hydrographs for G1216, North Benerembah](image2)
Hanwood Region

The results of the calibrated model show that the simulated water levels match well with the observed water levels (Figs. 7.15 and 7.16). The hydrographs of both piezometers (G273 and G381) show a cyclic response which indicates a periodic recharge and discharge during the irrigation and non-irrigation periods.

Figure 7.15 Calculated and observed Hydrographs for G273, Hanwood

Figure 7.16 Calculated and observed Hydrographs for G381, Hanwood
Yenda Region

The Figs. 7.17 and 7.18 show that the model adequately simulated the water levels in this region since close agreement is obtained between the observed and simulated heads in these observation wells and the trend of the observed ground water hydrograph is followed well by the modelled curve. There is a small ground water level decline from March 96 to September 97 and again from March 99 due to less groundwater recharge.

Figure 7.17 Calculated and observed Hydrographs for G1801, Yenda
The outputs of the model show that the model adequately simulated the water levels with a good agreement between the observed and simulated heads in the piezometers and the trend of the actual ground water hydrograph is followed well by the modelled curve (Figs. 7.19 and 7.20). The modelled ground water level is consistently lower than the observed groundwater level at piezometer G2698, due to lower recharge. The hydrograph of both piezometers reflect a small water level decline from 98 till the end of the calibration period, which shows lower recharge to the groundwater.
Figure 7.19 Calculated and observed Hydrographs for G2691, South Benerembah

Figure 7.20 Calculated and observed Hydrographs for G2698, South Benerembah
Kooba Region

The hydrographs show a close agreement between the observed and simulated heads in the piezometers and the overall trend of the observed groundwater hydrograph is followed by the modelled data (Figs. 7.21 and 7.22). The difference between the average of observed and simulated heads is less than 0.5 m, which indicates a close agreement between observed and simulated water elevations. The hydrograph of piezometer L1666 reflects an overall decline in the groundwater level.

Figure 7.21 Calculated and observed Hydrographs for G1338, Kooba
The results of the calibrated model show that the simulated water levels match the observed water levels both ‘qualitatively’ and ‘quantitatively’ (Figs. 7.23 and 7.24). The average error between the observed and modelled heads for both piezometers L1890 and L2447D is less than 1 m. The seasonal water level fluctuations in this area are small, which shows the limited outflow capacity of the aquifer.

**Murrami Region**

![Figure 7.22 Calculated and observed Hydrographs for L1666, Kooba](image-url)
Figure 7.23 Calculated and observed Hydrographs for L1890, Murrami

Figure 7.24 Calculated and observed Hydrographs for L2047D, Murrami
Gogeldrie Region

Figs. 7.25 and 7.26 show that the model adequately simulated the water levels in this region since a close agreement was obtained between the observed and simulated heads in these observation wells and the trend of the observed ground water hydrograph is followed closely by the modelled curve. Both hydrographs reflect an overall decline in the groundwater level, which is due to an increase in the groundwater abstraction and a decrease in the recharge.

![Figure 7.25 Calculated and observed Hydrographs for L1854s, Gogeldrie](image)
To further assess the performance of the model, spatial assessment of the “goodness” of fit between modelled and measured groundwater level contour plans is performed by comparing the modeled contours with the interpolated measured groundwater levels. Water level contours for different stress periods (September 1995-August 2000) are included in Appendix-L which show that the model replicates groundwater contours in the whole MIA very well particularly for the shallow layers (upper and lower Shepparton). There is a bit discrepancy in the deeper layers due to lack of piezometric data for these layers. A contour plan for the 49th stress period (September 1999) shows that calibrated model adequately predicted spatial distribution of water levels (Fig. 7.27). Since the model reproduces the interpreted direction of the groundwater flow and closely approximated water levels in most of the study area and there was no systematic over- or under-prediction of heads in most parts of the modeled area.
7.2.3 Statistical Performance Indicators

Using Australian Groundwater Modelling Guidelines quantitative calibration performance was assessed using statistics of piezometric head residuals (the difference between measured and modelled heads) in Table 7.1. It is not possible to draw absolute quantitative comparisons in regard to groundwater level contours, because contours are the result of interpolations between data points, and are therefore subjective, at least in part (subjective choices are made even when selecting parameters or methods of generating contours through software packages). Quantitative measures of the average error of the model are reported in Table 7.1.

However, these performance indicators provide lumped measures of calibration that do not indicate the spatial or temporal distribution of the error. In addition to these measures, it is important to show that there is no systematic error involved in the spatial distribution of differences between modelled and measured heads. The simplest way to do this is to present a scatter diagram. A Scattergram plot is produced with measured heads on the horizontal axis, and modelled heads on the vertical axis, with one point plotted for each pair of data at selected monitoring sites (Fig. 7.28). All the points occurred with a small degree of scatter about the line of perfect fit (a 45° line through the origin representing an unattainable perfect calibration). It is
also important that the plotted points in any area of the scattergram are not grouped consistently above or below the 45° line in any segment of the plot, as this indicates a consistent over- or under-prediction, and a likely fundamental flaw in the calibration. It can be clearly seen from the figure that there is no area of the scattergram where the points are grouped consistently above or below the 45° line in any segment of the plot. The coefficient of determination ($R^2$) is also calculated as 0.99, which indicates a very high degree of correspondence between the modelled and interpolated observations.

Figure 7.28 Scattergram of measured versus modelled heads
Table 7.1 Statistical Calibration Performance Measures (Middlemis, 2001)

<table>
<thead>
<tr>
<th>Description</th>
<th>Equation</th>
<th>Comments</th>
<th>Model Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sum of Residuals (SR)</td>
<td>( \sum_{i=1}^{n} Wi</td>
<td>hi - Hi</td>
<td>) [m]</td>
</tr>
<tr>
<td>Mean sum of Residuals</td>
<td>( \frac{SR}{n} )</td>
<td>Independent of sample size, but depends on the range in the measured values</td>
<td>0.56</td>
</tr>
<tr>
<td>Scaled Mean Sum of Residuals (SMSR)</td>
<td>( \frac{100 \cdot MRS}{\Delta H} = \frac{100 \cdot SR}{n \cdot \Delta H} ) [%]</td>
<td>SMSR is an intuitive relative measure which is independent of sample size and independent of the measurement range. 1.41</td>
<td></td>
</tr>
<tr>
<td>Sum of Squares (SSQ)</td>
<td>( \sum_{i=1}^{n} [Wi(hi - Hi)]^2 ) [m²]</td>
<td>The unit [m²] indicate that this is not an intuitive measure of performance. Depends on the sample size. 1416</td>
<td></td>
</tr>
<tr>
<td>Mean Sum of Squares</td>
<td>( \frac{SSQ}{n} )</td>
<td>Not an intuitive measure of performance but it is independent of the sample size</td>
<td>0.53</td>
</tr>
<tr>
<td>Root Mean Square</td>
<td>( RMS = \sqrt{\frac{SSQ}{n}} = \sqrt{\frac{\sum_{i=1}^{n} [Wi(hi - Hi)]^2}{n}} ) [m]</td>
<td>An absolute measure that is problem-dependent (i.e. its value is affected by the range in the measured values). It is usually thought to be the best error measure if errors are normally distributed. 0.75</td>
<td></td>
</tr>
<tr>
<td>Root Mean Fraction Square (RMFS)</td>
<td>( \frac{100 \cdot \frac{\sum_{i=1}^{n} [Wi(hi - Hi)]^2}{\Delta H} \cdot Wi}{Hi} ) [%]</td>
<td>This measure is affected by magnitude of Hi, which is determined by the datum. Model boundary conditions may constrain hi. An improved performance can be contrived by changing the datum to increase Hi. 0.60</td>
<td></td>
</tr>
<tr>
<td>Scaled RMFS (SRMFS)</td>
<td>( SRMFS = \frac{RMFS}{\Delta H} ) [%]</td>
<td>( \Delta H ) = mean of measured head values, which have a range of ( \Delta H ). 1.91</td>
<td></td>
</tr>
<tr>
<td>Scaled RMS (SRMS)</td>
<td>( SRMS = \frac{100 \cdot RMS}{\Delta H} ) [%]</td>
<td>SRMS and SRMFS should both be low (say less than 5% or some other agreed value), indicating that the ratio of error to total head differential is small. And hence errors are only a small part of the overall model response. 1.90</td>
<td></td>
</tr>
<tr>
<td>Coefficient of Determination (CD)</td>
<td>( \frac{\sum_{i=1}^{n} [Wi(Hi - \bar{H})]^2}{\sum_{i=1}^{n} [Wi(hi - \bar{H})]^2} ) []</td>
<td>CD tends to one for perfect calibration.</td>
<td>0.99</td>
</tr>
</tbody>
</table>
The statistics shown in Table 7.1 are all based on head residuals. A systematic error in elevations will bias all of the statistics. There are cases, however, when a simulated hydrograph might agree very well with a measured hydrograph in pattern and amplitude, but differ in absolute magnitude, so that the two curves run parallel to each other. Head-based statistics will suggest a poor calibration, when in fact the calibration might be very good. Legitimate elevation residuals can result from model discretisation and interpolation of the locations of measured and simulated sites, so that the real sites and model nodes are not at exactly the same place. To account for this effect, another technique used is the standard correlation function \( r \) between two time series (Zheng and Bennett, 1995):

\[
    r = \frac{\sum_{i=1}^{n} (H_i - \bar{H})(h_i - \bar{h})}{\sqrt{\sum_{i=1}^{n} (H_i - \bar{H})^2} \sqrt{\sum_{i=1}^{n} (h_i - \bar{h})^2}}
\]

where \( \bar{h} \) and \( \bar{H} \) are the means of the modelled and measured heads respectively.

The standard correlation function \( r \) between two time series is calculated as 0.99, which is approaching to unity, and is an indication for a good calibration.

### 7.3 Sensitivity Analysis

Sensitivity analysis was carried for aquifer properties \( K_h \), \( K_v \), \( S_y \) and \( S_s \). Results of the sensitivity analysis for shallow groundwater (first layer of the model) and deep groundwater (third layer of the model) are given in Table 7.2. The sensitivity analysis shows a slight increase in both shallow and deep groundwater levels if the horizontal hydraulic conductivity is decreased and vice versa. While the decrease in \( S_y \) of shallow formation and \( S_s \) of deep formation results in a decrease in hydraulic heads or vice versa. The model is least sensitive to vertical hydraulic conductivity.
<table>
<thead>
<tr>
<th>Factor</th>
<th>Spatial Groundwater Level in US(m)</th>
<th>Spatial Groundwater Level in CL(m)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Min</td>
<td>25% tile</td>
</tr>
<tr>
<td></td>
<td>1.75</td>
<td>101.73</td>
</tr>
<tr>
<td></td>
<td>1.5</td>
<td>101.72</td>
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<tr>
<td></td>
<td>1.25</td>
<td>101.71</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>101.70</td>
</tr>
<tr>
<td>0.75</td>
<td>101.70</td>
<td>115.33</td>
</tr>
<tr>
<td>0.5</td>
<td>101.69</td>
<td>115.34</td>
</tr>
<tr>
<td>0.25</td>
<td>101.68</td>
<td>115.34</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Factor</th>
<th>Spatial Groundwater Level in US(m)</th>
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<tr>
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<td></td>
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<tr>
<td></td>
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<td>101.70</td>
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<tr>
<td></td>
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<td>101.70</td>
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<tr>
<td>0.5</td>
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</tr>
<tr>
<td>0.25</td>
<td>101.70</td>
<td>115.33</td>
</tr>
</tbody>
</table>

### 7.4 Water Balance

One of the methods of expressing model results is through a water balance. Water Balance data provide both an indication of the relative magnitude of flow components within the study area, as well as a means to check that the model solution has remained stable. If there is an error in the iterative solution then it is likely to show up in the water balance. For that reason it is important to check that the model change in aquifer storage is equivalent to the total inflow-outflow.

External stresses such as wells, areal recharge, evaporation, drains and streams are simulated to calculate the water budget of each irrigation district of MIA and the average values in ML/season are presented for the whole calibration period. Water balance diagrams of all 7 districts for the calibration period (September 1995-August 2000) are included in Appendix-M. In the water balance diagrams storage changes are referred as $\Delta S$ with plus or minus sign. A minus sign refers to the water released from a storage of the layer and plus sign refers to the water added to the storage of the layer. Figure 7.29 and 7.30 show the water balance results of
the whole MIA during irrigation and non-irrigation periods between September 1995 and August 2000. The water balance results for the MIA have shown discrepancies of less than 0.01%, which is generally considered an acceptable error.

Figure 7.29 Water Budget (GL) of the whole MIA for Irrigation Periods: 1995-2000
Figure 7.30 Water Budget (GL) of the whole MIA for Non-Irrigation Periods: 1995-2000
8 SCENARIO ANALYSIS

Using the existing groundwater conditions at September, 2000 as "initial conditions" a number of future scenarios were studied to simulate the future dynamic response of aquifers under the MIA. The regional groundwater model was used to simulate the hydrodynamics of groundwater flow up to the year 2025 under six scenarios described below:

- Scenario-1 Dry Conditions (similar to 2001-02) continued for the next 25 years
- Scenario-2 Relatively Wet Conditions (similar to 1992-93) continued for the next 25 years
- Scenario-3 50% Reduction in Rice Area
- Scenario-4 75% Reduction in Rice Area
- Scenario-5 50% Reduction in Seepage from Channels
- Scenario-6 Piping of all channels in the MIA

The outputs of the groundwater flow model were used with the solute transport model to study the possible changes in the groundwater salinity over the same period. Detailed results of these scenarios are given in Appendix-N.

The relatively dry or wetness of different years can be assessed from Table-8.1 and Figure-8.1

<table>
<thead>
<tr>
<th>Year</th>
<th>Winter Rainfall (mm)</th>
<th>Summer Rainfall (mm)</th>
<th>Irrigation (mm)</th>
<th>Rain + Irrigation Summer (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1998/99</td>
<td>166</td>
<td>245</td>
<td>526</td>
<td>771</td>
</tr>
<tr>
<td>1999/00</td>
<td>261</td>
<td>348</td>
<td>413</td>
<td>761</td>
</tr>
<tr>
<td>2000/01</td>
<td>259</td>
<td>238</td>
<td>547</td>
<td>785</td>
</tr>
<tr>
<td>2001/02</td>
<td>165</td>
<td>164</td>
<td>586</td>
<td>750</td>
</tr>
<tr>
<td>1992/1993</td>
<td>179</td>
<td>398</td>
<td>437</td>
<td>835</td>
</tr>
</tbody>
</table>
In this section spatial changes in piezometric levels and groundwater salinity are discussed.

**Scenario-1 Dry Conditions (similar to 2001-02) continue for the next 25 years**

During 2001/02 irrigation water deliveries were 917,000 ML, summer rainfall was 164 mm and winter rainfall was 165 mm. For this scenario the total recharge computed using the calibrated model was assumed for the next 25 years. According to this scenario the groundwater levels will be in equilibrium after a fall of around 1 m under most of the areas. In some areas groundwater levels will rise by around 1 m e.g. under the north-west of Murrami, some parts of Yenda and South Benerembah. The higher groundwater level changes are likely to be in the north-east of Yenda (2-5 m). However the scenario results in the north-east of Yenda are less reliable due to a lack of piezometric data in this region.

Under dry climate and lower water availability scenario the groundwater salinity varies by less than 1000 µs/cm. The greatest groundwater salinity increases are predicted in the western part of Murrami, Yenda and in the north and south Benerembah.
Figure 8.2 Shepparton Groundwater Level Changes from 2000 to 2025 under Scenario-1 Dry Conditions

Figure 8.3 Shepparton Groundwater Salinity Changes from 2000 to 2025 under Scenario-1 Dry Conditions
**Scenario-2 Relatively Wet Rainfall Conditions (similar to 1992-93) continue for next 25 years**

During 1992/93 irrigation allocation was 685,000 ML, summer rainfall was 398 mm and winter rainfall was 179 mm. For this scenario the total recharge computed using the calibrated model was assumed for next 25 years. According to this scenario the groundwater levels will be in equilibrium after a fall of around 1 m under most of the areas. In some areas groundwater levels will rise by around 1 m e.g. under the north-west of Murrmi, some parts of Yenda and South Benerembah (Figure 8.4). The greatest groundwater level changes are likely to be in the north-east of Yenda (2-5 m). The scenario results in the north-east of Yenda are less reliable due to a lack of piezometric data in this region.

Under this scenario groundwater salinity levels will rise by more than 1000 µs/cm in the western part of Murrmi, Yenda and in the north and south Benerembah (Figure 8.9).

*Figure 8.4 Shepparton Groundwater Level Changes from 2000 to 2025 under Scenario-2 Wet Conditions*
According to these scenarios there will be a net decline in groundwater levels (hydrographs in Appendix-N) during the first couple of years and then a new quasi equilibrium will be established. In most of the areas the groundwater levels will decline by around 1 m (Figures 8.6 and 8.8).

Under these scenarios the groundwater salinity levels will rise by more than 1000 µS/cm in the western part of Murrami, Yenda and in the north and south Benerembah (Figures 8.7 and 8.9).
Figure 8.6 Shepparton Groundwater Level Changes from 2000 to 2025 under Scenario-3 50% Reduction in Rice Area

Figure 8.7 Shepparton Groundwater Salinity Changes from 2000 to 2025 under Scenario-3 50% Reduction in Rice Area
Figure 8.8 Shepparton Groundwater Level Changes from 2000 to 2025 under Scenario-4 75% Reduction in Rice Area

Figure 8.9 Shepparton Groundwater Salinity Changes from 2000 to 2025 under Scenario-4 75% Reduction in Rice Area
Scenario-5 and 6 Partial and full reduction of seepage losses from channels using irrigation and rainfall recharge of 2001/2002

For these scenarios the major change in groundwater levels occur in the Murrami and Gogeldrie areas. and the total recharge computed using the calibrated model was assumed for next 25 years (Figure 8.10 and 8.12). According to this scenario the groundwater levels will be in equilibrium after a fall of around 1 m under most of the areas.

Under this scenario the groundwater salinity levels will rise by more around 1000 µs/cm in the Murrami and Gogeldrie areas due to reduction of fresh quality recharge due to lesser/no seepage from channels.

![Figure 8.10 Shepparton Groundwater Level Changes from 2000 to 2025 under Scenario-5 Partial Reduction of Seepage Losses from Channels](image)
Figure 8.11 Shepparton Groundwater Salinity Changes from 2000 to 2025 under Scenario-5 Partial Reduction of Seepage Losses from Channels

Figure 8.12 Shepparton Groundwater Level Changes from 2000 to 2025 under Scenario-6 Full Reduction of Seepage Losses from Channels
Figure 8.13 Shepparton Groundwater Salinity Changes from 2000 to 2025 under Scenario-6 Full Reduction of Seepage Losses from Channels
9 GROUNDWATER TRENDS ON A REGIONAL BASIS

This report has provided insights into the groundwater dynamics, balance and salinity response of the aquifer systems underlying the MIA. Using modeling results and data from the detailed monitoring network (Figure 8.14), the following management options are described on an irrigation subregion basis.

Figure 9.1 Detailed piezometric monitoring network for the MIA

The discussion presented in this section is also aided by groundwater outflow rates calculated from recent water table fluctuations using a specific yield of 3 percent and fallow evaporation rates at different watertable depths. The rate of groundwater outflow was determined by equation 9.1.

\[
dQ = Sy \left( \frac{dh}{dt} \right) - \text{Evaporation rate} \quad (9.1)
\]
Where \( Sy \) = specific yield

\[
dh = \text{change in watertable depth}
\]

\[
dt = \text{time period (Complete spreadsheet calculations are shown in Table 9.1)}
\]

Table 9.1 Spreadsheet calculations for groundwater outflow at data logged piezometers. Outflow is shown in yellow (ML/ha/6 months). Values in bold indicate water table depths of less than 1.70m and hence require an evaporation rate to be subtracted from the groundwater outflow rate.

<table>
<thead>
<tr>
<th>PIEZO NO.</th>
<th>Date1</th>
<th>dt1</th>
<th>dh1</th>
<th>Date2</th>
<th>dt2</th>
<th>dh2</th>
<th>dh</th>
<th>dt</th>
<th>dh/dt</th>
<th>Sy(dh/dt)</th>
<th>ML/ha/day</th>
<th>ML/ha/6months</th>
</tr>
</thead>
<tbody>
<tr>
<td>1160</td>
<td>Sep-00</td>
<td>36770</td>
<td>4.2</td>
<td>Mar-01</td>
<td>36951</td>
<td>2.78</td>
<td>1.42</td>
<td>181</td>
<td>0.00785</td>
<td>0.00024</td>
<td>0.00235</td>
<td>0.43</td>
</tr>
<tr>
<td>3119</td>
<td>Mar-99</td>
<td>36220</td>
<td>1.6</td>
<td>Sep-99</td>
<td>36404</td>
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<td>0.82</td>
<td>184</td>
<td>0.00446</td>
<td>0.00013</td>
<td>0.00134</td>
<td>0.24</td>
</tr>
<tr>
<td>1073</td>
<td>Mar-99</td>
<td>36220</td>
<td>1.15</td>
<td>Sep-99</td>
<td>36404</td>
<td>0.20</td>
<td>0.95</td>
<td>184</td>
<td>0.00516</td>
<td>0.00015</td>
<td>0.00155</td>
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<tr>
<td>3174</td>
<td>Sep-99</td>
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<td>0.5</td>
<td>Mar-00</td>
<td>36586</td>
<td>0.06</td>
<td>0.44</td>
<td>182</td>
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<td>0.00007</td>
<td>0.00073</td>
<td>0.13</td>
</tr>
<tr>
<td>2026</td>
<td>Sep-01</td>
<td>37135</td>
<td>7.3</td>
<td>Mar-02</td>
<td>37316</td>
<td>4.24</td>
<td>3.06</td>
<td>181</td>
<td>0.01691</td>
<td>0.00051</td>
<td>0.00507</td>
<td>0.93</td>
</tr>
<tr>
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<td>1.76</td>
<td>Mar-01</td>
<td>36951</td>
<td>0.81</td>
<td>0.95</td>
<td>181</td>
<td>0.00525</td>
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| 1602      | Sep-00| 36770 | 4.38| Mar-01| 36951 | 4.00 | 0.38 | 181 | 0.00210 | 0.00006 | 0.00063 | 0.11     

Evaporation rates were estimated from a capillary rise model (van der Lely, 2002) for a Riverina non-self mulching clay (NSMC) soil type (Figure 9.2). As the capillary rise model was designed for fluctuations of the water table at a depth below a crop, a factor of 0.5 metres was added to the water table depth below root zone value (x axis). For example, a 0.4 metre depth below root zone was now equal to 0.9 metre depth below surface. That is, 0.5 metres compensates for the root zone depth.
Water table depths greater than 1.7 metres (1.2 metres in capillary rise model curve) were not subjected to evaporation factors as they were considered too far beneath the soil surface.

The resulting groundwater outflow rates are given in Figure-9.3.

Figure 9.2 Capillary rise curves adopted for some Riverina Plains Soils (van der Lely, 2002)
Figure 9.3 Groundwater outflow rates for data logged piezometers in the MIA. Values shown are in ML/ha/6 months. Two points without values shown in Yenda zone (purple) were recently installed piezometers and have no historical data.

North Benerembah Region

Figure 9.4 shows the location of piezometers in the North Benerembah region. The groundwater levels (Figures 9.5 and 9.7) in south west corner of North Benerembah are declining due to the impact of groundwater pumping further south of this area. The groundwater outflow rates are higher at the edge of the area as compared with the areas close to the Barren Box swamp. Areas close to the Barren Box swamp need to be managed within the groundwater outflow capacity by reducing net recharge to 0.15 to 0.35 ML/ha during the irrigation season.
Figure 9.4 Location of Piezometers in the North Benerembah

Figure 9.5 Groundwater Response at Piezometer G2026
Figure 9.6 Groundwater Response at Piezometer G3174

Figure 9.7 Groundwater Response at Piezometer G1073
Hanwood Region

Figure 9.8 shows the location of piezometers in Hanwood region. The groundwater levels are declining due to dry climate conditions and the impact of groundwater pumping in the Murrumbidgee catchment. The groundwater outflow rates are around 0.15 to 0.2 ML/ha/6 months. In terms of long term scenarios groundwater levels can rise in the south-west of this area and therefore on farm recharge should be reduced in this part of the area.

Figure 9.8 Piezometric Locations in the Handwood Area
Figure 9.9 Groundwater Response at Piezometer G381

Figure 9.10 Groundwater Response at Piezometer G1579
Figure 9.11 Groundwater Response at Piezometer G273
Yenda Region

Figure 9.12 shows the location of piezometers in the Yenda region. The groundwater levels in general fluctuate within 3 m from the ground surface (Figures 9.13 to 9.17). These piezometers are very responsive to rainfall and local recharge events. Due to the landlocked nature of local hydrogeology there is a risk of groundwater rise to the ground surface and soil salinisation if drainage of this region is not continued and monitored on a regular basis.

Figure 9.12 Piezometer Locations in the Yenda Area
Figure 9.13 Groundwater Response at Piezometer G327

Figure 9.14 Groundwater Response at Piezometer G1801
Figure 9.15 Groundwater Response at Piezometer G2452

Figure 9.16 Groundwater Response at Piezometer on Raccanello Road
Figure 9.17 Groundwater Response at Piezometer on Gribble Road
South Benerembah Region

Figure 9.18 shows the location of piezometers in the South Benerembah region. The groundwater levels are continuously declining (Figures 9.19 to 9.22). The overall gradual declining trends indicate an impact of groundwater pumping in the area. The longer term scenarios show a bit rise in the north of the area which can be controlled through better land and water management within South and North Benerembah area.
Figure 9.19 Groundwater Response at Piezometer G2062

Figure 9.20 Groundwater Response at Piezometer G2341
Figure 9.21 Groundwater Response at Piezometer G2190

Figure 9.22 Groundwater Response at Piezometer G1602
Kooba Region

Figure 9.23 shows the location of piezometers in the Kooba region. The groundwater levels in the south-west of the area are continuously declining (Figures 9.24 to 9.25) however the groundwater levels are fluctuating within 3 m in the north of the region (Figures 9.26 to 9.28). The northern part of this area needs to be carefully managed by keeping irrigation and rainfall recharge within the groundwater outflow capacity i.e. around 0.15 ML/ha/six months.
Figure 9.24 Groundwater Response at Piezometer L1535S

Figure 9.25 Groundwater Response at Piezometer L1326S
Figure 9.26 Groundwater Response at Piezometer G2128

Figure 9.27 Groundwater Response at Piezometer G1338
Figure 9.28 Groundwater Response at Piezometer L2139S
Murrami Region

Figure 9.29 shows the location of piezometers in the Murrami region. The groundwater levels in this area fluctuate within 3 metres from the groundsurface (Figures 9.30 to 9.33) indicating lower groundwater outflow capacity of the underlying aquifers. The scenario analysis has shown that the western part of this area has a possibility of groundwater and salinity rise in the future. The channel seepage in this region should be controlled on a priority basis. The irrigation and rainfall recharge needs to be reduced to less than 0.10 ML/ha/six months.

Figure 9.29 Piezometer Locations in the Murrami Area
Figure 9.30 Groundwater Response at Piezometer L2453

Figure 9.31 Groundwater Response at Piezometer L1808
Figure 9.32 Groundwater Response at Piezometer L1732S

Figure 9.33 Groundwater Response at Piezometer L2347S
Gogeldrie Region

Figure 9.34 shows the location of piezometers in the Gogeldrie area. The groundwater levels in this area are showing a gradual decline in the southern part of this area (Figures 9.37 and 9.38) due to deeper groundwater pumping in the region. The groundwater levels are relatively static or showing a lower rate of decline in the northern part of this area. The scenario analysis has shown that this area can show further decline in watertables if channel seepage is reduced.
Figure 9.35 Groundwater Response at Piezometer L1870S

Figure 9.36 Groundwater Response at Piezometer L2657
Figure 9.37 Groundwater Response at Piezometer L2280

Figure 9.38 Groundwater Response at Piezometer L2762
10 SUMMARY AND FUTURE DIRECTIONS

The following are summarised from the development of the MIA groundwater model:

- Detailed piezometric data and numerical model results have shown overall decline in the groundwater levels in the region. This decline is attributed to improved land and water management practices as well as a relatively dry climate over the last decade.

- Some areas within the MIA e.g. Yenda, Murrumai and some parts of the Kooba and Benerembah areas have very limited groundwater outflow capacities. These areas are at greater risk of shallow watertable and soil salinity problems if irrigation and winter cropping efficiency is not managed within the regional groundwater flow capacity.

- The existing data sets for the MIA are in a range of formats ranging from hardcopy tables and maps to Excel Spreadsheets. There is a need to bring together all this information in a GIS database by georeferencing and digitisation of the data. A significant amount of this work has been done in the present study.

- A tremendous amount of bore log data is now available in a digital format for the MIA area. More than 2000 borelogs were used to construct the aquifer lithology information for the MIA model.

- The piezometric level information is not continuous due to a number of piezometers being abandoned with the privatisation of irrigation companies. There is a need to critically reassess the active measuring points and select a critical monitoring network for assessing the climatic and management impacts on shallow watertables.

- The calibration of model response against the historic piezometric data was tested against Australian modeling standards.

- This model has been calibrated and used to simulate possible management scenarios. As with any model there is a need to keep this model updated and use it with other tools such as SWAGMAN Farm to convey complex modeling results and help determine sustainable irrigation levels on a farm by farm basis.
- The model is ready to formulate different land and water management options and to help determine on farm actions required to meet regional targets.
11 REFERENCES


12 Appendix A - Structure Contours
Figure A-1: Cross Section of Formations in the MIA at Easting 375625.

Figure A-2: Cross Section of Formations in the MIA at Easting 420625.
Figure A-3: Cross Section of Formations in MIA at Northing 6156875.

Figure A-4: Cross Section of Formations in the MIA at Northing 6184625.
Figure A-5: Cross Section of Formations in the MIA at Northing 6201875.
13 APPENDIX B - HYDRAULIC CONDUCTIVITY

For presentation purposes, the following graphs have been produced in ArcView using the Inverse Distance Weighted interpolation method, similar to the Inverse Distance Weighted method used in MODFLOW for each of the layers.
Figure B-1: Interpolated surface for Hydraulic Conductivity in the Upper Shepparton formation (m/day).
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Figure B-2 Interpolated surface for hydraulic conductivity in Lower Shepparton formation (m/day).
Figure B-3 Interpolated surface for hydraulic conductivity in Calivil formation (m/day).
Figure B-4 Interpolated surface for hydraulic conductivity in Renmark formation (m/day).
14 Appendix C - Specific Storage
Figure C-1: Interpolated surface for specific storage in Upper Shepparton formation (m⁻¹).
Figure C-2  Interpolated surface for specific storage in Lower Shepparton formation (m$^{-1}$).
Figure C-3  Interpolated surface for specific storage in the Calivil formation (m$^3$).
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Figure C-4 Interpolated surface for specific storage for Renmark formation in the MIA (m$^{-3}$).
15 APPENDIX D - SPECIFIC YIELD
Figure D-1  Specific Yield for the top 5m below surface in the MIA.
Figure D-2  Specific yield for 5 to 10m below the surface in the MIA.
16 APPENDIX E - GROUNDWATER ELEVATION – INITIAL CONDITIONS
Figure E-1  Groundwater Elevation (m) for Upper Shepparton for the initial conditions as at September, 1995.
Figure E-2  Groundwater Elevation (m) for Lower Shepparton for the initial conditions as at September, 1995.
Figure E-3  Groundwater Elevation (m) for Calivil for the initial conditions as at September, 1995.
Figure E-4  Groundwater Elevation (m) for Renmark for the initial conditions as at September, 1995.
17 APPENDIX F - DRILL LOG LOCATIONS
Figure F-1 The source of the drill logs used in the model, and the source.
18 Appendix G - Well Locations
Figure G-1  Location of the observation and abstraction wells used in the model.
19 Appendix H - Thickness of each formation in the model.
Figure H-1 Thickness of the Upper Shepparton Formation in the model area.

Figure H-2 Thickness of the Lower Shepparton Formation in the model area.
Figure H-3  Thickness of the Calivil Formation in the model area.

Figure H-4  Thickness of the Renmark Formation in the model area.
20 Appendix I — Salinity Distribution
Figure I-1: Spatial distribution of salinity in the Upper Shepparton formation, initial conditions.
Figure I-2 Spatial distribution of salinity in the Lower Shepparton formation, initial conditions.
21 Appendix J - Fortran Programs
21.1 **Scripts for assigning the Hydraulic conductivity values to each soil type. Four different programs for the four different databases.**

Key to databases

- Ary = DLWC, Griffith database
- Liz = DLWC, Leeton database
- Mirrool = Mirrool database
- Yanco = Yanco database

### 21.1.1 **ARYKNESTED.FOR**

```fortran
program AryKnested
    ! To define ARRAYS
    Real, dimension(10703) :: fd, td, dcl, drn, dsf,
    x KI, Kj, ddpls, ddpus, tdp, dtcp, dtrp, dtc, dtr, dts, ddp, dclp
    Real, dimension(1425) :: sddcl, sddrn, sddus, sddls, sddis, strat, strn,
    X strus, strls
    Real, dimension(1425) :: KCL, KRN, KLS, KUS
    Integer, dimension(10703) :: iestb, inthb
    Integer, dimension(10703) :: iest, inth
    Character*12, dimension(10703) :: bore
    Character*12, dimension(1425) :: boreb
    Character*10, dimension(10703) :: cdi, cdj, cdp
    Character*22, dimension(10703) :: des
    Character*12 borep

    open (4, file='d1-9999.prn')
    open (5, file='d1-Kcodes.prn')
    open (8, file='d1-Trans.prn', status='replace')
    open (9, file='d1-SUM.prn', status='replace')
    open (10, file='d1-negs.prn', status='replace')

    write(8,78)
```
Groundwater Model of the Murrumbidgee Irrigation Area

78 format('bore(i)',8x,'iestb(i)',2x,'inthb(i)',7x,'KUS(i)',9x,
x 'KLS(i)',9x,'KCL(i)',9x,'KRN(i)')
write(9,77)
77 format('bore',11x,'sddus',11x,'STRUS',9X,'sddls',9X,'STRLS',6X,
x 'sddcl',9X,'STRCL',6X,'sddrn',9X,'STTRN')
c Initialise the dummy arrays
do 111 i=1,1425
  sddcl(i)=0         ! Sum of Difference in From To Depth Calivil
  sddrn(i)=0         ! sum of difference in Fm To Depth Renmark
  sddus(i)=0         ! sum of difference in Fm To Depth Upper Shep
  sddls(i)=0         ! sum of difference in Fm To Depth Lower Shep
  strcl(i)=0          ! sum of transmissivity in Caliver aquifer
  strrn(i)=0          ! sum of transmissivity in Renmark aquifer
  strus(i)=0          ! sum of transmissivity in Upper Shep aquifer
  strls(i)=0          ! sum of transmissivity in Lower Shep aquifer
111 continue
c Read (i) file = d1-9999.prn
do 112 i=1,10703
  read (4,71) bore(i),fd(i),td(i),des(i),
x cdi(i),iest(i),inth(i),dcl(i),drn(i),dsf(i)
71 format (a12,f10.2,f10.2,a22,a10,i10,i10,f10.1,f10.1,f10.1)
c write(6,*) i
112 continue
c Read (j) file = d1-Kcodes.prn
do 222 j=1,87
  read (5, 72) cdj(j),Kj(j)
72 format (a10,e10.2)
c write(6,*) 'j=',j
222 continue
c Assign K to d1-9999.prn (i) file from (j) file
do 333 i=1,10703
do 444 j=1,87
  if (cdi(i).eq.cdj(j)) then
    Ki(i)=Kj(j)
goto 333
  endif
444 continue
333 continue
c DO LOOP to delineate the drill logs into their respective
aquifer, and then sum the difference in From To depth for Calivil,
Renmark, Upper and Lower Shepparton aquifers.
 Also to multiply the summed difference for a soil type by the
assigned
 hydraulic conductivity for that particular soil type. This gives the
 transmissivity for that particular soil type of that depth.
The total Summed transmissivity value for each aquifer is then
divided by
 the total summed depth of the aquifer to get the average
transmissivity
for that aquifer at that bore. This results in an output file with an averaged transmissivity per aquifer per bore.

borep=bore(1)

nb=1

idummy=0

do 555 i = 1, 10703

if(drn(i).eq.-999.and.dcl(i).eq.-999) then
goto 555
else
idummy=idummy+1
endif

if(idummy.eq.1.and.i.gt.1) then
borep=bore(i)
endif

dtc(i)=dsf(i)-dcl(i)    !Depth to Calivil (Surface - Cal Residual)
dtr(i)=dsf(i)-drn(i)    !Depth to Renmark (Surface - Ren Residual)
ddp(i)=td(i)-fd(i)      !Difference in Depth (From depth-To depth)

if (borep.ne.bore(i))then

  iestb(nb)=iestp
  inthb(nb)=inthp
  boreb(nb)=borep

  write(6,'*')'nb = ',nb
  borep= bore(i)

  UPPER SHEPPARTON
  If the sum of the transmissivity for Upper Shep is GT 0 AND the sum of the differences in depth in Upper Shep is GT 0 THEN
    if(strus(nb).gt.0.and.sddus(nb).gt.0)then
      write (*,'*')'tell me strus sddus',nb,borep,strus(nb),sddus(nb)
      KUS(nb)=strus(nb)/sddus(nb)
    else
      KUS(nb)=-999
    endif

  LOWER SHEPPARTON
  If the sum of the transmissivity for Lower Shep is GT 0 AND the sum of the differences in depth in Lower Shep is GT 0 THEN
    if(strls(nb).gt.0.and.sddls(nb).gt.0)then
      KLS(nb)=strls(nb)/sddls(nb)
    else
      KLS(nb)=-999
    endif

  CALIVIL
  If the sum of the transmissivity for Calivil is GT 0 AND the sum of the differences in depth in Calivil is GT 0 THEN
    if(strcl(nb).gt.0.and.sddcl(nb).gt.0)then
      KCL(nb)=strcl(nb)/sddcl(nb)
    else
      KCL(nb)=-999
    endif

555 continue

If the sum of the transmissivity for Renmark is GT 0 AND the sum of the differences in depth in Renmark is GT 0 THEN calculate the sums of trans divided by the sums of differences ELSE, give the boreb(nb) a value of -999 ie if there is no value >0 for Renmark for a bore, give the bore the value -999

\[
\text{if}(\text{strrn}(\text{nb}).\text{gt.}0.\text{and.}\text{sddrn}(\text{nb}).\text{gt.}0)\text{then}
\]
\[
\text{KRN}(\text{nb})=\text{strrn}(\text{nb})/\text{sddrn}(\text{nb})
\]
\[
\text{else}
\]
\[
\text{KRN}(\text{nb})=-999
\]
\[
\text{endif}
\]
\[
\text{nb}=\text{nb}+1
\]

\[
\text{endif}
\]

\[
\text{if} (\text{borep.eq.bore}(\text{i})) \text{ then}
\]
\[
\text{if} (\text{ddp}(\text{i}).\text{lt.}0) \text{ then}
\]
\[
\text{write}(10,79)\text{bore}(\text{i}),\text{fd}(\text{i}),\text{td}(\text{i}),\text{ddp}(\text{i})
\]
\[
79 \quad \text{format(a12,3f10.2)}
\]
\[
\text{endif}
\]

\[
\text{C UPPER SHEPPARTON}
\]
\[
\text{if To Depth is less than or equal to 12(m) THEN}
\]
\[
\text{if} (\text{td}(\text{i}).\text{le.}12) \text{ then}
\]
\[
\text{sddus(nb)=sddus(nb)+ddp(i)} \quad !\text{Sum all DeltaD to Up Shep}
\]
\[
\text{strus(nb)=ki(i)*ddp(i)+strus(nb)} \quad !\text{Sum of K * DeltaD + prev sum}
\]
\[
\text{write(*,**) 'I am summing ddp & sddus',bore(i),ddp(i),sddus(nb)}
\]
\[
\text{endif}
\]

\[
\text{C LOWER SHEPPARTON}
\]
\[
\text{if To Depth is greater than 12(m) AND less than the Depth to Calivil THEN}
\]
\[
\text{if} (\text{td}(\text{i}).\text{gt.}12.\text{and}.\text{td}(\text{i}).\text{lt.dtc}(\text{i})) \text{ then}
\]
\[
\text{sddls(nb)=sddls(nb)+ddp(i)} \quad !\text{Sum all DeltaD to Low Shep}
\]
\[
\text{strls(nb)=ki(i)*ddp(i)+strls(nb)} \quad !\text{Sum of K * DeltaD + prev sum}
\]
\[
\text{endif}
\]

\[
\text{C CALIVIL}
\]
\[
\text{if To Depth(Td) is greater than or equal to the Depth to Calivil (d(tc)) AND}
\]
\[
\text{if the To Depth is less than the Depth to Renmark (dtr) THEN}
\]
\[
\text{if} (\text{td}(\text{i}).\text{gt.dtc}(\text{i}).\text{and}.\text{td}(\text{i}).\text{lt.dtc}(\text{i}))) \text{ then}
\]
\[
\text{if(dcl(i).eq.-999) then}
\]
\[
\text{goto 555}
\]
\[
\text{endif}
\]
\[
\text{sddcl(nb)=sddcl(nb)+ddp(i)} \quad !\text{Sum all DeltaD to Cal}
\]
\[
\text{strcl(nb)=ki(i)*ddp(i)+strcl(nb)} \quad !\text{Sum of K * DeltaD + prev sum}
\]
\[
\text{endif}
\]

\[
\text{C RENMARK}
\]
\[
\text{if To Depth is greater than the Depth to Renmark THEN}
\]
\[
\text{if} (\text{td}(\text{i}).\text{gt.dtr}(\text{i})) \text{ then}
\]
\[
\text{if(drn(i).eq.-999) then}
\]
\[
\text{goto 555}
\]
endif
sddrn(nb)=sddrn(nb)+ddp(i)            !Sum all DeltaD to Ren
strrn(nb)=ki(i)*ddp(i)+strrn(nb)      !Sum of K * DeltaD + prev sum
endif

c     if(sddls(nb).lt.0.or.strls(nb).lt.0)then
      write(6,*) 'what the hell is this',bore(i),ddp(i),ki(i)
   c     endif
endif

589 borep=bore(i)
iestp=iest(i)
inthp=inth(i)

555 Continue

c     Final output - to WRITE each bore, its Easting and Northing, and averaged K value
   do 666 i=1,nb-1
   write(8,74) boreb(i),iestb(i),inthb(i),KUS(i),KLS(i),
   x KCL(i),KRN(i)
74    format (a12,2i10,4e15.5)
   write(9,76)boreb(i),sddus(i),strus(i),sddls(i),
   x strls(i),sddcl(i),strcl(i),sddrn(i),strrn(i)
76    format(a12,2e15.5,f10.2,e15.5,f10.2,e15.5,f10.2,e15.5)
   Continue
   end
21.1.2 LIZKNESTED.FOR

script for assigning the Hydraulic Conductivity values from
the unique value file for Liz Webb into a new file by combining the
K values with the drill log code for soil.
Path: c:\Murrumbidgee\Model\Fortran\DrillLogs\Hydraulic Consignment.
Project: c:\Murrumbidgee\Model\Fortran\DrillLogs\Hydraulic Consignment.dsp
Program name: c:\Murrumbidgee\Model\Fortran\DrillLogs\Hydraulic Consignment\LizKnested.for
Workspace: c:\Murrumbidgee\Model\Fortran\DrillLogs\DrillLogs.dsw

INPUT FILES(UNITS 4&5):
c:\Murrumbidgee\Model\Fortran\DrillLogs\Hydraulic Consignment\*.*
OUTPUT(UNIT 8): c:\Murrumbidgee\Model\Fortran\DrillLogs\Hydraulic Consignment\Final Trans Output

program LizKnested
To define ARRAYS
Real, dimension(7657) :: fd, td, dcl, drn, dsf,
 x Ki, Kj, ddpls, ddpus, tdp, dtcp, dtrp, dtc, dtr, dtls, ddp, dclp
real, dimension(442) :: sddcl, sddrn, sddus, sddls, strcl, strrn,
 x strus, strls
real, dimension(442) :: KCL, KRN, KLS, KUS
Integer, dimension(442) :: iestb, inthb
Integer, dimension(7657) :: iest, inth
Character*12, dimension(7657) :: bore
Character*12, dimension(442) :: boreb
Character*50, dimension(7657) :: cdi, cdj, cdp
Character*10, dimension(7657) :: des
Character*12 borep

open (4, file='d2-9999.prn')
open (5, file='d2-Kcodes2.prn')
open (8, file='d2-Trans.prn', status='replace')
open (9, file='d2-SUM.prn', status='replace')
open (10, file='d2-negs.prn', status='replace')

write(8,78)
78 format('bore(i)',8x,'iestb(i)',2x,'inthb(i)',7x,'KUS(i)',9x,
 x 'KLS(i)',9x,'KCL(i)',9x,'KRN(i)')
write(9,77)
77 format('bore',11x,'sddus',11x,'STRUS',9X,'sddls',9X,'STRLS',6X,
 x 'sddcl',9X,'STRCL',6X,'sddrn',9X,'STRRN')

Initialise the dummy arrays

do 111 i=1,442
sddcl(i)=0 ! Sum of Difference in From To Depth Calivil
sddrn(i)=0 ! sum of difference in Fm To Depth Renmark
sddus(i)=0 ! sum of difference in Fm To Depth Upper Shep
sddls(i)=0 ! sum of difference in Fm To Depth Lower Shep
strcl(i)=0 ! sum of transmissivity in Caliver aquifer
strrn(i)=0 ! sum of transmissivity in Renmark aquifer
strus(i)=0 ! sum of transmissivity in Upper Shep aquifer
strls(i)=0 ! sum of transmissivity in Lower Shep aquifer
111 continue

c Read (i) file = d2-9999.prn
do 112 i=1,7657
read (4, 71) bore(i), fd(i), td(i), des(i), cdi(i), iest(i), inth(i),
x dcl(i),drn(i),dsf(i)
71 format (a12,2f10.2,a10,a40,i10,i10,f10.1,f10.1,f10.1)
c write(6,*), bore(i), des(i), cdi(i)
112 continue

c Read (j) file = d2-Kcodes.prn
do 222 j=1,2571
read (5, 72) cdj(j), Kj(j)
72 format (a40,e10.2)
c write(6,*) 'j=', j
222 continue

c Assign K to d2-9999.prn (i) file from (j) file
do 333 i=1,7657
do 444 j=1,2571
if (cdi(i).eq.cdj(j)) then
   Ki(i)=Kj(j)
goto 333
endif
444 continue
333 continue

c DO LOOP to delineate the drill logs into their respective
aquifer, and then sum the difference in From To depth for Calivil,
Renmark, Upper and Lower Shepparton aquifers.
Also to multiply the summed difference for a soil type by the
assigned hydraulic conductivity for that particular soil type. This gives the
transmissivity for that particular soil type of that depth.
The total Summed transmissivity value for each aquifer is then
divided by the total summed depth of the aquifer to get the average
transmissivity for that aquifer at that bore. This results in an output file with an
c averaged transmissivity per aquifer per bore.

borep=bore(1)
nb=1
idummy=0
do 555 i = 1, 7657
if (drn(i).eq.-999.and.dcl(i).eq.-999) then
   goto 555
else
   idummy=idummy+1
endif
if (idummy.eq.1.and.i.gt.1) then
   borep=bore(i)
endif
dtc(i)=dsf(i)-dcl(i) !Depth to Calivil (Surface - Cal Residual)
dtr(i)=dsf(i)-drn(i) !Depth to Renmark (Surface - Ren Residual)
ddp(i)=td(i)-fd(i) !Difference in Depth (From depth-To depth)
if (borep.ne.bore(i)) then
   iestb(nb)=iestp
inthb(nb)=inthp
boreb(nb)=borep
c    write(6,*),'nb =',nb
    borep= bore(i)
c    UPPER SHEPPARTON
    If the sum of the transmissivity for Upper Shep is GT 0 AND the sum of the differences in depth in Upper Shep is GT 0 THEN
    if(strus(nb).gt.0.and.sddus(nb).gt.0)then
        write (*,*) 'tell me strus sddus',nb,borep,strus(nb),sddus(nb)
        KUS(nb)=strus(nb)/sddus(nb)
    else
        KUS(nb)=-999
    endif

    LOWER SHEPPARTON
    If the sum of the transmissivity for Lower Shep is GT 0 AND the sum of the differences in depth in Lower Shep is GT 0 THEN
    if(strls(nb).gt.0.and.sddls(nb).gt.0)then
        write (*,*) 'tell me strls sddls',nb,strls(nb),sddls(nb)
        KLS(nb)=strls(nb)/sddls(nb)
    else
        KLS(nb)=-999
    endif

    CALIVIL
    If the sum of the transmissivity for Calivil is GT 0 AND the sum of the differences in depth in Calivil is GT 0 THEN
    if(strcl(nb).gt.0.and.sddcl(nb).gt.0)then
        write (*,*) 'tell me strus sddus',nb,strcl(nb),sddcl(nb)
        KCL(nb)=strcl(nb)/sddcl(nb)
    else
        KCL(nb)=-999
    endif

    RENMARK
    If the sum of the transmissivity for Renmark is GT 0 AND the sum of the differences in depth in Renmark is GT 0 THEN calculate the sums of trans divided by the sums of differences
    ELSE, give the boreb(nb) a value of -999
    ie if there is no value >0 for Renmark for a bore, give the bore the value -999
    if(strrn(nb).gt.0.and.sddrn(nb).gt.0)then
        write (*,*) 'tell me strus sddus',nb,strrn(nb),sddrn(nb)
        KRN(nb)=strrn(nb)/sddrn(nb)
    else
        KRN(nb)=-999
    endif
    nb=nb+1
endif

if (borep.eq.bore(i)) then
if (ddp(i).lt.0) then
    write(10,79)bore(i),fd(i),td(i),ddp(i)
endif

79     format(a12,3f10.2)

C     UPPER SHEPPARTON

c     If To Depth is less than or equal to 12(m) THEN
if (td(i).le.12) then
    sddus(nb)=sddus(nb)+ddp(i)           !Sum all DeltaD to Up Shep
    strus(nb)=ki(i)*ddp(i)+strus(nb)    !Sum of K * DeltaD + prev sum
    write(*,*), 'I am summing ddp & sddus', bore(i), ddp(i), sddus(nb)
endif

C     LOWER SHEPPARTON

c     If To Depth is greater than 12(m) AND less than the Depth to Calivil
THEN
if (td(i).gt.12.and.td(i).lt.dtc(i)) then
    sddls(nb)=sddls(nb)+ddp(i)          !Sum all DeltaD to Low Shep
    strls(nb)=ki(i)*ddp(i)+strls(nb)    !Sum of K * DeltaD + prev sum
endif

C     CALIVIL

c     If To Depth(Td) is greater than or equal to the Depth to Calivil
(dtc) AND
if the To Depth(Td) is less than the Depth to Renmark (dtr) THEN
    if (td(i).ge.dtc(i).and.td(i).lt.dtr(i)) then
        if(dcl(i).eq.-999) then
            goto 555
        endif
        sddcl(nb)=sddcl(nb)+ddp(i)           !Sum all DeltaD to Cal
        strcl(nb)=ki(i)*ddp(i)+strcl(nb)    !Sum of K * DeltaD + prev sum
    endif
endif

C     RENMARK

c     If To Depth is greater than the Depth to Renmark THEN
if (td(i).gt.dtr(i)) then
    if(drn(i).eq.-999) then
        goto 555
    endif
    sddrn(nb)=sddrn(nb)+ddp(i)            !Sum all DeltaD to Ren
    strrn(nb)=ki(i)*ddp(i)+strrn(nb)     !Sum of K * DeltaD + prev sum
endif

    if(sddls(nb).lt.0.or.strls(nb).lt.0)then
    write(6,*), 'what the hell is this', bore(i), ddp(i), ki(i)
    endif

borep=bore(i)
iestp=iest(i)
inthp=inth(i)

555   Continue

c     Final output - to WRITE each bore, its Easting and Northing, and
averaged K value
for each aquifer it penetrates
do 666 i=1,nb-1
write(8,74) boreb(i),iestb(i),inthb(i),KUS(i),KLS(i),x KCL(i),KRN(i)
74 format (a12,2i10,4e15.5)
write(9,76)boreb(i),sddus(i),strus(i),sddls(i),
x strls(i),sddcl(i),strcl(i),sddrn(i),strrn(i)
76 format(a12,2e15.5,f10.2,e15.5,f10.2,e15.5,f10.2,e15.5)
666 Continue
end
21.1.3 MIRROOLKNESTED.FOR

```
c Script for assigning the Hydraulic Conductivity values from
the unique value file for Mirrool into a new file by combining the
K values with the drill log code for soil.
c Path:  c:\Murrumbidgee\Model\Fortran\DrillLogs\Hydraulic Consignment.
c Project:  c:\Murrumbidgee\Model\Fortran\DrillLogs\Hydraulic Consignment.dsp
c Program name:  c:\Murrumbidgee\Model\Fortran\DrillLogs\Hydraulic Consignment\MirroolKnested.for
c Workspace:  c:\Murrumbidgee\Model\Fortran\DrillLogs\DrillLogs.dsw
c
INPUT FILES(UNITS 4&5):
c:\Murrumbidgee\Model\Fortran\DrillLogs\Hydraulic Consignment\*.*
c
OUTPUT(UNIT 8):  c:\Murrumbidgee\Model\Fortran\DrillLogs\Hydraulic Consignment\Final Trans Output
```

```c
program MirroolKnested

To define ARRAYS
Real, dimension(12271) :: fd,td,dcl,drn,dsf,
  x Ki, Kj,ddpls,ddpus,tdep, dtcp, dtrp, dtc, dtr, dts, ddp,dclp
real, dimension(673) :: sddcl,sddrn,sddus,sddls,strcl,strrn,
  X strus,strls
real, dimension(673) :: KCL,KRN,KLS,KUS
Integer, dimension(673) :: iestb, inthb
Integer, dimension(12271) :: iest, inth
Character*10, dimension(12271) :: bore
Character*10, dimension(673) :: boreb
Character*50, dimension(12271) :: cdi, cdj, cdp
Character*22, dimension(12271) :: des
Character*10, borep

open (4, file='d3-9999.prn')
open (5, file='d3-Kcodes2.prn')
open (8, file='d3-Trans.prn', status='replace')
open (9, file='d3-SUM.prn', status='replace')
open (10, file='d3-negs.prn', status='replace')

write(8,78)
78 format('bore(i)',6x,'iestb(i)',2x,'inthb(i)',7x,'KUS(i)',9x,
  x 'KLS(i)',9x,'KCL(i)',9x,'KRN(i)')
write(9,77)
77 format('bore',11x,'sddus',11x,'STRUS',9X,'sddls',9X,'STRLS',6X,
  x 'sddcl',9X,'STRCL',6X,'sddrn',9X,'STRRN')

Initialise the dummy arrays

```
do 111 i=1,673
  sddcl(i)=0         ! Sum of Difference in From To Depth Calivil
  sddrn(i)=0         ! sum of difference in Fm To Depth Renmark
  sddus(i)=0         ! sum of difference in Fm To Depth Upper Shep
  sddls(i)=0         ! sum of difference in Fm To Depth Lower Shep
  strcl(i)=0         ! sum of transmissivity in Caliver aquifer
  strrn(i)=0         ! sum of transmissivity in Renmark aquifer
  strus(i)=0         ! sum of transmissivity in Upper Shep aquifer
  strls(i)=0         ! sum of transmissivity in Lower Shep aquifer
111 continue
```

```
c Read (i) file = d3-9999.prn
do 112 i=1,12271
read (4, 71) bore(i),fd(i),td(i),des(i),cdi(i),iest(i),inth(i),
```
x dcl(i),drn(i),dsf(i)
71   format (a10,2f10.2,a22,a40,i10,i10,f10.1,f10.1,f10.1)
c   write(6,*)) bore(i),des(i),cdi(i),dcl(i),drn(i),dsf(i)
112  continue
c   Read (j) file = d3-Kcodes.prn
do 222 j=1,2514
read (5, 72) cdj(j),Kj(j)
72   format (a40,e10.2)
c   write(6,*)) 'j=',j
222  continue
c   Assign K to d3-9999.prn (i) file from (j) file
do 333 i=1,12271
do 444 j=1,2514
if (cdi(i).eq.cdj(j)) then
   Ki(i)=Kj(j)
goto 333
endif
444  continue
333  continue
c   DO LOOP to delineate the drill logs into their respective aquifer, and then sum the difference in From To depth for Calivil, Renmark, Upper and Lower Shepparton aquifers.
   Also to multiply the summed difference for a soil type by the assigned hydraulic conductivity for that particular soil type. This gives the transmissivity for that particular soil type of that depth. The total Summed transmissivity value for each aquifer is then divided by the total summed depth of the aquifer to get the average transmissivity for that aquifer at that bore. This results in an output file with an averaged transmissivity per aquifer per bore.
borep=bore(1)
borep=bore(1)
229  nb=1
idummy=0
555  i = 1, 12271
if(drn(i).eq.-999.and.dcl(i).eq.-999) then
   goto 555
else
   idummy=idummy+1
endif
555  goto 555
if(idummy.eq.1.and.i.gt.1) then
   borep=bore(i)
endif
dtc(i)=dsf(i)-dcl(i)    !Depth to Calivil (Surface - Cal Residual)
dtr(i)=dsf(i)-drn(i)    !Depth to Renmark (Surface - Ren Residual)
ddp(i)=td(i)-fd(i)      !Difference in Depth (From depth-To depth)
if (borep.ne.bore(i)) then
   iestb(nb)=iestp
   iestb(nb)=iestp
   iestp=estp
inhb(nb)=inhp
boreb(nb)=borep
write(6,*)'nb =',nb
borep= bore(i)

UPPER SHEPPARTON

If the sum of the transmissivity for Upper Shep is GT 0 AND the sum of the differences in depth in Upper Shep is GT 0 THEN
if(strus(nb).gt.0.and.sddus(nb).gt.0)then
write (*,*) 'tell me strus sddus',nb,borep,strus(nb),sddus(nb)
KUS(nb)=strus(nb)/sddus(nb)
else
KUS(nb)=-999
endif

LOWER SHEPPARTON

If the sum of the transmissivity for Lower Shep is GT 0 AND the sum of the differences in depth in Lower Shep is GT 0 THEN
if(strls(nb).gt.0.and.sddls(nb).gt.0)then
KLS(nb)=strls(nb)/sddls(nb)
else
KLS(nb)=-999
endif

CALIVIL

If the sum of the transmissivity for Calivil is GT 0 AND the sum of the differences in depth in Calivil is GT 0 THEN
if(strcl(nb).gt.0.and.sddcl(nb).gt.0)then
KCL(nb)=strcl(nb)/sddcl(nb)
else
KCL(nb)=-999
endif

RENMARK

If the sum of the transmissivity for Renmark is GT 0 AND the sum of the differences in depth in Renmark is GT 0 THEN calculate the sums of trans divided by the sums of differences
ELSE, give the boreb(nb) a value of -999
ie if there is no value >0 for Renmark for a bore, give the bore the value -999
if(strrn(nb).gt.0.and.sddrn(nb).gt.0)then
KRN(nb)=strrn(nb)/sddrn(nb)
else
KRN(nb)=-999
endif
nb=nb+1
endif

if (borep.eq.bore(i)) then
if (ddp(i).lt.0) then
write(10,79)bore(i),fd(i),td(i),ddp(i)
C  UPPER SHEPPARTON
C     If To Depth is less than or equal to 12(m) THEN
if (td(i).le.12) then
    sddus(nb)=sddus(nb)+ddp(i)          !Sum all DeltaD to Up Shep
    strus(nb)=ki(i)*ddp(i)+strus(nb)    !Sum of K * DeltaD + prev sum
    write(*,*) 'I am summing ddp & sddus',bore(i),ddp(i),sddus(nb)
endif
C  LOWER SHEPPARTON
C     If To Depth is greater than 12(m) AND less than the Depth to Calivil THEN
if (td(i).gt.12.and.td(i).lt.dtc(i)) then
    sddls(nb)=sddls(nb)+ddp(i)          !Sum all DeltaD to Low Shep
    strls(nb)=ki(i)*ddp(i)+strls(nb)    !Sum of K * DeltaD + prev sum
endif
C  CALIVIL
C     If To Depth(Td) is greater than or equal to the Depth to Calivil (dtc) AND
C     if the To Depth is less than the Depth to Renmark (dtr) THEN
if(td(i).ge.dtc(i).and.td(i).lt.dtr(i)) then
    if(dcl(i).eq.-999) then
        goto 555
    endif
    sddcl(nb)=sddcl(nb)+ddp(i)           !Sum all DeltaD to Cal
    strcl(nb)=ki(i)*ddp(i)+strcl(nb)     !Sum of K * DeltaD + prev sum
endif
C  RENMARK
C     If To Depth is greater than the Depth to Renmark THEN
if(td(i).gt.dtr(i)) then
    if(drn(i).eq.-999) then
        goto 555
    endif
    sddrn(nb)=sddrn(nb)+ddp(i)            !Sum all DeltaD to Ren
    strrn(nb)=ki(i)*ddp(i)+strrn(nb)      !Sum of K * DeltaD + prev sum
endif
if(sddls(nb).lt.0.or.strls(nb).lt.0)then
    write(6,*)'what the hell is this',bore(i),ddp(i),ki(i)
endif
borep=bore(i)
iestp=iest(i)
inthp=inth(i)
555  Continue
C     Final output - to WRITE each bore, its Easting and Northing, and averaged K value
C     for each aquifer it penetrates
do 666 i=1,nb-1
    write(8,74) boreb(i),iestb(i),inthb(i),KUS(i),KLS(i),
              KCL(i),KRN(i)
    x KCL(i),KRN(i)
format (a10,2i10,4e15.5)
write(9,76)boreb(i),sddus(i),strus(i),sddls(i),
x strls(i),sddcl(i),strcl(i),sddrn(i),strrn(i)
76 format(a10,2e15.5,f10.2,e15.5,f10.2,e15.5,f10.2,e15.5)

Continue

dend
21.1.4 YANCOKNESTED.FOR

c Script for assigning the Hydraulic Conductivity values from
the unique value file for Yanco into a new file by combining the
K values with the drill log code for soil.
c Path:  c:\Murrumbidgee\model\Fortran\DrillLogs\Hydraulic Consignment.
c Project:  c:\Murrumbidgee\Model\Fortran\DrillLogs\Hydraulic
Consignment.dsp
Program name:  c:\Murrumbidgee\Model\Fortran\DrillLogs\Hydraulic
Consignment\YancoKnested.for
Workspace:  c:\Murrumbidgee\Model\Fortran\DrillLogs\DrillLogs.dsw
INPUT FILES(UNITS 4&5):
c:\Murrumbidgee\Model\Fortran\DrillLogs\Hydraulic Consignment\*.*
OUTPUT(UNIT 8):  c:\Murrumbidgee\Model\Fortran\DrillLogs\Hydraulic
Consignment\Final Trans Output

program YancoKnested

c To define ARRAYSs
Real, dimension(6536) :: fd,td,dcl,drn,dsf,
x Ki, Kj,ddpls,ddpus,tdp, dtcp,dtrp,dtc,dtr,dtls,ddp,dclp
real, dimension(1000) :: sddcl,sddrn,sddus,sddls,strcl,strrn,
x strus,strls
real, dimension(1000) :: KCL,KRN,KLS,KUS
Integer, dimension(1000) :: iestb, inthb
Integer, dimension(6536) :: iest, inth
Character*10, dimension(6536) :: bore
Character*10, dimension(1000) :: boreb
Character*50, dimension(6536) :: cdi, cdj, cdp
Character*22, dimension(6536) :: des
Character*10, borep

open (4, file='d4-9999.prn')
open (5, file='d4-Kcodes2.prn')
open (8, file='d4-Trans.prn', status='replace')
open (9, file='d4-SUM.prn', status='replace')
open (10, file='d4-negs.prn', status='replace')

write(8,78)
78 format('bore(i)',6x,'iestb(i)',2x,'inthb(i)',7x,'KUS(i)',9x, x 'KLS(i)',9x,'KCL(i)',9x,'KRN(i)')
write(9,77)
77 format('bore',11x,'sddus',11x,'STRUS',9X,'sddls',9X,'STRLS',6X, x 'sddcl',9X,'STRCL',6X,'sddrn',9X,'STRRN')

c Initialise the dummy arrays

do 111 i=1,1000
sddcl(i)=0 ! Sum of Difference in From To Depth Calivil
sddrn(i)=0 ! sum of difference in Fm To Depth Renmark
sddus(i)=0 ! sum of difference in Fm To Depth Upper Shep
sddls(i)=0 ! sum of difference in Fm To Depth Lower Shep
strcl(i)=0 ! sum of transmissivity in Caliver aquifer
strrn(i)=0 ! sum of transmissivity in Renmark aquifer
strus(i)=0 ! sum of transmissivity in Upper Shep aquifer
strls(i)=0 ! sum of transmissivity in Lower Shep aquifer
111 continue

c Read (i) file = d4-9999.prn

do 112 i=1,6536
read (4, 71) bore(i),fd(i),td(i),des(i),cdi(i),iest(i),inth(i),
x dcl(i),drn(i),dsf(i)
71 format (a10,2f10.2,a22,a40,i10,i10,f10.1,f10.1,f10.1)
c write(6,*) bore(i),des(i),cdi(i)

112 continue
c Read (j) file = d4-Kcodes.prn
do 222 j=1,434
read (5, 72) cdj(j),Kj(j)
72 format (a40,e10.2)
c write(6,*) 'j=',j
222 continue
c Assign K to d4-9999.prn (i) file from (j) file
do 333 i=1,6536
do 444 j=1,434
if (cdi(i).eq.cdj(j)) then
K(i)=Kj(j)
goto 333
endif
444 continue
333 continue
c DO LOOP to delineate the drill logs into their respective
aquifer, and then sum the difference in From To depth for Calivil,
Renmark, Upper and Lower Shepparton aquifers.
Also to multiply the summed difference for a soil type by the
assigned
hydraulic conductivity for that particular soil type. This gives the
transmissivity for that particular soil type of that depth.
The total Summed transmissivity value for each aquifer is then
divided by
the total summed depth of the aquifer to get the average
transmissivity
for that aquifer at that bore. This results in an output file with an
c averaged transmissivity per aquifer per bore.

borep=bore(1)
b=1
idummy=0
555 do 555 i = 1, 6536
if (drn(i).eq.-999.and.dcl(i).eq.-999) then
goto 555
else
idummy=idummy+1
endif
if (idummy.eq.1.and.i.gt.1) then
borep=bore(i)
endif
dtc(i)=dsf(i)-dcl(i) !Depth to Calivil (Surface - Cal Residual)
dtr(i)=dsf(i)-drn(i) !Depth to Renmark (Surface - Ren Residual)
ddp(i)=td(i)-fd(i) !Difference in Depth (From depth-To depth)
if (borep.ne.bore(i)) then
iestb(nb)=iestp
inthb(nb)=inthp
boreb(nb)=borep
write(6,*),'nb =',nb
borep= bore(i)
c
  UPPER SHEPPARTON
  If the sum of the transmissivity for Upper Shep is GT 0 AND the sum of the differences in depth in Upper Shep is GT 0 THEN
  if(strus(nb).gt.0.and.sddus(nb).gt.0)then
    write (*,*) 'tell me strus sddus',nb,borep,strus(nb),sddus(nb)
    KUS(nb)=strus(nb)/sddus(nb)
  else
    KUS(nb)=-999
  endif
C
  LOWER SHEPPARTON
  If the sum of the transmissivity for Lower Shep is GT 0 AND the sum of the differences in depth in Lower Shep is GT 0 THEN
    if(strls(nb).gt.0.and.sddls(nb).gt.0)then
      KLS(nb)=strls(nb)/sddls(nb)
    else
      KLS(nb)=-999
    endif
C
  CALIVIL
  If the sum of the transmissivity for Calivil is GT 0 AND the sum of the differences in depth in Calivil is GT 0 THEN
    if(strcl(nb).gt.0.and.sddcl(nb).gt.0)then
      KCL(nb)=strcl(nb)/sddcl(nb)
    else
      KCL(nb)=-999
    endif
C
  RENMARK
  If the sum of the transmissivity for Renmark is GT 0 AND the sum of the differences in depth in Renmark is GT 0 THEN calculate the sums of trans divided by the sums of differences
  ELSE, give the boreb(nb) a value of -999
  ie if there is no value >0 for Renmark for a bore, give the bore the value -999
    if(strrn(nb).gt.0.and.sddrn(nb).gt.0)then
      KRN(nb)=strrn(nb)/sddrn(nb)
    else
      KRN(nb)=-999
    endif
    nb=nb+1
  endif
  if (borep.eq.bore(i)) then
    if (ddp(i).lt.0) then
      write(10,79)bore(i),fd(i),td(i),ddp(i)
```fortran
79    format(a12,3f10.2)
endif

C     UPPER SHEPPARTON
c     If To Depth is less than or equal to 12(m) THEN
if (td(i).le.12) then
sddus(nb)=sddus(nb)+ddp(i) !Sum all DeltaD to Up Shep
strus(nb)=ki(i)*ddp(i)+strus(nb) !Sum of K * DeltaD + prev sum
write(*,*) 'I am summing ddp & sddus',bore(i),ddp(i),sddus(nb)
endif

C     LOWER SHEPPARTON
c     If To Depth is greater than 12(m) AND less than the Depth to Calivil THEN
if (td(i).gt.12.and.td(i).lt.dtc(i)) then
sddls(nb)=sddls(nb)+ddp(i) !Sum all DeltaD to Low Shep
strls(nb)=ki(i)*ddp(i)+strls(nb) !Sum of K * DeltaD + prev sum
endif

C     CALIVIL
c     If To Depth(Td) is greater than or equal to the Depth to Calivil (dtc) AND
c     if the To Depth is less than the Depth to Renmark (dtr) THEN
if(td(i).ge.dtc(i).and.td(i).lt.dtr(i)) then
if(dcl(i).eq.-999) then
goto 555
endif
sddcl(nb)=sddcl(nb)+ddp(i) !Sum all DeltaD to Cal
strcl(nb)=ki(i)*ddp(i)+strcl(nb) !Sum of K * DeltaD + prev sum
endif

C     RENMARK
c     If To Depth is greater than the Depth to Renmark THEN
if(td(i).gt.dtr(i)) then
if(drn(i).eq.-999) then
goto 555
endif
sddrn(nb)=sddrn(nb)+ddp(i) !Sum all DeltaD to Ren
strrn(nb)=ki(i)*ddp(i)+strrn(nb) !Sum of K * DeltaD + prev sum
endif

555   Continue

c     Final output - to WRITE each bore, its Easting and Northing, and
averaged K value
do 666 i=1,nb-1
write(8,74) boreb(i),iestb(i),inthb(i),KUS(i),KLS(i),
x KCL(i),KRN(i)
```

format (a10,2i10,4e15.5)
write(9,76)boreb(i),sddus(i),strus(i),sddls(i),
x strls(i),sddcl(i),strcl(i),sddrn(i),strrn(i)
format(a10,2e15.5,f10.2,e15.5,f10.2,e15.5,f10.2,e15.5)
Continue
end
21.2 Program for differentiating the drill logs into Calivil aquifer and Renmark aquifer. Four different databases.

21.2.1 ARY.F

```fortran
program ary
    character borep*12, bore*12, des*50, cd*10
    open(4, file='d1-9999.prn')
    ! open(9, file='dttest.prn')
    open(7, file='dlcal.prn', status='replace')
    open(8, file='dlren.prn', status='replace')
tdp=0
dtcp=0
dtrp=0

    do 33 i=1,10808
        read (4, 110) bore, fd, td, des, cd, iest, inth, dcl, drn, dsf
    110    format (a12, 2f10.2, a22, a10, i10, i10, f10.1, f10.1, f10.1)
    30     format (a10, i10, 2x, i10)
    40     format (2x, 'Bore No.', 4x, 'Easting', 4x, 'Northing')
        dtc=dsf-dcl
dtr=dsf-drn
    !        write (6,*) dtc, dtr
    !       if(borep.ne.bore) then
    !         write(9,20) bore, dtc, dtr
    !20   format (a10, f10.2, 2x, f10.2)
    !     endif
    !     write (6,*) bore, dtc, td
    if(tdp.gt.td) then
        if(tdp.gt.dtcp) then
            write (7,40)
            write (7,30) borep, iestp, inthp
        endif
    endif
    iestp=iest
    inthp=inth
    tdp=td
    borep=bore
    dtcp=dtc
    dtrp=dtr
    33     continue
end
```

! open(5, file='d2test.prn', status='replace')
! write (5, 13) bore, fd, td, des, cd, iest, inth, dcl, drn, dsf
!13  format (a10, 2f10.4, a22, a50, i10, i10, f10.1, f10.1, f10.1, f10.1)
! write (5, 112) bore, dtr, dtc
21.2.2 LIZWEB.F

program lizweb
    character borep*12,bore*12,des*50,cd*10
    open(4,file='d2-9999.prn')
    !    open(9,file='d2test.prn')
    open(7,file='d2cal.prn',status='replace')
    open(8,file='d2ren.prn',status='replace')
    tdp=0
dtcp=0
dtrp=0

    do 33 i=1,10000
        read (4, 110) bore,fd,td,des,cd,iest,inth,dcl,drn,dsf
        dtc=dsf-dcl
        dtr=dsf-drn
        !    write (6,*) dtc,dtr
        !       if(borep.ne.bore) then
        !     write(9,20) bore,dtc,dtr
        !20  format(a10,f10.2,2x,f10.2)
        !        endif
        !     write (6,*) bore,dtc,td
        if(tdp.gt.td) then
            if(tdp.gt.dtcp) then
                write (7,30) borep,iestp,inthp
            endif
            if(tdp.gt.dtrp) then
                write (8,30) borep,iestp,inthp
            endif
            iestp=iest
            inthp=inth
            tdp=td
            borep=bore
            dtcp=dtc
            dtrp=dtr
        endif
    end
    !       open(5,file='d2test.prn',status='replace')
    !        write (5, 13) bore,fd,td,des,cd,iest,inth,dcl,drn,dsf
    !13     format (a10,2f10.4,a22,a50,a10,i10,i10,f10.1,f10.1,f10.1)
    !        write (5, 112) bore,dtc,dtr

21.2.3 MIRROOL.F

program mirrool
    character borep*10,bore*10,des*22,cd*50
open(4,file='d3-9999.prn')
open(7,file='d3shep.prn',status='replace')
tdp=0
dtcp=0
dtrp=0
n=0
n1=0

do 33 i=1,12275
   read (4, 110) bore,fd,td,des,cd,iest,inth,dcl,drn,dsf
110  format (a10,2f10.4,a22,a50,i10,i10,f10.1,f10.1,f10.1)
30     format(i10,2x,a10,2x,i10,2x,i10)
   dtc=dsf-dcl
   dtr=dsf-drn
   n1=n1+1
   write (6,*) n1
   if(tdp.gt.td) then
      if(tdp.gt.dtcp) then
         n=n+1
         write (7,30) n,borep,iestp,inthp
      endif
   endif
   iestp=iest
   inthp=inth
   tdp=td
   borep=bore
   dtcp=dtc
   dtrp=dtr
33     continue
end

!       open(5,file='d2test.prn',status='replace')
!        write (5, 13) bore,fd,td,des,cd,iest,inth,dcl,drn,dsf
!13     format (a10,2f10.4,a22,a50,i10,i10,f10.1,f10.1,f10.1)
!    write (5, 112) bore,dtr,dtc

21.2.4     YANCO.F

program yanco
character borep*10,bore*10,des*22,cd*50
open(4,file='d4-9999.prn')
open(7,file='d4test.prn',status='replace')
open(8,file='d4cal.prn',status='replace')
open(9,file='d4ren.prn',status='replace')
tdp=0
dtcp=0
dtrp=0

do 33 i=1,10000
   read (4,110) bore,fd,td,des,cd,iest,inth,dcl,drn,dsf
110  format (a10,f10.2,f10.2,a22,a50,i10,i10,f10.1,f10.1,f10.1)
end
120  format(a10,i10,2x,i10)
!130  format(a10,a10,f10.2,f10.2,f10.2,f10.2)

!    if(borep.ne.bore) then
!    write (7,110) bore,fd,td,des,cd,iest,inth,dcl,drn,dsf
!    endif

    dtc=dsf-dcl
    dtr=dsf-drn

if(tdp.gt.td) then
!    write(6,*) bore,borep,td,tdp,dtc,dtcp
!    write(7,130) bore,borep,td,tdp,dtc,dtcp
!    endif

    iestp=iest
    inthp=inth

    tdp=td
    borep=bore
    dtcp=dtc
    dtrp=dtr

33     continue
end
21.3 Programs for differentiating the drill logs into those that are in the Shepparton aquifer. Four databases used.

21.3.1 ARYSHEP.FOR

! Program for Ary Van der Lely's bores in the Shepparton aquifer
! Within the model boundary = d1shpmdl.prn
! All bores included = d1shpall.prn
!
program aryshep
character borep*12,bore*12,des*22,cd*10
open(4,file='d1-9999.prn')
! open(7,file='d1shpmdl.prn',status='replace')
open(7,file='d1shpall.prn',status='replace')

n=0

do 33 i=1,10801
read (4, 110) bore,fd,td,des,cd,iest,inth,dcl,drn,dsf
110 format (a12,2f10.2,a22,a10,i10,i10,f10.1,f10.1,f10.1)
30   format(i10,2x,a12,2x,f10.1,2x,i10,2x,i10)
if(borep.ne.bore) then
! if(dcl.ne.-999) then
n=n+1
! write (6,*) n,bore,dcl,iest,inth
write (7,30) n,bore,dcl,iest,inth
! endif
endif
borep=bore
dclp=dcl
33    continue
end
!
!       open(5,file='d2test.prn',status='replace')
!        write (5, 13) bore,fd,td,des,cd,iest,inth,dcl,drn,dsf
13     format (a10,2f10.4,a22,a50,i10,i10,f10.1,f10.1,f10.1)
!    write (5, 112) bore,dtr,dtc

21.3.2 LIZSHEP.FOR

! Program for Liz Webb's bores in the Shepparton aquifer
! Within the model boundary = d2shpmdl.prn
! All bores included = d2shpall.prn
!
program lizshep
character borep*12,bore*12,des*51,cd*10
open(4,file='d2-9999.prn')
! open(7,file='d2shpmdl.prn',status='replace')
open(7,file='d2shpall.prn',status='replace')
n=0

do 33 i=1,7658
read (4, 110) bore,fd,td,des,cd,iest,inth,dcl,drn,dsf
110 format (a12,2f10.2,a51,a10,i10,i10,f10.1,f10.1,f10.1)
30 format(i10,2x,a12,2x,f10.1,2x,i10,2x,i10)
if(borep.ne.bore) then
! if(dcl.ne.-999) then
n=n+1
! write (6,*) n,bore,dcl,iest,inth
write (7,30) n,bore,dcl,iest,inth
! endif
endif
borep=bore
33 continue
end

! open(5,file='d2test.prn',status='replace')
! write (5, 13) bore,fd,td,des,cd,iest,inth,dcl,drn,dsf
!13 format (a10,2f10.4,a22,a50,i10,i10,f10.1,f10.1,f10.1)
! write (5, 112) bore,dtr,dtc

21.3.3 MIRROOLSHEP.FOR

! Program for Drill Logs in Mirrool area to be classified into Shepparton layer (ie above Calivil).
! Within the model boundary = d3shpmdl.prn
! All bores included = d3shpall.prn
!
program mirroolshep
character borep*10,bore*10,des*22,cd*50
open(4,file='d3-9999.prn')
open(7,file='d3shpmdl.prn',status='replace')
!
open(7,file='d3shpall.prn',status='replace')

n=0

do 33 i=1,12273
read (4, 110) bore,fd,td,des,cd,iest,inth,dcl,drn,dsf
110 format (a10,2f10.2,a22,a50,i10,i10,f10.1,f10.1,f10.1)
30 format(i10,2x,a10,2x,f10.1,2x,i10,2x,i10)
if(borep.ne.bore) then
if(dcl.ne.-999) then
n=n+1
! write (6,*) n,bore,dcl,iest,inth
write (7,30) n,bore,dcl,iest,inth
endif
endif
borep=bore

dclp=dcl

33    continue
end

! open(5,file='d2test.prn',status='replace')
! write (5, 13) bore,fd,td,des,cd,iest,inth,dcl,drn,dsf
!13   format (a10,2f10.4,a22,a50,i10,i10,f10.1,f10.1,f10.1)
! write (5, 112) bore,dtr,dtc

21.3.4    YANCOSHEP.FOR

! Program for Drill Logs in Yanco area to be classified into Shepparton layer (ie above Calivil).
! Within the model boundary = d4shpmdl.prn
! All bores included = d4shpall.prn
!
program yancoshep
character borep*10,bore*10,des*22,cd*51
open(4,file='d4-9999.prn')
open(7,file='d4shpmdl.prn',status='replace')
!
open(7,file='d4shpall.prn',status='replace')

n=0

do 33 i=1,6537
read(4,110) bore,fd,td,des,cd,iest,inth,dcl,drn,dsf
110   format(a10,f10.2,f10.2,a22,a51,i10,i10,f10.1,f10.1,f10.1)
30    format(i10,2x,a10,2x,f10.1,2x,i10,2x,i10)

if(borep.ne.bore) then
if(dcl.ne.-999) then
n=n+1
!
write (6,*), n,bore,dcl,iest,inth
write (7,30) n,bore,dcl,iest,inth
endif
endif

borep=bore
dclp=dcl

33    continue
end
21.4 Programs for extracting all unique descriptions of soil type from the drill logs. Four databases used.

21.4.1 ARYSOILS.FOR

! Program for extracting all unique descriptions of soil type from the drill logs. Just for Ary Van der Lely (DLWC). Stored c:\Murrumbidgee\model\fortran\scripts

program arysoils
  Character cdp*10, bore*10, des*22, cd*10
  open (4, file='d1-soils.prn')
  open (7, file='d1-codes.prn')

  n=0
  do 33 i=1,10800
    read (4, 110) bore, fd, td, des, cd, iest, inth, dcl, drn, dsf
  110    format (a10, 2f10.2, a22, a10, i10, i10, f10.1, f10.1, f10.1)

  112    format (I10, 2x, a10)

    if(cdp.ne.cd) then
      n=n+1
      write (7, 112) n, cd
    endif
    cdp=cd
  33    continue
end

21.4.2 LIZSOILS.FOR

! Program for extracting all unique descriptions of soil type from the drill logs. Just for LizWeb (DLWC, Leeton). Stored c:\Murrumbidgee\model\fortran\scripts

program lizsoils
  Character desp*50, bore*12, des*50, cd*10
  open (4, file='d2-soils.prn')
  open (7, file='d2-codes.prn')

  n=0
  do 33 i=1,7657
    read (4, 110) bore, fd, td, des, cd, iest, inth, dcl, drn, dsf
  110    format (a12, 2f10.2, a50, a10, i10, i10, f10.1, f10.1, f10.1)

  112    format (I10, 2x, a50)

    if(desp.ne.des) then
      n=n+1
      write (7, 112) n, des
    endif
  33    continue
end
endif

desp=des
33 continue
end

21.4.3  MIRROOLSOILS.FOR

! Program for extracting all unique descriptions of soil type from the drill logs.
! Just for Mirrool (produced from combined CSIRO & Murrumbidgee Irrigation efforts).
! Stored c:\Murrumbidgee\model\fortran\scripts

program mirroolsoils
Character cdp*50,bore*10, des*22, cd*50
open (4,file='d3-soils.prn')
open (7,file='d3-codes.prn')

n=0
n1=0
    do 33 i=1,12273
        read (4, 110) bore,fd,td,des,cd,iest,inth,dcl,drn,dsf
110     format (a10, f10.2, f10.4, a22, a50, i10, i10, f10.1,f10.1,f10.1)
        n1=n1+1
        write (6,*) n1
112     format (I10,2x,a50)
        if(cdp.ne.cd) then
            n=n+1
            write (7, 112) n,cd
        endif
        cdp=cd
33 continue
end

21.4.4  YANCOSOILS.FOR

! Program for extracting all unique descriptions of soil type from the drill logs.
! Just for Yanco (produced from combined CSIRO & Murrumbidgee Irrigation efforts).
! Stored c:\Murrumbidgee\model\fortran\scripts

program yancosoils
Character cdp*50,bore*10, des*22, cd*50
open (4,file='d4-soils.prn')
open (7,file='d4-codes.prn')

n=0
    do 33 i=1,6536
        read (4, 110) bore,fd,td,des,cd,iest,inth,dcl,drn,dsf
110     format (a10, f10.2, f10.4, a22, a50, i10, i10, f10.1,f10.1,f10.1)
        n1=n1+1
        write (6,*) n1
112     format (I10,2x,a50)
        if(cdp.ne.cd) then
            n=n+1
            write (7, 112) n,cd
        endif
        cdp=cd
33 continue
end
read (4, 110) bore,fd,td,des,cd,iest,inth,dcl,drn,dsf

110 format (a10, f10.2, f10.4, a22, a50, i10, i10, f10.1,f10.1,f10.1)

112 format (I10,2x,a50)

    if(cdp.ne.cd) then
        n=n+1
        write (7, 112) n,cd
        endif
        cdp=cd
    end

33      continue
end
21.5 Programs for assigning the Specific Storage to up to 5m below the surface and then between 5 and 10m below the surface

21.5.1 ARYSSALL.FOR

c Script for assigning the Specific Storage to all aquifers for Ary (DLWC ) data.
c The differences in depth are summed for each different soil type.
c Individual depths are multiplied by the Specific Storage for that particular
soil type, and then this value is divided by the total summed difference
c in depth for that aquifer.
c This gives an averaged Specific Storage for each aquifer.
c Path: c:\Murrumbidgee\model\Fortran\DrillLogs\Specific Storage.
c Project: c:\Murrumbidgee\Model\Fortran\DrillLogs\Specific Storage.dsp
c Program name: c:\Murrumbidgee\Model\Fortran\DrillLogs\Specific Storage\ArySsAll.for

c Workspace: c:\Murrumbidgee\Model\Fortran\DrillLogs\DrillLogs.dsw

c INPUT FILES(UNITS 4&5):
c:\Murrumbidgee\Model\Fortran\DrillLogs\Specific Storage\*.prn

c OUTPUT(UNITs 8,9,10,11): c:\Murrumbidgee\Model\Fortran\DrillLogs\Specific Storage\Ss All Output

program ArySsAll

c To define ARRAYS
Real, dimension(10703) :: fd,td,dcl,drn,dsf,
x Ki,Kj,dtc,dt,r,drp,Kk,Ss,ddpl,s,ddp,t,dtcp,dtcp,dtlr,dtls,dclp
real, dimension(1425) :: sddcl,sddrn,sddus,sddls,ssc,srrn,
x ssus,ssuls
real, dimension(1425) :: SSCL,SSRN,SSL,SSUS
Integer, dimension(1425) :: iestb, inthb
Integer, dimension(10703) :: iest, inth
Character*12, dimension(10703) :: bore
Character*12, dimension(1425) :: boreb
Character*10, dimension(10703) :: cdi, cdj, cd
Character*22, dimension(10703) :: des
Character*12 borep
open (4, file='d1-9999.prn')
open (5, file='d1-Kcodes.prn')
open (8, file='d1-SsAll.prn', status='replace')
open (9, file='d1-noSsAll.prn', status='replace')
open (10,file='d1-Ss&kAll.prn',status='replace')
open (11,file='d1-Ss&kAll.prn',status='replace')

write(8,78)
78 format('bore',11x,'iestb',5x,'inthb',10x,'SSUS',12x,'SSL',10x,
X 'SSCL',12x,'SSRN')
write(9,77)
77 format('bore',14x,'sddUS',11x,'sddUS',8x,'sddLS',7x,'sddLS',8x,
X 'sddcl',7x,'sddcl',8x,'sddrn',6x,'ssus')
write(11,80)
80 format('bore',15x,'fd',8x,'td',6x,'cd',12x,'ki',15x,'ss')
c Initialise the dummy arrays
do 111 i=1,1425
sddcl(i)=0         ! Sum of Difference in From To Depth Calivil
sddrn(i)=0         ! sum of difference in Fm To Depth Renmark
sddus(i)=0         ! sum of difference in Fm To Depth Upper Shep
sddls(i)=0         ! sum of difference in Fm To Depth Lower Shep
sssc1(i)=0          ! sum of transmissivity in Caliver aquifer
sssrn(i)=0          ! sum of transmissivity in Renmark aquifer
sssus(i)=0          ! sum of transmissivity in Upper Shep aquifer
ssssl(i)=0          ! sum of transmissivity in Lower Shep aquifer
111 continue
c Read (i) file = d1-9999.prn
do 112 i=1,10703
read (4,71) bore(i),fd(i),td(i),des(i),
   x cdi(i),iest(i),inth(i),dcl(i),drn(i),dsf(i)
71    format (a12,f10.2,f10.2,a22,a10,i10,i10,f10.1,f10.1,f10.1)
c write(6,*) i
112 continue
c Read (j) file = d1-Kcodes.prn
do 222 j=1,87
read (5, 72) cdj(j),Kj(j)
72    format (a10,e10.2)
c write(6,72) 'j=',j,cdj(j),Kj(j)
222 continue
c Assign K to d1-9999.prn (i) file from (j) file
do 333 i=1,10703
do 444 j=1,87
   if (cdi(i).eq.cdj(j)) then
      Ki(i)=Kj(j)
goto 333
   endif
444 continue
333 continue
c DO LOOP to circle thru the total file (d1-9999.prn) and assign Sy-values.
do 555 i=1,10703
do 666 j=1,87
   write(*,*)'tell me ','i
   if (cdi(i).eq.cdj(j)) then
      if(Ki(i).eq.1.0e-04)then
         Ss(i)=6.8e-06
goto 555
      endif
      if(Ki(i).eq.9.0e-06)then
         Ss(i)=2.1e-04
goto 555
      endif
      if(Ki(i).eq.4.5e-05)then
         Ss(i)=9.8e-03
   endif
555 continue
goto 555  
endif  
if(Ki(i).eq.95.0)then  
  Ss(i)=7.7e-06  
goto 555  
endif  
  if(Ki(i).eq.1.0e-02)then  
    Ss(i)=2.9e-04  
goto 555  
endif  
  if(Ki(i).eq.1.0e-02)then  
    Ss(i)=3.1e-03  
goto 555  
endif  
  if(Ki(i).eq.3.0e-01)then  
    Ss(i)=1.2e-03  
goto 555  
endif  
  if(Ki(i).eq.3.0e-07)then  
    Ss(i)=4.9e-06  
goto 555  
endif  
if(Ki(i).eq.1.0e-03)then  
  Ss(i)=5.9e-06  
goto 555  
endif  
  if(Ki(i).eq.3.0e-04)then  
    Ss(i)=5.9e-06  
goto 555  
endif  
  if(Ki(i).eq.3.2e+00)then  
    Ss(i)=7.1e-06  
goto 555  
endif  
  if(Ki(i).eq.1.0e-03)then  
    Ss(i)=6.8e-03  
goto 555  
endif  
if(Ki(i).eq.4.0e-05)then  
  Ss(i)=7.0e-06  
goto 555  
endif  
endif  

666   continue  
555   continue  

borep=bore(1)  
nb=1  
idummy=0  
do 888 i = 1, 10703  
if(drn(i).eq.-999.and.dcl(i).eq.-999) then  
goto 888  
else  
idummy=idummy+1  
endif  
if(idummy.eq.1.and.i.gt.1) then  
borep=bore(i)  
endif  

dtc(i)=dsf(i)-dcl(i)    !Depth to Calivil (Surface - Cal Residual)
\[
d tr(i) = dsf(i) - drn(i) \quad \text{! Depth to Renmark (Surface - Ren Residual)}
\]
\[
d dp(i) = td(i) - fd(i) \quad \text{! Difference in Depth (From depth-To depth)}
\]

if (borep.ne.bore(i)) then

  istb(nb) = istp
  intb(nb) = intp
  boreb(nb) = borep

  write(6,*)'nb =',nb
  borep= bore(i)

  UPPER SHEPPARTON
  If the sum of the transmissivity for Upper Shep is GT 0 AND the sum of
  the differences in depth in Upper Shep is GT 0 THEN
  if(sssus(nb).gt.0.and.sddus(nb).gt.0)then
  write (*,*) 'tell me sssus sddus',nb,borep,sssus(nb),sddus(nb)
  SSUS(nb)=sssus(nb)/sddus(nb)
  else
  SSUS(nb)=-999
  endif

  LOWER SHEPPARTON
  If the sum of the transmissivity for Lower Shep is GT 0 AND the sum of
  the differences in depth in Lower Shep is GT 0 THEN
  if(sssls(nb).gt.0.and.sddls(nb).gt.0)then
  SSLS(nb)=sssls(nb)/sddls(nb)
  else
  SSLS(nb)=-999
  endif

  CALIVIL
  If the sum of the transmissivity for Calivil is GT 0 AND the sum of
  the differences in depth in Calivil is GT 0 THEN
  if(ssscl(nb).gt.0.and.sddcl(nb).gt.0)then
  SSCL(nb)=ssscl(nb)/sddcl(nb)
  else
  SSCL(nb)=-999
  endif

  RENMARK
  If the sum of the transmissivity for Renmark is GT 0 AND the sum of
  the differences in depth in Renmark is GT 0 THEN calculate the sums of trans
  divided by the sums of differences
  ELSE, give the boreb(nb) a value of -999
  ie if there is no value >0 for Renmark for a bore, give the bore the value -999
  if(sssrn(nb).gt.0.and.sddrn(nb).gt.0)then
  SSRN(nb)=sssrn(nb)/sddrn(nb)
  else
  SSRN(nb)=-999
  endif
  nb=nb+1
endif

if (borep.eq.bore(i)) then
  if (ddp(i).lt.0) then
    write(10,79)bore(i),fd(i),td(i),ddp(i)
  endif
  format(a12,3f10.2)
endif

C UPPER SHEPPARTON
c If To Depth is less than or equal to 12(m) THEN
  if (td(i).le.12) then
    sddus(nb)=sddus(nb)+ddp(i)          !Sum all DeltaD to Up Shep
    sssus(nb)=Ss(i)*ddp(i)+sssus(nb)    !Sum of K * DeltaD + prev sum
  endif
  write(*,*) 'I am summing ddp & sddus',bore(i),ddp(i),sddus(nb)
endif

C LOWER SHEPPARTON
C If To Depth is greater than 12(m) AND less than the Depth to Calivil THEN
  if (td(i).gt.12.and.td(i).lt.dtc(i)) then
    sddls(nb)=sddls(nb)+ddp(i)          !Sum all DeltaD to Low Shep
    ssls(nb)=Ss(i)*ddp(i)+ssls(nb)      !Sum of K * DeltaD + prev sum
  endif

C CALIVIL
C If To Depth(Td) is greater than or equal to the Depth to Calivil (dtc) AND
  if the To Depth is less than the Depth to Renmark (dtr) THEN
    if(td(i).ge.dtc(i).and.td(i).lt.dtr(i)) then
      if(dcl(i).eq.-999) then
        goto 888
      endif
      sddcl(nb)=sddcl(nb)+ddp(i)           !Sum all DeltaD to Cal
      ssscl(nb)=Ss(i)*ddp(i)+sssc1(nb)     !Sum of K * DeltaD + prev
      endif
  endif

C RENMARK
C If To Depth is greater than the Depth to Renmark THEN
  if(td(i).gt.dtr(i)) then
    if(drn(i).eq.-999) then
      goto 888
    endif
    sddrn(nb)=sddrn(nb)+ddp(i)            !Sum all DeltaD to Ren
    sssrn(nb)=Ss(i)*ddp(i)+sssrnb      !Sum of K * DeltaD + prev
    endif
  endif

  if(sddls(nb).lt.0.or.sssls(nb).lt.0)then
    write(6,*') 'what the hell is this',bore(i),ddp(i),Ss(i)
  endif
endif

589 borep=bore(i)
iestp=iest(i)
inthp=inth(i)

888 Continue

do 999 i=1,nb-1
write(8,74) boreb(i),iestb(i),inthb(i),SSUS(i),SSLS(i),
x SSCL(i),SSRN(i)
74 format (a12,2i10,4e15.5)
write(9,76)boreb(i),sddus(i),sssus(i),sddls(i),
x sssls(i),sddcl(i),sssc1(i),sddrn(i),sssrn(i)
76 format(a12,2e15.5,f10.2,e15.5,f10.2,e15.5)
write(11,81)bore(i),fd(i),td(i),cdi(i),Ki(i),Ss(i)
81 format(a12,2f10.2,2x,a10,e15.5,2x,e15.5)
999 Continue
end

21.5.2 LIZSSALL.FOR

c Script for assigning the Specific Storage to all aquifers for Liz
(DLWC) data.
c The differences in depth are summed for each different soil type.
c Individual depths are multiplied by the Specific Storage for that
particular
c soil type, and then this value is divided by the total summed
difference
c in depth for that aquifer.
c This gives an averaged Specific Storage for each aquifer.
c Path: c:\Murrumbidgee\model\Fortran\DrillLogs\Specific Storage.
c Project: c:\Murrumbidgee\Model\Fortran\DrillLogs\Specific Storage.dsp
Program name: c:\Murrumbidgee\Model\Fortran\DrillLogs\Specific Storage\LizSsAll.for
Workspace: c:\Murrumbidgee\Model\Fortran\DrillLogs\DrillLogs.dsw
INPUT FILES(UNITs 4&5): c:\Murrumbidgee\Model\Fortran\DrillLogs\Specific Storage\*.*
OUTPUT(UNITs 8,9,10,11): c:\Murrumbidgee\Model\Fortran\DrillLogs\Specific Storage\Ss All Output

program LizSsAll
To define ARRAYS
Real, dimension(7657) :: fd,td,dcl,drn,dsf,
x Ki,Kj,dtc,dtr,ddp,Kk,Ss,ddpls,ddpus,tdd,ttcp,dtrp,dtls,dclp
real, dimension(442) :: sddcl,sddrn,sddus,sddls,sssc1,sssrn,
x sssus,ssssl
real, dimension(442) :: SSCL,SSRN,SSLS,SSUS
Integer, dimension(7657) :: iestb, inthb
Integer, dimension(7657) :: iest, inth
Character*12, dimension(7657) :: bore
Character*12, dimension(442) :: boreb
Character*40, dimension(7657) :: cdi, cdj, cdp
Character*10, dimension(7657) :: des
Character*12 borep

open (4, file='d2-9999.prn')
open (5, file='d2-Kcodes2.prn')
open (8, file='d2-SsAll.prn', status='replace')
open (9, file='d2-SsSAll.prn', status='replace')
open (10, file='d2-noSsAll.prn', status='replace')
open (11, file='d2-Ss&kAll.prn', status='replace')

write(8,78)
78 format('bore',11x,'iestb',5x,'inthb',10x,'SSUS',12x,'SSLS',10x,
c Initialise the dummy arrays

do 111 i=1,442
sddcl(i)=0         ! Sum of Difference in From To Depth Calivill
sddrn(i)=0         ! sum of difference in Fm To Depth Renmark
sddus(i)=0         ! sum of difference in Fm To Depth Upper Shep
sddls(i)=0         ! sum of difference in Fm To Depth Lower Shep
sssccl(i)=0       ! sum of transmissivity in Caliver aquifer
sssrn(i)=0        ! sum of transmissivity in Renmark aquifer
sssus(i)=0        ! sum of transmissivity in Upper Shep aquifer
ssssl(i)=0        ! sum of transmissivity in Lower Shep aquifer
111   continue

c     Read (i) file = d2-9999.prn

do 112 i=1,7657
read (4, 71) bore(i),fd(i),td(i),des(i),cdi(i),iest(i),inth(i),
x dcl(i),drn(i),dsf(i)
71    format (a12,2f10.2,a10,a40,i10,i10,f10.1,f10.1,f10.1)
c write(6,71) 'j=',j,cdj(j),Kj(j)
222   continue

c Assign K to d2-9999.prn (i) file from (j) file

do 333 i=1,7657
do 444 j=1,2571
if (cdi(i).eq.cdj(j)) then
Ki(i)=Kj(j)
goto 333
endif
444   continue
333   continue

c     DO LOOP to circle thru the total file (d2-9999.prn) and assign Sy-

values.

do 555 i=1,7657

do 666 j=1,2571

write(*,*),'tell me ',i

if (cdi(i).eq.cdj(j)) then
    if(Ki(i).eq.1.0e-04) then
        Ss(i)=6.8e-06
    endif
666   continue
555   continue
endif
    if(Ki(i).eq.9.0e-06)then
        Ss(i)=2.1e-04
        goto 555
    endif
    if(Ki(i).eq.4.5e-05)then
        Ss(i)=9.8e-03
        goto 555
    endif
    if(Ki(i).eq.95.0)then
        Ss(i)=7.7e-06
        goto 555
    endif
    if(Ki(i).eq.1.0e-02)then
        Ss(i)=2.9e-04
        goto 555
    endif
    if(Ki(i).eq.1.0e-02)then
        Ss(i)=3.1e-03
        goto 555
    endif
    if(Ki(i).eq.3.0e-01)then
        Ss(i)=1.2e-03
        goto 555
    endif
    if(Ki(i).eq.3.0e-07)then
        Ss(i)=4.9e-06
        goto 555
    endif
    if(Ki(i).eq.1.0e-03)then
        Ss(i)=5.9e-06
        goto 555
    endif
    if(Ki(i).eq.3.0e-04)then
        Ss(i)=5.9e-06
        goto 555
    endif
    if(Ki(i).eq.3.2e+00)then
        Ss(i)=7.1e-06
        goto 555
    endif
    if(Ki(i).eq.1.0e-03)then
        Ss(i)=6.8e-03
        goto 555
    endif
    if(Ki(i).eq.4.0e-05)then
        Ss(i)=7.0e-06
        goto 555
    endif
endif

666   continue
555   continue
borep=bore(1)
b=1
idummy=0
do 888 i = 1, 7657
if(drn(i).eq.-999.and.dcl(i).eq.-999) then
    goto 888
else
idummy=idummy+1
endif
if(idummy.eq.1.and.i.gt.1) then
  borep=bore(i)
endif
dtc(i)=dsf(i)-dcl(i)    !Depth to Calivil (Surface - Cal Residual)
dtr(i)=dsf(i)-drn(i)    !Depth to Renmark (Surface - Ren Residual)
ddp(i)=td(i)-fd(i)      !Difference in Depth (From depth-To depth)
if (borep.ne.bore(i))then
  iestb(nb)=iestp
  inthb(nb)=inthp
  boreb(nb)=borep
  c     write(6,*)'nb =',nb
  borep= bore(i)
  c     UPPER SHEPPARTON
  c     If the sum of the transmissivity for Upper Shep is GT 0 AND the sum of the differences in depth in Upper Shep is GT 0 THEN
  if(sssus(nb).gt.0.and.sddus(nb).gt.0)then
    c     write (*,*), 'tell me sssus sddus',nb,borep,sssus(nb),sddus(nb)
    SSUS(nb)=sssus(nb)/sddus(nb)
    else
      SSUS(nb)=-999
    endif
  c     LOWER SHEPPARTON
  c     If the sum of the transmissivity for Lower Shep is GT 0 AND the sum of the differences in depth in Lower Shep is GT 0 THEN
  if(sssls(nb).gt.0.and.sddls(nb).gt.0)then
    SSLS(nb)=sssls(nb)/sddls(nb)
    else
      SSLS(nb)=-999
    endif
  c     CALIVIL
  c     If the sum of the transmissivity for Calivil is GT 0 AND the sum of the differences in depth in Calivil is GT 0 THEN
  if(ssscl(nb).gt.0.and.sddcl(nb).gt.0)then
    c          write (*,*), 'tell me sssus sddus',nb,ssscl(nb),sddcl(nb)
    SSCL(nb)=ssscl(nb)/sddcl(nb)
    else
      SSCL(nb)=-999
    endif
  c     RENMARK
  c     If the sum of the transmissivity for Renmark is GT 0 AND the sum of the differences in depth in Renmark is GT 0 THEN calculate the sums of trans divided by the sums of differences
  c     ELSE, give the boreb(nb) a value of -999
  c     ie if there is no value >0 for Renmark for a bore, give the bore the value -999
```fortran
if (sssrn(nb).gt.0.and.sddrn(nb).gt.0) then
  SSRN(nb)=sssrn(nb)/sddrn(nb)
else
  SSRN(nb)=-999
endif

nb=nb+1
endif

if (borep.eq.bore(i)) then
  if (ddp(i).lt.0) then
    write(10,79)bore(i),fd(i),td(i),ddp(i)
  endif

79     format(a12,3f10.2)
endif

C     UPPER SHEPPARTON
C     If To Depth is less than or equal to 12(m) THEN
    if (td(i).le.12) then
      sddus(nb)=sddus(nb)+ddp(i)          !Sum all DeltaD to Up Shep
      sssus(nb)=Ss(i)*ddp(i)+sssus(nb)    !Sum of K * DeltaD + prev sum
    endif
    write(*,*),'I am summing ddp & sddus',bore(i),ddp(i),sddus(nb)
endif

C     LOWER SHEPPARTON
C     If To Depth is greater than 12(m) AND less than the Depth to Calivil
    THEN
    if (td(i).gt.12.and.td(i).lt.dtc(i)) then
      sddls(nb)=sddls(nb)+ddp(i)          !Sum all DeltaD to Low Shep
      ssssl(nb)=Ss(i)*ddp(i)+ssssl(nb)    !Sum of K * DeltaD + prev sum
    endif
endif

C     CALIVIL
C     If To Depth(Td) is greater than or equal to the Depth to Calivil
(dtc) AND
C     if the To Depth is less than the Depth to Renmark (dtr) THEN
    if(td(i).ge.dtc(i).and.td(i).lt.dtr(i)) then
      if(dcl(i).eq.-999) then
        goto 888
      endif
      sddcl(nb)=sddcl(nb)+ddp(i)           !Sum all DeltaD to Cal
      ssscl(nb)=Ss(i)*ddp(i)+sssccl(nb)    !Sum of K * DeltaD + prev
    endif
endif

C     RENMARK
C     If To Depth is greater than the Depth to Renmark THEN
    if(td(i).gt.dtr(i)) then
      if(drn(i).eq.-999) then
        goto 888
      endif
      sddrn(nb)=sddrn(nb)+ddp(i)            !Sum all DeltaD to Ren
      sssrn(nb)=Ss(i)*ddp(i)+sssrn(nb)      !Sum of K * DeltaD + prev
    endif
endif

C     if(sddls(nb).lt.0.or.sssls(nb).lt.0)then
C     write(6,*), 'what the hell is this',bore(i),ddp(i),Ss(i)
C     endif
endif
```
borep=bore(i)  
iestp=iest(i)  
inthp=inth(i)  

Continue

do 999 i=1,nb-1
  write(8,74) boreb(i),iestb(i),inthb(i),SSUS(i),SSLS(i),
  x SSCL(i),SSRN(i)
74  format (a12,2i10,4e15.5)
  write(9,76)boreb(i),sddus(i),sssus(i),sddls(i),
  x sssls(i),sddcl(i),sssc1(i),sddrn(i),sssrn(i)
76  format(a12,2e15.5,f10.2,e15.5,f10.2,e15.5)
write(11,81)bore(i),fd(i),td(i),cdi(i),Ki(i),Ss(i)
81  format(a12,2f10.2,2x,a10,e15.5,2x,e15.5)
999  Continue
end

21.5.3 MIRROOLOSSALL.FOR

c Script for assigning the Specific Storage to all aquifers for Mirrool
data.
c The differences in depth are summed for each different soil type.
c Individual depths are multiplied by the Specific Storage for that
particular
c soil type, and then this value is divided by the total summed
difference
c in depth for that aquifer.
c This gives an averaged Specific Storage for each aquifer.
c Path:  c:\Murrumbidgee\model\Fortran\DrillLogs\Specific Storage.
c Project:  c:\Murrumbidgee\Model\Fortran\DrillLogs\Specific Storage.dsp

program MirroolSsAll
  To define ARRAYS
  Real, dimension(12271) :: fd,td,dcl,drn,dsf,
  x Ki,Kj,dtc,dtr,ddp,Kk,Ss,ddpls,ddpus,tcp,dtcp,dtrp,dtls,dclp
  real, dimension(673) :: sddcl,sddrn,sddus,sddls,sssc1,sssrn,
  x sssus,sssls
  real, dimension(673) :: SSCL,SSRN,SSLS,SSUS
  Integer, dimension(673) :: iestb, inthb
  Integer, dimension(12271) :: iest, inth
  Character*10, dimension(12271) :: bore
  Character*10, dimension(673) :: boreb
  Character*40, dimension(12271) :: cdi, cdj, cdp

  Program name: c:\Murrumbidgee\Model\Fortran\DrillLogs\Specific Storage\MirroolSsAll.f
Character*22, dimension(12271) :: des
Character*10 borep

open (4, file='d3-9999.prn')
open (5, file='d3-Kcodes2.prn')
open (8, file='d3-SsAll.prn', status='replace')
open (9, file='d3-SsALL.prn', status='replace')
open (10, file='d3-noSsAll.prn', status='replace')
open (11, file='d3-Ss&kAll.prn', status='replace')

write(8,78)
78    format('bore',11x,'iestb',5x,'inthb',10x,'SSUS',12x,'SSLs',10x,
           X'SSCL',12X,'SSRN')
write(9,77)
77    format('bore',14x,'sddUS',11x,'sssUS',8X,'sddLS',7X,'sssLS',8X,
           X 'sddc1',7x,'sssCL',8x,'sddrn',6X,'sssRN')
write(11,80)
80 format('bore',15x,'fd',8x,'td',6x,'cd',12x,'ki',15x,'ss')

c     Initialise the dummy arrays

do 111 i=1,673
sddcl(i)=0         ! Sum of Difference in From To Depth Calivil
sddrn(i)=0         ! sum of difference in Fm To Depth Renmark
sddus(i)=0         ! sum of difference in Fm To Depth Upper Shep
sddls(i)=0         ! sum of difference in Fm To Depth Lower Shep
sssccl(i)=0          ! sum of transmissivity in Caliver aquifer
ssssrn(i)=0          ! sum of transmissivity in Renmark aquifer
sssus(i)=0          ! sum of transmissivity in Upper Shep aquifer
ssssl(i)=0          ! sum of transmissivity in Lower Shep aquifer
111      continue

c     Read (i) file = d3-9999.prn
do 112 i=1,12271
read (4, 71) bore(i),fd(i),td(i),des(i),cdi(i),iest(i),inth(i),
           x dcl(i),drn(i),dsf(i)
71    format (a10,2f10.2,a22,a40,i10,i10,f10.1,f10.1,f10.1)
c write(6,*) i
112      continue

c     Read (j) file = d3-Kcodes.prn
do 222 j=1,2514
read (5, 72) cdj(j),Kj(j)
72    format (a40,e10.2)
c write(6,72) 'j=',j,cdj(j),Kj(j)
222      continue

c     Assign K to d3-9999.prn (i) file from (j) file
do 333 i=1,12271
do 444 j=1,2514
   if (cdi(i).eq.cdj(j)) then
      Ki(i)=Kj(j)
goto 333
endif
444      continue
333      continue
c     DO LOOP to circle thru the total file (d3-9999.prn) and assign Sy-values.

do 555 i=1,12271
do 666 j=1,2514

c     write(*,*)'tell me ',i
    if (cdi(i).eq.cdj(j)) then
        if(Ki(i).eq.1.0e-04)then  
            Ss(i)=6.8e-06
            goto 555
        endif
        if(Ki(i).eq.9.0e-06)then
            Ss(i)=2.1e-04
            goto 555
        endif
        if(Ki(i).eq.4.5e-05)then
            Ss(i)=9.8e-03
            goto 555
        endif
        if(Ki(i).eq.95.0)then
            Ss(i)=7.7e-06
            goto 555
        endif
        if(Ki(i).eq.1.0e-02)then
            Ss(i)=2.9e-04
            goto 555
        endif
        if(Ki(i).eq.1.0e-02)then
            Ss(i)=3.1e-03
            goto 555
        endif
        if(Ki(i).eq.3.0e-01)then
            Ss(i)=1.2e-03
            goto 555
        endif
        if(Ki(i).eq.3.0e-07)then
            Ss(i)=4.9e-06
            goto 555
        endif
        if(Ki(i).eq.1.0e-03)then
            Ss(i)=5.9e-06
            goto 555
        endif
        if(Ki(i).eq.3.0e-04)then
            Ss(i)=5.9e-06
            goto 555
        endif
        if(Ki(i).eq.3.2e+00)then
            Ss(i)=7.1e-06
            goto 555
        endif
        if(Ki(i).eq.1.0e-03)then
            Ss(i)=6.8e-03
            goto 555
        endif
        if(Ki(i).eq.4.0e-05)then
            Ss(i)=7.0e-06
            goto 555
    endif
endif
endif

666 continue
555 continue

borep=bore(1)
 nb=1
 idummy=0
 do 888 i = 1, 12271
 if(drn(i).eq.-999.and.dcl(i).eq.-999) then
 goto 888
 else
 idummy=idummy+1
 endif
 if(idummy.eq.1.and.i.gt.1) then
 borep=bore(i)
 endif

dtc(i)=dsf(i)-dcl(i) !Depth to Calivil (Surface - Cal Residual)
dtr(i)=dsf(i)-drn(i) !Depth to Renmark (Surface - Ren Residual)
ddp(i)=td(i)-fd(i) !Difference in Depth (From depth-To depth)

if (borep.ne.bore(i)) then

 iestb(nb)=iestp
 inthb(nb)=inthp
 boreb(nb)=borep
 write(6,*),'nb = ',nb
 borep= bore(i)

 c UPPER SHEPPARTON
 c If the sum of the transmissivity for Upper Shep is GT 0 AND the sum
 of
 c the differences in depth in Upper Shep is GT 0 THEN
 if(sssus(nb).gt.0.and.sddus(nb).gt.0)then
 c write (*,*),'tell me sssus sddus',nb,borep,sssus(nb),sddus(nb)
 SSUS(nb)=sssus(nb)/sddus(nb)
 else
 SSUS(nb)=-999
 endif

 c LOWER SHEPPARTON
 c If the sum of the transmissivity for Lower Shep is GT 0 AND the sum
 of the
 c differences in depth in Lower Shep is GT 0 THEN

 if(sssln(nb).gt.0.and.sddls(nb).gt.0)then
 SSLS(nb)=sssls(nb)/sddls(nb)
 else
 SSLS(nb)=-999
 endif

 c CALIVIL
 c If the sum of the transmissivity for Calivil is GT 0 AND the sum of the
 c differences in depth in Calivil is GT 0 THEN
 if(ssscl(nb).gt.0.and.sddcl(nb).gt.0)then
 c write (*,*),'tell me sssus sddus',nb,ssscl(nb),sddcl(nb)
 SSCL(nb)=sssc1(nb)/sddcl(nb)
 else

SSCL(nb)=-999
endif

C RENMARK
C If the sum of the transmissivity for Renmark is GT 0 AND the sum of the
differences in depth in Renmark is GT 0 THEN calculate the sums of trans
divided by the sums of differences
C ELSE, give the boreb(nb) a value of -999
C ie if there is no value >0 for Renmark for a bore, give the bore the
value -999
if(ssrn(nb).gt.0.and.sddrn(nb).gt.0)then
SSRN(nb)=sssrn(nb)/sddrn(nb)
else
SSRN(nb)=-999
endif
nb=nb+1
endif

if (borep.eq.bore(i)) then
if (ddp(i).lt.0) then
write(10,79)bore(i),fd(i),td(i),ddp(i)
79     format(a12,3f10.2)
endif
C UPPER SHEPPARTON
C If To Depth is less than or equal to 12(m) THEN
if (td(i).le.12) then
sddus(nb)=sddus(nb)+ddp(i)    !Sum all DeltaD to Up Shep
sssus(nb)=Ss(i)*ddp(i)+sssus(nb)    !Sum of K * DeltaD + prev sum
write(*,*) 'I am summing ddp & sddus',bore(i),ddp(i),sddus(nb)
endif
C LOWER SHEPPARTON
C If To Depth is greater than 12(m) AND less than the Depth to Calivil
THEN
if (td(i).gt.12.and.td(i).lt.dtc(i)) then
sddl(nb)=sddl(nb)+ddp(i)       !Sum all DeltaD to Low Shep
ssssl(nb)=Ss(i)*ddp(i)+ssssl(nb)       !Sum of K * DeltaD + prev sum
endif
C CALIVIL
C If the To Depth is greater than or equal to the Depth to Calivil (dtc) AND
C if the To Depth is less than the Depth to Renmark (dtr) THEN
if(td(i).ge.dtc(i).and.td(i).lt.dtr(i)) then
if(dcl(i).eq.-999) then
goto 888
endif
sddcl(nb)=sddcl(nb)+ddp(i)       !Sum all DeltaD to Cal
sssccl(nb)=Ss(i)*ddp(i)+sssccl(nb)       !Sum of K * DeltaD + prev sum
endif
C RENMARK
C If To Depth is greater than the Depth to Renmark THEN
if(td(i).gt.dtr(i)) then
if(drn(i).eq.-999) then  
goto 888  
endif  
sddrn(nb)=sddrn(nb)+ddp(i)  !Sum all DeltaD to Ren  
sssrn(nb)=Ss(i)*ddp(i)+sssrn(nb)  !Sum of K * DeltaD + prev sum  
endif

if(sddls(nb).lt.0.or.sssls(nb).lt.0) then
  c   write(6,*) 'what the hell is this',bore(i),ddp(i),Ss(i)
c endif
end

589 borep=bore(i)  
iestp=iest(i)  
inthp=inth(i)  

888 Continue

do 999 i=1,nb-1

write(8,74) boreb(i),iestb(i),inthb(i),SSUS(i),SSLS(i),  
x SSCL(i),SSRN(i)  
74 format (a12,2i10,4e15.5)  
write(9,76)bore(i),sddus(i),sssus(i),sddls(i),  
x sssls(i),sddcl(i),sssc(i),sddrn(i),sssrn(i)  
76 format(a12,2e15.5,f10.2,e15.5,f10.2,e15.5,f10.2,e15.5)  
write(11,81)bore(i),fd(i),td(i),cdi(i),Ki(i),Ss(i)  
81 format(a12,2f10.2,2x,a10,e15.5,2x,e15.5)

999 Continue
end

21.5.4 YANCOSSALL.FOR

Script for assigning the Specific Storage to all aquifers for Yanco data.  
The differences in depth are summed for each different soil type.  
Individual depths are multiplied by the Specific Storage for that particular  
soil type, and then this value is divided by the total summed difference  
in depth for that aquifer.  
This gives an averaged Specific Storage for each aquifer.
Path: c:\Murrumbidgee\model\Fortran\DrillLogs\Specific Storage.
Project: c:\Murrumbidgee\Model\Fortran\DrillLogs\Specific Storage.dsp
Program name: c:\Murrumbidgee\Model\Fortran\DrillLogs\Specific Storage\YancoSsAll.for
Workspace: c:\Murrumbidgee\Model\Fortran\DrillLogs\DrillLogs.dsw
INPUT FILES(UNITS 4&5):
c:\Murrumbidgee\Model\Fortran\DrillLogs\Specific Storage\*.*
OUTPUT(UNITS 8,9,10,11): c:\Murrumbidgee\Model\Fortran\DrillLogs\Specific Storage\Ss All Output
program YancoSsAll
To define ARRAYs
Real, dimension(6536) :: fd,td,dcl,drn,dsf,
  x Kj,Kj,dc,dr,dp,Kk,Sa,ddpl,ddpu,tdp,dtcp,dtrp,dtls,dclp
real, dimension(1000) :: sddcl,sddrn,sddus,sddls,sscl,ssrn,
X ssus,ssls
real, dimension(1000) :: SSCL,SSRN,SSLS,SSUS
Integer, dimension(1000) :: iestb, inthb
Integer, dimension(6536) :: iest, inth
Character*10, dimension(6536) :: bore
Character*10, dimension(1000) :: boreb
Character*40, dimension(6536) :: cdi, cdj, cdp
Character*22, dimension(6536) :: des
Character*10 borep

open (4, file='d4-9999.prn')
open (5, file='d4-Kcodes2.prn')
open (8, file='d4-SsAll.prn', status='replace')
open (9, file='d4-SsSAll.prn', status='replace')
open (10, file='d4-noSsAll.prn', status='replace')
open (11, file='d4-Ss&kAll.prn', status='replace')

write(8,78)
78 format('bore',11x,'iestb',5x,'inthb',10x,'SSUS',12x,'SSLS',10X,
X 'SSCL',12X,'SSRN')
write(9,77)
77    format('bore',14x,'sddUS',11x,'sssUS',8X,'sddLS',7X,'sssLS',8X,
X 'sddcl',7x,'sssCL',8x,'sddrn',6X,'sssRN')
write(11,80)
80 format('bore',15x,'fd',8x,'td',6x,'cd',12x,'ki',15x,'ss')
c Initialise the dummy arrays
do 111 i=1,1000
  sddcl(i)=0         ! Sum of Difference in From To Depth Calivil
  sddrn(i)=0         ! sum of difference in Fm To Depth Renmark
  sddus(i)=0         ! sum of difference in Fm To Depth Upper Shep
  sddls(i)=0         ! sum of difference in Fm To Depth Lower Shep
  ssscl(i)=0          ! sum of transmissivity in Caliver aquifer
  sssrn(i)=0          ! sum of transmissivity in Renmark aquifer
  sssus(i)=0          ! sum of transmissivity in Upper Shep aquifer
  sssl(i)=0          ! sum of transmissivity in Lower Shep aquifer
111 continue
c Read (i) file = d4-9999.prn
do 112 i=1,6536
  read (4, 71) bore(i),fd(i),td(i),des(i),cdi(i),iest(i),inth(i),
x dcl(i),drn(i),dsf(i)
71    format (a10,2f10.2,a22,a40,i10,i10,f10.1,f10.1,f10.1)
c write(6,*) i
112 continue
c Read (j) file = d4-Kcodes.prn
do 222 j=1,434
  read (5, 72) cdj(j),Kj(j)
72    format (a40,e10.2)
c write(6,72) 'j=',j,cdj(j),Kj(j)
222 continue
c Assign K to d4-9999.prn (i) file from (j) file
do 333 i=1,6536
  do 444 j=1,434

if (cdi(i).eq.cdj(j)) then
  Ki(i)=Kj(j)
goto 333
endif

444 continue
333 continue

c DO LOOP to circle thru the total file (d4-9999.prn) and assign Sy-values.

do 555 i=1,6536
  do 666 j=1,434
    c write(*,*)'tell me ',i
    if (cdi(i).eq.cdj(j)) then
      if(Ki(i).eq.1.0e-04)then
        Ss(i)=6.8e-06
        goto 555
      endif
      if(Ki(i).eq.9.0e-06)then
        Ss(i)=2.1e-04
        goto 555
      endif
      if(Ki(i).eq.4.5e-05)then
        Ss(i)=9.8e-03
        goto 555
      endif
      if(Ki(i).eq.95.0)then
        Ss(i)=7.7e-06
        goto 555
      endif
      if(Ki(i).eq.1.0e-02)then
        Ss(i)=2.9e-04
        goto 555
      endif
      if(Ki(i).eq.1.0e-02)then
        Ss(i)=3.1e-03
        goto 555
      endif
      if(Ki(i).eq.3.0e-01)then
        Ss(i)=1.2e-03
        goto 555
      endif
      if(Ki(i).eq.3.0e-07)then
        Ss(i)=4.9e-06
        goto 555
      endif
      if(Ki(i).eq.3.2e+00)then
        Ss(i)=7.1e-06
        goto 555
      endif
    endif
  enddo
enddo

goto 555
endif
if(Ki(i).eq.1.0e-03)then
Ss(i)=6.8e-03
goto 555
endif
if(Ki(i).eq.4.0e-05)then
Ss(i)=7.0e-06
goto 555
endif
endif

666 continue
555 continue

borep=bore(1)
b=1
idummy=0
do 888 i = 1, 6536
if(drn(i).eq.-999.and.dcl(i).eq.-999) then
goto 888
else
idummy=idummy+1
endif
if(idummy.eq.1.and.i.gt.1) then
borep=bore(i)
endif
dtc(i)=dsf(i)-dcl(i) !Depth to Calivil (Surface - Cal Residual)
dtr(i)=dsf(i)-drn(i) !Depth to Renmark (Surface - Ren Residual)
ddp(i)=td(i)-fd(i) !Difference in Depth (From depth-To depth)

if (borep.ne.bore(i))then
iestb(nb)=iestp
inthb(nb)=inthp
boreb(nb)=borep
write(6,*)'nb =',nb
borep= bore(i)
endif

c UPPER SHEPPARTON
c If the sum of the transmissivity for Upper Shep is GT 0 AND the sum
of the differences in depth in Upper Shep is GT 0 THEN
if(sssus(nb).gt.0.and.sddus(nb).gt.0)then
write (*,*)'tell me sssus sddus',nb,borep,sssus(nb),sddus(nb)
SSUS(nb)=sssus(nb)/sddus(nb)
else
SSUS(nb)=-999
endif

C LOWER SHEPPARTON
C If the sum of the transmissivity for Lower Shep is GT 0 AND the sum
of the differences in depth in Lower Shep is GT 0 THEN
if(sssln(nb).gt.0.and.sddls(nb).gt.0)then
SSLN(nb)=sslss(nb)/sddls(nb)
else
SSLN(nb)=-999
endif
C     CALIVIL
C     If the sum of the transmissivity for Calivil is GT 0 AND the sum of
C     the differences in depth in Calivil is GT 0 THEN
C     if(ssscl(nb).gt.0.and.sddcl(nb).gt.0)then
          write (*,*), 'tell me sssus sddus',nb,ssscl(nb),sddcl(nb)
          SCCL(nb)=ssscl(nb)/sddcl(nb)
else
          SCCL(nb)=-999
endif
C     RENMARK
C     If the sum of the transmissivity for Renmark is GT 0 AND the sum of
C     the differences in depth in Renmark is GT 0 THEN calculate the sums of
C     divided by the sums of differences
C     ELSE, give the bore(b) a value of -999
C     ie if there is no value >0 for Renmark for a bore, give the bore the
C     value -999
        if(sssrn(nb).gt.0.and.sddrn(nb).gt.0)then
          SSRN(nb)=sssrn(nb)/sddrn(nb)
else
          SSRN(nb)=-999
endif
        nb=nb+1
    endif

    if (borep.eq.bore(i)) then

        if (ddp(i).lt.0) then
          write(10,79)bore(i),fd(i),td(i),ddp(i)
    79     format(a12,3f10.2)
        endif
    endif
C     UPPER SHEPPARTON
C     If To Depth is less than or equal to 12(m) THEN
    if (td(i).le.12) then
      sddus(nb)=sddus(nb)+ddp(i)          !Sum all DeltaD to Up Shep
      sssus(nb)=s(i)*ddp(i)+sssus(nb)    !Sum of K * DeltaD + prev sum
      write(*,*) 'I am summing ddp & sddus',bore(i),ddp(i),sddus(nb)
    endif
C     LOWER SHEPPARTON
C     If To Depth is greater than 12(m) AND less than the Depth to Calivil
    then
    if (td(i).gt.12.and.td(i).lt.dtc(i)) then
      sddls(nb)=sddls(nb)+ddp(i)          !Sum all DeltaD to Low Shep
      sssls(nb)=s(i)*ddp(i)+ssssl(nb)    !Sum of K * DeltaD + prev sum
      endif
C     CALIVIL
C     If To Depth(Td) is greater than or equal to the Depth to Calivil
    (dtc) AND
C     if the To Depth is less than the Depth to Renmark (dtr) THEN
    if(td(i).ge.dtc(i).and.td(i).lt.dtr(i)) then
      if(dcl(i).eq.-999) then
        goto 888

endif
sddcl(nb)=sddcl(nb)+ddp(i)           !Sum all DeltaD to Cal
sssc1(nb)=Ss(i)*ddp(i)+sssc1(nb)     !Sum of K * DeltaD + prev
sum
    endif

C     RENMARK
C     If To Depth is greater than the Depth to Renmark THEN
if(td(i).gt.dtr(i)) then
    if(drn(i).eq.-999) then
        goto 888
    endif
sddrn(nb)=sddrn(nb)+ddp(i)            !Sum all DeltaD to Ren
sssrn(nb)=Ss(i)*ddp(i)+sssrn(nb)      !Sum of K * DeltaD + prev
sum
endif

C          if(sddls(nb).lt.0.or.sssls(nb).lt.0)then
C          write(6,*) 'what the hell is this',bore(i),ddp(i),Ss(i)
C     endif
endif
589 borep=bore(i)
iestp=iest(i)
inthp=inth(i)
888 Continue

do 999 i=1,nb-1
    write(8,74) boreb(i),iestb(i),inthb(i),SSUS(i),SSLS(i),
           x SSCL(i),SSRN(i)
    write(9,76) boreb(i),sddus(i),sssus(i),sddls(i),
           x ssssl(i),sddcl(i),sssc1(i),sddrn(i),sssrn(i)
    write(11,81) bore(i),fd(i),td(i),cdi(i),Ki(i),Ss(i)
999 Continue
end
### 21.6 Program for assigning the Specific Yield to up to 5m below the surface and then between 5 and 10m below the surface

#### 21.6.1 ARYSYSTO10.FOR

```fortran
program ArySy5to10
  ! To define ARRAYS
  Real, dimension(10703) :: fd, td, dcl, drn, dsf,
  x Ki, Kj, dtc, dtr, ddp, Sy, Kk, Syk, Ss
  real, dimension(1425) :: sdd5, sdd10, ssy5, ssy10
  real, dimension(1425) :: SY5, SY10
  Integer, dimension(1425) :: iestb, inthb
  Integer, dimension(10703) :: iest, inth
  Character*12, dimension(10703) :: bore, borep
  Character*12, dimension(1425) :: boreb
  Character*10, dimension(10703) :: cdi, cdj, cdp
  Character*22, dimension(10703) :: des
  Character*12 borep

  open (4, file='d1-9999.prn')
  open (5, file='d1-Kcodes.prn')
  open (7, file='KandSy.prn')
  open (8, file='d1-Sy5to10.prn', status='replace')
  open (9, file='d1-SySUMs.prn', status='replace')
  open (10, file='d1-noSy.prn', status='replace')
  open (11, file='d1-sy&k.prn', status='replace')

  write(8,78)
  78 format('bore',11x,'iestb',5x,'inthb',10x,'SY5',12x,'SY10')
  write(9,77)
  77 format('bore',11x,'sdd5',11x,'SSY5',9X,'sdd10',9X,'SSY10')
  write(11,80)
  80 format('bore',15x,'fd',8x,'td',6x,'cd',12x,'ki',15x,'sy',12x,'ss')
```

---

The text continues with detailed assignments and calculations for the specific yield, including script definitions, input and output files, and the actual Fortran code for the program. The script assigns specific yields based on depth intervals below the surface and calculates the averaged specific yield for different soil types. It also involves reading and writing data from and to various files, which are specified in the program's input and output declarations.
c Initialise the dummy arrays

do 111 i=1,1425
sdd5(i)=0 ! Sum of Difference in From To Depth LE 5m
sdd10(i)=0 ! sum of difference in Fm To GT 5m LE 10m
ssy5(i)=0 ! sum of Specific Yield in LE 5m
ssy10(i)=0 ! sum of Specific Yield in GT 5m LE 10m
111 continue

c Read (i) file = d1-9999.prn

do 112 i=1,10703
read (4,71) bore(i),fd(i),td(i),des(i),
  x cdi(i),iest(i),inth(i),dcl(i),drn(i),dsf(i)
71    format (a12,f10.2,f10.2,a22,a10,i10,i10,f10.1,f10.1,f10.1)
c write(6,*) i
112 continue

c Read (j) file = d1-Kcodes.prn

do 222 j=1,87
read (5, 72) cdj(j),Kj(j)
72    format (a10,e10.2)
c write(6,72) 'j=',j,cdj(j),Kj(j)
222 continue

c Read (k) file = KandSy.prn

do 777 k=1,13
read (7,82) Kk(k),Syk(k)
82 format (e10.2,f10.3)
c write(6,82) Kk(k),Syk(k)
777 continue

c Assign K to d1-9999.prn (i) file from (j) file

do 333 i=1,10703
  do 444 j=1,87
    if (cdi(i).eq.cdj(j)) then
      Ki(i)=Kj(j)
goto 333
    endif
  444   continue
333 continue

c DO LOOP to circle thru the total file (d1-9999.prn) and assign Sy-values
  from the file (KandSy.prn). If the K-value in the total file
  are x , then assign the Specific yield field (Sy) in
  the total data set.

do 555 i=1,10703
  write(*,*)'tell me ','i
    if(Ki(i).eq.1.0e-04)then
      Sy(i)=0.05
    endif
    if(Ki(i).eq.9.0e-06)then
      Sy(i)=0.055
    endif
  555 continue
if(Ki(i).eq.4.5e-05)then
  Sy(i)=0.1
endif
if(Ki(i).eq.95.0)then
  Sy(i)=0.11
endif
if(Ki(i).eq.1.0e-02)then
  Sy(i)=0.055
endif
if(Ki(i).eq.1.0e-02)then
  Sy(i)=0.21
endif
if(Ki(i).eq.3.0e-01)then
  Sy(i)=0.11
endif
if(Ki(i).eq.3.0e-07)then
  Sy(i)=0.03
endif
if(Ki(i).eq.1.0e-03)then
  Sy(i)=0.065
endif
if(Ki(i).eq.3.0e-04)then
  Sy(i)=0.13
endif
if(Ki(i).eq.3.2e+00)then
  Sy(i)=0.19
endif
if(Ki(i).eq.1.0e-03)then
  Sy(i)=0.06
endif
if(Ki(i).eq.4.0e-05)then
  Sy(i)=0.055
endif

      continue

borep=bore(1)
b=1
idummy=0
do 888 i = 1, 10703
  if(drn(i).eq.-999.and.dcl(i).eq.-999) then
    goto 888
  else
    idummy=idummy+1
  endif
888  borep=bore(i)
ddp(i)=td(i)-fd(i) ; !Difference in Depth (From depth-To depth)
if (borep.ne.bore(i))then
  iestb(nb)=iestp
  inthb(nb)=inthp
  boreb(nb)=borep
  write(6,*)'nb =',nb
  borep= bore(i)
endif

      LESS THAN OR EQUAL TO 5M BELOW SURFACE
      If the sum of the Specific yield (ssy5) for depth below surface is LT or EQ to 0 AND
if (ssy5(nb).gt.0.and.sdd5(nb).gt.0) then
    c     write (*,*) 'tell me ssy5 sdd5',nb,borep,ssy5(nb),ssy10(nb)
    SY5(nb)=ssy5(nb)/sdd5(nb)
else
    SY5(nb)=-999
endif

if (ssy10(nb).gt.0.and.sdd10(nb).gt.0) then
    c     write (*,*) 'tell me ssy10 sdd10',nb,borep,ssy10(nb),sdd10(nb)
    SY10(nb)=ssy10(nb)/sdd10(nb)
else
    SY10(nb)=-999
endif

borep=bore(i)
iestp=iest(i)
inthp=inth(i)
888 Continue

end
21.6.2 LIZSY5TO10.FOR

c     Script for assigning the Specific Yield to up to 5m below the surface
and then between 5 and 10m below the surface for Liz (DLWC ) data.
The differences in depth are summed for each different soil type.
Individual depths are multiplied by the specific yield for that particular
soil type, and then this value is divided by the total summed
difference in depth for that overall depth (ie to 5m and then 5 to 10m).
This gives an averaged specific yield for the two depths.
Path:  c:\Murrumbidgee\model\Fortran\DrillLogs\Specific Yield.
Project:  c:\Murrumbidgee\Model\Fortran\DrillLogs\Specific Yield.dsp
Program name:  c:\Murrumbidgee\Model\Fortran\DrillLogs\Specific Yield\LizKnested.for
Workspace:  c:\Murrumbidgee\Model\Fortran\DrillLogs\DrillLogs.dsw
INPUT FILES (UNITS 4&5):
c:\Murrumbidgee\Model\Fortran\DrillLogs\Specific Yield\*.*
INPUT FILE (UNIT 7):  c:\Murrumbidgee\Model\KandSy.prn, and also
c:\Murrumbidgee\Model\Fortran\DrillLogs\Specific Yield\*.*
OUTPUT(UNITS 8,9,10,11):  c:\Murrumbidgee\Model\Fortran\DrillLogs\Specific Yield\Final Trans Output

program LizSy5sto10
To define ARRAYs
Real, dimension(7657) :: fd,td,dcl,drn,dsf,
x Ki, Kj,dtc,dtr,ddp,Sy,Kk,Syk
real, dimension(442) :: sdd5,sdd10,ssy5,ssy10
real, dimension(442) :: SY5,SY10
Integer, dimension(442) :: iestb, inthb
Integer, dimension(7657) :: iest, inth
Character*12, dimension(7657) :: bore
Character*12, dimension(442) :: boreb
Character*40, dimension(7657) :: cdi, cdj, cdp
Character*10, dimension(7657) :: des
Character*12 borep

open (4, file='d2-9999.prn')
open (5, file='d2-Kcodes2.prn')
open (7, file='KandSy.prn')
open (8, file='d2-Sy5to10.prn', status='replace')
open (9, file='d2-SysUMSs.prn', status='replace')
open (10, file='d2-noSy.prn', status='replace')
open (11, file='d2-sy&k.prn', status='replace')

write(8,78)
78 format('bore',11x,'iestb',5x,'inthb',10x,'SY5',12x,'SY10')
write(9,77)
77 format('bore',11x,'sdd5',11x,'ssy5',9x,'sdd10',9x,'ssy10')
write(11,80)
80 format('bore',15x,'fd',8x,'td',6x,'cdi',42x,'ki',15x,'sy')

Initialise the dummy arrays

do 111 i=1,442
sdd5(i)=0         ! Sum of Difference in From To Depth LE 5m
sdd10(i)=0         ! sum of difference in Fm To GT 5m LE 10m
ssy5(i)=0         ! sum of Specific Yield in LE 5m
ssy10(i)=0         ! sum of Specific Yield in GT 5m LE 10m
111   continue

c     Read (i) file = d2-9999.prn
do 112 i=1,7657
read (4, 71) bore(i),fd(i),td(i),des(i),cdi(i),iest(i),inth(i),
x dcl(i),drn(i),dsf(i)
71    format (a12,2f10.2,a10,a40,i10,i10,f10.1,f10.1,f10.1)
c write(6,*) bore(i),des(i),cdi(i)
112   continue

c     Read (j) file = d2-Kcodes.prn
do 222 j=1,2571
read (5, 72) cdj(j),Kj(j)
72    format (a40,e10.2)
c write(6,*) 'j=',j
222   continue

c     Read (k) file = KandSy.prn
do 777 k=1,13
read (7,82) Kk(k),Syk(k)
82 format (e10.2,f10.3)
c write(6,82) Kk(k),Syk(k)
777   continue

c     Assign K to d2-9999.prn (i) file from (j) file
do 333 i=1,7657
    do 444 j=1,2571
    if (cdi(i).eq.cdj(j)) then
        Ki(i)=Kj(j)
        goto 333
    endif
444   continue
333   continue

c     DO LOOP to circle thru the total file (d2-9999.prn) and assign Sy-
values
from the file (KandSy.prn). If the K-value in the total file
are x , then assign the Specific yield field (Sy) in
the total data set.

do 555 i=1,7657
    c write(*,*)'tell me ',i
    if(Ki(i).eq.0.1e-03)then
        Sy(i)=0.05
    endif
    if(Ki(i).eq.0.9e-05)then
        Sy(i)=0.055
    endif
555   continue
if(K(i).eq.0.45e-04) then
  Sy(i)=0.1
endif
if(K(i).eq.95) then
  Sy(i)=0.11
endif
if(K(i).eq.1e-02) then
  Sy(i)=0.055
endif
if(K(i).eq.1e-02) then
  Sy(i)=0.21
endif
if(K(i).eq.0.3) then
  Sy(i)=0.11
endif
if(K(i).eq.3e-07) then
  Sy(i)=0.03
endif
if(K(i).eq.1e-03) then
  Sy(i)=0.065
endif
if(K(i).eq.3e-04) then
  Sy(i)=0.13
endif
if(K(i).eq.3.2) then
  Sy(i)=0.19
endif
if(K(i).eq.1e-03) then
  Sy(i)=0.06
endif
if(K(i).eq.4e-05) then
  Sy(i)=0.055
endif
555 continue
borep=bore(1)
b=1
idummy=0
do 888 i = 1, 7657
if(drn(i).eq.-999.and.dcl(i).eq.-999) then
  goto 888
else
  idummy=idummy+1
endif
if(idummy.eq.1.and.i.gt.1) then
  borep=bore(i)
endif
ddp(i)=td(i)-fd(i) !Difference in Depth (From depth-To depth)
if (borep.ne.bore(i)) then
  iestb(nb)=iestp
  intb(nb)=inthp
  boreb(nb)=borep
  write(6,*)'nb = ',nb
  borep= bore(i)
endif

LESS THAN OR EQUAL TO 5M BELOW SURFACE
If the sum of the Specific yield (ssy5) for depth below surface is LT or EQ to 0 AND
the sum of the differences in depth is GT 0 THEN
divide the sum of the specific yield by the sum of the diffs in depth
ELSE give SY5(nb) the value of -999
if (ssy5(nb).gt.0.and.sdd5(nb).gt.0) then
   write(*,*),'tell me ssy5 sdd5',nb,borep,ssy5(nb),ssy10(nb)
   SY5(nb)=ssy5(nb)/sdd5(nb)
else
   SY5(nb)=-999
endif
if (ssy10(nb).gt.0.and.sdd10(nb).gt.0) then
   write(*,*),'tell me ssy10 sdd10',nb,borep,ssy10(nb),sdd10(nb)
   SY10(nb)=ssy10(nb)/sdd10(nb)
else
   SY10(nb)=-999
endif
nb=nb+1
endif
if (borep.eq.bore(i)) then
   if (Sy(i).eq.0) then
      Sy(i)=-999
      write(10,79)bore(i),fd(i),td(i),cdi(i)
      79     format(a12,2f10.2,2x,a40)
   endif
   c LESS THEN 5 M SPECIFIC YIELD CALCULATIONS
   If To Depth is less than or equal to 12(m) THEN
      if (td(i).le.5) then
         sdd5(nb)=sdd5(nb)+ddp(i)          !Sum all DeltaD to 5m
         syy5(nb)=Sy(i)*ddp(i)+syy5(nb)    !Sum of Sy * DeltaD + prev sum
      endif
      if (td(i).gt.5.and.td(i).le.10) then
         sdd10(nb)=sdd10(nb)+ddp(i)          !Sum all DeltaD to 10m
         syy10(nb)=Sy(i)*ddp(i)+syy10(nb)    !Sum of Sy * DeltaD + prev sum
      endif
   endif
   write(*,*),'I am summing ddp & sdd5',bore(i),ddp(i),sdd5(nb)
   write(*,*),'I am summing ddp & sdd10',bore(i),ddp(i),sdd10(nb)
endif
borep=bore(i)
iestp=iest(i)
inthp=inth(i)
888 Continue
do 999 i=1,nb-1
write(8,74)boreb(i),iestb(i),inthb(i),SY5(i),SY10(i)
74     format(a12,2i10,2e15.5)
write(9,76)boreb(i),sdd5(i),syy5(i),sdd10(i),syy10(i)
76     format(a12,f10.2,e15.5,f10.2,e15.5)
write(11,81)bore(i),fd(i),td(i),cdi(i),ki(i),sy(i)
81     format(a12,2f10.2,2x,a40,2x,e15.5,2x,e15.5)
999 Continue
end
21.6.3  MIRROOLSYSY5TO10.FOR

SCRIPT for assigning the Specific Yield to up to 5m below the surface and then between 5 and 10m below the surface for Mirrool data.
The differences in depth are summed for each different soil type.
Individual depths are multiplied by the specific yield for that particular soil type, and then this value is divided by the total summed difference in depth for that overall depth (ie to 5m and then 5 to 10m).
This gives an averaged specific yield for the two depths.
Path:  \Murrumbidgee\model\Fortran\DrillLogs\Specific Yield.
Project:  \Murrumbidgee\Model\Fortran\DrillLogs\Specific Yield.dsp
Program name: \Murrumbidgee\Model\Fortran\DrillLogs\Specific Yield\MirroolKnested.for
Workspace:  \Murrumbidgee\Model\Fortran\DrillLogs\DrillLogs.dsw
INPUT FILES (UNITS 4&5):
\Murrumbidgee\Model\Fortran\DrillLogs\Specific Yield\*.*
INPUT FILE (UNIT 7):  c:\Murrumbidgee\Model\KandSy.prn, and also c:\Murrumbidgee\Model\KandSy.prn, and also
\Murrumbidgee\Model\Fortran\DrillLogs\Specific Yield\*.*
OUTPUT (UNITS 8,9,10,11):  c:\Murrumbidgee\Model\Fortran\DrillLogs\Specific Yield\Final Trans Output

program MirroolSy5to10
To define ARRAYs
Real, dimension(12271) :: fd,td,dcl,drn,dsf,
  x Ki, Kj,dto,drr,pSy,kk,SYk
real, dimension(673) :: sdd5,sdd10,ssy5,ssy10
real, dimension(673) :: SY5,SY10
Integer, dimension(673) :: iestb, inthb
Integer, dimension(12271) :: iest, inth
Character*10, dimension(12271) :: bore
Character*10, dimension(673) :: boreb
Character*40, dimension(12271) :: cdi, cdj, cdp
Character*22, dimension(12271) :: des
Character*10 borep

do 111 i=1,673

OPEN (4, file='d3-9999.prn')
OPEN (5, file='d3-Kcodes2.prn')
OPEN (7, file='KandSy.prn')
OPEN (8, file='d3-Sy5to10.prn', status='replace')
OPEN (9, file='d3-SySUMs.prn', status='replace')
OPEN (10, file='d3-noSy.prn', status='replace')
OPEN (11, file='d3-sy&k.prn', status='replace')

WRITE(8,78)
78 FORMAT('bore',11x,'iestb',5x,'inthb',10x,'SY5',12x,'SY10')
WRITE(9,77)
77 FORMAT('bore',11x,'sdd5',11x,'ssy5',9x,'sdd10',9x,'ssy10')
WRITE(11,80)
80 FORMAT('bore',15x,'fd',8x,'td',6x,'cdi',12x,'ki',15x,'sy')

C Initialise the dummy arrays

DO 111 I=1,673
sdd5(i)=0         ! Sum of Difference in From To Depth LE 5m
sdd10(i)=0         ! sum of difference in Fm To GT 5m LE 10m
ssy5(i)=0         ! sum of Specific Yield in LE 5m
ssy10(i)=0         ! sum of Specific Yield in GT 5m LE 10m
111   continue

c     Read (i) file = d3-9999.prn
do 112 i=1,12271
   read (4, 71) bore(i),fd(i),td(i),des(i),cdi(i),iest(i),inth(i),
x dcl(i),drn(i),dsf(i)
71    format (a10,2f10.2,a22,a40,i10,i10,f10.1,f10.1,f10.1)
c write(6,*) bore(i),des(i),cdi(i),dcl(i),drn(i),dsf(i)
112   continue

c     Read (j) file = d3-Kcodes.prn
do 222 j=1,2514
   read (5, 72) cdj(j),Kj(j)
72    format (a40,e10.2)
c write(6,*) 'j=',j
222   continue

c     Read (k) file = KandSy.prn
do 777 k=1,13
   read (7,82) Kk(k),Syk(k)
82    format (e10.2,f10.3)
c write(6,82) Kk(k),Syk(k)
777   continue

c     Assign K to d3-9999.prn (i) file from (j) file
do 333 i=1,12271
do 444 j=1,2514
   if (cdi(i).eq.cdj(j)) then
      Ki(i)=Kj(j)
goto 333
   endif
444   continue
333   continue

DO LOOP to circle thru the total file (d3-9999.prn) and assign Sy-values
from the file (KandSy.prn). If the K-value in the total file are x , then assign the Specific yield field (Sy) in
the total data set.
do 555 i=1,12271
   if(Ki(i).eq.0.1e-03)then
      Sy(i)=0.05
   endif
   if(Ki(i).eq.0.9e-05)then
      Sy(i)=0.055
   endif

if(Ki(i).eq.0.45e-04)then  
Sy(i)=0.1  
endif  
if(Ki(i).eq.95)then  
Sy(i)=0.11  
endif  
if(Ki(i).eq.1e-02)then  
Sy(i)=0.055  
endif  
if(Ki(i).eq.1e-02)then  
Sy(i)=0.21  
endif  
if(Ki(i).eq.0.3)then  
Sy(i)=0.11  
endif  
if(Ki(i).eq.3e-07)then  
Sy(i)=0.03  
endif  
if(Ki(i).eq.1e-03)then  
Sy(i)=0.065  
endif  
if(Ki(i).eq.3e-04)then  
Sy(i)=0.13  
endif  
if(Ki(i).eq.3.2)then  
Sy(i)=0.19  
endif  
if(Ki(i).eq.1e-03)then  
Sy(i)=0.06  
endif  
if(Ki(i).eq.4e-05)then  
Sy(i)=0.055  
endif  
555 continue

borep=bore(1)  
nb=1  
idummy=0  
do 888 i = 1, 12271  
if(drn(i).eq.-999.and.dcl(i).eq.-999) then  
goto 888  
else  
idummy=idummy+1  
endif  
if(idummy.eq.1.and.i.gt.1) then  
borep=bore(i)  
endif  
ddp(i)=td(i)-fd(i) !Difference in Depth (From depth-To depth)

if (borep.ne.bore(i))then
  iestb(nb)=iestp  
inthb(nb)=inthp  
boreb(nb)=borep  
write(6,*)'nb = ',nb  
borep= bore(i)
c

<other code>

555 continue

borep=bore(1)  
nb=1  
idummy=0  
do 888 i = 1, 12271  
if(drn(i).eq.-999.and.dcl(i).eq.-999) then  
goto 888  
else  
idummy=idummy+1  
endif  
if(idummy.eq.1.and.i.gt.1) then  
borep=bore(i)  
endif  
ddp(i)=td(i)-fd(i) !Difference in Depth (From depth-To depth)

if (borep.ne.bore(i))then
  iestb(nb)=iestp  
inthb(nb)=inthp  
boreb(nb)=borep  
write(6,*)'nb = ',nb  
borep= bore(i)
c

<other code>

if the sum of the differences in depth is GT 0 THEN

<other code>
c divide the sum of the specific yield by the sum of the diffs in depth
   ELSE give SY5(nb) the value of -999
      if (ssy5(nb).gt.0.and.sdd5(nb).gt.0) then
         write (*,*) 'tell me ssy5 sdd5', nb, borep, ssy5(nb), ssy10(nb)
         SY5(nb) = ssy5(nb)/sdd5(nb)
      else
         SY5(nb) = -999
      endif
      if (ssy10(nb).gt.0.and.sdd10(nb).gt.0) then
         write (*,*) 'tell me ssy10 sdd10', nb, borep, ssy10(nb), sdd10(nb)
         SY10(nb) = ssy10(nb)/sdd10(nb)
      else
         SY10(nb) = -999
      endif
      nb = nb + 1
   endif
   if (borep.eq.bore(i)) then
      if (Sy(i).eq.0) then
         write(10,79)bore(i), fd(i), td(i), cdi(i)
         79     format(a10,2f10.2,2x,a40)
      endif
      C LESS THEN 5 M SPECIFIC YIELD CALCULATIONS
      if (td(i).le.5) then
         sdd5(nb) = sdd5(nb) + ddp(i)                !Sum all DeltaD to 5m
         ssy5(nb) = Sy(i)*ddp(i) + ssy5(nb)         !Sum of Sy * DeltaD + prev sum
      endif
      if (td(i).gt.5.and.td(i).le.10) then
         sdd10(nb) = sdd10(nb) + ddp(i)           !Sum all DeltaD to 10m
         ssy10(nb) = Sy(i)*ddp(i) + ssy10(nb)    !Sum of Sy * DeltaD + prev sum
      endif
      write(*,*)' I am summing ddp & sdd5', bore(i), ddp(i), sdd5(nb)
   endif
   borep = bore(i)
   iestp = iest(i)
   inthp = inth(i)
888 Continue
   do 999 i=1, nb-1
      write(8,74) boreb(i), iestb(i), inthb(i), SY5(i), SY10(i)
      74     format(a10,2i10,2e15.5)
      write(9,76) boreb(i), sdd5(i), ssy5(i), sdd10(i), ssy10(i)
      76     format(a10,2f10.2,e15.5,2f10.2,e15.5)
      write(11,81) bore(i), fd(i), td(i), cdi(i), ki(i), sy(i)
      81     format(a10,2f10.2,2x,a40,e15.5,2x,e15.5)
999 Continue
end
21.6.4 YANCOSY5TO10.FOR

Script for assigning the Specific Yield to up to 5m below the surface and then between 5 and 10m below the surface for Yanco data. The differences in depth are summed for each different soil type. Individual depths are multiplied by the specific yield for that particular soil type, and then this value is divided by the total summed difference in depth for that overall depth (ie to 5m and then 5 to 10m).

This gives an averaged specific yield for the two depths.

Path: \c:\Murrumbidgee\model\Fortran\DrillLogs\Specific Yield.
Project: \c:\Murrumbidgee\Model\Fortran\DrillLogs\Specific Yield.dsp
Program: \c:\Murrumbidgee\Model\Fortran\DrillLogs\Specific Yield\YancoKnested.for
Workspace: \c:\Murrumbidgee\Model\Fortran\DrillLogs\DrillLogs.dsw

INPUT FILES (UNITS 4&5):
\c:\Murrumbidgee\Model\Fortran\DrillLogs\Specific Yield\*. *
INPUT FILE (UNIT 7): \c:\Murrumbidgee\Model\KandSy.prn, and also \c:\Murrumbidgee\Model\Fortran\DrillLogs\Specific Yield\*. *

OUTPUT (UNITs 8,9,10,11): \c:\Murrumbidgee\Model\Fortran\DrillLogs\Specific Yield\Final Trans Output

program YancoSy5to10
To define ARRAYS
Real, dimension(6536) :: fd, td, dcl, drn, dsf,
  x Ki, Kj, dtc, dtr, ddp, Sy, Kk, Syk
real, dimension(1000) :: sdd5, sdd10, ssy5, ssy10
real, dimension(1000) :: SY5, SY10
Integer, dimension(1000) :: iestb, inthb
Integer, dimension(6536) :: iest, inth
Character*10, dimension(6536) :: bore
Character*10, dimension(1000) :: boreb
Character*40, dimension(6536) :: cdi, cdj, cdp
Character*22, dimension(6536) :: des
Character*10 borep

open (4, file='d4-9999.prn')
open (5, file='d4-Kcodes2.prn')
open (7, file='KandSy.prn')
open (8, file='d4-Sy5to10.prn', status='replace')
open (9, file='d4-SySUMs.prn', status='replace')
open (10, file='d4-noSy.prn', status='replace')
open (11, file='d4-sy&k.prn', status='replace')

write(8,78)
78 format('bore',11x,'iestb',5x,'inthb',10x,'SY5',12x,'SY10')
write(9,77)
77 format('bore',11x,'sdd5',11x,'ssy5',9X,'sdd10',9X,'ssy10')
write(11,80)
80 format('bore',15x,'fd',8x,'td',6x,'cdi',12x,'ki',15x,'sy')

Initialise the dummy arrays

do 111 i=1,1000
sdd5(i)=0  ! Sum of Difference in From To Depth LE 5m
sdd10(i)=0  ! sum of difference in Fm To GT 5m LE 10m
ssy5(i)=0  ! sum of Specific Yield in LE 5m
ssy10(i)=0  ! sum of Specific Yield in GT 5m LE 10m
111  continue

    c  Read (i) file = d4-9999.prn
    do 112 i=1,6536
        read (4, 71) bore(i),fd(i),td(i),des(i),cdi(i),iest(i),inth(i),
        x dcl(i),drn(i),dsf(i)
    71 format (a10,2f10.2,a22,a40,i10,i10,f10.1,f10.1,f10.1)
    c  write(6,*) bore(i),des(i),cdi(i),dcl(i),drn(i),dsf(i)
     112  continue

    c  Read (j) file = d4-Kcodes.prn
    do 222 j=1,434
        read (5, 72) cdj(j),Kj(j)
    72 format (a40,e10.2)
    c  write(6,*) 'j=',j
    222  continue

    c  Read (k) file = KandSy.prn
    do 777 k=1,13
        read (7,82) Kk(k),Syk(k)
    82  format (e10.2,f10.3)
     c  write(6,82) Kk(k),Syk(k)
    777  continue

    c  Assign K to d4-9999.prn (i) file from (j) file
    do 333 i=1,6536
        do 444 j=1,434
            if (cdi(i).eq.cdj(j)) then
                Ki(i)=Kj(j)
                goto 333
            endif
        444  continue
     333  continue

    c DO LOOP to circle thru the total file (d4-9999.prn) and assign Sy-values
    c from the file (KandSy.prn).  If the K-value in the total file
    c are x , then assign the Specific yield field (Sy) in
    c the total data set.
    do 555 i=1,6536
        c write(*,*),'tell me ',i
        if(Ki(i).eq.0.1e-03)then
            Sy(i)=0.05
        endif
        if(Ki(i).eq.0.9e-05)then
            Sy(i)=0.055
        endif
    555  continue
if(Ki(i).eq.0.45e-04)then
  Sy(i)=0.1
endif
if(Ki(i).eq.95)then
  Sy(i)=0.11
endif
if(Ki(i).eq.1e-02)then
  Sy(i)=0.055
endif
if(Ki(i).eq.1e-02)then
  Sy(i)=0.21
endif
if(Ki(i).eq.0.3)then
  Sy(i)=0.11
endif
if(Ki(i).eq.3e-07)then
  Sy(i)=0.03
endif
if(Ki(i).eq.1e-03)then
  Sy(i)=0.065
endif
if(Ki(i).eq.3e-04)then
  Sy(i)=0.13
endif
if(Ki(i).eq.3.2)then
  Sy(i)=0.19
endif
if(Ki(i).eq.1e-03)then
  Sy(i)=0.06
endif
if(Ki(i).eq.4e-05)then
  Sy(i)=0.055
endif
555 continue
borep=bore(1)
b=1
idummy=0
do 888 i = 1, 6536
  if(drn(i).eq.-999.and.dcl(i).eq.-999) then
    goto 888
  else
    idummy=idummy+1
  endif
  if(idummy.eq.1.and.i.gt.1) then
    borep=bore(i)
  endif
  ddp(i)=td(i)-fd(i) !Difference in Depth (From depth-To depth)
  if (borep.ne.bore(i))then
    iestb(nb)=iestp
    inthb(nb)=inthp
    boreb(nb)=borep
    write(6,'(i3)',i=6)nb
    borep= bore(i)
  endif

  c LESS THAN OR EQUAL TO 5M BELOW SURFACE
  c If the sum of the Specific yield (ssy5) for depth below surface is LT or EQ to 0 AND
  c the sum of the differences in depth is GT 0 THEN
c     divide the sum of the specific yield by the sum of the diffs in depth 
        c     ELSE give SY5(nb) the value of -999
        if (ssy5(nb) .gt. 0 .and. sdd5(nb) .gt. 0) then 
            write (*,*) 'tell me ssy5 sdd5', nb, borep, ssy5(nb), ssy10(nb) 
            SY5(nb) = ssy5(nb) / sdd5(nb) 
        else 
            SY5(nb) = -999 
        endif 
        if (ssy10(nb) .gt. 0 .and. sdd10(nb) .gt. 0) then 
            write (*,*) 'tell me ssy10 sdd10', nb, borep, ssy10(nb), sdd10(nb) 
            SY10(nb) = ssy10(nb) / sdd10(nb) 
        else 
            SY10(nb) = -999 
        endif 
        nb = nb + 1 
        endif 
        if (borep.eq.bore(i)) then 
            if (Sy(i).eq.0) then 
                c     Sy(i)=-999 
                write(10,79)bore(i),fd(i),td(i),cdi(i) 
                79     format(a10,2f10.2,2x,a40) 
            endif 
            c     LESS THEN 5 M SPECIFIC YIELD CALCULATIONS 
            c     If To Depth is less than or equal to 12(m) THEN 
                if (td(i).le.5) then 
                    sdd5(nb) = sdd5(nb) + ddp(i)         !Sum all DeltaD to 5m 
                    ssy5(nb) = Sy(i)*ddp(i) + ssy5(nb)     !Sum of Sy * DeltaD + prev sum 
                endif 
                if (td(i).gt.5.and.td(i).le.10) then 
                    sdd10(nb) = sdd10(nb) + ddp(i)         !Sum all DeltaD to 10m 
                    ssy10(nb) = Sy(i)*ddp(i) + ssy10(nb)     !Sum of Sy * DeltaD + prev sum 
                endif 
                write(*,*') 'I am summing ddp & sdd5',bore(i),ddp(i),sdd5(nb) 
            endif 
            if (td(i).gt.5.and.td(i).le.10) then 
                sdd10(nb) = sdd10(nb) + ddp(i)         !Sum all DeltaD to 10m 
                ssy10(nb) = Sy(i)*ddp(i) + ssy10(nb)     !Sum of Sy * DeltaD + prev sum 
                write(*,*') 'I am summing ddp & sdd10',bore(i),ddp(i),sdd10(nb) 
            endif 
            borep=bore(i) 
            iestp=iest(i) 
            inthp=inth(i) 
            888   Continue 
        do 999 i=1,nb-1 
        write(8,74) boreb(i),iestb(i),inthb(i),SY5(i),SY10(i) 
        74     format (a10,2i10,2e15.5) 
        write(9,76)boreb(i),sdd5(i),ssy5(i),sdd10(i),ssy10(i) 
        76     format(a10,f10.2,e15.5,f10.2,e15.5) 
        write(11,81)bore(i),fd(i),td(i),cdi(i),ki(i),sy(i) 
        81     format(a10,2f10.2,2x,a40,e15.5,2x,e15.5) 
        999   Continue 
end
21.7 Programs is to get the data from the original 3-column file into a grid-format of 106 x 113 grid cells.

21.7.1 PUMPING1.FOR

This program is to get the data from the original 3-column file into a grid-format of 106 x 113 grid cells.
The original file is not evenly spaced.
Aim is to get the 3-column data into the array, by putting the relative i and j values into their respective cells in the array.

Program Pumping1
To define ARRAYs

```
Real pumpval(113,106)
open (5, file='95ij-ren.txt') !57 row file with j,i and pumping
m3/day
open (8, file='95ij-rnG.txt') !output file

write(8,*)'113 106'
do 300 j=1,113
do 300 i=1,106

300 continue

nline=0

103 read (5,*, end=105) j,i,value
pumpval(j,i)=value+pumpval(j,i)
nline=nline+1
write (*,*) j,i,pumpval(j,i)
goto 103

105 write(6,*)'no of lines=',nline

250 format(113f10.2)

do 900 i=1,106
write (8,250)(pumpval(j,i),j=1,113)
900 continue

end
```
21.8 Program to convert 3-column file into a grid format of 106 x 113 grid cells.

21.8.1 Arrays.for

This program is to get the data from the original 3-column file into a grid-format of 106 x 113 grid cells. Each cell in the model will be 750m apart, so the increment in the original data file is 750m. The original data file is 750m increment in the x column.

```
program Array
    c To define ARRAYS
    Real, dimension(106,113) :: zvalue
    open (4, file='sfcegrdR.dat')
    open (8, file='sfcegrid.dat')

    format(15f10.3)
    write(8,*)(113,106')
    do 300 i=1, 106
        do 300 j=1, 113
            read (4,*) ix,iy,zvalue(i,j)
            write (*,*)(ix,iy,zvalue(i,j))
        300   continue
    do 900 i=1,106
        write (8,250)(zvalue(i,j),j=1,113)
    900   continue
    c do 900 i=1,106
    c write (*,*)(zvalue(i,j),j=1,113)
    c900   continue

    end
```
21.9  Program to convert 4-column file into a grid format,
from ArcView format into MODFLOW format.

21.9.1  ARCVIEW.FOR

This program is to get the data from the original 4-column file
into a grid-format of 106 x 113 grid cells.
Program calls:  gridid (row*1000+column), hriv (head, gwe),
rbot (river bed), criv(conductance).
Program outputs:  The 4-column data is placed in a 106 x 113 array,
by putting the relative i and j values into the respective cell in
the array.
File '*out.txt' is stored in c:\murrumbidgee\model\fortran\arrays
(folder delimtxt)
The respective output file is then loaded into Modflow River package.

program ArcView
To define ARRAYS

Real hriv1(113,106),rbot1(113,106),criv1(113,106)

open (5, file='allcells.txt') !gridid,hriv,rbot,criv
open (8, file='hrivout.txt') !output file
open (9, file='rbotout.txt')
open (10, file='crivout.txt')

do 300 j=1,113
   do 300 i=1,106
      hriv1(j,i)=0
      rbot1(j,i)=0
      criv1(j,i)=0
   300   continue

   nline=0
103 read (5,*, end=105) gridid,hriv,rbot,criv
   idx=gridid/1000
   jdx=gridid-idx*1000
   hriv1(jdx,idx)=hriv
   criv1(jdx,idx)=criv+criv1(jdx,idx)
   rbot1(jdx,idx)=rbot
   nline=nline+1
   goto 103
105 write(6,*)'no of lines=',nline

250 format(113f10.2)

   write(8,*)(hriv1(j,i),j=1,113)
   write(9,*)(rbot1(j,i),j=1,113)
   write(10,*)(criv1(j,i),j=1,113)

900 continue
end
22 Appendix K - Modelled and Observed Hydrographs
Figure XX.3: Calculated and Observed Hydrographs for Piezometer G1159

Figure XX.4: Calculated and Observed Hydrographs for Piezometer G1172S
Figure XX.5: Calculated and Observed Hydrographs for Piezometer G1196

Figure XX.6: Calculated and Observed Hydrographs for Piezometer G1216
Figure XX.7: Calculated and Observed Hydrographs for Piezometer G124

Figure XX.8: Calculated and Observed Hydrographs for Piezometer G1338
Figure XX.9: Calculated and Observed Hydrographs for Piezometer G1391

Mar-95 Sep-95 Mar-96 Sep-96 Mar-97 Sep-97 Mar-98 Sep-98 Mar-99 Sep-99 Mar-00 Sep-00
Head (m)
Calculated
Observed

Figure XX.10: Calculated and Observed Hydrographs for Piezometer G1400

Mar-95 Sep-95 Mar-96 Sep-96 Mar-97 Sep-97 Mar-98 Sep-98 Mar-99 Sep-99 Mar-00 Sep-00
Head (m)
Calculated
Observed
Figure XX.11: Calculated and Observed Hydrographs for Piezometer G1401

Figure XX.12: Calculated and Observed Hydrographs for Piezometer G1579
Figure XX.15: Calculated and Observed Hydrographs for Piezometer G1718

Figure XX.16: Calculated and Observed Hydrographs for Piezometer G1719
Figure XX.19: Calculated and Observed Hydrographs for Piezometer G1801

Figure XX.20: Calculated and Observed Hydrographs for Piezometer G1951
Figure XX.21: Calculated and Observed Hydrographs for Piezometer G1952

Figure XX.22: Calculated and Observed Hydrographs for Piezometer G2003
Calculated and Observed Hydrographs for Piezometer G2005

Calculated and Observed Hydrographs for Piezometer G2062
Figure XX.25: Calculated and Observed Hydrographs for Piezometer G2081

Figure XX.26: Calculated and Observed Hydrographs for Piezometer G209
Figure XX.27: Calculated and Observed Hydrographs for Piezometer G210

Mar-95 Sep-95 Mar-96 Sep-96 Mar-97 Sep-97 Mar-98 Sep-98 Mar-99 Sep-99 Mar-00 Sep-00

Head (m)

Calculated
Observed

Figure XX.28: Calculated and Observed Hydrographs for Piezometer G2190

Mar-95 Sep-95 Mar-96 Sep-96 Mar-97 Sep-97 Mar-98 Sep-98 Mar-99 Sep-99 Mar-00 Sep-00

Head (m)

Calculated
Observed
Figure XX.29: Calculated and Observed Hydrographs for Piezometer G2284

Figure XX.30: Calculated and Observed Hydrographs for Piezometer G2292
Figure XX.31: Calculated and Observed Hydrographs for Piezometer G2296

Figure XX.32: Calculated and Observed Hydrographs for Piezometer G2345s
Figure XX.33: Calculated and Observed Hydrographs for Piezometer G2452

Figure XX.34: Calculated and Observed Hydrographs for Piezometer G247
Figure XX.35: Calculated and Observed Hydrographs for Piezometer G2691

Figure XX.36: Calculated and Observed Hydrographs for Piezometer G2696
Figure XX.37: Calculated and Observed Hydrographs for Piezometer G2698

Figure XX.38: Calculated and Observed Hydrographs for Piezometer G2729
Figure XX.39: Calculated and Observed Hydrographs for Piezometer G273

Figure XX.40: Calculated and Observed Hydrographs for Piezometer G2730
Figure XX.41: Calculated and Observed Hydrographs for Piezometer G2767

Figure XX.42: Calculated and Observed Hydrographs for Piezometer G2771
Figure XX.43: Calculated and Observed Hydrographs for Piezometer G2772

Figure XX.44: Calculated and Observed Hydrographs for Piezometer G282
Figure XX.45: Calculated and Observed Hydrographs for Piezometer G2857

Figure XX.46: Calculated and Observed Hydrographs for Piezometer G2863
Figure XX.47: Calculated and Observed Hydrographs for Piezometer G301

Figure XX.48: Calculated and Observed Hydrographs for Piezometer G305
Figure XX.49: Calculated and Observed Hydrographs for Piezometer G3119

Figure XX.50: Calculated and Observed Hydrographs for Piezometer G3174
Figure XX.51: Calculated and Observed Hydrographs for Piezometer G327

Figure XX.52: Calculated and Observed Hydrographs for Piezometer G352
Figure XX.53: Calculated and Observed Hydrographs for Piezometer G381

Figure XX.54: Calculated and Observed Hydrographs for Piezometer G458
Figure XX.55: Calculated and Observed Hydrographs for Piezometer G505

Figure XX.56: Calculated and Observed Hydrographs for Piezometer G514
Figure XX.57: Calculated and Observed Hydrographs for Piezometer G516

Figure XX.58: Calculated and Observed Hydrographs for Piezometer G522
Figure XX.59: Calculated and Observed Hydrographs for Piezometer G535

Figure XX.60: Calculated and Observed Hydrographs for Piezometer G539
Figure XX.61: Calculated and Observed Hydrographs for Piezometer G557

Mar-95 | Sep-95 | Mar-96 | Sep-96 | Mar-97 | Sep-97 | Mar-98 | Sep-98 | Mar-99 | Sep-99 | Mar-00 | Sep-00

Head (m)

Calculated
Observed

Figure XX.62: Calculated and Observed Hydrographs for Piezometer G670

Mar-95 | Sep-95 | Mar-96 | Sep-96 | Mar-97 | Sep-97 | Mar-98 | Sep-98 | Mar-99 | Sep-99 | Mar-00 | Sep-00

Head (m)

Calculated
Observed
Figure XX.63: Calculated and Observed Hydrographs for Piezometer GW36575

Figure XX.64: Calculated and Observed Hydrographs for Piezometer L1326D
Figure XX.65: Calculated and Observed Hydrographs for Piezometer L1326S

Figure XX.66: Calculated and Observed Hydrographs for Piezometer L1327S
Figure XX.67: Calculated and Observed Hydrographs for Piezometer L1335S

Figure XX.68: Calculated and Observed Hydrographs for Piezometer L1536D
Figure XX.69: Calculated and Observed Hydrographs for Piezometer L1536S

Figure XX.70: Calculated and Observed Hydrographs for Piezometer L1602
Figure XX.73: Calculated and Observed Hydrographs for Piezometer L1709S

Figure XX.74: Calculated and Observed Hydrographs for Piezometer L1732D
Figure XX.75: Calculated and Observed Hydrographs for Piezometer L1732S

Figure XX.76: Calculated and Observed Hydrographs for Piezometer L1762D
Figure XX.77: Calculated and Observed Hydrographs for Piezometer L1762S

Figure XX.78: Calculated and Observed Hydrographs for Piezometer L1808
Figure XX.79: Calculated and Observed Hydrographs for Piezometer L1813D

Figure XX.80: Calculated and Observed Hydrographs for Piezometer L1813S
Figure XX.81: Calculated and Observed Hydrographs for Piezometer L1826D

Figure XX.82: Calculated and Observed Hydrographs for Piezometer L1826S
Figure XX.83: Calculated and Observed Hydrographs for Piezometer L1854D

Figure XX.84: Calculated and Observed Hydrographs for Piezometer L1854S
Figure XX.87: Calculated and Observed Hydrographs for Piezometer L1890

Figure XX.88: Calculated and Observed Hydrographs for Piezometer L1924D
Figure XX.89: Calculated and Observed Hydrographs for Piezometer L1924S

Figure XX.90: Calculated and Observed Hydrographs for Piezometer L1946D
Figure XX.91: Calculated and Observed Hydrographs for Piezometer L1946S

Figure XX.92: Calculated and Observed Hydrographs for Piezometer L1963D
Figure XX.93: Calculated and Observed Hydrographs for Piezometer L1963S

Figure XX.94: Calculated and Observed Hydrographs for Piezometer L1982D
Figure XX.95: Calculated and Observed Hydrographs for Piezometer L1982S

Figure XX.96: Calculated and Observed Hydrographs for Piezometer L2008D
Figure XX.97: Calculated and Observed Hydrographs for Piezometer L2047D

Figure XX.98: Calculated and Observed Hydrographs for Piezometer L2047S
Figure XX.99: Calculated and Observed Hydrographs for Piezometer L2066

Figure XX.100: Calculated and Observed Hydrographs for Piezometer L2069
Figure XX.101: Calculated and Observed Hydrographs for Piezometer L2117D

Figure XX.102: Calculated and Observed Hydrographs for Piezometer L2117S
Figure XX.103: Calculated and Observed Hydrographs for Piezometer L2131D

Figure XX.104: Calculated and Observed Hydrographs for Piezometer L2131S
Figure XX.105: Calculated and Observed Hydrographs for Piezometer L2139D

Calculated and Observed Hydrographs for Piezometer L2139S

Figure XX.106: Calculated and Observed Hydrographs for Piezometer L2139S
Figure XX.109: Calculated and Observed Hydrographs for Piezometer L2245

Figure XX.110: Calculated and Observed Hydrographs for Piezometer L2280
Figure XX.115: Calculated and Observed Hydrographs for Piezometer L2347S

Calculated and Observed Hydrographs for Piezometer L2357S

Mar-95 Sep-95 Mar-96 Sep-96 Mar-97 Sep-97 Mar-98 Sep-98 Mar-99 Sep-99 Mar-00 Sep-00

Head (m)

Calculated
Observed
Figure XX.119: Calculated and Observed Hydrographs for Piezometer L2367S

Figure XX.120: Calculated and Observed Hydrographs for Piezometer L2453
Figure XX.121: Calculated and Observed Hydrographs for Piezometer L2795

Figure XX.122: Calculated and Observed Hydrographs for Piezometer L2797
23 Appendix L - Observed and Simulated Water Level Contours
Computed and observed water level contours for US (Sep. 95)

Computed and observed water level contours for US (Mar. 96)
Computed and observed water level contours for US (Sep. 96)

Computed and observed water level contours for US (Feb. 97)
Computed and observed water level contours for US (Sep. 97)

Computed and observed water level contours for US (Feb. 98)
Computed and observed water level contours for US (Sep. 98)

Computed and observed water level contours for US (Mar. 99)
Computed and observed water level contours for US (Sep. 99)

Computed and observed water level contours for LS (Sep. 95)
Computed and observed water level contours for LS (Mar. 96)

Computed and observed water level contours for LS (Sep 96)
Computed and observed water level contours for LS (Feb. 97)

Computed and observed water level contours for LS (Sep. 97)
Computed and observed water level contours for LS (Feb. 98)

Computed and observed water level contours for LS (Sep. 98)
Computed and observed water level contours for CL (Sep. 95)

Computed and observed water level contours for CL (Mar. 96)
Computed and observed water level contours for CL (Sep. 96)

Computed and observed water level contours for CL (Mar. 97)
Computed and observed water level contours for CL (Sep. 97)

Computed and observed water level contours for CL (Mar. 98)
Computed and observed water level contours for CL (Mar. 99)

Computed and observed water level contours for RN (Sep. 95)
Computed and observed water level contours for RN (Mar. 96)

Computed and observed water level contours for RN (Sep. 96)
Computed and observed water level contours for RN (Mar. 97)

Computed and observed water level contours for RN (Sep. 97)
Computed and observed water level contours for RN (Mar. 98)

Computed and observed water level contours for RN (Sep. 98)
Computed and observed water level contours for RN (Mar. 99)

Computed and observed water level contours for RN (Sep. 99)
24 APPENDIX M - ZONE WISE WATER BUDGET FOR IRRIGATION AND NON-IRRIGATION PERIODS: 1995-2000
Water Budget (ML) of North Benerenbah for Irrigation Periods: 1995-2000
Water Budget (ML) of North Benerenbah for Non-irrigation Periods: 1995-2000
Water Budget (ML) of Hanwood for Irrigation Periods: 1995-2000
Water Budget (ML) of Yenda for Irrigation Periods: 1995-2000
Water Budget (ML) of South Benerembah for Irrigation Periods: 1995-2000
Water Budget (ML) of South Benerembah for Non-irrigation Periods: 1995-2000
Water Budget (ML) of Kooba for Irrigation Periods: 1995-2000
Water Budget (ML) of Kooba for Non-irrigation Periods: 1995-2000
Water Budget (ML) of Murrami for Irrigation Periods: 1995-2000
Water Budget (ML) of Murrumbindi for Non-irrigation Periods: 1995-2000
Water Budget (ML) of Gogeldrie for Irrigation Periods: 1995-2000
25 Appendix N - Hydrographs for the Future Scenarios
25.1 Appendix N-1 - Hydrographs for the Future Scenario-1: Dry Conditions (similar to 2001-02) continue for next 25 years
Computed Hydrograph for Piezometer G3174-North Benerembah

Computed Hydrograph for Piezometer G1216-North Benerembah
Computed Hydrograph for Piezometer G1338-Kooba

Computed Hydrograph for Piezometer G2772-Kooba
Computed Hydrograph for Piezometer G381-Hanwood

Computed Hydrograph for Piezometer G1579-Hanwood
Computed Hydrograph for Piezometer L2347S-Murrami

Computed Hydrograph for Piezometer L3132-Murrami
25.2 Appendix N-2 - Hydrographs for the Future
Scenario-2: Relatively wet rainfall conditions (similar to 1992-93) continue for next 25 years
Computed Hydrograph for Piezometer G1338-Kooba

Computed Hydrograph for Piezometer G2772-Kooba
Computed Hydrograph for Piezometer G273-Hanwood

Computed Hydrograph for Piezometer G282-Hanwood
Computed Hydrograph for Piezometer L1762S-Gogeldrie

Head (m)

Computed Hydrograph for Piezometer L1963S-Gogeldrie

Head (m)
25.3 Appendix N-3 - Hydrographs for the Future
Scenario-3: Fifty percent reduction in Rice areas and continue for next 25 years
Computed Hydrograph for Piezometer G1338-Kooba

Computed Hydrograph for Piezometer G2772-Kooba
Computed Hydrograph for Piezometer G505-Kooba

Computed Hydrograph for Piezometer L1535S-Kooba
Computed Hydrograph for Piezometer G381-Hanwood

Computed Hydrograph for Piezometer G1579-Hanwood
Computed Hydrograph for Piezometer L1762S-Gogeldrie

Computed Hydrograph for Piezometer L1963S-Gogeldrie
Computed Hydrograph for Piezometer L1982S-Gogeldrie

Computed Hydrograph for Piezometer L1870S-Gogeldrie
25.4 Appendix N-4 - Hydrographs for the Future
Scenario-4: Seventy five percent reduction in Rice areas
and continue for next 25 years
Computed Hydrograph for Piezometer G124-Yenda

Computed Hydrograph for Piezometer G247-Yenda
Computed Hydrograph for Piezometer G301-Yenda

Computed Hydrograph for Piezometer G1801-Yenda
Computed Hydrograph for Piezometer G505-Kooba

Computed Hydrograph for Piezometer L1535S-Kooba
Computed Hydrograph for Piezometer G2691-South Benerembah

Head (m)


Computed Hydrograph for Piezometer G2062-South Benerembah

Head (m)

Computed Hydrograph for Piezometer L1762S-Gogeldrie

Computed Hydrograph for Piezometer L1963S-Gogeldrie
25.5 Appendix N-5 - Hydrographs for the Future Scenario-5: Partial Reduction of seepage losses from channels using irrigation and rainfall recharge of 2001-02 and continue for next 25 years
Computed Hydrograph for Piezometer G273-Hanwood

Computed Hydrograph for Piezometer G282-Hanwood
Computed Hydrograph for Piezometer G381-Hanwood

Computed Hydrograph for Piezometer G1579-Hanwood
Computed Hydrograph for Piezometer L1982S-Gogeldrie

Computed Hydrograph for Piezometer L1870S-Gogeldrie
25.6 Appendix N-6 - Hydrographs for the Future Scenario-6: Full Reduction of seepage losses from channels using irrigation and rainfall recharge of 2001-02 and continue for next 25 years
Computed Hydrograph for Piezometer G505-Kooba

Computed Hydrograph for Piezometer L1535S-Kooba