RISK ASSESSMENT MODELLING FOR IRRIGATION DEVELOPMENT IN THE ANGAS – BREMER IRRIGATION AREA

REPORT BOOK 99/00002

by

S.R. HOWLES

PRIMARY INDUSTRIES AND RESOURCES SA

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RISK ASSESSMENT MODELLING FOR IRRIGATION DEVELOPMENT IN THE ANGAS – BREMER IRRIGATION AREA

S.R. HOWLES

Management in the Angas – Bremer Irrigation Area has reduced groundwater allocation to within the sustainable limits of the basin, primarily by conversion of groundwater to Murray River licence. In response, the confined aquifer pressure is returning towards pre-irrigation level, and watertables are rising.

Modelling was undertaken to assess the risks, with respect to rising watertables and salinisation, which may be associated with development of irrigation in the area. This work indicates that the importation of Murray River water into the area will result in rising watertables, particularly in the area to the south of Langhorne Creek. The area adjacent to Lake Alexandrina may not be at as great a risk as has been believed, although even small rises in this area are of significance. With increased use of Murray River water, the north of the area may be affected in the longer term. It is likely that the slow deterioration of groundwater quality is inevitable.

INTRODUCTION

HYDROGEOLOGY AND IRRIGATION DEVELOPMENT

The Angas – Bremer area is sited on a sub-basin on the south western extremity of the Murray Basin (Figure 1). The sedimentary pile superposes the Cambrian metasediments which act as the basin floor. The hydrogeology was investigated and reported in detail by Waterhouse *et al* (1978).

The unconfined aquifer comprises 10 – 35 m of inter-lensing sands, silts and clays of Quaternary age. Groundwater salinity ranges from 1 000 mg/L along the rivers to 30 000 mg/L at some distance from the rivers. This aquifer, with its generally poor quality water and low yields (up to 5 L/s), was developed primarily for stock water supply. Part of the sequence forms a thin confining layer between the unconfined and confined aquifers considered to be effective in the north, but less effective in the south of the area.

The confined aquifer is composed of 75 - 100 m of Tertiary age limestone. It has been primarily the uppermost 10 - 20 m which has been developed for irrigation. Groundwater salinity ranges from 1 500 to 3 000 mg/L near the Angas and Bremer Rivers. Salinity increases rapidly towards the basin margins and between the rivers, up to 10 000 mg/L. Yields are high, ranging between 10 - 40 L/s, dependent on aquifer hydraulic properties and well penetration. Hydraulic testing indicate a transmissivity of less than 500 m^2/day north of Langhorne Creek, 1 000 m^2/day in the central area, and 1 500 m^2/day in the south.

Prior to irrigation development, recharge occurred to both the confined and unconfined aquifers where the rivers cross the northern faulted basin margin. Further recharge to the confined aquifer occurred by vertical leakage from the unconfined aquifer beneath the rivers. Discharge from both aquifers allowed a continual flushing action preventing the build up of salt in the system. In the unconfined aquifer this occurred through springs and by lateral flow into Lake Alexandrina. Discharge from the confined aquifer occurred by lateral flow into the aquifer beneath the lake, and by vertical leakage to the unconfined aquifer in the south of the area.

Following irrigation development since the 1950s (leading to the extraction of 21 000 ML annually between the late 1970s and mid 1980s) a permanent regional drawdown developed in the potentiometric surface of the confined aquifer. A corresponding leakage induced depression developed in the watertable.

In response to these changes, induced leakage of saline water from the unconfined to confined aquifer, movement of saline water from the basin margins, and loss of the flushing mechanism resulted in a progressive salinisation of the confined aquifer.

WATER RESOURCE MANAGEMENT BACKGROUND

Groundwater management in the Angas - Bremer Proclaimed Wells Area since 1980 has been responsible for reducing groundwater allocation to within the sustainable limits of the basin (estimated to be 6 400 ML/year, composed of 5 000 ML natural recharge + 1 400 ML artificial recharge). This has been achieved primarily by the conversion of much of the groundwater licence to Murray River licence.

Both historically, and more recently groundwater use has been less than allocation (1996/97 – 2 100 ML of the 6 400 ML allocated). The use of Murray River water has also been less than allocation (1996/97 – 11 700 ML of the 23 250 ML allocation). As a result of the changes in water management occurring in the area, the pressure in the confined aquifer has been returning towards the pre-irrigation scenario, and the water table has shown a steady rise.

A balance must be developed, between the use of groundwater and the use of Murray River water, to ensure rising watertables are controlled.

In the longer term, sustainable irrigation depends on the ability to understand the response of the groundwater system and to manage the water balance. If rising watertables become a serious problem, new management policy will need to be developed. Policies may include conjunctive use and/or drainage or dewatering.

MODELLING OBJECTIVES

The modelling objective was to develop and visually calibrate a simplified hydrogeological model of the Angas – Bremer area to assess the risks associated with the changes in water usage and development of irrigation in the area in response to water resource management strategies.

As a result of the modelling it was expected that comment could be made regarding:

- The areas which may be at risk from a rising watertable, and the likely timing of the event
- The potential for dryland salinisation
- The implications for groundwater quality and the accumulation of salt in the system

DEVELOPMENT OF MODFLOW MODEL PARAMETERS

LAYERS:

- Layer-1: unconfined aquifer
- Layer-2: confining bed
- Layer-3: confined aquifer

NO-FLOW BOUNDARIES – INACTIVE CELLS

In this case the inactive cells (Figure 2) were set in:

- The area of the fractured rock in the north west
- The northeast and southwest, as the potentiometric surface indicates a flow through the area from the north west to the south east.
- The south east, at distance from the area of interest

HYDRAULIC CONDUCTIVITY:

As previously outlined hydraulic testing indicates a transmissivity of less than 500 m^2/day north of Langhorne Creek, 1 000 m^2/day in the central area, and 1 500 m^2/day in the south. In the model a hydraulic conductivity of 17.7 m/day was used in the south, and 10 m/day in the north. These hydraulic conductivity values accommodate the required high recharge rate from the rivers where they cross the fault.

Waterhouse *et al* (1978) suggested that “hydraulic conductivities (of the unconfined aquifer) are an order of magnitude lower than those in the confined aquifer”. The value of 1 m/day for the ‘x’ and ‘y’ component result in a good representation of the watertable, when used in conjunction with the values assigned for the vertical hydraulic conductivity of the confining bed. This value may however be a maximum (pers comm S Barnett).

Although the vertical hydraulic conductivity of the confining bed for the north is stated to be zero m/day by Waterhouse *et al* (1978), it is likely to have a small but finite value. Hydraulic testing indicates a range of values in the north, which are calculated as the maximum values following the end of hydraulic testing. The value of 0.00001 m/day was adopted as this allows the head distribution in the unconfined aquifer to be adequately represented. A value of 0.017 m/day was used in the south of the area, the average of the values suggested by Waterhouse *et al* (1978)

STORAGE:

A specific yield of 0.1 was assumed for the unconfined aquifer (measured from core samples by Waterhouse *et al* (1978)). This may be high due to the generally fine sand – silty/clay nature of this aquifer. Hydraulic testing indicates a storage coefficient for the confined aquifer of 0.0005, which is probably satisfactory throughout the area.

HYDRAULIC BOUNDARIES:

Recharge to the confined aquifer occurs via leakage through the confining bed, where it has a higher vertical hydraulic conductivity, and where the rivers cross the faulted basin margin (perhaps up to 5 000 ML/year according to Waterhouse *et al* (1978)). River recharge to the unconfined aquifer may be as high as 3 500 ML/year (Waterhouse *et al* (1978).

HYDRAULIC BOUNDARIES FOR LAYER-1:

- The lake area in the south east was set as a constant head boundary area of 0.75 m (lake level)
- The northeast and southwest boundaries were set as no-flow boundaries
- The northwest boundary was set as a general head boundary
- River recharge at the fault, directly into the confined aquifer, was set as 4 000 ML/year for the Bremer, and 1 000 ML/year for the Angas. This was based on the larger flow in the Bremer River, and the potentiometric surface and salinity data, which indicates recharge in the faulted basin margin. This recharge to the confined aquifer results in an adequate representation of the head distribution for steady state conditions.
- Additional river bed recharge down stream of the fault totalling 1 250 ML/year (a drainage rate of 120 mm) was assumed for the Angas and Bremer rivers, and Mosquito Creek. This value, although smaller than the figure of 3 500 ML/year mentioned by Waterhouse *et al* (1978), adequately represents the head distribution for steady state conditions. Further recharge would require higher hydraulic properties for the unconfined aquifer than may be realistic.
- Evapotranspiration, from the watertable adjacent to Lake Alexandrina and in the north of the area, of 800 mm/year was assumed (less than the pan evaporation at Milang of ~1 100 mm/year). Evapotranspiration from irrigation was taken into account in the estimated 15% drainage used during irrigation.
- Rainfall recharge was considered to be minimal and was ignored

HYDRAULIC BOUNDARIES FOR LAYER-3:

- The boundary of the lake was set as a general head boundary
- The northwest boundary was set as a general head boundary
- The northeast and southwest boundaries were set as no-flow boundaries

MODEL CALIBRATION

PRE-PUMPING CONDITIONS

Initial calibration involved the generation of a satisfactory pre-pumping (steady state) confined aquifer potentiometric surface. The pre-pumping head distribution (Figure 3), was compiled some years ago from historical records. There is no such compilation for the unconfined aquifer.

The head distribution generated by the model for the unconfined aquifer (Figure 4) looks realistic, especially when compared to the February 1993 (Figure 5, time of minimum depth to water following the 1992 flooding), although there is less recharge mounding in the central area. The steady state head distribution generated by the model (Figure 6) for the confined aquifer is a good representation of the pre-pumping data.

HEAVY PUMPING, MARCH 1987

Heavy groundwater pumping during the 1986/87 summer resulted in the extraction of 20 080 ML, with a drainage from irrigation of 4 016 ML (at 20% - used to represent inefficient irrigation).

The head distribution generated by the model for the unconfined aquifer (Figure 7) is a reasonable representation of the real cone of depression

(Figure 8). There is a lack of real data for the north of the area to compare the model results with.

The steady state head distribution generated by the model for the confined aquifer (Figure 9), is a reasonable representation of the real head distribution of the stressed aquifer (Figure 10), when the simplicity of the model is considered.

CURRENT IRRIGATION ACTIVITY, MARCH 1997

Irrigation during the 1996/97 summer (the most recent available data) resulted in the pumping of 2 100 ML of groundwater , and the application of 11 700 ML of Murray River water. Drainage from irrigation from both sources amounts to 2 070 ML (at 15% - used to represent more efficient irrigation). The area under irrigation approximates the 6 109 Ha reported to be under irrigation by irrigators during 1998.

The head distribution generated by the model for the unconfined aquifer (Figure 11) is not entirely satisfactory.

The heads are approximately 1 m higher than the real head distribution (Figure 12) in the south of the area, and the 18 m head contour in the north of the area extends down river to Langhorne Creek, rather than being restricted to the northern boundary. In addition the model results in a surface with a less pronounced recharge mound associated with the Bremer River in the south of the area. The transient model results in a more accurate representation of the observed head distribution.

The steady state head distribution generated by the model for the confined aquifer (Figure 13), is reasonable representation of the real head distribution (Figure 14). The model results in a surface which is less pronounced around the Bremer River, but the heads along the river are a good fit.

MODEL TRANSIENT RUNS

The timesteps were set as follows:

- Pumping and irrigation drainage from November to March inclusive = 150 days
- River recharge from April to October inclusive = 215 days

Day from	Day to	Process	Year	Stress period
0	150	Pumping + drainage	1	1
150	365	River recharge	1	2
365	515	Pumping + drainage	2	3
515	730	River recharge	2	4
730	880	Pumping + drainage	3	5
880	1095	River recharge	3	6
1095	1245	Pumping + drainage	4	7
1245	1460	River recharge	4	8
1460	1610	Pumping + drainage	5	9
1610	1825	River recharge	5	10
1825	1975	Pumping + drainage	6	11
1975	2190	River recharge	6	12
2190	2340	Pumping + drainage	7	13
2340	2555	River recharge	7	14
2555	2705	Pumping + drainage	8	15
2705	2920	River recharge	8	16
2920	3070	Pumping + drainage	9	17
3070	3285	River recharge	9	18
3285	3435	Pumping + drainage	10	19
3435	3650	River recharge	10	20
3650	3800	Pumping + drainage	11	21
3800	4015	River recharge	11	22
4015	4165	Pumping + drainage	12	23
4165	4380	River recharge	12	24
4380	4530	Pumping + drainage	13	25
4530	4745	River recharge	13	26
4745	4895	Pumping + drainage	14	27
4895	5110	River recharge	14	28
5110	5260	Pumping + drainage	15	29
5260	5475	River recharge	15	30
5475	5625	Pumping + drainage	16	31
5625	5840	River recharge	16	32
5840	5990	Pumping + drainage	17	33
5990	6205	River recharge	17	34
6205	6355	Pumping + drainage	18	35
6355	6570	River recharge	18	36
6570	6720	Pumping + drainage	19	37
6720	6935	River recharge	19	38
6935	7085	Pumping + drainage	20	39
7085	7300	River recharge	20	40

Scenario-1: Hydraulic response under the current groundwater and Murray River water use

Current groundwater and River Murray water use (1996/97) resulted in the pumping of 2 100 ML of groundwater, and the application of 11 700 ML of River Murray water. Drainage from irrigation from both sources amounts to 2 070 ML (at 15%). The model was run for 40 stress periods (20 years).

Both the summer (end of pumping, Figure 15) and winter (end of river recharge, Figure 16) head distributions generated by the model for the unconfined aquifer at stress periods-5 and 6 are a reasonable representation of the real head distributions (Figures 12, 17 – depth to water is given in Figure 18). The model indicates that there is little difference between the summer and winter surfaces, however the end of summer surface has slightly higher heads than the winter surface. The watertable slowly rises by up to 2 - 3 m in the north of the area during the 20 year simulation to an elevation of 16 - 18 m, but remains stable in the south (Figures 19 – 24).

Both the summer (Figure 25) and winter (Figure 26) head distributions generated by the model for the confined aquifer at stress period-5 and 6 are a reasonable representation of the real head distributions (Figures 14, 27). The surfaces generated by the model are slightly higher, by 1 – 2 m in the north, and have a less pronounced recharge mound around the Bremer River. The head distribution remains stable through the 20 year simulation (Figures 28 - 33).

In summary, the results of this scenario indicate that under the current groundwater pumping and River Murray water use the watertable will slowly rise over the next 20 years. Due to the greater depth to water in the north this is not likely to present a problem. However the area to the south of Langhorne Creek, which has a shallow watertable (less than 4 m), would be affected within the next 10 years (September 1996 watertable elevation and depth to water are given in Figures 17, 18). In the long term, if the watertable continues to rise, a more wide spread problem may develop in the north. This is supported by the current rises in the observation wells in the north west of the area of 0.5 m/year over the past few years. The head distribution in the confined aquifer will remain relatively stable and indicates a flow through the system throughout the year.

Note

The winter head distribution for stress period-6 at end of winter recharge (Figure 16) is used as the “current maximum watertable equivalent”, to which future scenarios are compared.

Scenario-2: Hydraulic response under the current groundwater and Murray River water use, combined with a wet year

This scenario involves pumping 2 100 ML of groundwater, and the application of 11 700 ML of Murray River water. Drainage from irrigation of from both sources amounts to 2 070 ML (at 15%). The model was run for 40 stress periods (20 years).

The effects of extensive flooding in a wet year was represented by the area flooded in 1992, which results in additional river recharge of 7 000 ML, assuming 100 mm accession to the watertable.

The head distribution generated by the model for the unconfined aquifer following the wet year (Figure 34) indicates a more widely developed 16 m head contour in the north of the area when compared to scenario-1 (Figure 22). The results for stress period 24 (Figure 35) similarly reflect this observation in comparison to that from scenario-1 (Figure 36).

In summary, the results of this scenario indicate that under the current groundwater and Murray River water use, combined with the occurrence of a wet year, there would be a more widely spread development of the watertable in the north of the area (compared to scenario-1), the result of this would persist for at least two years.

Scenario-3: Hydraulic response under the current groundwater use, but with all the allocated Murray River water used

This scenario involves pumping 2 100 ML of groundwater, and the application of 23 250 ML of Murray River water. Drainage from irrigation of from both sources amounts to 3,802 ML (at 15%). The model was run for 40 stress periods (20 years). The area under irrigation was expanded to 9 450 Ha.

The head distribution generated by the model for the unconfined aquifer indicates a rapid development of the watertable (Figures 37 - 44) when compared to the “current maximum watertable equivalent”. The watertable rises by up to 4 m in the north of the area during the 20 year simulation to an elevation of 18 m (where evapo-transpiration takes effect in the model), but remains stable in the south.

The head distribution generated by the model for the confined aquifer indicates the very slow development of increased head (Figures 45 - 48).

In summary, the results of this scenario indicate that under the current groundwater pumping and use of the full Murray River allocation, the watertable rise will affect the area to the south of Langhorne Creek. This impact may occur within 5 – 10 years. In the long term, if heads continued to rise, a more widespread problem may develop in the north. The head distribution in the confined aquifer will remain stable, with a slow development of increased head, and a flow through the system will be maintained throughout the year.

Scenario-4: Hydraulic response if all allocated groundwater and Murray River water were used

This scenario involves pumping 6 400 ML of groundwater, and the application of 23 250 ML of Murray River water. Drainage from irrigation of from both sources amounts to 4 447 ML (at 15%). The model was run for 40 stress periods (20 years).

The head distribution generated by the model for the unconfined aquifer indicates a rapid development of the watertable (end of summer, Figures 49 - 56) when compared to the “current maximum watertable equivalent”. The watertable rises by up to 4 m in the north of the area during the 20 year simulation to an elevation of 18 m (where evapotranspiration takes effect in the model). The watertable remains relatively stable in the south, but indicates a very slight drawdown in response to pumping from the confined aquifer, which recovers following winter recharge.

The head distribution generated by the model for the confined aquifer (Figures 57 - 60) indicates the slow development of a cone of depression during winter. The summer surface indicates recovery, however there is a very slow contraction of the contours to the north indicating a compounded problem in the long term.

In summary, the results of this scenario indicate that with the use of all the groundwater and Murray River water allocated, the watertable rise will affect the area to the south of Langhorne Creek. This impact may occur within 5 – 10 years. In the long term, if heads continued to rise, a more widespread problem may develop in the north.

The head distribution in the confined aquifer indicates that pumping exceeds recharge. The confined aquifer will slowly develop a cone of depression which will result in leakage of saline water from the unconfined aquifer and increased salinisation of the confined aquifer. Flow through the system would only occur for part of the year.

It is possible that the interaction between the two aquifers, especially if a sufficiently developed cone of depression results, may protect the area to the south of Langhorne Creek from waterlogging.

Scenario-5: Sustainable Murray River use with sustainable groundwater use

This scenario involves pumping 5 000 ML of groundwater (equal to the estimated natural recharge), and the application of 20 000 ML of Murray River water. Drainage from irrigation of from both sources amounts to 3 750 ML (at 15%). The model was run for 40 stress periods (20 years).

The head distribution generated by the model for the unconfined aquifer indicates a slightly slower development of the watertable (Figures 61 - 68) when compared to the scenario-4.

The head distribution generated by the model for the confined aquifer (Figures 69 - 72) indicates a slight development of a cone of depression during winter. Under this pumping regime the basin is operating close to the sustainable level, from the hydraulic pressure view point.

In summary, the results of this scenario indicate that with the use of 5 000 ML of groundwater and 20 000 ML of Murray River water, the watertable rise will affect the area to the south of Langhorne Creek which may occur within 5 – 10 years. In the long term, if heads continued to rise, a more widespread problem may develop in the north. The head distribution in the confined aquifer indicates that the basin is being pumped close to the sustainable level from the pressure point of view.

DISCUSSION

AREAS AT RISK OF RISING WATERTABLES AND DRY LAND SALINISATION

Although the model does not indicate that there will be a problem with rising watertables in the south of the area adjacent to Lake Alexandrina (beyond the pre-pumping condition), due to the shallow depth to water even small rises will be of significance. PIRSA observation wells indicate a relatively stable situation following an initial period of rise in response to decreased groundwater pumping and use of Murray River water. This rise is the system coming to equilibrium with the new water management and the watertable may not rise beyond the pre-pumping levels. This would be expected to result in waterlogging and salinisation of some of the land adjacent to the lake.

Watertables in the north of the area may develop more rapidly than the model indicates. The unconfined aquifer in this area is likely to be a more complex system than the simple single layer used in the model. PIRSA observation wells in this area have indicated a steady rise over the last few years at rates of 0.5 m/year, which is greater than that indicated by the model (0.2 m/year). The existence of water in some of 6 m deep irrigators observation wells in this area indicates that the PIRSA unconfined aquifer observation wells, which tend to be of the order of 15 - 20 m total depth, may be monitoring a slightly deeper aquifer. If the existence of shallow water represents an extensive aquifer, then irrigation losses may result in a watertable problem earlier than indicated by the model.

The area which should be considered at most risk, as indicated by the model, is the area to the south of Langhorne Creek, which historically has a shallow watertable (Figure 18). This area is likely to experience problems within the next 10 years under the current groundwater and Murray River water use, and would be at significant risk within 5 years under current groundwater use combined with full use of the Murray River allocation. Areas where watertables approach the surface will result in dry land salinisation

Ongoing monitoring of both the PIRSA observation wells, and the irrigators network, will indicate the extent of rising watertables.

SALT ACCUMULATION AND THE EFFECT ON GROUNDWATER QUALITY

The use of 23 250 ML/year of Murray River water with a salinity of (say) 500 mg/L will result in the importation of 10 000 tonnes of salt annually. Concentration through irrigation will result in accession of more saline water to the already (generally) saline groundwater of the unconfined aquifer.

In scenario-4, where all the allocated groundwater and Murray River water were used, the development of a cone of depression would result in the salt building up in the system and the more rapid deterioration of groundwater quality.

The pumping of the confined aquifer in a sustainable manner from the hydraulic point of view (maintaining a flow through the system), may not protect it from salinity rises. This can only be achieved if the confined aquifer is maintained at a pressure greater than the unconfined aquifer in the south of the area (the north of the area may be protected to a some degree by the confining bed, although leaking wells may represent localised problems), which in turn may result in a more rapid problem with watertable development from imported Murray River water.

It is likely that the groundwater quality of the confined aquifer will slowly deteriorate in the long term.

CONCLUSION

Modelling indicates that:

- The importation of Murray River water into the area will result in rising watertables, particularly in the area to the south of Langhorne Creek
- The area adjacent to Lake Alexandrina may not be at as great a risk from rising watertables as has been believed, although even small rises in this area are of significance
- With increased use of Murray River water, the north of the area may be affected by rising watertables in the longer term
- It is likely that the slow deterioration of groundwater quality in the confined aquifer is inevitable

There is a desire to continue the economic development within the Angas - Bremer area. For this to occur a clear approach to the water resource management will need to be developed. Due to the complexity of the groundwater system, attempts to manage watertables may result in the unwanted response in one of the other components of the system. Such responses must be appreciated when making decisions regarding the transfer of further Murray River water into the area. The long term viability of the confined aquifer may not be guaranteed without engineering intervention.

The tendency at this point is often to undertake more refined modelling to obtain quantitative predictions of the impacts of various management scenarios. Further modelling will however be hampered by:

- The lack of widespread data on the hydraulic properties of the aquifers
- Extent and nature of the confining bed
- Poor knowledge of the recharge from the Angas and Bremer rivers, irrigation from the rivers, and anthropogenic flooding

Further investigative work that could be undertaken in the field to address these data deficiencies include:

- The hydraulic properties of the unconfined aquifer, (and possibly the confining bed) from laboratory analysis of cores and possibly field hydraulic testing (using PIRSA and irrigators shallow observation wells). Further data may be obtained from geophysical logging of observation wells penetrating the confined aquifer.
- Soil types and drainage from irrigation
- River recharge, which can only be satisfactorily undertaken by the construction of gauging stations on both rivers; but is complicated by the diversions which occur from both rivers, and a lack of suitable sites. It is possible that nests of piezometers adjacent to the rivers may allow the calculation of losses from the rivers. Hydraulic monitoring may result in useful data regarding losses from the Bremer River in the area of the fault.

Further desk studies include:

- Analyse irrigators annual reports which may provide further detail on irrigation application rates and river diversion practices
- Further assess hydrogeologic data which may better define the nature and extent of the confining bed

Modelling should also include:

- The use of the natural surfaces for the layers (including a more complex multi layered unconfined aquifer)
- More detailed calibration using the observation well data, and annual production/injection rates (where available).

This costly work may result in revealing little more about the future behaviour of the system than the simple modelling described in this report. Further work, as outlined above, is not recommended at this time. Instead, it is recommended that resources be allocated to the upgrading/extending the observation network, monitoring and data review. In addition, hydraulic modelling of scenarios developed in the Water Allocation Plan may be warranted, using the current model, together with modelling of the salinity response.

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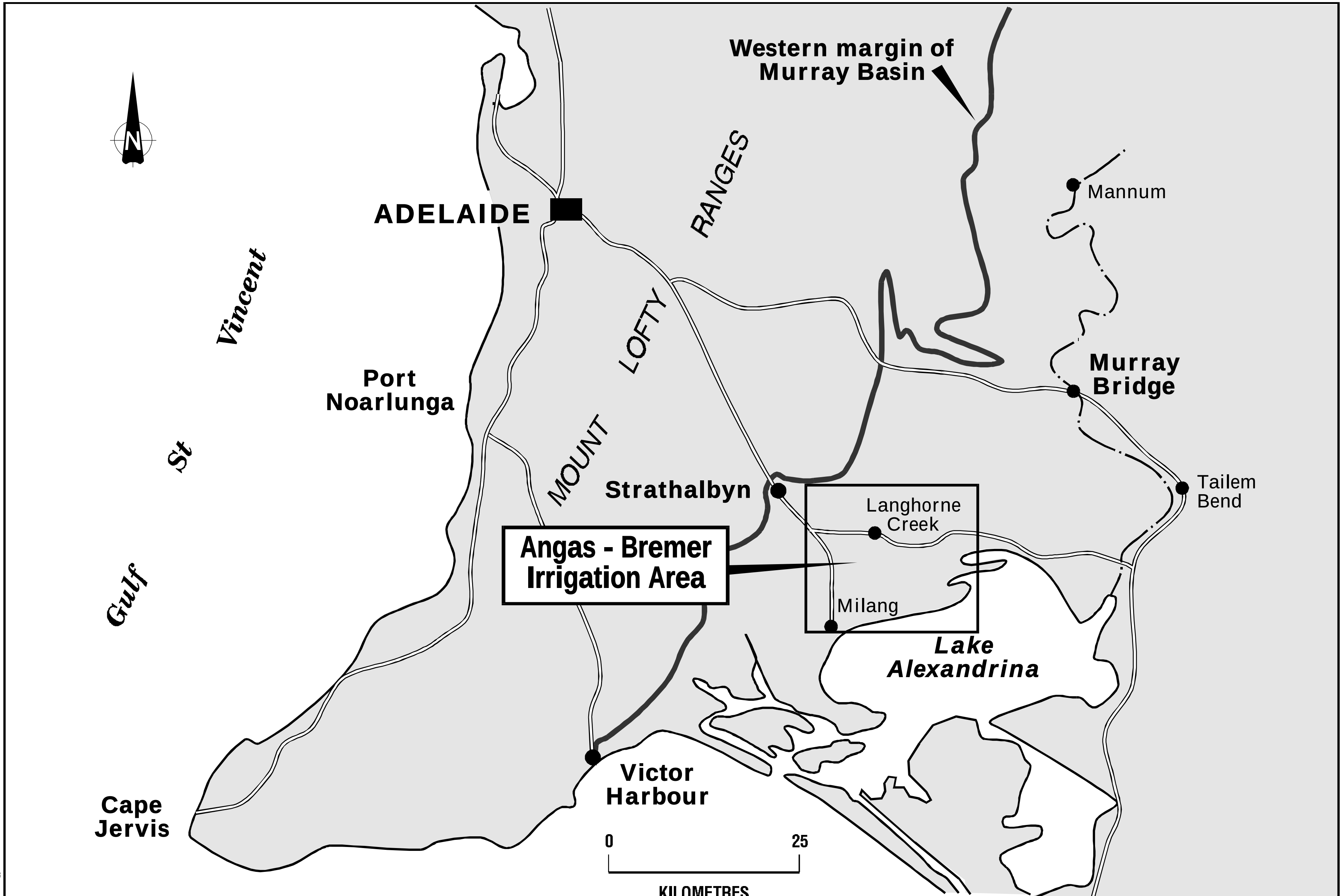


Figure........1

AN ASSESSMENT OF THE WATER RESOURCE ISSUES
IN THE ANGAS - BREMER IRRIGATION AREA

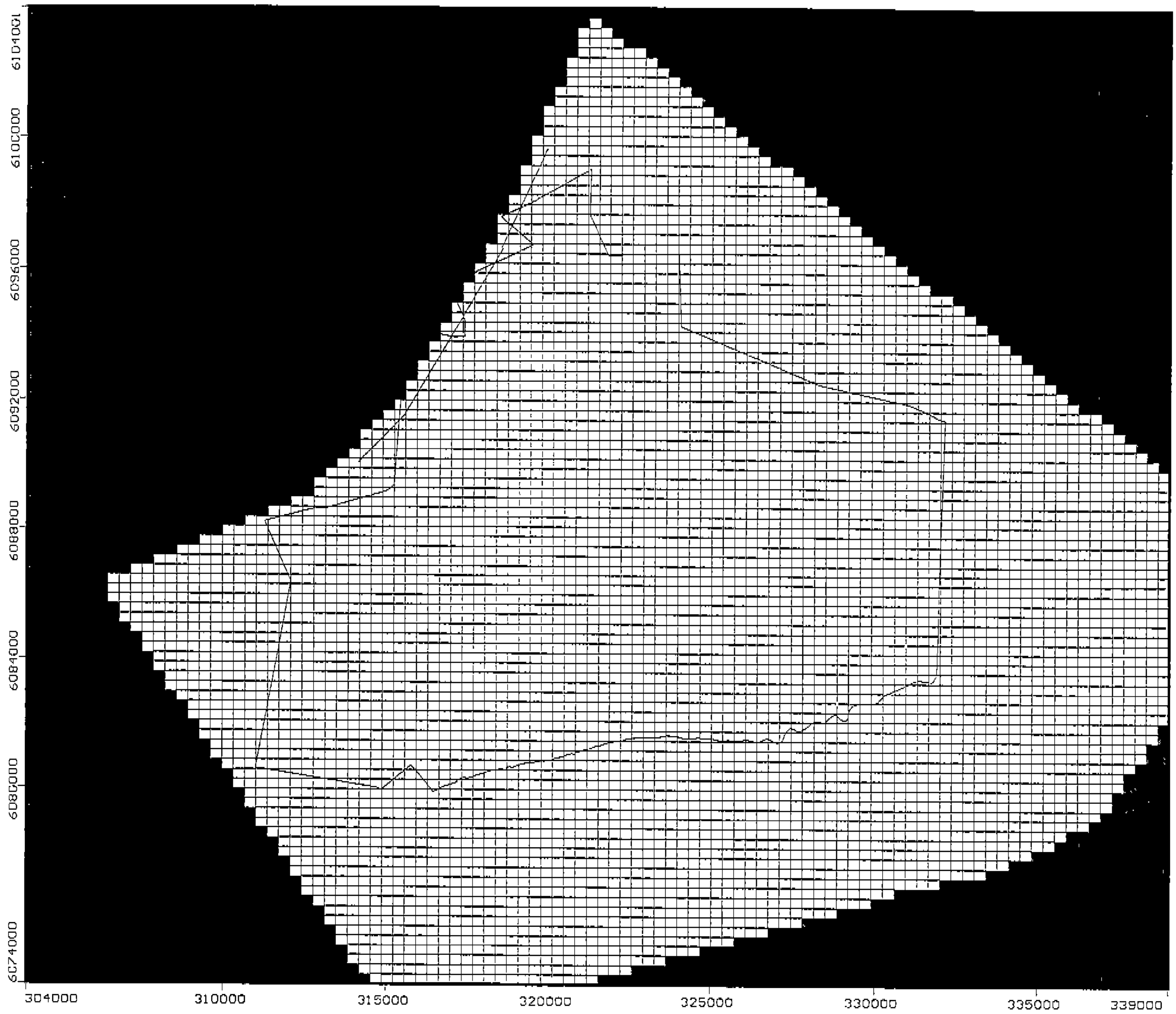
REGIONAL LOCALITY PLAN

MINES AND ENERGY
SOUTH AUSTRALIA

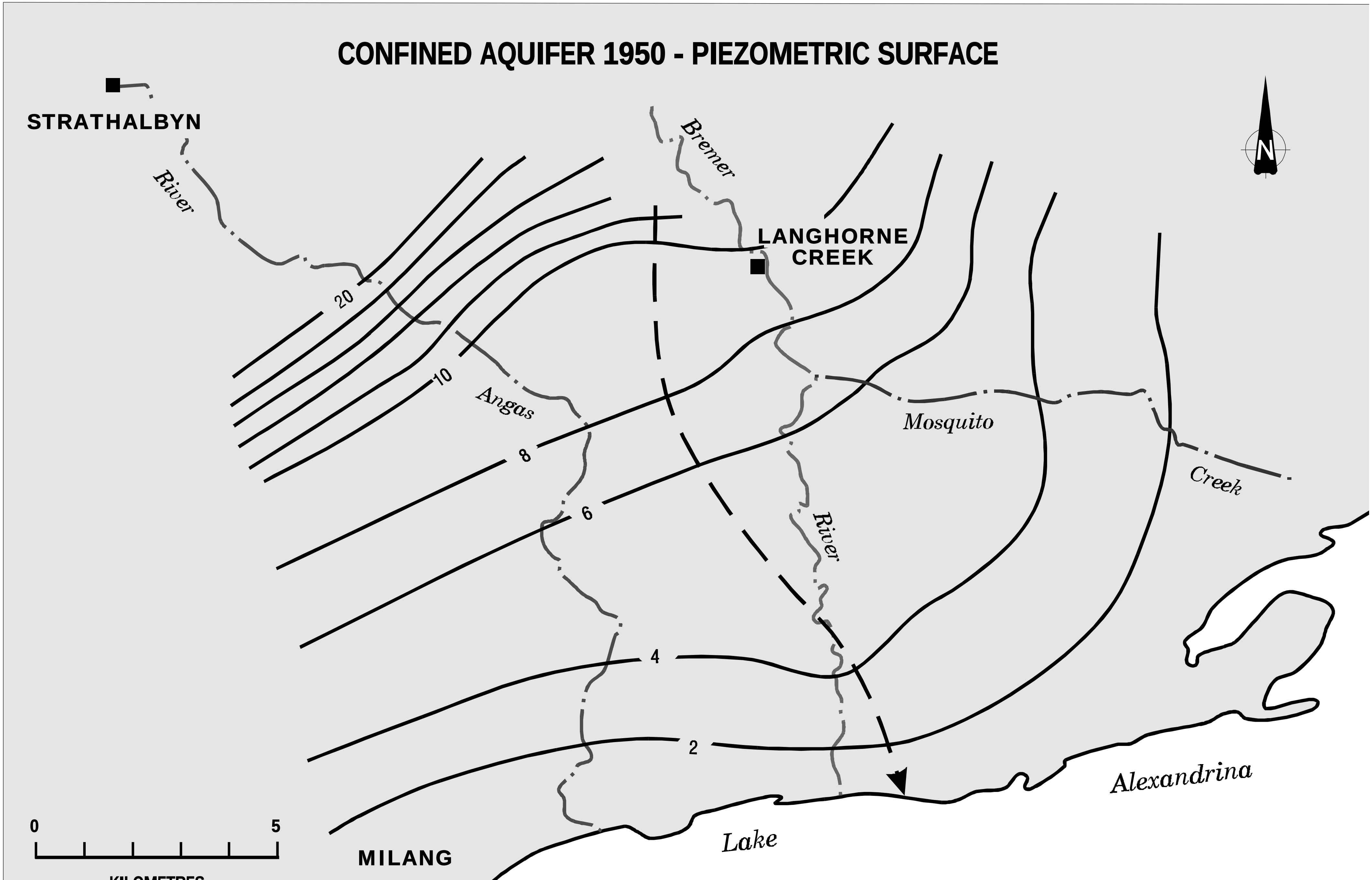
95-696

Job No. 6279sh.cdr

Figure 2: Model no-flow boundaries – inactive cells



Dept. of Mines & Energy – Australia Project: ANGAS–BREMER RISKS Description: INACTIVE CELLS Modeller: S R HOWLES 24 Nov 98	Visual MODFLOW v.2.60, (C) 1995–1997 Waterloo Hydrogeologic Software NC: 100 NR: 100 NL: 3 Current Layer: 1



AN ASSESSMENT OF THE WATER RESOURCE ISSUES
IN THE ANGUS - BREMER IRRIGATION AREA

PRE-IRRIGATION CONFINED AQUIFER PIEZOMETRIC SURFACE,1950

95-699 MESA

Job No. 6279sh.cdr

Figure 4:
Unconfined aquifer model pre-pumping (steady state) head distribution

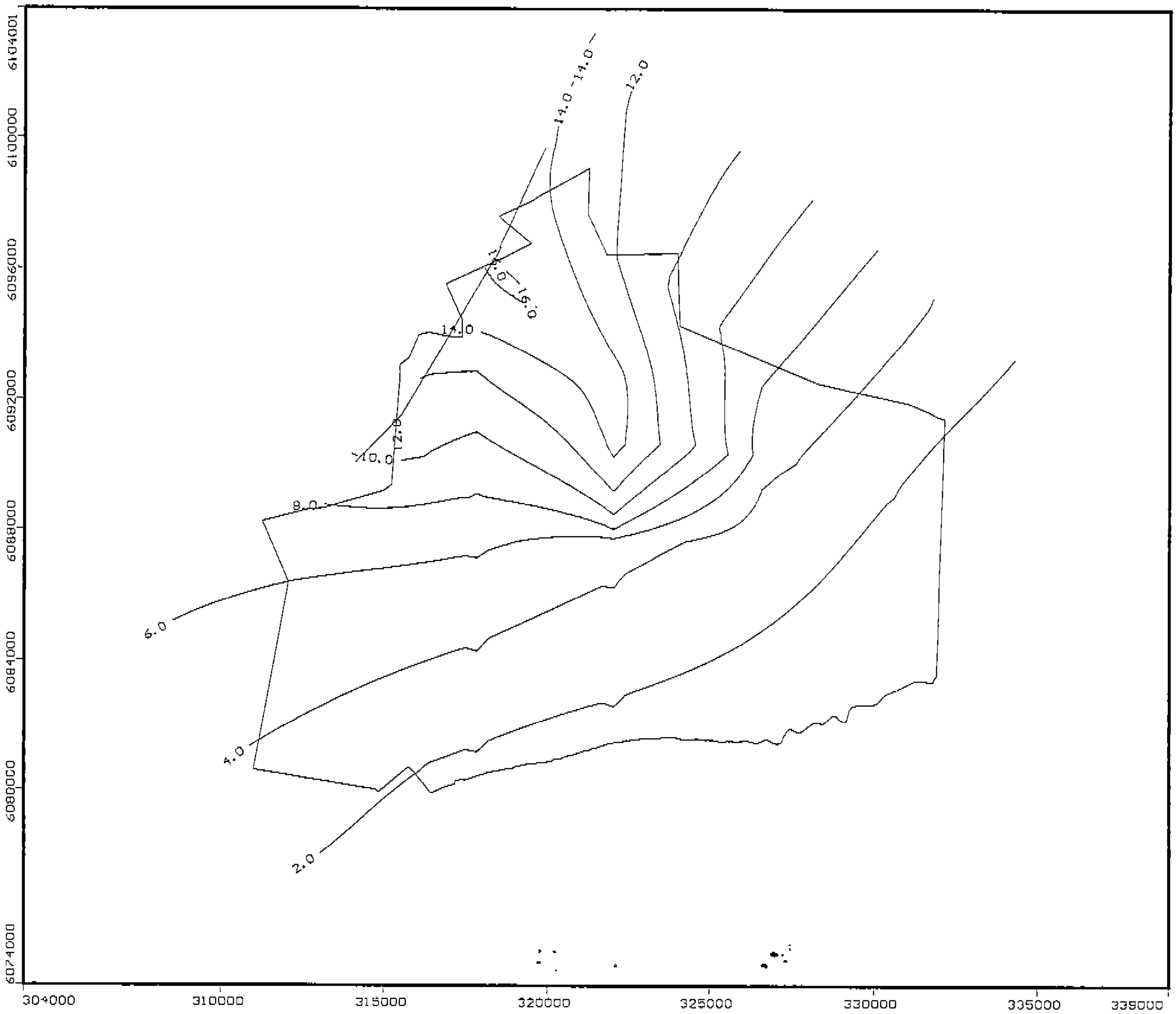


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Figure 5: Unconfined aquifer actual head distribution February 1993

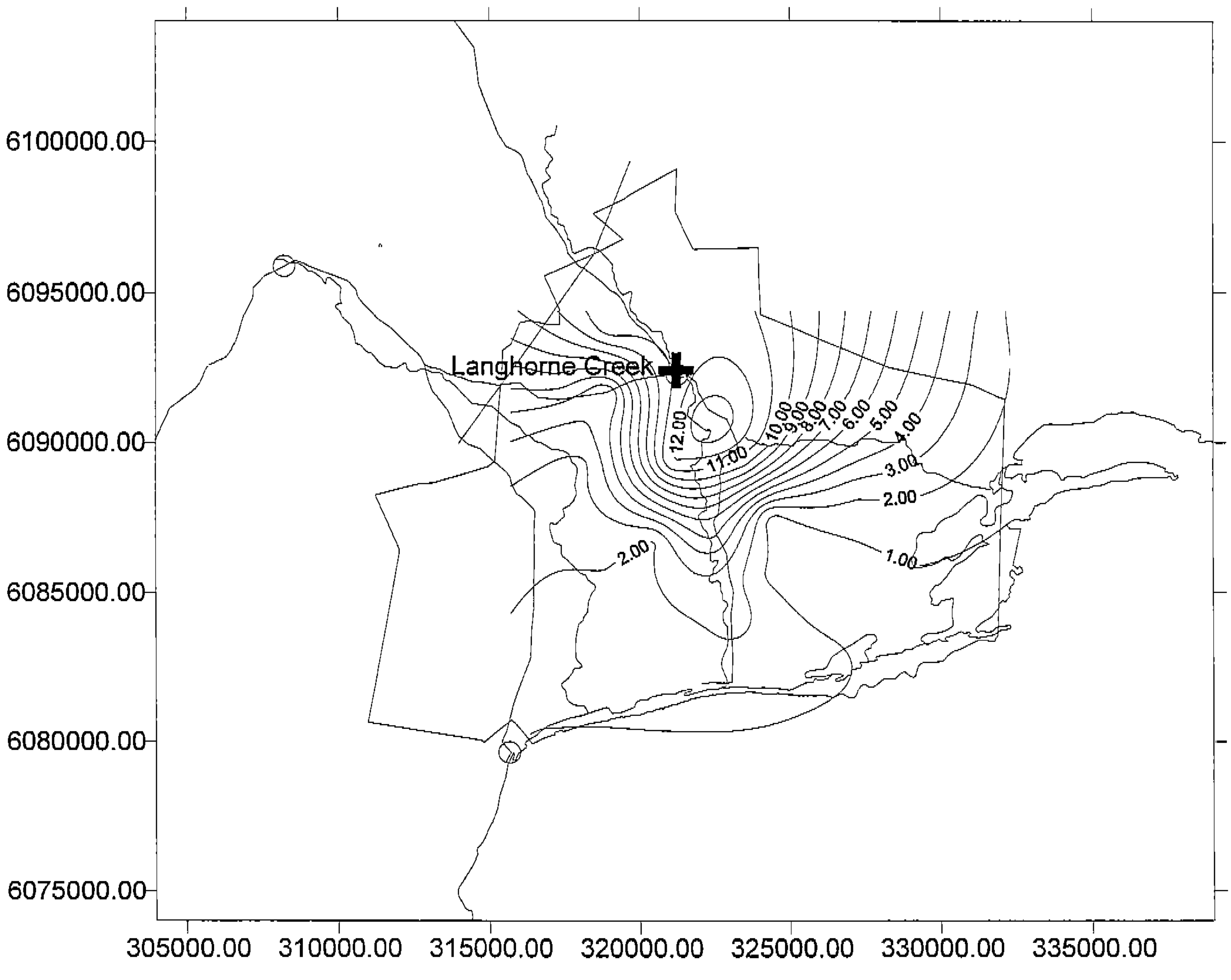
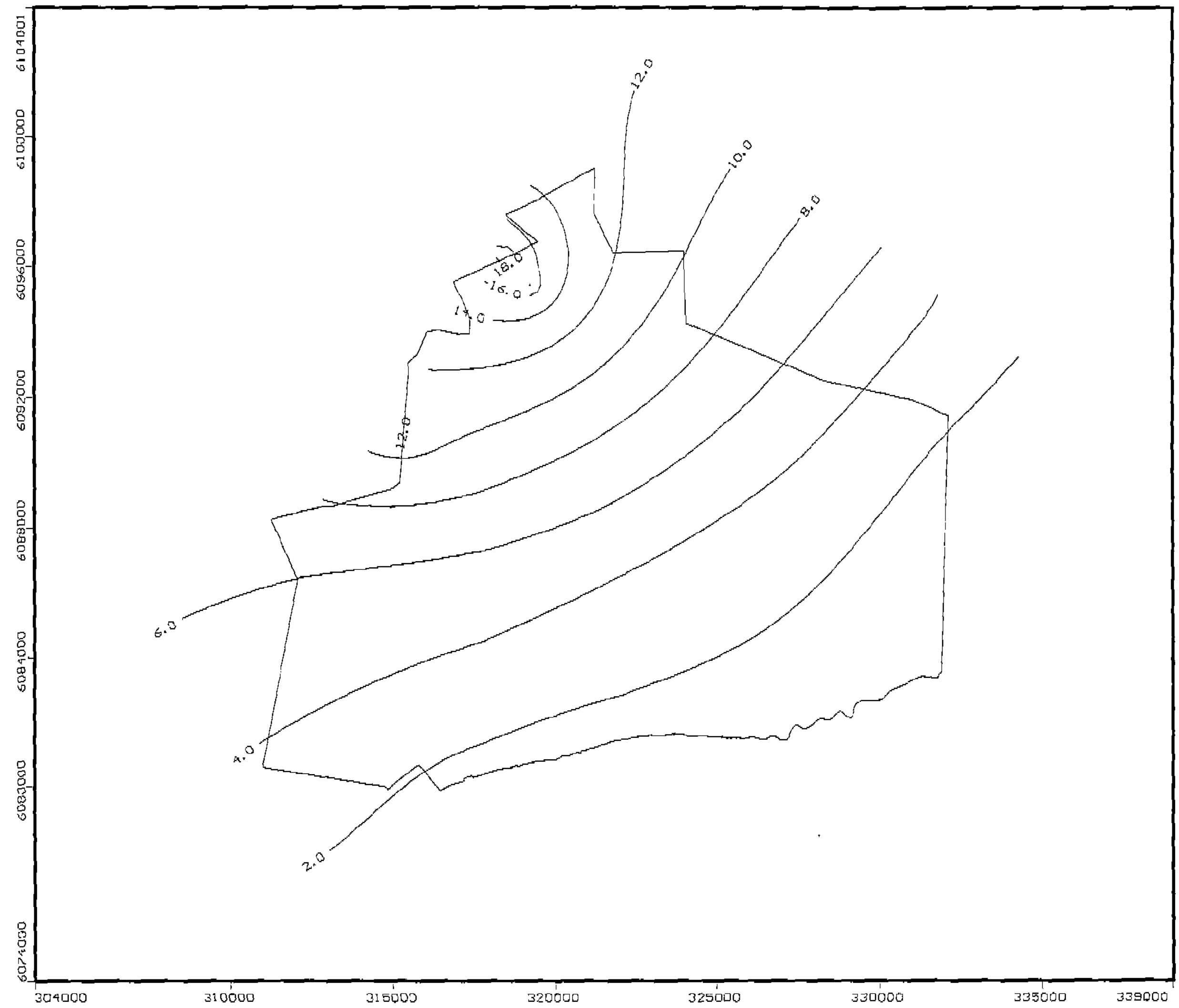


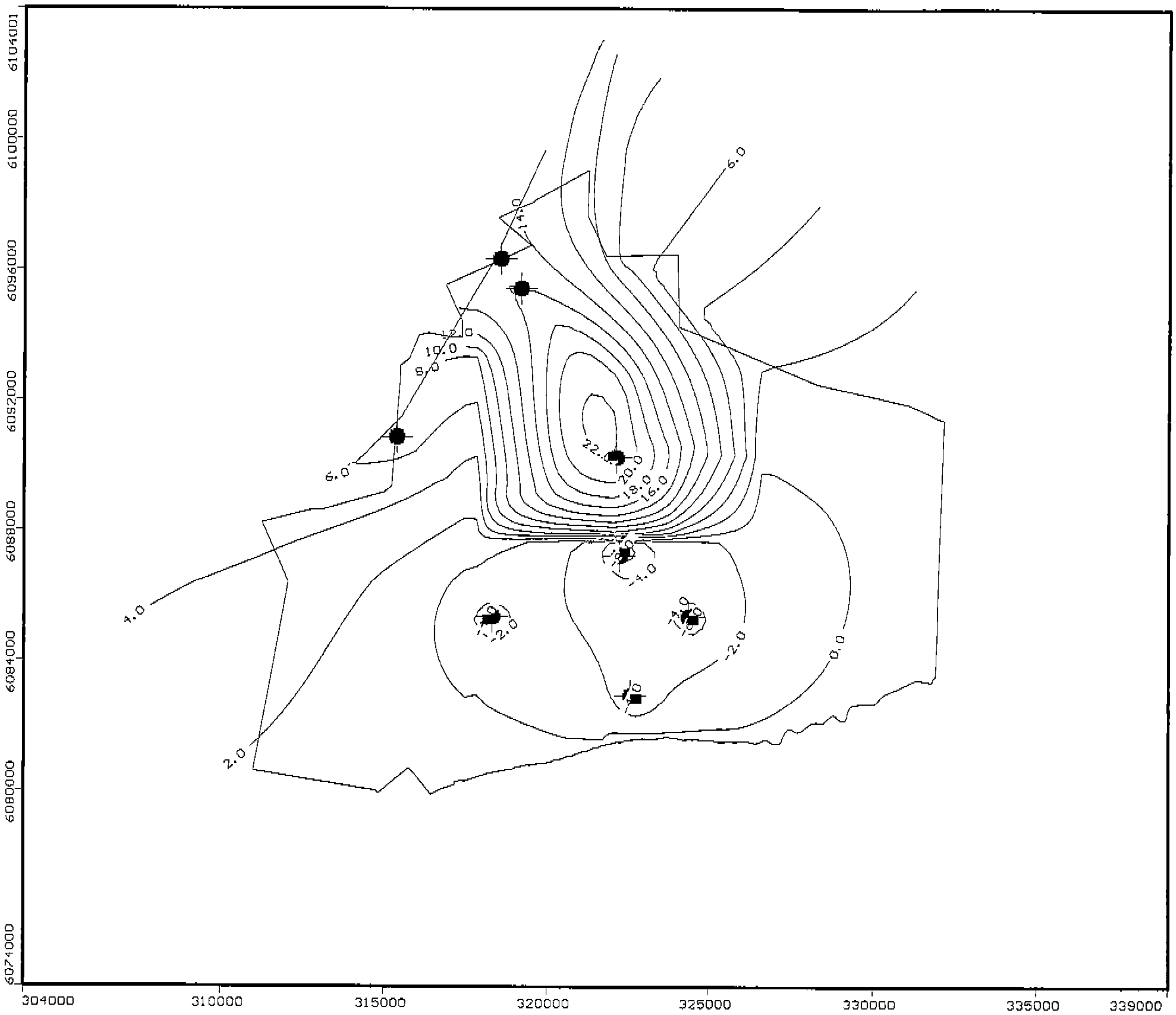
Figure 6:
Confined aquifer model pre-pumping (steady state) head distribution



Dept. of Mines & Energy - Australia
Project: ANGAS-BREMER RISKS
Description: T: S-STATE PRE-PUMPING
Modeller: S R HOWLES
20 Nov 98

Visual MODFLOW v.2.60, (C) 1995-1997
Waterloo Hydrogeologic Software
NC: 100 NR: 100 NL: 3
Current Layer: 3

Figure 7:
Unconfined aquifer model head distribution (steady state) 1986/87 pumping



Dept. of Mines & Energy – Australia Project: ANGAS–BREMER RISKS Description: Q: S–STATE 1987 WATER USE Modeller: S R HOWLES 22 Nov 98	Visual MODFLOW v.2.60, (C) 1995–1997 Waterloo Hydrogeologic Software NC: 100 NR: 100 NL: 3 Current Layer: 1

Figure 8: Unconfined aquifer actual head distribution March 1987

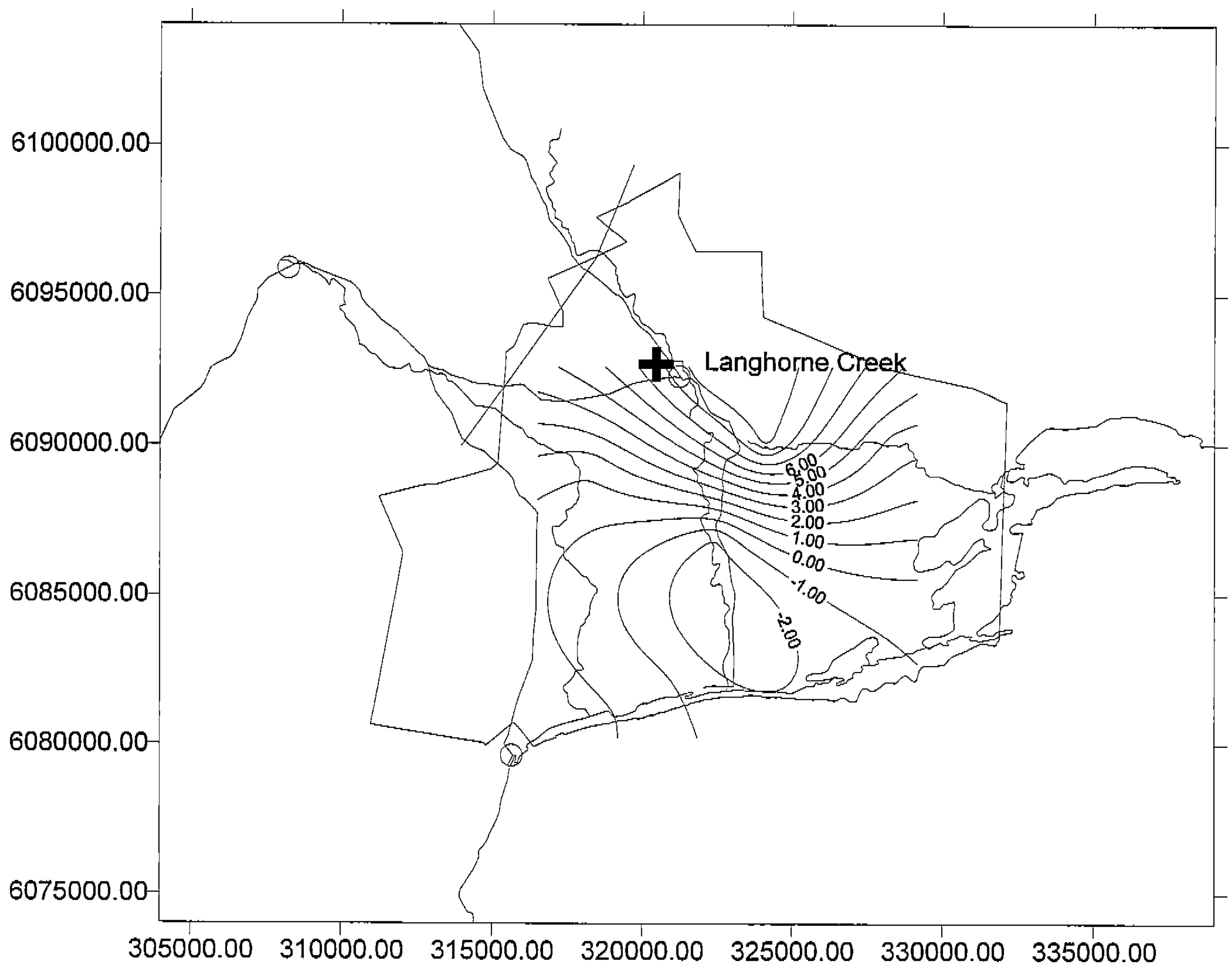
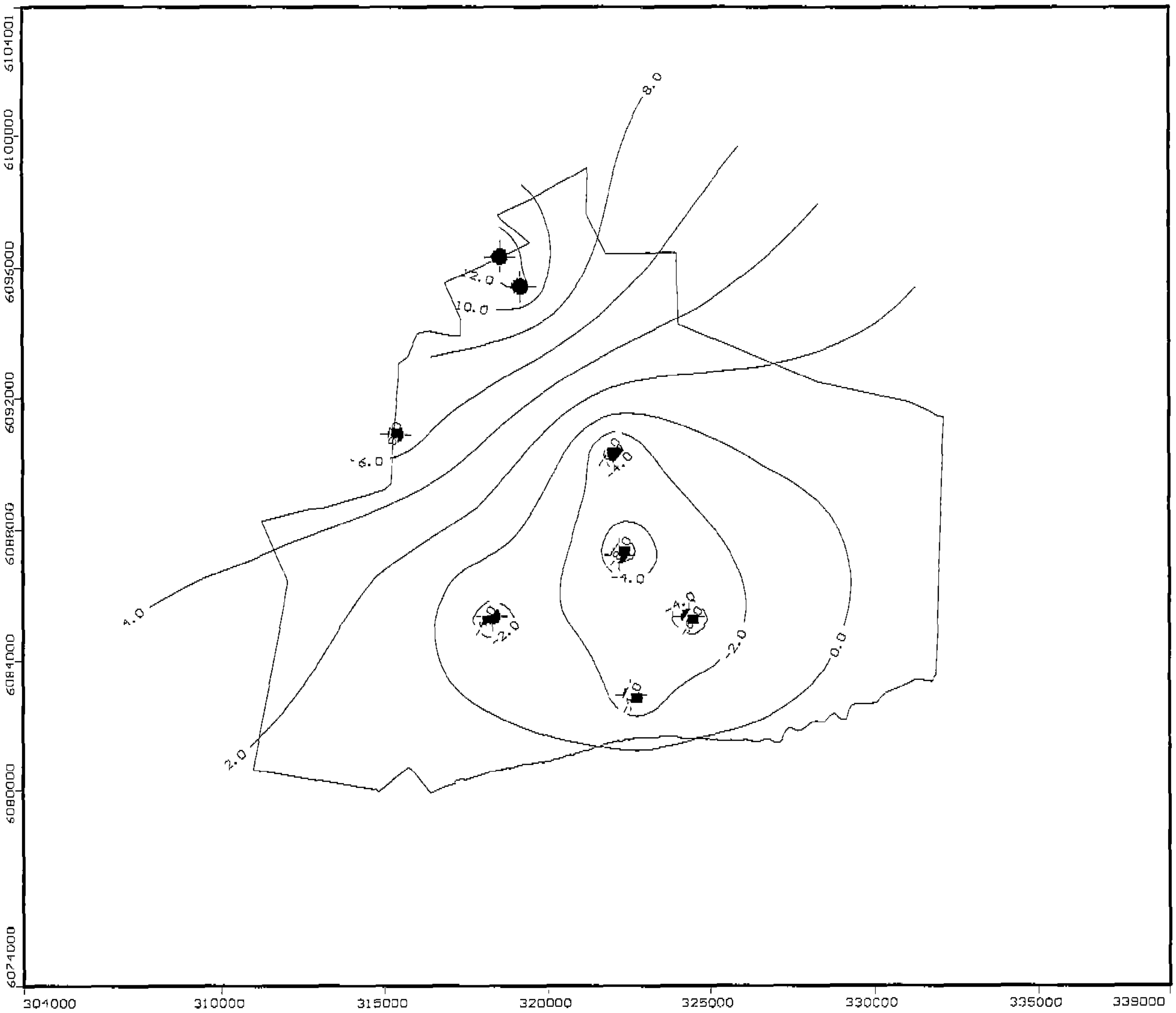


Figure 9:
Confined aquifer model head distribution (steady state) 1986/87 pumping



Dept. of Mines & Energy – Australia Project: ANGAS–BREMER RISKS Description: T: S–STATE 1987 WATER USE Modeller: S R HOWLES 22 Nov 98	Visual MODFLOW v.2.60, (C) 1995–1997 Waterloo Hydrogeologic Software NC: 100 NR: 100 NL: 3 Current Layer: 3

Figure 10: Confined aquifer actual head distribution March 1987

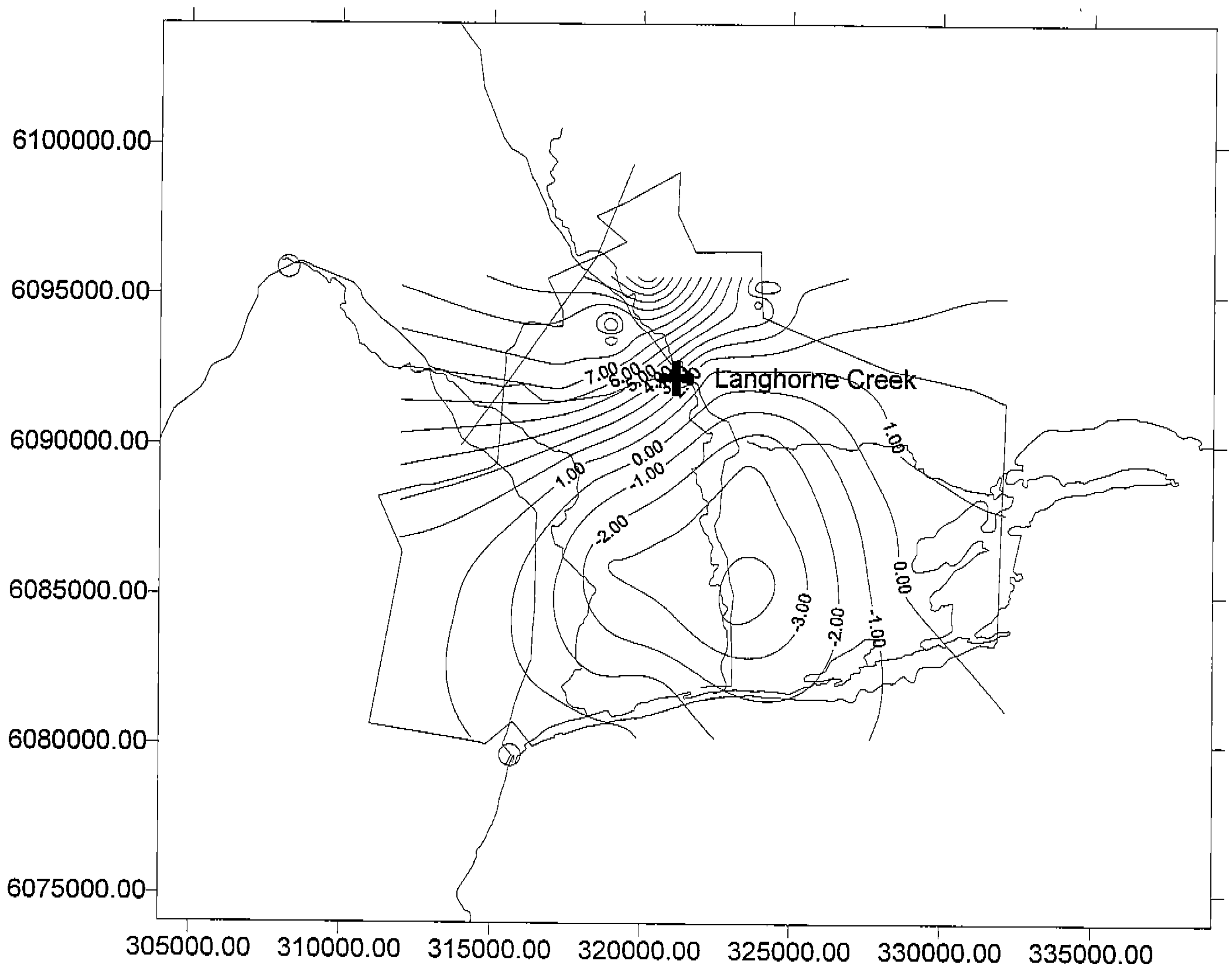
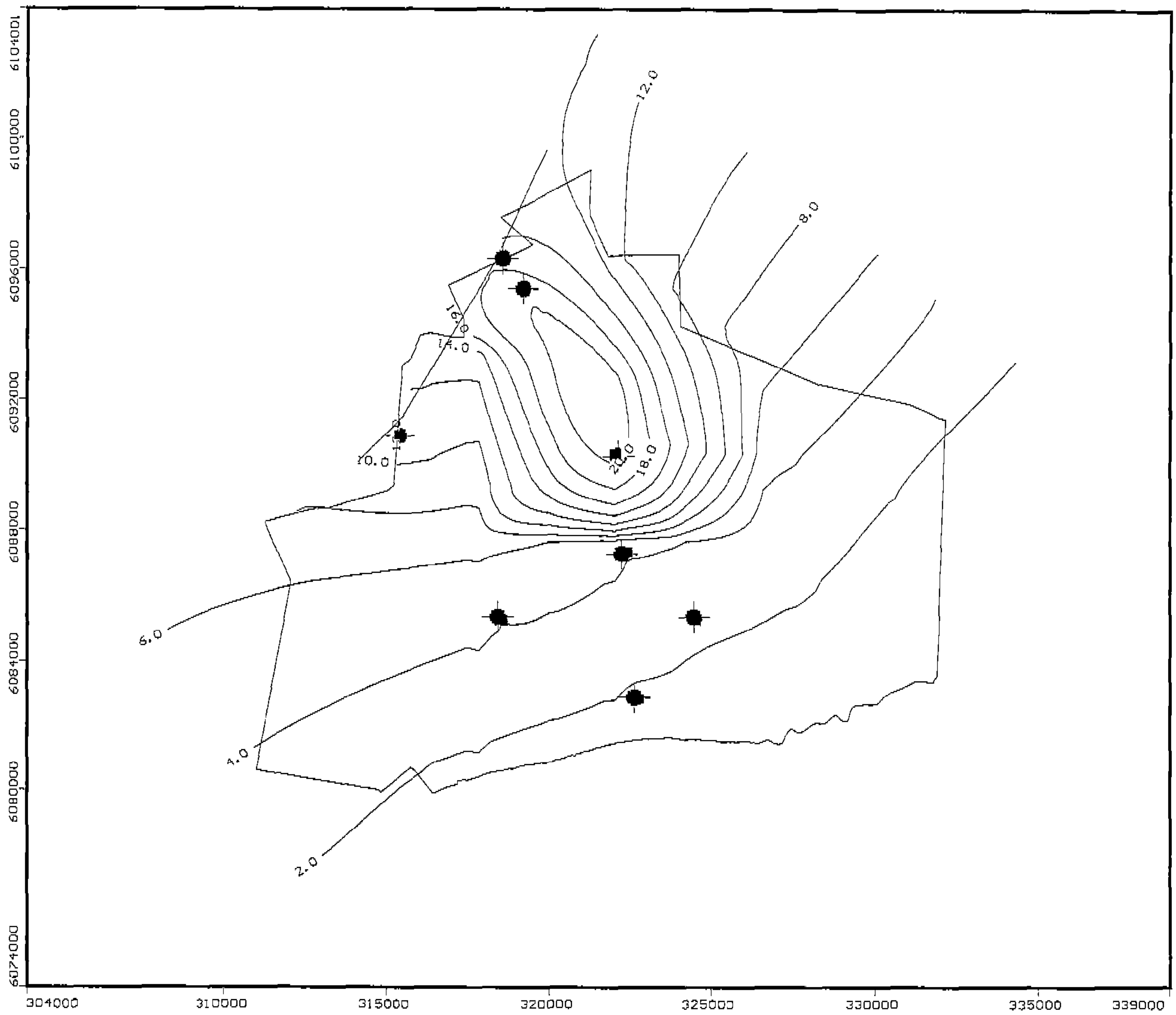


Figure 11:
Unconfined aquifer model head distribution (steady state) 1996/97 pumping



Dept. of Mines & Energy - Australia Project: ANGAS-BREMER RISKS Description: Q: S-STATE 1997 WATER USE Modeller: S R HOWLES 20 Nov 98	Visual MODFLOW v.2.60, (C) 1995-1997 Waterloo Hydrogeologic Software NC: 100 NR: 100 NL: 3 Current Layer: 1

Figure 12: Unconfined aquifer actual head distribution March 1997

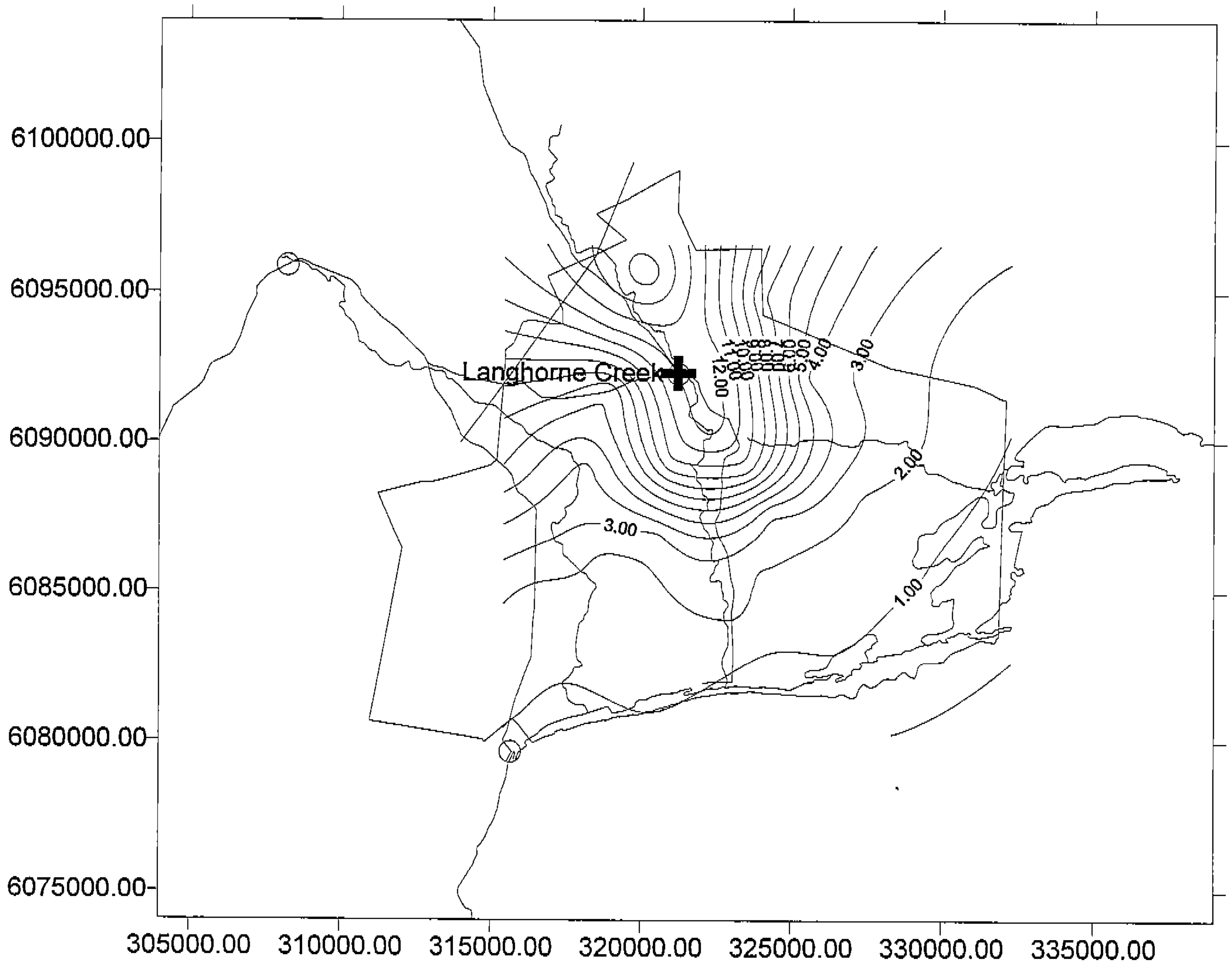
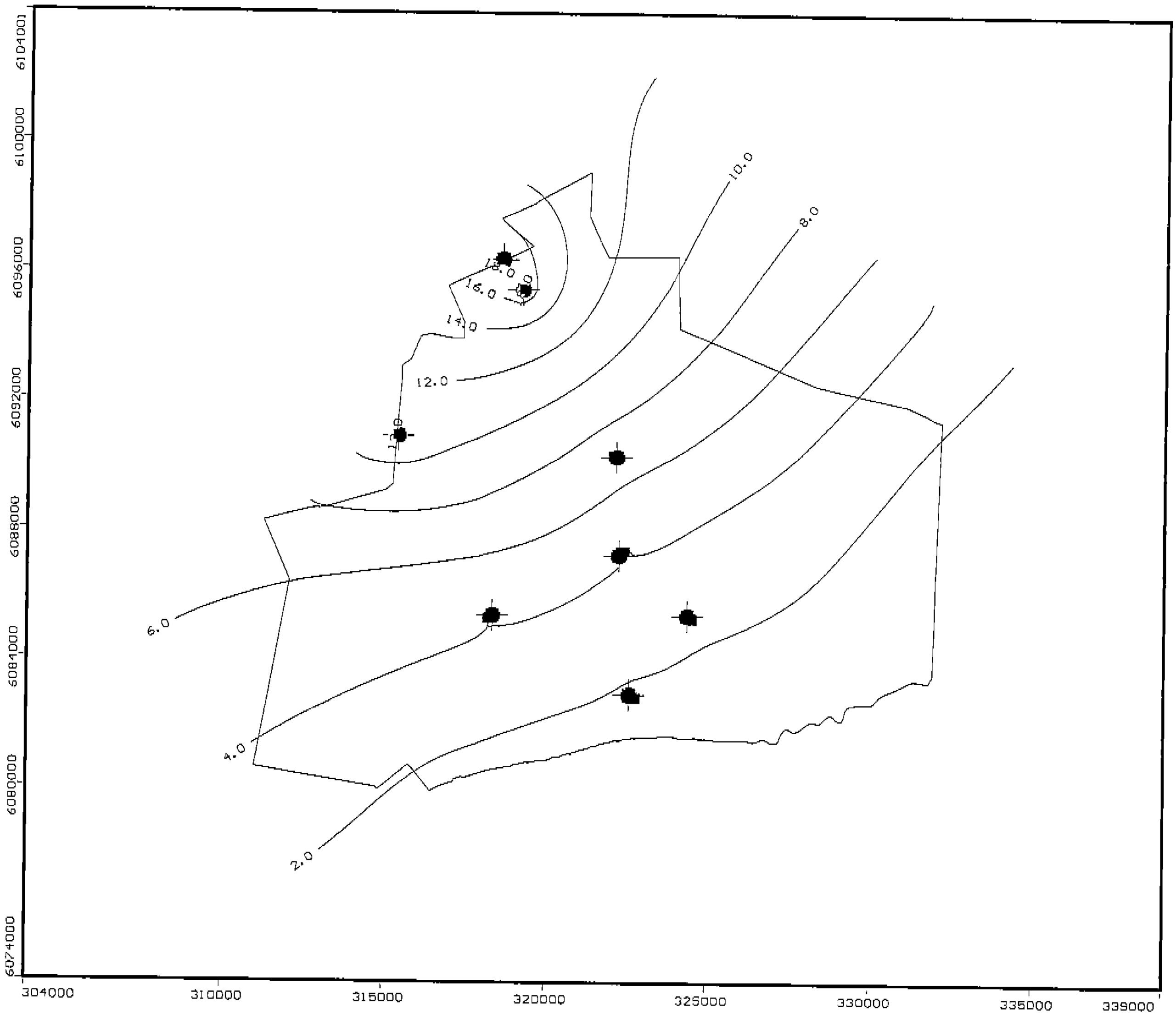


Figure 13:
Confined aquifer model head distribution (steady state) 1996/97 pumping



Dept. of Mines & Energy - Australia
Project: ANGAS-BREMER RISKS
Description: T: S-STATE 1997 WATER USE
Modeller: S R HOWLES
20 Nov 98

Visual MODFLOW v.2.60, (C) 1995-1997
Waterloo Hydrogeologic Software
NC: 100 NR: 100 NL: 3
Current Layer: 3

Figure 14: Confined aquifer actual head distribution March 1997

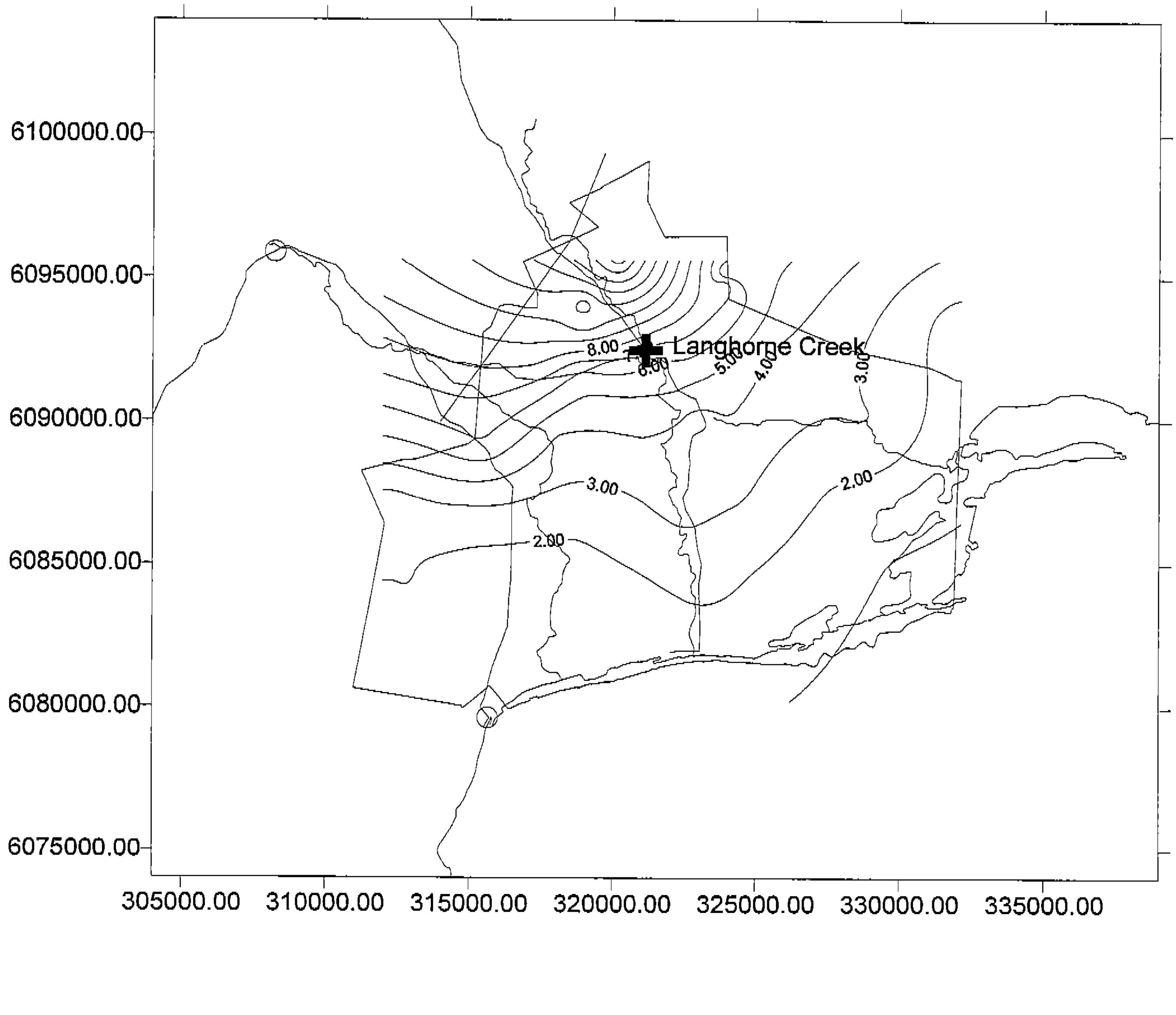
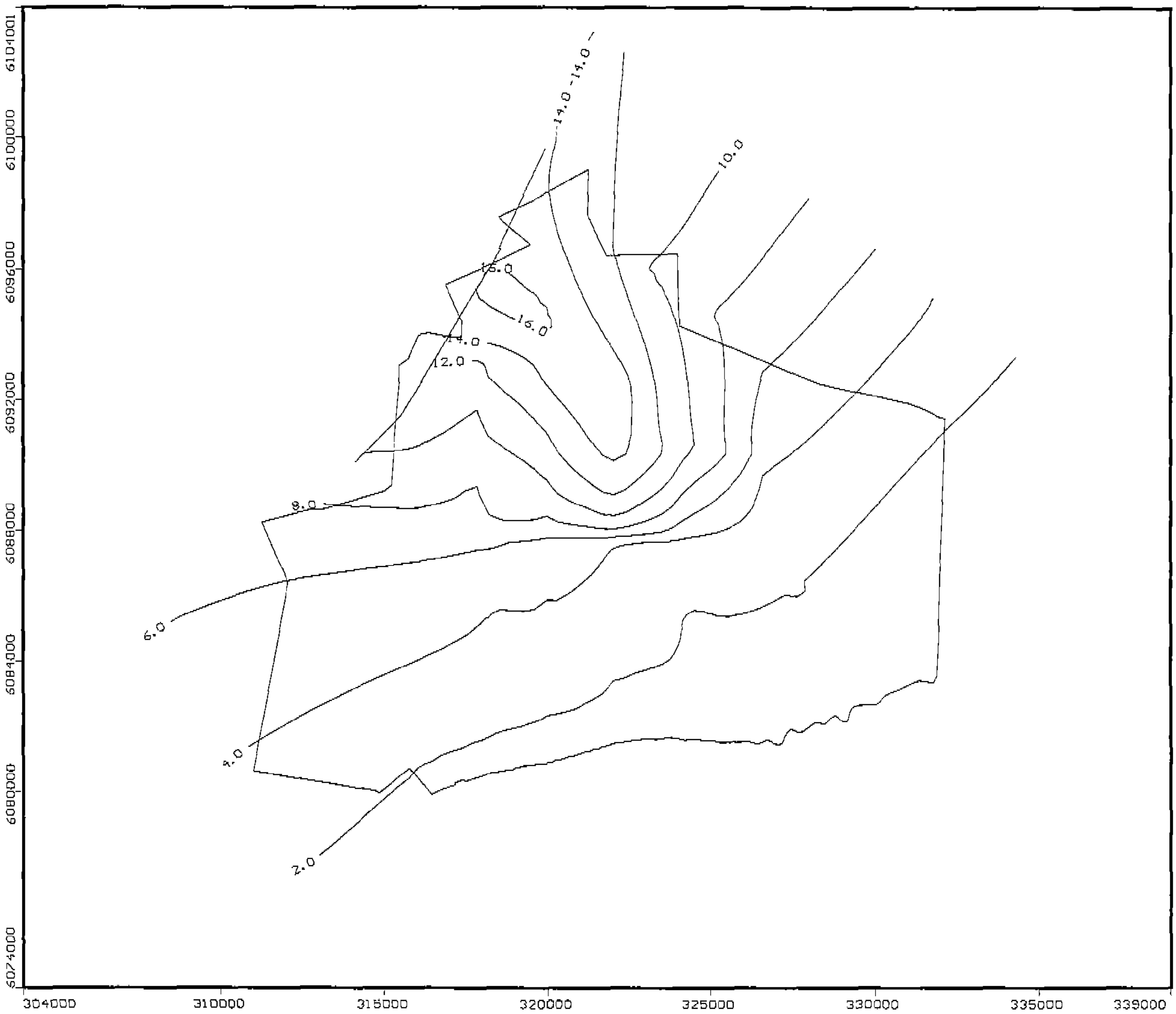
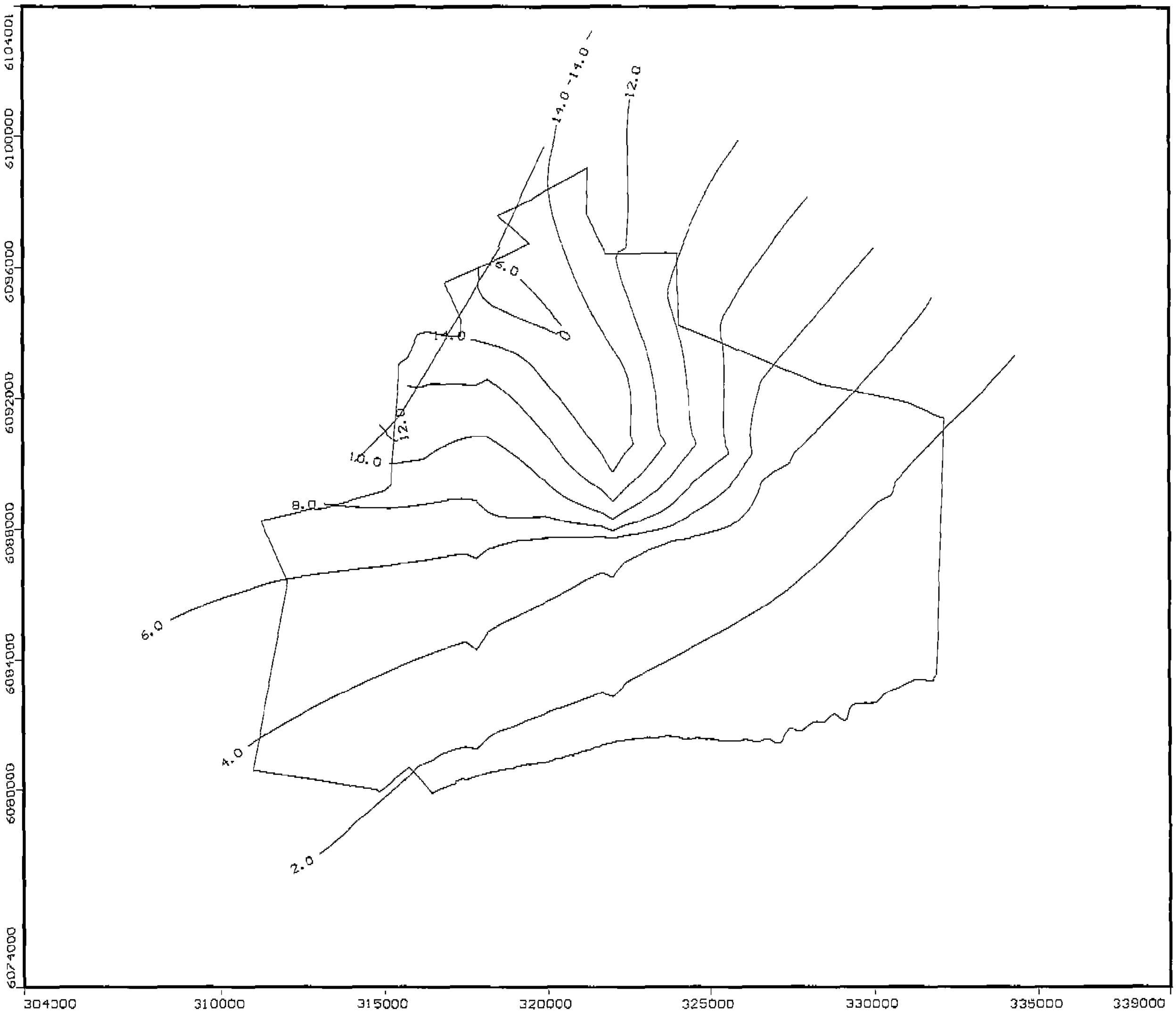


Figure 15:
Unconfined aquifer model head distribution (end pumping), scenario-1 stress period-5



Dept. of Mines & Energy – Australia Project: ANGAS–BREMER RISKS Description: Q: TRNS STRESS PERIOD–5 Modeller: S R HOWLES 22 Nov 98	Visual MODFLOW v.2.60, (C) 1995–1997 Waterloo Hydrogeologic Software NC: 100 NR: 100 NL: 3 Current Layer: 1

Figure 16:
Unconfined aquifer model head distribution (end river recharge), scenario-1 stress period-6, current maximum watertable equivalent



Dept. of Mines & Energy – Australia Project: ANGAS–BREMER RISKS Description: Q: TRNS STRESS PERIOD–6 Modeller: S R HOWLES 14 Dec 98	Visual MODFLOW v.2.60, (C) 1995–1997 Waterloo Hydrogeologic Software NC: 100 NR: 100 NL: 3 Current Layer: 1

Figure 17: Unconfined aquifer actual head distribution September 1996

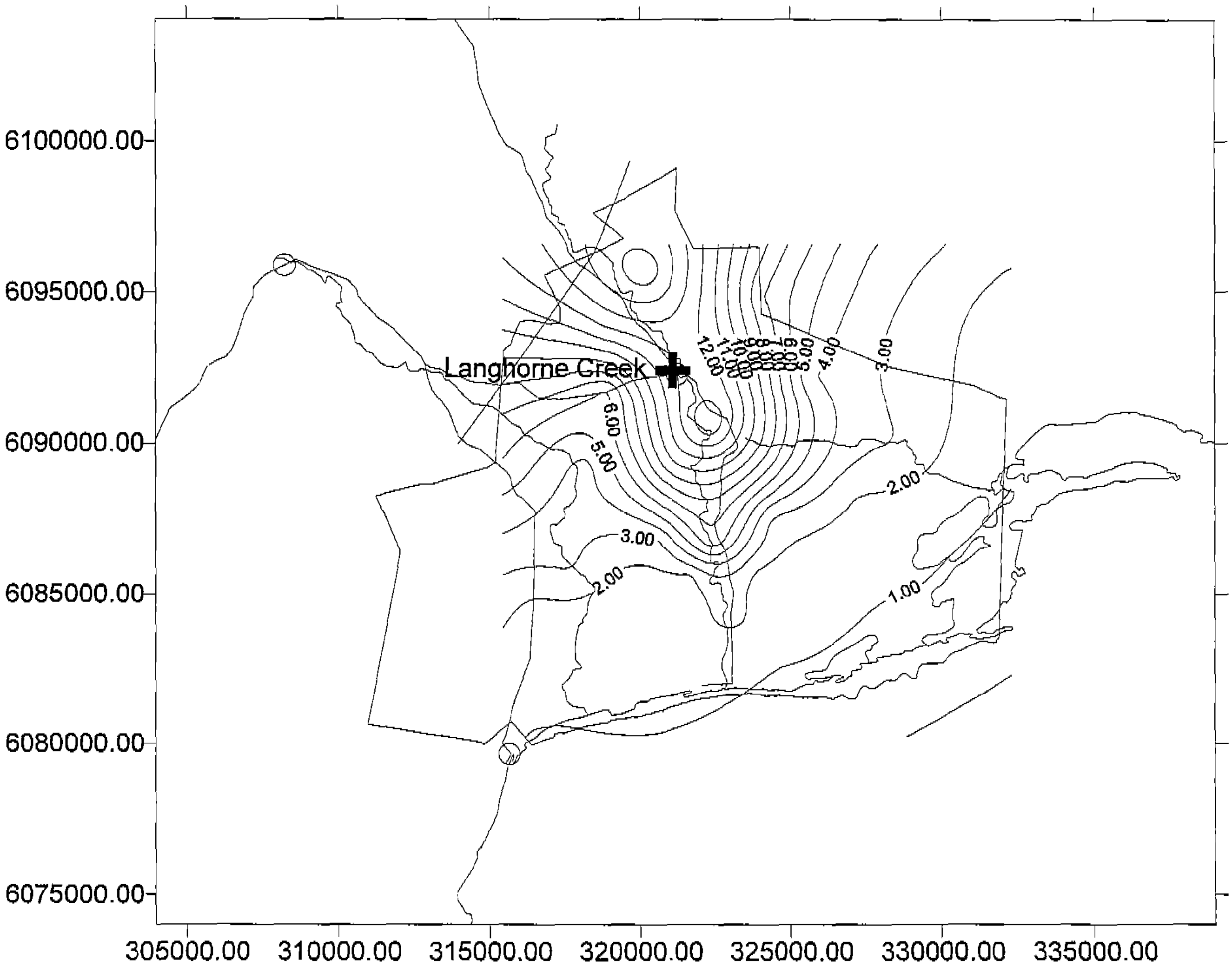


Figure 18: Unconfined aquifer actual depth to water September 1996

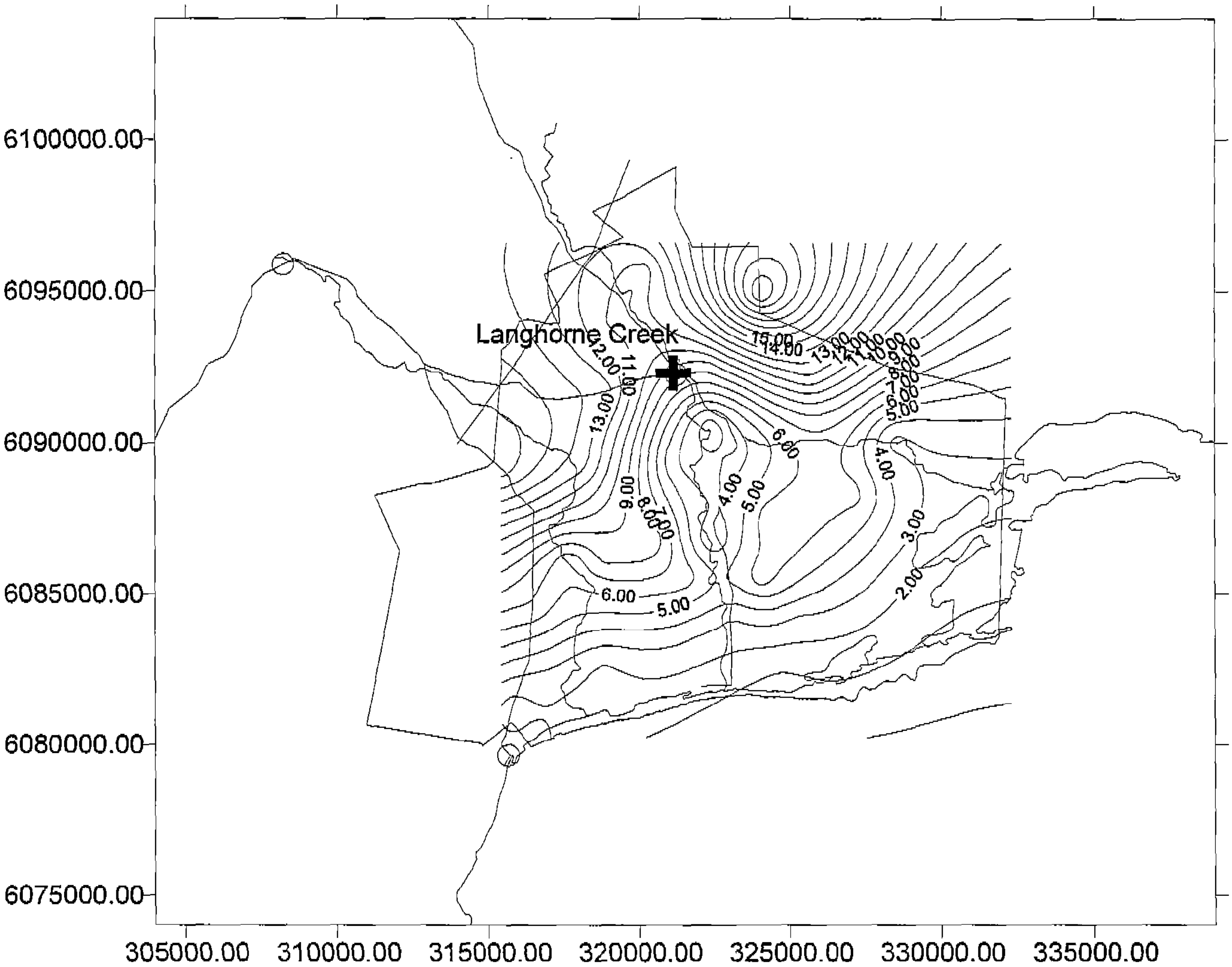
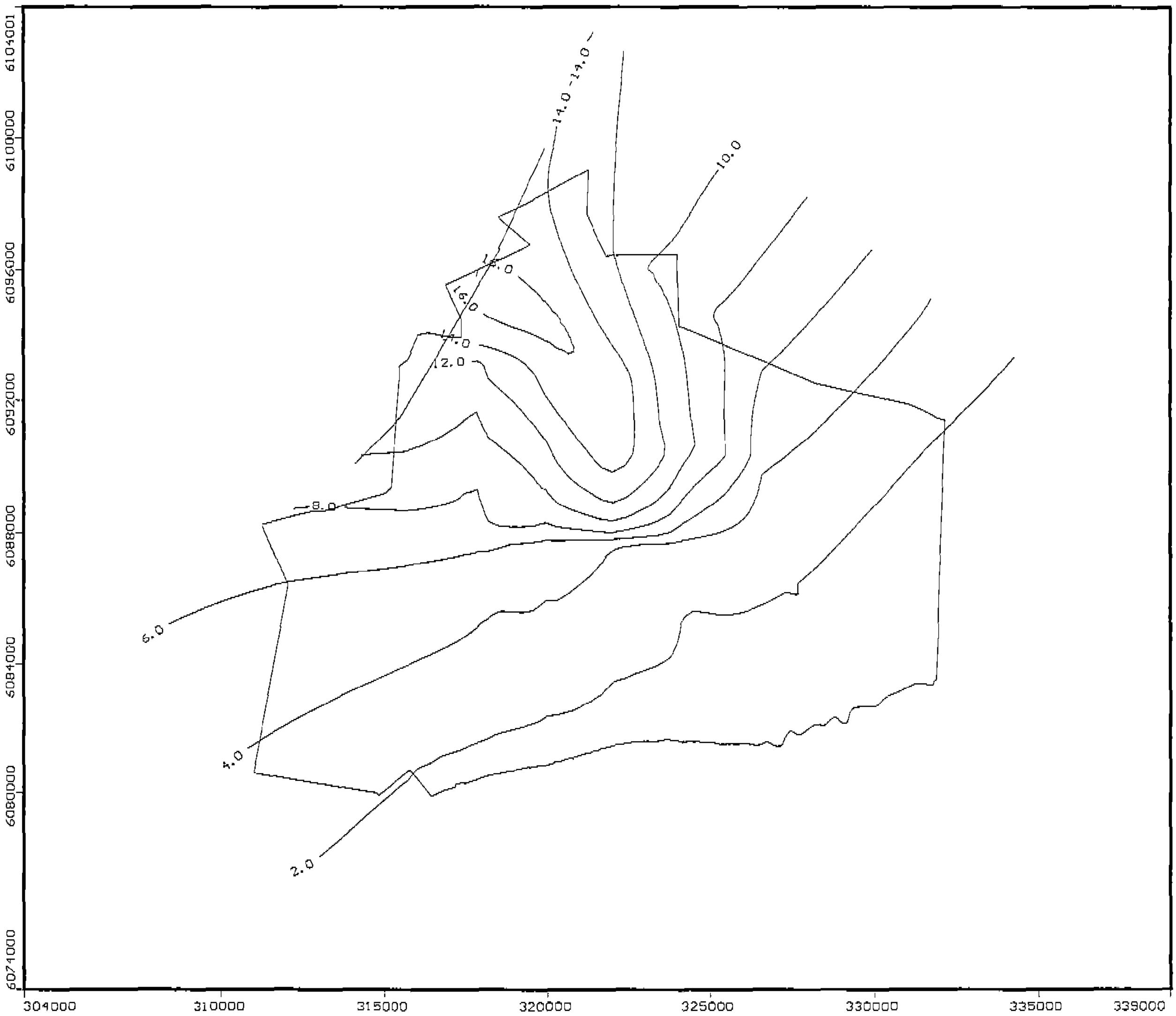
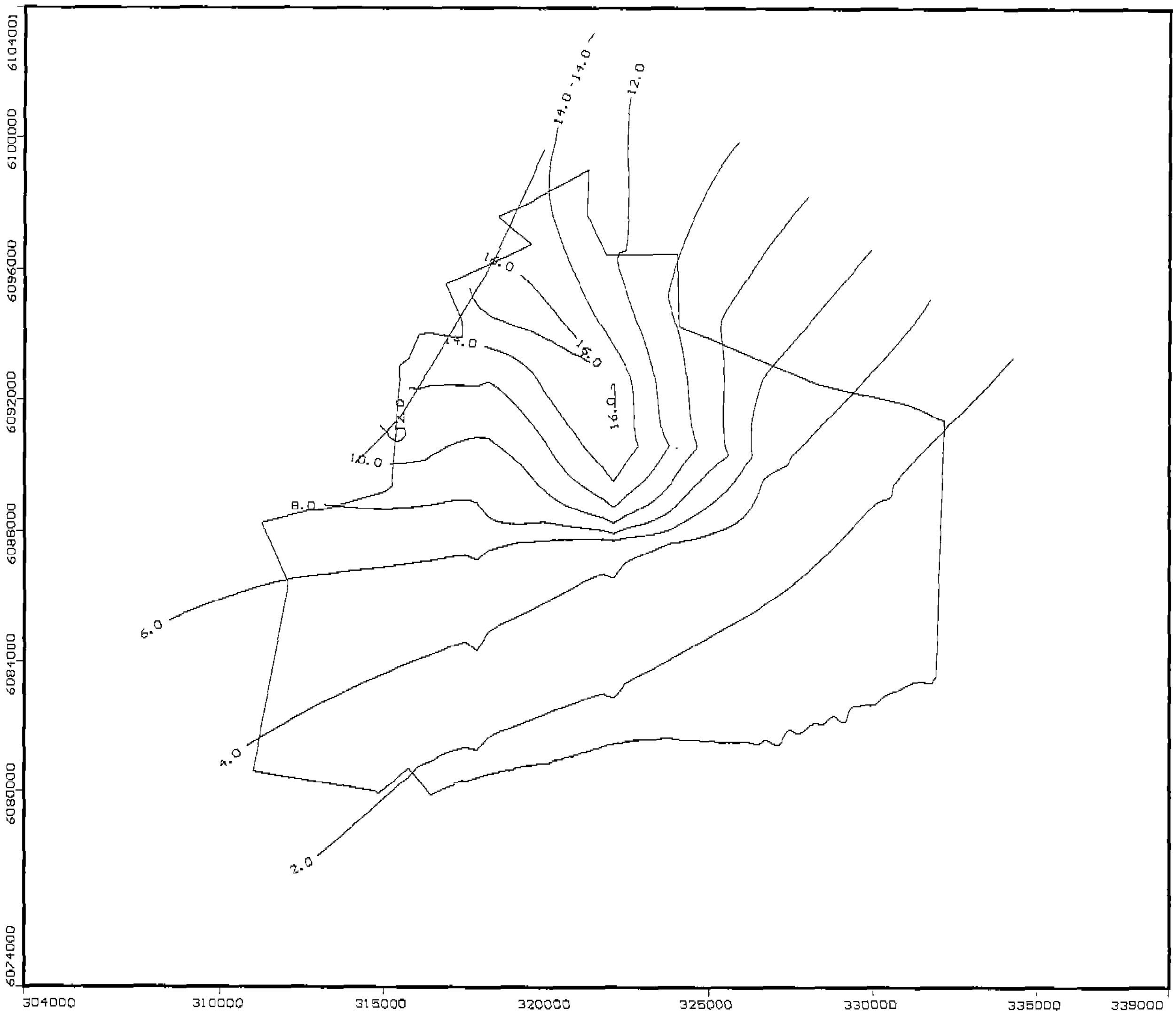


Figure 19:
Unconfined aquifer model head distribution scenario-1 stress period-9



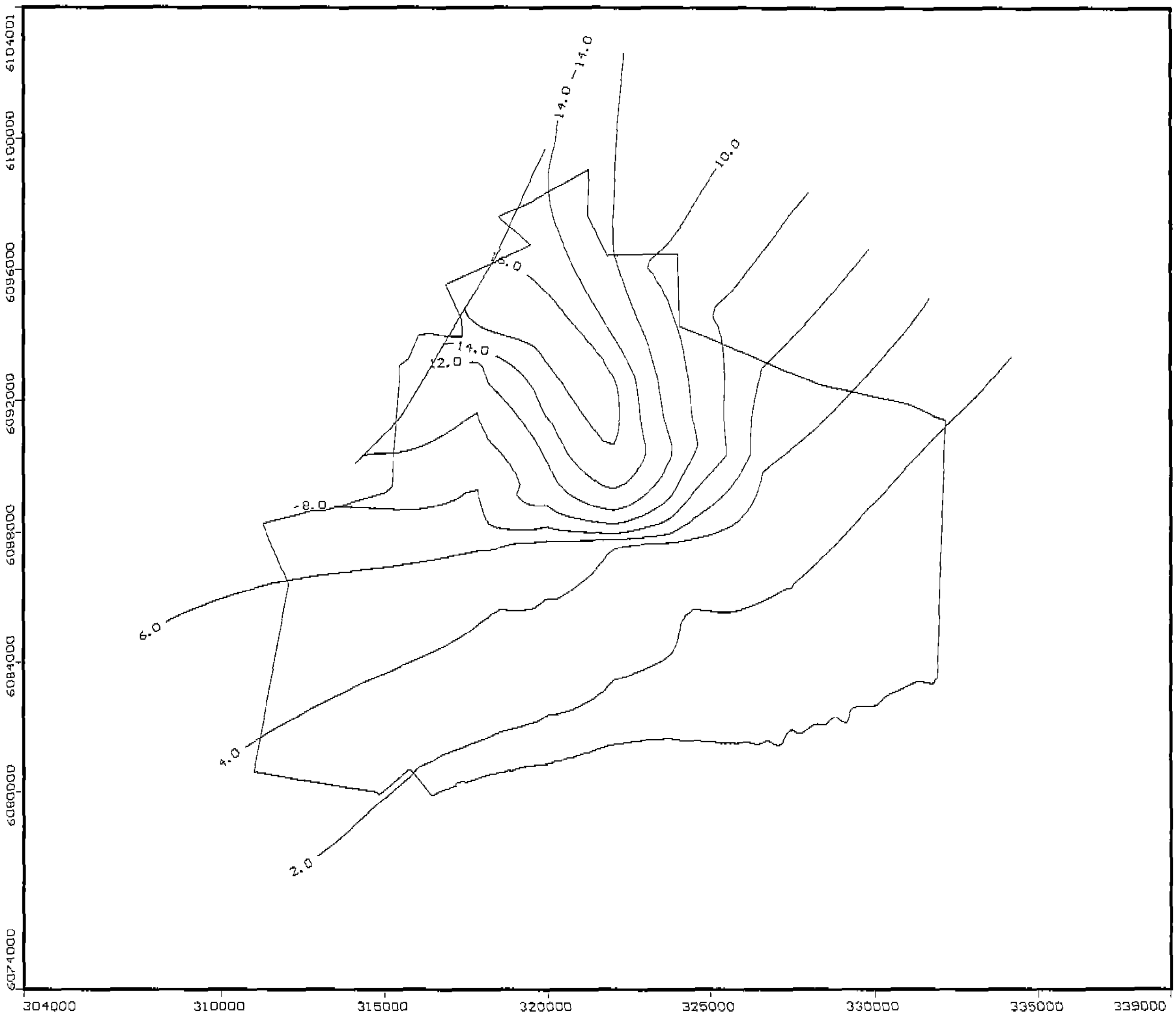
Dept. of Mines & Energy – Australia Project: ANGAS–BREMER RISKS Description: Q: TRNS STRESS PERIOD–9 Modeller: S R HOWLES 22 Nov 98	Visual MODFLOW v.2.60, (C) 1995–1997 Waterloo Hydrogeologic Software NC: 100 NR: 100 NL: 3 Current Layer: 1

Figure 20:
Unconfined aquifer model head distribution scenario-1 stress period-10



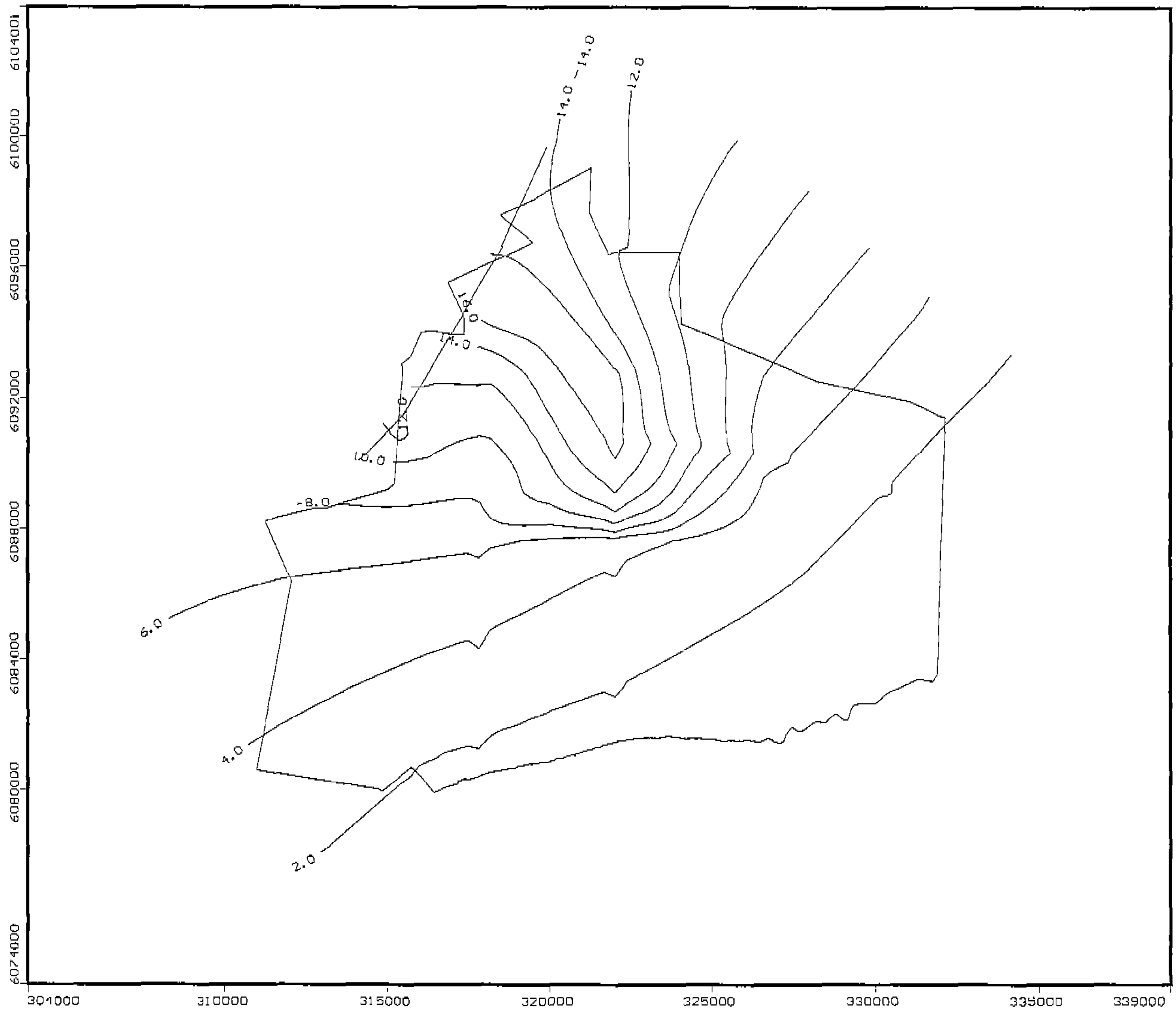
Dept. of Mines & Energy – Australia Project: ANGAS–BREMER RISKS Description: Q: TRNS STRESS PERIOD–10 Modeller: S R HOWLES 22 Nov 98	Visual MODFLOW v.2.60, (C) 1995–1997 Waterloo Hydrogeologic Software NC: 100 NR: 100 NL: 3 Current Layer: 1

Figure 21:
Unconfined aquifer model head distribution scenario-1 stress period-19



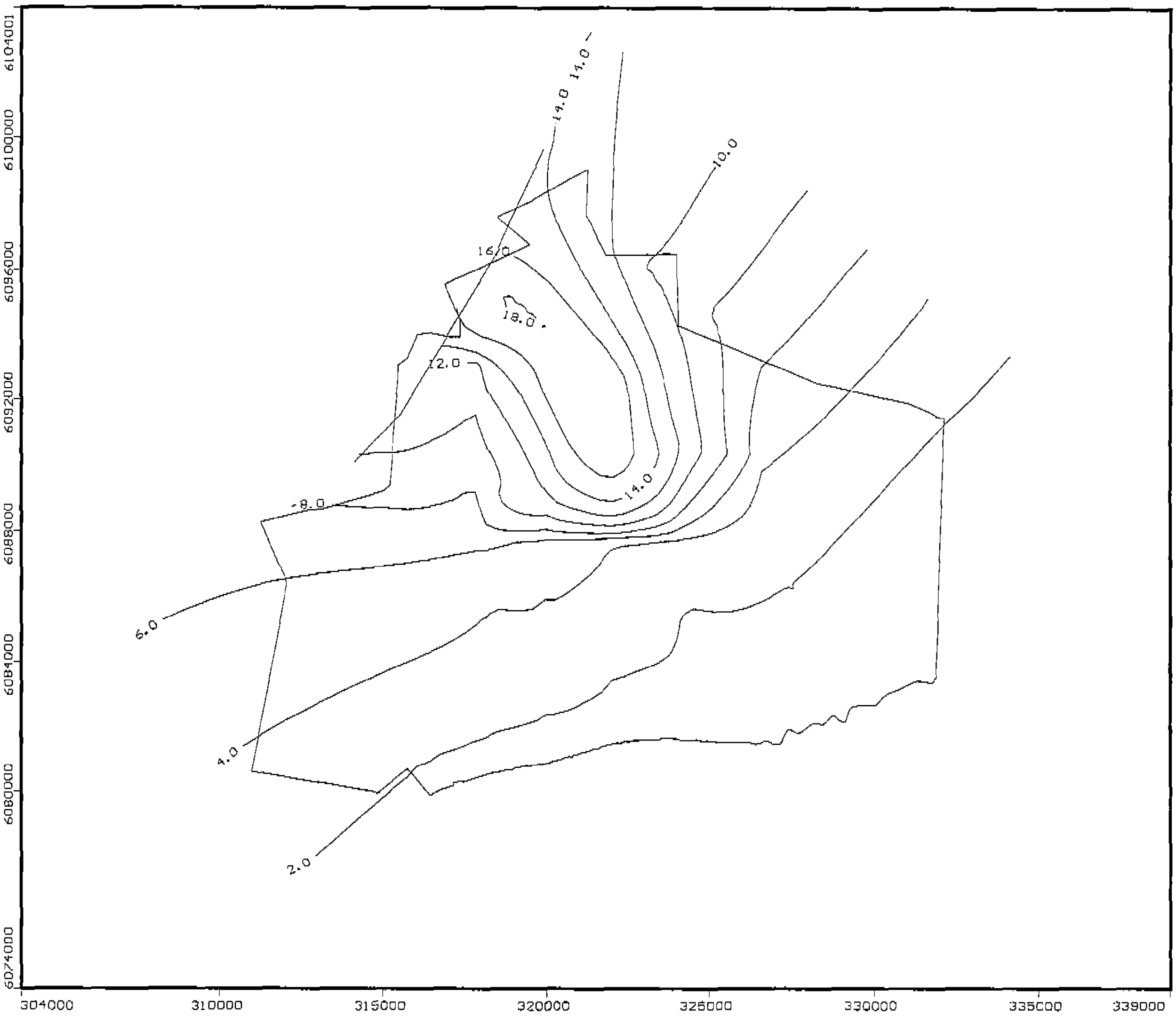
Dept. of Mines & Energy – Australia Project: ANGAS-BREMER RISKS Description: Q: TRNS STRESS PERIOD-19 Modeller: S R HOWLES 22 Nov 98	Visual MODFLOW v.2.60. (C) 1995-1997 Waterloo Hydrogeologic Software NC: 100 NR: 100 NL: 3 Current Layer: 1

Figure 22:
Unconfined aquifer model head distribution scenario-1 stress period-20



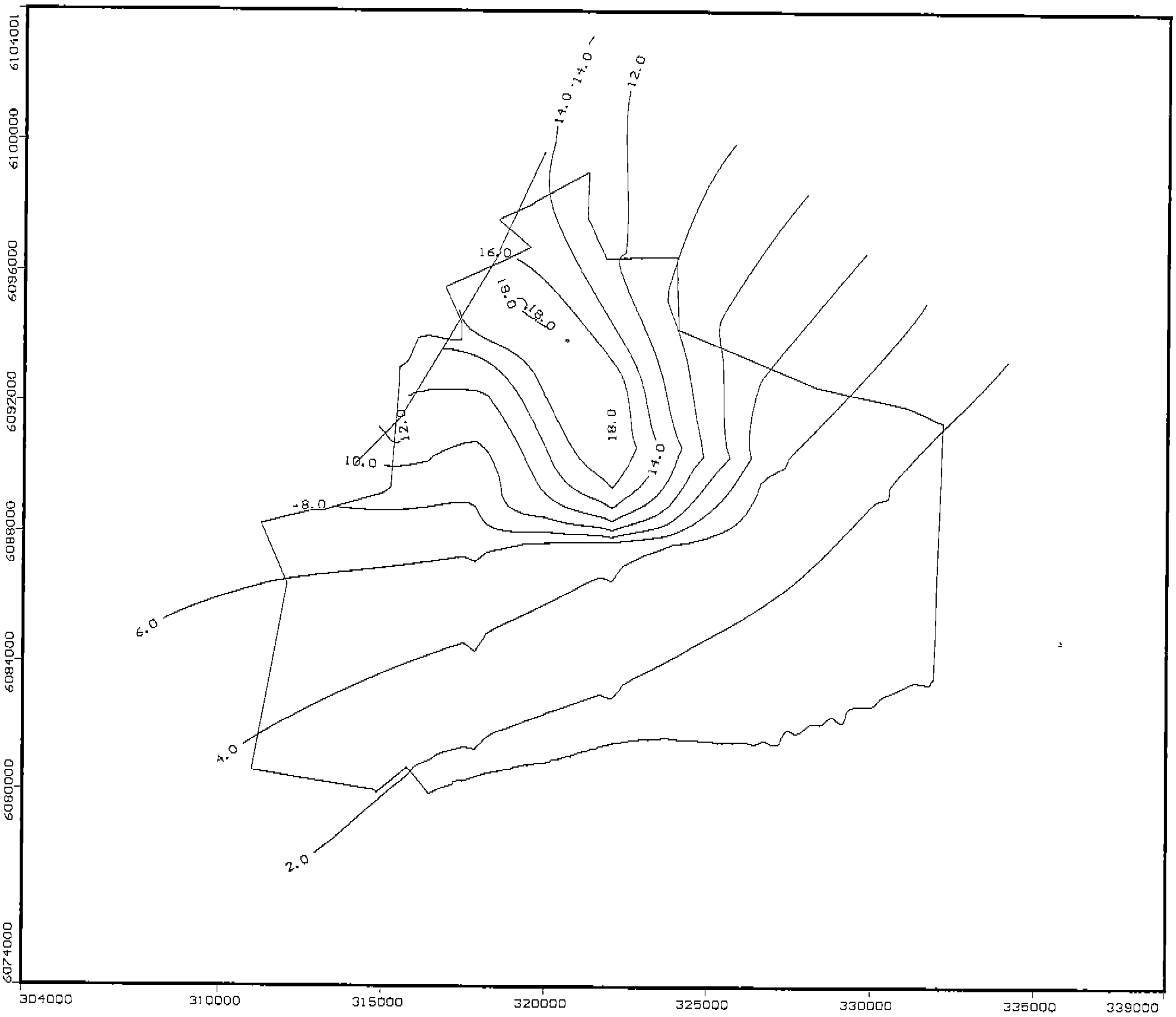
Dept. of Mines & Energy – Australia Project: ANGAS–BREMER RISKS Description: Q: TRNS STRESS PERIOD–20 Modeller: S R HOWLES 22 Nov 98	Visual MODFLOW v.2.60, (C) 1995–1997 Waterloo Hydrogeologic Software NC: 100 NR: 100 NL: 3 Current Layer: 1

Figure 23:
Unconfined aquifer model head distribution scenario-1 stress period-39



Dept. of Mines & Energy - Australia Project: ANGAS-BREMER RISKS Description: Q: TRNS STRESS PERIOD-39 Modeller: S R HOWLES 22 Nov 98	Visual MODFLOW v.2.60. (C) 1995-1997 Waterloo Hydrogeologic Software NC: 100 NR: 100 NL: 3 Current Layer: 1

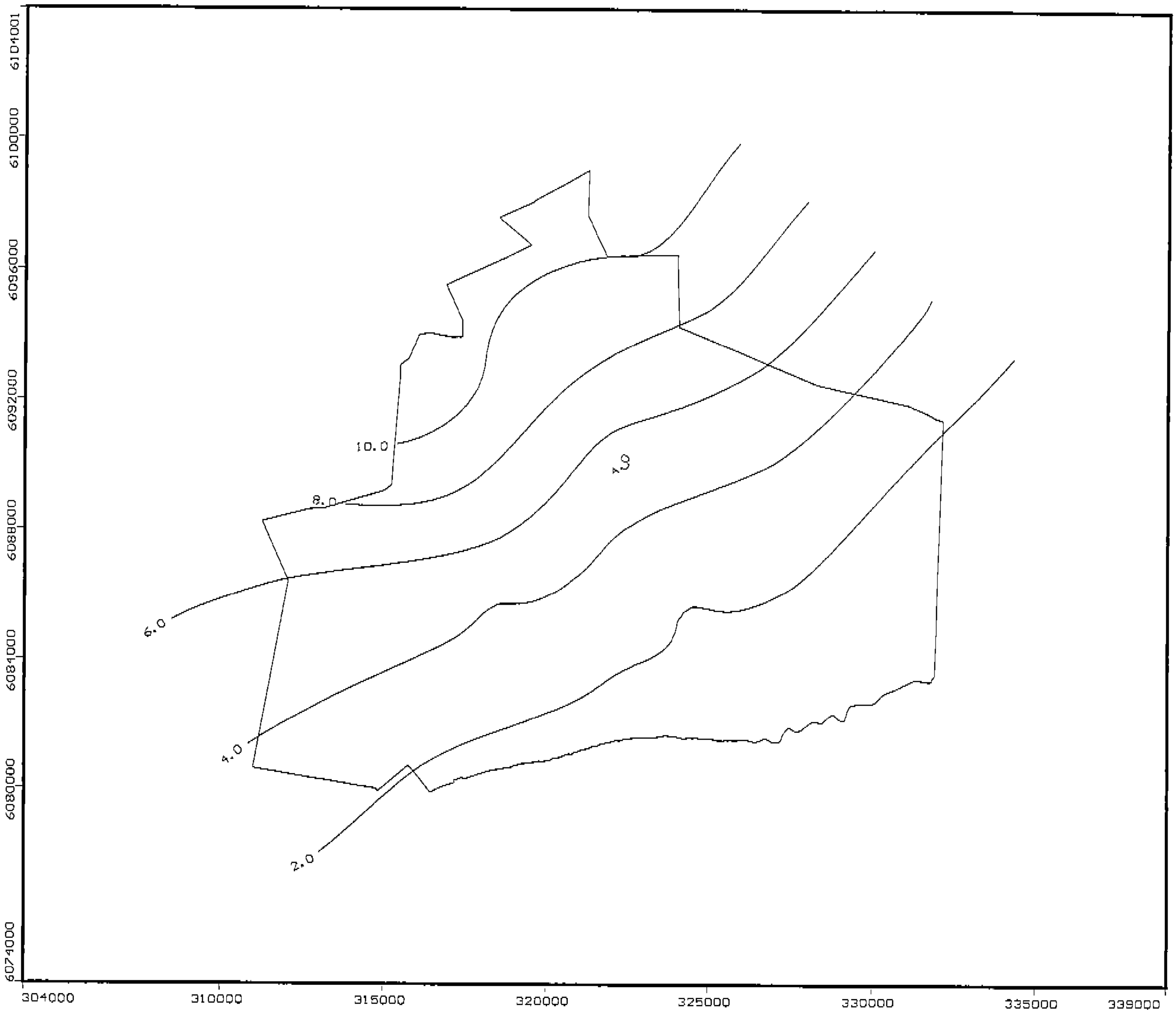
Figure 24:
Unconfined aquifer model head distribution scenario-1 stress period-40



Dept. of Mines & Energy – Australia
Project: ANGAS–BREMER RISKS
Description: Q: TRNS STRESS PERIOD–40
Modeller: S R HOWLES
22 Nov 98

Visual MODFLOW v.2.60, (C) 1995–1997
Waterloo Hydrogeologic Software
NC: 100 NR: 100 NL: 3
Current Layer: 1

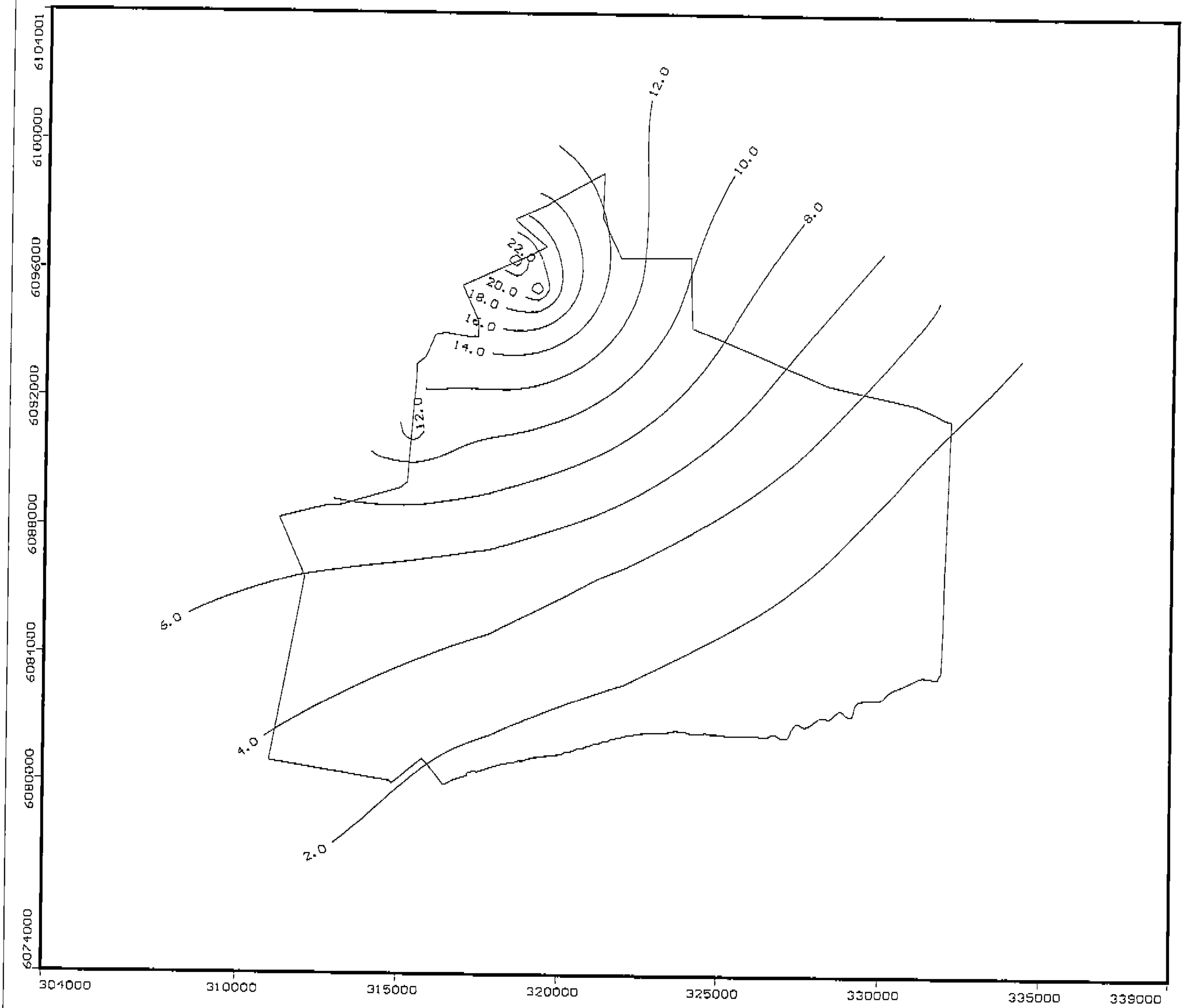
Figure 25:
Confined aquifer model head distribution scenario-1 stress period-5



Dept. of Mines & Energy – Australia
Project: ANGAS–BREMER RISKS
Description: T: TRNS STRESS PERIOD–5
Modeller: S R HOWLES
22 Nov 98

Visual MODFLOW v.2.60, (C) 1995–1997
Waterloo Hydrogeologic Software
NC: 100 NR: 100 NL: 3
Current Layer: 3

Figure 26:
Confined aquifer model head distribution scenario-1 stress period-6



Dept. of Mines & Energy – Australia
Project: ANGAS-BREMER RISKS
Description: T: TRNS STRESS PERIOD-6
Modeller: S R HOWLES
22 Nov 98

Visual MODFLOW v.2.60, (C) 1995–1997
Waterloo Hydrogeologic Software
NC: 100 NR: 100 NL: 3
Current Layer: 3

Figure 27: Confined aquifer actual head distribution September 1996

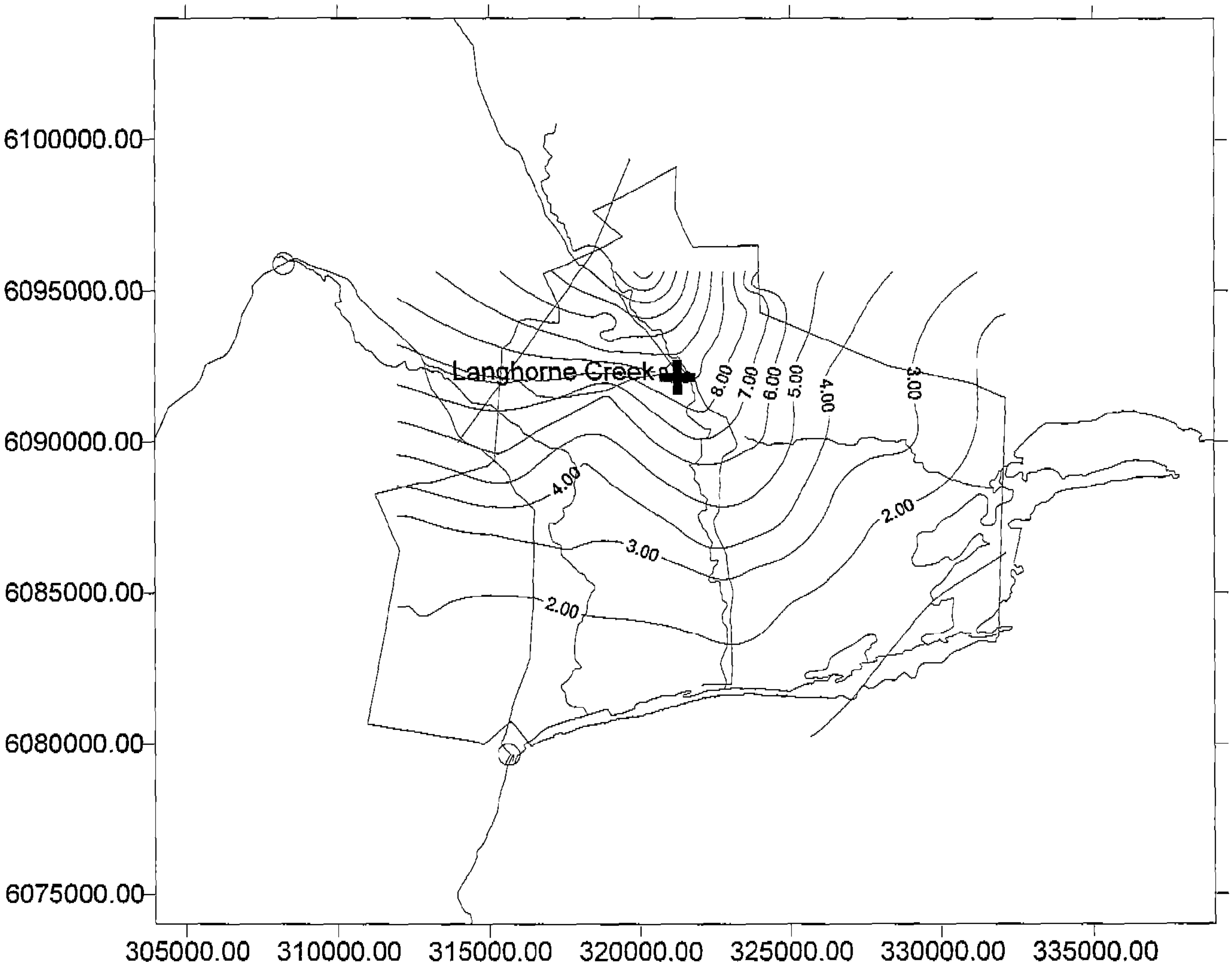
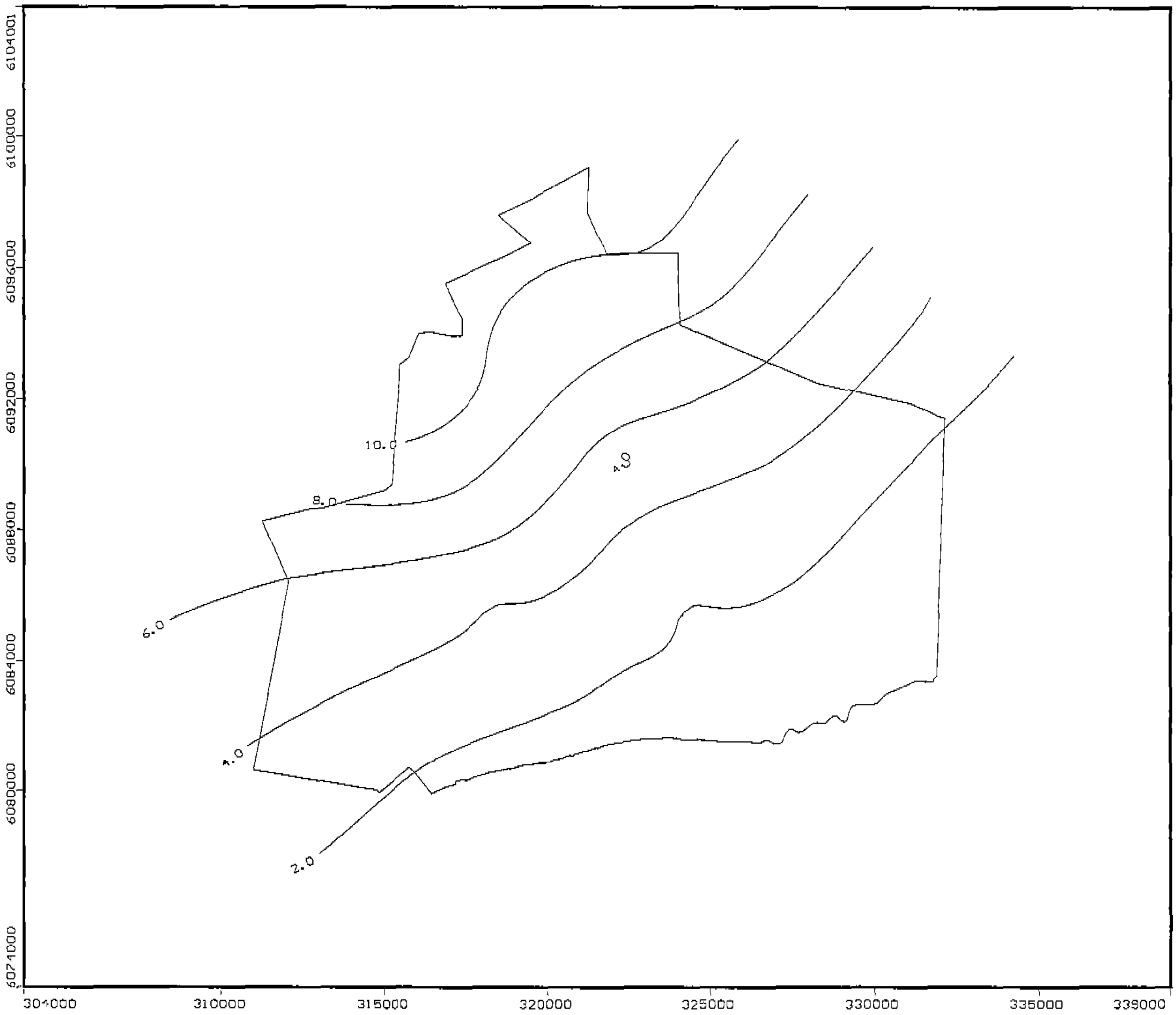


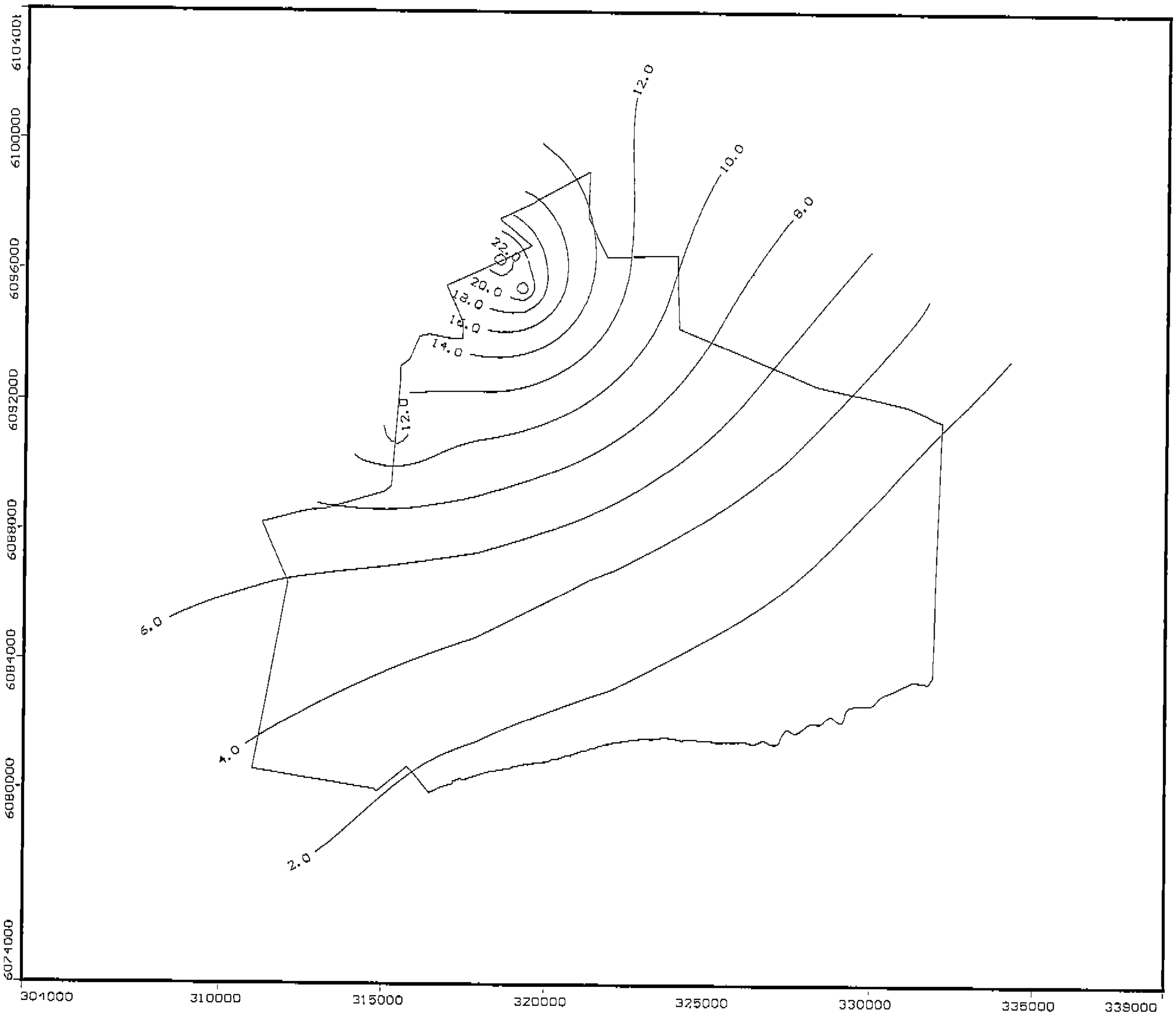
Figure 28:
Confined aquifer model head distribution scenario-1 stress period-9



Dept. of Mines & Energy – Australia
Project: ANGAS–BREMER RISKS
Description: T: TRNS STRESS PERIOD–9
Modeller: S R HOWLES
22 Nov 98

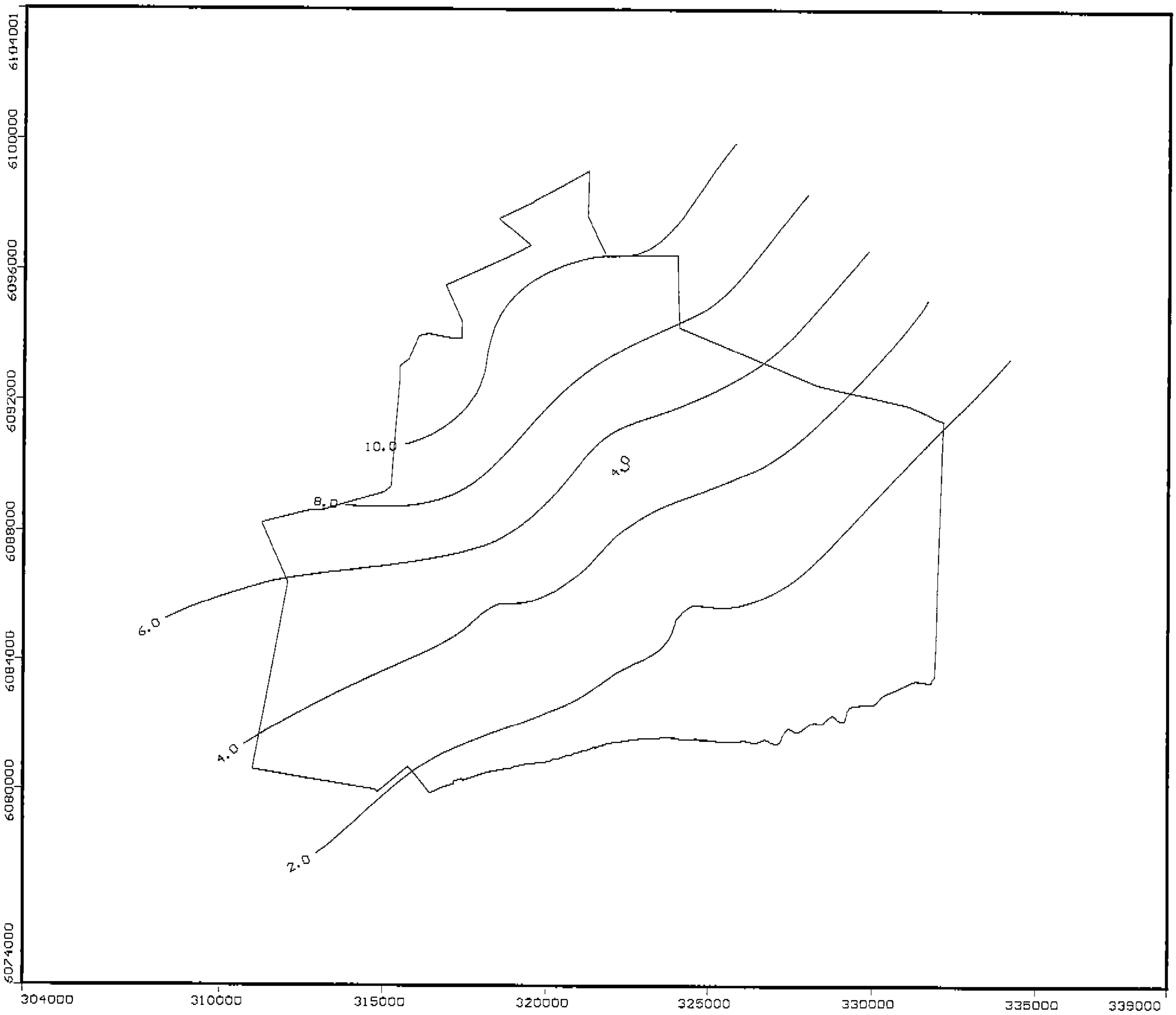
Visual MODFLOW v.2.60, (C) 1995–1997
Waterloo Hydrogeologic Software
NC: 100 NR: 100 NL: 3
Current Layer: 3

Figure 29:
Confined aquifer model head distribution scenario-1 stress period-10



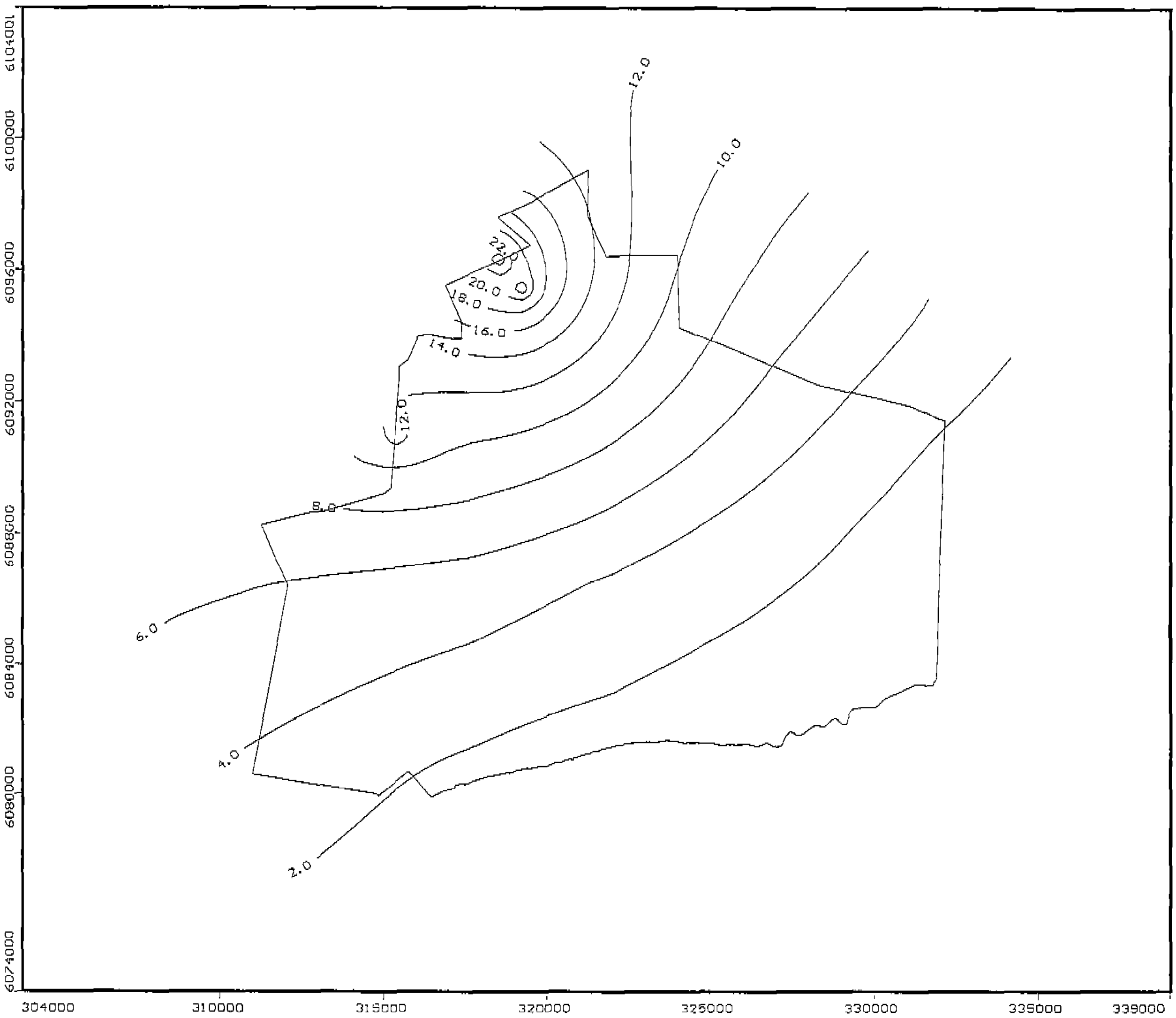
Dept. of Mines & Energy – Australia Project: ANGAS–BREMER RISKS Description: T: TRNS STRESS PERIOD–10 Modeller: S R HOWLES 22 Nov 98	Visual MODFLOW v.2.60, (C) 1995–1997 Waterloo Hydrogeologic Software NC: 100 NR: 100 NL: 3 Current Layer: 3

Figure 30:
Confined aquifer model head distribution scenario-1 stress period-19



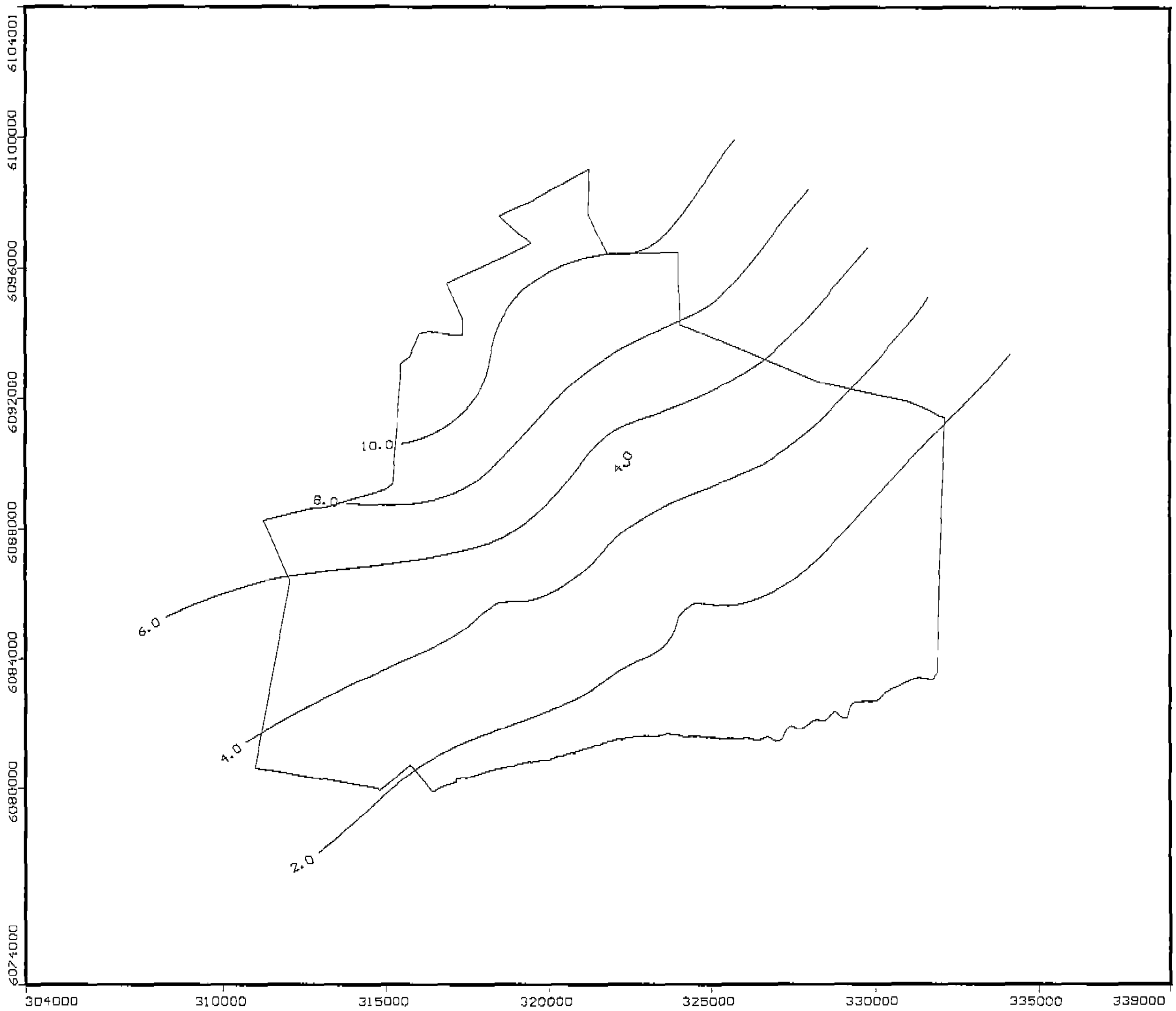
Dept. of Mines & Energy – Australia Project: ANGAS–BREMER RISKS Description: T: TRNS STRESS PERIOD–19 Modeller: S R HOWLES 22 Nov 98	Visual MODFLOW v.2.60, (C) 1995–1997 Waterloo Hydrogeologic Software NC: 100 NR: 100 NL: 3 Current Layer: 3

Figure 31:
Confined aquifer model head distribution scenario-1 stress period-20



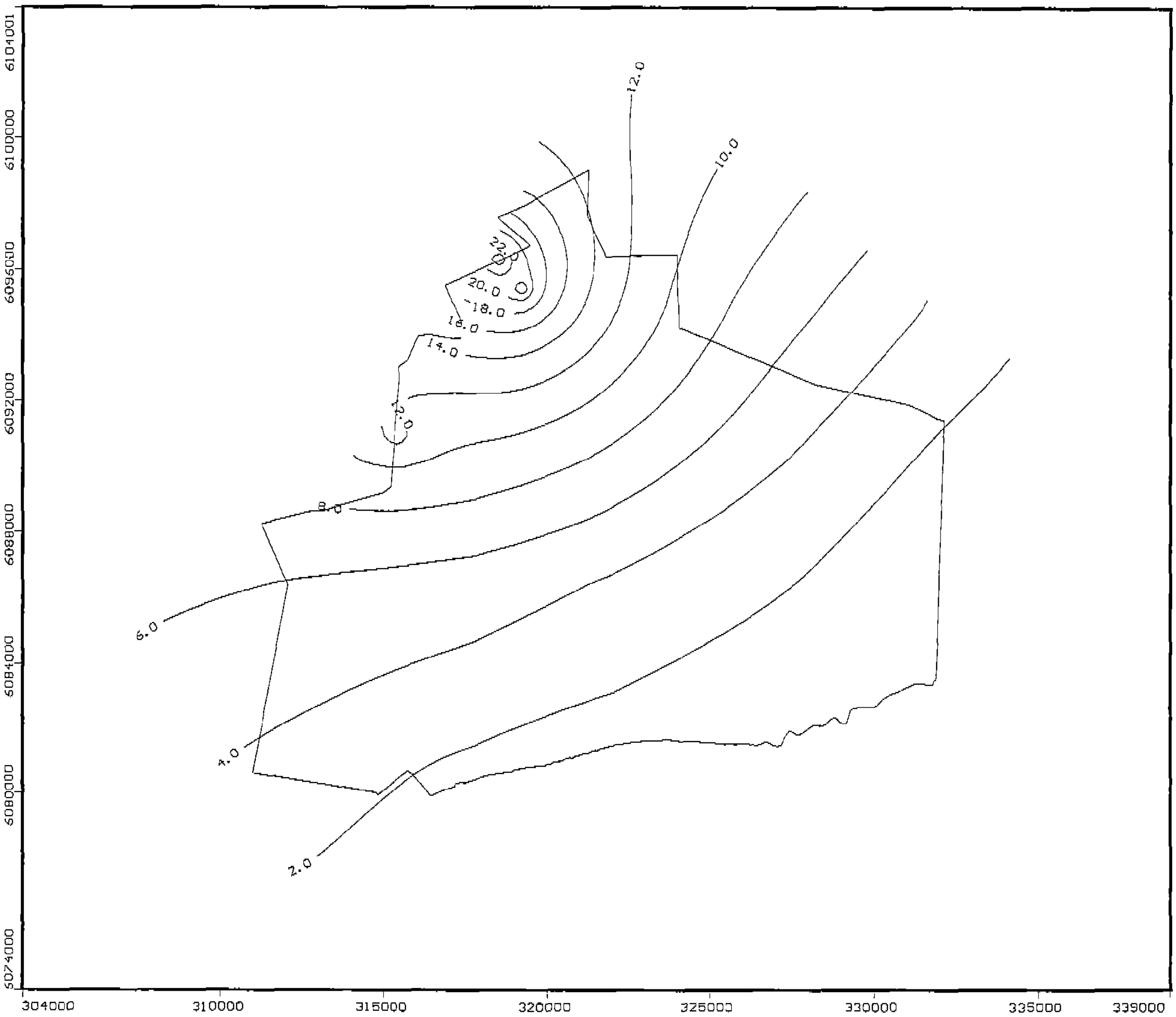
Dept. of Mines & Energy – Australia Project: ANGAS–BREMER RISKS Description: T: TRNS STRESS PERIOD–20 Modeller: S R HOWLES 22 Nov 98	Visual MODFLOW v.2.60, (C) 1995–1997 Waterloo Hydrogeologic Software NC: 100 NR: 100 NL: 3 Current Layer: 3

Figure 32:
Confined aquifer model head distribution scenario-1 stress period-39



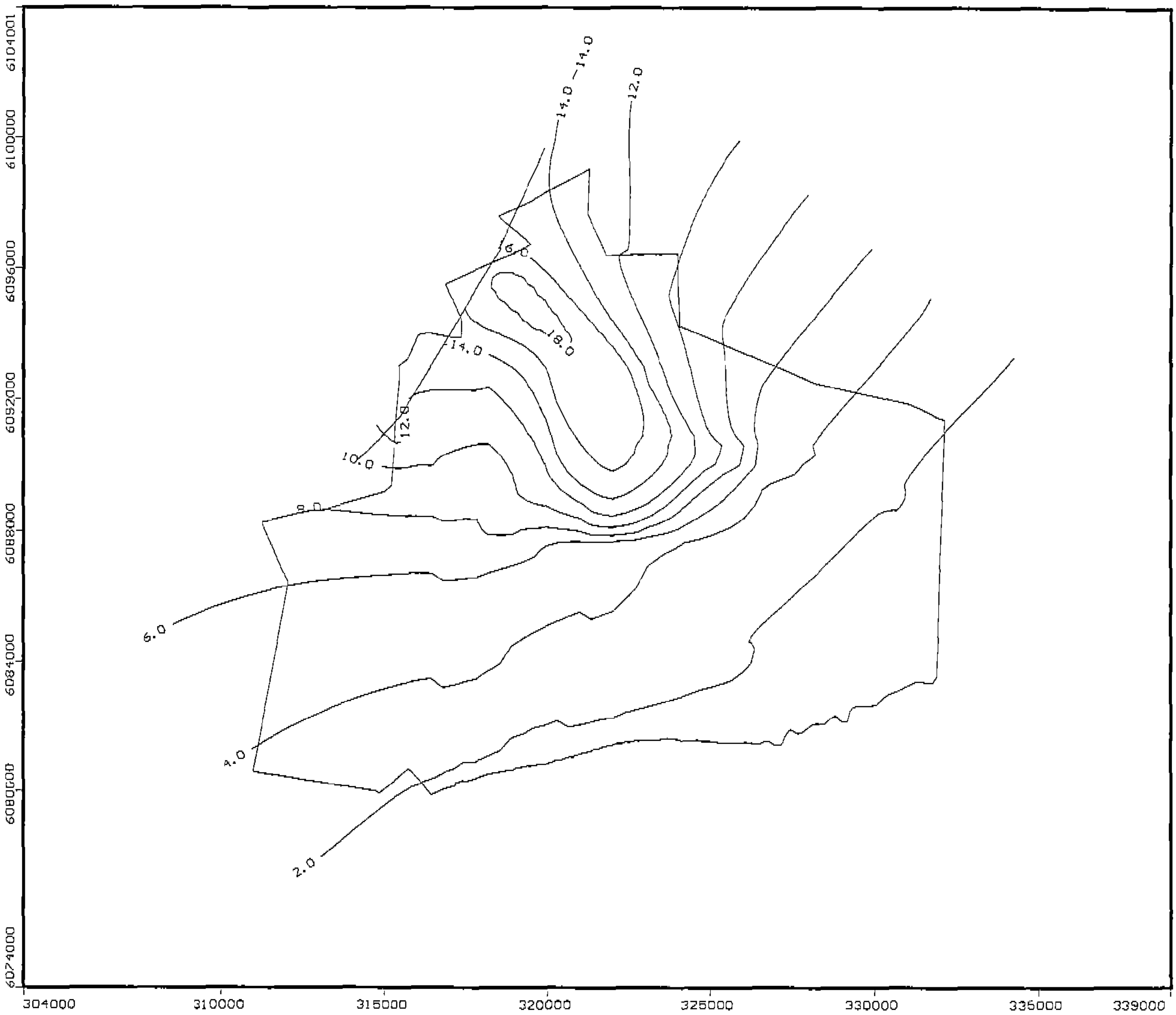
Dept. of Mines & Energy - Australia Project: ANGAS-BREMER RISKS Description: T: TRNS STRESS PERIOD-39 Modeller: S R HOWLES 22 Nov 98	Visual MODFLOW v.2.60, (C) 1995-1997 Waterloo Hydrogeologic Software NC: 100 NR: 100 NL: 3 Current Layer: 3

Figure 33:
Confined aquifer model head distribution scenario-1 stress period-40



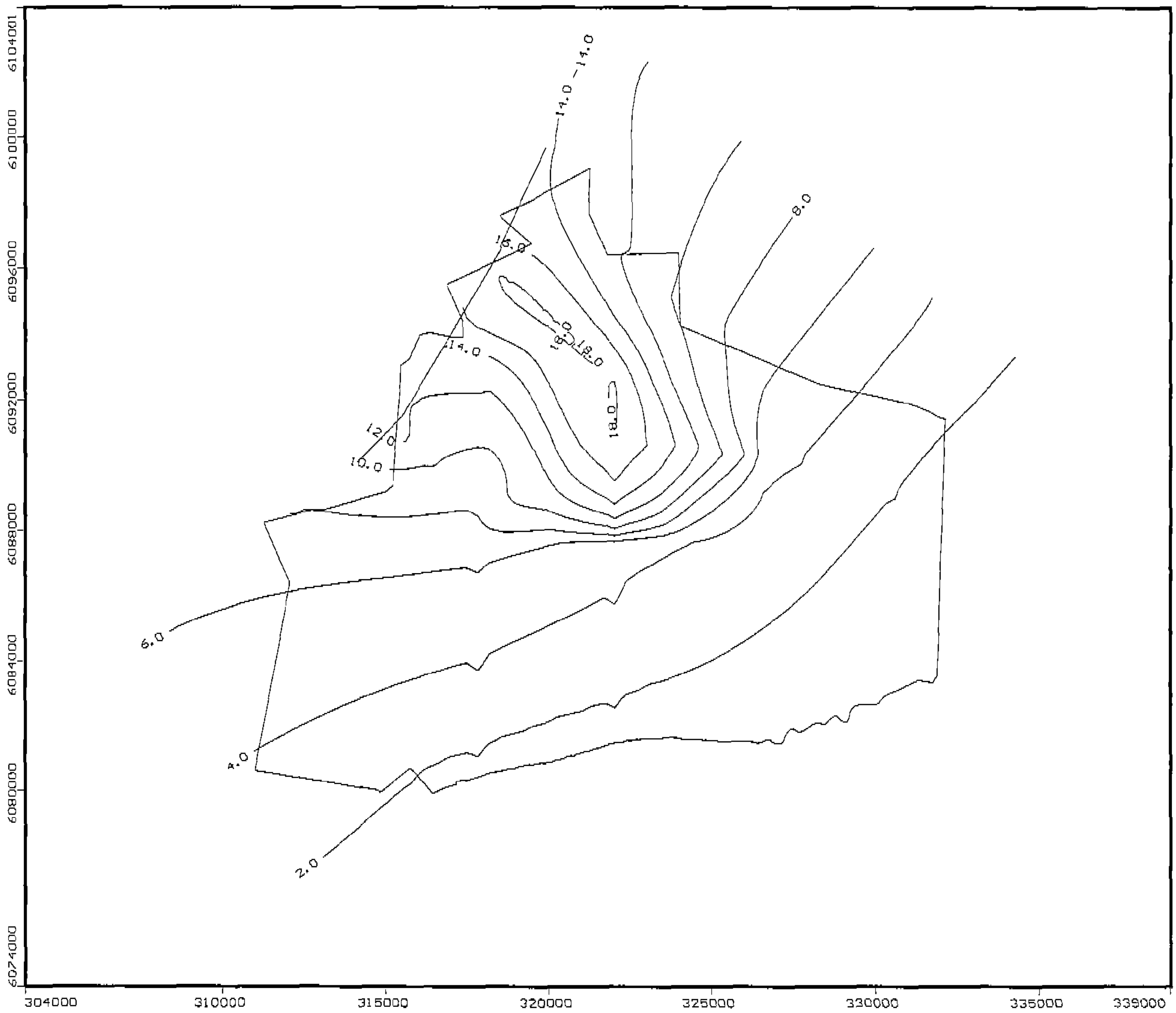
Dept. of Mines & Energy – Australia Project: ANGAS–BREMER RISKS Description: T: TRNS STRESS PERIOD–40 Modeller: S R HOWLES 22 Nov 98	Visual MODFLOW v.2.60, (C) 1995–1997 Waterloo Hydrogeologic Software NC: 100 NR: 100 NL: 3 Current Layer: 3

Figure 34:
Unconfined aquifer model head distribution scenario-2 stress period-20



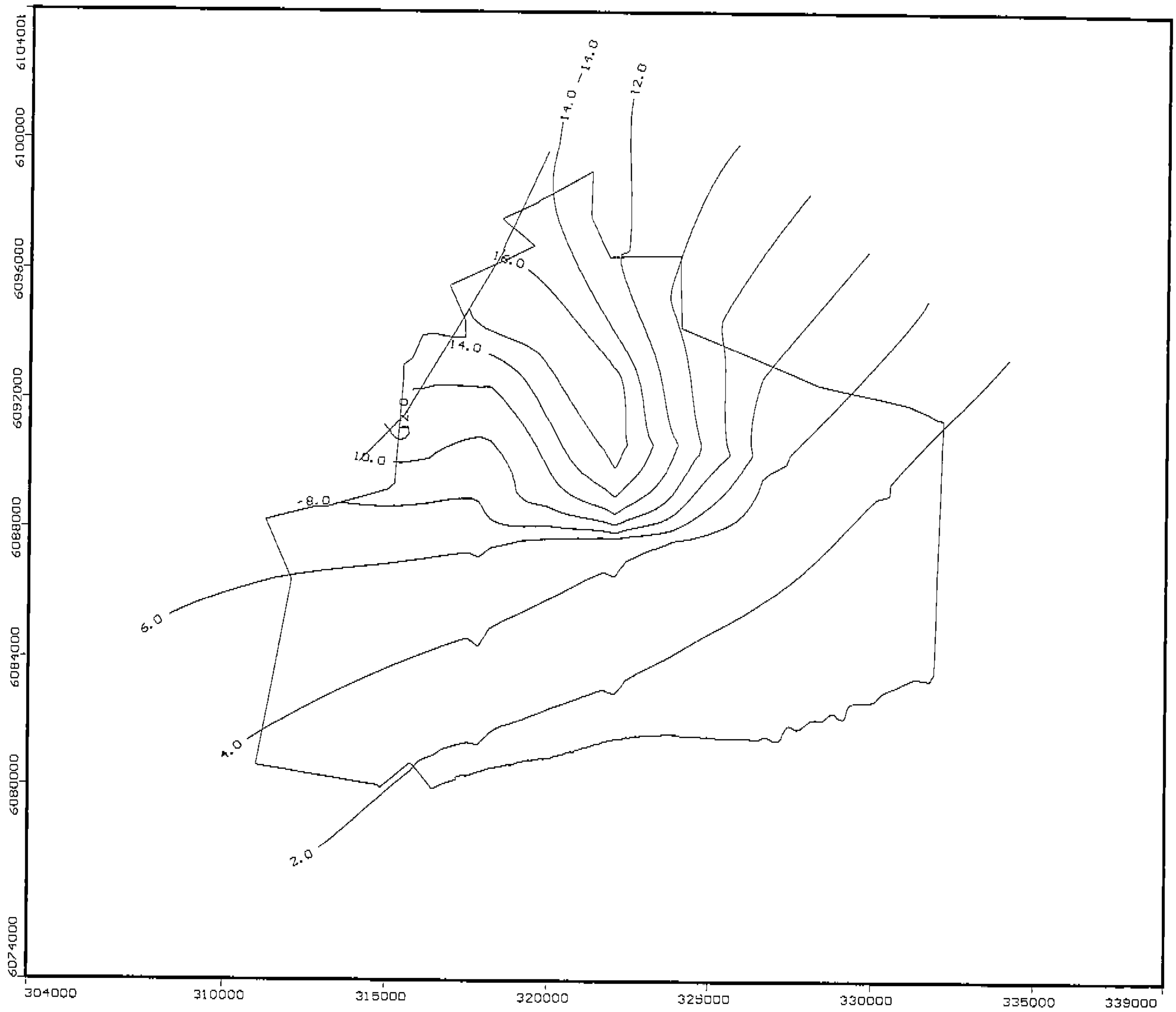
Dept. of Mines & Energy – Australia Project: ANGAS-BREMER RISKS Description: Q: TRNS STRESS PERIOD-20 Modeller: S R HOWLES 24 Nov 98	Visual MODFLOW v.2.60, (C) 1995-1997 Waterloo Hydrogeologic Software NC: 100 NR: 100 NL: 3 Current Layer: 1

Figure 35:
Unconfined aquifer model head distribution scenario-2 stress period-24



Dept. of Mines & Energy - Australia Project: ANGAS-BREMER RISKS Description: Q: TRNS STRESS PERIOD-24 Modeller: S R HOWLES 24 Nov 98	Visual MODFLOW v.2.60, (C) 1995-1997 Waterloo Hydrogeologic Software NC: 100 NR: 100 NL: 3 Current Layer: 1

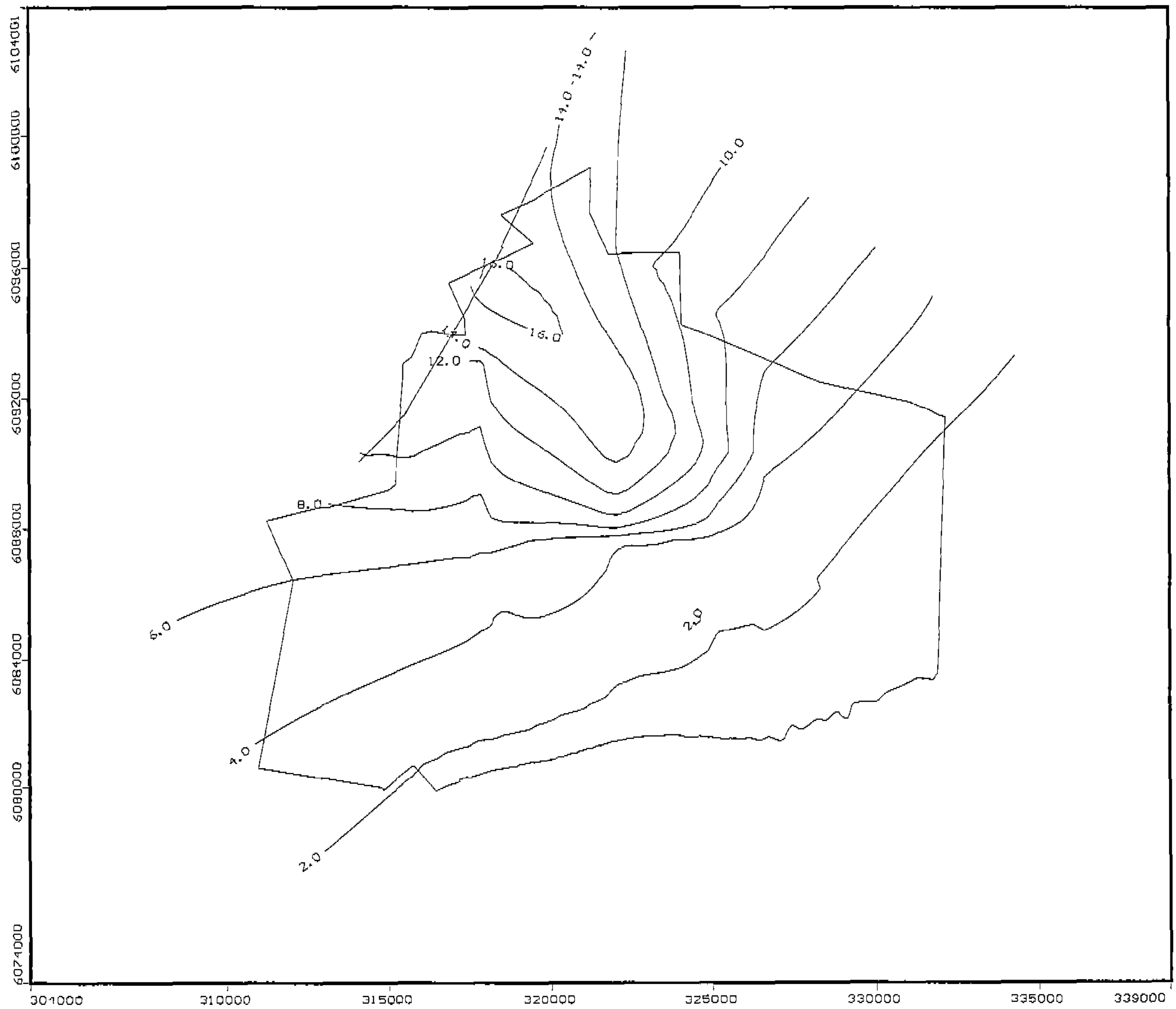
Figure 36:
Unconfined aquifer model head distribution scenario-1 stress period-24



Dept. of Mines & Energy – Australia
Project: ANGAS–BREMER RISKS
Description: Q: TRNS STRESS PERIOD–24
Modeller: S R HOWLES
23 Nov 98

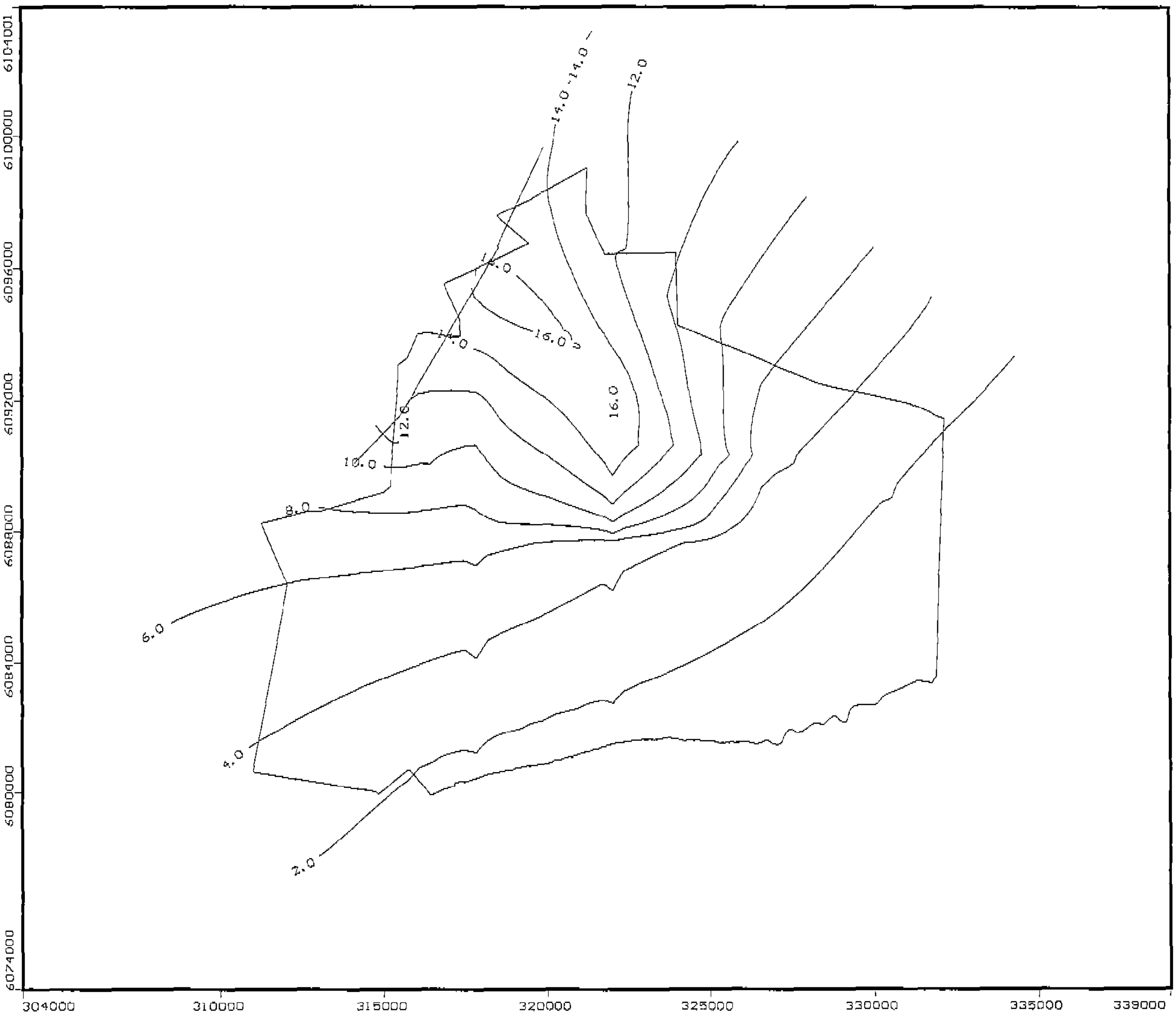
Visual MODFLOW v.2.60, (C) 1995–1997
Waterloo Hydrogeologic Software
NC: 100 NR: 100 NL: 3
Current Layer: 1

Figure 37:
Unconfined aquifer model head distribution scenario-3 stress period-5



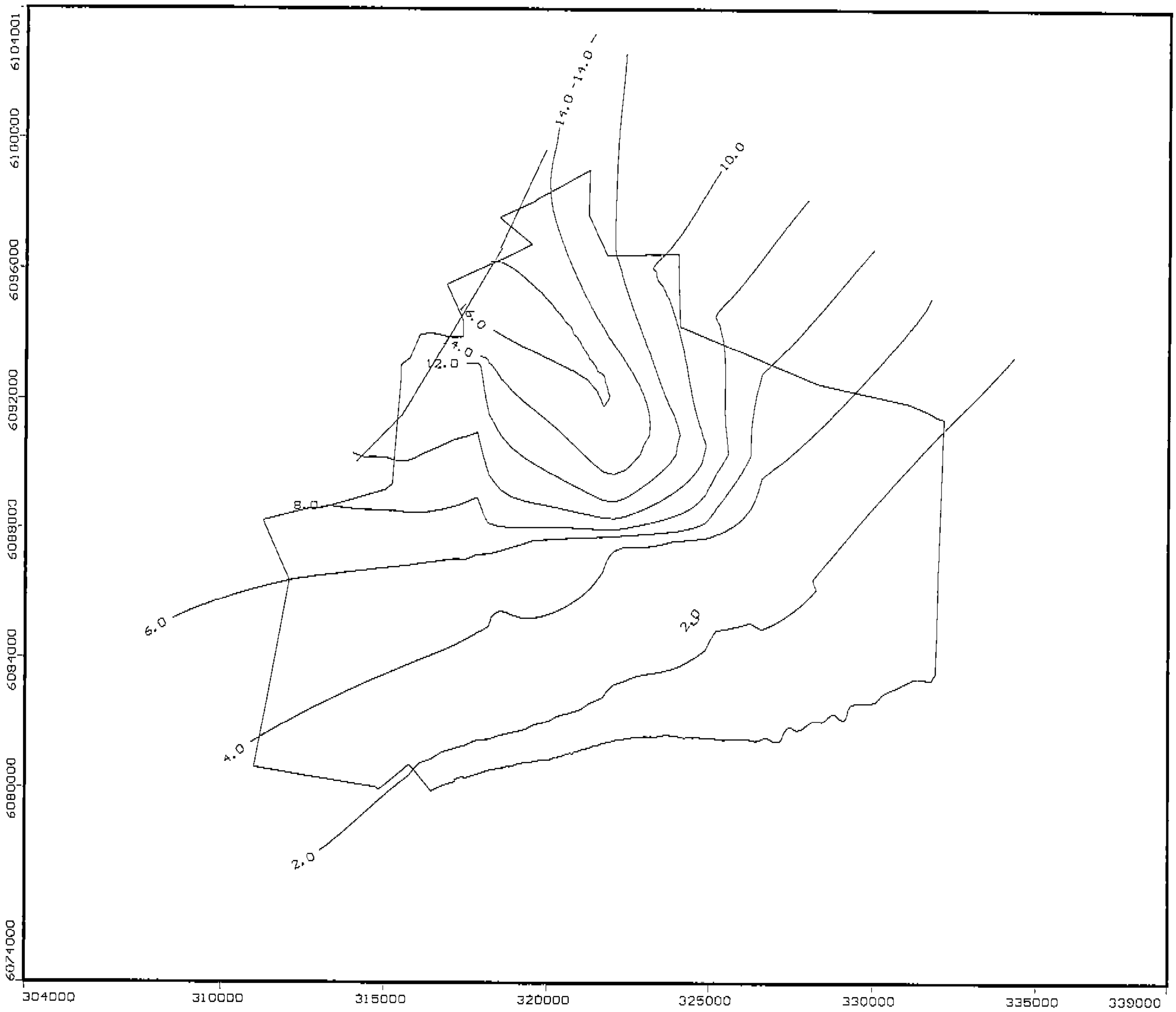
Dept. of Mines & Energy – Australia	Visual MODFLOW v.2.60, (C) 1995–1997
Project: ANGAS–BREMER RISKS	Waterloo Hydrogeologic Software
Description: Q: TRNS STRESS PERIOD–5	NC: 100 NR: 100 NL: 3
Modeller: S R HOWLES	Current Layer: 1
22 Nov 98	

Figure 38:
Unconfined aquifer model head distribution scenario-3 stress period-6



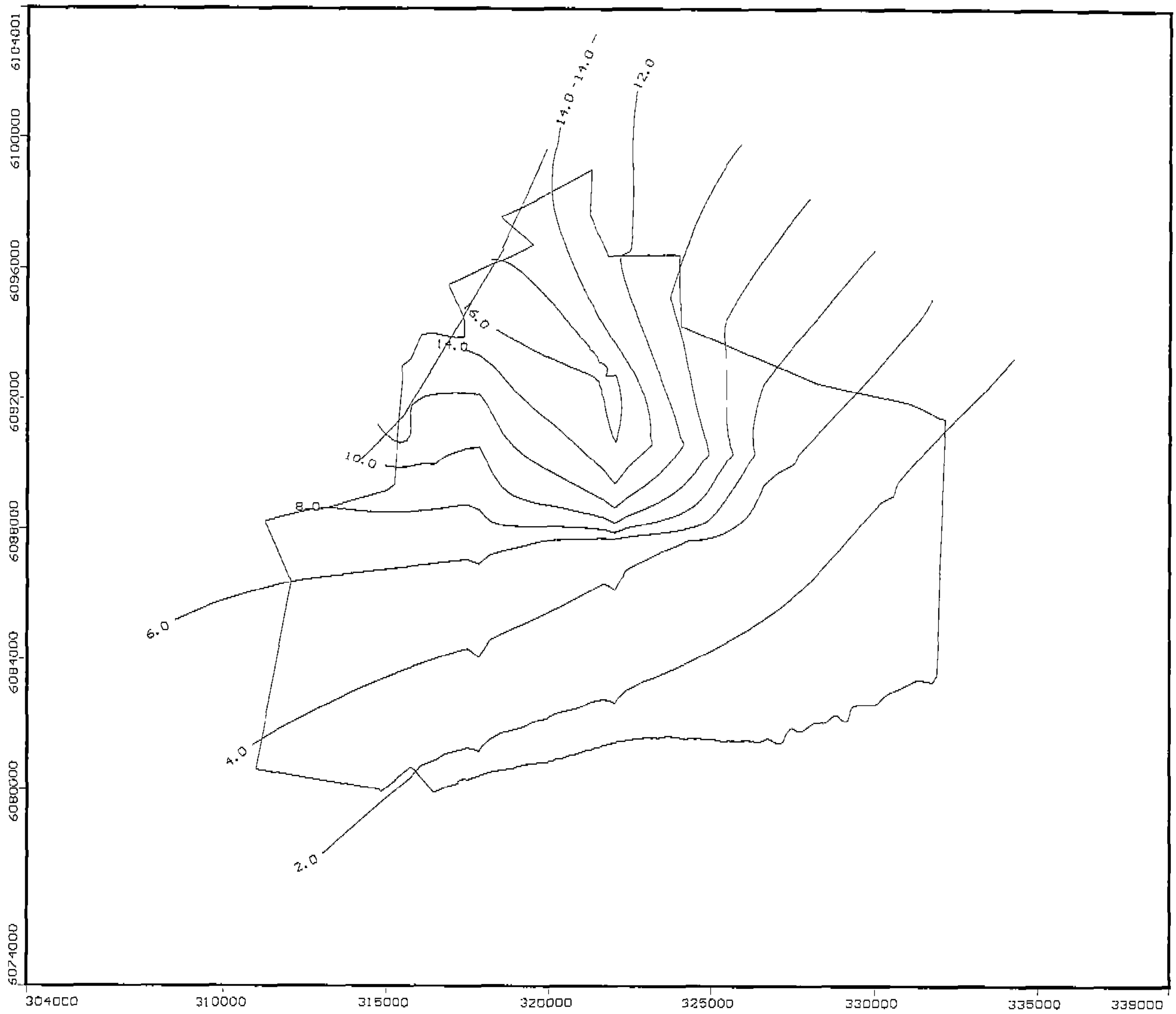
Dept. of Mines & Energy – Australia Project: ANGAS–BREMER RISKS Description: Q: TRNS STRESS PERIOD–6 Modeller: S R HOWLES 22 Nov 98	Visual MODFLOW v.2.60, (C) 1995–1997 Waterloo Hydrogeologic Software NC: 100 NR: 100 NL: 3 Current Layer: 1

Figure 39:
Unconfined aquifer model head distribution scenario-3 stress period-9



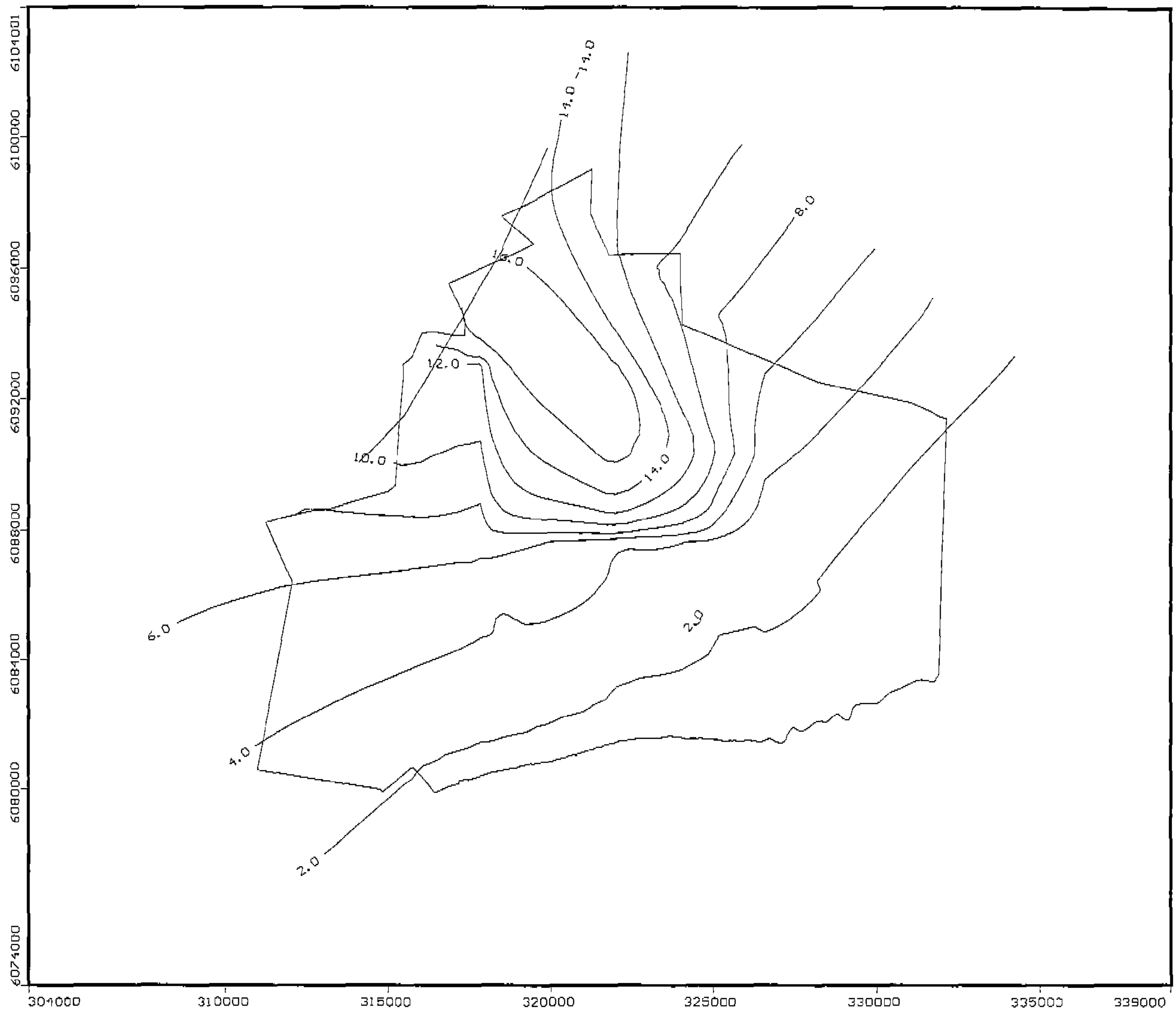
Dept. of Mines & Energy – Australia Project: ANGAS–BREMER RISKS Description: Q: TRNS STRESS PERIOD–9 Modeller: S R HOWLES 22 Nov 98	Visual MODFLOW v.2.60, (C) 1995–1997 Waterloo Hydrogeologic Software NC: 100 NR: 100 NL: 3 Current Layer: 1

Figure 40:
Unconfined aquifer model head distribution scenario-3 stress period-10



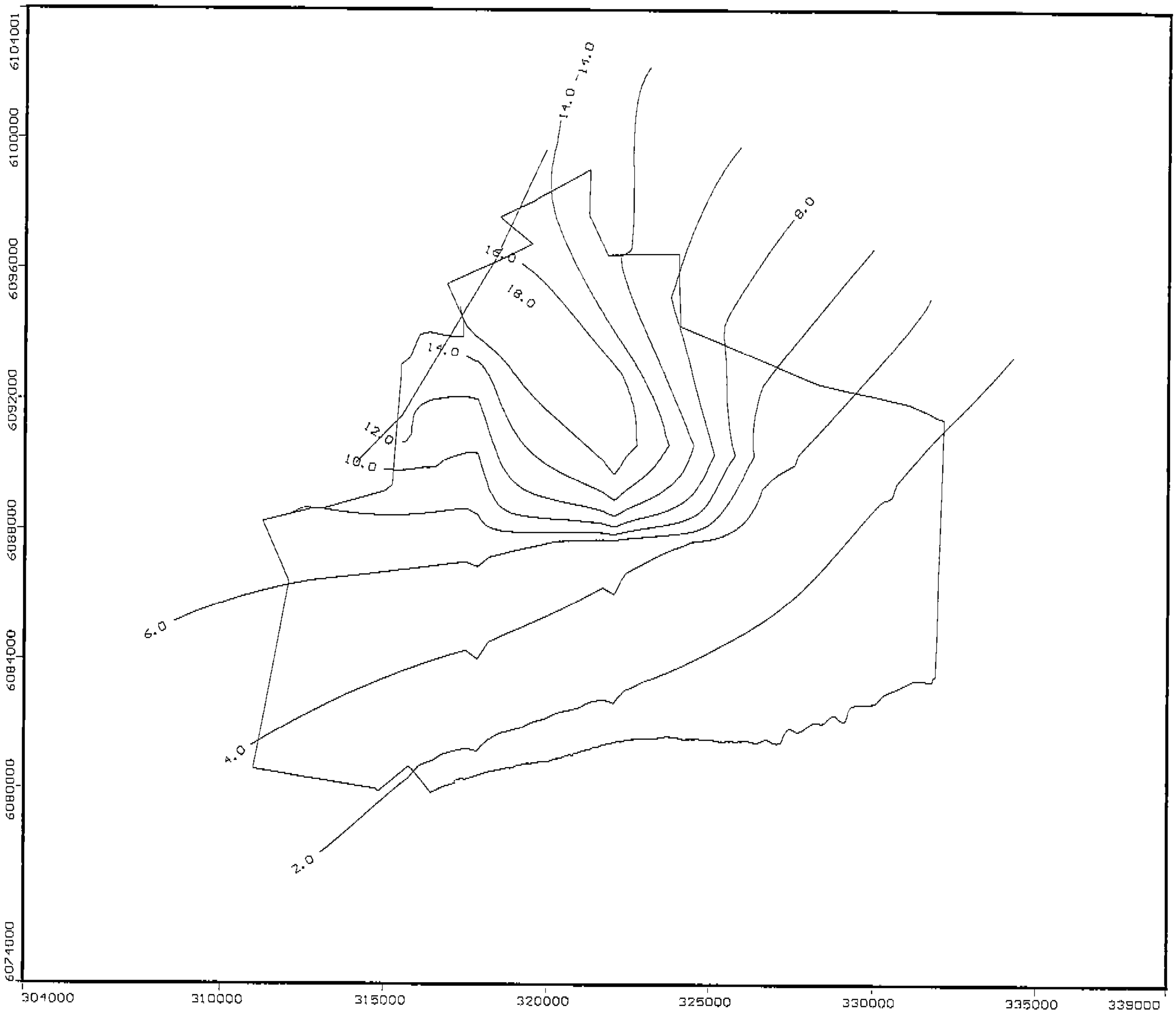
Dept. of Mines & Energy – Australia Project: ANGAS–BREMER RISKS Description: Q: TRNS STRESS PERIOD–10 Modeller: S R HOWLES 22 Nov 98	Visual MODFLOW v.2.60, (C) 1995–1997 Waterloo Hydrogeologic Software NC: 100 NR: 100 NL: 3 Current Layer: 1

Figure 41:
Unconfined aquifer model head distribution scenario-3 stress period-19



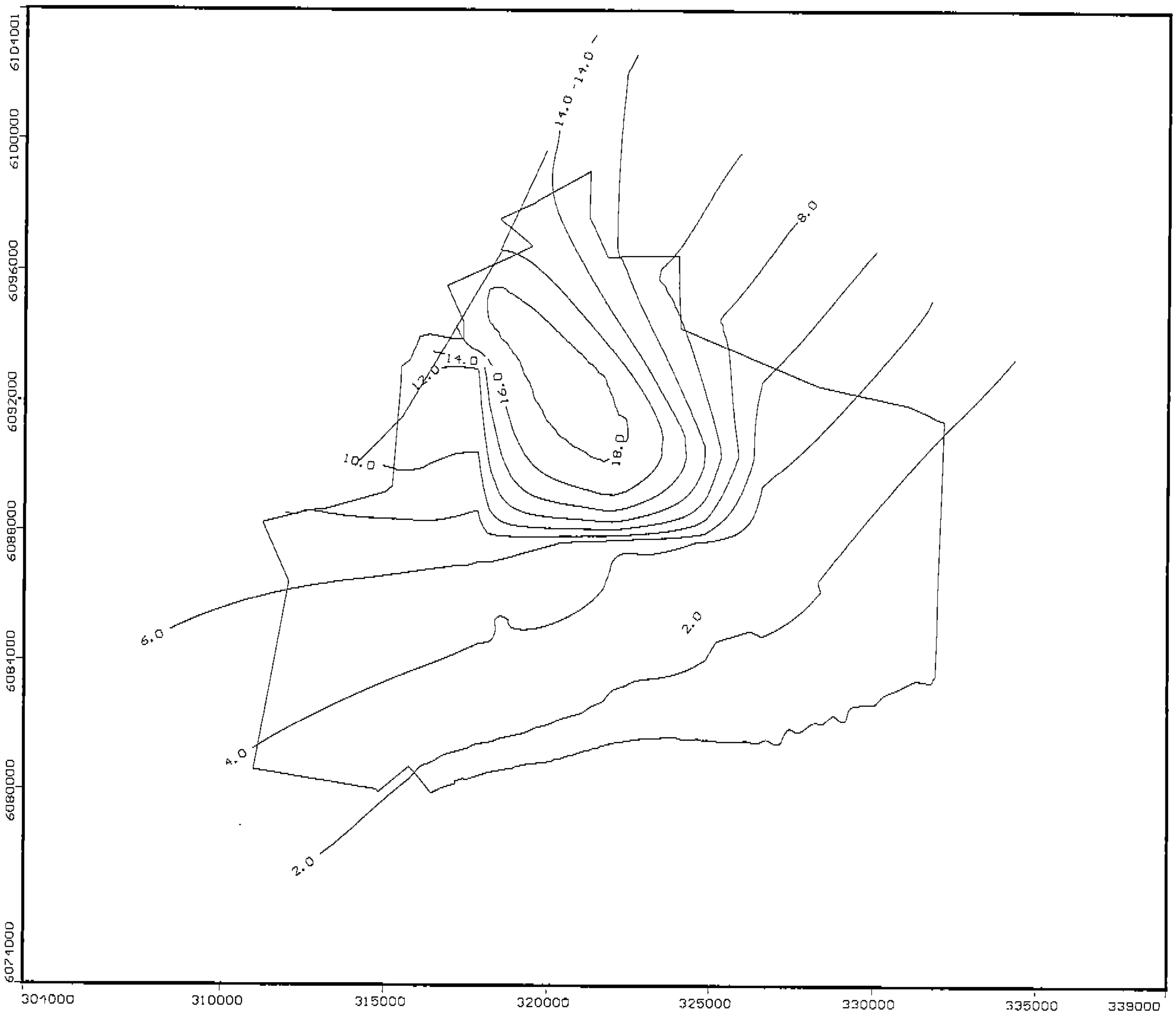
Dept. of Mines & Energy – Australia Project: ANGAS–BREMER RISKS Description: Q: TRNS STRESS PERIOD–19 Modeller: S R HOWLES 22 Nov 98	Visual MODFLOW v.2.60, (C) 1995–1997 Waterloo Hydrogeologic Software NC: 100 NR: 100 NL: 3 Current Layer: 1

Figure 42:
Unconfined aquifer model head distribution scenario-3 stress period-20



Dept. of Mines & Energy – Australia Project: ANGAS–BREMER RISKS Description: Q: TRNS STRESS PERIOD–20 Modeller: S R HOWLES 22 Nov 98	Visual MODFLOW v.2.60, (C) 1995–1997 Waterloo Hydrogeologic Software NC: 100 NR: 100 NL: 3 Current Layer: 1

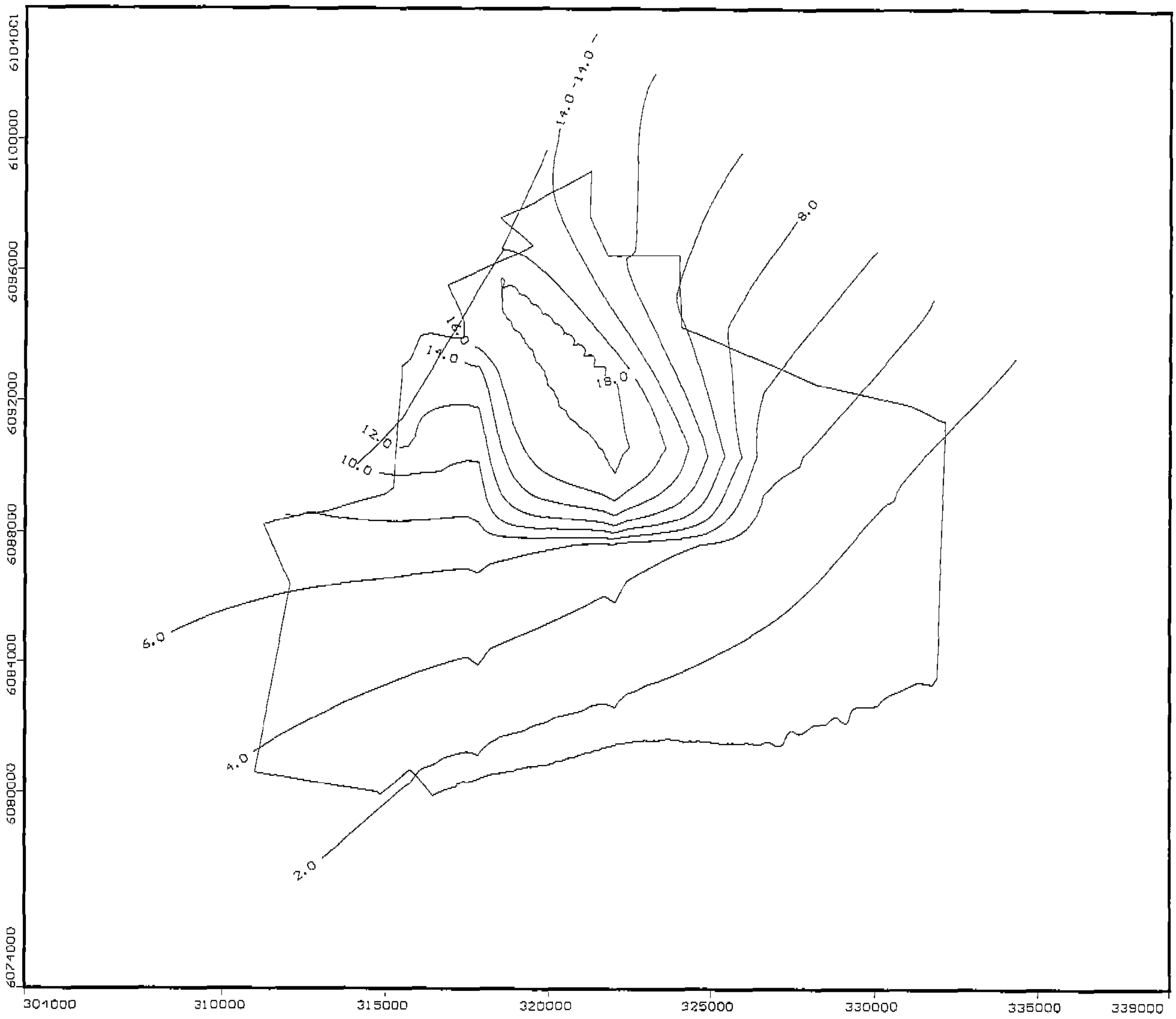
Figure 43:
Unconfined aquifer model head distribution scenario-3 stress period-39



Dept. of Mines & Energy – Australia
Project: ANGAS–BREMER RISKS
Description: Q: TRNS STRESS PERIOD–39
Modeller: S R HOWLES
22 Nov 98

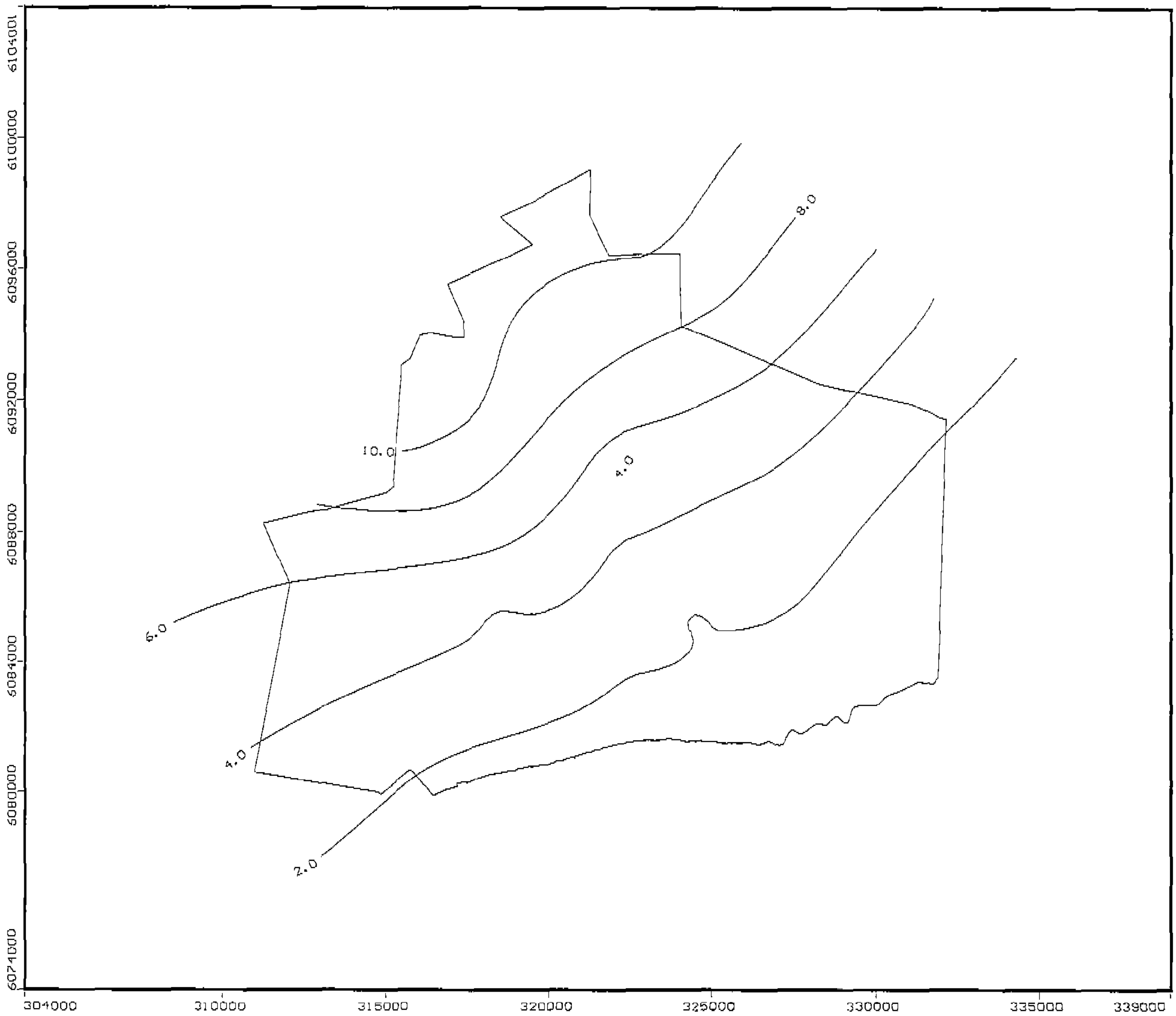
Visual MODFLOW v.2.60, (C) 1995–1997
Waterloo Hydrogeologic Software
NC: 100 NR: 100 NL: 3
Current Layer: 1

Figure 44:
Unconfined aquifer model head distribution scenario-3 stress period-40



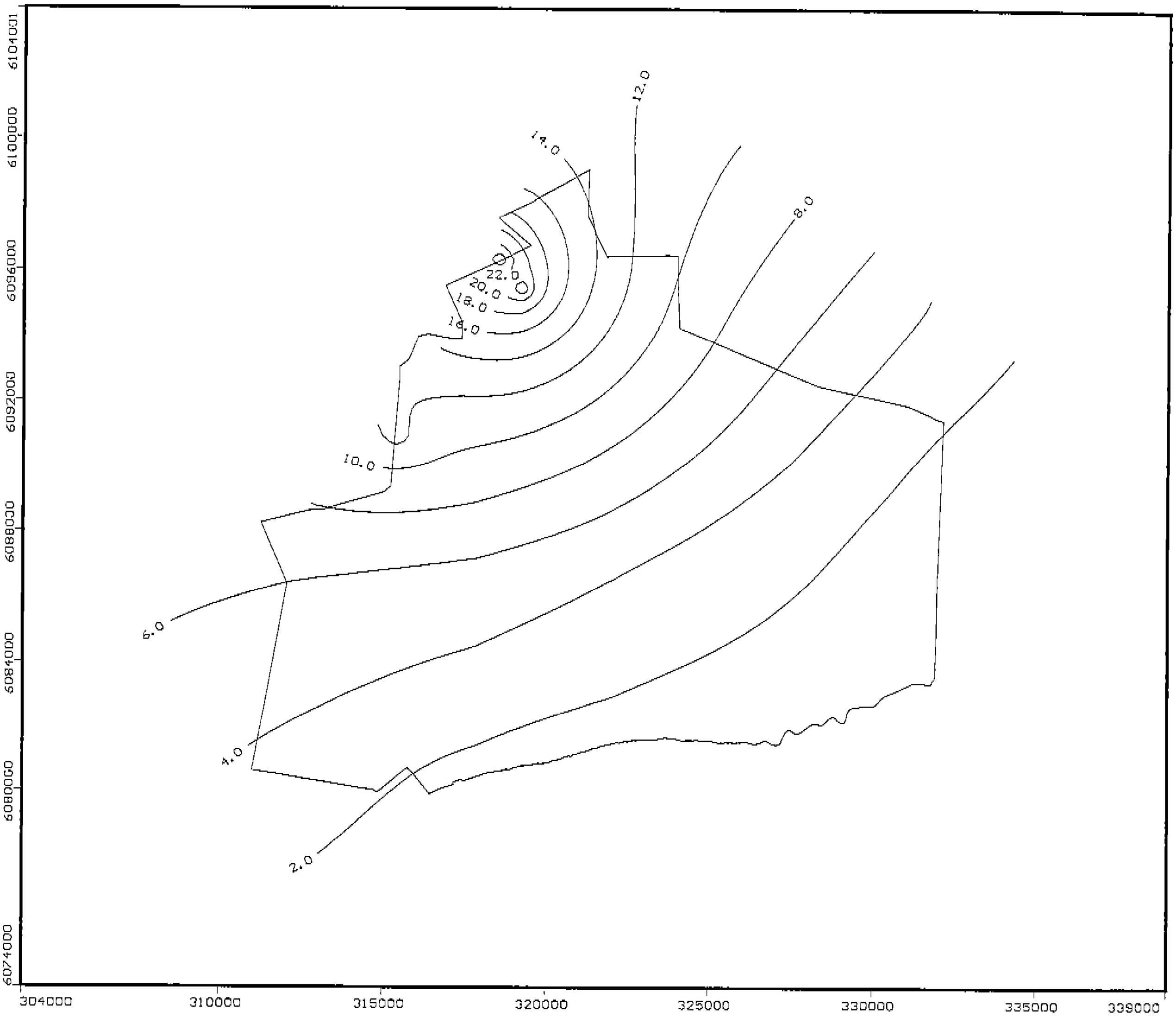
Dept. of Mines & Energy – Australia Project: ANGAS–BREMER RISKS Description: Q: TRNS STRESS PERIOD–40 Modeller: S R HOWLES 22 Nov 98	Visual MODFLOW v.2.60, (C) 1995–1997 Waterloo Hydrogeologic Software NC: 100 NR: 100 NL: 3 Current Layer: 1

Figure 45:
Confined aquifer model head distribution scenario-3 stress period-5



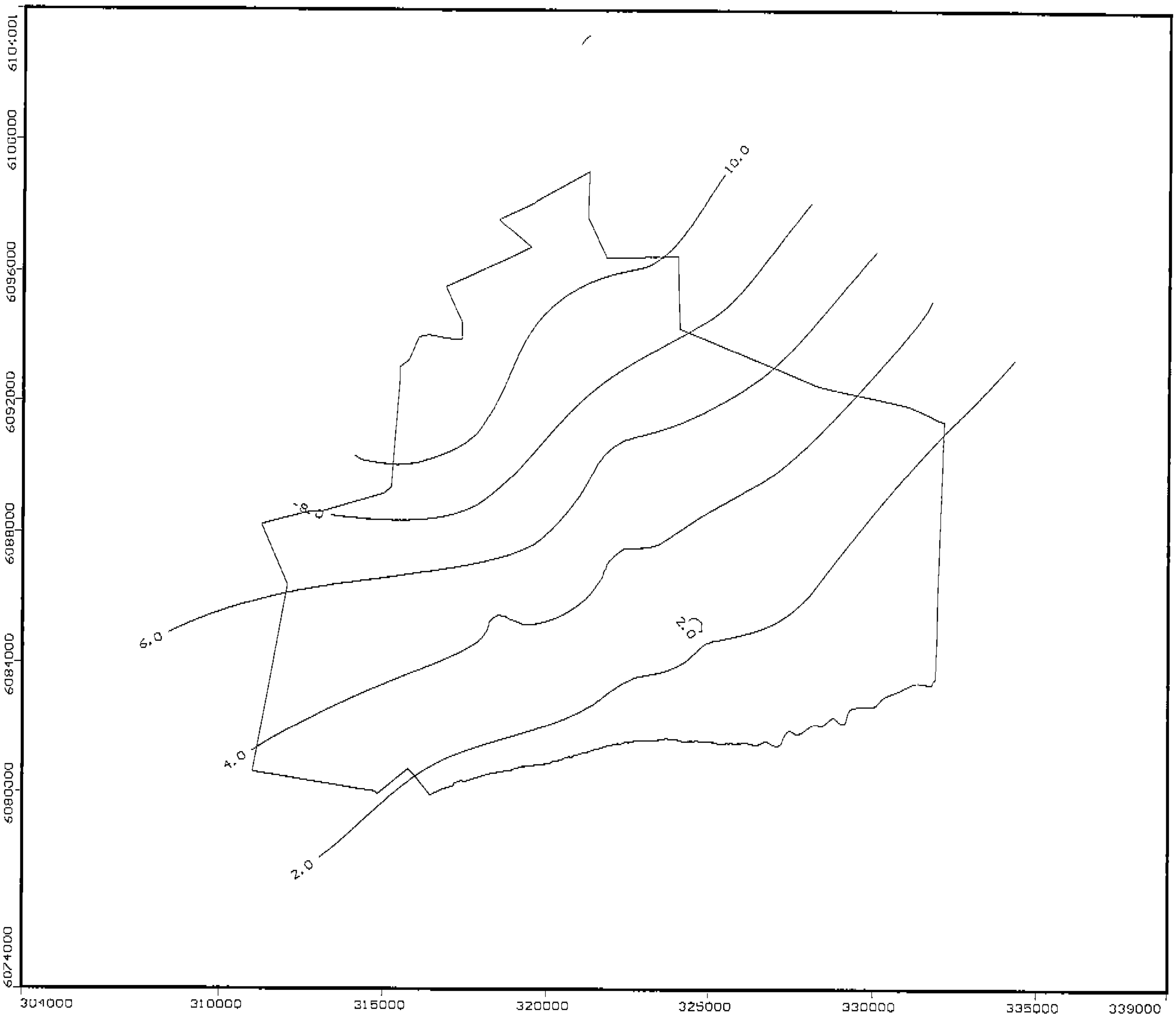
Dept. of Mines & Energy – Australia Project: ANGAS–BREMER RISKS Description: T: TRNS STRESS PERIOD–5 Modeller: S R HOWLES 22 Nov 98	Visual MODFLOW v.2.60, (C) 1995–1997 Waterloo Hydrogeologic Software NC: 100 NR: 100 NL: 3 Current Layer: 3

Figure 46:
Confined aquifer model head distribution scenario-3 stress period-6



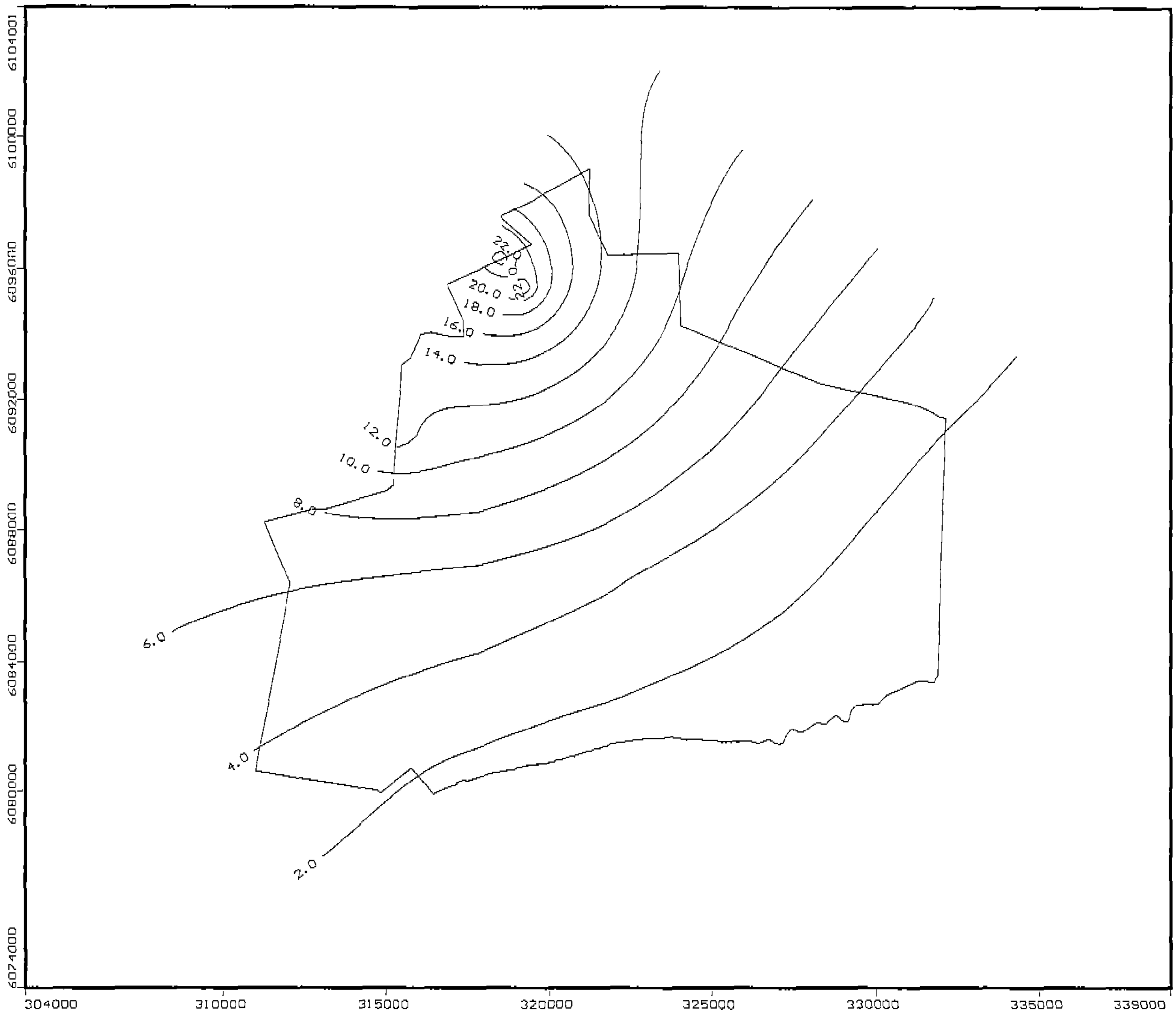
Dept. of Mines & Energy – Australia Project: ANGAS–BREMER RISKS Description: T: TRNS STRESS PERIOD–6 Modeller: S R HOWLES 22 Nov 98	Visual MODFLOW v.2.60, (C) 1995–1997 Waterloo Hydrogeologic Software NC: 100 NR: 100 NL: 3 Current Layer: 3

Figure 47:
Confined aquifer model head distribution scenario-3 stress period-39



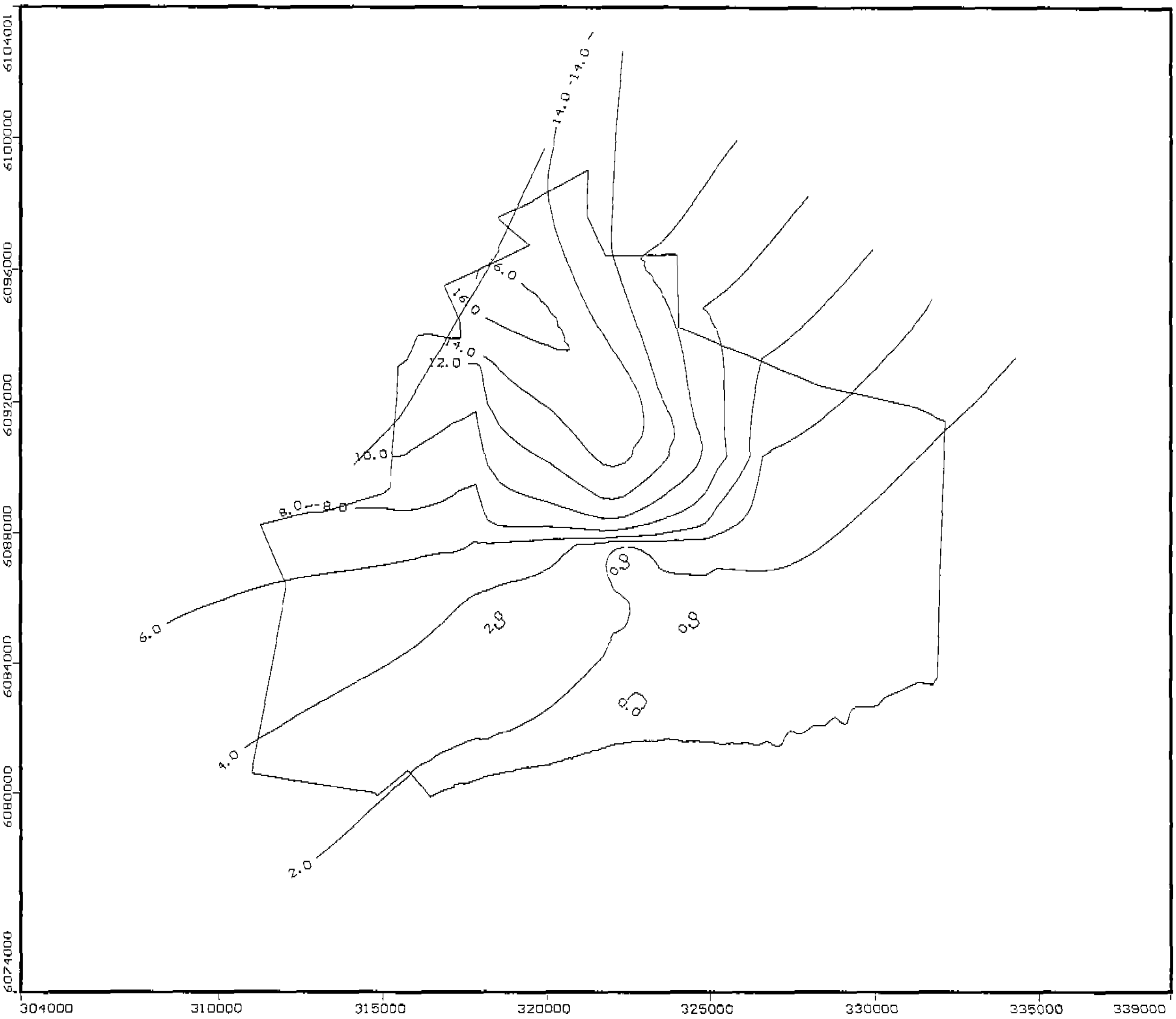
Dept. of Mines & Energy – Australia Project: ANGAS–BREMER RISKS Description: T: TRNS STRESS PERIOD–39 Modeller: S R HOWLES 22 Nov 98	Visual MODFLOW v.2.60, (C) 1995–1997 Waterloo Hydrogeologic Software NC: 100 NR: 100 NL: 3 Current Layer: 3

Figure 48:
Confined aquifer model head distribution scenario-3 stress period-40



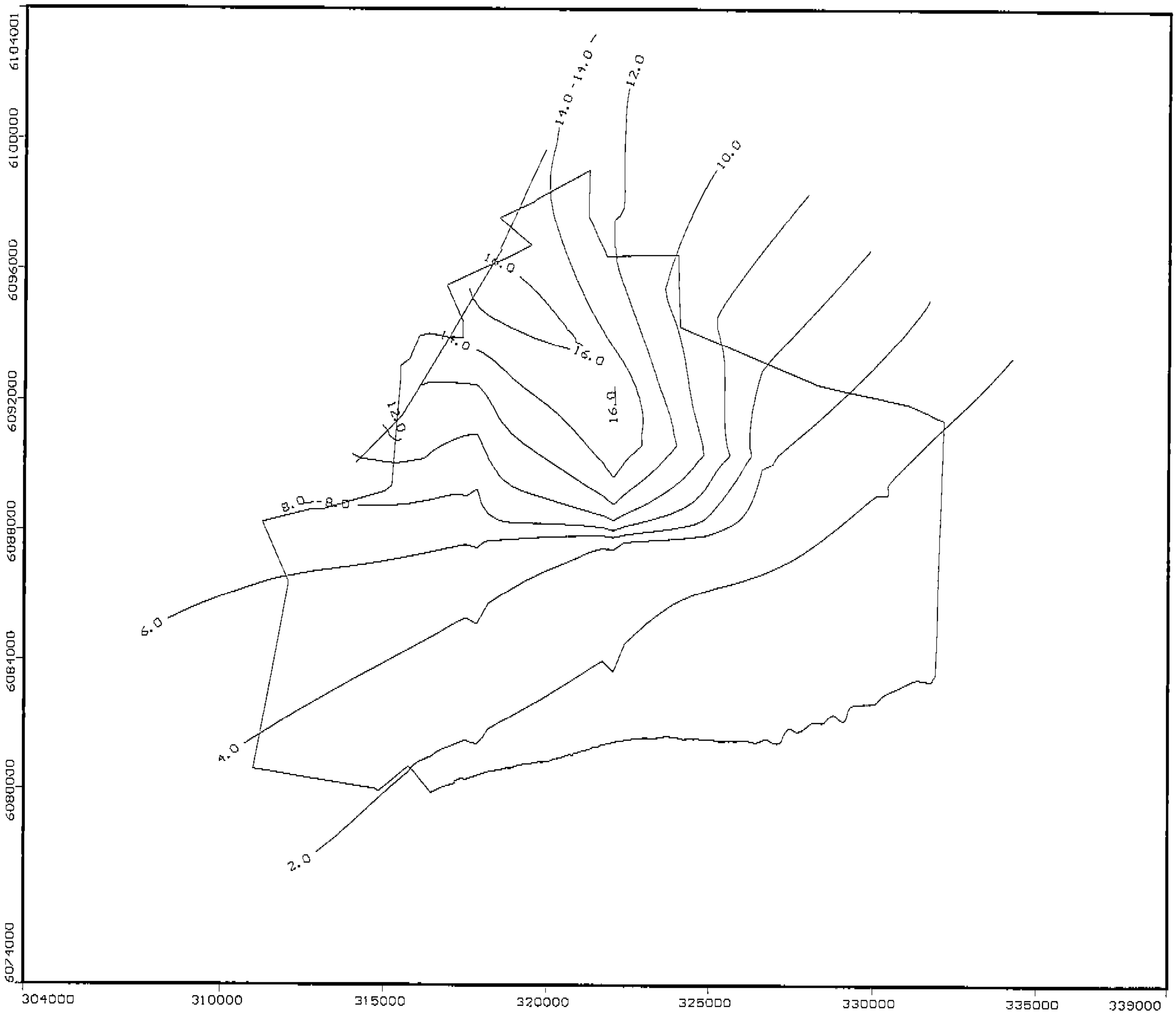
Dept. of Mines & Energy – Australia Project: ANGAS–BREMER RISKS Description: T: TRNS STRESS PERIOD–40 Modeller: S R HOWLES 22 Nov 98	Visual MODFLOW v.2.60, (C) 1995–1997 Waterloo Hydrogeologic Software NC: 100 NR: 100 NL: 3 Current Layer: 3

Figure 49:
Unconfined aquifer model head distribution scenario-4 stress period-5



Dept. of Mines & Energy – Australia Project: ANGAS–BREMER RISKS Description: Q: TRNS STRESS PERIOD–5 Modeller: S R HOWLES 22 Nov 98	Visual MODFLOW v.2.60, (C) 1995–1997 Waterloo Hydrogeologic Software NC: 100 NR: 100 NL: 3 Current Layer: 1

Figure 50:
Unconfined aquifer model head distribution scenario-4 stress period-6



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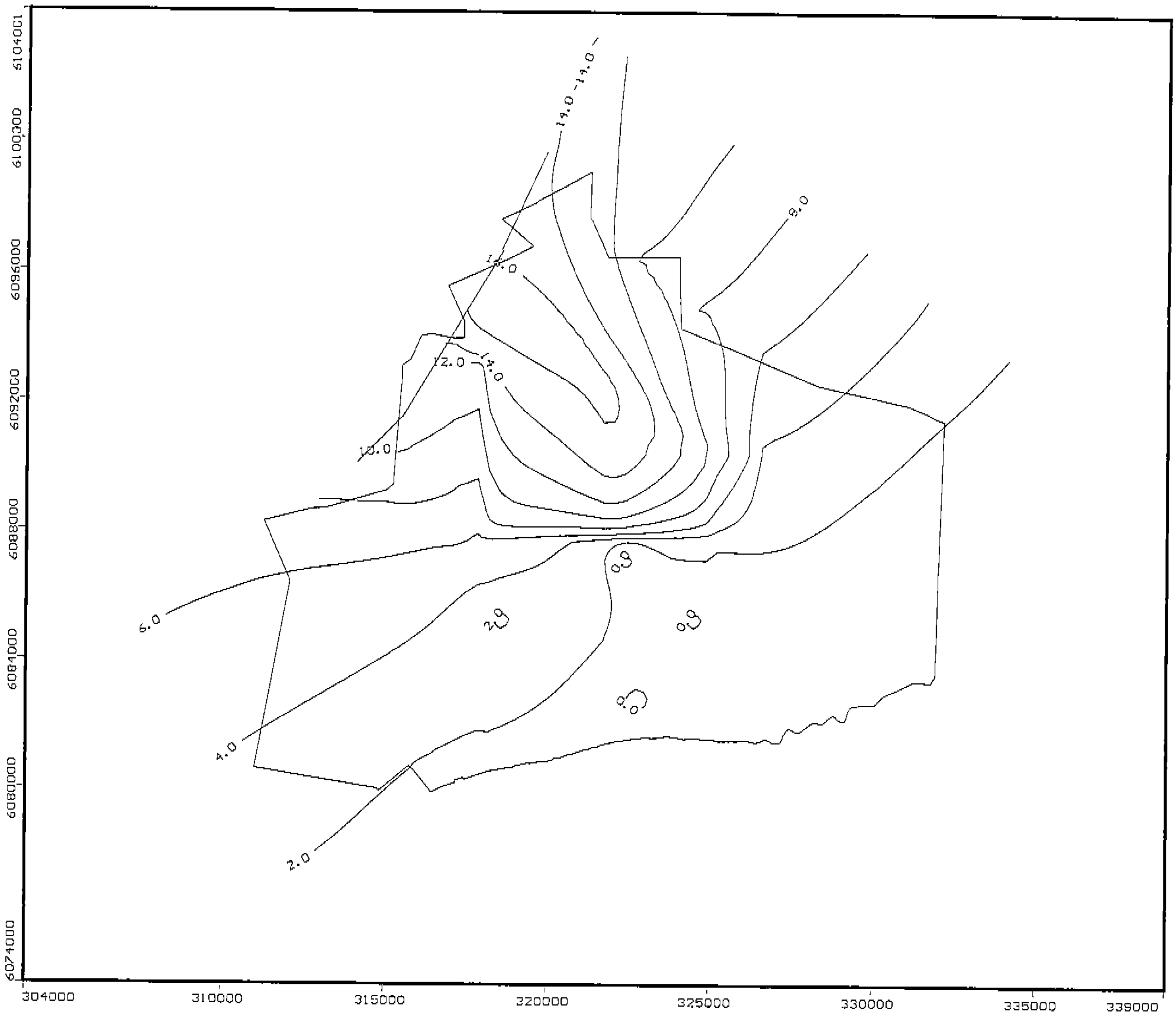
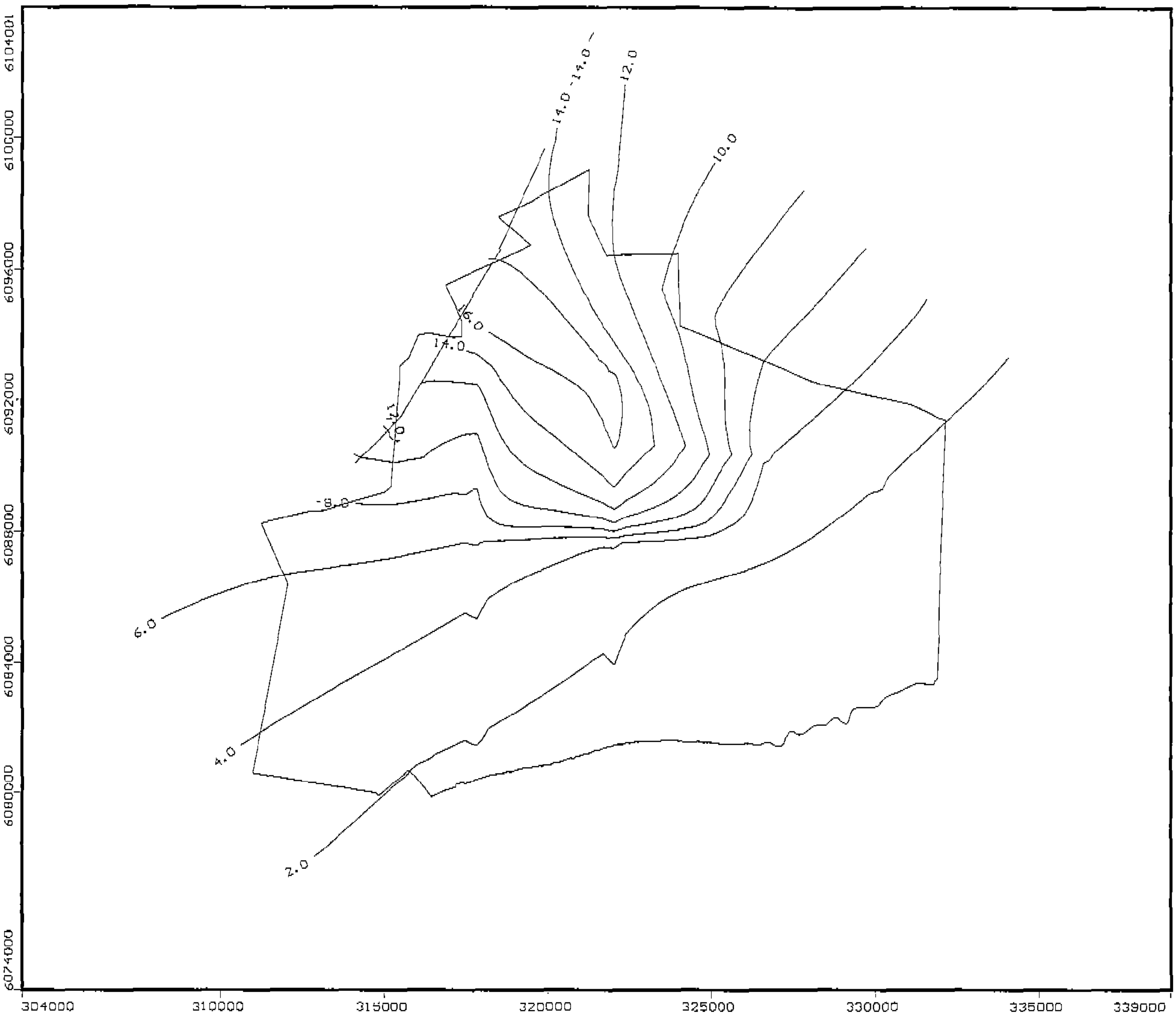
Visual MODFLOW v.2.60, (C) 1995–1997
Waterloo Hydrogeologic Software
NC: 100 NR: 100 NL: 3
Current Layer: 1

Figure 51:
Unconfined aquifer model head distribution scenario-4 stress period-9



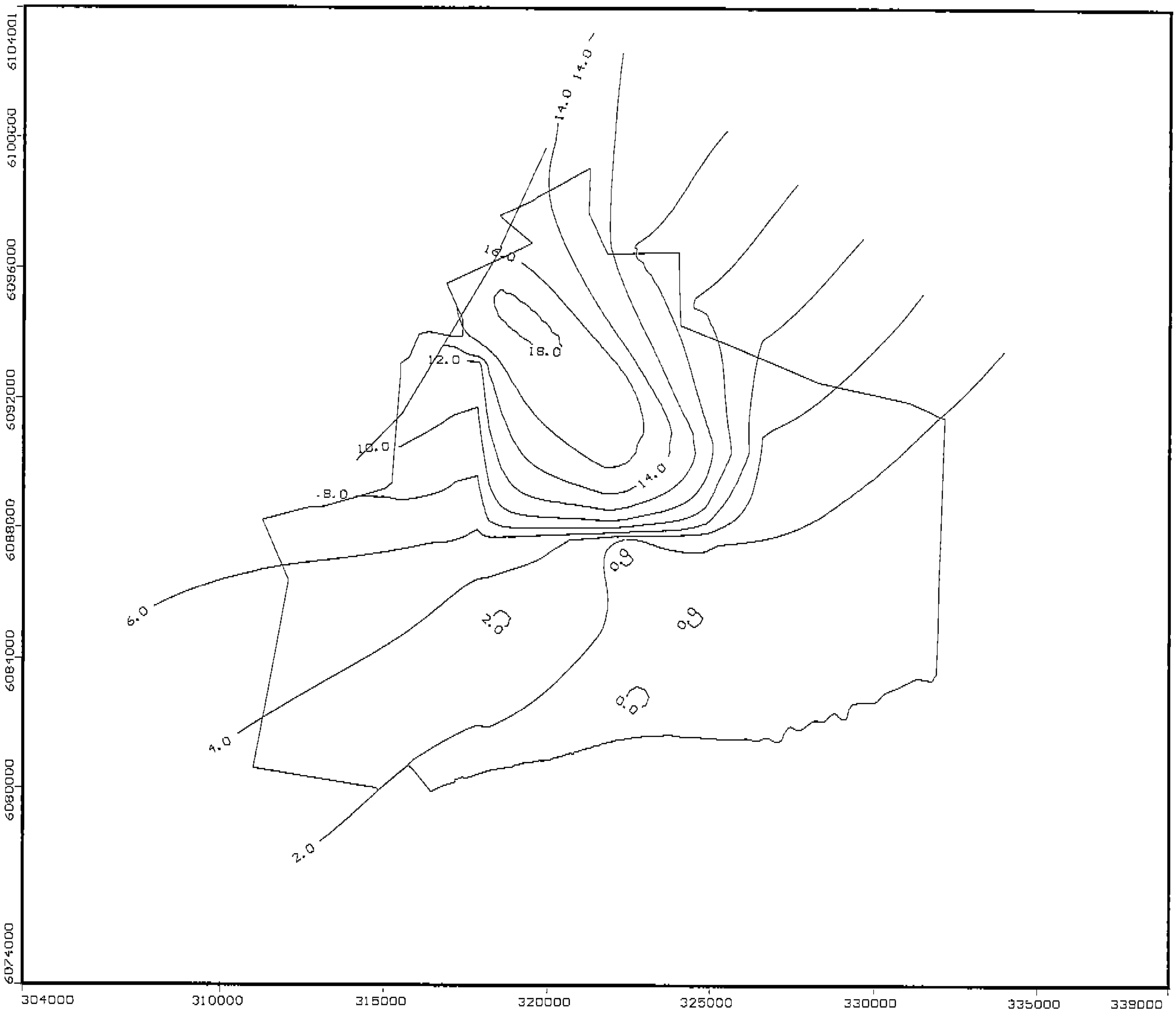
Dept. of Mines & Energy – Australia Project: ANGAS–BREMER RISKS Description: Q: TRNS STRESS PERIOD–9 Modeller: S R HOWLES 22 Nov 98	Visual MODFLOW v.2.60, (C) 1995–1997 Waterloo Hydrogeologic Software NC: 100 NR: 100 NL: 3 Current Layer: 1

Figure 52:
Unconfined aquifer model head distribution scenario-4 stress period-10



Dept. of Mines & Energy – Australia Project: ANGAS–BREMER RISKS Description: Q: TRNS STRESS PERIOD–10 Modeller: S R HOWLES 22 Nov 98	Visual MODFLOW v.2.60, (C) 1995–1997 Waterloo Hydrogeologic Software NC: 100 NR: 100 NL: 3 Current Layer: 1

Figure 53:
Unconfined aquifer model head distribution scenario-4 stress period-19



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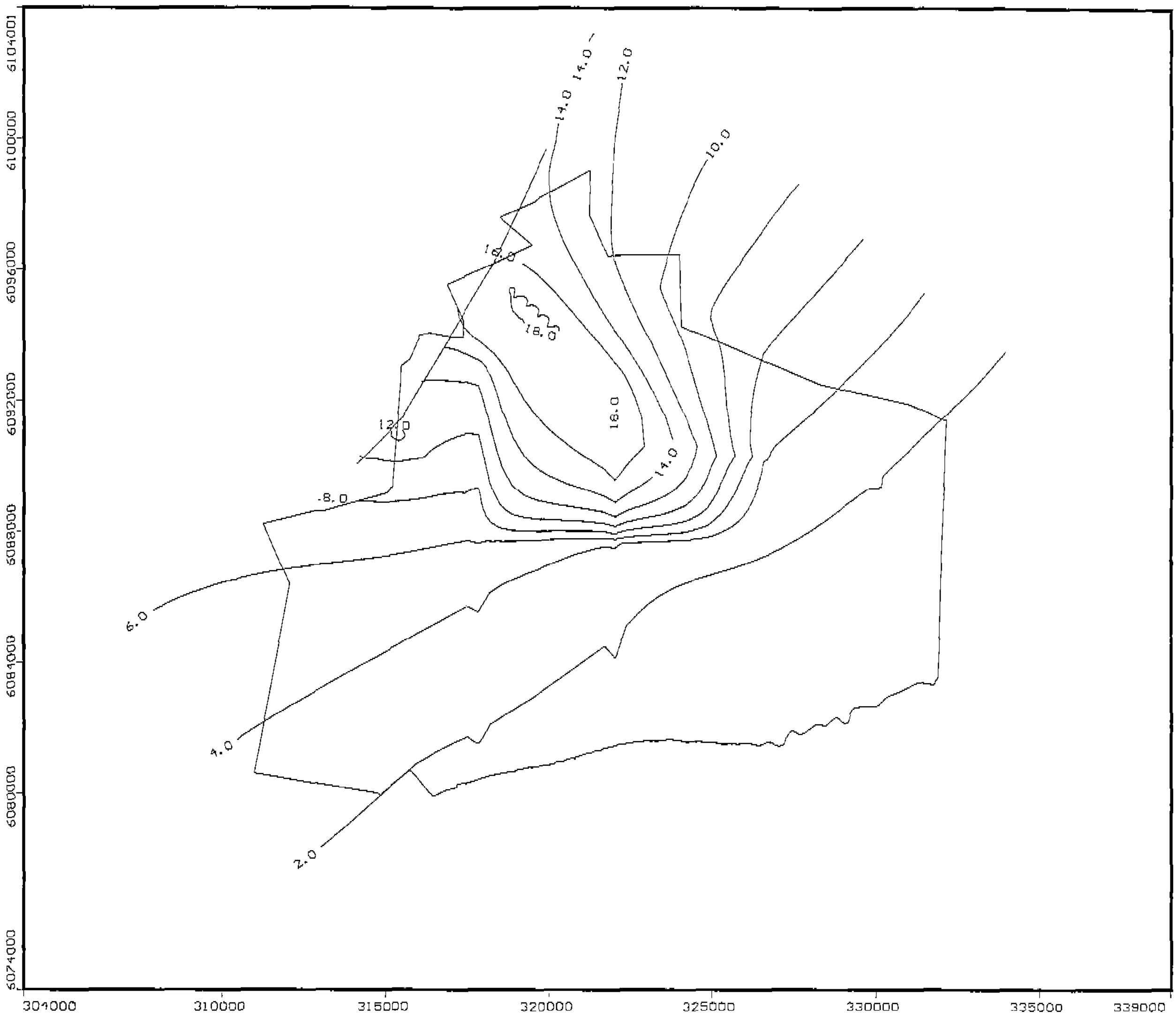
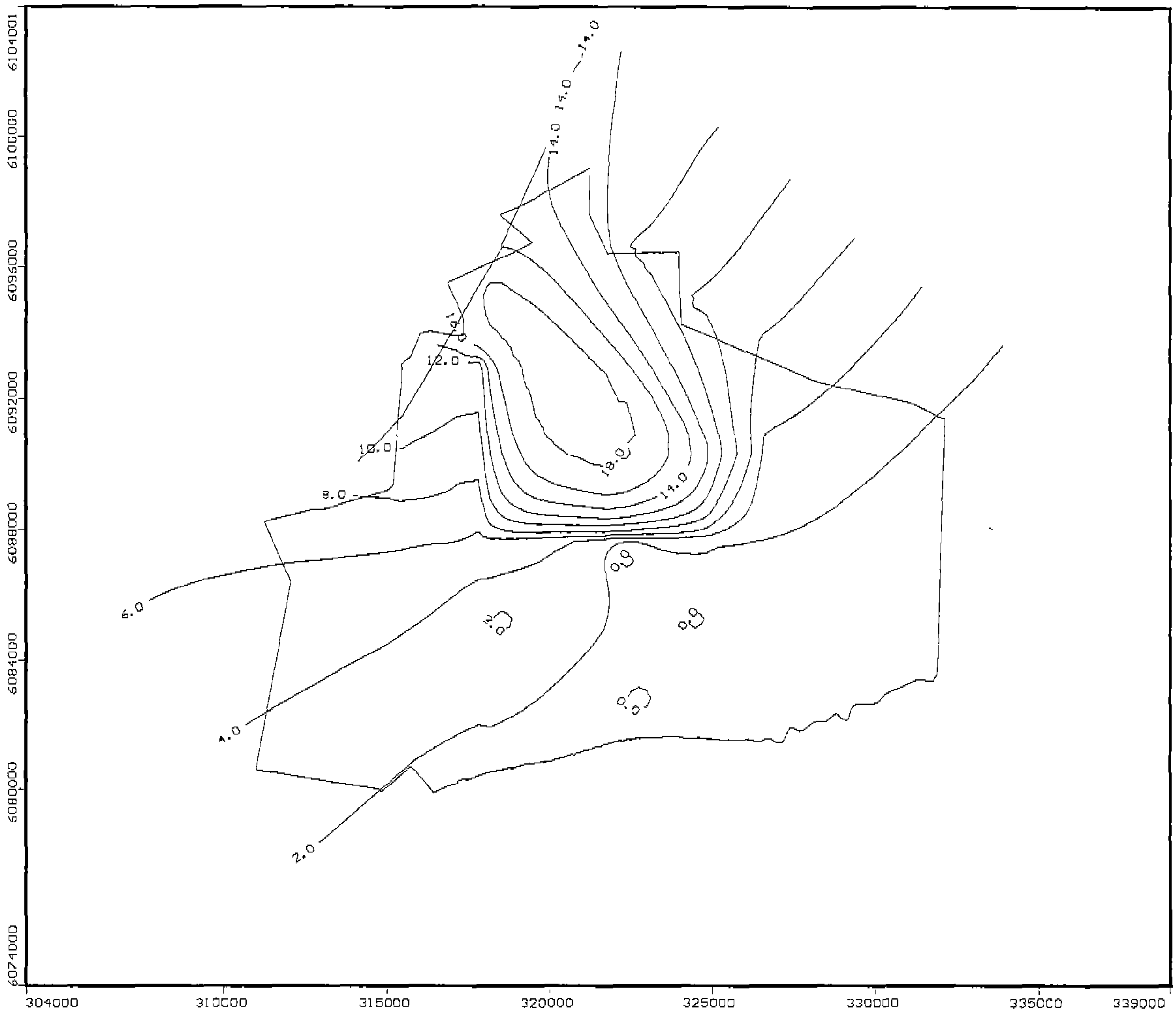
Visual MODFLOW v.2.60, (C) 1995–1997
Waterloo Hydrogeologic Software
NC: 100 NR: 100 NL: 3
Current Layer: 1

Figure 54:
Unconfined aquifer model head distribution scenario-4 stress period-20



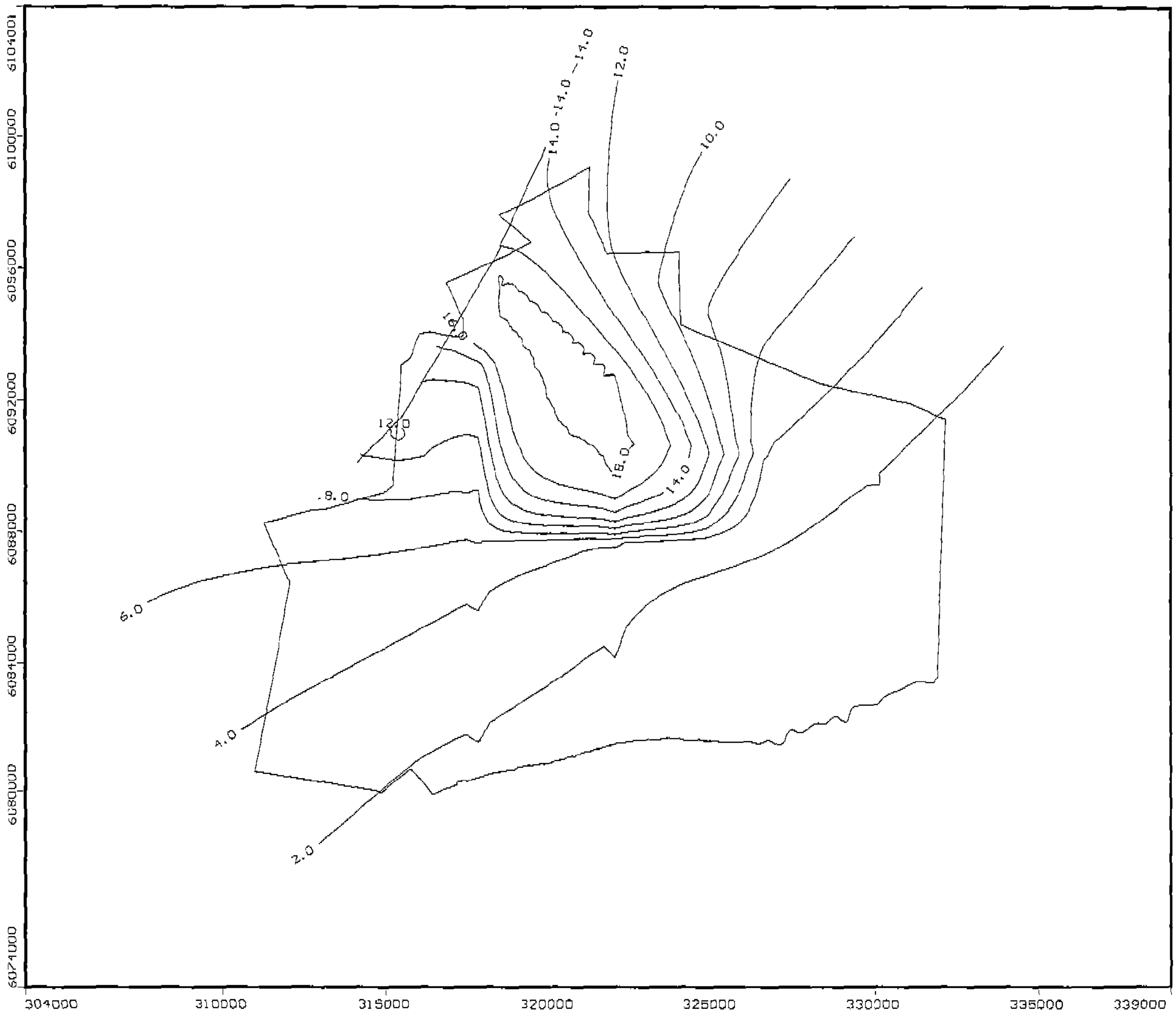
Dept. of Mines & Energy – Australia Project: ANGAS–BREMER RISKS Description: Q: TRNS STRESS PERIOD–20 Modeller: S R HOWLES 22 Nov 98	Visual MODFLOW v.2.60, (C) 1995–1997 Waterloo Hydrogeologic Software NC: 100 NR: 100 NL: 3 Current Layer: 1

Figure 55:
Unconfined aquifer model head distribution scenario-4 stress period-39



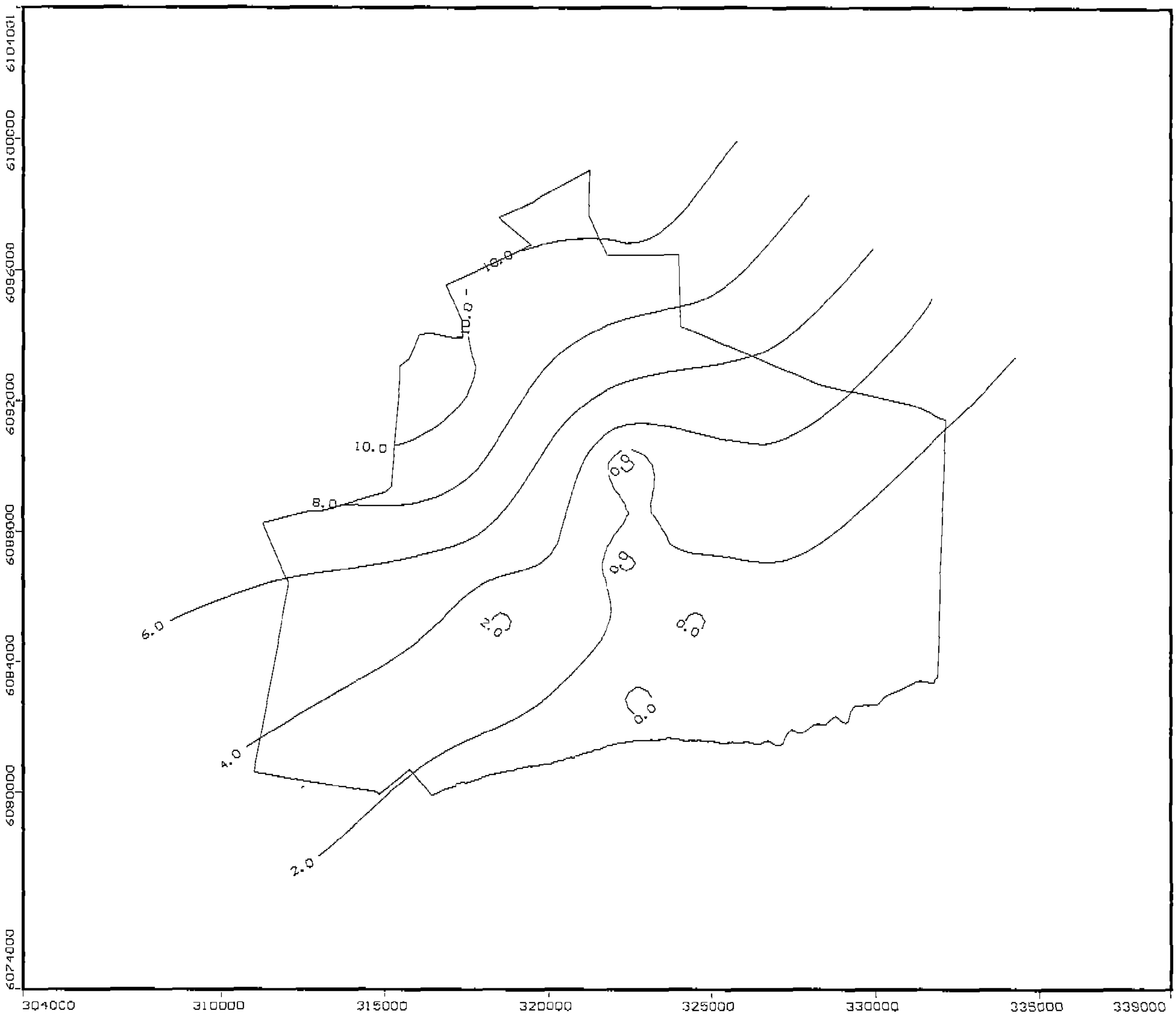
Dept. of Mines & Energy – Australia Project: ANGAS–BREMER RISKS Description: Q: TRNS STRESS PERIOD–39 Modeller: S R HOWLES 22 Nov 98	Visual MODFLOW v.2.60, (C) 1995–1997 Waterloo Hydrogeologic Software NC: 100 NR: 100 NL: 3 Current Layer: 1

Figure 56:
Unconfined aquifer model head distribution scenario-4 stress period-40



Dept. of Mines & Energy – Australia Project: ANGAS–BREMER RISKS Description: Q: TRNS STRESS PERIOD–40 Modeller: S R HOWLES 22 Nov 98	Visual MODFLOW v.2.60, (C) 1995–1997 Waterloo Hydrogeologic Software NC: 100 NR: 100 NL: 3 Current Layer: 1

Figure 57:
Confined aquifer model head distribution scenario-4 stress period-5



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Description: T: TRNS STRESS PERIOD–5
Modeller: S R HOWLES
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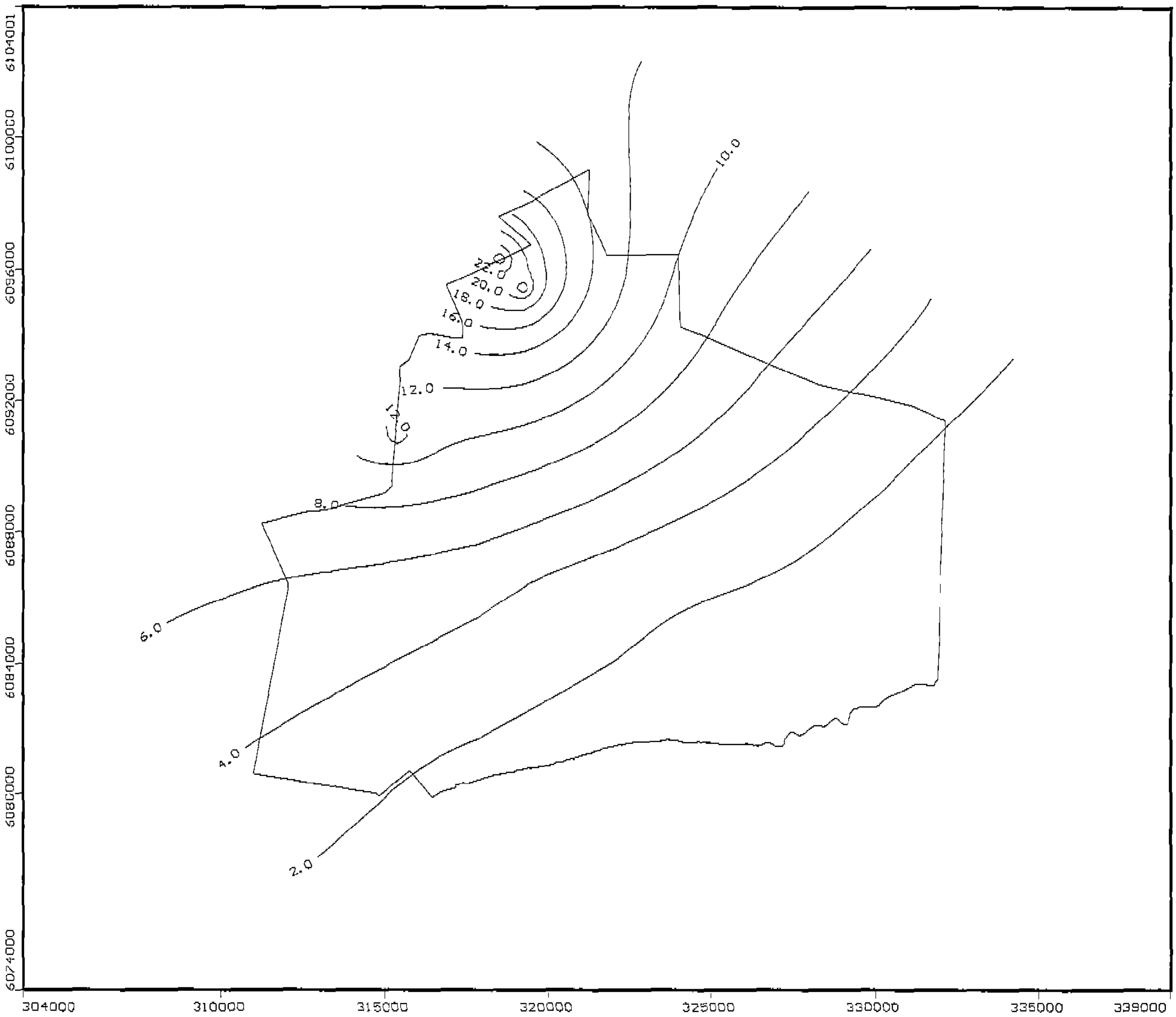
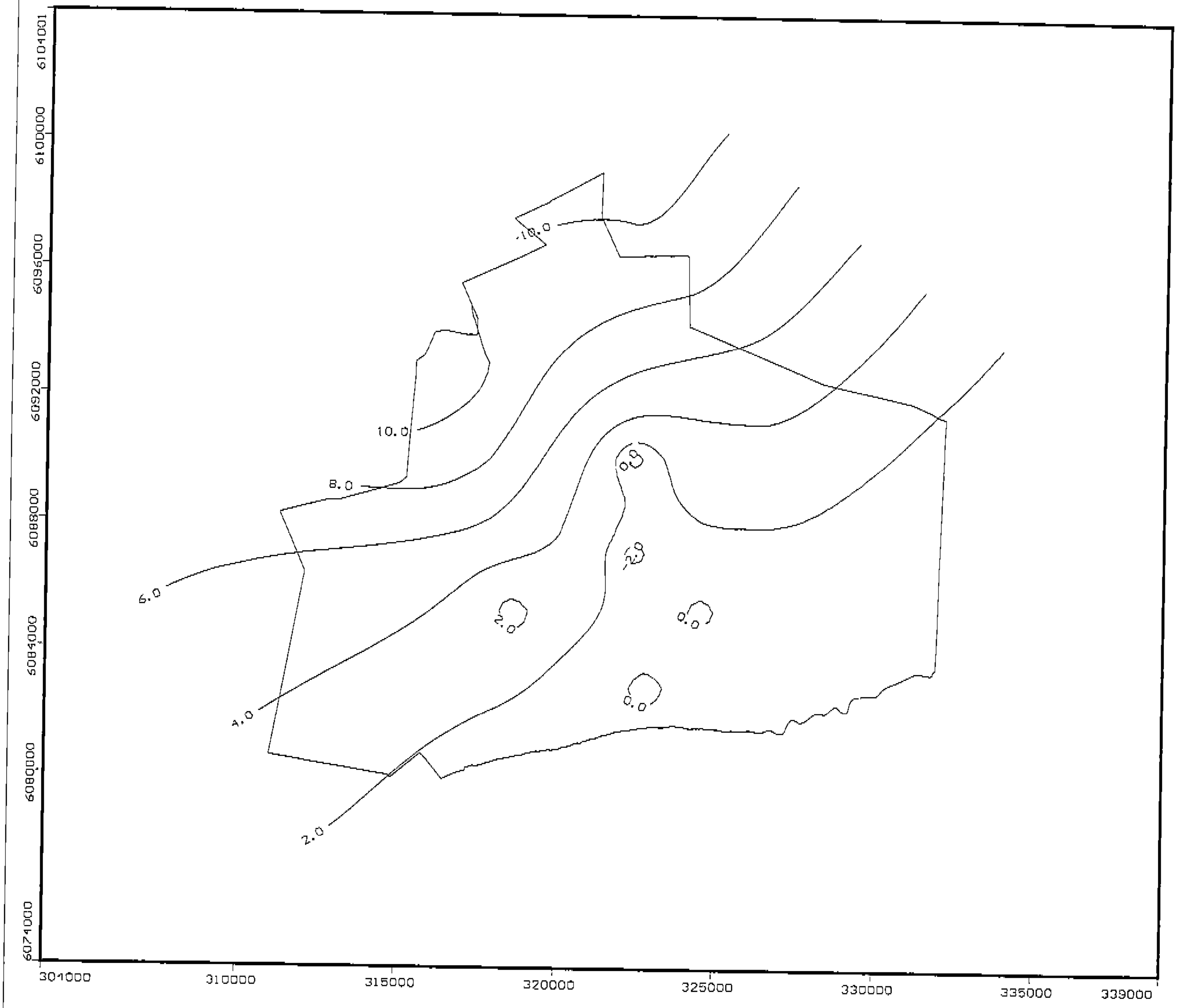
Visual MODFLOW v.2.60, (C) 1995–1997
Waterloo Hydrogeologic Software
NC: 100 NR: 100 NL: 3
Current Layer: 3

Figure 58:
Confined aquifer model head distribution scenario-4 stress period-6



Dept. of Mines & Energy - Australia Project: ANGAS-BREMER RISKS Description: T: TRNS STRESS PERIOD-6 Modeller: S R HOWLES 22 Nov 98	Visual MODFLOW v.2.60, (C) 1995-1997 Waterloo Hydrogeologic Software NC: 100 NR: 100 NL: 3 Current Layer: 3

Figure 59:
Confined aquifer model head distribution scenario-4 stress period-39



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Modeller: S R HOWLES
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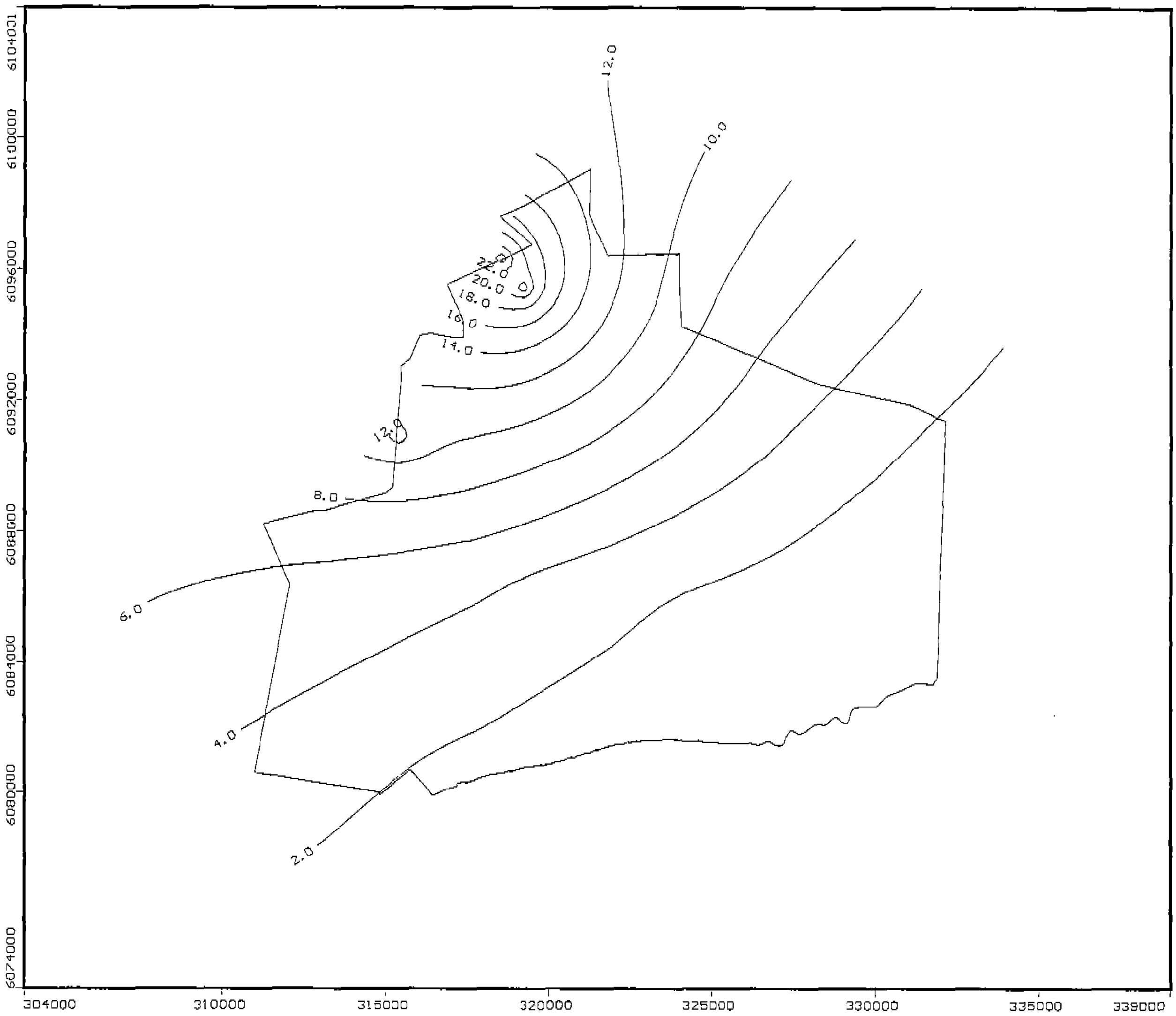
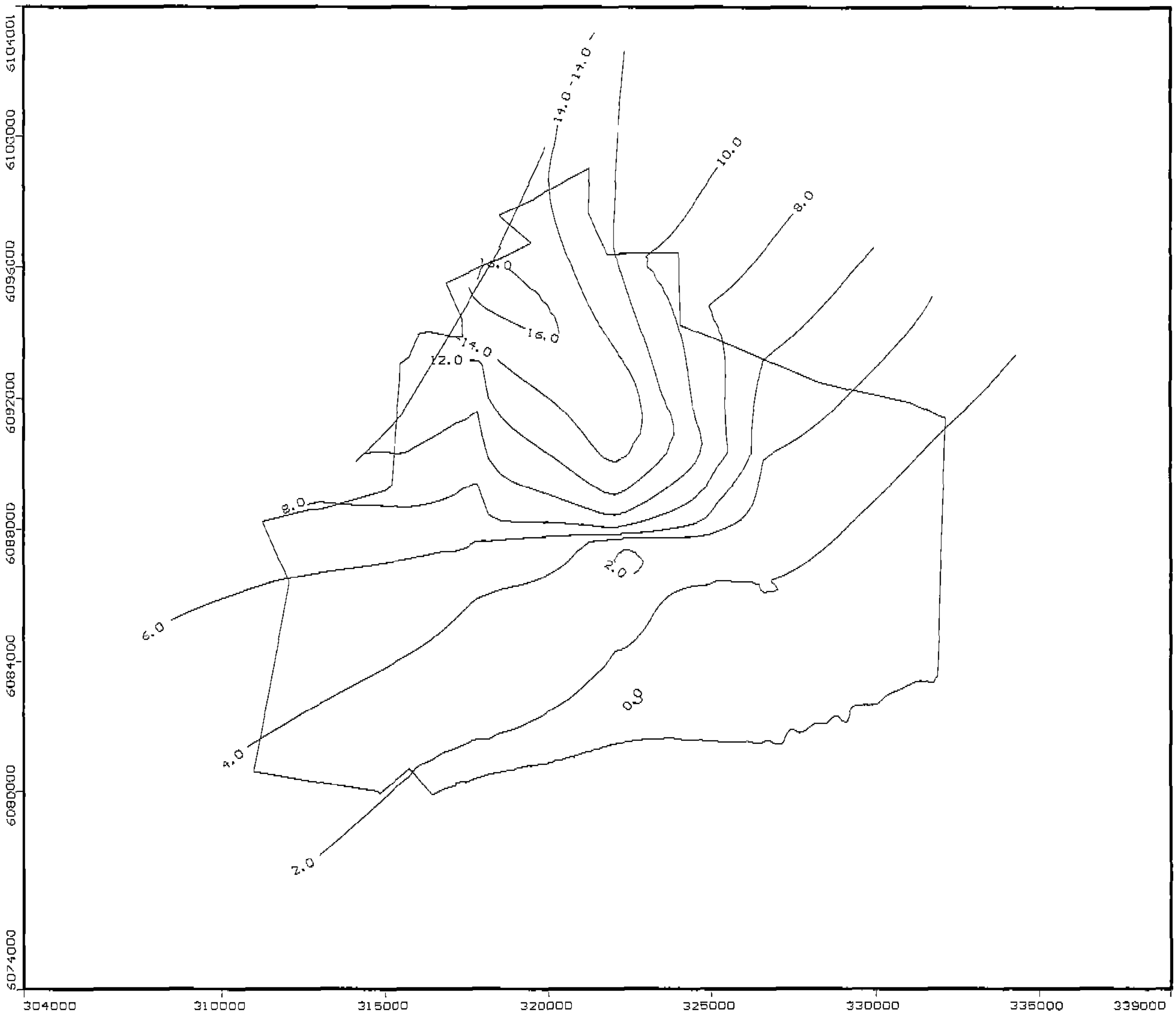
Visual MODFLOW v.2.60, (C) 1995–1997
Waterloo Hydrogeologic Software
NC: 100 NR: 100 NL: 3
Current Layer: 3

Figure 60:
Confined aquifer model head distribution scenario-4 stress period-40



Dept. of Mines & Energy - Australia Project: ANGAS-BREMER RISKS Description: T: TRNS STRESS PERIOD-40 Modeller: S R HOWLES 22 Nov 98	Visual MODFLOW v.2.60, (C) 1995-1997 Waterloo Hydrogeologic Software NC: 100 NR: 100 NL: 3 Current Layer: 3

Figure 61:
Unconfined aquifer model head distribution scenario-5 stress period-5



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Modeller: S R HOWLES
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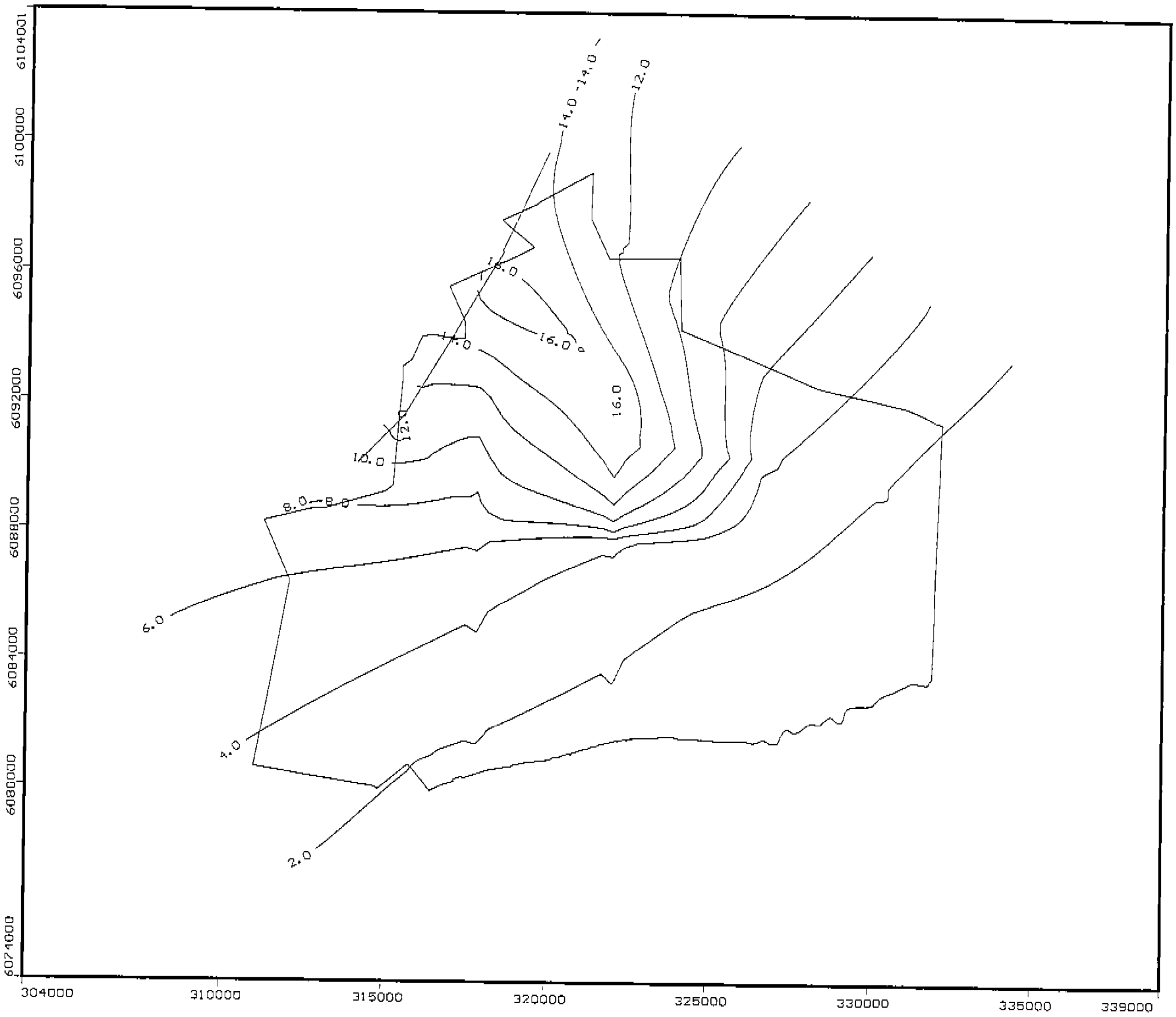
Visual MODFLOW v.2.60, (C) 1995-1997
Waterloo Hydrogeologic Software
NC: 100 NR: 100 NL: 3
Current Layer: 1

Figure 62:
Unconfined aquifer model head distribution scenario-5 stress period-6



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Description: Q: TRNS STRESS PERIOD–6
Modeller: S R HOWLES
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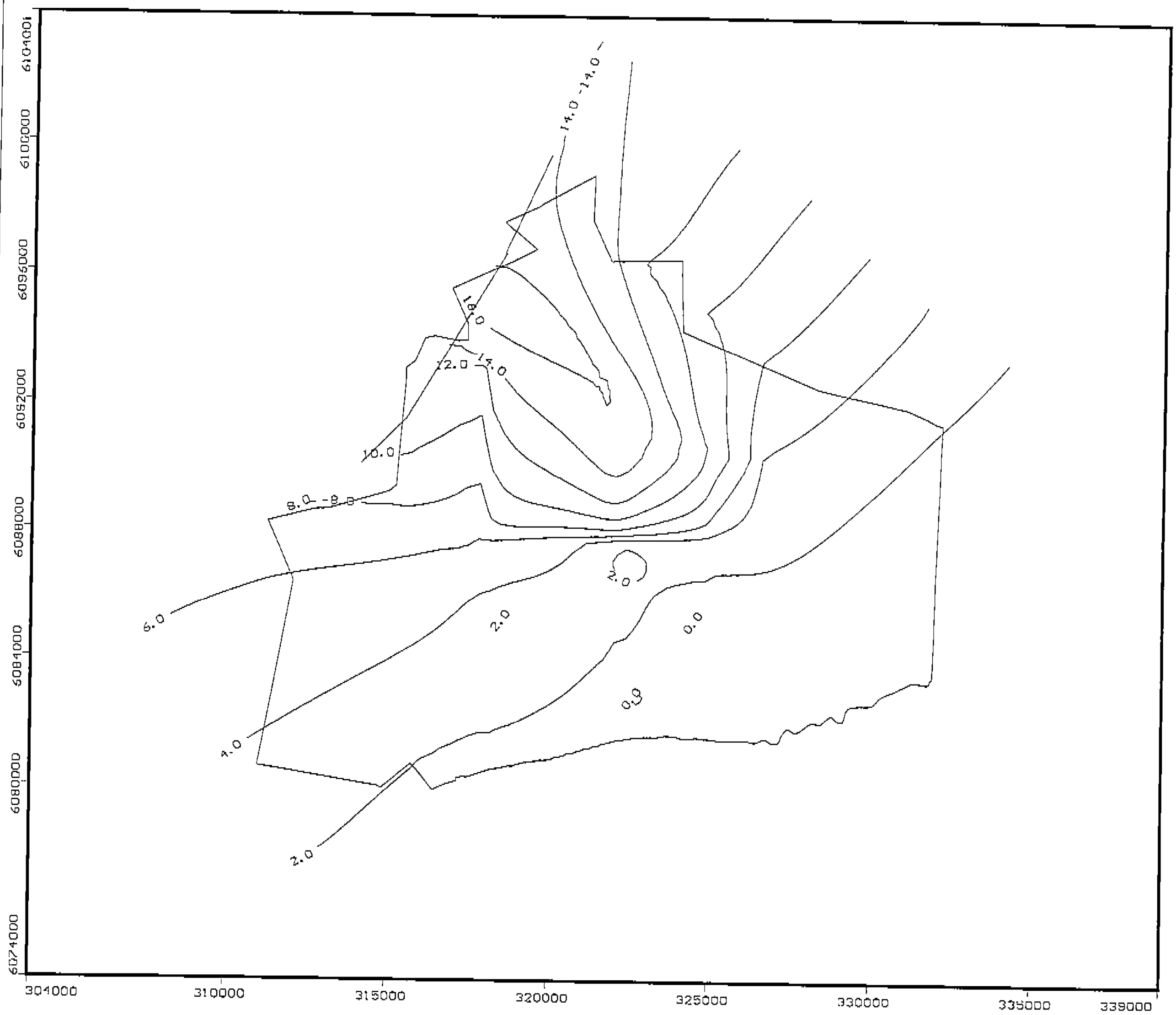
Visual MODFLOW v.2.60, (C) 1995–1997
Waterloo Hydrogeologic Software
NC: 100 NR: 100 NL: 3
Current Layer: 1

Figure 63:
Unconfined aquifer model head distribution scenario-5 stress period-9



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Project: ANGAS–BREMER RISKS
Description: Q: TRNS STRESS PERIOD–9
Modeller: S R HOWLES
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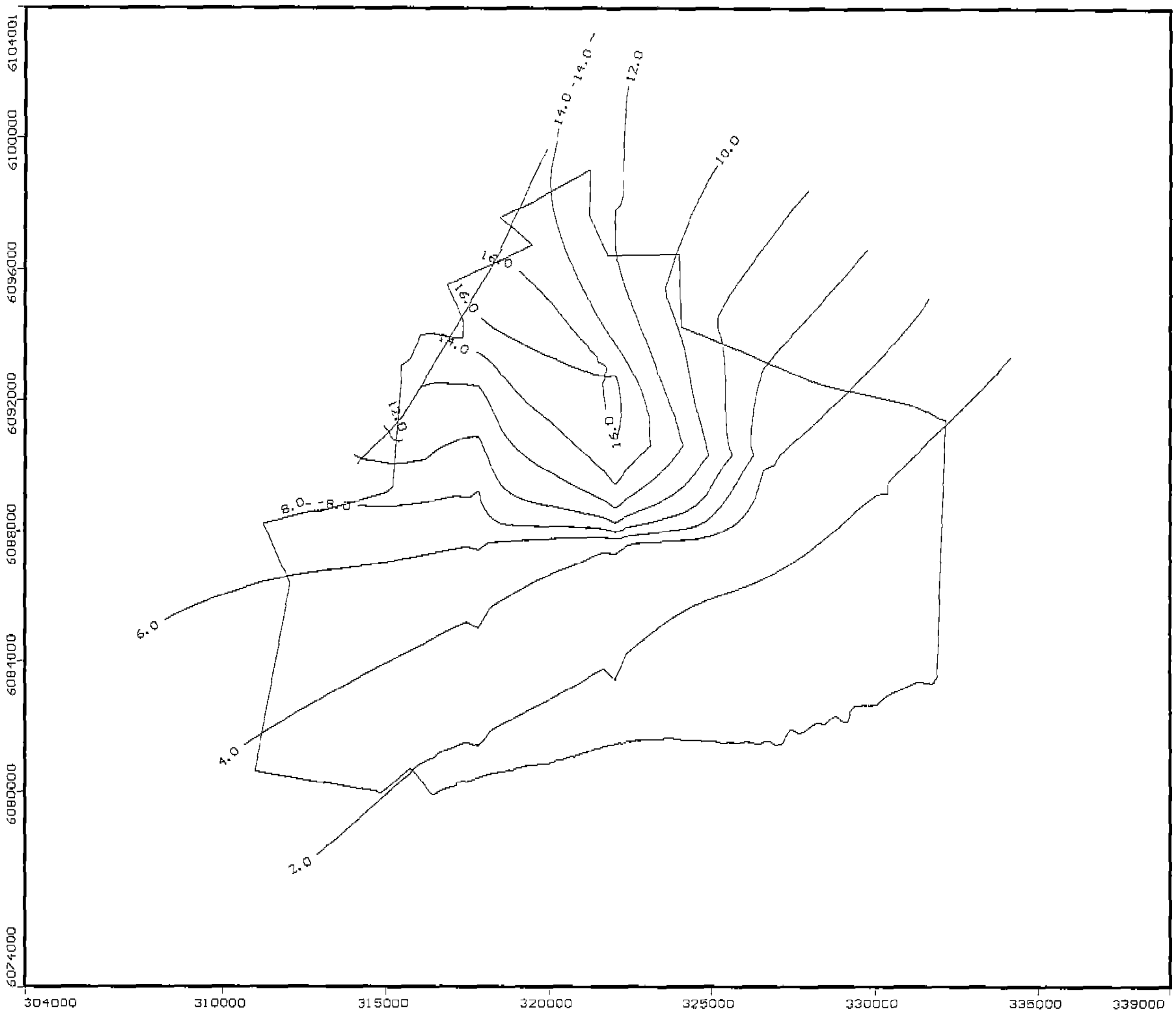
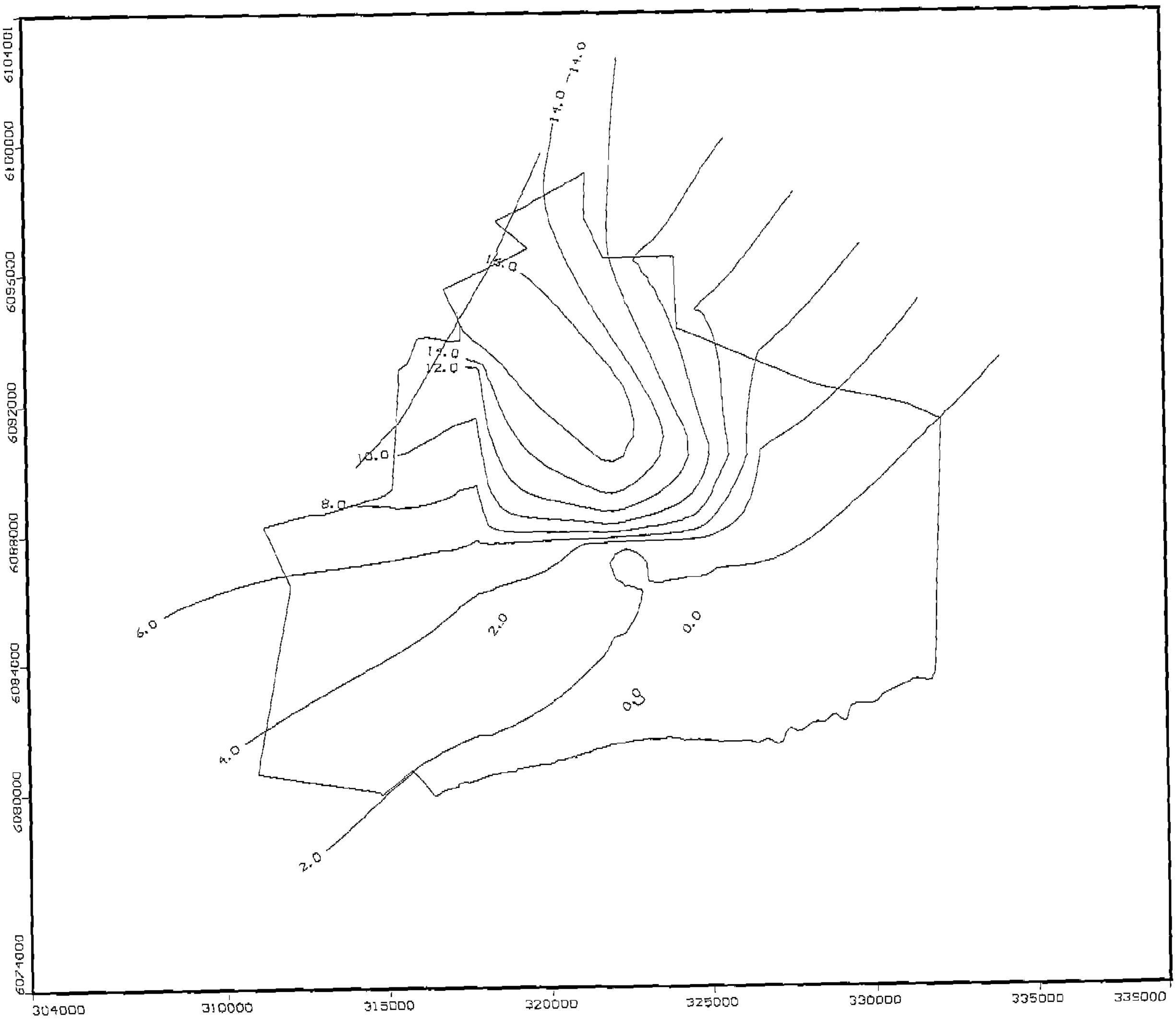
Visual MODFLOW v.2.60, (C) 1995–1997
Waterloo Hydrogeologic Software
NC: 100 NR: 100 NL: 3
Current Layer: 1

Figure 64:
Unconfined aquifer model head distribution scenario-5 stress period-10



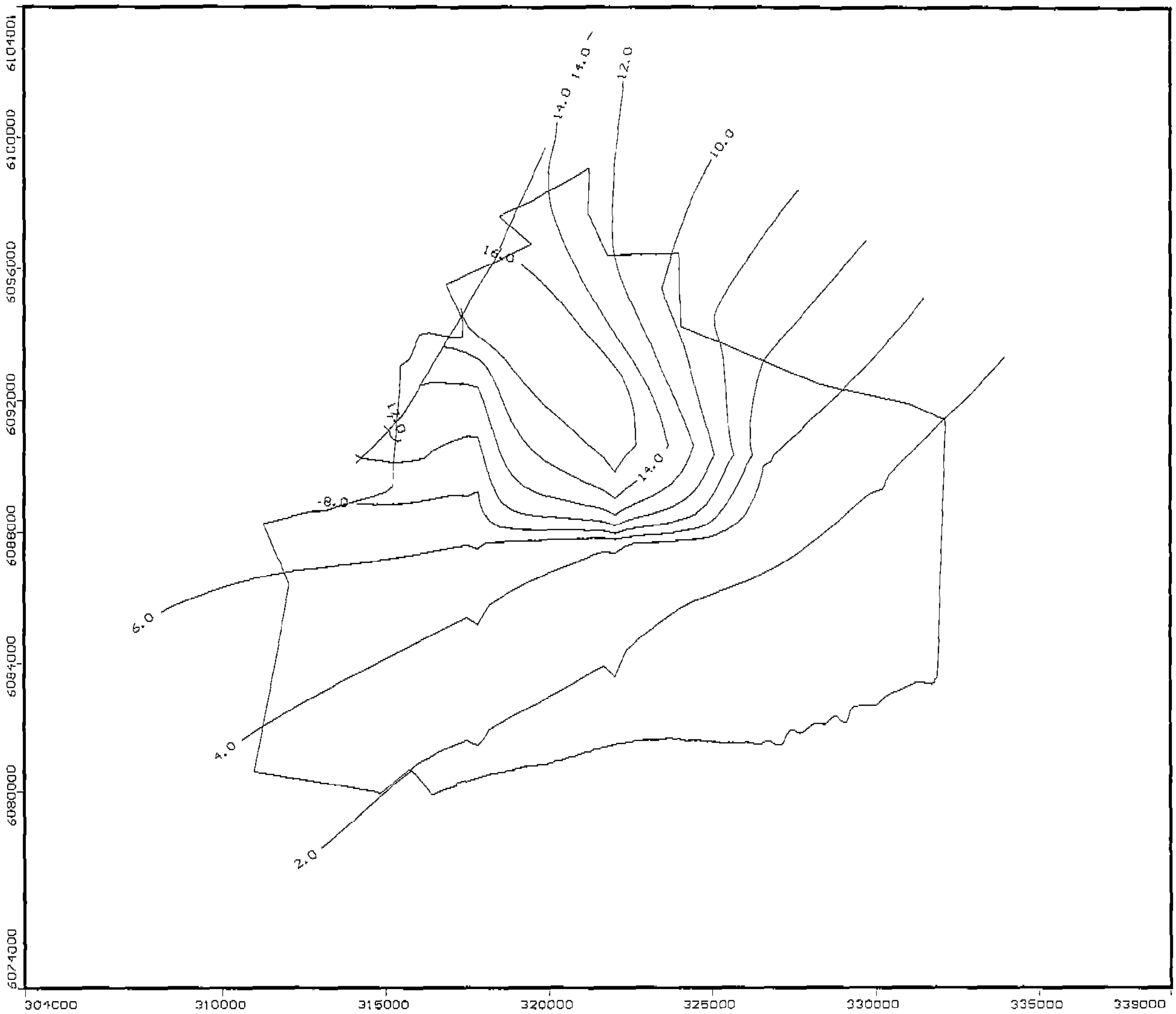
Dept. of Mines & Energy – Australia Project: ANGAS–BREMER RISKS Description: Q: TRNS STRESS PERIOD–10 Modeller: S R HOWLES 23 Nov 98	Visual MODFLOW v.2.60, (C) 1995–1997 Waterloo Hydrogeologic Software NC: 100 NR: 100 NL: 3 Current Layer: 1

Figure 65:
Unconfined aquifer model head distribution scenario-5 stress period-19



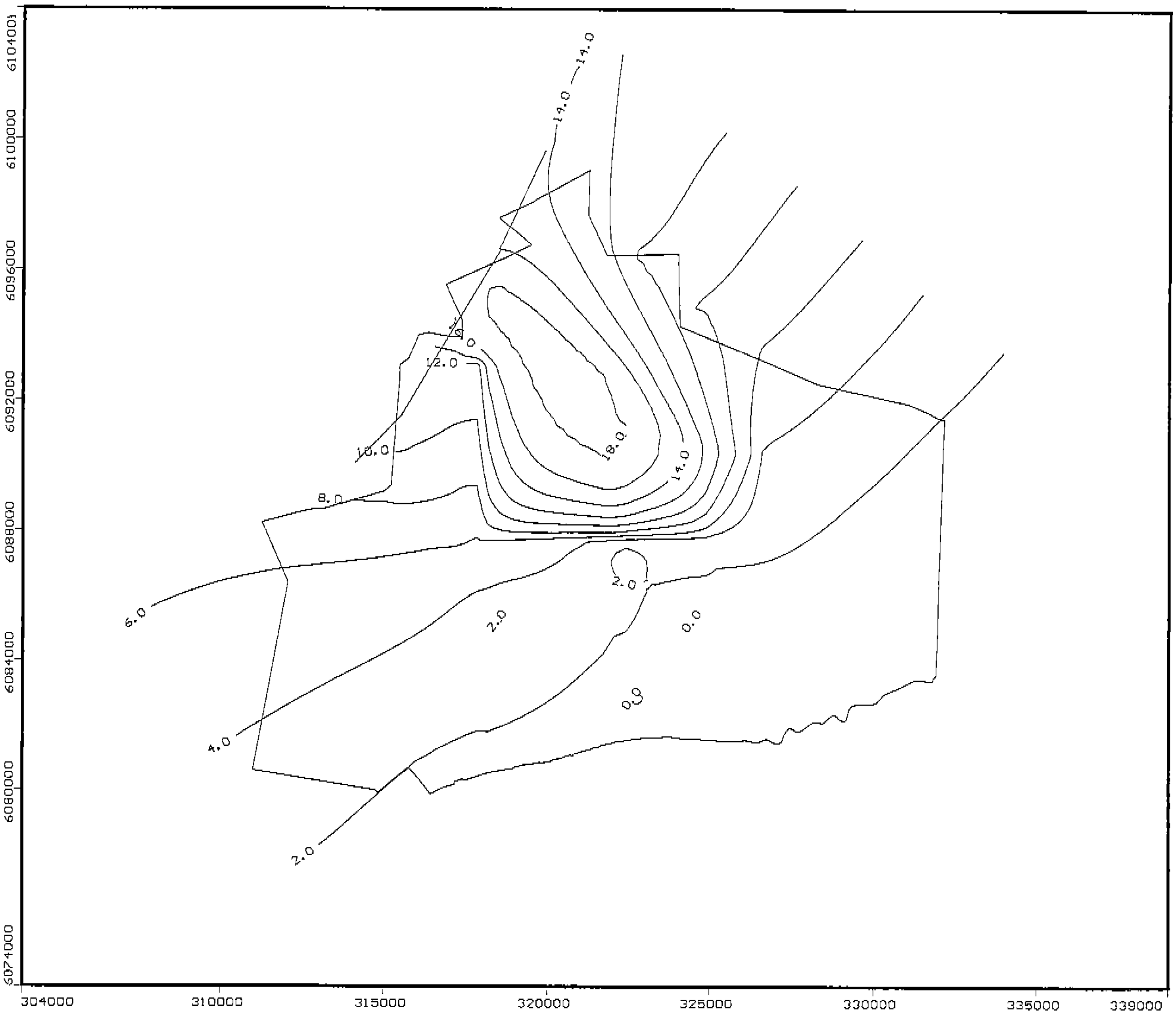
Dept. of Mines & Energy – Australia Project: ANGAS–BREMER RISKS Description: Q: TRNS STRESS PERIOD–19 Modeller: S R HOWLES 23 Nov 98	Visual MODFLOW v.2.60, (C) 1995–1997 Waterloo Hydrogeologic Software NC: 100 NR: 100 NL: 3 Current Layer: 1

Figure 66:
Unconfined aquifer model head distribution scenario-5 stress period-20



Dept. of Mines & Energy – Australia Project: ANGAS-BREMER RISKS Description: Q: TRNS STRESS PERIOD-20 Modeller: S R HOWLES 23 Nov 98	Visual MODFLOW v.2.60, (C) 1995-1997 Waterloo Hydrogeologic Software NC: 100 NR: 100 NL: 3 Current Layer: 1

Figure 67:
Unconfined aquifer model head distribution scenario-5 stress period-39



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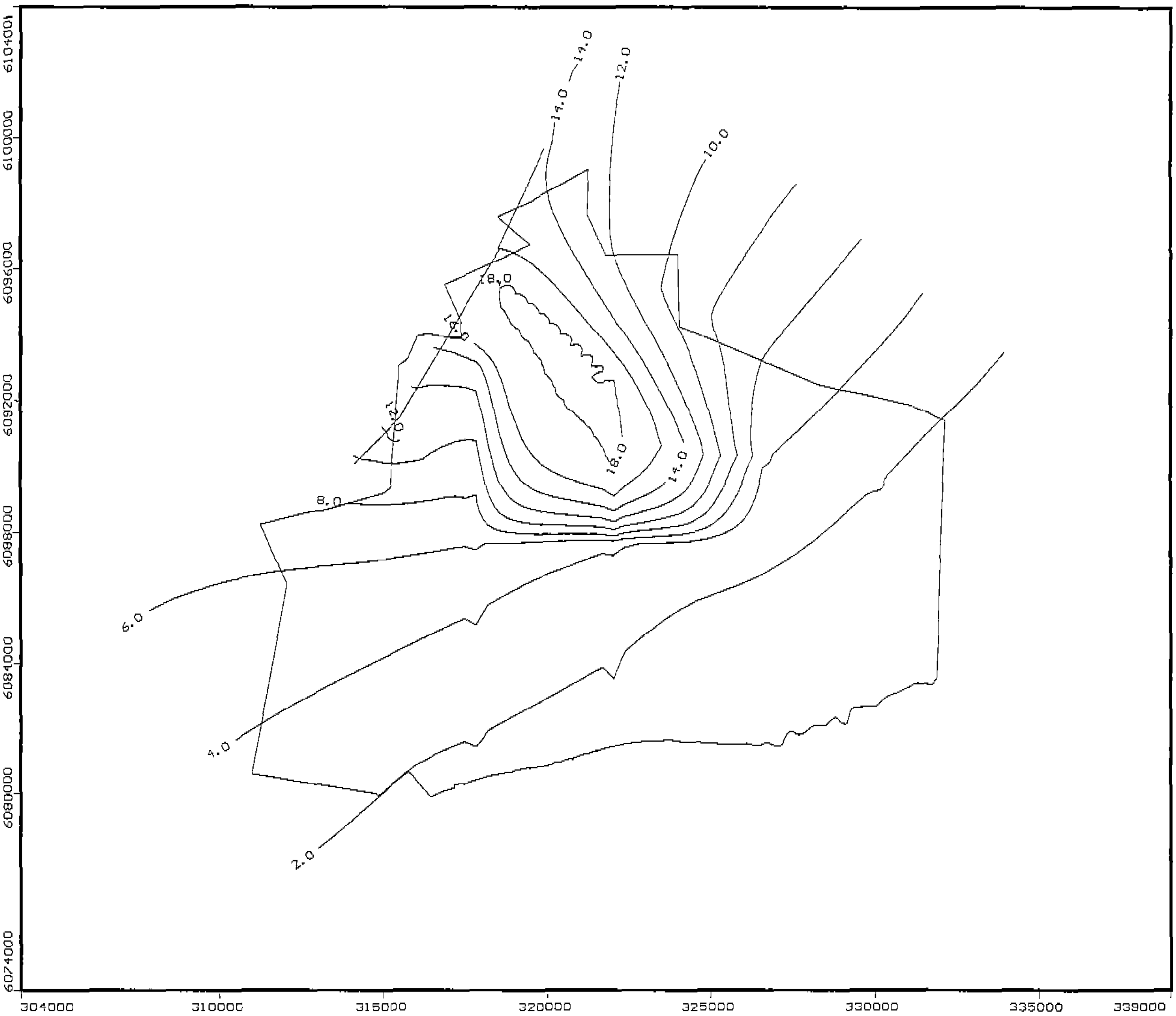
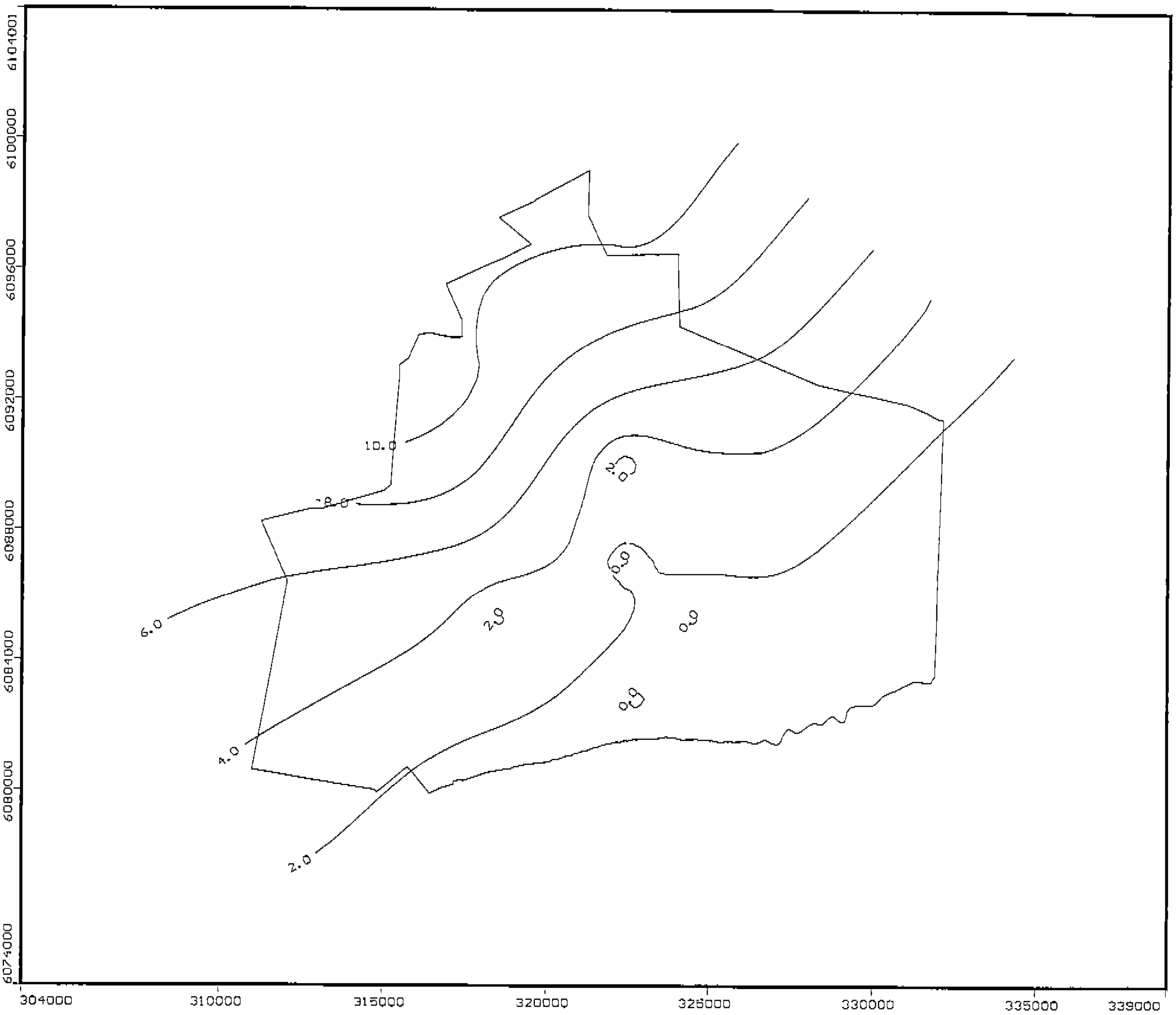
Visual MODFLOW v.2.60, (C) 1995–1997
Waterloo Hydrogeologic Software
NC: 100 NR: 100 NL: 3
Current Layer: 1

Figure 68:
Unconfined aquifer model head distribution scenario-5 stress period-40



Dept. of Mines & Energy - Australia Project: ANGAS-BREMER RISKS Description: Q: TRNS STRESS PERIOD-40 Modeller: S R HOWLES 23 Nov 98	Visual MODFLOW v.2.60, (C) 1995-1997 Waterloo Hydrogeologic Software NC: 100 NR: 100 NL: 3 Current Layer: 1

Figure 69:
Confined aquifer model head distribution scenario-5 stress period-5



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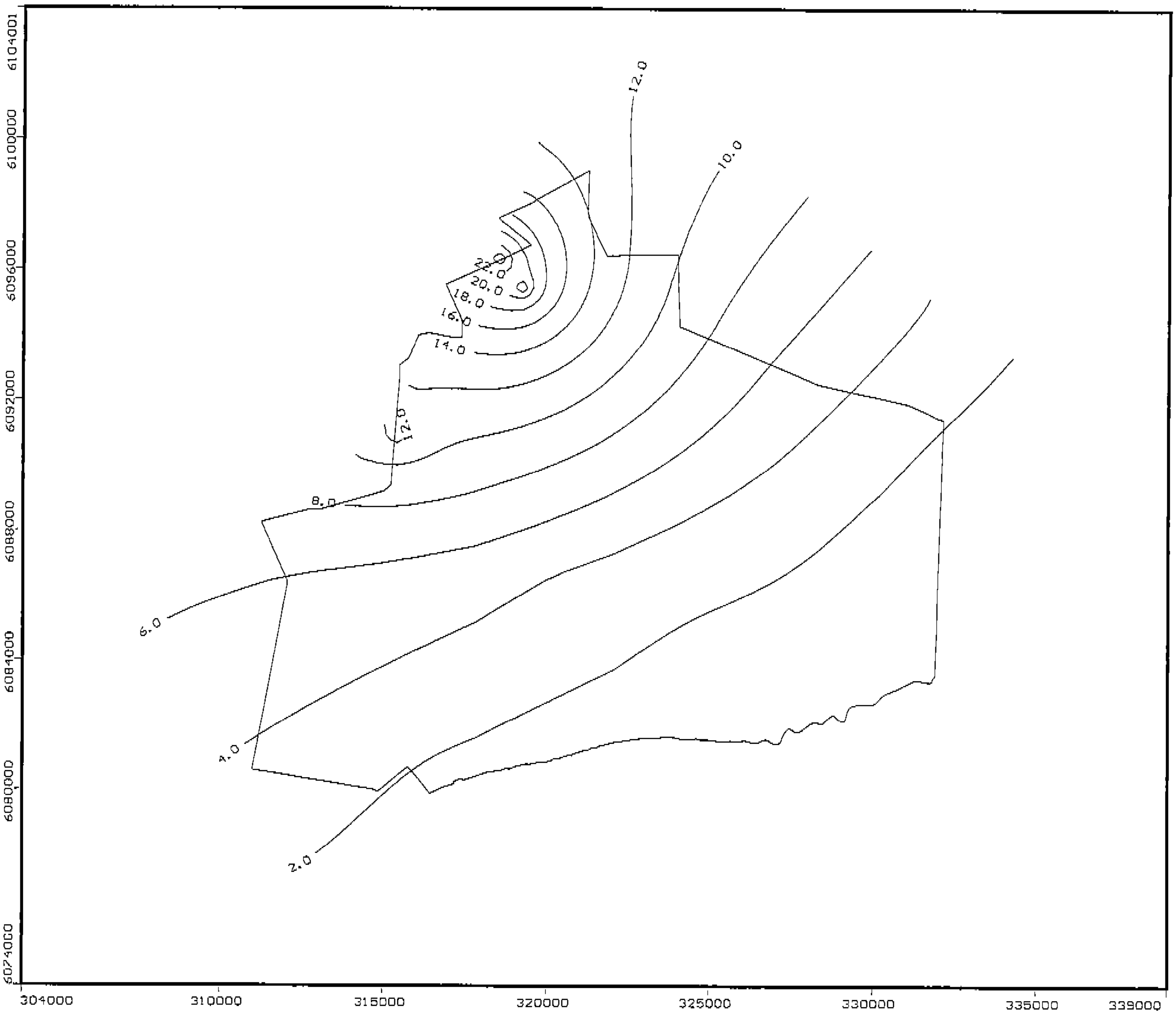
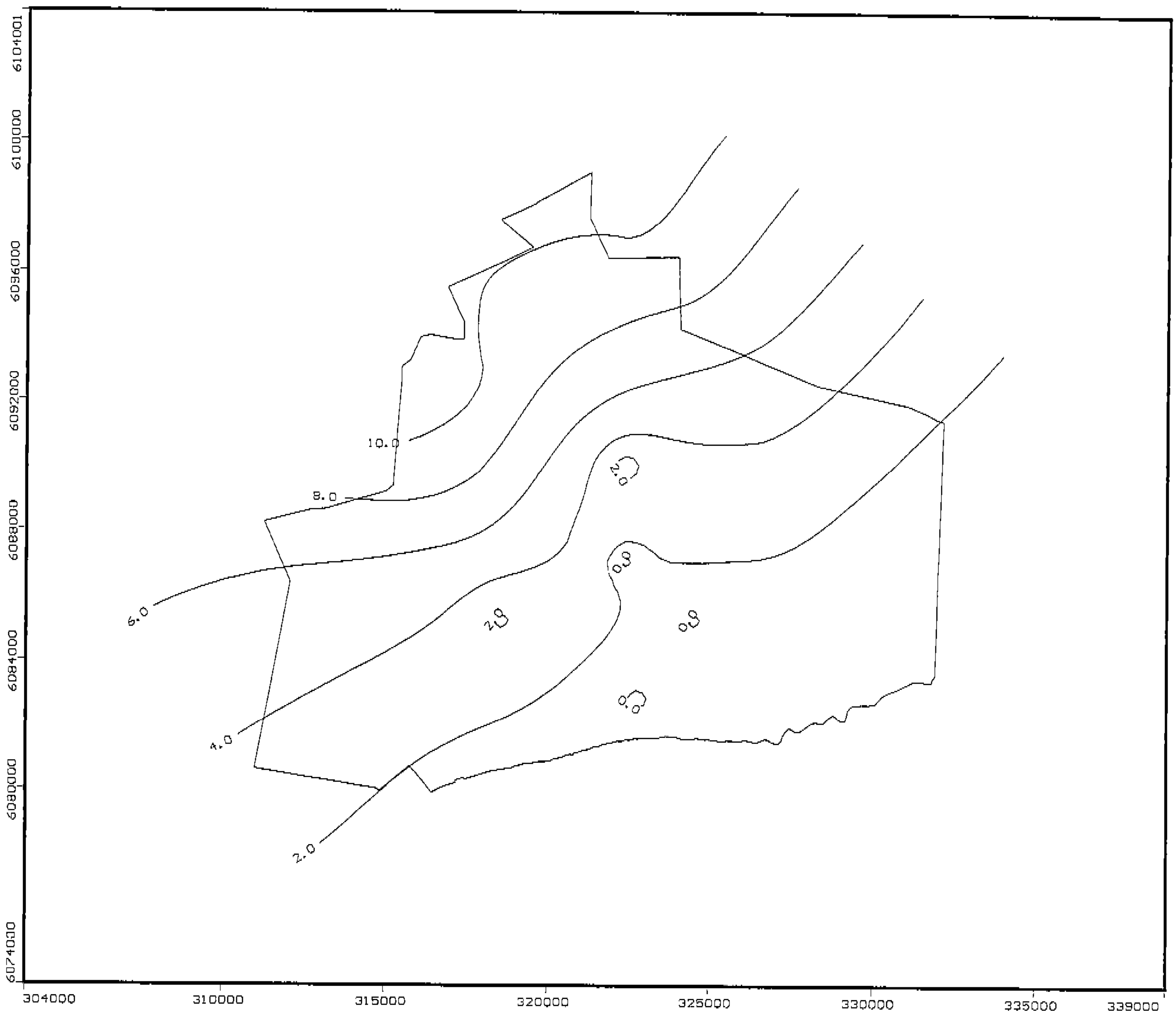
Visual MODFLOW v.2.60, (C) 1995–1997
Waterloo Hydrogeologic Software
NC: 100 NR: 100 NL: 3
Current Layer: 3

Figure 70:
Confined aquifer model head distribution scenario-5 stress period-6



Dept. of Mines & Energy – Australia Project: ANGAS–BREMER RISKS Description: T: TRNS STRESS PERIOD–6 Modeller: S R HOWLES 23 Nov 98	Visual MODFLOW v.2.60, (C) 1995–1997 Waterloo Hydrogeologic Software NC: 100 NR: 100 NL: 3 Current Layer: 3

Figure 71:
Confined aquifer model head distribution scenario-5 stress period-39



Dept. of Mines & Energy – Australia
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Modeller: S R HOWLES
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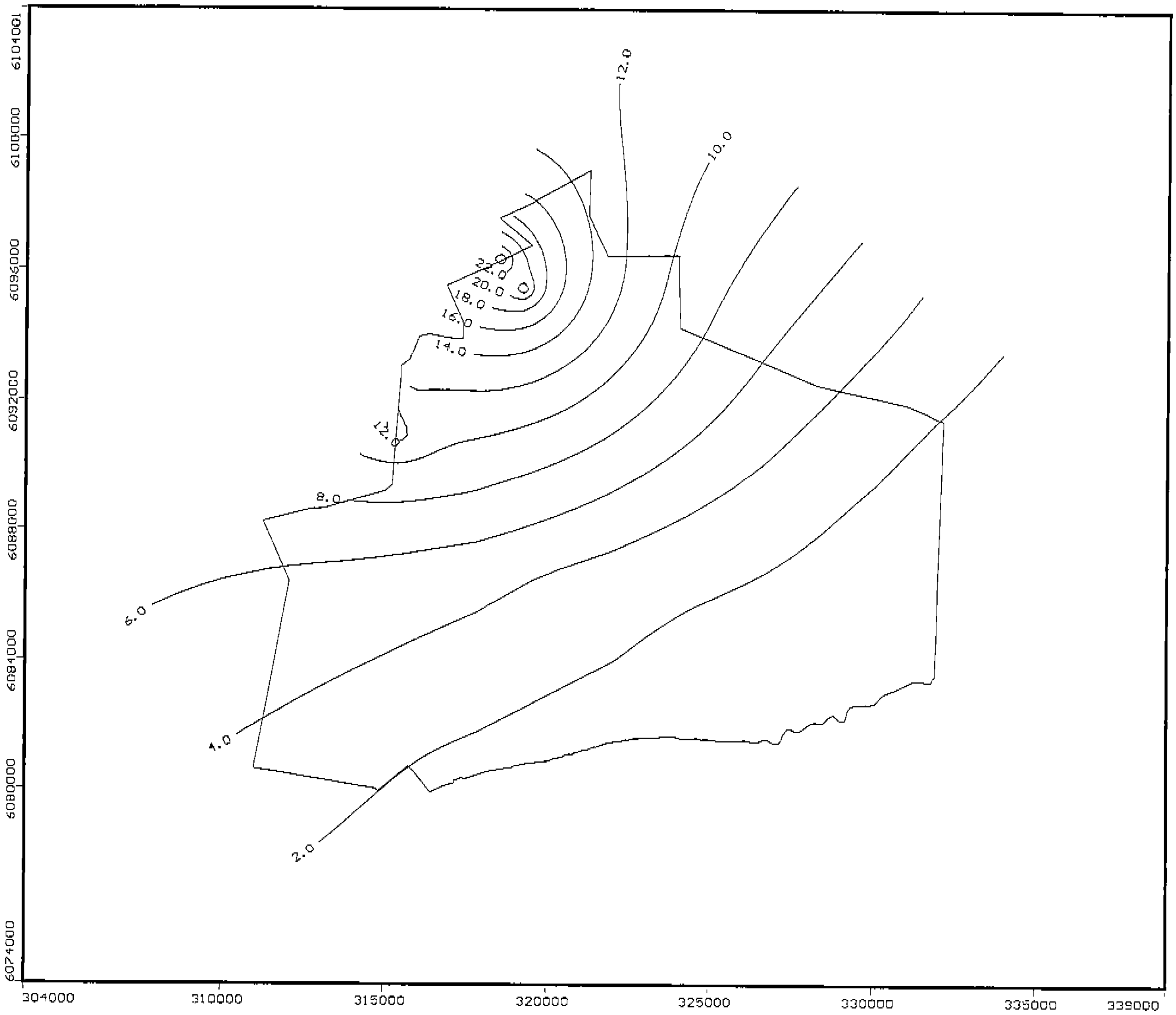
Visual MODFLOW v.2.60, (C) 1995–1997
Waterloo Hydrogeologic Software
NC: 100 NR: 100 NL: 3
Current Layer: 3

Figure 72:
Confined aquifer model head distribution scenario-5 stress period-40



Dept. of Mines & Energy – Australia Project: ANGAS–BREMER RISKS Description: T: TRNS STRESS PERIOD–40 Modeller: S R HOWLES 23 Nov 98	Visual MODFLOW v.2.60, (C) 1995–1997 Waterloo Hydrogeologic Software NC: 100 NR: 100 NL: 3 Current Layer: 3