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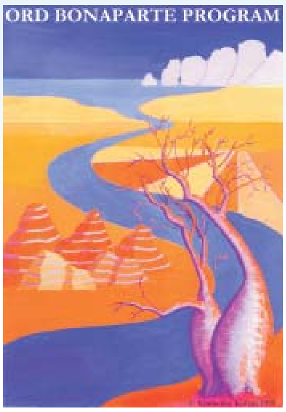

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CSIRO LAND and WATER

PRELIMINARY APPRAISAL OF SALINITY DEVELOPMENT IN THE PACKSADDLE CREEK AREA

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ABSTRACT

Factors contributing to the development of secondary salinity in the Packsaddle Plain include:

- shallow groundwater levels;
- sluggish groundwater gradients in the western part of Packsaddle Plain, east of Packsaddle Creek; and
- waterlogging and continuous evaporation from surface water discharged from the drains and saline groundwater discharged to the surface in the area.

Areas where water levels are less than 2 m from the soil surface are likely to become saline if drainage in this area is not improved to remove the excess water.

HYDROLOGICAL ZONES IN PACKSADDLE PLAIN

The construction of Kununurra Diversion Dam and the filling of Lake Kununurra created a backwater effect in Packsaddle Plain. The rising water levels in the lake caused similar rises in groundwater levels in the north and west of Packsaddle Plain. The hydrological boundary formed by Packsaddle Creek in the west and the backwater effects of Lake Kununurra created a semi-closed basin (Packsaddle Basin). The basin is divided into two hydrological zones: (a) Lake Kununurra Zone (H) between the lake in the east and north and the irrigation channels Sp and Sp1 in the central part of the Plain; and (b) Packsaddle Creek Zone (I) west of the irrigation channels and east of Packsaddle Creek (Salama *et al*., 2002a) (Figure 1).

RISE IN GROUNDWATER LEVELS IN HYDROLOGICAL ZONES H AND I

Influence of Lake Kununurra

Groundwater in Packsaddle Plain is controlled by the water levels in Lake Kununurra and leakage of lake water into the surrounding aquifer system. In effect, these areas have become sub-surface extensions of the Lake.

Following the formation of Lake Kununurra in 1963, groundwater levels in some bores (P2, P13, P14, P18 and P20) rose almost to the water level in the lake. Lateral groundwater movement was the primary cause of rising groundwater levels in the area immediately adjacent to Lake Kununurra, while it took longer for water levels at distant locations from the lake to rise (Salama *et al*., 2002a; O'Boy *et al*., 2001).

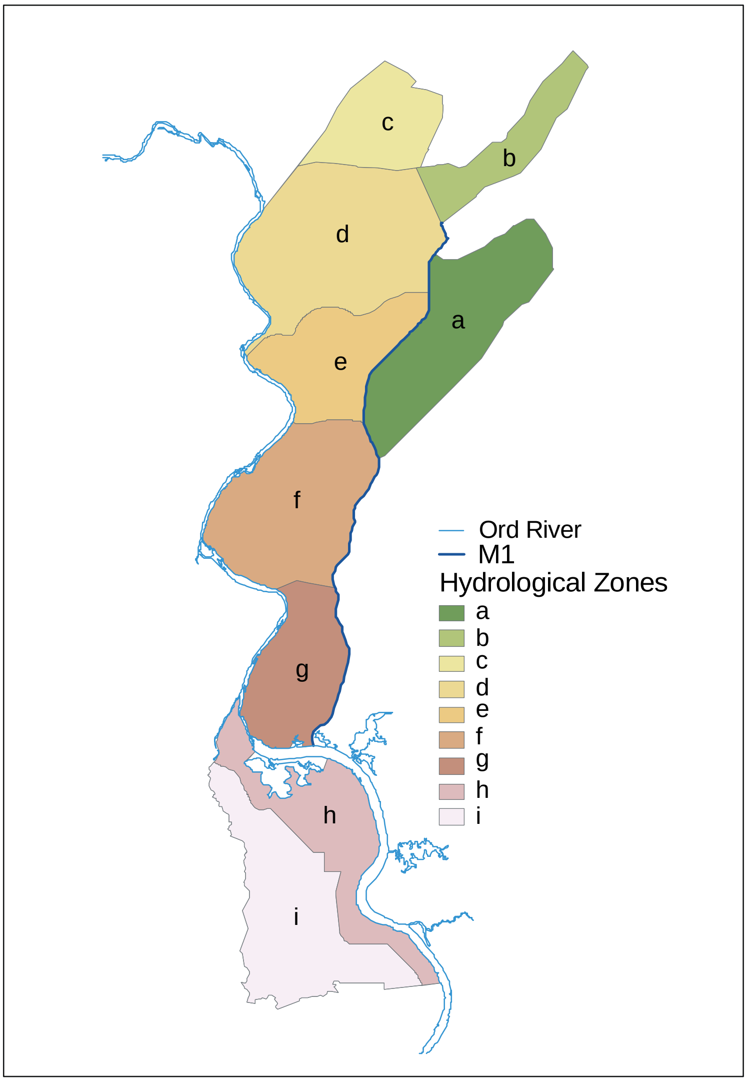


Figure 1: Hydrological Zones of the Ord

The rise in groundwater level following the formation of Lake Kununurra in the southern Packsaddle area (i.e. bores PS5, P7, P8, PS1, P9 and P10) was approximately 2-3 m lower than in areas of maximum water level rise.

In the northwest area of Packsaddle Plain east of Packsaddle Creek (bores PS1/78, PS2/78, P12 and P17), groundwater rise in response to the formation of Lake Kununurra was approximately the same as in areas of maximum water level rise. Groundwater accession in this area is likely to have been controlled by groundwater discharge into lowlands adjacent to Packsaddle Creek.

Hydrographs of bores P7, PS1, PS5, P17, P18 and P20, in the central and southern parts of Packsaddle Plain, indicate a more rapid rise in groundwater from around 1995 onwards. A similar but subdued trend in groundwater rise in the northwestern Packsaddle area is indicated by the hydrographs for bores P2, P12, PS1/78 and PS2/78. It is notable that the groundwater level in some bores (P2, P7, P13, P14 and P18) has risen up to 2 m above the lake level, suggesting that current groundwater rises are the result of increased groundwater recharge from applied irrigation water and leakage from supply channels and drains. This is consistent with the fact that the lake water is pumped to an elevation above lake level to supply the irrigation system in Packsaddle Plain. The direction of groundwater flow in the northern parts of Packsaddle Plain is now from the irrigation area back towards Lake Kununurra.

Historical Groundwater Levels

Historical groundwater level trends show that in the late seventies the rise in groundwater levels was progressing southward from the diversion dam and filling Packsaddle basin with the highest water level near the dam at 40 m AHD. In the early eighties, the gradients were mainly from Lake Kununnura towards Packsaddle Creek (O'Boy *et al*., 2001; Yesertener, 1997). The highest water level at that time was 42 m in the eastern side of Packsaddle Plain. In 2000, the groundwater level in the central area of Packsaddle was 44 m AHD and 42 m AHD near Packsaddle Creek. This shows that the water levels rose by about 8 m in this area with reversal of gradients towards Packsaddle Creek (Figure 2).

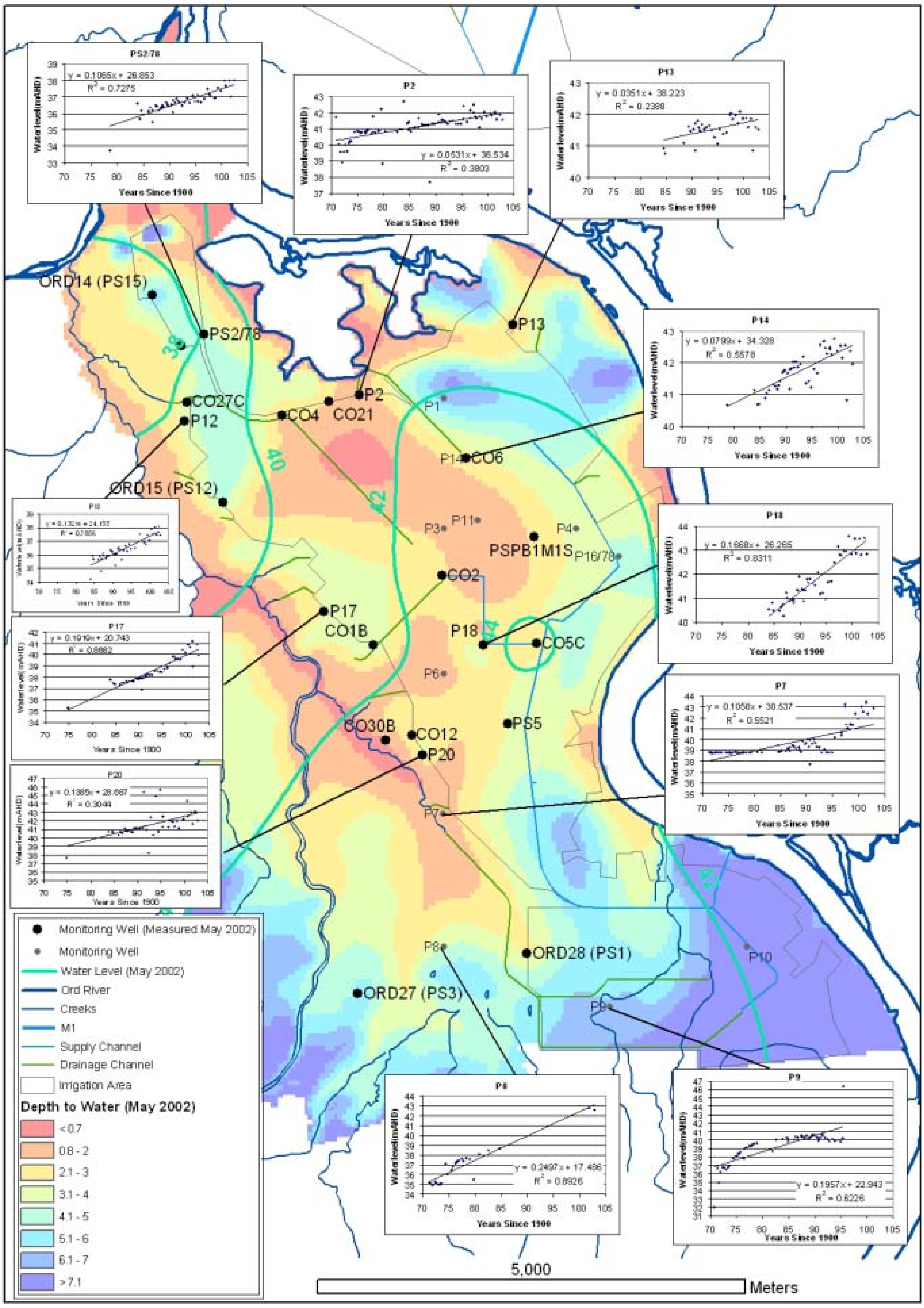


Figure 2: Water level trends and direction of groundwater flow in Packsaddle area showing the mound in the central area and groundwater discharge towards Packsaddle Creek area

The bores in Zone H in Packsaddle Plain (P2, P11, P13 and P14) are located mainly within the meander of the Ord River, with the exception of P7 located farther to the south (Figure 3). These bores had stable water levels from 1975 to 1985 and rates of water level rise of 0.16 – 0.2 m/yr from 1985 to 1995. In contrast, the bores in Zone I located farther to the south and closer to Packsaddle Creek had greater rates of water level rise (Figures 4(a) and (b)). In particular, bores P6, P8, P9 and P10 had an average water level rise rate of 0.72 m/yr from 1973 to 1975. The average water level rise from 1995 to 2000 for the bores located in the southern part of Zone I was 0.36 m/yr, which is twice the average water level rise for bores in the northern part of Zone I near Packsaddle Creek.

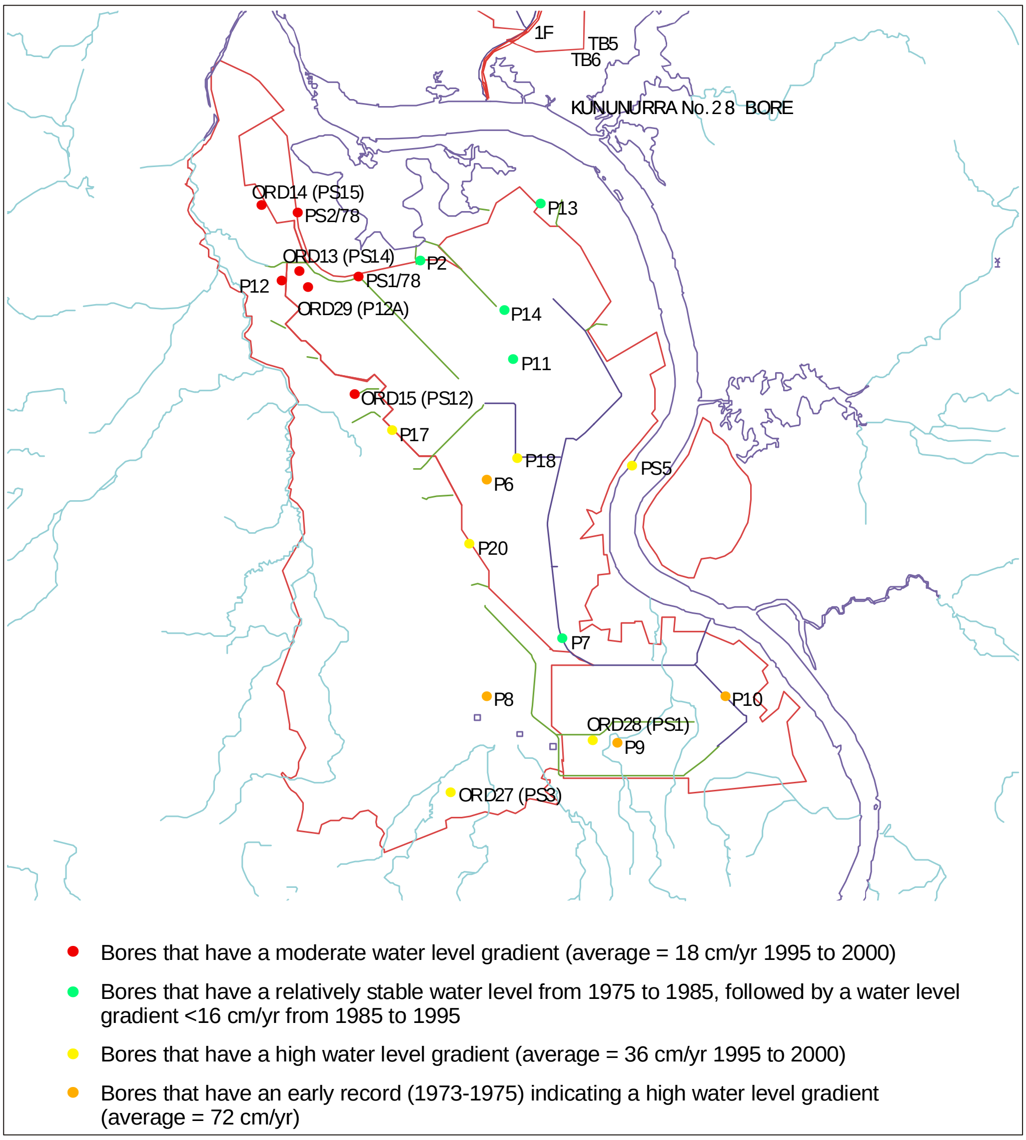
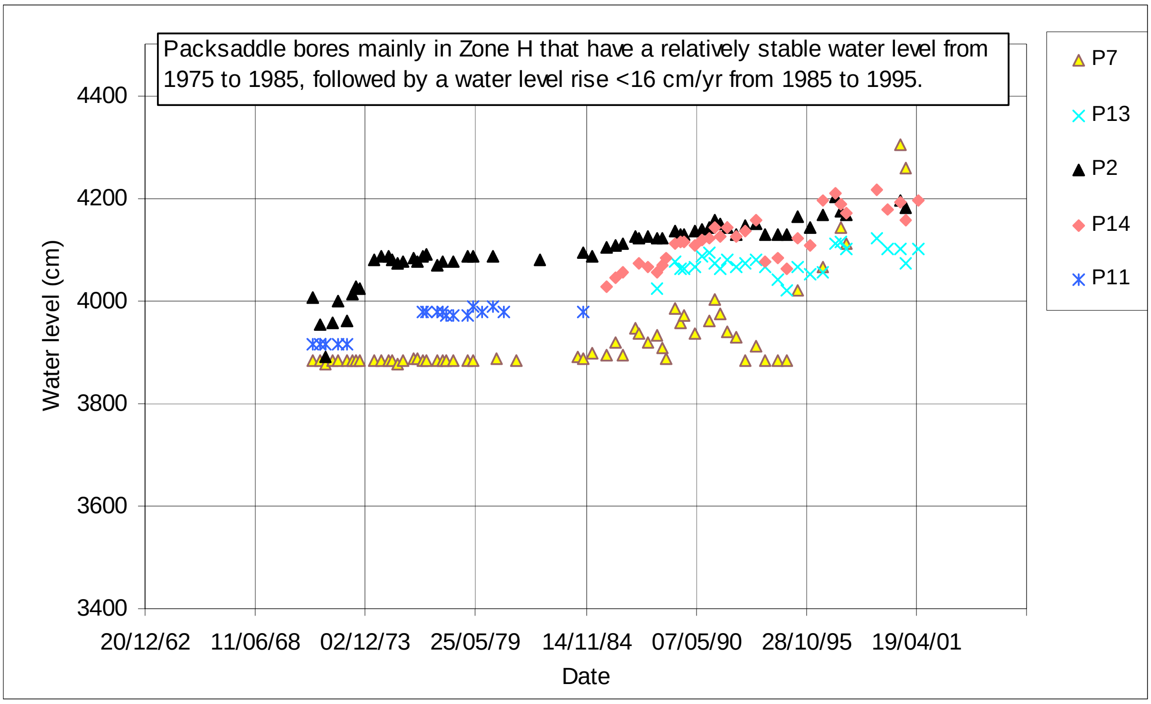
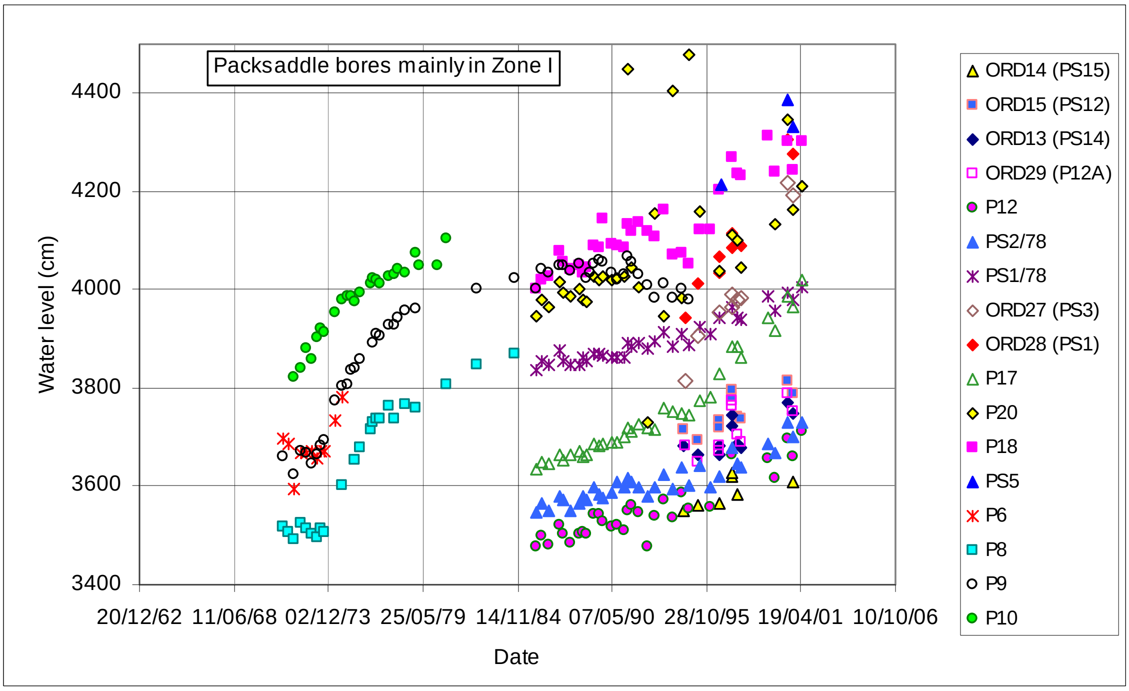


Figure 3: Location of bores in the Packsaddle Plain irrigation area categorised by their hydrograph characteristics

(a)



(b)



Figures 4(a) and (b): Hydrographs for bores in the Packsaddle Plain (Zones H and I). The rise in water level is consistently higher for the bores in Zone I from 1970 to 2000.

WATER QUALITY AND SALINITY IN PACKSADDLE PLAIN

Construction of the Diversion Dam restricted the northerly flow of groundwater. Water samples upstream of the dam (CO21 and CO4) show some mixing with surface water, but less than the expected proportion; this may be due to trapping of the original groundwater behind the dam. Water samples from upstream of the irrigation area (ORD27 and ORD28) show more mixing with surface water than water sampled from the central irrigation area. The isotopic data in the central area of Packsaddle show that seepage is slower than in other areas. This is mainly due to the presence of a thick mudstone layer that extends to about 10 m below the surface and hinders vertical infiltration. The mixing pattern is rather complicated and controlled by the lithology and gradients away from seepage zones. (Salama et al., 2002b).

Surface water is mainly Ca, Mg, HCO_3 type, while groundwater in the area is mainly saline (Na, Cl) with high total dissolved salts. Groundwater near the supply channels and drains has lower soluble salts than farther away, mainly due to dilution by mixing with fresh water that seeps from irrigation structures.

The salinity of the shallow groundwater varies significantly throughout the whole Ord Irrigation Area (Figure 5). The electrical conductivity (EC) of the shallow groundwater ranges between 1,000 and 21,600 μS/cm. The water is of low salinity risk if the EC is less than 250 μS/cm. It has medium salinity risk if the EC is between 250 and 750 μS/cm). Therefore, almost all of the shallow groundwater in the Ord Irrigation area is unsuitable for irrigation. In the central part of the Packsaddle Plain the shallow groundwater salinity (EC) is very high (>9,000 μS/cm). The high salinity zone extends to the western area at the junction of the tributaries of Packsaddle Creek. Since the shallow groundwater is relatively saline, it may pose a serious threat to agriculture if it rises closer to the soil surface (Ali and Salama, 2003).

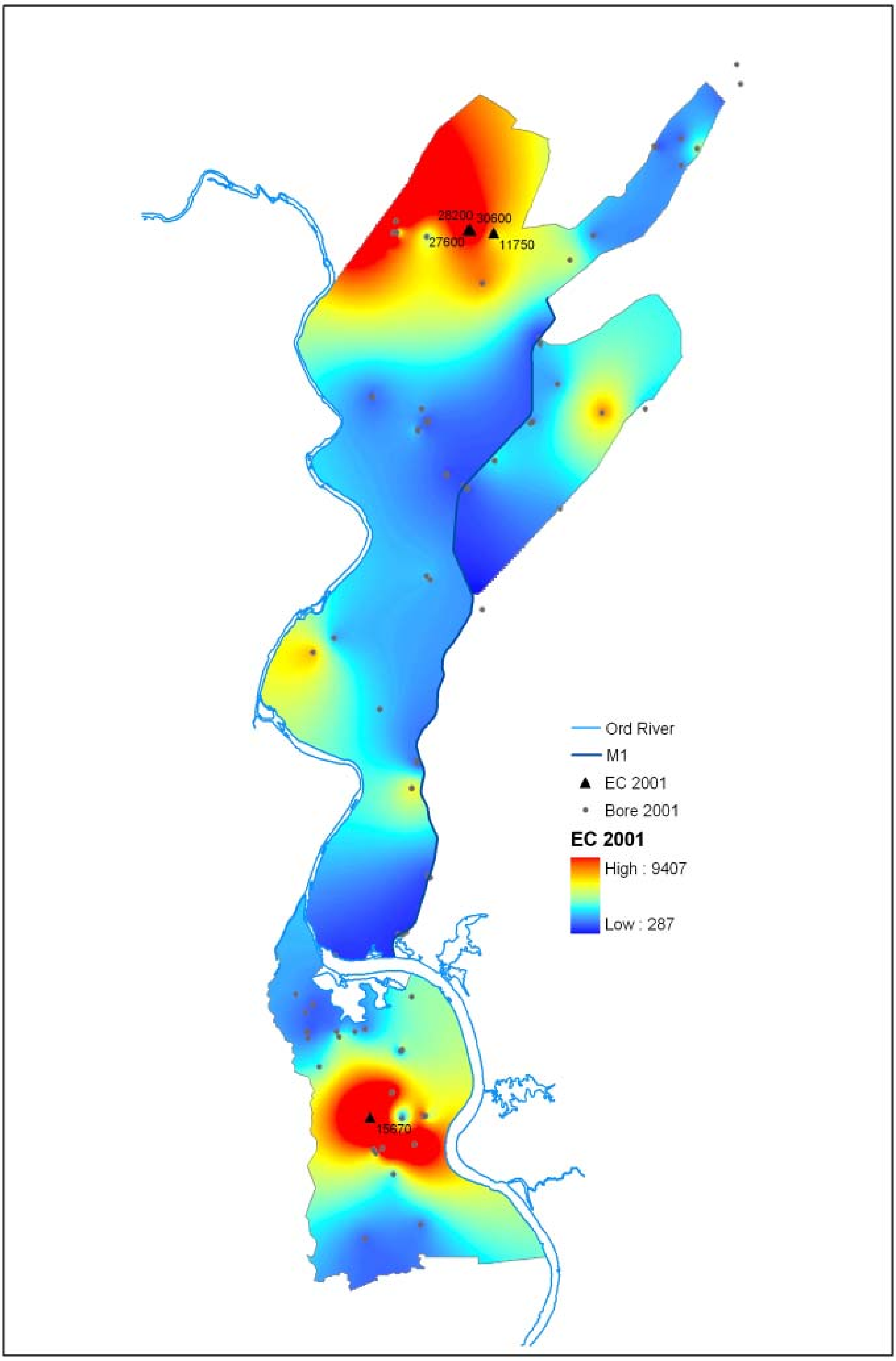


Figure 5: Shallow water table salinity in the Ord irrigation area in 2001

Development of salinity

Analysis and groundwater modelling (Ali and Salama, 2003) showed that the critical water table depth, where the risk of soil salinisation is minimal, is 2.0 m from the soil surface. Similarly, the risk of soil sodicity (sodium rich soils) was shown to be unlikely if the depth to water table was more than 1.5 m from the soil surface. If the water table is at a depth of 1.0 m from the soil surface for a substantial period, it is likely to cause severe soil salinity, especially in the shallow layers of the soil profile. Depth to water in 2001 was 1-3 m in Zone H and 3-5 m in Zone I as compared to 4-9 m in Zone H and 7-10 m in Zone I in the late eighties. Most of the drains in the area discharge into the eastern Packsaddle tributary before it reaches Packsaddle Creek, causing a backwater effect and helping raise the groundwater to near the surface. This is beside the presence of thick clays and mudstones of very low permeability in the western area which acts as a barrier for groundwater flowing towards Packsaddle Creek and causes groundwater discharge. Due to these factors, depth to groundwater in the area around the eastern tributary connected to Packsaddle Creek is less than 0.7 m from the soil surface, while larger areas surrounding that are less than 2 m (Figure 6).

It is estimated that there are about 20-25 ha affected by salinity west of the irrigation area and the affected area has increased several fold in the last 3-5 years. Aerial photography from the 1980s indicates some apparent salinity in the area, while more recent aerial photography in 1999 (Figure 6) shows a much wider spread of affected areas.

Results from recent studies indicate that the shallow groundwater levels and the sluggish groundwater gradients in the western part of Packsaddle Plain east of Packsaddle Creek, and the continuous evaporation from the surface water discharged from the drains and saline groundwater discharged to the surface in the area, are all contributing towards the development of secondary salinity. Areas with groundwater water levels less than 2 m from the soil surface are likely to become saline if the drainage in this area is not improved to remove all the excess water.

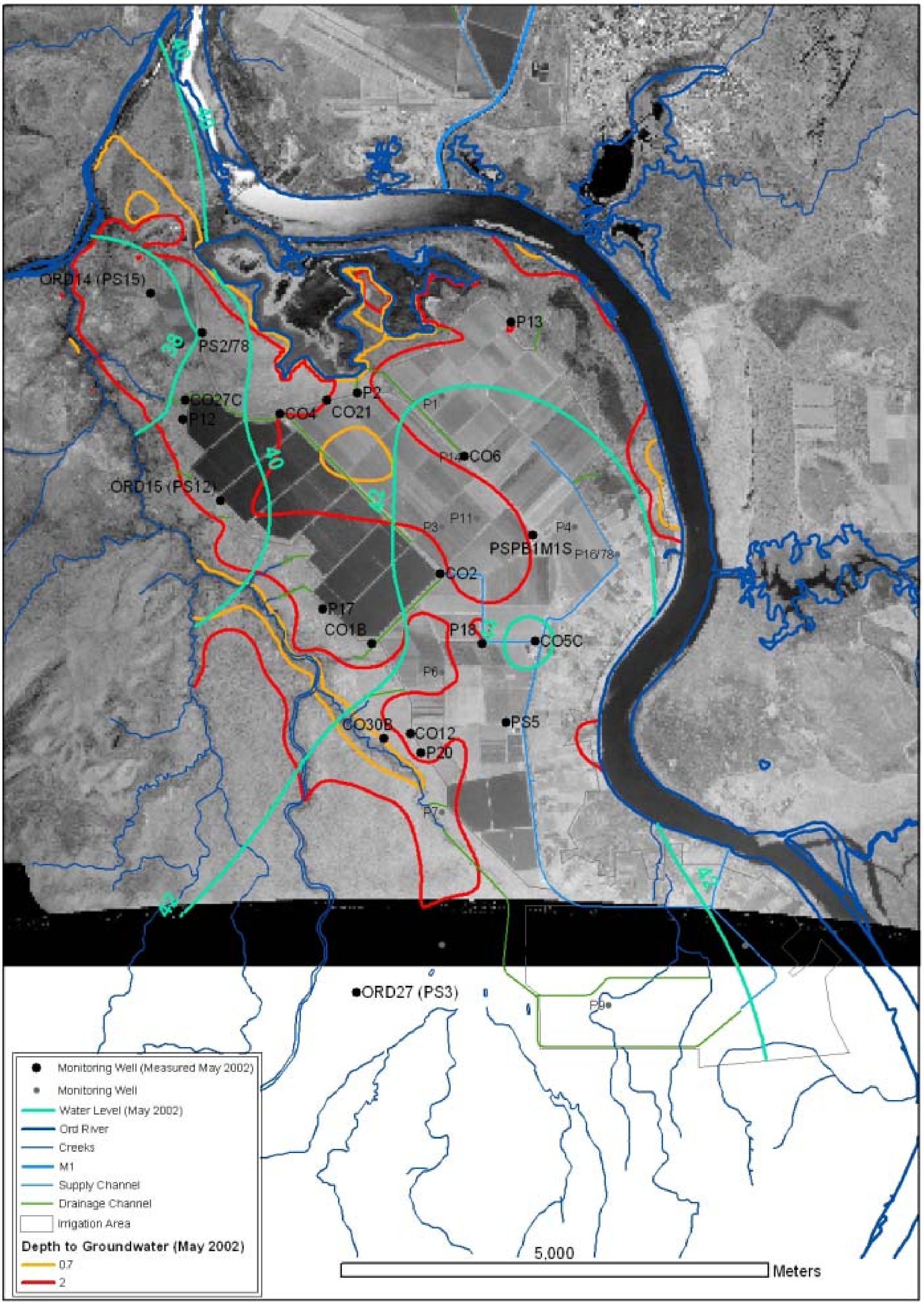


Figure 6: Water level and depth to water map showing the shallow depth to water in the area around Packsaddle Creek and in the central area of Packsaddle Plain. All areas with groundwater levels lower than 2 m are likely to develop salinity if accumulating salts are not frequently leached

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