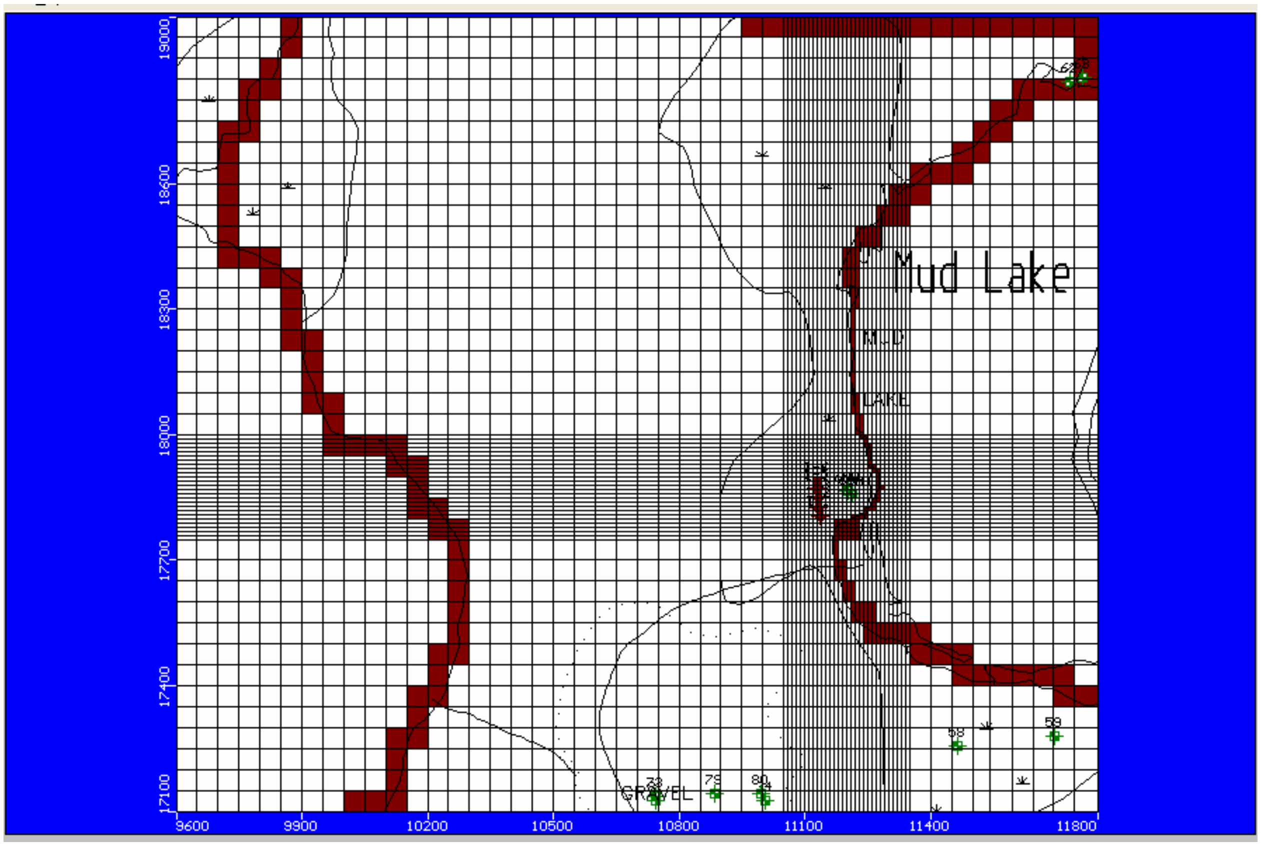
South Bay Injection Test (Preliminary Modelling Results)

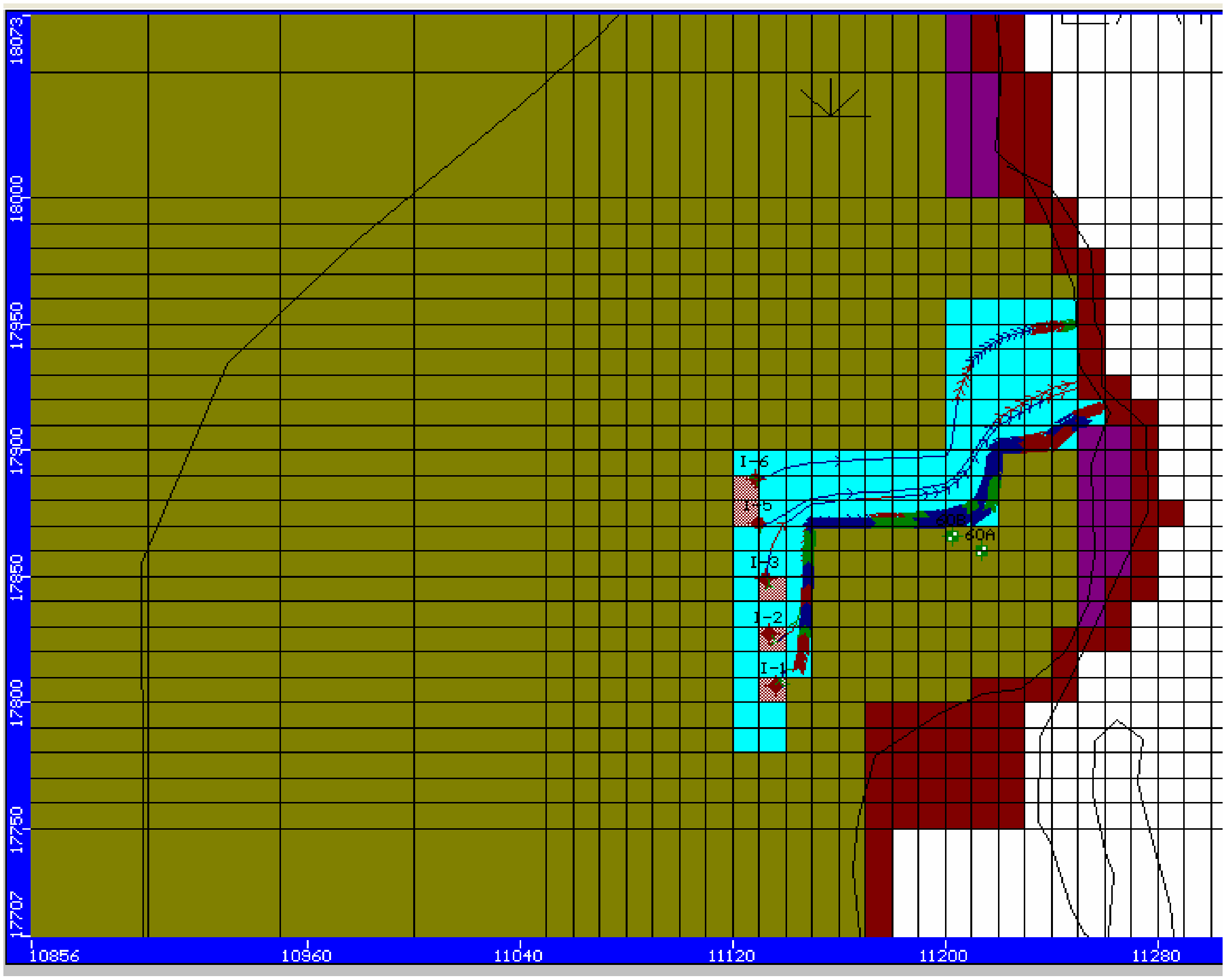
The South Bay Groundwater Flow Model was refined in the area of the injection test using a 10 ft x 10 ft grid, as shown below.



The six injection wells were modelled assuming a flow of 5 m^3/day for I1, I2, I3, I5, and I6 and 2.5 m^3 for I4. They were assumed to inject water at that rate for a period of 20 days. The model was used to simulate transient flow conditions by assuming a period of 1000 days with no injection in order to establish equilibrium conditions prior to injection. Then the 20 day injection period was modelled followed by another 180 days after injection was ceased. The top of the clay layer was adjusted in the modelled region based on rod measurements performed during 2001 and 2002. In addition, the 2002 results of measurements of electrical conductivity with the rods were used to determine the preferred transport path to Mud Lake.

A constant concentration of 1000 mg/L was modelled at the location of the six injection wells during the 20 day injection period. It was assumed to be zero prior to the injection and return to zero afterward.

The motion of particles released from the injection wells at the commencement of the injection is shown on the following figure. This shows the preferential path in blue. The marks on the pathlines represent the distance travelled with the groundwater in 10 days. It can be seen that the general groundwater flow is about 2/3 of the way to Mud Lake from I5 and I6 within 20 days.



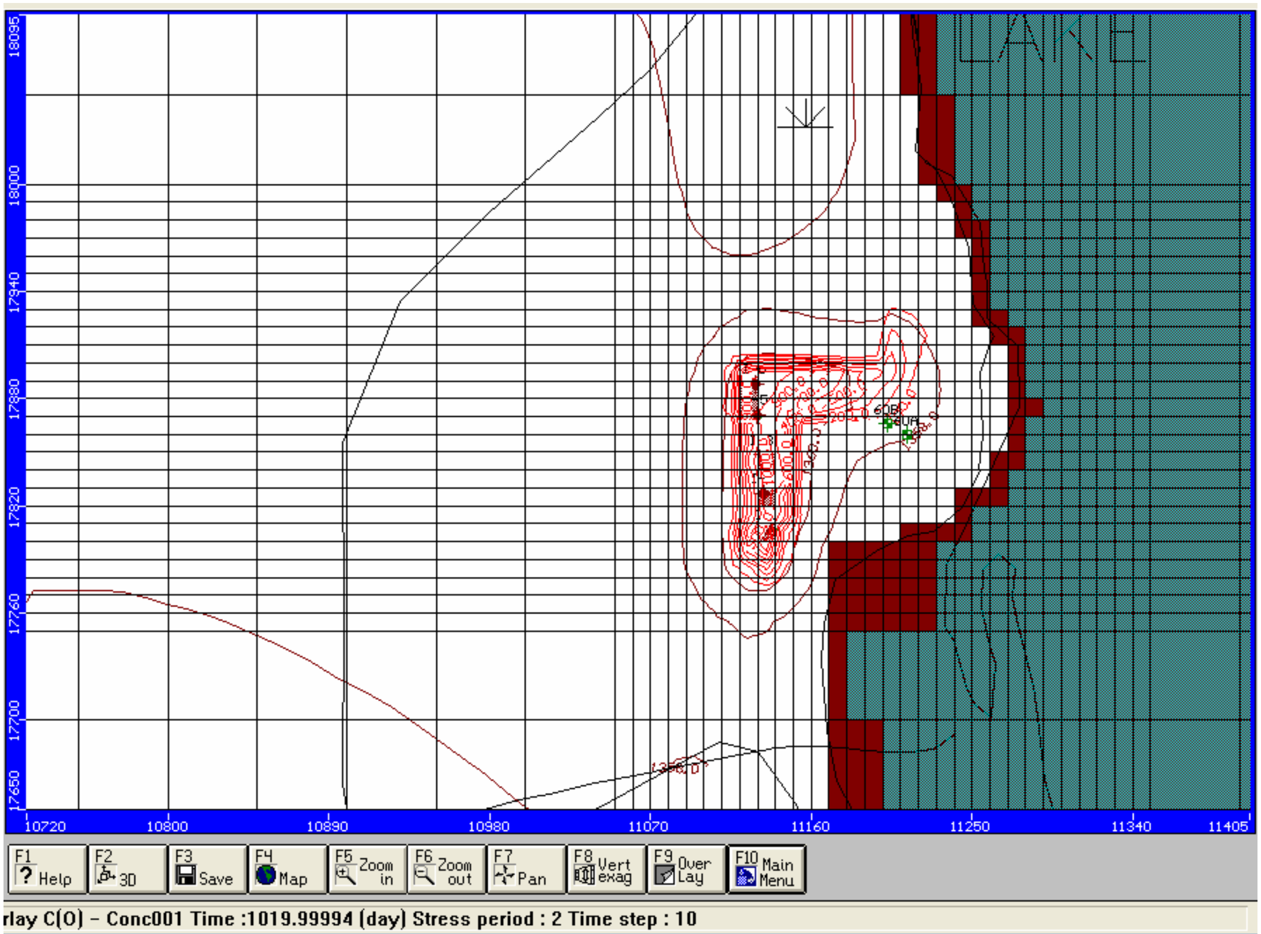
The flow of groundwater along the preferred path is calculated using the Zone Budget routine of Visual Modflow. The blue area above represents the Zone established along the preferential path. All the flow occurs within the upper layer of the model. The underlying layer is a tight clay maintaining artesian conditions in the sand/gravel layer underneath. Well 60A, screened in the sand/gravel layer is the source of the injection water.

The flows in the blue zone are shown in the Table below.

Time period	Input (m^3/day)			Output (m^3/day)	
	Surrounding Zone	Clay Zone below	Injection Wells	Mud Lake	Surrounding Zone
Just Before Injection	0.4	0.007	-	0.4	0
During Injection	0.07	0	27.5	19.1	6.4
One year after Injection	0.25	0.005	-	0.3	0

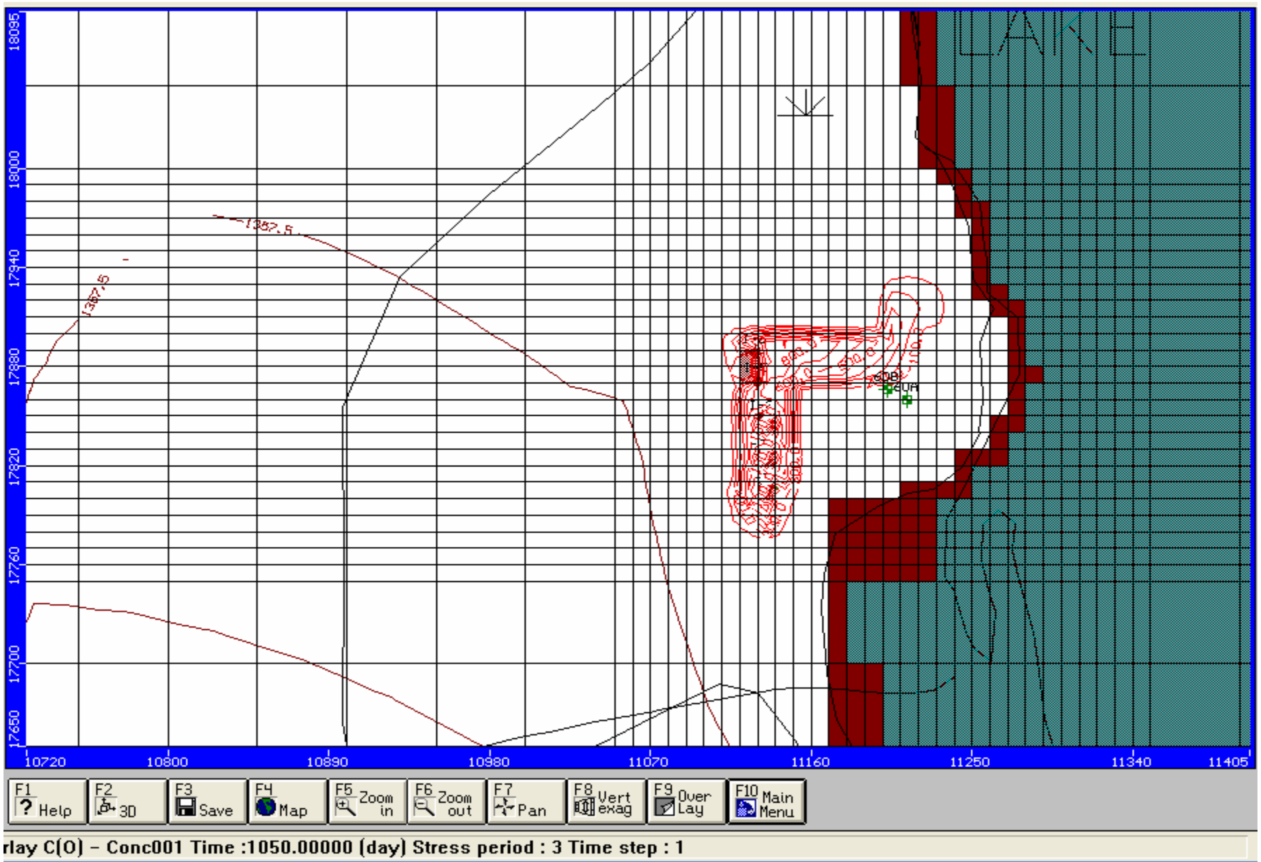
The results in the Table indicate that there is very little flow through the region under normal conditions; however, during injection, the flow through the system increases almost 70 times. This large change in flow is probably what is responsible for the creation of the preferential path.

The following figures show the head equipotentials and the concentrations of the injected materials at the end of the injection (1020 days), 50 days after the start of injection (1050 days), and 200 days after the start of injection (1200 days).



The concentration contours are in 100 mg/L intervals, thus the furthest distance of travel of 0.1 of the initial concentration is shown. It can be seen that this contour has reached to within 10 m of mud Lake within the 20 day pumping test. The equipotential at the injection wells is slightly over 1360 ft, slightly higher than the 1359 head actually present. This indicates that the hydraulic conductivity assumed for the preferential path is slight lower than necessary to transmit the water, or that the size of the path is actually larger than assumed. However, the model simulation is considered to provide a reasonable approximation of the flow regime. Again, as has already been stated, the large volume of water injected compared to the capacity of the upper layer to transmit water under normal conditions is probably responsible for creating the high conductivity preferential groundwater flow path.

It can also be seen from the simulations at 1050 days and 1200 days that after injection has ceased, the transport of the chemicals is much slower.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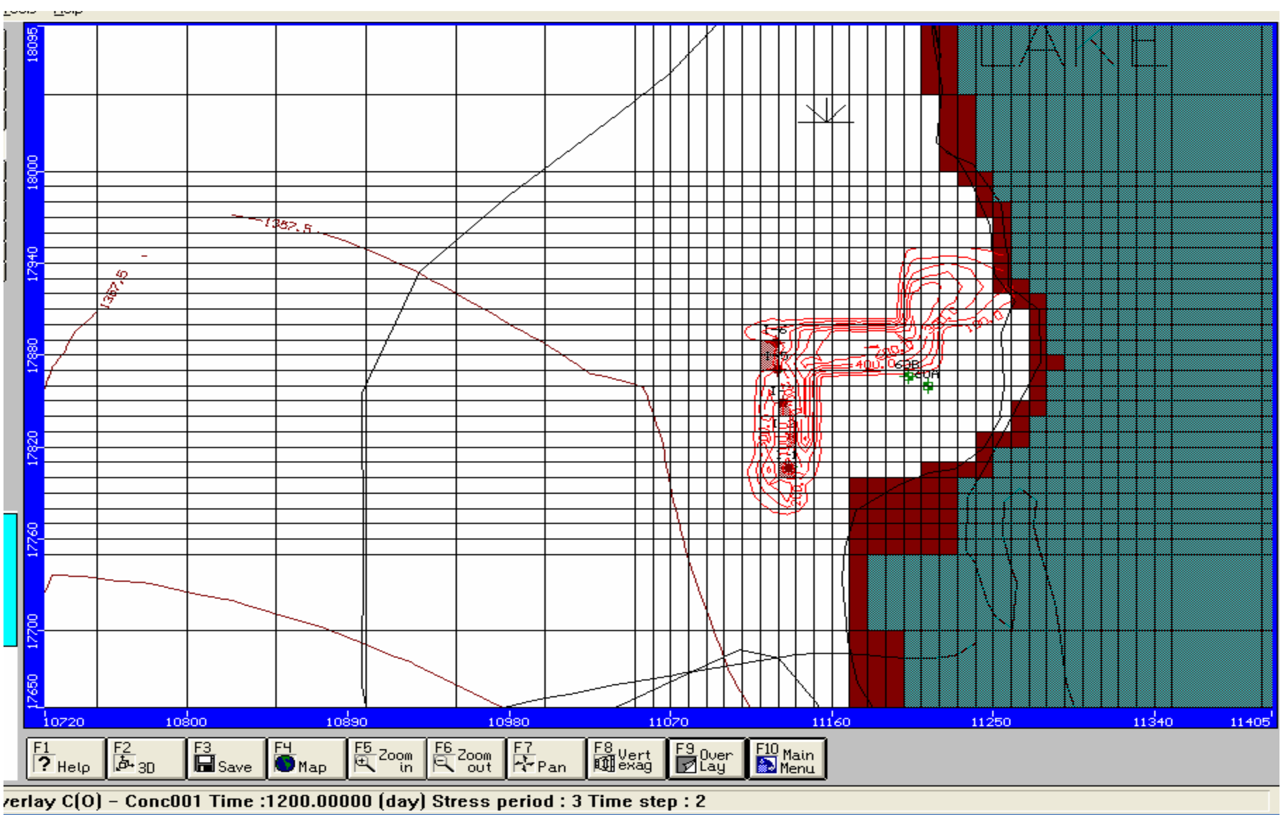
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This modelling exercise has shown that the following groundwater flow characteristics are important considerations in the planning of a larger scale injection wastewater treatment system:

- In the present injection test, the use of 6 injection wells within a relatively small area has resulted in the injection of about 70 times the normal volume of water normally flowing in the groundwater system to Mud Lake.
- This large change in water volume has likely resulted in the creation of a preferential pathway of relatively high hydraulic conductivity and thus shorter than desired transit times for the added chemicals and wastewater.
- Transit times are estimated to be of the order of 20 - 30 days for the 10% concentration contour.

The following adjustments are recommended for a larger scale injection system:

- Injection wells should be spaced at least 50 feet apart and have flows of less than 4 m^3/day (about 10 times the normal flow volume).
- A water balance should be made to determine the volume of water requiring treatment and the size of the area required to provide the necessary delay for the injection treatment system to be effective.