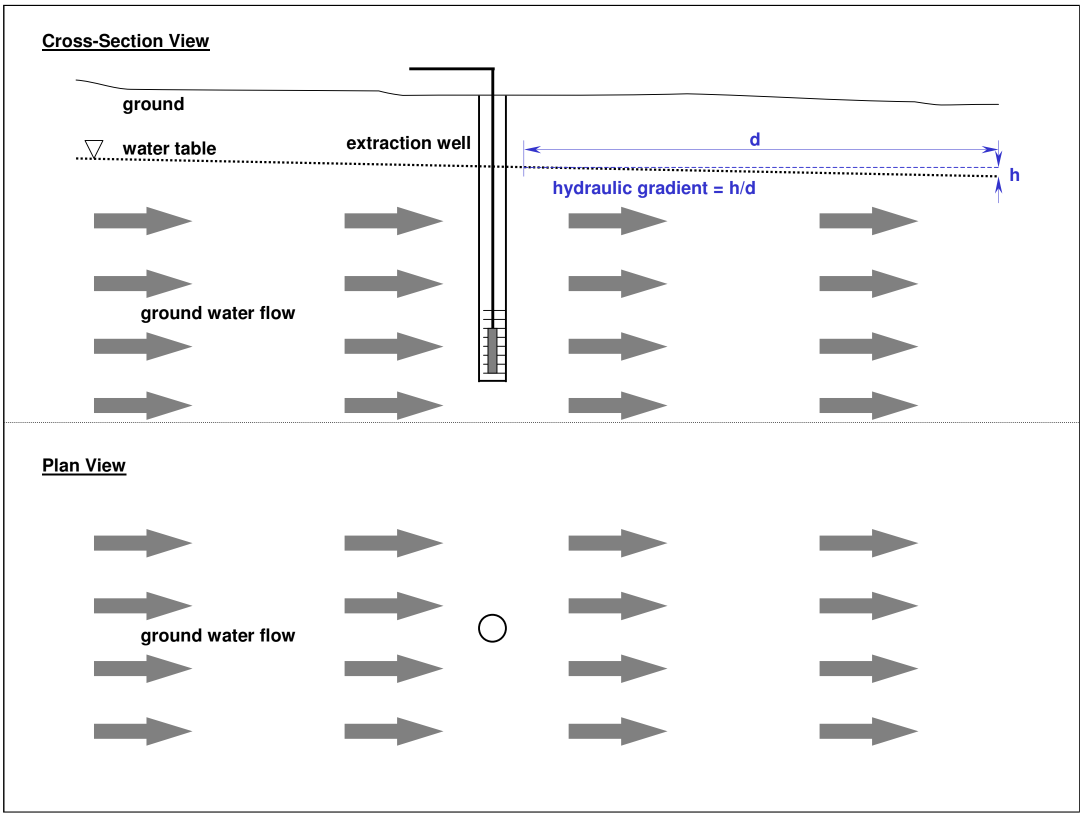


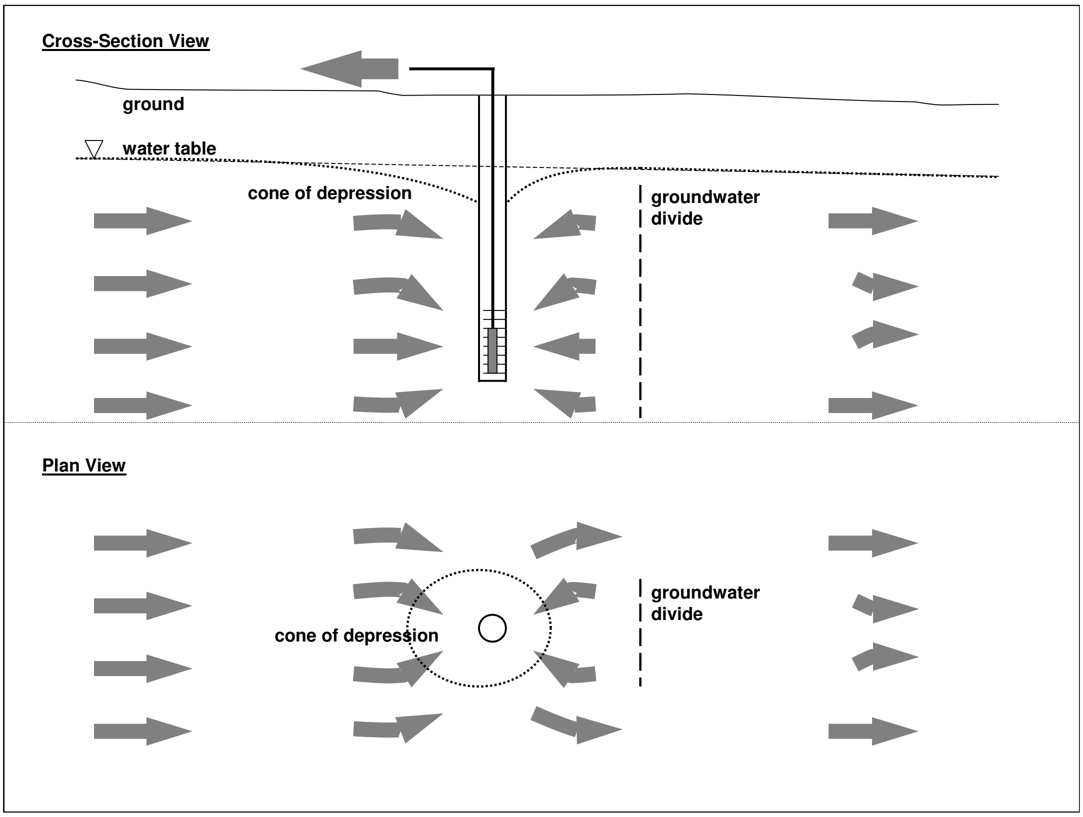
In normal, undisturbed conditions, groundwater flows through porous media in the direction of the *hydraulic gradient*.

The top of this saturated zone of the aquifer is called the *water table*. An aquifer with a water table is called *unconfined*.

Hydraulic gradient is simply measured as the change in water level (often measured relative to sea level) over the distance travelled.

The rate at which groundwater travels is a function of the *hydraulic conductivity*, and the *hydraulic gradient*. The equation is known as *Darcy's law*.

Hydraulic conductivity (K) is a measure of the ability of an aquifer to transmit fluid. A high K value indicates high groundwater flow conditions. K is a function of both the porous medium and the fluid.



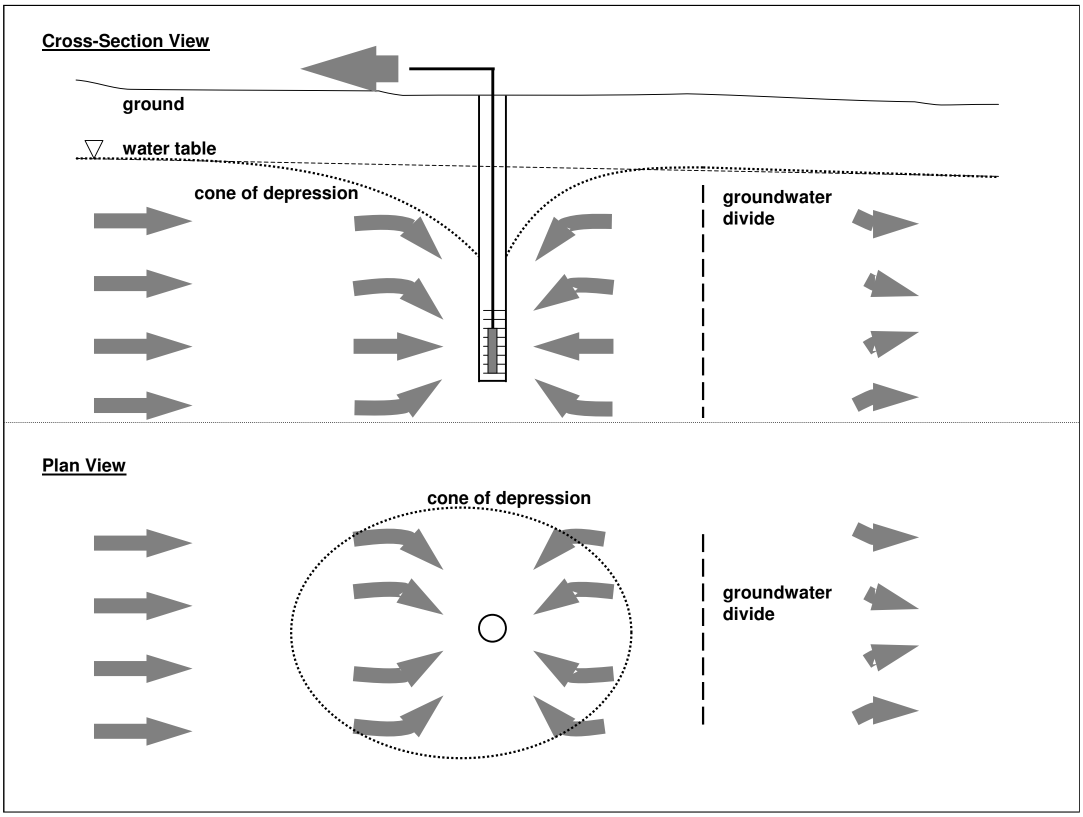
If a groundwater extraction well is activated, the natural gradient of the water is disturbed. Groundwater is drawn towards the extraction well.

At the water table a *cone of depression* is formed, with the deepest point at the well.

The shape of the cone is a function of the *hydraulic conductivity* and the *rate of groundwater extraction*.

(One way to visualise why a cone of depression forms is to imagine digging a hole in the sand at the beach near the water's edge. When you dig down below the water level it takes some time for the water to flow into the hole and equilibrate with the water level. This is due to the hydraulic conductivity of the sea water through the sand.)

At some point downgradient of the extraction well the water table will resume its normal slope. This point is known as the *groundwater divide* – where groundwater is no longer drawn towards the extraction well, but resumes its normal flow along the natural hydraulic gradient.

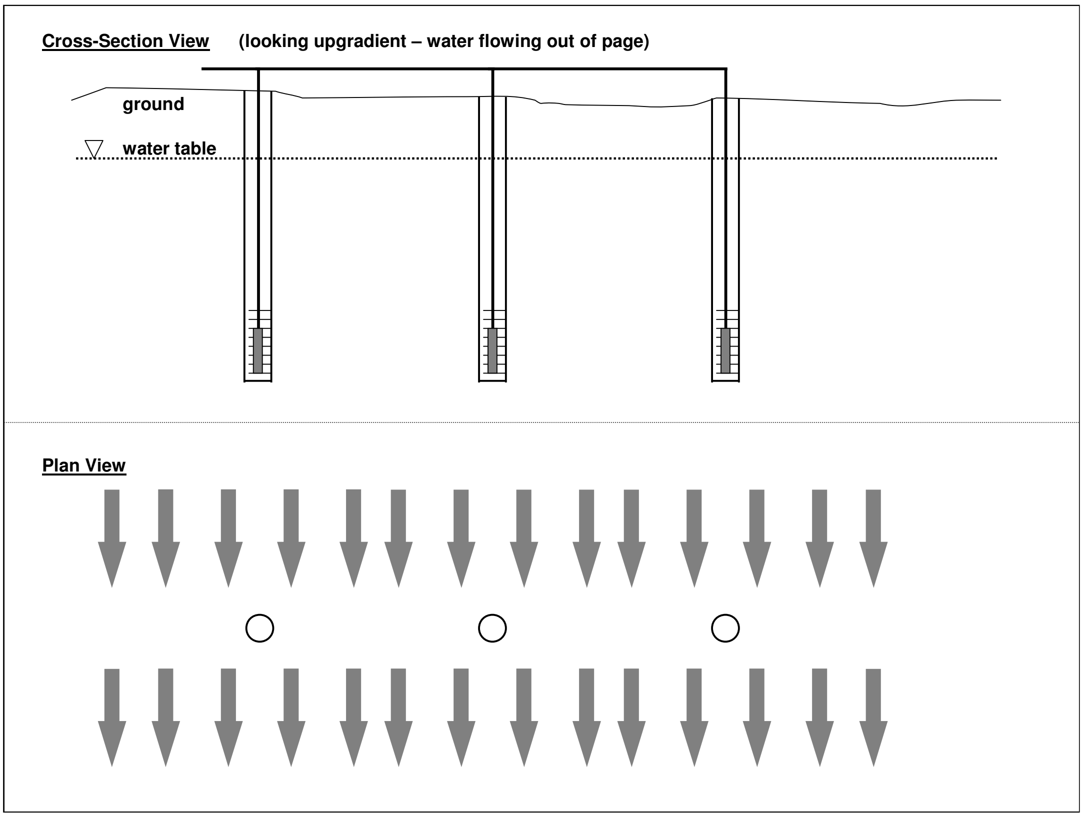


Pumping harder from the extraction well

•Increases the depth of the cone of depression,

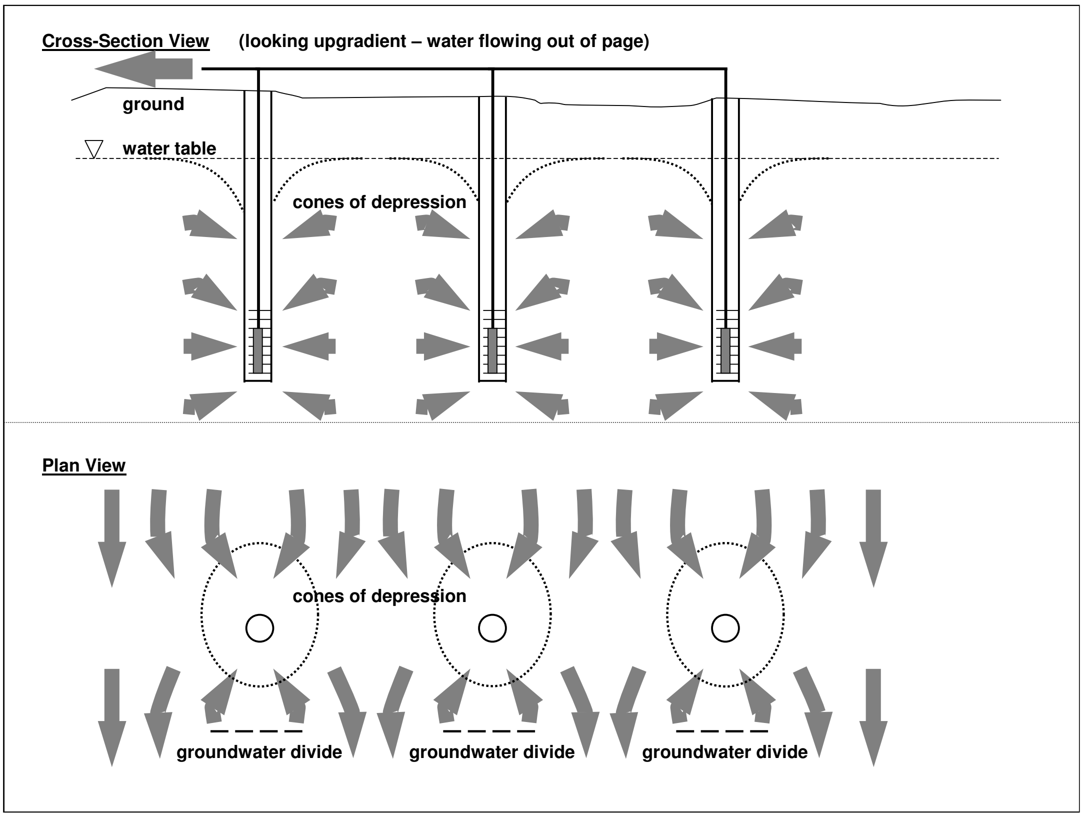
•Broadens the edge of the cone of depression, and

•Moves the groundwater divide further downgradient.

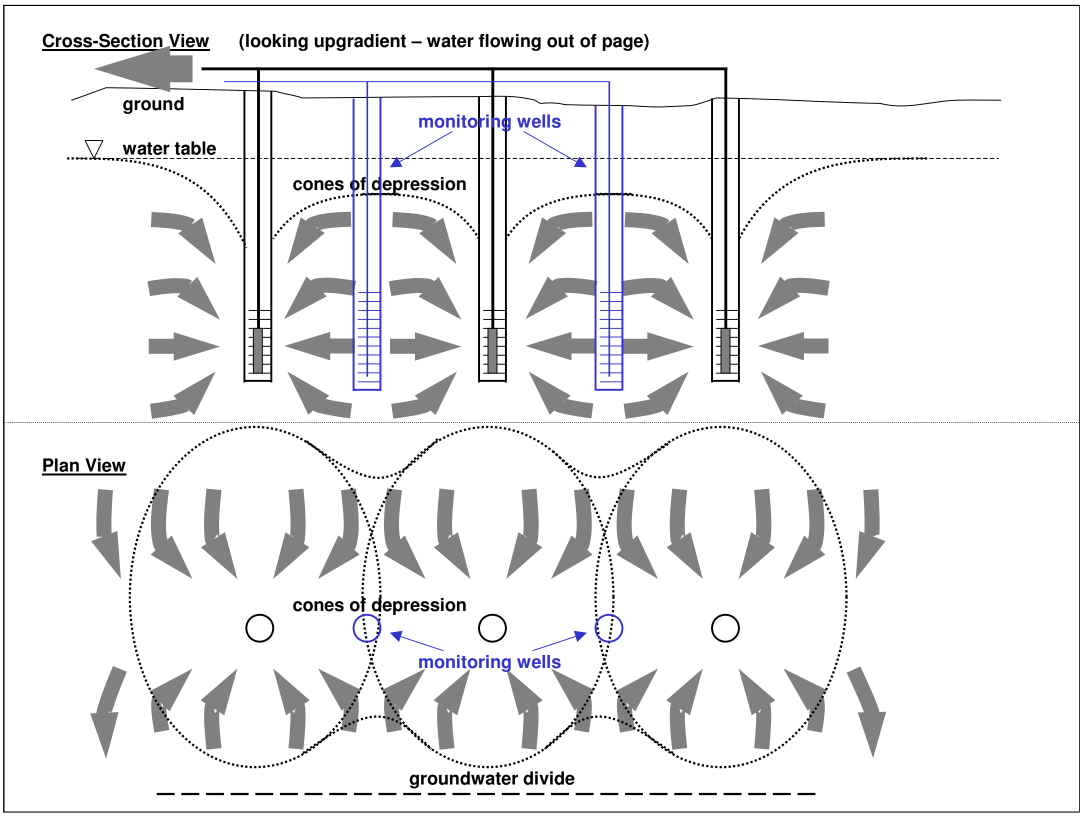


A *hydraulic containment line* is formed by positioning a series of extraction wells adjacent to each other.

(Note that the orientation of the view has changed from the preceding slides.)



Once again, extracting groundwater from each of the extraction causes cones of depression to form around each extraction well and groundwater divides to form downgradient of each extraction well.



Pumping harder causes the cones of depression to overlap and merge.

The water table between the extraction wells is lowered, and no groundwater flows past these points, thus forming the *hydraulic containment line*. A continuous groundwater divide is formed downgradient.

Monitoring wells installed between the extraction wells are used to measure the distance that the water table has been drawn down.

Excessive pumping rates can result in:

•Excessive draw down of the water table, which can lead to *subsidence*;

•Wasted effort – uncontaminated water can drawn back from downgradient or in from the sides, resulted in wasted pumping and treatment energy and cost; and

•Pumps running dry, which can damage them.

In the case of the Secondary Containment Line along Foreshore Road, excessive pumping could cause salt water to be drawn back to the extraction wells. Salt water would require more treatment – particularly reverse osmosis – and could also lead to corrosion in the Groundwater Treatment Plant.