CHAPTER 7 ENVIRONMENTAL (WATER QUALITY) INVESTIGATION

7.1 Groundwater Quality Monitoring

A water quality investigation at 45 monitoring points was executed, and total of three monitoring investigations was conducted together with the water sampling and water quality analysis. The water quality monitoring investigation is summarized, as follows:

- Groundwater levels have decreased gradually by as much as 1 to 2 m in the period of four years.
- Since groundwater levels have decreased both upstream and downstream of trench 2, it is presumed that the volume of groundwater has decreased over all. .
- Generally speaking, pH values are almost neutral with fluctuation in range of 6.5 to 7.5. But pH values decreased to the range of 4 to 5 locally in the tailings impoundment and at bore hole MW-3 near the foot of tailings dam.
- At MW-12 downstream of Trench -2, pH values shifted to the alkaline side of pH 8 to 9.
- TDS had almost no fluctuation during this 4-year period.
- Na concentrations generally exhibited a tendency to increase during this 4-year monitoring period.

7.2 Result of Water Analysis

Each of the water quality samples was analyzed for the following 12 parameters: pH, EC, water temperature, Hg, Cd, Cr, As, Pb, Cu, Zn, SO_4 and Cl. The result of water analysis is summarized, as follows:

- pH ranges from 5.8 to 8.9. The pH of groundwater in the tailing dam and Lasail West mine water presented weakly acidic in range of pH 5.8 to 6.0.
- Electric Conductivity presented a high value of 7.66 S/m at the tailings impoundment and decreased with distance downstream along Wadi Suq.
- Hg presented somewhat higher values at the tailings impoundment and in the mine water samples.
- Cd presented higher values at the tailings impoundment and mine water of Aarja.
- As presented high value at the tailing impoundment and its high concentration zone elongated toward the northwest.
- Pb, Cu and Zn presented high concentrations at the tailings impoundment, extending to the northwest, and in the mine water of the Aarja and Lasail West mines.
- SO_4 presented high concentration at the tailings impoundment, extending to the northwest, in the mine water of Aarja and Lasail West, and the area around Magan.
- Cl presented high concentration at the tailings impoundment, extending to the northwest, and downstream along Wadi Suq.

The correlation of water quality (average value) among the monitoring points is described (Figure 7.1), as follows:

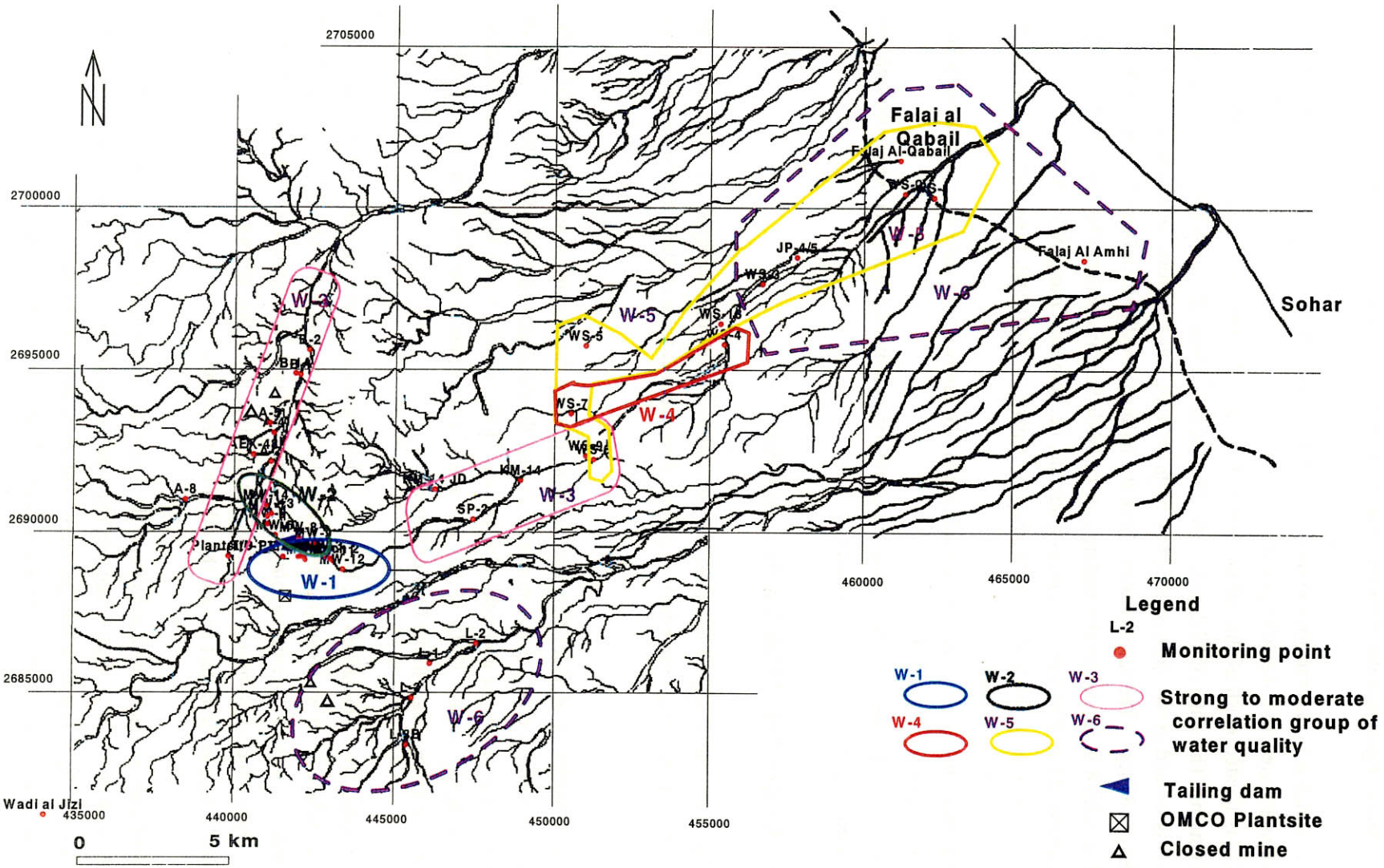

Figure 7.1 Correlation Map of Water Quality

- The water quality of groundwater at the monitoring points is divided into six groups, namely W-1 to W-6.
- Group W-1, which is found from the tailing dam to MW-12 well along Wadi Suq, is directly affected by the seepage water from the tailing dam.
- Group W-2 is located north of the tailing dam and in the tributaries of Wadi Suq and Wadi Bani Umar al Gharbi. The water of W-2 is strongly affected by the seepage water from the tailing dam.
- Group W-3 is located in the upper and middle parts of Wadi Suq and from northwest of the tailing dam to Bayda Village. The seepage water from the tailing dam slightly affects the water of W-3.
- Group W-4, which is located in the middle part of Wadi Suq, is characterized by relatively high concentrations of Cl. W-4 water quality is moderate, i.e. between Group W-3 and W-5.
- Group W-5, which is found in the middle and lower parts of Wadi Suq, is thought to exhibit the original water quality of Wadi Suq.
- Group W-6 presents the water quality of Wadi al Jizi. Groundwater of the lower part of Wadi Suq has a correlation with Wadi al Jizi.
- The classification of water quality among the monitoring points excellently corresponds with the classification of groundwater of drill holes.

7.3 Groundwater Modeling of Wadi Suq and Simulation

As part of this study, modeling of the groundwater and contamination transport of Wadi Suq was undertaken to evaluate the long-term effects of potential countermeasures on the groundwater quality in Wadi Suq.

The groundwater modeling of Wadi Suq was performed using the computer software MODFLOW. Contamination transport prediction was performed using the computer software MT3DMS. Both of these programs are available in a commercial version of the United States Department of Defense Groundwater Modeling System GMS v3.0. The model encompassed the entire Wadi Suq and its tributaries from the tailings dam to the Gulf of Oman.

We have performed two simulations. The first is for the case where no remedial measures are implemented at KM 14, but with capping of tailing dam. The second is for the case where a cut-off trench was installed at KM 14 with capping of the tailing dam. The simulation was performed to estimate the future concentration and spread of the chloride since this chemical is considered very mobile and would spread the fastest among the other contaminants.

As the first simulation was performed to estimate the future concentrations of chloride with time with no trench cut-off at KM 14, it is shown that the chloride concentration will exceed 600 mg/L at the discharge point of Falaj al-Qabail within 20 years. The chloride contamination will also reach the vast alluvial plains of Wadi Suq within 20 years and definitely within 30 years (Figure 7.2). And, at Falaj al-Qabail, the concentration is shown to increase from 150 mg/L to about 950 mg/L in 30 years.

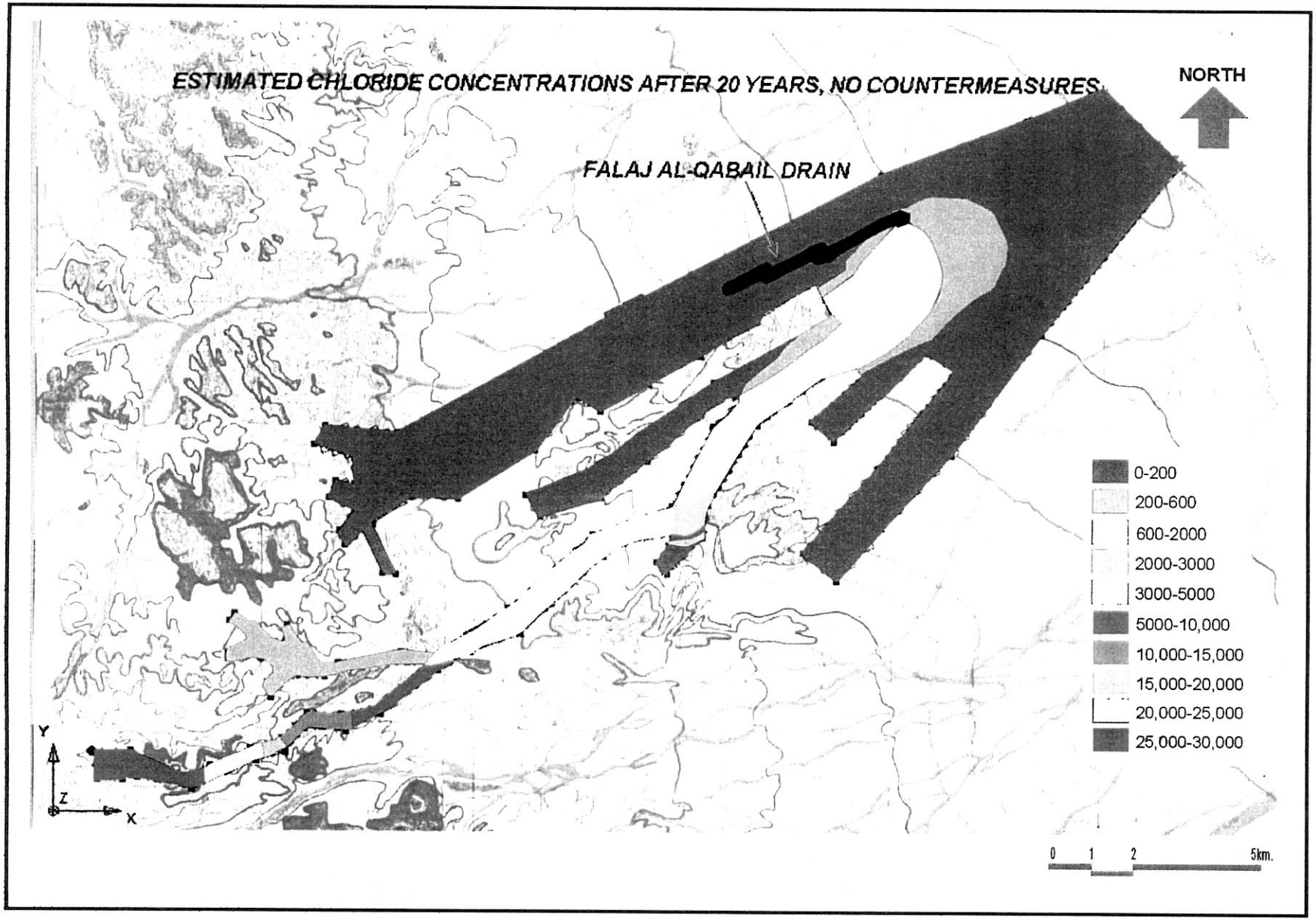

Figure 7.2 Estimated Chloride Concentration After 20 Years No Cutoff Trench at KM14