

APPENDIX C

CHINLE WATER-QUALITY TREND ANALYSES

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C.0 WATER-QUALITY TREND ANALYSES

Water-quality trend analyses are presented for the Chinle mixing-zone wells for each of the chemical constituents except vanadium, thorium-230 and radium-226 plus radium-228 (see section C.1). Trend analyses of these three constituents were not done because the majority of the analysis results are below laboratory detection limits. No significant concentrations of these constituents have been measured in water collected from Chinle background aquifer wells. Trend analyses are also presented for water-quality data collected from wells located in the Upper, Middle and Lower Chinle non-mixing zones in Sections C.2, C.3 and C.4, respectively. Only 2003 data collected in June or earlier was available when ERG conducted their statistical analyses. These plots present data collected through July of 2003.

No significant trend was detected in more than one well for any water-quality constituent in the Chinle mixing-zone water or the three individual non-mixing zone aquifers. Modest trends were identified for a specific constituent in some individual wells, but the magnitude of these isolated trends was very small and the data range was consistent with that of other wells in the same ground-water system. The majority of wells and constituents had no discernible trends. Following extreme value removal based on statistical testing, and exclusion of small portions of the data for reasons discussed in subsequent sections, the data were considered acceptable for use in trend and background water-quality analyses.

C.1 CHINLE MIXING ZONE TREND ANALYSIS

Sulfate concentrations in water collected from Upper Chinle wells located in the mixing zone are presented in Figure C.1-1. A gradual decrease with time in sulfate concentrations in well CW9 is demonstrated on Figure C.1-1. This gradual change in concentration in the lower permeability zone of the Upper Chinle aquifer is thought to be naturally occurring. Water quality in well CW9 has not been routinely measured in recent years but the appropriate Chinle water-quality parameters are being updated by sampling in 2003. Well CW10 was abandoned during re-sloping of the Large Tailings pile. Two samples have also been collected from the two new Upper Chinle wells, CW50 and CW52 (see Figure C.1-1). Sulfate concentrations in water taken from the Middle Chinle wells in the mixing zone are plotted versus time on Figure C.1-2, and are relatively steady with the exception of a couple of potential outliers. These two slightly anomalous points were not excluded by statistical analysis. Sulfate concentrations in the Lower Chinle wells in the mixing zone are presented in Figure C.1-3. No significant trends are observed in these Lower Chinle wells.

TDS concentrations in water samples taken from Upper Chinle wells situated in the mixing zone are presented in Figure C.1-4. TDS concentrations in these Upper Chinle wells do not show consistent long-term trends. Similar plots of TDS concentrations for the Middle Chinle wells in the mixing zone are presented in Figure C.1-5. These TDS concentrations are also fairly steady with time, except for one outlier that is part of the well CW35 data. Those data points labeled as outliers on the trend figures were removed from the data set prior to the statistical calculation of background concentration. TDS concentrations for the Lower Chinle wells are presented in Figure C.1-6.

Chloride concentrations in the mixing zone of the Upper Chinle aquifer are presented in Figure C.1-7. Chloride concentrations have remained low in these four Upper Chinle aquifer wells. Plots of chloride concentrations in water collected from the Middle Chinle mixing-zone wells are presented on Figure C.1-8. One data point is labeled as outlier.

This outlier was identified based on statistically testing the chloride data in the Chinle mixing zone and was removed prior to calculation of background concentrations. Figure C.1-9 presents time plots of chloride concentrations in the Lower Chinle wells in the mixing zone. These plots demonstrate no discernible trend over time.

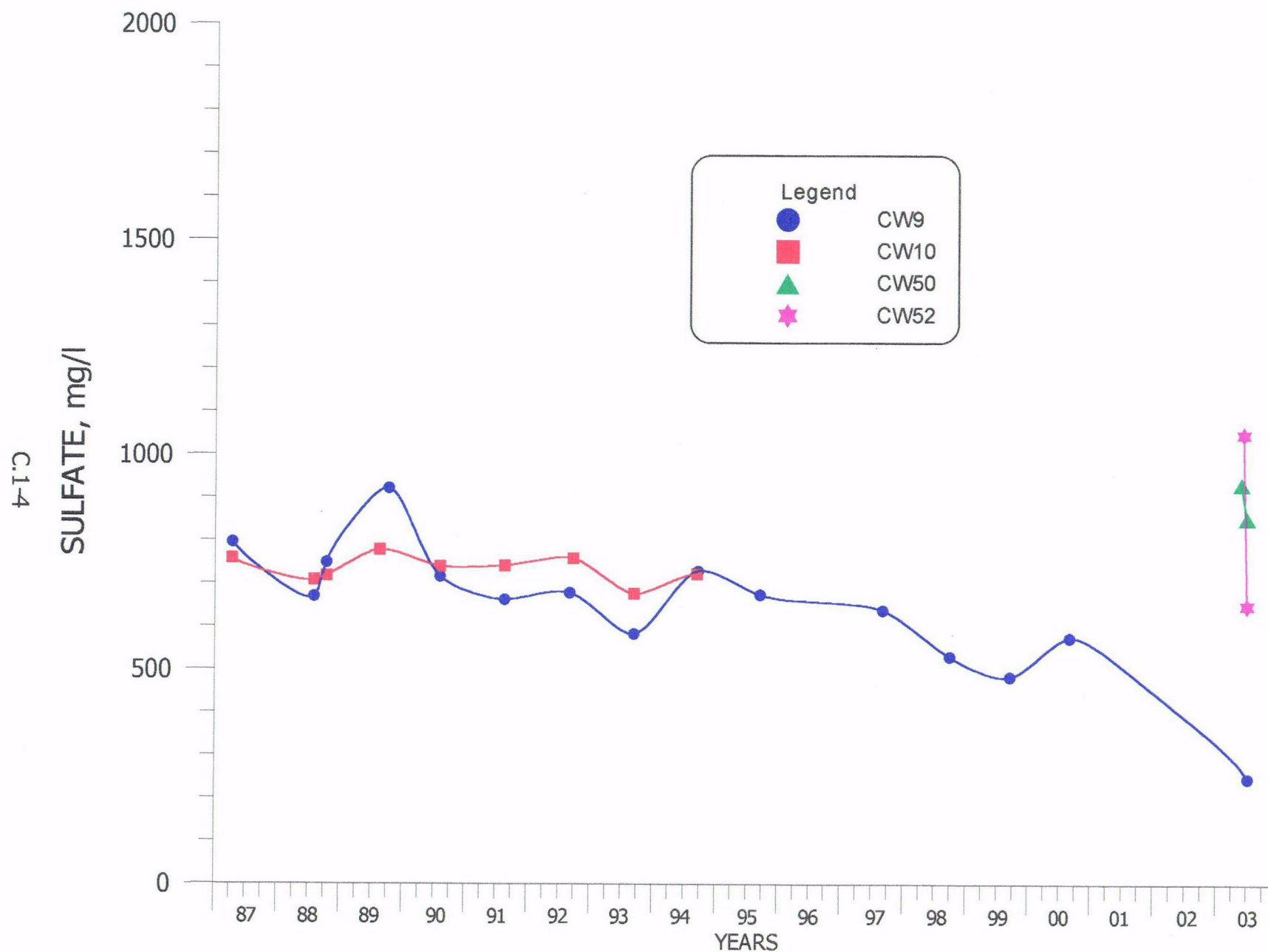
Uranium concentrations in the Upper Chinle mixing-zone wells are presented on Figure C.1-10. Variations in uranium concentration with time in these wells have been small. Figure C.1-11 presents uranium-concentration plots for the Middle Chinle wells located in the mixing zone. Samples taken from these Middle Chinle aquifer wells contain concentrations generally between zero and 0.2 mg/l, with some temporal variation but no discernible long-term trends. The magnitude of these concentrations illustrates that the Middle Chinle aquifer contains significant uranium in solution. Uranium concentrations in the Lower Chinle mixing-zone wells are presented in Figure C.1-12. In these wells concentrations are small and have remained steady over time.

Selenium concentrations in water sampled from the Upper Chinle mixing-zone wells are presented in Figure C.1-13. All of these selenium concentrations are low except one slightly higher value in a sample taken from well CW9. However, this particular sample concentration is within the natural range for this constituent in the Chinle aquifer. Figure C.1-14 presents time plots of selenium concentrations for the Middle Chinle wells in the mixing zone. Selenium concentrations naturally vary over a larger range in these Middle Chinle wells. The larger value from well CW35 was not selected as an outlier in the statistical testing. Selenium concentrations in the Lower Chinle mixing zone vary over a slightly smaller range and have been fairly steady with time (see Figure C.1-15).

Molybdenum concentrations in water collected from the mixing zone wells are presented in Figures C.1-16 through C.1-18. These plots show small molybdenum concentrations in the Chinle mixing zone wells with no discernible changes with time.

The nitrate concentrations in the mixing-zone water are presented as time plots on Figures C.1-19 through C.1-21. The magnitude of nitrate concentrations in some of the Middle Chinle wells west of the West Fault are large, but are deemed to be naturally occurring. These concentrations illustrate the potential for dramatic variation in natural nitrate concentrations in the Middle Chinle aquifer mixing zone. Nitrate concentrations have not been routinely measured in the Chinle aquifer in recent years, because this constituent is not of concern at the Grants Project site. However, updated nitrate analyses are included for 2003 Chinle on these plots but were not available when the ERG statistical analyses were done.

Vanadium, thorium-230 and radium-226 plus radium-228 concentrations or activities are not routinely measured in most Chinle wells. Historic concentrations or activities for these constituents have been small, but samples were analyzed for these parameters in 2003 to update the data set.



**FIGURE C.1-1. SULFATE CONCENTRATIONS FOR UPPER CHINLE WELLS
CW9, CW10, CW50 AND CW52 IN CHINLE MIXING ZONE.**

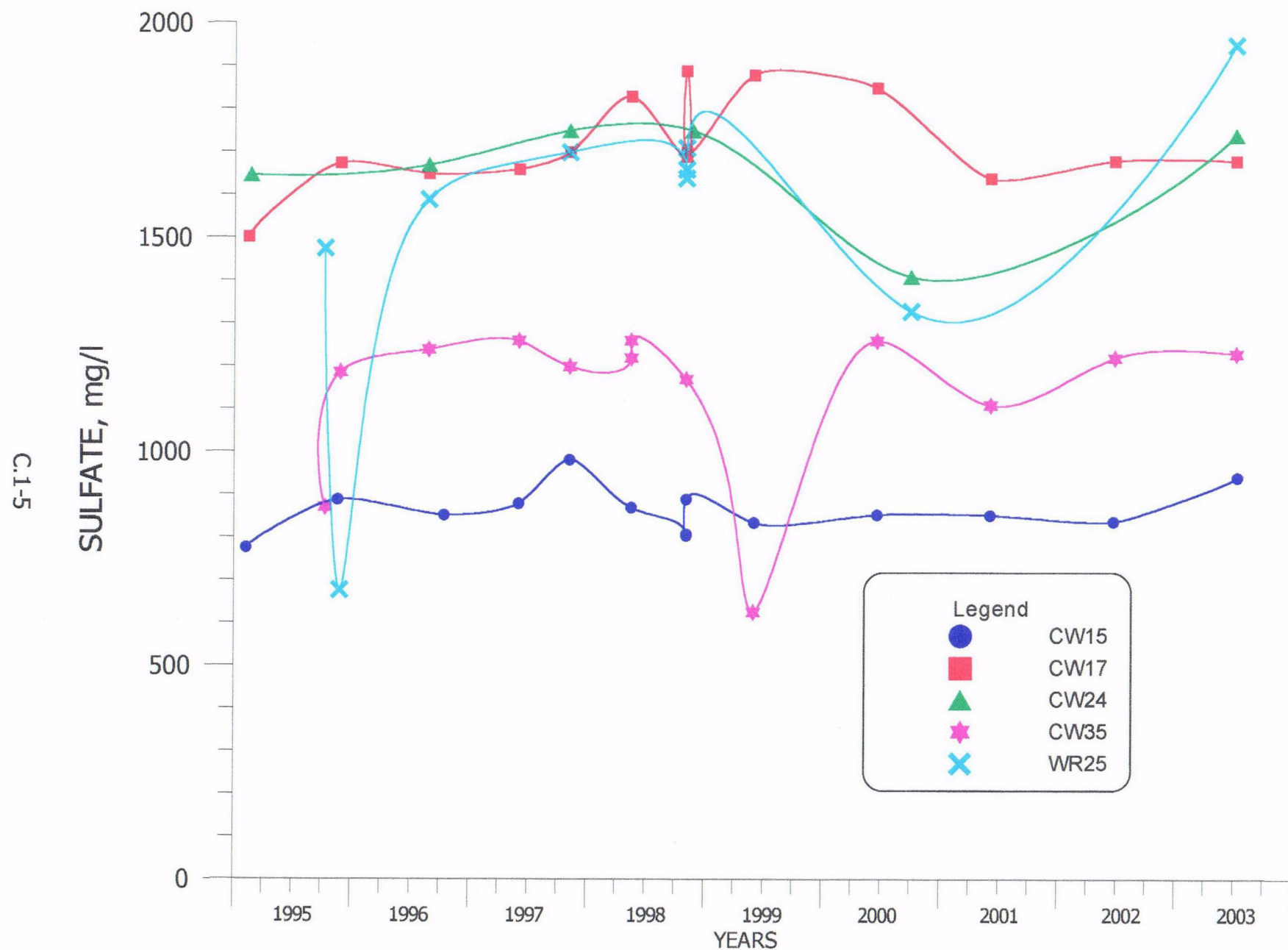


FIGURE C.1-2. SULFATE CONCENTRATIONS FOR MIDDLE CHINLE WELLS CW15, CW17, CW24, CW35 AND WR25 IN CHINLE MIXING ZONE.

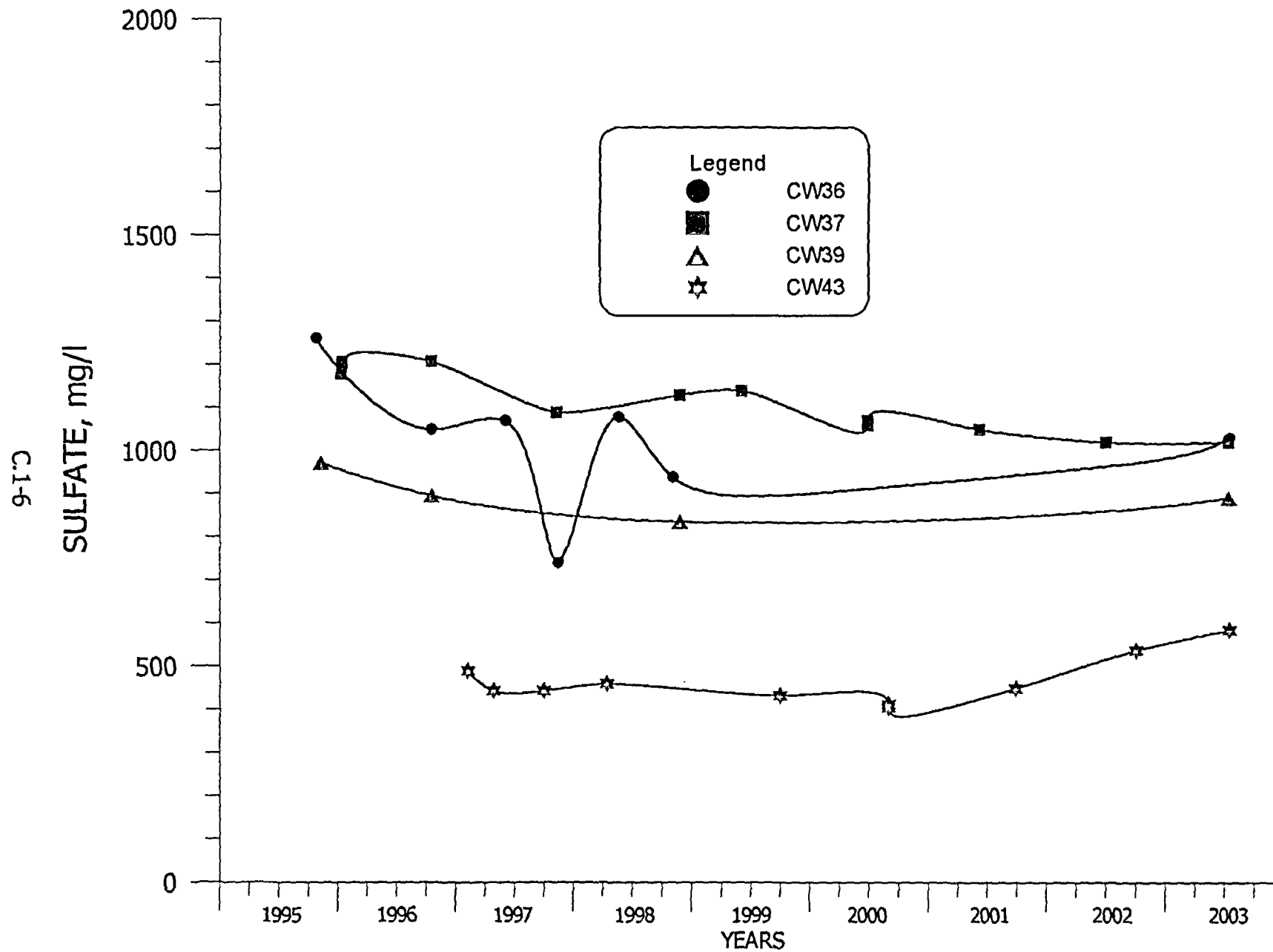
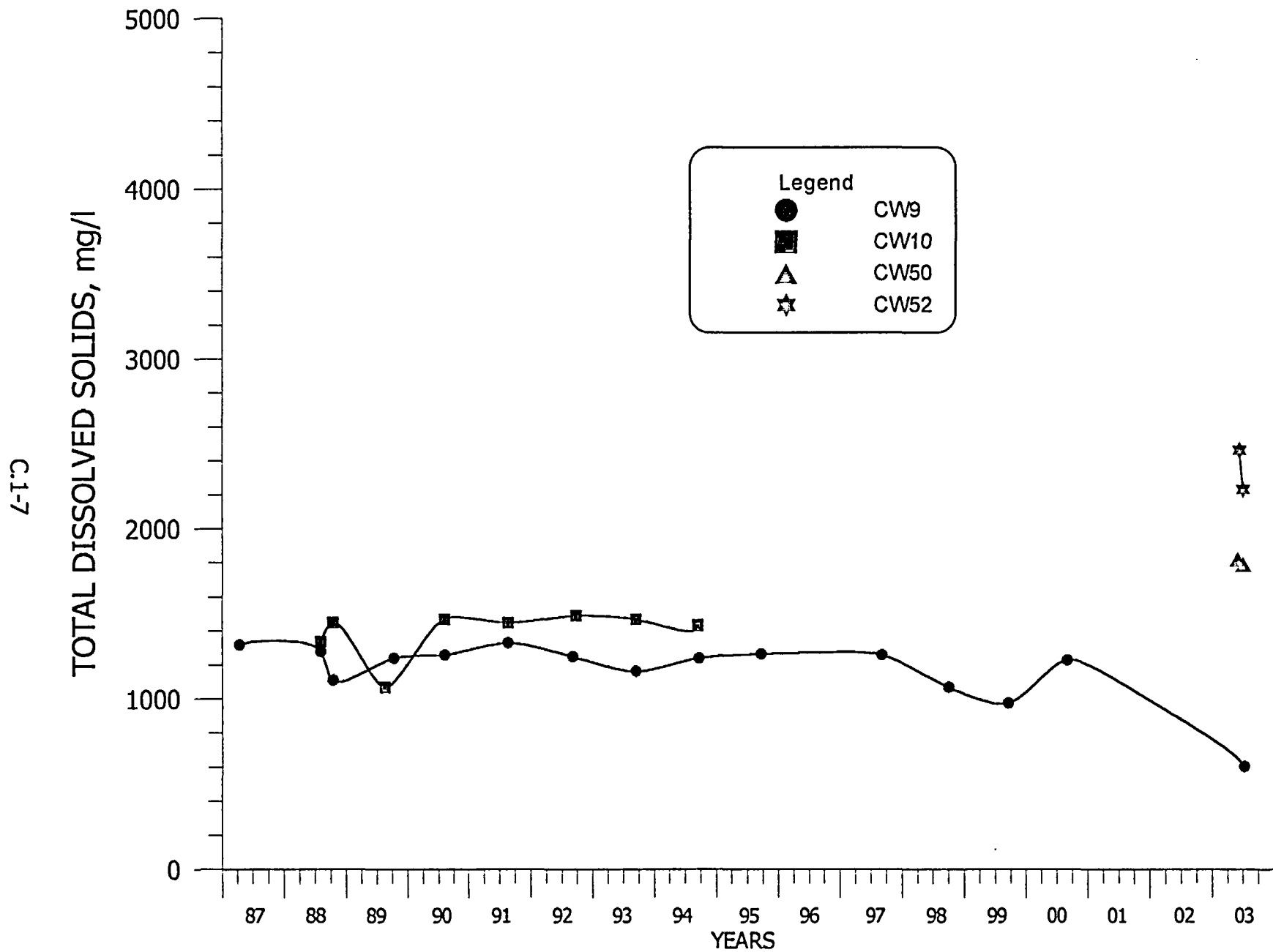


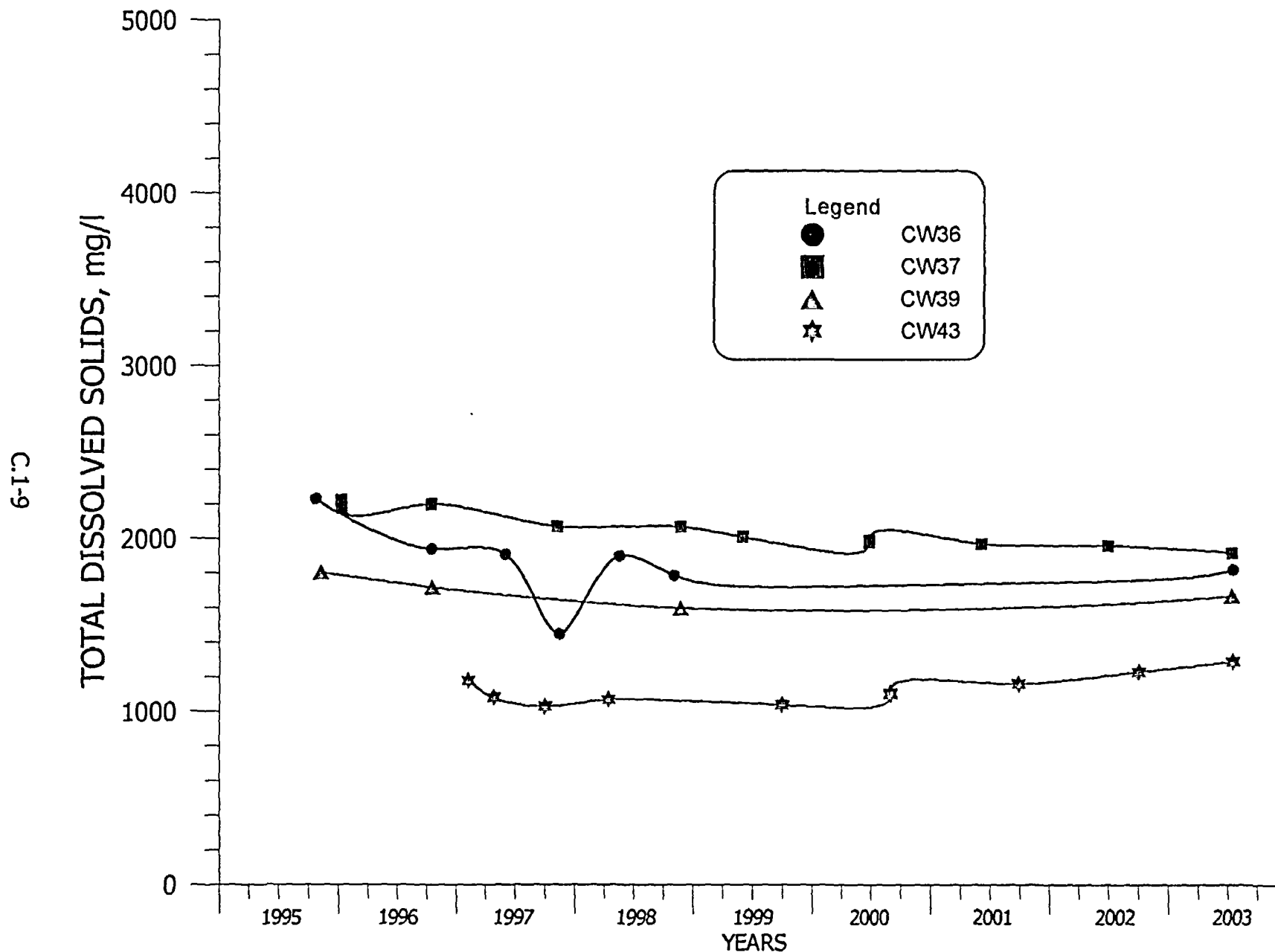
FIGURE C.1-3. SULFATE CONCENTRATIONS FOR LOWER CHINLE WELLS CW36, CW37, CW39 AND CW43 IN CHINLE MIXING ZONE.



**FIGURE C.1-4. TDS CONCENTRATIONS FOR UPPER CHINLE WELLS
CW9, CW10, CW50 AND CW52 IN CHINLE MIXING ZONE.**



FIGURE C.1-5. TDS CONCENTRATIONS FOR MIDDLE CHINLE WELLS CW15, CW17, CW24, CW35 AND WR25 IN CHINLE MIXING ZONE.



**FIGURE C.1-6. TDS CONCENTRATIONS FOR LOWER CHINLE WELLS
CW36, CW37, CW39 AND CW43 IN CHINLE MIXING ZONE.**

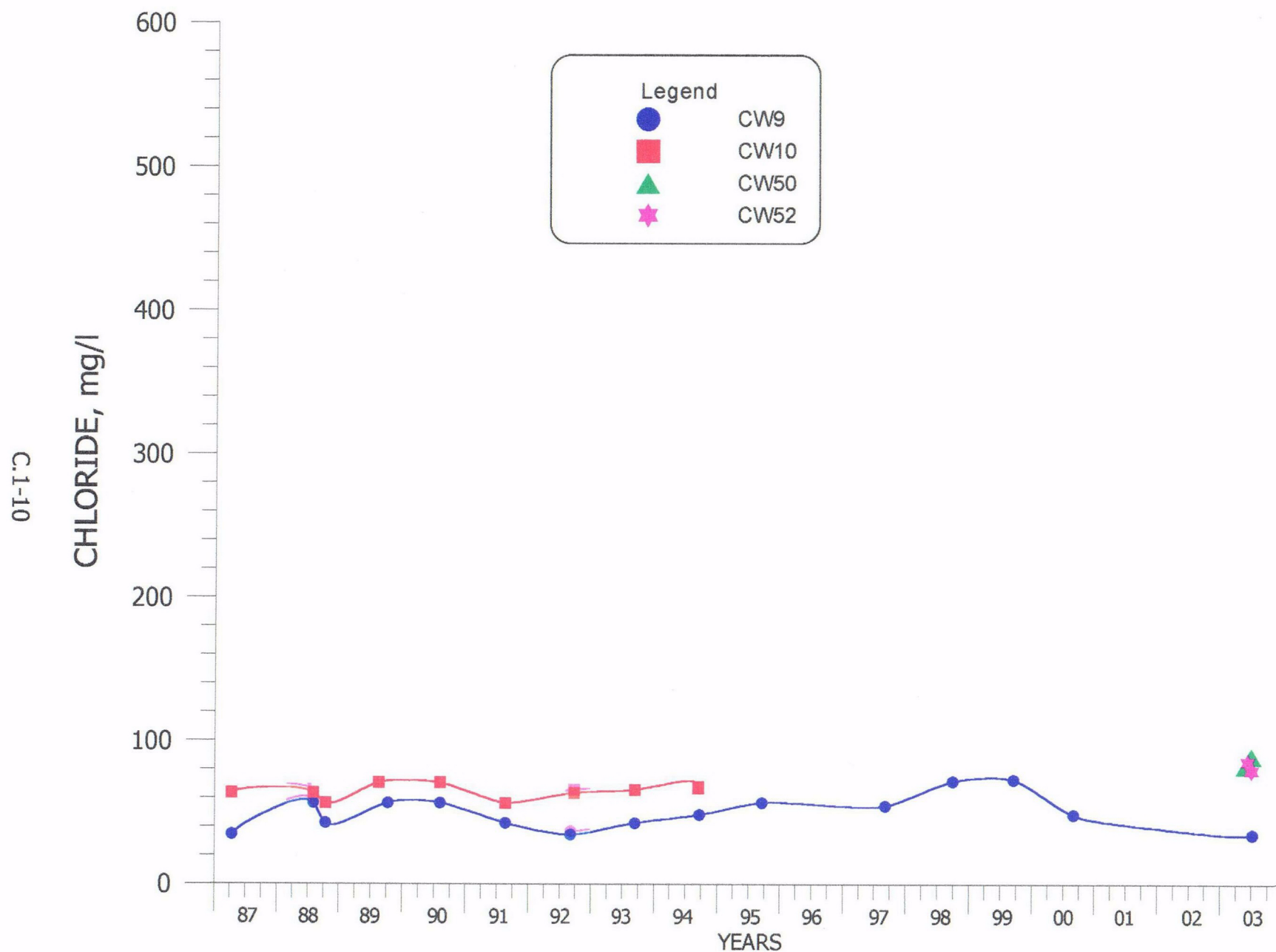


FIGURE C.1-7. CHLORIDE CONCENTRATIONS FOR UPPER CHINLE WELLS CW9, CW10, CW50 AND CW52 IN CHINLE MIXING ZONE.

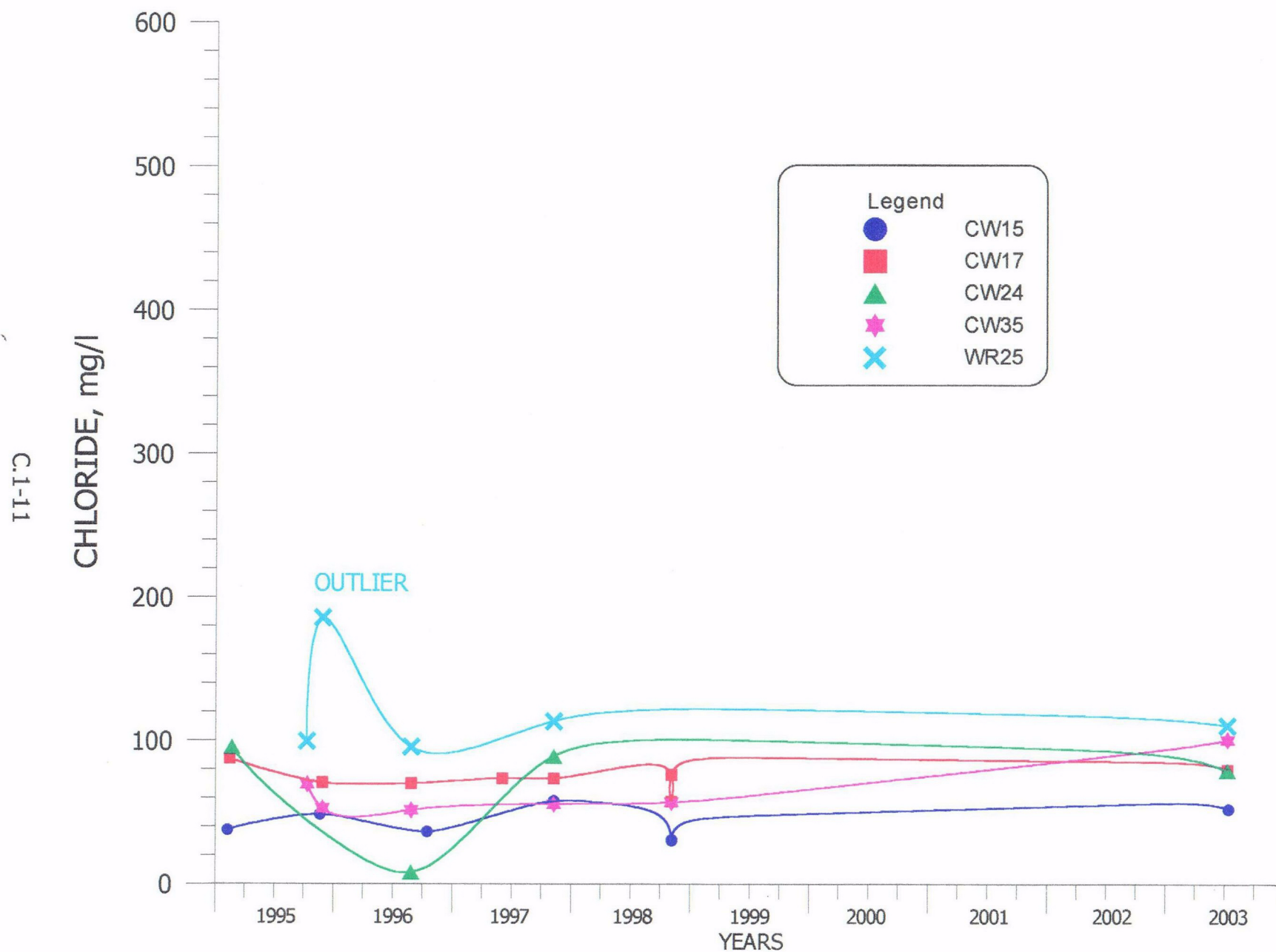


FIGURE C.1-8. CHLORIDE CONCENTRATIONS FOR MIDDLE CHINLE WELLS CW15, CW17, CW24, CW35 AND WR25 IN CHINLE MIXING ZONE.

C.1-12

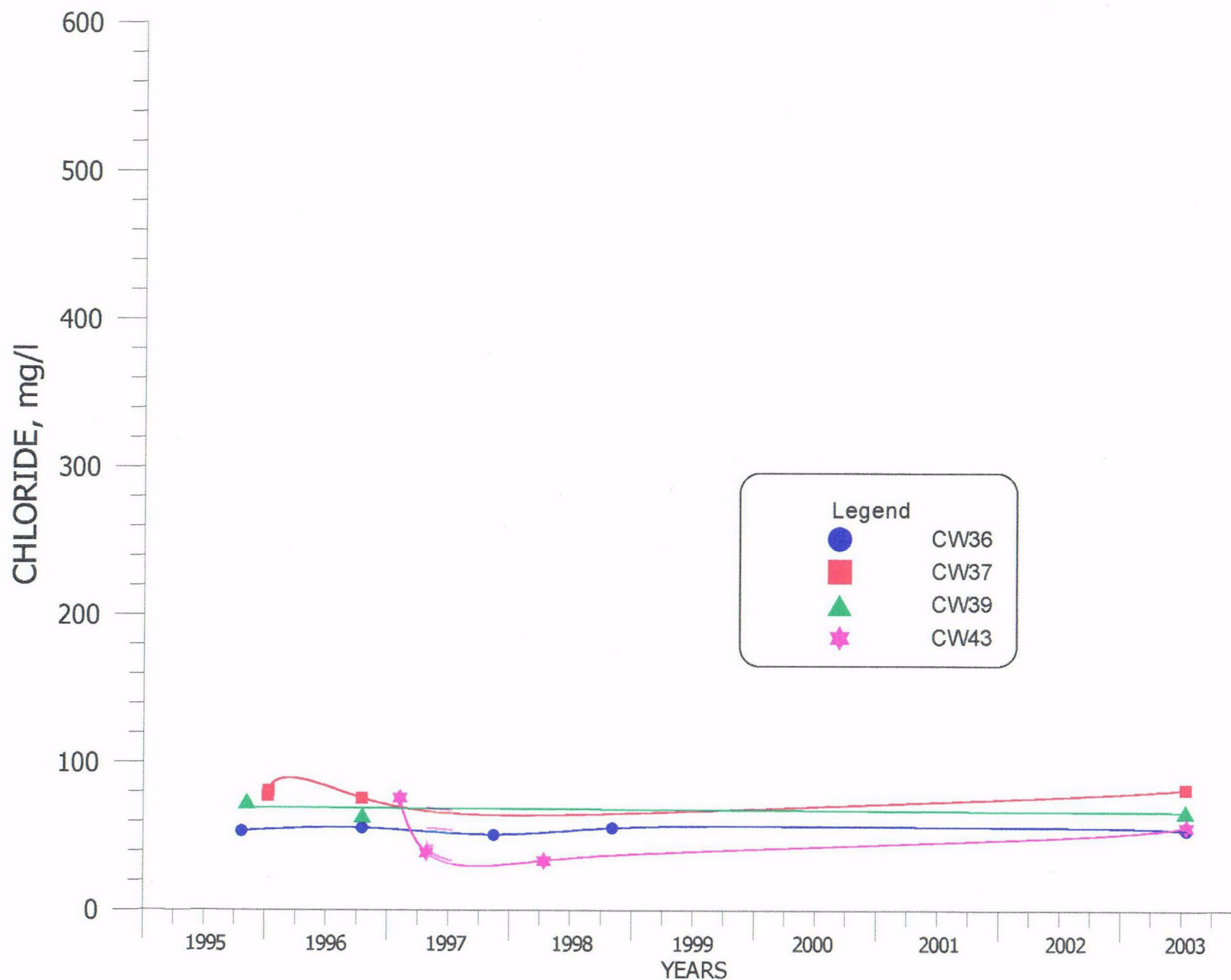


FIGURE C.1-9. CHLORIDE CONCENTRATIONS FOR LOWER CHINLE WELLS CW36, CW37, CW39 AND CW43 IN CHINLE MIXING ZONE.

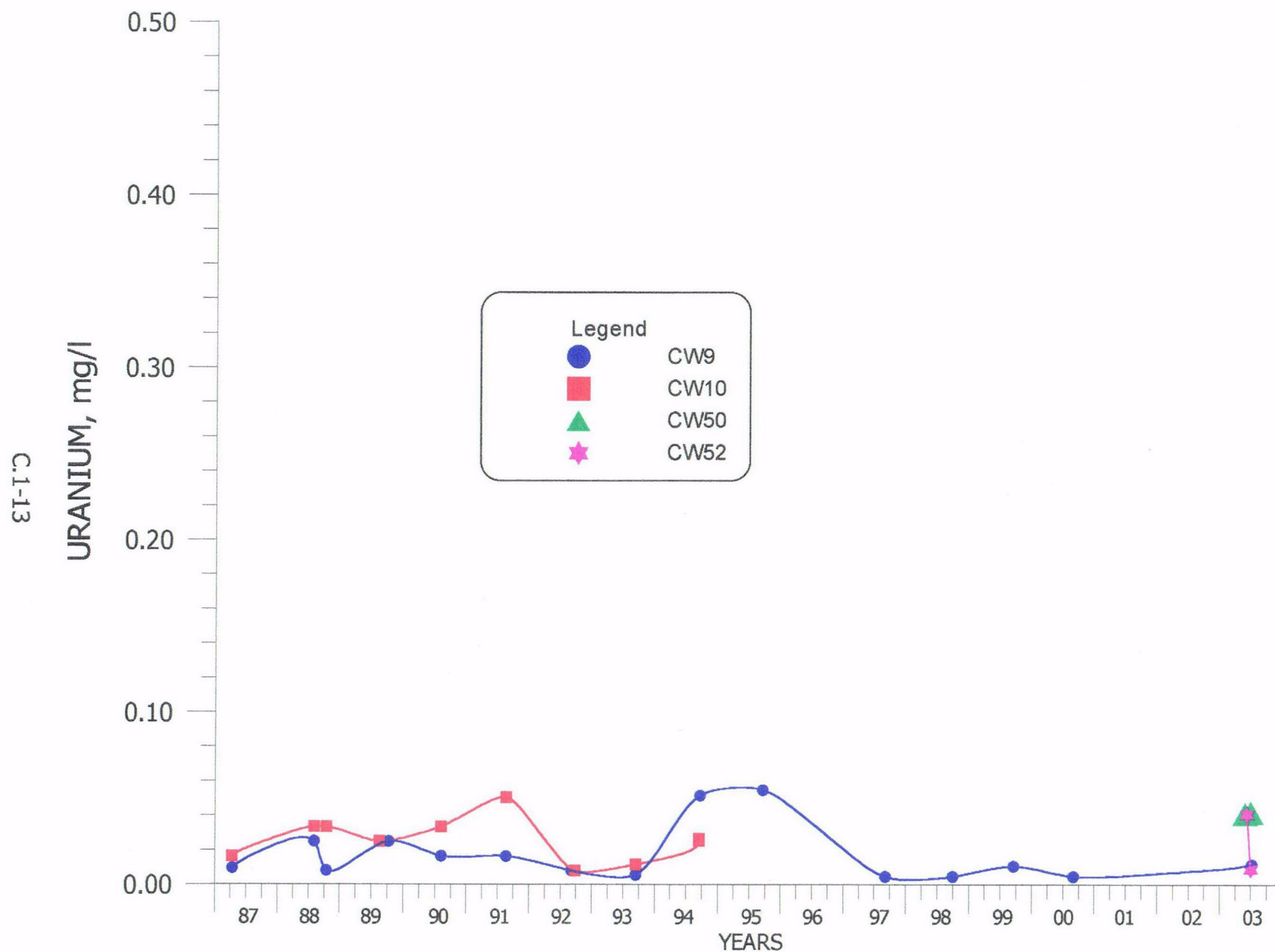


FIGURE C.1-10. URANIUM CONCENTRATIONS FOR UPPER CHINLE WELLS CW9, CW10, CW50 AND CW52 IN CHINLE MIXING ZONE.

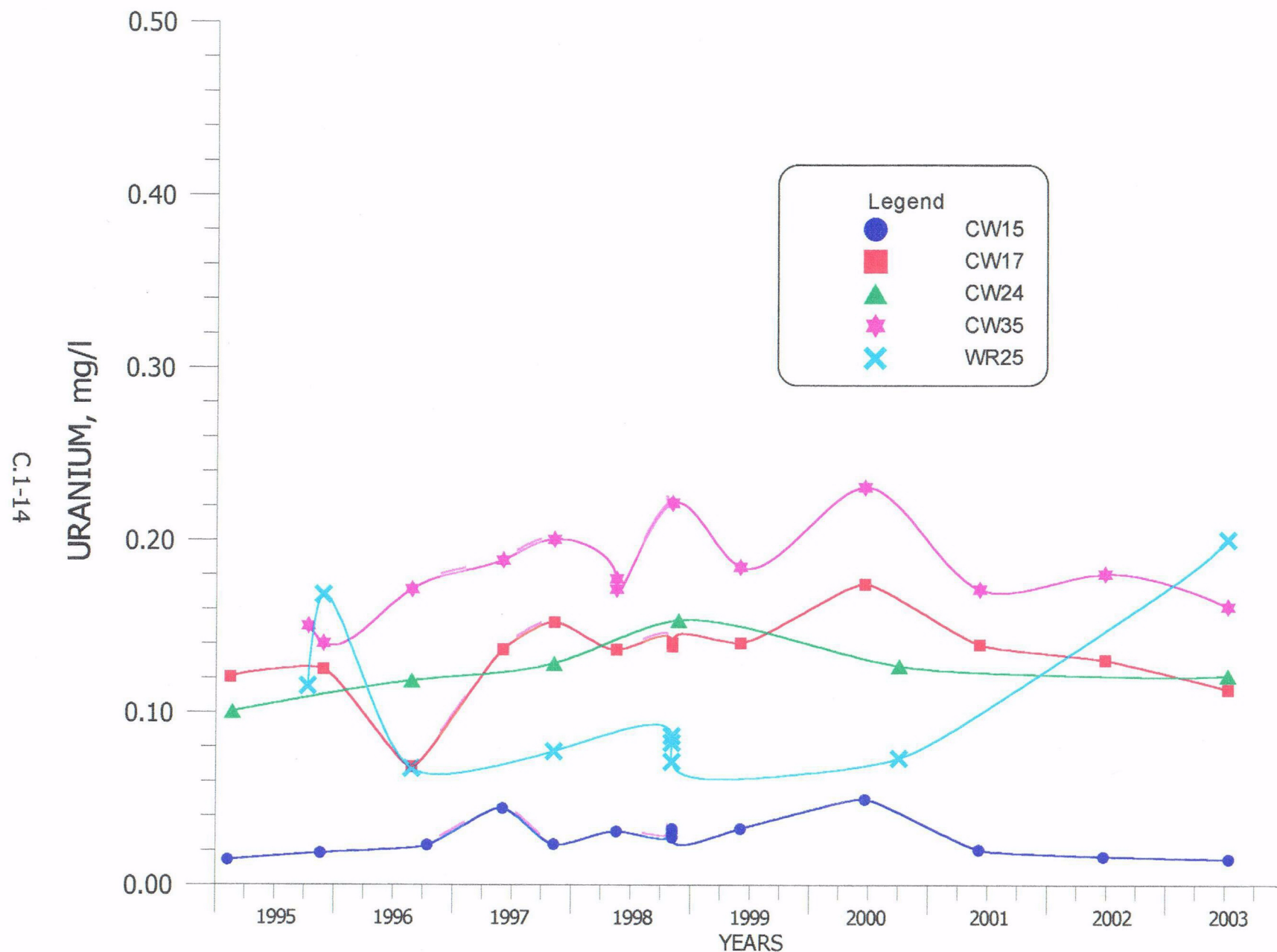


FIGURE C.1-11. URANIUM CONCENTRATIONS FOR MIDDLE CHINLE WELLS CW15, CW17, CW24, CW35 AND WR25 IN CHINLE MIXING ZONE.

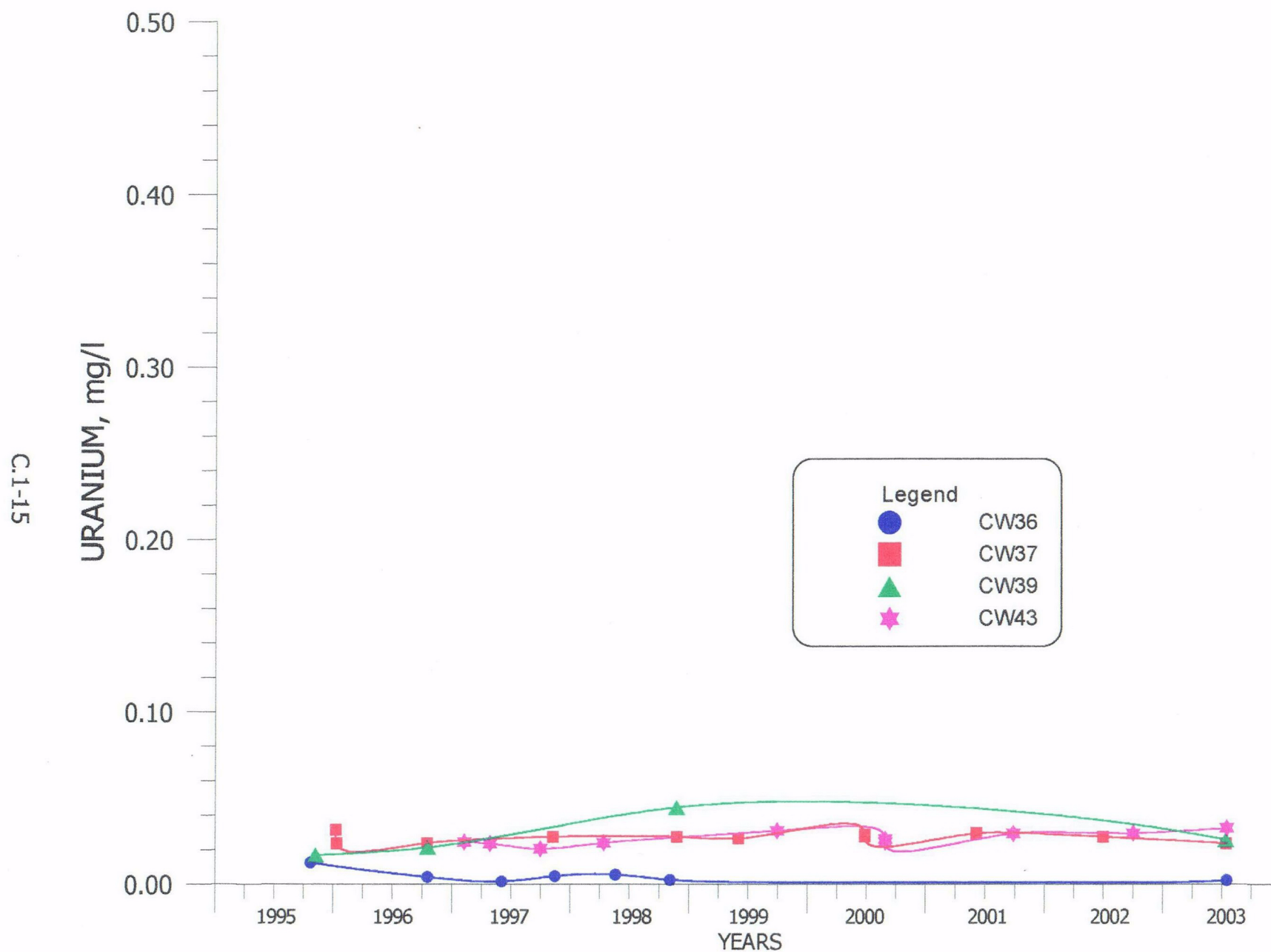


FIGURE C.1-12. URANIUM CONCENTRATIONS FOR LOWER CHINLE WELLS CW36, CW37, CW39 AND CW43 IN CHINLE MIXING ZONE.

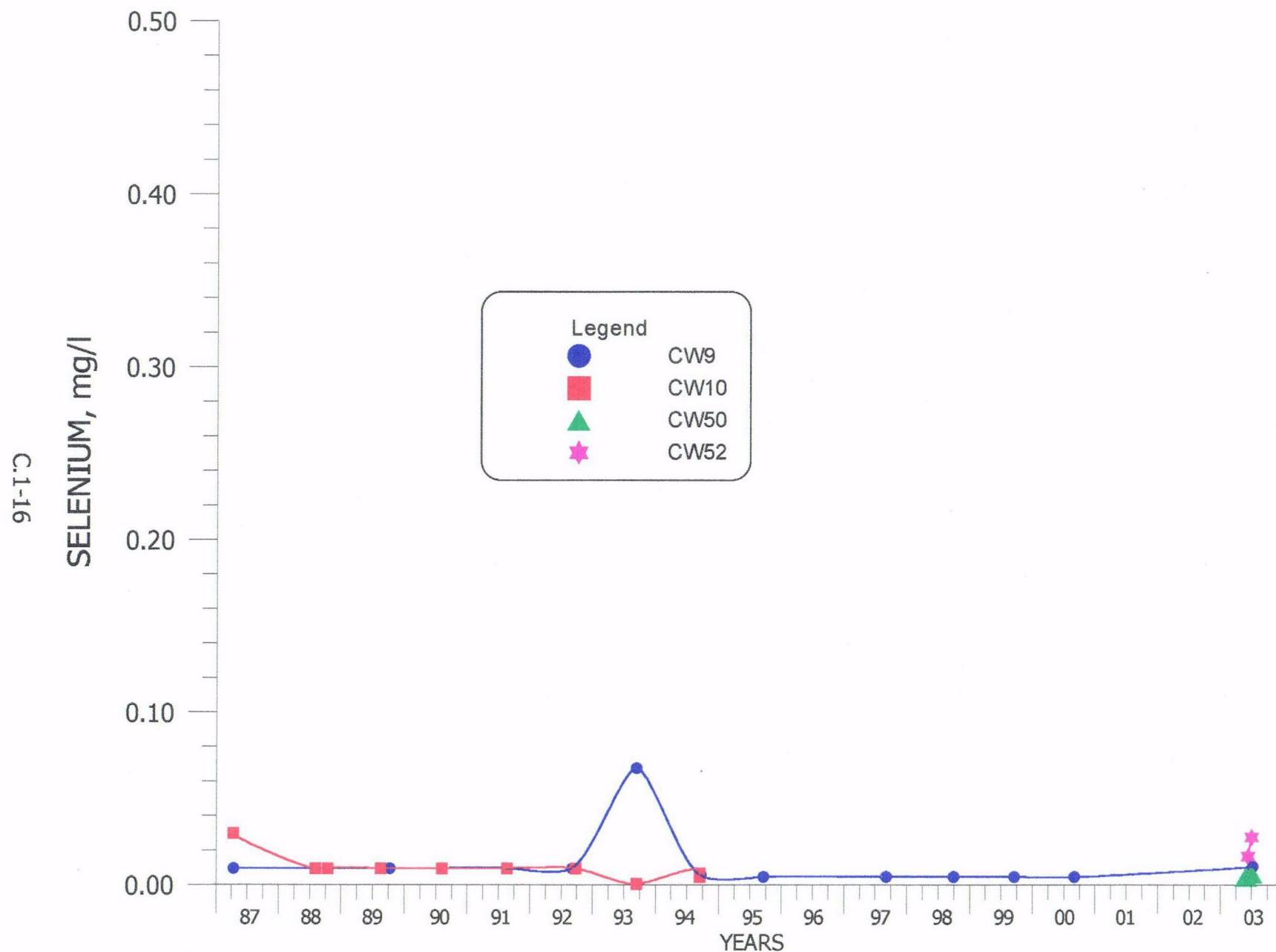


FIGURE C.1-13. SELENIUM CONCENTRATIONS FOR UPPER CHINLE WELLS CW9, CW10, CW50 AND CW52 IN CHINLE MIXING ZONE.

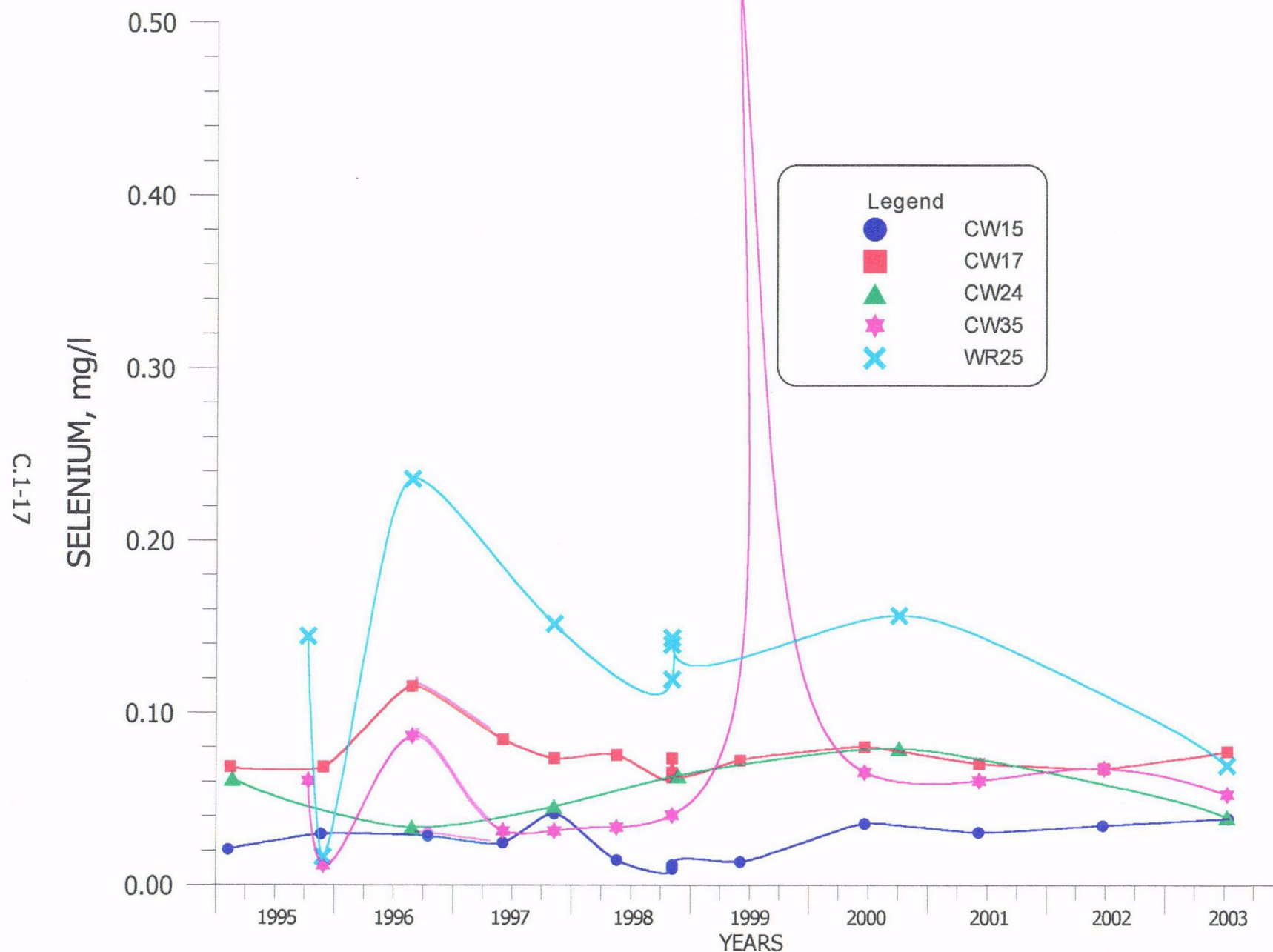


FIGURE C.1-14. SELENIUM CONCENTRATIONS FOR MIDDLE CHINLE WELLS CW15, CW17, CW24, CW35 AND WR25 IN CHINLE MIXING ZONE.

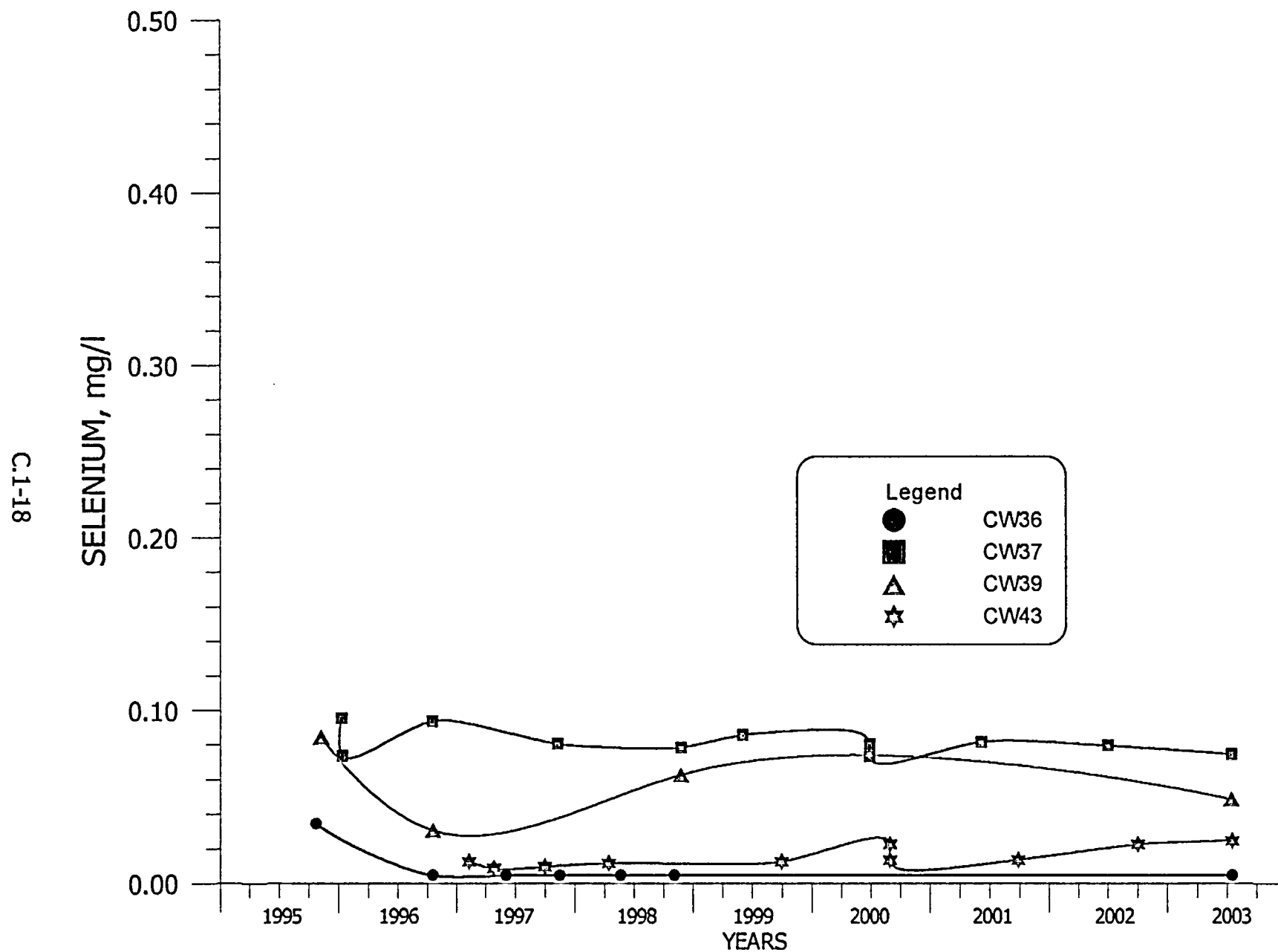


FIGURE C.1-15. SELENIUM CONCENTRATIONS FOR LOWER CHINLE WELLS CW36, CW37, CW39 AND CW43 IN CHINLE MIXING ZONE.

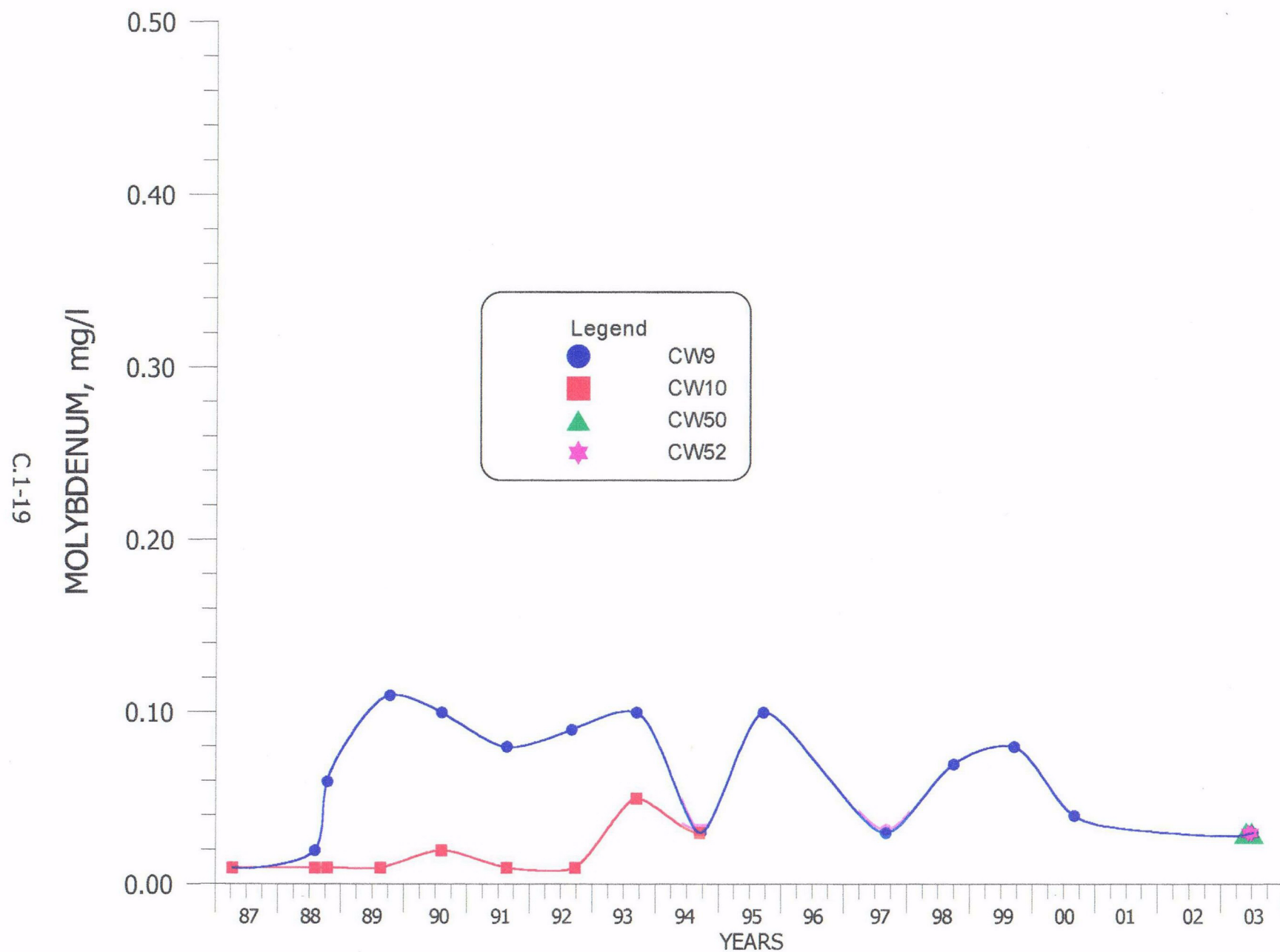


FIGURE C.1-16. MOLYBDENUM CONCENTRATIONS FOR UPPER CHINLE WELLS CW9, CW10, CW50 AND CW52 IN CHINLE MIXING ZONE.

C.1-20

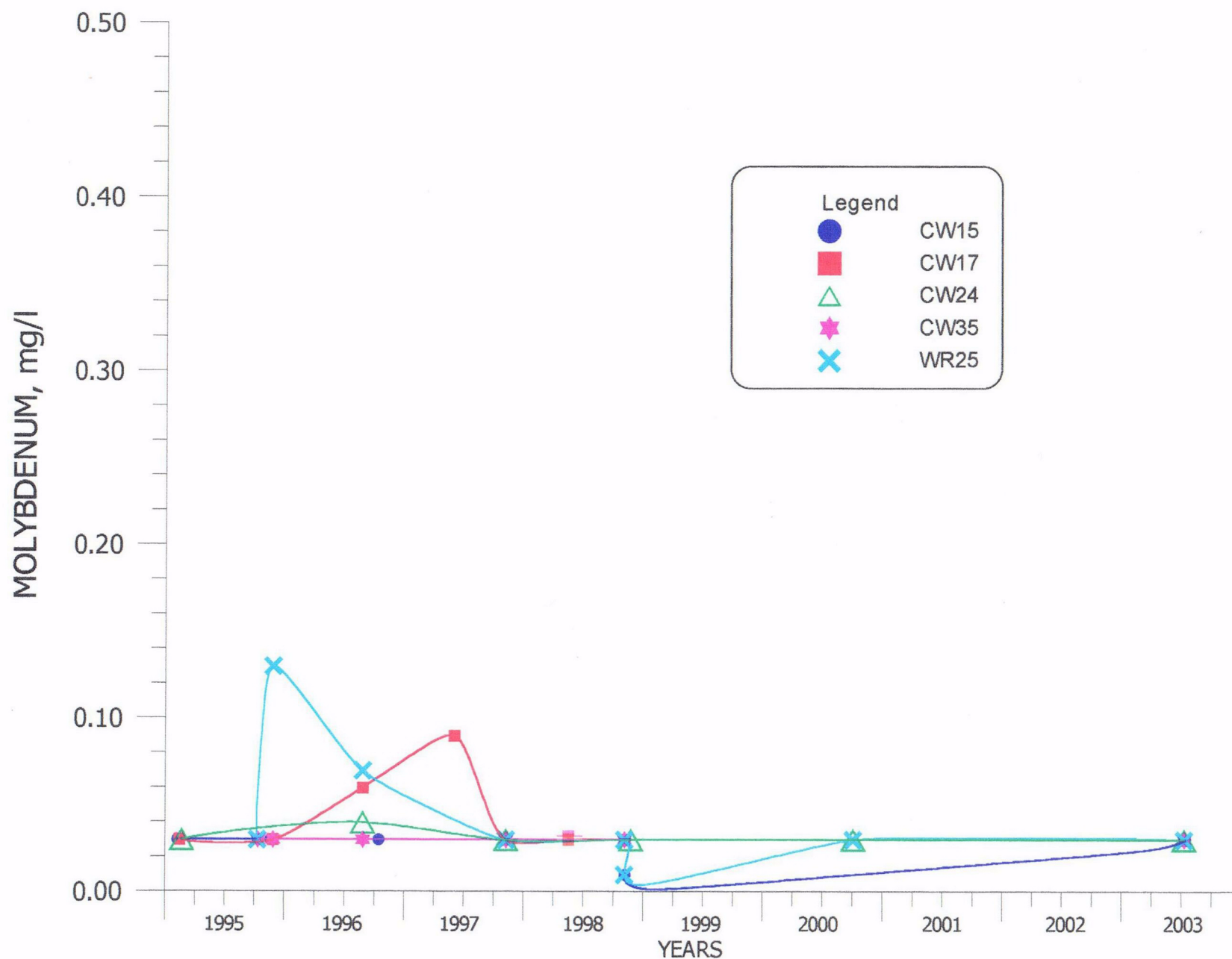


FIGURE C.1-17. MOLYBDENUM CONCENTRATIONS FOR MIDDLE CHINLE WELLS CW15, CW17, CW24, CW35 AND WR25 IN CHINLE MIXING ZONE.

C.1-21

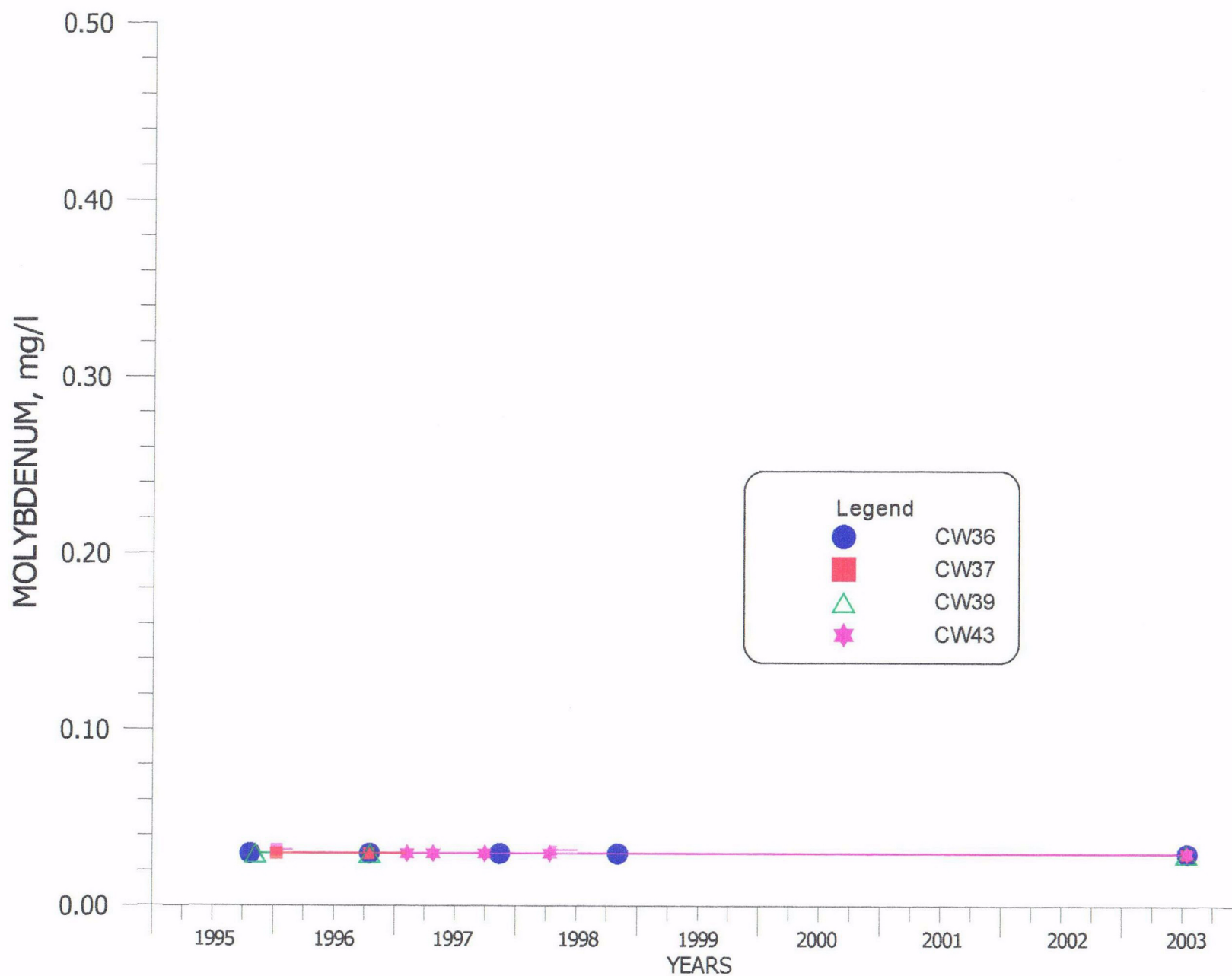


FIGURE C.1-18. MOLYBDENUM CONCENTRATIONS FOR LOWER CHINLE WELLS CW36, CW37, CW39 AND CW43 IN CHINLE MIXING ZONE.

C.1-22

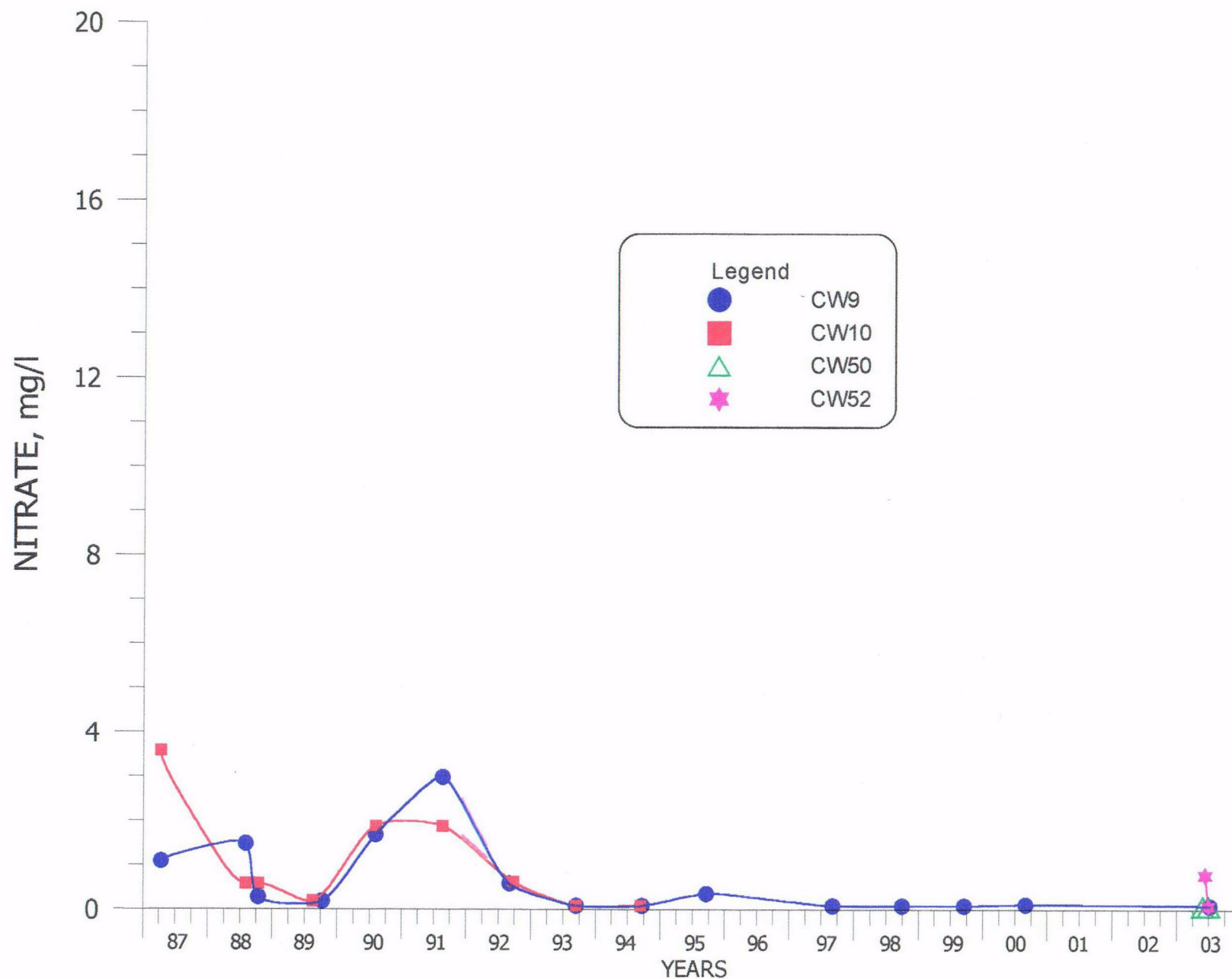


FIGURE C.1-19. NITRATE CONCENTRATIONS FOR UPPER CHINLE WELLS CW9, CW10, CW50 AND CW52 IN CHINLE MIXING ZONE.

C.1-23

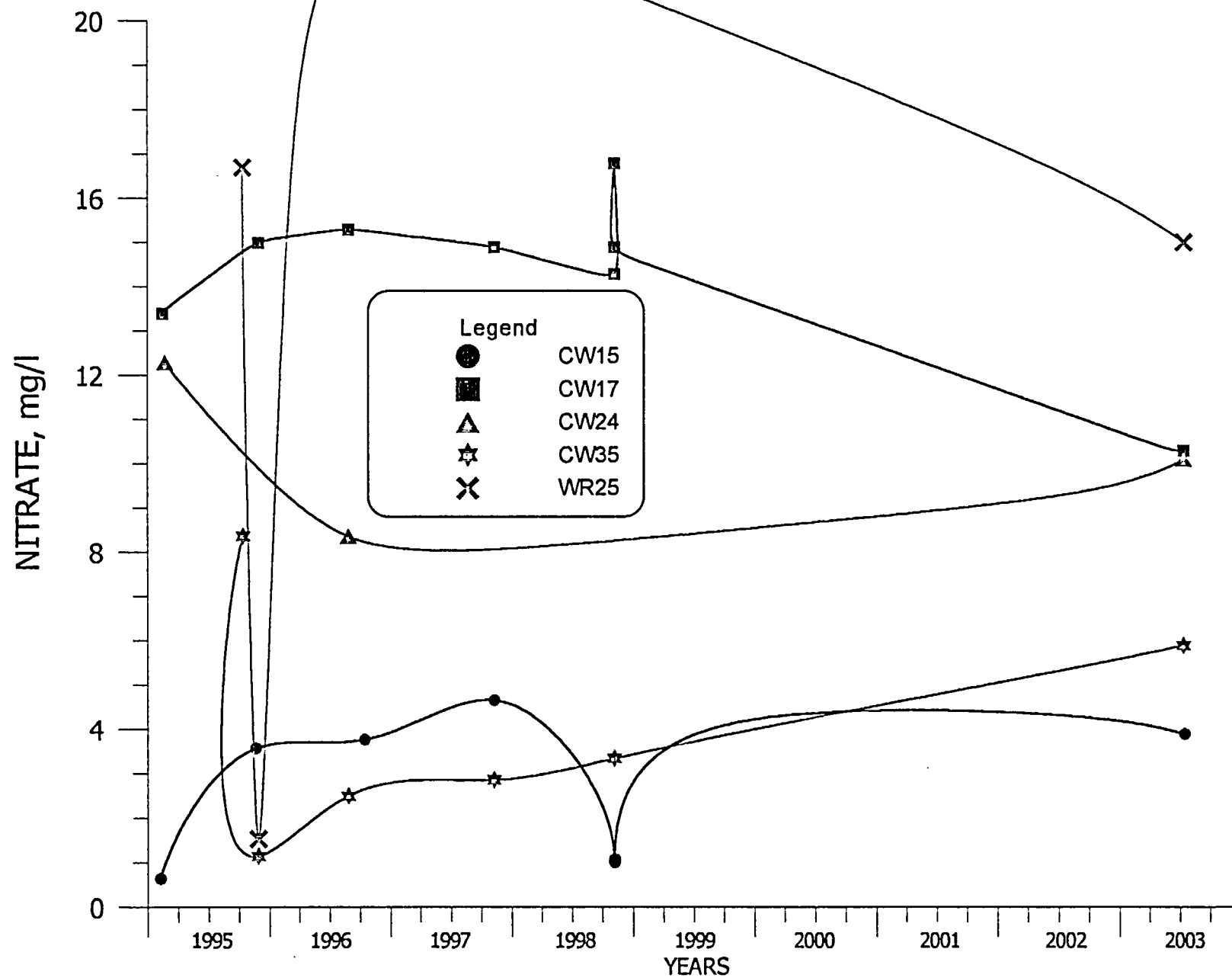


FIGURE C.1-20. NITRATE CONCENTRATIONS FOR MIDDLE CHINLE WELLS CW15, CW17, CW24, CW35 AND WR25 IN CHINLE MIXING ZONE.

C.1-24

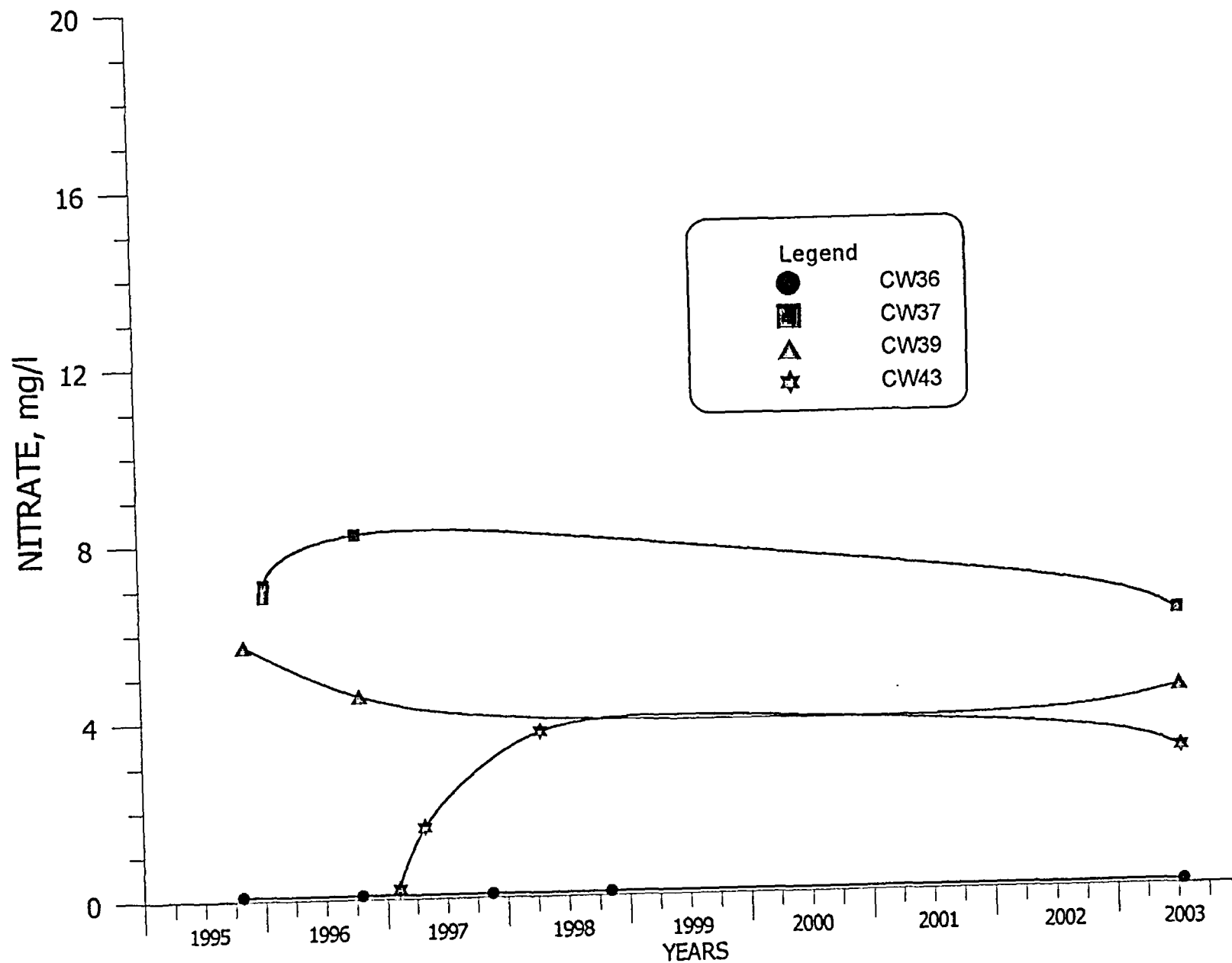


FIGURE C.1-21. NITRATE CONCENTRATIONS FOR LOWER CHINLE WELLS CW36, CW37, CW39 AND CW43 IN CHINLE MIXING ZONE.