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EVALUATION OF POPULATION RISK DUE TO A CONTAMINATED MULTIINPUT
WATER DISTRIBUTION NETWORK

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ABSTRACT

The city of Milan (Italy) lies over an aquifer, which supplies drinking water to about 1,700,000 inhabitants. Groundwater is polluted by improperly disposed of chlorinated hydrocarbons in the 15 to 150 ppb range. The distribution network is fed by wells and pumping plants scattered all over the city area and yield water containing different contaminant species in different amounts, which also vary in time. Our aim has been to evaluate the amounts of pollutants which reach the end user and eventually to estimate the risk they entail. A number of sampling points was established soon after pollution was first detected (1977). Concentration data from said points allowed the "zoning" of the city: areas were looked for where time averaged (1 year) concentration values fell within a given range. Zones were defined by a simple statistical preprocessing of data followed by deterministic interpolation. Zone contour sensitivity with respect to data from additional sampling points has been studied.

The second problem, i.e. risk assessment, is now being considered. A database containing a detailed city map and the number of inhabitants living in each house block has been created. We can therefore compute:

- a) how many people drink water containing given levels of given contaminants;
- b) how high is the toxicological risk in a given city area.

These results will be applied to water distribution management and to aquifer reclamation. Moreover, they will be fed back into the data collection procedure, in order to optimise the location of sampling points and the time intervals between samples.

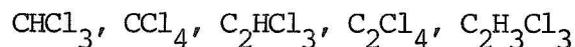
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STRUCTURE OF MILAN MUNICIPAL AQUEDUCT

- more than 600 wells, screened from 40 to 100 metres in an alluvial aquifer lying under the urbanised area
- 39 pumping plants, where wells are clustered
- more than 2,100 km of a highly interconnected water distribution network
- more than 1,750,000 inhabitants served.

THE CONTAMINATION

- Chlorinated solvents



were detected as contaminants of well water since 1976.

- These data depict the 1985 situation:

THE IMPLICATIONS

- Two main practical problems arose:
 - 1 - control of aquifer contamination
 - 2 - evaluation of effective population exposure through distributed drinking water
- The solution of pb. n° 1 requires enormous financial resources and will take some decades.
- Therefore priorities in interventions are set by spatial distribution of exposure levels.

EVALUATION OF MILAN POPULATION EXPOSURE DUE TO DRINKING WATER

- Phase 1: monitoring water distribution system
- Phase 2: mapping population density
- Phase 3: evaluating exposure
- Phase 4: assessing risk.

PHASE 1

- 86 sampling points in the network selected according to the following pragmatic criteria:

- approximate contamination level at given area
- estimated population density in given area
- type of land use (residential vs. commercial and industrial)
- pumping plant outlets included in sampling point set.

As required, sampling are not uniformly distributed throughout the city area.

- Bimonthly sampling frequency
- Headspace GLC/ECD analysis of chlorinated solvents
- Data processing
 - hardware: CILEA's UNIVAC 1100/90 (Segrate, Milan)
 - preliminary statistical assumption: total concentration values are samples of normally distributed process
 - compute mean value (m), standard deviation ($s.d.$), $m - s.d.$ and $m + s.d.$ at each sampling point
 - divide city area into 33×33 point uniform grid, s.t. mesh area $\hat{=} 0.22$ km sq, consequently sampling points need not coincide with grid points
 - interpolate said values by inverse distance weighted law (SURFACE II graphics package)
 - plot maps of contamination contours

PHASE 2

- Population census (1971) data discretised at house block level (more than 9500 blocks)
- hardware: Univac 1100/90
- population density referred to 33×33 grid

PHASE 3

- Exposure at a point of 33×33 grid :=

(total solvent concentration) x (population density)

PHASE 4

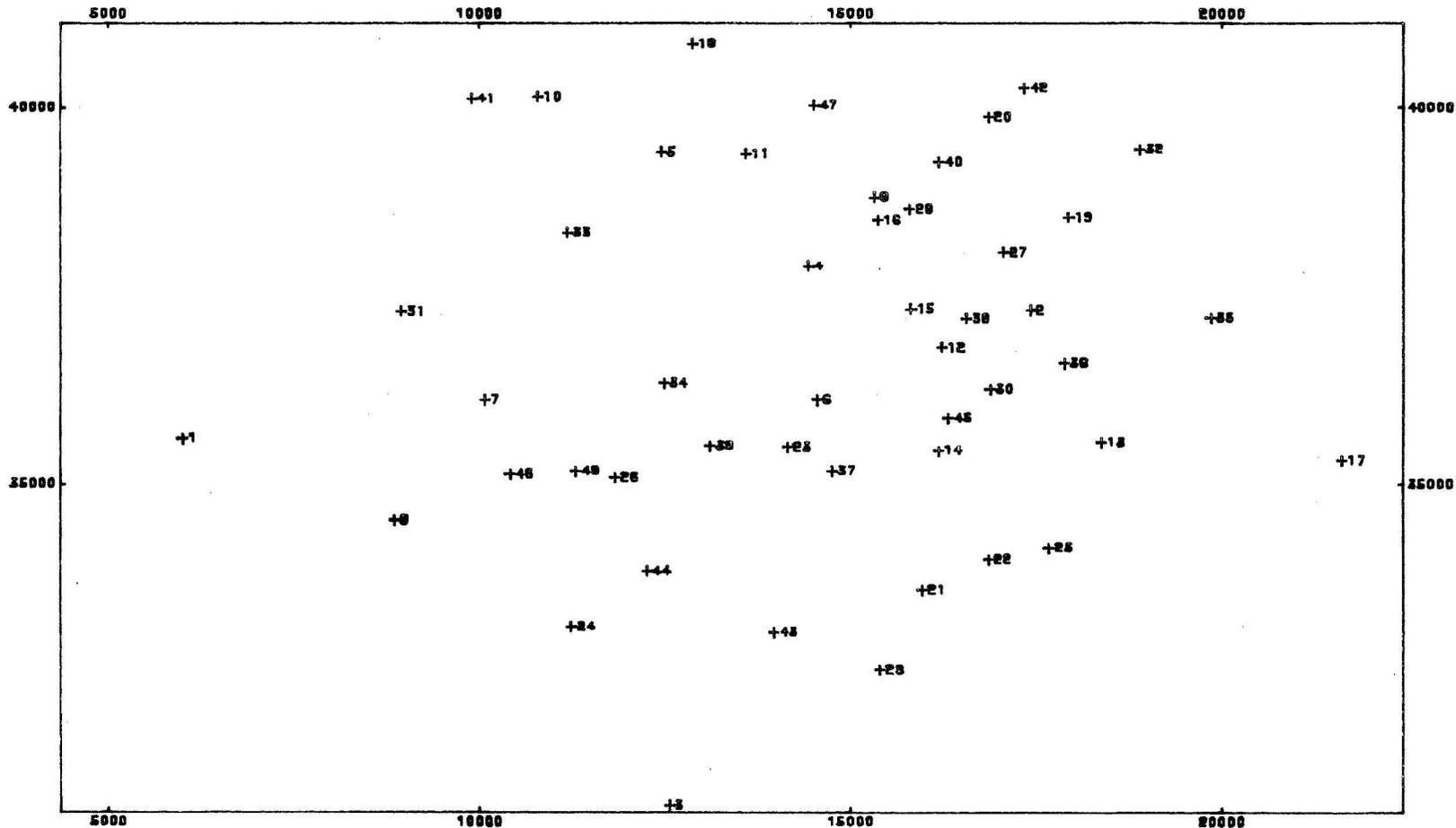
- A pragmatic & conservative approach assessment has been chosen:
 - * 10^{-6} excess tumor death due to 2 litres/day lifelong consumption of water containing 1 $\mu\text{g/litre}$ of total chlorinated solvents
- Risk at a point of 33 x 33 grid :=
(population density) x (total chlor. solvent concentration) x 10^{-6}
- Compute total risk & risk level distribution
- Plot maps of risk contours
- Evaluate spatial distribution of risk

REMARKS

- Main objectives of this approach:
 - * to estimate how many people are drinking which kind of water and where
 - * to supply a simple decision making tool to the public health Authorities
- Once the influence area of each pumping station is better defined, modelling & management of an intervention at water supply sources (contaminated ground, wells, pumping station, network) will be allowed.
- All process phases are computer assisted
- The model needs some refinements:
 - * sampling point value meaning and statistical relevance
 - * cross-check with different interpolation methods (e.g. "kriging")
 - * updating of census data
 - * separate processing of data for each solvent (concentration values, intrinsic risk level)

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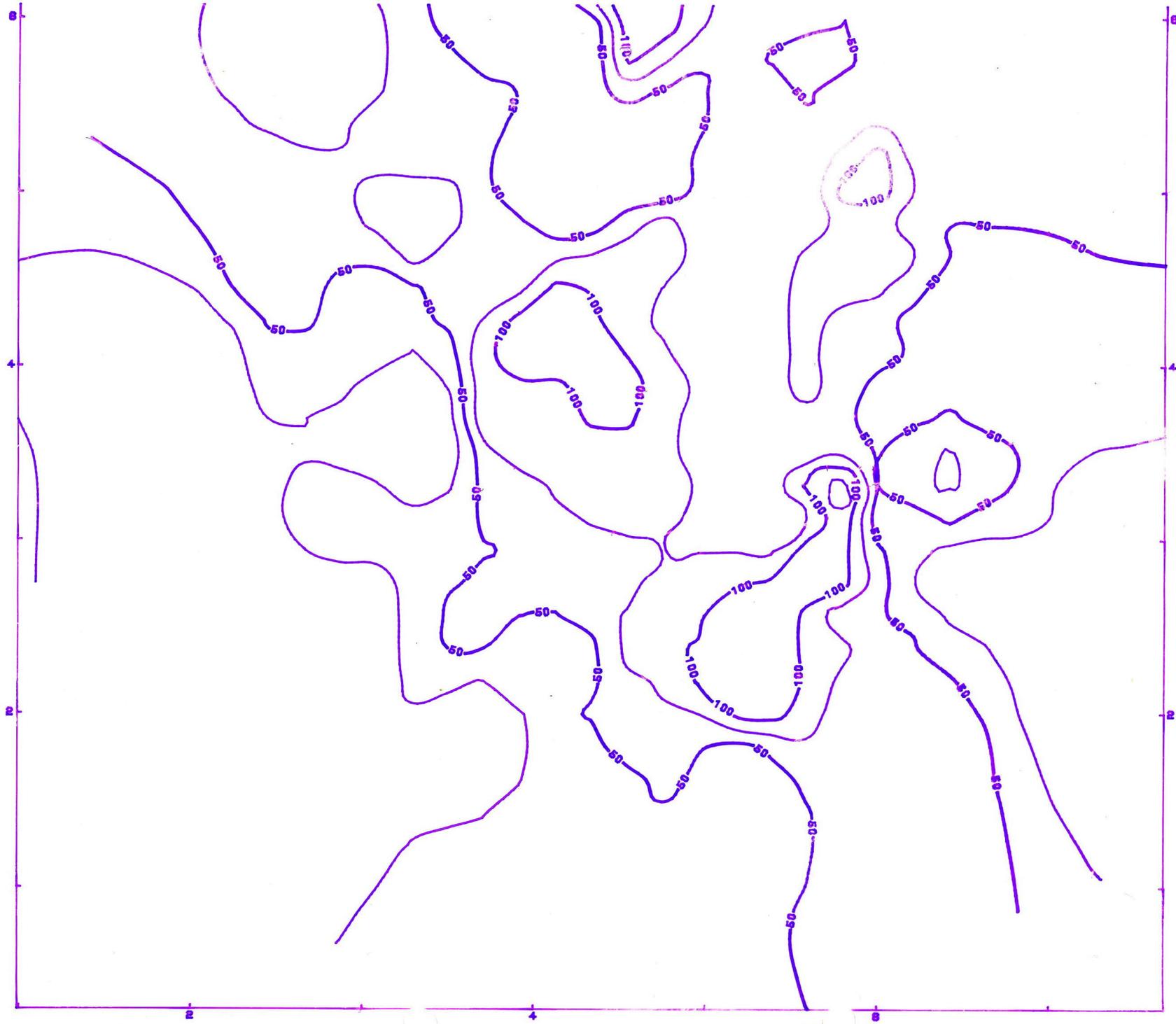
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12 STOP



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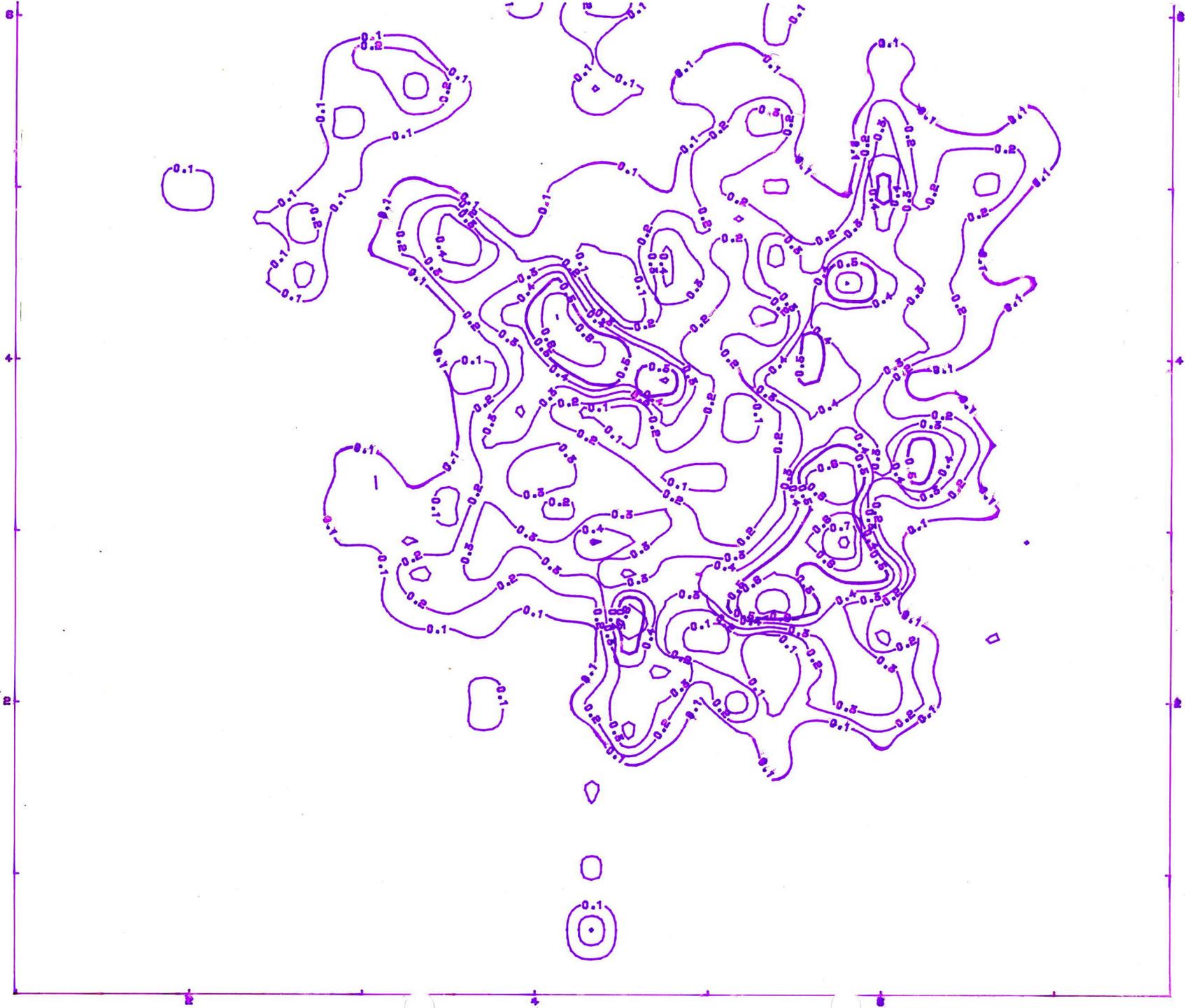
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