State Nuclear Regulatory Committee of Ukraine

Institute of geological sciences, National Academy of Sciences of Ukraine

SCREENING ASSESSMENT OF RADIONUCLIDE MIGRATION IN GROUNDWATER FROM THE "DNEPROVSKOE" TAILINGS IMPOUNDMENT (DNEPRODZERZHYNSK CITY) AND EVALUATION OF REMEDIAL OPTIONS

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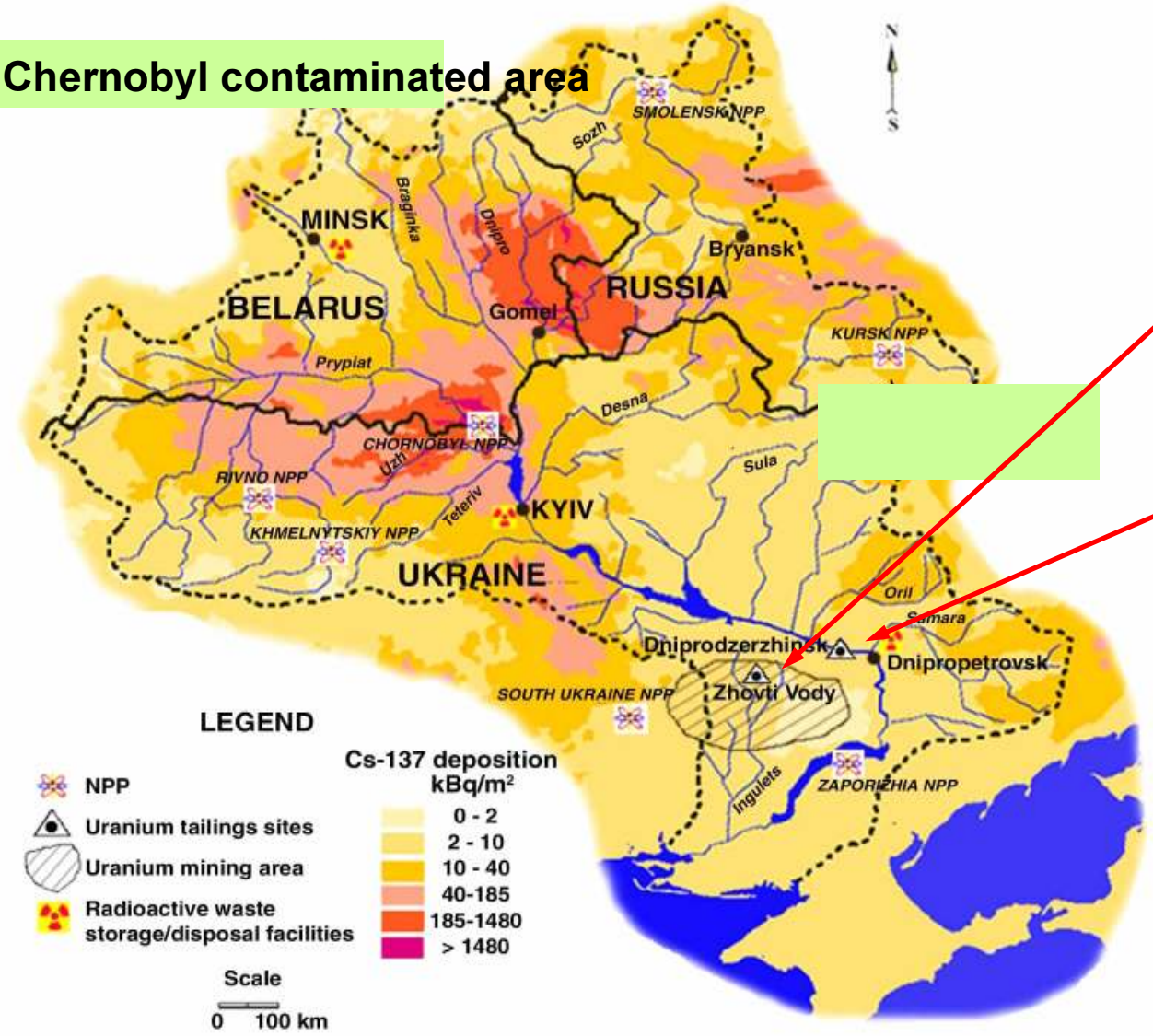
- Location of Prydneprovsky Chemical Plant (PCh.P) and general characteristic of its tailings.
- Hydrogeological conditions and monitoring system.
- Screening assessment of radionuclide migration from “Dneprovskoe” tailings:

  - radionuclide transport modeling software,

  - parameters of the radionuclide transport model,

  - modeling predictions of groundwater transport of uranium from tailings “Dneprovskoe” to Dnepr River under different remediation scenarios.
- Conclusions

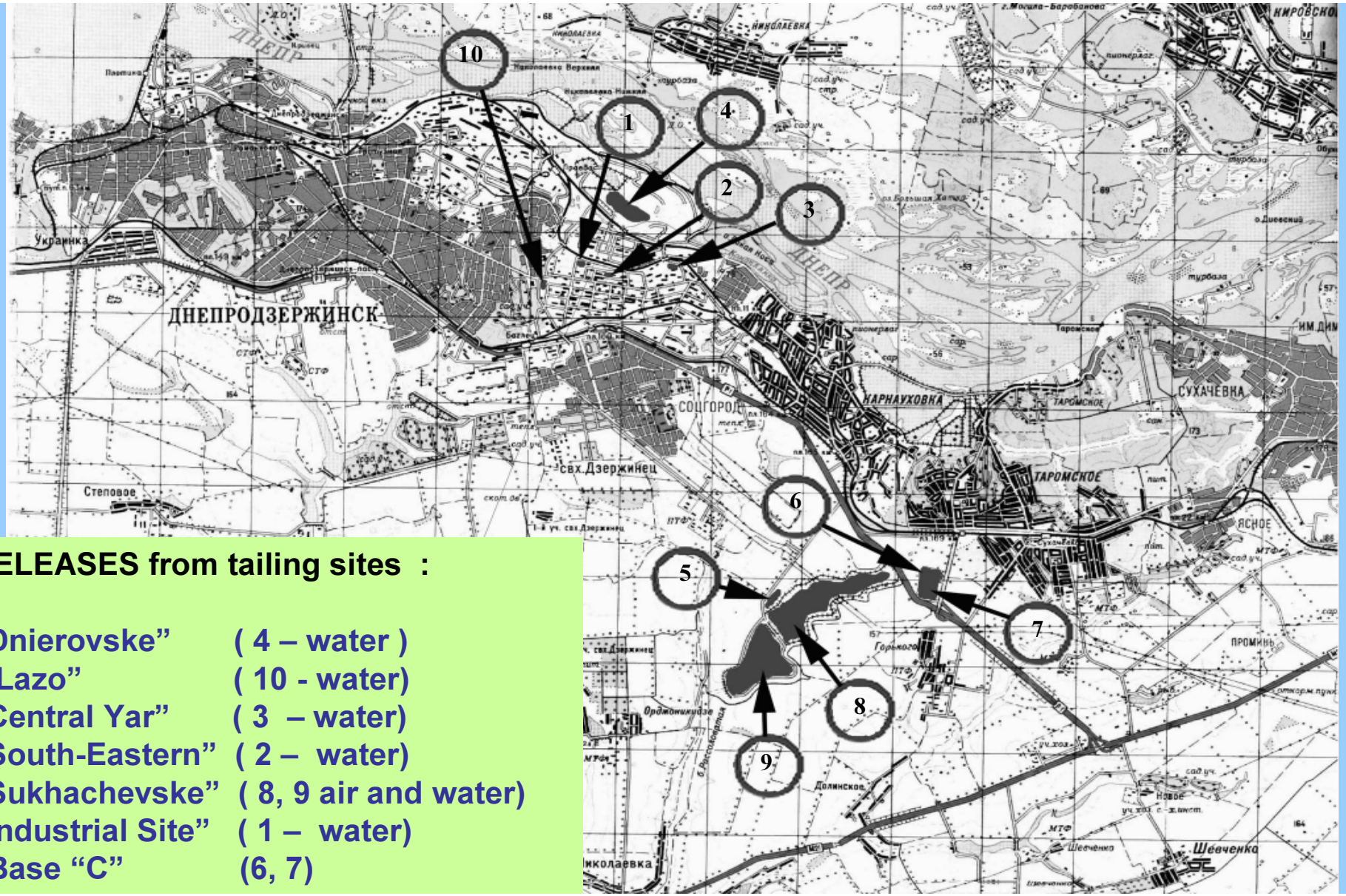
Chernobyl contaminated area



Uranium Mining and Milling area

Dneprodzerzhinsk site

Uranium tailings in Dneprodzerzhinsk site



RELEASES from tailing sites :

"Dnierovske"	(4 – water)
"Lazo"	(10 - water)
"Central Yar"	(3 – water)
"South-Eastern"	(2 – water)
"Sukhachevske"	(8, 9 air and water)
"Industrial Site"	(1 – water)
"Base "C"	(6, 7)


р.Дніпро
шламовідстійник КХЗ
золонакопичувач ДМК
Хвостосховище
"Дніпровсьек"
р.Коноплянка
ПХЗ
кар;єр
Тритузний

Basic objects subject to the control and rehabilitation

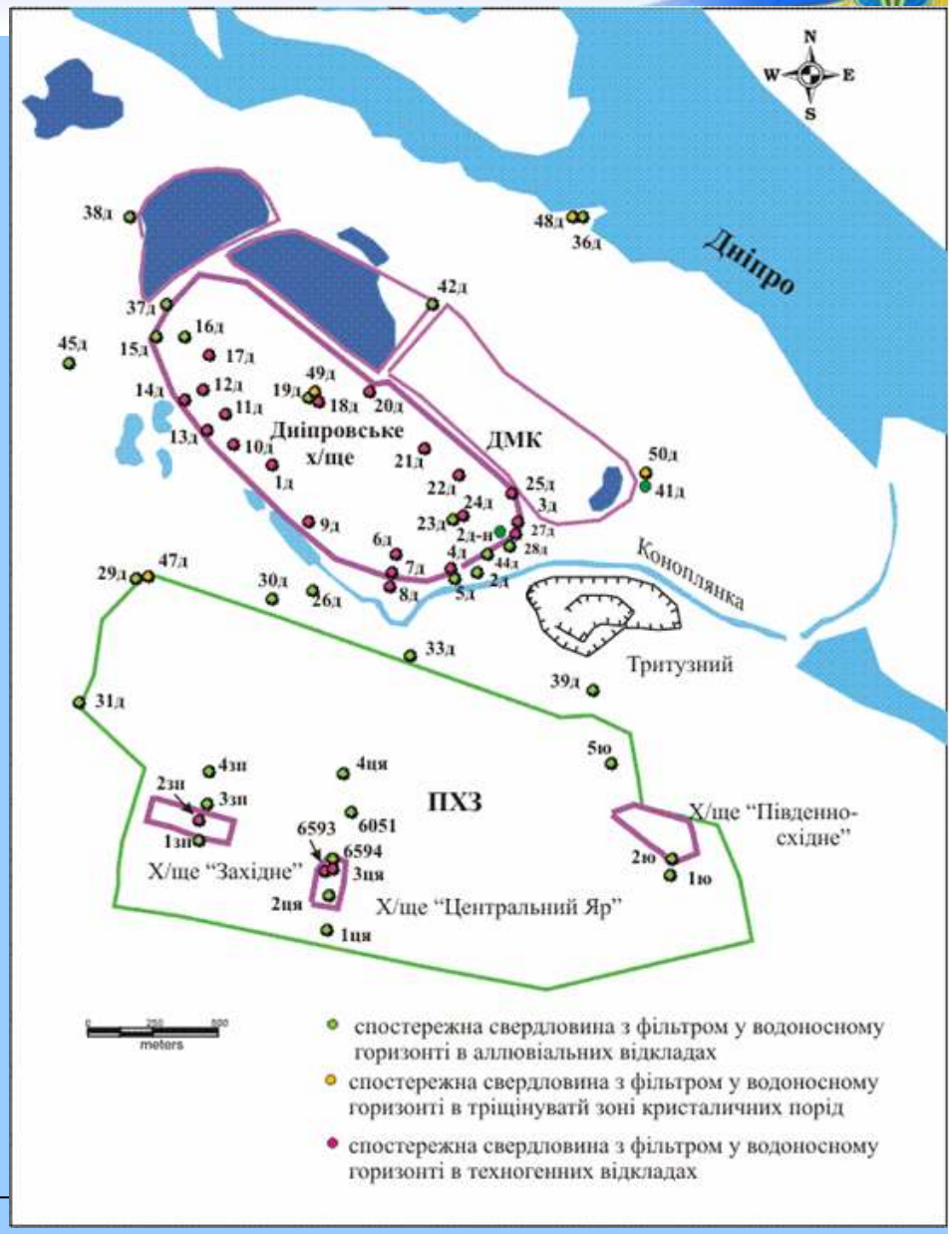
“Dneprovskoe” tailings

General characteristics of the PCh.P tailings

Tailing names	Period of operation	Area, hectares	Amount of the waste, x10^6 t	Volume, x10^6 m^3	Gross activity, TBq
„Western“	1949-54	6.0	0.77	0.35	180
„Central yar“	1951-54	2.4	0.22	0.10	104
„South-Eastern“	1956-80	3.6	0.33	0.15	67
“Sukhachevskoe” 1st section	1968-83	90	19.0	8.6	710
“Sukhachevskoe” 2nd section	1983-92	70	9.6	4.4	270
„Base C“	1960-91	25	0.3	0.15	440
„Dneprovskoe“	1954-68	73	12.0	5.9	1400
„Lantan fraction“	1965-88	0.06	0.0066	0.0033	130

The monitoring well network at PChP site

The system of the hydrogeological monitoring consists of 57 wells. The 49 of these wells are setted at the tailings "Dneprovskoe". The tailings "Western" is equipped by 4 wells, a the tailings "Central Yar" is equipped by 3 wells. There are no monitoring wells at the tailings "South-East".



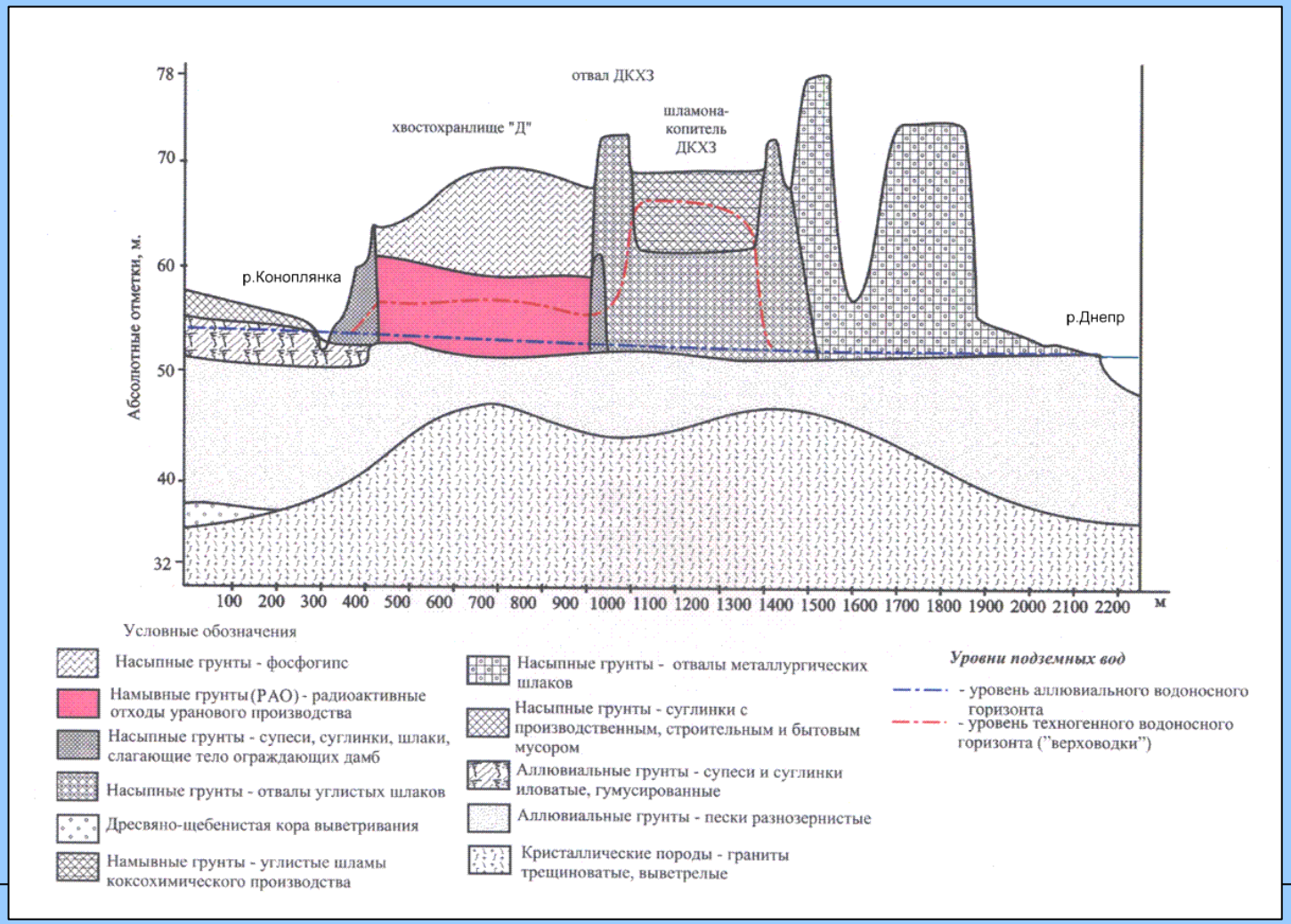
The monitoring well network at PChP site

The 4-D control well

Table 3. Radiation characteristics of groundwater of "D" site in selected wells for years 2005/2006 (Voitsekhovitch et al., 2006)

Well #	Salinity g/L	U-234 Bq/L	U-238 Bq/L	Σα Bq/L	Σβ Bq/L	$^{234}U/^{238}U$
2-D	7,3 7,2	0,73±0,16 <0,03	0,90±0,18 0,20±0,02	2,62±0,78 0,23±0,04	4,6±1,4	0,81 0,42
4-D	6,4 11,1	0,26±0,05 2,5±0,5	0,22±0,05 2,4±0,5	0,84±0,24 5,0±1,0	10±3	1,18 1,04
19-D	19,3 18,4	7,3±1,3 9,38±2,40	6,8±1,3 5,69±0,31	15,1±3,0 16,0±3,2	7,9±2,3	1,07 1,6
16-D	2,3	2,36±0,35	2,41±0,35 5,4±1,2	5,8±1,4 5,8±1,2	-	0,98
48-D	5,8	0,09±0,03 0,40±0,06	0,09±0,03 0,43±0,06	< 0,2 0,8±0,04	2,0±0,6	1,00

Geological cross-section of tailing “D” along Konoplianka - Dnepr line



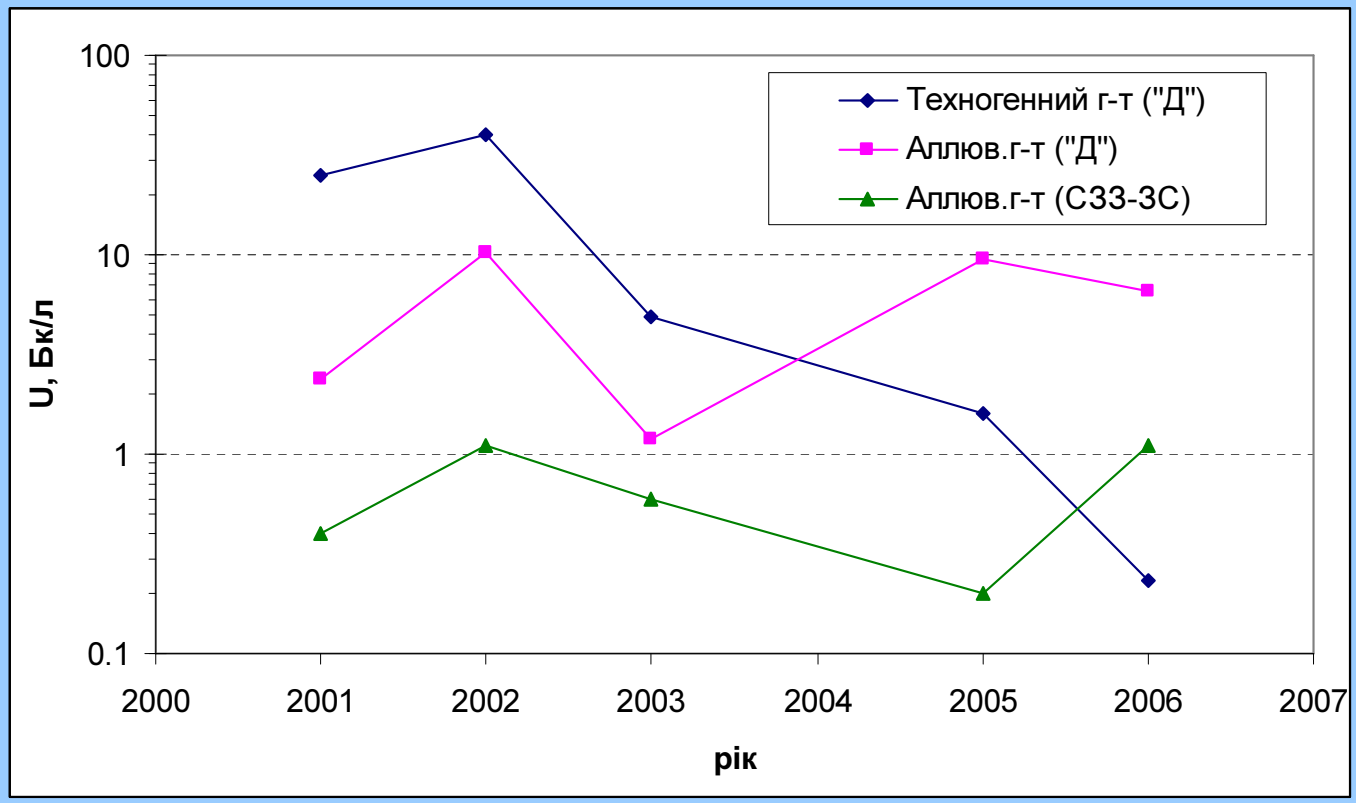
Contents of water - soluble salts in tailing materials

Salt type	CONTENT ml g in 100 g dry material / % in dry material	
	from	to
KNO_3	8,1/0,008	117,3/0,12
KCl	0	7,5/0,007
$NaNO_3$	87,9/0,09	895,1/0,9
NaCl	0	1971,5/2
Na_2SO_4	0	776,7/0,8
$Mg(NO_3)_2$	0	923,8/0,9
$MgCl_2$	0	43,8/0,04
$MgSO_4$	24,1/0,02	1270,7/1,3
$Ca(NO_3)_2$	0	946,9/0,9
$CaCl_2$	0	29,4/0,03
$CaSO_4$	186,6/0,19	1274,2/1,3
$Ca(HCO_3)_2$	0	149,8/0,15

Specific activity of main radionuclides in tailing materials

Specific activity, Bq/kg	U	^{226}Ra	^{230}Th	^{210}Pb	^{210}Po
average	3576	1772	13927	24207	18445
max	12238	10656	41699	90650	71410

Average contents of uranium in underground waters within zone of tailing pond “D”, control and observation zone (2000-2006)

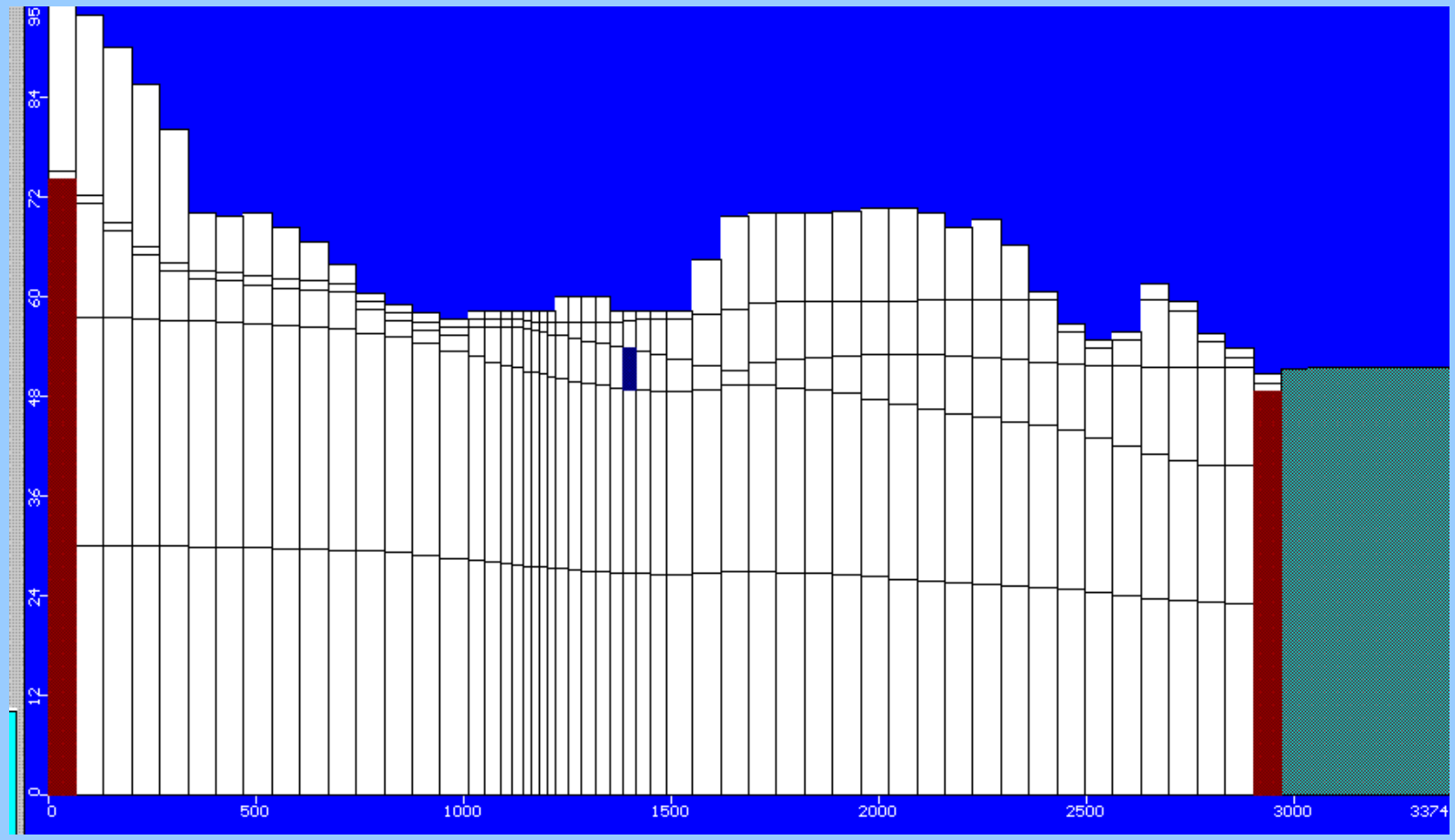


Filtration model of tailings “D” site

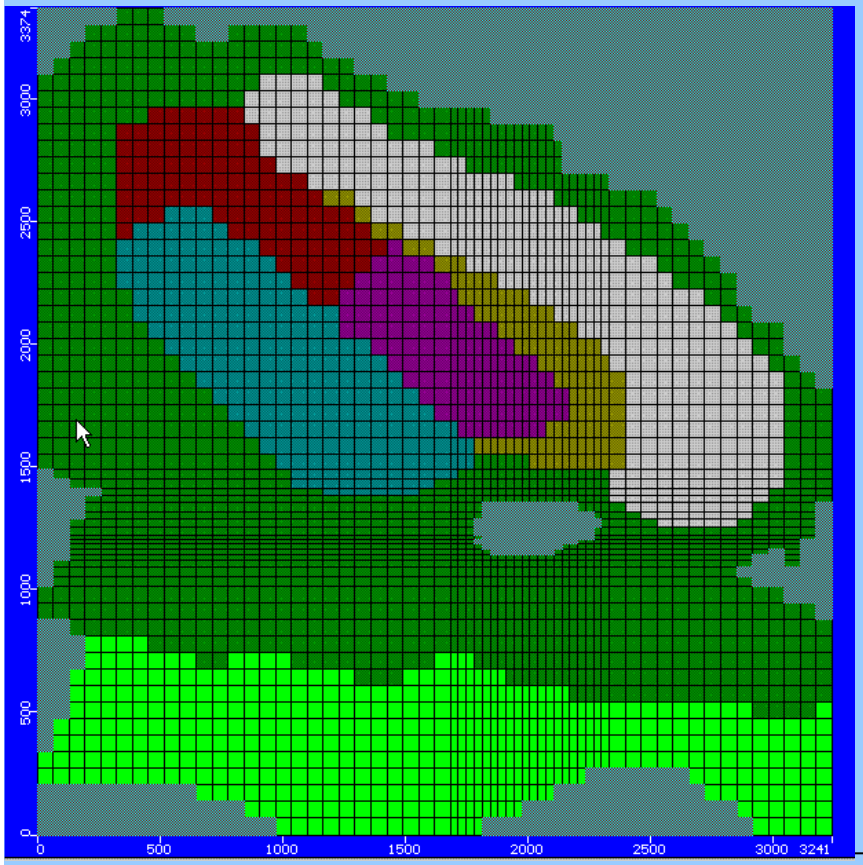
Visual Modflow 3.0 PRO is integrated soft for 3-D modeling of underground water flow and pollution (radionuclide) migration. It included design module MODFLOW, MODPATH, ZoneBudget, MT3Dxx/RT3D, and WINPEST

Filtration zone and boundary condition for modeling

Cross section of filtration model along 21 column



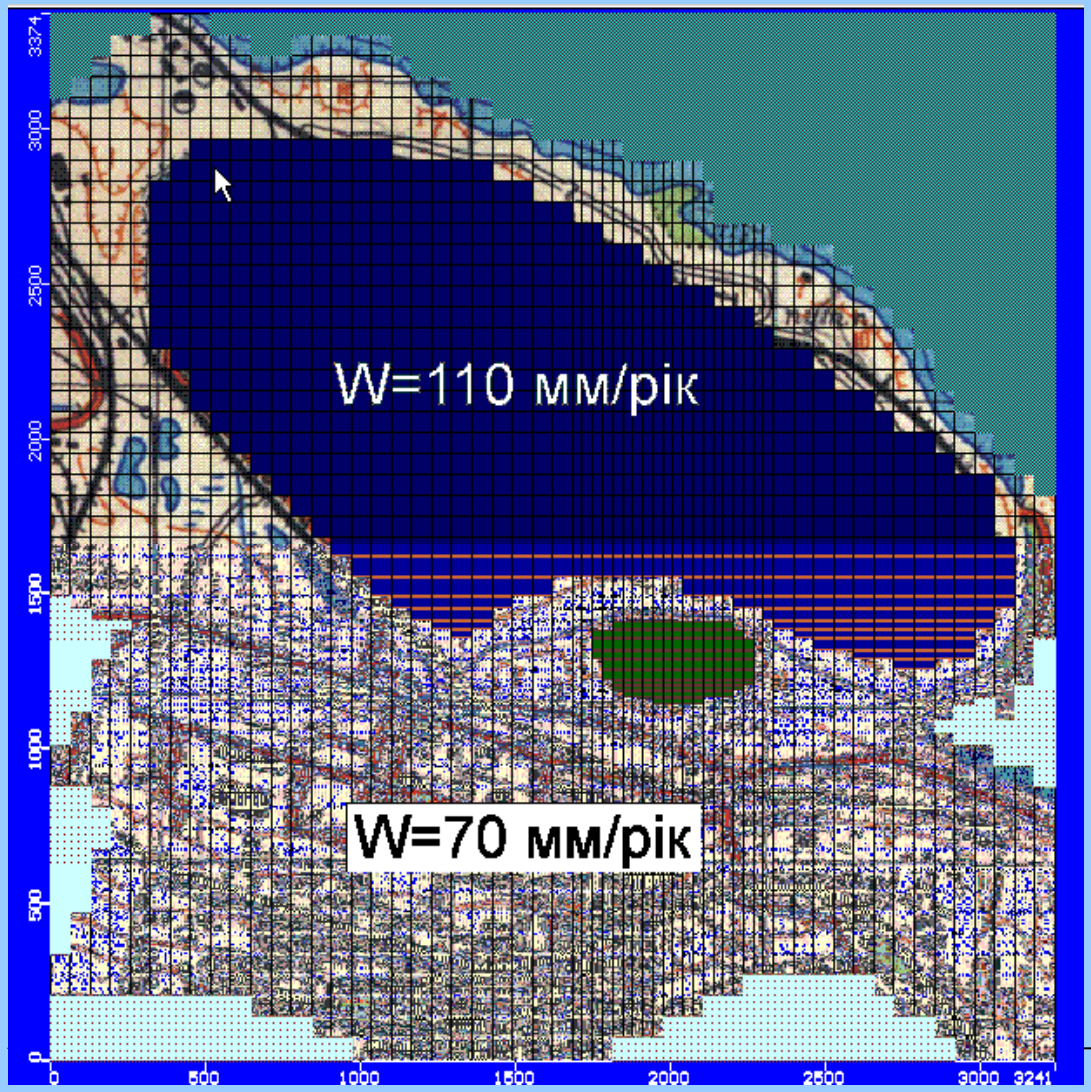
Dispersion of filtration property of rocks in zone of 2-nd calculation layer of filtration model



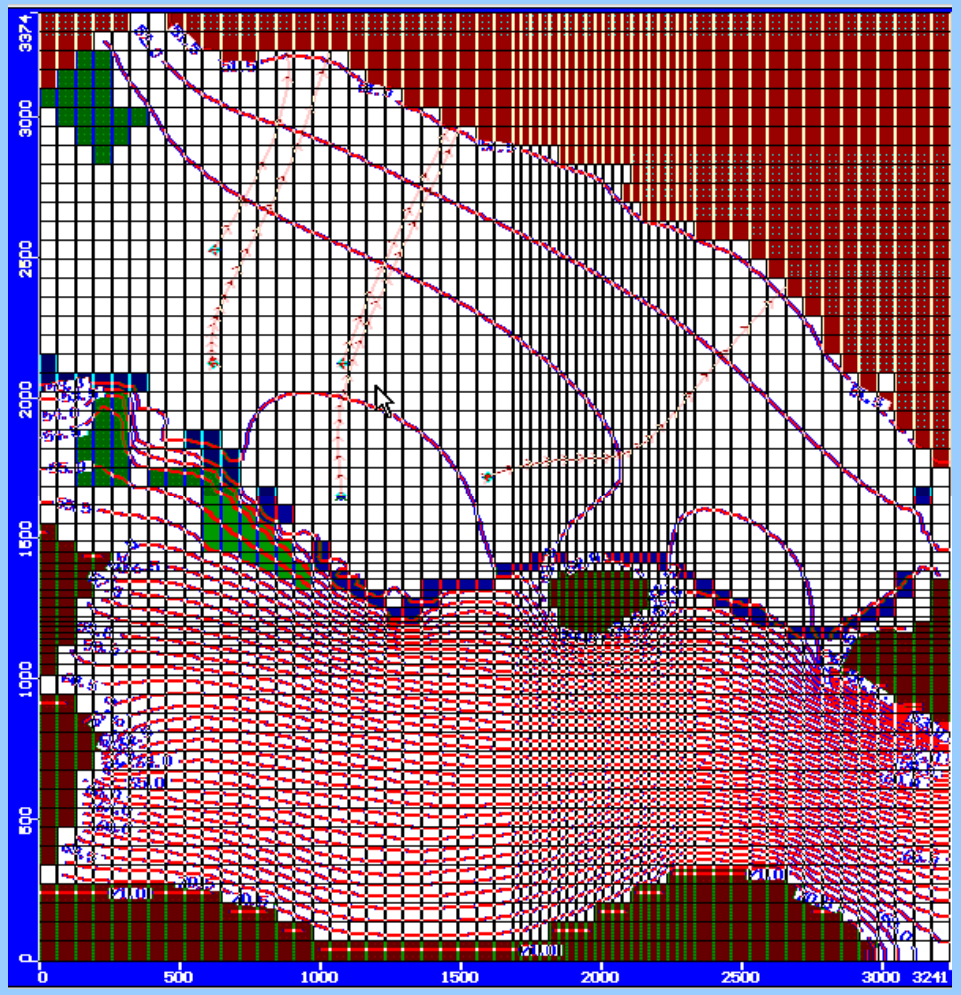
Conductivity

Zone	Kx [m/d]	Ky [m/d]	Kz [m/d]	Active	Distribution Array
1	0.1	0.1	0.1	☑	☐
2	5.5	5.5	5.5	☑	☐
3	7	7	7	☑	☐
4	0.01	0.01	0.01	☑	☐
5	0.68	0.68	0.68	☑	☐
6	0.5	0.5	0.5	☑	☐
7	0.67	0.67	0.67	☑	☐
8	0.67	0.67	0.67	☑	☐
9	0.3	0.3	0.3	☑	☐
10	1	1	1	☑	☐
11	0.1	0.1	0.1	☑	☐

Color scale of filtration coefficients

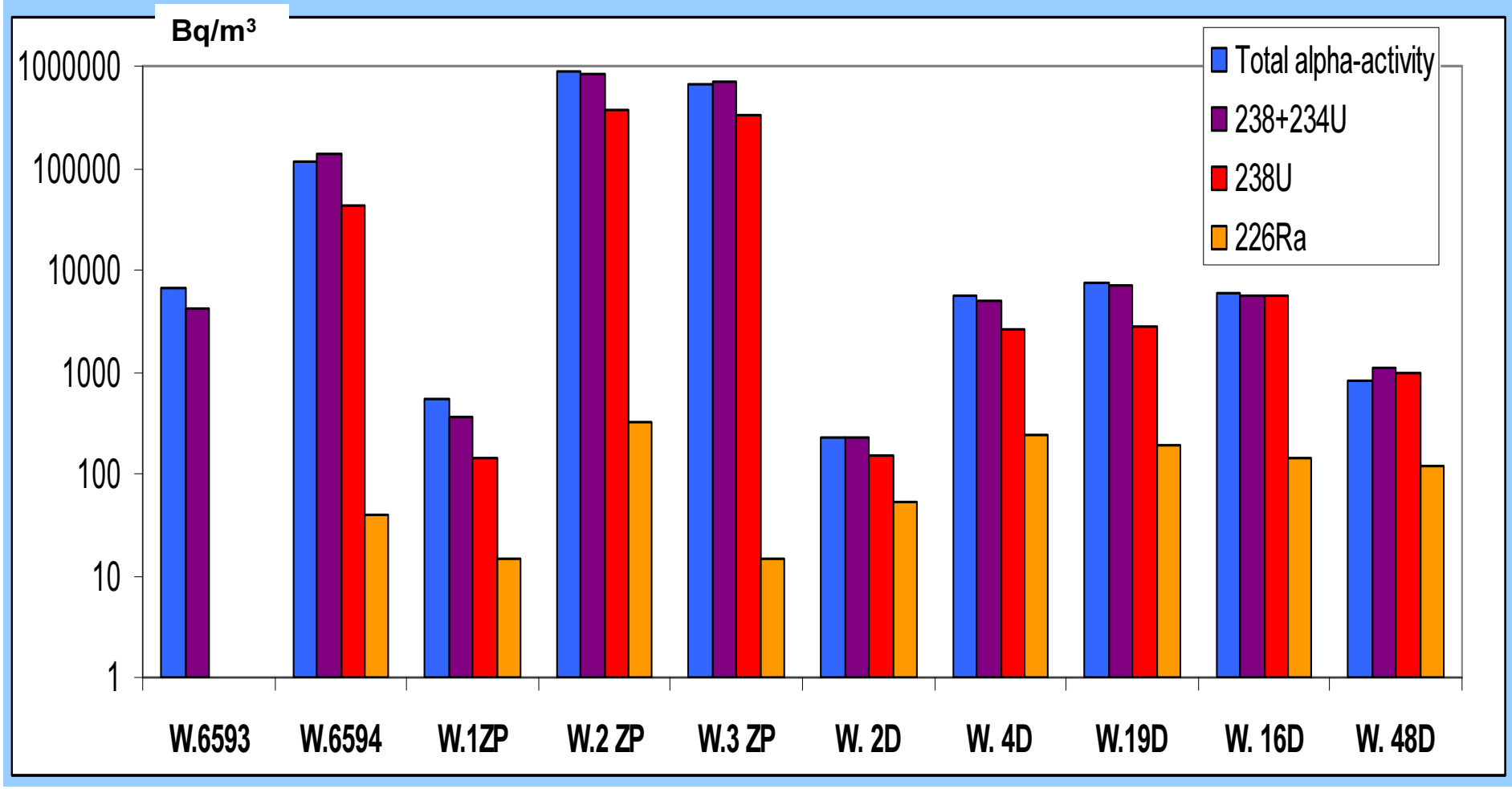


Dispersion of filtration feed (input) in filtration zone of tailings “D”



Dispersion of underground water layers on calibration stage.
(real conditions for Treetuzny pit)

$^{234,238}U$ и ^{226}Ra in porous water of tailings 2006-2007



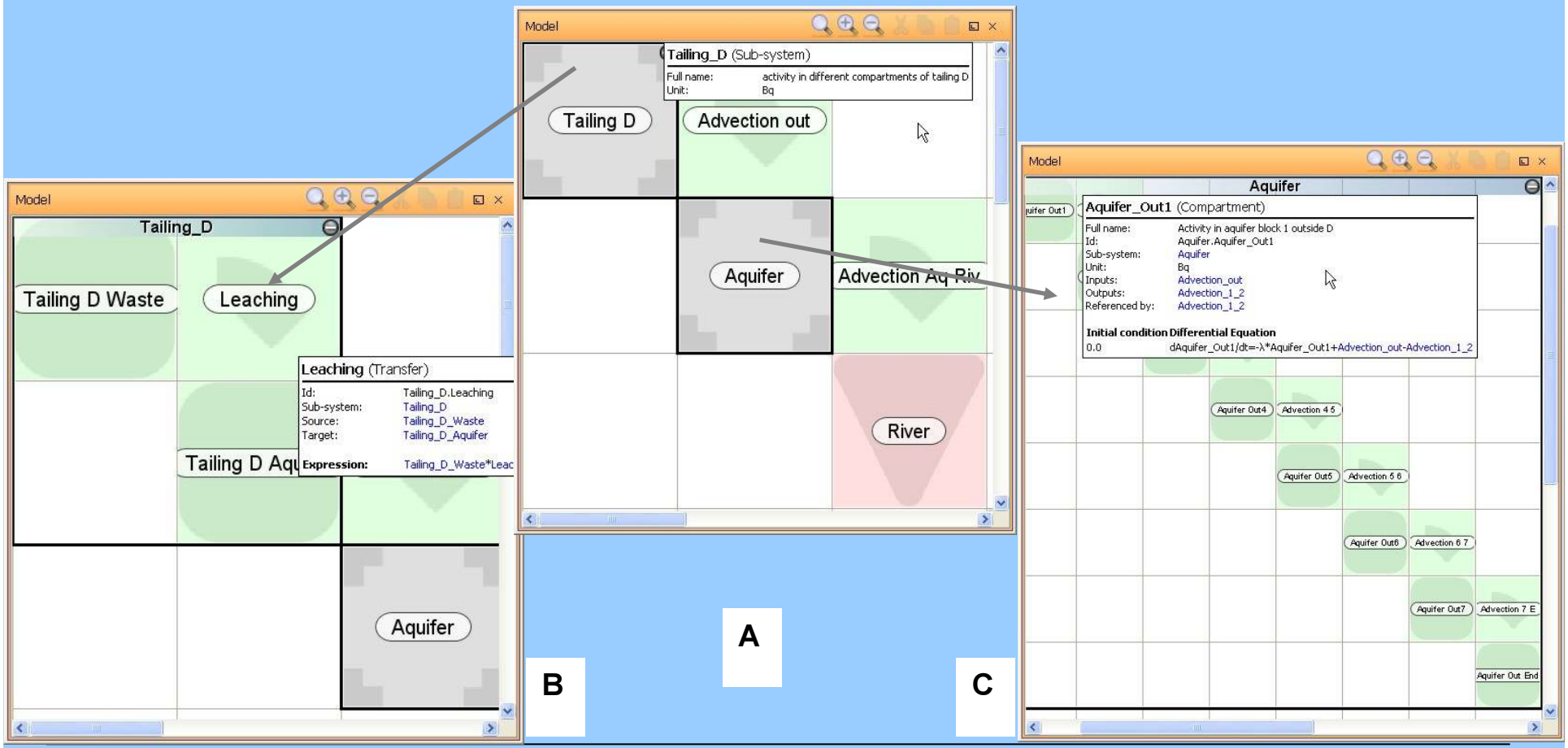
Tailing "Centralny Yar"

Tailing "Zapadnoe"

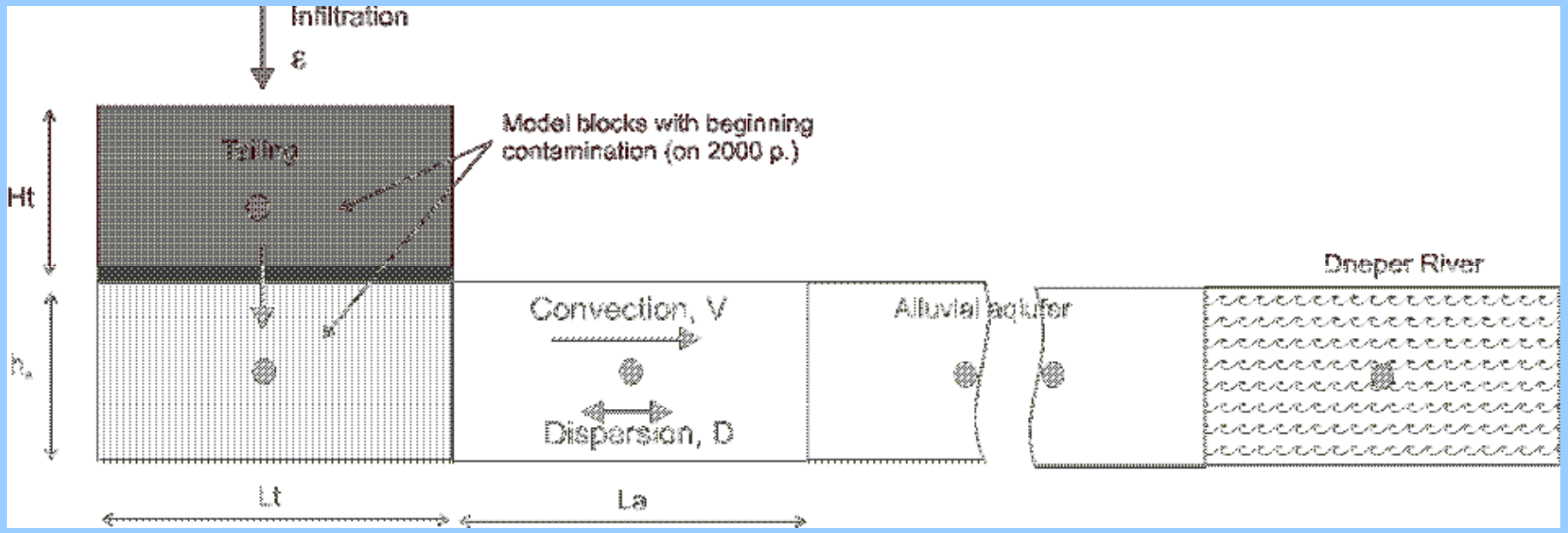
Tailing "Dniprovske"

- Prediction calculation for radionuclide migration from tailings “D” carried out by use of the “Ecolego” soft, developed by SSK.

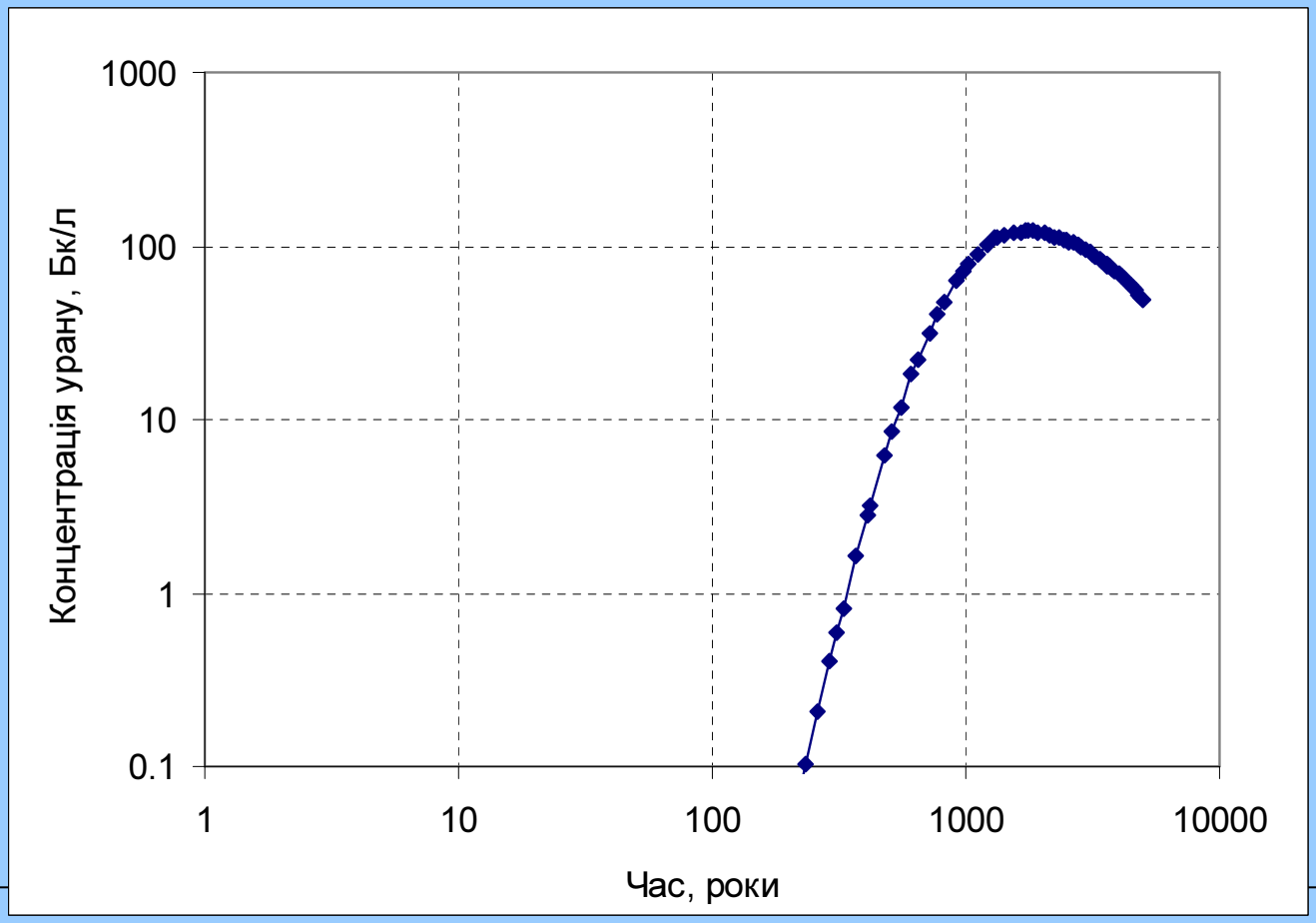
"Ecolego" interaction matrix for radionuclide migration model from "D" tailings: (A) – general matrix, (B) – tailing sub system matrix; (C) aquifer sub system matrix



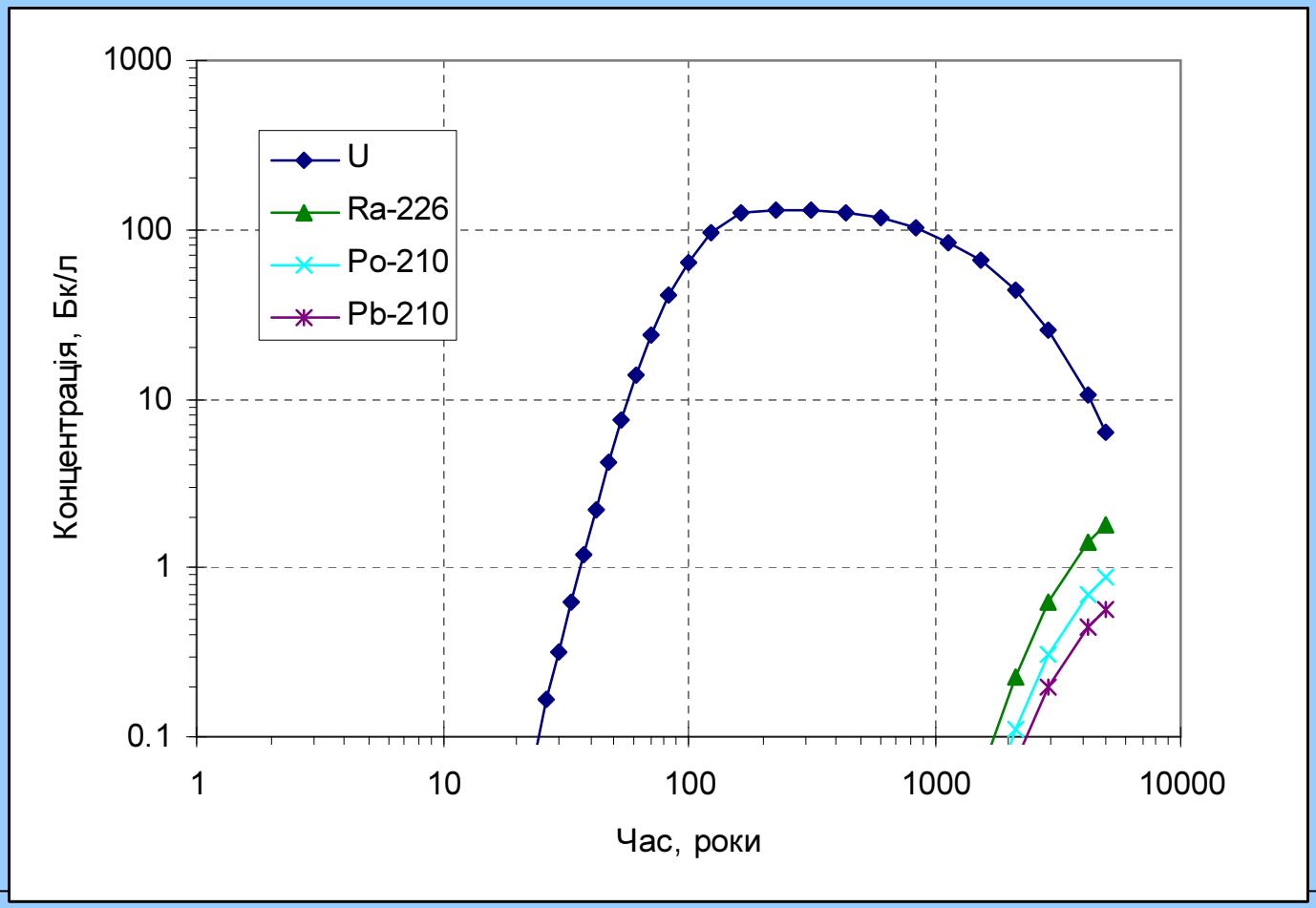
Block scheme of radionuclide migration from “D” tailings



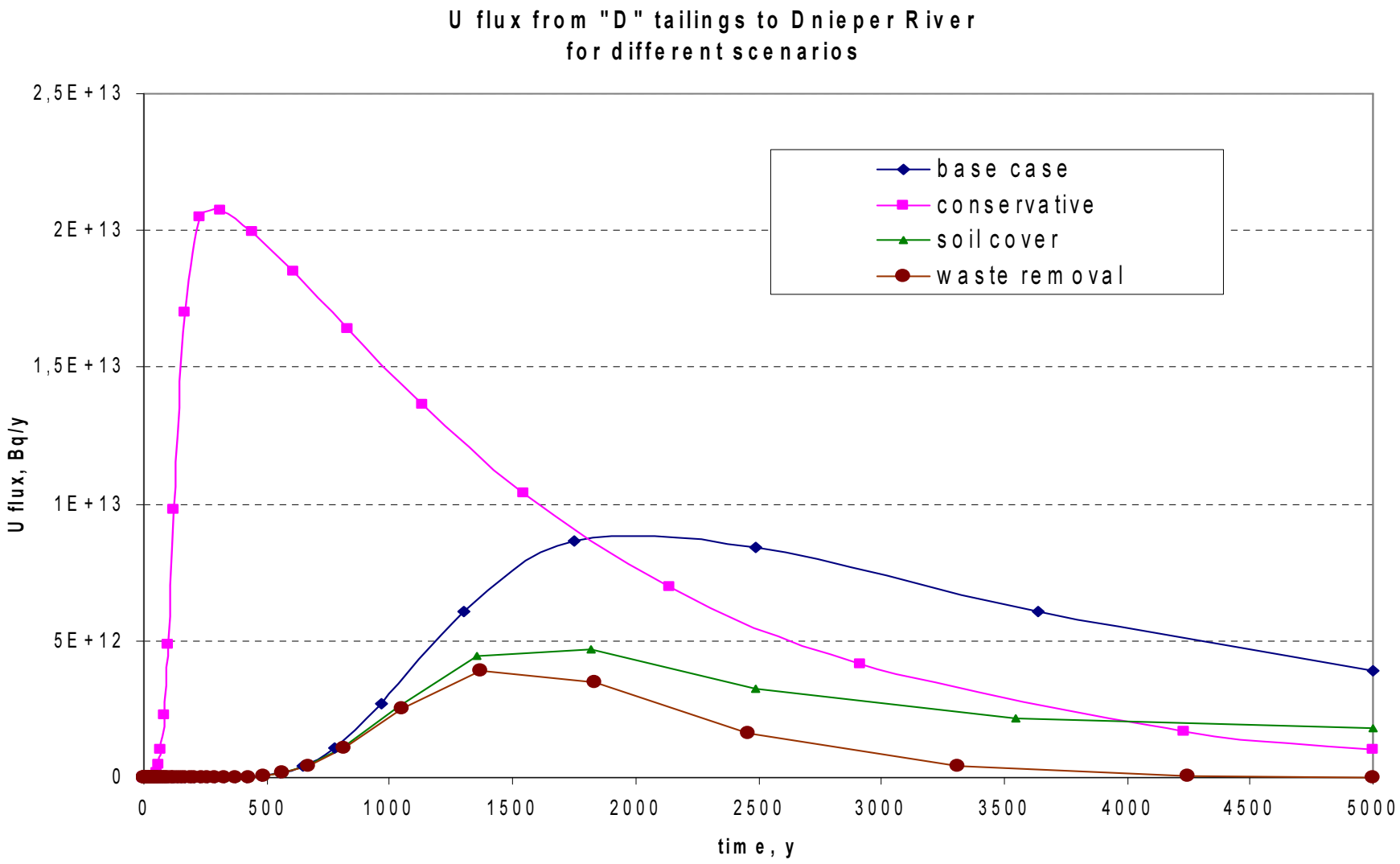
Result of modeling: Base prediction. U concentration in alluvial aquifer on 750 m distance from "D" tailings



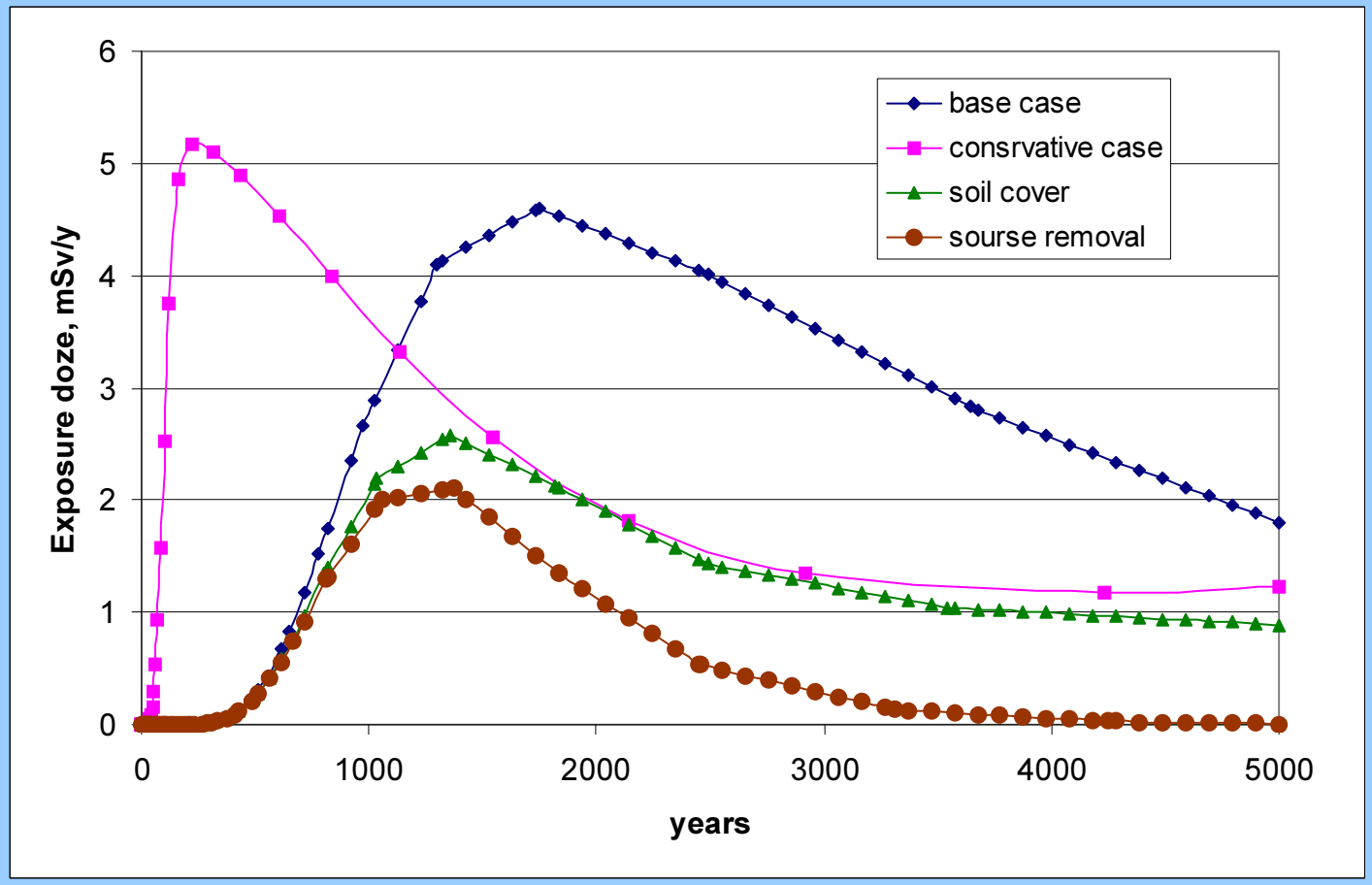
Result of modeling: Conservative prediction. Radionuclide concentration in alluvial aquifer on 750 m distance from “D” tailings



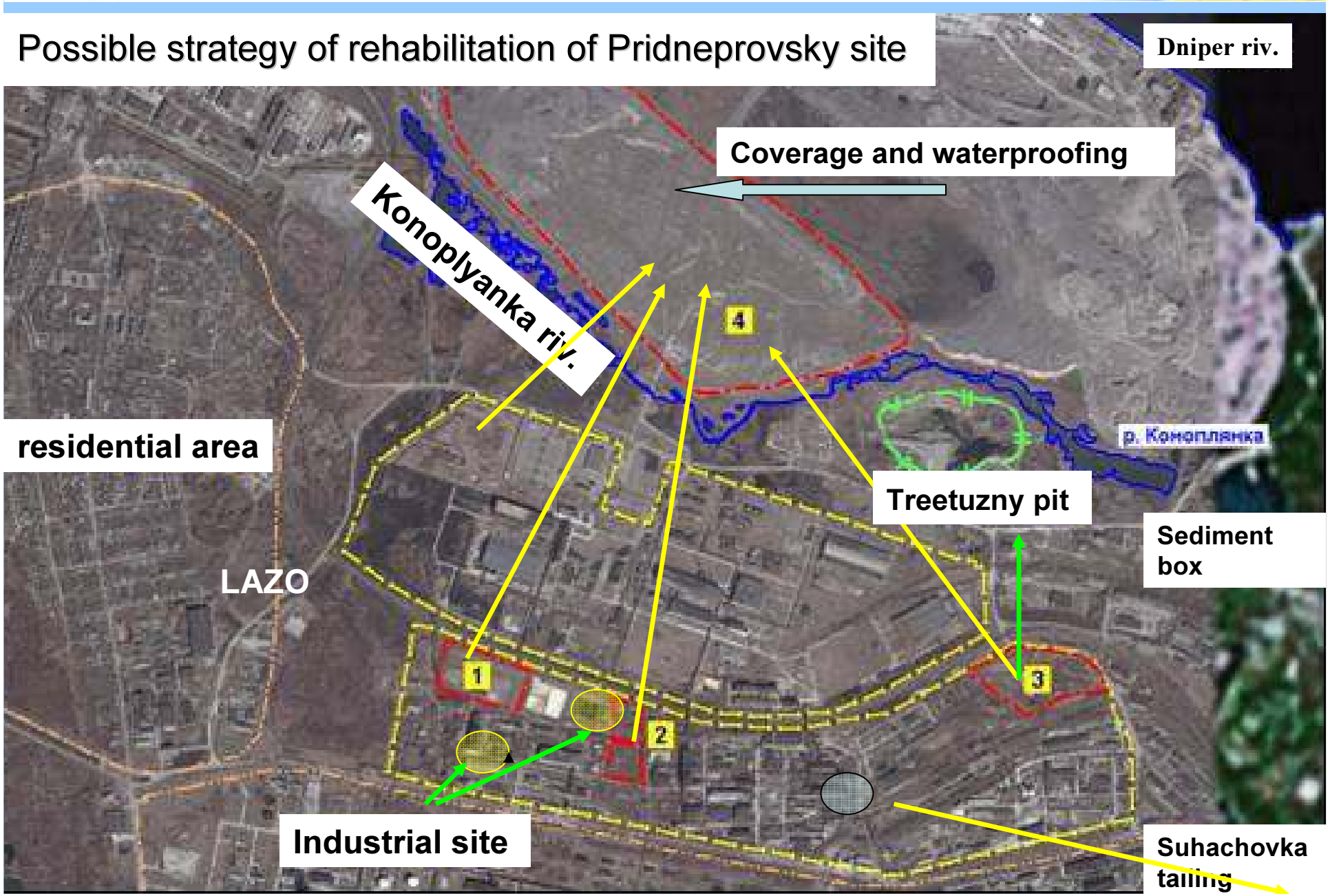
U flux from “D” to Dnepr river for different scenario



Preliminary estimations of effect of tail material deleting or coverage of tailing surface (population dose exposure due to water use on 750 m distance from "D" tailings)



Possible strategy of rehabilitation of Pridneprovsky site



Problems

- Verification of dates.
- Uncertainty and inconsistency of dates.

SUMMARY

- Main source of contaminations – formation of thehnogenic aquifers. Max predicted value of U-concentrations in groundwater on control zone (rehabilitation case) has twice decrease in comparison with base case. Isolation or removing of tailings in the first 1500 years gives the same effect for groundwater contamination. Main sources of contamination is initial radioactive contamination of alluvial aquifer under tailing which exist in both scenarios.

SUMMARY

- For base scenario U-flux to Dneper start in 500 y, max flux (8,7×10E+12 Bq/y) rich in 2000 y.
- For conservative scenario U-migration process occur more fast. Visible U-flux has started in 50 y., max flux (21×10E+12 Bq/y) rich in ≈300 y.
- Covering or removing of tailing result in decreasing of U-flux in twice in comparison of base scenario and have the same effect in first predicted 2000-2500 y.

SUMMARY

- Perspective and effective economical approach could be tailing conservation in-situ by creation of soil cover, which minimize infiltration of atmospheric precipitation into tailing body and minimize of radioactive contamination of ground water.

Result of successful rehabilitation

THANK YOU!