Radioactive wastes repository of high ecological safety.

In worldwide practice of about fifty years solidified low and intermediate level radioactive wastes are stored or disposed in near surface repositories. The near surface repositories are presented with constructions of 4 meter and more in depth (fig.1).

An experience, accumulated with specialists of different countries in a field of near surface repositories operation, has shown that failures of construction integrity occur in some cases. The failures result in radionuclide release out of storage confines. Key factor, effected on integrity of walls and overlays of repositories, is construction disturbance, caused with temperature fluctuation during a year. In countries with low air temperature water, contained in pores and cracks of a construction, freezes in winter. This fact leads to increased stress in the construction and results in its failure.

With purpose to construct a radioactive waste repository of high ecological safety and reliable containment, MosNPO "Radon" specialists developed an advanced type of a repository - large diameter well (LBD) one.

A new repository corresponds to a well with a diameter from 1 to 5-6 m. A depth of the wells depends on geological and hydrogeological conditions of a site and its diameter - on drilling rig capabilities and performance parameters of the repository in whole.

Project of construction of a demonstration unit of LILW storage in large diameter wells at MosNPO "Radon" disposal site near Sergiev Posad has been developed. The aim of the project is development of a technology of LDW repository construction and pilot operation of the new repository during 25-30 years.

Near surface repository

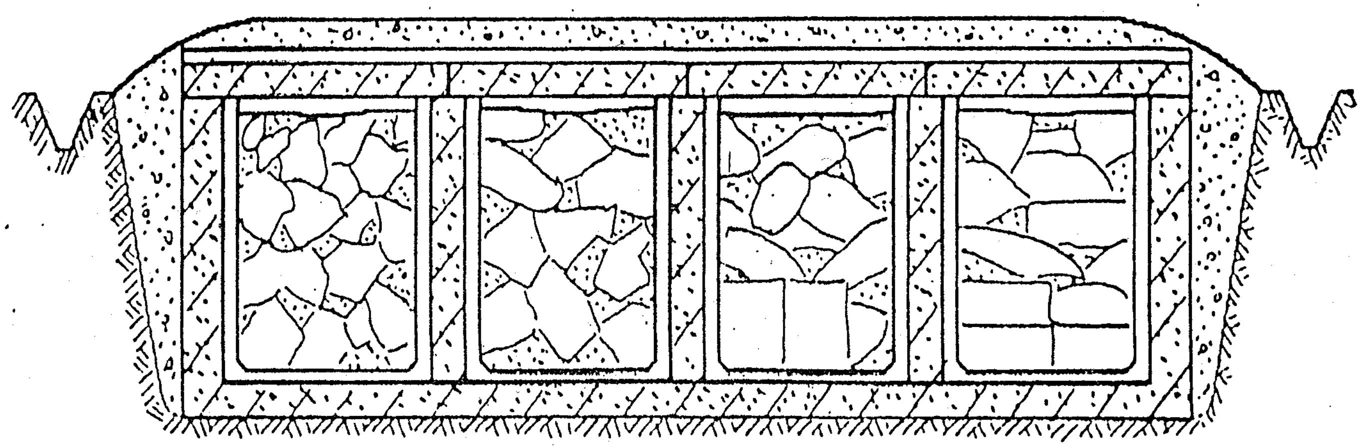


Fig. 1

The project provides construction of 9 wells with a diameter from 1.9 to 4 m and with a depth from 40 to 50 m (fig. 2). The wells are drilled in a grid of 7.2 x 7.2. For radiation and geological monitoring 16 wells are constructed.

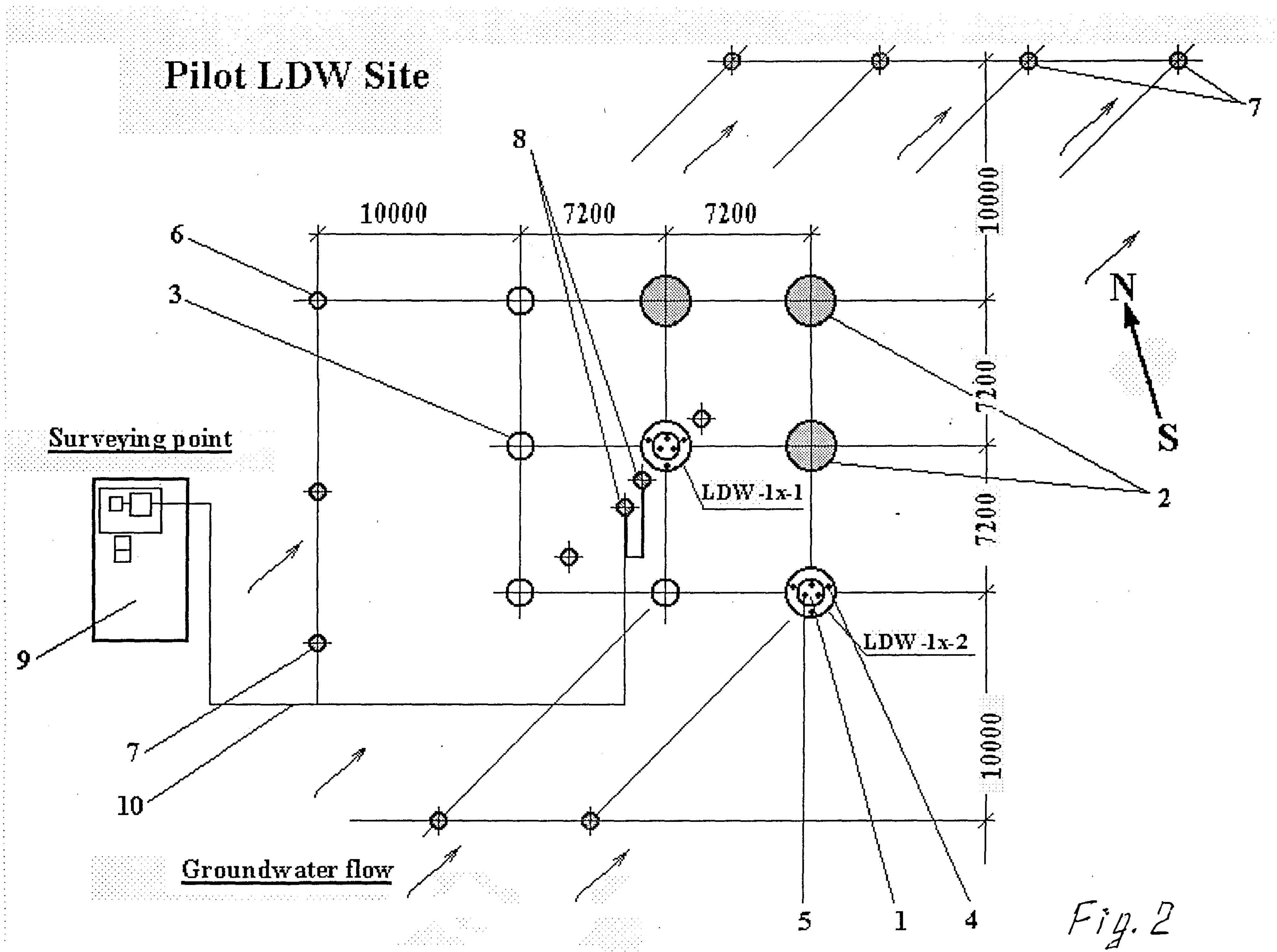
Geology of the test site for LDW construction comprises of moraine firm loam with 65-70 m in thickness (fig.3). The loam includes several sand lenses. In range of 44.8-46.4 m an interbed of clayey sand is in presence. The sand interbed and the lenses contain water, permeability of the sands is between 0.01 and 0.1 m/day. Permeability of clay stratum is about $n*10^{-3}$ m/day.

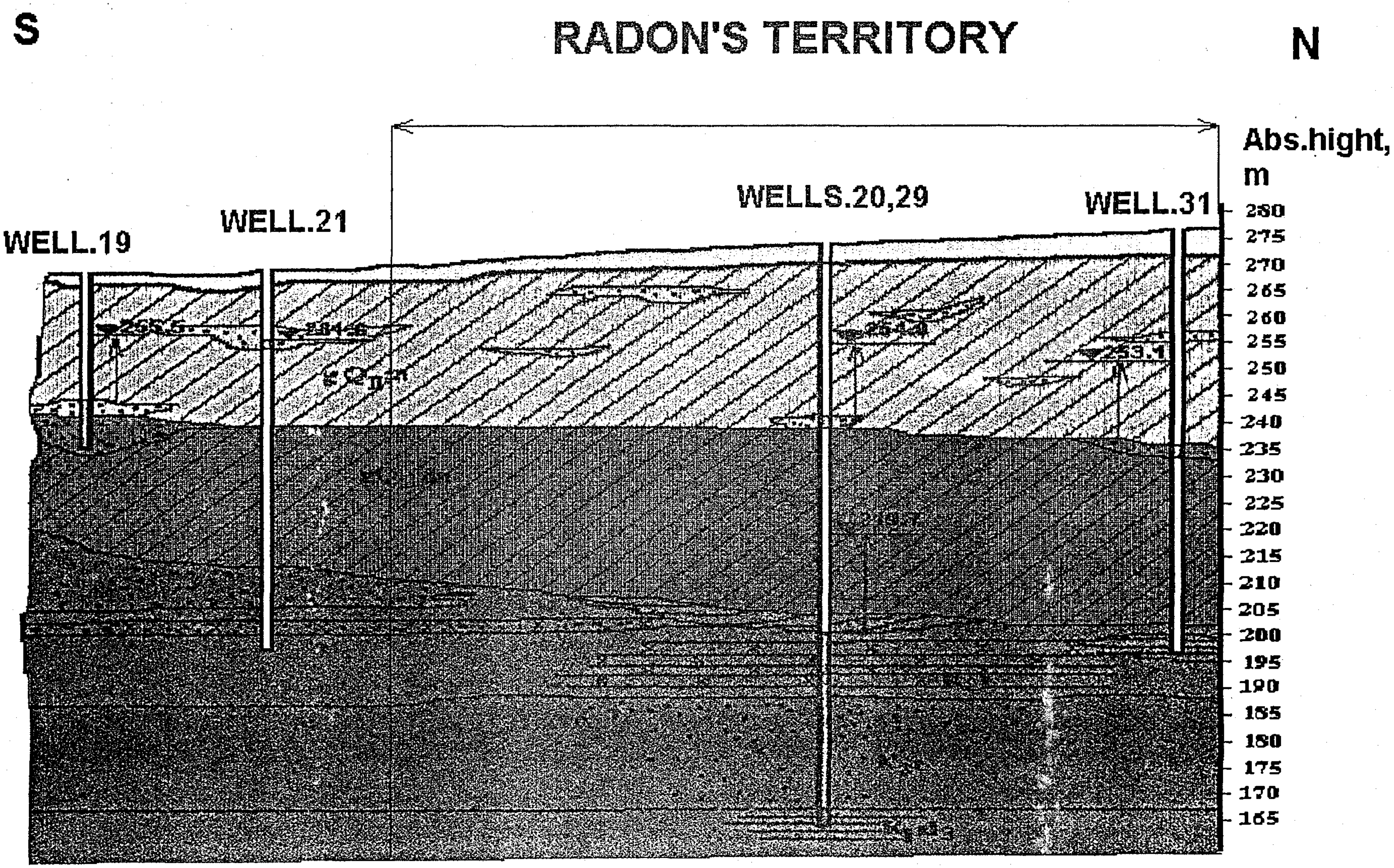
Below of 70 m there is a sandstone stratum with interlayers of clays. Summary thickness of the stratum is about 20 m. The sandstones contain water, its permeability is from 1 to 3 m/day. This is constant aquifer with hydraulic pressure up to 45 m above the roof. The water is not suitable for water supply.

In accordance with the project, 2 LDW repositories has been constructed at MosNPO "Radon" Site. These are wells with 1.5m internal diameter and 40 m in depth (fig. 4).

The wells were drilled with A-50 drilling rig by means of rotary boring a 1.9 m diameter borehole, washed with clay mud (fig.5). At completion a well was cased with a steel pipe of 1.5 m in diameter and with 16-20 mm wall thickness. After the casing string had been set, a drill string borehole annulus was filled with bentonite-cement mortar for providing isolation of the casing from surrounding rocks. Then the bentonite-cement mortar solidified, clay drilling mud was pumped out from well.

In a dry well containers with solidified radioactive wastes were set with special lowering column. As containers metal 200 l drums with 0.6 m diameter were used.


Pilot LDW Site
8
7
10000
7200
7200
10000
6
3
N
7200
S
Surveying point
LDW-1x-1
2
7200
9
LDW-1x-2
7
10
10000
Groundwater flow
5
1
4
Fig. 2



"RADON" ENTERPRISE GEOLOGICAL PROFILE

Fig. 3

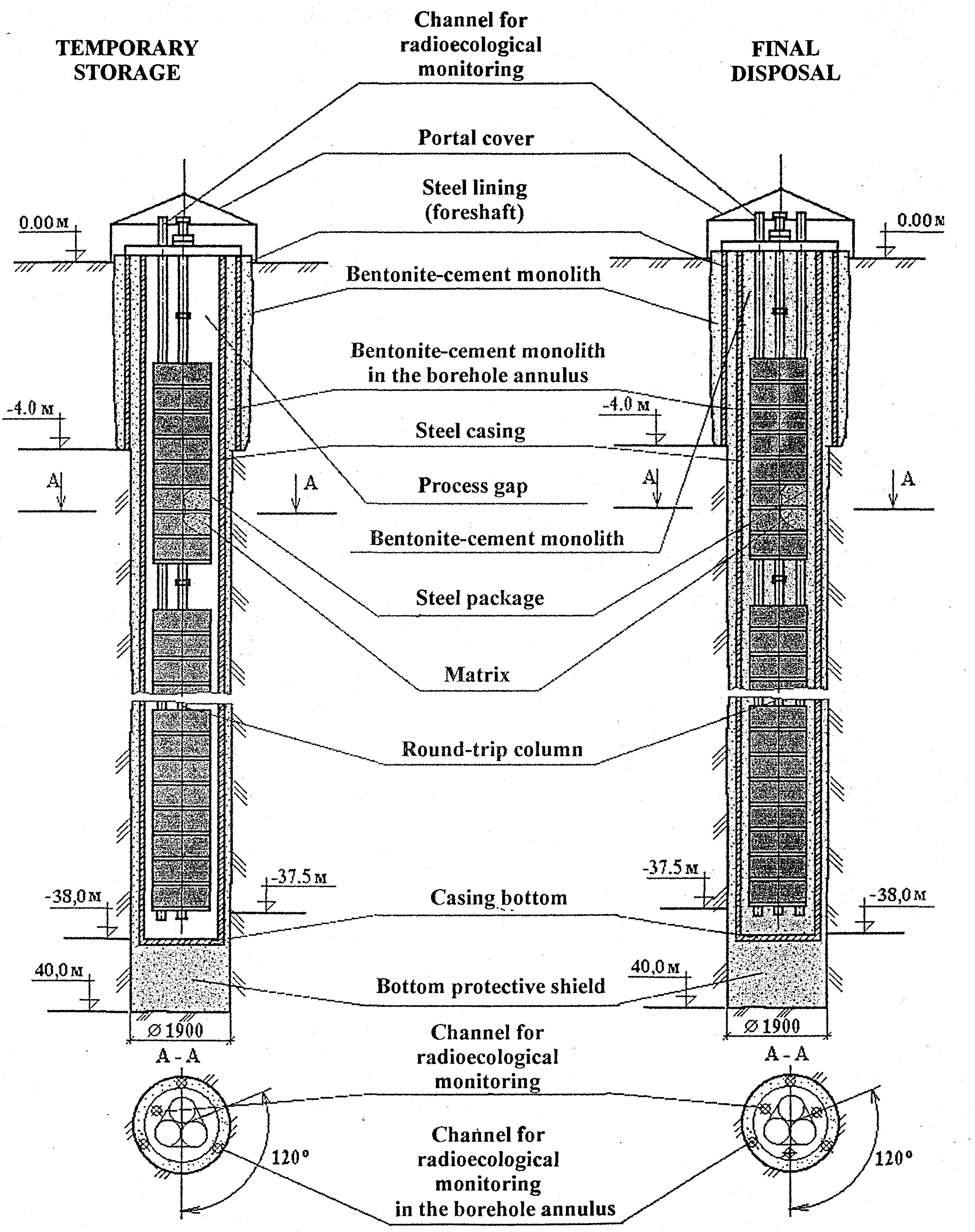
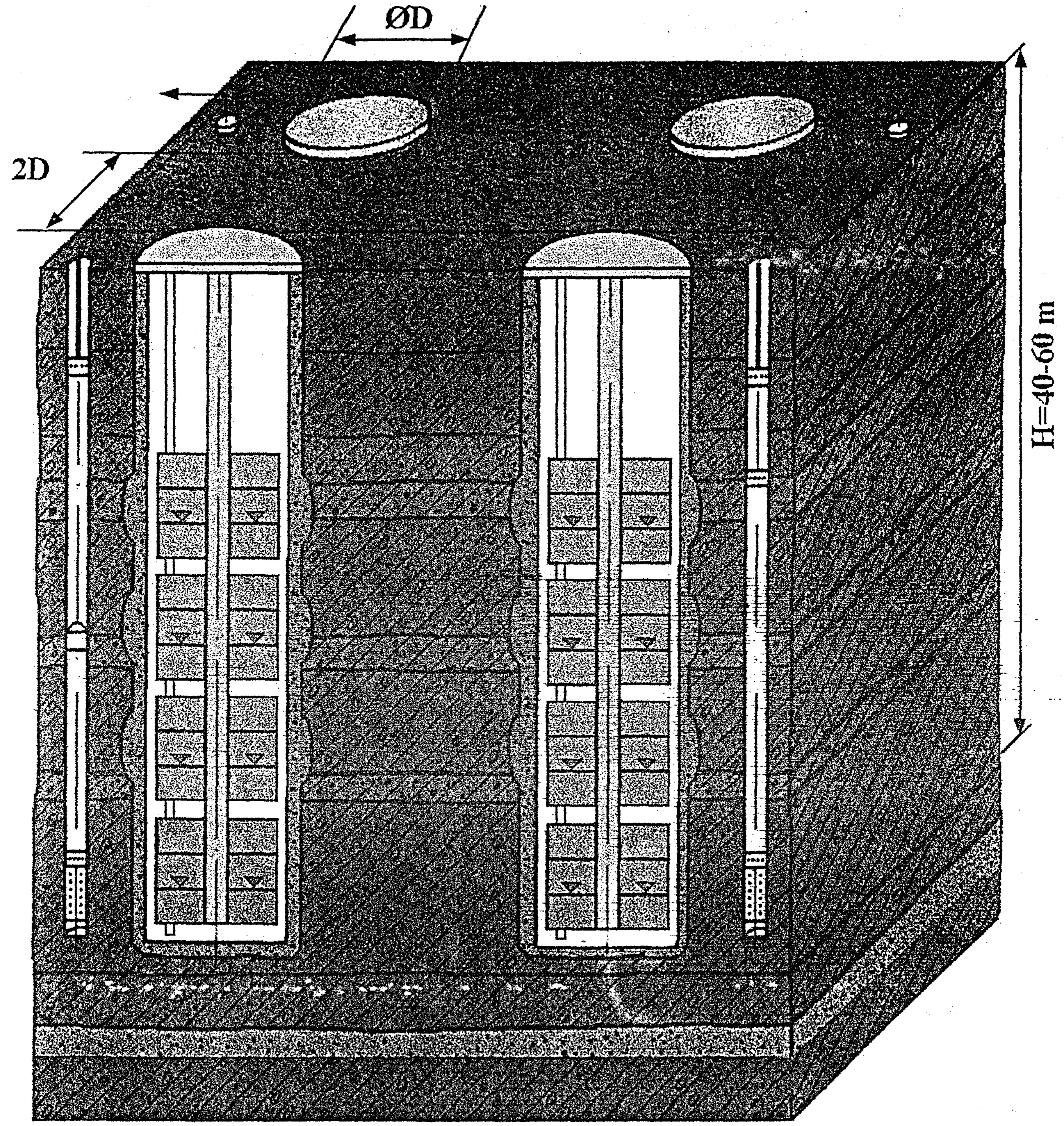

TEMPORARY STORAGE
Channel for radioecological monitoring
FINAL DISPOSAL
Portal cover
Steel lining (foreshaft)
0.00м
0.00м
Bentonite-cement monolith
Bentonite-cement monolith in the borehole annulus
-4.0 м
-4.0 м
Steel casing
A
A
A
A
Process gap
Bentonite-cement monolith
Steel package
Matrix
Round-trip column
-37.5 м
-37.5 м
-38,0 м
-38,0 м
Casing bottom
40,0 м
40,0 м
Bottom protective shield
⌀1900
⌀1900
A - A
A - A
Channel for radioecological monitoring
120°
120°
Channel for radioecological monitoring in the borehole annulus

Fig. 4

LDW DEPOSITORIES



Patents: №2143758 от 20.04.98
№2143759 от 22.07.98

Fig. 4-1

It is worth to notice that the wells may be used both as storages and as disposals. In the first case the LILW containers are stored in a dry well and may be recovered in any time. In the second case, void space between containers and casing pipe is filled with bentonite-cement mortar and the wastes will not subject to recovery.

Control of near field rocks and leakproofness of a repository is provided with a monitoring system. The system consists of wells equipped with a set of high resolution seismic gages and radiometric equipment for monitoring any possible radionuclide release out of repository boundaries.

A layout of wells and special channels for monitoring of LDW repositories are given in fig. 6.

Geological monitoring wells are located between adjacent repositories. In a well of geological monitoring observations of rock conditions while LDW drilling are performed. The results of stress deformation field observations will serve as a base for determination of a safe distance between LDW repositories from point of view of rock stability. Radiation is controlled in the working zone of a repository, in a casing pipe annulus and in hosting rocks. The radiation monitoring results in conclusions about isolation of LILW containers and the repository as a whole.

In the working zone radiation monitoring is performed by means of periodical gamma-logging into a work string. Using the same channel possible water penetration into the repository is controlled.

To control the isolation of a construction, 3 metal perforated pipes as channels are set at whole depth of a repository in a casing string annulus. At these channels gamma-logging is performed periodically and hydrodynamic mode of underground water is controlled.

It is worth to notice that the wells may be used both as storages and as disposals. In the first case the LILW containers are stored in a dry well and may be recovered in any time. In the second case, void space between containers and casing pipe is filled with bentonite-cement mortar and the wastes will not subject to recovery.

Control of near field rocks and leakproofness of a repository is provided with a monitoring system. The system consists of wells equipped with a set of high resolution seismic gages and radiometric equipment for monitoring any possible radionuclide release out of repository boundaries.

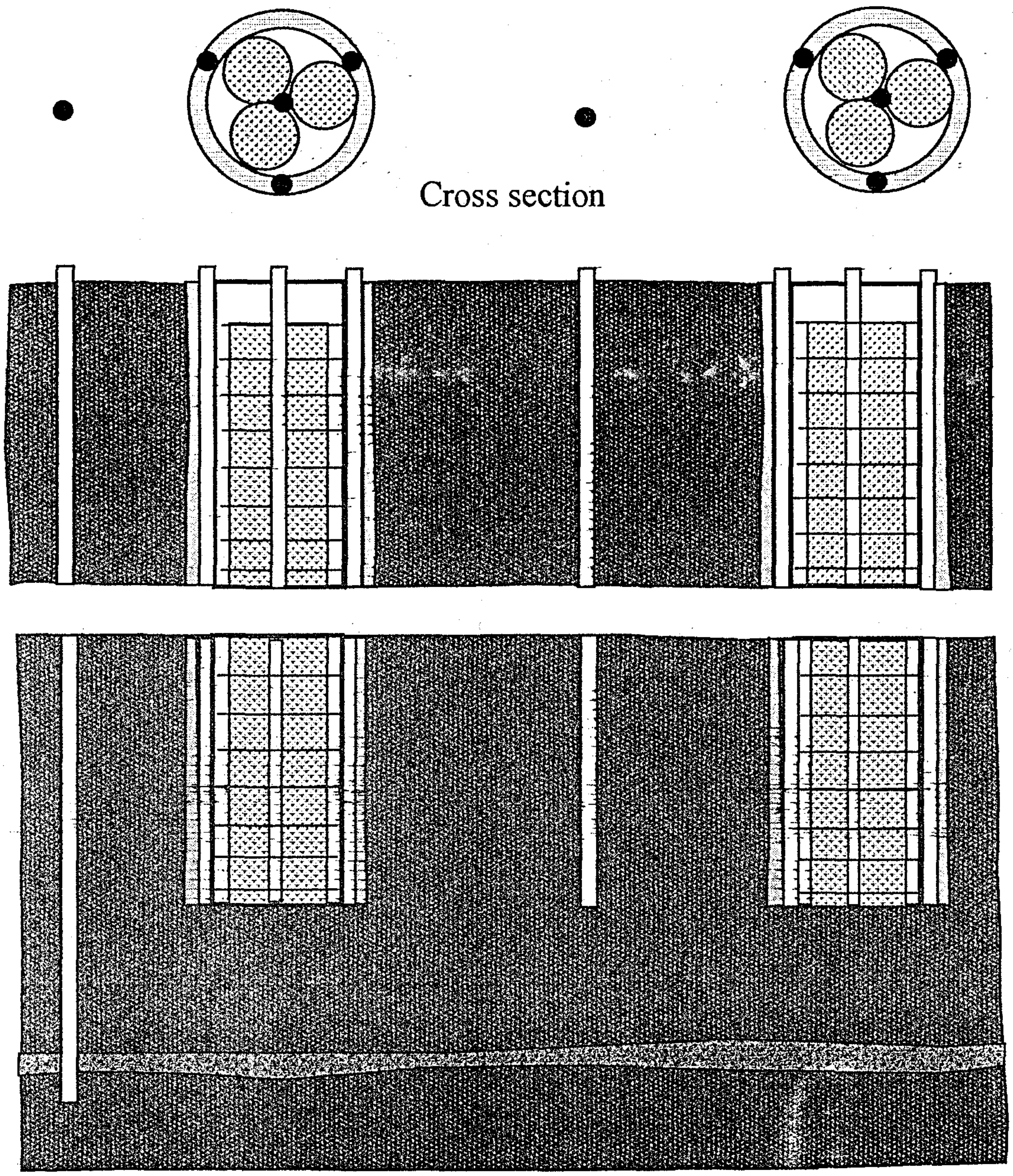
A layout of wells and special channels for monitoring of LDW repositories are given in fig. 6.

Geological monitoring wells are located between adjacent repositories. In a well of geological monitoring observations of rock conditions while LDW drilling are performed. The results of stress deformation field observations will serve as a base for determination of a safe distance between LDW repositories from point of view of rock stability. Radiation is controlled in the working zone of a repository, in a casing pipe annulus and in hosting rocks. The radiation monitoring results in conclusions about isolation of LILW containers and the repository as a whole.

In the working zone radiation monitoring is performed by means of periodical gamma-logging into a work string. Using the same channel possible water penetration into the repository is controlled.

To control the isolation of a construction, 3 metal perforated pipes as channels are set at whole depth of a repository in a casing string annulus. At these channels gamma-logging is performed periodically and hydrodynamic mode of underground water is controlled.

LAYOUT OF WELLS FOR RADIATION
AND GEOLOGICAL MONITORING



LEGEND:

- Radiation monitoring wells
- Geological monitoring wells

Fig. 6.

In certain conditions of Sergiev Posad site control of possible radionuclide release from a repository in hosting rocks is performed in a well, located 2 m along of the construction wall. The well opens a water containing interbed, located at about 47 m depth and is situated along underground water movement. Control of soil background radiation, hydrodynamic mode of the aquifer and radionuclide content of underground water is performed by virtue of gamma-logging and water sampling.

The developed monitoring system allows to control construction impermeability and surrounding rock stability with high level of reliability.

On a ground of ecological reliability comparative analysis of near surface and LDW repositories significant advantages of the latest were determined. The comparative analysis was performed on a base of multibarrier protection approach. These results are given in table 1.

Table 1.

Protection barriers in near surface and LDW repositories.

Protection barrier	LILW repository types	
	Near surface	LDW
Solidified matrix	+	+
Waste package	+	+
Repository wall (reinforced concrete wall in near surface repository and metal pipe in LDW)	+	+
Bentonite-cement stone in a casing annulus	-	+
Hosting rocks	+	+

It may be seen from the table 1, LDW repositories have 4 engineered barriers, near surface ones - 3. Both types of repositories have one natural barrier - surrounding soils. As it was mentioned above, walls of a near surface repository undergo periodical stresses caused with season temperature fluctuation during a year. This results in construction integrity failure and in essential decrease of wall service as a protection barrier.

In a case of using LDW for radioactive waste disposal an additional barrier will appear as bentonit-cement filling of voids between waste packages and casing pipe.

In conclusion some words about results of technical and economical parameters comparison for near surface and LDW repositories, which are given in table 2.

In the table LDW repositories with diameter of 1.5, 2.0 and 3.5 m and with depth of 40, 50 and 60 m were considered. An area of a near surface repository, which together with a monitoring system occupies about 0.2 hectare, was taken for comparison. As it follows from table 2, a payload volume of a LDW repository for this area will exceed in 2-5.3 times (depending on LDW characteristics) the same parameter for near surface one (position 4 in table 2). In other words, an area needed for LILW storage and disposal decreases in 2-5 times. It should be noted that specific costs for 1 m^3 construction (position 2, table 2) are 2.6-3.3 times higher for LDW than for a near surface repository. But this overcost will be compensated with those expenses, which would be required at siting work for new near surface facilities.

Thus, the given comparative analysis of near surface and LDW application has shown significant LDW advantages both in ecological safety and in performance parameters.

Table 2.

Comparative technical and economical parameters of repositories.

Parameters	LDW repository							Near surface repository
	LDW diameter, m							
	1,5		2,0		3,5			
	Depth, m							
	40	50	40	50	40	50	60	
Area of a repository, ha	0,2	0,2	0,2	0,2	0,2	0,2	0,2	0,2
Amount of wells	130	130	108	108	41	41	41	-
Payload volume of a repository, m^3	8300	10600	12200	15600	14200	18100	22100	4200
Specific payload volume, m^3 per 1 m^2 of surface/ relative units	4,0 / 2,0	5,0 / 2,5	5,8 / 2,9	7,4 / 3,7	6,8 / 3,4	8,7 / 4,35	10,6 / 5,3	2,0 / 1,0
Specific capital costs on 1 m^3 of payable volume, relative units.	3,3	3,2	2,4	2,3	1,9	1,6	2,6	1,0