Industry is faced with a most complex problem — the provision of places for storing industrial wastes: ashes and cinders of thermal power stations, tailings of mining and concentrating plants, sludge of meat-packing plants, etc. These wastes are usually stored by the hydraulic method in special hydraulic-fill dumps: ash dumps, tailings ponds, sludge storage ponds, etc.

When designing hydraulic-fill dumps two main problems related to environmental protection arise: appropriation of large agriculturally valuable land areas (directly for the dump and borrow pits for its construction) and pollution of groundwaters by mineralized waters of the system for hydraulic removal of the wastes and subirrigation of the territory in the region of the dump.

To prevent the entry of water from the hydraulic-fill dumps into the groundwaters (in the case of the absence of low-permeability soils in the base), it is recommended to construct a continuous watertight facing in the base. The following types of watertight facings are used in practice depending on the material: soil (clay, loam), polyethylene film with protective and underlying soil layers, and asphaltic concrete.

Each of these facings, in addition to high costs, large labor expenditures, and consumption of large volumes of scarce materials, has also another basic shortcoming — each substantially reduces the storage capacity of the dump. This is due to the fact that the thickness of each of the facings (except the asphaltic concrete facing) is at least 1 m. As is known, storage capacity is the main index of a hydraulic-fill dump: with a minimum capacity the dump does not justify its purpose, and with a maximum capacity it provides stable and efficient operation of power and industrial enterprises.

For example, the Priozersk Cellulose Plant was closed due to unsatisfactory operation of the sludge storage pond. It should be noted that in the standards [1, 2] there is not even a hint about a substantial decrease of the capacity of a hydraulic-fill dump when a watertight facing is constructed in its base.

To create watertight facings and construct embankments, the organization of special borrow pits beyond the limits of the hydraulic-fill dump is required. Excavation of the pits generally distorts the natural landscape and changes the hydrological regime. In the case of excavating 1 million m$^3$ of soil with a pit depth of 10 and 2 m, respectively 10 and 50 ha of land areas are used.

All problems related to land use touched upon — appropriation of large areas for the hydraulic-fill dumps and excavation of borrow pits — are usually not analyzed together by specialists and are not discussed by the public. We note that the cost of constructing a facing by traditional methods is 8-10 rubles/m$^2$, in which case the ecological damage, which presently is not amenable to evaluation, is not taken into account.

In the present work it is suggested to increase the storage capacity of hydraulic-fill dumps by constructing a watertight facing from soil of a borrow pit on the bottom of the dump with possible uncovering of a natural impervious layer. Practice shows that specialists who do not care what the hydraulic-fill dump is intended for categorically object to this measure in view of
Fig. 1. Hydraulic-fill dump with construction of a borrow pit in its base and preservation of recreation zones which fell into the area of appropriation in the case of absence of this pit: 1) boundary of area of appropriation for the dump in the presence of a pit; 2) and 4) additional area of appropriation for the dump and borrow pit in the case of the absence of the pit; 5) primary embankment of hydraulic-fill dump; 6) front of excavation of the pit and construction of embankment; 7) piles of high-quality soil intended, for example, for selling to other organizations.

possible pollution of groundwaters. However, these specialists by virtue of ignorance make technical decisions which have a more destructive effect on the environment — additional appropriation of large, often quite agriculturally valuable land areas (Fig. 1) and change in the hydrological regime of groundwaters as a consequence of organizing the pit.

The soil should be excavated with consideration that if an impervious bed is uncovered, then the area of the pit will subsequently be covered by a watertight facing. For this purpose, the pit should have a regular geometric form, smooth bottom, and gentle slopes, not steeper than 1:4. The last factor is due to slope stability — with consideration of the primary embankment and filling of the pit with water, as well as its emptying of excess water before the start of operation of the dump.

During excavation and storing in piles, the sand should be separated into sand, gravel, loam, etc. In the case of excavating the soil by a dredge, it is necessary to organize hydraulic piles with classification of the material by size by constructing successive sections. The soil removed from the pit can be used for constructing various elements of the hydraulic-fill dump and also for selling to other organizations.

Construction of the watertight facing in the pit is possible "dry" [1] or under water. The latter case is most characteristic.

For conditions of flooding the pit with water, the construction of a watertight facing from low-permeability soils is possible by the following three methods.

**Striplike Placing of Soil on Ice.** The sequence of performing works by this method is as follows [3] (Fig. 2).

After the formation of an ice cover 4 the pit is divided into equidistant sections — strips 5. The soil 6 is placed on one of the strips with a uniformly increasing height in cross section, which provides nonuniform distribution of the load on the ice. For cohesion of the ice with the soil and imparting the required shape to it, the soil must be moistened and frozen. After this, the ice cover 4, starting from the side of the soil with the greatest load, is sawed along the boundaries of the strips. As a consequence of the nonuniform distribution of the load on the ice cover, the ice block 8 turns over and sinks into the water and the soil is deposited on the bottom of the pit. The ice either descends or in the case of weak cohesion with the soil again floats to the water surface. By performing this set of operations successively on the other strips, the soil is placed over the entire base