

**PROPOSED ENVIRONMENTAL GUIDELINES FOR OPEN PIT GRAVEL PRODUCTION IN SLOVENIA**

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This paper presents the open pit gravel production constraints arising from the author's recent proposal of environmental guidelines for gravel production in Slovenia. The guidelines relate to gravel extraction from Quaternary (mainly Pleistocene) gravel deposits, which are also aquifers representing Slovenia's main source of drinking water. In this alpine and hill-covered country, these gravel deposits are Slovenia's main arable land bearing formations and thus its primary arable land areas. These are also the areas most affected by settlement and urbanization, which are substantially degrading this resource. Environmental guidelines for gravel production should therefore allow for the protection of ground water resources and, in view of its scarcity, also for the protection of arable land. Finally, as any open pit development affects the landscape in general, these guidelines should foresee measures for the reduction of the adverse impact of gravel production on the landscape.

**BACKGROUND**

In Slovenia, most of the gravel is extracted from the Quaternary (mainly Pleistocene) gravel deposits which fill up river valleys and tectonic depressions in this otherwise mountainous and hilly country. Annual gravel and sand consumption per capita in Slovenia dropped from 1.6 to 0.8 m<sup>3</sup>(<sup>1</sup>) in the period from 1980 - 1990. Taking into account the Slovene population, the country's annual gravel and sand consumption fell from 3.5 to 1.7 million m<sup>3</sup>, resulting in an annual rate of land degradation of the order of 10 to 30 hectares. Though this consumption may be partly substituted by the consumption of other solid rock aggregates in future, it is still likely that large volumes of gravel and sand materials will be required and, consequently, significant land areas and numerous sites will actually or potentially be affected or degraded.

Quaternary gravel and sand deposits, which in Slovenia originate mostly from carbonate rocks, form significant aquifers. In some regions these may be the only ground water resources available. When used as a source of drinking water, their waters generally require very little pretreatment and are regarded as the country's primary drinking water resources(<sup>2</sup>). In Slovenia, 60% of all drinking water consumed comes from ground water sources and thus primarily from these aquifers. It is therefore vital to maintain, if not upgrade, the relatively high standards of their protection and preserve their ground water quality.

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Given the country's alpine and hilly topography, Quaternary gravel and sand deposits form flat areas, which represent the primary arable land in Slovenia. Since Slovenia's "available arable land per capita" is among the lowest in Europe, it has to be regarded and preserved as one of the country's most vital natural resources. In this respect, the areas affected by gravel production have to be minimized to the greatest possible extent. This is one aspect of environmental protection where significant progress may still be made.

It is a well-known fact that any open pit development affects the local landscape - by changing and generally degrading it. However, by properly applying the principles of landscape architecture, such degradation can not only be avoided, but even reversed. It may eventually lead to revitalization instead of merely rehabilitation, and to improvement or upgrading instead of merely partial restoration. The guidelines should give incentives in this respect.

This contribution presents open pit gravel production constraints arising from the author's recent proposal of environmental guidelines for gravel production in Slovenia<sup>(3)</sup>. The guidelines relate to gravel extraction from gravel deposits, which are also aquifers representing the country's main source of drinking water.

## WATER RESOURCES PROTECTION GUIDELINES

### Basic Statements

The sand and gravel river deposits, which are the main source of gravel produced in Slovenia, usually contain, below an almost unaquified surface layer, an aquified layer. These deposits are thus aquifers, which are often regionally or locally significant sources of drinking water. In locating gravel pits and extracting gravel in these pits, it is therefore vital to observe the guidelines and requirements for the protection of water sources at such locations.

The existence of gravel pits in the inner or outer protection zones (water resources protection zones I or II) around existing or foreseen drinking water wells is not admissible.

A gravel pit already operating within the inner or outer protection zone (water resources protection zones I or II) around an existing or foreseen drinking water well should be liquidated immediately and rehabilitated in accordance with special water resources protection requirements.

New gravel pits should not be opened within the influential protection zone (water resources protection zone III) around an existing or foreseen drinking water well.

An existing gravel pit may operate within the influential protection zone (water resources protection zone III) around an existing or foreseen drinking water well in accordance with special water resources protection requirements.

In the event that a gravel pit already existing within an influential protection zone cannot operate in compliance with the special water resources protection requirements, the gravel production within this area must be discontinued and rehabilitation and revitalization measures implemented in accordance with the said requirements.

Gravel production in sand/gravel pits outside protection zones may be conducted in accordance with general water resources protection guidelines.

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Gravel production should primarily be located in those parts of aquifers lying downstream from drinking water wells which already exist, are foreseen in urban plans or will probably exist in future due to the characteristics of aquifers and ground water.

Gravel production should primarily be located in parts of aquifers with long-term or permanently degraded ground water.

Gravel production in the flood areas of rivers and their branches is allowed only if the inrush of river water into the gravel pit area does not worsen the quality of ground water downstream from the gravel pit.

Gravel production in the flood areas of rivers and streams is possible only if such exploitation does not intensify the erosive activity of flood waters.

Gravel production in the areas of existing or foreseen water accumulations is desired in order to increase or maintain the usable volume of reservoirs - if this does not degrade the quality of water in the river or reservoir, or intensify the erosive activity of rivers in the period up to the construction of water reservoirs.

The extraction of gravel from the beds of rivers and streams is desired in cases when such exploitation in areas with intensive sedimentation processes reduces the danger of floods, provided this does not result in the intensified erosive activity of rivers or the degradation of river water quality.

In order to reduce the effects of gravel production on ground water and other elements of the environment, efforts should be devoted to reducing the number of active gravel pits by concentrating production in a few large gravel pits located in accordance with the basic guidelines presented in this section.

In order to reduce the effects of gravel production on ground water and other elements of the environment, efforts should be devoted to reducing gravel consumption and (following the example of some developed countries) allowing it to be used solely in the production of first-class concretes and in the construction of buildings and facilities whose characteristics justify the use of such concretes.

### **GENERAL GUIDELINES**

Already in the planning phase of a gravel pit, its owner is obliged to determine and document the quality of ground water, the direction of its flow and the fluctuations in the ground water level in the selected exploitation area prior to the commencement of planned gravel production.

Already in the planning phase of a gravel pit, its owner is obliged to assess the effects of gravel production and rehabilitation or revitalization activities on the regime and quality of ground water, and to select appropriate technical solutions and technological procedures in order to reduce such effects.

If the ongoing or subsequent rehabilitation of a gravel pit also foresees its partial or complete filling with waste materials and substances, its owner must determine, in the planning phase of the gravel pit, the types and sources of filling materials which are admissible from the aspect of their influence on ground water.

During the operation of a gravel pit, its owner is obliged to monitor the regime (water level fluctuations, direction of flow) and quality of ground water before its inflow into the active area of the pit and after its outflow from this area, and to document the

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results of controls and observations in a day book. The operating process of the gravel pit should also include rehabilitation or revitalization procedures.

The filling of gravel deposits with waste materials and substances is not allowed without special approval and appropriate control of the type and source of filling material. The results of controls are to be documented on a regular basis.

Silt appearing as a waste product of gravel production during the separation of natural sand and gravel sediments may be deposited in the abandoned or inactive part of a gravel pit, provided this is performed in a manner which does not endanger the safety of users of this area.

Following the termination of operation and the rehabilitation of a gravel pit, its owner or his/her nominee shall be obliged to monitor the quality of ground water prior to its inflow into the gravel pit and after its outflow from the area on a quarterly basis for an additional 10 years, and to document the results of controls and observations in a day book.

The scope and frequency of controls of ground water following the termination of operation and the revitalization of a gravel pit shall be determined in accordance with the manner of utilizing revitalized gravel pits, and the owner of a revitalized gravel deposit shall be solely responsible for such controls.

In the event that a project also foresees the excavation of gravel below the ground water level (the so-called "wet gravel pit") and the transformation of the pit into an artificial lake after its shutdown and rehabilitation, the depth of the gravel pit should be sufficiently below the minimum ground water level to prevent the degradation of the lake into a marsh.

## GENERAL CONDITIONS

As early as in the planning phase of a gravel pit, the following should be determined: the limits of the exploitation area, final size and depth of the pit, the direction of the pit's development from its opening to its closing, the course and characteristics of transport and the course of access and service routes to the pit, the characteristics and spatial arrangement of permanent and temporary structures, excavation technology, internal transport and separation of materials, characteristics and distribution of production machinery and facilities, mode of removing and depositing humus, manner of depositing silt, and the procedures for the rehabilitation or revitalization of the pit area. All the mentioned elements of the project should ensure that the influences of the gravel pit on ground and surface waters are within allowable limits.

All transport routes in the pit area, where the risk of pollution with liquid fuels and lubricants is present, should be paved, made impervious to water and oils, and furnished with drainage channels. Paved surfaces should be closed in at the edges with raised curbs, and the joints between the paved surfaces and curbs made impervious to water and oils. Meteoric waters from these surfaces should be directed through a properly functioning oil separator of adequate size prior to their discharge.

The owner is obliged to ensure the regular maintenance of all devices, as well as the harmless removal of waste oils and fats (by burning or returning them to the refinery).

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It is not permissible to store larger quantities of liquid fuels in the gravel pit area, but only small stocks for day-to-day requirements. Transport vehicles should obtain fuel outside the gravel pit area.

Toilets should be located outside the gravel pit, and faeces should be directed through a three-unit cesspool, which must be regularly emptied, or preferably through a biological purifying device, prior to being discharged.

Transportation throughout the entire exploitation area of the pit, including service and access routes, must be organized in a manner preventing any risk of collision or overturning of vehicles.

The gravel pit should be secured by a fence in order to prevent any unauthorized depositing of wastes.

The owner is obliged to form a team from among its workers, which shall be trained for emergency intervention in the event of any unforeseen leakage of liquid fuels and lubricants, as well for preventing the penetration of any such liquids into the ground and ground water.

The owner of the pit shall be liable for any damages occurring as a result of improper exploitation, improper operation of devices or inadequate maintenance, including any damage caused to ground water as a result of discharged waste waters or the emission of harmful substances.

The owner of the pit shall be liable for any harmful effects of pit operation on neighbouring farming areas.

If, at any time after the discontinuation of production and the rehabilitation of the gravel pit, the quality of ground water has been found to have deteriorated due to the depositing of prohibited waste materials, the owner or its legal successor shall be liable for any such damages and shall bear the costs of rehabilitation of the area affected.

### **SPECIAL (RESTRICTED) CONDITIONS**

The special water resources protection requirements for gravel production in the influential protection zone include: the utilization of a verified extraction and processing technology with no adverse effects on the quality and capacity of the protected drinking water well, the direction of exploitation activities and necessary transport routes away from existing and foreseen wells, the rehabilitation or revitalization of the exploited area in a manner verified as harmless for the quality and capacity of the drinking water well, and stricter internal and external environmental monitoring and control of the effects of production activities on ground water. The extraction and processing technology is considered to include the transport of equipment, machinery and materials to the exploitation area, within and out of the area.

The design and operation of permanent structures and production facilities, the arrangement of transport routes, and the storage of fuels, lubricants and other substances must be in conformity with item 6.4 of the "Safety Measures in an Influential Protection Zone - Water Resources Protection Zone III, area with mild protection regime" of the Regulations for the Determination of Water Resources Protection Zones of Ground Water and Underground Water Resources<sup>(4)</sup>.

During operation under special conditions, all the general requirements that have not been tightened under the special conditions are to remain applicable.

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## SOIL AND ARABLE LAND PROTECTION GUIDELINES

### Basic Statements

Gravel exploitation should be given priority in areas with a deeper exploitable layer of sand and gravel sediments, as this allows for the increased production of gravel per unit of degraded or environmentally transformed area.

The entire thickness of a sand/gravel deposit should be utilized in areas selected for gravel production in order to reduce the extent of areas degraded by gravel production.

In gravel production, priority is given to those exploitation techniques and technologies which enable the production of the highest possible quantity of gravel per unit of degraded land or land with transformed purpose of use and which, after the termination of production, ensure adequate rehabilitation and revitalization of the production area.

In order to protect the soil and high-quality agricultural land, gravel exploitation should preferentially be directed to areas with poorer soil or with inferior or degraded land.

### General Guidelines

Already in the planning phase of a gravel pit, the owner is obliged to determine the depth, internal structure and composition of a sand/gravel deposit in the foreseen exploitation area, and to determine and properly document the available geological reserves.

Already in the planning phase of a gravel pit, the owner is obliged to determine and properly document the exploitable reserves in the foreseen exploitation area and the foreseen manner and extent of gravel production. The project concept of gravel production should enable exploitation with maximum utilization of the natural resource. In the production-affected areas, the exploitable reserves should therefore be as close as possible to the geological reserves.

Already in the planning phase of a gravel pit, the owner is obliged to determine the manner of removing humus, its temporary depositing and the manner and purpose of its subsequent use. The owner shall use the removed humus for the rehabilitation of the same gravel pit. Humus may be sold or used at another location only in cases when a project foresees a surplus of humus materials due to the partial or complete transformation of the gravel pit into an artificial lake.

If a project foresees the rehabilitation of the gravel pit by its transformation into a green area, the owner is obliged, on an ongoing basis, to arrange, supply with humus and greenery all the abandoned areas and pertaining banks affected by production, in accordance with the approved project documents relating to the exploitation and rehabilitation or revitalization of gravel pits. Only the necessary manipulative areas and the active part of the gravel pit need not be rehabilitated.

If a project foresees the rehabilitation of a gravel pit by its partial or complete transformation into an artificial lake, the owner is obliged, on an ongoing basis, to arrange the abandoned areas foreseen for flooding and the nearby banks affected by production, in accordance with approved project documents relating to the exploitation and rehabilitation

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or revitalization of the gravel pit. The owner is also obliged, in accordance with the said documents, to regularly arrange all abandoned areas not foreseen for flooding and nearby banks affected by production. Only the necessary manipulative areas and the active part of the gravel pit need not be rehabilitated.

In order to ensure the stability of gravel pits, the inclination of banks should not exceed 1 : 1.5, while their shape and arrangement should be determined in detail in the planning phase of the gravel pit.

## **LANDSCAPE PROTECTION GUIDELINES**

### **Basic Statements**

Gravel production is a technically and technologically relatively simple process which allows for the relatively low-cost adaptation of the shape and size of gravel pits and the manner of their rehabilitation and revitalization to nontechnical and nontechnological criteria.

The landscaping and architectonic arrangement of the entire exploitation area already during the exploitation phase and after closing of the pit should not only prevent the degradation of the landscape and environment, but allow for its revaluation and, wherever possible, the improved quality of the landscape and the environment.

In order to protect the landscape, a priority task is to direct gravel production to areas with less valuable or degraded landscape. Gravel production in such areas will allow for the creation of a material and technical basis for the redesign, revaluation and improved quality of the landscape and environment.

### **General Guidelines**

Already in the planning phase a gravel pit, the owner is obliged to prepare a landscape design plan for the entire exploitation area as an independent project concept, taking into account, to a reasonable extent, the technical and technological limitations of gravel production.

If the partial or complete transformation of the gravel pit into an artificial lake is foreseen after the termination of gravel production, an ecological development plan must be prepared for the entire affected area, taking into account the limnological and ecological characteristics of the new environment, the planned utilization of this environment (recreation, fish farming, etc.) and, to a reasonable extent, the technical and technological limitations of gravel production.

The gravel production project must be in line with the landscape development plan for the area and, in the event of the pit's transformation into an artificial lake, also with the ecological development plan for the flooded area. The planned final landscape design of the area and the intermediate stages of landscape development of the area during gravel production should be taken into account.

## CONCLUSIONS

In future, gravel and sand consumption may be partially substituted by the consumption of other solid rock aggregates. However, it is likely that large quantities of gravel and sand will nevertheless be required, which will affect significant land surfaces and involve numerous sites of actually or potentially degraded environment.

The optimal environmental management of sand and gravel exploitation should include several measures and incentives:

- As regards demand, it should promote the substitution of sand and gravel aggregates by solid rock originating substitutes, whose production is less arable land degrading.
- From the aspect of urban planning, it should advance the production of sand and gravel at locations where this is beneficial for the environment (man-made river water reservoirs) or does not additionally degrade it (urban, infrastructure or other underground excavations).
- Further with respect to urban planning, it should advocate the siting of sand and gravel pits in environmentally degraded areas or in places where the resulting harmful effects on water resources or arable land are insignificant.
- Further with respect to urban planning, it should support production in a reduced number of open pits.
- From the aspect of production, however, it should promulgate the planning, exploitation and reclaiming of open sand and gravel pits in a manner which is least harmful for the environment.

The environmental guidelines for gravel production offer several incentives and measures to be undertaken in such activities. By clearly specifying the open gravel and sand pit design and production constraints, they help to regulate this sensitive domain and allow for new, environmentally sound development.