

SUMMARY OF ECOLOGICAL RISK ASSESSMENT

An “*Ecological Risk Assessment*” for the Cinkarna Celje production site has been performed between April and November 2018 as an addition to the “*Human Health Risk Assessment*” completed in 2017.

The evaluation was based on the procedures of the contaminated site management framework of the Netherlands (“*Soil Protection Act*” and “*Soil Remediation Circular*”), which provides a guideline on best management practice and intervention values for the most common harmful substances for the risk assessment of contaminated soil and groundwater.

This approach was selected because the “*Dutch List*” as part of the contaminated site management framework of the Netherlands is currently the most common reference respected internationally.

In 2016 and 2017, a significant impact on the groundwater within the boundaries of the Cinkarna Celje site was detected due to considerable concentrations of potentially harmful substances, in particular zinc, arsenic and chlorobenzene, exceeding the applicable thresholds for both, soil and groundwater quality. Elevated values were also detected for copper, lead and cadmium. The pattern of detected substances indicates that the different contamination sources were caused by historic deposal of former production residues and did not originate from current site operations.

The adjacent rivers Hudinja and Ložnica function as hydraulic barriers; therefore, it can be excluded that polluted groundwater migrates to off-site downgradient areas. However, the on-site groundwater impacts contribute to the measured pollution in the surface water of the rivers, as do known contaminated sites on the opposite river bank and other unidentified sources upgradient to the Cinkarna Celje site.

In order to characterize the potential ecological impacts of contaminated on-site groundwater discharging into the adjacent rivers, ecological tests on the effluent groundwater and multi-habitat sampling of benthic invertebrates in the rivers have been conducted in 2018.

In addition, surface water from the Hudinja and Ložnica rivers was sampled at multiple locations to assess the rivers chemical burden prior and after the rivers passage along the CINKARNA Celje Production site’s boundaries. River water discharge measurements have been conducted to allow for a comparison of contaminant loads estimated in the river water and groundwater. The balancing of contaminant loads in groundwater was conducted based on a computer-aided calculation model. Prior to the establishment of this hydro-geological groundwater fate & transport model, several other supportive measures were conducted, including the installation of 13 new groundwater monitoring wells, soil sampling for chemical

analysis and X-ray microanalysis, an extensive groundwater monitoring campaign and hydro-chemical calculations.

Although the chemical analysis of river water doesn't indicate an adverse impact, the ecological testing conducted on the contaminant effluent groundwater confirms a deterioration of the ecological status of the Hudinja and Ložnica rivers.

Whereas the modelled contaminant transport for arsenic in groundwater is in good agreement with the ecological impacts observed at the Ložnica river at the inflow location of the assumed arsenic source area ("Old Voglayna river bed"), the existence of other currently unknown arsenic source areas along the Hudinja river have to be taken into consideration.

Further investigation is required locally for a detailed assessment of the impact by on-site zinc and chlorobenzene contaminated groundwater at two locations.

In accordance with the rationale of the risk assessment, two on-site sub-areas have to be classified as "serious contamination" and "remediation urgently required". These sub-areas are directly related to an adverse ecological impact on the rivers, an "inacceptable" contaminant migration in on-site groundwater, or both.

Other on-site sub-areas have to be classified as "serious contamination". These sub-areas show an exceedance of the intervention value concentration of at least one potentially harmful substance and an exceedance of the maximum tolerable size / volume of the affected sub-area.

CDM Smith recommends to implement the following measures:

- (1) Immediate measures (hydraulic containment measures) in order to prevent further contaminant migration via on-site groundwater at sub-areas classified as "serious contaminations requiring urgent remediation" including preparatory measures;
- (2) Continuation of regular groundwater monitoring, especially at sub-areas classified as "serious contamination", and
- (3) Further delineation investigations and monitoring programs for surface- and groundwater.