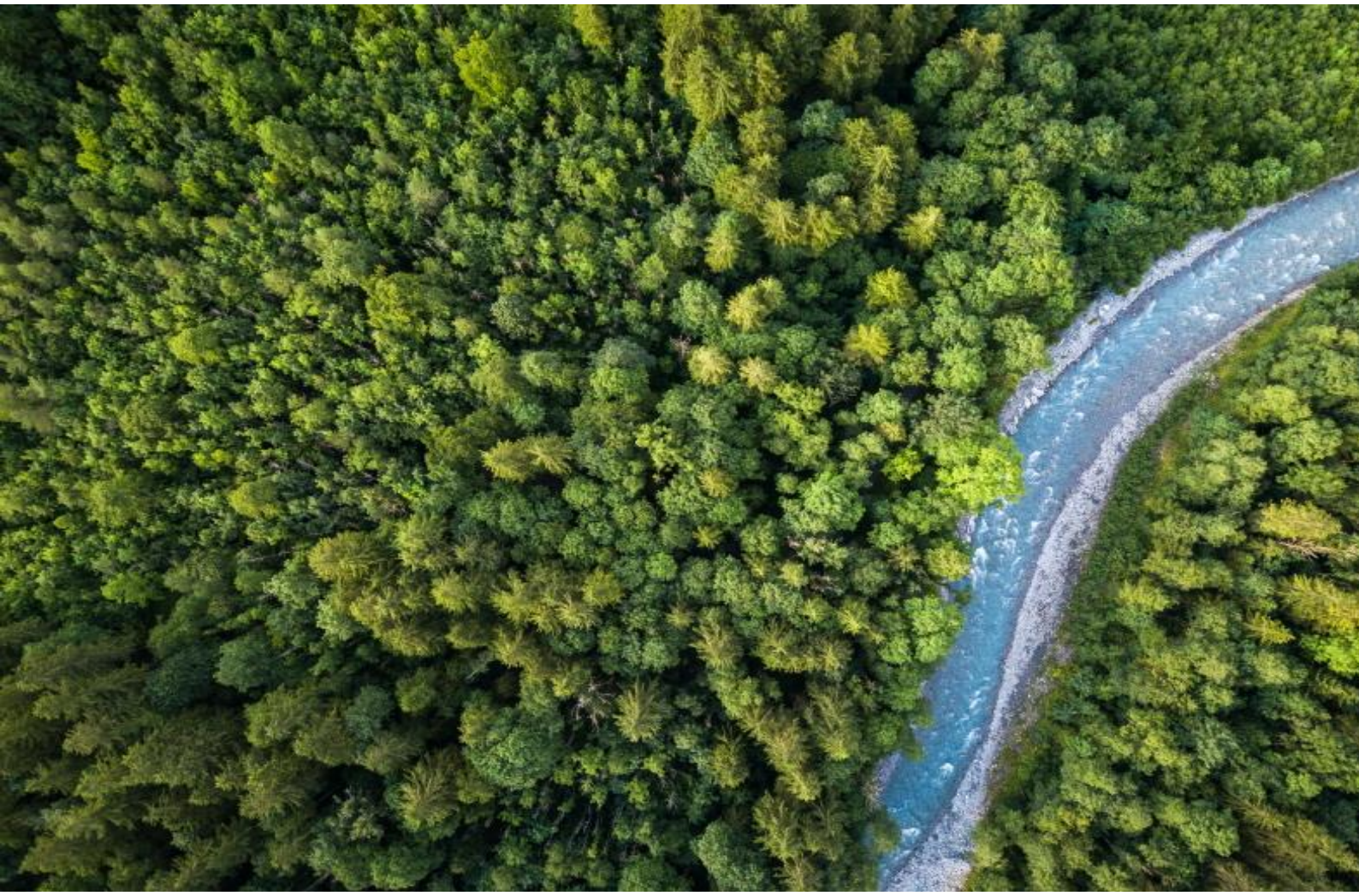

Vanadium Recovery Project Oy

Environmental permit application for vanadium recovery plant

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1 Introduction

1.1 Context

VRP Oy is applying for an environmental permit for a new operation of the vanadium recovery project. EIA report for the project has been completed and submitted to authorities. The plant is expected to produce vanadium pentoxide at the rate of up to 9,000 tonnes per year.

Vanadium is considered a critical raw material. Vanadium consumption worldwide increased from 40,000 tonnes to over 100,000 tonnes per year during the period 2001–2019. In 2019, over 100,000 tonnes of vanadium was produced, of which 59 % in China, 9 % in South Africa and 8 % in Russia. There is currently no mining of vanadium ore in Europe. The worldwide demand for vanadium is estimated to grow further, as for example the production of vanadium redox flow batteries and the addition of vanadium to lithium-ion battery cathode chemistries. Vanadium is primarily used in the manufacture of high-grade steel and stainless steel, and additionally in the manufacture of vanadium chemicals used in titanium alloys and energy storage (batteries). The aim of the Vanadium Recovery Project (VRP) is to produce high-purity vanadium pentoxide for the needs of the European industry.

Critical Metals Ltd (CMS), entered into an agreement with the steel producer, SSAB, to purchase slag by-product from SSAB steel production plants in Oxelösund and Luleå, Sweden, and from Raahe, Finland. Vanadium-rich slag from steel industry constitutes a very high grade raw material source.

The vanadium recovery plant will promote circular economy and restrict the use of non-renewable natural resources in a growing vanadium demand situation. The plant will also have a positive climate impact because the main raw material is from stockpiles but also the use of industry recovered CO_2.

Technical feasibility and scoping studies for the VRP have been conducted and further investigations, project planning and engineering are ongoing. A pilot plant was commissioned and operated for 24 days (in three campaigns) in Perth, Australia between June and September 2021. A final investment decision will be made in late 2022 and if positive, detailed engineering, procurement, and project execution are scheduled to commence in 2023 with commissioning scheduled for the second half of 2024. Commercial production is scheduled to commence in late 2024.

1.2 EIA alternatives

Environmental Impact Assessment has been conducted for the operation in 2021. The EIA report was submitted on September 27th 2021 to the authorities and the public hearing period is September 29th to November 29th 2021. The EIA procedure is expected to be complete in January 2022. The EIA includes the following alternatives:

- Alt.1: Construction of the VRP in Tahkoluoto, Pori. The plant is expected to produce vanadium pentoxide product (powder or flake) at the rate of up to 9,000 tonnes per year. In addition, two by-products will be produced including a calcium carbonate $CaCO_3$ rich stabilised slag material (SSM) at the rate of 415,000 dry tonnes per year and sodium sulphate at up to 30,000 dry tonnes per year. As a raw material, the plant will use slag feedstock from steel industry with a maximum throughput of 300,000 dry tonnes per year.
- Alt. 1a: Slag feedstock from steel industry, which is used as raw material in the VRP, has not received the status of by-product for vanadium recovery

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- Alt. 1b: SSM produced in the VRP has not yet received the status of by-product, in which case it is transported to be stored in an existing area authorised for an equivalent type of activity.
- Alt. 0: The project will not be implemented.

The EIA is presented in the Appendix 1.

1.3 Permitted operation

Based on the environmental impact assessment, the project including the sub-alternatives assessed in the EIA procedure can be considered feasible regarding environment. The applicant has chosen to apply for the environmental permit based on alternative 1/1b. This means that plant is expected to produce vanadium pentoxide powders or flakes at the rate of up to 9,000 tonnes per year. In addition, two other by-products will be produced including SSM at the rate of 415,000 dry tonnes per year and sodium sulphate at up to 30,000 dry tonnes per year. SSM produced in the vanadium recovery plant has not yet received the status of secondary product, in which case it is transported to be stored in an existing area authorised for an equivalent type of activity. As a raw material, the plant will use slag feedstock from steel industry with a maximum capacity of 300,000 dry tonnes per year.

The operations requiring a permit are based on the Environmental Protection Act (YSL 527/2014), and pursuant to it, on the Environmental Protection Decree (YSA 713/2014). This permit application is for a new operation. According to the Industrial Emissions Directive and the Environmental Protection Act (reference to Annex 1, Table 1, subsection 4.a of the Environmental Protection Act.) the plant operation falls under *manufacturing of non-metals, metal oxides or other inorganic compounds such as calcium carbide, silicon, silicon carbide*.

The environmental permit authority for the plant is the Regional State Administrative Agency of Southern Finland.

1.4 Initiating an activity subject to a permit regardless of appeal

The applicant applies for the right to commence activities under the permit enforcement of the permit regardless of appeals pursuant to section 199 of the EPA.

As is shown below in chapter 8 the environmental impacts of the project are limited to some additional noise and dust emission as well as an increase in road use. In normal operations the plant does not cause soil contamination or risk of groundwater pollution, in addition the process water of the plant is circulated back into the process. The plant will be constructed in an area already used for industrial activities, and as regards for example noise the emissions from the plant do not materially differ from activities already conducted in the area. The area is an industrial area and residential areas and other sensitive targets are located far from the site. Hence, the plant has minor environmental impacts, which do not significantly affect the current environmental status in the area. The construction of the plant does not change the current environmental status of the area significantly. The nature of the environmental impact of the project are such that a stop in the operations would also stop the impacts, consequently enforcement of the decision does not render possible appeals worthless.

As also stated in chapter [1.2] of the EIA Report, the European Commission has classified Vanadium as a critical raw material. Critical raw materials refer to raw materials that are of great importance in the EU, but with high risk to availability (European Commission). In 2020 the global vanadium production by raw material type was 114 000 t/a, 63% was

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produced in China and only 7 % was produced in Europe. It is estimated that by 2025 the global vanadium consumption has reached 170,000 t/a. This increase is expected as vanadium is a key component in the production of the batteries that are needed as Europe moves towards a zero-carbon economy. This need for raw material was again emphasized as a part of the COP26 commitments to stop selling new combustion engine vehicles in Europe by the end of 2035. In order for this target to be reachable the plants that produces the raw materials should be up and running without delay. The applicant holds that the above reasons (covered more in detail in the EIA Report) constitute justified reasons for granting the right to initiate activities under the permit regardless of appeals.

The applicant aims to have the plant in commercial production by December 2024. Albeit a decision on this application is expected during 2022, in Finland most environmental permit decisions are appealed and the general handling times for appeals is two years or more at the Vaasa Administrative Court, and in order for the Plant to be in commercial production by December 2024, start-up and preproduction needs to commence well before that. Consequently, there is a need for the applicant to have the right to commence operations regardless of appeals.

For the avoidance of doubt the Company would also like to note that the meadow dwarf has been relocated from the area in October 2021.

The Company will set a financial guarantee of 150,000 euros for the initiation . The sum is based on estimation of restoration of the area should the permit decision later be overturned on appeal. This will be set as guarantee, insurance or pledged deposit, which will be decided later.

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2 General description of the operation and summary for public

VRP Oy is applying for an environmental permit for a new operation of the vanadium recovery project. The plan is to locate the VRP at the Port of Pori in Tahkoluoto. The plant is expected to produce vanadium pentoxide at the rate of up to 9,000 tonnes per year.

Vanadium is considered a critical raw material and has been on the European Union critical raw materials list since 2017. The worldwide demand for vanadium is estimated to grow further, as for example the production of vanadium redox flow batteries and the addition of vanadium to lithium-ion battery cathode chemistries. The aim of the Vanadium Recovery Project (VRP) is to produce high-purity vanadium pentoxide for the needs of the European industry.

VRP Oy will use by-products from SSAB's steel production and recover high-purity vanadium for use in energy storage solutions and specialty alloys without the need to mine and process vanadium via traditional methods. The vanadium recovery plant will promote circular economy. The plant will also have a positive climate impact because the main raw material is from stockpiles but also the sequestration of industry recovered CO_2.

A final investment decision will be made in late 2022 and if positive, detailed engineering, procurement, and project execution are scheduled to commence in 2023 with commissioning scheduled for the second half of 2024. Commercial production is scheduled to commence in late 2024. The duration of construction of the plant is about 18-months. It is estimated that a maximum of a few hundred persons will work on site in construction phase. The plant will employ approximately 120 fulltime employees. The plant will be operated 7 days a week, 24 hours a day for 365 days a year.

The process is hydrometallurgical and uses water as an input. All wastewaters are recycled and no wastewater is discharged from the plant to the environment. The plant does not have significant impacts to the environment or to human health. Compliance with noise guide values and ambient air guideline values for dust have been confirmed by modelling.

3 Applicant

The applicant of this permit application and the party responsible for the plant operation is the Finnish company Vanadium Recovery Oy (3240046-3). The company is a wholly owned subsidiary of Recycling Industries Scandinavia AB (RISAB). The extract from the Register of Companies is presented in Appendix 2.

CMS (www.criticalmetals.eu) and its wholly owned subsidiary company RISAB are responsible for the VRP. CMS and RISAB are the counterparties to an agreement with steel producer SSAB whereby CMS will purchase slag from SSAB in Finland and Sweden.

Australian registered company Neometals Ltd (NMT) is the largest shareholder in CMS (holding approx. 19.9%) (www.neometals.com.au). NMT and its wholly owned subsidiary company Avanti Materials Ltd are the financial and technology partners of CMS for the VRP. Subject to the parties making a final investment decision (FID), CMS will transfer a 50% equity interest in RISAB to NMT.

Details of the contact person of the permit application and the plant are presented in Appendix 3 due to GPRD requirements.

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3.1 Contracts

The plant area is located on plot 609-73-36-2 and the storage areas on plot 609-430-1-18. The plot 609-73-36-2 owned by the Porin Satama Oy and the storage areas on property 609-430-1-18 owned by the City of Pori. CMS has made preliminary land lease agreement with the Port. The final land lease will be between the Port and VRP Oy.

VRP Oy will make electricity and sewer contract before starting the operation.

3.2 Environmental insurance

VRP Oy will acquire an environmental insurance to cover incidents and accident cases, natural disasters etc. This insurance will be of a level and type commensurate for similar sized and similar capital cost processing facilities. The details of the insurance are not yet known. The insurance documents may be provided to the environmental supervision authorities when the construction starts.

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4 Site location and environmental setting

4.1 Location

The plan is to locate the VRP at the Port of Pori in Tahkoluoto (Figure below). In addition to port operations, there are plenty of other industrial activities in the Tahkoluoto area. The total size of the VRP area is approximately 24 hectares. The process plant is in the southern area. Slag and SSM can be stored both in the southern stockpiles and slag also in the northern storage area.

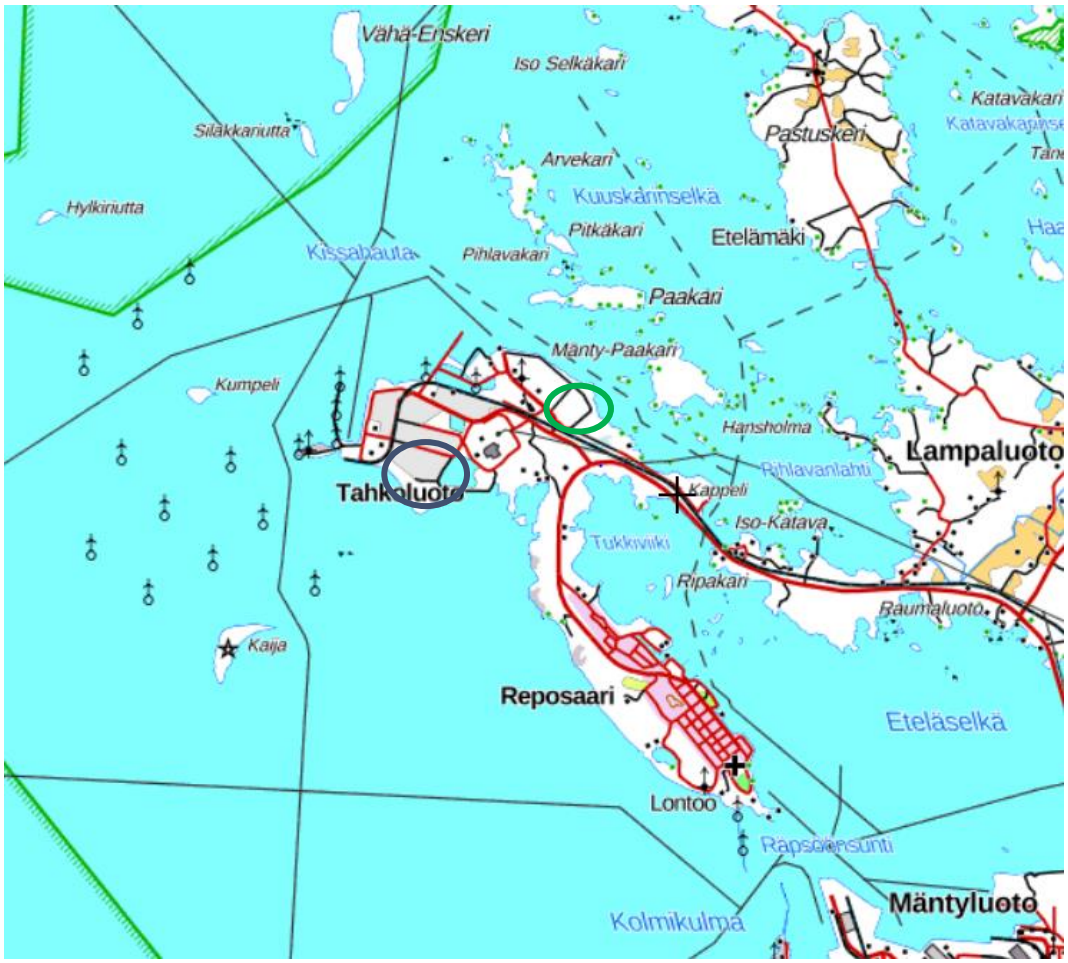

Figure 1. Site location at Tahkoluoto, the southern area is marked with blue circle and the northern area with green circle. The southern area is for the plant and two stockpiles and the northern area is only for stockpiling. (Karttapaikka)

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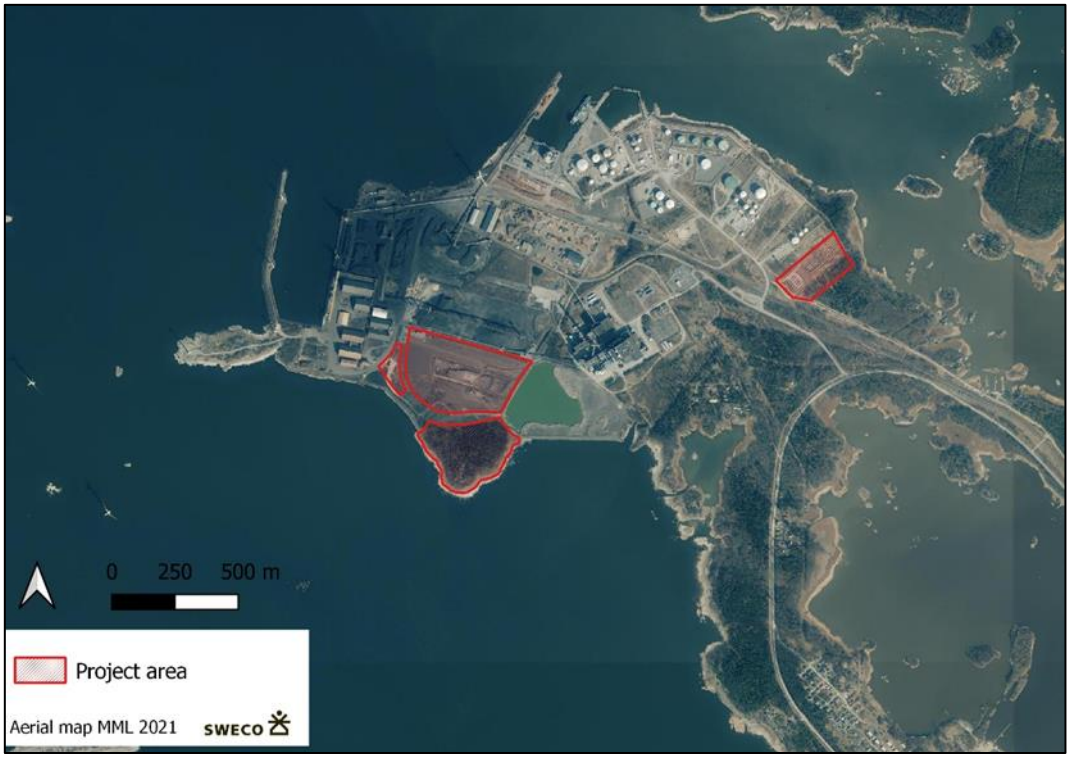

Figure 2. Specific site locations (Sweco 2021a).

Figure 3. Plots and plot numbers marked in the map. (Karttapaikka)

4.2 Sensitive areas and subjects

Currently three people live in the Tahkoluoto area. There are empty residential buildings in the area. Permanent housing is vanishing from the area. In the Katainniemi area, the city has purchased properties vacated from residential use to establish a safety-zone for the port area. There are leisure-time homes in islands north of Tahkoluoto and over

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approximately 2 km from the VRP process site. There are a total of 144 leisure-time properties or lease parcels of land in the Tahkoluoto-Paakarit area. (City of Pori 2020).

The nearest residential buildings to the southern VRP area are in the east in Parkkiluoto residential area 1 km from the VRP area. The nearest leisure-time homes to the northern VRP area are 200 m and 300 m to the southwest of the VRP area. The nearest residential areas are in Parkkiluoto and Kaitainniemi. These are located 1,200 m and 800 m from the VRP site, respectively. Larger residential area is located at Reposaari.

The nearest school, kindergarten and camping site are located about 2 km to the southeast of the VRP area in Reposaari.

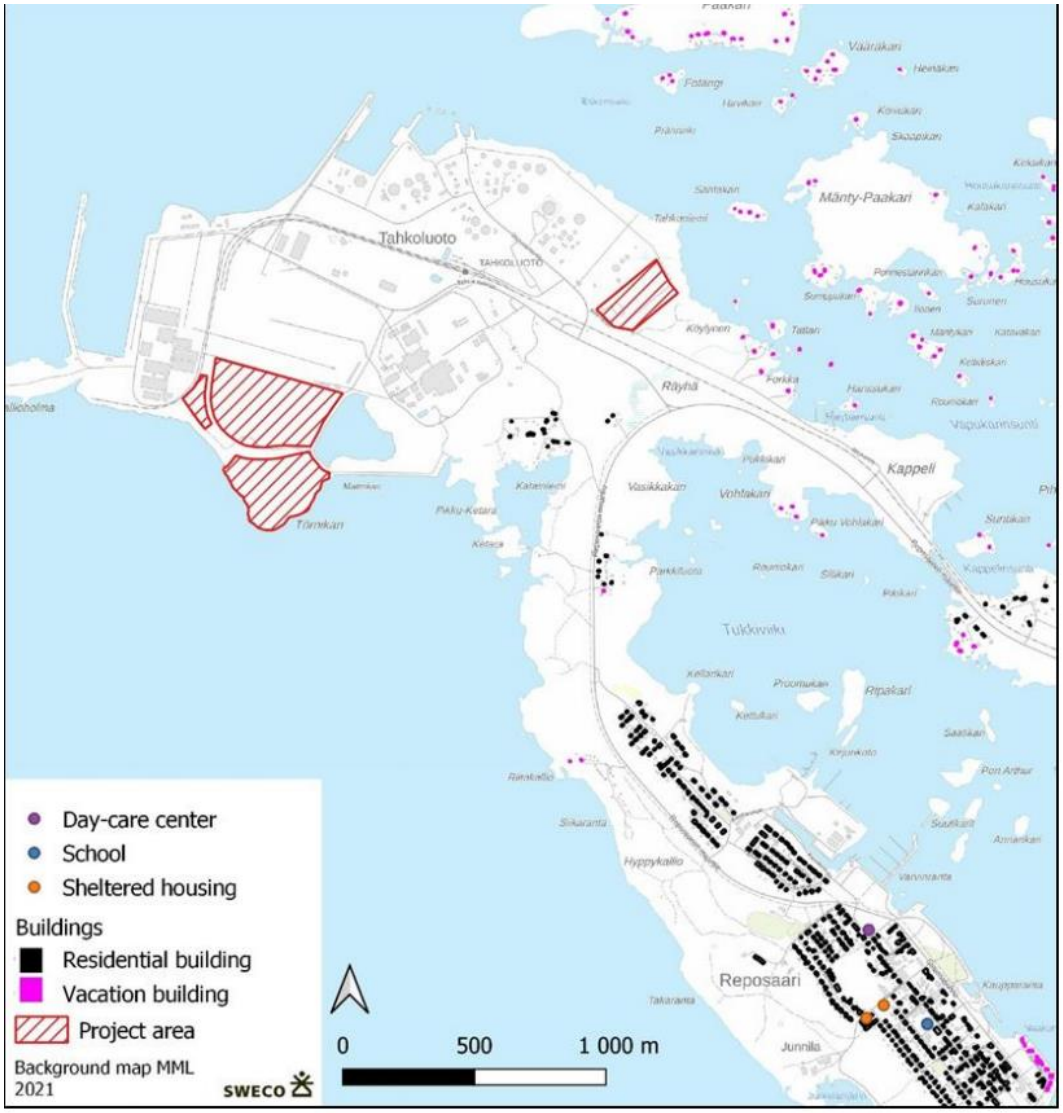

Figure 4. Residential houses and other sensitive targets and the VRP areas marked in red. (Sweco 2021a).

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4.3 Environmental setting

4.3.1 Geology

The bedrock of Tahkoluoto consists of silicate sandstone, rapakivi granite, dolerite and tonalite. In addition, quartz diorite as well as olivine diabase can be found in the area. The bedrock in the planned VRP area is silicate sandstone, rapakivi granite and tonalite. (GTK Maankamara)

The predominant soil type in the Tahkoluoto area is sandy moraine and not known soil type. Areas of fine sand and bedrock can also be found in the eastern part. (GTK Maankamara)

The expansion and development of the port has been based on the integration of islands, rocks, and water areas by embankments, and filling the basins behind the embankments. (City of Pori 2020). Hence the soil layers above the bedrock in the area consist largely of fill soil. The water area to the northeast of Törnikari, the embankment basin has been filled with fly ash and bottom ash of coal. A total of approximately 6.8 ha of the filling has been completed and approximately 3.6 ha of the area has not been filled yet.

It was found in the survey on construction conditions (Sweco 2021b) that the area consists of very dense filling soil to a depth of about 1.5 m and patchy filling soil to a depth of 4.5 m. Moraine layers exist beneath the filling soil. Bedrock surface in the southern VRP area is located at a depth of about 13.0 – 21.6 m. Ground level varies between +0 to +6.3 with average ground level being approximately at level +3.0.

No sites in the MATTI soil condition database are in the southern VRP area. One MATTI-site (ID 100312997) is in the northern VRP area. The site is the eastern part of the storage area of Neste Oy (currently Fortum Oy). The area was remediated in 2008 by Ramboll Finland Oy. It was described in the report that residual concentrations did not exceed the goals of remediation, and no separate monitoring programme was suggested for the area. Although the property was found to be sufficiently remediated, potential contaminated soil may be found during earthworks and the quality of the soil will be examined before excavation works.

Preliminary soil contamination investigation was performed in the VRP area in 2021 by Sweco. As the land use in the area is designated for industrial and port operations and no sensitive sites are in the immediate vicinity of the VRP areas, the higher guideline values pursuant to the Vna 214/2007 are applied to the assessment of soil contamination and need for remediation. Based on the results, samples included concentrations of arsenic, cobalt, mercury, nickel, antimony, and vanadium that exceeded the threshold values in the southern VRP area. In addition, arsenic concentration exceeded the lower guideline value in one sample. Concentrations of harmful substances exceeding threshold values were not detected in the northern VRP area. As the higher guideline values were not exceeded, there is no need for soil remediation works considering that the existing insensitive land use (industrial area) will prevail in the area.

The baseline study is presented in Appendix 4 and soil contamination investigation report in Appendix 5.

4.3.2 Groundwater

The nearest important groundwater areas suitable for water supply are 14 km from the VRP area. No groundwater monitoring wells are in the Tahkoluoto area.

Groundwater follows the sea water level in an area, where filling soil is very permeable to water. Groundwater flows towards the sea. Due to the variation in the sea water level,

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water can, however, occasionally flow from the shore towards inland (Ator Consultants Oy 2016, Tahkoluodon Polttoöljy Oy, decision on environmental permit 2008).

4.3.3 Hydrology

The VRP area is in the coastal region of the Bothnian Sea and in the Reposaari-Outoori water body area. Comprehensive baseline monitoring information is available from the marine area outside of Pori. Joint monitoring of the Kokemäenjoki River and the Pori marine area is used to track the amount of load being directed to the Kokemäenjoki River and the Pori marine area and its impacts on the state of the water system. The latest monitoring report is from 2021 by KVVY. The report is presented in the Appendix 6.

The water quality in the marine area outside of Pori has improved over a long-term period. As early as in the 1970s, the reduction in phosphorus load significantly reduced the eutrophication. In the mid-1980s, oxygen conditions started to improve both in river and marine areas. Outside of the old waste water discharge site of the Pori pigment factory, iron concentrations were still remarkably high in the 1980s and the pH-value was low. All pigment plant monitoring stations had an average iron concentration of 234 µg/L in 2020. Today, concentrations have occasionally increased mainly by river waters flowing to the southern marine area of Pori (KVVY 2021).

The ecological state of Reposaari-Outoori area has been estimated as satisfactory and physicochemical state as good. The biological state of the water body is satisfactory.

The marine area outside of Pori receives environmental load from the river basin via the Kokemäenjoki River. There are so-called point sources of wastewater load directed into the water system from municipal waste water treatment plants, the industrial sector and thermal power plants. In addition to the point source load, the Kokemäenjoki River is loaded by diffuse load. In marine areas outside of Pori, river waters cause turbidity in the surface water and affect the nutrient concentrations. In the surrounding waters of the Reposaari island, eutrophication has occasionally been stronger than in the surrounding area, and the area has more clearly belonged to slightly eutrophic waters. (Sweco 2021a)

Currently, wastewaters from the Kaanaa industrial area are directed to the sea area on the southern side of Mäntyluoto outside of Pori approximately 7 km from the VRP area. Wastewaters from the ash treatment plant of Fortum Waste Solutions Oy and the planned bioconversion plant are also directed to the same water outlet. (Sweco 2021a)

Further information of the water quality can be found in the EIA (Appendix 1) and the water monitoring of the area in Appendix 6.

4.3.4 Air quality

The main sources of air emissions in the Pori region are traffic and energy production. The sulphur dioxide emissions were 198 tonnes, nitrogen oxides emissions 317 tonnes and dust emissions 7 tonnes in 2020 from major industrial operations and energy production. (City of Pori 2021)

The City of Pori measure air quality in cooperation with the cities of Harjavalta and Rauma, as well as with major industry and energy production facilities in the region (City of Pori Environmental and Health Surveillance Department 2021). Air quality is measured at three locations in Pori. Two of these are in the city centre, and one is in Pastuskeri which is approximately 4.5 km northeast from the VRP area.

In addition, vegetation impact studies or bioindicator studies and heavy metal dispersal studies have been carried out in the Harjavalta–Pori area since 1990 together with the major

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industry in the region. The next bioindicator study will be conducted in the South Satakunta and Pori region during the years 2022-2023 (City of Pori 2021).

The limit or threshold values pursuant to the Government Decree (79/2017) were not exceeded in 2020 for any measured component in Pori. The air quality guideline values in accordance with the Government Decision (480/96) were exceeded once, the daily guideline value for inhaled particles PM10 (70 µg/m^3) was exceeded in the city centre, as the value was 79 µg/m^3 in February 2020. (City of Pori 2021)

The Government Decree on Airborne Arsenic, Cadmium, Mercury, Nickel and Polycyclic Aromatic Hydrocarbons (113/2017) defines target values for the calendar year calculated as annual averages for arsenic, cadmium and nickel. The target values were not exceeded in Pori in 2020. (City of Pori 2021)

The latest air quality report is presented in Appendix 7.

4.3.5 Nature and nature protection

Three Natura areas are less than 10 km from the VRP area: Gummandoora Archipelago, Kokemäenjoki River Delta and Preiviikinlahti. The Natura area "Pooskeri Archipelago" is located approximately 11 km to the north-east of Tahkoluoto. Natura areas are presented in Figure below.

- The Gummandoora Archipelago Natura area (FI0200075, SAC/SPA) is approximately 2 km to the north of the VRP. The Gummandoora Archipelago Natura area is part of the Bothnian Sea National Park and the internationally valuable bird area (IBA) of the Oura-Enskeri Archipelago. There are several small nature reserves on private land in the islands of the Natura area. The site is almost entirely included in the coast protection programme. The area is protected by the Environmental Protection Act and the Water Act. The Natura area is also part of the Luvia archipelago, which is one of the sites in the coast protection programme.
- The Kokemäenjoki River Delta Natura area (FI0200079, SAC/SPA) is approximately 6 km to the south-east of the VRP. The area is the largest delta formation in the Nordic countries, which includes many different biotopes from submerged plant communities to mowed meadows and groves with common alder. The size of the Natura area is 2 885 hectares. The area is a very significant bird area. The area is part of the water bird habitats protection programme, Project Mar -programme, protection programme of the Nordic biotopes and the SL-area of the regional plan.
- The Preiviikinlahti Natura area (FI0200080, SAC) is approximately 7 km to the south of the VRP. Preiviikinlahti is a large and relatively shallow bay. The following sub-areas of the Natura area are part of the water bird habitats protection programme: Ooviiki area, part of the Lahdenperä area, Isosanta-Riitsaranlahti area and Enäjärvi area. The cape of Herranpäivät and part of the Enäjärvi area are nature conservation areas. 23 habitat types and one mammal (otter) constitute the protection objectives of the area.

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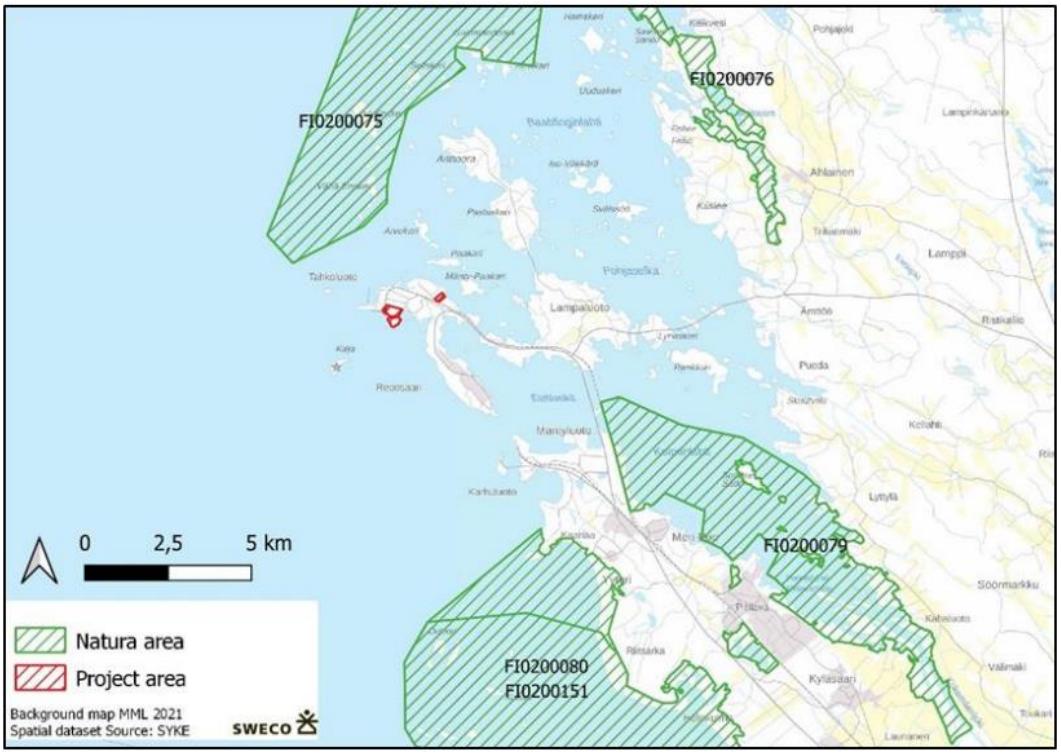

Figure 5. Natura areas within 10 km of the VRP project area (Sweco 2021a).

In addition there are nature conservation areas presented in Figure 6 below. The coastal area including the archipelago outside of Pori, Rauma, Pyhäranta and Uusikaupunki are part of the Bothnian Sea National Park (KPU020037). The national park is part of the National Conservation Programme of state-owned areas. The shortest distance from the VRP to the Bothnian Sea National Park is 3 km. The Natura areas of Gummandoora Archipelago and Preiviikinlahti partly overlap with the area of the national park. There are several nature reserves on private land in the Natura areas. The nearest nature reserves on private land to the VRP are the Badstuskär (YSA201568) nature reserve located in Iso-Enskeri island on the northern side of Tahkoluoto at about 5 km as well as the Loukkukari (YSA240804) and Uusiväkkärä (YSA207171) nature reserves located in Iso-Väkkärä island at a distance of about 5 km to the north-east of the VRP.

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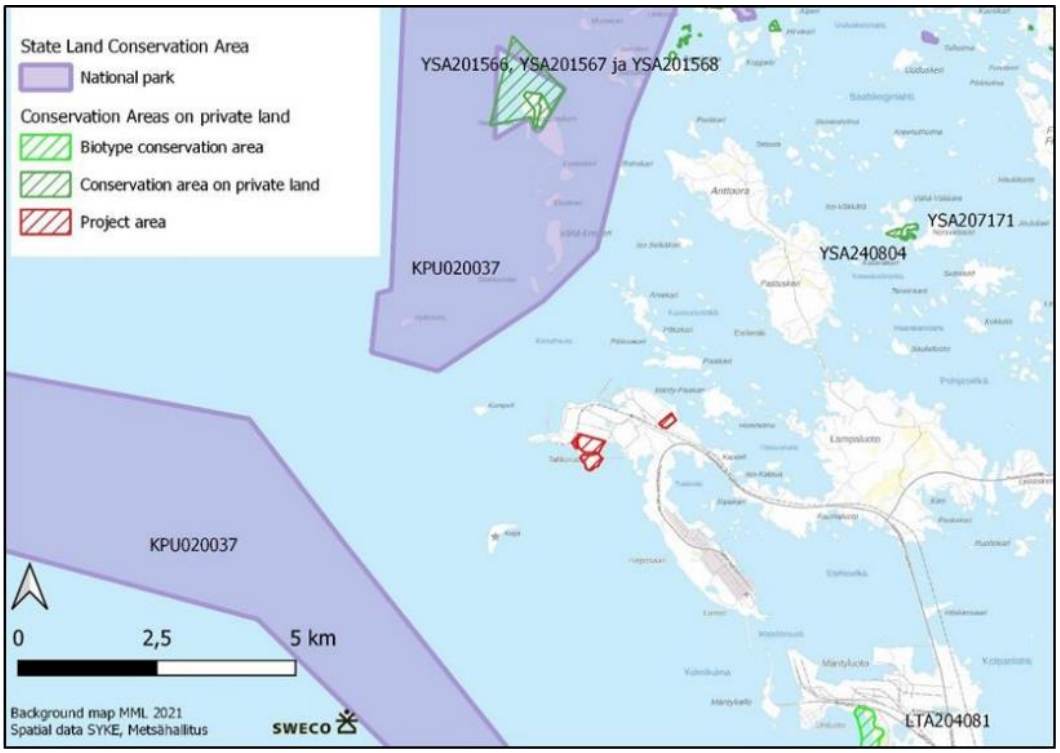

Figure 6. National parks and other conservation areas. The VRP areas are marked in red. (Sweco 2021a).

Valuable bird areas near the VRP area are presented in Figure 7. The Pori water bird habitat and coastal area outside of the City of Pori (nearest distance about 2.5 km), which is an extensive system consisting of archipelago, sea bays, river deltas and eutrophic lakes, is part of the internationally valuable bird areas (IBA). The internationally valuable bird area of the Oura-Enskeri Archipelago is an extensive archipelago area outside of Merikarvia. The Pori water bird habitat as well as the Rauma-Luvia and Pori archipelago are included in the internationally important bird areas (IBA). The IBA and nationally important (FINIBA) - areas are partly overlapping. The regionally important bird area network has been specified because of the Satakunta MAALI project . Regionally important bird areas (MAALI) include the areas of Kokemäenjoki River Delta-Kirrinsanta-Levo, Gummandoora-Merikarvia, Kaijakari-Enskeri and Preiviiki fields-Maaviiki. The MAALI-areas are national and more extensive areas than the important bird areas in Finland, and they partly overlap with the above-mentioned areas. (Sweco 2021a)

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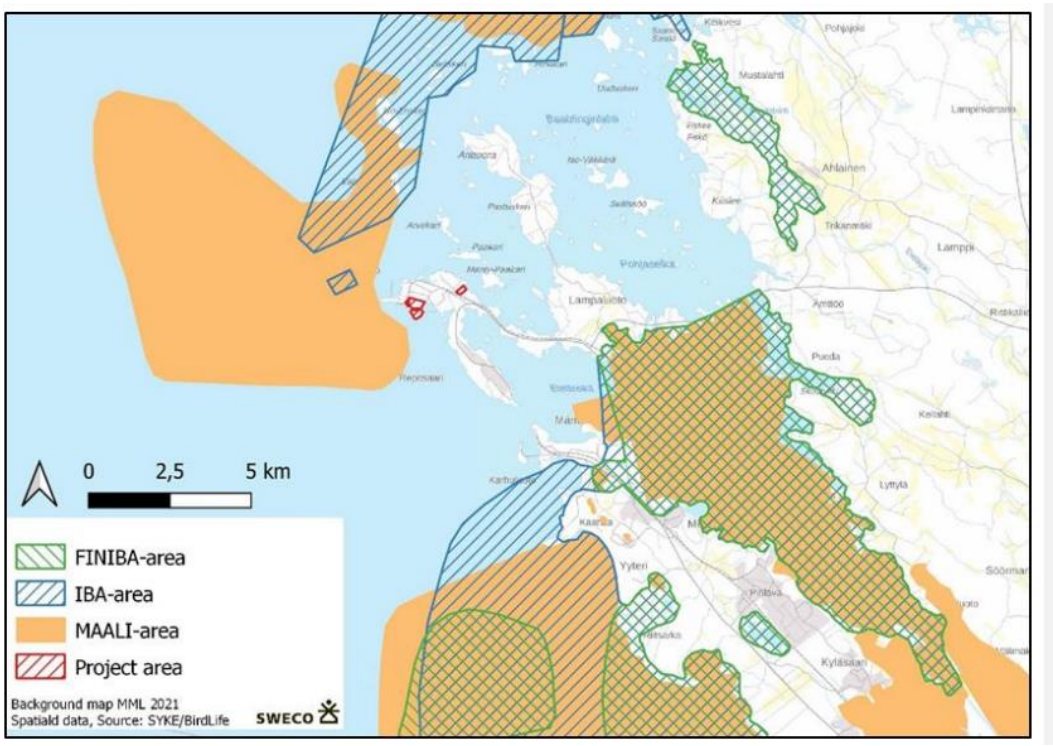

Figure 7. In the map there are marked the regionally (MAALI area), nationally (FINIBA area) and internationally important bird areas (IBA area). (Sweco 2021a).

4.3.5.1 Tahkoluoto area

In the surrounding area of Tahkoluoto, the most significant natural values include the natural beach areas of Ketaranlahti, Tukkiviikki, Räyhä and Kappeli, as well as the unbuilt parts of the islands (City of Pori 2020).

A nature study was conducted in the Tahkoluoto area in 1996. Based on the study the Tahkoluoto area has beach groves with common alder in the shore areas of Ketaranlahti and Tukkiviikki, in Räyhä (Köylynen) and on the southern shore of the MäntyPaakari island to the northeast of Tahkoluoto. Törnikari, where the VRP is located, is mentioned in the 1996 study as a very rocky low growth and outer archipelago type of juniper grove surrounded by a narrow common alder belt. For example, insect species of sunny and warm habitats may be found in the fringe areas of Törnikari (City of Pori 2020).

A comprehensive nature study was prepared in 2020 for the key natural areas of the component master plan (Ahlman 2020) (master plan area shown in figure 13). The study area did not cover the VRP process site but it covered the northern stockpile area. Regarding vegetation, it was stated in the nature study that the integrated chains of succession concerning groves and common alder communities on a coast with postglacial rebound constitute the most significant natural value in the study area. It was found that the nesting bird population in the master area is very diversified including 65 different species. Based on observations, 2 valuable bird areas were confined in the area. One of them concerns the small coastal zone on the western side of the Räyhänsuntti boat harbour, where e.g. critically endangered common pochard, a small great crested grebe population and other wetland species are nesting. The most significant bird area is Ketaranlahti and the nearby areas of Pikku-Ketara and Ketara. A significant number of notable species are nesting in the area, such as several tufted ducks, common eiders, coots, terns and several other wetland species.

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The nature study 2020 of the master plan area was supplemented during spring-summer 2021 regarding areas shown in figure below including vegetation and habitat types, bats, nesting bird population, remarkable butterfly species, flying squirrel and moor frog. In addition, a separate butterfly study was performed to examine the potential meadow dwarf species of sunny and warm habitats occurring in the area.

According to the nature study, no signs of flying squirrel or moor frog, no observations of bats or specifically valuable nesting bird populations were identified. Instead, e.g. seagull populations were found around islands. Regarding vegetation, valuable plant species can mainly be found in the Tahkoluoto meadow area on the eastern side of the power plant.

A butterfly species, meadow dwarf (*Elachista triatomea*), was identified in Tahkoluoto. It is not included in Annex IV or Annex II of the Habitats Directive. It has been defined as a threatened species in Appendix 4 of the Nature Conservation Decree, but neither as a specially protected species nor a species under protection pursuant to Appendix 2 of the Nature Conservation Decree. Meadow dwarf has been classified as an endangered species (EN).

Meadow dwarf lives in fields, hillsides and meadows. Red fescue (*Festuca rubra*) and sheep fescue (*F. ovina*) are the food plants of meadow dwarf. The larvae of the species dig out the leaves of red fescue in April-June. Red fescue is a loosely tufted, very numerous and widely spread grass. The habitats of it include various fresh meadows and road verges. Sheep fescue is also very numerous and widely spread species, which grows in dry meadows, fields, moors, and rocks (Ahlman Group 2021).

The current state of meadow dwarf in Tahkoluoto, Pori was examined in five field surveys during May–mid July 2021. The field surveys focused at first on discovering fescues, which are the food plants for larvae, and potential leaf mines of fescues. After this the surveys included plenty of "sweeping" or netting of previously discovered fescue communities to find mature individuals. Furthermore, leaf mines were still surveyed.

The most significant sites of red fescue communities and site of sheep fescue community in the Tahkoluoto area are presented in figure below. In addition, red fescue can also sparsely be found along other roads and around the foundations of wind power stations in Tahkoluoto. The food plant forms a typical small-scale metapopulation network connected by roads and road verges, which also act as flight routes (Ahlman Group Oy 2021). Leaf mines made by the larvae of meadow dwarf were found in the three most significant sites of red fescue communities (areas 1, 2 and 4 in the Figure below).

As a mitigation measure to prevent negative impact of the VRP to the meadow dwarf, suitable sites for creating a new red fescue community were evaluated in the Tahkoluoto area in the nature survey. A plan to relocate the meadow dwarf and its feeding plant, red fescue, from the location 4 was made. A relocation plan was submitted to the ELY Centre in September 2021. The ELY Centre accepted this. The red fescue was relocated in October 2021 by Port of Pori and supervised by City of Pori. Further information of the relocation is presented in Appendix 8.

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Figure 8. Supplementary areas of the nature study 2021 are outlined with red and the most abundant red fescue (marked with purple no 1-5) and sheep fescue (marked with red no 6) communities.

4.3.6 Noise and vibration

In the Tahkoluoto area noise is generated by the oil and chemical port operation and related transport activities as well as by the operation and related transport activities of power plants and industrial plants (crushing plant, LNG terminal, loading and unloading activities in the rock storage area).

Noise studies are conducted regularly at the Tahkoluoto area. The latest noise measurements regarding the noise generated by the port were made during spring 2021 by Sitowise Oy. The noise measurements have been performed in the nearest residential and leisure home areas around the Tahkoluoto port area. The results are presented in the table below. The equivalent continuous sound levels were below 45 dB in all measurement points, except the power plant, where it is was 46 dB. According to the measurement report the main sources of noise were by-passing road traffic and sounds of nature. The uncertainty of the noise measurement results varies between ± 6-8 dB based on the distance between measuring points and sources of noise. The guideline value of 55 dB for the equivalent continuous sound level based on the Government Decision 993/92 for permanent residential houses was not exceeded. The measured equivalent continuous sound level does not exceed the guideline value of 45 dB based on the Government Decision 993/92 for holiday houses, but considering the uncertainty in measurement, the measured value cannot be verified in accordance with the guideline for measuring environmental noise (Sitowise 2021).

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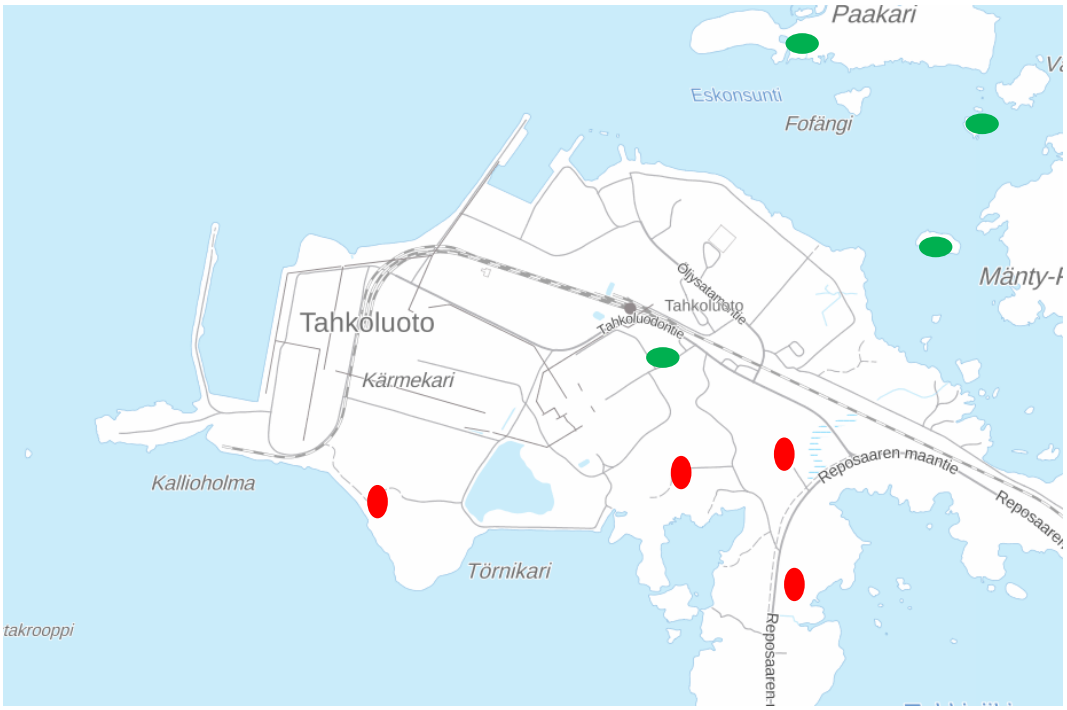

Figure 9. Measuring points. The green locations were measured when the wind blow from southwest/west and the red locations when the wind blow from northwest. (based on Sitowise 2021)

Table 1. Measured noise levels in the monitoring locations (based on Sitowise 2021).

Monitoring location		Measured equivalent continuous sound level LAeq dB, measurement period 30 min	Further information
1	Reposaari main road 927 (Räyhä)	44 (± 7)	Nature sounds are dominant, industrial noise and traffic noise.
2	Reposaari main road 982 (Parkkiluoto)	42 (± 7)	Noise from by-passing traffic and nature sounds are dominant.
3	Reposaari road 10 (Katainniemi)	43 (± 7)	Nature sounds are dominant, industrial noise can be detected.
4	Törnikari	44 (± 7)	Industrial noise and sounds of birds and boats.
5	Paakari	43 (± 8)	Dull industrial noise mixed with the sounds of waves. Sounds of birds and summer residents.
6	Hirvikari	43 (± 8)	Dull industrial noise and bird sounds.
7	Santakari	44 (± 8)	Dull industrial noise and bird sounds.
8	Power station gate	46 (± 6)	Dull industrial noise and bird sounds.

Based on the noise modelling of 11 wind power stations in the existing wind farm of Suomen Hyötytuuli Oy and 6 inland wind power stations (Figure below), the calculated

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equivalent continuous sound levels (LAeq) caused by the existing wind power stations are 36–39 dB at nearest receptor points (disturbed sites) closest to the VRP area (R8 and R9).

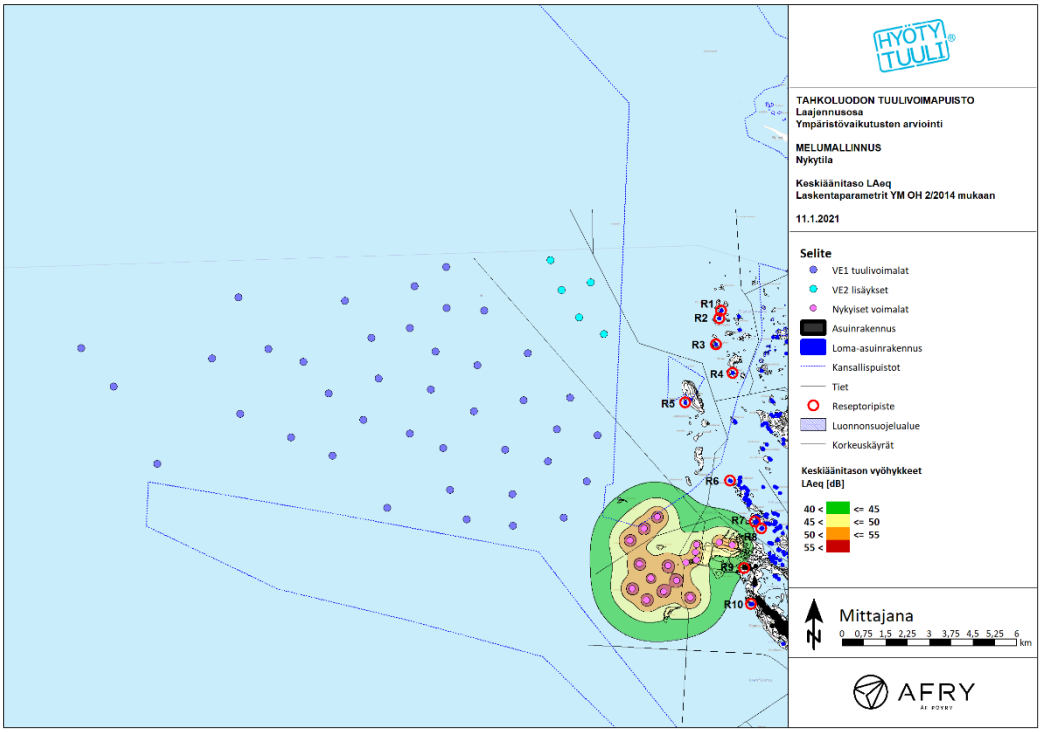

Figure 10. Noise modelling of off-shore wind farm. (AFRY Finland Oy 2021)

Feedback related to vibration has also significantly increased in the Pori area in recent years due to growing train traffic volumes. The ongoing railway upgrading project will include new type of tracks that will reduce vibration. Based on drillings, soil along the Pori–Mäntyluoto rail section is more fine-grained and softer, which makes the area more susceptible to vibration. (Sweco 2021a)

4.3.7 Traffic

Road traffic between Pori and Tahkoluoto is directed along the Mäntyluoto road (highway 2) as well as the Reposaari main road (regional road 269) or from highway 8 via the Pori archipelago road (regional road 272). For potential special transports, a supplementary transport route leads to Tahkoluoto port from highway 8 along regional roads 272 and 269.

The average daily traffic volume on the Reposaari main road between Mäntyluoto and Tahkoluoto is about 1,900 – 2,500 vehicles and about 800 vehicles on the Pori archipelago road (regional road 272) at Lampaluoto providing a connection to the Reposaari main road. Heavy traffic volume is about 320 vehicles/day on this road section of the Reposaari main road and about 130 vehicles/day on the Pori archipelago road. On the Reposaari main road, a pedestrian and bicycle way exists only between Reposaari and Tahkoluoto port junction. (Sweco 2021a)

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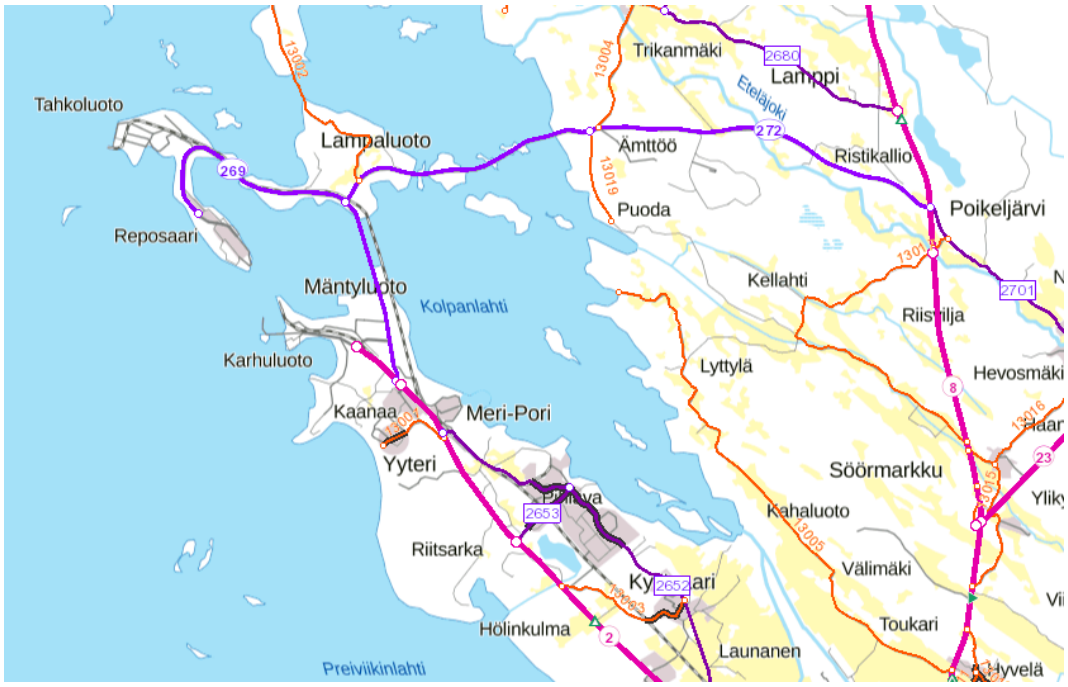

Figure 11. Road number map (Väylävirasto).

Pori-Mäntyluoto-Tahkoluoto is a single track rail section for freight traffic operations. The rail section has been upgraded several times. The electrification of the Pori–Mäntyluoto rail section was completed in 2019-2020 and the electrification of the Mäntyluoto–Tahkoluoto rail section was completed in 2021. (Sweco 2021a)

There is a railway track to the Tahkoluoto area. The freight transport volumes in tonnes have varied between 0.03-1 million/a and the number of trains varied between 50-984 annually during 2017-2020. (Sweco 2021a)

There are two deep-water channels leading to the Tahkoluoto port. A 10.0 metre fairway leads from the south-west to the oil and chemical port and a 15.3 m fairway leads from the north-west to the deep-water port. A 3.4 metre fairway bypasses Tahkoluoto on the western side and runs from the ports in Ostrobothnia to the ports in southwest Finland. (Sweco 2021a)

The fairway coming from the north-west passes through the Natura area of Gummandoora Archipelago (FI0200075). On average, 250-350 vessels visit the Tahkoluoto port every year. Based on the statistics of import freight traffic in the port of Pori (City of Pori 2018), the share of the traffic volume in the Tahkoluoto deep-water port is estimated to be about 70 – 80 % of the total traffic volume (250-350 vessels/year) in the Tahkoluoto port. The operation of the deep-water port has previously been linked especially to the import of coal to two power plants in Tahkoluoto. One of the plants has already been closed and the remaining plant is only used as a reserve power station, and it will possibly be completely shut down by the year 2029. (Sweco 2021a)

4.4 Land use

4.4.1 Regional plan

The Satakunta Regional Plan, was adopted on December 17th, 2009 and become final by a decision of the Supreme Administrative Court in March 2013.

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In the regional plan, the VRP process plant area (southern area) is designated for port operations (LS), southern part of the VRP area in Törnikari is located in white area (no area reservation), and some parts are also located in energy supply and industrial expansion area (EN).

In the regional plan, the northern VRP area is in an area having the plan symbol T1. The plan symbol designates significant industrial and warehouse areas, where plants manufacturing and storing hazardous chemicals can be located, and which must comply with the EU Directive 96/82/EY regarding the control of major accident hazards involving hazardous substances (SEVESO II Directive).

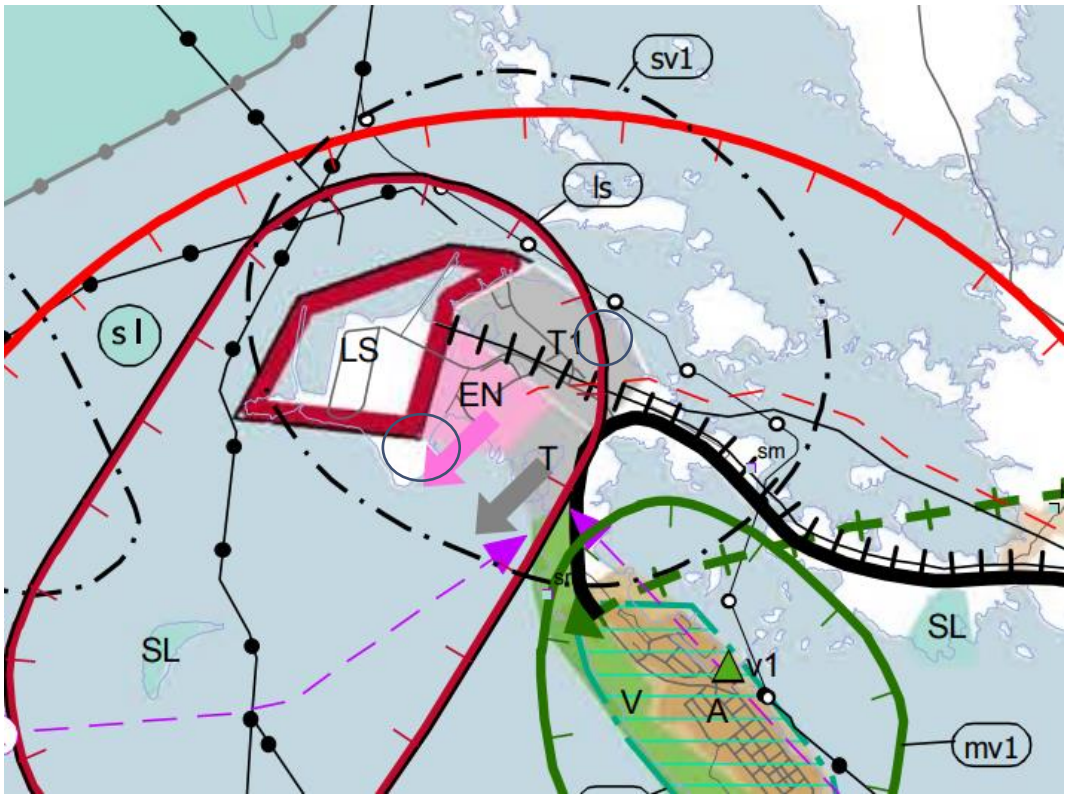

Figure 12. An extract from the Satakunta regional plan, 2009. The VRP areas are indicated with blue circles. Regional road (thick black line), railway (black cross line), fairway (black dotted line, open dotted line), power line (thin black line), indicative power line route (thin red line), natural gas network connection from land and sea (purple dashed line), development area of port operations (red/black line with brackets inwards), nationally significant development zone of multi-centric regional structure of the Kokemäenjoki River valley (bright red line with brackets inwards), safety zone of hazardous chemicals (consulting zone, black dashed dotted line).

The port area is surrounded by an area with the plan symbol sv-1 designated as the safety zone for a facility manufacturing or storing hazardous chemicals (consulting zone). When planning of risky operations within the safety zone, the fire and rescue authority and the Finnish Safety and Chemicals Agency (TUKES), if needed, must be provided an opportunity to provide a statement. There are provisions also for flood risk control and water management.

The Satakunta phase regional plans 1 or 2 do not have plan symbols in the VRP area.

4.4.2 Master plan

There is no legally binding master plan in the area. The area has the Reposaari-Tahkoluoto-Lampaluoto-Ämttöö component master plan, which was approved by the city council on

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March 24th, 1997, and which has no legal effect. In the component master plan, both the southern and the northern VRP area are designated as industrial areas (T, grey area).

The Tahkoluoto−Paakarit component master plan 2040 is currently under preparation in the Tahkoluoto area (Figure below). It was in public display during July-August in 2021. The main idea of the plan is to secure the operations and enable the development of the Tahkoluoto deep-water port and chemical port in the future, while preparing for port extension. The "Reposaari-Tahkoluoto-Lampaluoto-Ämttöö" component master plan (1997) will be revised to a legally binding master plan for Tahkoluoto and its surrounding area as well as for its northern, predominantly city-owned islands. The city of Pori has informed the applicant that the plan of the city is to approve the Tahkoluoto–Paakarit component master plan during 2022.

The VRP southern areas are in the areas designated for industrial, warehousing and energy supply area, where hazardous chemical use or manufacturing plant may be located (plan symbol TEN/kem). Also the most western part of the VRP area extends to port area (plan symbol LS). The northern VRP area is in the areas designated for industrial area, where environment imposes special requirements to the type of operations (plan symbol TY). Minor part of the area seems to extend to the area of port and related industry and warehousing traffic area (plan symbol L-1).

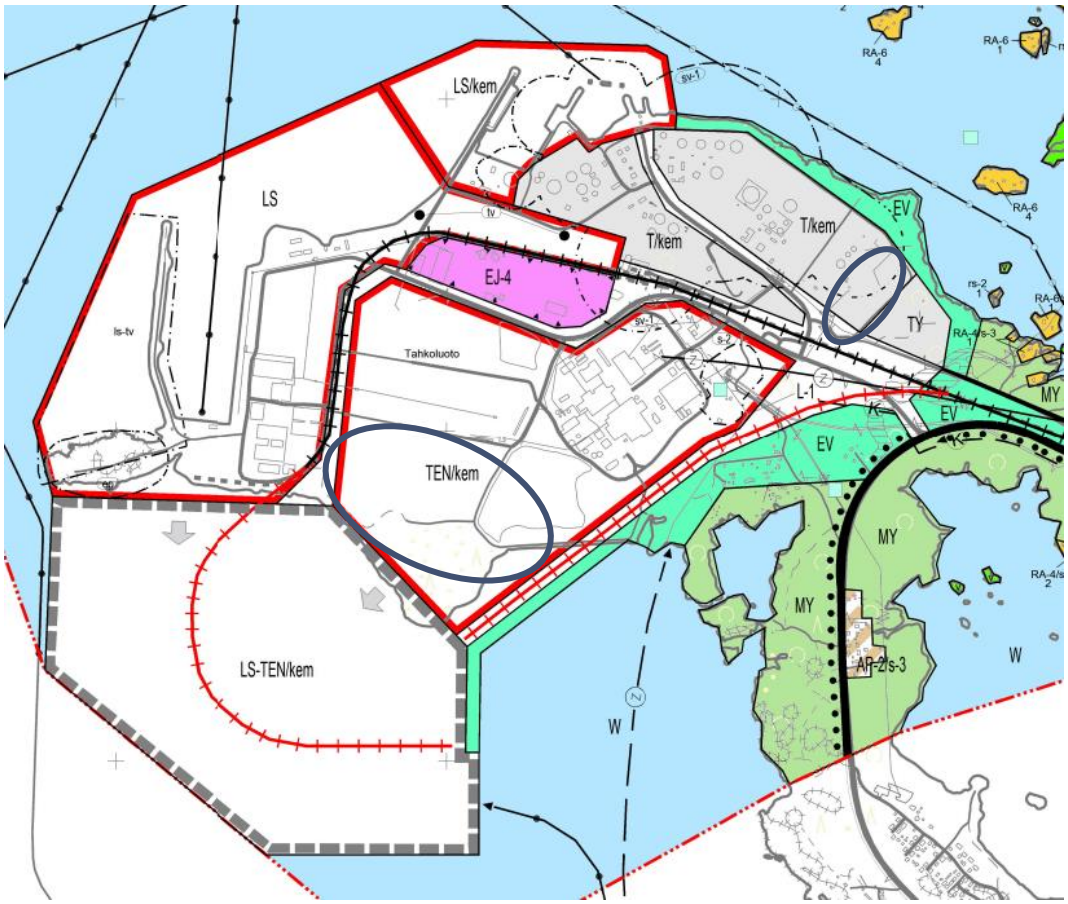

Figure 13. An extract from the Tahkoluoto-Paakarit master plan draft. The VRP areas are estimated by blue circles in the map.

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4.4.3 City plan

Tahkoluoto 73 detailed plan is valid in Tahkoluoto area (Figure below, gained legal effect on August 21st, 1986). The VRP areas are designated for block area of Industrial and Warehouse Buildings (grey area in the map, plan symbols T-9 and TV-1).

- This means that in the southern area power plants, buildings and structures related to power generation, distribution and transfer, as well as buildings serving the storage of inflammable liquids up to 5 000 m^3 can be built in the block area. Activities in the block area must not generate a noise level greater than 45 LAeq dB (A) for the residences located in the detailed plan area. The project area has the plan symbol of t+42 indicating the maximum permitted approximate height position for open storage allowed in the area.
- In the northern area buildings serving the storage of inflammable liquids and related necessary office, social service and other service buildings as well as related residences for emergency and service personnel can be built in the block area.

Figure 14. The VRP area is estimated within blue circles. (Pori Map Service). The white area is area with no land use plan.

According to City of Pori a change to the city plan is planned within the next 1-3 years (M15, Tahkoluoto 70.). The area would include whole Tahkoluoto.

TUKES has made a statement that it does not object to situate the VRP plant to the area with the current T-9 land use designation. City of Pori has also made a statement that the designated land use would be suitable for the plant and that the detailed plan is sufficient.

The statements are presented in Appendix 9 (Tukes) and Appendix 10 (City of Pori).

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4.5 Neighbours and other stakeholders

The neighbours and other stakeholders are presented in the Appendix 11. The range of the stakeholders is 2 km. In addition to these the Reposaari Association is considered a stakeholder.

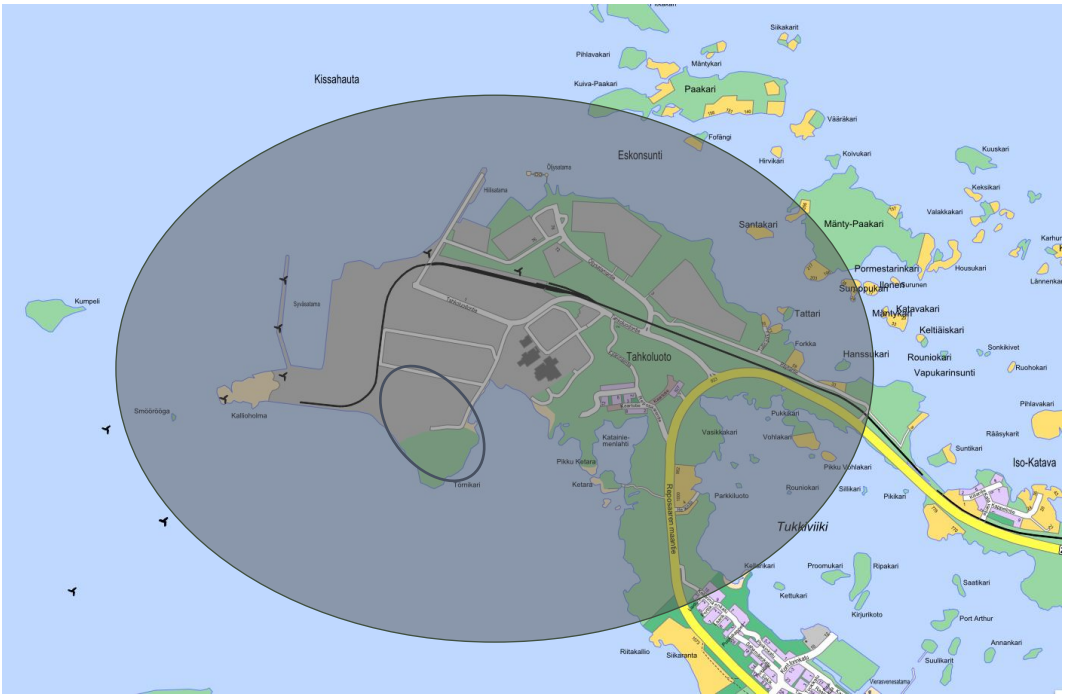

Figure 15. Estimated range of stakeholders. The radius is roughly 2 km. The VRP process area is marked with dark blue.

5 Operation of the vanadium recovery plant

5.1 Construction, schedule, and operating phase

Final investment decision will be made in late 2022 and construction is scheduled to commence in the first half of 2023 with commissioning scheduled for late 2024.

The duration of construction of the plant is about two years. It is estimated that a maximum of a few hundred persons will work on site in construction phase.

The plant will employ approximately 120 fulltime employees. The plant will be operated 7 days a week, 24 hours a day for 365 days a year. There will be planned maintenance regularly.

5.2 Raw materials

Slag for feedstock will be sourced from SSAB Group stockpiles in Sweden in Oxelösund and Luleå, and Finland in Raahe. The amount of slag used annually is 300 000 dry tonnes.

SSAB steel operations in Scandinavia produce slag at a rate of more than 200 000 dry tonnes per year. A large percentage of the slag produced in the steel making process is returned to the blast furnaces. Slag that is not useful in the blast furnaces has been used in construction materials and or stockpiled. Today, there is about 1.76 million tonnes of slag

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available for vanadium recovery. This would amount to the consumption of the plant for almost 6 years at a rate of 300,000 dry tonnes per annum.

5.2.1 Quality of slag

All the slag used as feed for the VRP is called LD-slag. This name comes from the slag originating from the Linz-Donawitz (LD) converter. It is a byproduct from steel production.

The quality of the slag varies slightly depending on its source. The vanadium pentoxide grade at the slag stockpile in Luleå is about 4% V_2O_5 and at Oxelösund and Raahe is about 3.2-3.8%. These are some of the highest-grade vanadium feedstock sources in the world. The CaO grade of the slags differs. The grade of CaO in the slag will affect the amount of SSM produced at the plant. The higher the CaO grade, more SSM is produced.

The moisture content of the slag is approximately 10% and its pH is around 11. The slag particle size is minimum 10 mm.

Slag is not classified as a hazardous substance according to the CLP Regulation. Based on the safety data sheet (SSAB Merox Ab 2018, Appendix 12), treatment of slag does not require special measures regarding environmental safety.

Table 2. Shares of slag in annual use and percentage of slag components.

	Raahe	Luleå	Oxelösund
Estimated share from all slag used	35 %	50%	15%
Components (% w/w)			
V_2O_5	3.8	4.3	3.2
CaO	47.7	42.5	41.4
Fe_2O_3	22.2	24.9	25.3
SiO_2	12.4	9.0	11.5
Al_2O_3	1.7	1.7	1.3
TiO_2	1.1	1.4	1.2
MnO	2.8	3.1	3.4
P_2O_5	0.9	0.6	0.5
SO_3	0.1	0.1	0.2
MgO	2.0	8.8	8.7
Cr_2O_3	0.4	0.2	0.6

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Figure 16. Slag stockpile (left) and slag material (right) (Neometals).

Based on the solubility and toxicity test slag does not have high metal solubility and its toxic concentrations in aquatic environment are not high. The test results are presented in Appendix 12.

5.2.2 Slag by-product status

The slag is defined in the environmental permit (dated March 22nd, 2016) of SSAB's Raahe plant as a by-product. In Sweden the status of by-product is not defined in environmental permits. According to the Swedish legislation, the status of slag, which is transported from the plants in Luleå and Oxelösund, is defined as a by-product by the decision of the operator. This is controlled by the supervisory authority of the facility.

The Waste Framework Directive defines by-products as a substance or object, resulting from a production process, the primary aim of which is not the production of that item. Use of slag as a raw material for vanadium pentoxide production in the proposed plant meets the criteria (article 5) of the Waste Framework Directive (646/2011):

Table 3. Fulfilment of the by-product criteria of the Waste Framework Directive and national Waste Act 5a.

Criteria	Slag
(a) further use of the substance or object is certain;	The operation of the VRP is based entirely on the utilisation of slag. The procurement of raw material for the vanadium recovery plant is based on completed agreements between the project developer and the slag supplier, currently SSAB. Based on these agreements, the project developer will purchase the raw material.
(b) the substance or object can be used directly without any further processing other than normal industrial practice;	The slag is not processed or treated at the VRP, except for occasional crushing, before feeding it to the process. Crushing is considered normal industrial practice.
(c) the substance or object is produced as an integral part	Slag is an inseparable and essential part of the steel production process, without being the main product of the steel plant. Slag is generated when refining the iron into steel in the LD-furnace.

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of a production process; and	During steel production, slag is tapped into a slag pot, which is transferred to the cooling yard of the steel smelter, where slag is cooled down with water. With no other prior actions, slag is transported to the vanadium recovery process.
(d) further use is lawful, i.e. the substance or object fulfils all relevant product, environmental and health protection requirements for the specific use and will not lead to overall adverse environmental or human health impacts.	According to the regulation on the Classification, Labelling, and Packaging of substances and mixtures (so-called CLP Regulation, EC No 1272/2008), slag has no hazard classification. Both SSAB Europe Oy (Raahe) and SSAB EMEA Ab (Oxelösund and Luleå) as manufacturers of the substance have registered slag pursuant to the REACH Regulation. Slag is treated according to the prepared safety data sheet. Along with the REACH registration, it meets all requirements regarding environmental and health protection.

5.2.3 Transport and storing of slag

Slag will be delivered by ships to Tahkoluoto. Transport of slag from Sweden to Finland is not considered as international waste transport. Based on the discussions with the Finnish Environmental Institute, they do not object to the slag status as a by-product, if the slag is considered a by-product in Sweden.

In the port, a grab dumps slag into a loading chute, from which it goes along a conveyor to a so-called stacker, which piles up the slag to a desired site in the storage field behind the quay.

Slag will then be transported either by trucks and/or conveyors to the plant. Slag is stockpiled uncovered on site (stockpile A or B and possibly C) (see Appendix 13). It is estimated that the maximum total amount of slag to be stockpiled on site will be approximately 2.4 million tonnes. There will be a need to stockpile various quantities of slag to avoid interruptions in supply and provide opportunity to select or blend feed to the operation.

The maximum height of the slag stockpiles is 15 m. Slag has been stockpiled uncovered at SSAB sites in Luleå, Oxelösund and Raahe for several years.

The slag stockpile areas will have a surface liner to prevent any leaching penetrating into the ground and the surface will be inclined in such a way that stormwaters and snow melt will flow to a collection pond. The liner and pond structure is presented in Appendix 14.

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5.3 Process

The main process steps of the plant are:

- Feed (slag) receipt and pre-treatment (comminution)
- Integrated leach and regrind circuit
- Solid/liquid separation including repulp washing of leach residue solids
- Solvent extraction vanadium purification circuit
- Vanadium pentoxide (V_2O_5) production

A simplified process flowsheet is presented below. The process stages are described in the following sections. The process plant lay-out is presented in Appendix 15.

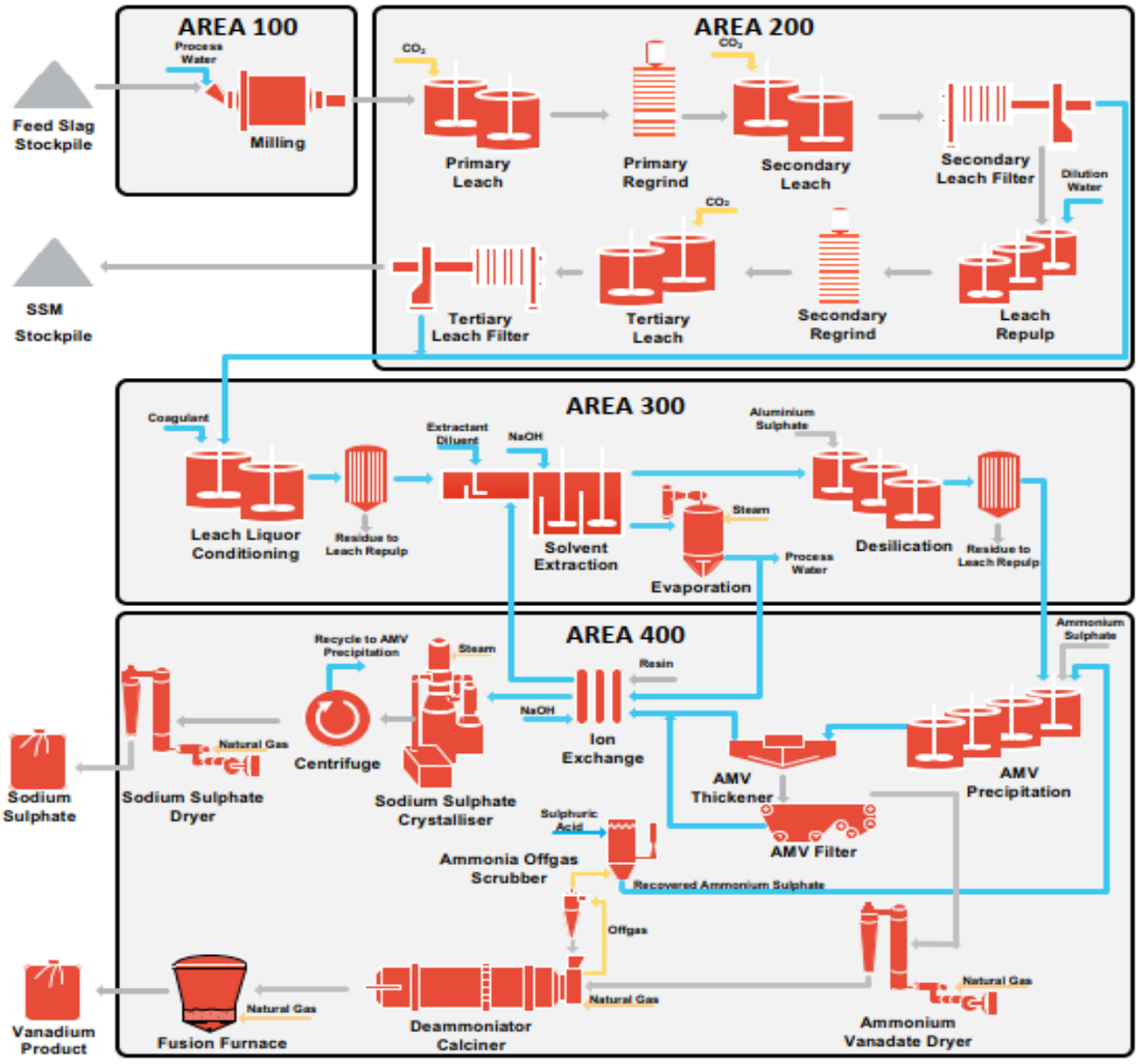

Figure 17. Simplified process flowsheet.

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5.3.1 Feed receipt and grinding

The feed will be delivered to the plant as predominately < 10 mm particles and will be screened to remove oversize material. There will also likely be a magnetic stage for removal of high-iron (more magnetic) material. Screened feed will be fed to the single ball mill or other dry grinding system (e.g., High Pressure Grinding Roll or Vertical Roller Mill) to be ground. The amount of slag fed will be approximately 38 dry tonnes hourly. The target particle size for the primary leaching stage is P80 of 75 µm and the mill discharge will be classified using hydro-cyclones (or similar). The overflow (undersize) will progress to the first primary leach tank (or a primary leach feed holding tank), while the underflow (oversize) is returned to the ball mill.

5.3.2 Leach and regrind

Sodium carbonate leaching occurs in at least two stages with inter-stage regrinding.

After the primary alkaline leaching with sodium carbonate solution, primary leach discharge is passed directly to a re-grind mill for further particle size reduction and exposure of fresh leachable mineral surfaces. This is followed by secondary leaching with a sodium carbonate solution under similar moderate temperature and atmospheric pressure leaching.

Through the leaching process the calcium in the slag (which comes from the excess lime from the steel mill) reacts with the carbonate to produce calcium carbonate. During this process the vanadium is made available for leaching and deports into the leach solution. Carbon dioxide gas is sparged into the leach reactors to maintain the required pH by regenerating carbonate ions, which are consumed in the calcium carbonate precipitation and ensure selective leaching of the vanadium. Additional regrind and leach stages could be added if needed to ensure an optimum portion of the vanadium is recovered from the slag feed.

During the above leaching process carbon dioxide is sequestered and calcium carbonate is formed causing an increase in the mass of solids in the leach slurry.

5.3.3 Solid/liquid separation and solids repulp washing

Following the leach process, the residual solids are separated from the leach solution. A combination of thickener (if needed) and pressure filter (with counter current washing) is used to separate the pregnant leach solution (PLS) from the leach residue. The well washed leach residue contains a calcium carbonate rich fine material with all the insoluble and weakly soluble minerals from the feed slag. The leach residue is the secondary product called SSM.

The SSM is washed in hot water at a high liquid to solid ratio to further remove any residual soluble vanadium and sodium ions. Following the wash, the SSM is thickened and filtered to reduce residual moisture and transferred to temporary storage.

The counter current wash water streams (containing low levels of vanadium and reagents) are reused in the circuit to ensure optimal retention of any remaining soluble vanadium and any dissolved sodium. SSM repulp water and primary wash water may be processed through an ion exchange system to recover dissolved vanadium and the barren water reused in the SSM wash stage.

Alternatively, a bleed stream of SSM repulp and wash water may be taken directly or through the evaporator (to increase sodium concentration) prior to recycling to the leach circuit, to manage sodium concentration, and ensure the water balance is maintained in the wash circuit. Condensate can be used as hot water in the SSM wash circuit. When the ion exchange (IX) columns are loaded they are stripped with a sodium hydroxide solution and

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the small volume of vanadium rich eluate is used to make up strip or scrub liquor for use in the solvent extraction (SX) system.

5.3.4 Vanadium purification

The vanadium-bearing PLS is treated with CO_2 to adjust the pH to the optimal value of 9-12 for SX and a small quantity of coagulant is added. The PLS is then passed through at least one polishing filter to remove any fine or colloidal silica and the SX feed is ready for purification.

Solvent extraction uses an organic phase (consisting of an extractant, phase modifier and diluent) to selectively extract vanadium from the PLS and leave the sodium and other ions in the raffinate. During this phase the vanadium has moved from the aqueous feed to the organic phase. The extracted aqueous phase (raffinate) is returned to the process water tank and reused in the comminution and leaching circuit. The recycle of raffinate to the process ensures the return of most of the sodium ions back to the leach circuit. The raffinate may also be passed through the evaporator to remove excess water and increase the sodium concentration in process water prior to its reuse in the comminution or leach circuit. Condensate can be used as incoming wash water on the filters.

The organic phase loaded with vanadium is passed through one or more scrubber contactors to ensure any entrained PLS or weakly extracted species are removed from the organic phase. The scrubber in the SX circuit removes any entrained or weakly extracted species from the organic phase back to the aqueous phase. The loaded scrub solution is combined with the PLS SX feed solution entering the SX circuit and no wastewater is generated. The scrubbed organic is then contacted with a strip solution to recover the vanadium in a clean aqueous strip solution for further processing. The stripped organic is recycled to the extraction stage and used continuously in the SX circuit.

The organic reagents used in the process are circulated several times until they degrade in the process. As organic chemicals degrade, they are likely to transfer to fine aggregates, which are removed from the organic phase using a combination of tricanter (centrifuge) and filter. Water soluble organic degradation products are transferred to process water circulation until it is removed by organic filters.

Crud is generated in the solvent extraction process. The crud is removed from the SX system and put it through a tricantor (a centrifuge) to recover clean organic and clean aqueous which can both be returned to the SX circuit. The amount of crud is estimated to be 1-2 tonnes annually. The crud is mixed with SSM as it enters the repulp wash circuit described above to remove any soluble species.

5.3.5 Desilication, ammonium metavanadate precipitation and V_2O_5 production

Desilication of the PLS is achieved using industry standard procedures whereby the pH is initially reduced to approximately 8 by adding sulphuric acid and subsequent addition of aluminium sulphate. The combined aluminium/silicon precipitate formed in this step is then removed by filtration. Only very minor quantities of solids are generated in this process, and these are washed on the filter before again being combined with repulp solids and joining leach residue as SSM.

The filtrate is treated with a combination of sulphuric acid (if needed) and ammonium sulphate / sodium sulphate (including recycled crystalliser brine) to precipitate ammonium metavanadate (AMV) and leave a sodium sulphate containing solution. The AMV is collected by filtration and thoroughly washed with dilute ammonium sulphate solution to be free of sodium salts to improve the quality of the AMV cake.

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The barren sodium sulphate solution and primary wash water is transferred to a sodium sulphate crystallisation circuit whereby the sodium sulphate secondary product can be obtained, and any residual crystalliser liquor is recycled back for reuse in the AMV precipitation circuit.

Filtrate from the AMV product filter is heated using steam in a crystallisation circuit and reaches super saturation with respect to sodium sulphate and cooled to crystallise. The resulting Glaubers salt (sodium sulphate decahydrate or $Na_2SO_4.10H_2O$) is then dried to produce anhydrous sodium sulphate for sale. Alternatively, a direct anhydrous sodium sulphate crystalliser may be considered.

Steam from the evaporator/crystalliser is passed through a heat exchanger to transfer energy to other process solutions and the condensate is captured at 50 – 70 °C to be reused as SSM wash water or in reagent make-up.

Figure 18. Selected Bags of AMV product (weighing 3-5kg each) produced during the pilot plant operation.

AMV feed material (cake) (containing up to 25 % moisture) is dried at ~100°C in a flash dryer (alternatively the AMV dries in the first part of the deammoniator). Next, AMV feed material is heated to approximately 650°C in a calciner (deammoniator), and the temperature is maintained for the required time, to obtain carbon- and sulphur-free vanadium pentoxide.

Alternatively, dried vanadium pentoxide powder is sent to a fusion furnace and flaking wheel for the V_2O_5 flake production.

V_2O_5 product (either powder or flake) is packaged for sale and stored in a product shed until shipment.

Off gas from the deammoniator will contain ammonia and sulphur gases which will be scrubbed by sulphuric acid to form ammonium sulphate which can be recycled back to the AMV reactor thus recovering valuable reagents and reducing emissions.

The carbonate leaching has achieved 70 % to 80 % vanadium recovery in bench scale, mini pilot and full pilot scale test work.

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5.4 Products

Three types of products are produced in the process. The quantities of the products are presented in the table below. In this permit application SSM is also considered waste because the by-product status of SSM is not fully defined at time of the submittal of the environmental permit application.

Table 4. Annual production and maximum storage of products.

Product	Produced tonnes annually (max)	Maximum storage (t)
Vanadium pentoxide	9000	4500
SSM	415 000 dry tonnes (545 400 wet tonnes)	1 245 000 dry tonnes (1 635 000 wet tonnes)
Sodium sulphate	30 000	7 500

REACH Regulation (EC/1907/2006) obligations will be fulfilled based on the REACH action plan, which will be prepared later. The necessary REACH registrations will be prepared for manufactured products and the other obligations of the REACH Regulation will be complied with.

5.4.1 Vanadium pentoxide

The primary product of the process is high-purity (minimum of 98.5%) vanadium pentoxide (V_2O_5) powder or flake. The maximum production of V_2O_5 will be around 9000 dry tonnes per year. The vanadium pentoxide will be stored on site in a shed in sealed bags and/or drums until shipment is made to off-take partners.

Figure 19. Vanadium pentoxide of the pilot plant in powder form.

The CAS number of vanadium pentoxide is 1314-62-1 and it has the following hazard statements:

- H302: Harmful if swallowed
- H332: Harmful if inhaled
- H335: May cause respiratory irritation
- H341: Suspected of causing genetic defects
- H361d: Suspected of damaging the unborn child
- H372 Causes damage to organs through prolonged or repeated exposure (if chemical is inhaled)
- H411 Toxic to aquatic life with long-lasting effects

The material safety data sheet is presented in Appendix 16.

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5.4.2 By-products

At maximum capacity up to 30 000 tonnes of anhydrous sodium sulphate (Na_2SO_4) will be produced each year. It can be either produced as anhydrous sodium sulphate or decahydrate sodium sulphate (Glaubers salt). Sodium sulphate can be used in the paper manufacturing process, in glass production and as a filler in detergent powders. Sodium sulphate will be stored in bags in a lockable shed. The maximum storage is three (3) months capacity, 7,500 tonnes.

The CAS number of the sodium sulphate would be 7757-82-6. It has no hazard statements. The material safety data sheet is presented in Appendix 17.

The produced sodium sulphate meet the criteria (article 5) of the Waste Framework Directive (646/2011) (see table below).

Table 5. Fulfilment of the by-product criteria of the Waste Framework Directive and the national Waste Act 5a.

Criteria	By-product, Sodium sulphate
(a) further use of the substance or object is certain;	The sodium sulphate has existing markets, globally over 12 million tons are produced annually, and the product can be used by several applications in glass production, pulp and paper, soaps and detergents and textile industries.
(b) the substance or object can be used directly without any further processing other than normal industrial practice;	The grade/purity of the produced sodium sulphate is on the level of typical commercial grade (>98%) and it can be used without further processing.
(c) the substance or object is produced as an integral part of a production process; and	Yes, Sodium sulphate is being produced as an integral part of the production of vanadium pentoxide
(d) further use is lawful, i.e. the substance or object fulfils all relevant product, environmental and health protection requirements for the specific use and will not lead to overall adverse environmental or human health impacts.	According to the regulation on the Classification, Labelling, and Packaging of substances and mixtures (so-called CLP Regulation, EC No 1272/2008), Sodium sulphate has no hazard classification. Manufacturer of the substance will register by-product (sodium sulphate) pursuant to the REACH Regulation. Sodium sulphate will be treated according to the prepared safety data sheet. Along with the REACH registration, it meets all requirements regarding environmental and health protection.

In addition, minor amounts of ferrous material (0-10,000 tonnes annually) may be produced from the magnetic stage of the feedstock handling. This may be returned to the steel mills or sold for other industrial use.

5.4.3 Stabilised Slag Material (SSM)

The SSM will be a by-product in the future. At the time of this environmental permit application the analyses of SSM and its application in industry are still ongoing. Hence the by-product status of SSM is not applied in this application. The applicant will amend the permit when the SSM uses are further developed.

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The market for the SSM is being developed. It is a new product and is gaining market acceptance via the provision of data, samples and customer test work. This process takes time, but CMS is confident the SSM will be highly sought after. The applicant has therefore requested 3 years of intermediate storage to provide the time to develop the market and move the SSM to customers. As the market develops the quantities of SSM stored on site will decrease.

The SSM is unique in that it is a carbon negative that stores or "locks up" the carbon used in the hydrometallurgical process. It that way the SSM is acting as a "carbon sink" or a "carbon bank". The SSM is significantly more inert that the slag feedstock and potentially can be used as filler, for example, in the production of clinker, cement, concrete, asphalt, polymers, paper/cardboard and as a soil improver. The SSM can also be used as a neutralising agent.

SSM is a calcium carbonate rich fine material. Insoluble and weakly soluble minerals are unchanged from those in the feed slag. Similar components are present in the SSM as in the slag. Typical particle size of SSM is <10µm, with natural pH of about 11. The filtered SSM has a water content of about 25 – 35 % depending on the filtration method and the level at which the material is dried during filtration.

Figure 20. SSM generated in the pilot plant. The material is solid.

Based on the analyses from the pilot plant SSM mainly consists of calcium carbonate and iron (table below). The Material Safety Declaration of SSM is presented in Appendix 18.

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Table 6. SSM compounds

Compound	Share in SSM
$CaCO_3$	45 – 60 %
Fe	10 – 20 %
Si	3.0 – 4.0%
Mg	3.5 – 5.0 %
Mn	1.5 – 2.5 %
Al	0.5 – 1.0 %
Ti	0.3 – 1.0 %
V	0.3 – 0.5 %
P	0.1 – 0.3 %

SSM will be transported by conveyor and / or trucks to a storage area. At maximum capacity about 415 000 dry tonnes (equivalent to about 545 000 tonnes assuming approximately 32 % moisture content) of SSM will be produced per year. The maximum storage of the SSM will be about 1 245 000 dry tonnes, which covers three (3) years of intermediate storage. The SSM is stored outdoor in the plant area in stockpiles (stockpiles A and/or B). The maximum height of the SSM stockpiles is 10 meters. The stockpile areas will have liner to prevent leachate from the stockpiles entering the surface. The liner will enable the collection of stormwater, and melt snow from the stockpile area to be directed to the dedicated ponds. The liner structure is presented in Appendix 14.

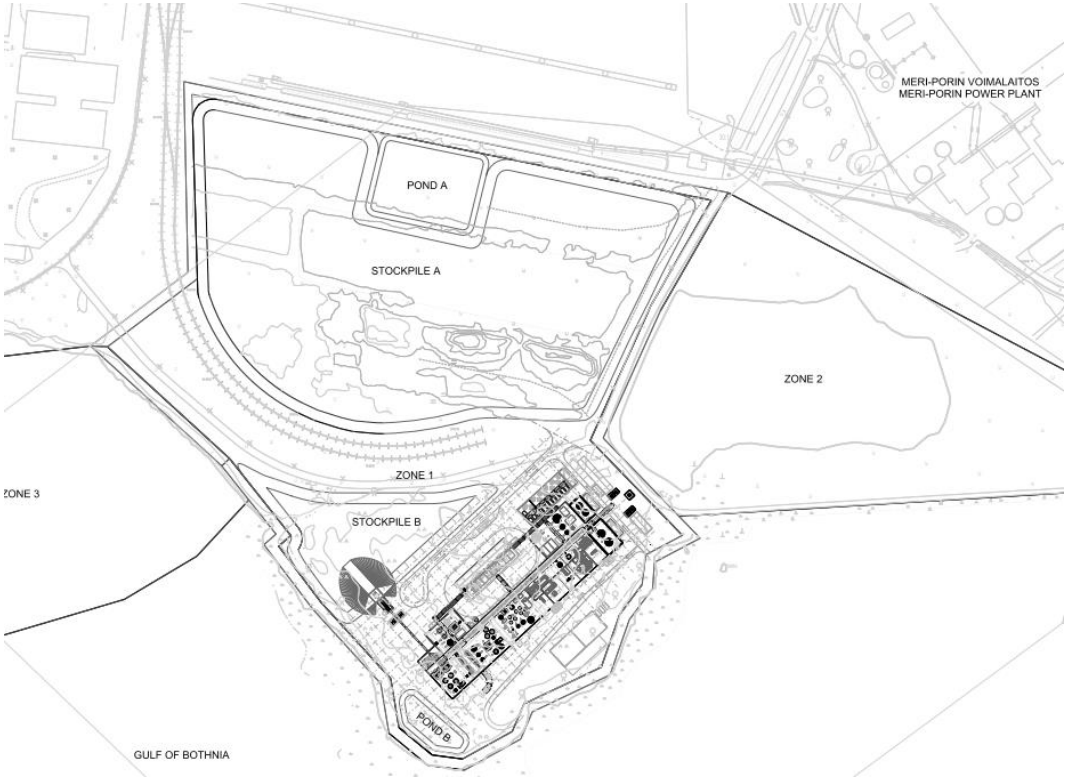

Figure 21. Location of the SSM stockpiles (A and/or B) near the plant area.

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5.4.3.1 SSM waste guarantee

If SSM has not received the status of by-product at the time of commissioning it is considered waste.

SSM has gone through extensive testing. Its solubility was tested according to the Decree on the Recovery of Certain Wastes in Earth Construction (so-called MARA Decree 843/2017) and the Decree on Landfills (331/2013), and the results were compared to the limit values provided by the Decrees. Based on the test results, the most significant substances dissolving from SSM to water are vanadium and chrome. The solubility of vanadium (about 74.6 – 77.2 mg/kg) exceeded the limit values provided by the MARA Decree for the criteria of using both covered and paved structures. The solubility of chrome (< 0.5 – 2.66 mg/kg) exceeded the limit values for covered structures, but not for paved structures. Based on the solubility test, SSM can be disposed to landfill areas for conventional waste. The test results are presented in Appendix 18.

The VRP is not economically feasible if SSM does not received by-product status. The applicant is planning to have only 3-year storage of SSM. There are existing disposal sites that can receive SSM as waste, classified to waste from metal oxide production (EWC 0603). One of these is Fortum's disposal site at Peittoo area in Pori. Lassila & Tikanoja Oy also have disposal sites which accept waste from metal oxide production. It should be noted that there is several years of time until possible disposal of SSM is required. The plant is planned to be running in 2024/2025 and the intermediate storage at the plant area is for three years of operation with maximum capacity. Hence the applicant has roughly 6 years to develop markets for the SSM and obtain classification of the SSM as a by-product.

The applicant will set a waste guarantee for SSM to cover to possible waste disposal costs of the SSM. The applicant suggest that the guarantee is 13.6 euros/tonne. This includes the disposal cost of 10 euros/tonne, transportation costs to Peittoo landfill area (cost for 40 tonne truck at 2.5 euros/km, distance16 km) and VAT (24%).

The applicant request that the waste guarantee will be set in stages. As noted above the aim of the applicant is to have the SSM approved as a by-product without delay, and at the time of the drafting of this application (November 2021) there are several uses for the SSM that are looking very promising. The maximum capacity for the SSM intermediate storage is as presented above 1 245 000 dry tonnes, the applicant holds that it is unlikely that the full capacity will taken into use as the aim is as noted above to sell SSM as a by-product.

The Supreme Administrative Court's decision issued on 12 May 2016 number 2031, the Supreme Administrative Court, held that a waste guarantee for a landfill could be calculated according to the area of the landfill that is put into operation but not closed. Here, due to the nature of the SSM as well as fact that the onsite storage is only intermediate, a periodization of the issuance of the guarantee based on area of the intermediate storage taken into use but not closed is not a feasible solution. Instead the applicant proposes, that it will every six months in advance provide the ELY Centre with an estimate for the production of SSM for the following six-month-period (until it is granted by-product status) and accordingly set the guarantee for the production estimate. This production estimate could then at the of the six-month period be verified by the ELY Centre and any corrections needed could be taken into account in the estimate for the next six-month period.

In the report of the Ministry of the Environment on needs for developments on waste guarantees it was recommended already in 2009 that plants that are required to provide very high guarantees, should not be required full guarantees, if the obligations covered by the guarantee have not yet arisen. The report referred to landfills and noted that filling of a landfill could be taken into account in the amount of guarantee, and that the accumulation

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of the guarantee could be based on e.g., the reported amount of waste (Kievari et al. 2009).

By lodging the guarantee in phases based on advance estimates, it would be ensured that the guarantee corresponds to the waste to be produced in the near future, e.g., six months. Thus, there would always be a guarantee in place that covers the SSM at the intermediate storage as well as SSM that the applicant estimates that it will produce during the next six-month period.

Once SSM has been granted by-product status for one or more uses, the aim of the applicant is naturally to have a high turnaround of supply.

The applicant would also like to note that SSM can also be regarded as a vehicle for CO_2 storage. The applicant notes that at this moment CO_2 storage in products is an unregulated field, but with the increased urgency to move towards a zero carbon economy it cannot be excluded that the SSM will in the future also from a regulatory and not just a factual perspective be regarded as CO_2 storage vehicle. From a factual perspective it will of course be a CO_2 storage vehicle from the start.

5.5 Ancillary operations

The gas will be provided by a pipeline to the site. The gas is provided by Gasum Oy from the LNG terminal in Pori. Natural gas is used to power the boiler and to maintain vanadium pentoxide furnace.

The boiler design is not finished yet. The fuel power of the gas boiler is estimated at >5-<20 MW. The boiler will be equipped with Lox-Now burner and the stack height will be 25-30 meters from ground surface and it will fulfill the requirement of the decree 1065/2017 for the stack height.

In addition to chemicals, other utilities required in the plant include raw water, potable water, instrument air, process compressed air for filter cleaning and natural gas for calciner operation and HVAC unit (air heating).

5.6 Use of energy and efficiency

Electricity consumption of the plant is estimated to be approximately 90.4 GWh per year. Most of the electricity is utilised in the production process. The electricity is obtained from local power grid.

A total of about 400 000 GJ of natural gas is used for steam production, which is needed in the process. The buildings are presently heated via electric HVAC units. Alternatively, the heat needed for heating buildings can possibly be acquired from Pori Energia.

Heat exchangers will be used when practicable to optimise heat energy efficiency.

5.7 Buildings and structures

The plant area consists of the plant and stockpiles (3). The plant consists of several buildings.

In addition to the plant building there are separate warehouses, energy plant and office premises.

The following buildings and facilities are included on VRP site:

- Administration
- Central Control Room

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- Laboratory
- Crib
- Ablutions
- Storage Warehouse
- Maintenance Warehouse
- Car Park

5.8 Water use and wastewater

5.8.1 Water use

Raw water will be sourced from the public water utility provider and stored in raw water storage tanks. The maximum amount of raw water used in the process each year is estimated to be about 180 000 tonnes. The total amount of water will be comprised of recycled water, water collected from stockpile run-off and fed raw water.

Potable water will be sourced from the public water utility provider. The amount of potable water expected to be used each year is about 4 500 tonnes. This includes, for example, water for safety showers, laboratory use, drinking water and ablutions.

VRP water balance is negative, which means that the process plant is consuming, not producing water. Raw water is required to compensate for the water lost in the process. The largest consumer of water is SSM. The water from the process ends up in the SSM which locks the moisture in due to very fine particle size.

The water balance illustrated below illustrates the overall water balance for the VRP, not considering any captured water returns from the stockpile run-off ponds. It is possible that the amount of raw water requiring purchase would decrease if most of the rain and snow could be captured and returned to the process. It is envisaged that the return water could be recycled in the process without further treatment.

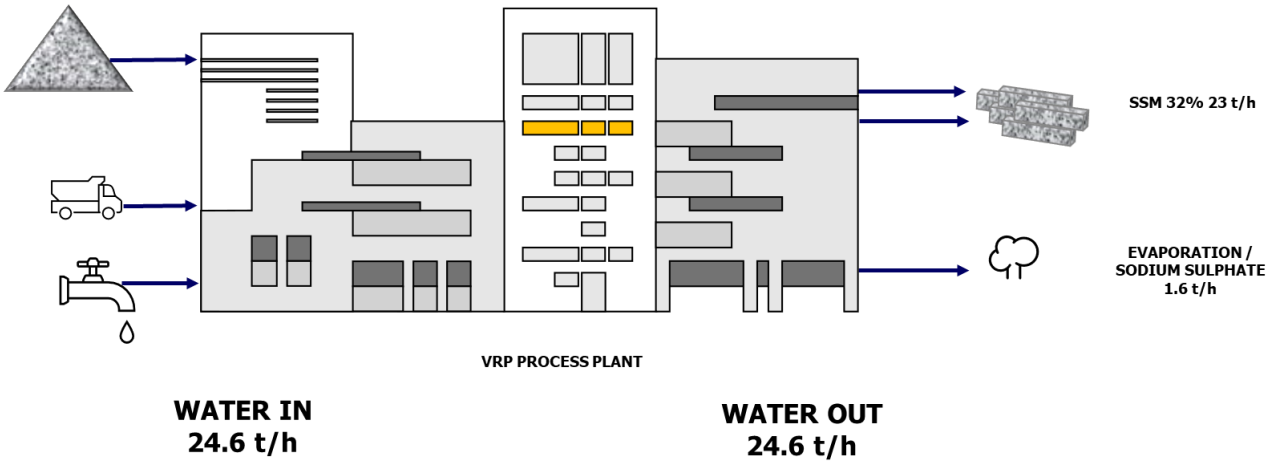

Figure 22. Water balance.

5.8.2 Wastewater

No wastewater is generated and discharged from the plant. All process wastewater is recycled. The only water leaving the process will be sequestered into the SSM (assumed moisture content about 30 %). Excess process water will be evaporated, and condensate is used in the process.

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Sanitary wastewater will be discharged to the municipal sewer and wastewater treatment plant.

5.9 Stormwaters and run-off waters

Stormwater and run-off water are generated in areas storing slag and SSM. Based on average rainfall, the volume of annual accumulated water is about 125 000 m^3. In normal situations, all rain and snow melt from the stockpiles and paved areas will be captured in the ponds and be re-used in the process to reduce the demand for raw water.

The ponds which gather the waters from the stockpiles and the plant area have been designed for an average year and once in 50 years recurring wet year. In the southern VRP area, there will be two basins having a size of 7,000 m^2 (pond A volume 13,800 m^3) and 2,500 m^2 (pond B volume 5,050 m^3). In the northern VRP area, the size of the basin is about 2,900 m^2 (pond C, volume 5,900 m^3). The structures of the ponds are presented in Appendix 14.

Location of the ponds in presented in Appendix 13. The stormwaters are expected to be neutral in pH. Solid material that gathers in the basins is removed and transferred to the process.

Overflow situations of basins can occur, for example, with the commissioning of the plant or with exceptionally high volumes of rain or melt water, when the need for process water is lower than the generated volume of stormwater. In overflow situation, water is directed in a controlled way along an overflow drain to the sea, when most of the solid substance falls into the basin.

5.10 Handling and storing of chemicals

Several chemicals are used in the process. The main substance used is CO_2. It is used as a reagent in the carbonate leaching process in leach circuit and production of carbonate to the process. Other chemicals are also used. The main reagents used in the process are:

- sulphuric acid reactant in desilication and AMV precipitation, for adjusting pH and the gas scrubber for ammonium rich exhaust gas;
- sodium carbonate as a make-up in leaching;
- sodium hydroxide used in the CO_2 scrubber, in the vanadium scrub and strip solution, and as needed in leach solution make-up;
- ammonium sulphate precipitant to form AMV;
- coagulant and aluminium sulphate is used in desilication;
- flocculant used in thickeners; and
- organic reagents used in the solvent extraction process are an aromatic free diluent, extractant and phase modifier.

The used chemicals, consumptions and maximum storages are presented in the table below.

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Table 7. Chemicals used in production. Estimated annual amounts and maximum storages.

Chemical	Form	Estimated used volume (t/a)	Maximum storage (t)	CAS number	Hazard statement
Carbon dioxide (CO_2)	Gas	80 000 - 100 000	1 350	124-38-9	H281
Sulphuric acid (H_2SO_4, 94 %)	Liquid	18 000	1 500	7664-93-9	H314, H290
Sodium hydroxide (NaOH 50 %)	Liquid	32 500	2 700	1310-73-2	H290, H314
Sodium carbonate ($NaCO_3$)	Solid	12 000	1 000	497-19-8	H319
Ammonium sulphate ($(NH_4)_2SO_4$)	Solid	5 300	450	7783-20-2	H402, H412
Aluminium sulphate ($Al_2(SO_4)_3$)	Solid	450	40	10043-01-3	H290, H318
Organic diluent (aliphatic hydrocarbon)	Liquid	71	10	64742-47-8	H226
Organic extractant (quaternary ammonium)	Liquid	22	5	63393-96-4	H226
Organic modifier (inhibitor of phase formation)	Liquid	18	5	112-70-9	H226
Coagulant (Polysil)	Liquid	99	2	-	H226
Diesel	Liquid	1800 m^3	~20 m^3	68334-30-5	H351
Natural gas	Gas	11 000 000 m^3	No storage	74-82-8	H220

H220: Extremely flammable gas
H226: Flammable liquid and vapour
H281: Contains refrigerated gas; may cause cryogenic burns or injury
H290: May be corrosive to metals
H314: Causes severe skin burns and eye damage
H318: Causes serious eye damage
H319: Causes serious eye irritation
H351: Suspected of causing cancer
H402: Harmful to aquatic life
H412: Chronic aquatic toxicity

Carbon dioxide used in the vanadium recovery plant is transported by vessels, trucks and/or pipeline to the VRP project area from outside of Tahkoluoto. Natural gas comes directly by pipeline.

Chemicals will be stored in tanks at the plant area. The tanks will be positioned in the bunded area designed to capture a full tank spill. The location of the tanks will be further defined in the detailed design. Bases and acids will be stored separately.

The diesel is used for fuelling machinery. The tank will be located outdoors. It will be equipped with secondary basin (110%), overfill alarm and a lock.

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The liquid chemicals will be unloaded in a specific area designed for unloading. The diesel unloading area may be located separately. The unloading areas will have structures according to the applicable chemical safety law. An oil separator (class 1) will be placed in the diesel unloading/fuelling area.

5.11 Traffic arrangements

The traffic to and from the plant will comprise of sea, rail and road transport.

The raw material from Sweden is transported by vessels to the port and from there by trucks to the plant. Slag from Raahe can be transported either by vessel or rail. The estimated transport volume is about 20 vessels/year. When the vessels arrive at the port, typically 100–200 truckloads of slag are transported from the deep-water port to the southern VRP area. If larger quantities of slag for feedstock are transported to Tahkoluoto in the early phases of operation, slag will be transported to the northern VRP area and the daily traffic volume can be 250–350 trucks per day. These truck transports are made around the clock.

Other domestic raw material is transported by train or trucks. Chemicals and CO_2 are transported by trucks. These transports are done in daytime.

Bucket loaders and trucks are used for the internal traffic on site, for example, in transport between the plant and port and storage areas.

Final products are transported to the customers either by vessels, trucks or trains or by a combination of them. In a situation, when products would only be transported by trucks, the transport volume would be about 35 truckloads daily. In a maximum situation, if, for example, transports of SSM occurred at certain time of the year, the estimated product transport volume would be 65 truckloads. Truck transport from the VRP plant take place mainly in daytime.

5.12 Operational risks, accidents and failure situations

Risk assessment has been conducted as an expert evaluation in 2021. More detailed risk assessment will be performed in the future. Chemical safety permitting will be applied from Tukes in the beginning of 2022.

Risk mapping prepared during project planning was used in the identification of environmental risks, which was supplemented by the conclusions from the environmental risk assessment workshop held in May 2021. Potential accidents and incidents include, for example, accidental emissions, chemical leaks and fires.

Failures in process and purification equipment are prevented by good planning, process monitoring and regular service and inspections of equipment. Process and scrubber failures could occur, for example, during blackouts. The need for the preparation for blackouts is considered in the plant design.

Liquid chemicals used in the plant include sulphuric acid, sodium hydroxide (lye), organic solvents and diesel fuel. Carbon dioxide is also transported and stored as a liquid. The amount of organic solvents is small in the plant. Chemical leaks can occur with tank fillings and unloading of tanker trucks because of hose damage, overflow or flange leak, equipment failure in process or from collisions with pipelines. Preparations are made for liquid chemical leaks by surface impoundment and drain shut-off system. Surface levels of tanks are monitored by alarm gauges.

Leaks in the low pressure natural gas pipeline on site could cause mechanical damage, for example, as a result of collision with machinery. Pipeline damage is prevented through

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planning, warning systems, maintenance, and periodic inspections in accordance with standards. Potential collisions can be minimised in transport route planning.

Fires are prevented by minimising ignition sources and fire load near the combustible targets. Risk is reduced by the choice of materials, compartmentation, and other fire technical solutions. Potential fire situations are considered in the location of tanks, and distances are designed based on the legal requirements and modelling of heat radiation. Preparations are made for fire situations by developing firefighting systems, which are defined in more detail in the fire safety plan. Firefighting water management in the area is planned according to the regulations so that firefighting wastewater cannot spread to the environment.

Fire risk is usually related to the solvents used in the solvent extraction process. Preparations for the risk are made in plant and process design, and necessary fire protection systems are constructed for the process. The organic solvent used in the leaching process of the vanadium recovery plant has a high ignition temperature (> 70 °C). When process temperature is under < 40 °C, evaporation and gasification of the solvent is minor. In case organic or electrical fires, foam could be used.

A contingency plan will be done drafted separately when the detailed design is completed.

6 Emissions, discharges and waste and their mitigation

6.1 Emissions to air

6.1.1 Process emissions

The process will generate emissions to air. These are nitrogen oxides (NOx), dust, ammonia (NH_3) and carbon dioxide. The main sources of air emissions are nitrogen oxides and dust.

The maximum annual emissions from the process have been estimated. These are presented in the table below.

Table 8. Annual maximum main process emissions to air (tonnes /a).

	NOx	Particles	NH_3	CO_2
Total emissions	4.8	6.8	2	- 61 000*

*This includes only reduction of own production, i.e., Scope 1 emissions

There are several process phases where emissions to air are produced. The main air emission sources are the ammonia off-gas scrubber and the gas boiler. The emissions sources are marked in the lay-out plan of the site in Appendix 19.

The main emission sources and the estimated maximum emission concentrations are presented in the table below. Gaseous emissions are further described in Appendix 21 in waste gas inventory.

The flash dryer and the deammoniator will have a common scrubber to reduce ammonia emissions. There are three process phases/equipment where dust emissions may be generated. These are all equipped with bag house filters or similar technology.

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Table 9. Main air emission sources (ducted/point source only) with estimated maximum concentrations.

Process phase	Emission source	Description of abatement	Estimated concentrations emissions (mg/Nm^3)					
			SO_2	NOx	NH_3	Dust	Vanadium	TVOC
AMV production	Ammonia offgas scrubber for flue gases from the deammoniator and flash dryer	Offgas is scrubbed in sulphuric acid solution to recover ammonia	-	<350	<100	<30	<1	-
	Fusion furnace							
Sodium sulphate manufacturing	Sodium Sulphate cake Drier	Sodium sulphate scrubber	-	<350	-	-	-	-
Gas boiler	Steam production	The boiler will be equipped with Low-NOx burners	-	<100	-	-	-	-

6.1.2 Dusting from outdoor stockpiles

Dust from the stockpiles (slag and SSM) will likely be suppressed via a water reticulation system. The moisture content of SSM is about 30 % so dust emissions are not very high, but the surface of stockpiles can dry up especially in summertime when water reticulation may be necessary. Water for reticulation can be sourced from the stormwater ponds.

Slag can occasionally be crushed on site and water jets are used for minimizing dust emissions.

Transport and handling of the slag and SSM can cause dusting. Dusting will be reduced by using covered trucks and covering and enclosing conveyor belts and crushers, where possible. Dusting of paved roads and storage areas can be prevented with cleaning and watering. Water reticulation of slag stockpiles and roads are presented as best available technology for controlling of fugitive dust emissions in BAT-conclusions for iron and steel industry (BATC 11 and 79) (2012/135/EU).

The dust diffuse emissions from the stockpiles and the traffic routes of the operation were estimated in the dust modelling (Appendix 22). The estimated diffuse dust emissions from the stockpiles are 8.2 tonnes annually (PM10 5 tonnes and PM2.5 3.2 tonnes). These include material transfer and wind erosion. The emissions from traffic are estimated at 3 tonnes annually.

6.2 Wastewater discharges

There will be no process wastewater discharges to the sewer or water bodies. Only sanitary wastewater will be discharged to the municipal sewer.

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Excess process water will be evaporated and condensate is used in the process. The only water leaving the process will be contained within the SSM which has an assumed moisture content of about 30 %.

6.3 Stormwater

In a normal operating situation there will no storm water discharges from the plant area or the stockpiles.

The ponds gathering the water from the stockpiles and the plant area have been designed to hold all storm waters in typical weather events. This means that the storm water ponds A, B and C have been dimensioned to receive and hold water that is accumulated from the pile areas as well from the plant area for 5 days lasting rain (rare storm event). The rain fall during 5 days is 170.4 mm (recurrence 1/50 years). The highest precipitation at Pori was 43 mm in 2020 during one day. The definition of heavy rain in Finland is over 20 mm of rain in one day (24h) and internationally 40 mm rain in one day (24h). The ponds have been designed to collected 5 day rain, i.e., 170.4 mm rain, and they also can collect the rain from shorter heavy rain events, because the rain volume will be less. The rain volume of 170.4 mm considers climate change (+20%).

The rainwater retention and permeability in the piles is not fully known. In calculations the water retention in piles is assumed to be nil. It is assumed the slag material is more permeable and therefore the water retention in slag piles is not significant. On the other hand, it is estimated that SSM material is less permeable and therefore the surface runoff is more affective factor.

Hence pond's overflow may take place very rarely, e.g. once in 100 years (recurrence 5d which 95% of cases occur). The amount of overflow was calculated to be 2,875 m^3 per occasion from all three ponds.

- Pond A 1,604 m^3
- Pond B 587 m^3
- Pond C 684 m^3

Results of the leaching tests were used to estimate the stormwater in the following sections. The stormwaters do not contain substances that are listed in Annex I table A of Decree 1022/2006.

Stormwater quality from slag storage

There are leaching test made for the slags at Raahe and Luleå. Also in Oxelåsund there is a slag landfill where the seepage is monitored. The results of these are presented in the table below. Based on the results the concentrations of metals are fairly low in water. The concentrations are higher in the seepage than in the leaching tests. Concentrations of metals are below the maximum permitted emission limit (Decree 1022/2006). Almost all concentrations are also below the annual average environmental quality standard values (AA-EQS), except for lead concentration in the seepage of the slag landfill in Oxelösund which exceeds the AA-EQS value. All metal concentrations are below the maximum environmental quality standard values (MAC-EQS). The EQS values refer to the concentration of the substance in water (i.e. diluted discharge) that should not be exceeded, not the concentration of the discharged water. Hence the EQS values are not fully comparable to the analysed concentrations presented in the table.

The water from slag stockpiles and from the ponds to the sea (only once in 100 years) can be assumed to contain similar or lower concentrations of metals and other substances compared to the leaching test results. The pH of the waters from the stockpiles is estimated

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at 8-9. The following assumption have been considered in the calculation of the load to the sea in one occasion:

- The estimation is based on a calculation considering the average concentration from the leaching test results because these are considered to represent the overflow situation better than the seepage results. However, the leachate results will still overestimate the actual concentrations because in heavy rain event the water runoff from the stockpiles is fast.
- The volume of 1,271 m^3 during the occasion. This assumes that the stockpiles B and C would be of slag. This is considered the most likely scenario at the plant.

Table 10. Leaching test results of slag and seepage of slag landfill.

Parametre	Leaching test results, Raahe	Leaching test results of slag at Luleå		Oxelösund slag landfill seepage		Limit values (mg/l) from Decree 1022/2006	Estimated maximum emission in one occasion in kilograms
	L/S10	2018, L/S10	2019, L/S10	Average between 2018-08/2021	Maximum between 2018-08/2021		
As (mg/l)	<0.002	<0.0005	<0.0005	0.0007	0.001		0.0016
Cd (mg/l)	<0.0005	0.0001	0.00019	0.0002	0.0003	0.01 (maximum permitted emission limit) 0.0002 (AA-EQS) 0.0006 (MAC-EQS)	0.0004
Co(mg/l)	<0.003	<0.00005	<0.00005	0.0005	0.0009		0.0019
Cr (total) (mg/l)	0.03	0.0631	0.0112	0.217	0.545		0.0592
Cu (mg/l)	<0.005	<0.001	<0.001	0.015	0.032		0.0038
Fe (mg/l)	<0.01	0.005	0.009	0.04	0.06		0.0095
Hg (mg/l)	<0.0002	<0.00002	<0.00002	<0.00002	<0.00002	0.005 (maximum permitted emission limit) 0.00007 (MAC EQS)	0.00003
Mn (mg/l)	<0.001	0.003	0.005	0.0017	0.0017		0.0038
Mo (mg/l)	0.4	0.12	0.109	0.28	0.42		0.3235
Ni (mg/l)	<0.01	<0.0005	<0.0005	0.003	0.0079	0.0086 (AA-EQS) 0.034 (MAC-EQS)	0.0067
Pb (mg/l)	0.004	0.0004	<0.0002	0.004	0.0098	0.0013 (AA-EQS) 0.014 (MAC-EQS)	0.0027
Se (mg/l)	0.001	<0.003	<0.003	NA	NA		0.0025
V (mg/l)	<0.002	0.0307	0.0284	0.02	0.05		0.0208
Zn (mg/l)	0.02	<0.002	<0.002	0.017	0.037		0.0140
pH	NA	12.5	12.5	11.9	12.4		8-9
Conductivity (mS/m)	NA	869	883	557	910		
Suspended solids (mg/l)	Na	NA	NA	6.5	13		

Stormwater quality from SSM storage

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Leaching tests have been performed for SSM (EN12457-3, EN 16192). Based on the results the concentrations of metals are quite low. The most significant substances dissolving from SSM to water are vanadium and chrome. The results are presented in the table below. The metal concentrations are below the maximum permitted limits (Decree 1022/2006). Almost all concentrations are also below the annual average environmental quality standard values (AA-EQS), except for cadmium concentration which exceeds the AA-EQS value. All metal concentrations are below the maximum environmental quality standard values (MAC-EQS). The EQS values refer to the concentration of the substance in water (i.e. diluted discharge) that should not be exceeded, not the concentration of the discharged water. Hence the EQS values are not fully comparable to the analysed concentrations presented in the table

The water from SSM stockpiles and from the ponds to the sea (only once in 100 years) can be assumed to contain similar or lower concentrations of metals and other substances compared to the leaching test results. The pH of the waters from the stockpiles is estimated at 8-9. The following assumption have been considered in the calculation of the load to the sea in one occasion:

- The estimation is based on a calculation considering the leaching test results and the infiltration and run-off from the stockpile. The infiltration (relative water amount) was assumed 30% and the run-off (relative water amount) 70%. This is presented in the fourth column from the left.
- The volume of 1,604 m^3 during the occasion. This assumes that the stockpile A would be of SSM. This is considered the most likely scenario at the plant.

Table 11. Leaching test results of SSM.

Parametre	**Leaching test results**		**Estimated concentrations considering infiltration and runoff**	**Limit values (mg/l) from Decree 1022/2006**	**Estimated maximum emission in one occasion in kilograms**
	Sample 1 L/S2	**Sample 2 L/S2**			
As (mg/l)	0.0012	<0.001	0.019		0.031
Ba (mg/l)	0.0039	0.0025	0.0006068		0.001
Cd (mg/l)	<0.0005	<0.0005	0.00148	0.01 (maximum permitted emission limit) 0.0002 (AA-EQS) 0.0006 (MAC-EQS)	0.0024
Co(mg/l)	<0.0005	NA	NA		0.029
Cr (total) (mg/l)	0.976	0.005	0.098		0.16
Cu (mg/l)	0.0012	0.003	0.00056		0.0009
Hg (mg/l)	0.00001	0.000014	0.0004	0.005 (maximum permitted emission limit) 0.00007 (MAC EQS)	0.0006
Mo (mg/l)	0.0011	0.0046	0.019		0.0297

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Parametre	Leaching test results		Estimated concentrations considering infiltration and runoff	Limit values (mg/l) from Decree 1022/2006	Estimated maximum emission in one occasion in kilograms
	Sample 1 L/S2	Sample 2 L/S2			
Ni (mg/l)	<0.003	<0.003	0.015	0.0086 (AA-EQS) 0.034 (MAC-EQS)	0.024
Pb (mg/l)	<0.001	<0.001	0.0185	0.0013 (AA-EQS) 0.014 (MAC-EQS)	0.0297
Se (mg/l)	<0.005	<0.005	0.0037		0.0059
V (mg/l)	8.13	14.3	0.0037		0.0059
Zn (mg/l)	<0.002	0.0087	2.8564		4.58
pH	10.1	10	8-9		
Conductivity (mS/m)	104	36			
Suspended solids (mg/l)	586	336	15		
DOC (mg/l)	4.55	1.4	0.755		1.21
Phenol index (mg/l)	0.006	<0.005	0.04		0.06
Cl^- (mg/l)	37.9	30.2	4		6.42
F^- (mg/l)	0.286	0.87	0.0773		0.12
SO_4^{2-} (mg/l)	5.9	7.4	0.736		1.18

6.4 Noise and vibration

The process equipment of the vanadium recovery plant is located indoors, and minor noise is generated by the process facility. The plant's operating noise is a stagnant humming sound due to operating equipment and fans. Grinding and crushing may cause higher noise levels. Crushing will be done outdoors and grinding indoors. Crushing may be done 4 times annually and the duration of the crushing per occasion is 120 hours. Crushing will be done only during daytime. The plant will be built with the latest equipment available, and the equipment noise levels are considered in the selection of equipment.

The most significant outdoor source of noise includes the machinery working on stockpiles and around the process facility in unloading and loading operations. Noise is also generated by transport.

Grinding and crushing may cause vibration only locally. The plant operations do not cause vibration. The railway traffic may cause vibration nearby the track.

6.5 Emissions to soil and groundwater

The plant's normal operations do not involve emissions to soil or groundwater. Water collection from the structures and stockpiles of the slag and SSM storage area prevents the entry of materials from these storage areas directly or via stormwater and seepage water to the soil and groundwater.

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If slag or SSM falls to the ground in an accident situation on site outside of the storage area, it can be recovered quickly and no significant amounts of slag or dissolved substances would not enter the soil.

6.6 Waste and waste management

The process does not generate large amounts of waste. Some amounts of sludges (e.g. 060503) and filters (e.g. 150202* or 150203) from water circulation systems are generated. Most of the unwanted solids collected from process waters and process filters can be added to the repulp circuit prior to becoming a component of SSM. In case this is not possible for some reason the waste fractions are disposed accordingly. In addition, conventional municipal waste (e.g. 200301) is generated in the plant, such as organic waste (200108), energy waste (e.g. 200139), paper, and cardboard waste (200101). The hazardous waste fractions mainly comprise waste oils from maintenance operations (e.g. 1301 and 1302 waste oils). Waste will be handled by local waste management companies that have appropriate permissions for their operation. The waste management contracts will be made before the operation start.

7 Best available techniques applied

According to the Environmental Protection Act (527/2014), permit provisions must be based on the BAT-level (Best Available Techniques) in accordance with the EU Industrial Emissions Directive.

The vanadium recovery plant activities correspond to best available techniques (BAT) reference document for the Common Waste Water and Waste Gas Treatment/Management Systems in the Chemical Sector (published May 30th 2016).

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BAT Item	BAT description	Implementation at the vanadium recovery plant
Environmental management systems		
BAT 1.	To improve the overall environmental performance, BAT is to implement and adhere to an environmental management system (EMS).	The plant will have environmental management system in place. The system will be certified according to ISO 14001 or similar. The environmental management will be set up before the commencement of the operation. Certification will be applied for later.
BAT 2.	In order to facilitate the reduction of emissions to water and air and the reduction of water usage, BAT is to establish and to maintain an inventory of waste water and waste gas streams, as part of the environmental management system (see BAT 1), that incorporates all of the following features: (i) information about the chemical production processes, including: (a) chemical reaction equations, also showing side products; (b) simplified process flow sheets that show the origin of the emissions; (c) descriptions of process-integrated techniques and waste water/waste gas treatment at source including their performances; (ii) information, as comprehensive as is reasonably possible, about the characteristics of the waste water streams, such as: (a) average values and variability of flow, pH, temperature, and conductivity; (b) average concentration and load values of relevant pollutants/parameters and their variability (e.g. COD/TOC, nitrogen species, phosphorus, metals, salts, specific organic compounds); (c) data on bioeliminability (e.g. BOD, BOD/COD ratio, Zahn-Wellens test, biological inhibition potential (e.g. nitrification)); (iii) information, as comprehensive as is reasonably possible, about the characteristics of the waste gas streams, such as: (a) average values and variability of flow and temperature; (b) average concentration and load values of relevant	The inventories for wastewater and waste gas streams are presented in Appendix 21.

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	pollutants/parameters and their variability (e.g. VOC, CO, NOX, SOX, chlorine, hydrogen chloride); (c) flammability, lower and higher explosive limits, reactivity; (d) presence of other substances that may affect the waste gas treatment system or plant safety (e.g. oxygen, nitrogen, water vapour, dust).	
Monitoring		
BAT 3.	For relevant emissions to water as identified by the inventory of waste water streams (see BAT 2), BAT is to monitor key process parameters (including continuous monitoring of waste water flow, pH and temperature) at key locations (e.g. influent to retreatment and influent to final treatment).	The circulated wastewater will be monitored for • Flow • pH • Temperature • Vanadium concentration • Sodium concentration The monitoring locations will be decided in the detailed design phase. There are no wastewater discharges from the plant to water bodies in a normal operation.
BAT 4.	BAT is to monitor emissions to water in accordance with EN standards with at least the minimum frequency given below. If EN standards are not available, BAT is to use ISO, national or other international standards that ensure the provision of data of an equivalent scientific quality.	Not applicable to the plant. There are no process water discharges to water bodies.
BAT 5.	BAT is to periodically monitor diffuse VOC emissions to air from relevant sources by using an appropriate combination of the techniques I-III or, where large amounts of VOC are handled, all of the techniques I-III. I. sniffing methods (e.g. with portable instruments according to EN 15446) associated with correlation curves for key equipment; II. optical gas imaging methods; III. calculation of emissions based on emissions factors, periodically validated (e.g. once every two years) by measurements.	According to the waste gas inventory there is only one VOC emission source which is related to the solvent extraction. Only very minor VOCs are produced at the plant. The plant will estimate periodically the VOC emissions based on emission factors.
BAT 6.	BAT is to periodically monitor odour emissions from relevant sources in accordance with EN standards.	Potential odour sources include: fugitive ammonia from the AMV reactor or deammoniator and odours related to the organic reagents used in SX or used as flocculants/coagulants. The odour emissions are anticipated to be very minimal and well contained. Due to very minimal odour emissions, no odour measurement are presented to be performed regularly.
Emissions to water		

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Bat 7.	Water usage and waste water generation In order to reduce the usage of water and the generation of waste water, BAT is to reduce the volume and/or pollutant load of waste water streams, to enhance the reuse of waste water within the production process and to recover and reuse raw materials.	The process uses low volumes of water. Raw water usage has been minimised by recycling of wastewaters to be used as process water. All process water is recycled at the plant. This also recovers raw materials back to the process. Water use is reduced by also using stormwater and snow melt in the process.
BAT 8.	Waste water collection and segregation In order to prevent the contamination of uncontaminated water and to reduce emissions to water, BAT is to segregate uncontaminated waste water streams from waste water streams that require treatment.	Wastewater streams are not segregated. All waters are reused at the plant as "process water".
BAT 9.	In order to prevent uncontrolled emissions to water, BAT is to provide an appropriate buffer storage capacity for waste water incurred during other than normal operating conditions based on a risk assessment (taking into account e.g. the nature of the pollutant, the effects on further treatment, and the receiving environment), and to take appropriate further measures (e.g. control, treat, reuse).	All process water is recycled. Preliminary operational risks have been analysed (no report available). Further risk assessment will be done before commissioning of the plant.
BAT 10.	Waste water treatment In order to reduce emissions to water, BAT is to use an integrated waste water management and treatment strategy that includes an appropriate combination of the techniques in the priority order given below. a) Process-integrated techniques b) Recovery of pollutants at source c) Waste water pre-treatment d) Final waste water treatment	All wastewater is recycled at the plant. This also recovers the raw materials. No waters are discharged to water bodies.
BAT-associated emission levels (BAT-AELs)		
BAT 11.	In order to reduce emissions to water, BAT is to pretreat waste water that contains pollutants that cannot be dealt with adequately during final waste water treatment by using appropriate techniques.	Not applicable. All wastewater is recycled at the plant. No waters are discharged to water bodies.
BAT 12.	In order to reduce emissions to water, BAT is to use an appropriate combination of final waste water treatment techniques. Final waste water treatment is carried out as part of an integrated waste water management and treatment strategy (see BAT 10).	Not applicable. All wastewater is recycled at the plant. No waters are discharged to water bodies. The stormwaters and waters from the stockpiles are directed to process through sedimentation pond and a screen to remove possible larger items, e.g. trash.

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		The sludge is removed from the ponds by suitable equipment when needed and placed in the process.
Waste		
BAT 13.	In order to prevent or, where this is not practicable, to reduce the quantity of waste being sent for disposal, BAT is to set up and implement a waste management plan as part of the environmental management system (see BAT 1) that, in order of priority, ensures that waste is prevented, prepared for reuse, recycled or otherwise recovered.	The plant will set up a waste management plan as part of the environmental management system when the operation starts. Only minor amounts of waste are generated in the process. CMS will apply for by-product status for SSM in the near future. SSM will not be considered waste in the long run. The market for SSM has not been fully developed yet during the time of preparing this application.
BAT 14.	In order to reduce the volume of waste water sludge requiring further treatment or disposal, and to reduce its potential environmental impact, BAT is to use one or a combination of the techniques given below. a) Conditioning b) Thickening/dewatering c) Stabilisation d) Drying	Small amounts of crud is generated in the process and some other minor amounts of silicate materials. These are mixed with the SSM and they do not represent waste fractions. Sludge from sedimentation basins is fed to the process.
Emissions to air		
BAT 15.	Waste gas collection In order to facilitate the recovery of compounds and the reduction of emissions to air, BAT is to enclose the emission sources and to treat the emissions, where possible.	Emission abatement devices are further described in the BAT2 in Appendix 21.
BAT 16.	Waste gas treatment In order to reduce emissions to air, BAT is to use an integrated waste gas management and treatment strategy that includes process-integrated and waste gas treatment techniques. The integrated waste gas management and treatment strategy is based on the inventory of waste gas streams (see BAT 2) giving priority to process-integrated techniques.	There are set air emission mitigation equipment in place at the plant. The air emission sources are identified and presented in the waste gas inventory (Appendix 21). The waste gas inventory will be updated before commencing operation.
BAT 17.	Flaring In order to prevent emissions to air from flares, BAT is to use flaring only for safety reasons or non-routine operational conditions (e.g. start-ups, shutdowns) by using one or both of the techniques given below. a) Correct plant design b) Plant management	There is no flaring performed at the plant.
BAT 18.	In order to reduce emissions to air from flares when flaring is unavoidable, BAT is to	There is no flaring performed at the plant.

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	use one or both of the techniques given below. a) Correct design of flaring devices b) Monitoring and recording as part of flare management	
BAT 19.	Diffuse VOC emissions In order to prevent or, where that is not practicable, to reduce diffuse VOC emissions to air, BAT is to use a combination of the techniques.	There are no significant diffuse VOC emissions from the plant. The plant does not use large quantities of chemicals that contain VOCs.
BAT 20.	Odour emissions In order to prevent or, where that is not practicable, to reduce odour emissions, BAT is to set up, implement and regularly review an odour management plan, as part of the environmental management system (see BAT 1), that includes all of the following elements: (i) a protocol containing appropriate actions and timelines; (ii) a protocol for conducting odour monitoring; (iii) a protocol for response to identified odour incidents; (iv) an odour prevention and reduction programme designed to identify the source(s); to measure/estimate odour exposure; to characterise the contributions of the sources; and to implement prevention and/or reduction measures.	The odour emissions are estimated to be minor and well contained. Currently no odour measurement is planned for the plant. In case there will be odour complaints or notable odour outside the plant, odour measurements will be conducted.
BAT 21.	In order to prevent or, where that is not practicable, to reduce odour emissions from waste water collection and treatment and from sludge treatment, BAT is to use one or a combination of the techniques given below. (a) Minimise residence times (b) Chemical treatment (c) Optimise aerobic treatment (d) Enclosure (e) End-of-pipe treatment	Not applicable. All process wastewater is reused in the process.
BAT 22.	Noise emissions In order to prevent or, where that is not practicable, to reduce noise emissions, BAT is to set up and implement a noise management plan, as part of the environmental management system (see BAT 1), that includes all of the following elements: (i) a protocol containing appropriate actions and timelines; (ii) a protocol for conducting noise monitoring; (iii) a protocol for response to identified noise incidents;	The plant operation does not cause significant noise. The plant will be built, and equipment will be chosen based on Best Available technology to reduce noise emissions. The plant will participate in noise monitoring of the Tahkoluoto area.

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	(iv) a noise prevention and reduction programme designed to identify the source(s), to measure/estimate noise exposure, to characterise the contributions of the sources and to implement prevention and/or reduction measures.	
BAT 23.	In order to prevent or, where that is not practicable, to reduce noise emissions, BAT is to use one or a combination of the techniques given below. (a) Appropriate location of equipment and buildings (b) Operational measures (c) Low-noise equipment (d) Noise-control equipment (e) Noise abatement	Noise emissions have been reduced during the design phase by situating the plant in such a way that noise guideline values are not exceeded at the residential houses and areas.

The storage and handling of slag is included in the Best Available Techniques (BAT) reference document and BAT conclusions for the iron and steel industry (published in 2013). The storage and handling of slag at the VRP plant can be similar. For this reason, the I&S BAT-conclusions in this case can also be considered.

BAT Item	**BAT description**	**Implementation at the vanadium recovery plant**
Diffuse dust emissions from materials storage, handling and transport of raw materials and (intermediate) products		
BAT 11.	BAT is to prevent or reduce diffuse dust emissions from materials storage, handling and transport by using one or a combination of the techniques mentioned below. … VII. Techniques for the handling and processing of slag include: — keeping stockpiles of slag granulate damp for slag handling and processing since dried blast furnace slag and steel slag can give rise to dust — use of enclosed slag-crushing equipment fitted with efficient extraction and bag filters to reduce dust emissions … IX. Techniques to consider during material transport include: — the damping of dusty routes by water sprays, e.g. at slag-handling operations	Slag and SSM stockpiles will likely be suppressed via a water reticulation system. Dusting of paved roads and storage areas can be prevented with cleaning and watering.
Air emissions		
BAT 79.	BAT for on-site slag processing is to reduce dust emissions by using one or a combination of the following techniques: I. efficient extraction of the slag crusher and screening devices with subsequent off-gas cleaning, if relevant II. transport of untreated slag by shovel loaders III. extraction or wetting of conveyor transfer points for broken material	Slag and SSM stockpiles will likely be suppressed via a water reticulation system. Slag can occasionally be crushed on site and water jets are used for minimising dust emissions.

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	IV. wetting of slag storage heaps V. use of water fogs when broken slag is loaded. The BAT-associated emission level for dust in the case of using BAT I is < 10 – 20 mg/Nm3, determined as the average over the sampling period (discontinuous measurement, spot samples for at least half an hour).	

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8 Impacts to the environment

8.1 Impact to nature, nature values and built environment

The VRP will not have significant direct or indirect impacts on relevant Natura areas, nature conservation areas and valuable bird areas in the Tahkoluoto area and the surroundings.

- Growing vessel traffic on the deep-water channel due to the project is not estimated to have impacts on the bird population, which constitutes the protection objective of the nearest Natura area Gummandoora Archipelago or impacts on the habitats and species or integrity of the Natura area. The nearest nature conservation area (Bothnian Sea National Park) and sites of nature conservation programmes (Gummandoora and Pooskeri Archipelago) are mostly located in the same area near the VRP area as the above-mentioned Natura area, and no impacts are assessed to occur in these.
- Emissions to air from the VRP will be minor and the impacts (dust emissions) will not extend far away from the VRP area. Emissions to air are not estimated to have significant impacts on the nearby nature conservation areas.
- Noise emission is the only potential impact on bird population during the operation of the plant. Noise is generated already today from the Tahkoluoto port and industrial area and wind power stations, but regardless, there is a large bird population in the surroundings of Tahkoluoto. Based on studies prepared in 2020 and presented in the EIA, nesting birds feel comfortable on the nearest bird islets, Kaijakari and Kumpeli. It is assessed that the increasing noise level due to the implementation of the VRP will neither cause significant changes to the current situation nor significant impacts on the valuable bird areas.

The plant's operation would impact the meadow dwarf community because the location of the feeding plant, red fescue, is within the operational area. The meadow dwarf has been relocated from the plant area. This relocation was accepted by the ELY Centre and it was done in October 2021. It has been assessed that the relocation will not impair the meadow dwarf community in the whole Tahkoluoto area.

The project conforms to the valid Satakunta regional plan, the component master plan with no legal effect and the ongoing draft component master plan. The area has a valid detailed plan and the project is in line with the detailed plan. The implementation of the project will reinforce and support the operations of the existing port and industrial area and will not change the community structure. The surrounding environment of the VRP area has been for a long time in the impact area of the port and industrial area and related heavy traffic, noise and potential emissions.

The nearest nationally significant landscape areas and nationally or regionally significant built cultural environments are not in proximity to the VRP area. The Reposaari community located at a distance of 2 km to the south/southwest from the VRP area is a built-up cultural environment of national significance. The VRP is not assessed to have a significant impact on the preservation of the values.

New construction in the Tahkoluoto area will not fundamentally change the landscape viewed from the sea. However, the changes in the area will obviously be observable changes, when examining the port and industrial area more closely. Occurred changes will mainly merge with the existing milieu.

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8.2 Impacts to waterbodies and their use

The VRP does not take process water or other water from the sea, and no wastewaters or stormwaters from the plant are directed to the water system. Only sanitary wastewater will be discharged to the municipal sewer.

Overflow of pond water from the slag and SSM storage areas is possible, but is expected to be very rare (once in hundred years). Overflow may happen during heavy rain periods lasting several days. The estimated overflow volumes and emissions and loads are presented in the table in section 6.3.

The loads in an overflow situation are not assessed to have impacts to the sea. The overflow water is quickly diluted in the sea and concentrations in sea water will be significantly lower. Only very minor, short-term, and local impacts on the water system can be assessed to occur. No detectable and long-term impacts will occur. The discharge will not jeopardize the water body obtaining good ecological status by the end of 2027.

The plant is not contradictory to the marine management plan, water management plan for the Kokemäenjoki River–Archipelago Sea–Bothnian Sea water management area and maritime spatial plan in the area, as there will be no emissions to the water system from the operation of the plant. The VRP will have no impacts on the chemical or ecological state or fish stock of the Reposaari-Outoori water body during operation. Therefore, it is not expected to have an impact on the use of water areas either.

8.3 Impacts to air quality

The main impacts to air quality are from dust emissions and they are estimated to remain local. The emissions from the operation originate from process (point source emissions), stockpiles and traffic (diffuse emissions). Particle emissions are the most significant component of air emissions and greatest proportion compared to the existing emissions from the industry in the Pori area (see table below). The process and diffuse dust emissions will increase the total dust emissions in the Pori region.

Table 12. Estimated annual emissions (tonnes) from the operation and comparison to the emissions in the Pori region (percentage) as based on data from 2020.

Emission component	**Emissions from operation**				**Total emissions in Pori**	**Share on total emissions in Pori (%)**	**Share of emissions from industry and energy production in Pori (%)**
	Maximum process emissions to air (ducted and stack sources)	Diffuse emissions (stockpiles and internal traffic)	Emissions from traffic (transport by trucks and ships)	Total emissions			
NOx	5		29.4	34.4	675	*5.1*	*9.3*
Dust	6.8	11.2	1.3	19.3	15	*129**	*276**
SO_2	-		0.08	0.08	198	*0.04*	*0.04*
Ammonia	2			2		*NA*	*NA*

**the plant increases the dust emission in Pori*

The point source emissions are emitted to the air through 25 or 30 meter stacks. Hence the emissions are dispersed at that height and their impact to local air quality is not assessed to be significant.

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A dispersion of PM10 and PM2.5 particulate emissions of the plant were modeled by ENWIN with AERMOD dispersion modelling software (PM10 particles, ≤10 µm particle size and PM2.5 particles, ≤ 2.5 µm particle size, i.e. fine particles). Dust modelling is presented in Appendix 22. In dispersion modelling the plant's process emissions and fugitive emissions were considered (storage areas, material transfer and wind erosion and traffic between the fields and the ship unloading traffic).

The impact on air quality of PM10 and PM2.5 particulate emissions from the vanadium recovery plant were below the air quality guidelines and limit values in the nearest residential areas and recreational sites. The plant's greatest dusting effects take place in the storage areas and the Tahkoluoto industrial area.

The daily concentration of PM10 particles in relation to the national guideline value was 11-16 µg PM10/m^3 at the nearest residential and leisure properties, which is 16-23 % of the PM10 daily guideline value (70 µg PM10/m^3). Concentrations were also below the new WHO daily guideline value of PM10 (45 µg/m^3). In relation to that the daily concentrations of PM2.5 in the nearest residential areas and leisure facilities of the plant were 1.5-3 µg PM2.5 /m^3 (10 % -20 % of WHO's PM2.5-daily reference value). The annual concentrations of both particle size fractions remain low at the nearest residential sites. The annual dusting impacts are centralized in storage areas of the plant.

8.4 Impacts to soil and groundwater

The VRP is in an industrial area, which is mostly unnatural land. There are no classified groundwater areas in the immediate vicinity of the VRP area. The plant's normal operation does not cause emissions to soil, bedrock, or groundwater. Water collection from the structures and stockpiles of the slag and SSM material storage area prevents the entry of materials from storage area directly or via stormwater and seepage water to the soil and groundwater.

Other exceptional situations, such as chemical leaks can cause impacts on soil, will be considered in the risk assessment.

8.5 Noise and vibration impacts

Noise modelling of the VRP operation, including related transport volumes, was performed in 2021. The assessment was based on the tentative design of the plant and transport volumes, existing traffic volumes and data on existing noise levels in the impact area of the plant. Potential noise mitigation impacts from the stockpiles of slag and SSM, and facilities were not considered.

Based on modelling (Appendix 23), the noise level generated both in daytime and at night by the operation of the facility and its traffic is under 50 dB in the nearest residential areas in Katainniemi, Parkkiluoto and Reposaari, which means that the daytime guideline value (maximum of 55 dB) and nighttime guideline value (maximum of 50 dB) will not be exceeded. The nighttime guideline value will be exceeded regarding one residential building in the immediate vicinity of the Reposaari main road due to noise from heavy traffic volumes at Iso-Katava.

According to the detailed plan there is set a noise limit for 45 dB for the noise caused by the plant to residential houses and areas. The noise of the VRP plant (excluding the traffic) does not exceed 45 dB in the nearest residential buildings. Regarding the nearest residential building in the Katainniemi area, the noise level generated by the operation of the plant is just below 44 dB at the front of the building both in daytime and at night. Hence the noise level of the plant is in line with the valid detailed plan.

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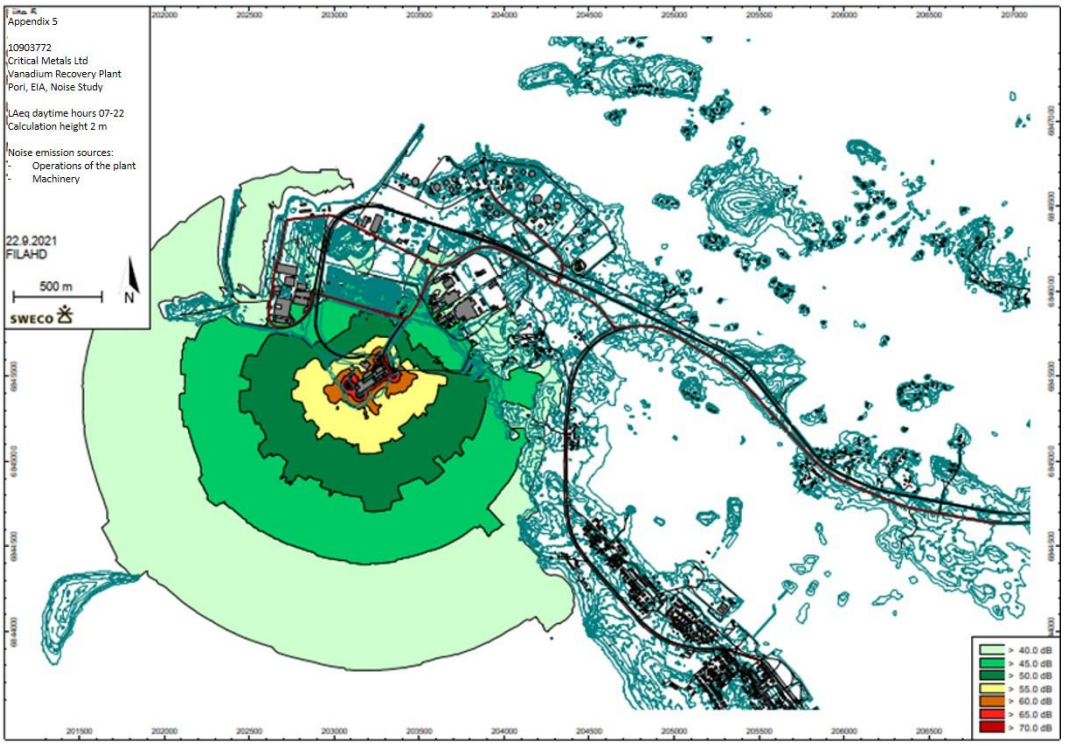

Figure 23. Noise generated in daytime by the operation, machinery and traffic of the plant. Maximum situation, in which the noise suppression of slag stockpiles is not considered. (Sweco 2021c)

The daytime equivalent continuous sound level generated by total traffic volume will probably be lower than 50 dB or a maximum of 55 dB at a few holiday homes located at a distance of about 500–800 m from the chemical port in the northeastern part of Tahkoluoto. At night, noise level of 50 dB will not be exceeded. Daytime equivalent continuous sound levels of less than 45 dB can be generated in Mäntypaakari area.

Guideline values may be exceeded both in daytime and at night due to noise generated by total traffic volume at residential buildings in the Iso-Katava and Reposaari area in the immediate vicinity of the Reposaari main road. Noise guideline values can also be exceeded in the south along the Reposaari main road for residential buildings located in the immediate vicinity of the road. Noise guideline values are probably exceeded in these areas already today.

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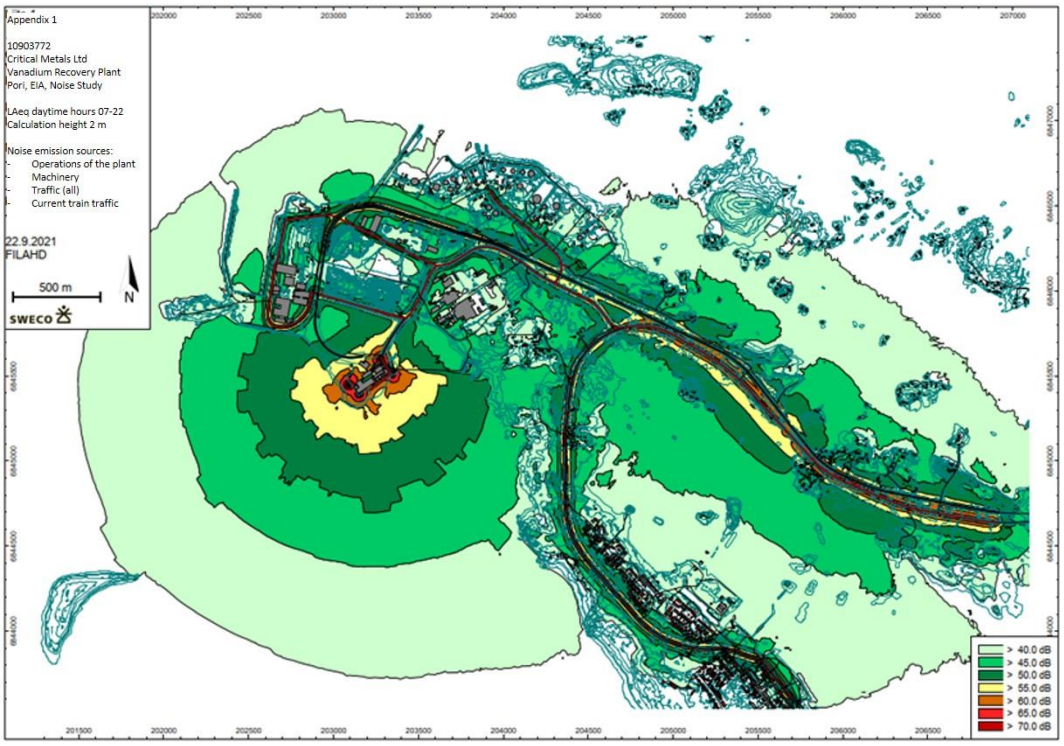

Figure 24. Noise generated in daytime by the operation, machinery and traffic of the plant and the existing traffic. Maximum situation, in which the noise suppression of slag stockpiles are not taken into account. (Sweco 2021c)

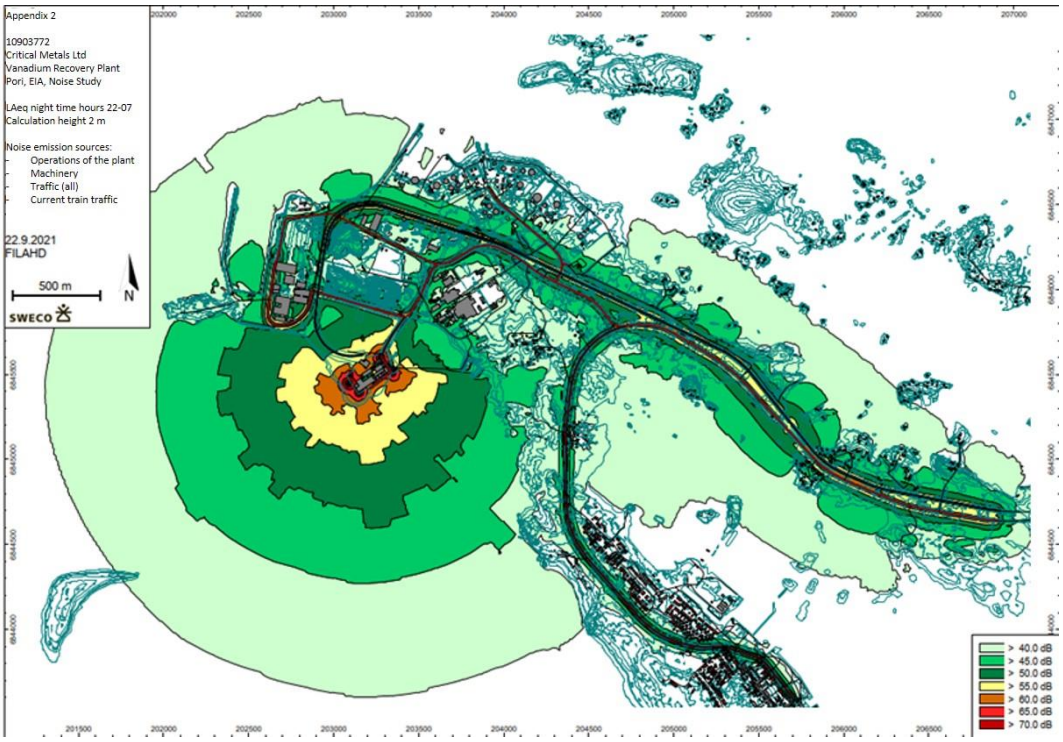

Figure 25. Noise generated in night-time by the operation, machinery and traffic of the plant and the existing traffic. Maximum situation, in which the noise suppression of slag stockpiles is not considered. (Sweco 2021c)

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The plant operation does not produce vibration. The transport of raw material and products will be done mostly by vessels and trucks, hence there is no significant increase in trail traffic that could cause vibration impacts.

8.6 Impacts to general well-being and human health

The project is in line with the commercial and industrial strategy of the city of Pori, as the project investment will have positive impacts on business development, economic life and employment. The plant will employ about 120 persons. Planning and design of the project will also have an employment effect.

During the normal operation of the plant no impacts are estimated to be caused on the well-being of the nearest residential areas and no significant disturbance to the recreational use of the environment. It is assessed that the operation of the plant and related traffic will not have significant harmful impacts on human health. Road traffic will to some extent increase the disturbance from traffic in the immediate vicinity of traffic routes. The disturbance caused by traffic will be similar both in the construction and operation phase.

Potential dust emissions from stockpiles are not estimated to have detectable impacts either on the permanent residential areas or even on the nearest holiday homes. Exhaust gases related to the operation of the plant promote the impacts which deteriorate air quality near the traffic routes, but these emissions are not estimated to cause detectable health impacts.

As a part of EIA procedure, the resident survey was performed (presented in Appendix 1). Opinions and attitudes on the project and its potential impacts as well as information on the existing use of the area were inquired. The opinions received were quite polarized. Some of the respondents were of opinion that the vanadium recovery plant would fit very well in the Tahkoluoto area and some thought that it will fit very poorly in the area. The fear of impacts especially on the nearby valuable natural environment, water system and landscape, as well as the noise, smell, and air quality impacts were emphasized in the results. The impacts on well-being and recreational opportunities in the nearby area were also suspected to be negative. Potential impacts on the vitality, economy, business life and employment in the area were considered as positive impacts.

8.7 Impacts to traffic

The vessel traffic will increase due to VRP operations by 17%. This is not assessed to cause impacts to the other vessel traffic.

It is estimated that the total road traffic volume will grow by less than 15 % and heavy traffic volume by more than 30 % on the Reposaari main road leading to Tahkoluoto. Impacts on traffic on the Reposaari main road south of Lampaluoto and on the Pori archipelago road depend on the distribution of departing traffic from the VRP area. Depending on the route choice, the potential growth of heavy traffic volumes is significant, about 30 %, on the Reposaari main road and about 50 % on the Pori archipelago road. Total traffic volume can grow by 10 – 20 % on these roads. The internal traffic volumes in Tahkoluoto will also increase.

Growing traffic volumes may impact traffic safety and the performance of the Reposaari main road junction (regional road 269) and Tahkoluoto road. Traffic safety could be improved by widening the road leading to Tahkoluoto or constructing a pedestrian and bicycle way along the Reposaari main road between Mäntyluoto and Tahkoluoto. The construction of road lighting on the Pori archipelago road would improve traffic safety for its part. The responsibility for improvements of the public roads are with the national and local road authorities (Finnish Transport Infrastructure Agency and the Traffic Department of the regional ELY Centre) in cooperation with City of Pori.

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9 Monitoring

The preliminary monitoring of the plant is presented below. CMS suggest that a monitoring plan of the plant is drafted after the environmental permit decision is received and submitted for approval to the supervising authority before starting of the operation.

9.1 Operational monitoring

The entire plant facility is controlled by a master centralised process control system, that is housed in a single centralised control room. All monitoring and controlling for the plant will be conducted from the centralised control room.

- Level control sensors will be used on hoppers, bins, and tanks.
- Where flow control is required, Variable Speed Drives (VSDs)or control valves as applicable will be used for controlling flow.
- Flowmeters and pressure sensors will be used for controlling either pump VSD's or control valves on process piping as applicable.
- Temperature sensors are used on high temperature process streams such as steam and boiler systems.
- Temperature control
- pH sensors are used on tanks with CO_2 addition.

The operational monitoring is done by automation. Performance monitoring by the automation system monitors flows, pH, pressure, temperatures, and key emission components (e.g. particles) on an ongoing basis. The measuring location are not know yet. The measuring equipment is serviced according to the manufacturer's instructions and calibrated at least once a year. Deviations from the norm will be reported and immediate corrective action initiated.

The slag quality is followed by the quality information received from the slag provider and occasional separate samples taken at the plant.

The product quality is followed by regular analyses.

If SSM is to be disposed to a landfill, analyses according to Decree 332/2013 will be made before its disposal.

An essential part of the review of operations also includes inspection rounds performed by process personnel.

The operational monitoring includes keeping record of:

- operating hours of the process plant and the gas boiler;
- quantity of raw materials, fuels, chemicals, and products;
- quantity and quality of operational waste; and
- quantities delivered to the various recovery and treatment sites and to the landfill.

9.2 Emission monitoring

The gas boilers are measured every 3 years by external party. The total annual emissions are estimated based on the emission measurement data or fuel emission factors.

Emissions to air (point source) will be measured in the commissioning phase of the facility and emissions will be monitored by periodical measurements, when needed.

Potential dust emissions related to slag treatment and storage are monitored during regular inspection rounds by sensory analysis of potential dust generation on site and in the immediate vicinity. Monitoring also includes the sensory analysis of potential odour impacts.

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9.3 Impact monitoring

Noise emission measurements will be done to confirm the modelling results when the process plant is in operation.

The plant will participate in the air quality monitoring of the area.

The situation of meadow dwarf will be monitored in Tahkoluoto for three years by surveying the newly created red fescue community.

Groundwater quality will be followed regularly to confirm that the stockpiles do not affect it. Two groundwater wells will be installed to the site area and samples will be taken once a year. The analysed parameters are metals, VOCs, oil hydrocarbons and pH.

In case of a major storm when run-off water may be discharged from the ponds to the sea the following analyses are taken from the pond water: pH, suspended solids, metals.

9.4 Measurement and calculation methods, devices and quality assurance

Measurements, sampling, analysis, and calibration shall be performed in accordance with the standards of the European Committee for Standardisation (CEN) or, in their absence, in accordance with ISO, SFS or an equivalent national or international standard in general use.

9.5 Reporting

Once a year, the operator shall submit a monitoring report to the environmental protection authority and the municipal authority.

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10 Applicant's suggestions for permit limits

Based on the plant operations and the inventories the applicant suggests limit values for air emissions and noise. The plant does not discharge any wastewater; hence no limit values are suggested.

10.1 Emissions to air

The applicant suggests the following limit values for the emissions to air. These limit values are considered to represent the best available technology.

Table 13. Suggested air emission limit values for the operation. All are in unit mg/Nm^3 and weekly averages (except for the boiler which would be measuring average).

Emission source	NOx	NH_3	Dust	Vanadium
AMV production	350	100	30	1
Gas boiler	100 mg/Nm^3 O_2 3%	-	-	-

These limit are considered the best available technology for a plant producing vanadium pentoxide and having similar technologies in the production (i.e. deammoniator and scrubber and fusion furnace). These values based on the information received from the technology supplier and they are used for similar process in Australia.

The gas boiler will reach the emission limit values set in the decree 1065/2017, which are 100 mg/Nm^3 (O_2 3%) for NOx emissions.

These limit values are for the normal operating conditions. The applicant suggests the following OTNOC situations when the emissions limit would not apply. These are:

- start-up and shut-down of the plant and gas boiler;
- unplanned shutdown;
- malfunction of bag filters; and
- malfunction of scrubber.

These situations will be further clarified in the monitoring plan which will be prepared before starting of the operation.

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10.2 Noise

The applicant suggests noise limit values to set separately for the VRP plant industrial noise and for the combined noise in the area. The suggested limit values are presented in the table below.

Table 14. Suggested noise limit values for the operation.

	Daily equivalent level (24h)	Noise limit value, daytime (07-22)	Noise limit value, night-time (22-06)
Noise level caused by the VRP plant only (not including traffic)	45 dB L_{Aeq} daily equivalent level	-	-
Noise level caused by the operation of the VRP plant together with the noise generated by the other activities must not exceed the nearest living space in areas used outdoors		55 dB	50 dB

The Supreme Administrative Court has in a decision, issued 5 February 2010 number 194, regarding the Fortum Power and Heat Oy Meri-Pori plant held that the 45 dB noise requirement set in the valid detailed plan concerns each operator separately in the land use plan block and not all operators jointly.

The applicant holds that the noise generated by the plant fulfils the 45 dB requirement set in the valid detailed plan. This is also verified by the noise modelling. The suggested limit values are also in line with the environmental permit decision of Meri-Pori power heat plant (ESAVI/320/04.08/2012) as amended by the aforementioned Supreme Court decision. The applicant holds that as in the aforementioned decision, the suggestion for noise emissions cannot be held to cause undue harm as defined in section 17 (1) of the Joint Properties Act (26/1920, as amended) either by itself or together with other operators in the land use plan block.

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