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MANAGEMENT AND UTILIZATION OF CLEAN SURPLUS SOIL

Soil bank operations of Ekokaari Oy

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ABSTRACT

Construction projects generate large volumes of surplus soil, posing both environmental and economic management challenges. In the Kymenlaakso region, limited soil disposal capacity points out the need for systematic and well-defined surplus soil management practices. As sustainability and material circulation gain importance in environmental policy and construction, the reuse of clean surplus soil has become an increasingly important topic.

This study was commissioned by Ekokaari Oy, which plans to launch clean surplus soil management operations in 2026. The objective was to develop practical tools to support the initiation of new soil bank and soil disposal operations. A qualitative research approach was applied, combining literature review, expert interviews and observations participating in the operations of the company. The theoretical framework addresses regulations and standards for surplus soil management, regional soil resources and risks in Kymenlaakso, and best practices for surplus soil reception and utilization.

As a result, three tools were developed: a product catalogue defining five soil categories based on technical properties and reuse potential, a decision tree for incoming surplus soil loads, and a process flow chart covering all phases of clean surplus soil management. These tools are designed to simplify material handling, clarify responsibilities, and support consistent decision-making in daily operations and they provide a practical starting point for managing clean surplus soils. Since the tools are specifically tailored to Ekokaari Oy's operational context, broader application would require adaptation to different operational environments. The study also includes reflections on surplus soil management practices in other countries, as well as recommendations for future applications. Overall, the thesis contributes to advancing circular economy principles and promoting sustainable management of soil resources in Finland.

Keywords: soil, surplus soil, utilization of surplus soil, soil bank, circular economy

CONTENTS

TERMS AND ABBREVIATIONS

Clean surplus soil is uncontaminated soil material that has been excavated during construction activities and is no longer needed for its original purpose

Contaminated soil is soil material that has been polluted, caused by human activities

Waste is a discarded substance or a substance that is obligated or intended to be discarded

The soil disposal site refers to the permanent placement of soil classified as waste, without intention of reuse it

The soil bank enables reuse of surplus soils, provide temporary storage for materials, and allow processing such as screening before reuse

End-of-waste procedure occurs when the material ceases to be waste and becomes a product. The product is then subject to product legislation instead of waste legislation

Circular economy is a system keeping the material in circulation to maintain the value of it and reducing the amount of waste generated

Biodiversity refers to the diversity of nature, encompassing the variety of ecosystems, the number, abundance and genetic variation within species

Sustainability encompasses ecological, economic, and social dimensions, aiming to meet present needs without compromising the ability of future generations to meet their own

1 INTRODUCTION

Construction activities generate large volumes of surplus soil, which in the EU constitutes the largest waste stream by volume (EEB 2023). In Finland, approximately 20-30 million tons of surplus soil is generated annually (Circhubs n.d.) Although most of it is clean and technically reusable, a significant share of it is still disposed of in landfills (EEB 2023).

Surplus soil can serve as a valuable resource in landscaping, infrastructure development, and other construction-related applications (Chica et al. 2023; Hale et al. 2021). It can also replace virgin aggregates and soil materials (Circhubs n.d.). In the Kymenlaakso region, there is an increasing need for proper sustainable surplus soil management. One significant upcoming construction project is the improvement of traffic safety on the VT15 highway between Kouvola and Kotka, scheduled to begin in 2026 (Väylävirasto 2025).

In response to regional needs, Ekokaari Oy, a subsidiary of Kymenlaakson Jäte Oy, plans to establish soil bank and disposal operations at the Keltakangas Waste Center in Kouvola. The company has applied for an amendment to its environmental permit ESAVI/19264/2021, and operations are expected to commence in 2026. Soil banks have been identified as effective mechanisms for coordinating surplus soil storage, processing, and utilization (Huhtinen et al. 2018).

As surplus soil management represents a new business area for the company, the objective of this thesis was to develop clear, practical, and implementable operational tools for the management of clean surplus soil. The work focused on defining product specifications for accepted soil materials, developing a decision tree to support soil reception, and designing a process flowchart to illustrate the overall surplus soil management system.

The study addresses the following research questions*:* what criteria should guide the acceptance and processing of clean surplus soils, and how can reusable materials be systematically distinguished from soil destined for final disposal? This question was examined through a combination of theoretical research, qualitative expert interviews, and active observation and participation in Ekokaari Oy’s operations. By integrating regulatory requirements, circular economy principles, regional soil characteristics in Kymenlaakso, and utilization opportunities for clean surplus soils, the study provides a structured and practical foundation for Ekokaari Oy’s future operations and contributes to the broader development of sustainable surplus soil management practices in Finland.

2 THEORETICAL FRAMEWORK

The theoretical framework of this thesis addresses standards and regulations governing the management of clean surplus soils in soil bank and disposal operations, and perspectives related to sustainability and circular economy. It reviews regional soil characteristics in Kymenlaakso to anticipate material types and potential risks and analyzes soil characterization and separation practices applied upon soil load arrival phase. The framework also considers opportunities for reuse of different types of soil materials.

2.1 Regulations and standards for managing surplus soil

Surplus soil management in Finland is governed by both European Union and national legislation. At the EU level, the Waste Framework Directive (2008/98/EC) establishes the core principles of waste management and introduces the concept of end-of-waste status, allowing materials to exit the waste regime once they meet defined quality and safety criteria and have a clear market for reuse (Directive 2008/98/EC). To strengthen soil governance, the EU adopted the Soil Monitoring and Resilience Directive in December 2025. This directive obligates Member States to monitor soil health and address risks such as contamination, erosion, and biodiversity loss, supporting safe and sustainable reuse of surplus soils. (Directive 2025/2360.)

Under Finnish regulations, surplus soil may be classified as a by-product instead of waste if its reuse is certain, and it requires no further treatment and poses no risks to human or the environment. Compliance with contaminant thresholds set in Government Decree 214/2007 is mandatory, and soil from potentially contaminated sites must be tested to confirm safety. (Ministry of the Environment 2015.) Producers of clean surplus soil must verify quality through documentation, including material descriptions, selected parameters, and standard test results, ensuring compliance with geoenvironmental and geotechnical requirements (Hale et al. 2021).

Soil banks, where surplus soil is stored for future use, are regulated by the Waste Act (646/2011), and Environmental Protection Act (527/2014), alongside technical standards such as the Finnish Transport Infrastructure Agency's guidelines and RYL quality requirements. Storage shorter than one year is generally considered temporary, and longer periods may be permitted for documented infrastructure projects. Permit requirements depend on scale. Sites handling more than 50000 tons annually require approval from the Regional State Administrative Agency (AVI), while smaller facilities fall under municipal oversight. (Reinikainen 2021.) Environmental permits specify acceptable soil types and contaminant limits based on the Government Decree 214/2007 on the Assessment of Soil Contamination and Remediation Needs (PIMA Decree), with flexibility for areas with naturally high background concentrations (Ministry of the Environment 2015).

When reuse is not possible, surplus soil must be disposed of in landfills regulated by the Waste Act (646/2011), Environmental Protection Act (527/2014), and the Government Decree on Landfills (331/2013). Landfilling requires an environmental permit and is considered the last option under the waste hierarchy (Figure 1), which prioritizes prevention, reuse, recycling, and recovery before disposing of the material (Waste Act 646/2011).

Figure 1. Waste hierarchy as a waste management principle (Waste Act 646/2011)

2.2 Sustainability challenges and circular economy approaches

Globally soil ecosystems underpin biodiversity, nutrient cycling, and carbon storage, making soil a key factor in environmental sustainability worldwide (EEB 2023). Over the past decades, the construction industry has driven economic growth but also generated significant waste (Chica et al. 2023). In Finland, construction consumes about 70 million tons of virgin aggregates annually, mainly for infrastructure projects. At the same time, these projects produce large volumes of surplus soil, which is often disposed of rather than reused, increasing emissions from material production. (GTK 2021.)

Barriers limiting the reuse of surplus soils include material quality constraints, organizational challenges related to project management and planning, as well as logistical and regulatory barriers. Regulatory barriers, such as unclear legislation and the lack of harmonized guidelines, often make reuse more complex and less attractive than landfilling. These factors bring to light material reuse and highlight the need for improvements in surplus soil management systems globally. (Hale et al. 2021.) One of the main sustainability challenges of managing surplus soils is the lack of proper soil disposal sites. It can lead to unauthorized dumping and cause environmental damage. For example, in Uusimaa, the scarcity of official surplus soil disposal areas has resulted in illegal soil deposits, including, for example, cases where clay soil has been dumped in forests. (Jaakkola 2025.) Such activities are unlawful and may lead to environmental degradation. Also, in Levi in 2023, an unauthorized dumping site containing approximately 7000 cubic meters of surplus soil was uncovered. The deposited soil caused waste and sludge to spread into peatland water systems and into a ditch flowing into a nearby lake. (Palomaa 2023.)

A circular economy approach to material handling differs from the traditional linear model, as seen in Figure 2. In linear economy model, the materials move from extraction to disposal (Geissdoerfer et al. 2017). In a circular economy system, materials are reused, recycled, or maintained, minimizing waste and regenerating natural systems. Applying these principles in tools such as Life Cycle Assessment (LCA) can be used. LCA evaluates environmental impacts across a material's life cycle and helps compare reuse options based on carbon emissions. (Ellen MacArthur Foundation n.d.)

Figure 2. Linear and circular economy differences (Geissdoerfer et al. 2017)

Reusing surplus soils instead of landfilling reduces the need for virgin materials (Hale et al. 2021). Also, optimizing aggregate use and encouraging on-site reuse reduce transportation emissions and the carbon footprint (GTK 2021). Ideally, soil is reused promptly on-site, minimizing environmental impacts and avoiding long-term storage (Ministry of the Environment 2015). Soil bank acts as a connecting service for utilization and surplus materials. It can also provide temporary storage for soil that cannot be transported directly between construction sites. From the soil bank, materials can later be delivered as-is or processed, such as by screening, before reuse. (Huhtinen et al. 2018.) Successful reuse requires systematic processes, including quality testing, risk assessment, and identifying suitable applications. Structured management ensures surplus soil from construction and demolition projects is directed to new uses, keeping the material in circulation, as seen in Figure 3, with landfill as the last resort. (Hale et al. 2021.)

Figure 3. The circular process for soil reuse in construction projects (Hale et al. 2021)

2.3 Soil resources and risk factors in the Kymenlaakso region

Soil is a complex mixture of minerals, water, air, organic matter, and living organisms, forming the Earth's upper crust and covering most of its land surface (Kichura 2021). Soil has a vital role in nutrient cycling, water regulation, and ecosystem diversity (EEB 2023). Soil supports food production. About 95% of human food originates from soil. Soil also acts as a carbon sink, storing carbon directly and through vegetation. (Rocha-Santos et al. 2025.)

Humus, an organic matter in soil, is composed of decomposed plant and animal material and occurs as a thin surface layer on top of mineral soils. Depending on its integration with mineral soil, the vegetation it originates from, and the decomposition processes, humus can be classified as mull, mor, or moder. Mull is well-mixed humus where roots and other organic matter decompose rapidly in alkaline soil. Mor is raw humus where organic material decomposes slowly in distinct layers under acidic conditions, and moder is an intermediate form. (Britannica n.d.) Organic soils, which consist mostly of organic material, such as peatlands, are common in Finland. Peatlands cover approximately 30% of the land area and store about two-thirds of the country's carbon reserves. (Ministry of the Environment 2023.)

Mineral soils are widespread in Finland (Ministry of the Environment 2023). They are classified into sorted mineral soil types and tills. Sorted minerals are divided into fine-grained and coarse-grained minerals. (Haavisto-Hyvärinen & Kutvonen 2007.) Finland's soil maps classify mineral soil categories further using RT system in comparison with GEO system, as seen in Table 1 below. Both classification systems agree that boulders, stones, and gravel are coarse-grained and clay is fine-grained, but there are differences in intermediate fractions. (GTK n.d.a.)

Table 1. Classification of mineral soils in Finland (GTK n.d.a: adapted in English)

Grain size (mm)	RT soil classification	GEO soil classification	Categorization
> 1000 1000-60 60-2.0 2.0-0.2 0.2-0.06	Boulders Large Stones Small stones, gravel Sand Coarse silt sand	Boulders Stones Gravel Coarse and medium sand Fine sand	Coarse-grained soils
0.06-0.02 0.02-0.002 < 0.002	Fine silt sand Silt Clay (30%)	Coarse silt Medium and fine silt Clay	Fine-grained soils

Till, an unsorted crushed rock material, is the most common soil type in Finland, as seen in Figure 4 below. Glacial activity detached and crushed bedrock material, making moraine formations, and till is the sediment of it. (Haavisto-Hyvärinen & Kutvonen 2007.) Depending on its origin and depositional history, till consists of poorly sorted sediments containing particles that range from large boulders to fine-grained material (GTK n.d.b). Till can be classified as sandy till, gravelly till, and silty till. Approximately 75% of Finnish tills are sandy till, 10% gravelly till, and 15% fine-grained till. (Haavisto-Hyvärinen & Kutvonen 2007.)

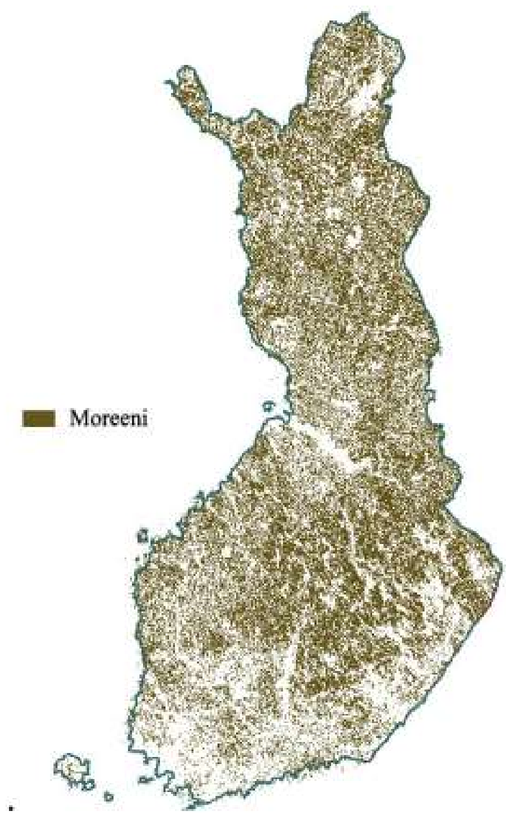

Figure 4. Moraine formations across Finland (Haavisto-Hyvärinen & Kutvonen 2007)

In Kymenlaakso region, there are seven categorized nature areas, each with its own dominant soil and natural type. In Northern Kymenlaakso, there is the lake area, the Salpausselkä ridges, and the cultivated plain area. In Southern Kymenlaakso, there are peatland and forest areas, lake and forest areas, as well as the archipelago landscape area and the coastal landscape area. (Regional Council of Kymenlaakso 2013.)

According to the Geological Survey of Finland’s Maankamara service (GTK 2018), the soil composition in Northern Kymenlaakso region is highly varied. In Figure 5, the landscape consists of bedrock formations, and there are extensive and continuous zones across the area. Clay deposits are also highly significant. They stand out as one of the most prominent soil types in Kymenlaakso region, covering large low-lying areas and river valleys, particularly in the western parts. The region also contains small patches of sandy moraine, moraine ridges, and fine-grained sediments. (GTK 2018.)

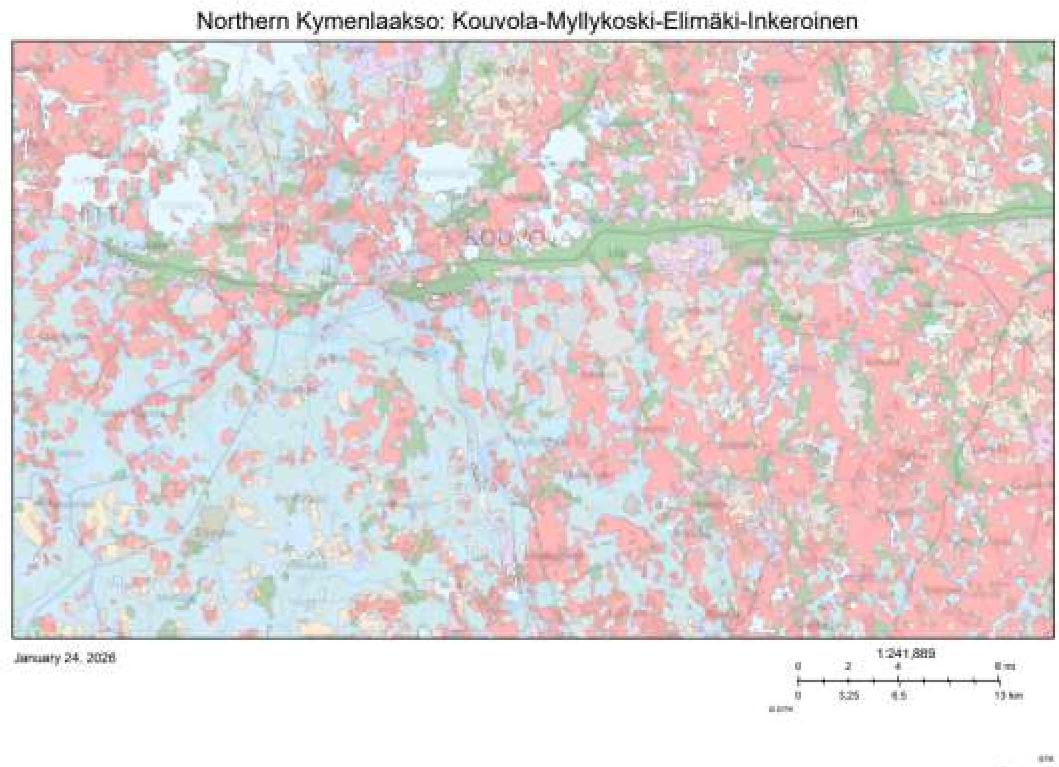

Figure 5. Soil types across Northern Kymenlaakso. Reddish areas indicate bedrock, yellow shows mixed soil types, green is coarse-grained soils, and light gray represents peat layers. Light blue is clay (dominant in western parts), and light purple indicates fine-grained soil areas. (GTK 2018.)

Another unique factor influencing soil in Northern Kymenlaakso is the presence of the Salpausselkä ridges. Figure 6 below shows it stands out as a prominent landscape feature rising above the surrounding terrain in GTK (2018) Maankamara soil map and extend east-west across the region. These terminal moraine formations were formed during the Ice Age through glaciofluvial processes, as meltwater streams deposited coarse grained soil, such as gravel and sand, beneath the ice sheet. Their sunny slopes composed of sand and gravel with a thin humus layer, create dry, warm conditions that support specialized vegetation adapted to these environments. (Finnish Environmental Institute 2022b.) The ridge areas are surrounded by diverse habitats, including, for example, kettle bogs, and spring-fed zones (Finnish Environmental Institute 2022a).

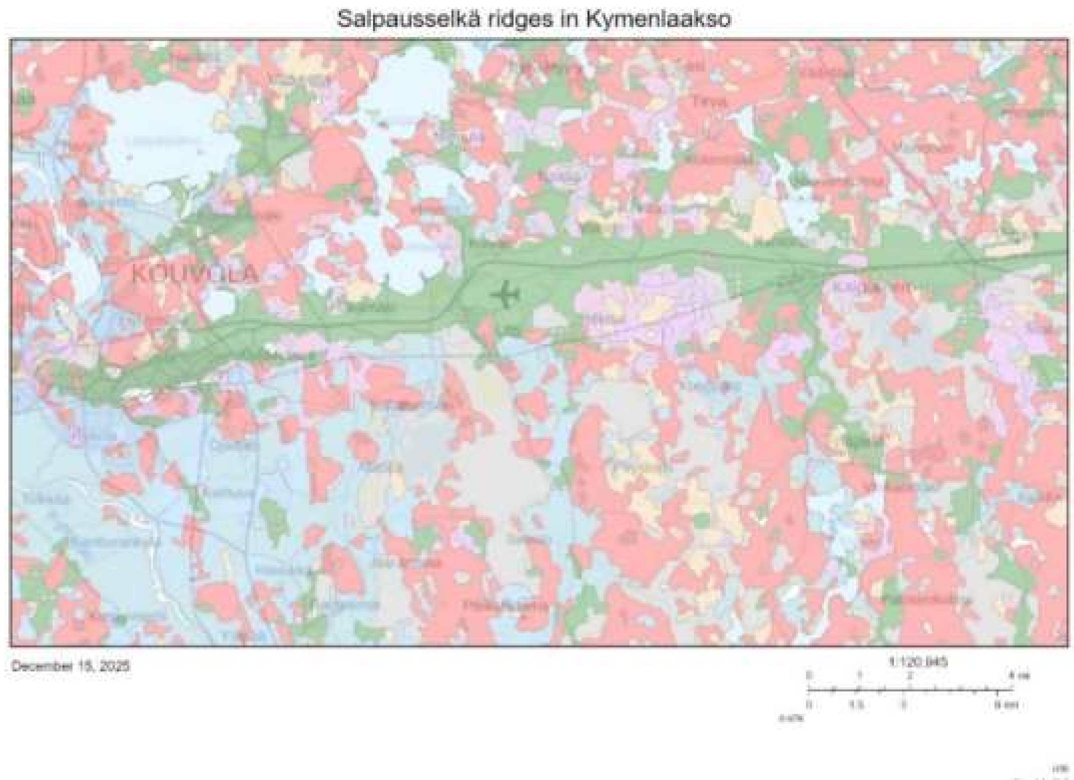

Figure 6. Salpausselkä ridges running east-west through Northern Kymenlaakso (green zone), contrasting with surrounding bedrock areas (red) and other soil types (GTK 2018).

The sea and coastal zones, seen in Figure 7, shape the soil and natural landscape of Southern Kymenlaakso (Finnish Environment Institute 2022). The bedrock consists mainly of rapakivi granite, which is exposed in many places but elsewhere lies beneath thick layers of various soils, including, for example, clay areas. The coastal area is characterized by dominant moraine and rocky shores, complemented by surface gravel and sand deposits. Gravel and sandy beaches have developed as wave action has separated fine-grained material from the moraine. (Regional Council of Kymenlaakso 2013.)

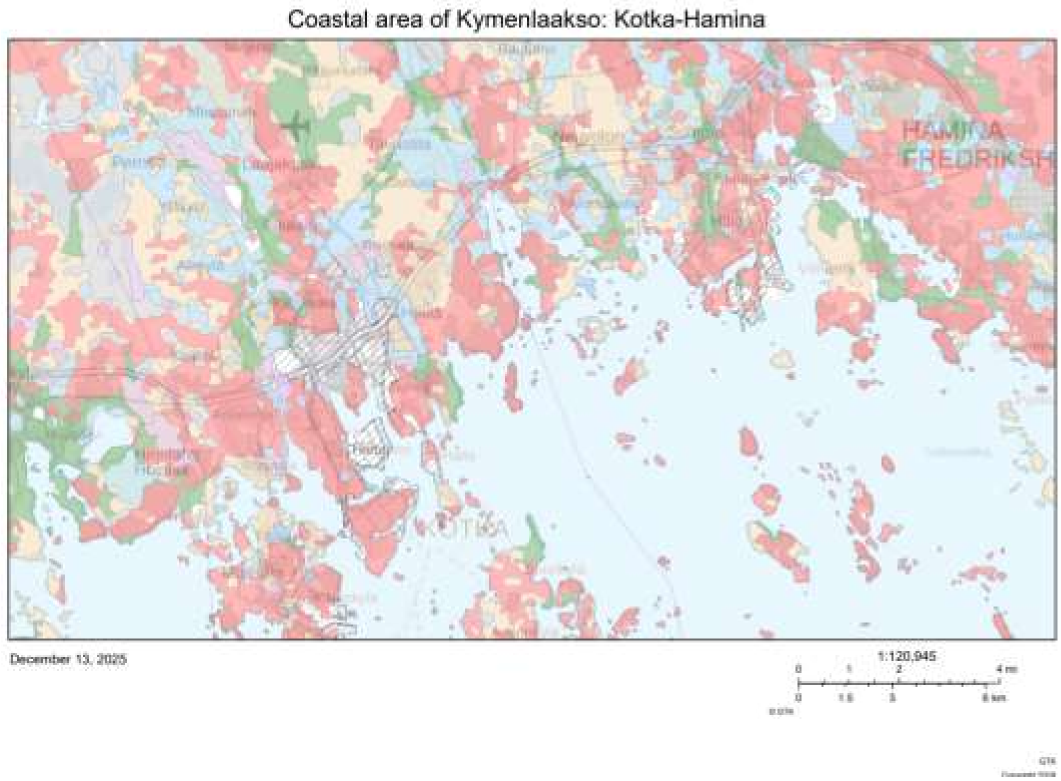

Figure 7. Soil distribution in the Kymenlaakso coastal area. Red indicates bedrock. Green areas are sandy moraine deposits & yellow highlights glaciofluvial formations and moraine ridges. Light blue is clay, light purple unspecified fine-grained soils, and light grey indicates peat layers. Hatched areas are unmapped. (GTK 2018.)

Although surplus soil loads are generally expected to be clean, potential contamination risks in surplus soil loads must be considered. Contaminated soil has been degraded by harmful substances introduced through human activity which can impair soil quality posing risks to environment and human health. For example, contaminated soil may include areas polluted by oil. (Ministry of the Environment 2014.) Contamination can also result from chemicals such as heavy metals, which can accumulate in urban green areas and remain stored in the soil. When their concentrations exceed harmful thresholds, soil quality deteriorates, reducing species abundance and biodiversity negatively affecting plant and animal health. (Nousiainen 2024.) Also, natural occurring acid sulphate soils are common in coastal areas of Finland. These soils typically consist of dark, silty or clayey mud containing sulphides. Construction on such soil can cause severe acidification and metal-rich runoff. When sulphides oxidize, they release acidity and create leachate harmful to soil quality. For this reason, construction on acid sulfate soils is subject to strict regulation. (Ministry of the Environment 2022.)

Also, invasive plant species are widespread in Finland and pose an additional risk to soil quality if they are transported with soil. Invasive plants are species that spread to new areas and would not naturally occur there without human influence. By occupying habitats and monopolizing resources, the harmful invasive species limit the growth and survival of native species and thereby threaten biodiversity. (The Finnish Association for Nature Conservation n.d.) In Finland, common harmful invasive plant species include, for example, the rugosa rose, giant hogweed, knotweed species, and lupine (Huusela et al. 2021). Harmful invasive species must be disposed of appropriately to prevent the spread, for example by delivering them to a waste management facility for safe destruction (Huhtinen 2021). However, the limited availability of designated disposal sites for invasive plant species has led to situations where such material has been improperly deposited in the environment, contributing to the further spread of harmful species (Huusela et al. 2021).

2.4 Reception and visual assessment of clean surplus soil

Soil characterization describes soil properties and supports soil management by providing detailed information about soil conditions (Ternikar et al. 2025). Soil classification is conducted to better understand soil quality and soil health (Alvarez Padilla 2023). Soil classification involves grouping soils based on their physical, chemical, and biological characteristics, all of which influence soil quality (FAO n.d.a).

Physical properties of soil include, for example, texture, density, porosity, and moisture content (FAO n.d.a). Because soil has multiple characteristics, dividing soils into classes is important for enabling a common scientific language (Alvarez Padilla 2023). When soils are further classified, for example, according to moisture and consistency, they can be divided into four states, solid, semisolid, plastic, and liquid (Das 2010). Chemical properties include pH and nutrient content. Biological properties refer to organic matter and living organisms, for example, bacteria and other microorganisms, that influence soil processes and fertility (Alvarez Padilla 2023).

Visual inspection of soil examines its general appearance and physical characteristics, such as color, odor, and texture, which vary between different soil types (Kichura et al. 2021). Observations from visual inspection help classify soil type and determine its suitability for reuse or disposal. This method also enables the identification of foreign materials, such as roots or unwanted waste. If anomalies in soil quality are detected, such as an unusual odor that may indicate chemical contamination, laboratory analyses may be performed. (ABSOILS n.d.)

Soil color can provide insights into both the minerals present and the processes occurring within the soil, indicating its suitability for different uses. Dark soils usually indicate a high level of decomposed organic matter, and red soils reflect the presence of iron. (FAO n.d.b.) Sandy soils often contain visible reddish minerals and feldspar grains and can be distinguished by sight and touch. Gravelly soils typically include gravel, small stones, and often sand, sometimes mixed with finer material. (Haavisto-Hyvärinen & Kutvonen 2007.) Till is generally grey or greyish-brown, and its grains, rocks, or boulders are mainly sharp-edged (GTK n.d.b). Humus is dark brown or black, and plant remains can be visible (Britannica n.d.).

In field conditions, soil texture largely determines how soil can be practically analyzed (Alvarez Padilla 2023). Soil texture, defined by the composition and distribution of particle sizes, is an important physical property influencing soil classification and identification (Ternikar et al. 2025). Differences in soil texture can be assessed by touch. For example, sand feels gritty and coarse and does not hold together when shaped (Ritchey et al. 2015; Haavisto-Hyvärinen & Kutvonen 2007). Silt feels smooth and powdery, like flour, while clay is hard and cracked when dry and becomes sticky and moldable when wet (Ritchey et al. 2015). Humus feels soft and crumbly and leaves an earthy smell on the hands (Britannica n.d.).

Simple field-based tactile methods provide a practical way to assess soil texture without laboratory analysis, based on how the soil feels and behaves when handled (Alvarez Padilla 2023). A common technique involves moistening a small amount of soil and forming it into a ball. If the ball does not hold together, the soil is likely high in sand content. The sample can then be rubbed between the fingers to further evaluate its texture. To estimate clay content, the soil can be rolled between the thumb and forefinger to form a ribbon. Longer, cohesive ribbons indicate higher clay content, and shorter ribbons suggest sandy or loamy soils. (Ritchey et al. 2015.) When dry clay is rubbed, it crumbles into pieces rather than forming powder (GTK n.d.).

2.5 Surplus soil processing and utilization opportunities

The growing view of treating surplus soil as a resource rather than waste has opened up reuse possibilities in construction and infrastructure projects (Chika et al. 2023). Typical applications include landscaping, landfills, and road construction (Hale et al. 2021). Factors affecting soil reuse include geotechnical and geoenvironmental characteristics. Geotechnical properties cover, for example, compressibility, particle size distribution, hydraulic conductivity, and plasticity, and geoenvironmental factors involve aspects such as pH. (Hale et al. 2021.) The particle size distribution affects the soil's behavior including becompactability, strength, frost susceptibility, and permeability (Murske n.d.).

Processing and techniques for surplus soil reuse vary depending on the material. Also, recycled soils often require different measures compared to virgin soils. Pavement and embankment structures perform as intended when surplus soils are properly planned, dimensioned, and constructed. (Harju 2019.) Humus-rich soil utilization and their applications include green construction projects, such as parks and noise barriers. Humus-rich soils, for example, stabilize slopes, making them suitable for landscaping and ecological restoration projects. (Chika et al. 2023.) Humus can also improve soil functionality when combined with mineral components such as sand, creating a nutrient-rich and water-retentive material with enhanced bearing capacity. This mixture is ideal, for example, for green construction applications like noise barriers and parks. (Deeb et al. 2020.)

Coarser soils are generally easy to utilize (Chicka et al. 2023). Till in Finland is considered a durable and load-bearing material with good potential for reuse in infrastructure projects, either in its natural state or after processing. Sand till and fine-grained till are commonly used in construction, for example as embankment material for roads and as sealing material in earth dams. Sand till is commonly used for road embankments and as sealing material. (Haavisto-Hyvärinen & Kutvonen 2007.) Gravel till, depending on its boulder content, can be used as a substitute for natural gravel. Gravel is a valuable material for road surfacing and as aggregate in concrete, and due to its grain size distribution, it is widely utilized as a construction material and can also be suitable for crushing (Haavisto-Hyvärinen & Kutvonen 2007). Both screened gravel and sand are suitable for base and sub-base layers in roads (Harju 2019). Sand can also be sed, for example, in mold production to improve the structure of the soil and the movement of water within the material, which is an important property in breeding grounds (Kekkilä n.d.).

Fine-grained soils are harder to utilize in construction due to their low strength capacity. These features make, for example, fine sand lack stability, although it has a good drainage (ProChemical n.d.). Especially soils containing clay minerals, display cohesive behavior when moisture is present (Das 2010). As the water content increases, the strength of the soil decreases (Murske n.d.). Clay as a surplus soil material presents significant challenges for utilization (ABSOILS n.d.). Clay tends to shrink when dry and swell when wet, leading to soil movement and cracking beneath structures, which makes its use in natural form problematic. For effective application, any structure must be designed to tolerate these volumetric changes. (ProChemical n.d.) Stabilization techniques, such as treating clay soils with lime or cement, can enhance their bearing capacity and make them suitable for foundation layers. This improvement occurs because lime and cement react chemically with clay minerals, reducing plasticity and increasing strength through chemical bonding reactions. Clay blended with cement or lime has been successfully applied, for example, in road base layers, ground improvement methods, and certain structural components. (Chica et al 2023.) Stabilized soils can then be reused for applications such as landscaping, reducing the need for landfill disposal (ABSOILS n.d).

There are possibilities to utilize invasive plant species. Treatment possibilities include, for example, composting for green mass, biogas production, or plant-based dye manufacturing. Currently, at waste treatment facilities that accept invasive plant species, the material is typically destroyed by burial and covered with clean soil. Incineration is also possible but generally not considered an environmentally friendly disposal method. New approaches for disposing invasive plants, such as steam treatment, are being tested. However, these methods can fail to destroy all harmful plant parts and require careful monitoring. (Huusela et al. 2021.)

3 MATERIALS AND METHODS

This chapter describes the methods used to develop the thesis and the products. The approach combined three sources: a literature review for background knowledge, participant observation during the internship, and expert interviews to gain operational insights. Also, the tool development and data analysis of the results are explained.

3.1 A Literature review

This thesis adopted a functional approach that combines a literature review with qualitative methods, including participant observation and expert interviews. The aim was to develop practical solutions rather than new theory, focusing on understanding the phenomenon and structuring knowledge into a logical and usable framework rather than conducting systematic or statistical research.

The methodology was based on Vilkka and Airaksinen (2003), supported by Kananen (2014*)* and Tuomi and Sarajärvi (2018). These sources guided the qualitative design, semi-structured interviews, and analysis. The theoretical background was compiled using Finnish and international scientific databases and targeted web searches. Peer-reviewed articles from platforms such as ResearchGate and ScienceDirect provided information on surplus soil characteristics and management practices. GTK’s Maankamara map service was used for regional soil data analysis, and company's internal documents provided organizational context and information on upcoming soil management activities.

Literature related to soil materials was reviewed to identify typical surplus soil types in Finland and in Kymenlaakso. The classifications were kept concise to ensure practical usability and consistency, drawing on GTK's mineral soil classification system and reuse potential the literature showed. The decision tree for arriving soil loads was theoretically grounded in the company's waste transfer documentation and supported by observations. The company's existing flowchart for oily contaminated soils served as a starting point for the process flow chart. The process flowchart followed JHS 152 (2012) guideline examples for operational models and KPIs, with indicator design possibilities informed by Org (n.d.), Simsek (2025), and Mischke (2025).

3.2 Observation & practical experience

Participant observation was conducted during an internship at Ekokaari Oy in summer and fall 2025 to complement the literature indicated. Active involvement in daily operations enabled observation of material flows, reception procedures, and employees' work practices. Key observations were recorded in a notebook and later organized in an Excel spreadsheet for analysis and comparison.

Work at the weighbridge was particularly valuable for understanding reception procedures, material routing, and categorization of soil types and related products. Observations of oily soil reception showed differences between handling clean and contaminated soils, and existing product catalogs provided reference points for structuring the product catalog for clean surplus soils. These insights ensured that theoretical classifications matched operational realities and supported the development of realistic products.

3.3 Expert interview

To complement the literature review and internship observations, expert interviews were conducted to clarify operational reasoning and decision-making. Interviewees included the CEO of Ekokaari Oy, and a maintenance engineer of

Ekokaari Oy, as well as an infrastructure client, providing managerial, technical, and customer perspectives.

A theme interview approach with four themes was chosen to allow flexibility and depth. The questions were based on theoretical findings and field observations and focused on practical challenges, regional conditions, material flows, and operational models. Due to the functional nature of the thesis and the small sample size, the interviews were used as expert validation instead of statistical analysis. Together with observations and literature, the interviews ensured that the process descriptions reflect both theoretical understanding and practical realities.

3.4 Data analysis and tool development

Interview transcripts and observation notes were analyzed qualitatively. The interview material was reviewed alongside field notes and organized in an Excel table under predefined themes, with color coding used to highlight links to roles, actions, and risks. This approach enabled comparison across sources without software-based or statistical analysis and supported interpretive depth.

The product categorization diagram was primarily developed from literature and refined using field observations. It was structured to highlight key material properties, reuse potential, and handling routes. Canva was used to present soil types visually, applying concise text blocks and color coding to enhance clarity and usability of the tool.

The process flow diagram and decision tree were created by synthesizing interview findings, observations, and internal company materials. They were designed to reflect actual operational practices for managing clean surplus soils. The company’s process description template was adapted in Microsoft Word, and visual elements such as green arrows and a circular economy symbol were added to emphasize optimal reuse pathways and sustainability. The decision tree, created in Canva, guides users through key decision points to ensure alignment with company practices.

4 RESULTS

This chapter presents the results of the product catalogue, the decision tree, and the process flow chart. The rationale for selecting product groups is based on technical properties, reuse potential, and management requirements. The decision tree includes essential information, reducing the need for clarification at the reception stage when the soil load arrives and the pre-information is missing. The process flow chart provides a framework for practical implementation of the handling of clean surplus soils from the customer to final disposal.

4.1 Product catalogue

The soil product categorization resulted in five groups: humus, clay soils, fine-grained mineral soils, coarse-grained mineral soils, and soils containing invasive plant species. This classification reflects both material characteristics and practical requirements for reuse and management (Table 2). The product list made for company is provided as a reference in Appendix 1. The grouping was kept concise to align with the company’s preference for clarity and to avoid an excessive number of product types, while still covering the dominant soil fractions and operational challenges identified in the research. The pricing for clean surplus soils reflects the relative difficulty of reuse the soil material: the harder to utilize, the higher the price.

Table 2. Selected soil product categories, key properties, reasons for separate classification, placement in the waste management center & typical treatments, identification and pricing logic.

Product Name	Key Properties	Reason for Separate Category	Placement / Typical Treatment	Visual & Tactile Identification	Pricing Logic
Humus	Organic topsoil, mold, low stone content	Can be utilized for green construction/ landscaping (fewer loads expected)	Soil bank → Separation (possible roots or foreign parts)	Dark brown/black color, loose structure, earthy smell, soft	Own price category due to special features
Clay soils (<0.006 mm)	Clay, silt, cohesive, shrink-swell behavior	Difficult to reuse naturally, large volumes stockpiled	Disposal (landfilling) → No utilization	Greyish brown, smooth, sticky and holds shape + long ribbons when wet / hard and cracked when dry	Highest price due to complexity to utilize
Fine-grained mineral soils(0.06 –2.0 mm)	Sand, high fines content, friction features	Common in tills, needs screening	Soil bank → Screening	Light brown/grey, gritty feel, does not hold shape when moistened, short ribbons	Medium price, reuse possibilities
Coarse-grained mineral soils (2.0–60 mm)	Small stones and gravel, low fines, friction soils	Common in tills, excellent load-bearing capacity, easy to reuse	Soil bank → Screening or crushing	Visible stones and gravel, rough texture, cannot form a ball or ribbon	Lowest price, easiest to reuse
Invasive plant species soil	Contains plant parts (e.g. roots, seeds)	Requires special handling to prevent spread	Disposal → Burial under clean soil	May contain roots, seeds, or plant fragments, mixed with humus & other soil types	Own price category

Humus was included as its own category because based on the theory, its properties and potential uses differ from other soil materials. Its re-use is generally restricted to specific applications rather than a wide range of construction projects, and the volume of soil expected to arrive is significantly lower compared to other materials due to its thin top layer. It also often contains, for example, roots that increase handling work at the reception site.

As stated in theory, clay and silt are cohesive soils with particle sizes under 0,006 mm and are the most difficult to utilize in their natural state, often requiring stabilization. Their limited reuse potential justifies their classification as a separate category, as they frequently end up in landfills, resulting in the highest price category. Fine-grained mineral soils were assigned to represent finer friction soils. At the company`s request avoid having too many products, mineral soils suitable for reuse were broadly divided into fine-grained soils, describing sandier loads, and coarse-grained soils, representing gravelly loads. Fine-grained mineral soils were placed in the medium price category because, based on theoretical knowledge, they can potentially be utilized through processes such as screening. However, their usability is lower compared to coarser materials due to higher moisture content and lower bearing capacity. Coarse-grained mineral soils, on the other hand, are easy to reuse with minimal processing, for example by crushing, and that makes the price lowest. Soil including harmful invasive species was designated as a separate category because based on theory they have a biosecurity risk and they need isolated placement.

These five surplus soil product groups were selected to represent the most significant material streams and utilization opportunities identified in the Kymenlaakso region, and to align with Ekokaari Oy's operational needs. The classification was supported by GTK GEO and RT mineral soil guidelines, which provided a technical basis for structuring the categories. This approach balances technical suitability, environmental responsibility, and operational simplicity, enabling practical implementation. It promotes transparent cost allocation and encourages the reuse of easily processed materials, as lower pricing motivates stakeholders to supply such materials.

4.2 Decision tree for arriving soil loads

The decision tree developed for the reception of surplus soil loads mirrors the actual operational logic observed during the study. Each decision point was derived from company practices and internal documents and validated through field observations, interviews or theory ensuring that the structure reflects real-world workflows. The observation, elements and decision questions are seen in Table 3. The decision tree intended for company use is provided in Appendix 2.

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Table 3. Decision tree observations, elements and decision questions

Element	Decision question	Company`s current or future practices	Theory/ observation or interview based	Impact on decision tree design
Contaminated soil handling	Does the material contain oil?	Oily soils have a dedicated treatment process	Observed reception of oily soils confirmed distinct workflows	Decision point for contamination directing oily soils to specialized route
Waste/ construction waste routing	Does the material contain waste, brick or concrete?	Brick/concrete directed to landfill or own spots to crushing	Observed routing of brick/concrete loads to landfill/ to their own spots	Non-soil branch guiding to landfill/crushing.
Acceptance /Biosecurity	Does the material contain invasive plant species?	Loads with invasive species can be sent to special location	Observation: reception checks identified cases, interview+ theory: invasive plants require special treatment	Acceptance checkpoint for risk management
Clay Check	Is the material primarily clay?	Clay to disposal due to distinct properties	Interview: ‘Clay loads harder to utilize and go landfilling’	Separate clay branch ensures correct routing (surplus soil disposal)
Texture check, possibility to utilize:mineral soil or humus	Is the material possible to utilize? Is it primarily sand, gravel, or humus?	Texture informs routing to soil bank for utilization	Theory based: these materials are easiest to reuse and go to soil bank	Branch directs material to soil bank
Exception handling	If none of the above, the load is directed to quarantine lane for further inspection	Supervisor involvement required for unclear or exceptional cases	Observed cases where special judgment was needed to prevent misrouting	Escalation pathway ensures compliance in exceptional scenarios

The process begins with the arrival of a material load and the first critical question: “Is the material oily?” Observations and theory confirmed that oily soils require a separate handling process, and they have a dedicated product catalog and treatment route. This justified the inclusion of a distinct branch for contaminated soils, ensuring that such loads are directed immediately to specialized handling without entering clean soil processing streams. If the material is not oily, the next checkpoint addresses construction waste: “Does the material contain waste or concrete?” Field observations showed that brick and concrete loads were consistently routed to landfill or crushing in their own spots at the waste management center and soil material including waste goes to regular landfilling. This operational pattern led to a separate branch for soil materials including something else than mineral soils or humus, maintaining efficiency in waste management.

For mineral soils and humus, classification by texture is essential. The decision tree includes questions such as “Is the material primarily clay” or “Is the material good for utilization including primarily sand, gravel, small stones, or humus”. In this case the theoretical background and the utilization opportunities revealed that sandier and gravelly loads were directed to soil bank while clay required its own route due to its difficulty to reuse and end-up in landfilling. These branches ensure accurate routing to prevent unnecessary moving of loads from one place to another and optimize resource recovery. Biosecurity considerations were integrated through the question: “Does the material contain harmful invasive plant species?” At the reception phase the waste worker checks identified cases where invasive species were present in loads, requiring special disposal. Including this checkpoint in the decision tree strengthens risk management and prevents ecological harm.

Finally, the tree includes a critical escalation point: if none of the answers before applied, the load must be directed to wait in a quarantine lane for further inspection. This step is triggered when material characteristics do not fit predefined product categories or when uncertainty arises regarding acceptance criteria. Observations indicated that such cases may require managerial judgment to prevent incorrect routing or compliance issues. Including this escalation pathway ensures flexibility in the system, allowing exceptional cases to be handled appropriately without disrupting overall workflow.

The weighbridge process has a central role in operational decision-making. Observations showed that routing decisions are made in real time based on material specifications and contamination status especially when there is a lack of pre-information. The decision tree replicates this logic, ensuring consistency and clarity in acceptance criteria and routing. Overall, the decision tree consolidates findings into a structured tool that supports efficient, transparent, and sustainable material management. It reflects observed practices, integrates risk controls, and provides clear guidance for both routine and exceptional scenarios, thereby improving operational reliability and environmental responsibility.

4.3 Process flow chart

The process flow diagram represents the sequence of steps and their interconnections within clean surplus soil management. This diagram (Figure 8) is a condensed version of the process flow that has been made for use for the company. The full version is in Appendix 3.

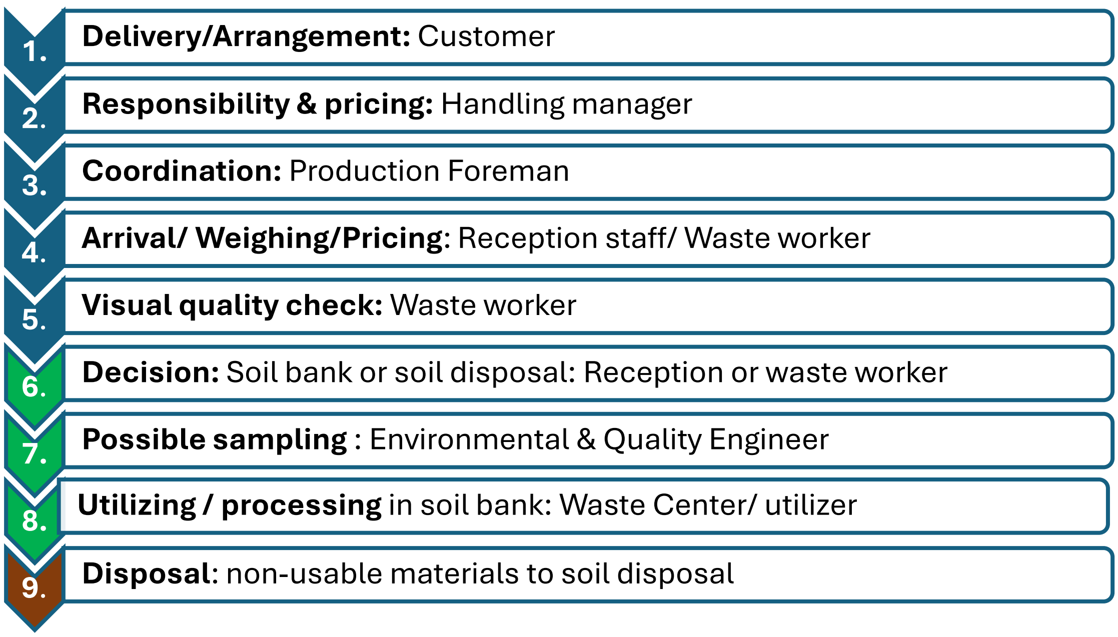

Figure 8. Process flow chart for clean surplus soil (short version). Circular Economy Path: From Decision (Step 6) to Step 8 (Utilization) instead of Step 9 (Disposal)

The clean surplus soil reception process consists of several different steps designed to ensure proper handling and quality control. Each table below includes the process step, key actions, main insights that influenced its inclusion, and an illustrative key performance indicator (KPI). Although the research is qualitative, KPIs are presented as examples commonly used in practice to monitor efficiency, quality, and reuse performance, for instance, reception lead time, and percentage of accurate quality decisions. These indicators do not represent quantitative measurement within this thesis but demonstrate how operational success is typically evaluated in the industry. In every step, all workers, with main responsibility on the handling manager, ensure compliance and promote reuse when possible, according to circular economy principles.

Table 4. Step 1: Delivery

Role	Purpose	Key Actions	Evidence	Risks & Mitigation	KPI
Customer	Deliver or arrange delivery	Transfer documents, verify soil quality, inform reception in advance	‘Accurate info in advance supports the utilization’, ‘Quantity & quality of the material’, ‘Cooperation between actors’	**Risk**: Missing info → unnecessary work. **Mitigation:** Checklist for arriving soil loads	Time delay, % of process waste

The process starts at Step one, as shown in Table 4, where the customer is responsible for delivering or arranging the load. Key actions include managing transfer documents and delivery notes, as well as verifying soil quality. The best scenario is that the customer informs the reception site in advance about the quantity and quality of the arrival material to ensure management efficiency. Interview responses emphasized the importance of advance information, accurate material quantity and quality, and strong collaboration between different stakeholders. The main risk at this step is missing information when the load arrives, which can lead to unnecessary work and a waste of time, such as moving a load from the soil bank to disposal if the quality does not match what was reported. Mitigation measures include using a minimum information checklist. KPIs for this step could be time delays and process waste time.

Table 5. Step 2: Responsibility

Responsible Role	Purpose	Key Actions	Interview Evidence	Risks & Mitigation	KPI
Handling Manager	Clarifying staff responsibility roles and pricing	Confirm roles, responsible for the operations	‘Clear roles for each worker: reduce confusion and save time’, ‘An effective soil bank: collaboration with construction project designers and clients’	**Risk:** Miscommunication between stakeholders **Mitigation**: regular communication between all parties	The number of role-related misunderstandings

In Step two, as shown in Table 5, the handling manager clarifies staff responsibilities and pricing. Clear roles reduce confusion and save time. Interview responses emphasized the importance of well-defined roles for all employees to avoid misunderstandings and improve efficiency. An effective soil bank also requires collaboration with construction project designers and clients to ensure smooth operations and accurate material flow. The main risk at this step is unclear responsibilities and insufficient coordination, which can lead to delays and errors in material handling. KPI for this step could be the number of role-related misunderstandings.

Table 6. Step 3: Daily communication

Responsible Role	Purpose	Key Actions	Interview Evidence	Risks & Mitigation	KPI
Production Foreman	Communication, informing	Daily planning, updating yard	'Lanes allocated and communicated to avoid mixing a map base: what materials is in each location', 'Lack of follow-up plans/target'	**Risk:** e.g. lane confusion **Mitigation**: clear communication	Keeping to schedule

In Step three, as shown in Table 6, the production foreman is responsible for daily communication and planning. The foreman plays a central role in coordinating field activities, clarifying who is responsible for each task, and ensuring visibility of material locations. Interview responses highlighted the importance of allocating lanes and communicating these clearly to avoid material mixing. The main risk at this step could be, for example, lane confusion, and the mitigation of clear communication. The KPI for this step could be keeping to schedule.

Table 7. Step 4: Arrival/ Weighing/ Pricing

Responsible Role	Purpose	Key Actions	Interview Evidence	Risks & Mitigation	KPI
Reception Staff	Receiving and registering the arriving load, billing	Register arrival, verifying transfer docs	'Advance info about arriving loads', 'camera logs link tipper and pile'	**Risk:** Missing info on arrival (additional work), billing disputes **Mitigation:** checklist	Reception lead time, weighing error, number of billing disputes

In Step four, as shown in Table 7, the reception staff receive, register, and weigh the arriving soil loads. They also verify transfer documents. Interview responses highlighted the value of advance information. The main risk in this step could be lacking pre-information, which could cause delays and additional work. Mitigation includes using a standardized checklist. KPIs for this step could be reception lead time and weighing accuracy or billing disputes.

Table 8. Step 5: Visual quality check

Respon-sible Role	Purpose	Key Actions	Interview Evidence	Risks & Mitigation	KPI
Waste Worker	Fast quality check	Visual check / verifying correct location	'Sensory checks', 'Visual check before tipping', 'Go/Hold/ Reject decision', 'The masses mix easily: difficult to utilize', 'If a single load of contaminated soil is added to a soil pile, the entire pile is unusable'	**Risk:** Wrong acceptance **Mitigation:** quarantine lane	Contamination incidents

In Step five, as shown in Table 8, waste workers ensure material quality and proper pile management. If the quality of an incoming soil load does not match the pre-informed specifications or if there is no pre-information, they perform a quick visual inspection and decide whether the material goes to the soil bank or directly to disposal. Keeping loads properly separated is critical, as one contaminated load can compromise an entire pile. Daily routines include maintaining distinct piles by building them by fraction and monitoring and relocating them as needed. For example, good mineral soil and clay must remain separated to preserve quality. Interview responses emphasized the importance of visual checks, clear communication, and practical tools such as maps and camera logs linking the tipper to the corresponding pile to enhance traceability and prevent mixing. The main risk in this step could be incorrect acceptance or mixing of materials, which can be mitigated, for example, by using quarantine lanes for questionable loads and visual aids for pile management. KPI could be, for example, contamination incidents or the number of incorrect decisions.

Table 9. Step 6: Decision

Responsible Role	Purpose	Key Actions	Interview Evidence	Risks & Mitigation	KPI
Reception worker or waste worker	To decide if the material goes to soil bank or disposal	Check delivery documents, make decision, record decision, inform driver, direct load to correct location	'Everyone uses the same terminology', 'Clear infographic: easy to interpret' 'friction soils easiest to utilize'	**Risk:** Wrong decision **Mitigation**: clear guidelines **Risk:** Missing documentation **Mitigation:** No decision until complete info	Contamination incidents/ month, number of incorrect decisions

Step six, shown in Table 9, involves making the decision on whether the material goes to the soil bank or directly for disposal. This decision is made either by the receiving worker or the waste center staff. At this stage, it is crucial that all relevant documents are available and that materials are correctly recorded in the system. It is also important to guide the driver to deliver the soil to the correct location. Interview responses highlighted the importance of using consistent terminology and clear, concise infographic to simplify the workflow. The main risk in this step could be an incorrect decision, which can be mitigated through employee training and easy-to-use checklists. Tight schedules can also lead to mistakes, so user-friendly decision-support tools are helpful in this regard. Key KPIs could include the number of mixing incidents or incorrect decisions/month.

Table 10. Step 7: Sampling / Quality quarantine

Responsible Role	Purpose	Key Actions	Interview Evidence	Risks & Mitigation	KPI
Environmental and quality team	Verifying questionable loads	Spot samples	'Oil contamination risk'; 'Chemical quality for metals/sulfates/chlorides'	**Risk:** Cross-contamination **Mitigation**: fenced quarantine	Quarantine dwell time

In step seven (Table 10), Environmental and quality team verifies questionable loads by taking spot samples when the loads are in quarantine lane. Risks include oil contamination, and chemical quality issues, for example metals, sulfates, chlorides, which were mentioned in the interview answers. Mitigation involves quarantine areas. KPI could be, for example, quarantine dwell time.

Table 11. Step 8: Utilizing / processing in soil bank

Responsible Role	Purpose	Key Actions	Interview Evidence	Risks & Mitigation	KPI
The waste center (the utilizer)	Use the material in landfill construction / Prepare material for reuse, for example in mold production	Screening, compliance with regulations	'Current: landfill cover & future: replace purchased sand in mold production', 'frictional soils easiest to utilize', 'Test & learn: expand storage area to maximize the utilization', 'Reception sites planned in advance' 'Can replace virgin aggregates' 'Effective recycling: developers actively utilize recycled products'	**Risk:** Failed reuse attempt **Mitigation:** written standards	Rework rate

In step eight, seen in Table 11, the utilizer, the waste management center prepares soil for reuse through screening and compliance with regulations. Based on interviews, clean soil is currently used mainly as landfill cover. In the future, plans include expanding applications such as replacing purchased sand in mold production or can replace virgin aggregates with frictional soils being the easiest to utilize. Initially, rental machines are going to be used for testing before expanding utilization. Planning reception sites in advance and experimenting with different methods are key to finding ways to maximize reuse and recycling would be effective if construction developers actively utilized recycled products. The main risks involve incorrect material recipes and misrouting, which can be mitigated through written quality, compliance, and safety standards. KPI in this section could be, for example, rework rate.

Table 12. Step 9: Disposal

Responsible Role	Purpose	Key Actions	Interview Evidence	Risks & Mitigation	KPI
Waste management center	Allocate to disposal & to support the proper disposal of soil materials in the region	Record decision reuse or landfilled	'To separate materials into those directed to the soil bank or disposal.' 'challenge in using: ensuring contaminant levels do not exceed acceptable thresholds.' 'camera surveillance to mitigate the risks' ' 'challenge: changes in construction plans: material not needed at the originally intended location.' 'The region has a limited number of officially authorized disposal sites: operations improve it','a need for official disposal site in this area'	**Risk:** reusable material goes landfilling or contaminated to soil bank **Mitigation:** checklist, camera surveillance	% reused vs landfilled

The final step (Table 12) addresses the final allocation of surplus soil that cannot be reused or processed further. The waste management center is responsible for determining whether remaining material is directed to a disposal site, ensuring that the decision is documented for traceability. By offering official disposal site, the waste center also strengthens local soil management capacity. The purpose of this step is to maintain clarity between materials designated for reuse and those requiring landfilling, reducing the risk of misclassification. This could be mitigated by using a checklist or a camera surveillance. Interview insights for this process step indicated that the primary goal is to separate materials either for placement in the soil bank or for disposal, while ensuring that contaminant levels in incoming soils do not exceed regulatory thresholds. It was also noted that materials initially intended for reuse may ultimately be directed to landfill if the original reuse plan changes, for example due to project delays or the withdrawal of funding at the construction site. Performance could be monitored through the KPI percentage of material reused versus landfilled, which provides a measurable indicator of circularity and operational efficiency.

5 DISCUSSION

Together with creating practical tools tailored to the company's workflows, this thesis aimed to embed circular economy principles into the concept of clean surplus soil management. This study demonstrates that even simple, structured instruments can promote circular economy values, such as reuse over disposal, and stakeholder collaboration, within everyday operational practices.

The research questions focused on identifying the criteria that should guide the acceptance and processing of clean surplus soils, and on distinguishing reusable materials from soils destined for disposal. These questions were addressed through the development of the product catalogue, decision tree, and process flow map, which together provided a practical framework for operational decision-making. By mapping technical properties, environmental suitability, documentation requirements, and reuse potential, the tools offered concrete answers to how clean surplus soils can be classified and managed.

Regionally, a few sites in or close to Kymenlaakso currently accept clean surplus soils on a larger scale for businesses. In Kouvola, municipal surplus soils are accepted for deposition at Maijanaro landfill, operated by the City of Kouvola (City of Kouvola n.d.). Nearby, companies such as Maaroll in Sipoo, RTA-Yhtiöt, and Salpamaa in Lahti also receive surplus soils, with Salpamaa further processing these materials into recycled products (Maaroll n.d.; Salpamaa n.d.; RTA-Yhtiöt n.d.). Also, the digital platform Maapörssi enables offering and receiving surplus soils, which regional actors can utilize (Maapörssi n.d.). However, based on the review, there are no nearby larger scale surplus soil reception sites in the southern part of the Kymenlaakso region, for example in the Kotka-Hamina area, indicating that the greatest regional need for surplus soil management is concentrated there. This suggests that the Keltakangas waste center, operated by Kymenlaakson Jäte and Ekokaari Oy, could serve as a key hub for receiving surplus soils from South Kymenlaakso and surrounding areas. The location is also well suited for receiving surplus soils generated by the construction of passing lanes along the VT15 highway.

Although surplus soil recycling is still limited in Finland, the reuse of surplus soils is gradually developing, particularly as actors explore circular economy opportunities and joint operational models. Millions of cubic meters of surplus soils are generated annually, but only a fraction is reused, and a significant portion is considered unsuitable for construction. This underscores the growing importance of improving the utilization of surplus soils, particularly clay, to increase the circular economy share of earth materials. New operational models are being proposed to bring together actors from different sectors to develop joint business opportunities around circular economy principles, but these plans remain in their early stages. (Kallio et al. 2021.)

International examples demonstrate how structured systems can advance circular economy goals in soil management while ensuring environmental protection (Hale et al. 2021). In the Netherlands, Grondbank Leeuwarden operates as a centralized soil bank, reducing CO_2 emissions and serving as a testing ground for new reuse methods under a ‘”learning by doing” approach (Circle Economy n.d.). Sweden has integrated recycling areas near construction sites, with thorough permitting and environmental assessments to ensure compliance and quality (Huhtinen et al. 2018; Hale et al. 2021). Norway has a permit system and long-term resource planning through large coastal quarries, which stands out for efficient logistics and maritime material exports (Hale et al. 2021). France uses soil passports and traceability systems to support a target of 70% reuse of excavated soils (Hale et al. 2021). In New South Wales, Australia, sampling, testing, and concentration thresholds for natural surplus soils requires a mandatory document, allowing reuse when criteria are met. These examples show that the reuse of clean surplus soils is technically and environmentally feasible across different countries but implementation varies widely. Centralized soil banks, integrated recycling areas, and mandatory quality standards support efficient, safe reuse, and voluntary guidelines and case-specific permits allow flexibility. Overall, national regulations, permitting systems, and logistics strongly influence how effectively surplus soils can be reused.

Despite practical contributions, this thesis study is characterized by several limitations. The reliance on interviews and observational data introduces interpretive subjectivity, as findings are shaped by researcher perspective and contextual nuances. The theoretical foundation is fragmented. For example, literature on surplus soil management and soil banks is scarce, which constrained triangulation and limited opportunities for comparative synthesis. The tools developed are tailored to this company's operational context and cannot be universally standardized without significant adaptation. Also, the absence of quantitative evaluation means that the results cannot be objectively verified. A different approach could have included a partial quantitative study combined with a larger number of expert interviews. This would have strengthened the generalizability of the findings.

The subjective nature of the research reflects its pragmatic intent to create simple, actionable tools that facilitate the company's transition into new operational territory. Usability was prioritized over universal applicability, which aligns with the applied nature of the work to understand the phenomenon rather than create new theory. Considering professional growth, the process of developing these tools has deepened expertise in soil circular economy, classification, and risk management. This knowledge will be valuable in future work, supporting the implementation of sustainable practices in resource management. The research process was particularly challenging due to the limited availability of studies, especially on specific topics such as soil banks or soil management comparisons, which required synthesizing information from multiple sources to build a comprehensive understanding of the topic.

6 CONCLUSIONS

This thesis examined how clean surplus soils can be accepted, processed, and directed to soil bank for utilization or disposal through clear operational criteria. Grounded in circular economy principles emphasizing reuse, traceability, and resource efficiency, the study developed practical tools for Ekokaari Oy: a product catalogue, a decision tree, and a process flow map. These tools provide a simple structured framework for evaluating incoming soil loads, distinguishing soils suitable for reuse from those requiring disposal.

The findings revealed that, despite some regional and national surplus soil recycling activities, limited reception capacity in Southern Kymenlaakso constrains reuse and may increase the risk of inappropriate surplus soil handling. Initiating operations at the Keltakangas Waste Center will improve regional capacity of surplus soil management and support controlled, reuse-oriented material flows. International examples show that the management of surplus soil varies across countries but also that structured acceptance criteria, traceability, and quality-based processes are effective enablers of circular soil management.

The study is limited by its qualitative, subjective, case-specific approach and the lack of quantitative validation. Nevertheless, it demonstrates that straightforward, practical instruments can translate circular economy principles into everyday actions. Overall, by providing practical and implementable answers to the research questions, this thesis contributes to the advancement of sustainable surplus soil management in Finland. Future development should focus on practical testing, continuous performance monitoring, and adaptation to evolving operational conditions. The tools can be updated as the company’s operations evolve. Although initially developed for the current operational context, they are flexible and adaptable to future changes. Clean surplus soils will first be utilized in Ekokaari Oy’s own landfill operations, and screened sand in mold production. Over time, these materials also have significant potential to be developed into marketable recycled products. This could further support company`s circular economy practices and promote local sustainability and economic development.

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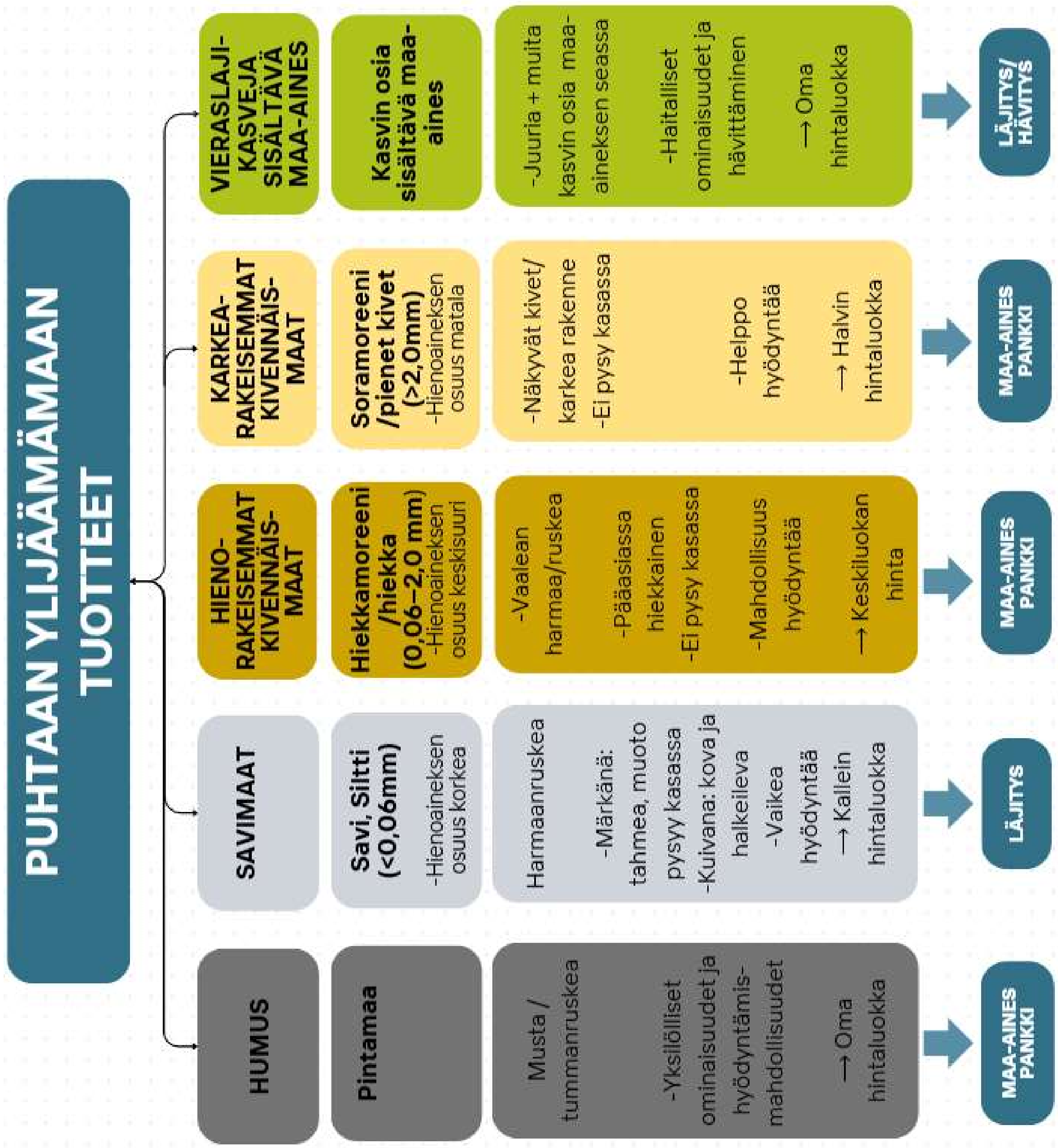
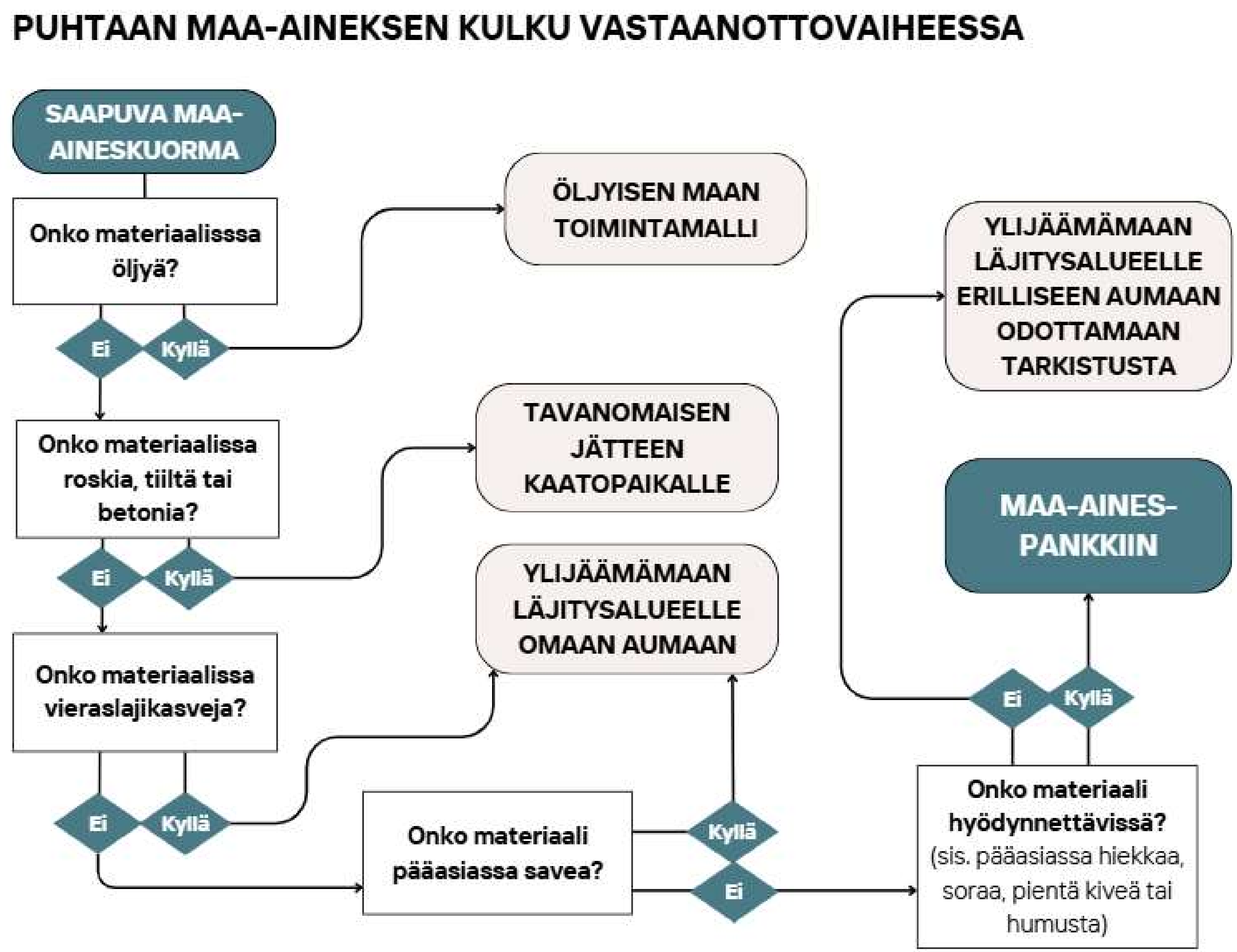
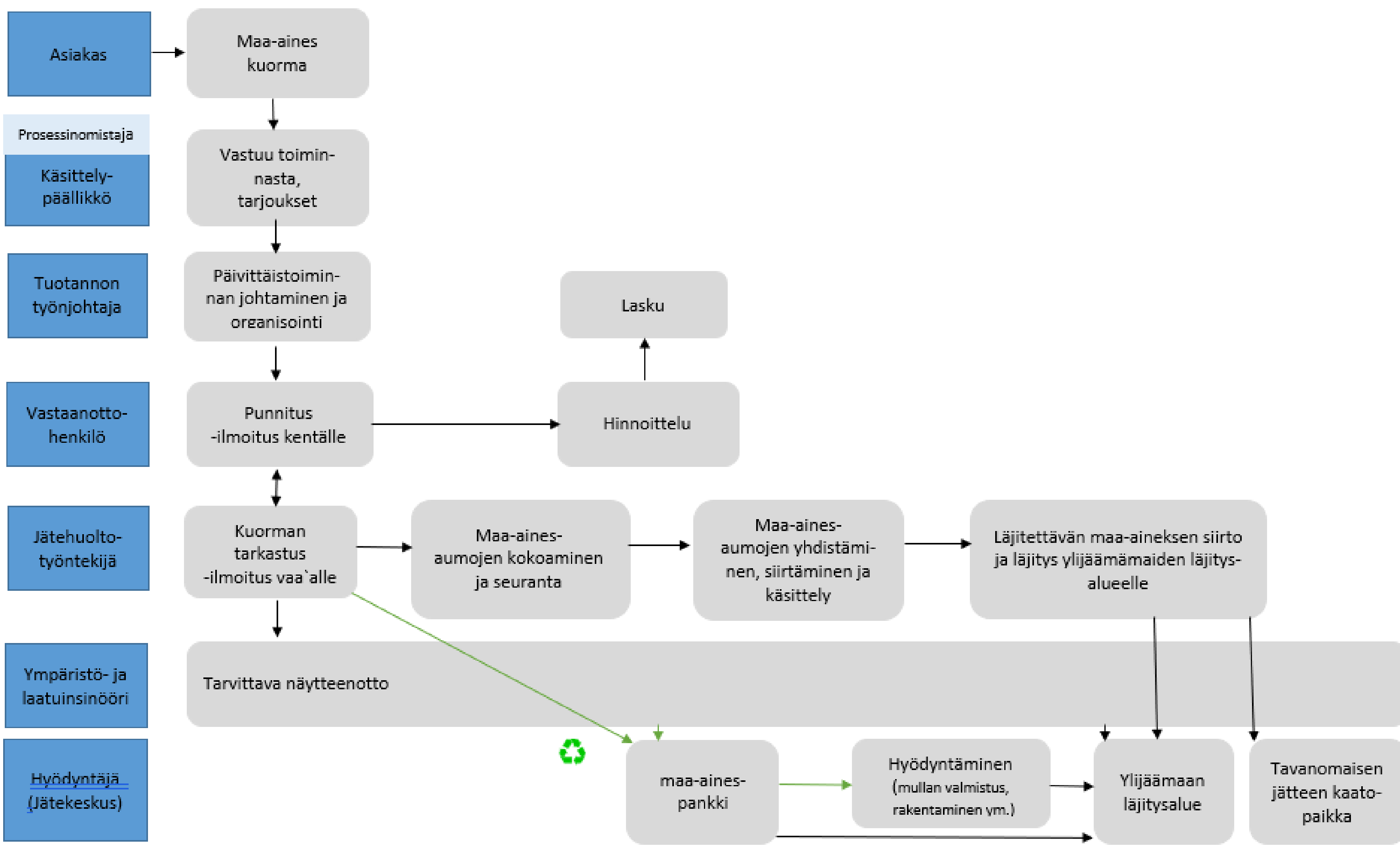
Waste Act 646/2011.

Appendix 1


PUHTAAN YLIJÄÄMÄMAAN TUOTTEET
HUMUS
Pintamaa
Musta / tummanruskea
-Yksilölliset ominaisuudet ja hyödyntämis-mahdollisuudet
→ Oma hintaluokka
MAA-AINES PANKKI
SAVIMAAT
Savi, Siltti (<0,06mm)
-Hienoaineksen osuus korkea
Harmaanruskea
-Märkänä: tahmea, muoto pysyy kasassa
-Kuivana: kova ja halkeileva
-Vaikea hyödyntää
→ Kallein hintaluokka
LÄJITYS
HIENO-RAKEISEMMAT KIVENNÄIS-MAAT
Hiekkamoreeni /hiekka (0,06–2,0 mm)
-Hienoaineksen osuus keskisuuri
-Vaalean harmaa/ruskea
-Pääasiassa hiekkainen
-Ei pysy kasassa
-Mahdollisuus hyödyntää
→ Keskiluokan hinta
MAA-AINES PANKKI
KARKEA-RAKEISEMMAT KIVENNÄIS-MAAT
Soramoreeni /pienet kivet (>2,0mm)
-Hienoaineksen osuus matala
-Näkyvät kivet/ karkea rakenne
-Ei pysy kasassa
-Helppo hyödyntää
→ Halvin hintaluokka
MAA-AINES PANKKI
VIERASLAJI-KASVEJA SISÄLTÄVÄ MAA-AINES
Kasvin osia sisältävä maa-aines
-Juuria + muita kasvin osia maa-aineksen seassa
-Haitalliset ominaisuudet ja hävittäminen
→ Oma hintaluokka
LÄJITYS/ HÄVITYS


PUHTAAN MAA-AINEKSEN KULKU VASTAANOTTOVAIHEESSA
SAAPUVA MAA-AINESKUORMA
Onko materiaalisssa öljyä?
Ei
Kyllä
ÖLJYISEN MAAN TOIMINTAMALLI
Onko materiaalissa roskia, tiiltä tai betonia?
Ei
Kyllä
TAVANOMAISEN JÄTTEEN KAATOPAIKALLE
Onko materiaalissa vieraslajikasveja?
Ei
Kyllä
YLIJÄÄMÄMAAN LÄJITYSALUEELLE OMAAN AUMAAN
Onko materiaali pääasiassa savea?
Kyllä
Ei
Onko materiaali hyödynnettävissä? (sis. pääasiassa hiekkaa, soraa, pientä kiveä tai humusta)
Ei
Kyllä
YLIJÄÄMÄMAAN LÄJITYSALUEELLE ERILLISEEN AUMAAN ODOTTAMAAN TARKISTUSTA
MAA-AINES-PANKKIIN

Appendix 3


Asiakas
Maa-aines kuorma
Prosessinomistaja
Käsittely-päällikkö
Vastuu toimin-nasta, tarjoukset
Tuotannon työnjohtaja
Päivittäistoimin-nan johtaminen ja organisointi
Lasku
Vastaanotto-henkilö
Punnitus -ilmoitus kentälle
Hinnoittelu
Jätehuolto-työntekijä
Kuorman tarkastus -ilmoitus vaa`alle
Maa-aines-aumojen kokoaminen ja seuranta
Maa-aines-aumojen yhdistämi-nen, siirtäminen ja käsittely
Läjitettävän maa-aineksen siirto ja läjitys ylijäämämaiden läjitys-alueelle
Ympäristö- ja laatuinsinööri
Tarvittava näytteenotto
Hyödyntäjä (Jätekeskus)
maa-aines-pankki
Hyödyntäminen (mullan valmistus, rakentaminen ym.)
Ylijäämaan läjitysalue
Tavanomaisen jätteen kaato-paikka