



ISWA

International Solid Waste Association

Waste sorting plants

Extracting value from waste

An introduction

About ISWA

The International Solid Waste Association, is a global, independent and non-profit making association, working in the public interest to promote and develop sustainable waste management.

ISWA's objective is the worldwide exchange of information and experience on waste management. The association promotes the adoption of acceptable systems of professional waste management through technological development and improvement of practices for the protection of human life, health and the environment as well as the conservation of materials and energy

as the conservation of materials and energy resources.

ISWA's vision is an Earth where no waste exists. Waste should be reused and reduced to a minimum, then collected, recycled and treated properly.

Residual matter should be disposed of in a safely engineered way, ensuring a clean and healthy environment.

All people on Earth should have the right to enjoy an environment with clean air, earth, seas and soils. To be able to achieve this, we need to work together.



Introduction

This report is an introduction to waste sorting plants and describes the framework conditions influencing the sorting plant (economically and technically), their technical configuration and capabilities and the factors that should be considered when setting a planning process in motion. It aims to spread knowledge of waste sorting plants and the role they can play in the waste management system.

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Table of contents

Introduction	3
List of Tables	4
List of Figures	5
Summary	6
Framework conditions for sorting plants	8
Value drivers / cost drivers for material recovery.....	8
Policy tools – regulatory push.....	9
Policy tools – creating market pull	9
Material recovery: collection and sorting	10
Sorting plants in the wider waste management system.....	11
Sorting plants	12
Waste sorting plants in the waste management chain	12
Facilities and operation.....	12
Positive vs. negative sorting	12
Manual versus automatic sorting	13
Sorting technologies – a brief overview	13
Emerging technologies	15
Limits to sorting.....	15
Planning and managing a sorting plant	16
Business case.....	16
Planning.....	18
Operational	21
Health, safety and the environment.....	22
Annex 1 – Flow diagram of a mixed municipal waste sorting plant	25
Annex 2 – Flow diagram of a mixed plastic waste sorting plant	27
Annex 3 - Factors related to health, safety and the environment	29

List of Tables

Table 1 - Collection and sorting combinations.....	10
Table 2 - Overview of waste sorting technologies	13
Table 3 - Overview of Pre-start works and their estimated duration.....	19
Table 4 - Site Selection Evaluation Criteria	20

List of Figures

Figure 1 - Sorting plants in the waste management system.....	11
Figure 2 - Processes of a Waste Sorting Plant.....	12
Figure 3 - Effect of price volatility on income, on average (I) and over time (II)	17
Figure 4 - Layout of a Sorting Plant.....	21
Figure 5 - Process of Preventing Environmental, Health and Safety Hazards.....	23

Summary

In its crudest form, mixed municipal waste has little value. The individual materials contained in mixed municipal waste, however, do have value: once recovered, they can replace virgin materials in the manufacture of new products, and removing them from the waste stream reduces the amount of waste sent to final treatment. Waste sorting plants can be used to recover materials from the municipal waste stream by acting as a filter between collection and disposal.

Interacting economic and policy drivers provide a framework for implementing and operating waste sorting plants. The economic drivers for material recovery are the value of the material recovered, the costs associated with alternative waste management routes, and any additional direct funding of subsidy provided. Policy tools play a vital role in moderating this framework: landfill and incineration taxes, landfill bans and recycling targets on the one hand create supply push, and Green Public Procurement (GPP), raw material taxes and industry targets on the other create demand pull. Both the push and the pull effects help drive material recovery from waste and waste sorting plants as a technical solution.

The configuration of a waste sorting plant, the efficiency of the sorting process chosen and the quality of the material output is highly dependent on the characteristics and composition of the collected waste. The collection system and sorting plant together form the overarching system for recovering useful material from waste. As such, it is essential that they are complimentary to maximise the material recovery. The overall design of the material recovery system (including the sorting facility) is largely defined by the composition and quantity of waste, local economic conditions, policy targets and the demand for the recovered materials.

Waste sorting plants themselves can be more or less technically complex, but generally comprise a series of sorting processes supported by a variety of ancillary facilities designed to manage the process and maintain output quality. At the plant, waste undergoes a series of procedures that refine the material stream, extracting specific materials that can be recycled, or removing material suitable only for disposal. Termed positive and negative sorting respectively, most sorting plants rely on both types of sorting to produce clean fractions of sufficiently high quality.

A variety of techniques are used to separate materials in a waste stream. Moving beds, drums and screens, and air separators are used to differentiate materials by size, weight and density, while other sorting technologies utilize magnets and eddy currents to recover ferrous and non-ferrous metals. Some plastic is separated by exploiting its physical properties, but the bulk of plastic recovery relies on identification of the plastic with sensor technology and subsequent mechanical removal from the waste stream.

Sorting plants designed to accept mixed municipal waste, where all household waste is collected in a single waste stream, are capable of extracting metals and glass, and typically contaminated plastics. The waste entering such a plant is already too intermingled at the point of collection, prohibiting high-quality recycling.

Facilities sorting co-mingled dry recyclables tend to produce considerably higher quality materials for recycling. Depending on the extent of the sorting processes the output from the initial sorting can either go directly into manufacturing processes or into additional fine sorting. There is no fixed mixture of materials that qualifies as comingled dry recyclables, but metals and plastics are particularly suited for co-collection and are very easy to separate. Paper and cardboard can also be collected together or mixed with plastic and metal, although some level of contamination should be expected, while glass should ideally be kept separate from paper and cardboard, as glass fragments seriously degrade the recyclability of the paper and cardboard and can damage paper manufacturing equipment.

When deciding whether to invest in and operate a waste sorting plant, multiple aspects have to be taken into consideration. In addition to the economic, political and infrastructure framework, there are a variety of administrative and technical considerations that must be addressed to ensure that the plant is well founded and viable in the long term.

It is essential to ensure that there is a solid business case for a waste sorting plant. This needs to focus on the flows of revenue and the costs of operating the plant, but also the quantity and quality of available waste



for sorting. The economic viability of sorting plants often rests on a political decision to promote recycling and the subsequent financial and policy tools used to achieve that aim. A thorough understanding of these policy tools and their likely future trajectory is crucial to ensure long-term stability of the plant. Output materials will feed into raw material markets, either in direct competition with recovered materials from other waste sorting plants or with virgin raw materials. Understanding of these markets, hereunder price structures, actors, trading conditions and size is vitally important for long-term viability.

Planning, building and equipping a waste sorting plant can be a long process, typically taking between two to five years from the initial decision to build a plant to commencement of operation. Once a feasibility study and a business case have been developed, a site must be selected. Early and consistent public engagement is important to ensure a successful permitting process.

The conceptual design of the sorting plant should be tailored to the anticipated waste input and the

planned output. The core of the plant is the sorting line, but this must be supported by ancillary facilities for monitoring, quality control, environmental management, storage and transport, as well as for employee health and safety. Waste sorting plants are industrial installations and require regular maintenance, and this necessity should be planned for both financially (both for maintenance costs and costs of down time) and logistically (management of incoming waste and fulfilling supply contracts during downtime).

A large variety of health, safety and environmental issues need to be considered during the planning and operation of a waste sorting plant. Pollution to air, soil and water need should be reduced to at least below legislative or permitting thresholds, as should nuisance factors like noise and vibration, litter, traffic and the proliferation of vermin. The potential for exposure to hazardous materials also needs to be managed, while security, fire and other risks need to be assessed, planned for and managed according to the relevant existing standards.

If planned and operated properly waste sorting plants can help increase recycling, reduce waste disposal and replace virgin raw materials in the manufacture of new products. They are a vital component in advanced waste management.



Framework conditions for sorting plants

This chapter outlines the forces driving the separation and recovery of materials in municipal waste and for construction of waste sorting plants.

Value drivers / cost drivers for material recovery

The economic rationale for material recovery is a composite of two factors: the economic value of the material recovered and the financial costs associated with alternative waste management routes (and thus the level of fees that can be extracted from waste producers). These two income streams (together with any direct public subsidy) must together cover the costs of collecting and sorting the waste. As countries develop, the balance of importance between these factors shifts from value drivers to cost drivers.

In developing economies, the material value alone can be sufficient to drive formal or informal collection and sorting of some waste fractions. While a fragmented legislative framework for waste management and lack of enforcement resources can lead to illegal waste disposal and inconsistent practices, low labour costs mean that manual sorting can be financially viable. The recovered material can either be sold locally to manufacturing industries or can be sold to brokers and then onto the global marketplace. For example, in most countries the informal sector is involved in collecting metal: it is valuable, easy to transport and has a dependable global market. Depending on the income level there is also a market for the collection of certain types of paper and cardboard, plastic bottles and film and glass bottles.

As countries prosper and develop, however, rising labour, infrastructure and variable operating costs serve to make the value of recovered material insufficient to drive material recovery¹.

At the same time, however, as countries develop, the environmental impact of waste management starts to become a more pressing issue: partly because other more-pressing issues have been satisfied (basic human needs are being met), but also because economic development tends to be closely tied to waste generation: as a country develops, it produces more and more waste that need to be managed.

In highly regulated, market-based regimes, cost avoidance, coupled with reduced opportunity for easy disposal, is typically the primary driver for material recovery. While the drivers originate in environmental concern, the implementing mechanism is invariably an economic penalty for not following the tenets of the environmental legislation. Landfill taxes, gate fees, incineration taxes, etc. serve to increase the costs of disposal. A crucial aspect of this approach is the producer pays principle (see box). This gives the waste producer (or waste owner in situations where consumers are not charged a differentiated waste management fee based on waste generation) an economic incentive to minimise the impacts of the

waste they are responsible for: now they are not only paying for the practical removal of waste (labour, logistics), but also the impacts of that waste on the environment.

Making alternative disposal routes more expensive does not make material recovery cheaper, but it does make it relatively more economically viable – it is now possible to charge waste generators for the collection and sorting of waste, which helps to support higher material recovery costs.

The Polluter Pays Principle

The polluter pays principle is the cornerstone of environmental and waste regulation. It places economic responsibility for environmentally undesirable outcomes on the 'polluter'. In principle, this should mirror the degradation cost to the environment – so an action that degrades the environment a little, costs a little, while an action that degrades the environment a lot, costs a lot. In practice, putting a price on 'a lot' and 'a little' is expensive, time consuming and value-laden, so actual implementation of the polluter pays principle tends to be pragmatic – the 'price' tends toward the equilibrium between what is effective, practically enforceable and politically palatable. This is particularly important to acknowledge in developing countries, where there is often limited enforcement capacity and a population economically sensitive to increases in waste disposal costs.

¹ However, collection and recovery of some clean commercial and industrial waste streams (eg. plastic film, paper) is economically viable even in developed countries.

Policy tools – regulatory push

Essential preconditions for resource recovery start with strong national and local government leadership. Through policies, laws, regulations, rate structures, fees and taxes, governments have a tremendous influence over material flows. A variety of policy tools are used to minimise the environmental impacts of waste and promote the extraction of material from waste. The most common of these are:

- landfill and/or incineration taxes,
- landfill ban on organic or non-treated MSW,
- mandatory separation and collection of recyclables,
- consumer-oriented economic incentives for recycling MSW

Countries using several of the above instruments have a higher municipal waste recycling rate than the countries using few or no instruments. National and regional waste management plans can support in directing the waste into sorting and recycling operations, but need to be complemented with appropriate recycling infrastructure and instruments for diversion away from landfill. Countries that have increased the landfill tax by more than 50% over the last 10 years, and have introduced a landfill ban on organic waste or non-pre-treated municipal waste, have shown positive steps to moving up the waste hierarchy. Introduction of mandatory separate collection of certain municipal waste fractions, e.g. paper, metal, plastic, and glass, contributes to a greater level of subsequent sorting and recycling. Finally, countries using economic incentives aimed at households to promote recycling, e.g. pay-as-you-throw schemes, perform much better in ensuring a constant flow of waste for subsequent sorting and recycling.



Policy tools – creating market pull

An associated arsenal of policy instruments can be used to support the market for secondary materials. These include:

- Green Public Procurement – public authorities procure goods made with, or containing a fraction of, secondary raw materials.
- Industry targets on use of recovered materials in production and manufacturing.
- Quality standards for end-of-waste.
- Raw materials taxes.

These tools each serve to support and expand the market for recycled materials, which increases the incentives to collect and sort materials from waste streams. The first two instruments (GPP and targets for inclusion of recycled material) directly expand and stabilise the market by increasing demand. The third provides security and transparency for the market, and the fourth makes materials recovered from waste relatively more competitive.

In addition to the above, specific policies and initiatives that can

promote separate collection and sorting plants include:

- *Recycling targets*
Recycling targets drive the need for separate collection and recycling. Exactly how these targets are defined and measured strongly influences the need for sorting plants.
- *EPR systems*
An implementation of the polluter pays principle, whereby producers assume, either voluntarily or through regulatory mandate, responsibility for the management of their products when they become waste. EPR is used particularly for packaging and packaging waste². EPR schemes can directly finance waste collection and sorting, depending on how the scheme is implemented and administered. Under EPR schemes, the costs of funding waste management and material recovery are passed on to the consumer.

It would be naïve to suggest that any given combination of these instruments guarantees success. The mix of policy instruments should be tailored to the local/region conditions, infrastructure and culture to stand the best chance of increasing material recovery.

² EPR is also used extensively for more specific waste types that are not within the scope of this report including: WEEE, Batteries and tyres.

Material recovery- collection and sorting

The policies and market forces described in the previous section provide a framework for the recovery of materials from municipal waste. Sorting plants are a more or less sophisticated technology response to this framework, extracting material fractions from collected waste.

There are three overarching collection/sorting configurations that are typically used to recover material:

All three configurations use sorting plants to produce separate material fractions. The three different collection configurations required different

sorting technologies and result in different quantities and qualities of output material for recycling.

Generally speaking, quality of output materials increases as the quality of input materials increases. Sorting mixed municipal waste typically results in a metal, plastic and glass fractions for recycling, together with a large amount of RDF. Typically the aim of sorting mixed municipal waste is to reduce the amount of waste going to landfill, rather than achieving high recovery rates for recycling. The quality of the materials removed is

therefore typically lower than that from plants sorting mixed dry recyclables or source separated recyclables. The quality can be increased by separately collecting biowaste, removing the main contaminant from mixed municipal waste.

TABLE 1- COLLECTION AND SORTING COMBINATIONS

Collected for recycling	Sorting
Mixed municipal waste	'Dirty' MRF - removing primarily metal, plastic and glass.
Mixed dry recyclables	Sorting into metal, plastic, glass and paper for use or further sorting.
Source-separated recyclables	Fine-sorting individual material fractions



Sorting mixed dry recyclables will result in relatively clean fractions of paper, plastic, metal and glass (or whatever fractions have been collected together) for direct use by industry or for further sorting into specific types (for example, from a gross plastic fraction into PET, HDPE, PE, PP). Source-separated clean fractions can be sent directly to this fine sorting, and results in the highest quality recycled material.

This illustrates the fundamental symbiosis between collection and sorting systems. They are the two complementary components of the system for extracting materials from waste.

Ambitions at the national and international level for material recovery have a strong influence on the type of collection/sorting system employed. Generally speaking, the

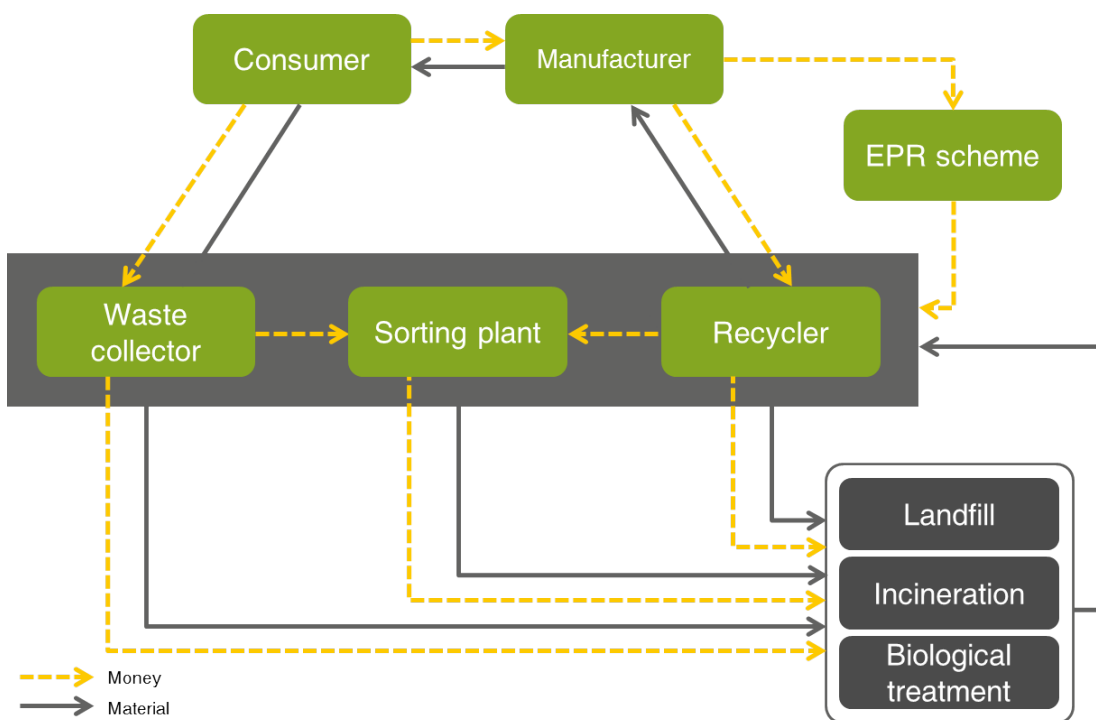
more stringent the targets for material recovery, the stronger the driver for source separated multi-stream collection and subsequent sorting.

Sorting plants in the wider waste management system

Implementing a waste sorting plant is a complex balancing exercise. Figure 1 shows an example of the complex business environment that waste sorting plants operate within.

It is important to highlight that for successful high quality sorting, the technical and logistic elements of a waste management system have to operate in concert with the softer elements related to the prevailing culture and practices surrounding waste in households, businesses and the waste management industry.

FIGURE 1 - SORTING PLANTS IN THE WASTE MANAGEMENT SYSTEM



Sorting plants

Waste sorting plants in the waste management chain

Waste sorting facilities, together with collection infrastructure, act as a filter in the waste management chain, extracting more or less finely sorted material fractions that can be diverted directly into manufacturing or sold as commodities on the local or global market, and reducing the quantity of waste for final disposal. Waste sorting plants sit between collection infrastructure on one side and material markets and disposal on the other: they must be designed and implemented with consideration to both. The exact configuration of a sorting plant is largely dependent on the planned input, the desired output, and the level of technology and financing available.

Waste sorting facilities demand a critical and steady mass of input waste material to be financially viable. A shortfall in input waste means both a drop in gate fees and a reduced quantity of output material to sell. As such, they are often extra-municipal or regional, serving multiple municipalities from a central location to ensure long-term economic viability.

Facilities and operation

Waste sorting facilities receive waste from collectors and process this waste in a number of stages. The result is one or more clean material fractions for recycling or further sorting, and a residual component for disposal – typically incineration or landfilling.

The configuration of sorting facilities varies from simple manual sorting lines

to complex, automated multi-process sorting lines. The sorting process lies at the core of the waste sorting plant, but is supported by a number of pre-input and post-output ancillary processes that enable the smooth running of the facility (Figure 2).

Positive vs. negative sorting

There are two different conceptual approaches to sorting waste: positive sorting and negative sorting. Positive sorting focuses on identifying and removing a desired fraction from the input waste stream (i.e. eddy current which targets specifically non-ferrous materials). Negative sorting focuses instead on identifying and removing a non-desired fraction (i.e. eliminating plastic bottles without the specific polymer properties required). Generally speaking, positive sorting results in a high-quality material product, but at the cost of efficiency, whilst negative sorting tends to be more efficient, although at the cost of quality of the obtained materials.

In practice, waste sorting plants may use both approaches – for example, the manual removal of contamination from the waste at the start of the sorting line (negative sorting) followed by automated removal of material fractions (positive sorting), then another round of manual sorting at the end of the line to remove any residual contaminants (negative sorting) to ensure quality.

Manual versus automatic sorting

There are two technical approaches to sorting waste into individual

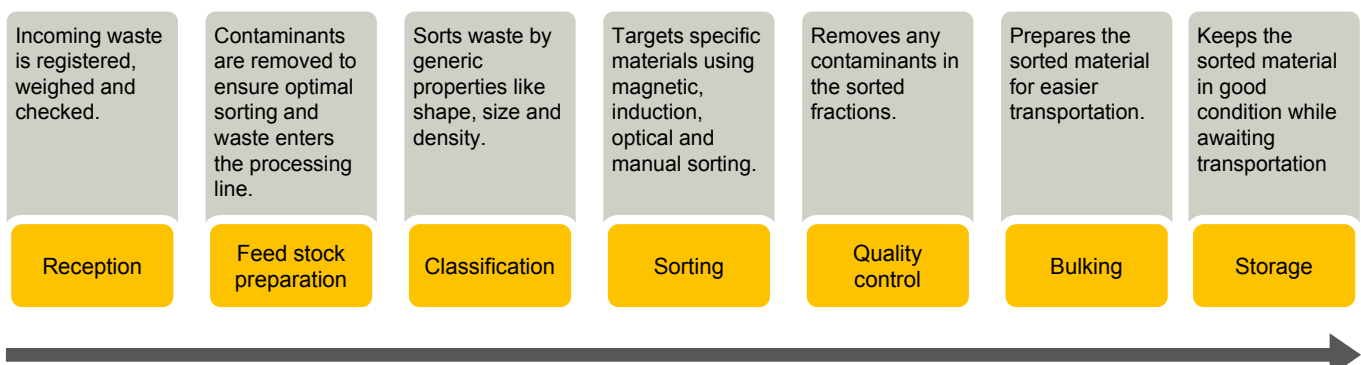
material streams: manual sorting and automated/mechanical sorting. Configuration of the sorting line is highly dependent upon the incoming waste stream, the purpose of the plant and the market it operates in. In advanced economies, the market structure supports and demands sophisticated technology-based sorting solutions. In emerging economies, lower tech solutions may suffice and are more realistic given labour costs and maintenance programmes.

The deciding factors in the choice of technology to be used are:

- **Performance:** meet the output specification as desired from the business case;
- **Reliability:** perform a required function under stated conditions for a specified period of time;
- **Costs:** reflect the income and payback time of sorting facility;
- **Maintenance requirements:** care or upkeep of machinery and property;
- **Environment, health and safety aspects:** impacts on immediate surrounding and employees;
- **Risks:** factors that could influenced technical and financial operation;
- **Familiarity with technology:** knowledge about and opinion on available technology.

Most commonly, sorting plants use a combination of manual and automated sorting techniques, as some steps in the sorting process are best handled manually, while other steps benefit

FIGURE 2 - PROCESSES OF A WASTE SORTING PLANT



from more targeted, safer and less costly automation. This occurs particularly with centralised sorting facilities, where large volumes of mixed waste/ mixed dry recyclables or separately collected recyclables arrive from kerbside collection programmes, together with recyclables from commercial and industrial sources.

Labour-intensive manual sorting operations are used for quality control at the end of the sorting process to ensure that the sorted fractions meet the demanded technical specifications. Manual sorting operations are also used for pre-sorting incoming materials. This removes unwanted or contaminated materials, enabling the downstream highly-automated systems to operate at optimal efficiency.

The successful use of automated sorting lies in determining how each material stream responds when introduced to certain technologies or techniques. The key is locating the right technology at the right stage in the sorting process to cause a single material stream to behave differently from others. Some automated sorting technologies rely instead on identifying and subsequently physically removing a particular material type, a subtly different approach (see Sorting technologies – a brief overview, below).

Sorting technologies – a brief overview

Waste composition influences the steps and the technologies applied:

as countries develop, the MSW generated tends to become a complex mixture of materials that demands complex technology-based sorting process to extract clean fractions. Such technologies must have the ability to sort an increasingly diverse range and volume of materials regardless of size, moisture content and/or contaminant level.

This high level of variation in waste streams usually leads to a combination of technologies that are applied to successfully separate the waste. Table 2 briefly describes some of the main technologies employed in waste sorting plants.

TABLE 2 - OVERVIEW OF WASTE SORTING TECHNOLOGIES

Waste screening	• Trommel screen	1. An angled rotating cylinder with holes that allow waste of a given size to fall through.
	• Disk Screen	2. A bed of vertical-spaced discs that transports large waste items but allows smaller items to drop through the gaps.
	• Oscillating screen	3. A vibrating/oscillating declined bed that allows smaller waste to pass through while transporting larger waste to the end.
Air separation	• Zigzag air classifier	4. Waste is dropped through an upward air current in a zig-zag shaped flue. Light waste is blown to the top, while heavier waste falls to the bottom
	• Rotary air classifier	5. A trommel screen separator with an air current that captures the light-weight fraction.
	• Cross-current air classifier	6. Waste is fed on a conveyor and dropped through an air stream. The light components are blown horizontally to a collection point and the heavy components drop through.
	• Suction hood	7. Sucks light weight waste directly from the conveyor belt.
Ballistic Separation		8. A steeply inclined bed with a perforated plate screen deck, with alternate vibrating elements. Light fractions are lifted by cams to the top of the bed, heavy fractions fall to the bottom.
Film grabber		9. Waste is accelerated onto a rotating drum with spikes. These hook plastic film and let other waste drop.
Magnetic separation		10. Magnets either lift ferrous metal from the waste, or hold ferrous metal to the conveyor while other waste is allowed to drop.
Eddy current separation		11. Eddy currents are used to push non-ferrous metals with magnets into separate collection points, with non-metallic waste falling into another.
Manual Sorting		12. Employees are positioned beside the conveyor and manually remove materials either in positive or negative sorting.
Sensor technology	• NIR (Near infrared)	13. Used to differentiate between plastics (PET, HDPE, PVC, PP and PS).
	• VIS (Visual spectrometry)	14. Used to identify materials based on colour.
	• XRF (X-ray Fluorescence)	15. Used to differentiate between metals / alloys (for example, copper from steel).
	• XRT (X-ray Transmission)	16. Identifies materials based on atomic density – for example, halogens and organic components.
	• EMS (electromagnetic sensor)	17. Identifies metals based on their conductivity.



The flow diagrams in Annex 1 (dirty MRF) and Annex 2 (plastics) illustrate how these technologies can be combined in a sorting plant.

Emerging technologies

Robotics technology

Robotic technology promises to significantly increase the sorting efficiency of some waste streams, and could be particularly valuable in waste streams containing hazardous materials, as it could enable fine sorting without human intervention. Typically, a conveyor belt feeds the waste past a package of sensors including visible spectrum cameras, NIR spectroscopic cameras, 3D laser scanners and metal sensors, while robotic arms operate above the conveyor belt, removing materials as the waste moves past underneath.

One of the key advantages of robotic technology is that it need not focus on a single waste fraction, but can be used to collect multiple fractions at the same time – depositing them into separate collection bins. Trials are currently focusing on the different material fractions in C&D waste, but there is no reason to assume that the technology will not be suitable for wider application in one form or another.

Recognition technology

Sorting techniques that do not rely on the physical properties of a material for separation require some form of material identification. Table 2 above gives a brief overview of the sensor technologies currently used in the waste sorting industry. While the accuracy and sensitivity of these technologies continues to be honed, new technologies for identifying different materials in waste streams are being developed.

For example, the use of RFID tags in packaging has been proposed to allow identification and classification of individual packaging items. The concept involves embedding RFID tags in individual packaging items, which could then be read either at collection or at the sorting plant to enable precise sorting of different plastic types. The main hurdle to wider use of this technology is price, but there are also concerns about the potential contaminating effect of the tag itself.

Limits to sorting

In principle, there is no limit to what material fractions can be sorted from waste, but in practice there are a variety of factors that limit the possibilities for and effectiveness of waste sorting:

1. Mixed materials in collected waste can impact the quality of the final product for recycling. There are a few good examples: when paper is recovered from mixed waste it is difficult to meet the quality standards of the food sector due to organic content and potential hazardous materials; when glass and paper are collected and sorted together, the smallest residue of glass may affect the quality of the paper and damage the processing equipment in the paper mill. This is the primary limiting factor when sorting mixed municipal waste.
2. The presence of hazardous materials. For example, the sorting of construction and demolition waste containing asbestos is not recommended for health reasons: in the breaking and crushing process asbestos may be released and dispersed through the air.
3. It may be practically possible to extract good quality material fractions safely, but doing so is not necessarily economically viable.
4. Different materials in the waste stream have similar physical properties which reduce the sorting efficiency and quality of the final product.

Planning and managing a sorting plant

The following section outlines specific factors that should be considered when planning to invest in or develop a waste sorting plant. This section is divided into factors related to the business case, those related to the planning process, and factors related to operating the plant.

Business case

The waste sorting plant will exist within an economic framework. The following factors should be considered when compiling a business case for a waste sorting plant.

Ensuring long-term stability of supply

A stable economic operating environment requires long-term stability in the amount and quality of waste delivered for sorting. Waste analysis and market analysis can help predict future waste quantities. Such analyses need to account for current recycling targets and be sensitive to likely future waste and resource policy developments. Similarly, such an analysis should also be sensitive to other developments – such trends in packaging. The current (and future) configuration of the local collection infrastructure, both in terms of what is collected and how, but also by whom and under what conditions, should also inform the analysis.

A medium (approximately 5 years) to long term (approximately 15 to 20 years) investment outlook is essential.

Output

It is important to plan for how the material recovered by the waste sorting plant will be marketed. For example, will the facility produce for an open market, or for a single buyer? How does it compete with sorting plants delivering similar materials or alternative materials? And how do the output materials compete with virgin materials? The market landscape can be complex, heavily moderated by policy, industrial structure and local conditions, availability of raw materials and often volatile, as the

global price of raw materials reacts to external forces.

Securing a long-term, reliable outlet for the materials produced by the sorting plant may not be feasible, but medium-term supply contracts with individual buyers (within industry or brokers) can help provide a level of certainty.

Quality standards

Many of the issues inhibiting the market for secondary materials are directly link to quality. The primary way to define the quality of secondary material products is by using generic quality standards, end-of-waste criteria, or grades for secondary materials that have been implemented by, or on behalf of, suppliers and buyers on a regional, national or global level.

Quality standards for secondary materials are a compromise between what can be economically achieved by WSPs and the demands of the recycling market. Material collectors, sorting experts and the reprocessing industry must be involved when creating economy-wide generic standards. Regulators, who often initiate and standardise the process, may also inspect facilities to ensure compliance. However, this level of quality control may not be possible across the board, i.e. where policy is underdeveloped or not enforced.

An alternative to generic quality standards is to define standards through bi-lateral arrangements between supplier and processor. With only a few stakeholders involved in the arrangement, standards can be drawn up and implemented in a short period of time and it can guarantee sales, fixes prices and provide long-term commitment. However, the disadvantage of this approach is that it restricts the sale of materials to other suppliers that have other specification requirements.

Ideally, sorting facilities should have the flexibility to adapt to changes in demand specification without compromising operations.

It is vitally important that the sorting plant must be able to meet and maintain the quality standards and specifications demanded by the market. This builds trust and confidence in the product and may ultimately enable negotiation of a higher price for the recovered materials.

Cost estimates

The costs related to a waste sorting plant are incurred during the planning, construction, commissioning, operation, and decommissioning phases of its lifecycle.

During planning, costs are related to site selection, (conceptual) design activities, permit applications and preparation of tender documentation and tender procedure. During the construction phase, costs are related to land purchase, process equipment, supporting equipment, maintenance, labour, environmental protection and civil works. Commissioning costs include investment in equipment, supporting equipment, services and civil works. Decommissioning costs can be difficult to determine as the time horizon for the plan is potentially distant.

Investment in process machinery is only a fraction of the initial technical investment costs: this figure will double to quadruple once supporting equipment, engineering, packaging, transportation, erection and commissioning are included. On top of this, depending on the type of plant, and labour and environmental legislation, the requirements for supporting facilities and related civil works could at least double the equipment investments costs.

Capital costs are primarily related to depreciation of equipment³. The inherent life span for static equipment is around 10 to 12 years. However, the business case of many sorting plants relies on the existence of policy instruments, making the plant vulnerable to political change. It is therefore wise to consider for the life span of process-related items on the

³ The buildings also depreciate, but these are often generic and can be put to other uses

same timespan as political planning. This could imply that depreciation times for equipment could be as low as 4 to 5 years.

Operational costs are associated mainly with labour, energy and resource consumption, maintenance, insurance, monitoring and control. Maintenance and insurance can be expressed as a percentage of investments. Together this would be around 10-15% of the investment. Maintenance costs are often underestimated: sorting plants require ongoing maintenance, which in turn requires the availability of spare parts and qualified engineers. Other items are specific to the sorting plant and should be identified during preparation of the business case. On top of the operational costs are the disposal costs or income from sale of the products.

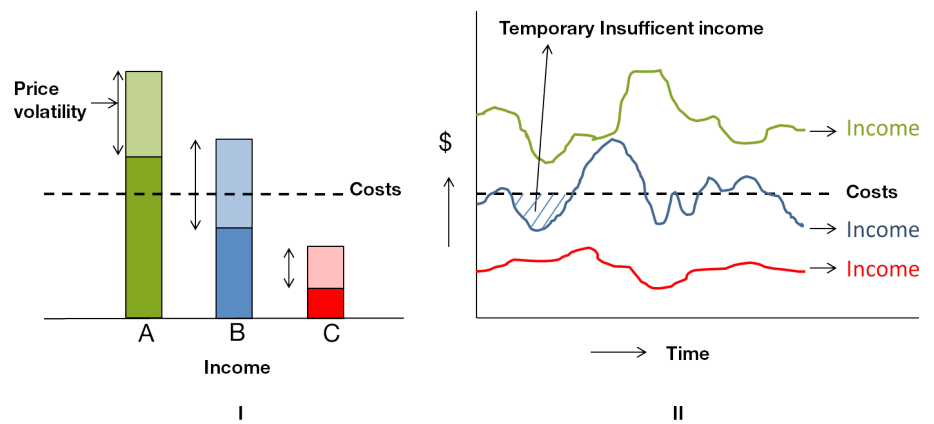
Income generation

Operating costs of the sorting plant are typically covered by the sale of recovered material and by fees from waste generators and potentially also EPR schemes.

Ideally, the income from sale of the recovered material would be sufficient to cover the operational costs of the plant. The feasibility of this is dependent on the price, quantity, and quality of the recovered materials. Unfortunately, commodity prices are volatile and sales are coupled to short-term variations in market demand (see textbox). Figure 3 presents three scenarios for the income from material sales from a sorting plant.

Scenario 'A', where income levels are always above costs level despite price fluctuations, provides the ideal operating environment for a sorting plant. It is economically viable without the assistance of policy instruments. In scenario B, the income is sometimes above costs level and sometimes below. Although the average income in scenario B may be above costs, the facility could suffer cash flow difficulties during times of low prices and either require external support or

FIGURE 3 - EFFECT OF PRICE VOLATILITY ON INCOME, ON AVERAGE (I) AND OVER TIME (II)



cease operation. A detailed analysis of future cash flows is required in such a scenario to ensure appropriate steps are in place from the outset to address short-term cash flow difficulties. In scenario C income is always below costs level and will require ongoing economic support for the WSP to be viable.

Even when the costs of the sorting plants are covered, there might not be sufficient margin to cover costs for collection and transport (where these services are not provided by another funding pool). A robust funding system needs to be in place to offset any deficit in funding.

The financial viability of a sorting plant is grounded in a robust, long-term financial analysis. Such an analysis should include an analysis of future cash flows and revenues, a tariff and affordability analysis, defining the sources of long-term finance, and an understanding of the legislative framing landscape.

Capacity Planning and Operational time

Capacity planning is the process of determining the maximum amount of material that a WSP can process in a given period due to potential constraints such as quality problems, delays, material handling, insufficient resourcing and operational hours.

The planning of the design capacity has to take into account that the

volume of waste arriving to the site is unlikely to be consistent over time. There will be daily, weekly and seasonal fluxes in waste delivery. The design should accommodate additional storage areas to account for peaks in the potential variations in the delivery of waste or extra treatment capacity.

The capacity throughput is further dependent the plant's operating hours; be it over a continuous 24 hour period or less (as a result of environmental or legal issues). Large plants located in urban industrial zones may operate 24 hours, 7 days per week, while suburban and rural plants commonly open early in the morning (6 a.m. to 7 a.m.) and close in the early evening (5 p.m. to 6 p.m.).

Plant breakdowns and temporary maintenance stops affect the capacity of the sorting line. To prevent this, a plant may use several lines to limit the risk of a complete drop in capacity or install back-up equipment at vulnerable positions in the line. This is especially valid for larger plants. For maintenance stops lasting longer than a certain period, not included in the capacity planning, contractual arrangements with alternative waste sorting plants should be considered.

Planning

A multitude of factors related to planning need to be considered in the processes of developing a waste sorting plant. The following section outlines the most important.

Legal

Starting a new business or activity or changing an existing activity is often necessitates licences and permits. Local conditions determine which licences are needed, with the following aspects common in most parts of the world:

- **Business Licence:** This licence is connected to the facility owner. It allows the licence holder to operate a business within the area. In many countries arranging a business licence is connected to the tax office.
- **Environmental permit:** This permit addresses control measures that need to be taken to limit the impact on the environment or local community. Normally this concerns emissions to air, water and soil, noise and vibrations, waste management, physical and cultural heritage, landscape and visual amenity, and socio-economics. In most case the fire department is involved in this procedure.
- **Building permit:** This permit relates to structural matters and compliance with building regulations.

All these licences have different procedures. In all cases, the information related to the plant processes and operations will be submitted to the relevant authority, followed by assessment, objections, decision and appeal procedures.

Obtaining a licence for waste sorting plants can be especially difficult. The local populace may oppose the development of a WSP because of perceived potential nuisance factors like noise, increased traffic flow, odour and local air pollution.

To address these issues, the application should be well prepared, focussing on all environmental and social aspects so to prevent delays. It is recommended to communicate



early and closely with the community about the plans and provide them with first-hand information.

to offset costs of environmental protection policy, delays might occur in the feasibility stage and permitting stage.

Project planning

The realisation of a WSP requires a number of decisions and procedures which need to be followed.

Table 3 provides an overview of typical process steps and time required. The critical path in the planning phase is pre-feasibility study, business case appraisal, conceptual design, permit approval, procurement, planning application and detailed design, site clearance, construction and commissioning period. Stakeholder involvement is continuous throughout the process.

This process can take several years from the initial concept to commencing operation. In economies where development of the waste sorting plant is being driven by the market demand for raw materials, some of the steps might go faster. Where the development occurs in an economy where the primary driver is the need

TABLE 3 - OVERVIEW OF PRE-START WORKS AND THEIR ESTIMATED DURATION

	Concept	Estimated duration (Months)
1	Pre-feasibility study	0-3
2	Business case appraisal	0-6
3	Financial arrangements	0-6
4	Site selection	0-12
5	Procurement	6-9
6	Conceptual design	3-5
7	Planning application/detailed design	6-12
8	Permit application	6-12
9	Site clearance and construction works	12-18
10	Instalment of process equipment	1-3
11	Test periods	0-3
12	Stakeholder involvement	Continuous

Site Selection

The selection of a suitable site for the effective functioning of a WSP is paramount. The methodology and criteria used for assessing the suitability of sites and areas should be dependent on project criteria and local constraints. It requires careful consideration of multiple alternative solutions and potentially conflicting criteria, including economic, technical-operational, environmental and social factors (including stakeholder communication and dialogue). Factors that could be assessed when evaluating the selection of sites are outlined in Table 4.

The process of selection normally starts with a list of available or desired sites, which is checked against knock-out criteria. After removal of sites in breach of the knock-out criteria, the remaining sites are ranked in line with desire to investigate the site further. Only the top ranked sites will be examined in detail.

The reality is that WSPs are normally located close to waste sources, existing waste management facilities or near markets for the materials.

An Environmental and Social Impact Assessment (ESIA) serves as a

useful tool for the identification, prediction and evaluation of actual and potential adverse (and beneficial) impacts of a proposed WSP so that recommendations can be built into the design and cost-benefit analysis without causing major delays or increased design costs.

Conducting an ESIA is not a ridged process, but must be tailored to the local conditions, the planned development and the local legislator requirements. An ESIA contains five core steps:

- **Screening** – Establish whether an ESIA is required
- **Scoping** – Establish what the ESIA should include
- **Baseline** – Establish the existing environmental and social baseline
- **Impact assessment** – Evaluate the potential impacts from the proposed sorting plant
- **Environmental management and monitoring** – ensure appropriate ongoing management and monitoring of impacts along the development timeline.

TABLE 4 - SITE SELECTION EVALUATION CRITERIA

Economic aspects	<ul style="list-style-type: none"> • Costs of transport to and from site • Purchase value of the land • Development costs • Availability of (local) labour force
Technical operational	<ul style="list-style-type: none"> • Technical characterization (i.e. hydrological evaluation) • Access roads • Distance from utilities
Physical Features	<ul style="list-style-type: none"> • Topography • Water Resources • Surface Soils
Human Values	<ul style="list-style-type: none"> • Human Health • Landscape and Visual Intrusion • Recreation • Historic Environment & Built Heritage • Population • Employment Opportunities • Air Quality • Noise and Vibration
Ecological Features	<ul style="list-style-type: none"> • Flora & Fauna • Habitats & Ecosystem Services • Designated Sites
Climate	<ul style="list-style-type: none"> • Temperature • Wind Direction
Land Features	<ul style="list-style-type: none"> • Development Potential • Land use Designation & Conflict
Logistics	<ul style="list-style-type: none"> • Traffic & Access • Proximity to Users • Availability of Utilities • Adjacent Land Use

Operational

Technical and operation factors that should be considered when developing and running a waste sorting plant are outlined in the following section.

Conceptual design and logistics

Figure 4 illustrates the conceptual layout of a typical sorting plant.

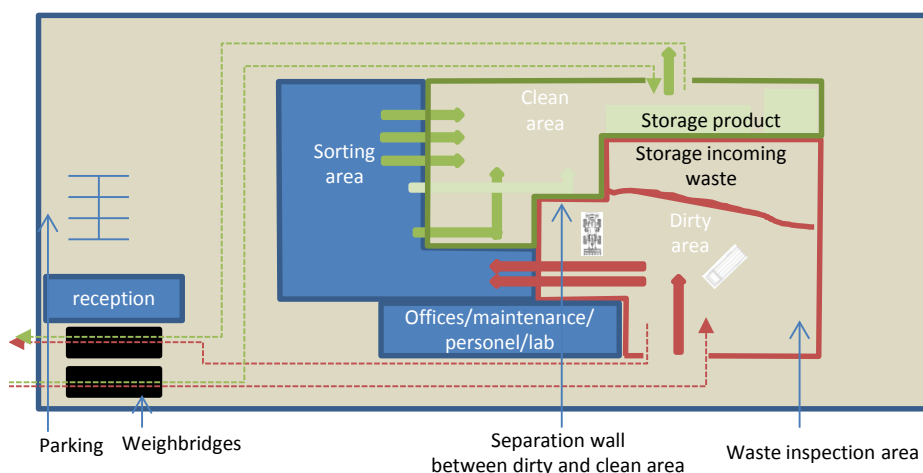
The reception facilities at the entrance of the site check incoming and outgoing traffic, register movements of vehicles and record volume of feedstock. Upon arrival the incoming waste should also be inspected in an area separate from other incoming wastes.

In the processing area the waste enters the waste reception hall, which should be large enough to store waste for 3-7 days. The processing area further consists of the sorting area where all the waste is prepared and sorted. Recovered materials are stored in the storage area awaiting transportation from site.

A number of supporting facilities may also be necessary: a laboratory is recommended to analyse the quality of the feedstock and product; a designated maintenance area is useful where tools and machinery can be stored to repair the plant; a waste water treatment area for contaminated water. For larger plants fuelling and washing facilities for trucks should be considered. In addition, appropriate facilities for site staff and visitors are also necessary and may include: toilets, showers and hand basins, with soap and towels or a hand-dryer; drinking water supply; change rooms with lockers; canteen or area to take meals and have a break; offices; car parking.

When designing a waste sorting plant it is important to assess the layout of the plant in relation to logistics. Key areas must be reserved for parking, the weighbridge, transport (routes in/out and whilst stationary), unloading and pre-sorting, bulking and storage, site offices, and welfare facilities. Routing should be logical and crossing should be minimised to prevent accidents.

FIGURE 4 - LAYOUT OF A SORTING PLANT



The waste storage area should be large enough to store waste that accumulates when the plant is undergoing maintenance or downtime. Due to the likely density of waste, height constraints and fire regulations, the land area required for storage may be significant.

The interior of the facility should be large enough to allow for unanticipated material storage, changes in interior layout, addition of new equipment to accommodate increases in population and the possibility for programme expansion, and evolution in the waste stream composition. The ceiling should be high enough to accommodate equipment specification and bulk vehicles.

Depending on the market conditions, longer storage of the final product(s) might be required. This should not be underestimated as sorting operations may need to stop if the storage area becomes full.

It is good practice for the site to make a distinction between 'dirty' and 'clean' areas, designated for both incoming waste and outgoing secondary material. Carefully designated storage bays are a useful tool in this respect – the ramps and tunnels may be integrated into their design.

A variety of vehicles may operate within a sorting plant, including front loaders, bobcats, fork lifters and heavy good vehicles. As such,

internal and external roads should be designed to include signs, markings and barriers. All vehicles should be subject to regular maintenance and service programmes to ensure that vehicles are running as efficiently as possible, with procedures in place to monitor fuel use. A robust formal Traffic Management Plan should be implemented to record maintenance activities.

Utility Supply

WSPs require electricity to operate equipment, such as sorting line technologies, balers and compactors, internet and phone connections and lighting. Also required is connection to drinking water supply, process water supply for facility cleaning and restrooms, and a connection to sanitary sewer systems for waste-water disposal. In case of emergencies, back-up utility supply should be explored.

Operation and maintenance

A facility-specific operations and maintenance plan should be produced that includes the following elements:

- Facility operating schedule: Days of the week, hours each day, and holidays.
- Staffing plan: Lists duties by job title, minimum staffing levels, and typical work schedules.
- Description of acceptable and unacceptable wastes, and procedures for diverting restricted waste before and after unloading.
- Operating methods for each component of the facility, including waste-screening methods, weighing procedures, tipping floor and storage operations, and onsite clean-up.
- Management product quality, including standards.
- Description of maintenance procedures for each component, including the building, equipment, vehicles and utilities.
- Employee training.
- Health & Safety provisions.
- Record keeping procedures.
- Contingency plans in the event of equipment failure.
- Emergency procedures.

Sorting plant equipment requires regular maintenance. The design of the plant should facilitate access to all parts of the sorting line. Depending on the size of the sorting plant this may include the use of walking platforms which provide access to elevated parts of the sorting line,

or permanently installed cranes to remove/move machinery.

Maintenance should be planned to allow for efficient operation, i.e. to manage unforeseen stoppages or maintenance requirements.

Continuous Evaluation of WSP Performance

A multi-criteria, systematic decision approach is needed when evaluating the performance of a WSP. A Performance Measurement Plan (PMP) can be used to appraise the key aspects relating to the plant operation, including:

- Cost
- Collection systems and input volumes
- Contamination
- Sorting facilities – material sampling and transparency
- Material recovered
- Material quality benchmarking and standards
- Machinery operation and maintenance

Once this baseline information has been established it can be used to achieve pre-defined objectives, which may include driving up the quality of recycle, ensuring compliance with waste regulations (if applicable) and improving system efficiency.

Health, safety and the environment

A large number of factors related to health, safety and the environment need to be addressed in the planning, construction and operation

of waste sorting plants. The factors briefly described in this section are elaborated in Annex 3.

Air Pollution

Particulate Matter (PM)

On-site operations can generate Particulate Matter (PM) that can induce respiratory issues for site personnel, visitors, local residents and neighbours.

Odour

On-site operations can generate odour when sorting biodegradable material. This can impact upon site personnel, visitors, local residents and neighbours.

Water and Soil Pollution

Rainfall and run-off water that flows from roofs, roads, parking lots, and landscaped areas could become 'polluted' by coming into contact with waste on site. This can cause a negative impact upon surface water, ground water, soil, human health, and flora and fauna.

Noise and Vibration

Noise can be generated by the sorting operation and movement of vehicles associated with the plant. The impact of noise is determined by strength and duration, and can affect site personnel, visitors, local residents and neighbours resulting in sleep impairment, stress and temporary and/or permanent hearing loss etc.

Litter

Incoming waste loads can drop litter, and wind can blow delivered waste beyond site boundaries and cause an environmental nuisance.



Traffic

Both on and off-site traffic has the potential to create congestion, additional noise, air pollution and accidents that can impact upon site personnel, visitors, local residents and neighbouring workforces.

Flies, Vermin and Birds

Biodegradable waste attracts flies, vermin and birds. These can cause negative impacts upon human health and be a nuisance.

Exposure to Potentially Hazardous Equipment and Substances

Site operatives at WSPs work in close proximity to a variety of hazards, including: equipment with moving parts (e.g. conveyor belts, blades, balers, and compactors), wastes that can cause injury or disease (e.g. heavy or sharp objects and needles) and potentially contaminated substances (i.e. fuel and foul sewage). Facility operators should therefore develop a Hazard Management Plan (HMP) in line with national and local workplace safety regulations (where applicable) to minimise the risk of injury from such hazards.

Security

A breach in security can impact on both site staff and the trespassers themselves. As such, perimeter fencing and lockable gates should be installed. Signs should be posted around the perimeter, with warnings about potential risks due to falls and contact with waste. Signs should be posted in multiple languages (if applicable). Closed-circuit television (CCTV) should be used.

Fire

No wastes should be burned within the boundaries of the site, but a fire could start as a result of poorly maintained equipment or the inappropriate storage of waste. Sorting facilities often have high ceilings, which can allow fires to spread quickly and place site operatives in danger. Dealing with fires will impact upon human health, surface water, ground water, natural ground, and flora and fauna.

To address the risk of fire, ceiling sprinkler systems, fire/smoke alarms, and fire hoses should be in place on site. This equipment should be clearly marked and tested at appropriate intervals to confirm integrity. Site personnel should be made aware of their location, trained in their correct use, and know when it is safe to use them. Strict compliance with pre-acceptance and acceptance procedures should be adhered to at the site to ensure that explosive, flammable and oxidising wastes are not received. The site should be a designated 'no smoking area'.

A Fire Safety Strategy should be in place and include the following elements:

- Separation and/or control of hazards.
- Control/elimination of ignition sources.
- Adequate passive fire safety measures and means of escape.
- Fire detection systems.
- First aid.
- Mobile firefighting equipment (i.e. fire extinguisher and fire blanket).

A fire at the site should be regarded as an emergency situation and appropriate action taken immediately, including calling the professional fire department. Ideally the local fire department should be invited to assess and practice dealing with a potential fire at the WSP.

Risk Assessment of Hazards

Health and safety hazards require thorough risk assessments, formulated on a site-by-site basis. They should be based on individual site conditions, layout, equipment, waste composition and operator needs. Common risks within sorting facilities include manual handling; slips, trips and falls; being hit by moving, flying or falling objects; contact with moving machinery; and needles/sharps. Each risk assessment should identify the hazards, decide who might be harmed and how, evaluate the risks, decide on precautions and control measures (i.e. suitable training, regular housekeeping and PPE), and implement the findings. The risk assessment should be reviewed and updated as necessary.

FIGURE 5 - PROCESS OF PREVENTING ENVIRONMENTAL, HEALTH AND SAFETY HAZARDS



ANNEXES



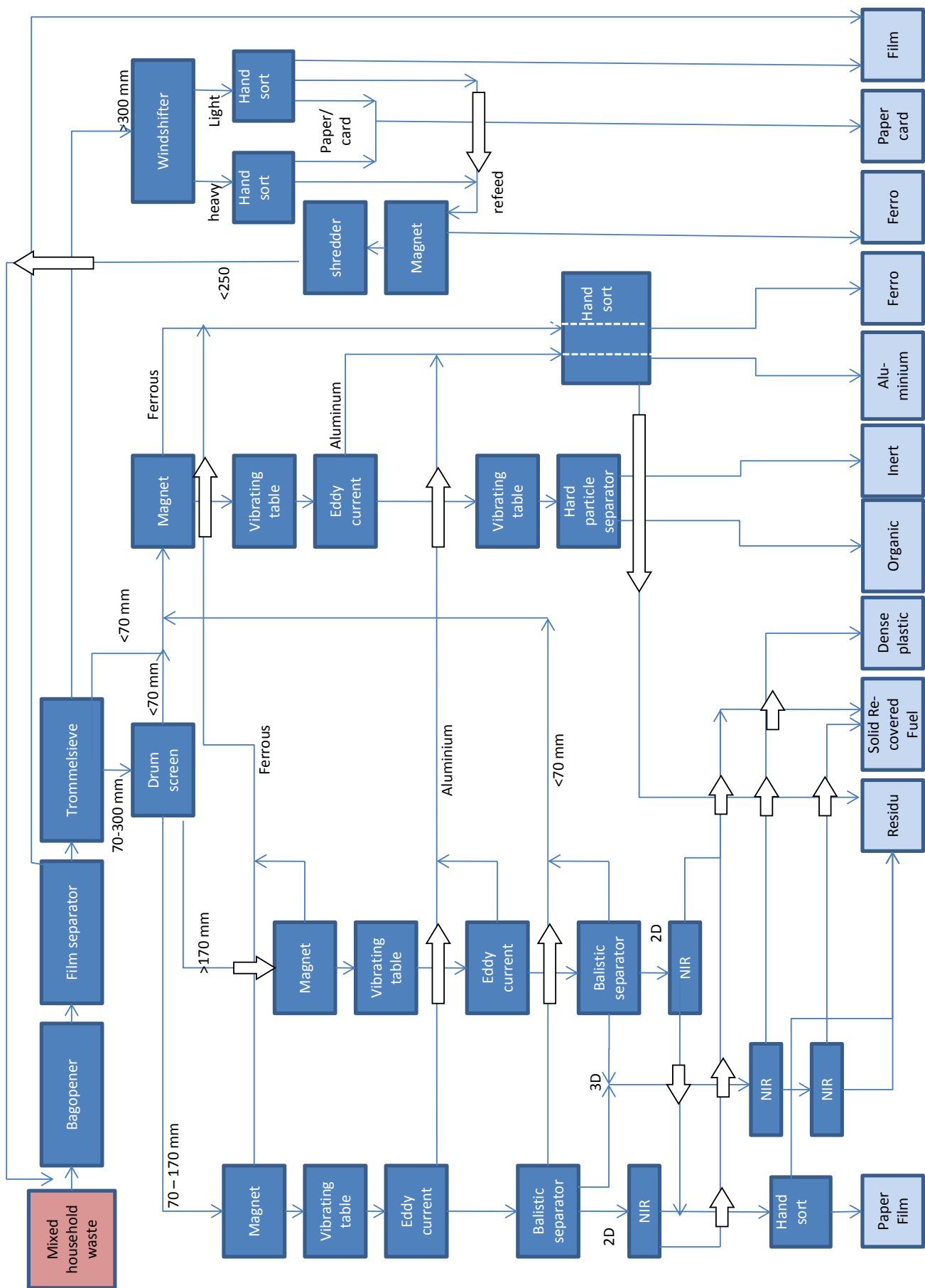
Annex 1 - Example of of a mixed municipal waste sorting plant (dirty MRF)

The material received at the facility is weighed and undergoes inspection, followed by the removal of the bulky and/or potentially contaminated materials by manual sorting. The material then goes through an automated bag breaker to remove the waste from the bag and make it available to the film grabber and sieve which separate films and fines. An air classifier, magnet and eddy current separator separates the non-metal, ferrous metal and non-ferrous metal (aluminium) based on their physical properties.

Recovered recyclables are weighted and temporarily stored in separated bins or in delineated areas. When sufficient volumes are reached, materials are bulked using balers, shredders, pelletisers and compactors. Non-recoverable or non-target materials can then undergo pre-treatment and preparation for conversion into RDF for energy recovery and/or composting / anaerobic digestion of the organic biodegradable stream.

Automated dirty MRFs (sorting plants for MSW) are capable of processing up to 40 tonnes per hour of mixed municipal waste. Paper, card and organic waste from this type of facility is not suitable for material recovery due to contamination, and the plastic fraction tends to be of poor quality. The majority of the output from dirty MRFs is refuse derived fuel for use in energy to waste plants.

Flow diagram of a mixed municipal waste sorting plant

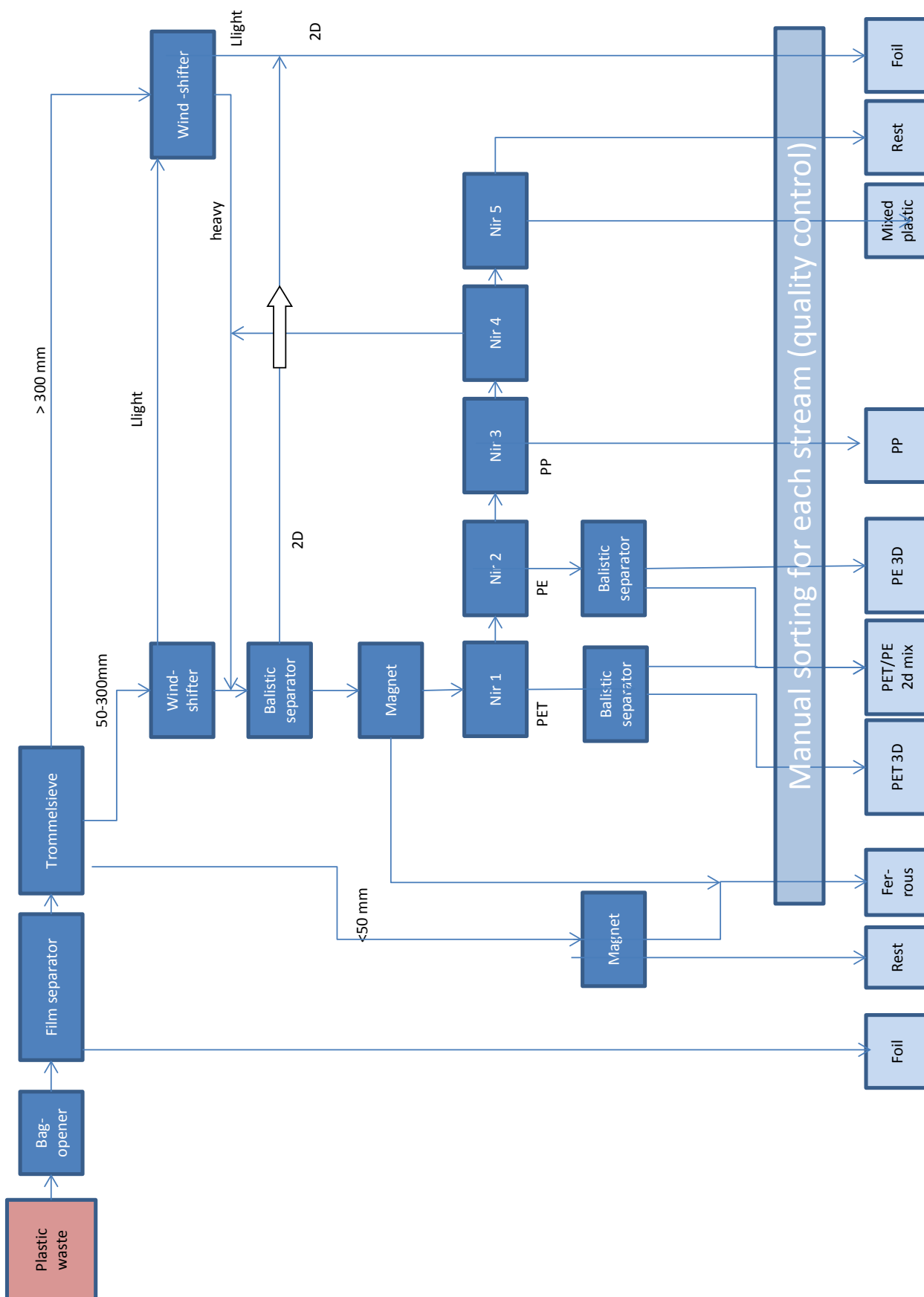


Annex 2 - Example of a mixed plastic waste sorting plant

The plastic waste arrives and is weighed upon entry. It is then unloaded and made ready to enter the sorting line. At the start of the sorting line, a bag opener ensures that the waste is ready for sorting. The mixed plastic waste is then fed through a film separator. This removed film to prevent it impeding the rest of the sorting process. The waste is then fed through a trommel sieve, which separates the waste by size. Small fines fall through and, after passing through a magnetic sorter to remove ferrous metal, form a residual waste fraction. Medium and large sized plastic waste is then fed into wind shifters to separate heavy and light plastic fractions, and ballistic separators to separate rolling (3D) waste and flat (2D) waste. The flat and light plastic waste is combined to form a plastic foil material fraction.

The heavy, rolling plastic from the ballistic separator is then passed through a magnetic sorter to extract the ferrous metal components, after which the plastic waste is suitable for a series of NIR sorting processes, which separate different plastic types by identifying and mechanically removing them (often by air blast or flipper) from the waste stream. For PET and PP, further ballistic processes are used to sort 3D and 2D elements. Most sorting plants also use manual sorting as quality assurance at the end of the process for each material type.

Flow diagram of a mixed plastic waste sorting plant



Annex 3 - Factors related to health, safety and the environment

In this annex the factors related to health, safety and the environment in the main report are further elaborated upon.

Air Pollution

Particulate Matter (PM)

On-site operations can generate Particulate Matter (PM) that can impact (i.e. induce respiratory issues) upon site personnel, visitors, local residents and neighbours. Generic preventative measures could include:

- Paving roads on site.
- Use of a bowser to spray water onto haul roads and waste storage and processing areas during dry and dusty conditions.
- Utilise wheel-washes on incoming and outgoing vehicles.
- Align building openings to minimise exposure to prevailing winds.
- Install plastic curtains or roller shutter doors over building openings.
- Keep station doors closed during operating hours, except when trucks are entering or exiting.
- Install misting systems over tipping areas to “knock down” dust particles.
- Implement speed limit restrictions on site haul roads.
- Cover loads of wastes that have the potential to emit significant dust during transport.
- Undertake dust monitoring at specified locations on and off site, if applicable.
- Provide all site staff with PPE, including high-visibility clothing, FFP3 mask, and safety glasses.

Odour

On-site operations can generate odour when sorting biodegradable material. This can impact upon site personnel, visitors, local residents and neighbours. Generic preventative measures could include:

- Enclose or cover loads of wastes.
- Refuse to accept certain highly odorous wastes.
- Remove any other odorous waste from the premises as soon as practicable.
- Increase the distance between the odour source and the receptor.
- Practice “first-in, first-out” waste handling practices.
- Regularly inspect and monitor waste handling areas.
- Frequently clean/wash down waste handling areas.
- Install ventilation systems with air filters or scrubbers.
- Plant vegetative barriers, such as trees, to absorb and disperse odours.
- Install plastic curtains or roller shutter doors on entrances and exits to contain odours when doors are opened to allow vehicles to enter or exit.

Regularly evaluate the prevailing wind direction and monitor odour at specified locations on and off site (i.e. sensitive areas, settlements), if applicable.

Water and Soil Pollution

Rainfall and run-off water that flows from roofs, roads, parking lots, and landscaped areas could become 'polluted' by coming into contact with waste on site. This can cause a negative impact upon surface water, ground water, soil, human health, and flora and fauna. Generic preventative measures could include:

- Locate plants outside local flood zones, if applicable.
- Cover the waste - use rain-tight and leak tight HGVs and containers.
- Keep surface water free of runoff contamination from waste, mud, and fuel/oil.
- Implement impervious surfaces (i.e. paved surfaces) and engineered drainage systems. Ensure that there are sealed systems in place for potentially contaminated leachate from stored waste, so that it is collected separately from surface water.
- Use secondary containment around temporary storage areas, i.e. fuel.
- Collect soils samples on-site and within immediate location to establish baseline conditions.
- Monitor the composition of the surface water (e.g. sampling at agreed locations; upstream/downstream of the site, monthly/ quarterly basis).
- Monitor the flow and composition of foul water/sewer discharge.
- Undertake site walkover (including of nearby surface water courses) at agreed intervals.
- Provide all site staff with PPE, including steel tipped boots and gloves.

Noise and Vibration

Noise can be generated by the operation and movement of vehicles (i.e. traffic) associated with the plant. The impact of noise is determined by strength and duration, and can affect site personnel, visitors, local residents and neighbours resulting in sleep disturbance, stress and temporary and/or permanent hearing loss etc. Generic preventative measures could include:

- Select quiet working equipment.
- Shut down equipment when not in use.
- Set a site speed limit of 15km per hour (or appropriate to site conditions and surroundings).
- Enclose all waste-handling operations.
- Use concrete walls and structures, which absorb sound better than metal structures.
- Install shielding or barriers, such as trees, berms, or walls, around the facility to block and absorb noise.
- Insulate building walls with sound-absorbing materials.
- Locate administrative buildings between sources of noise and community.
- Locate sorting plant building openings (i.e. doors) away from receptors.
- Keep doors closed during operating hours, except when vehicles are entering or exiting.
- Establish operating hours that avoid early morning or late-night operations.
- Set facility noise level limits and adhere to them.
- Record incidents of noise or vibration that exceed these limits – these should be diarised so that potential causes can be identified and procedures put in place to eliminate them.
- Provide all site staff with PPE, including noise dampening earplugs/ muffs.

Litter

Litter can be contained within the incoming waste loads, and cause an environmental nuisance. Generic preventative measures could include:

- Covering all incoming and outgoing loads.
- Implementing daily litter inspections and pick up at the facility and on surrounding streets.
- Installing a perimeter fence to prevent windblown litter from leaving the site.

Traffic

Both on and off-site traffic has the potential to create congestion, additional noise, air pollution and accidents that can impact upon site personnel, visitors, local residents and neighbouring workforces. Generic preventative measures could include:

- Create a robust and formal transport management plan.
- Design internal and external roads to include highly visible markings, barriers and signs (i.e. speed restrictions, traffic flow and separation areas between vehicles and pedestrian movements).
- Drivers should be appropriately trained and licensed.
- Create acceleration, deceleration, or turning lanes at site entrances and exits (where applicable) to maintain steady traffic flows around facility.
- Work with the community to designate inbound and outbound Heavy Goods Vehicles (HGV) traffic routes and ensure that drivers follow these routes.
- Avoid traffic flows adjacent to noise sensitive property.
- Restrict incoming HGVs queueing on public streets, i.e. if inadequate space is available on site to accommodate waiting HGVs, use a remote site as a waiting area for HGVs.
- Where possible, schedule incoming traffic so that it does not coincide with local rush hours.
- Regularly maintain and service vehicles to ensure they are running as efficiently as possible.
- Switch off vehicle when not in use (both on-site and visiting vehicles).
- Provide all site staff with PPE, including high-visibility clothing and steel tipped boots.

Flies, Vermin and Birds

Biodegradable waste attracts flies, vermin and birds. These can cause negative impacts upon human health. Generic preventative measures include:

- Hiring a professional licensed pest control company with expertise and experience in controlling specific vermin populations.
- Seal or screen openings that allow rodents and insects to enter the building, such as door and window frames, vents, and masonry cracks.
- Implement practices that reduce the likeliness of attracting vermin.

Exposure to Potentially Hazardous Equipment and Substances

Site operatives at WSPs work in close proximity to a variety of hazards, including equipment with moving parts (e.g. conveyor belts, blades, balers, and compactors), wastes that can cause injury or disease (e.g. heavy or sharp objects and needles) and potentially contaminated substances (i.e. fuel and foul sewage). Facility operators should therefore develop a Hazard Management Plan (HMP) in line with national and local workplace safety regulations (where applicable) to minimise the risk of injury from such hazards. This should incorporate:

- Supplying site staff with all necessary PPE.
- Displaying brightly coloured warning signs around equipment and machinery.
- Regularly maintain and monitor equipment and machinery.
- Implemented emergency shut down mechanisms on equipment and machinery.
- Keep all areas clean and tidy.
- Check bunds and tanks for leaks.
- Check the provision of oil spillage kits and absorbent materials.
- Ensure tanks and containers are secured against unauthorised access.
- Provide continuous staff training.
- Make emergency phone numbers visible and accessible.



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