# Steel Sheet Piling

# Redevelopment of a landfill

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# Steel sheet piling for reconditioning of a landfill in Austria.

The Institute for the Protection of the Environment of Lower Austria has recently carried out a pilot project in the field of redeveloping a landfill near Horn, north west of the austrian capital Vienna.
Set on sloping ground, for more than 20 years this landfill has taken the household waste of the area and has reached saturation point.
The project consists of removing the old refuse under cover of a watertight enclosure of sheet piling, especially chosen for economical reasons, and then installing a watertight floor before storing non-usable waste in the space thus marked out.
This redevelopment increases the life of the waste operation by eight years offering an additional containment space of 130.000 $m^3$.

# 1 Scope

*Background information*
*on regional waste management*

The 21 administrative districts in Lower Austria are divided into 5 waste-disposal regions, each of which covers 4 or 5 administrative districts. Individual regional associations in the waste-disposal regions perform administrative and logistical duties connected with waste disposal, whereas the Lower Austria Environmental Protection Institute (NUA) provides and operates processing and waste-disposal plants.


The Horn and Waidhofen landfills, both administered by the NUA, are located together with the Gmünd landfill (which the NUA took over from the Gmünd municipality in 1994) in the north-west waste-disposal region and covered between 20% and 30% of the total regional waste-disposal requirement.

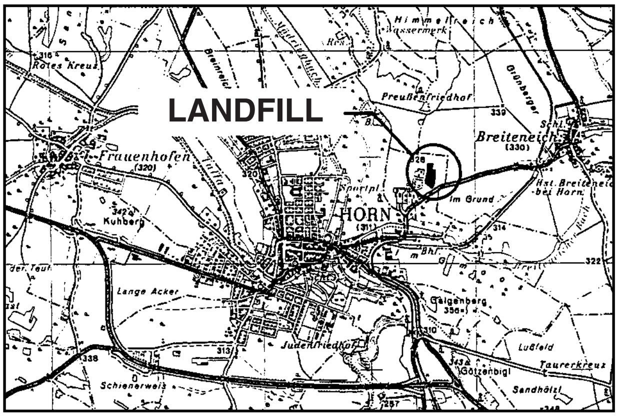
In anticipation of the emerging regional waste-disposal bottlenecks in the region, the closure of the Gmünd site at the end of 1991 due to unsatisfactory technical equipment, the filling of the Waidhofen and Horn sites by 1997 and 1995/96 respectively, every effort was made in advance to prepare and implement new sites. Although the regional amount of waste at landfill sites has continued to decrease since 1988 (from approximately 30 000 tonnes approximately 20 000 tonnes per annum), the search for long-term sites in the region could not have bridged a temporary waste-disposal gap, as any new landfill projects would have been vetoed on account of current developments in environmental legislation, in particular the introduction of legislative principles regarding the establishment of thermal waste processing plants in Austria as well as the increasingly keen competition in the waste-disposal market. Due to a combination of political and administrative considerations regarding waste disposal, more and more existing landfill sites have been adjusted / redeveloped since the early 90s in order to cover the regional waste-disposal requirement over the medium term (10 to 15 years) and in order to be able to co-finance the required investments from the earning capacity. These considerations apply in particular to sites which require redevelopment as a consequence of obsolete or defective equipment.

These outline conditions eventually resulted in the project known as **“Landfill in Horn/Redevelopment and Continued Operation”**.

# 2 Information about the initial situation

## 2.1. *Introduction*

The landfill is located directly on the north-east boundary of the regional capital, Horn, in the area of a clay pit and a former brickworks.




The pit is polygonal and is approximately 270 m long, 70 - 100 m wide, 4 - 15 m deep and has an area of approximately 2.7 ha.

In the north and east the pit is limited by farmland; in the south the land has been developed and fenced off by federal road 45 and in the west industrial areas and waste land adjoin each other on ground which has a slight elevation. The nearest housing estates in Horn are located approximately 900 m to the west as the crow flies and Breiteneich is situated approximately 1 km to the east.

On account of the location and height of the clay deposits, extraction work resulted in an extremely uneven pit floor and steep, partially vertical walls which were reduced to flatter embankments on the southern edge due to the descending ground.

When the brickworks closed down and the production equipment dismantled in the early 70s, the owner of the land (municipality of Horn) used the pit as a landfill for local refuse.

When the NUA was established as a public corporation in 1974, the equipment and operation of a well-run landfill, encompassing a large regional catchment area (mainly the district of Horn), was transferred to the NUA pursuant to its statutory mandate.

Pursuant to the Austrian water protection law (WRG) which was amended by an adaptation and amendment notification in 1977, 1983 and 1985, the NUA was authorised to operate the landfill from 1974 until February 1995. After this date the site was temporarily closed for redevelopment work on account of the unsatisfactory operating results and on the basis of a modified management concept for the regional sites.

During its 21 years of operation the landfill received approximately **180 000 m³** of refuse, consisting of household and bulky refuse, household type industrial waste, excavated earth from roadworks and building rubble (in accordance with the current agreement on waste).

The main part of the landfill, the VA01 landfill sections in the north and the adjoining VA02 section, have no comprehensible base seal or seepage water collector (VA01) and no comprehensible base seal or seepage-water collector documented in the quality of the landfill (VA02).

In 1986 the most southerly section (VA03) was equipped with a mineral base seal and defined seepage-water collection. The seepage water will be fed into the public sewerage system via an intermediate tank for a limited period until 1997.

The infrastructure of the landfill also consists

of an office container, a weighbridge, a compactor as well as telephone and water connections . As subsequent detailed tests indicated, there is a non-representative groundwater control system via groundwater probes. The landfill grounds are fenced in.

### **2.2.** *Geology*

Horn is located on the north-east edge (i.e. on the bend) of the so-called Horn basin, a tectonic syncline within the basement rock of the Bohemian Massif.

This basin is up to 200 m deep, consists of a sand and gravel sediment and is an ideal groundwater reservoir which should be conserved; **the basin is estimated to have a volume of 30 to 40 million m³ of potentially usable groundwater.**

The southern part of the Horn basin was declared a groundwater conservation area and extends almost as far as the southern edge of the town of Horn; however, the town and, therefore, the landfill site are not included in the southern part.

The close proximity of the landfill to the sensitive groundwater reserves of the town was always of great concern whenever extension/redevelopment concepts were considered for landfill in Horn. These concepts defined the extent and quality of the geological/hydrogeological tests and created the decisional base for the examination of other options.

# 3 Project development

In 1991 an initial project to prolong the operating period of the landfill was submitted for official authorisation; the aim of the project was to seal and finish the surface, subject to a berm filling being deposited on the existing body of waste.
The aim was to increase the volume by approximately **80 000 m³**.

The project was not authorised for implementation, as no statement or only inadequate statements could be made about the existing landfill and the quality of the site with regard to continued operation.

Basic research work was therefore required before actual planning of the landfill could commence, with main emphasis on the following field tests.

## **3.1.** *Testing the quality of the site from a hydrogeological point of view*

A total of 16 exploratory bores were drilled down to a depth of approximately 50 m around the landfill; 11 of the bores were extended for groundwater monitoring probes. In order to specify the precise drilling locations, geoelectrical equipment was utilised over a large area as an indirect means of providing preliminary information.

The aim of the tests was to :

- Establish the location, extent and quality of existing aquifers and groundwater impoundments and assess the suitability of inserting vertical sealing systems (diaphragm wall, narrow wall)

- Ascertain the direction of flow of the groundwater, the speed and flow rate of the groundwater

- Provide a qualitative and quantitative assessment of the contaminant dispersion mechanisms, particularly with reference to the protected groundwater area and the drinking-water wells in Horn.

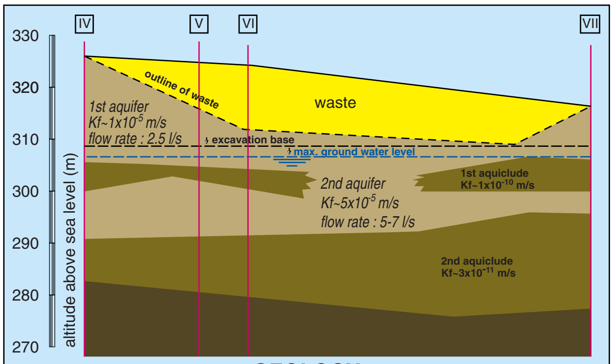
- Ascertain the hydrochemical conditions in the area adjacent to the landfill and assess groundwater pollution.

The aformentioned points were dealt with at the end of 1991 and were concluded one year later with the publication of the comprehensive expert report.

The results of the tests can be summarised as follows :

- There are 2 groundwater impoundments, the first of which is situated directly underneath the original pit base and is 4 to 8 m thick and has a permeability of $k = 1.10^{-10}$ m/s, although identified as non-continuous in the eastern area of the landfill.

The second impoundment is located at a depth of approximately 25 m and is 2 to 15 m thick, has a permeability of $k = 3.10^{-11}$ m/s and merges into the non weathered basement rock at a depth of approximately 40 m.




**GEOLOGY**

- The groundwater flows from a high point just west of the landfill radially in an arc of approximately 180° northwards and southwards via an easterly direction at speeds ranging from 10 cm/day to 1 m/day. The groundwater flow rate at the first water table just below the surface is approximately 2.5 l/s and at the second deeper water table approximately 5 to 7 l/s.

- The probes in the vicinity of the landfill indicate a significant impairment in the quality of the groundwater. Both the hydraulic gradient and the speed decrease at a distance of approximately 200 m east of the landfill; a significant reduction in groundwater pollution was also observed at this distance. This indicates that the contaminant-dispersion mechanisms or the actual dispersion of contaminants are restricted locally.

- The water table is approximately 3.5 to 4 m below the deepest point of the pit base; the highest ever expected water table (HGW) is just below the pit base. Therefore, the new base of the landfill had to be raised.

- The drinking-water wells in Horn are therefore not affected by the emissions.

- The expert report describes the general landfill site as suitable, including the safety options which consist of enclosing the site and implementing additional hydraulic procedures.

## **3.2.** *Legal situation*

The original authorisation for the installation and operation of the landfill was implemented pursuant to the relevant provisions of the WRG.

On account of the Austrian Waste Management Law (AWG) which came into force in 1990, the authorisation for landfills over 100 000 $m^3$-or for mainly alterations to such sites-will be transferred to this more extensive and more complex law. The authorisation documents were co-ordinated with the WRG based on the legal opinion that (with reference to the appropriate transitional provisions in the AWG) the WRG should also apply and authorisation should therefore be based on the former valid water laws. These laws could then be re-applied by implementing the appropriate technological improvements at the landfill.

- The authorities were in agreement with this legal opinion, although subject to the qualification that, if this procedure were to be implemented, **the volume of the site could not be increased by expanding the area**; this accounted for the selected construction method as an essential planning requirement.

- The authorities consented to continue operation due to an increase in volume only on condition that the site was extensively modernised according to the state of the art; this excluded merely applying safety measures followed by the placing of a berm filling on the existing site.

- Co-ordination of the project contents with the additionally required administrative authorisation procedures pursuant to the Lower Austrian building regulations and the Lower Austrian nature conservation law.

- Negotioations and the conclusion of preliminary agreements with the owners of the adjacent pieces of land. in the construction schedule these areas had been intended fur use as manipulation areas and for the construction site infrastructure.

## **3.3.** *Waste management / business-management aspects*

When the Gmünd landfill was acquired for redevelopment including the Waidhofen and the Horn landfill, a new regional management programme was formulated which had to be temporarily co-ordinated with the individual construction projects and which took account of the business-management viewpoints but nevertheless ensured that waste continued to be disposed of reliably.

The following agreement was reached with the regional associations.

- Since 1995 waste has been disposed of only at one particular landfill in the region. The parallel operation of several sites was desirable as the sites were in close proximity to the main refuse-collection points but was discontinued for reasons of costs.

- The time required for the redevelopment work in Horn was derived from his agreement. This site should be operational by the middle of 1996, replacing the Waidhofen landfill.

### **3.4.** *Examination of options*

Research should be implemented in order to ascertain, particular from the cost benefit aspect, whether the complete redevelopment of the landfill and optimisation of its volume followed by continued operation (maintaining of profitability) can be considered more favourable than a safety option followed by shutdown of the landfill operation.

Individual options were assessed for technical feasibility (technological risk), including long-term reliability and consequences of the redevelopment (quality risk).

Investment costs were also taken into account for the construction work, and subsequent operating and maintenance costs were forecast for a period of 30 years.

**3 safeguard options and 2 redevelopment options with 3 suboptions** were examined.

*OPTION 1* :

Retention-wall enclosure in the second groundwater impoundment, groundwater lowering, operation discontinued.

*OPTION 2 :*

Retention-wall enclosure in the first groundwater impoundment with improvement of the rock in the area of the impoundment gap, groundwater lowering, operation discontinued.

*OPTION 3 :*

Retention wall enclosure in the first groundwater impoundment with relocation of the waste onto the existing site in the area of the impoundment gap, groundwater lowering, operation discontinued.

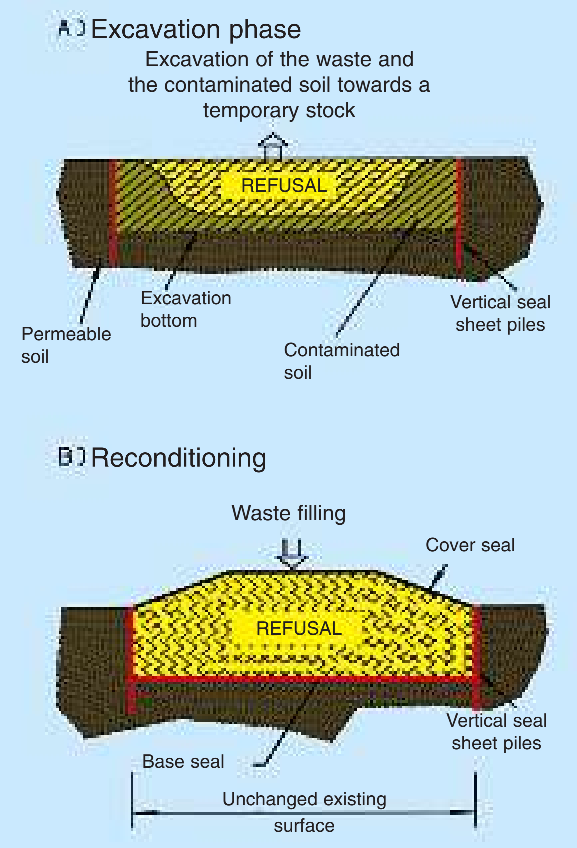
*OPTION 4 :*

Waste completely relocated and renewed operation of landfill according to the state of the art, embankment gradient 1:2, volume optimisation, operation continued.

*OPTION 5 :*

Waste completely relocated and redevelopment of the landfill according to the state of the art by means of a vertical, load-bearing retention wall in the sides of the pit and a composite seal on the base of the pit, volume optimisation, operation continued.
As suboptions to Option 5, a diaphragm wall, a contiguous bored pile wall and steel sheet piling were tested for the vertical sealing system.

**An examination of the options revealed that the most favourable redevelopment procedure was Option 5, especially in conjunction with anchored steel sheet piling** as :




CONSTRUCTION PHASES

- this option **corresponds to the statutory authorisation prerequisites**

- the **volume optimisation** is obtained on a given constant area. The net volumetric gain is approximately **145 000 m³** including berm filling.

- the site **remains secure** on account of the continued operation and **is covered for a period of 7 to 8 years** (dependent on waste coming in) **by the regional waste-disposal requirement**.

- **the technical equivalence of the sheet piling sealing system in comparison with conventional composite seals** can be demonstrated from the particular viewpoint of the redevelopment project.

Although this is the first time that steel sheet piling is being used in the referred project for sealing of an Austrian landfill, the following arguments were decisive in obtaining official authorisation for the system.

- **The technological properties of steel have been known for decades** based on its use in a wide range of applications; in particular, the corrosion resistant properties of the material and exposure to corrosion under the influence of aggressive media (e.g. saltwater)have been extensively documented.

- The development of special coatings for use in the landfill area increases the reliability of sealing the system over a long period.

- The **factory-made system components ensure a uniform quality** and make the system completely resistant to production-related quality fluctuations under site conditions.

- **Prefabricated steel sheet piles, transport and delivery logistics** which have been coordinated with the construction progress, reduce the work force on the construction site **and optimise construction**.

These circumstances comply with the tight deadlines.

- If wall sections descend to a depth of 15 m, the wall must be anchored; the entire system must therefore have a certain flexibility (especially when the anchors are being tightened) without reducing the impermeability of the system due to cracks or fractures resulting from shearing or compression stresses.

The material of the steel piles has a **higher elasticity** which satisfies **these requirements** to a much greater extent **than comparable reinforced concrete structures**, even in the area of the welded interlocks.

- **A comparison of the estimated production costs** with those of the retention-wall system

(diaphragm wall or contiguous bored pile wall) indicated that **the cost of steel sheet piling was approximately 30 % to 20 % less**.

Examination of the options was concluded in spring 1993 : immediately thereafter the submitted plan was authorised for the entire project.

## **3.5.** *Construction draft*

A construction draft and redevelopment plan derived from the examination of options formed the basis of the project concept. This draft is divided into 4 phases, the contents and sequence of which became components of the authorisation notification and which indicated the following significant points:

- Construction of the infrastructure required for the actual relocation work (intermediate storage areas, manipulation areas, contaminated/clean water sampling) implemented in Phase 0 from the middle of 1994.

- Gradual relocation of the landfill waste in 3 phases of 90 000 m$^3$ to 110 000 m$^3$ each from autumn 1994 to summer 1997.

- Reconstruction of the landfill site in 3 sections, each one subsequent to a relocation phase, and refilling of the new landfill sections at the same time as the relocation work is being implemented.

The site is operational again from the middle of 1996.

- Surface finish of the filled landfill sections and recultivation.

- Removal of the intermediate storage and return of the areas to a condition suitable for agriculture by the end of 1997.

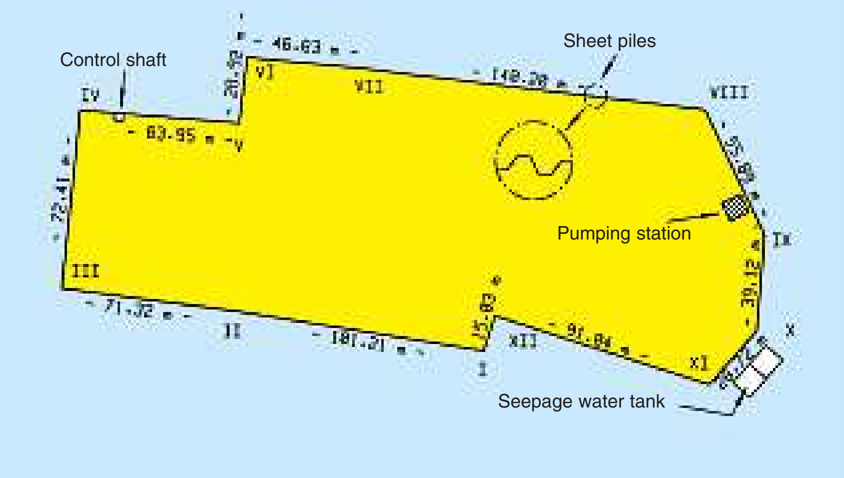
- At the same time as the redevelopment work is being implemented, the intention is to completely rebuild the infrastructure of the landfill, e.g. service buildings, weighbridge, and to reinstall the seepage-water storage plant and the groundwater sampling system based on hydrogeological test results.

Seepage-water purification will commence at the end of 1997 in a central purification plant which is not located on the site (light-load biology / microfiltration / reverse osmosis).

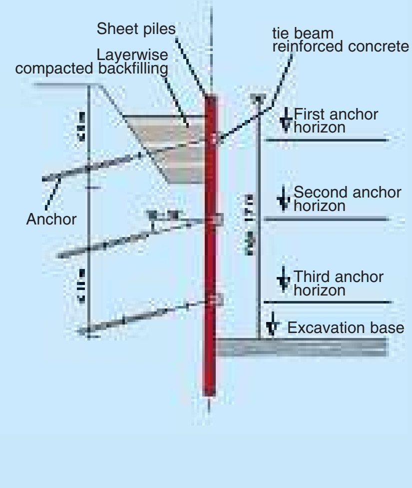
- In order to avoid further adjustment orders from the authorities, the draft requires a progressive and foresighted landfill technology, especially from the point of view of maintaining in a long-term specified quality of the sealing systems and determining to what extent the seepage-water drainage and storage plant can be monitored and redeveloped.

- Co-ordination of planning and construction with the available investment funds and the officially stipulated period.

The project concept was submitted in August 1993 for official approval; negotiations took place in January 1994, resulting in a positive decision at the beginning of June 1994.




STEEL SHEET PILES LAYOUT




TYPICAL CROSS SECTION

## 3.6. *Quality assurance*

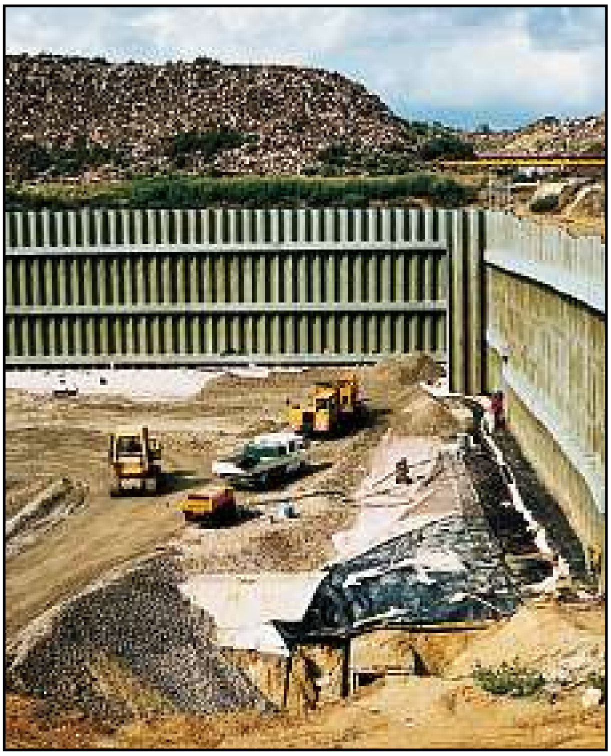
Construction-related quality assurance (QA) had already been included in the project documents under the auspices of the relevant authorised and accredited testing institutes or universities and in agreement with the authorities.

This extensive description of the designated QA procedures in the project facilitated rapid official authorisation and stipulated the technical and time-related interfaces between the involved companies and the external monitors.

The intensive co-operation between project designers and external monitors during the project phase was important in so far as the selected building method and/or the combination of a wide range of building materials and building-material properties were used to formulate detailed structural solutions. These solutions will have to be tested for quality on-site and shown to be equivalent to standard designs during the production phase.

The following construction-related QA procedures (external monitoring) have been integrated in the construction programme:

- Subsoil assessment and earth statics
- Checking materials, process engineering and acceptance quality of the base sealing system (mineral components / plastic sealing membrane).
- Checking process engineering and acceptance quality of the welded interlocks of the sheet piles.



- Checking the process engineering and acceptance quality of the sheetpiling coating.
- Checking the transfer procedures with reference to the guidelines of air pollution control and the sampling of illegal deposits by a separate chemical inspectorate.
- Implementation of relocation work in compliance with a safety concept together with a procedural and alarm plan in the event of damage.
- Monitoring the building work by a waterboard landfill inspectorate appointed by the authority.

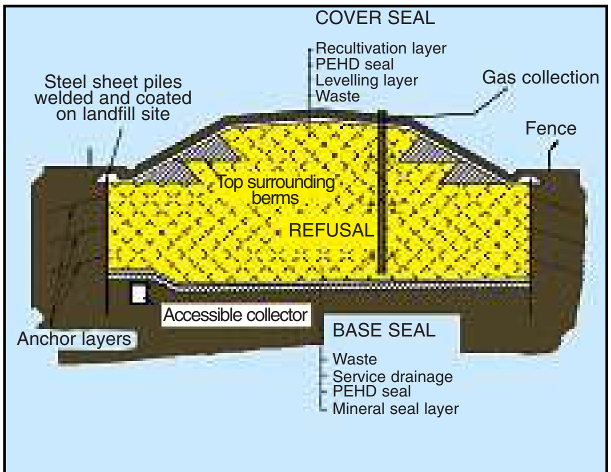
# 4 Technical description of the procedures

## 4.1. *Planning requirements and principles*

The planning requirements covered both the reconstruction and/or adaptation of the landfill and redevelopment of the existing site by relocation of the waste.

The individual components of the site must correspond to the standard of a landfill for the disposal of waste up to and including eluate class IIIb, pursuant to ÖNORM S2070 (mainly household refuse and household-type refuse). As a result, the quality requirements were derived from the relevant guidelines and standards in accordance with the method of adjudication employed by the authorities.

The future disposal area will be adjusted to the current site conditions. The total area is 26 400 $m^2$. by constructing a level landfill base which is surrounded by vertical pit walls and placing infill berms, the total usable landfill volume will be approximately **317 000 $m^3$**.



TYPICAL CROSS SECTION OF THE LANDFILL

The landfill consists of the following installation components:

- Horizontal base seal
- Vertical base seal (enclosure wall)
- Seepage water sampling, drainage and storage
- Surface finish and recultivation
- Seepage water back-irrigation
- Active degasification
- Infrastructure and service installations

In the following points only the sealing system will be considered in more detail. The remaining installation components will be explained in brief.

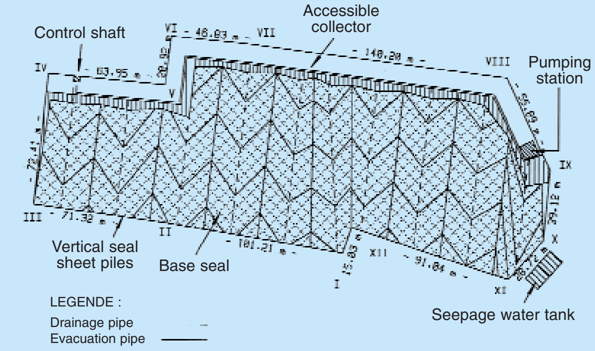
Scheduling of the relocation work, required co-ordination with the landfill reconstruction (phase planning, required building provisions, etc.) and implementation will also be considered.

## 4.2. *Horizontal base seal*

Pursuant to the Austrian guidelines for landfills the base seal consists of a composite seal with the following structure:

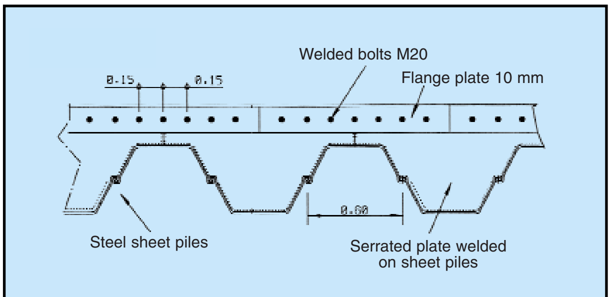
- Compaction of the excavation level (if required with additional levelling layer)
- 60 cm impervious mineral course in two layers with a maximum permeability of kf < 1 . $10^{-9}$ m/s
- 2 mm plastic sealing sheet made of PEHD
- Protective non-woven fabric (1000 $g/m^2$)
- 50 cm surface drainage consisting of 16/32 gravel

Slotted PEHD pipes are arranged in the surface drainage at a maximum distance of 30m. The selected inner diameter of 20 cm enables the lines to be flushed and a television probe to be conveyed. The longitudinal slope of the base seal is 2 % and at least 3 % crosswise.




BASE SEAL AND SEEPAGE WATER SYSTEM

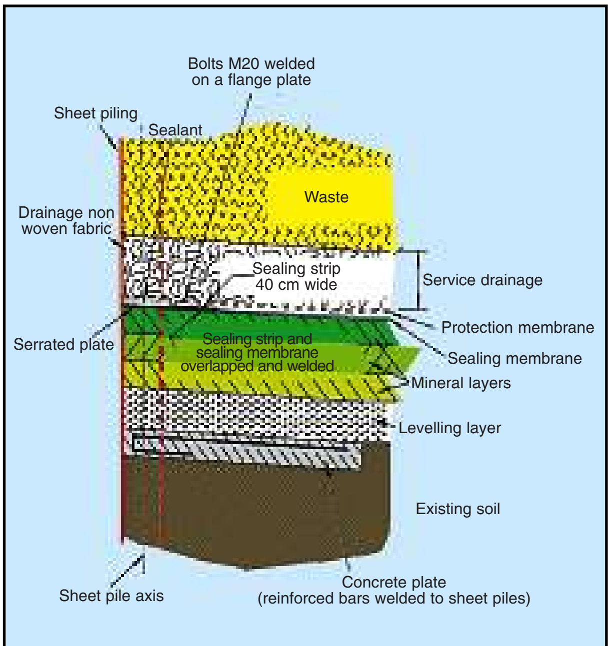
The base seal is connected to the vertical enclosure wall by means of serrated plates welded to the steel sheet piling; a PEHD strip is




PLAN VIEW

fixed to the serrated plates by means of a loose flange. The strip is connected to the general PEHD seal.

Also a reinforced concrete drag plate is located under the base seal in the base area of the enclosure wall for relocation of the settlements.




DETAIL OF THE CONNECTION BETWEEN SHEET PILES AND THE BASE SEAL

## 4.3. *Vertical seal*

The examination of the various options revealed that **the most favourable technical and economical solution for the vertical seal of the referred landfill was an enclosure with watertight steel sheet piling**. The steel piles are characterised by their interlocks which connect the individual piles to a continuous unit. Sheet piling structures are particularly advantageous if they can also be simultaneously used as an excavation protection.

For permanent steel structures, some specific criteria have to be taken into account, one of them being corrosion. A loss of 0.4 mm was measured on both sides of inland structures which were over 40 years old. According to factory specifications and/or literature, the “average corrosion rate” should be $V_{100} = 0.006$ mm/a, i.e. 0.6 mm per 100 years. The thickening of the protective corrosion layer even slows down the degradation. In the referred case the sheet piling is coated on the landfill side; as a result corrosion can only occur on the earth side. Therefore only 50% of the aforementioned values are expected.

There are two options available for sealing the landfill, sealing or welding the locks. Seals are frequently used to encase contaminated areas. However, there is a certain risk of damage occurring, especially when long piles are used.

As, in the case of the referred method, the inner side of the wall is left exposed and a seal is connected of the base seal, the second option of welding the locks was preferred. The main advantage of this method is absolute impermeability and monitoring of the latter by direct test procedures.

In order to calculate the sheet pile stability, the ground characteristics were determined from the cores of exploratory boreholes.

The inner friction angle of the sand in the upper areas was calculated to be approximately $\Phi = 35°$ and for the deeper silt layers from $\Phi = 19°$ to $\Phi = 22°$; this greatly impedes the toe support of the piles in the high wall area.

As far as the static method of functioning is concerned, a cantilever wall is an effective solution at heights between 4 m and 6 m; up to 3 horizontal anchor layers are required as the height of the wall increases. The toe support of the wall under the excavation base is nevertheless required.

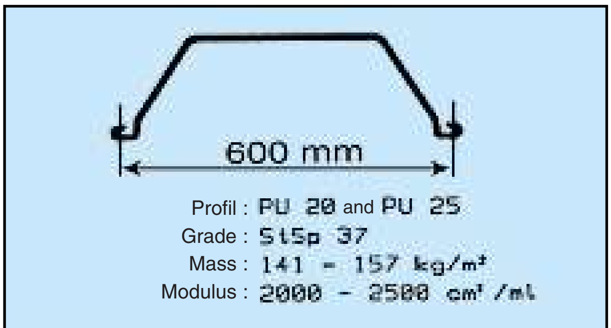
The anchor layers are positioned in succession from top to bottom as the body of waste is excavated. The wall is subject to the greatest forces at the point of the deepest excavation due to the pressure of the earth on one side. During the refilling and earth covering procedures, the pressures of the earth are compensated to a great extent by the inner pressures. However, the anchors are designed to be permanent.

Each anchor can withstand a load up to 900 kN and the lateral distance between the anchors is 2.4 m or 3.6 m. The lengths of the anchors are between 15 and 24.5 m.

The objective of using one unique sheet pile section for the whole job was nearly attained. **The unanchored low areas as well as the single or multi-layered anchored high areas can be covered by the PU 20 section manufactured by Arcelor Long Commercial / ProfilARBED**. The lengths of the piles range from 8.5 m to 21.0 m.

The **PU 25 section** was selected for construction reasons only for the northern part of the wall which contained a large percentage of silt and was up to 21 m deep. When laid out, the total sheet piling wall has a perimeter length of 760 m and an area of 10 600 m$^2$. 7 000 m$^2$ are situated above the base seal and act as a vertical seal.

The total length of the walings is approximately 1 100 m; approximately 360 anchors are



SHEET PILES SECTIONS

required with a total length of over 8 000 m.

The installed sheet piling locks are welded on-site on the waste side at a minimum weld throat of 6 mm. The length of the weld seams is approximately 5 900 m in total.

Additional corrosion protection is also provided on the waste side by a 2- component high solids epoxy coating applied in two layers onto a primer coating. The total thickness of the coating system is approximately 500 µm. Before the paint is applied, the entire exposed wall surface is sandblasted. In order to protect the sheet piling from mechanical damage, a protective non-woven fabric (1 000 g/m$^2$) is installed between the waste and the coated surface of the sheet piling.

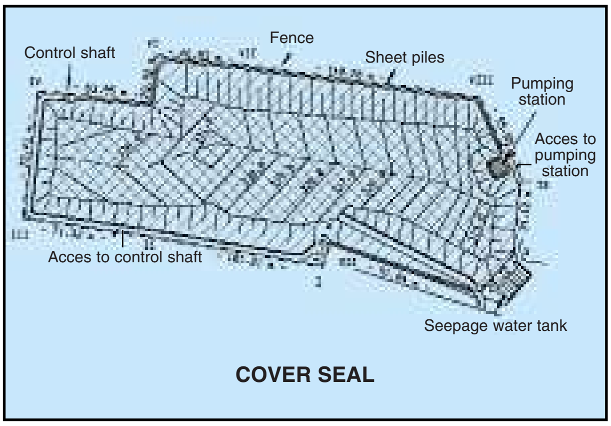
## **4.4.** *Other installation components*

The landfill seepage water is collected at the base of the landfill in the surface filter located above the base seal and is discharged via drainage pipes leading underneath the landfill base

into an accessible 330 m long collector. At the end of the collector is a pumping station in which the incoming water, controlled by the pumps, is temporarily stored in three 6 m$^3$ storage tanks and then pumped into the seepage-water tank (V = 705 m$^3$). The seepage water is processed decentrally.

All the tanks are lined with a PEHD double-walled system which can be tested for leaks by means of a partial vacuum.

The surface of the landfill is in the shape of a hill which is up to 10 m high and has a lateral slope of 1 : 2.5 over the surrounding land. the surface is also sealed by a PEHD seal onto which a recultivation layer at least 1 m thick is placed. The surface water is collected and




conveyed to two drainage wells.

Equipment placed under the surface seal will facilitate the back-irrigation of the seepage water and simultaneously allow the body of waste to be used as a reservoir.

The body of waste is degasified by gas wells and horizontal collectors which are connected to a central compressor station. The landfill gas is disposed of in compliance with emission limit values in a high-temperature flare.

The gas can be utilised provided the quality and quantity of the gas is adequate.

The outer structures required for the current operation of the site consist mainly of a service building, a compactor garage and the required roads and tracks within the landfill area. The monitoring and control equipment for the installed machinery is housed in a control room in the pump station.

The infrastructure is supplemented by a new design of control system for groundwater based on hydrogeological tests.

## **4.5.** *Scheduling*

Several periods were defined for the implementation of the entire project :

- Construction preparation (Phase 0)
- Redevelopment (Phase I to III)
- Continued operation (Phase IV to VII)

The subdivision of the redevelopment and continued operation phases results from local allotments and/or volume-related arrangements which are made during redevelopment.

Phase 0 consists of all preparatory procedures which are required for the start of the actual redevelopment work. With this aim in view all the land bordering the landfill with an area of approximately 43 000 m$^2$ was adapted and developed with the required service and disposal plant in order to be able to manipulate and temporarily store the excavated volumes. In particular, intermediate asphalt-sealed storage and traffic areas with approximately 19 000 m$^2$ were constructed with individual contaminated-water sewerage systems. The required seepage-water collecting tank was also constructed for subsequent expansion of the landfill as well as an additional PEHD sealed retention tank for seepage water from the intermediate storage during the redevelopment period.

Phases I and II consist of the actual procedures for redeveloping the landfill in Horn following Phase 0. The individual redevelopment phases consist of the following principal tasks :

| | Phase I | Phase II | Phase III | TOTAL |
|---|---|---|---|---|
| excavation | 110 000 m$^3$ | 110 000 m$^3$ | 90 000 m$^3$ | **310 000 m$^3$** |
| re-installation | | 60 000 m$^3$ | 120 000 m$^3$ | **180 000 m$^3$** |
| sheet piling layout | 270 m | 230 m | 280 m | **760 m** |
| base seal | 5 000 m$^2$ | 9 000 m$^2$ | 13 000 m$^2$ | **27 000 m$^2$** |

The cubage difference between the excavation and filling is therefore **130 000 m$^3$**. On the one hand, useful fractions will be used for the construction of the landfill (impervious mineral course, levelling layers, berms, recultivation), on the other hand, excess material with an eluate class < 1a will be relocated and deposited.

The entire redevelopment work is scheduled over a period of 3.5 years.

From the point of view of the project, close attention is paid to the prevention of emissions and protection of the employees by precise scheduling of tasks according to an exact timetable; a generally valid safety concept (procedural and alarm plan) is also implemented. The technological procedures for preventing strong odours and/or the emission of pollutants consist of pre-aerating and degassing the body of waste. The “Bio-impulse aeration” was utilised which was developed by the contractor especially for these types of applications. As a result the anaerobic landfill gas environment is replaced by aerobic conditions; the atmospheric air is injected intermittently under high pressure into the body of waste via pressure lances, then extracted via suction probes and the odour is stabilised by means of a biofilter connected downstream.

## **4.6.** *Implementation of the project*

Preparations were implemented as soon as authorisation was received from the authorities. The entire project was divided into the following tasks :

- Purchase of steel sheet piles (1 600 to)
- Commencement of construction phase 0 (construction preparation)
- Commencement of construction phase I-III (actual redevelopment)
- Other tasks (e.g. electro-mechanical plant, procedures on completion of the redevelopment work)

The sheet piles were put out to tender throughout Europe in a two-stage procedure pursuant to ÖNORM A2050. As far as the search for interested parties was concerned, those companies which were capable of undertaking the work were first established according to formulated criteria. In the subsequent negotiating phase Arcelor Long Commercial/ProfilARBED (Luxembourg) was established as the company which had the best offer from a technical and economical point of view.

The sheet piles were purchased by the owner for a better management of the total budget and the possibility to determine directly which materials were to be used at the required quality features. The contract issued to Arcelor Long Commercial consists of supplying the sheet piles and coating them on site.

The preparatory procedures required for the actual redevelopment (Phase 0) consisted of ground, road and reinforced concrete work and were awarded to a local construction company on the basis of a public invitation to tender. The work was implemented in spring/summer 1994.

The construction phases I-III, the actual redevelopment and reconstruction of the landfill, are the major component of the referred project and were put out for public invitation to tender in spring 1994. A joint venture, consisting of two local companies and two other companies with the relevant experience, had the best offer and was awarded the contract.

The work commenced in July 1994. Construction difficulties occurred in summer/autumn 1994 due to subsoil conditions, requiring a change to the construction programme and consequently to the timetables and deadlines. Phase I was concluded and Phase II started by the beginning of September 1995. Phase III was completed in September 1997.

# 5 Costs

Cost otherview:

| COMPONENTS | proportion of AF |
|---|---|
| overheads (GK) | 8,4 % |
| sheet piling | 29,5 % |
| base sale | 12,1 % |
| relocation | 28,1 % |
| pump station/collector/seepage-water tank | 11,5 % |
| surface seal | 2,8 % |
| degasification/see-page water back-irrigation | 1,1 % |
| rising structures | 1,0 % |
| outdoor facilities | 2,6 % |
| recultivation | 2,2 % |
| administration | 0,6 % |
| TOTAL BUILDING COSTS (BK) | 100,0 % |

To reduce costs, the following measures were taken:

- optimisation of the construction schedule,
- more economical design of the construction infrastructure,
- re-utilisation of reclaimed earthwork materials (especially for the mineral seal)
- incomplete use of order reserves.

Despite keen price competition, the take-over price for the waste-disposal market is expected to be retained for the medium term, thereby ensuring that the redevelopment costs and operating costs will be covered by the continued operation until the predicted end of the filling.

This is a significant economic criterion for the project.

# 6 Summary and conclusions

Consideration of legal, technical and economical outline conditions resulted in the referred project.

The following assessment refers to the fundamental technical advantages of the selected building procedure and in this respect also applies to landfills which operate along similar lines.

The vertical landfill seal made of interlocking steel sheet piles

- fulfils the objective of maximising the volume on a specified area

- facilitates the excavation of the existing landfill at the same time as construction the vertical landfill seal by welding and coating the sheet piles

- ensures the long-term function of the sealing system on account of its material properties (elasticity) and increased protection to corrosion under a wide range of load conditions (condition of construction, partial or compete filling)

- can be implemented much more economically than comparable reinforce concrete structures which have an equivalent functional quality

- facilitates optimum utilisation of the available time frame, provided that the building schedule and the production and just-in-time delivery of the sheet piles are strictly observed and that there is continuous close coordination between the supplier of the sheet piles and the construction company during the individual construction phases.

This time frame had been geared to the advantages of the prefabricated sealing-wall elements during the planning phase. In this respect the partially interchangeable sheet piles had to be available at the right time in order to retain the “critical path” in the construction schedule.

The final advantage mentioned above could not be completely utilised during the first two phases : in Phase I the construction period was extended by approximately two months due to installation problems and bad weather. In Phase II another brief delay occurred when an incorrect shipment was delivered in conjunction with a French railways strike.

Now that the construction period has elapsed, it appears that the selected construction method has come up to expectations, that the project will come to a satisfactory conclusion from an economic point of view and, all in all, that the utilisation of sophisticated solutions by means of increased and long-term quality assurance has been justified.

# 7 Project participants

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Grün-Bilfinger/Vienna
Graf/Horn
Ferro Bentonit/Horn

Driving contractor : W. Heiss GmbH
Bauunternehmer - Rammtechnik/Perchtolsdorf

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