Título del Trabajo Fin de Máster:

Study of the processes for designing a landfill of municipal solid waste. Sellent landfill, Valencia

Autor: Óscar Romera Martínez

Director: Evaristo Manuel López Porta

ESCUELA DE CAMINOS; CANALES Y PUERTOS

DEDICATORIA:

A Mercedes,

Por ser ese fuerte pilar en mi vida. La persona que me ha apoyado en todo momento hasta el último segundo. Siempre enseñándome la cara buena de las cosas.” No hay malas decisiones, solo decisiones”

Óscar

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Resumen

La tesis de máster defendida por Oscar Romera Martinez diseña un vertedero de residuos solidos urbanos en la cuenca mediterránea, en el municipio de Sellent. Se desarrolla el cálculo de procesos internos en vertederos de residuos sólidos urbanos. La gestión de residuos sólidos urbanos (RSU) es uno de los principales retos ambientales del mundo desarrollado y no desarrollado. Dentro de estos, los impactos ambientales de mayor consideración están relacionados con el lixiviado que se genera en ellos. El lixiviado de rellenos sanitarios es uno de los principales contaminantes de fuentes de agua, tanto superficial como subterránea, y constituye un factor de gran preocupación. Igualmente la producción de gas en verederos en un impacto importante para el cambio climático. Este trabajo estima la producción y el volumen de lixiviados y de gases de un vertedero sin previo tratamiento de residuos. Además son calculados los asentamientos generados por presión en carga e los residuos. Los resultados se obtienen a partir de la topografía de la zona y de información bibliográfica.

Una vez realizado los cálculos se realiza de nuevo el cálculo de los procesos con otra alternativa. Esta alternativa costa de una planta de tratamiento de residuos (reciclado y compostaje) previa al deposito en vertedero.

Con la comparación de ambos vertederos, la segunda alternativa cumple con el objetivo de reducir impactos ambientales, debido a menor relación de gas-residuo y mayor vida útil, siendo este un punto de gran importancia al ser un problema de la gestión de residuos.

Abstract

Thesis, is defended by Óscar Romera Martínez, design a landfill of municipal solid waste in Mediterranean basin, in district of Sellent (Valencia).It is carried out the calculation of internal process in landfill. The municipal solid waste management (MSW) is one important problem in developed world and underdeveloped world. In this situation, one of these environmental impacts of highest consideration is leachate which is produced in landfills. The leachate of landfills is one principal problem of pollution water, as superficial water as groundwater. Equally, gas production is important environmental impact for climate change. This document estimates production and quantity of leachate and gases, without pretreatment of waste. In addition, it calculated settlement for pressure. Altitude landfill change with pressure, for this reason settlement can change shelf life. The results are obtained by topographic information and bibliographic information.

Having made the evaluation, the calculation is done again, with other alternative. e This alternative has treatment plant of waste(recycling and recovery) before disposal in landfill.

With both calculations, It can be to compare. The second alternative meet the criteria of reduction environment impacts, beside of less gas-waste relationship and better shelf life, this factor is important due to be one of biggest problem of waste management.

Resum

La tesi de màster defensada per Oscar Romera Martinez dissenya un abocador de residus solguts urbans en la conca mediterrània, en el municipi de Sallent. Es desenvolupa el càlcul de processos interns en abocadors de residus sòlids urbans. La gestió de residus sòlids urbans

(RSU) és un dels principals reptes ambientals del món desenvolupat i no desenvolupat. Dins d'aquests, els impactes ambientals de major consideració estan relacionats amb el **lixiviado que es genera en ells. El lixiviado de farciments sanitaris és un dels principals contaminants de fonts d'aigua, tant superficial com a subterrània, i constitueix un factor de gran preocupació. Igualment la producció de gas en verederos en un impacte important per al canvi climàtic. Aquest treball estima la producció i el volum de lixiviados i de gasos d'un abocador sense previ tractament de residus. A més són calculats els assentaments generats per pressió en càrrega i els residus. Els resultats s'obtenen a partir de la topografia de la zona i d'informació bibliogràfica.

Una vegada realitzat els càlculs es realitza de nou el càlcul dels processos amb una altra alternativa. Aquesta alternativa costa d'una planta de tractament de residus (reciclat i compostatge) prèvia al diposite en abocador.

Amb la comparació de tots dos abocadors, la segona alternativa compleix amb l'objectiu de reduir impactes ambientals, a causa de menor relació de gas-residu i major vida útil, sent est un punt de gran importància en ser un problema de la gestió de residus.

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Chapter 1. Introduction

In European union, the problemen of management waste is perceptible as increase of waste and management it, especially waste elimination. Through directive 1999/31/CE, it is done a particular system for elimination of waste in landfill. Spain is one country which has been used landfills to eliminate its waste. several landfill has been closed to break the law. A strategy of prevention and recycling has been installed, both of them to reduce the amount and content of hazardous substances and adverse impacts on human health and the environment from waste (directiva 2008/98/CE), taking more importance in prevention.

Prevention of waste is a combination of different steps that are adopted before the product is a waste, It is established a hierarchy of waste management focusing on prevention, reuse, recycling, recovery and finally disposal, the latter being the last link but for the moment necessarily existent.

Rejections of solid waste are components of waste are not able to recycle or recovery. The application, design and operation of MSW landfill involves the application and convination of scientific principles, engineering and economic. It has always been used as disposal landfill method. Also, landfill is historically the most used for being the most economical.

Since the early 1990s, Climate change has been a reality that reinforced the change of SWM. Biodegradable Landfill waste, which is the major source to emisions of methane, and a strengthened focus on energy recovery from waste (Wilson, 2007). This idea led a new policy of management of law and targets such as recycling of ompost and a responsibility production. An example is bans landfill for recyclable materials (Marshal y Farahbaksh). A method for recover valuable materials and reduce methane emissions is the EU Directive policies about reduction in levels of biodegradable material into landfill (wilson, 2007).

A different point of view in Public concerns must be considered.In the past, poor practices have left the public with negative idea of new SWM strategies (Wilson, 2007). Solutions such as, compost which is sustainable has had problems with overcoming public attitudes. Thereforee affective communication is required and active participation of all relevant stakeholders (Schübeler, 1996)

It is defined the below concept;

Landfills are the physical facilities used for disposal, in the floor of earth. This material is rejections from solid waste. sanitary Controlled landfill is defined as engineering installation for disposal of solid waste, designed and operated to minimize environmental impacts and public health.

Landfill Gases are gases that are produced from waste

Leachate is a liquid that is accumulated in the depths of landfill Leachate is the result of precipitation, run-off and infiltration besides of loss of moisture form the waste itself.

The document is divided into 4 chapters. The first chapter is the own introduction and 4 and are the conclusions

The second chapter, state of art, is itemized into 7 part, where the first reports about policy framework in Europe, Portugal and Spain. Second part focuses on waste as element and third part defines types of landfills according to the literature. Fourth part give a study about liner. Fifth, sixth and seventh focus on the processes in landfills, gas generation, leachate and settlements

Finally, Chapter 3 the case study is performed on the landfill Sellent, Valencia and comparative with second lanfilld.

1.1 Background for Sellentlandfill

Sellent is an area (Plan zonal V5) where it is need installations of waste disposal. This area isformed by La Costera, La Safor, La ValldÁlbaida, La Canal de Navarres y el valle de Ayora-cofrentes. COR is the administration which management this área. It would be built a new plant of recovery, treatment, and disposal in Llanera de Ranes, Valencia. This project will have bellow characteristic:

20 years of life
Planned investment :> 94 million euros
Jobs employment during construction: 50 people
Fixed staff: Around 60 people
Recovery of recoverable fractions at least 9%
Production rejections maximum 44%
Line for treatment of organic matter
Packaging line and shredding pruning and gardening waste.
Treatment inert and bulky.
Capacity: 3 million m3

Temporarily, until the plant is established, the Consortium is using the infrastructure of the plant Fontcalent (Alicante)

Source:COR

Chapter 2. Stat of art

2.1 Solid municipal waste management

2.1.1 Solid waste management of Spain and Portugal

The management of municipal solid waste (MSW) is currently one of the most serious and controversial issues faced by the local and regional authorities of a country. Europe require the hierarchy of options, based on the following order to priority:Prevention, preparing for reuse, recycling, other types of recovery and the disposal of waste(Directive 2008/98/EC).In addition, and as has been mentioned previously, Biodegradable organic matter must be gradually reduced to less quantity (directive 1999/31/CE).Despite important technological advances, improved legislation and regulatory systems in the field of waste management in addition to more sophisticated health surveillance, public acceptance of the location of new waste disposal and treatments facilities is still very low due to concern about adverse effects on the environment and human health

In addition, we cite other European directives which referred to wastes are:

Legal Framework in europe

- Directive 91/156 / EEC on waste (Prevention, reduction and recovery)
- Decision 2000/532 / establishing a list of wastes 2001/118 / EC
- Directive 2008/98 / EC on waste (Waste Framework Directive)
- Directive 94/62 / EC on Packaging and Packaging Waste
- Decision 2003/33 / EC waste acceptance criteria in landfills
- Directive 2004 / 12CE relative to packs and packaging waste directive amending Directive 94/62 / EC
- Directive 2000/76 / EC on the incineration of waste
- Directive 2008/1 / EC concerning integrated pollution prevention and control of pollution IPPC
- Directive 2010/75 / EC on industrial emissions integrated prevention and control of pollution, repeal last two.

Portugal

Up to the end of the last century, Municipal solid waste was mostly disposed in open dumps in Portugal. The country had one important problem of environmental impact, contaminating soil and groundwater. In 1997, Strategic Plan for Urban Waste Management Services (PERSU) was approved with EU funds. The waste state had one change. In the country were closed more 300 dumps, due to create Regional systems for management of MSW, until 2002.For this purpose, facilities for the valorization (e.g. sorting facilities) and disposal of MSW (such as landfills and incineration plants) were built and selective collection systems were implemented. In that same year, 1997, a sector-specific regulator was created: the Institute for the Regulation of Water and Solid Waste (IRAR),currently the Water and Waste Services Regulation Authority (ERSAR).

Promote the quality of service and at the same time ensure the economic sustainability of the utilities are some targets of PERSU, beside protect the users´ interests.The technical regulation and related matters were under the responsibility of the Waste Institute (INR- Waste National institute). Despite the institutes had good results, it was necessary to redefine strategies, because of difference with EU. For this reason these strategies became visiblestrhough a new strategic plan (PERSUII).This document defines the main priorities and actions to be implemented by the various players in the MSW sector and the targets to achieve for the period 2007–2016. Portuguese Environment Agency (APA) was become fused with Waste National Institute, this agency was assigned with the responsibility of developing and monitoring the implementation of environmental policies.

According to information of APA, table 1 . We see the composition of wastes to period of time 1996 to 2001, according to work of ResiduosSolidosUrbanos- Consepção, Construção e Exploração de Tecnossistemas.

Table 1. Physical composition of MSW

Components	APA (inst. Res, 2006)	Before of Separate collection,pinto , Lopes , 2004)
Cardboard paper	26.40	29.08
Glass	7.40	9.43
Plastic	11.10	10.53
Metal	2.75	3.62
Textile	2.60	2.35
Wood	0.50	n.d
Fermentable material	26.50	27.26
Green	3.15	n.d
Fine	14.25	12.86
Other materials	5.35	4.84

Source: Tchobanoglous (1993)

This composition is similar to other countries which are identical situation. Nevertheless organic fraction is bigger that other. This fact we show significance in organic recovery.

In Portugal should increase volume of recycling waste then this would simultaneously contribute to increase the efficiency of waste utilities, such as increase of the life span of landfills. But it must be understand that new processes ,as composting, increase the cost for the system of waste (Carvalho& Marques, 2014).

Additionally, there was the need to articulate the vision, objectives, targets and measures the reference plane for municipal waste with the project of the National Waste Management Plan (PNGR), orienting document of national waste policy

Spain

In Spain 484.8 kg of municipal waste were collected per capita, it is less 3.9% that last year. The final waste became 44.9 million tons, 10% more than in 2011. if 22.4 million tons of which were collected 18.3 are mixed waste and 4.1 million were collected separate waste. (INE, 2014)

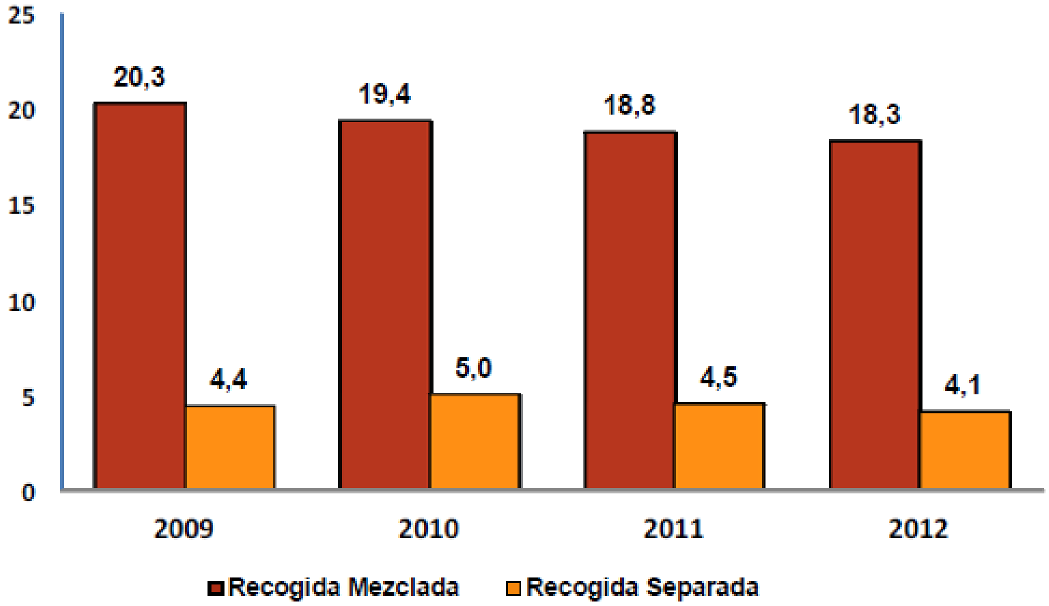


Figure 1. Quantity of waste in Spain per year. Red is quantity of mix waste and orange collected separate waste -Unit :Millon tones -Sources: Statistics National Institute, Spain.

Paper and carton is the waste fraction that is recycled with 26%. But metal fraction is more important in larger quantities (10108.9 ton). Per capita, in Spain one person produce 484.8 kg of waste per year, 3.9 % less in 2011. 44.9 million tons of Wastes were treated both from urban and non-urban. This year had been 10% superior to last year. The treatment percentage is 53.6% went to recycling. 39.6% at discharge and 6.8 % for incineration. (INE, 2014)

A European legislation, the Spanish regulatory framework is the below

- Ley 22/2011 of waste and contaminate soil - (D 2008/98 / EC)
- Ley 11/1997 on packaging and packaging waste (D 94/62 / EC)
- Real Decreto 653/2003 incineration waste (D 2000/76 / EC)
- Real Decreto 1481/2001 se regula la eliminación de residuos mediante depósito en vertedero (D99 / 31 / EC)
- Ley 16/2002 en prevención y control de la contaminación (D 96/61 and D 2008/1 / EC) 2009 NationalIntegratedWaste Plan fortheperiod 2008-2015

2.2 Types and characteristics of waste

2.2.1 Definition and classification of waste

Concept of waste is normally used to define how material which is deposited and rejected because of consumer society. A material may be reused, recycling and recovery so that is possible. In Diccionario Manual de la Lengua Española, wasteisdefinedhow:

1. n. Fraction or part of a whole.
2. n. All those come of decomposition or destruction.
3. n. Material that is useless after it has been used for a work or process.
4. n. Material that is result of subtraction or division.

Ley 22/2011, de residuos y sueloscontaminados define waste as, any substance or solid that its own cast aside or set out or must cast aside.

Waste can be from residential, commercial, institutional, industrial… In addition, waste is difference on composition. Classification is reported in the below table 2.

Table 2. Sources of solid waste within a community

Source	Typical facilities, activities, or location where wastes are generated	Types of solid wastes
Residential	Single-family and multifamily dwellings; low-, medium-,and high-density apartments; etc.	Food wastes, paper, cardboard, plastics, textiles, leather, yard wastes, wood, glass, tin cans, aluminum, other metal, ashes, street leaves, special wastes (including bulky items, consumer electronics, white goods, yard wastes collected separately, batteries, oil, and tires), and household hazardous wastes
Commercial	Stores, restaurants, markets, office buildings, hotels, motels, print shops, service stations, auto repair shops, etc.	Paper, cardboard, plastics, wood, food wastes, glass, metal wastes, ashes, special wastes (see preceding), hazardous wastes, etc.
Institutional	Schools, hospitals, prisons governmental centers, etc.	Same as for commercial
Industrial (nonprocess wastes)	Construction, fabrication, light and heavy manufacturing, refineries, chemical plants, power plants, demolition, etc.	Paper, cardboard, plastics, wood, food wastes, glass, metal wastes, ashes, special wastes (see preceding), hazardous wastes, etc
Municipal solid waste*	All of the preceding	All of the preceding
Construction and demolition	New construction sites, road repair, renovation sites, razing of buildings, broken pavement, etc.	Wood, steel, concrete, dirt, etc.
Municipal services (excluding treatment facilities)	Street cleaning, landscaping, , catch-basin cleaning, parks and beaches, other recreational areas, etc.	Special wastes, rubbish, street sweepings landscape and tree trimmings, catch basin debris; general wastes from parks, beaches, and recreational areas

Source	Typical facilities, activities, or location where wastes are generated	Types of solid wastes
Treatment facilities	Water, wastewater, industrial treatment processes, etc.	Treatment plant wastes, principally composed of residual sludges another residual materials
Industrial	Construction, fabrication, light and heavy manufacturing, refineries, chemical plants, power plants, demolition, etc. hazardous waste	Industrial process wastes, scrap materials, etc.; nonindustrial waste including food wastes, rubbish, ashes, demolition and construction wastes, special wastes, and
Agricultural	Field and row crops, orchards, vineyards, dairies, feedlots, farms, etc.	Spoiled food wastes, agricultural wastes, rubbish, and hazardous wastes

*municipal solid waste is assumed to all exception of industrial process waste and agricultural solid waste

Source: Tchobanoglous (1993)

Classification of wasteison base articulo 6 de la Ley 22/2011, de residuos y suelos contaminados. The aims of this document is municipal solid waste, no dangerous waste due to material is domestic

Municipal solid waste, in Ley22/2001 de residuos y sueloscontaminados define as" those that are produced in municipality or influence area, such as residential, commercial, office and service."

It can be to do a classification with three grups .

Classification of MSW

inert	Ash, dirt, glass, tin cans, boons…
fermentable	Food
combustibles	Plastics, paper, card board, wood, textile rubbers…

Source: Xavier Llauró Fábregas(1999)

Furthermore, it can be municipal solid waste those that are not dangerous with origenfrom other site. However, the majority are domestic waste. The domestic waste is organic material that is produced by use and cleaning food and rest of food. Besides of paper, carton board, material of plastic (glass, plate, cutlery), packaging materials and other materials such as glass, tin cans.

2.2.2 Composition of waste

It is important to know composition of waste then it is important to know quantity of existing materials that are individually. In this case it is known characteristic of a whole. Composition provides information that is used to manage, plan and evaluate waste. Thus, the design of landfills is based on this information.

The composition is variable, depend of factors such as:

- Standard of living

- Season of year
- Weather
- Origin
- Economic index
- Cultural habit

The Percentage of domestic waste in relation to MSW is 50-75%, so it depends of community (Tchobanoglous, Thisen, & Vigil, 1993). Components that constitute MSW are presented in table 3, percentage by weigh. They are components that they are considered as the most important and appropriate for characterization of waste.

Table 3. Typical physical composition of residential MSW excluding recycled materials and moisture of component

Component	Range	Percent By Weight
Organic		
Food waste	6-18	9
Paper	25-40	34
Card board	3-10	6
Plastics	4-10	7
Textiles	0-4	2
Rubber	0-2	0,5
Leather	0-2	0,5
Yard Wastes	5-20	18,5
Wood	1-4	2
Mics. Organics		79,5
Inorganic		
Glass	4-12	8
Tin Cans	2-8	6
Aliminum	0-1	0,5
Other Metal	1-4	3
Dirt,ashect.	0-6	3

Source: Tchobanoglous (1993)

Then, It can be gotten informatin about quemical composition. It is obtained by composition of defernts fraction, sucha as table 4.

Table 4. Elementary analysis of MSW

%weight	USA average	Regio l, 1982 CM Barcelona
H2O	23.2	55
C	27.5	18.6
H	3.7	2.5
O	20.6	12
N	0.45	0.8

CL	0.5	0.9
S	0.83	0.08
Inert	23.4	9.2
P	-	0.32
K	-	0.6
Calorific value	2683Kcal/kg	1972kcal/kg

Source: Ralea,(1987)

2.2.3 Physical and quemical characteristic

It may be known physical and quemical characteristic of waste in order to do a good management and design.

<u>Physical characteristic</u>

Moisture content

Moisture is expressed two ways, wet weight and dry-weight. Wet weight is used in management waste; it is expressed with below equation. In Spain, average moisture is 50% (Seco Torrecillas, Ferrer Polo, Segura Sobrino, & Barrat Baviera, 2001), but it depend on site. The values are 25% to 60%. Organic material is fraction that hand on more moisture. Textiles are material that make available less moisture.

$$M = (\frac{w - d}{w}) \times 100$$

Where;

M=moisture content

w=initial weight of sample as delivered,kg

d= weight of sampleafter drying at 105°C,kg

Table 5. Moisture content

Component	Percent By Weight	Moisture content %	Dry weight, kg
Organic			
Food waste	9	70	2.7
Paper	34	6	32.0
Card board	6	5	5.7
Plastics	7	2	6.9
Textiles	2	10	1.8
Rubber	0,5	2	0.5
Leather	0,5	10	0.4
Yard Wastes	18,5	60	7.4
Wood	2	20	1.6
Miss. Organics	79,5		
Inorganic			
Glass	8	8	7.8
Tin Cans	6	3	5.8
Aluminum	0,5	2	0.5
Other Metal	3	3	2.9
Dirt,ashect.	3	8	2.8

Source: Tchobanoglous (1993)

Specific weight

Specific weight is important to calculate capacity of landfill. It is defined as the material per unit volume (kg /m3). It might be known that specific weight is reported such as uncompact, compacted... In Landfill, municipal solid waste can be a specific wight of 590 to 742 kg/m3 well compacted (Tchobanoglous, Thisen, & Vigil, 1993).

Particle size and size distribution

The size and size distribution of component materials in solid wastes are an important consideration in recovery of materials, especially with treatment plant. For this reason is a important factor before disposal in landfill or with other methods. Tchobanoglous use below equations for characterizes particle size.

$$S_c = l$$

$$S_c = (\frac{l + w}{2})$$

$$S_c = \left(\frac{l + w + h}{3}\right)$$

$$S_c = (l \times w)^{\frac{1}{2}}$$

$$S_c = (l \times w \times h)^{1/3}$$

Where;

Sc=Sice of component, in (mm)

l= length, in (mm)

w=Width, in (mm)

h=heigt, in(mm)

Field Capacity

The field capacity of waste materials is of critical importance in determining the formation of leachate in landfills. It is defined as quantity of water that material can retain. When field capacity is overcome it is produced leachate. Municipal solid waste can have a value of field capacity of 50% to 60% (Tchobanoglous, Thisen, & Vigil, 1993).

Permeability of compacted waste

The hydraulic conductivity of compacted waste governs the movement of liquids and gases in a landfill.

<u>Chemical Characteristic</u>

Chemical properties of MSW are important to know well, because they are necessary for recovery and treatment of waste, as combustion. Chemical composition is used in design of landfill. The important properties to be known are:

Proximate analysis

Fusing point of ash

Ultimate analysis

Energy content

For design of landfill it is defend ultimate analysis and energy contest.

Ultimate analysis of solid waste

It is determined percentage of C(carbon), H(Hydrogen), O (oxygen), N(nitrogen) , S(sulfur). The result is used to define composition of MSW and used on differences design process

Table 6. composition of MSW and used on differences design process

	Percent By weight (dry basis)					
Organic	carbon	Hydrogen	Oxigen	Nitrogen	Sulfur	Ash
Food waste	48,0	6,4	37,6	2,6	0,4	5,0
Paper	43,5	6,0	44,0	0,3	0,2	6,0
Card board	44,0	5,9	44,6	0,3	0,2	5,0
Plastics	60,0	7,2	22,8			10,0
Textiles	55,0	6,6	31,2	4,6	0,2	2,5
Rubber	78,0	10,0		2,0		10,0
Leather	60,0	8,0	11,6	10,0	0,4	10,0
Yard Wastes	47,8	6,0	38,0	3,4	0,3	4,5
Wood	49,5	6,0	42,7	0,2	0,1	1,5
Mics. Organics						
Inorganic						
Glass	0,5	0,1	0,4	0,1		98,9
Tin Cans	4,5	0,6	4,3	0,1		90,5
Aliminum	4,5	0,6	4,3	0,1		90,5
Other Metal	4,5	0,6	4,3	0,1		90,5
Dirt,ashect.	26,3	3,0	2,0	0,5	0,2	68,0

Source: Tchobanoglous (1993)

2.2.4 Energy content of solid waste components

The characteristic of waste defined the designs of installations and recovery.

If it can be not have information about energy content with analysis, it can be used approximate chemical equation to calculate energy content

2.3 Types of Landfills

The two groups of landfills are natural attenuation and landfills and containment landfills. Landfills attenuation, their study is of interest to know the natural processes that occur inside, thus we can know the importance of control of system. Besides, the specific case of landfills in abandoned quarries study.

Attenuate and disperse landfills

Older designs where the site is unlined and there is uncontrolled release of leachate and landfill gas to the environment. The movement of leachate is allowed away from the site the surrounding environment over a long period of time so that the leachate is diluted, reduced in toxicity and dispersed (Willianms, 1998). It is old system that is not built at present. It allow infiltration this document has not aims to explain attenuate and disperse landfills, see (Varquero Diaz, 2003; Willianms, 1998) to more information.

Containment landfills

Containment Landfills were beginning in the Unite State (EEUU) with (APA) created, because of waste accumulation and poor image. Leachate and landfill gas are contains for a liner material. The degradation processes take places within landfills mass until stabilization is complete.

Three are other types of containment landfills how co-disposal landfills, entombment landfills, sustainable landfills (Willianms, 1998). Co- disposal landfills are the disposal of industrial and commercial wastes, which may be solid or liquid form may be hazardous, with bioactive waste such as municipal solid waste. Entombment landfills aims to contain the waste by preventing biodegradation and the formation of leachate and landfill gas. Sustainable landfills; this treats the landfill site as a controlled bioreactor rather than an uncontrolled biodegradation process. The stabilization can be in 30-50 years.(Willianms, 1998). The biodegradation is accelerated as a controlled bioreactor. Thus leachate is recirculated to accelerate.

Landfills which are built underground have some advantages

- It is increased storage capacity per unit area
- Land has been excavated which may be used for liner
- Other constructions can use closing landfill.
- Stability and erosion are not critical to long-term
- The disadvantages will need leachate pumping and there are limitation with the water table.

2.3.1 Site selection

The location of landfill is vital importance to miss environment impacts. This location must keep in mind some aspect.

- It must optimize the distance between origin and place of disposal.
- Good support and waterproofing
- Obey the law. it is important aspect draw up a short list of appropriate locations. Thus, we avoid unnecessary costs (Tchobanoglous, Thisen, & Vigil, 1993).

The public opinion is an important aspect besides geotechnical and economic judgment. Then the choice will be in stages. Finally we have one or two locations that will be studied deeply. There are maps and information which we need it for the study. These can be:

- Topographic maps
- Geological maps
- Hydrogeological studies
- Ground use maps
- Road maps
- Water usage maps
- Swelling maps
- Aerial photographs

- Type and volume of waste
- Information collection and management of waste

These studies give us the information to settle lining and inside seal, environmental and health impact, help to design and monitoring impact programmer. The information allows an assessment of soil and bedrock grain sizes mineralogy and permeability, and groundwater levels. In addition, the previous use of the site, meteorological data, transports infra-structure assesse. A topographical survey is undertaken to calculate the available void space and therefore the waste capacity of the site. Location and design are important to do the closure. Meaning, the use that we will give the location; it will be one design criteria of landfill.

Varquero Diaz (2003) In his book explain criteria for the choice of siting, they are:

- Stage of ruling out
- Stage of delimiting
- Stage of valuation

2.4 LINER

2.4.1 Landfill liner materials

We must study which is the best material for system about economic and useful. There are a great variety of natural and synthetic mineral materials and synthetic materials which are used in the construction of landfill containment site. Type waste will be one parameters to design, furthermore the geological and hydrogeological conditions in the surrounding environment, the prediction of the properties of the derived leachate and the resistance of the liner to the leachate (Willianms, 1998).Permeability is a factor that said us which type of liner material used, which is measured as Hydraulic conductivity.

Depending on the applicable local, state, or European regulations, landfills may be designed with single, composite, or double liner. A single liner is constructed of clay or a geomembrane. A composite liner, which is the minimum liner required by RCRA subtitle D, consisted of two layers; the bottom is a clay material and the top layer is a geomembrane. The two layers of a composite liner are in intimate contact to minimize leakage. A double liner may be either two single liners or two composite liners. It must be install a leachate collection systme on liner.The geosynthetic clay liner has been introduced for use as the top component in the double liner system.

2.4.2 Geologic liner

Clay is type of land which have particles are same or minor than 0,002mm. Its granulometric curve is S form, thus its permeability is down, for this is suitable to be natural liner. Then the fine grain size means that porosity is also extremely low and consequently permeability is very low. The clay is normal use in because; it's economic, big capacity for attenuation of leachate. The clay soil reduced the movement of contaminate element by reduced the hydraulic conductivity (Varquero Diaz, 2003). In addition, in situ clay may be utilized as the underlying material of the landfill of the local geological environment lends itself to this choice of site selection, the clay acting as a further low permeability barrier beneath the liner system. When situ clay is used as a design barrier, it is studied completely its properties as such potential inhomogeneities in the clay strata , in this case, it is excavated and re-laid. Normally, layer is formed with natural clay liner in landfill sites and to be compacted into layer of between 0.6 ad 1.0 thick (Willianms, 1998). The factors which can affect the usability and performance of a particular clay soil in its use in a landfill liner system include porosity and permeability, which in turn depend on clay mineralogy, particle size distribution, plasticity,strength, moisture content and compaction.

In construction of liner, the compaction of soil produce changes in mechanical property. in this fact, permeability is influenced for diameter small pores and tortuosity:

$$K = \frac{1}{k_0 \times T_f^2 \times S_0^2} \times \frac{e^3}{1+e} \times \frac{\gamma}{\mu}$$

Where:

K= coefficient permeability

K_0=factor of pore shapes

T_f= Tortuosity factor

S_0=surface per unit volume of the particle

e=empty relation

ϒ= unit weight of liquid

μ= liquid viscosity

Source:Varquero Diaz, (2003)

Hydraulic conductivity (Permeability)

Darcy´s law is an empirical law describing the flow of a fluid though a porous material. The law relates the flow rate of the fluid to a cross-sectional area of the porous material and the hydraulic gradient by way of a contant, the coefficient of permeability.

$$Q = KiA$$

Q= Flow rate

K = coefficient of permeability, permeability or hydraulic conductivity

i = hydraulic gradient (the pressure difference between the top and bottom of the layer of material)

A =Cross- Sectional area

Hydraulic conductivity or permeability therefore represents the aese with which a fluid such as leachate will flow through the liner material. The units of measurement are typically cm/s or m/s. Typical hydraulic coductivities of natural and synthetic or processed materials and waste are given below.

Table 7. Typical hydraulic conductivities

Material	Hydraulic conductivity(permeability)
Naturals materials	
Well-graded, clean gravels, gravel-sand mixture	$2 x10^{4}$
Poorly graded, clean sands, gravely sands	$5 x10^{-4}$
Silty sands, poorly graded, sand-silt mixture	5 x10-5
Inorganic silts and clayey silts	$5 x10^{-8}$
Mixture of inorganic silt and clay	$2 x10^{-9}$
Inorganic Clay of high plasticity	$5 x10^{-10}$
Syntheticirpoecessedmatreials	
Compacted clay liner	$1 x10^{-8}$
Bentonite-enhaced soil	$5 x10^{-10}$
Geosynthetic clay liner	$1 x10^{-10}$
Flexible membranes	$1 x10^{-13}$
Geotextile	$1 x10^{-4}$
Geonet	$2 x10^{-1}$
Waste	
Municipal soild waste as placed	$1 x10^{-5}$
Shredded municipal solid waste	$1 x10^{-4}$
Baled municipal solid waste	$7 x10^{-6}$

Sources: Willianms, 1998

There are other pores more important, cleft. For this, the compaction is indispensable in natural liner. Optimus moisture content is decisive, because it is related with soil texture and permeability. Thus, if soil humidity is high, clay provides dispersed texture and permeability low.Optimus moisture content is determined by a standard test which produces a maximum dry density when a clay soil is compacted liners which are slightly wetter than the optimum moisture content, in which case care must be taken to stop this water from migrating away.

Table 8. Permeability and optimus moisture of deferments soil.

Symbol	Coefficient permeability(cm /s)	Optimus moisture%
GW	$2 x 10^{-2}$	11-8
GP	$5 x 10^{-2}$	14-11
GM	$>5 x 10^{-7}$	12-8
GC	$>5 x10^{-8}$	14-9
SW	$>5 x10^{-4}$	16-9
SP	$>5 x10^{-4}$	21-12
SM	$>2 x10^{-5}$	16-11
SM-SC	$>1 x10^{-6}$	15-11
SC	$>2 x10^{-7}$	19-11
ML	$>5 x10^{-6}$	24-12
ML-CL	$>2 x10^{-7}$	22-12
CL	$>5 x10^{-8}$	24-12
OL		33-21
MH	$>2 x10^{-7}$	40-24
CH	$>5 x10^{-8}$	36-19

Generally, the appropriate soil to be liner may have percentage of fines between 40%-50%, plastic rate between 10%-30%, limit liquate between 25%-30% and clay content 18%-25%. (Varquero Diaz, 2003)

The material is excavated and then it is blended to form a homogeneous material. The material is excavated from the source site and blended to form a homogeneous material. Sometimes, it may necessary to sieve and move large rocks. The material is transported an spread by bulldozers and scrapers at the site, then is compacted by large roller vehicles to form a more homogeneous layer.

We will do laboratory test to know reaction of soil with leachate. Polluting substance can change property clays. It occur for

Dissolution of soil mineral

Change of structure clay

Precipitation

2.4.3 Betonies-enhanced soil

When the naturally occurring clay soil does not have a low permeability, bentonite clay is added to form a bentonite-enhanced soil. Bentonies is a mixture of clay minerals, preincipally of montmorillonite type.

Bentonite-enhanced soil will have lower permeabilities when mass of waste builds up in the overlying landfill because it further swell under pressure To ensure the formation of homogeneous low permeability, bentonite quantity must be suitable, for example, if it used sodium bentonite is added at between 5 and 15 % but if it used calcium bentonite quantity will be greater because of swelling properties. in addition, It is mixed and the moisture content is adjusted to produce the lowest permeability

2.4.4 Geosynthetic liner materials

There are some materials which, is apply in sheet, it is used in liner landfills

- Geomembranes
- Geotextiles
- Geonets
- Waterproofing Geosynthetic
- Draining geosynthetic
- Geogrid

2.4.5 Geomembranes or flexible membrane

Geomembranes are polymers with additive and with extremely low permeability. It is suitable material for liner, also economic and chemical tolerance. The membranes come in sheets or rolls ranging from 5 to 15m wide and up to 500 m in length, and range in thickness typically from 0, 75 mm to 3, 00 mm. There are a range of properties which define the suitability for use of the various membranes in landfill applications, including density, tensile strength, puncture resisteance, tear resistance, resistance to ultraviolet light and ozone and chemical resistance (Willianms, 1998).Membrane chemical resistance is very important.

High density polyethylene (HDPE) is polyethelene the most used because its hydraulic conductivity is really low.

Table 9. Value of Characteristic

	unit	Rule	Value
Thickness	Mm	UNE53.221	1,5
Density	g/cm3	UNE53.020	>0,94
Melt flow index	g/10min	UNE53.200	0,5
Carbon black content	%	UNE53.375	2,5±0,5
Ash content	%	UNE53.375	0,05
Dispersion of carbon black	-	UNE53.131	4
Hadness shore D		UNE53.130	60±5
Bending at low Temperature	-	UNE53.358	Ok
Resistance percussion	-	UNE53.358	Ok
Tensile yield strength traction Elongation		UNE104.300	
Traction strength	MPa		35
Limiete elastic	MPa		17
Elongation at break	%		800
Elongation at yield	%		17
Perforation strength		UNE104.104	
Perforation strength	N/mm		>15
Walk	mm	UNE53.358	
Accelerated articial aging		UNE53.358	<15
Alargameinto at break	%	UNE53.358	140
Tear strength	N/mm	UNE104.358	2
Heat resistance	%	UNE53.358	
Thermal aging		UNE53.358	
Elongation at break	%		<15

Source:Varquero (2003)

In function of lining, geomembranes are placed under wastes to minimize risk of leachate leak. It avoids pollution aquifer. In function of covering, geomembranes are placed over final situation to avoid percolation of precipitation. In addition, it is used under others buildings to avoid risk with leachate and gas. Strongarea are lined with HDPE but it is low useful life.

2.4.6 Geotextiles

It is flat textile which is permeable, for this reason it is not used for containment. It is used for protection for polymer plastic membranes and filtration material to filter out fine-grained particles from the leachate.

We can differentiate between four functions of geotextiles that are protection, filter, drain, support (Varquero Diaz, 2003)Like protection, it may avoid punching shear with soil in that case, geotextile must be set up correctly. TABLA.like filter, its function will be avoided the silting. The Geotextile will be used, it depend on waste and quantities of waste, besides of surrounding.TABLA. Like drain, it is secondary function and if it need more draining, it is installed draining geosynthetic.

Table 10. Minimum required value for protection geotextile

Characteristic	unit	Rule	Value
Thickness under 2KN/m2	mm	EN 964	3
Resistance percussion CBR	N	EN ISO 12236	2000
Traction strength	KN/m	EN ISO10319/1	20
Elongation at break	%	EN ISO 10319/1	80

Source: Varquero(2003)

Table 11. Minimum required value for filtre geotextile

Characteristic	unit	Rule	Value
Thickness under 2KN/m2	mm	EN 964	1.3
Resistance percussion CBR	N	EN ISO 12236	1500
Traction strength	KN/m	EN ISO10319/1	9
Elongation at break	%	EN ISO 10319/1	60

Soruce: Varquero(2003)

Geonets

Geonets are porous sheets of plastic netting used as drainage layers to carry leachate or landfills gas. The main are of Geonets is drainage , and they are used as alternatives to naturally well-drained materials such as course sands or gravels, but require less thickness to achieve the same effectiveness.

2.4.7 Draining geosynthetic.

It is union on Geonets with geotextile to make material filtering.

2.4.8 Geogrid

It is polymeric sheets structures which are used on physical contact with soil or other materials.it is used to reinforce soil. Their important characteristics are traction and elongation.

2.5 Landfill Gases

A solid waste landfill can produce gas landfill and leachate as the principals outputs, it can be conceptualized as a biochemical reactor. Landfill gas is a product mainly of the methanogenic stage of degradation of biodegradable wastes. It is a saturate compost of methane and carbon dioxide and other elements. This gases can be moved and be dangerous for explosion. In addition, gases can be used to produce energy or can be flared under controlled conditions to eliminate the discharge of harmful constituents to the atmosphere. Global Climate change and odors are targets to reduce with capturing LFG.

There are aspects which have influence about quantity of gas. These aspects are such as , waste composition, fraction of biodegradable material , moisture content, nutrients content; especial operation, leachate recirculation, liner system, etc; and weather .

Some factors are considered as important fact in order to gas collection.

- Covered daily: it is decreased free circulation of gases
- Liquid waste: it make difficult on circulation of gases
- Vertical circulation of liquid: it make difficult on circulation of gases
- Scarce depth: air gets into landfill during pumping.
- permeability liner:

Capping system has different problems, the principals problems are:

- the extraction may be difficult conditions, because of settlement and breaking installation
- Obstruction of pipes for condensate
- gases Pumping
- Water and air in the system , because of suction
- Breaking pipes and getting in site of air

2.5.1 Composition and Characteristics of Landfill Gas

Decomposition the organic fraction is source of principal landfill gases. The principles gases are methane and carbon dioxide which are odorless. The minor components such as organic esters, sulphide give landfill gas a malodorous smell. It typical percentage distribution of gases found in a MSW landfill in reported in table12 and data on molecular weight and density are presented in TABLE13

Table 12. Typical Constituents Found in and Characteristics of Landfill Gas

Component	Percent (dry volume basis)
Methane	45–60
Carbon dioxide	40–60
Nitrogen	2–5
Oxygen	0.1–1.0
Ammonia	0.1–1.0
Sulfides, disulfides, mercaptans, etc.	0–1.0
Hydrogen	0–0.2
Carbon monoxide	0–0.2
Trace constituents	0.01–0.6
Characteristic	**Value**
Moisture content	Saturated
Specific gravity	1.02–1.06
Temperature, °F	100–160
High heating value, Btu/std ft^3	475–550

Source:Tchobanoglous (1993)

Table 13. Molecular Weight and Density of Gases Found in Sanitary Landfill at Standard Conditions (0°C, 1 atm)

Gas	Formula	Molecular weight	Density	
			g/L	lb/ft^3
Air		28.97	1.2928	0.0808
Ammonia	NH_3	17.03	0.7708	0.0482
Carbon dioxide	CO_2	44.00	1.9768	0.1235
Carbon monoxide	CO	28.00	1.2501	0.0781
Hydrogen	H_2	2.016	0.0898	0.0056
Hydrogen sulfide	H_2S	34.08	1.5392	0.0961
Methane	CH_4	16.03	0.7167	0.0448
Nitrogen	N_2	28.02	1.2507	0.0782
Oxygen	O_2	32.00	1.4289	0.0892

Note: For ideal gas behavior, the density is equal to mp/RT where m is the molecular weight of the gas, p is the pressure, R is the universal gas constant, and T is the temperature.

Source: Tchobanoglous(1993)

Landfill gas can be explosive because of its components which are flammable. When these components are mixed with air in good condition (5 to 15 percent methane) will be explosive (Tchobanoglous, Thisen, & Vigil, 1993). The concentration of these gases that may be expected in the leachate will depend on their concentration in the gas phase in contact with the leachate, as estimated using Henry´s law. Because carbon dioxide will affect the pH of the leachate, carbonate equilibrium data that can be used to estimate the pH of the leachate.

2.5.2 Generation of Landfill Gases

The generation of the principal gases is thought to occur in five more or less sequential phases, as illusted FIG 2.

Phase I- initial adjustment. In first phase, there is microbial decomposition as after disposal. The source of both the aerobic and the anaerobic organism responsible for decomposition. It is produce aerobic decomposition because there are air trapped within the landfill.

Phase II- trasition phase. Oxygen is depleted and anaerobic conditions begin to develop. Nitrate and sulfate are reduced to nitrogen gas and hydrogen sulfide. If there is leachate, its pH starts to drop due to present organic acids and concentration of CO2 is elevated.

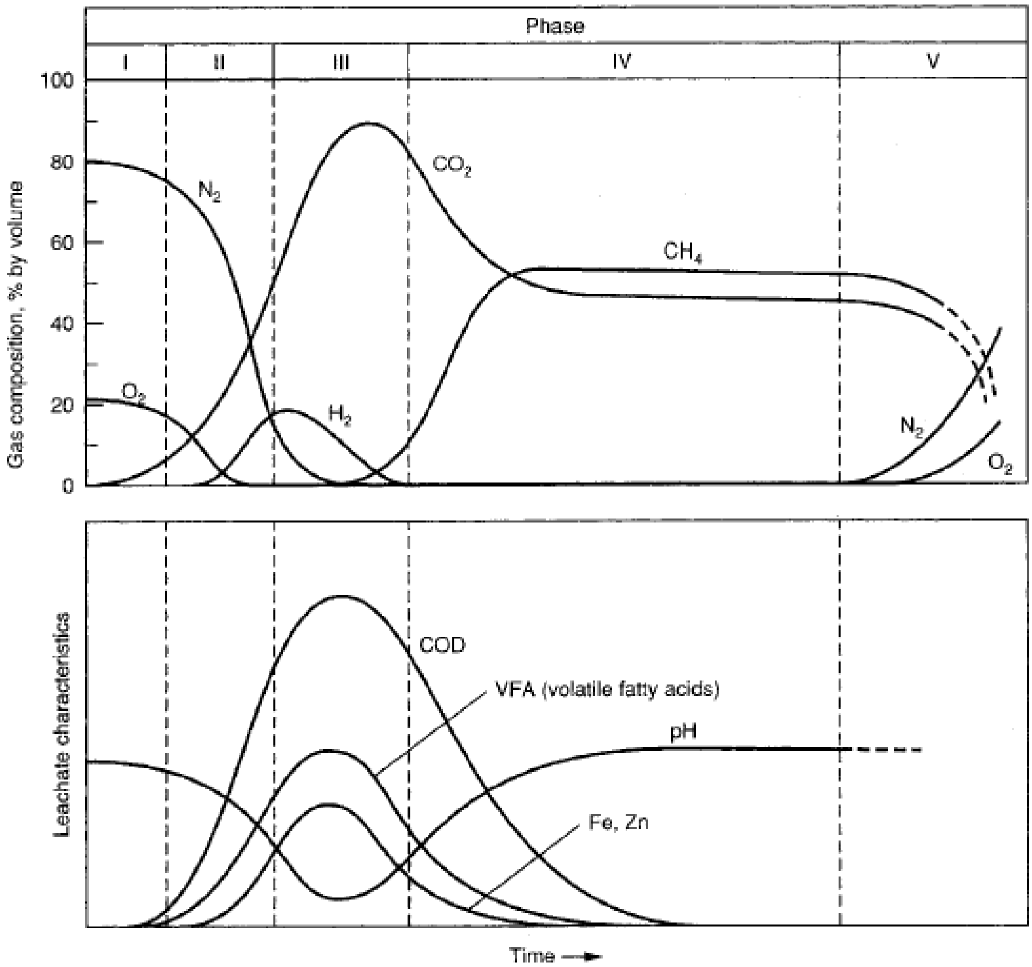


Figure 2. Generalized phase in the generation of landfill gases (I- Initial Adjustment, II – Transition Phase III – Acid Phase IV- Methane Femrnation, and V Maturation Phase). Source: Tchobanoglous, G., Thisen, H., & Vigil, S. A. (1993). Integratede Solid Waste Management:engeneerng Principles and Management Issues. Mcgrauw-Hill.

Source: Tchobanoglous (1993)

Phase III—Acid Phase.

In Phase III, known as the acid phase, the bacterial activity initiated in Phase II is accelerated with the production of significant amounts of organic acids and lesser amounts of hydrogen gas.The first step in the three-step process involves the enzymemediated transformation (hydrolysis) of higher-molecular-mass compounds (e.g., lipids, organic polymers, and proteins) into compounds suitable for use by microorganisms as a source of energy and cell carbon. The second step in the process (acidogenesis) involves the bacterial conversion of the compounds resulting from the first step into lower-molecularweight intermediate compounds as typified by acetic acid (CH3COOH) and small concentrations of fulvic and other more complex organic acids. CO2 is the principal gas generated during Phase III. Smaller amounts of hydrogen gas (H2) will also be produced.The microorganisms involved in this conversion, described collectively as nonmethanogenic, consist of facultative and obligate anaerobic bacteria.These microorganisms are often identified in the literature as acidogens or acid formers.

Phase IV—Methane FermentationPhase. Group of microorganisms which converts the acetic acid and hydrogen gas fromed by the acid formersin the acid phase to methane and CO2, become mor predominant. These microorganisms are anaerobic and are called methonogenic.

As acids and h2 are converted CH4 and CO2, pH of leachate will rise to more neutral values (6-8).

Phase V—Maturation Phase. Phase V, is begin after organic material has been converted to CH4 and CO2. Portions of the biodegradable material that were previously unavailable will be converted.

Duration of Phases.

The duration of the phases in the production of landfill gas will vary depending on the distribution of the organic components in landfill, the availability of nutrients, the moisture content of waste, moisture routing through the waste material, and the degree of initial compaction. Typical data on the percentage distribution of principal gases found in a newly completed landfill as a function of time are reported in Table 14.

Table 14. Avarage percent by volume

Time interval since cell completion, months	Average percent by volume		
	Nitrogen, N_2	Carbon dioxide, CO_2	Methane, CH_4
0–3	5.2	88	5
3–6	3.8	76	21
6–12	0.4	65	29
12–18	1.1	52	40
18–24	0.4	53	47
24–30	0.2	52	48
30–36	1.3	46	51
36–42	0.9	50	47
42–48	0.4	51	48

Source: Tchobanoglous(1993)

Gas Production

The volume of gas produced and recovered need ideal condition of constant of moisture, besides of hydrologic condition. It is important besides of the compositon of the gas sucha as, percentage methane, moisture content. Mathematical and computer models for predicting gas yelds are based on population, per capita generation, waste composition and moisture content, percent actually landfilled, and expected methane or landfill gas yielf per unit dry weight of biodegradable waste. It used approximate quemical formula for calculate gas production. This formula has form $CaH_bO_cN_d$,and it is supposed full conversion of organic waste to CH4 and CO2.

In theory the biological decomposition of one ton of MSW produces 442 m3 of landfill gas containing 55% methane(CH4) and a hat value of 19,730 kJ /m3. (Aarne Vesilind, Worrell, & Reinhart, 2002)

The following equation describe the general anaerobic transformation of the organic portion of the solid waste placed in a landfill.

$$Organic\ matter + H2O + nutrients \rightarrow new\ cells + resistant\ organic\ matter + CO2 + CH4 + NH3 + H2S + heat$$

If Organic matter and resistant organic matter are represented one generalized form, $C_aH_bO_cN_d$, and assuming methane, carbon dioxide, and ammonia are the principal gases that are produced.

$$C_aH_bO_cN_d + \left(\frac{4a-b-2c+3d}{4}\right)H_2O \rightarrow \left(\frac{4a+b-2c-3d}{8}\right)CH_4 + \left(\frac{4a-b+2c+3d}{8}\right)CO_2 + dNH_3$$

****

Source :Tchobanoglous,(1993)

Gas production has variation with time. Generally, it can divide organic matter into two part, classifications: (1) those materials that will decompose rapidly (3 months to 5 years) and (2) those materials that will decompose slowly (up to 50 years or more)(see figure 3). The overall rate of decomposition will depend on the organic components in landfill, the availability of nutrients, the moisture content of waste, the routing of moisture through the fill, and the degree of initial compaction. It is produced a peak within the first year, and slowly tapers off, for gas produced from rapidly decomposable material. When material is slowly decomposable, a peak will be 5 year after deposited.

It is used a triangular model where altitude is peak rate of gas production and the total gas produced is shown with triangular area. It is calculate rate of gas production and gas production during one year according to figure 3.

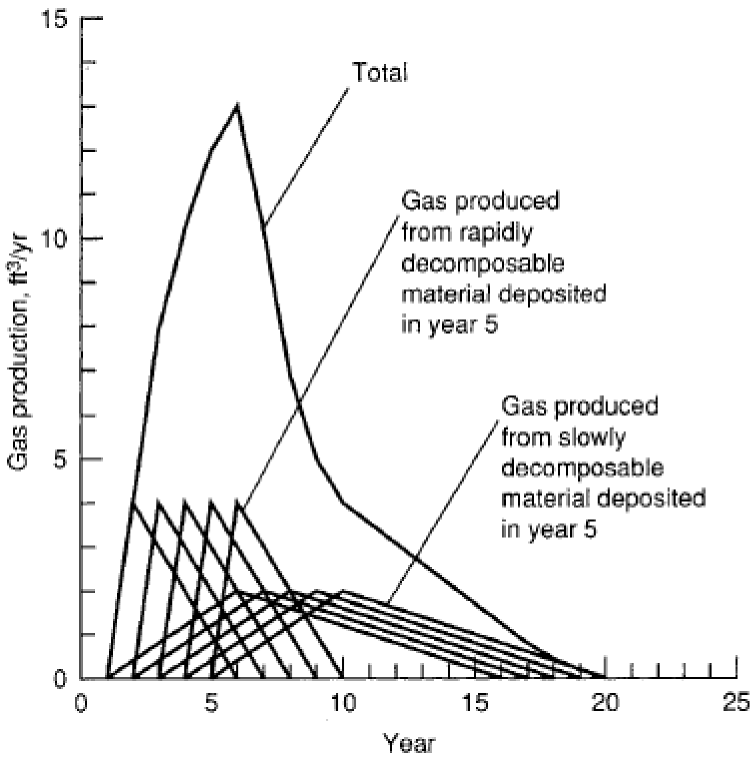


Figure 3. Graphical representation of gas production over a 5 year period from the rapidly and slowly decomposable organic material placed in a landfill.

Source: Tchobanoglous (1993)

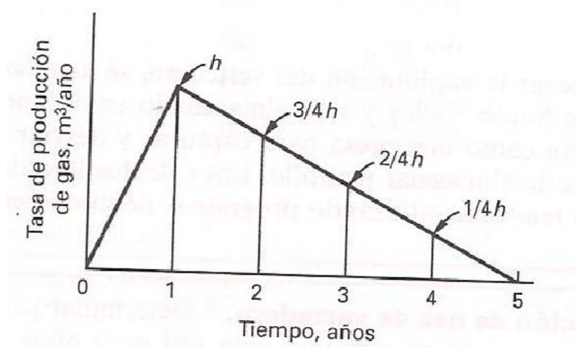


Figure 4. Triangular model about rate production

The moisture is necessary in anaerobic decomposition. If moisture is insufficient to allow for the complete conversion of the biodegradable organic constituents, the gas production will present other form. Therefore, the duration of gas production is longer that if moisture is optimus. An example of the effect of reduced moisture content on the production of landfill gas in illustrated in FIG 5.

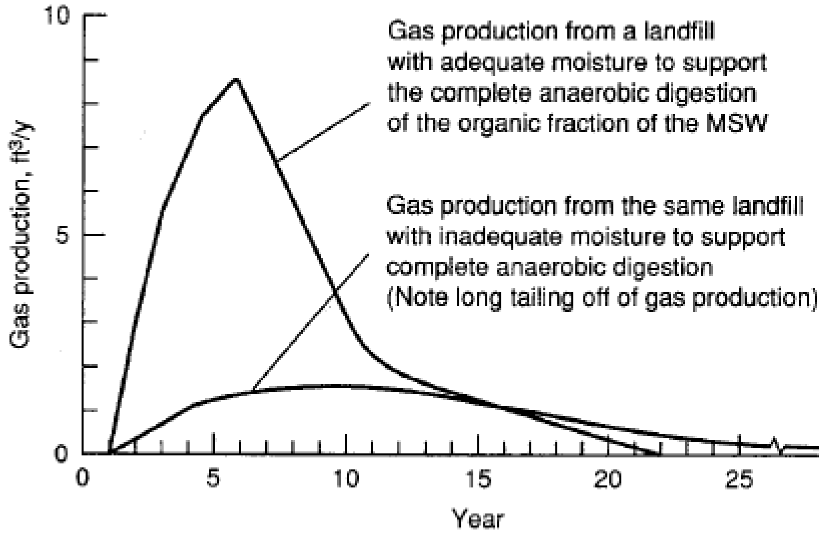


Figure 5. Effect of reduced moisture content on the production of landfill gas.

Source: Tchobanoglous (1993)

2.6 Leachate

Leachate may be defined as liquid that percolated though solid waste and has extracted dissolved (Tchobanoglous, Thisen, & Vigil, 1993). The composition of the leachate will depend on the heterogeneity and composition of the waste, the stage of biodegradation reached by the waste, moisture content and operational procedures. In most landfills leachate is composed of the liquid that has entered the landfill from external sources, such a as surface drainage, rainfall, groundwater, and water from underground springs and the liquid produced from the decomposition of the wastes. Leachate system has as an objective to capture leachate and transport it to treatment plant. This system must avoid that leachate arrive at liner.

2.6.1 Composition of Leachate

The precipitation is percolate and is mixed with different components of the waste. In landfill, organic material is undergoing decomposition, water also percolates through solid waste and chemical constituents are leached into solution. In addition to make of liquid product in process chemical and biological in the waste. The characteristics of leachate are influenced by the waste material deposited in the site. The decomposition rate of the waste also depends on aspects such as pH, temperature, aerobic or anaerobic conditions, and the associated types of micro-organisms. Representative data on the characteristics of leachate are reported in table ***. Typical physical, chemical, and biological monitoring parameters that are used to characterize leachate are summarized in table

Table 15. Typical data on the composition of leachate from new and mature landfills

Constituent	Value, mg/L*		
	New landfill (less than 2 years)		Mature landfill (greater than 10 years)
	Range†	Typical‡	
BOD_5 (5-day biochemical oxygen demand)	2,000–30,000	10,000	100–200
TOC (total organic carbon)	1,500–20,000	6,000	80–160
COD (chemical oxygen demand)	3,000–60,000	18,000	100–500
Total suspended solids	200–2,000	500	100–400
Organic nitrogen	10–800	200	80–120
Ammonia nitrogen	10–800	200	20–40
Nitrate	5–40	25	5–10
Total phosphorus	5–100	30	5–10
Ortho phosphorus	4–80	20	4–8
Alkalinity as $CaCO_3$	1,000–10,000	3,000	200–1000
pH	4.5–7.5	6	6.6–7.5
Total hardness as $CaCO_3$	300–10,000	3,500	200–500
Calcium	200–3,000	1,000	100–400
Magnesium	50–1,500	250	50–200
Potassium	200–1,000	300	50–400
Sodium	200–2,500	500	100–200
Chloride	200–3,000	500	100–400
Sulfate	50–1,000	300	20–50
Total iron	50–1200	60	20–200

Source:Integrate Solid waste Managament: engineer Principals and Managament issues, Tchobanoglous et al 1997

Chemical composition of leachate will vary depending on the age of landfill and the events proceeding the time of sampling. For example, if a leachate sample is collected during the acid phase of decomposition, the pH calue will be low and the concentrations of BOD5, TOC,COD, nutrients, and heavy metals will be high. If, on the other hand, a leachate sample is collected during the methane fermentation phase, the pH will be in the range from 6.5 to 7.5 and the BOD5, TOC, COD and nutrient concentration values will be significantly lower. The pH of the leachate will depend not only on the concentration of the acids that are present but also on the partial pressure of the CO2 in the landfill gas that is in contact with the leachate.

A water balance on the landfill may indicate the potential for the formation of leachate. (Tchobanoglous, Thisen, & Vigil, 1993). The water balance involves summing the amounts of water entering the landfills and subtracting the amounts of water consumed in chemical reactions and the quantity leaving as water vapor. The quantity of water the in excess of moisture-holding capacity of landfills material will be leachate quantity which is due to treat.

The componests that make up the water balance for a landfill cel are identified in FIG***. The principal sources include the water entering the landfill cell from aboce, the moisture in the solid wate, the moisture in the cover material, and the moisture in the sludge, ing the disposal of sluge is allowed. The principal sinks are the water leaving the landfill as part of the landfill gas, as satured water vapor in the landfill gas, and as leachate.

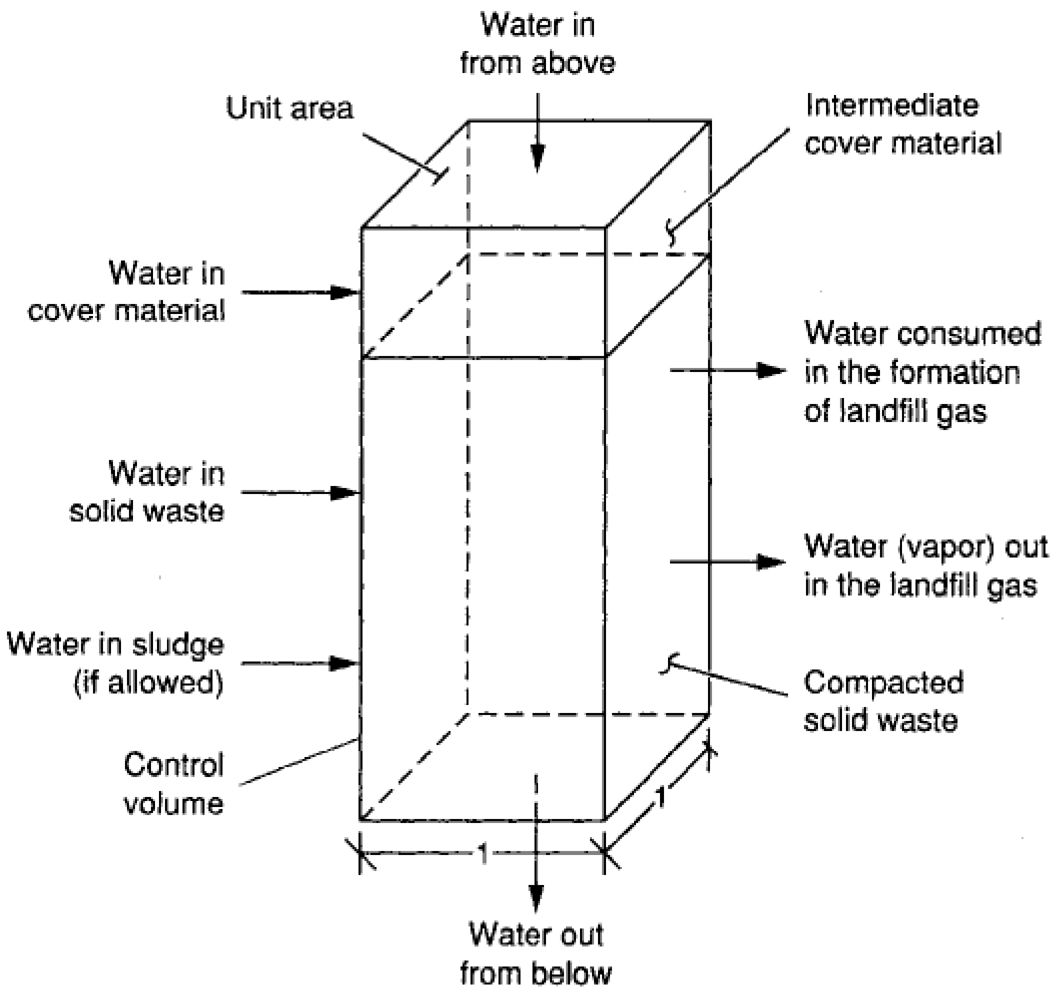


Figure 6. Definition sketch for water balance used to assess leachate formation in a landfill. Source (Tchobanoglous, Thisen, & Vigil, 1993).

Source: Tchobanoglous (1993)

Water entering from above. For the upper layer, the precipitation has percolated through the cover material. The water has percolated through the solid waste of the layer below the upper layer, this water come from percolation form the upper layer. One of the most critical aspects in the preparation of a water balance for a landfill to determine the amount of the rainfall that actually percolates though the landfill cover layer.

Water entering in solid waste. The water entering the landfill with the waste materials is that moisture inherent in the waste material as well as moisture that has been captured in transport and condition of the storage(rainfall, atmosphere..) . There is variability of the moisture content during the wet and dry seasons, it may be to do a series test.

Water entering in cover material. The amount of water entering with the cover material will depend on the type and source of the cover material and the season of the year.

Water leaving from below. Water leaving from the bottom of the cell place directly over the intermediate leachate collection system is termed leachate.

Water consumed in the formation of landfill gas. The anaerobic decomposition of the organic constituents in MSW need waster, the water is consumed. Calculation of water consumed can be estimated using below formula.

Example;

$$C_{68}H_{111}O_{50}N + 16H_2O \rightarrow 35CH_4 + 33CO_2 + NH_3$$

The mass of water consumed per pound of dry rapidly biodegradable volatile Solids (RBVS) destroyed is

Water cosumed $=\frac{288.0}{1741.0} = 0.165\ kg\,\frac{H_2O}{kg}\,RBVS\ destroyed$

If there are 223.61 Kg/m3 RBVS destroyed, it will be 7.3789 kg H_2O/m^3

Water lost as water vapor. When landfill gas is saturated in water vapor, water vapor is escaped of landfill.

Other Water losses and gains. During disposal, other water losses which it can be considered or not, such as evaporation. This depend of author

Landfill field capacity. The potential quantity of leachate is the amount of moisture within the landfill in excess of the landfill FC.

2.7 Settlement characteristics of landfills

Settlement is produced by decomposition and increasing overburden mass. Decomposition produce leachate and gas for this reason landfill lost weight and volume. In addition, water percolates into and out of landfill produce settlement. This effect is important for installation of landfill as gas recovery.Effect of waste decomposition can be lost 30-40% of original volume. Effect of overburden pressure can change the specific weight of the material placed in the landfill. The maximum specific weight of solid waste residue in a landfill under overburden pressure will vary from 1.000 to 1.300 kg /m3. The following relationship can be used to estimate the increase in the specific weight of the wste as a function of overburden pressure;

$$SW_p = Sw_i + \frac{p}{a + b * p} \tag{1}$$

Where;

SW_p=specific weight of the waste material at pressure p, kg/m3

SW_i=Initial compacted specific weight of waste kg/m3

P= overburned pressure, kg/m2

a= empirical constant, m3,kg/m2

b=empirical constant,m3/kg

the extent of settlement depend on the initial compaction, the characteristics of the waste, the degree of decomposition, the effects of consolidation when water and air are forced out the compacted solid waste, and the height of the completed fill. in the first five years settlement is done 90 percent of total.

Chapter 3. Sellent Landfill

The landfill has direct method of disposal ,so mass disposal. The waste trucks put inside with specific weight of 700kg/ m3 (Tchobanoglous, Thisen, & Vigil, 1993). This alternative has not recovery and recycling management, only selective collection (12%) (Generalitat Valenciana, 2010).

3.1 Geometric Design of landfill

It is calculated the geometric design with topographic plan(.dwg). the calculations have been done by AUTOCAD Civil 3D 2012®. The results are :

Excavation	
Cutting	1.437.285 m3
Embankment	38.489 m3
Gross Capacity	3.174.794 m3
Net Capacity	2.600.000 m3

See ANEXO I,Plans.

3.2 Site and land features

Sellent is a district of Valencia, Spain. It is south of Valencia(61km). The Sellent landfill is located in an area of conifers and dry farming, the area is steep with ravine that end in Sellent river. Landfill is located in Camí del Realenc and Barranco de Carles. Tosasal de la Font in the West and La Font del Pinar and motorway in the East.

The highest elevation of the landfill area is lower 100 and more.180 UTM coordinates referred to the approximate geographic center of the discharge area are:

X=710535.21 m E

Y=4323612.49 m N

Figure 7. Localization of landfill(1)

Figure 8. Localization of landfill(2)

Figure 9. Localization of landfill(3)

This localization has not protégé area (RED 2000, wetland, ZEPA). It is around the hilly area and inside a depression. For this reason, it is an ideal area because it is not appreciable for other nearly areas. Consequently, this project will get an important drain system to avoid run-off.

3.2.1 Access

The area is accessible from motorway,A7, exit to Sellent and after directo road to landfill, before sellent. This road leads to the facility where the spill controls area. The route from the intersection belongs to the landfill project (Geoportal).

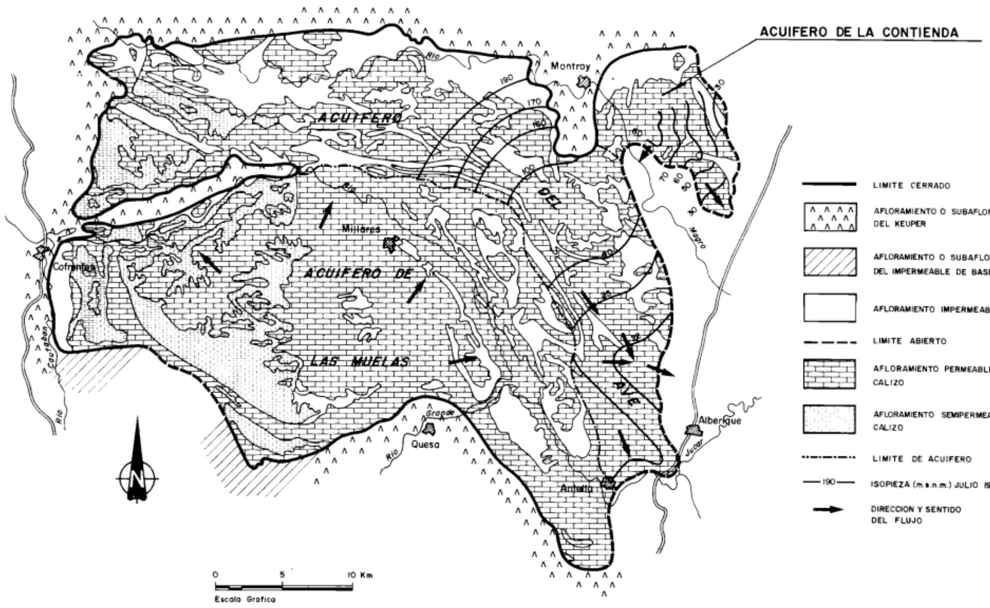
3.2.2 Geology

From a typological point of view the area is dominated by Mesozoic Triassic materials system in the typical average number Keuperfacies. Clay predominates with gypsum, besides there are marl and sandstone. In the closest areas are dolomites and limestone (Geoportal) (Ministerio de Agricultura) (Visor cartografico Generalitat Valenciana).

3.2.3 Hydrogeology

In the area, phreatic level is deep. The landfill will get control piezometers, one at head of landfill and other one in the point close of landfill. The study area belongs from a hydrogeological point of view, Caroch aquifer system, System No. 52, and within this the subsystem "North Caroch" 52.3 specifically provided in the subsystem limit in the southern part (Geoportal) (Visor cartografico Generalitat Valenciana).

Figure 10. As shown in the figure is in a permeable limestone area



Source: Instituto Geologico y Minero

3.2.4 Vegetation

After studying the biota of Sellent and in terms of flora, plant species that deserve some form of protection or t which one are already mainly in the environment of Pinar / scrub, composed of sensitive species Silenediclinis, Chamaeropshumilis, Sideritistragoriganum subsp. tragoriganum, Teucriumpseudochamaepytis, Teucriumhomotrichum, Teucriumcapitatum subsp. capitatum, Thymus vulgaris and Thymus piperellasubsp.aestivus, so any action on the habitat in which the presence of such species would result in the loss of evidence interesting species for conservation.

However, the large distribution of these species (except Silenediclinis) present throughout the Valencia region, where that biodiversity is been lost. In the case of Silenediclinis the valuation of the plant communities in the municipality and preserving communities developed under the best forms of protection in line with the results of the valuation is advised.

3.2.5 Fauna

The results for the preparation of this report are presented. Given the limitations imposed by time, format and logistics considerations and partial assessments are to be regarded only as guidance. Described below is the list of species in which these potential species that could be found in the municipality, on the source of the Conselleía de territoriIhabitage.

Especie	Nombre vulgar	CNEA	Conv. Berna	Conv. Bonn	CVEA	UICN	Dir. Hábit
Capra pyrenaica	Cabra montés		III			Vulnerable	IV - V
Crocidura rusula	Musaraña gris		II - III		II- Proteg	Preoc. Men	
Eptesicus serotinus	Murciélago hortelano	Int. Esp	II				IV
Erinaceus europaeus	Erizo europeo		III		II- Proteg		
Hypsugo savii	Murciélago montañero	Int. Esp	II				IV
Lepus granatensis	Liebre ibérica					Preoc. Men	
Martes foina	Garduña		III		II- Proteg	Preoc. Men	
Microtus duodecimcostatus	Topillo mediterráneo					Preoc. Men	
Mus musculus	Ratón común					Preoc. Men	
Mus spretus	Ratón moruno					Preoc. Men	
Myotis myotis	Murciélago ratonero grande	Vulnerable	II		I- Vulnerab		II - IV
Oryctolagus cuniculus	Conejo común					Preoc. Men	
Rattus norvegicus	Rata parda					No evaluad	
Suncus etruscus	Musgaño enano		III		II- Proteg	Preoc. Men	
Sus scrofa	Jabalí					Preoc. Men	
Vulpes vulpes	Zorro rojo					Preoc. Men	

Soruces: Arbatec (2011)

Table 16. bird

Especie	Nombre vulgar	CNEA	Conv. Berna	Conv. Bonn	CVEA	UICN	Dir. Aves	Dir. Hábit
Acrocephalus scirpaceus	Carricero común	Int. Esp	II	II				
Alectoris rufa	Perdiz roja		III			Datos Insuf	III.1 - II.1	
Apus apus	Vencejo común	Int. Esp	III					
Asio otus	Búho chico	Int. Esp	II			Datos Insuf		
Athene noctua	Mochuelo europeo	Int. Esp	II					
Bubo bubo	Búho real	Int. Esp	II				I	
Caprimulgus europaeus	Chotacabras europeo	Int. Esp	II				I	
Caprimulgus ruficollis	Chotacabras cuellirrojo	Int. Esp	II					
Carduelis carduelis	Jilguero	Int. Esp	II					
Carduelis chloris	Verderón común	Int. Esp	II					
Cettia cetti	Ruiseñor bastardo	Int. Esp	II	II				
Charadrius dubius	Chorlitejo chico	Int. Esp	II	II				
Cisticola juncidis	Buitrón	Int. Esp	II - III	II				
Columba palumbus	Paloma torcaz		III				III.1 - II.1	
Coturnix coturnix	Codorniz común		III			Datos Insuf	II.2	
Cuculus canorus	Cuco común	Int. Esp	III					
Delichon urbica	Avión común	Int. Esp	II					
Emberiza cirlus	Escribano soteño	Int. Esp	II					

Especie	Nombre vulgar	CNEA	Conv. Berna	Conv. Bonn	CVEA	UICN	Dir. Aves	Dir. Hábit
Falco tinnunculus	Cernícalo vulgar	Int. Esp	II	II				
Galerida cristata	Cogujada común	Int. Esp	III					
Hippolais polyglotta	Zarcero común		II	II				
Hirundo rustica	Golondrina común	Int. Esp	II					
Lanius senator	Alcaudón común	Int. Esp	II			Casi Amen		
Luscinia megarhynchos	Ruiseñor común	Int. Esp	II					
Merops apister	Abejaruco europeo	Int. Esp	II	II				
Miliaria calandra	Triguero		III		II-Proteg			
Motacilla alba	Lavandera blanca	Int. Esp	II					
Motacilla flava	Lavandera boyera	Int. Esp	II					
Muscicapa striata	Papamoscas gris	Int. Esp	II	II				
Oriolus oriolus	Oropéndola	Int. Esp	II					
Parus cristatus	Herrerillo capuchino	Int. Esp	II					
Parus major	Carbonero común		II					
Passer domesticus	Gorrión común				III-Tutelad			
Passer montanus	Gorrión molinero							
Phylloscopus bonelli	Mosquitero papialbo	Int. Esp	II	II				
Saxicola torquata	Tarabilla común	Int. Esp	II					
Serinus serinus	Verdecillo		II					
Streptopelia turtur	Tórtola europea		III			Vulnerable		
Sturnus unicolor	Estornino negro		II - III		III-Tutelad			
Sylvia hortensis	Curruca mirlona	Int. Esp	II	II				
Sylvia melanocephala	Curruca cabecinegra		II	II				
Turdus merula	Mirlo común		III				II.2	
Tyto alba	Lechuza común	Int. Esp	II					
Upupa epops	Abubilla	Int. Esp	II					

Soruces: Arbatec (2011)

Table 17. Amphibian and reptile:

Especie	Nombre vulgar	CNEA	Conv. Berna	Conv. Bonn	CVEA	UICN	Dir. Hábit
Alytes obstetricans	Sapo partero común	Int. Esp	III				IV
Bufo bufo	Sapo común		III		II-Proteg		
Bufo calamita	Sapo corredor	Int. Esp	II				IV
Lacerta lepida	Lagarto ocelado		II		II-Proteg		
Malpolon monspessulanus	Culebra bastarda		III		II-Proteg		
Mauremys leprosa	Galápago leproso		III		II-Proteg		II - IV
Natrix maura	Culebra viperina	Int. Esp	III				
Pelodytes punctatus	Sapillo moteado común	Int. Esp	III				
Podarcis hispanica	Lagartija ibérica	Int. Esp	III				
Psammodromus algirus	Lagartija colilarga	Int. Esp	III				
Rana perezi	Rana común		III		II-Proteg		V
Tarentola mauritanica	Salamanquesa común	Int. Esp	III				

Soruces: Arbatec (2011)

3.2.6 Land use

Landscape has one combination of olive grove, scrub and conifers. Scrubs are in low site and conifers and groves in high site. Conifers have a significant visual barrier to the impact of the landfill. The landscape quality is middle as fragility. In more detail, the landfill is present in the trough forming mostly scrub and a little bit of conifers surrounded by a crop of olives.

3.3 Meteorological information

The area has the agroclimatic station (RED CRMS) of Xativa. It has the following climatic and geographical characteristic.

Metorological data	Latitude	Longitude	Altitude
Zativa, El Reglelenc	39º05´Nº	0º28´W	29 m.s.s.m.

Figure 11. Localization of meteorological station

<u>Temperature</u>

Thedatumabove the temperatures are shown below.

Table 18. . Temperaurure of Xativa station T: average temperature, TM: mean maximum; Average Tm of the minimum

	T(°C)	TM(°C)	Tm(°C)
Month	10,2	16,7	3,6
January	11,3	18,1	4,4
Frebruary	13	20,5	5,4
March	15,3	22,8	7,7
April	19,2	27	11,3
May	23,2	31,2	15,2
June	26,6	35	18,3
July	26,8	34,5	19,1
August	24,2	31,8	16,5
September	19	25,9	12
October	13,8	20,9	7,1
November	10,5	16,9	4,1
December	17,7	25,1	10,4

Source:own elaboration by Department of Agriculture (2015)

January is the coldest month with a minimum average of 3.6°C and minimum -9°C. Average Maximum temperature 35°C and 47°C maximum datum

<u>Precipitation</u>

The area where landfill is located, it is characterized by drought in summer (July and August)

The precipitation is:

Table 19. Precipitation per month

	Average Precipitation(mm)	days with precipitation
Month	68,4	4,8
January	44,2	4,2
Frebruary	59,8	4,4
March	53,8	5,7
April	49,5	5,7
May	25,7	3,6
June	6,3	1,1
July	14,1	2
August	58,5	3,5
September	120,9	5,7
October	107,9	5,6
November	84,3	5,6
December	693,4	51,9

Source: own elaboration by Department of de agriculture of Spain (2015)

The most raining month, October, which average is 121mm in contrast whit July which is the driest. It has been observed alteration of temperatures and humidity for one year. It can be seen in bellow graph 8 diagram Guassen) this situation.

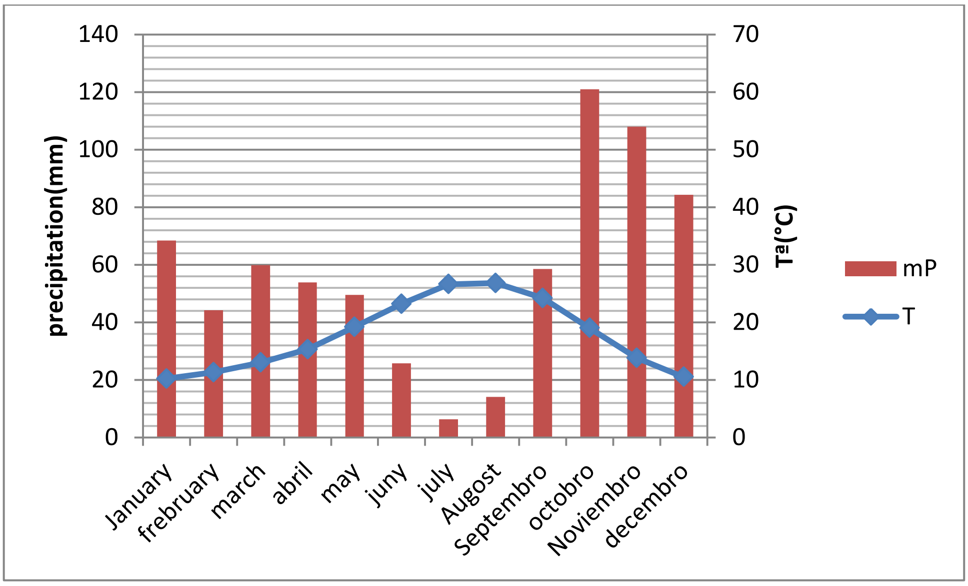


Figure 12. Diagram of Gaussen

Source: own elaboration

From this diagram we obtain a graphical analysis of variables from the thermometer and rainfall. Gaussen (1954) considered that a dry month, when rainfall have a lower value than twice, the average monthly temperature (P <2t). Thus, the area that is below the temperature curve corresponds to the dry season, according with June, July and August.

Water balance

From the average data, it can be calculated evapotranspiration table of Thomthwaite(1955).

Table 20. Hidric balance

	T(°C)	P (mm)	PET(cm)	B(cm)	v(cm)	Ret(cm)	Def(cm)	Sup(cm)	AET(cm)	R(cm)	aI	hI
January	10,2	68,4	1,9	4,9	0,0	10,0	0,0	4,9	1,9	4,4	0,0	5,7
Frebruary	11,3	44,2	2,3	2,1	0,0	10,0	0,0	2,1	2,3	3,3	0,0	2,5
March	13,0	59,8	3,6	2,3	0,0	10,0	0,0	2,3	3,6	2,8	0,0	2,7
April	15,3	53,8	5,3	0,1	0,0	10,0	0,0	0,1	5,3	1,4	0,0	0,1
May	19,2	49,5	9,0	-4,1	-4,1	5,9	0,0	0,0	9,0	0,7	0,0	0,0
June	23,2	25,7	13,0	-10,4	-5,9	0,0	4,5	0,0	8,5	0,4	5,2	0,0
July	26,6	6,3	13,9	-13,3	0,0	0,0	13,3	0,0	0,6	0,2	15,3	0,0
August	26,8	14,1	13,9	-12,5	0,0	0,0	12,5	0,0	1,4	0,1	14,4	0,0
September	24,2	58,5	11,8	-6,0	0,0	0,0	6,0	0,0	5,8	0,0	6,8	0,0
October	19,0	120,9	6,9	5,2	5,2	5,2	0,0	0,0	6,9	0,0	0,0	0,0
November	13,8	107,9	3,3	7,5	7,5	10,0	0,0	2,7	3,3	1,3	0,0	3,0
December	10,5	84,3	1,9	6,5	6,5	10,0	0,0	6,5	1,9	3,9	0,0	7,5

Legend: t: average temperature; Prec: average rainfall; PET: potential evapotranspiration; B: water balance; V: Variation in water retention in the soil; Ret: Water retention in the soil; Def: water deficit in the soil; Area: Surplus water in the soil; ETR: actual evaporation; R: arroyada; Ia: aridity index; Ih: Humidity Index.

Climatic indices of that season are:

Global Index: -3.6
Martonne aridity index: 25.0
Water deficit of Gaussen: 12.6
Index of continental Gorczynsky: 24.3

According to the above data, climate type according to the classification of Thornthwaite is: C1 B'3 a's2. This classification is composed of four letters and a few sub-indices, the first two letters, capital letters, refer to the moisture content and thermal efficiency of the particular area (climate: dry sub humid, thermal efficiency: mesothermal). The third and fourth letters, lowercase letters, corresponding to the seasonal variation of concentration temperature and humidity in summer, respectively (Deficit important in summer).

Infiltration

Water infiltration in the cover liner is one data for calculation of leachate. It is evaluated 20% of precipitation as run-off in landfill. Infiltration is calculated by Moisture gain; or loss and Cover material deficit. Material cover givesus field capacity and permanent wilting point. For one covering layer of clay loam, field capacity is 27% and permanent wilting point is 12% (Tchobanoglous, Thisen, & Vigil, 1993).

Table 21. Wasterinflitration

	mm					
Month	Precipitation	Evapotranspiration	Runoff	Moisture gain; or loss	Cover material deficit	Potential Percolates though Cover
January	68,4	19	13,68	35,72	0	22,22
Frebruary	44,2	23	8,84	12,36	0	0
March	59,8	36	11,96	11,84	0	0
April	53,8	53	10,76	-9,96	-9,96	0
May	49,5	90	9,9	-50,4	-60,36	0
June	25,7	130	5,14	-109,44	-135	0
July	6,3	139	1,26	-133,96	-135	0
August	14,1	139	2,82	-127,72	-135	0
September	58,5	118	11,7	-71,2	-135	0
October	120,9	69	24,18	27,72	-107,28	0
Noviember	107,9	33	21,58	53,32	-53,96	0
December	84,3	19	16,86	48,44	-5,52	29,42
January	68,4	19	13,68	35,72	0	22,22
Frebruary	44,2	23	8,84	12,36	0	0
March	59,8	36	11,96	11,84	0	0
April	53,8	53	10,76	-9,96	-9,96	0
May	49,5	90	9,9	-50,4	-60,36	0

Source: Own elaboration

It has been estimated annual infiltration 51.64 mm through the covering layer

3.4 Life cycle

Waste generation

Waste generation ride on population that live in an specific area. The area is considered for waste disposal. But this generation is calculated with annual production (Kg /inhab year) or daily production (Kg /inhab day). They are historic values which are obtained from waste generation. Solid waste rates include all the fraction of municipal waste. It is considered 12% of collection of wastes separated for this reason it is used 88% on design of landfill (PIRCV,2010)

Table 22. Waste quantities (2005-2010) on tax population

Solid waste rates based on tax population (kg /capita day)						
Region	2005	2006	2007	2008	2009	2010
Valencia	1,21	1,31	1,43	1,42	1,27	1,19
Comunitat Valenciana	1,30	1,34	1,38	1,34	1,31	1,25

Source: PIRCV

These values are used like base to calculate future waste generation rates. It is calculated three trends, one linear and two polynomials. The linear trend is more representative that polynomial trend which have negative values. Although linear trend is not good for real data, but its values tend to smaller values like PIRCV say.

Table 23. Generation rates provided (2011-2036).It is used liner trend.

Year	kg/capita day(poli 2°)	kg/capita day(poli 3°)	kg/capita day (linear)	Kg/capita year
2016	-1,21	-0,10	1,16	421,96
2017	-1,85	-0,27	1,16	423,74
2018	-2,57	-0,40	1,15	420,71
2019	-3,35	-0,48	1,14	417,68
2020	-4,21	-0,49	1,14	414,65
2021	-5,14	-0,42	1,13	411,62
2022	-6,14	-0,26	1,12	408,59
2023	-7,20	0,00	1,11	405,56
2024	-8,34	0,38	1,10	402,53
2025	-9,55	0,88	1,09	399,50
2026	-10,84	1,52	1,09	396,47
2027	-12,19	2,31	1,08	393,44
2028	-13,61	3,27	1,07	390,41
2029	-15,10	4,40	1,06	387,38
2030	-16,67	5,71	1,05	384,35
2031	-18,30	7,23	1,04	381,32
2032	-20,01	8,95	1,04	378,29
2033	-21,79	10,90	1,03	375,26
2034	-23,64	13,08	1,02	372,23
2035	-25,55	15,51	1,01	369,20
2036	-27,54	18,20	1,00	366,17

These provided generation rates ensure compliance of “ anexo 5 del PIRCV, programa de prevencion “ and Directive 2008/98/CE and ley 22/2011 “sobreresiduos y sueloscontaminados.” Aim is to reduce generation rate 10% in 2020.

1.2 Population study

The area belongs to Plan Zonal V5 then they are considered on design of landfill are:

La Valld'Albaida,

La Canal de Navarrés

El Valle de Ayora

The district belong to these region are

Alcúdia de Crespins, l'
Barxeta
Canals
Cerdà
Estubeny
Font de la Figuera, la
Genovés
Granja de la Costera, la
Llanera de Ranes
Llocnoud'EnFenollet
Llosa de Ranes, la
Mogente
Montesa
Novelé
RotglàiCorberà
Torrella
Vallada
Vallés
Xàtiva
Agullent
Aielo de Malferit
Aielo de Rugat
Albaida
Alfarrasí
Atzenetad'Albaida
Bèlgida
Bellús
Beniatjar
Benicolet
Benigànim
Benissoda
Benisuera
Bocairent

Bufali
Carrícola
Castelló de Rugat
FontanarsdelsAlforins
Guadasséquies
Llutxent
Montaverner
Montitxelvo
Olleria, l'
Ontinyent
Otos
Palomar, el
Pinet
Pobla del Duc, la
Ráfol de Salem
Rugat
Salem
Sempere
Terrateig
Anna
Ayora
Bicorp
Bolbaite
Chella
Cofrentes
Cortes de Pallás
Enguera
Jalance
Jarafuel
Millares
Navarrés
Quesa
Teresa de Cofrentes
Zarra

In 2014, register of population is 186.631 inhabitants for these municipalities otherwise it is used concept of population tax.

Calculation of population tax

The aims of this part are defined and calculated population tax. It has been defined population tax as resident population more non-resident that have one direct link(work, studies, second home) and tourism quantity .

$$Pololation\ tax = register\ of\ inhabitants + non_{resident} + tourism\ population$$

It is differ between register of inhabitants and census. Register of inhabitants is data source of people that have resident in this municipality. It is annually. Census is result of theprocess with data set such as demographic, economic and social. It is done every 10 year.

Non-resident is population that do not live in municipalities, but it has direct link such as people that work or study in addition people that have second home.

$$Total\ Non_{resident} = Non_{resisdent}\ working + Non_{residnet} studying + seasonal\ population(second\ home)$$

This information is obtained by census. In census, this information is offered as lined population that doesn't live in this town but is working, studying or has second home.

$$Non_{resident} working = 0{,}19 \times population\ \ doesn\acute{}t\ reside\ but\ work$$

$$Non_{resident} studying = 0{,}21 \times population\ \ doesn\acute{}t\ reside\ but\ study$$

$$Seasonal\ population = 0{,}33 \times population\ \ doesn\acute{}t\ reside\ but\ has\ second\ home$$

Source :Annex 6 , PIRCV(2010)

Table 24. Calculation of Total Non_resident by municipalities with more 10.000 inhabitants,census(2001)

Municipalities with more 10.000 inhabitants	(1)	(2)	(3)	(4)	(5)	(6)
Alaquàs (Valencia)	3926	824,46	655	124,45	1179	389,07
Canals (Valencia)	963	202,23	481	91,39	643	212,19
Xàtiva (Valencia)	4912	1031,52	2332	443,08	2335	770,55
Ontinyent (Valencia)	2354	494,34	1078	204,82	1718	566,94
Total	12155	2552,55	4546	863,74	5875	1938,75

(1)Inhabitants don't reside but work

(2)Non-resident

(3)Inhabitants don't reside but study

(4)Non-resident studying

(5)Inhabitants don't reside bur has second home

(6)Season population

Source : Compilation based on information supplied by the Forces.(census 2001,INE)

Table 25. Percentage of variation by census(2001) and total non-resident

	Census ,2001	Total Non-resident(7)	%variation between census and non-resident
Studied municipalities	110398	5355,04	0,04851

(7)=(2)+(4)+(6)
Source: Own elaboration

$$Non_{resident} = register\ of\ inhabitans \times \%_{varation\ betwewn\ census\ and\ non_{resident}}$$

It has been obtained by data of municipalities which have more 10.000 inhabitants, but is extrapolated other municipalities.

Tourism population
Tourism population is defined as maximum available bed-places in these regions per year. It is used tourists capacities and occupancy rate, Bed-places are places that is offered by hotels, hostels, campsites, apartments, youth hostels and rural accommodation.

$$Tourism\ population = bed.places \times occupancy\ rate$$

Table 26. Example of bed-places (2014)

Region	Hotels	Hostels	Youth hostels	Apartm ents	Camps ite	Rural accommod ation	Total
El Valle de Cofrentes-Ayora	657		18	156	357	412	
La Canal de Navarrés	55	22		41	985	476	
La Costera	102	16	39	29		214	
La Valld'Albaida	294	11	77	133	1087	377	
	1108	49	134	359	2429	1479	5558

Source:GeneralitatValencianaconselleria de tourisme

Table 27. Tourism population by bed-places and occupancy rates

Year	Bed-places	Occupancy Rates (%)	Tourism population (inhabitants)
1996	4732	35,10	1661
1998	4966	36,36	1806
1999	5012	33,20	1664
2000	5558	36,90	2051
2001	5307	39,16	2078
2002	5003	35,01	1752
2003	5130	35,27	1809
2004	4933	30,30	1495
2005	4325	31,52	1363
2006	4962	32,79	1627
2008	5069	34,95	1772
2009	5439	29,83	1622
2010	5603	21,06	1180
2011	5751	36,67	2109

2012	5820	31,60	1839
2013	5563	32,31	1797
2014	5636	35,74	2014

Source: Own elaboration

Years	Register of inhabitants	Non_resident	Tourism population	Population Tax
1996	169602	8227	1661	179490
1998	169861	8239	1806	179906
1999	170561	8273	1664	180498
2000	171546	8321	2051	181918
2001	174296	8455	2078	184829
2002	177427	8606	1752	187785
2003	180795	8770	1809	191374
2004	183005	8877	1495	193377
2005	184804	8964	1363	195131
2006	185670	9006	1627	196303
2008	192191	9323	1772	203285
2009	192703	9347	1622	203673
2010	193256	9374	1180	203810
2011	193535	9388	2109	205032
2012	193657	9394	1839	204890
2013	186631	9053	1797	197481
2014	188470	9142	2014	199626

Source: Own elaboration based on information supplied by INE
Unit: Inhabitants

It has been done a prediction of population based on population tax. It is calculated two trends, linear and logarithmic.

Table 28. Equation of trends and value of regression quadratic (R)

Trend	Equation	R
Liner	y= 0,0219x + 1,5291	0.975
Logarithmic	y = 0,3922ln(x) + 0,7996	0.98

Source: Own elaboration

In this study, logarithmic trend is more appropriate that linear trend because of its R. Quadratic regression is close to one. In addition, results become realer given that population does not increase much more. One study of Instituto Valenciano de Estadistica (IVE) has predicted that population of this region will reduce. For this reason the result will be safer sites.

Table 29. Prediction of Tax population

Years	Tax Populations
2017	208962
2018	209997
2019	210999
2020	211970

Years	Tax Populations
2021	212912
2022	213827
2023	214716
2024	215581

Years	Tax Populations
2025	216422
2026	217242
2027	218041
2028	218820
2029	219581
2030	220323
2031	221049
2032	221758
2033	222452

Years	Tax Populations
2034	223131
2035	223795
2036	224446
2037	225083
2038	225708
2039	226321
2040	226922
2041	227512

Source: Own elaboration
Unit: Inhabitants

3.4.1 .Shelf life of Landfill

Shelf life of landfill can be known with volume that cumulative quantity a year .

Net Capacity is calculated in part of design landfill.

Table 30. Calculate of live cycle. It is obtained 24 year of shelf life

Year since start the landfill operation	Year	Tax Population	kg/capita year(1)	Yearly quantities (Kg /year)	Yearly volume(m3/year)	Cumulative quantity(kg)	Cumulative quantity(tn)	Cumulative Volume(m3)
1	2017	208962	372,90	77920810,39	111315,44	77920810,39	77920,81	111315,44
2	2018	209997	370,23	77746729,71	111066,76	155667540,10	155667,54	222382,20
3	2019	210999	367,56	77555052,75	110792,93	233222592,85	233222,59	333175,13
4	2020	211970	364,90	77346780,37	110495,40	310569373,21	310569,37	443670,53
5	2021	212912	362,23	77122826,22	110175,47	387692199,44	387692,20	553846,00
6	2022	213827	359,56	76884026,75	109834,32	464576226,19	464576,23	663680,32
7	2023	214716	356,90	76631149,72	109473,07	541207375,91	541207,38	773153,39
8	2024	215581	354,23	76364901,69	109092,72	617572277,60	617572,28	882246,11
9	2025	216422	351,56	76085934,40	108694,19	693658212,00	693658,21	990940,30
10	2026	217242	348,90	75794850,37	108278,36	769453062,37	769453,06	1099218,66
11	2027	218041	346,23	75492207,87	107846,01	844945270,24	844945,27	1207064,67
12	2028	218820	343,56	75178525,14	107397,89	920123795,38	920123,80	1314462,56
13	2029	219581	340,90	74854284,23	106934,69	994978079,62	994978,08	1421397,26
14	2030	220323	338,23	74519934,34	106457,05	1069498013,96	1069498,01	1527854,31
15	2031	221049	335,56	74175894,78	105965,56	1143673908,74	1143673,91	1633819,87
16	2032	221758	332,90	73822557,60	105460,80	1217496466,34	1217496,47	1739280,67
17	2033	222452	330,23	73460289,96	104943,27	1290956756,30	1290956,76	1844223,94
18	2034	223131	327,56	73089436,24	104413,48	1364046192,54	1364046,19	1948637,42
19	2035	223795	324,90	72710319,87	103871,89	1436756512,41	1436756,51	2052509,30
20	2036	224446	322,23	72323245,08	103318,92	1509079757,49	1509079,76	2155828,22
21	2037	225083	319,56	71928498,40	102755,00	1581008255,90	1581008,26	2258583,22
22	2038	225708	316,90	71526350,02	102180,50	1652534605,92	1652534,61	2360763,72
23	2039	226321	314,23	71117055,05	101595,79	1723651660,97	1723651,66	2462359,52

Year since start the landfill operation	Year	Tax Population	kg/capita year(1)	Yearly quantities (Kg /year)	Yearly volume(m3/year)	Cumulative quantity(kg)	Cumulative quantity(tn)	Cumulative Volume(m3)
24	2040	226922	311,56	70700854,62	101001,22	1794352515,59	1794352,52	2563360,74
25	2041	227512	308,90	70277976,94	100397,11	1864630492,53	1864630,49	2663757,85

If landfill has 2.620.000 m3 of capacity, in year 25 the capacity is overtake. Consequently live cycle will be 24 year.

3.5 Composition

The waste comes from municipalities that have been aforementioned. The information used is Composition of Valencia Province that will be used in design process.

Table 31. Waste Composition of Valencia province

Component	Valencia Wastes%
Organic material	47,3
Paper/Card board	17,5
Plastics	9
Glass	8,7
Metal	3,5
Metal No Fe	0,6
other	13,4
Total	100

Source: (Generalitat Valenciana, 2010)

It is used the information of table 31 in order to do the next calculations. It is extrapolated real information to bibliographic information as a result, to have same chapters that the bibliographic.

Table 32. Composition of waste base on Tchobanoglous(1993)

	Perct. By Weitht Val.	Dry Weight kg
Organic		
Food waste	15,9	4,8
Paper	14,9	14,0
Card board	2,6	2,5
Plastics	9,0	8,8
Textiles	3,5	3,2
Rubber	0,9	0,9
Leather	0,9	0,8
Yard Wastes	32,8	13,1

	Perct. By Weitht Val.	Dry Weight kg
Wood	3,5	2,8
Mics. Organics		
Inorganic		
Glass	8,7	8,0
Tin Cans	3,5	3,4
Aliminum	0,1	0,1
Other Metal	0,6	0,6
Dirt,ashect.	3,0	2,8
	100	65,74

Souce:own elaboration

It is used equation for calculation of content moisture. The information of table 32 is employed;

$$M = \left(\frac{w - d}{w}\right) \times 100$$

$$M = \left(\frac{100 - 65.74}{100}\right) \times 100 = 34.26\ \%$$

It is determined the percentage distribution of the major elements composing the waste on base table 32. This stage is necessary for determination of approximate chemical formula. It is gotten below table.

Table 33. Distribution of major elemts composing the waste(kg).

	Composition By weight (dry basis), kg					
Organic	Carbon	Hydrogen	Oxigen	Nitrogen	Sulfur	Ash
Food waste	2,30	0,31	1,80	0,12	0,02	0,24
Paper	6,08	0,84	6,15	0,04	0,03	0,84
Card board	1,10	0,15	1,11	0,01	0,00	0,12
Plastics	5,29	0,64	2,01	0,00	0,00	0,88
Textiles	1,75	0,21	0,99	0,15	0,00	0,08
Rubber	0,68	0,09	0,00	0,02	0,00	0,09
Leather	0,48	0,06	0,09	0,08	0,00	0,08
Yard Wastes	6,27	0,79	4,98	0,45	0,04	0,59
Wood	1,40	0,17	1,21	0,01	0,00	0,04
Mics. Organics						
Inorganic						
Glass	0,04	0,01	0,03	0,01	0,00	7,92
Tin Cans	0,15	0,02	0,15	0,00	0,00	3,07
Aliminum	0,00	0,00	0,00	0,00	0,00	0,09
Other Metal	0,03	0,00	0,03	0,00	0,00	0,55
Dirt,ashect.	0,73	0,08	0,06	0,01	0,01	1,88
Total	26,30	3,36	18,62	0,89	0,11	16,47

Source: Own elaboration

Table 34. Summary Table: Distribution of elements composing waste with water and without water

	Weight, kg		**Moles**	
Component	Without H2O	With H2O	Without H2O	With H2O
carbon	26,30	26,30	2110,32	2110,32
Hydrogen	3,36	7,17	3212,64	6863,90
Oxigen	18,62	49,07	1147,02	2990,91
Nitrogen	0,89	0,89	62,02	62,02

Sulfur	0,11	0,11	3,19	3,19
Ash	16,47	16,47	2110,32	2110,32

Source: Own elaboration

Finally, it is determined approximate chemical formula with sulfur and without sulfur.

Table 35. Auxiliary calculation

	Nitrogen=1		**Sulfur = 1**	
Component	Without H2O	With H2O	Without H2O	With H2O
carbon	34,28	34,28	651,76	651,76
Hydrogen	52,09	111,10	990,36	2112,20
Oxigen	18,22	48,02	346,35	912,88
Nitrogen	1,00	1,00	19,01	19,01
Sulfur	0,05	0,05	1,00	1,00

Source: Own elaboration

Approximate chemical formula;

Without water and without sulfur

$$C_{34,28}H_{52,09}O_{18,22}N_1$$

With water and without sulfur

$$C_{34,28}H_{111,10,}O_{48.02}N_1$$

Without water and with sulfur

$$C_{651,76}H_{99,36}O_{19.01}N_{19,01}S_1$$

With water and with sulfur

$$C_{651,76}H_{2112,20}O_{912,88}N_{19,01}S_1$$

Estimation of energy content of waste based on chemical composition

Estimation of energy based on approximate composition with water and sulfur (equation ***).

Table 36. Moles of approximate chemical formula for estimation of energy content

Component	**moles**	**g/mol**	**g**	**%**
carbon	651,76	12,00	7821,12	31,49
Hydrogen	2112,20	1,00	2112,20	8,50
Oxigen	912,88	16,00	14606,07	58,81
Nitrogen	19,01	14,00	266,17	1,07
Sulfur	1,00	32,00	32,00	0,13
			24837,56	100,00

Source:Own elaboration

If energy content are not available, approximately for individual waste materials can be determined by equation***, known as the modified Dulong formula (Tchobanoglous, Thisen, & Vigil, 1993).

$$\frac{KJ}{Kg} = (145C + 610\left(H_2 - \frac{1}{8}O_2 + 405 + 10N\right) \times 2{,}326$$

$$\frac{KJ}{Kg} = 13223{,}57$$

$$\frac{\text{Kcal}}{\text{kg}} = 3158{,}40$$

Water consumed in the formation of landfill gas

The organic constituents consume water because of decomposition based on equation:

$$C_{27}H_{65}O_{28}N_1 + 7{,}67H_2O \rightarrow 19{,}33CH_4 + 17{,}83CO_2 + NH_3$$

Table 37. Results of water consumed

Water Consumed	**0,1864**	**kg water /kg SVRB**
	0,1925	kg water/m3 gas

The amount of gas that can be derived from the organic constituents in Landfill

It takes two separate calculations according to the rate of biodegradability. They are readily biodegradable () and slowly biodegradable (). The approximate chemical formula is calculated but considered fractions. In the garden waste fraction 60 percent are considered readily biodegradable. With the following results:

Rapidly decomposable organic constitutes

$$C_{27}H_{65}O_{28}N$$

Slowly decomposable organic constitutes

$$C_{18}H_{26}O_9N$$

The amount of gas can be estimated with the equation ***. It is understood that perfect situation of conditions such as water required for reaction.

Rapidly decomposable organic constituents

$$C_{27}H_{65}O_{28}N_1 + 7{,}67H_2O \rightarrow 19{,}33CH_4 + 17{,}83CO_2 + NH_3$$

Rapidly decomposable organic constitutes

$$C_{18}H_{26}O_9N_1 + 9H_2O \rightarrow 11CH_4 + 9CO_2 + NH_3$$

The weights of methane and carbon dioxide are 0,717 and 1,978 kg/m3, respectively (see Tchobanoglous(1993), pag 383)

Table 38. M3 produced of methane and CO2 with rapidly decomposable and slowly decomposable

Rapidly decomposable		**unit**
methane	14,5034	m3 N
CO2	13,6912	m3 N
Slowly decomposable		
methane	7,2104	m3 N
CO2	5,7478	m3 N

With this information is calculated total theoretical amount of gas generated per unit dry weight of organic matter destroyed.

Vol/kg	**0,9681**	**m3/kg**	**Rapidly decomposable**
Vol/kg	1,0021	m3/kg	Slowly decomposable

Biogas will has 52,75% volume of methane.

The water lost as water vapor in landfill duo to be saturated of water. When gas is saturated in water quantity of water escaping on based perfect gas law (see***)

Table 39. Variables for perfect gas law. Result of water lost as water vapor.

P	4,82	kn/m2
V	1	l
R	0,082	atm l/ºK
T	305	K
n	0,1927	mol
Result	0,0035	kgH2O/m3 landfill gas

Source: Own elaboration based on Tchobanoglous(1993)

3.6 Gas production

The variation rate in the production of biogas in the rapidly biodegradable matter is me five years or less. On rapidly biodegradable material is 5 to 50 years. (Tchobanoglous, 1993).Tochobanoglous (1993) uses a triangular model for calculating the gas production gas. This model has the highest gas production and one year and five years to rapidly and slowly biodegradable respectively. Being the area of this triangle the total produced in kg / m3. As to above the optimum moisture content for the generation of gas in a landfill is 50-60%, and in this case the residues have a lower percentage of ...., Ie gas production will always be less than the theoretically calculated. As such the data obtained for the rate of gas for rapidly biodegradable are represented. To determine the gas produced from organic material quickly and slowly biodegradable per kilogram of total waste landfilled, it has increased the production rate by% of total RB and LB% respectively and also has been considered a material 75 RB available for 50% decomposition and LB available for decomposition as production.

In the case of readily biodegradable material gas it is generated during the first 5 years with a total of 0,9681kg gas / m3 with the following distribution of gas production in five years.

Table 40. Quantities of gas production RB in 5 years

Year	1	2	3	4	5
m^3/kg waste	0,0423	0,0740	0,0529	0,0317	0,0106

Source: Own elaboration

Table 41. Generation of cumulative gas for RB

Year	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
m3 gas /kg waste	0,0423	0,1163	0,1692	0,2009	0,2115	0,2115	0,2115	0,2115	0,2115	0,2115	0,2115

Year	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037
m3 gas/kg waste	0,2115	0,2115	0,2115	0,2115	0,2115	0,2115	0,2115	0,2115	0,2115	0,2115

Year	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047
m3 gas/kg waste	0,2115	0,2115	0,2115	0,2115	0,1692	0,0952	0,0423	0,0106	0,0000	0,0000

Source: Own elaboration

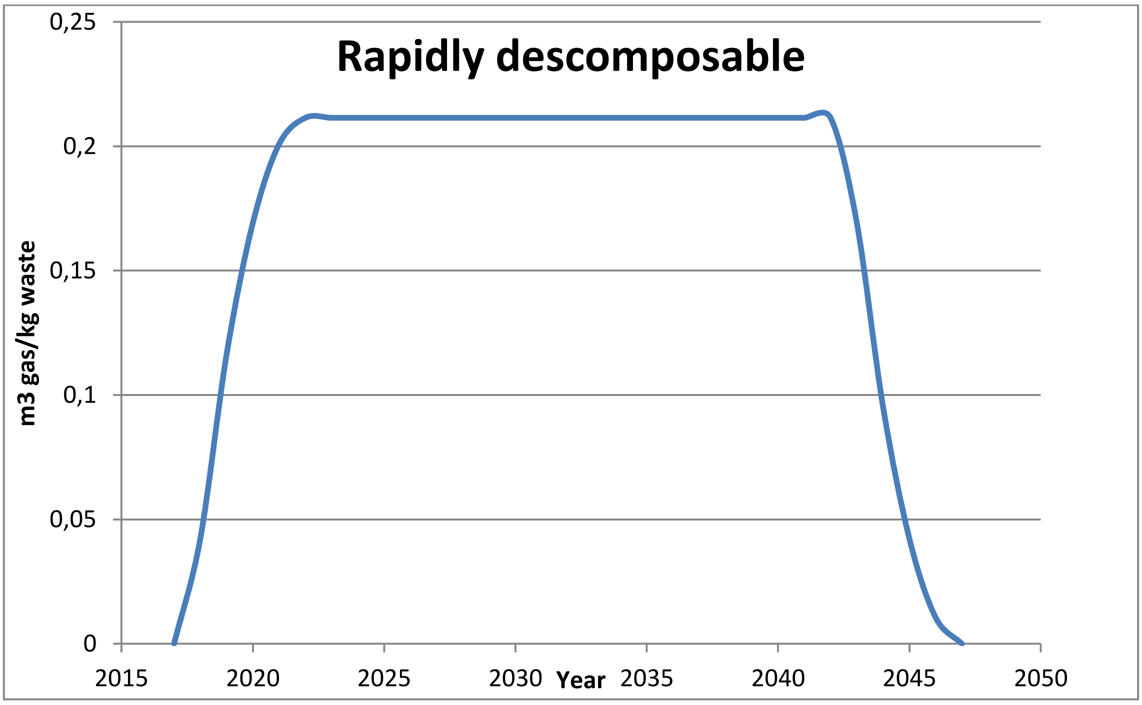


Figure 13. Graph of cumulative gas generation RB

Source: Own elaboration

Table 42. Quantities of gas production RB in 15 years

Year	2017	2018	2019	2020	2021	2022	2023
Kg gas/m^{3}waste	0,0009	0,0026	0,0043	0,0060	0,0078	0,0082	0,0073

Year	2023	2024	2025	2026	2027	2028	2029	2030	2031
Kg gas/m^{3}waste	0,0073	0,0065	0,0056	0,0048	0,0039	0,0030	0,0022	0,0013	0,0004

Source: Own elaboration

Table 43. Cumulative gas Generation LB

Year	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
Kg gas/m3 waste	0,0009	0,0035	0,0078	0,0138	0,0216	0,0298	0,0371	0,0436	0,0492	0,0540	0,0579

Year	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038
Kg gas/m3 waste	0,0609	0,0631	0,0644	0,0648	0,0648	0,0648	0,0648	0,0648	0,0648	0,0648	0,0648

Year	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049
Kg gas/m3 waste	0,0648	0,0648	0,0648	0,0639	0,0613	0,0570	0,0510	0,0432	0,0350	0,0276	0,0212

Year	2050	2051	2052	2053	2054	2055	2056
Kg gas/m3 waste	0,0155	0,0108	0,0069	0,0039	0,0017	0,0004	0,0000

Source: Own elaboration

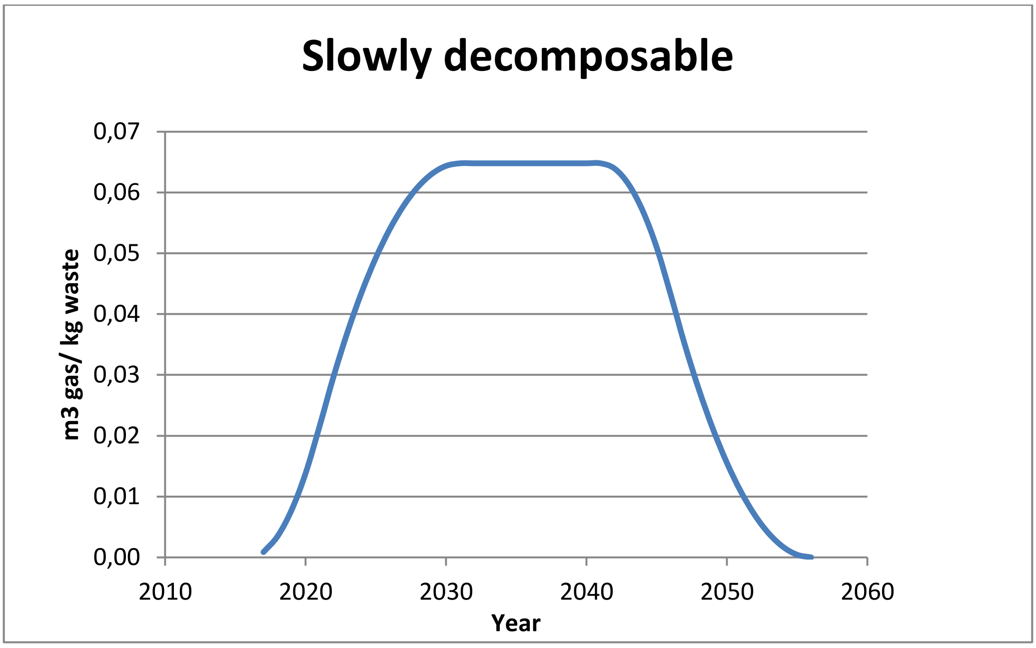


Figure 14. Graph of the cumulative gas generation Parallel B

Source: Own elaboration

Table 44. Gas production per kg waste from each

Year	2017	2018	2019	2020	2021	2022	2023
Rapidlydecomposable	0,0000	0,0423	0,0740	0,0529	0,0317	0,0106	0,0000
Slowlydecomposable	0,0000	0,0009	0,0026	0,0043	0,0060	0,0078	0,0082
Total	0,0000	0,0432	0,0766	0,0572	0,0378	0,0183	0,0082

Year	2024	2025	2026	2027	2028	2029	2030	2031
Rapidlydecomposable								
Slowlydecomposable	0,0073	0,0065	0,0056	0,0048	0,0039	0,0030	0,0022	0,0013
Total	0,0073	0,0065	0,0056	0,0048	0,0039	0,0030	0,0022	0,0013

Source: Own elaboration

Table 45. Total cumulative Production

Year	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
Rapidlydecomposable	0,0000	0,0423	0,1163	0,1692	0,2009	0,2115	0,2115	0,2115	0,2115	0,2115	0,2115
Slowlydecomposable	0,0000	0,0009	0,0035	0,0078	0,0138	0,0216	0,0298	0,0371	0,0436	0,0492	0,0540
TOTAL	0,0000	0,0432	0,1198	0,1769	0,2147	0,2331	0,2413	0,2486	0,2551	0,2607	0,2655

Year	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038
Rapidlydecomposable	0,2115	0,2115	0,2115	0,2115	0,2115	0,2115	0,2115	0,2115	0,2115	0,2115	0,2115
Slowlydecomposable	0,0579	0,0609	0,0631	0,0644	0,0648	0,0648	0,0648	0,0648	0,0648	0,0648	0,0648
TOTAL	0,2693	0,2724	0,2745	0,2758	0,2763	0,2763	0,2763	0,2763	0,2763	0,2763	0,2763

Year	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049
Rapidlydecomposable	0,2115	0,2115	0,2115	0,2115	0,1692	0,0952	0,0423	0,0106	0,0000		
Slowlydecomposable	0,0648	0,0648	0,0648	0,0648	0,0639	0,0613	0,0570	0,0510	0,0432	0,0350	0,0276
TOTAL	0,2763	0,2763	0,2763	0,2763	0,2331	0,1565	0,0993	0,0615	0,0432	0,0350	0,0276

Year	2050	2051
Rapidlydecomposable		
Slowlydecomposable	0,0212	0,0155
TOTAL	0,0212	0,0155

Source: Own elaboration

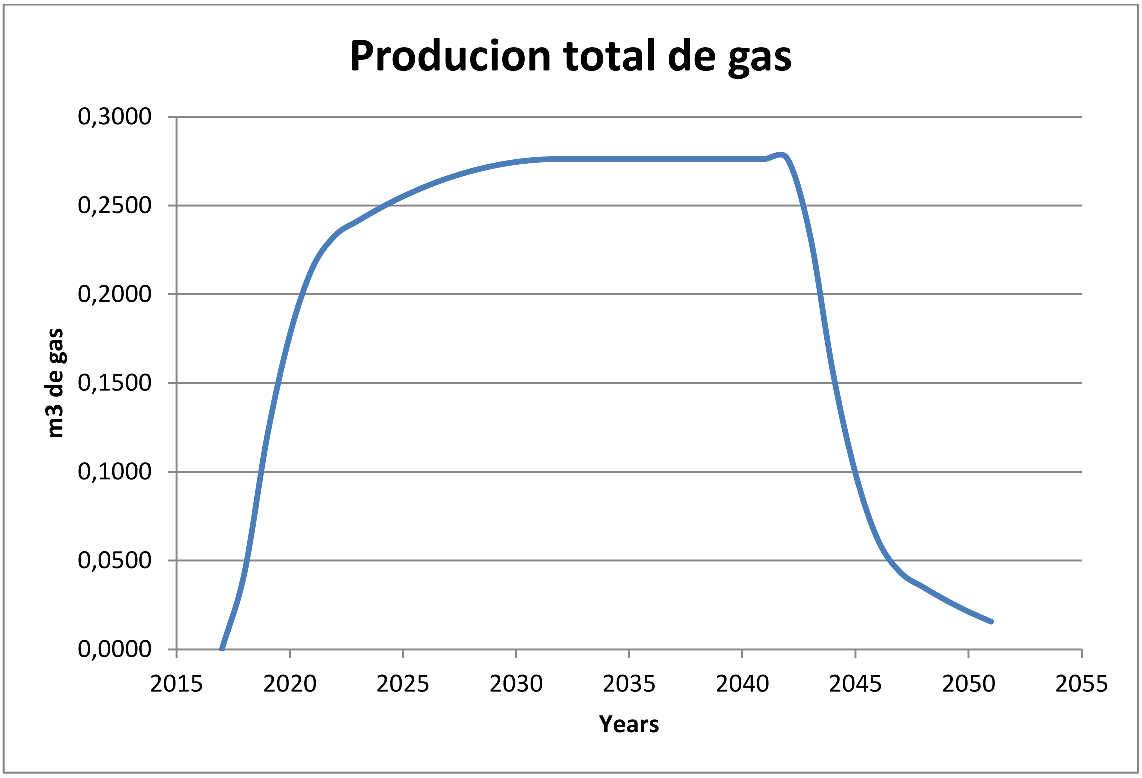


Figure 15. Graph of the total cumulative production

Source: Own elaboration

The gas production per kg of waste deposited is multiplied by the production of waste previously estimated a value for total gas each year produccido

Table 46. m3 gas produced

Year	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
m3 gas total	0,00	1.502.698,83	4.160.706,16	6.132.276,88	7.421.147,83	8.031.995,73	8.289.087,40	8.513.275,63	8.704.795,24	8.863.914,36

Year	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036
m3 gas/kg waste	0,2655	0,2693	0,2724	0,2745	0,2758	0,2763	0,2763	0,2763	0,2763	0,2763
Kg waste per year	75492207,87	75178525,14	74854284,23	74519934,34	74175894,78	73822557,6	73460289,96	73089436,24	72710319,87	72323245,08
m3 gas total	8.990.931,80	9.086.174,67	9.149.996,31	9.182.774,39	9.184.909,21	9.156.822,18	9.113.203,62	9.068.482,62	9.022.701,69	8.975.900,75

Year	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046
m3 gas total	8.928.117,37	8.879.386,92	8.829.742,74	8.779.216,34	8.727.837,47	8.675.634,32	7.275.606,16	4.854.141,22	3.087.897,30	1.918.172,06

Year	2047	2048	2049	2050	2051	TOTAL m3
m3 gas total	1.349.454,29	1.095.575,45	867.596,10	665.726,66	490.170,47	226.976.070,16

Source: Own elaboration

3.7 Leachate

For calculation of leachate, it is done one simplification and hypostasis of landfill. It has been done these hypostasis because of nature of Solid waste landfill is imprecise. There are many factors that depend of this. It is impossible to know 100% of real information.

These are hypothesis that it has been considered:

It is filled horizontal every year with the same volume. In this fact, it is filled in 24 year.

Gasps and biogas are water saturation

Sludges are not admitted in the landfill

Field capacity depend of overburden pressure that there be.

Leachate that it is produced in a level, it will begin down level (1) in the same level. Total Leachate will be leachate of level 1.

Cover liner is inert, for this reason it is considered no biodegradable.

Moisture content is homogeneous and with the same valor every years.

It is not considered Settlement, but it is known that is important.

Density of leachate is the same value that water, it is not important mistake because is similar.

After landfill closure, the water infiltration is non-existent but it has been calculated 51.64 mm for infiltration in liners.

Leachate model has simplifications geometric in the landfill. It is considered rectangular prims. The total volume is (2.600.000m3) the same and the altitude too. For this reason, surface change (36.333, 3m2). The landfill has 24 stages which them altitude is 3 m.

Table 47. Information of landfill for calculation of leachate

Weight of cover material	**kg**	**306,00**
Weight of solid waste	kg	1645,00
Total weight of lift	kg	1951,00
Dry weight of solid waste	kg	1081,59
Moisture content in solid waste	kg	563,41
Rainfall weight	kg	584,71
Total weight of lift	kg	2535,71

Source: own elaboration

Now, below table it has been calculated leachate of level 1 in 24 year.

Table 48. Leachate of level 1 during 24 year

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Gas produce	m3	0,00	70,99	126,01	94,07	62,13	30,18	13,50	12,08	10,66	9,24	7,82	6,39	4,97	3,55	2,13	0,71	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Weight of gas produced	kg	0,00	95,06	168,73	125,96	83,19	40,41	18,08	16,17	14,27	12,37	10,47	8,56	6,66	4,76	2,85	0,95	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Weight of water consumed	kg	0,00	13,67	24,26	18,11	11,96	5,81	2,60	2,33	2,05	1,78	1,50	1,23	0,96	0,68	0,41	0,14	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Weight of water vapor	kg	0,00	2,48	4,41	3,29	2,17	1,06	0,47	0,42	0,37	0,32	0,27	0,22	0,17	0,12	0,07	0,02	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Wight of water	kg	1148,12	1131,97	1103,30	1081,90	1067,77	1060,90	1057,83	1055,08	1052,66	1050,55	1048,78	1047,32	1046,19	1045,38	1044,90	1044,73	1044,73	1044,73	1044,73	1044,73	1044,73	1044,73	1044,73	1044,73
Dry wight of solid waste	kg	1081,59	1000,20	855,72	747,87	676,65	642,04	626,57	612,72	600,50	589,91	580,95	573,61	567,91	563,84	561,40	560,58	560,58	560,58	560,58	560,58	560,58	560,58	560,58	560,58
Average wight	kg	1420,85	1372,08	1285,51	1220,89	1178,21	1157,47	1148,20	1139,90	1132,58	1126,23	1120,86	1116,47	1113,05	1110,61	1109,15	1108,66	1108,66	1108,66	1108,66	1108,66	1108,66	1108,66	1108,66	1108,66
Weight level 1			3266,73	4856,16	6223,35	7445,35	8581,99	9674,96	10740,56	11782,65	12804,63	13809,53	14800,14	15779,02	16748,63	17711,29	18669,22	19624,10	20576,59	21526,89	22475,16	23421,55	24366,18	25309,18	26250,65
Fc		0,47	0,37	0,32	0,28	0,26	0,24	0,23	0,21	0,20	0,19	0,19	0,18	0,17	0,17	0,16	0,16	0,15	0,15	0,15	0,14	0,14	0,14	0,13	0,13
Water help in solid waste in lift	kg	507,06	369,81	270,09	210,81	174,73	154,21	141,32	130,70	121,83	114,37	108,05	102,69	98,14	94,28	91,02	88,30	85,92	83,72	81,69	79,81	78,05	76,42	74,89	73,46
Lechatefomed	kg	641,06	762,16	833,21	871,09	893,04	906,69	916,50	924,38	930,83	936,19	940,73	944,63	948,05	951,10	953,87	956,44	958,82	961,01	963,05	964,93	966,68	968,32	969,85	971,28
Water remaing	kg	507,06	369,81	270,09	210,81	174,73	154,21	141,32	130,70	121,83	114,37	108,05	102,69	98,14	94,28	91,02	88,30	85,92	83,72	81,69	79,81	78,05	76,42	74,89	73,46
Total weight of lift	kg	1894,65	1676,00	1431,81	1264,68	1157,37	1102,25	1073,89	1049,41	1028,33	1010,27	995,00	982,30	972,05	964,12	958,42	954,88	952,50	950,30	948,27	946,39	944,63	943,00	941,47	940,04

Source: Own elaboration

Table 49. Kg leachate per surface of landfill and m^3 leachate per year

	kg/m²	m³/Year
1	641,06	23291,72
2	762,16	27691,82
3	833,21	30273,32
4	871,09	31649,72
5	893,04	32447,07
6	906,69	32943,12
7	916,50	33299,59
8	924,38	33585,85
9	930,83	33819,99
10	936,19	34014,82
11	940,73	34179,68
12	944,63	34321,56
13	948,05	34445,82
14	951,10	34556,64
15	953,87	34657,31
16	956,44	34750,53
17	958,82	34837,07
18	961,01	34916,84
19	963,05	34990,62

	kg/m²	m³/Year
20	964,93	35059,07
21	966,68	35122,75
22	968,32	35182,15
23	969,85	35237,70
24	971,28	35289,77
25	0,00	0,00
26	29,24	1062,47
27	51,17	1859,32
28	51,50	1871,31
29	50,36	1829,80
30	51,82	1882,85
31	51,88	1884,85
32	51,96	1887,77
33	51,71	1878,90
34	51,78	1881,32
35	51,69	1878,05
36	51,63	1875,97
37	51,63	1875,79

Source: Own elaboration

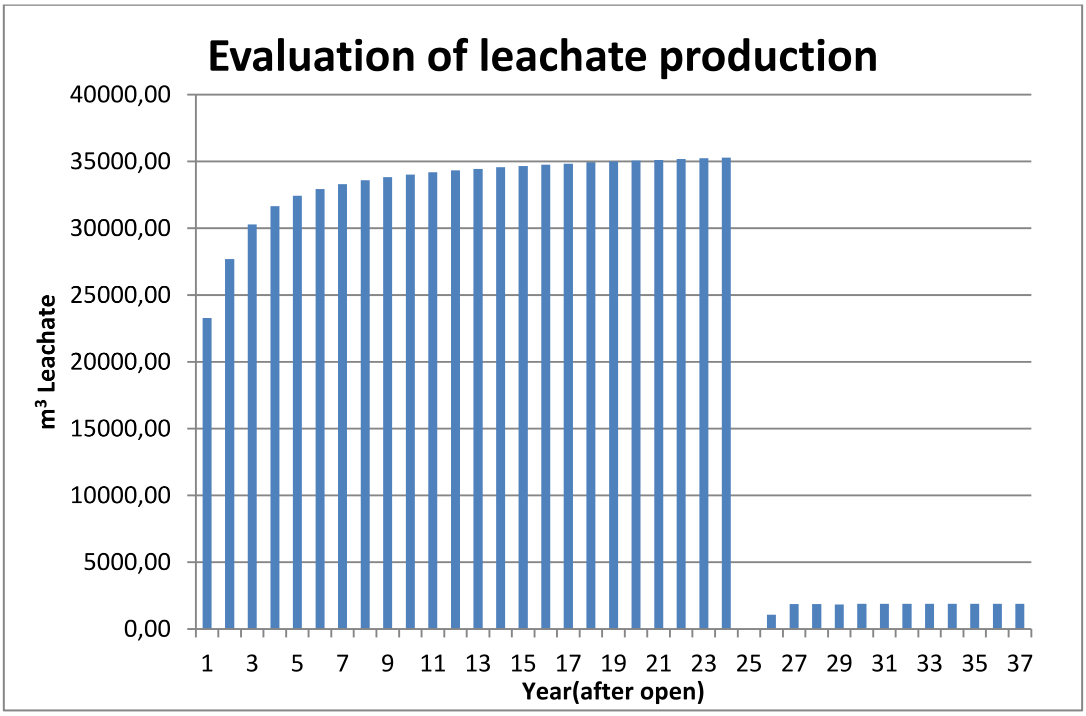


Figure 16. m^3 leachate produced per year

Source: Own elaboration

3.8 Settlement

It is calculated the settlement by the effect of pressure overload. The hypothesis is considered an initial compaction of 700 kg / m3 and not above 1200 kg / m3 within the landfill compacting. As a result, it can be estimate the specific weight of the material at a level with the formula ***, shown the following expression

$$Sw_p = 700 + \frac{p}{31.11 + 0.0018 * p}$$

Where p is calculated with the weight at each level and the own half. The height is related to the amount of remaining starting material and level at the end of the year. Therefore the overall height is previously estimated but the covering latura not compact. Runningthefollowingresults:

Table 50. Ejemplo de l calulo de Alturas para el año 5 de cada nivel considerado.

		24º	23º	22º	21º	20º	19º	18º	17º	16º	15º	14º	13º	12º	11º
p	kg/m2	1100,32	2885,65	4439,56	5787,80	6998,83	8128,64	9216,71	10278,37	11317,24	12336,54	13339,17	14327,82	15305,00	16273,08
SW	kg/m3	733,25	779,49	813,54	839,37	860,13	877,71	893,22	907,18	919,83	931,39	942,00	951,81	960,91	969,41
Δh	m	2,17	1,76	1,38	1,14	0,99	0,91	0,86	0,82	0,79	0,76	0,73	0,71	0,69	0,68
h	m	2,32	1,91	1,53	1,29	1,14	1,06	1,01	0,97	0,94	0,91	0,88	0,86	0,84	0,83

		10º	9º	8º	7º	6º	5º	4º	3º	2º	1º	
p	kg/m2	17234,35	18191,00	19144,69	20096,08	21045,37	21992,70	22938,21	23882,02	24824,26	25765,01	
SW	kg/m3	977,38	984,89	991,97	998,68	1005,04	1011,08	1016,83	1022,30	1027,52	1032,51	
Δh	m	0,67	0,66	0,65	0,65	0,64	0,63	0,63	0,62	0,62	0,61	
h	m	0,82	0,81	0,80	0,80	0,79	0,78	0,78	0,77	0,77	0,76	24,36

Source: Own elaboration

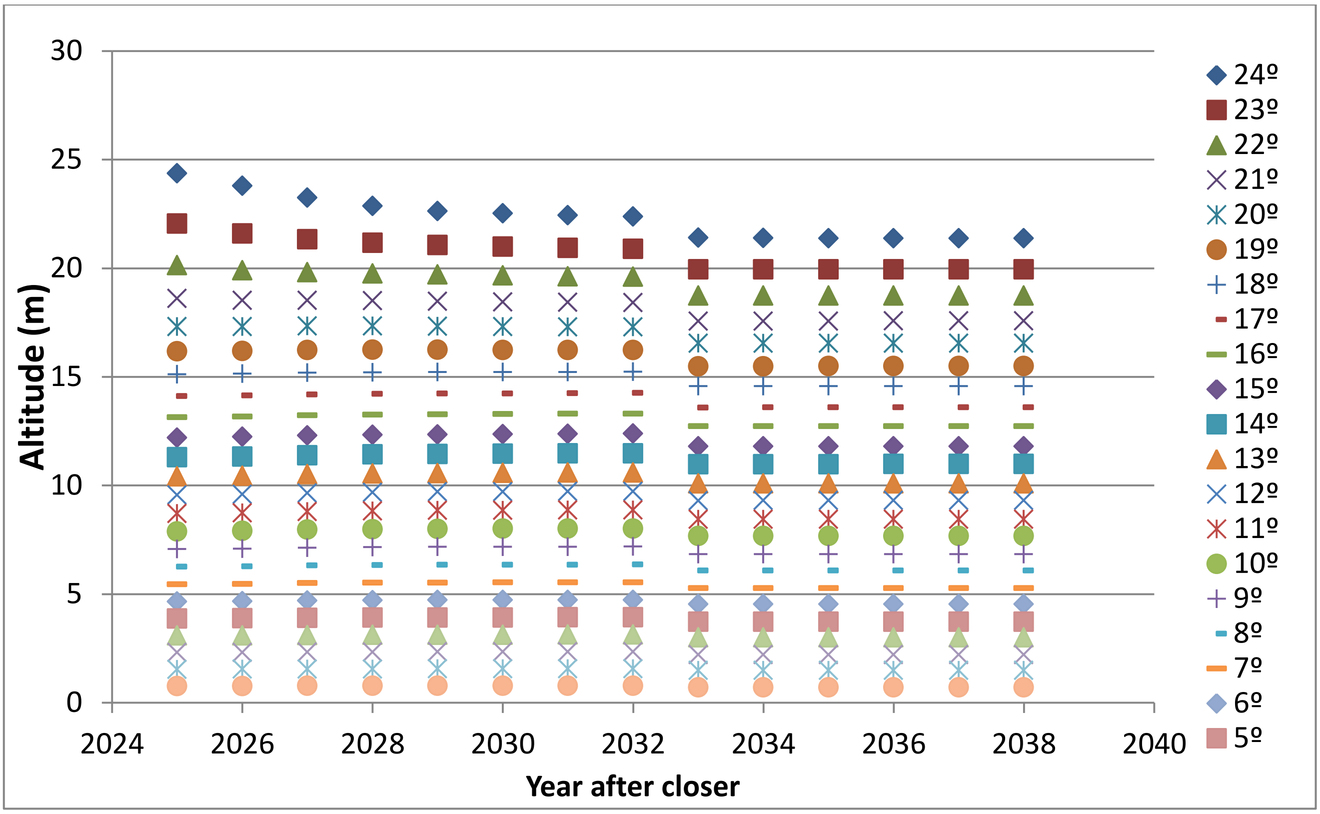
Table 51. Recopilación de resultados de asentamientos. se señala la altura final de vertedero.

Year/ level	24º	23º	22º	21º	20º	19º	18º	17º	16º	15º	14º	13º	12º	11º
2025	2,32	1,91	1,53	1,29	1,14	1,06	1,01	0,97	0,94	0,91	0,88	0,86	0,84	0,83
2026	2,19	1,69	1,39	1,21	1,11	1,05	1,01	0,97	0,93	0,91	0,88	0,86	0,85	0,83
2027	1,91	1,52	1,29	1,17	1,10	1,05	1,00	0,96	0,93	0,90	0,88	0,86	0,85	0,84
2028	1,70	1,41	1,25	1,16	1,09	1,04	0,99	0,96	0,93	0,90	0,88	0,86	0,85	0,84
2029	1,56	1,35	1,24	1,15	1,08	1,03	0,99	0,95	0,92	0,90	0,88	0,87	0,85	0,84
2030	1,53	1,33	1,22	1,14	1,07	1,02	0,98	0,95	0,92	0,90	0,88	0,87	0,86	0,84
2031	1,50	1,31	1,20	1,12	1,06	1,02	0,98	0,95	0,92	0,90	0,88	0,87	0,86	0,85
2032	1,48	1,29	1,19	1,11	1,06	1,01	0,98	0,95	0,92	0,90	0,89	0,87	0,86	0,85
2033	1,46	1,21	1,18	1,02	1,05	0,92	0,98	0,86	0,92	0,82	0,89	0,79	0,86	0,77
2034	1,45	1,20	1,18	1,02	1,05	0,92	0,98	0,86	0,93	0,82	0,89	0,79	0,86	0,77
2035	1,44	1,20	1,17	1,02	1,05	0,92	0,98	0,86	0,93	0,82	0,89	0,79	0,86	0,77
2036	1,43	1,20	1,17	1,02	1,05	0,92	0,98	0,86	0,93	0,82	0,89	0,79	0,86	0,77
2037	1,43	1,20	1,17	1,02	1,05	0,92	0,98	0,86	0,93	0,82	0,89	0,79	0,86	0,77
2038	1,43	1,20	1,17	1,02	1,05	0,92	0,98	0,86	0,93	0,82	0,89	0,79	0,86	0,77

Year/	10º	9º	8º	7º	6º	5º	4º	3º	2º	1º	total
level	0,82	0,81	0,80	0,80	0,79	0,78	0,78	0,77	0,77	0,76	24,36
2025	0,82	0,81	0,80	0,80	0,79	0,79	0,78	0,78	0,77	0,77	23,78
2026	0,83	0,82	0,81	0,80	0,80	0,79	0,79	0,78	0,77	0,77	23,24
2027	0,83	0,82	0,81	0,81	0,80	0,79	0,79	0,78	0,78	0,77	22,86
2028	0,83	0,82	0,82	0,81	0,80	0,79	0,79	0,78	0,78	0,77	22,62
2029	0,83	0,83	0,82	0,81	0,80	0,80	0,79	0,78	0,78	0,77	22,52
2030	0,84	0,83	0,82	0,81	0,80	0,80	0,79	0,78	0,78	0,77	22,44
2031	0,84	0,83	0,82	0,81	0,80	0,80	0,79	0,78	0,78	0,77	22,37
2032	0,84	0,75	0,82	0,74	0,80	0,73	0,79	0,72	0,78	0,71	21,40
2033	0,84	0,75	0,82	0,74	0,80	0,73	0,79	0,72	0,78	0,71	21,39
2034	0,84	0,75	0,82	0,74	0,80	0,73	0,79	0,72	0,78	0,71	21,38
2035	0,84	0,75	0,82	0,74	0,80	0,73	0,79	0,72	0,78	0,71	21,37
2036	0,84	0,75	0,82	0,74	0,80	0,73	0,79	0,72	0,78	0,71	21,37
2037	0,84	0,75	0,82	0,74	0,80	0,73	0,79	0,72	0,78	0,71	21,37

Source: Own elaboration

Figure 17. Grafica de estabilizacion del efecto de carga en el asentamiento de vertedero



Source: Own elaboration

Alternative: Landfill+ Treatment plant(Recoiling and composting)

In this part, it has been carried out alternative of disposal. this alternative will be treatment plant with composting and landfill. It will have different condition., such as waste composition, specific weight. Biodegradable material is reduced, for this reason it complies RD 1481/2001 on reduction in biodegradable material in landfill. In addiction, the waste quanty is redced by recycling. The hierarchy of waste management is obeyed by this alternative, as Ley 22/2011 say.

Therefore, this method has a treatment plant where material is recycled and organic materil is transported to line compost. Disposal in landfill is changed. After treatment, wastes make up compact prism. Specific weight will be 1 tn / m3 (Tchobanoglous, Thisen, & Vigil, 1993). It increase on base other landfill. The tratament plan wil have the bellow efficiency:

Table 52. Efficiency of recovery on base installation of Comunidad Valanciana

Component	% recycling
Organic material	16,8
Paper/Card board	11,1
Plastics	5,42
Glass	6
Metal	32,9
Metal No Fe	32,9
other	0,44

Source: Gallardo Izquierdo(2014)

The waste composition after treatment pant will be.

Component	TABLE Valencia Wastes
Organic material	44,87
Paper/Card board	17,75
Plastics	9,71
Glass	9,33
Metal	2,68
Metal No Fe	0,46
other	15,21
	100

Source: Own elaboration on base Gallador Izquierdo (2014)

The leakes of plant are 20,6% of total . The percentage waste disposal is 67%7. The moisture is 34,78%. The shefe life is 34 year

The composition formula change ,so can be compare the bellow information:

	Landfill	Landfill + Tratament plant
% Methane	52,76	53,62
%CO2	47,24	46,38
Vol RD/kg waste	0,9681	0,9616
Vol LD/kg waste	1,0021	1,0021
kcal/kg	3158,40	3147,17

Source: Own elaboration

	2017	2018	2019	2020	2021	2022	2023	2024	2025
m3 gas RD/kg	0,0000	0,0416	0,0728	0,0520	0,0312	0,0104	0,0000		

m3 gas LD/kg	0,0000	0,0008	0,0025	0,0041	0,0058	0,0075	0,0079	0,0070	0,0062
m3 gas Total /kg waste	0,0000	0,0424	0,0752	0,0561	0,0370	0,0178	0,0079	0,0070	0,0062

	2026	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	
m3 gas RD/kg								0,2079
m3 gas LD/kg	0,0054	0,0046	0,0037	0,0029	0,0021	0,0012	0,0004	0,0621
m3 gas Total /kg waste	0,0054	0,0046	0,0037	0,0029	0,0021	0,0012	0,0004	0,2700

Source Own elaboration

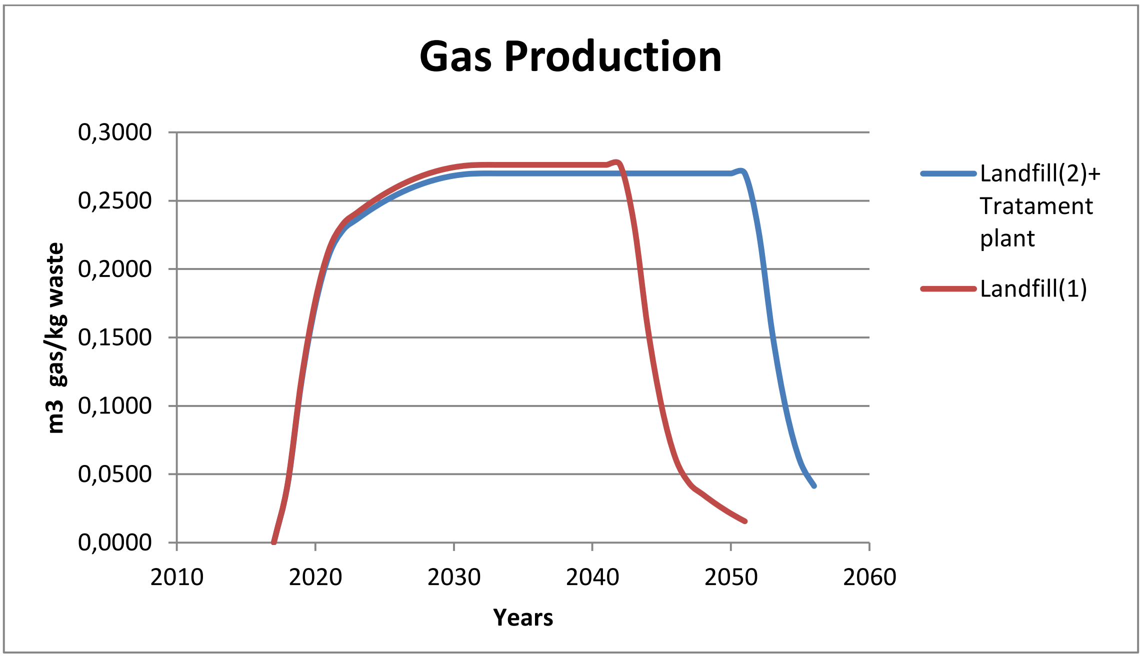


Figure 18. Comparative production gas between two alternatives

Year	2017	2018	2019	2020	2021	2022	2023	2024	2025
m3 gas total	0	1.476.648,73	4.087.662,15	6.022.315,93	7.284.297,42	7.878.219,75	8.124.015,92	8.338.249,20	8.521.146,27

Year	2026	2027	2028	2029	2030	2031	2032	2033	2034
m3 gas total	8.672.965,60	8.793.994,94	8.884.549,07	8.944.967,78	8.975.614,12	8.976.872,73	8.949.148,41	8.906.519,11	8.862.812,37

Year	2035	2036	2037	2038	2039	2040	2041	2042	2043
m3 gas total	8.818.069,73	8.772.330,23	8.725.630,56	8.678.005,29	8.629.487,03	8.580.106,55	8.529.892,94	8.478.873,73	8.427.075,02

Year	2044	2045	2046	2047	2048	2049	2050	2051	2052
m3 gas total	8.374.521,53	8.394.979,82	8.415.082,31	8.434.841,14	8.454.267,88	8.473.373,50	8.492.168,44	8.510.662,66	7.173.857,24

Year	2053	2054	2055	2056	2057	2058
m3 gas total	4.801.829,28	3.032.967,03	1.867.270,51	1.304.739,70	1.056.839,16	5.845.233,87

Year	2059	2060	2061	2062	2063	2064
m3 gas total	3.835.934,73	2.348.531,47	1.304.739,70	626.275,06	234.853,15	52.189,59

After closed of both landfill, gas production in this alternative is bigger that the fist alternative duo to quantity of managed waste. For this reason, gas-waste relationship is better in this alternative.

It is calculated leachate with variable hypothesis. The geometric is the same but it has one difference, quantity levels (34 levels). Altitude of level is 1,7 m. It is shown the bellow results:

Table 53. Leachate generation

	kg/m2	m3/Year
1	701,36	25482,79
2	888,02	32264,67
3	981,44	35658,91
4	1027,67	37338,61
5	1053,44	38275,01
6	1069,75	38867,38
7	1081,79	39305,08
8	1091,31	39650,90
9	1098,99	39930,11
10	1105,33	40160,28
11	1110,66	40353,97
12	1115,24	40520,46
13	1119,27	40666,76
14	1122,89	40798,28
15	1126,22	40919,26
16	1129,35	41033,09
17	1132,28	41139,57
18	1134,98	41237,39
19	1137,46	41327,58
20	1139,75	41411,03
21	1141,89	41488,46
22	1143,87	41560,52
23	1145,72	41627,75
24	1147,45	41690,63
25	1149,07	41749,57
26	1150,60	41804,94
27	1152,03	41857,06
28	1153,38	41906,20
29	1154,66	41952,62
30	1155,87	41996,54
31	1157,01	42038,17
32	1158,10	42077,66
33	1159,14	42115,20
34	1160,12	42150,92
35	0,00	0,00
36	0,00	0,00
37	30,91	1123,10
38	45,23	1643,27
39	47,82	1737,50
40	49,67	1804,65
41	50,10	1820,45
42	50,56	1836,88
43	51,22	1861,02
44	51,49	1870,77
45	51,29	1863,55
46	51,34	1865,18
47	51,63	1875,85

The same way, the settlements are calculate, but initial specific weigh is 1tn /m3 and maximum specific weight is 1,20 tn/m3 for pressure weight

Table 54. Altitude of last level of landfill

year	TOTAL m
2035	27,46
2036	26,97
2037	26,54
2038	26,25
2039	26,06
2040	25,97
2041	25,91
2042	25,85
2043	25,81
2044	25,80
2045	25,79
2046	25,79
2047	25,78
2048	25,78

Chapter 4. Conclusion

Hereafter, it is shown the conclusion which have been obtain in this document.

The localization meets the criteria of ANEXO I RD 1481/2001. Therefore the site is suitable for construction of landfill. There are not protected reserves. Besides there are not endangered species. Finally, landfill does not affect groundwater.

The capacity of landfill is 2.600.000 on based geographic and study geometric. Waste generation associated with population, it has been obtain 24 year of shelf life, without settlements.

The gas quality is suitable for recovery, more 40% methane. The quantity is enough for good efficiency (Cogesar, 2015)Consequently, an economic study will be done to ensure sustainability.

Leachate calculation has limitations for hypothesis, see chapter 3.6. It has been calculated 35.289,77 m3, after closed.

The sentiments are very important. Altitude level is reduced 60% of design. It may be said that shelf life of landfill will increase.

Comparative with second alternative, it is can obtained bellow information

It is reduced 37% of waste in landfill.

Gas-waste relationship is lower that first alternative.

There are more leachate production because of there are more year of exploitation.

<u>Limitations</u>

The composition data are approximate with information of Comunidad Valenciana. The composition is in several calculations.

The gas calculation is ideal for the best production, it will be less production in the reality.

The leachate calculation is on based hypothesis, so it is only one approximation.

The site information is bibliographic, and then it will need in situ test.

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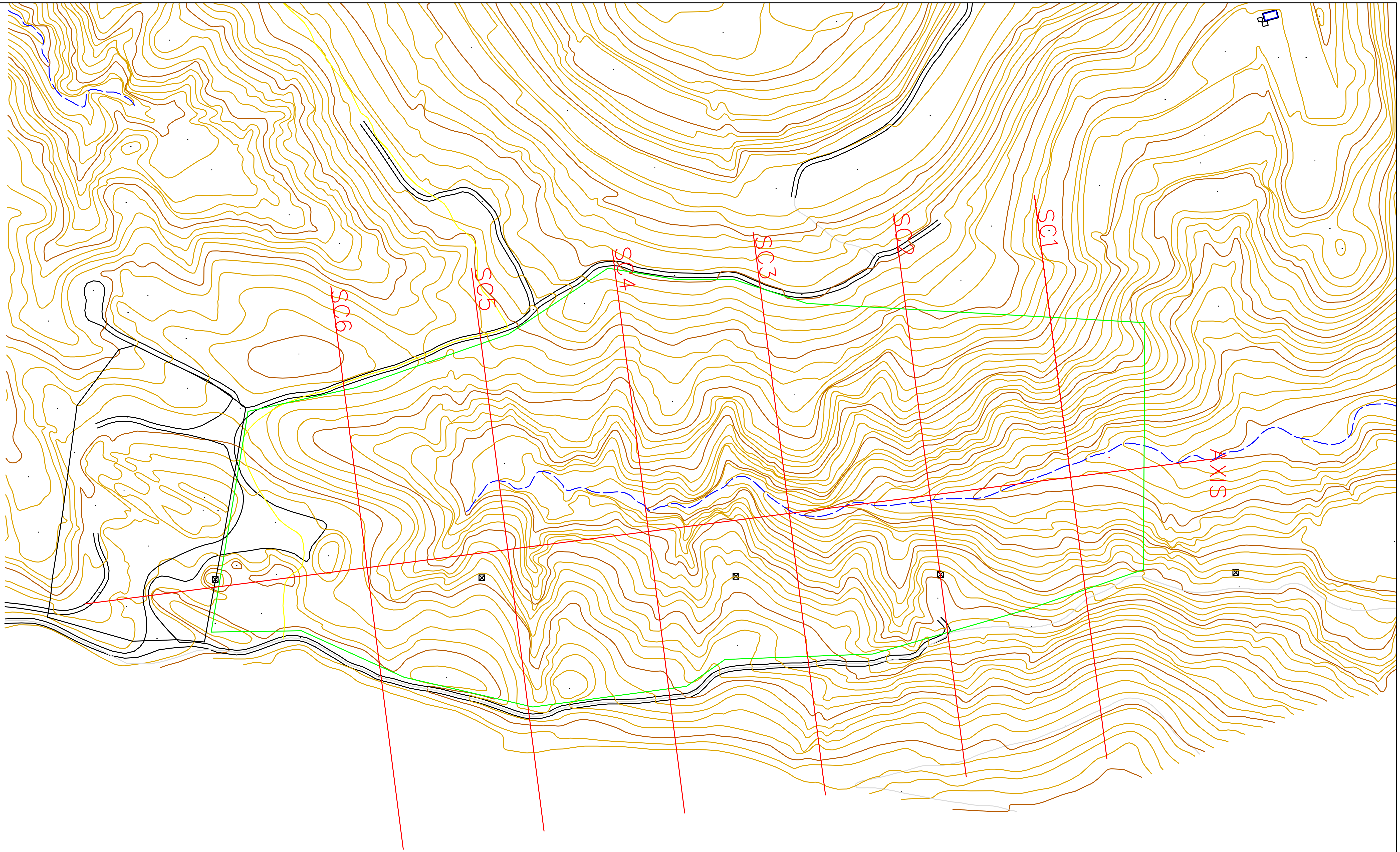
Directive 2008/98/EC of the European Parliament and of the Council of 19th November 2008, on Waste

Ley n 22/2011 de 28 julio de residuos y suelos contaminados

ANEXO I: Plans



MÁSTER EN INGENIERÍA AMBIENTAL
ESCUELA DE CAMINOS, CANALES Y PUERTOS
UNIVERSIDAD POLITÉCNICA DE VALENCIA

AUTOR : ÓSCAR ROMERA MARTÍNEZ
SUPERVISOR UPV : EVARISTO MANUEL LOPEZ
SUPERVISOR ISEP : EUNICE VILAVERDE FOTSAO

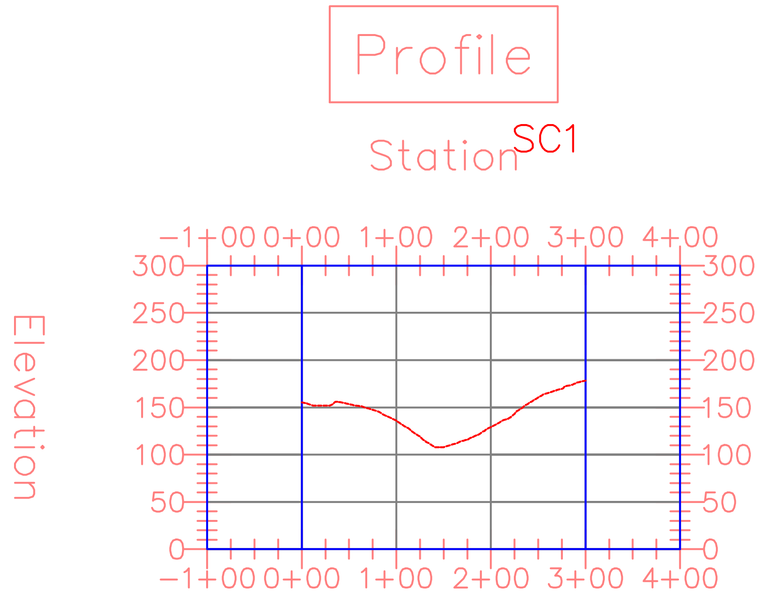
ESCALA: 1:2000

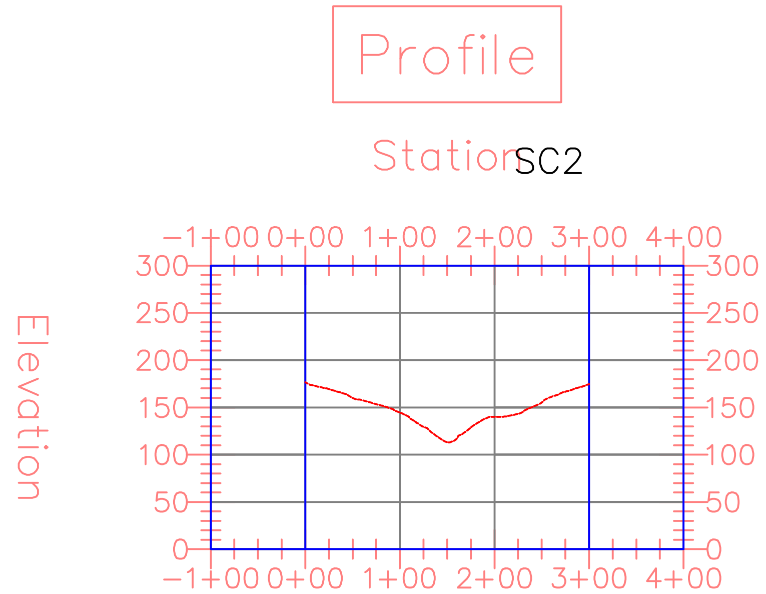
FECHA: SEPTEMBER

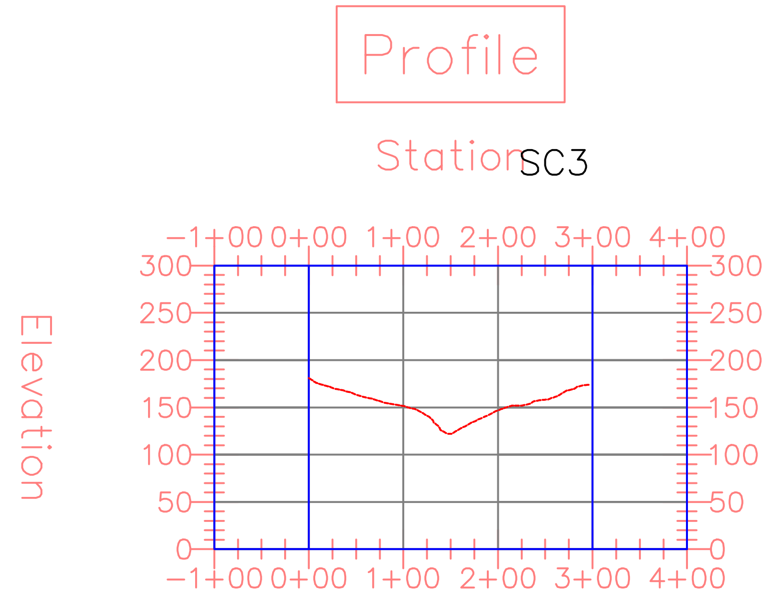
TITLE OF PROJECT: Study of the processes for designing a landfill of municipal solid waste. Sellent Landfill, Valencia

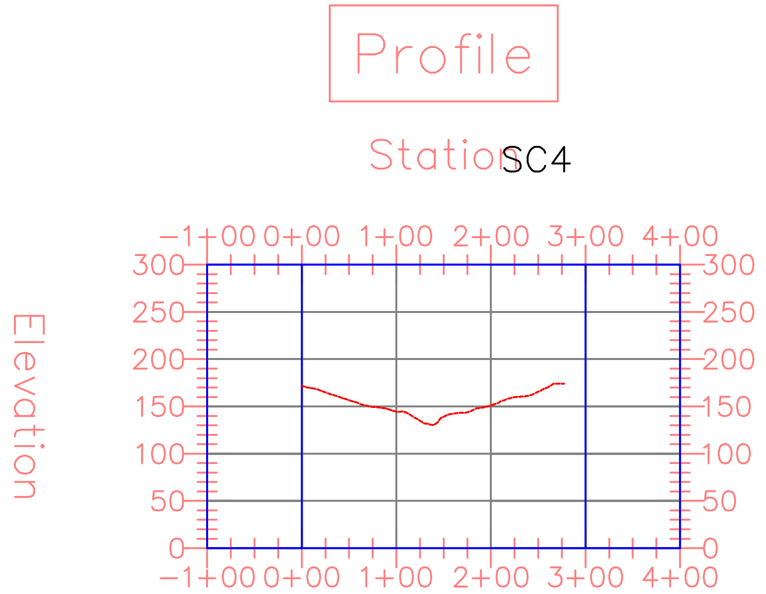
PLAN: Topogrphic Plant, State 0

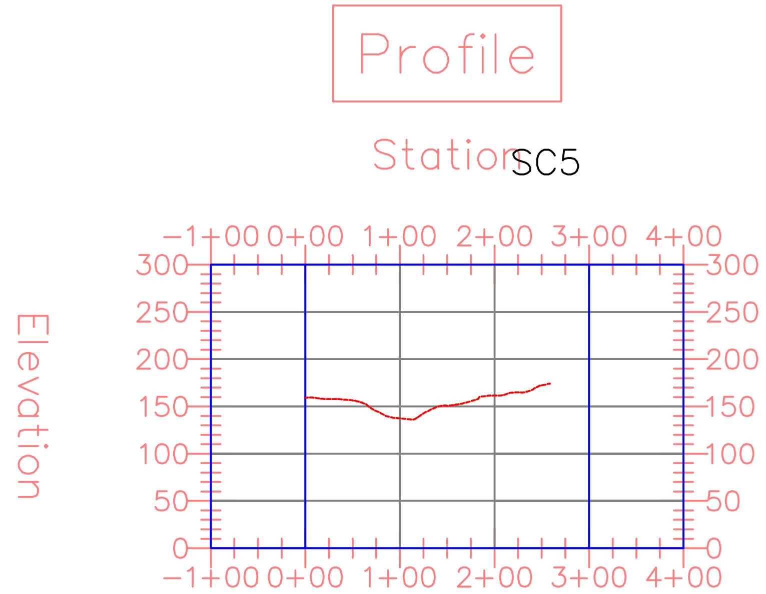
NUMER: P 1.1
1 de 6

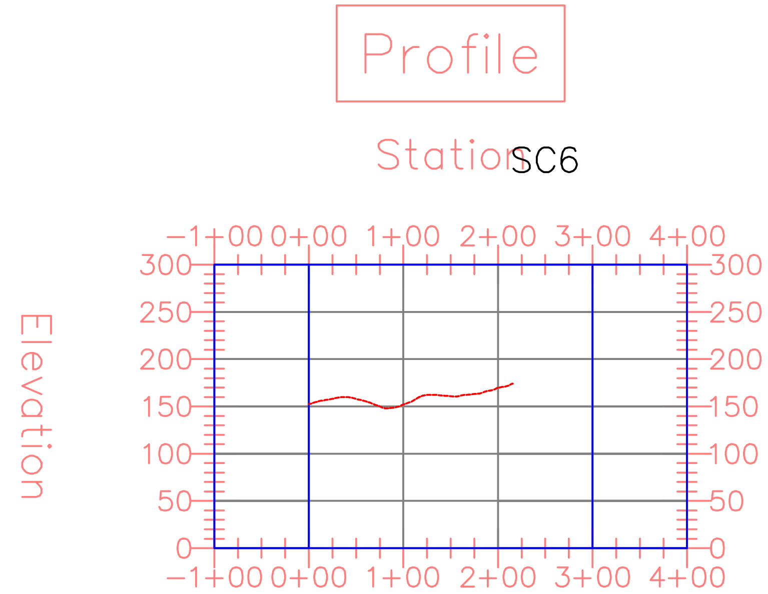












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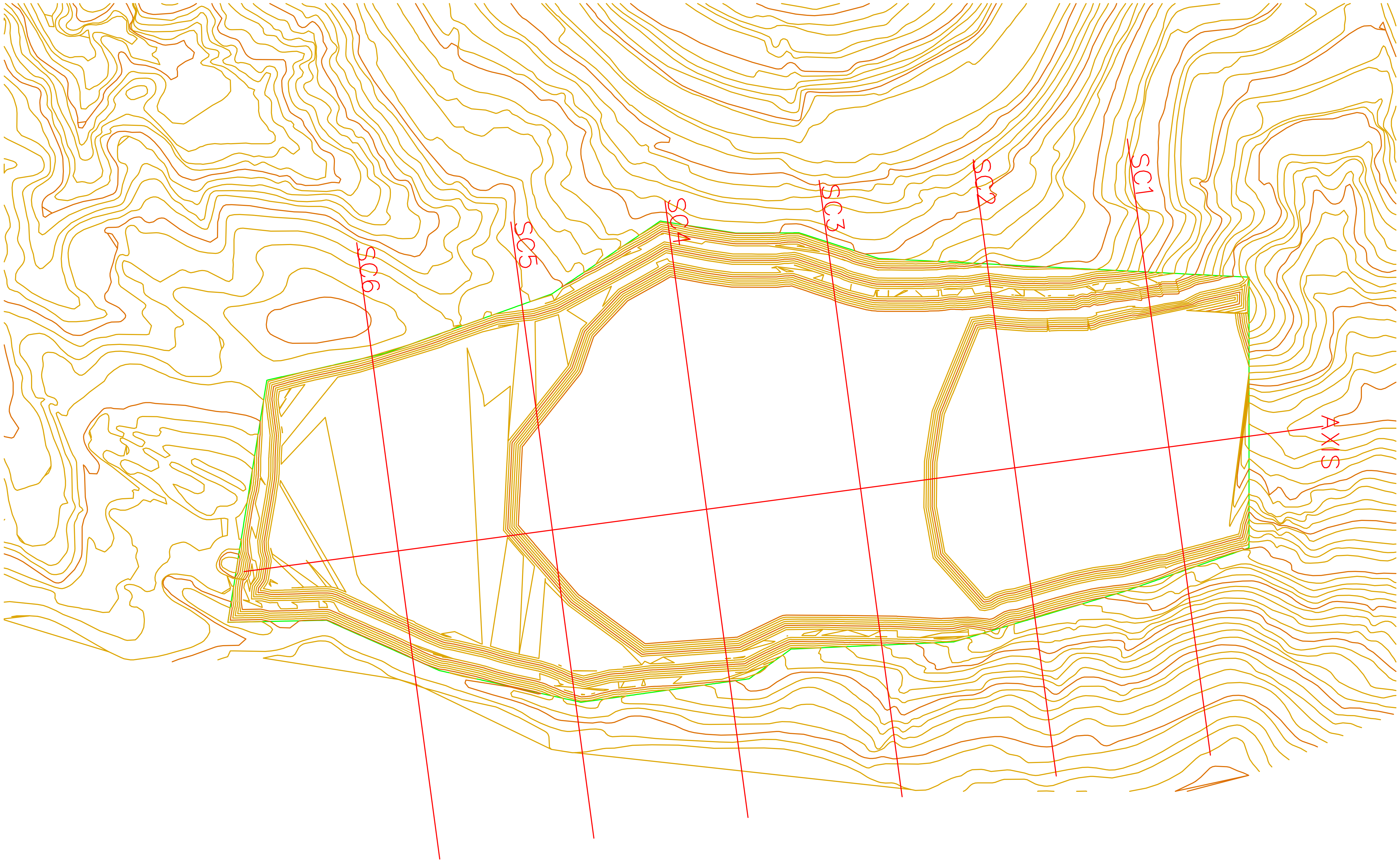

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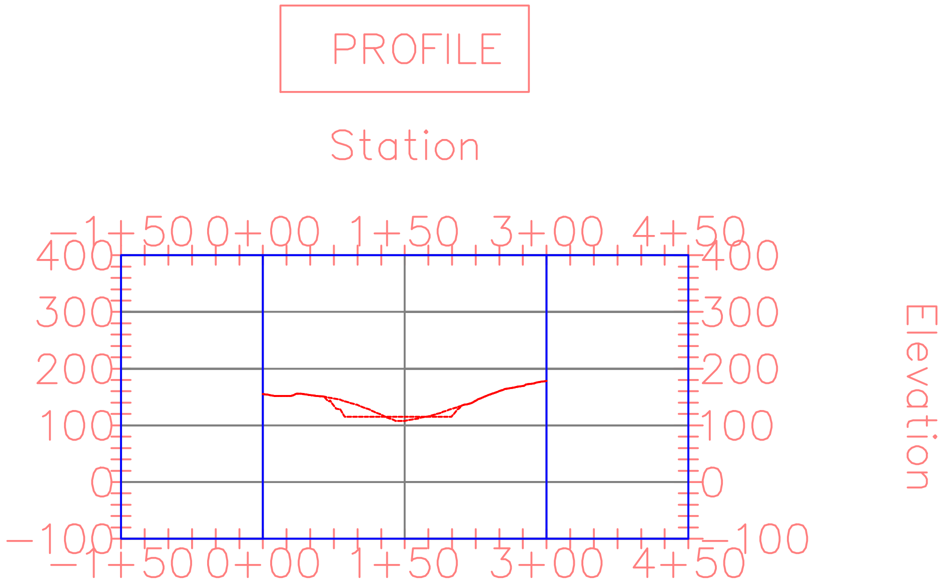

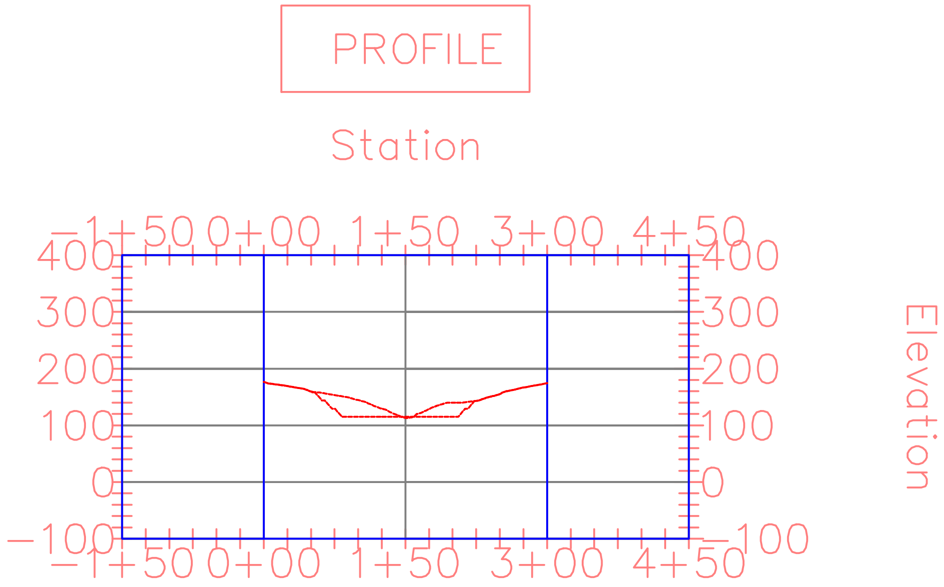

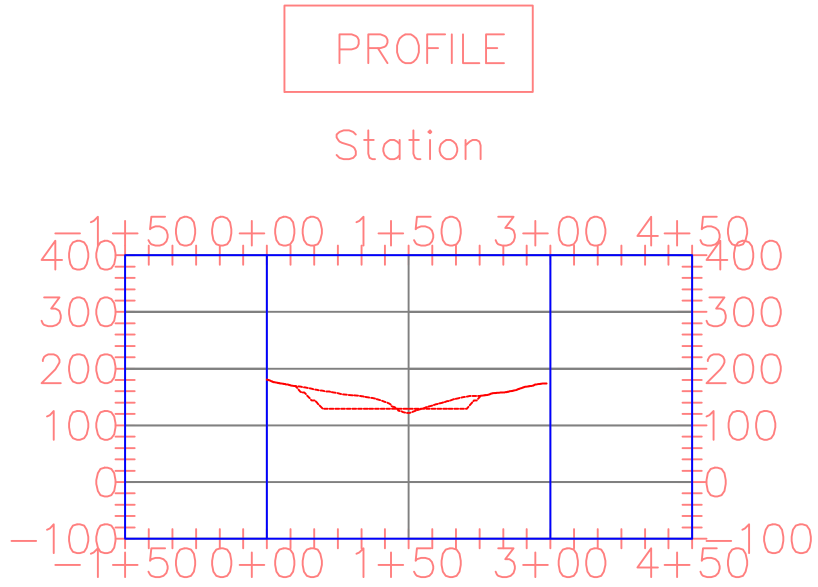

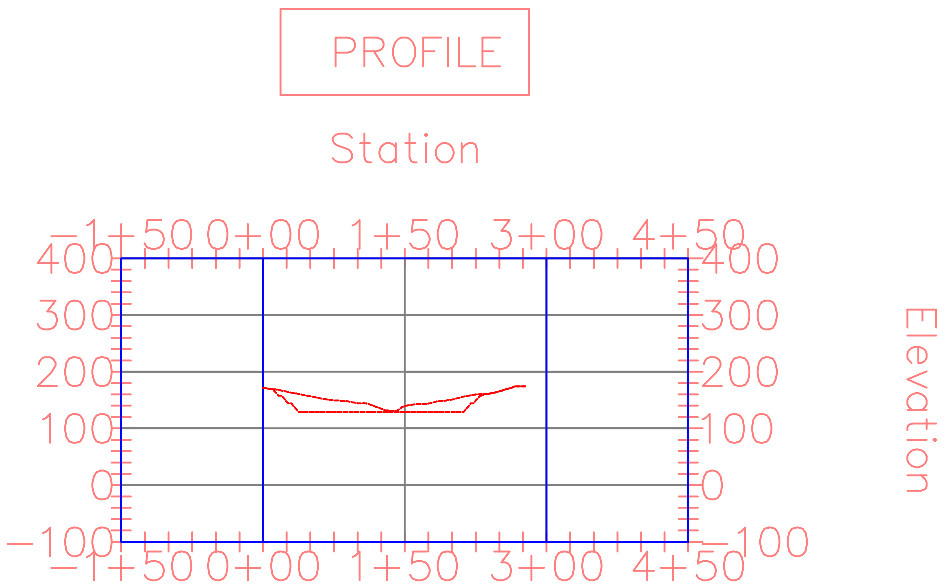

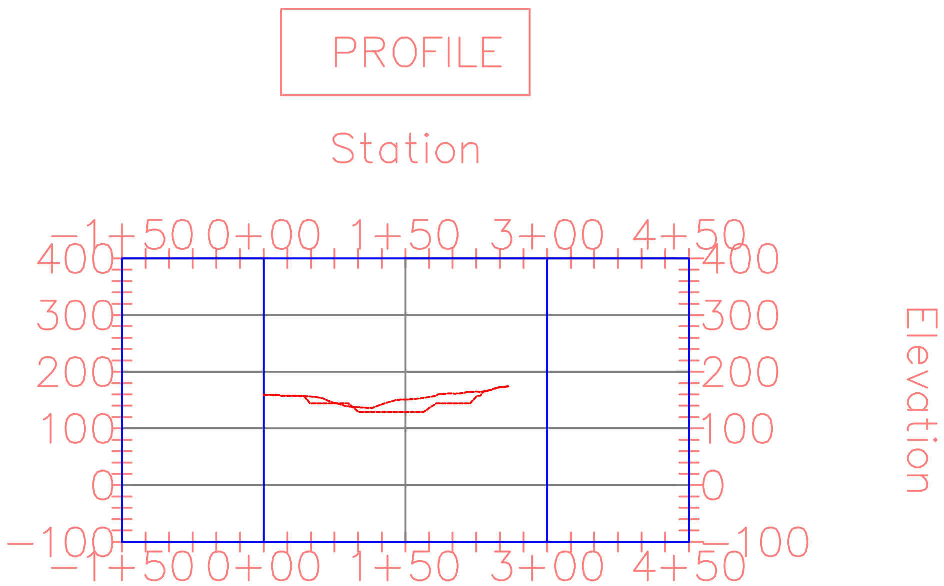

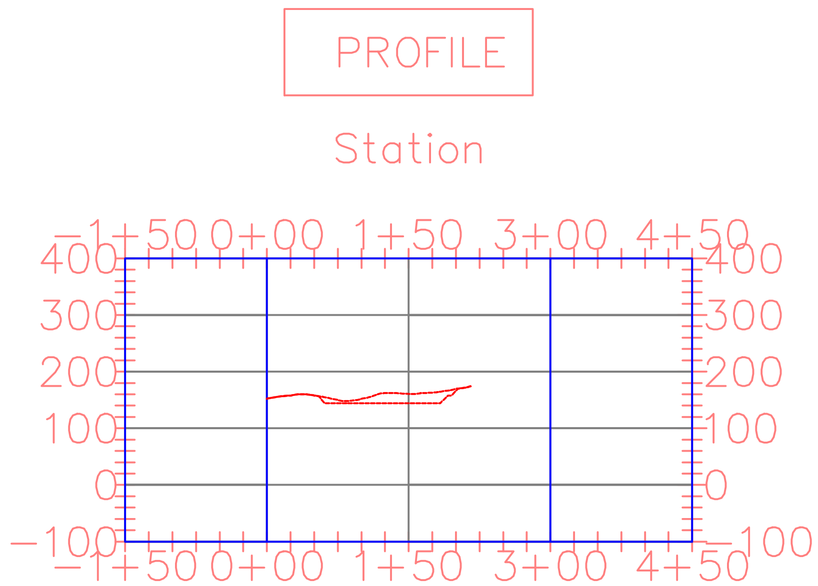

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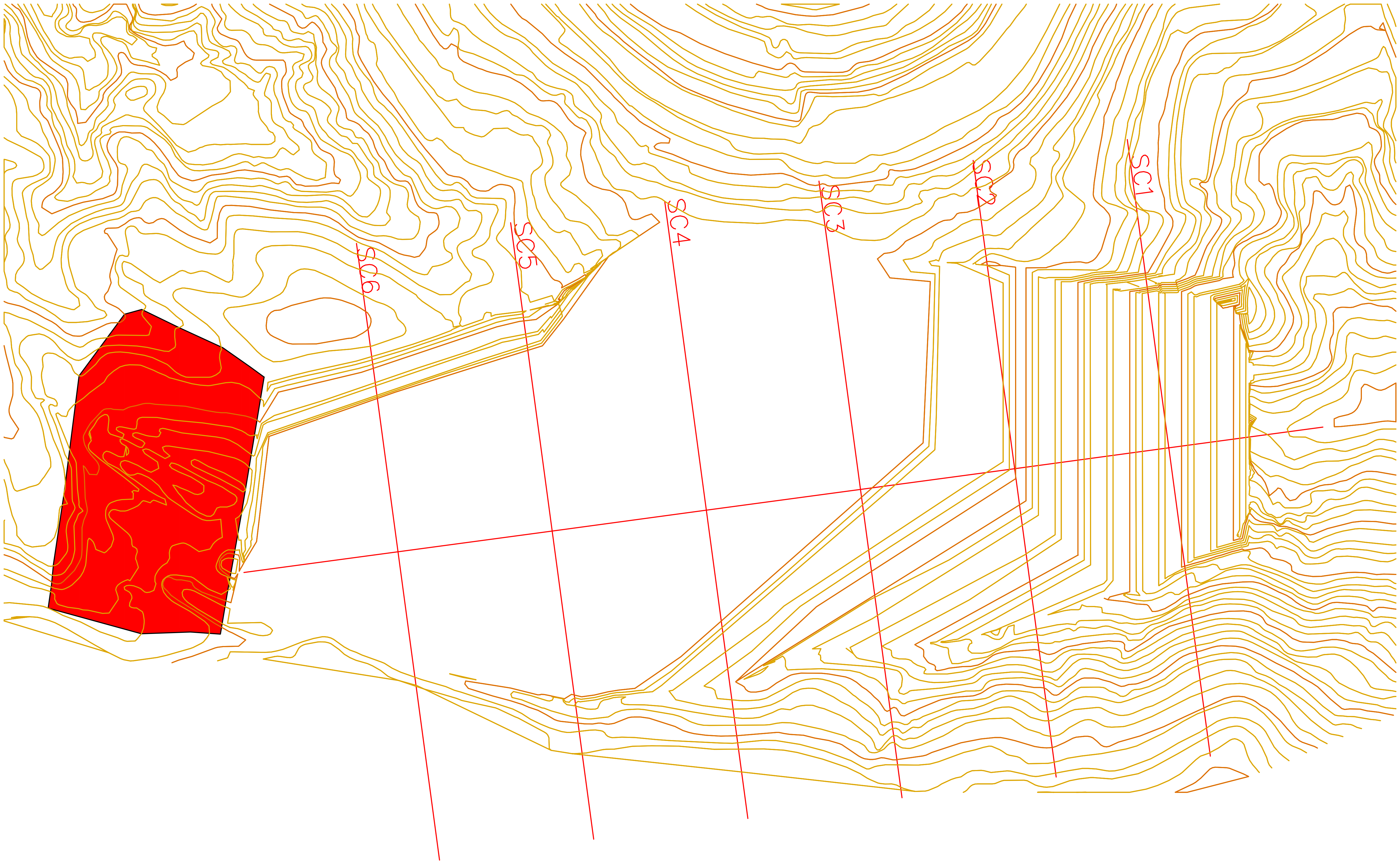

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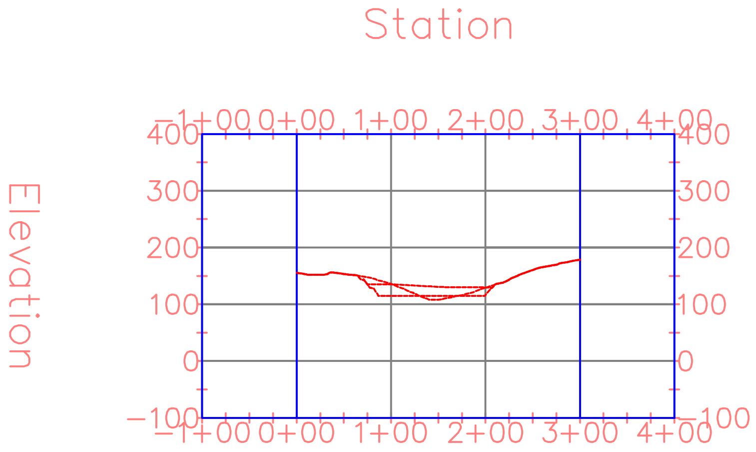
Alignment – (1) PROFILE



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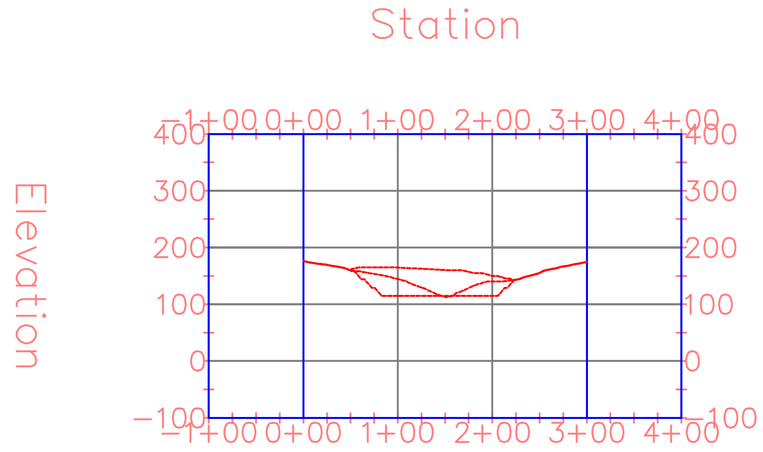

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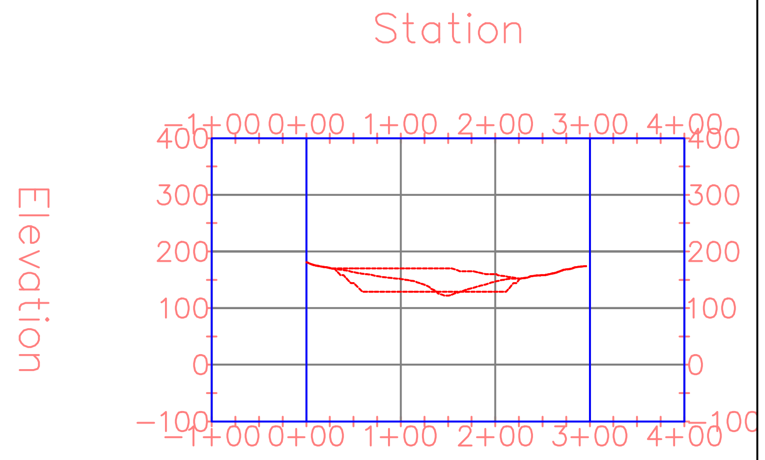

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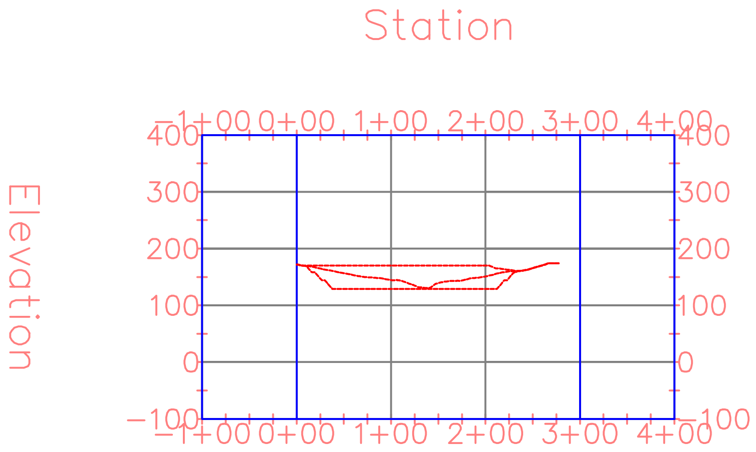

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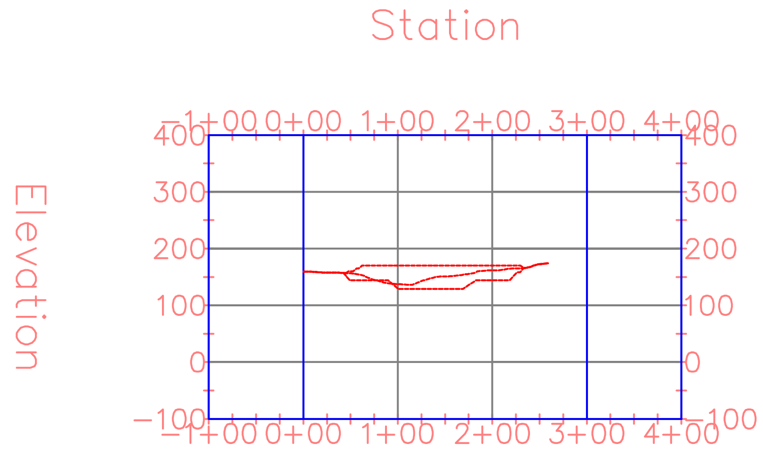

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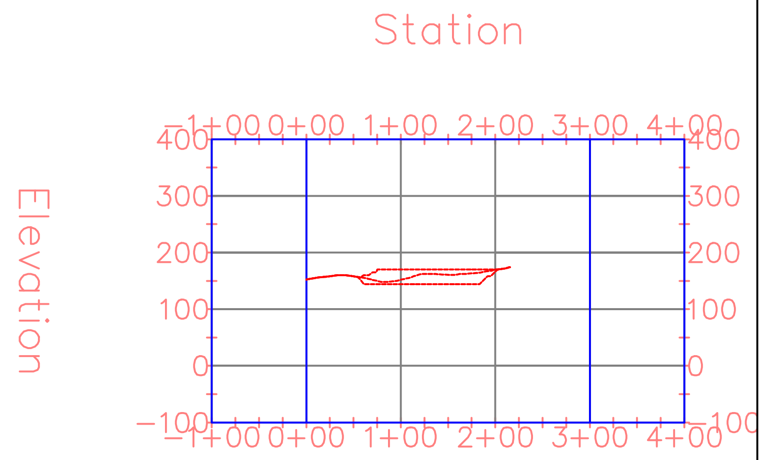

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