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Gauci V.

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Supply of Irrigation Water in a Semi-Arid Area

Vincent Gauci
Sant' Antnin Sewage Treatment Plant, Marsascala

Abstract. *The water supply problem has always been considered a priority issue on the political agenda of successive governments. In the agricultural sector, the Sant' Antnin Sewage Treatment Plant has been a major investment in the provision of irrigation water to the S.E. area of Malta. About four hundred and fifty farmers benefit from the operation of the Project, the two major positive results being an increase in vegetable production and the reduction of sewage outflow into the Mediterranean Sea.*

Titre. Approvisionnement en eau irriguée dans les zones semi-arides.

Résumé. Le problème de l'approvisionnement en eau a toujours été une priorité dans les dossiers politiques des gouvernements successifs. Dans le secteur agricole, le *Sant' Antnin Sewage Treatment Plant* a constitué un investissement majeur pour l'approvisionnement en eau irriguée dans le sud-est de Malte. Environ quatre cent cinquante agriculteurs bénéficient de ce projet dont les conséquences principales sont : une augmentation de la production légumière et une diminution des eaux usées déversées dans la Méditerranée.

Keywords. Water supply – Irrigation – Sewage treatment – Sludge – Composting.

I. – Landmarks in the Local History of Water Supply

Malta does not have any permanent streams, lake or rivers. The water supply problem has always been high up in the priority list of the authorities which have, from time to time, governed these islands. This is reflected in local legislation where we find, for example, that every house should have an underground cistern of adequate capacity for rain-water collection, and that first class water cannot be used for irrigation but only for human consumption.

The main landmarks in the history of the local water supply are the following:

The first people who tackled the water problem were the Knights of St. John who in 1615 supplied the newly built capital city, Valletta, with water obtained from springs in the Rabat area via a specially constructed aqueduct. Later on, this aqueduct was replaced by pipelines, leaving the old channels for agriculture. Other towns were successively connected to this system.

Appendix 1 shows the geological structure of the Maltese Islands. It was during the 18th century that exploitation of underground resources started. Malta has a calcareous geology with two aquifers. The smaller, shallower aquifer consists of highly fissured Upper Coralline Limestone and Greensand, resting upon a bed of clay. For this reason, it is called a Perched Aquifer, and was the first to be exploited. This aquifer is present mainly in the Rabat-Mgarr area, especially North of a great geological fault which runs from North-East to South-West.

The Main Aquifer (highest point of the water table: 4 m above mean level, also known as the Mean Sea Level Aquifer), is made up of highly fissured Lower Coralline Limestone which extends below the whole island. In this aquifer, fresh water floats on sea water, due to the small density difference.

Boreholes and galleries were sunk in both aquifers and up to about 30 years ago, water extracted from underground sources was adequate to meet the domestic and agricultural water demand of the local community. Both aquifers are replenished by the relatively low annual rainfall. The mean annual rainfall is 530 mm. This figure must be seen in conjunction with the corresponding evapotranspiration of about 420 mm. Over the whole area of the Maltese Islands, the net available amount is equivalent to 27 million m^3 of water per year. However, during storms, an estimated 80% of this water may be lost as surface runoff to the sea. The safe yield from the groundwater reserves has been estimated at 15 to 20 million m^3 of water per year.

A steady increase in the annual water demand occurred during the last forty years. This was due to various factors which included the slow but steady increase in population (including the increase in the tourist population), the increase in the standard of living and industrialization.

Overexploitation of groundwater resources led to a gradual salinity increase. During the sixties, the Government approved the purchase and installation of four sea-water multi-flush distillers, each having a capacity of 4,550 m^3 of freshwater per day. Moreover, the Government entered into an agreement with the World Health Organisation to the effect that a team of foreign consultants, together with local personnel, were entrusted with a detailed study of the local water and wastes situation. The results of these studies, together with a number of recommendations, were presented to Government in a multi-volume Masterplan in the early seventies. In their recommendations, the team of experts urged Government to, among other things, proceed with the installation of a wastewater treatment plant, whose effluent could be used for irrigation.

The recommendations were shelved for some time and the increased water demand was met by drilling more boreholes. In the meantime, groundwater salinity continued to increase. The Swedish Consultancy Group VBB (1978) was entrusted with a Preinvestment study concerning the setting up of a Liquid and Solid Waste Disposal Project.

In 1980, a Reverse Osmosis Plant, producing 18,180 m^3 of freshwater per day from sea-water was built at Ghar Lapsi. This was subsequently expanded to produce 22,725 m^3 of water per day. Since then, other Reverse Osmosis Plants have been set up both by Government and by private enterprise. Today, Reverse Osmosis Plants produce the equivalent of over one half of the fresh water domestic requirements of the Maltese Islands.

The Sant' Antnin Sewage Treatment Plant (SASTP) was commissioned in 1983, and since then it has been producing water for irrigation. During 1990, plant effluent started to be used at the nearby industrial estate for the washing of garments. SASTP is currently being upgraded to increase effluent production from 7,000 m^3/day to 12,000 m^3/day. Adjacent to the SASTP, a Solid Waste Composting Plant (300t/day) has been constructed for the treatment of municipal solid waste. The compost is expected to bring about significant improvements in soil texture when applied to land. During 1991, a Consultancy Project was assigned by Government for the drafting of a Sewage Master Plan for the Maltese Islands. In their outline plan, the team of consultants have recommended the construction of three sewage treatment plants over a period of ten years. One of these plants will be located in Gozo. Such plants will eliminate marine discharge of untreated sewage as well as augment freshwater resources.

II. – The Sant' Antnin Sewage Treatment Plant (SASTP)

Of the total area of 12,000 ha under cultivation in Malta, only about 4% is under irrigation; the rest may be described as dry or semi-irrigated land, which depends more or less upon rain which falls during the period September to April.

Prior to the installation of the SASTP, irrigated land depended on water supplied from privately-owned wells, usually tapping the Perched Aquifer. For this reason, irrigated land was found mainly in the Rabat-Mgarr area. The SASTP was designed to augment the irrigated area on these Islands by 500 ha, particularly in the South-East region which traditionally has been always under dry-land cultivation. Moreover, the groundwater in the region is not of a high quality so that there is no risk of ground water pollution.

The current maximum throughput of the SASTP is 7,000 m^3 per day. Sewers draining the inland parts of Malta (Dingli, Rabat, Siggiewi, Zebbug, Mosta, Naxxar, Balzan, Lija, Attard, Birkirkara and Hamrun with a total population equivalent to 100,000) converge to the Marsa Pumping Station from where wastewater is pumped to SASTP. The raw wastewater is strong, having a BOD of 500 mg/l and a total Kjeldahl Nitrogen of 74 mg/l but heavy metals and other toxic elements, characteristic of industrial discharges, are insignificant.

A block diagram and a plan of the SASTP are shown in Appendices 2 and 3. The wastewater is first subjected to biological treatment by the Activated Sludge Technique, followed by rapid sand filtration and disinfection. Since unrestricted irrigation is practised in the area, the reclaimed water has to reach adequate health standards. Faecal Coliform concentrations of less than 100 per 100ml in 80% of the samples have been achieved by complete carbonaceous and nitrogenous oxidation, coupled with the presence of free residual chlorine in the water as it leaves the Plant. Mean results of routine analysis are shown in Appendix 4. The reclaimed water is pumped to 5 reservoirs situated on high ground. Their total capacity is equivalent to a 24 h supply, and the water flows to the fields by gravity in open channels which have been specially built on the rubble walls that separate the individual fields. A sixth reservoir serves industrial concerns.

Sludge, a by-product of treatment, is pumped to a nearby sewer which discharges to the sea. Once the Composting Plant is in operation the sludge will be mixed with the putrescible fraction of solid waste and co-composted.

Biological plants, like the one at Sant’ Antnin, are easily upset by wrong biomass management operations, waste-water feed flow fluctuations and insufficient aeration capacities. Periods of biological instability result in a deterioration of effluent quality. The Plant may take several weeks to recover. In order to avoid mismanagement, it is necessary to have the operation of the Plant always under control. In the case of SASTP, this is achieved by daily monitoring and the keeping of up-to-date records.

Around 35 people are employed on the Sant’ Antnin Project. These include laboratory staff, mechanical engineers, foremen, electrical and mechanical fitters and a number of skilled and unskilled labourers. Some of these are day workers on a shift system.

Regarding agricultural management, how and what to cultivate, is entirely in the hands of the local farmers. About 450 farmers in the area benefit from the Project. Furrow irrigation is practised, but spray irrigation and drip irrigation are also used. The crops cultivated in the region are mainly vegetables. These include potatoes, tomatoes, broad and runner beans, vegetable marrow, green pepper, turnips, cabbages, cauliflower, lettuce, strawberries and clover.

The capital cost for the Sant' Antnin Project was Lm 5.8 million (16 million US$) of which Lm 0.5 million (1.4 million US$) were the foreign component, comprising designs and machinery supplied by an Italian firm.

Reclaimed water is pumped to irrigation during the period March to November. The cost of this water amounts to 12 cents per m^3(*). This includes salaries, power, chemicals, fuel, maintenance and water distribution. An annual nominal fee of Lm 36 per ha of irrigated land is charged. The revenue collected is a mere 4 % of the effluent cost.

Apart from the financial aspect, however, one must also consider other factors which are less easily quantifiable, viz. the increase in agricultural production, the creation of new job opportunities and also the reduction of pollution which would otherwise have resulted in the disposal of the wastewater by discharge into the Mediterranean Sea.

III. – Problems encountered

During the first years the farmers were reluctant to use the effluent on full scale but now the supply is not meeting the demand.

Before the start of the Project, most of the farmers in the area were part-timers and their main produce consisted of vegetables. After ten years' operation, most of the farmers are still part-timers and they are rather slow to change their farming habits.

A biological Treatment Plant requires a fairly constant throughput. The daily wastewater flow through the Sant' Antnin Plant is adjusted from time to time in such a way that the throughput is equivalent to the predicted highest daily demand during the period. The demand, however, fluctuates widely especially at times of significant rainfall; a fraction of the treated wastewater is inevitably wasted.

Wastewater is rather high, reflecting the high salinity of the domestic water supply. The SASTP does not have facilities to reduce waste-water salinity. Consequently, the reclaimed water salinity is high (Electrical Conductivity: 4,000 microS/cm, Sodium Absorption Ratio: 15). Strictly speaking, it must be considered as a water of marginal quality, needing special agricultural management techniques. However, no special techniques have been adopted and still no salinity problems have as yet emerged. Salts accumulate in the soil during the dry season, to be washed down again by heavy rain during winter. Also, some of the crops cultivated are generally considered as intolerant to salinity, *e.g.* strawberries and runner beans; nevertheless, they have been cultivated with success. This is related to the permeable nature of the calcareous soil in the area.

Another problem is related to the distribution of the reclaimed water from the reservoirs to the fields. The open-channel system was adopted because of its lower cost and because it is the traditional distribution system for irrigation water in these Islands. The system, however, is prone to water losses, is very labour intensive, both for its operation and its maintenance, and often results in the farmers next to the reservoirs getting most of the water.

IV. – Some thought for the future

The substitution of vegetable crops with more water-responsive, salt-tolerant industrial crops seems to be an attractive proposition. Cultivation of fodder crops, for instance, besides reducing the health risks, would cut down on the importation of fodder. This would require considerable mechanisation. In this respect, the fragmentation of the land and the lack of agricultural co-operatives in the region pose definite problems which must be overcome.

With respect to the salinity of reclaimed water, the problem would be solved if the salinity of the domestic supply could be lowered. With the increasing contribution of desalination plants to the domestic supply, it is reasonable to predict that the salinity of the domestic supply, and therefore that of the resulting wastewater, will in time decrease.

The extension and upgrading of the effluent distribution system should be seriously considered; first of all so as to cover the whole 600 ha in the immediate vicinity of the SASTP, and then, possibly, to take the reclaimed water to other areas at present under dry-land cultivation. This will involve changing the present system based on open channels to a closed pipe system. Modern application techniques based on micro-irrigation should also be encouraged.

Note

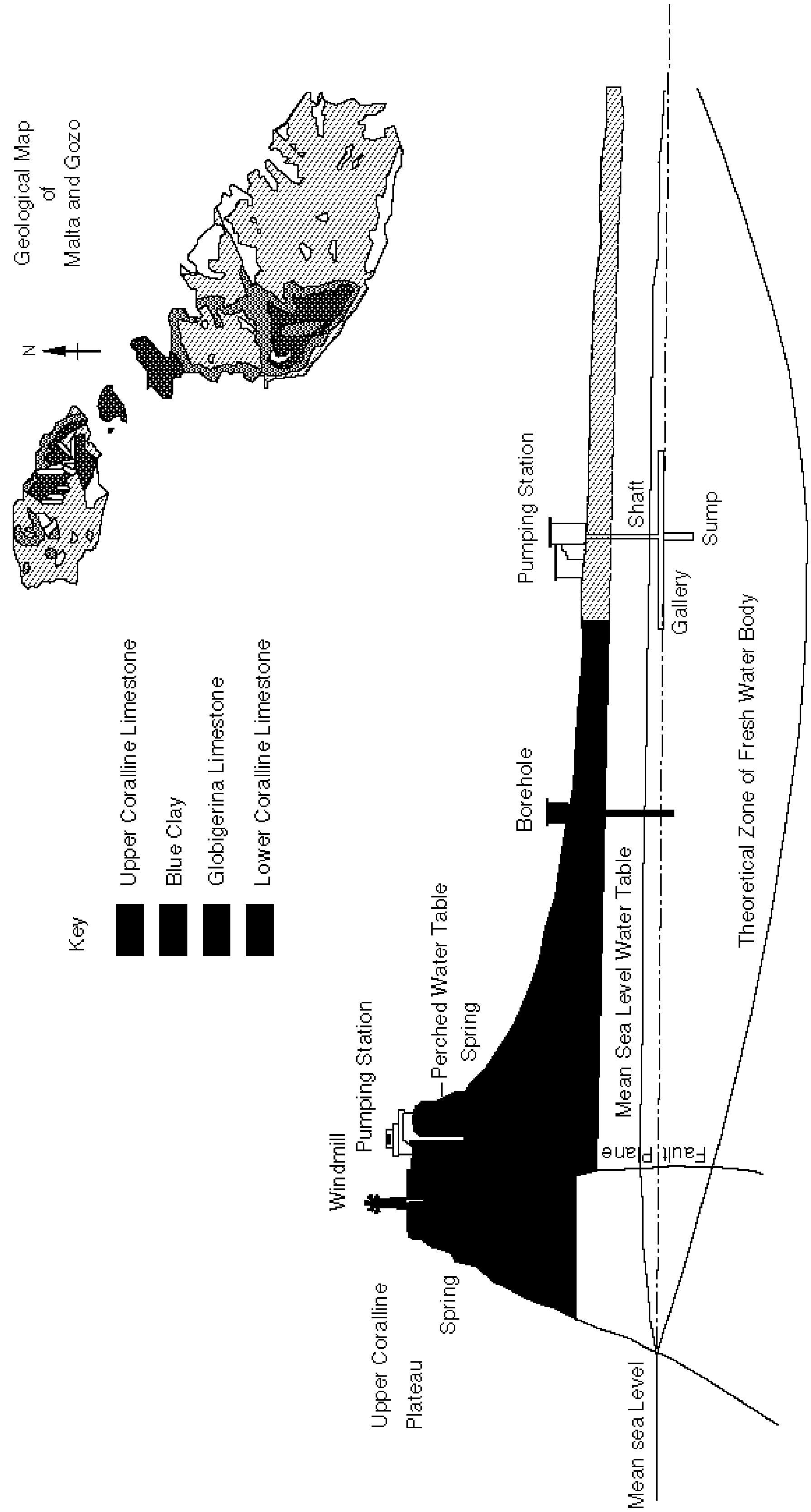
(*) 100 cents = Lm 1.

References

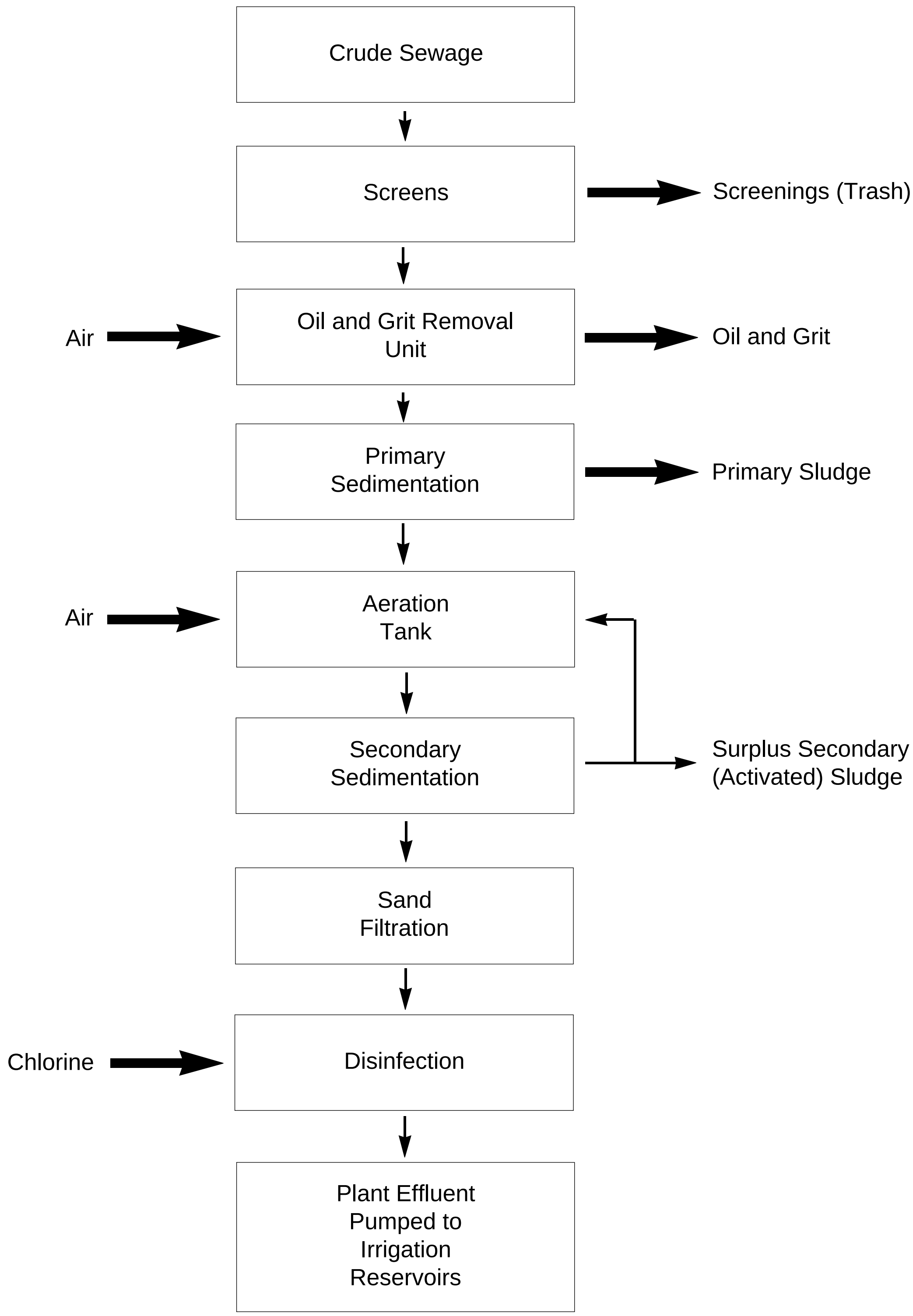
Vattenbyggnadsbyran (VBB) (1978). Purification and refuse pulverisation/Composting Project. Pre-investment Study and Project Preparation Report. Prepared by VBB, member of SWECO, Stockholm.

Appendix 1

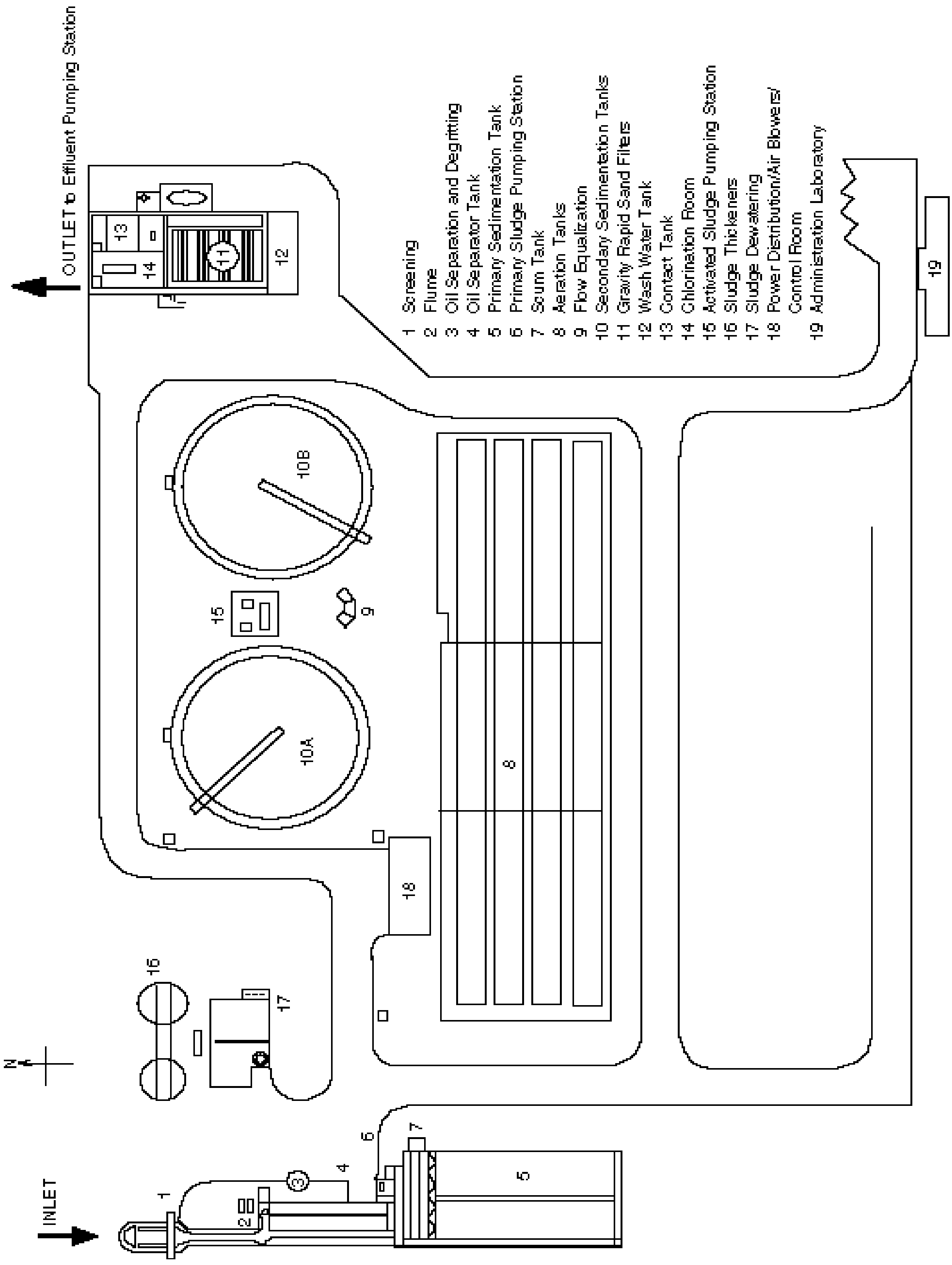
The Geological Cross Section of Malta



Appendix 2
Summary of Sewage Treatment Stages



Appendix 3


OUTLET to Effluent Pumping Station
1 Screening
2 Flume
3 Oil Separation and Degritting
4 Oil Separator Tank
5 Primary Sedimentation Tank
6 Primary Sludge Pumping Station
7 Scum Tank
8 Aeration Tanks
9 Flow Equalization
10 Secondary Sedimentation Tanks
11 Gravity Rapid Sand Filters
12 Wash Water Tank
13 Contact Tank
14 Chlorination Room
15 Activated Sludge Pumping Station
16 Sludge Thickeners
17 Sludge Dewatering
18 Power Distribution/Air Blowers/
Control Room
19 Administration Laboratory
10B
10A
INLET
N

Appendix 4

Sant' Antnin Sewage Treatment Plant laboratory
Mean Routine Analytical Results
(based on samples taken during period March-November)

Analytical Parameter	S/S*	SE	SFE	FE
pH	7.4	7.1		7.2
Turbidity (NTU)		12.5	2.8 (77%)**	3.1
EC (microS/cm)	4097	3744		4033
Suspended Solids (mg/l)	205	25 (88%)	4 (84%)	
Chloride (mg Cl/l)		1002		
Ammoniacal N (mg/l)	74	0.4 (100%)		
Nitrate N (mg/l)		47		
COD (mg/l)	472	55 (88%)	36 (35%)	
BOD (mg/l)	251	10 (96%)	6.7 (33%)	
Alkalinity (mg $CaCO_3$/l)		198		
MBAS (mg LAS/l)		0.06		0.07
Boron (mg B/l)		1.0	1.0	
Faecal Coliforms (/100 ml)		10^5	10^5	<1

* S/S: Settled Sewage (Primary Effluent)
SE: Secondary Effluent
SFE: Sand Filtered Effluent
FE: Final Effluent

** Values in parenthesis refer to the % reduction from preceeding stage.