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SMART 2 – IWRM

Work package 3.1:

Decentralised wastewater treatment and reuse

Deliverable No. 301

**Delivery of sites/Model Village with an existing sewer
system for approx. 650 pe (three plants)**

Deliverable 302:

**General Design of the wastewater treatment and reuse
(WWT&R) units in the villages and/or suburban
community**

Authors and Institution

Ministry of Water and Irrigation, Jordan

Helmholtz Centre for Environmental Research - UFZ

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DELIVERABLES 301-302: IMPLEMENTATION OF SELECTED TECHNOLOGIES FOR WASTEWATER TREATMENT AND REUSE IN JORDAN

The UFZ participation in the SMART II project has for main objectives “the large development of wastewater treatment (...) and the use of water resources of different qualities in order to increase the available water yield and ensure the durability of their utilization”.

The Work Package 3.1 (WP 3.1) gives the task to develop, implement at a pilot scale and evaluate the selected decentralized solutions for closing the local water (and nutrient) cycle in the Jordan Valley.

However, the implementation of the decentralised wastewater treatment and reuse solutions remains limited by the framework given by the Jordanian standards for irrigation water (JS 893/2006). The standards are presented below (Table 1):

Table 1: Jordanian Standards for Irrigation water (JS 893/2006)

Allowable limits per end use		Irrigation			Groundwater recharge	Discharge to wadis, streams or water bodies
Parameter	Unit	Cooked Vegetables, Parks, Playgrounds and Sides of Roads within city limits	Fruit Trees, Sides of Roads outside city limits, and landscape	Field Crops, Industrial Crops and Forest Trees		
Class of water		A	B	C		
Biological Oxygen Demand	mg/L	30	200	300	15	60*
Chemical Oxygen Demand	mg/L	100	500	500	50	150**
Dissolved Oxygen	mg/L	>2	-	-	>2	>1
Total suspended solids	mg/L	50	150	150	50	60**
pH	unit	6-9	6-9	6-9	6 – 9	6-9
Turbidity	NTU	10	-	-	2	-
Nitrate	mg/L	30	45	45	30	45
Ammonium	mg/L	-	-	-	5.0	
Total Nitrogen	mg/l	45	70	70	45	70
Escherichia Coli	MPN or cfu/100 mL	100	1000	-	<2.2	1000
Intestinal Helminths Eggs	Egg/L	< or = 1	< or = 1	< or = 1	< or =1	< or =1
Fats Oils Grease	mg/L	-	-	-	8.0	8.0

* For biological WWTP or WWTP with polishing ponds BOD₅ is considered as the filtered BOD.

** For biological WWTP or WWTP with polishing ponds the allowable limits is twice this number.

To reach the objectives of WP 3.1, different wastewater treatment and reuse systems have to be installed in Jordan.

For individual sites:

- Three modified septic tanks to treat the wastewater coming from individual households representing 10 to 20 PE.
- Two ecotechnologies (treatment wetlands) to treat the wastewater coming from individual households representing 10 to 20 PE.
- Two or three sequencing batch reactors (SBR) to treat the wastewater coming from individual households representing 10 to 20 PE.

For Collective sites:

- One ecotechnology (treatment wetland) to treat the wastewater produced by a small development of around 250 PE.
- One sequencing batch reactor (SBR) to treat the wastewater produced by a small development of around 250 PE.
- One Membrane bio-reactor (MBR) to treat the wastewater produced by a small development of around 150 PE.

Thus at least nine sites have to be identified as suitable to implement one of the decentralized solutions.

The first chapter will focus on the general design of each technology, presenting their main components and highlighting how they fit into each site.

A second chapter will be dedicated to the site selection process. A first part will describe the criteria identified as essential to ensure that the sites correspond to the project context and to the technology requirements. A second part will describe the site selection process and a third part will present the sites officially selected

A third chapter will discuss the difficulties of the process and the importance of local and administrative support.

1 GENERALS DESIGN FOR DECENTRALIZED WASTEWATER TREATMENT SYSTEMS IN THE INVESTIGATION AREA

1.1 THE MODIFIED SEPTIC TANK TECHNOLOGY

The Modified Septic Tank is a low cost Technology providing dual treatment: 1) an anaerobic treatment (a 2-compartment Septic Tank) followed by 2) a two-stage aerobic treatment (attached growth). The technology is designed to comply with the Jordanian Standard JS893-2006.

The Modified Septic Tank was developed to meet the specific treatment demand exerted by domestic wastewater in the decentralised contexts of 1) residential areas, households, villas and mansion, 2) recreational areas and 3) camping sites.

The advantage of the Modified Septic Tank technology over conventional anaerobic or aerobic treatment systems are:

- Smaller footprint (compactness).
- Ability to cope with seasonal variations: Modified Septic Tanks can be successfully installed at site locations experiencing variations in wastewater quantity and quality.
- Higher treatment efficiency by providing aerobic and anaerobic treatment.
- Low sludge production compared to traditional activated sludge systems.
- Low energy costs.

In Modified Septic tanks, the raw wastewater flows first into the two compartments septic tank to undertake a primary treatment reducing the solids load of the system. The primary treated wastewater flows by gravity from the 2nd compartment of the septic tank into the aerobic treatment section where it is treated in two different stages (each stage comprises an aeration chamber followed by a clarification chamber). The aerobic reactors contain plastic media for biofilm growth and air diffusers. Air blowers are used to provide the required air/oxygen to the aerobic reactors and the air lift sludge return pumps.

While part of the organic pollutants is removed inside the anaerobic reactor, the two-stage aerobic reactor is responsible for the removal of the rest of the organic pollutants and the nitrification of ammonia (NH_4 transformed in NO_3). The compressed air that is introduced into the aeration chamber through the diffusers serves also as a mixing/stirring device that promotes the growth of the microorganisms attached to the surface of the plastic media. This improves the degradation of pollutants.

The mixed liquor then flows by gravity into the final clarification compartment. Clean water stays at the top and flows outside the Modified Septic Tank (into the Reuse / Irrigation Tank) while the settled sludge is pumped (by an air lift pump) back to the aeration compartment.

The process and technical drawings of the Modified Septic tanks are presented below (Figure 1 and 2).

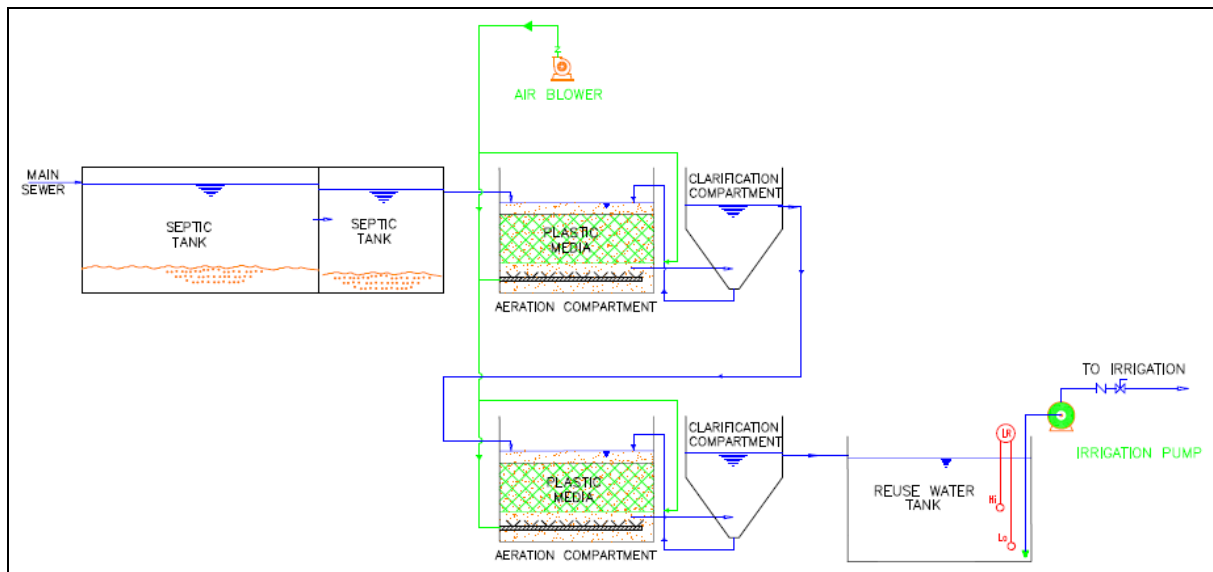


Figure 1: Process diagram of a Modified Septic tank.

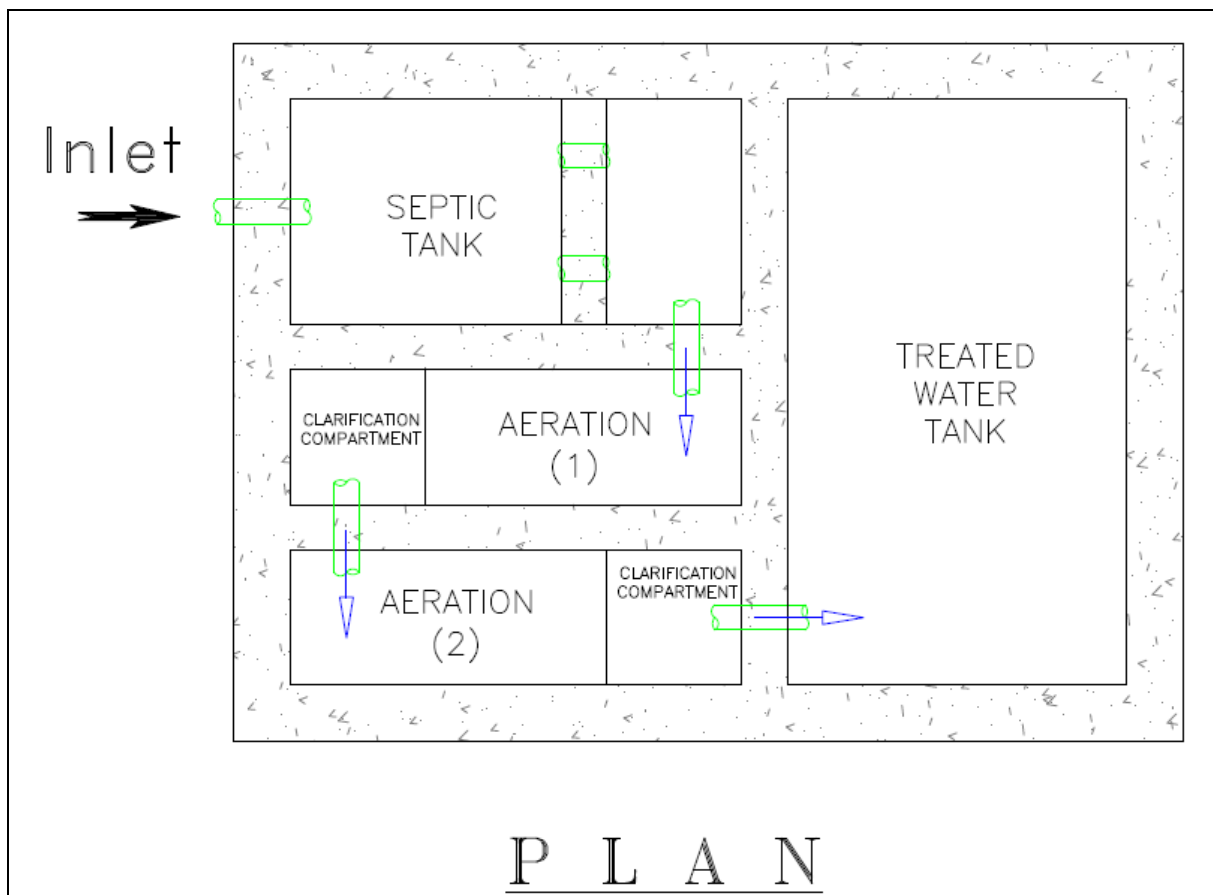


Figure 2: Typical technical drawing of the Modified Septic Tank.

1.2 THE ECOTECHNOLOGIES – TREATMENT WETLANDS

1.2.1 GENERAL PRESENTATION OF TREATMENT WETLANDS

By definition, wetlands are land areas that are wet during part or all of the year because of their location in the landscape. A wetland is also defined by the fact that it is wet long enough to exclude plant species that cannot grow in saturated soils and wet long enough to alter soil properties because of the chemical, physical and biological changes that occur during flooding. Because of their specific conditions and despite adverse effects (low dissolved oxygen, etc.), wetlands are highly productive ecosystems (Kadlec and Wallace. 2009).

Treatment wetlands are man-made systems that reproduce natural wetlands processes to take advantage of this high biological activity to transform, reduce or store common pollutants such as BOD, TSS, nitrogen, phosphorus, etc. Some of these transformed pollutants are also used as nutrients to feed the ecosystem and develop its biological activity. In treatment wetlands, the ecosystem (bacteria, insects, plants, etc.) is used to treat wastewater while in other wastewater treatment systems it is the use of machinery, chemicals and power that perform the same functions. The main costs involved with the use of treatment wetlands are those related to their construction as operation and maintenance costs are reduced.

A variety of constructed wetlands have been created to treat different types of effluent (domestic, municipal or industrial wastewater, landfill leachate or stormwater runoff...) and fit different locations facing a wide range of constraints (high or low temperatures, high evaporation or precipitations, etc.). However, treatment wetlands can be classified in two main categories: Free Water Surface flow wetlands (FWS) and Subsurface Flow wetlands. This last category encompasses two different types of wetland: Horizontal Flow (HSSF) and Vertical Flow (VF) wetlands.

In FWS wetland water/effluent flows on top of a soil layer inhabited by plants. Shallow water zones (around 30cm deep) are dominant to ensure that healthy emergent plant communities are growing. Some deeper water zones are also provided to offer a different environment and improve treatment and hydraulic performance. FWS wetlands are also interesting from an ecological point of view as numerous wildlife species are attracted by the likeness to natural wetlands. However, FWS wetlands can be quite sensitive to the load or the type of pollutants and are usually used as tertiary treatment steps.

Subsurface flow wetlands on the other hand are made of a "box" filled with porous media (usually gravel or sand) and are identified by the way the water moves through the system (water flowing horizontally or vertically). Subsurface flow systems are able to treat higher loads of pollutants than FWS and can be used as a secondary treatment step. Subsurface flow systems are usually more intensified systems. They tend to require the input of some energy (loading, aeration, etc.) in order to reach optimum treatment performance. However if topography helps, gravity can be used to lower energy requirements. Subsurface flow systems are typically more expensive to build than FWS wetlands (require porous media, pumps or dosing systems, pipes, etc.) but they are also more

compact (low surface requirement) and avoid the constraint of an open water area (lower water losses by evaporation, no mosquitoes, etc.).

Within the SMART project, only subsurface flow wetlands were considered because of their compactness, their treatment performance, their robustness and water efficiency.

1.2.2 HORIZONTAL SUBSURFACE FLOW WETLANDS

Horizontal subsurface wetlands are saturated shallow beds (25 to 60 cm deep) filled with media (usually gravel) in which the wastewater flows horizontally (Figure 3). Horizontal subsurface wetland typically receives primary treated effluent in order to avoid clogging issues. Wastewater is loaded into an inlet zone filled with coarse media (gravel) in order to ensure good flow distribution and to limit the risks of clogging. During its course through the media, wastewater underwent treatment through the exposure to the biofilm growing at the surface and in the porosity of the media. The treated wastewater is collected in an outlet zone also filled with coarse media (gravel) to improve hydraulic conductivity. The outlet pipe is usually connected to an adjusting rising pipe allowing modifying the water level to ensure that no overflow occurs on top of the wetland.

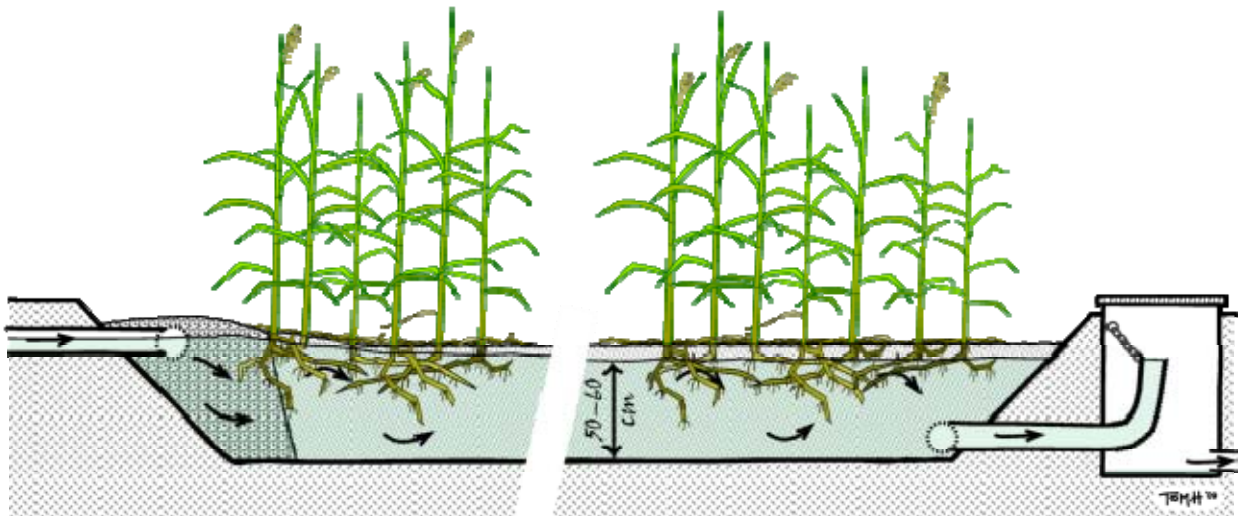


Figure 3: Horizontal Subsurface Flow Wetland.

The conditions in horizontal subsurface wetlands are mainly anaerobic as the bed is saturated with wastewater thus lowering the possibilities of oxygen transfer. These conditions are perfect for nitrites/nitrates removal as primary treated wastewater usually has enough remaining BOD to ensure proper denitrification. Conversely the conditions are rather unfavourable for the nitrification of the ammonium that leaves the primary treatment as the oxygen available in wastewater is usually lower than the oxygen required for total nitrification. However, ammonium can be removed by plant uptake and is not part of the parameters under monitoring in the Jordanian standards for irrigation water. Besides, horizontal subsurface flow wetlands are good at solids removal (BOD and TSS)

because the slow flow through the media ensure a long contact time with the biofilm that consumes the nutrients.

Horizontal subsurface flow wetlands are also interesting systems as they can be operated without the use of power if the topography is helping (gravity fed systems). They have also low operation and maintenance requirements due to their design and are very robust systems able to recover quickly after abnormal load (quality and/or quantity).

Horizontal subsurface flow wetlands are thus interesting systems to be used in the decentralised context of Jordan and were selected to be implemented within the SMART project.

1.2.3 VERTICAL SUBSURFACE FLOW WETLANDS

Vertical subsurface flow wetlands exist in different designs but they all are characterised by a vertical movement of the water through a profound bed (60 to 100 cm deep) filled with media (sand or fine gravel) (Figure 4). Usually vertical subsurface wetlands are loaded with primary treated effluent in order to avoid clogging issues. The effluent is intermittently brought to the bed through a network of dotted pipes that spread the flow to the entire surface of the bed. The effluent then trickles down until it reaches the outlet zone filled with coarser media (gravel) to improve hydraulic conductivity. In the outlet zone, a network of dotted pipe of big dimension ensures that the water leaves the system upon collection.

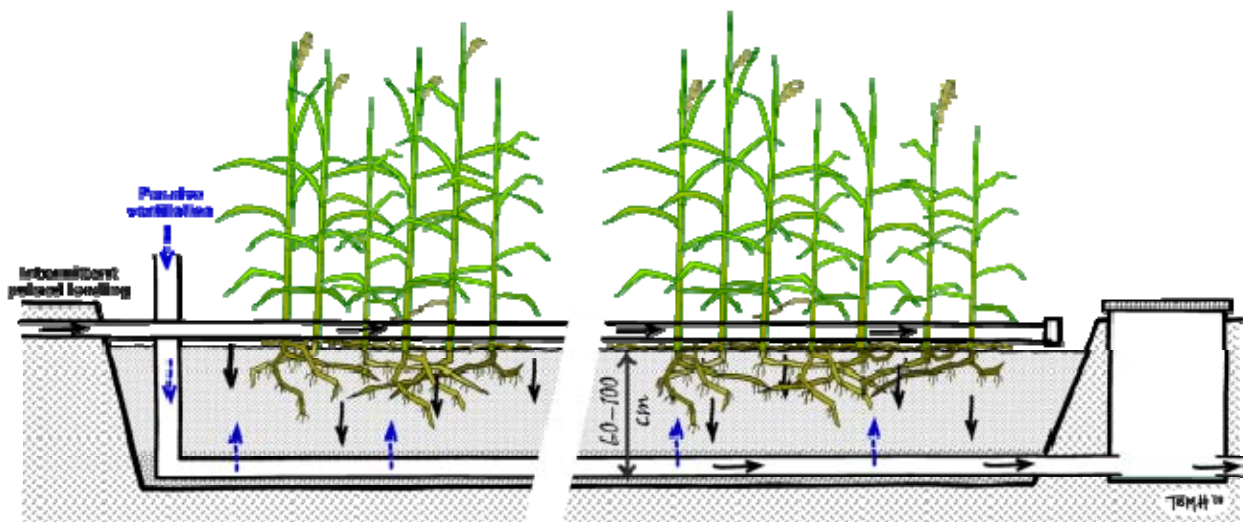


Figure 4: Vertical Unsaturated Subsurface Flow Wetland.

Typical vertical subsurface flow wetlands are usually unsaturated environments. This allows the development of a biofilm that will aerobically treat the effluent. These conditions are favorable to the nitrification of ammonium-nitrogen and to the reduction of the accumulated solids (BOD and TSS) between loadings. Conversely, the aerobic conditions are unfavourable to the denitrification of nitrite and nitrate-nitrogen. Nitrates can be removed by plant uptake but is also a parameter that is

monitored in the Jordanian standards for irrigation water because of the existing pollution of water bodies (eutrophication, etc.).

To reduce the level of nitrate-nitrogen in the treated effluent, two systems were installed and tested at Fuhais (see Deliverable 306) in order to increase the treatment performances. The first system consists in a series of two vertical flow subsurface wetlands separated by denitrification tanks providing the carbon source required to enhance nitrogen removal. The second system (Figure 5) consists in a modification of a typical vertical subsurface flow wetland where the treated effluent is recirculated into the first or second chamber of the septic tank in order to enhance effluent's denitrification (the conditions are anaerobic in a septic tank).

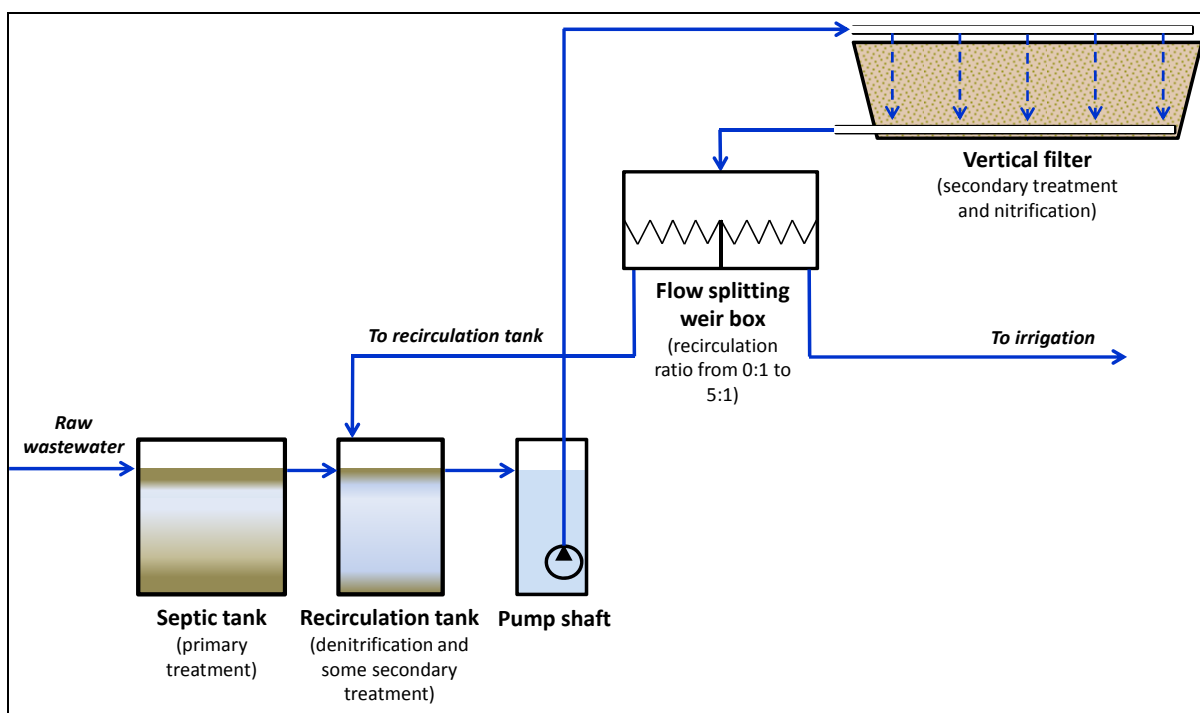


Figure 5: Recirculating Vertical Flow Wetland as installed at Fuhais.

Vertical subsurface flow systems are also low operation and maintenance technology even if they require a little bit more input than horizontal flow systems. Indeed, vertical flow wetlands are usually fitted with pumps in order to evenly distribute the effluent on the bed or to recirculate the effluent and thus need regular visits (every few months) to control that everything works well. On the other hand, vertical subsurface flow wetlands are very robust systems and able to recover quickly from abnormal loading (quality and/or quantity) thus lowering maintenance requirement.

Vertical subsurface flow wetlands are thus interesting systems to be used in the decentralised context of Jordan and were selected to be implemented within the SMART project.

1.2.4 SELECTION OF THE APPROPRIATE ECOTECHNOLOGY

Compared to the technology provided by the other project partners, treatment wetlands are not limited to one form but exist as a wide range of systems able to cope with diverse conditions and situations (industrial and domestic wastewater, landfill leachate and mine water, etc.). Within the SMART project, different types of treatment wetlands have been selected to fit more accurately to the sites' possibilities and to the land-owners' requests.

Selecting wetland technology was however constrained by the need to reach a balance between three main factors:

- The treatment performance: according to the local constraints (land available and size of the reuse area, presence of a nearby aquifer or well, etc.), the treatment requirements were not the same for each site.
- The robustness of the system: the systems should be able to cope with variable inflow to fit the local wastewater production pattern (presence of visitors for an extended period, high variation of wastewater production between winter and summer, etc.). The systems should also be able to work with limited operation and maintenance requirements and be able to recover quickly in case of malfunction.
- The energy input required and possible: in rural and peri-urban area of Jordan the population is usually poor while energy and especially electricity can be very expensive. Power can then be a limitation to the implementation of decentralised wastewater treatment and reuse systems if the local population is not able to pay for it. Power can also be a technological limitation as more intensified systems have usually higher treatment performances but require power input (pumping, aeration, etc.). Thus it was necessary to adapt each system's design to the house-owner ability and/or willingness to pay for the power required.

The last two factors were key issues that highly impacted the choice of treatment wetland technology. However, even if energy free wetlands (gravity fed systems) are usually not performing as well as energy intensive wetlands, the design of the entire treatment and reuse systems was adapted to lower the risks of pollution and pathogen exposure of the population. The treatment wetland itself was designed to provide the required treated wastewater quality and the reuse option was designed as a supplementary treatment step or as a last treatment barrier (backup) in case of unexpected event.

Note: In order to adapt the systems to the local conditions and requirements, the wetlands are sometimes left unplanted. This lowers water losses while only marginally decreasing treatment performances. However, if left unplanted, the systems, while technically still ecotechnologies are not treatment wetlands anymore but modified gravel or sand filters...

1.3 SEQUENCING BATCH REACTOR – THE AQUAMAX SYSTEM

The sequencing batch reactor (SBR) works according to the activated sludge principle using the retention process. With this, the contaminants from the wastewater are degraded by suspended micro-organisms (activated sludge) and converted into biomass. In SBRs, most of the treatment phases happen within one tank in order to reduce the infrastructure required. SBR is a very compact technology. The process diagram is presented in Figure 6.

End of the cycle:

Beginning of the cycle:

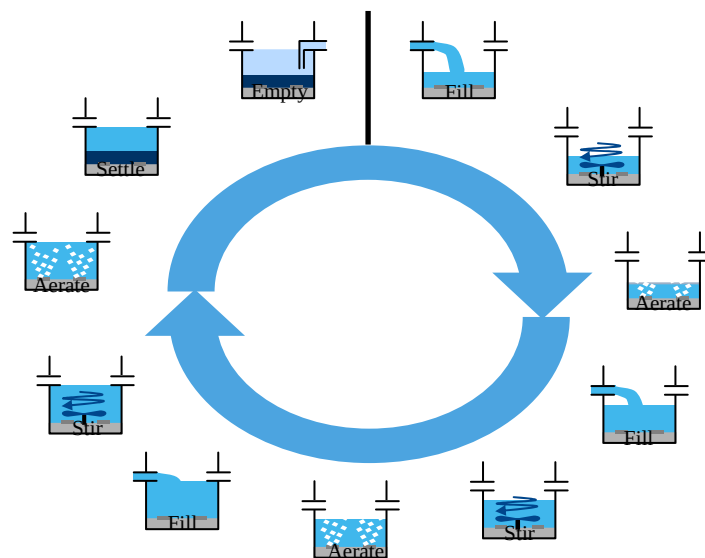


Figure 6: Sequencing Batch Reactor – Process Diagram – AQUAmax® CLASSIC

In the AQUAmax® SBR, the wastewater first reaches a coarse interceptor (pre-treatment) that is also used as buffer tank for the raw influent. Then, every two hours – according to the principle of the communicating pipes and with the help of an excess sludge pump – the retained wastewater is fed into the aeration stage of the SBR (biological reactor). The aeration takes place intermittently via a submersed motor aerator (injection principle). After six hours the aeration phase ends and the settling phase begins. After about two hours of settling time, the treated wastewater is pumped out using the clarified water pump. The switch-off point is determined via a float switch (minimum water level in the reactor). After ca. eight hours, with the end of the clarified water removal, the cycle is ended and a new one begins.

For systems bigger than 50 PE, ATB developed a SBR system (AQUAmax® Professional XL) that separates primary treatment and buffer compartments or tanks. After the primary treatment the effluent flows by gravity into the buffer. From this buffer, the pre-treated wastewater is pumped into the biological reactor. The aeration of these systems takes place using a submersible surface aerator.

The SBR achieves its full treatment performance after a run-up period of four to six weeks. With more extreme under-loading or temperatures lower than 12°C, the run-up time can be increased until the microbiology has developed completely.

Additional information

Sludge and clear water removal:

The excess sludge in the biological reactor is pumped into the primary treatment tank and stocked with the primary sludge. The treated wastewater is evacuated by the Clearwater pump.

Holidays/energy-saving operation (stand-by mode):

If over a period of more than four hours, no wastewater flows into the plant, the water level in the biological reactor remains on its lowest level and the system switches automatically to the energy-saving/holidays operation. For big systems (> 50 PE), the period can vary because of the additional buffer). The aeration time is reduced to the point where the micro-organisms have enough oxygen to survive. Once the usual loading returns, the SBR switches back to normal operation.

Operation and maintenance:

The small wastewater treatment plants are to be checked by the operators at regular interval and must be serviced twice a year by a specialist. Both examination and service are important to ensure the treatment performance and the long term operation of the plant. The sludge removal of the primary settling stage usually takes place once a year but the frequency can be increased if required. Hence it is recommended to control sludge level in the primary treatment tank as part of the maintenance routine in order to optimise and adapt the removal to the working conditions.

1.4 THE MEMBRANE BIO-REACTOR TECHNOLOGY

The HUBER Membrane Bio-Reactor (MBR) system is a combination of biological wastewater treatment and high-efficient solids/liquid separation. The principle of membrane filtration is based upon the separation of the solids suspended in an aqueous solution by means of pressure difference. While the water permeates through the membrane, the solids, bacteria and even most viruses are retained on the concentrate side on the membrane surface where they are removed by relative movement. The pressure differential necessary to pass the liquid through the membrane depends on the membrane pore size and membrane quality.

Figure 7 show a MBR process diagram. Mechanically pre-screened wastewater is biologically treated and separated from the activated sludge by ultrafiltration plate membranes. Membranes are made of polyether sulphone with very high filtration properties and a nominal pore size of 150 kDa (38 nm = 0.038 μm). The pores are small enough to prevent the passage of all solids, bacteria, cells, fats, oils, colloids and macromolecules as well as most viruses.

The reactor volume of and space requirement of MBR systems is only about 25 – 40 % of conventional activated sludge systems. As a result, the dissolved solids concentration in the aeration tank can be increased to about 10 – 12 g/l and conventional secondary clarifiers or additional treatment stages, such as filtration or UV treatment, are not required. The surplus sludge removed from MBR filter chambers has a concentration of dissolved solids of approximately 1 to 1.5 % (0.3 to 0.5 % in conventional biological systems). This means a sludge reduction of more than 50 %. The significantly reduced investments and operating costs for sludge thickening are therefore another positive aspect.

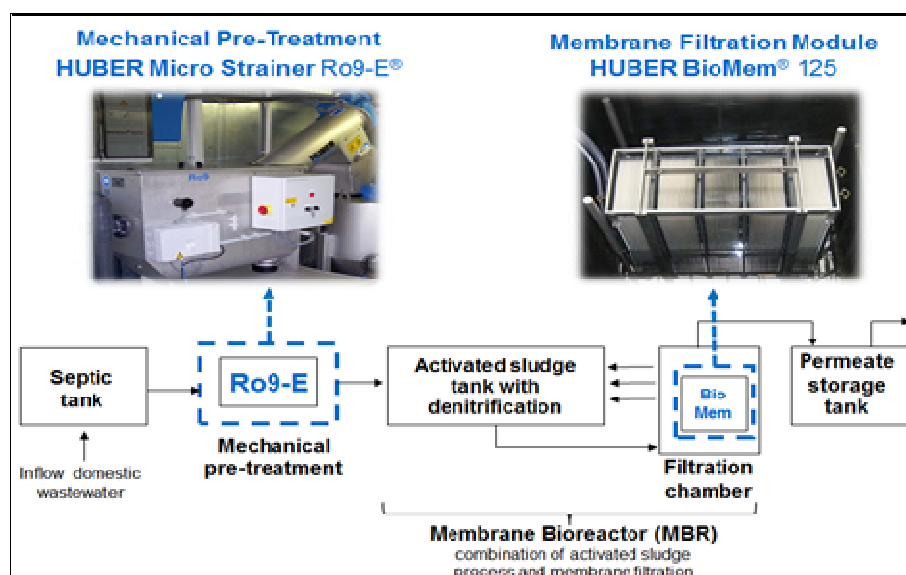


Figure 7: Membrane Bio-Reactor Technology – Process Diagram

A ROTAMAT® Micro Strainer Ro 9 (Figure 8) is installed directly in the channel or in a separate tank. Wastewater flows through the open front end of the screen basket, through screen bars or perforations that retain solids in the screen basket. The degree of separation of floating, settling and

suspended solids depends on the spacing of the screen bars or perforation size. Blinding the screen surface add an extra filtering capacity so that solids smaller than the bar spacing or perforation can be retained. The system starts operation when a certain upstream water level is exceeded due to the screen surface blinding. A robust stainless steel screw removes the wastes from the screen basket's surface. Additional cleaning is achieved by wear-resistant brushes fitted to the screw flights. The screw conveyor transports the wastes through a closed and inclined pipe to a plastic container.



Figure 8: Schematic drawing of a ROTAMAT® Micro Strainer Ro 9

The use of membrane filtration represents a key technology in the field of water reuse. The Huber solution is therefore based on the combination of conventional activated sludge system and ultrafiltration instead of secondary clarification. Figure 9 shows a description of a MBR. The membrane module (1) can be installed directly in the biological system or in separated filtration chambers using guiding rods (2). The ultrafiltration modules (3) separate activated sludge from permeate which is pumped out for discharge (4). Air tubes (5) below the membrane ensure the removal of clogging materials, in the gaps between the plates membranes, preventing fouling.

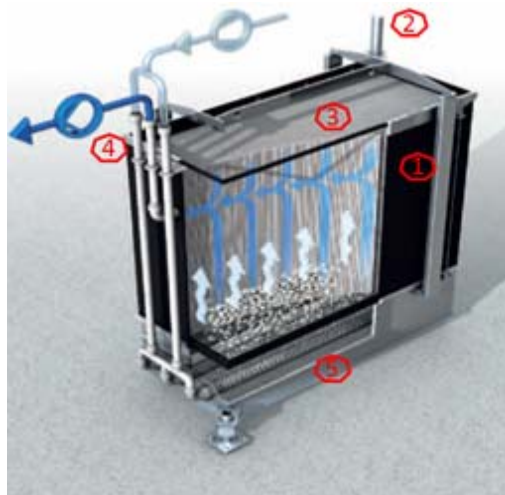


Figure 9: Huber BioMem® Bioreactor

1.5 REUSE TECHNOLOGIES

1.5.1 SUBSURFACE TRENCH IRRIGATION

Subsurface trench irrigation consists in a water distribution pipe installed in a trench and covered with a chamber that provides a large volume of underground void space. Treated effluent flows through a dotted pipe that spread the effluent in the entire length of the trench. Figure 10 shows a description of the system. Subsurface irrigation trench can also be filled with coarse media (gravel) if a chamber is not available.

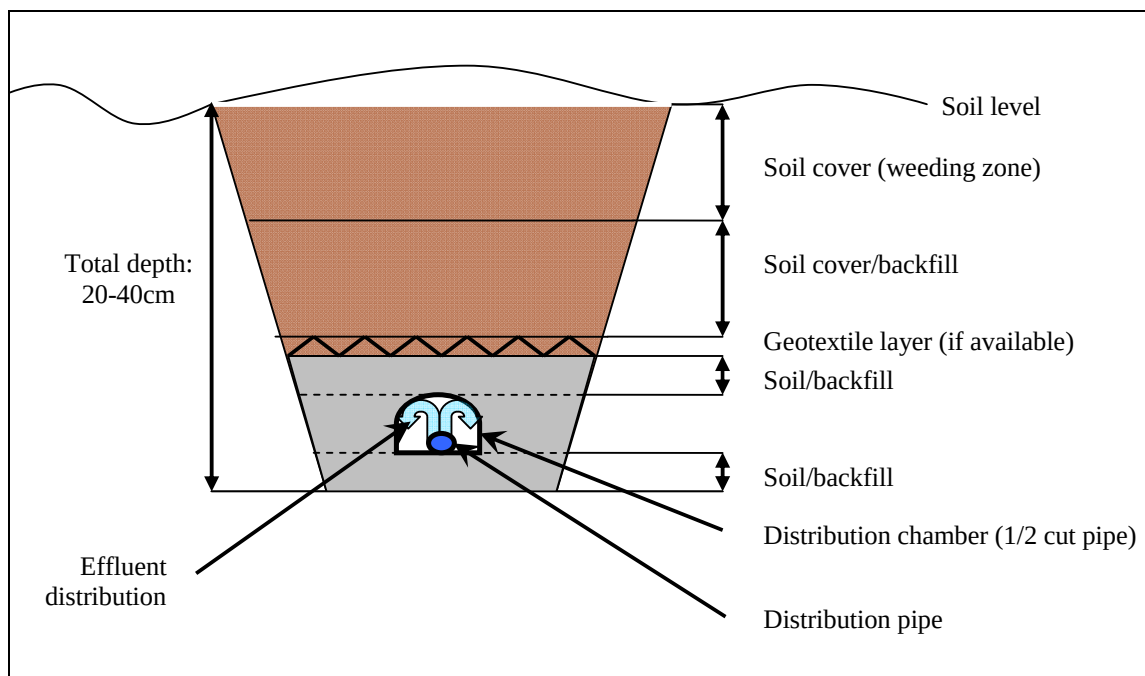


Figure 10: Subsurface irrigation trench

The trench's depth depends on the use of the field, the type of soil and the depth of the bed rock. Usual depth is about 20-30 cm from the top of the chamber. The trench is first filled with a layer of sand or gravel to facilitate effluent transfer into the trench. Then a pipe with holes drilled on the top is installed and covered with a chamber (or a half cut pipe of large diameter). If possible, the system is covered by a layer of geotextile to avoid roots penetration. Then the trench is filled with media (soil).

During operation, the effluent is sent to the distribution pipe using a pump or a dosing system. It is spread into the chamber through the holes on the top of the pipes. While impacting the chamber walls, the effluent is sprayed and exposed to the air, stimulating the soil's bioactivity. This can be a supplementary treatment step. Irrigation efficiency is also enhanced through oxygen transfer to the soil. Finally, spraying the treated effluent improves flow distribution by increasing the loading surface.

Maintenance requirement is limited, especially when the effluent underwent secondary or tertiary treatment, as few solids are likely to enter the system. However, it usually required to keep an access to the end of the irrigation lines to ensure aeration and to allow for the flushing of the distribution lines in order to decrease potential clogging. This extends the lifespan of the system.

Plants can be grown on top or on the side of the system. As subsurface trench irrigation requires a certain amount of work to be installed and is a permanent unmovable fixture when installed, trees are usually planted in the vicinity.

In the Jordanian context, the pipes should be buried deep enough to allow for common agricultural/gardening practices like weeding for water losses reduction (e.g. 30 cm minimum). However, whatever the system's depth, mechanical work (tractor) is to be forbidden over the irrigation area to ensure the integrity of the system (crushing, damage, etc.). Handwork on the other hand is not a problem. Trench irrigation is usually cheap to operate and can be gravity fed (power free) if topography helps. Subsurface irrigation can also be used for infiltrating the excess of water and can flush salts' accumulation when the plants' water requirements are low (winter).

Subsurface trench irrigation is a very robust system and is "permanently" installed (10-20 years). The system itself is easily constructed and the only important requirement is to maintain each irrigation line on a horizontal level to ensure a good flow repartition. Usually, the pipes are in PVC and only need to be glued together.

1.5.2 DRIP IRRIGATION

Drip irrigation (Figure 11) consists in applying frequently a very small amount of water in direct proximity of the plant's roots, on top or directly below ground. Drip irrigation is a very efficient irrigation method as it allows bringing to the plant the required volume of water while reducing losses due to evaporation. It also lowers the risks of pathogen contamination and plants' diseases as irrigation water never gets in direct contact with the plant itself.



(Source: <http://www.irrigationdirect.com> (left) and <http://pakagri.blogspot.com> (right))

Figure 11: Surface Drip Irrigation: emitter (left) and plantation (right)

Surface drip systems are installed on the ground and can be relocated to irrigate different locations and to prevent damage during agricultural work (harvest, etc...). However, it usually requires energy to operate and needs an extensive network of pipes, valves and emitters in order to control and adequately distribute the water to the plants. It also requires filtration devices to avoid the clogging of pipes and emitters. Fertilisers or pesticides can be dosed directly into the irrigation water and delivered to the plants through the use of the drip irrigation.

In some situations, surface drip irrigation has been found responsible for the build-up of salinity in the top soil layers due to lack of leaching fraction (the volume irrigated is calculated to meet the plants' demand). Nevertheless, surface drip irrigation is a very interesting solution but it requires specific knowledge and precautions for installation, operation and maintenance in order to obtain the expected results.

Subsurface drip irrigation (figure 12) is using the same principle and equipment as surface drip irrigation but the irrigation lines and/or emitters are located below ground. This reduces the risks of damaging the system by weather exposure (sun) or by breaking parts while moving the lines. Subsurface drip irrigation is even more water efficient and safer in terms of pathogen contamination than surface drip irrigation as water is brought directly into the roots in the ground. However, this system does not offer the flexibility of surface systems as it is "permanently" installed. Maintenance is thus more critical in order to ensure long-term efficiency.



(Source: <http://www.hometips.com> (left) and <http://www.askgillevy.com> (right))

Figure 12: Subsurface drip irrigation

2 SELECTING THE SITES FOR INSTALLING DECENTRALISED WASTEWATER TREATMENT AND REUSE SYSTEMS.

2.1 THE SITE SELECTION CRITERIA

In order to facilitate the site selection, a set of criteria have been identified based on the project description, some technological requirements and the first visits to the proposed sites in Jordan. The criteria were selected to assess the suitability and practicality of the site according to the project's description and under the local conditions. However, the type and importance of criteria varies according to the type of system installed. Because the community-based systems (150-250 PE.) are more complex, they have been allocated 11 criteria whereas the onsite 10-20 PE systems have been allocated 9 criteria.

The criteria are presented below. The two criteria specific to the community-based systems are presented at the end. When requirements between the community-based and the onsite systems are different, each one is discussed.

- Size of the population concerned by the project (in PE.): The project aims to provide a decentralized treatment solution individual household (10-20 PE.) or for community 150 or 250 PE.). This criterion evaluates the closeness of the site's population to the project requirements. Variability is expected but shouldn't be excessive to meet the budget's constraints.
- Type of population: The project is aimed to serve rural or residential areas with decentralized wastewater treatment solutions. Community sites can, of course, include the commercial activities present in the area surveyed but should keep them as only a small component of the total. Onsite systems however should include only domestic wastewater.
- Presence of a sewer network and/or an existing treatment system: community-based sites must be fitted with a sewer network that connects the individual households to a small-scale treatment system that fails to provide adequate treatment (e.g. septic tank or cesspit). The existing sewer network should be in relatively good condition as the budget does not allow for sewer construction reparation. All small systems must be located in a non-sewered area or must not be serviced by a functioning treatment system.
- Land available to install the treatment system: this criteria aim to answer if a site offers sufficient land to build a treatment system. Land availability means that the local government or the onsite resident own the land required to install a treatment system. Sites with little or no land available were refused even if the situation advocated including the site in the project. Sites requiring transfer of land ownership were also excluded from the selection process as, in Jordan, a transfer of land ownership (private to public) can be long, expensive and complex.
- Need for treatment and reuse of the water: This criterion aim to determine if the proposed site requires the construction of a wastewater treatment and reuse system. The points

considered included the impact on environmental and public health of the existing wastewater treatment infrastructure and the need for reusing treated effluent at the site. Installing a wastewater treatment system should help decreasing local risks (pollution, population exposure to pathogens, etc.), even if the reuse opportunities in the site's vicinity are limited (grazing, etc.).

- Existence of a potential reuse for the treated water: This criterion evaluates the possibility of reusing the treated effluent produced onsite. It assesses the presence of farms, fields, gardens and other potential reuse activities but also evaluates the topography and geography of the reuse location (elevation and distance from the treatment site, etc.) in order to determine what will be the constraints for water reclamation.
- Location, accessibility and distance to the site: Sites located close to each other, close to the SMART 1 – Fuhais site and to the Al-Balqa University or within the study area or will be preferred than the sites further away. Ideally, a selected site will be easily accessible from Amman or Al Balqa University in order to reduce travel time and expenses during the construction, operation, maintenance and monitoring phases of the project. However, in regard to some more significant criteria (e.g. size and type of population) location will not be critical if the site is accessible.
- Site constraints for constructing a treatment system: Some local conditions (geology, topography, site layout, etc.) can induce difficulties that would increase the budget required for construction. These conditions were identified in order to simplify the later work and to adapt the design to the local constraints.
- Stakeholder engagement: This criterion evaluates the involvement of local stakeholders (Ministries, Municipalities, etc.) in the management of wastewater at a specific site. It is mainly aimed to determine the level of local support provided by landowners, inhabitants and farmers for the long-term operation and maintenance of the wastewater treatment and reuse system.

Criteria specific to the community-based systems:

- Distance from existing sewer to potential treatment site: This criterion evaluates the distance of the potential site to the existing wastewater source or septic tank. If the distance is important, the cost of the infrastructures required (pipework, electricity connection, etc.) will be high thus not necessarily feasible.
- Existence of a local support: Local support (Mayor, Municipality, site owners, local inhabitants, farmers, etc.) could be important to ensure the project's success, to speed it up on the administrative side and to support both the construction stage and operation and maintenance of the facilities.

2.2 THE SITE SELECTION PROCESS

The first step of the site selection was to identify the sites that could fit the project's general description and constraints. The SMART II local partners (Eng. Nabil Wakileh, Dr. Bassim Abbassi, Eng. Bassam Saleh, Eng. Ali Subbah, Eng. Maysoon Al-Zoubi and Eng. Khawlah) have been consulting their databases and activating their network in order to obtain a first list of potential sites. Differences were made between individual household systems that required a more local knowledge and community systems that required more insight from the administration.

The sites identified were then visited a first time by the local partners (Eng. Nabil Wakileh and Dr. Bassim Abbassi). The sites were then separated between the one requiring further assessment then and those being rejected. A second visit of the potential sites was then organised with the delegates from UFZ and the Local partners to identify which technology could be implemented at the site according to specific technical requirements. These visits were the first opportunity to go through all the criteria in order to identify each site's advantages and drawbacks.

The list of all the small sites visited including a short description is presented in Table 3. The sites selected are highlighted to facilitate their identification. A total of 13 small sites have been visited. In some cases, the selection was evident while for some sites, more reflection was required. The sites that were deemed the most promising were presented to the relevant company-partners and were visited by their representatives travelling to Jordan. Meanwhile, the local partners were investigating the local context, contacting local governments and administrations to obtain maps, drawings and ownership status in order to enable the company-partners to take a decision.

The decision for the small sites (households systems) was a lot easier and straightforward than for the community systems. Once a small site was "unofficially" selected, a document package was prepared. It included the technical description of the system, a presentation of the general design and maps to identify the location of the systems at the site. A set of contracts and was also prepared, describing the duty and responsibilities of each party for the length of the SMART II project (see in appendix the contract for Mr Hadidy). This package was then transmitted to the site-owner for review.

After a few weeks of review time, each site-owner was invited to a signature ceremony attended by all the project's partners and hosted by the President of the Al-Balqa University (see Table 2).

Some small sites had also been selected as back-up solutions if some house-owners were withdrawing from the project. Actually this situation happened two times before the signature of the contracts. Thus two systems had to be redesigned according to the new sites constraints.

Table 2: List of the persons attending at the contracts' signature ceremony.

Name	Structure	Name	Structure
Dr. Ikhlaf Al Tarawneh	<i>Al-Balqa University</i>	Dr. Roland Müller	<i>UFZ</i>
Dr. Bassim Abbassi	<i>Al-Balqa University</i>	Dr. Manfred van Afferden	<i>UFZ</i>
Eng. Iyad Al-Zreiqat	<i>Al-Balqa University</i>	Eng. Thomas Aubron	<i>UFZ</i>
Ghenwa Makhamreh	<i>Al-Balqa University</i>	Hussein eshwak	<i>As-Salt Municipality</i>
Bassam Saleh	<i>WAJ</i>	Dr. Stefania Paris	<i>Huber SE</i>
Ahmad Uleimat	<i>WAJ</i>	Andrea Kandler	<i>BAUER</i>
Thomas Gester	<i>ATB</i>	Mr. Hadidy	<i>(Owner)</i>
Eng. Nabil Wakileh	<i>NAW&CO</i>	Mr. Fakhri Hassan	<i>(Owner)</i>
Eng. Fares Wakileh	<i>NAW&CO</i>	Eng. Ghalib Al-Hiyari	<i>(Owner)</i>

For the community systems, the site selection process was complicated by the fact that the current regulatory conditions are changing in Jordan with the transfer of wastewater treatment ownership from WAJ to the Municipalities. This created a delicate situation where while interested in the project, the municipalities were very reluctant to take over any form of responsibility due to lack of resources and knowledge to handle the systems. It was thus necessary to create a framework where municipalities would be owners but subcontracting operation and maintenance to private companies that would be paid through the benefits extracted from the sales of treated wastewater..

A list of the big sites visited and selected is presented in Table 4.

Table 3: List of the small sites visited

Sr.	Name of Owner & Tel No.	Property Location	Occupancy (EP) Current / Future	Total Land Area (m2)	Building surface (m ²)	Possible future expansion (m ²)	Land area available for Irrigation (m ²)	Brief Description	Status (Technology selected)
1	Mohamd Bashir Al Hadidy (0777426064)	East of Salt N 32° 2' 47.77" E 35° 45' 29.39"	7 / 11	16,000	2 x 250	????	15,000	Existing Percolating Pit	Treatment Wetland (Horizontal Flow)
2	Mr Salem Hassan Abu Rumman	Zay	19/31	3,100	550 (2 x 225 +100)	1 x 225	2,000	Existing Percolating Pit	Treatment Wetland (Vertical Flow???)
3	Ghalib Abdul Halim Al Hiyari (0777201301)	Salt N 32° 3' 12.18" E 35° 44' 56.82"	8 / 15	1061 + 938 = 1999	2 x 300 (2 Storey Build.)	1 x 300	1,200	sealed underground collection tank	Modified Septic Tank
4	Mohamd Maher Shehabi (0795503821)	Suwaileh- Hommar Princess Alia 60+57 N 32° 1' 39.31" E 35° 49' 18.84"	6 / 10	912	2 x 315	1 x 315 1 x 157	580	Septic Tank + percolating pit	Modified Septic Tank
5	Eng. Ismail Akeel (0795549024)	Swaileh - Salt Road N 32° 1' 56.82" E 35° 48' 44.91"	8 / 8	900	3*300=900	None	350	Nothing (new construction)	Modified Septic Tank
6	Fakhri Y. A. Hassan (0795654473)	Fuhais N 31° 59' 54" E 35° 47' 23"	25 / 25	4,412.46	2 Houses (6 apartments)	None	3,400	Existing Percolating Pit (one only) Rain Water tank (45 m ³)	ATB - SBR
7	Ahmad Sulaiman Ahmad Al Awamleh (0777480600)	Zay - Dahiat Al Ameer Ghazy N 32° 52' 6.59" E 35° 42' 45.54"	7 / 14 (+10 to 20 Visitors in the evening)	4,354	200	1 x 150	3,000	Existing Percolating Pit	ATB -SBR
8	Mr. Ali Al Dabbas (0777306686)	West of Salt - Near Majareeb N 32° 2' 11" E 35° 42' 22"	9 / 14	1,350	2*260=520	????	600	Existing Percolating Pit	Cancelled (ATB)
9	Hala Karam Haddad	Salt N 32° 4' 12" E 35° 43' 16"	6 / 10	1500	400	250	1,000	Existing Percolating Pit	Cancelled (Modified Septic Tank)
10	Issam M.H. Al-Ali (0795520173 or 064710503)	Fuhais N 32° 1' 22.65" E 35° 47' 11.43"	9 / 16	2170	768	360	1200	Existing Percolating Pit	Refused
11	Mr. Abdul Karim Al Kharabsheh (0777944944)	North of Salt - Za'tari N 32° 4' 41.16" E 35° 46' 16.93"	27 / 35		2*250=500 + Ground Floor of 250 Shops	????	200	Existing Percolating Pit	Refused
12	Mrs. Samanta Mahdi Al-Saifi	Bader Al-Jadeeda 9-Ras Khalaf, 121 N 31° 58' 22" E 35° 47' 45"	15 / 18	4445	1955	Not Possible	1,700	Wastewater Collection Tank	Refused
13	Sukhtian Villa (0795522399)	Bader Al-Jadeeda N 31° 58' 50" E 35° 47' 15"	10 / 10	7028	Villa = 1920 Guard House = 119	Not Possible	≈ 5,000	Nothing (new construction)	Refused

Table 4: List of the big sites visited

No.	Site Name	Location	Estimated occupancy (EP)	No. of households or buildings	Reuse area available	Short description	Status (Technology Chosen)
1	Nursing Home	Fuhais 32°1'8.99"N 35°45'59.06"E	50 (current) to 85 (expected)	1 + 1 under construction	Yes	House for retired people and retired priests. Fit the project in terms of size and reuse possibilities.	Accepted, pending contract (ATB - SBR)
2	Maghareeb Phase III	As-Salt 32°2'14.64"N 35°42'1.35"E	160 (current) to 310 (expected)	16 (current) to 31 (expected)	Possibly (farming area nearby)	Third part of the Maghareeb development to be built. Size and failing treatment system fit the project.	Accepted, pending contract (Huber - MBR)
3	Maghareeb Phase I	As-Salt 32°2'32.22"N 35°41'41.29"E	750	75	Possibly (farming area nearby)	First part of the Maghareeb development to be built. Failing treatment system fit the project but size a bit big requires a new partner.	Under discussions (Ecotechnology) (site technically difficult)
4	Shobak Phase I	Shobak 30°30'58.61"N 35°31'38.97"E	340	56	Yes	First part of the Shobak development to be built. Size and reuse possibilities fit the project. Existing treatment system unfit for the site.	Under discussions (site administratively complex)
5	Al-Balqa College - Zay	Zay 32°6'39.00"N 35°44'14.40"E				3 to 5 septic tanks/cesspits are receiving the raw wastewater from the Al-Balqa College	Under survey (site could be used as a back-up)
6	Maghareeb Phase II (zone II, III, IV and VI)	As-Salt 32°2'12.49"N 35°41'52.30"E	1410 (current) to 3130 (expected)	141 (current) to 313 (expected)	Possibly (farming area nearby)	Second part of the Maghareeb development to be built. Failing treatment system fit the project but size too big.	Refused (too big)
7	Maghareeb Phase II (zone I)	As-Salt 32°2'17.86"N 35°41'42.73"E	460 (current) to 750 (expected)	46 (current) to 75 (expected)	Possibly (farming area nearby)	Second part of the Maghareeb development to be built. Failing treatment system fit the project but size would require a new partner. No land available for building a treatment system.	Refused (no site available)
8	Zmaila	Zmaila 32°30'16.05"N 35°36'20.12"E	200 to 250 (estimated)	33	Possibly (farming area nearby)	Small development for poor people in the Jordan valley. Size and failing treatment system fit the project. Land may not be available and administrative issues.	Refused (refused by development administration)
9	Ma'addi	Ma'addi 32°9'55.21"N 35°37'29.67"E	150 to 250 (estimated)	20 - 30	Possibly (farming area nearby)	Old development in in the Jordan valley. Failing treatment systems fit the project but reuse difficult.	Refused (no local support)
10	North Ghor/Waqqas village	North Ghor 32°32'36.78"N 35°36'39.30"E	700 to 1000 (estimated)	+/- 100	Possibly (farming area nearby)	Palestinian refugee camp and small village nearby. No sewer network and no land easily available.	Refused (no sewer network)
11	North Ghor/Waqqas hospital	North Ghor 32°32'35.28"N 35°36'31.18"E	90 (visits per day, no night stay))	1	Not clear (urban area)	Palestinian refugee camp. Hospital effluent with probably a lot of chemicals (disinfectants and medicines)	Refused (not domestic effluent)
12	North Ghor/Waqqas school	North Ghor 32°32'36.00"N 35°36'28.51"E	1000 (500 morning and 500 evening)	1	Not clear (urban area)	School for the palestinian refugee camp. Students in 2 shifts (girls then boys). Effluent with low BOD and high nitrogen	Refused (not domestic effluent)
13	Sweimeh	Sweimeh 31°46'4.49"N 35°35'54.47"E	5000 (estimated)	???	Yes	Very poor village, low wastewater production and probably very concentrated in pollutants. Village spread over big area.	Refused (no sewer network)
14	Pella (plant nursery)	Pella 32°26'29.02"N 35°35'52.92"E	100 (estimated)	10 - 15	Yes	Poor village in the Jordan valley. High reuse possibilities but size a bit small for the project and no sewer network.	Refused (no sewer network)

3 PRESENTATION OF THE SMALL SITES

The study area of the work-package 3.1 encompasses only the portion of the SMART II project area located around Wadi Shueib. More significantly, the small sites have all been selected according to their location relative to Al-Balqa University and the Fuhais research and demonstration site for logistical purpose (operation and maintenance, monitoring of the systems, organisation of site visits, etc.). All the selected sites are in a 15 – 20 minutes radius car drive from both the Fuhais and the As-Salt cities. Figure 13 shows the location of the selected small sites relative to the Al-Balqa University and the Fuhais Research and Demonstration site.

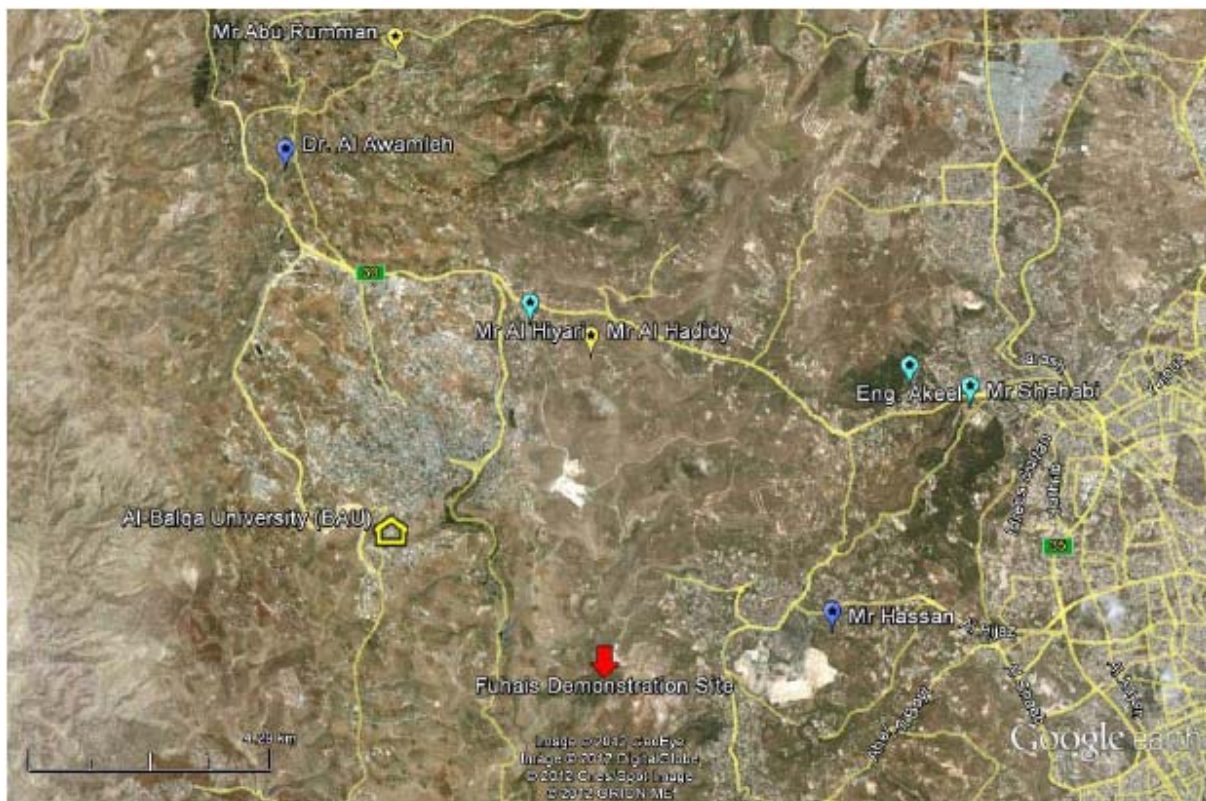


Figure 13: Map of the selected sites in the study area.

3.1 MODIFIED SEPTIC TANK – MR GHALIB HIYARI

3.1.1 SITE PRESENTATION

Location:

Village:	As-Salt
Block:	Al Shafa Al Janooby, 50
Parcel N°.::	195 & 194
Coordinates:	N 32° 3' 12.18"
	E 35° 44' 56.92"

Summary:

The site is located in an area north of As-Salt. The house is not connected the sewer network. The wastewater is drained from the building into a sealed underground tank located under the car park area.

Site Description:

The site is located at the north of As-Salt, a drive of almost fifteen minutes from Al-Balqa University. The land consists actually in two plots merged together in one site. The house consists in a two-story high building with the second floor just finished. The first floor is currently occupied while the second floor can be inhabited anytime. Additionally, there is the possibility to build a third floor but it is not planned for the near future. The site also accommodates a garden of approximately 1000 m², planted with decorative plants but also olive and fruit trees.

Occupancy

The current occupancy of the site is about 8 PE but the second floor could be occupied in the near future, adding another 4 PE. According to the house owner, the expected maximum population should be 15 PE but if another floor is added, the total population could reach up to 20 PE.

Fresh Water Supply & Consumption

The house is connected to the municipal water mains. The current water consumption for 8 PE varies from 260 m³ in 2008 to 343 m³ in 2010. The available water bills allowed estimating the water consumption at about 75 L/PE/day in winter and 100 L/PE/day in summer. Of this consumption, approximately 10 m³ of water are used every summer month for irrigating a small part of the garden.

Wastewater collection and Disposal

The site's area is not serviced by the sewer network. The wastewater is drained from the building by two separate lines. The wastewater is collected into an underground sealed tank of approximately 40 m³ of storage capacity that is emptied once or twice a month according to the requirements.

Advantages of the this site

- The house is not connected to a sewer network.
- The house has a garden of about 1000 m² where treated wastewater can be reused.
- The site is located in the study area (about 15 min from Al-Balqa University).
- The house owner is a civil engineer and has a good understanding of environmental issues.

3.1.2 GENERAL DESIGN:

As the building is connected to the wastewater storage tank by two different sewer lines, the first task is to connect these lines together into a manhole in order to feed the Modified Septic Tank treatment system. However, from the manhole, a bypass will be installed in order to resume previous operation (collecting wastewater into the underground tank).

The Modified Septic Tank will be constructed as a single tank with four compartments (a 2 chamber septic tank followed by a 2 stage aerobic treatment). The modified septic tank is to be built on the side of the building, nearby the existing underground storage tank.

First, the wastewater will flow into a two chamber septic tank of 4.60 m³, corresponding to a retention time of 5 days for a 8 PE occupancy, 2.7 days for 15 PE and 2 days for 20 PE. Then, the primary treated effluent will go through a 2 stage aerobic treatment step. Each stage is made of an aeration chamber and a settling chamber. The two stages are operated in series. At a normal flow each aeration chamber has a retention time of about 12 hours and 4 hours at peak flow. The settling chambers have a retention time of 3 hours at normal flow and 1 hour at peak flow. Finally, the treated wastewater will be collected by gravity in an irrigation tank of 2.3 m³, equivalent to a one day retention time.

The treated wastewater is then pumped to the garden to be reused through a subsurface irrigation system to lower the household water consumption while avoiding potential exposure to the effluent.

System components

- 1) The wastewater treatment plant – Modified Septic Tank Technology:
 - The system consists in an underground reinforced concrete tank divided in several compartments: a 2-chambers septic tank, 2 aeration chambers and 2 clarification chambers. The chambers will be fitted with manholes to provide access for maintenance purpose.
 - The aeration system consists in an air blower that is installed on the ground level, in a cabinet. Air diffusers, internal pipes and valves will be installed inside the aeration chambers.
- 2) The reuse System – subsurface irrigation
 - The treated wastewater collection tank (irrigation Tank).
 - The irrigation pump with a float.
 - The subsurface irrigation lines.
- 3) Other Components
 - Electric power will be taken from the main electric distribution board.
 - The connecting pipes between the Modified Septic Tank, the irrigation tank and the irrigation lines.

Site and construction drawings

Figure 14 shows the survey of the site done before the construction. Figures 15 and 16 present the general design of the treatment system and the layout of the property with the system.

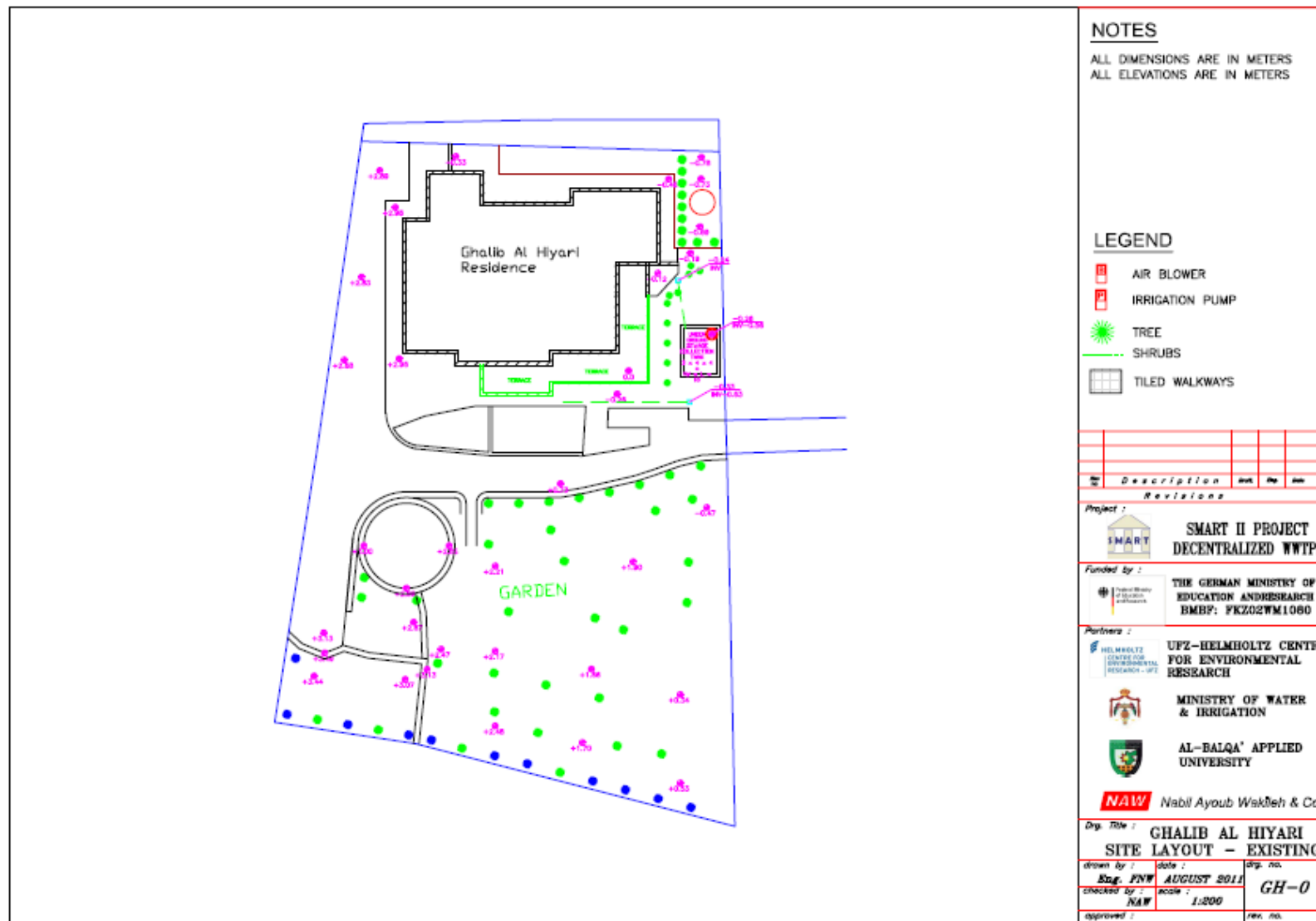


Figure 14: The property of Mr Ghalib Hiyari.

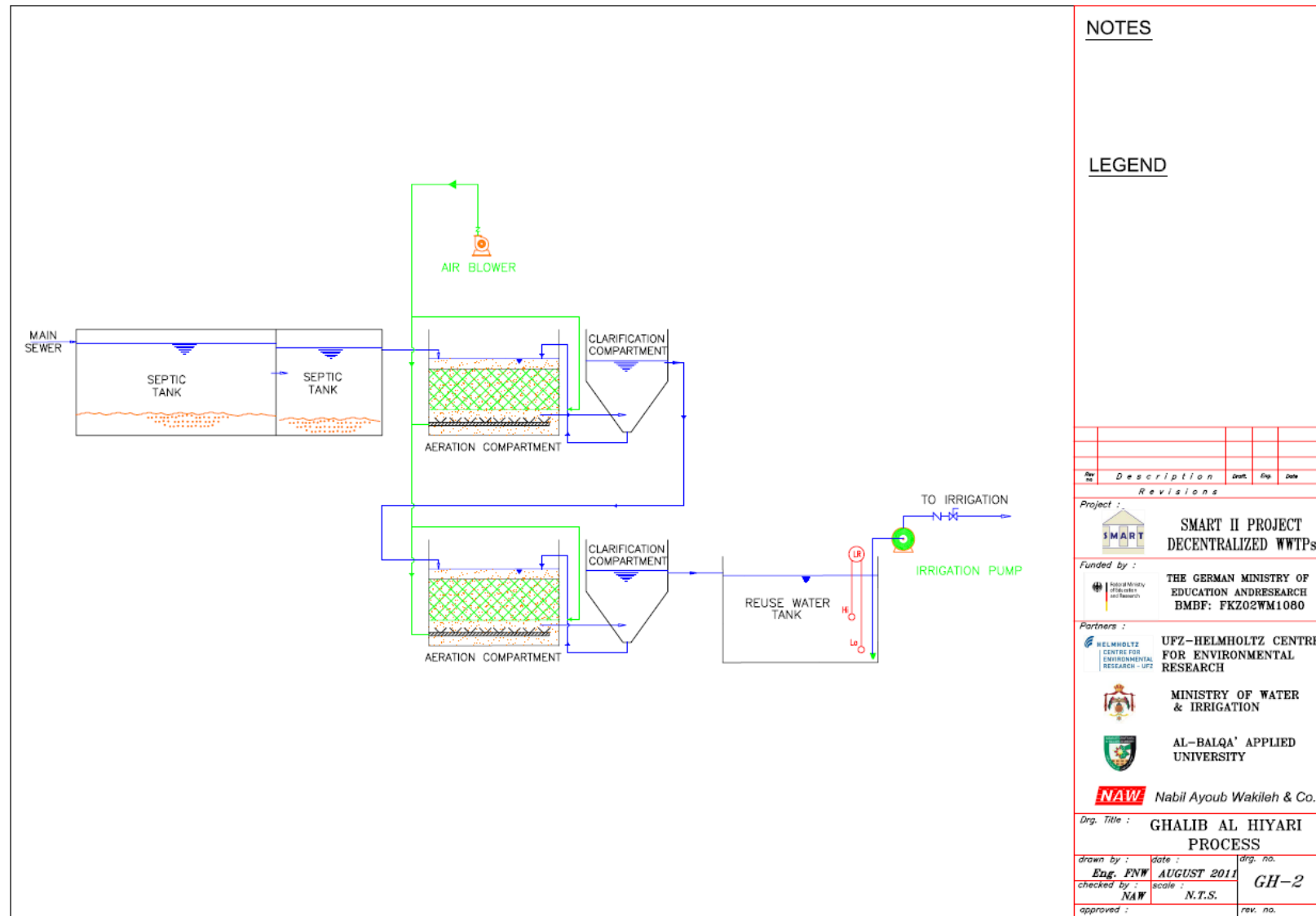


Figure 15: General design of the Treatment system.

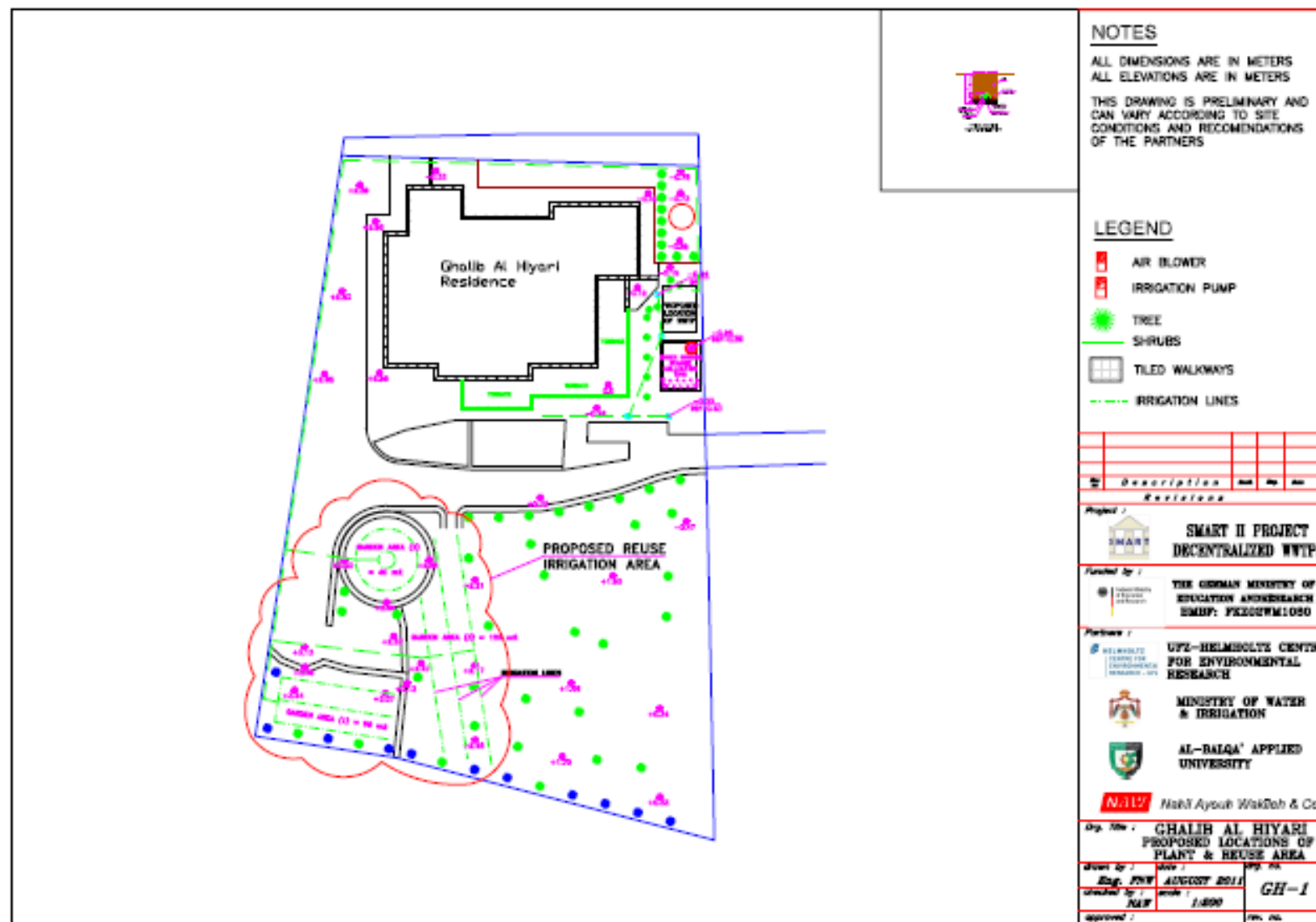


Figure 16: Layout of the treatment system.

3.2 MODIFIED SEPTIC TANK – MR MOHAMAD MAHER AL SHEHABI

3.2.1 SITE PRESENTATION

Location:

Village: Sweileh
 Block: Princess Alia 1
 Parcel N°: 57
 Coordinates: N 32° 1' 39.31"
 E 35° 49' 19.94"

Summary:

The site was identified by an engineering company. It is located between Fuhais and Sweileh, nearby the main road. The site is not connected to the sewer network. The wastewater is collected in an infiltration pit located under the car park area.

Site Description:

The site is located between the towns of Fuhais and Sweileh, nearby the main road, an approximately 15 minutes' drive from Al-Balqa University. The building includes a basement and a house on the first floor for an area of 630 m² (315 m² for each floor). The basement is used as a utility floor and is not designed as an apartment. The site also includes a 580 m² garden planted with ornamental plants and flowers but also olive and fruit trees.

Occupancy

Six people (6 PE) currently occupy the building. According to the house owner, the occupancy could reach up to 10 PE in the future. However, as another floor could be added on top of the building, the maximal occupancy could reach up to 16 PE.

Fresh Water Supply & Consumption

The house is connected to the municipal water mains. The water consumption is estimated to be 100 L/PE/day.

Wastewater collection and Disposal

The area is not serviced by a sewer collection network. At the site the wastewater is drained from the house into a properly designed and built septic tank but then is sent into an infiltration pit. The pre-treatment and infiltration systems are located under the car park area.

Advantages of the this site

- The house is not connected to a sewer collection system.
- The house has a garden of approx. 580 m² where water can be reused.
- The site is located in the study area, only 15 min from Al-Balqa University by car.
- The house owner is a mechanical engineer who has a good understanding of the environmental issues.

3.2.2 GENERAL DESIGN:

The existing septic tank, as properly designed and built, is used as a primary anaerobic treatment step. The existing infiltration pit is retained and used an emergency overflow for the new system and as a back-up system to be used in case of maintenance or malfunction.

The existing septic tank has a volume of 4.80 m³, corresponding to 4.8 days of retention time for an occupancy of 10 PE. If the occupancy reaches 16 PE, the retention time will be 3 days, which is sufficient to ensure a proper primary treatment. Leaving the septic tank, the primary treated wastewater flows by gravity into the two aerobic treatment stages of the Modified Septic Tank.

The two aeration stages of the Modified Septic Tank are built nearby the existing primary treatment and infiltration pit, under the car park area. Each aeration stage is composed of an aeration chamber followed by a settling chamber. Each aeration chamber has a retention time of about 11 hours at normal flow and 3.75 hours at peak flow. Each settling chamber has a retention time of about 3.75 hours at normal flow and 1.25 hours at peak flow. The total retention time will be about 30 hours at normal flow and about 10 hours at peak flow.

Following the aeration treatment stages, the treated wastewater is collected in an irrigation tank of 1.6 m³ capacity (1 day retention time). From this tank, the water is be pumped out into the garden where a subsurface irrigation system is be installed

System components

1) The wastewater treatment plant – Modified Septic Tank Technology:

- The system consists in two underground reinforced concrete tanks. The existing septic tank that is kept in operation. A new aeration treatment tank divided in several

compartments: 2 aeration chambers and 2 clarification chambers. The new chambers will be fitted with manholes to provide access for maintenance purpose.

- The aeration system consists in an air blower that is installed on the ground level, in a cabinet. Air diffusers, internal pipes and valves will be installed inside the aeration chambers.

2) The reuse System – subsurface irrigation

- The treated wastewater collection tank (irrigation Tank). NOTE: The irrigation tank is constructed directly adjacent to the aerobic treatment tank because of space constraints.
- The irrigation pump with a float.
- The subsurface irrigation lines.

3) Other Components

- Electric power will be taken from the main electric distribution board.
- The connecting pipes between the Modified Septic Tank, the irrigation tank and the irrigation lines.

Site and construction drawings

Figure 17 shows the survey of the site done before the construction. Figures 18 and 19 present the general design of the treatment system and the layout of the property with the system.

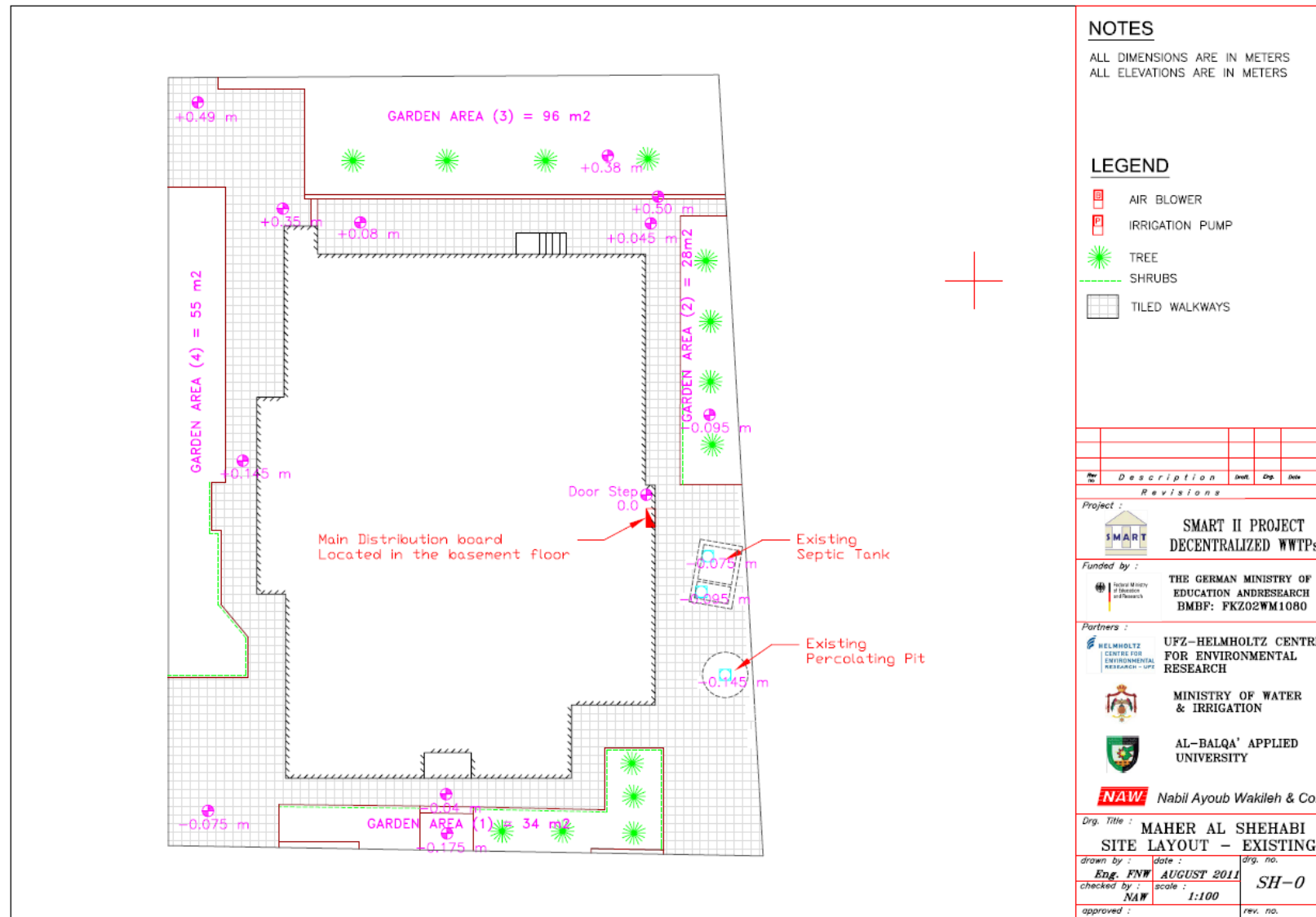


Figure 17: The property of Mr Mohamad Maher Al Shehabi.

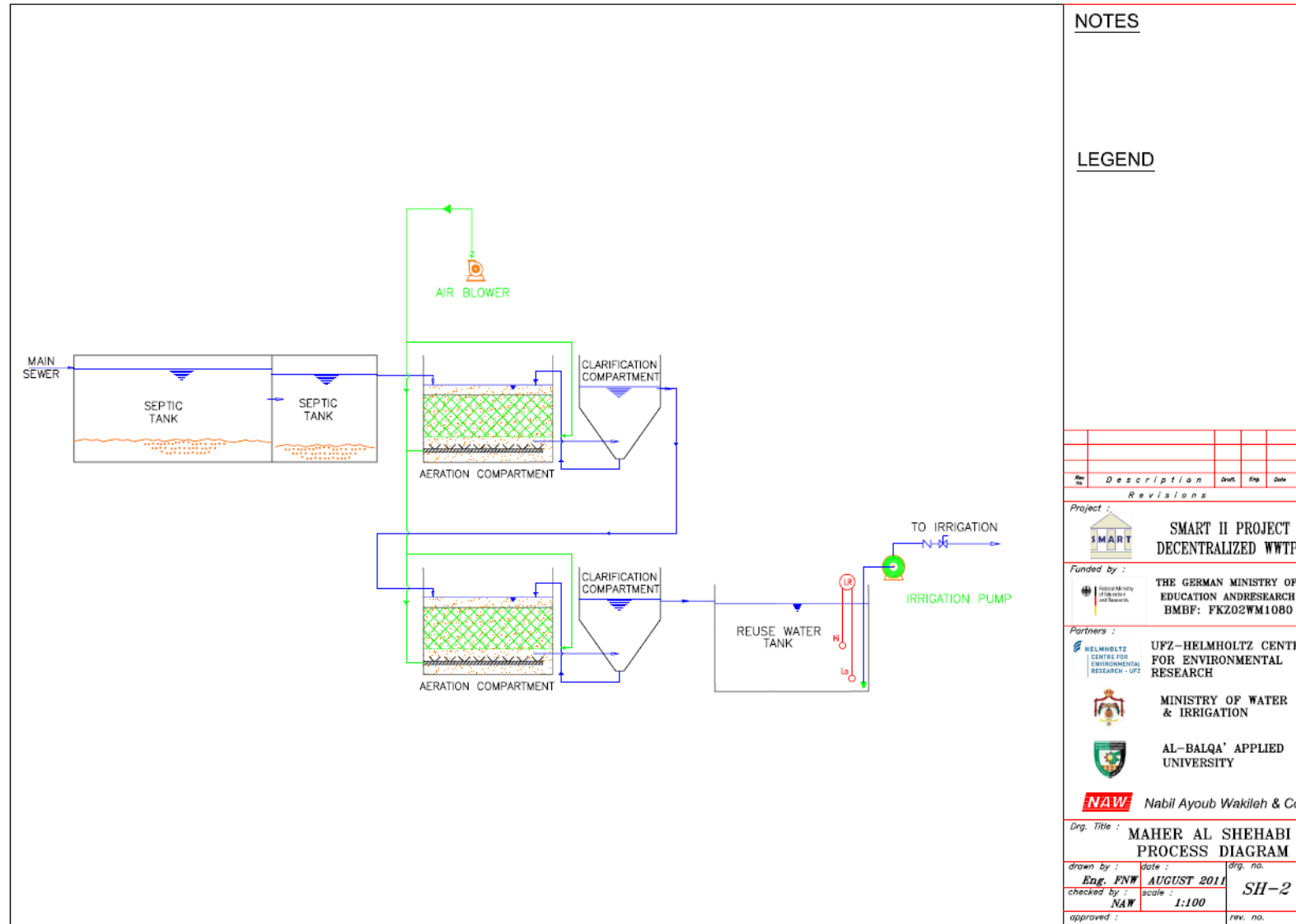


Figure 18: General design of the treatment system.

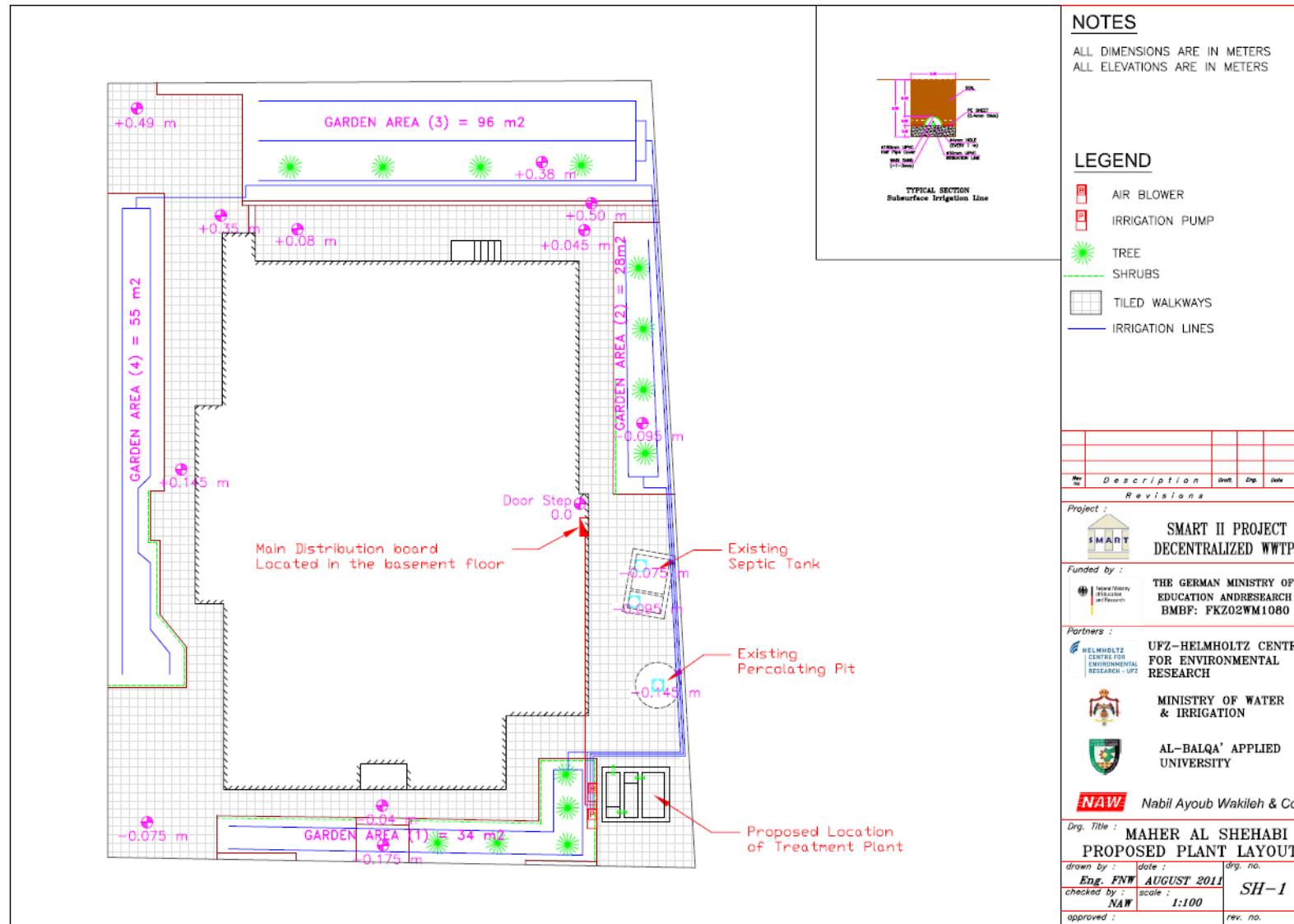


Figure 19: Layout of the treatment system.

3.3 MODIFIED SEPTIC TANK – ENG. ISMAIL AKEEL

3.3.1 SITE PRESENTATION

Location:

Village:	Sweileh
Block:	Sultani, As-Salt
Parcel N°:	417
Coordinates:	N 32° 1' 56.82"
	E 35° 48' 44.91"

Summary:

The site was identified by NAW&CO. It is located between As-Salt and Sweileh, nearby the main road. The building was under construction with no possibility to be connected to the sewer network. A decentralised wastewater management system had to be installed but the owner was really interested in the reuse possibilities (thus excluding a cesspit scenario).

Site Description:

The site is located between the towns of As-Salt and Sweileh, nearby the main road, an approximately 20 minutes' drive from Al-Balqa University. The site consists in a 3 storey house with a total area of 900 m² (300 m² per floor). The building consists of 4 bedrooms, 6 toilets, 2 kitchens, a swimming pool, etc. The site also includes an approximately 350 m² garden planted with lawn but also ornamental plants and flowers.

Occupancy

Eight people (8 PE) currently occupy the building. According to the house owner, the occupancy is not expected to increase in the future. However, peak flow occupancy could reach up to 15 PE.

Fresh Water Supply & Consumption

The house is not connected to the municipal water mains and the water is brought by tanker trucks. The water consumption is estimated to be about 150 L/PE/day.

Wastewater collection and Disposal

The area is not serviced by a sewer network. The building was under construction and had to be provided with a decentralised wastewater management system. The owner was really interested in a system offering reuse possibilities (thus excluding a cesspit scenario).

Advantages of the this site

- The house needs a wastewater treatment system as it cannot be connected to the sewer.
- The house has a garden of approx. 350 m² where water can be reused.
- The site is located in the study area, only 20 min from Al-Balqa University by car.
- The house owner is an engineer who has a good understanding of the environmental and operational issues.

3.3.2 GENERAL DESIGN:

As the building was under construction, the general design was quite easy with no retrofitting constraints. The population was also limited, reducing the size requirement. Concerning the reuse area, the garden was available but with the constraints of surface irrigation (sprinkler and drip) necessitating the installation of a chlorine disinfection unit.

The wastewater is thus to be sent from the building directly to a Modified Septic Tank made of a four –compartments underground concrete tank. Two of these compartments are a proper septic tank and the two last compartments are aeration chambers (attached aerobic reactors).

The septic tank has a volume of 6.9 m³, equivalent to more than 5 day of retention time in normal flow conditions (8 PE*150 L/PE/day). Once primary treated, the effluent flows by gravity to the aerobic treatment section of the Modified Septic Tank. This aerobic section consists in two aeration stages. Each stage is made of an aeration and a settling compartment. The overall retention time aeration is 44 h (2*22) at normal flow. The retention time for settling is 15 h (2*7.5 h) at normal flow.

The treated wastewater then leaves the Modified Septic Tank by gravity and is collected in a 1.2 m³ irrigation tank (1 day HRT). Chlorine is dosed directly into the irrigation tank to ensure effluent disinfection. From this tank, the water is pumped to the irrigation system.

The irrigation system consists in fixed sprinkler irrigation of the lawn. A drip irrigation system has also been installed for watering trees and ornamental plants and trees.

System components

1) The wastewater treatment plant – Modified Septic Tank Technology:

- The system consists in one underground reinforced concrete tank divided in 4 chambers: a 2-chambers septic tank and two aeration reactor chambers each consisting in an

aeration compartment and a clarification compartment. The chambers will be fitted with manholes to provide access for maintenance purpose.

- The aeration system consists in an air blower is installed on the ground level, in a cabinet. Air diffusers, internal pipes and valves will be installed inside the aeration chambers.

2) The reuse system – sprinkler and drip systems

- The treated wastewater collection tank (irrigation Tank) with chlorine disinfection unit.
- The submersible irrigation pump with a float.
- The irrigation network (connection pipes, drip lines and emitters and sprinkler heads).

3) Other Components

- Electric power will be taken from the main electric distribution board.
- The connecting pipes between the Modified Septic Tank, the irrigation tank and the irrigation lines.

Site and construction drawings

Figure 20 shows the survey of the site done before the construction. Figures 21 and 22 present the general design of the treatment system and the layout of the property with the system.

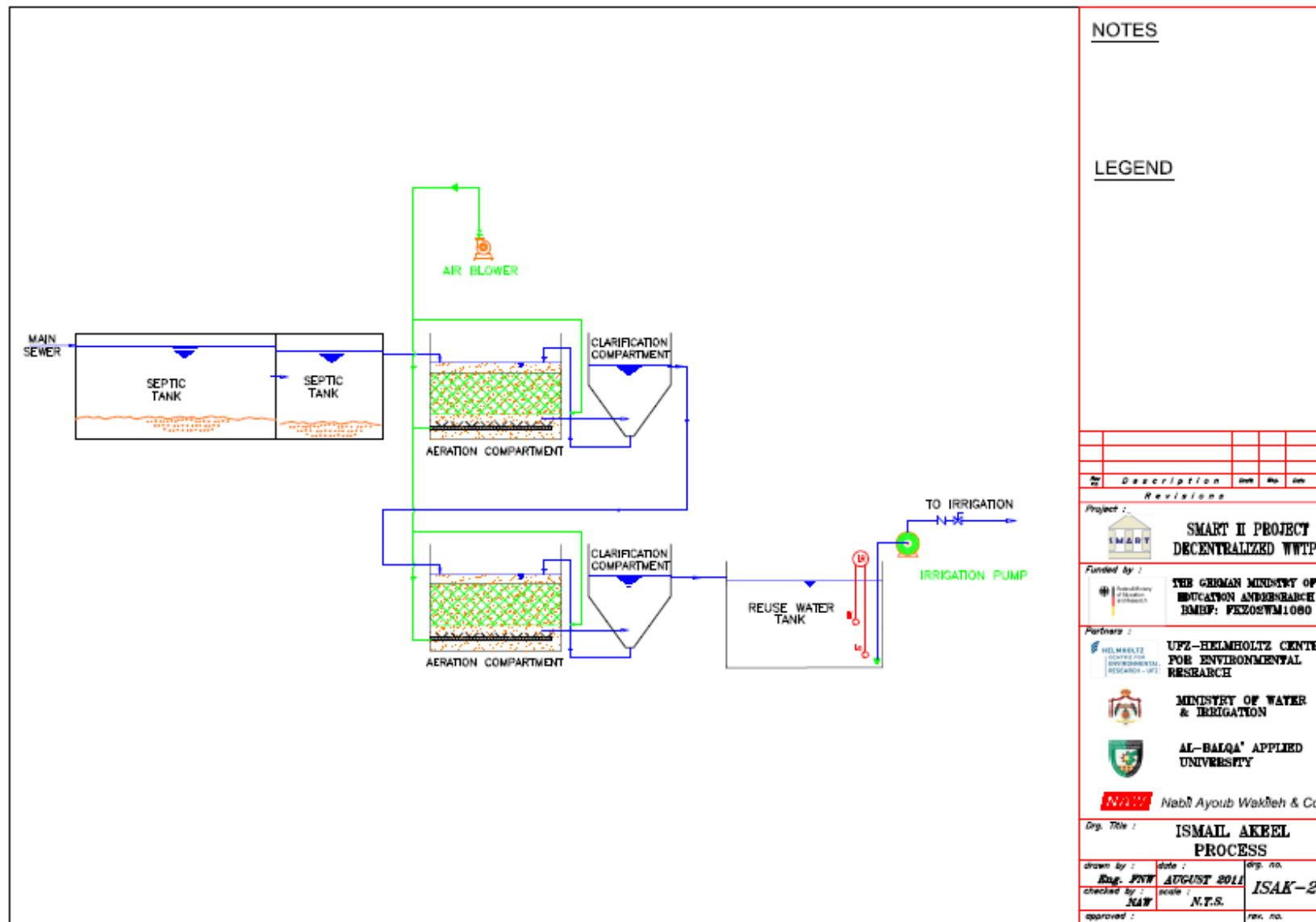
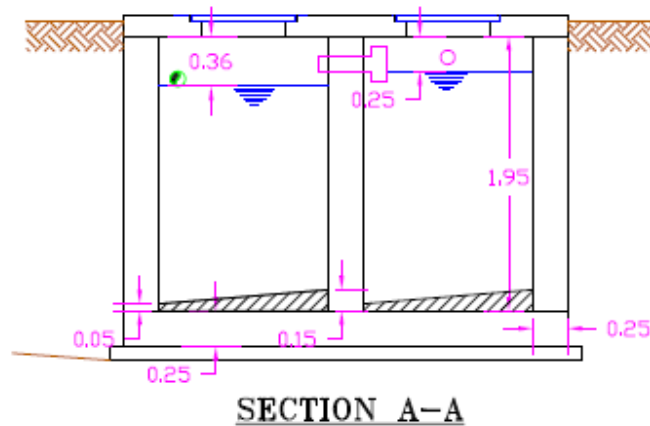
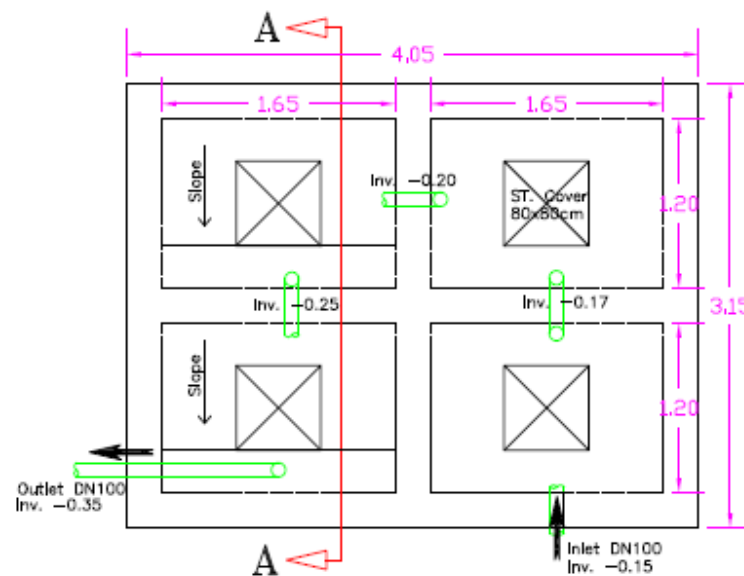


Figure 20: Treatment process at Mr Akeel.

NOTES

ALL DIMENSIONS ARE IN METERS
ALL ELEVATIONS ARE IN METERS

THIS DRAWING IS PRELIMINARY AND
CAN VARY ACCORDING TO SITE
CONDITIONS AND RECOMMENDATIONS
OF THE PARTNERS

LEGEND

Project :
**SMART II PROJECT
DECENTRALIZED WWTPs**

THE GERMAN MINISTRY OF
EDUCATION AND RESEARCH
BMBF: FKZ02WM1080

Partners :
HELMHOLTZ
CENTRE FOR
ENVIRONMENTAL
RESEARCH - UFZ

MINISTRY OF WATER
& IRRIGATION

AL-BALQA' APPLIED
UNIVERSITY

NAW Nabil Ayoub Wakileh & Co.

Eng. Title :
**ISMAIL AKKEL
TANKS**

drawn by : Eng. JNW	date : AUGUST 2011	desig. no. : ISAK-4
checked by : NAW	scale : 1:25	rev. no. :
approved :		

Figure 21: General design of the treatment system

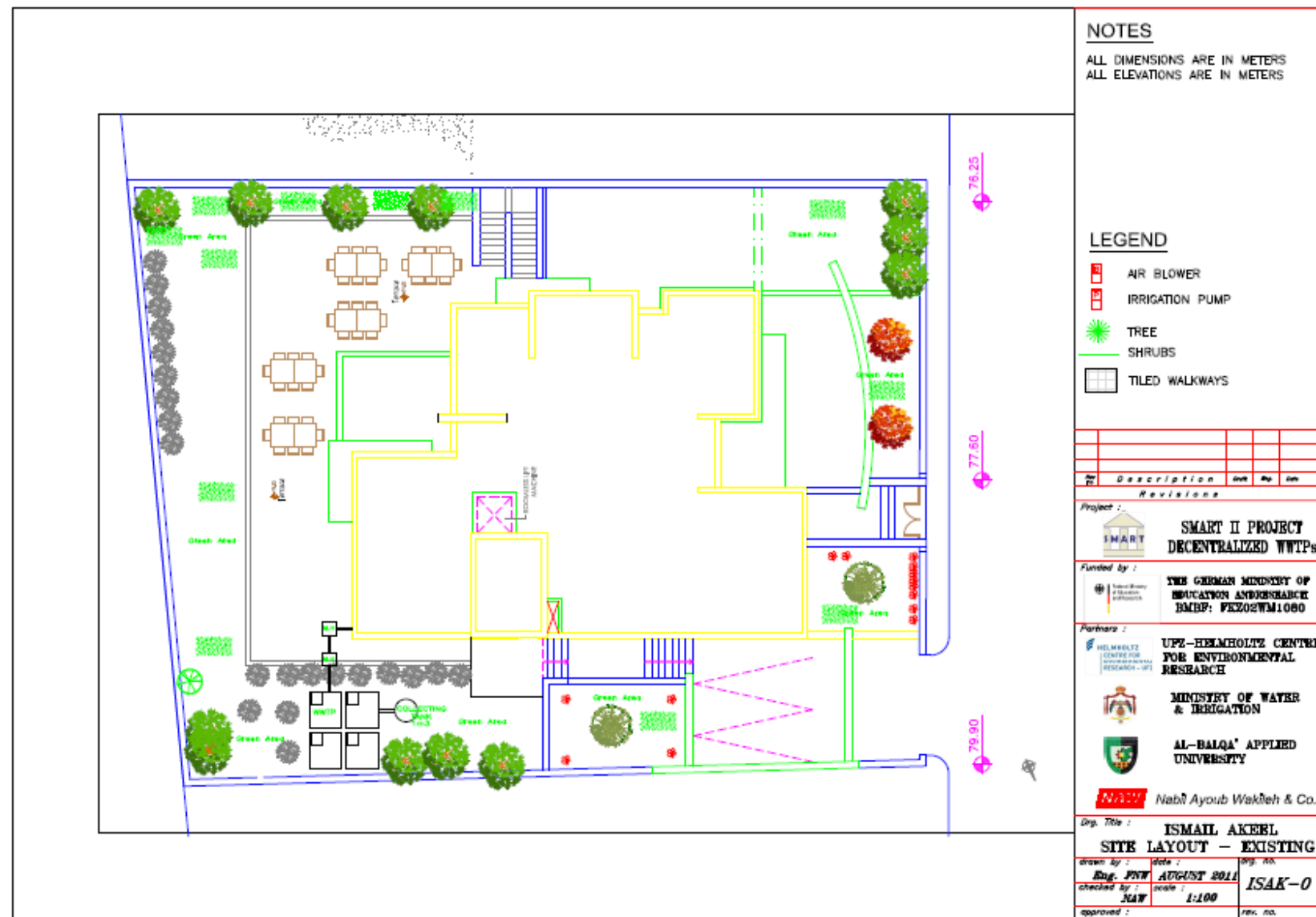


Figure 22: Layout of the site and treatment system.

3.4 CONSTRUCTED WETLAND – MR BASHIR EL HADIDY

3.4.1 SITE PRESENTATION

Location:

Village:	As-Salt
Block:	Al-Maysa – 54
Parcel No.:	70
Coordinates:	N 32° 2' 47.77"
	E 35° 45' 29.39"

Summary:

The house owner was identified and contacted by Dr. Bassim Abbassi. The house is located on the east of As-Salt in a remote area. The site is not connected to a sewer collection system. The wastewater is drained from the house into a percolating pit located in the garden.

Site Description:

The house is located on the east of Salt, in a remote area about 10 minutes' drive from the Balqa University. The house is a 2 storey building having a total area of 500 m² (250 m² per floor) and is constructed over a 16,000 m² land. The house has a large planted garden area of approx. 15,000 m². The garden is planted with various kinds of trees but mainly olives and fruits trees.

Occupancy

The current normal occupancy is about 7 PE but guests are often received and the occupancy can reach 14 PE for extended amount of time (weekends or holiday weeks). It is also expected that the normal household population will reach 10 to 12 PE in the near future (ca. 20 PE at peak flow). The system's design had thus to reflect these variation of volumes.

Fresh Water Supply & Consumption

The house is connected to the municipality water mains. The potable water consumption is estimated to be 115 L/PE/day.

Wastewater collection and Disposal

There is no sewer collection systems servicing the area and the house is connected to a percolating pit Located in the garden. Its dimensions are approx. 4 x 4 m.

Advantages of the this site

- The house is not connected to the sewer system.
- The house has a large garden of approx. 15,000 m² which is available for reuse. The location is not far from the Balqa University.
- The house owner is well qualified for doing the maintenance and his daughter works at the University. This family is aware of environmental issues.

3.4.2 GENERAL DESIGN:

The septic tank

Primary treatment of the wastewater is achieved by a septic tank that collects the house's effluent. The septic tank will digest the solids and modify some nitrogen species. The septic tank has 2 chambers, a retention time 4 days in normal flow and minimum 2 days under peak flow conditions.

The Horizontal Subsurface Flow Wetland (HSSFW)

Once leaving the septic tank, the effluent goes through a HSSFW. It is filled with an 10 – 20 mm gravel media that allows the development of a biofilm that removes some nitrogen as well as the organic compounds (BOD, TSS, COD, etc.). The wetland is fitted with a wet well to control water level and send the effluent to the irrigation tanks. The HSSFW has an area of approximately 40 m² and will have a retention time of about 6.5 days in normal flow when the household population will reach design capacity. In summer, water losses through evaporation could reach up to 40 % of the normal flow and an average of 10-15 % losses through the year for a planted system. As reuse is of primary importance, the system is current not planted to maximise water efficiency. However, plantation is always possible if the house owner asks for it.

The irrigation tank and irrigation field

Following the HSSFW, the treated effluent flows into an irrigation tank fitted with a dosing device that sends the effluent to the irrigation field. This dosing system works mechanically (power free). The effluent is distributed between 3 irrigation lines of 30 m length each to spread the treated effluent over a wide area of the orchard. Around 170 m² of irrigation field are used.

The backup system

To avoid any problem and to ensure proper maintenance, the wetland can be bypassed. The septic tank can be easily reconnected to the existing cesspit as the pipework has been installed. This will ensure that the effluent infiltrated is at least primary treated.

Site and construction drawings

Figure 23 shows the survey of the site done before the construction. Figures 24 and 25 present the general design of the treatment system and the layout of the property with the system.

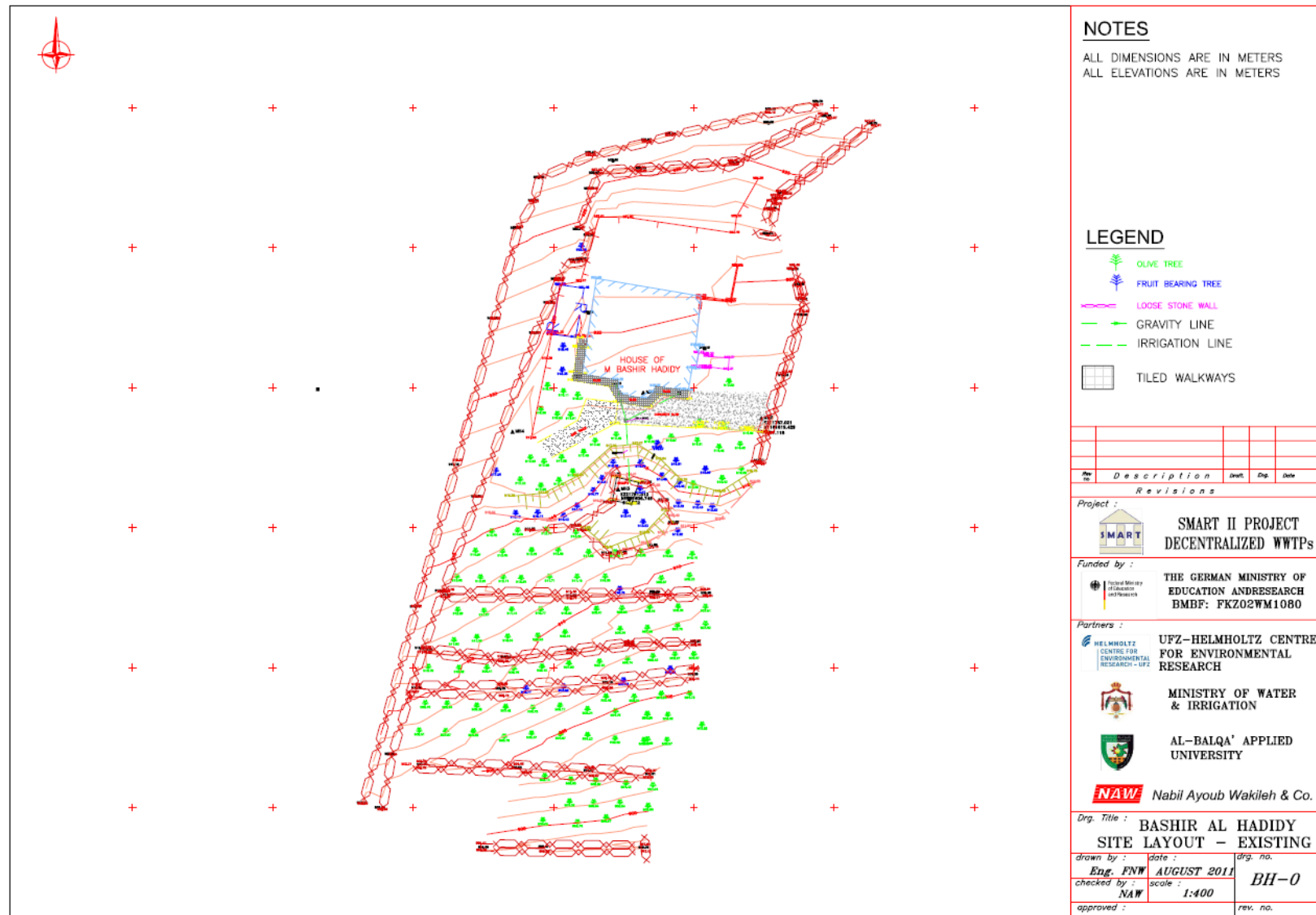


Figure 23: The property of Mr Bashir El Hadidy.

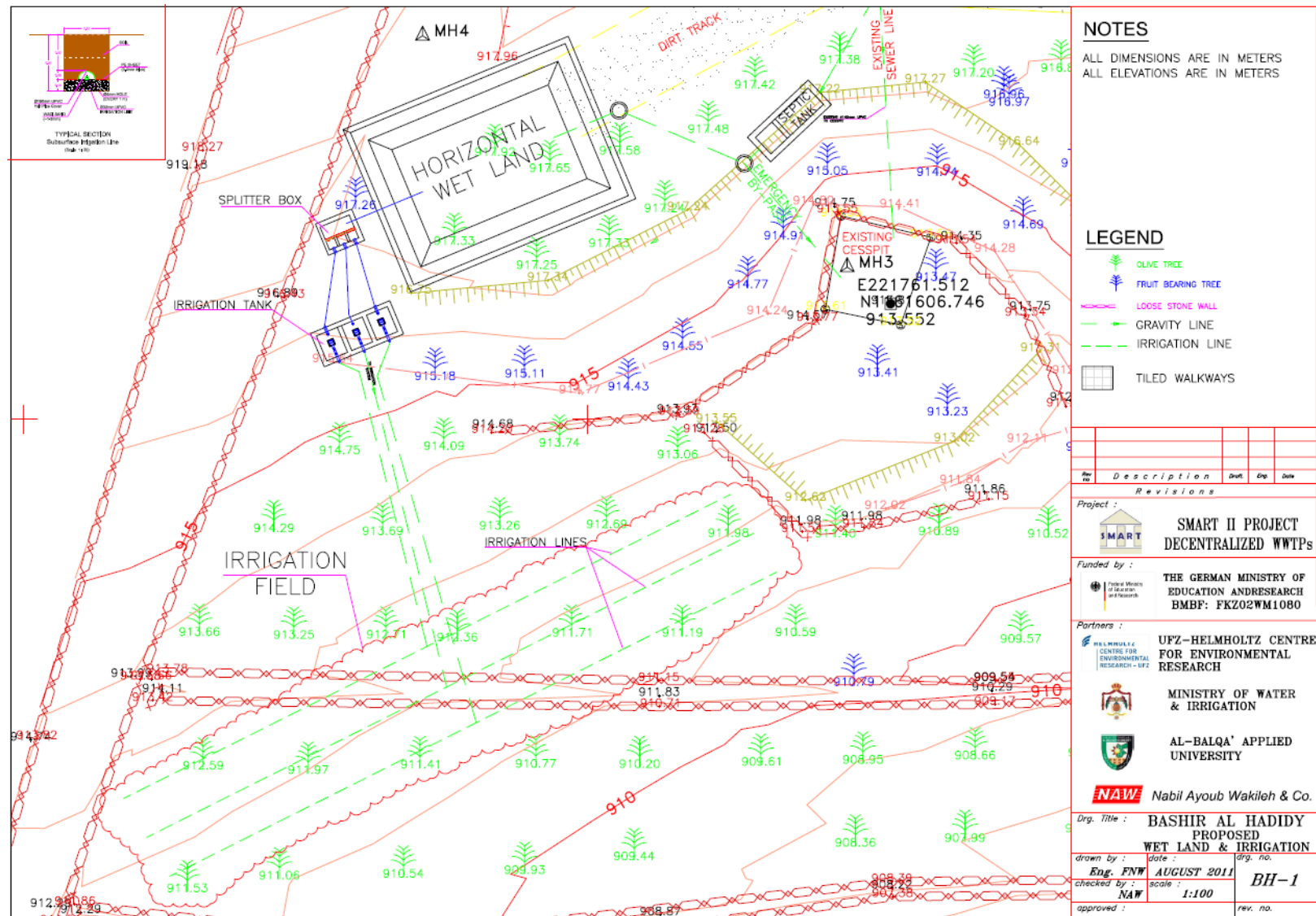


Figure 25: Layout of the treatment system.

3.5 TREATMENT WETLAND – MR SALEM HASSAN ABU RUMMAN

3.5.1 SITE PRESENTATION

Location:

Village:	As-Salt – Um Jouzeh
Block:	Al-Balad – 5
Parcel No.:	469
Coordinates:	32° 5'49.05"N 35°44'7.48"E

Summary:

The site was identified by Dr. Bassim Abbassi. The house is located in the Zay Area – Um Jouzeh area, north of As-Salt. The site is not connected to the sewer network. The wastewater is collected from the building and sent to two percolating pits located in the garden. The second percolating pit is installed in series compared to the first one. It receives that and is used to infiltrate the overflow from the first pit.

Site Description

The plot is located in the Um Jouzeh area, between Zai and As-Salt north of As-Salt in the. It takes approximately 15 min to drive from Al-Balqa University to the site. The site encompasses a two storey house. The basement covers 100 m² but is not used while both the first and the second floor are 225 m². The first floor is made of two apartments and the second floor of one single apartment. The total built area covers 550 m² without the big terrace that borders the house. According to municipal regulations, the construction of another two floors is allowed but not expected at short term. The total surface of the site is about 3100 m² of which the garden covers approximately 2000 m². This garden is mainly planted with olive and fruit trees but an area is reserved for animals (goats, sheep and chickens).

Occupancy

The current normal site occupancy is about 19 PE. The house owner could build the allowed two additional floors within the next 10 years to house his family as his children marry. Normal occupancy could then reach up to 31 PE.

Fresh Water Supply & Consumption

The building is connected to the municipal water mains. According to available data (water bills), the current monthly average water consumption is about 35 m³ ranging from 25 m³/month in winter time to 45 m³/month in summer time. This gives an approximate water consumption of 80 L/PE/day.

Wastewater collection and Disposal

The site is not serviced by a sewer network. The building is connected to two percolating pits in series. The first one receives the wastewater from the house and the second, located on a terrace below, receives the overflow from the first pit (what is not infiltrated).

Advantages of the this site

- The house is not connected to a sewer network.
- The house has a big garden of approximately 2000 m² that will facilitate the reuse of treated wastewater.
- The site is located in the study area (close to Al-Balqa University).
- The family living at the site is experiencing a more difficult economic situation and would be a good demonstration of how the SMART II project could improve the situation.

3.5.2 GENERAL DESIGN:

As things stands at the time this report is written, the site at Mr Abu Rumman has been selected. However, the design has not been approved due to different reasons:

- Uncertainty considering the size of the system due to high variation in expected population number according to the different sources.
- Uncertainty concerning the type of reuse expected.
- Uncertainty concerning the ability/willingness of the owner to do the proper maintenance.

System components

Despite the uncertainties, it is clear that the following elements will be included in the treatment system:

- 1) A septic tank as primary treatment that will be designed to properly retain the solids. The question of the location of the septic tank at the site is important in order to ensure proper maintenance and especially the regular pump out of the solids.

- 2) A treatment wetland to treat the wastewater. The type of wetland selected will fit the constraints of size, robustness, operation and maintenance requirements and of construction and operation budget. A quite passive system will probably be preferred in order to lower energy consumption and moving parts replacement (pumps, etc.).
- 3) A reuse system that will probably take the form of subsurface irrigation to limit the possibilities of human exposure and avoid the need of disinfection.

Site drawings

Figure 26 shows the survey of the site done before the construction.

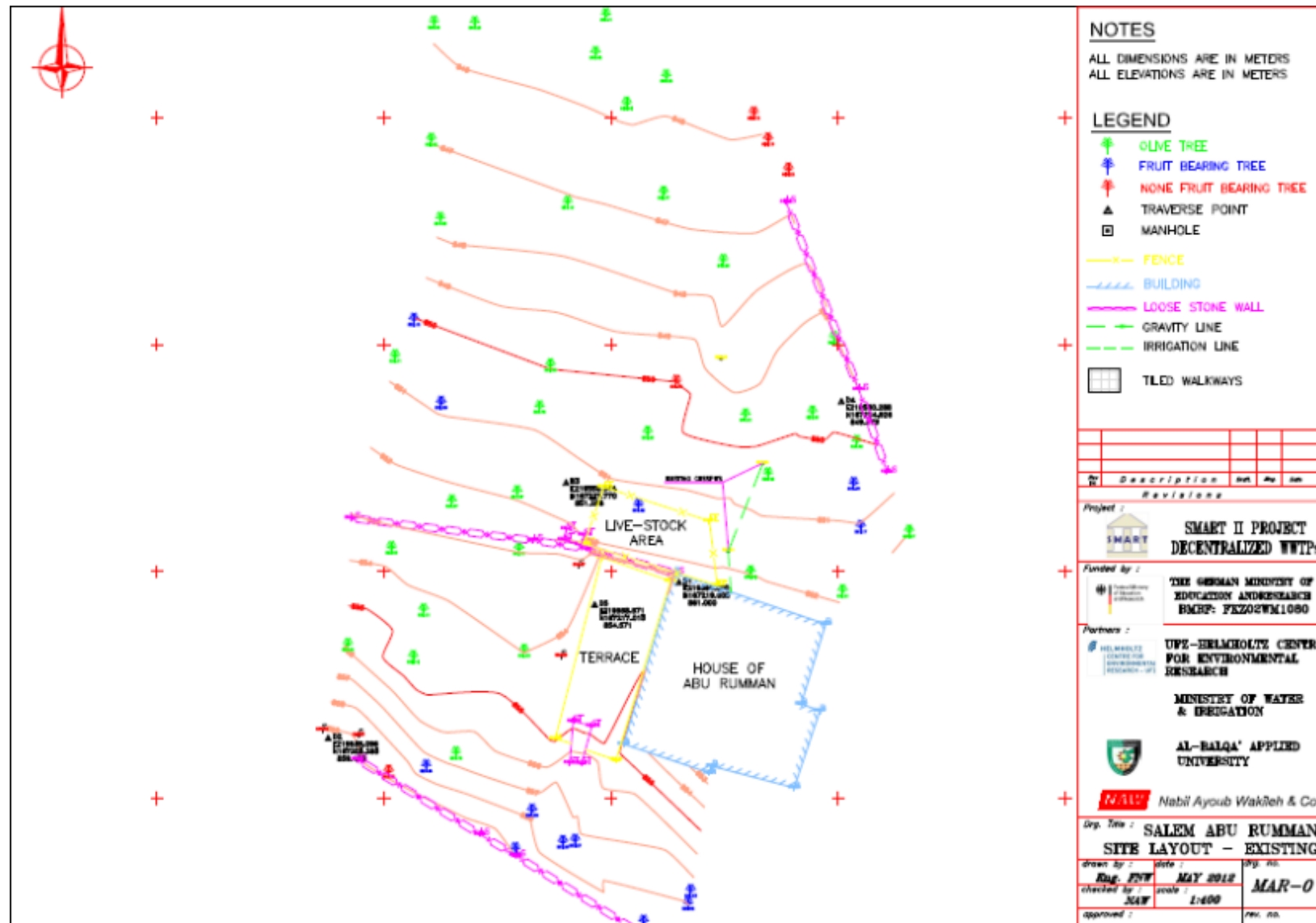


Figure 26: The property of Mr Abu Rumman

3.6 SEQUENCING BATCH REACTOR – MR FAKHRI HASSAN

3.6.1 SITE PRESENTATION

Location:

Village:	Fuhais – 395
Block:	Al Dair, 17
Parcel N°:	422
Coordinates:	N 31° 59' 54"
	E 35° 47' 23"

Summary:

The site was identified by Eng. Iyad Al-Zrekat. The house is located east of Fuhais. The site is not connected to the Fuhais sewer network. The wastewater is collected and drained from the building and sent to a percolating pit located in the garden.

Site Description

The plot is located east of Fuhais (east of the cement factory, only five minutes' drive from the Fuhais research and demonstration site). The site comprises 2 buildings for a total area of 1340 m². Each building is divided in apartments occupied by entire families. The first building is the older of the two. It is a two-storey high house but it also has a basement. The second building is newer; it has three storeys and a basement. The overall constructed area covers 4,412 m². The site also includes a garden of approximately 3,400 m² planted mainly with olive and fruit trees.

Occupancy

The current normal site occupancy is about 25 PE. It is expected to reach up to 30 PE. During peak flow, it is possible that the total population will reach up to 45 PE. These data are taken into consideration during the design phase. This site is a little bit bigger than expected (10-20 PE) but in the Jordanian context, it is considered as a typical site.

Fresh Water Supply & Consumption

The buildings are connected to the municipal water mains. According to the available data, (water bills), the current water consumption is around 1000 m³ per year or 110 L/PE/day. The buildings are connected to a 45 m³ rainwater tank.

Wastewater collection and Disposal

The site area is not serviced by a sewer network. The buildings are connected to a percolating pit that infiltrates the wastewater in the garden.

Advantages of the this site

- The buildings are not connected to the sewer system.
- The site has a big garden (approx. 3,400 m²) that will facilitate the reuse of treated wastewater.
- This site is located in the study area (close to Fuhais and Al-Balqa University).
- The house owner is aware of the environmental issues and interested by the project.

3.6.2 GENERAL DESIGN:

The general concept for this site is to connect the buildings to a Sequencing Batch Reactor (AQUAmax@CLASSIC 17 – 50 Z) treatment system and to reuse the treated wastewater in the garden through a subsurface irrigation system to avoid potential contact with the effluent. The reuse system forms an important final stage of the treatment chain, providing a last treatment barrier with additional purification capabilities through the plant uptake of the nutrients and soil filtration.

The wastewater first reaches a coarse interceptor to remove the solids (plastics, cigarette butts, etc.) that could have entered the system. The two pre-treatment tank/compartments also serve as buffer tanks and have a maximum capacity of about 15 m³.

Then the wastewater reaches the Sequencing Batch Reactor. SBRs are based on the principle of activated sludge systems: suspended microorganisms treat and digest the wastewater contaminants' and convert them into biomass. Stirring, aeration and settling happen in the same tank (see 1.1.3). This tank has a maximum capacity of about 6.6 m³.

The treated wastewater is then collected in an irrigation tank. The irrigation tank has a volume of approx. 8.9 m³ (more than the required minimum volume of one day retention of treated effluent production). The treated effluent is sent to the irrigation field by a pump. A system is installed to split the effluent into the different irrigation lines in the garden. That allows an efficient control of the volume applied, according to the area, the plant requirements and the soil capacity. The irrigation surface required is around 520 m².

The treatment system remains connected to the existing cesspit as a backup solution. This allow disposal of the effluent in case of power failure and allows carrying out the system's maintenance without overfilling the tanks.

System components

- 1) The wastewater treatment plant – SBR technology:
 - The connection pipes to bring wastewater from the buildings to the treatment system.
 - A concrete made primary treatment chamber (below ground).
 - A concrete made SBR chamber. This chamber is below ground and fitted with technical equipment.
 - The ductwork for power cables from the SBR chamber to the control box.
 - The outdoor control box, including the control panel and the GMS module.
- 2) The reuse System – subsurface irrigation:
 - The treated wastewater collection tank (irrigation Tank).
 - The irrigation pump with a float.
 - The subsurface irrigation lines.
- 3) The backup system:
 - A pipe to bypass the treatment system and restore the original sewage management solution.
- 4) The other constituents:
 - The electric power will be brought from the main electric distribution board to the outdoor control box.
 - The connecting pipes between the SBR, the irrigation tank and the irrigation line.

Site and construction drawings

Figure 27 shows the survey of the site done before the construction. Figures 28, 29 and 30 present the general design of the treatment system and the layout of the property with the system.

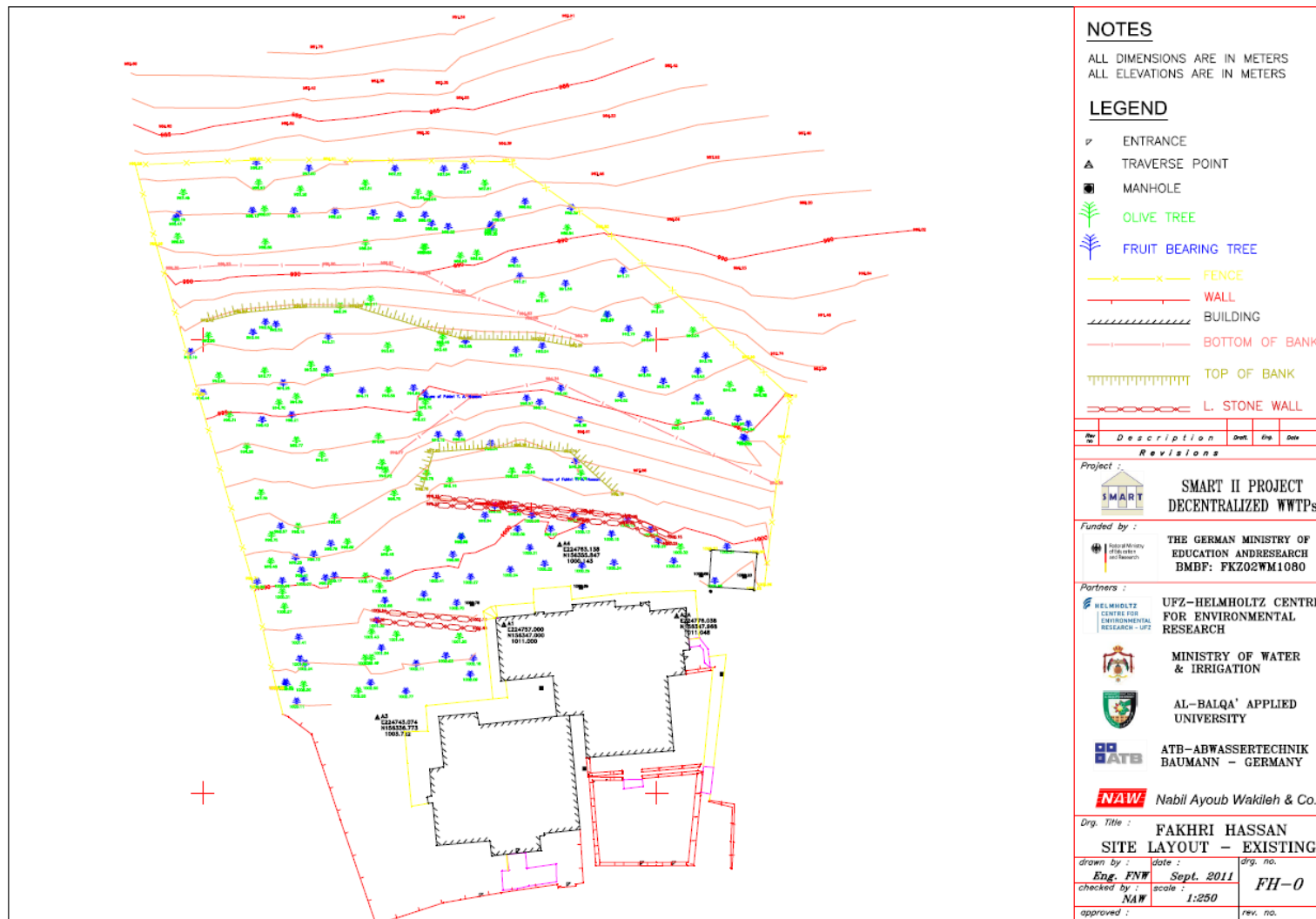


Figure 27: The property of Fakhri Hassan

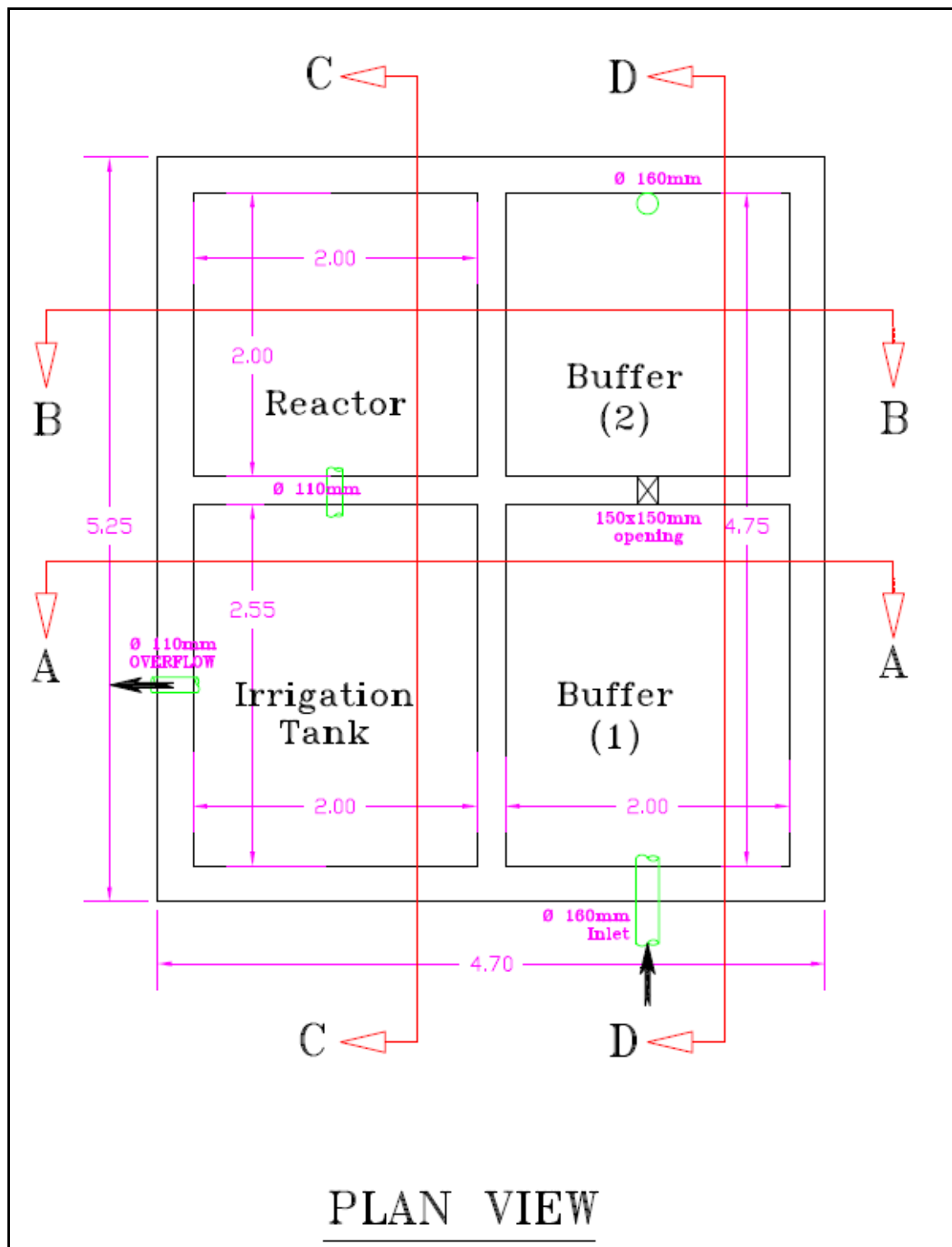


Figure 28: General design of the Treatment system – Plan view

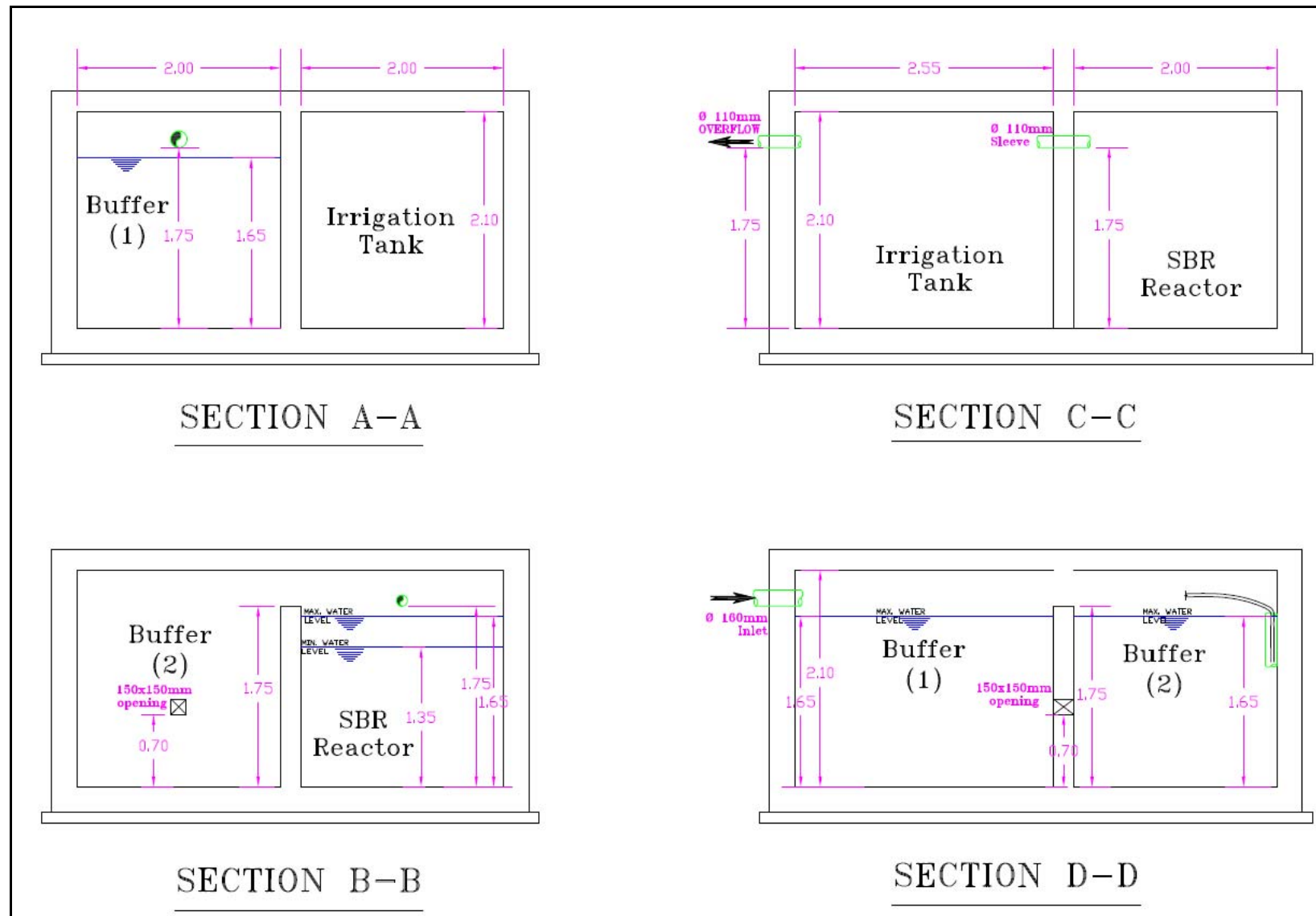


Figure 29: General design of the Treatment system – Section view

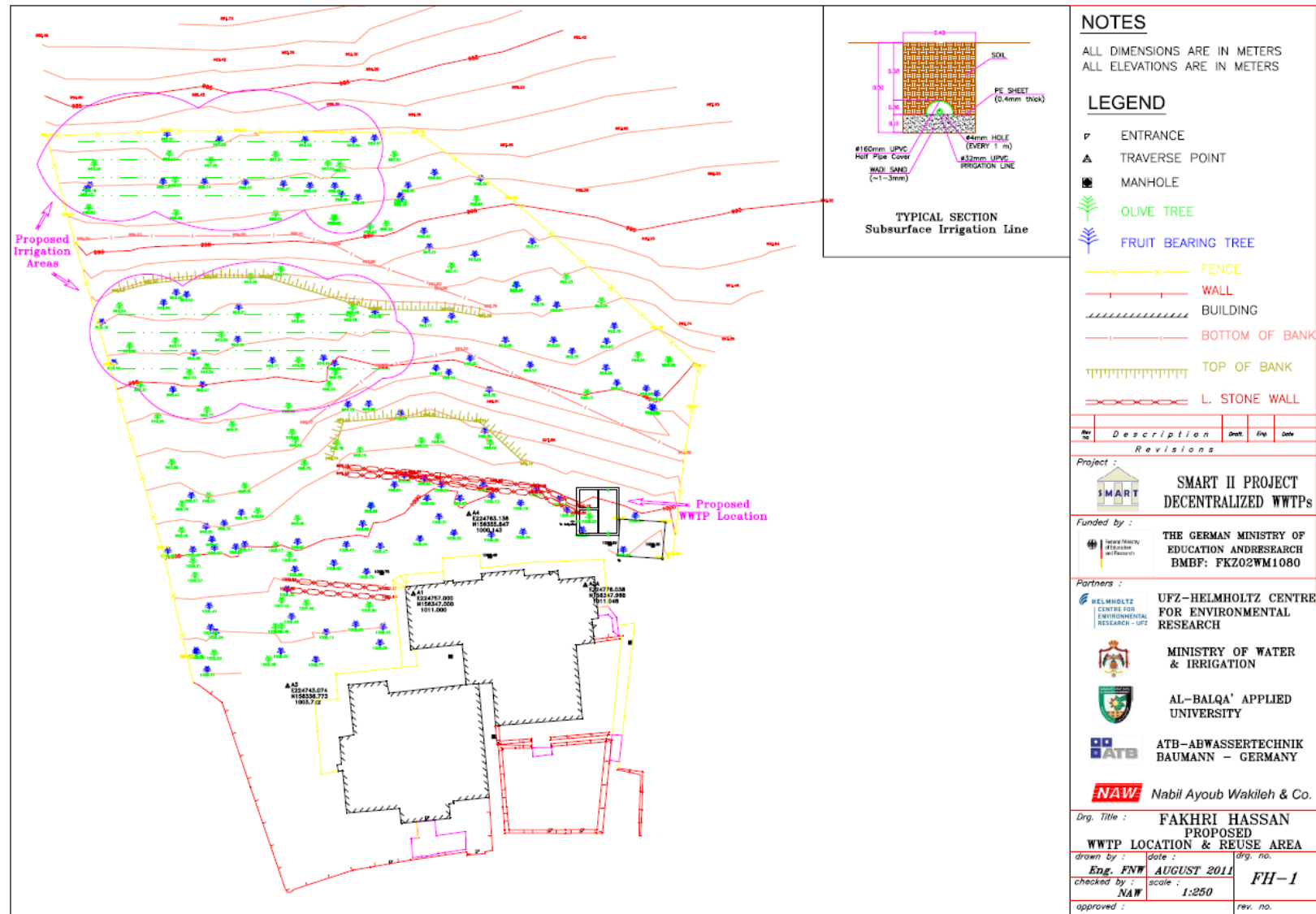


Figure 30: Layout of the treatment system

3.7 SEQUENCING BATCH REACTOR - DR. AHMAD AL AWAMLEH

3.7.1 SITE PRESENTATION

Location:

Village:	As-Salt – Zay Area
Block:	Tabaah, 20
Parcel No.:	139
Coordinates:	N 32° 5' 49.36"
	E 35° 44' 4.21"

Summary:

The site was identified by Dr Bassim Abbassi. The house is located north of As-Salt. The site is not connected to the As-Salt sewer network. Wastewater is collected and drained from the building and sent to a percolating pit located in the garden.

Site Description:

The plot is located north of As-Salt, a 10 minutes' drive from Al-Balqa University. The site comprises one household an area of 200 m² (150 m² for the house itself plus 50 m² for the basement). The total surface of the site is 4,354 m² out of which about 3,000 m² are used as a garden. In this garden, at least 1,500 m² are located at a lower level and are planted with olive and fruit trees. This garden offers plenty of possibilities as a reuse area

Occupancy

The current normal site occupancy is 7 PE. However, the house owner is currently planning to add another floor to his house. The expected occupancy would then reach about 14 PE. The house owner also regularly receives up to 10-20 visitors in the evening. These guests though are only visiting for a few hours at a time.

Fresh Water Supply & Consumption

The building is connected to the municipal water mains. It is estimated that the water consumption is about 100 L/PE/day during winter time and about 115 L/PE/day in summer. For the current 7 PE occupancy, this means about 0.8 m³/day.

The wastewater treatment system is designed for a maximum occupancy of up to 16 PE (e.g. about 1.84 m³/day). This can be regulated by modifying the water level in the tanks which is given by the position (height) of the unit in the biological reactor and the settings in the control panel.

According to the house owner, potable water is also used in the garden for irrigation purpose. However this use is restricted because of the size of the garden. Reusing treated wastewater should then help lowering the household water consumption.

Wastewater collection and Disposal

The site area is not serviced by a municipal sewer network. The buildings are connected to a percolating pit that infiltrates the wastewater in the garden. The size of the existing cesspit is not known but is, according to site observations, quite small. In any case, the cesspit is unlikely to be able to cope with an increase in occupancy (14 PE when another floor is built). That would result in either higher operation costs due to regular pumping out requirements or to health and environmental hazards in case of overflow.

Advantages of the this site

- The House is not connected to the sewer system.
- The site has a big garden (approx. 3,000 m²) that will offer a perfect opportunity to reuse the treated wastewater and lower the house owner's water bill.
- This site is located in the study area (close to Al-Balqa University).
- The house owner is aware of the environmental issues and interested by the project.

3.7.2 GENERAL DESIGN:

The general concept for this site is to connect the buildings to a Sequencing Batch Reactor (AQUAmax@CLASSIC 1 – 16 Z) treatment system and to reuse the treated wastewater in the garden through a subsurface irrigation system to avoid potential human contact with the effluent.

The wastewater first reaches a coarse interceptor to remove the solids (plastics, cigarette butts, etc.) that could have entered the system. The two pre-treatment tanks/compartments also serve as buffer tanks and have a maximum volume of about 8.4 m³.

Then the wastewater reaches the Sequencing Batch Reactor. SBRs are based on the principle of activated sludge systems: suspended microorganisms treat and digest the wastewater contaminants' and convert them into biomass. Stirring, aeration and settling happen in the same tank. This tank has a capacity of about 3.6 m³.

The treated wastewater is then collected in an irrigation tank. The irrigation tank has a volume of approx. m³ (one day retention of treated effluent production). The irrigation surface required is around 4.9 m² (more than the minimum required volume of one day retention of treated effluent production). The treated effluent is sent to the irrigation field by a pump. A system is installed to split the effluent into the different irrigation lines in the garden. That allows an efficient control of the

volume applied, according to the area, the plant requirements and the soil capacity. The irrigation surface required is about 330 m².

The treatment system remains connected to the existing cesspit as a backup solution. This allows disposal of the effluent in case of power failure and allows carrying out the system's maintenance without overfilling the tanks.

System components

1) The wastewater treatment plant – SBR technology:

- The connection pipes to bring wastewater from the buildings to the treatment system.
- A concrete made primary treatment chamber (below ground).
- A concrete made SBR chamber. This chamber is below ground and fitted with technical equipment.
- The ductwork for power cables from the SBR chamber to the control box.
- The outdoor control box, including the control panel and the GMS module.

2) The reuse System – subsurface irrigation:

- The treated wastewater collection tank (irrigation Tank).
- The irrigation pump with a float.
- The subsurface irrigation lines.

3) The backup system:

- A pipe to bypass the treatment system and restore the original sewage management solution.

4) The other constituents:

- The electric power will be brought from the main electric distribution board to the outdoor control box.
- The connecting pipes between the SBR, the irrigation tank and the irrigation line.

Site and construction drawings

Figure 31 shows the survey of the site done before the construction. Figures 32, 33 and 34 present the general design of the treatment system and the layout of the property with the system.

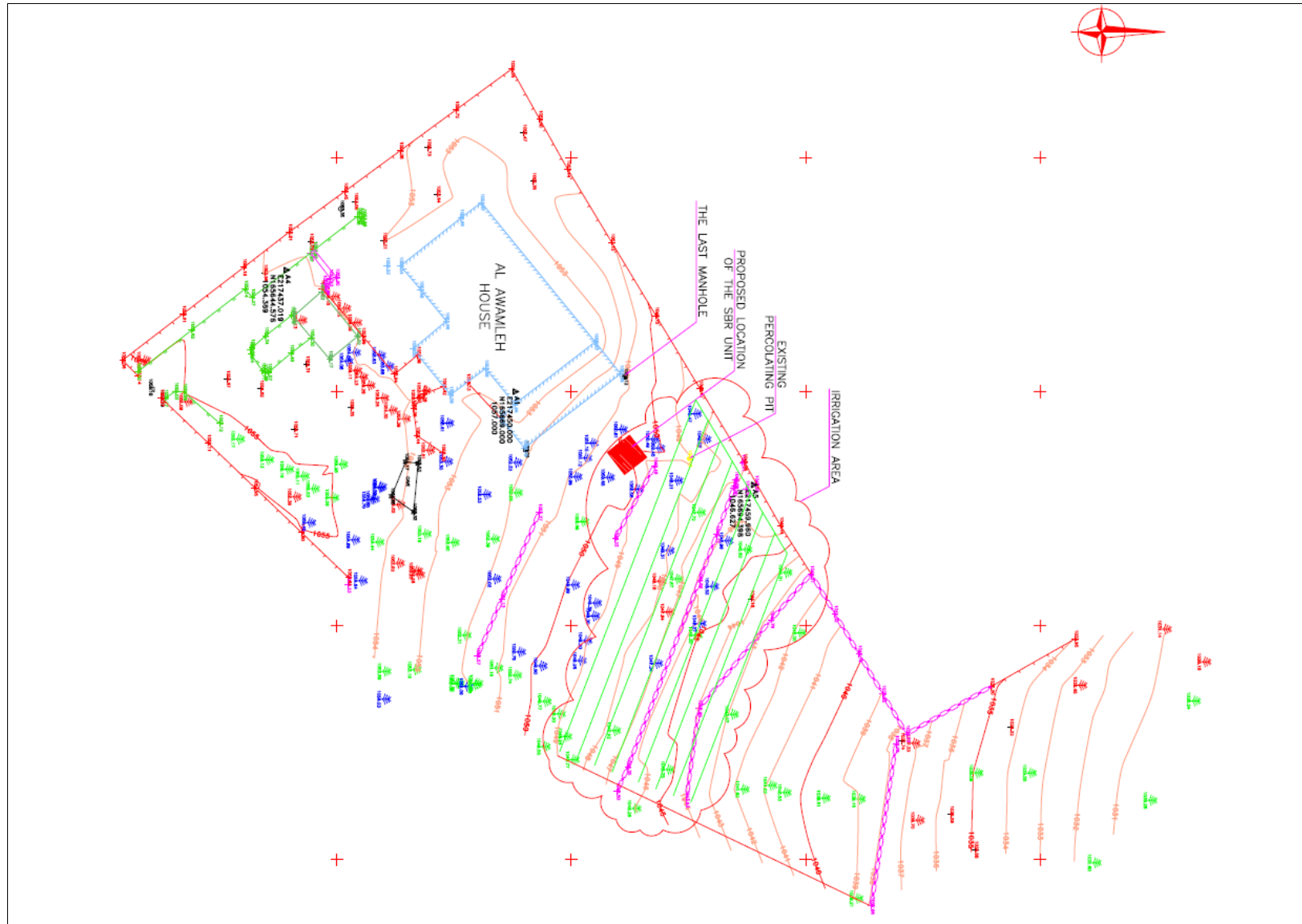


Figure 31: The property of Dr. Ahmad Al Awamleh

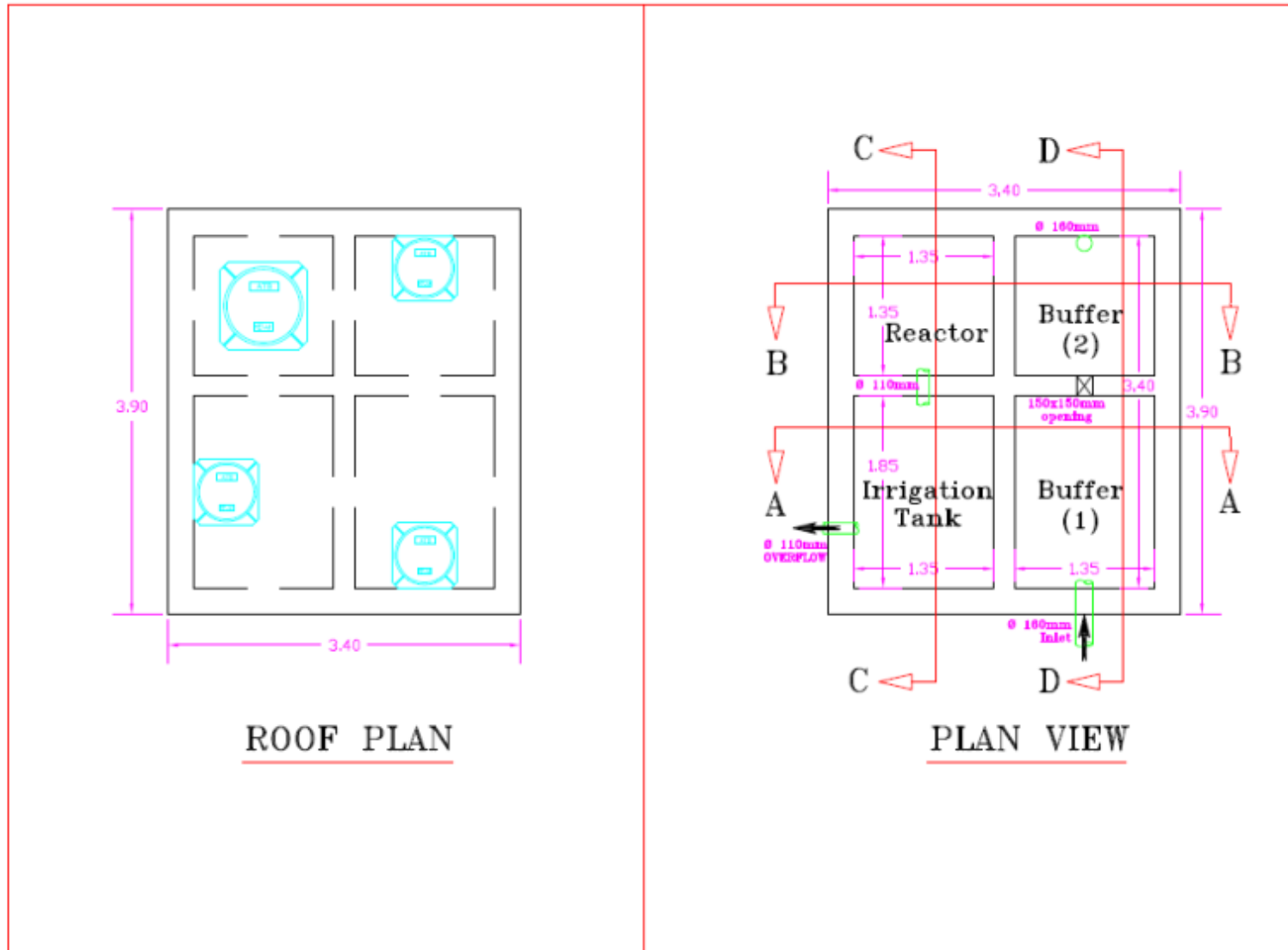


Figure 32: General design of the treatment system – Plan view

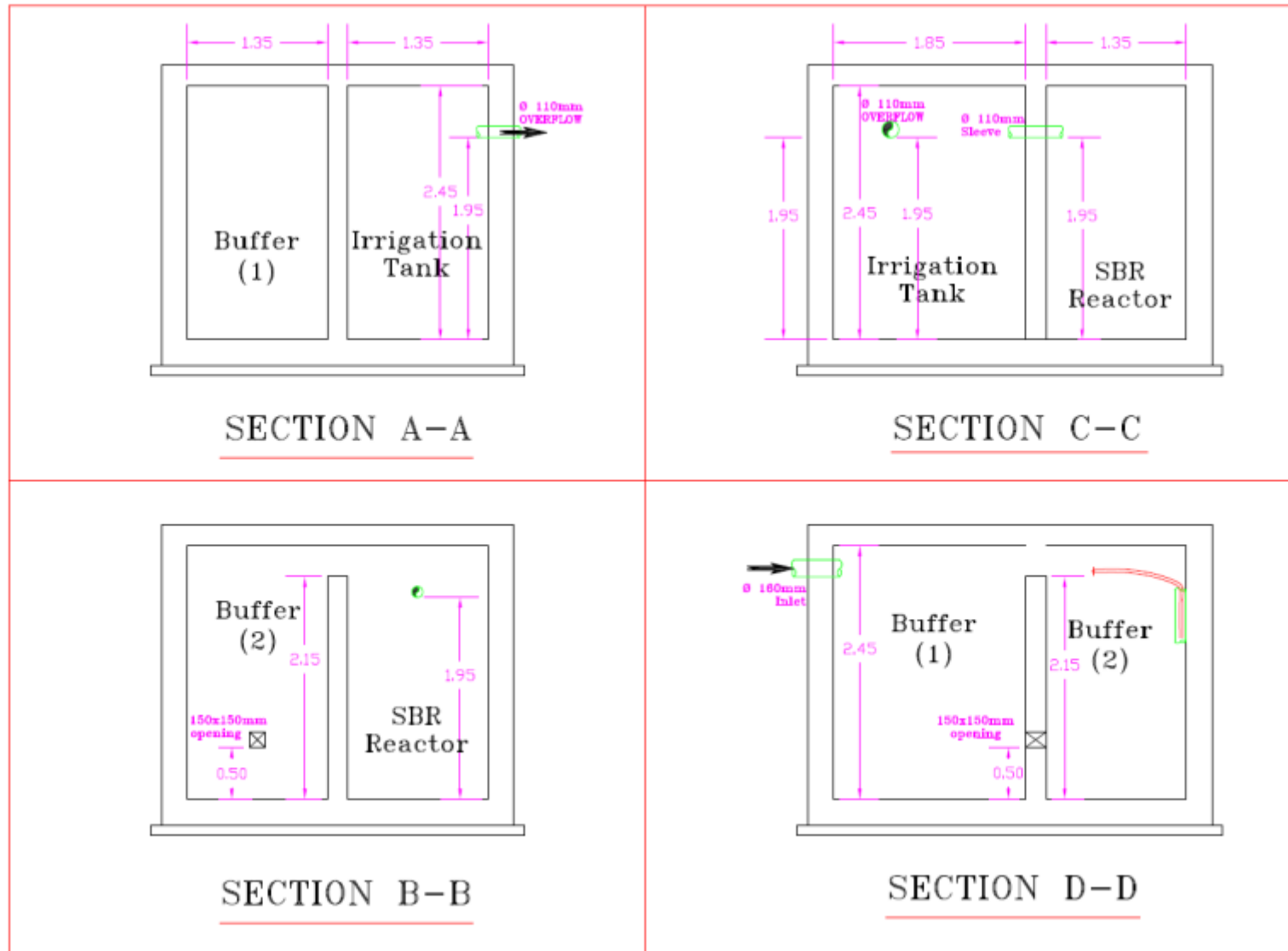


Figure 33: General design of the treatment system – Section view



4 PRESENTATION OF THE COLLECTIVE SITES

4.1 SEQUENCING BATCH REACTOR – THE NURSING HOME (FUHAIS)

4.1.1 SITE PRESENTATION

Location:

Village:	Fuhais - 395
Block:	Al- Saqiriah - 6
Parcel No.:	11, 17 and 86
Coordinates:	N 32° 1' 8.99" E 35° 45' 59.06"

Summary:

Based on the information passed from the Ministry of Water & Irrigation to Dr. Bassim Abbassi, we were informed that the Nursing Home located on the west side of Fuhais, an area not connected to the sewer collection system, had a problem with its sewage disposal system, requiring the pumping out of 10-15 m³ of wastewater every 2 to 3 days and that the problem was only going to get worse (and more expensive) as it was planned to extend the room capacity of the Nursing Home. Besides, the potable water consumption was also an issue as some of it was used in the property's garden, increasing the water bill.

Site Description:

The site is located just outside the residential area in Fuhais, some 3 minutes' drive from Fuhais. An asphalted road leads directly to the complex. The site is well organized (inside / outside) and is operated by a non-profit organization: "The Sisters of the Cross".

The property consists in 45,000 m² of land donated by a priest to build the Nursing Home.

The house was designed by "Dar Al Handaseh Engineering & Consulting" and was constructed in the year 2000. The building is 3 storeys high, the ground floor is dedicated to the facilities (reception, office, visitors' hall, kitchen, Laundry, etc.); the residents are living in the 1st & 2nd floors with the rooms arranged in a similar way as in hospitals. The 1st floor is dedicated to the ladies while the 2rd floor is reserved to the men. Each floor comprises several rooms of different size and shape (single bed, 2-beds and up to 5-beds rooms). Each room has its own toilet.

The existing building is actually the first phase of a complex housing old people. Considering the fact that the building is only 50% occupied and that the complex was established in 2000, it is not clear if and when the entire site will be constructed. However, it is planned to start in 2012 a separate building housing retired priests.

The building is surrounded by a large garden which is part of the Nursing Home's property. The garden is planted with olive and fruits trees of all sorts. A small vegetable garden and a picnic area for the residents have also been installed in the site.

Occupancy

The current population includes 35 residents (≈ 35 PE), 4 Nuns living onsite ($= 4$ PE) and 12 employees in two shifts (≈ 12 PE). The current population is estimated to be around 50 PE but the building is not fully occupied.

The building is sized for a maximum occupancy of 90 to 100 PE but full occupancy is not expected in the near future. However, a new building to house 15 retired Priests is under construction (started in 2012) and it is likely that new staff will also be hired at the time the residents arrive.

To be conservative in the design, a possible increase in residents and staff numbers was assumed. This increase has been estimated to be one (1) resident per year over the next 10 years plus 3 staff and 1 Nun. The numbers are presented in Table 5.

Table 5: Occupancy of the Nursing Home

	Main building Current size	Main building Size in 10 years	Priests extension Full occupancy	Design size (building + extension)
Residents (PE)	35	45	15	60
Nuns (PE)	4	5	/	5
Staff (PE)	12	15	5	20
TOTAL (PE)	51	65	20	85

Fresh water supply and consumption

The Nursing Home is connected to the municipality water mains but its water use differs from traditional dwellings and is probably closer to a hotel or a hospital. The place is very well maintained to comply with health and safety requirements.

Part of the fresh water is used for the gardens' irrigation. The volumes are estimated as 1 m³/day during winter time and 2 m³/day during summer time.

Within the building's compound, potable water is used for human consumption (kitchen, shower...) but also for the cleaning of the building and its surroundings and for watering the decorative plants.

The estimated water consumption is presented below:

- Average Daily flow: 5 m³/day
- Minimum Daily Flow: 4 m³/day
- Maximum Daily Flow: 7.5 m³/day

Wastewater collection and Disposal

The Nursing Home is not connected to a sewer network. It is serviced by a three-chamber septic tank of about 46 m³. However, this septic tank is not connected to any disposal system and is currently used only as a storage tank.

The nuns managing the Nursing Home routinely call for a truck to pump out the effluent from the septic tank. This usually happens every two to three days. The pumped out wastewater is sent to the Fuhais municipal wastewater treatment plant.

It is possible that the existing septic tank is not water tight. During construction of the new treatment system, the condition of the septic tank will be controlled and potential leakages will be fixed.

The wastewater production is estimated to be on average 5 m³ per day as the pumping trucks are coming every 2 to 3 days to pump out a volume of 10 to 15 m³ of wastewater.

The wastewater production is thus estimated to be approximately 100 L/PE/day and the BOD₅ load 60 g/PE/day. For conservative reasons, the design will be based on a BOD₅ of 67 g/PE/day.

For design considerations, it is also estimated that the Nursing Home may produce up to 8.5 m³ of effluent per day when the Priests will arrive and if new residents are hosted by the institution.

Advantages of the this site

- The site is in a rural location and not connected to the sewer system.
- Land is available to install an onsite wastewater treatment system.
- The garden is big enough to ensure all year long reuse of the treated wastewater.
- The location is in the SMART study area, close from the Fuhais demonstration and research site and the Al-Balqa University.
- The site is well managed and organized. Close attention is already paid to the management of the wastewater. Thus it is expected that a new wastewater treatment and reuse system should be properly operated and maintained as well.

4.1.2 GENERAL DESIGN:

The general concept for this site is to use the existing septic tank with its existing inflow pipework to connect it to a Sequencing Batch Reactor treatment system and to reuse the treated wastewater in the garden through a drip irrigation system to maximise the water efficiency. The reuse system forms

an important final stage of the treatment chain, providing a last treatment barrier with additional purification capabilities through the plant uptake of the nutrients and soil filtration.

The wastewater is collected in the existing 3-chambers septic tank. The last two chambers are used as buffer for the biological treatment unit. The total volume of the septic tank/buffer reaches 46 m³ divided between a 27 m³ first chamber followed by two 9.5 m³ chambers.

Adjacent to the septic/buffer tank, a new tank is to be built underground. This tank of about 11.3 m³ will be the biological reactor and will be fitted with the AQUAmax® Professional XL1-100 equipment. The wastewater will then be pumped into a storage tank but will pass through a disc-filter and a UV disinfection unit. The aim of the disc-filter is to remove the remaining suspended solids that could decrease the performances of the disinfection unit. The filtration and disinfection are important steps in order to ensure surface reuse of the treated effluent.

The storage tank is fitted with a multistage pump whose aim is to send the treated effluent to an irrigation tank located 200 m away and 20 m uphill, on the other side of the property. This irrigation tank is to be installed above ground to allow for an energy-free, gravity-fed drip irrigation system to be used. Only seven of the upper fields of the garden will be irrigated because the remaining fields are located closer to the building and are sometimes used to produce non-cooked vegetables. The drip irrigation will be used to improve the fruit production (olives and stone fruits) that can be sold by the institution. The main irrigation lines will be buried to avoid damage while the sub-main and lateral lines will be above ground so they can be manipulated or removed if necessary.

The backup solution (power failure, etc.) for the treatment system consist in the installation of a connection between the buffer and the storage tanks. This will allow the collected wastewater to flow from one tank to the other instead of overflowing the compound in case of power or mechanical failure. If the time required to fix the problem is longer than the storage capacity allows for (1.4 days of storage at full capacity), then a pumping truck will have to be called (e.g. back to the current situation).

System components

1) The wastewater treatment plant – SBR technology:

- The connections to bring wastewater from the existing septic tank to the new biological treatment system.
- A concrete made SBR chamber beside the existing septic tank to be fitted with technical equipment.
- The ductwork for power cables from the SBR chamber to the control box.
- The outdoor control box, including the control panel and the GMS module.

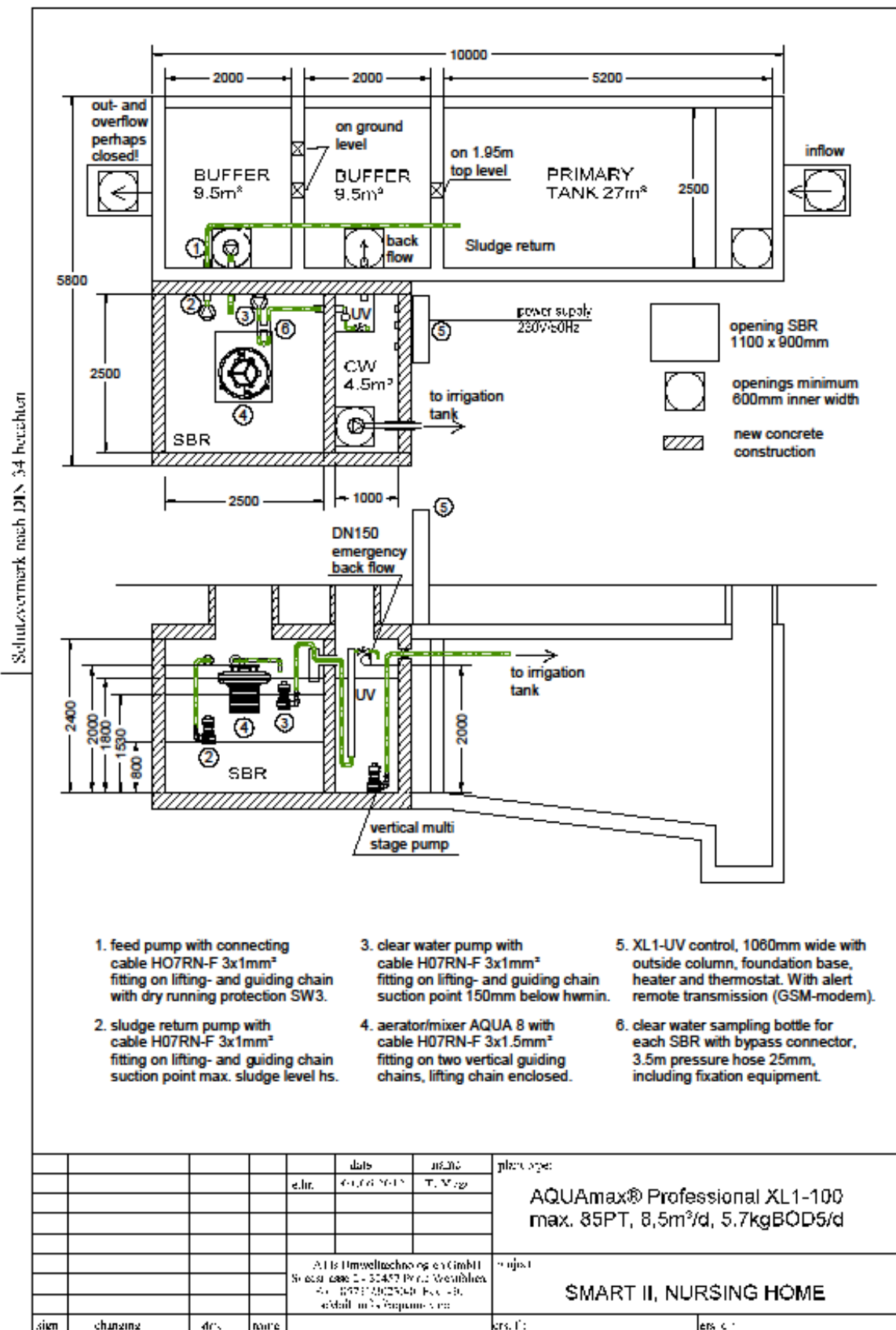
2) The disinfection unit:

- A concrete storage tank for treated effluent fitted with a UV disinfection unit. This tank is located besides the septic tank and the biological reactor.
- A treated effluent's pump to send the treated effluent through the UV unit.

- The disc-filter to prevent any solids to be pumped through the UV disinfection unit.
 - The UV disinfection unit.
- 3) The reuse system – subsurface irrigation:
- A vertical multistage pump to send the disinfected effluent to the irrigation system.
 - The above ground irrigation storage tank.
 - The irrigation pipes (mains and sub-mains) to bring the treated effluent from the storage tank to the irrigation lines.
 - The above ground irrigation lines (laterals polyethylene pipes) with their drip emitters and valves.
- 4) The backup system:
- An overflow hole connects the buffer tank and the storage tank (UV unit tank).
 - If the system cannot be restarted within the storage capacity of the system, pumping truck service have to be organised to empty the buffer and storage tanks..
- 5) The other constituents:
- The electric power will be brought from the main electric distribution board to the outdoor control box.
 - The connecting pipes between the SBR and the irrigation tank.

Site and construction drawings

Figure 35 shows the survey of the site done before the construction. Figures 36 and 37 present the general design of the treatment system and the layout of the property with the system.



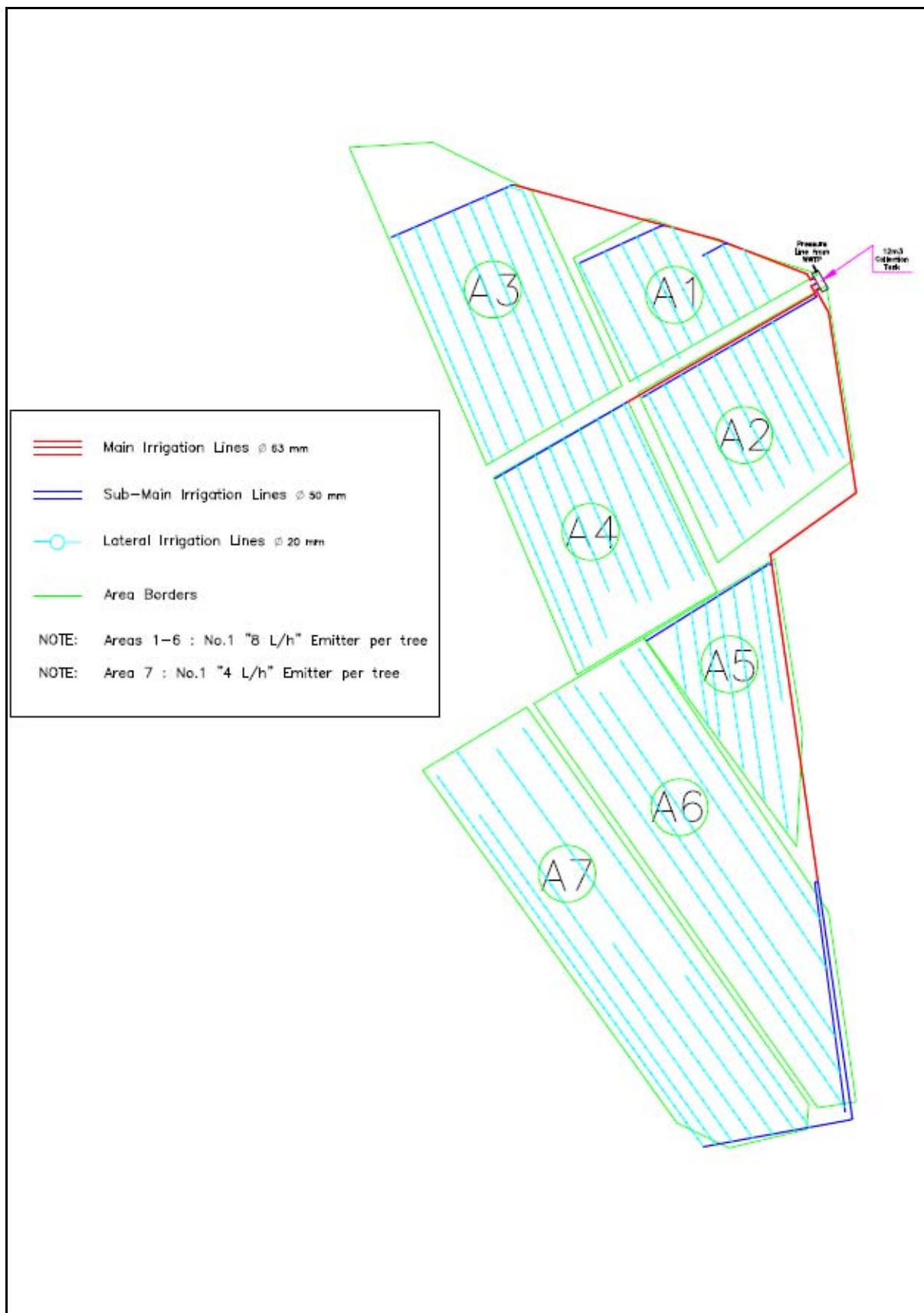


Figure 37: Layout of the irrigation system

4.2 MEMBRANE BIO-REACTOR – MAGHAREEB PHASE 3 (AS-SALT)

The place selected as the community site for the Huber's membrane bio-reactor is located at Maghareeb, a village of As-Salt.

Discussions are still under between the different project-partners (Huber SE, NAW&CO, the Ministry of Water and Irrigation and the As-Salt Municipality) to define the contracting responsibilities. As the terms of the contract are still not 100 % clear and as different modifications to the design have already been made to accommodate earlier discussions, the presentation of the site and of the selected design will be included in the final report of the WP 3.1 of the SMART II Project.

4.3 THE TREATMENT WETLAND SITE

This site where the treatment wetland for a community will be installed has still not been identified. The main reason is the difficulty to fit the budget requirements to the selection criteria and especially to the sewer connection, to the space available and to the population connected.

Actually 3 sites are still being surveyed and discussed by the different partners.

The final site selected will be presented and the design discussed in the final report of the WP 3.1 of the SMART II Project.

5 GENERAL DISCUSSION ABOUT THE SITE SELECTION PROCESS

Due to the size requirements, the selection of the small and big sites was a totally different process. For the small sites, the direct interaction with the house-owners and their ability to take responsibility for the systems installed made it a very straightforward process. The only difficulty experienced was related to the fact that two site owners decided to pull out of the project a few days before signing their contract. To avoid the related drawbacks (delay due to the need to find new sites, to proceed with the new surveys and to realise new designs), the signature of a “memorandum of understanding” expressing the interest of the house-owners to the project should have been required. This would have avoided unnecessary costs and waste of time by stating the responsibility of the house-owner (compensation for the costs engaged for survey if decision to pull-out, etc.).

For the big sites however, the task is a lot more complex. Following the main factors for complications:

- One potential construction sites (SBR, treatment wetland) that have been already preselected in project phase one had to be rejected due to complains of a few but influential private landowners although the majority of the population, the Ministry of Water and Irrigation and the municipality were supporting the project.
- Many identified settlements or clusters of houses (suburban and rural) were bigger than the population requirement of 250 inhabitants defined in the project proposal and thus lead to budget constraints.
- Restrictions in funding of infrastructures, especially sewer networks.
- Land availability for construction of the decentralized treatment system
- Currently, as Jordan is moving toward the decentralisation of responsibilities to the local governments (municipalities, etc.). However, this proves difficult for decentralized wastewater treatment systems as these new competences require knowledge and resources that are not necessarily available at the local level.
- For some sites the landowner of the potential construction plot was different from the potential future owner of the treatment plant generating contractual complications.
- Unclear responsibilities for future operation and maintenance of the treatment systems led to low acceptance for overtaking the ownership of the treatment system.
- Unclear administrative and regulatory framework conditions at all levels for implementing decentralized wastewater treatment and reuse systems.