Assessment of Energy, Water and Waste Reduction Options for the Proposed AMISOM HQ Camp in Mogadishu, Somalia and the Support Base in Mombasa, Kenya

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Technical Report

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Rationale

The Environmental Policy for UN Field Missions, applying to both the Department of Peacekeeping Operations (DPKO) and the Department of Field Support (DFS), came into effect on 1 June 2009. This policy, developed in cooperation with UNEP, provides a minimum set of environmental standards and objectives for UN Field Missions. These standards have been developed to minimise the environmental footprint of peacekeeping operations while maximizing the efficient use of natural resources. Application of these standards should reduce the overall consumption of natural resources and production of wastes, thereby reducing potential conflicts with local communities and enhancing the reputation of the UN as a leading organization in green practices, technology and sustainability. In some cases, the application of greener technology also improves the self-sufficiency of bases, for example through energy and water production, thereby reducing dependency on external supplies.

Given its environmental mandate, UNEP has been requested by DPKO and DFS to provide technical assistance in the implementation of this policy in the field. As an initial pilot operation, UNEP undertook a preliminary assessment of the resource-demand and operating practices of two proposed African Union Mission to Somalia (AMISOM) camps, in Mogadishu (HQ Camp), Somalia and Mombasa, Kenya (Support Base) in June 2009. Each camp has been designed for 200 person occupation over a period lasting 10 years. The assessment compared the existing design parameters and operational specifications for each site and screened 132 potential resource efficiency measures that could be applied to achieve a reduction in energy and water consumption as well as waste production and disposal. Each option was ranked using a traffic light system of green (these are considered as feasible), yellow (further study required) and red (not feasible) according to practicality, technical robustness and financial implications. This ranking of potential resource efficiency measures was designed as an initial input to the DFS/UNSOA engineering team for further consideration and costing during the elaboration and finalization of the designs and subsequent procurement process. This report summarizes the outcomes of this assessment and provides a set of immediate, medium and long-term recommendations to DPKO and DFS for reducing energy, water and waste footprints at the two sites considered as well as in the design of future camps in other countries.

Findings

- **Energy:** A total of 64 resource efficiency measures were considered in order to reduce energy consumption at the two sites. For the HQ Camp, 41 were ranked as green, 17 as yellow and 6 as red. For the Support Base, 37 were ranked as green, 22 as yellow, and 5 as red. Of the green ranked options, the analysis found that energy consumption could be reduced by 26% at the HQ Camp and by 32% at the Support Base if the green ranked resource efficiency measures were adopted. Based on the calculated reduction in energy consumption, the carbon footprint of the HQ Camp could be reduced by 994 tonnes/year while the Support Base could be reduced by 673 tonnes/year. The most significant savings at both sites come from the adoption of technologies for solar thermal cooling (or use of waste heat for cooling from diesel generators), solar water heating and external lighting based on solar or wind energy. Evaporative cooling, such as the Coolerado-type cooling system could also be considered at the Support Base. While significant on-site renewable energy could be produced by large solar panel arrays, wind turbines, fuel cells, and waste to energy systems, they require further study and cost modelling to ensure compatibility in a military setting.

- **Water:** A total of 18 resource efficiency measures were considered in order to reduce water consumption at the two sites.

10 were ranked as green and 8 as yellow. Of the green options, the analysis found that water consumption could be reduced by 42% at both sites through the adoption of the identified measures. The most significant savings come from the use of waterless urinals, high-efficiency toilets, and aerated shower heads. While composting toilets could significantly reduce water use, they were ranked as a yellow option as they are untested in a peacekeeping camp. In terms of potential water production, rainwater harvesting, grey water recycling and solar distillation all offer good potential. However, they also require further study and should be tested on a trial basis before being adopted within the standard design.

- **Solid waste:** A total of 48 resource efficiency measures were considered to reduce solid waste production at the two sites. For the HQ Camp, 23 were ranked as green, 15 were ranked as yellow, and 10 as red. For the Support Base, 23 were ranked as green, 20 as yellow, and 5 as red. With regard to the safe disposal of waste, the adoption of the waste protocols established for the United Nations Mission in Sudan (UNMIS) and adopted on 4 March 2009 is strongly recommended. These serve as a good baseline of best practice against which further work can be carried out. Existing waste generation profiles collected from UNMIS suggest that on average, peacekeeping staff produce 1.2 kg of waste per day. The analysis found that at both locations the estimated total volume of waste produced can be reduced by 15% through a combination of food waste reduction measures and improvements in the supply chain. At the HQ Base, the total amount channelled to landfill can be reduced by up to 61% and at the Support Camp up to 88% based on the adoption of waste management measures including segregating and recycling commodity waste in local markets, composting, and incineration. At the Support Camp only, anaerobic digestion was deemed to be a suitable measure for waste disposal.

- **Liquid waste:** Only two resource efficiency measures were considered to address liquid waste production and disposal at the two sites. At both locations, the analysis found that grey water disposal to soakaway ponds could be reduced by 66% by recycling grey water for toilet flushing, vehicle washing and other non-sensitive uses. At the Support Base, anaerobic digestion was deemed to be a suitable measure for addressing black water disposal. The analysis found that black water requiring treatment could be reduced by up to 30% through the use of anaerobic digestion. A detailed feasibility analysis is required to evaluate technologies that could be used to produce a "closed-loop" system to help manage energy, water and waste in a more sustainable fashion, and in particular to assess waste to energy systems.

The unique security profile and environmental conditions at each site resulted in two major differences in the suite of proposed resource efficiency measures. First, the energy efficient but water-intensive Coolerado-type cooling system was deemed suitable for only the Support Base due to possible water scarcity at the HQ Camp. Second, security concerns at the HQ Camp relating to the presence of methane gas may also prevent the successful use of the recommended waste reduction technologies (anaerobic digestion) – this risk would require additional assessment before the recommended technology is precluded. Given the differences in the operational conditions of the camps, the Support Base would be the preferred location for conducting pilot testing of new resource efficiency technologies.

Priority recommendations

This assessment provides a series of immediate, medium and long-term recommendations which can contribute to the successful implementation of the DPKO-DFS Environmental Policy for UN Field Missions and will help to reduce the resource-consumption, waste production and greenhouse gas emissions of peacekeeping operations. The five most important recommendations are:

- **Immediate review and adoption of green ranked measures:** Green ranked measures have been assessed as being feasible on the basis of their cost (both capital and operational), robustness for use in the field and ease of use. In this respect they are considered to be suitable for immediate deployment into the design of new camps and the operation of existing camps. The DFS/UNSOA engineering team should conduct a technical review of the green ranked resource efficiency measures listed in this report in order to identify the measures that can be immediately adopted in the design of the HQ Camp and Support Base. This selection process should also be complimented by a comprehensive modelling exercise to ensure that optimum use of resources and technical feasibility are addressed. Resource savings may be realised outside of those identified in this report through such a modelling exercise.

- **Further study and pilot testing of yellow ranked measures:** The DFS engineering team should further assess the yellow ranked measures identified in this report, including a detailed cost-benefit analysis as well as operational feasibility studies. If possible, lessons learned from the adoption of these technologies in other peacekeeping operations should be collected and reviewed for best practice. Ideally, a selection of yellow ranked options including large solar panel arrays, wind turbines, composting toilets, grey water recycling, rain water harvesting and solar distillation should be pilot tested at the Support Base given its lower security profile. This could be followed by a pilot hand-over and training of the technology to the host government and local community.

- **Feasibility study on closed loop bioenergy production:** A detailed feasibility study should be undertaken to evaluate optimum processes and technologies that could be integrated to produce a "closed loop" bioenergy system to better manage energy, water and waste in peacekeeping missions. Such a study should consider solid and liquid waste volumes, calorific value, storage and treatment, as well as potential energy yields from anaerobic digestion processes in the form of biogas. Further, it would evaluate conversion of biogas to electrical and heat energy using conventional engines and alternative technologies such as fuel cells.

- **Environmental impact assessments:** Prior to the installation of the HQ Camp and Support Base, an environmental baseline study should be undertaken in order to record the baseline environmental conditions. In addition an environmental impact assessment should be performed. These assessments will also facilitate the development of an appropriate environmental management plan and subsequent mitigation measures for anticipated impacts.

- **Development of a Sustainability Appraisal Camp Toolkit (SACT):** A dedicated "how to" toolkit is needed for UN peacekeeping activities that would help deliver sustainability objectives in a practical manner on the ground. It is important that a holistic approach is formulated covering the five main phases of a camp lifecycle: identification of sites, planning, set up, management and decommissioning/liquidation. Such a tool kit should be aligned with existing UN policies, procedures and tools and also include case studies of best practice.

Acronyms List

AC	Air Conditioning
AMISOM	African Union Mission in Somalia
BMS	Building Management System
BREEAM	Building Research Establishment Environmental Assessment Method
CASBEE	Comprehensive Assessment System for Building Environmental Efficiency
CEB	UN Chief Executive Board
DFS	Department of Field Support
DPKO	Department of Peacekeeping Operations
EIA	Environmental Impact Assessment
EBS	Environmental Baseline Study
EMP	Environmental Management Plan
FOI	Swedish Defence Research Agency
GHG	Greenhouse Gas
GRI	Global Reporting Initiative
HLCM PN	High-Level Committee on Management Procurement Network
HQ	Headquarters
IT	Information Technology
LED	Light Emitting Diode
LSD	Logistics Support Division
LEED	Leadership in Energy and Environmental Design
MDG	Millennium Development Goal
MSW	Municipal Solid Waste
ODS	Ozone-Depleting Substance
Pa	Per annum
PCDMB	Post-Conflict and Disaster Management Branch
PIR	Passive Infra-Red
PV	Photovoltaics
REAP	Re-engineering Assessment Practices
REEIO	Regional Economy Environment Input Output model
SACT	Sustainability Appraisal Camp Toolkit
SUN	Sustainable United Nations
UNEP	United Nations Environment Programme
UNHCR	United Nations High Commissioner for Refugees
UNMIS	United Nations Mission in Sudan
UNSOA	United Nations Support Office for AMISOM
VSD	Variable Speed Drive

1 Introduction

UN peacekeeping camps make an important contribution to the recovery and sustainability of zones impacted by conflicts. However, the introduction of troops and support infrastructure can place considerable demands on natural resources. Additional stress, ranging from environmental pollution to resource degradation, can also be placed on the poverty and health of local populations if environmental impacts are left unmanaged.

DPKO and DFS are keen to develop a practical approach to the identification of sites, planning, set up, management and decommissioning/ liquidation of peacekeeping camps which will minimise potential impacts on the environment, maximize economic efficiency and base security, and enhance the lives of people living around these installations.

In response to a growing recognition of the importance of environmental management in peacekeeping operations, the DPKO/DFS Environmental Policy came into effect on 1 June 2009. The policy, developed in cooperation with UNEP, was intended to minimise the environmental footprint of UN Field Missions and maximize the efficient use of natural resources within each phase of a mission. Given its environmental mandate, UNEP has been requested by DPKO and DFS to provide technical assistance in the implementation of this policy in the field. As an initial pilot operation, a team of UNEP experts worked with the UNSOA team (UN Support Office to AMISOM) and assessed the design parameters and operational specifications relating to the construction and operation of two proposed African Union Mission to Somalia (AMISOM) camps, in Mogadishu, Somalia (HQ Camp) and Mombasa, Kenya (Support Base). The methodology and assumptions used to conduct the assessment is presented in chapter 2.

The first objective of the assessment was to determine baseline figures for energy and water consumption as well as waste production based on the existing designs and standards. Projected carbon footprints for each site were

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Water bladder installed by Troop Contributing Countries, MONUC, Kindu

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Water bottling facility, MONUC

also calculated. The findings of the baseline assessment were compiled with input from the DFS/UNSOA Engineering Team. By applying the standardised occupation and consumption parameters of DFS, baseline demand profiles were generated and then adapted to reflect the environmental conditions specific to Mogadishu and Mombasa. The baseline assessments are presented in chapter 3.

The second objective of the assessment was to review and identify potential resource efficiency measures that could be applied during the design, construction and operation of the camps to achieve a reduction in energy and water consumption as well as waste production. Each measure was rapidly screened within the context of the operating environment of the AMISOM camps. Three main criteria were considered: practicality (ease of use), technical robustness and financial implications. A 'traffic light' categorisation system was adopted to rank measures and technologies. Within the grading system, initiatives ranked as 'green' are those considered to be applicable in the immediate term and are detailed further within chapter 4 of this report. These are considered to be measures that can be immediately deployed into the design of new camps or into the operation of existing camps. Initiatives categorised as 'yellow' require further study before they can be integrated into the design. Finally those classified as 'red' are deemed as not applicable at this time. All of the technology options and best practices considered are listed in appendices 2, 3, 4 and 5.

The third objective of the assessment was to compare the baseline figures with revised figures reflecting the adoption of the green ranked measures in order to determine the potential reductions and savings. This ranking of potential resource efficiency measures and calculation of potential reductions was designed as initial input to the DFS/UNSOA engineering team for further consideration and costing during the elaboration and finalization of the designs and subsequent procurement process for the two sites. These calculations are presented in chapter 5.

Finally, the assessment also considered best practice for conducting environmental baseline studies, environmental impact assessments, monitoring, and evaluation (chapter 6) and integrating sustainability into the camp life cycle, including identification of sites, planning, set up, management and decommissioning/liquidation (chapter 7).

The main conclusions and recommendations of the report are presented in chapter 8. They are intended to support the integration of resource efficiency measures into the design of the HQ Camp and Support Base respectively. In addition, following this review, it is hoped that key efficiency measures and technologies will be incorporated into the generic plans for future camp design, as part of the ongoing progress towards the implementation of the DPKO/DFS Environmental Policy for UN Field missions.

2 Assessment methodology

2.1 Step 1. Development of 'baseline' datasets

Step 1 of the assessment was to obtain and analyze the design specifications and operational parameters of the HQ Camp and Support Base. Baseline datasets were calculated for energy and water consumption as well as estimates of waste production and disposal mechanisms. This was an iterative process conducted by UNEP in close cooperation with DFS and UNSOA in which key information gaps were identified and the main assumptions were documented. As information gaps were filled and assumptions refined, the baselines were improved. These baseline datasets allow potential resource efficiency measures to be identified, evaluated and ranked in Step 2. The amount of potential reductions from the adoption of green ranked resource efficiency measures can then be calculated in Step 3. The baseline datasets that were generated and the assumptions that were used are described in the following section.

The detailed design specifications and operational parameters for the HQ Camp and Support Base are listed in Table 1. These parameters are the standard baseline against which all camps are constructed. They are the basis for the baseline energy and water consumption calculations as well as waste production found in chapter 3. Standardization is in place for ease of construction in different locations as well as to retain consistent knowledge of the product and design functionality. While this is the ideal approach to maximize design and construction efficiency, it can also hinder innovation and the adoption of alternative designs and resource efficiency measures, particularly in the context of UN procurement procedures.

The baseline design specifications and operational parameters follow a modular approach and are standardised wherever possible for 200 person occupation over a lifespan of 10 years. The proposed parameters are based on a set of provisions allocated per occupant. These provisions vary based on the rank and privilege of each occupant. Despite internal variance, the provisions remain constant between the two sites, providing consistency for baseline data calculations. The baselines for energy, water and waste were formulated using arithmetic calculations in a spreadsheet developed specifically by DFS (see Figure 1).

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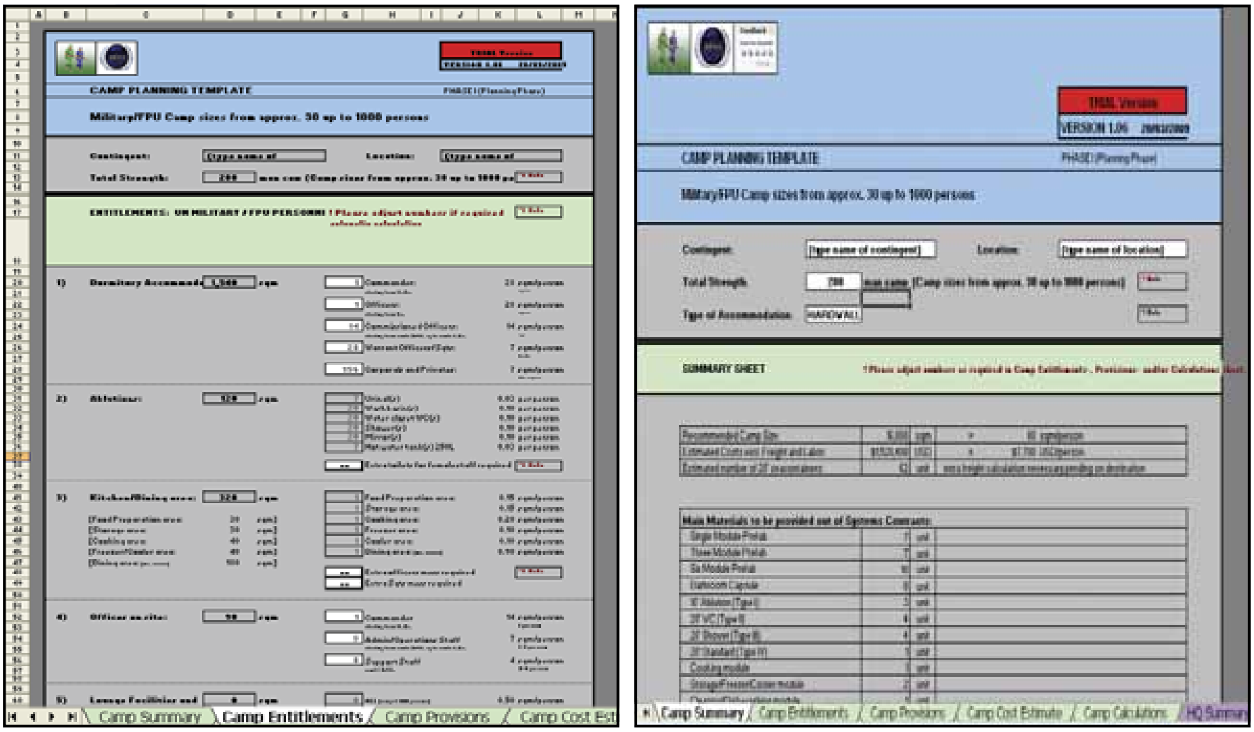
A typical peacekeeping camp ablution container featuring solar thermal panels, MONUC, Kinshasa

Table 1. Design Specifications and Operational Parameters for the HQ Camp and Support Base

Design Feature	HQ Camp	Support Base
Occupancy	200 people	Same
Compound	Secure compound of 15000 m^2 (500 m x 300 m).	Same
Structure	2 storey reinforced concrete 'bunker' design based around the requirement for 28 m^2 'capsule' accommodations (7 m^2 per person, 4 people sharing). The design is based around a central pool, up to 1.5 m depth, to be used as a water reservoir.	Constructed from pre-fabricated units based on the 'capsule' approach for accommodation within a space provision of 28 m^2 (7 m^2 per person, 4 people sharing).
Walls	External walls will be constructed of 200 mm reinforced concrete. Internal partition walls will be constructed from gypsum or dry brick with standard 50 mm insulation. Ground floor will be protected by a high earth berm or bund.	The pre-fabricated walls will be insulated and conform to standardised procurement specifications.
Living Accommodation	Living accommodation is based on the ground floor, with offices above. Dimensions of the accommodation block are 65 m x 79 m x 8.65 m height. Windows 40 cm high will be installed below an overhang to provide some daylight and natural ventilation.	Natural ventilation will be provided by windows and open doors, subject to security considerations.
Catering	Messing is from a single cooking module containing standard cooking facilities, 2 freezer modules containing 2 x 1400 litre fridges and 1 x 803 litre freezer), and 1 dishwashing module containing a single front loader dishwasher.	Same
Offices	Offices are proposed to be serviced with 1 computer per individual (200 total), supported with 20 copier / printers. These will run for 24 hours per day.	Offices are proposed to be serviced with 1 computer per individual (200 total), supported with 20 copier / printers. These will run for 8 hours per day.
Recreation	There will be 3 recreation modules complete with 1 TV set each.	Same
Internal lighting	Internal lighting is conventional fluorescent units; 2 x 40 watts – 800 of each.	Same
External lighting	External lighting is proposed to be 250 W, 230 lamp-posts fitted with timers, supplementing 200 x 250 W and 250 x 400 W sodium flood lights. External lighting is to be provided for 5 hours per night averaged over the year.	Same
Air Conditioning	Provided by powered split-air conditioner (AC) units with an air change 5 times per hour provided by natural means such as open doors and windows. Ambient or required temperatures is 20 – 24 degrees centigrade. Air conditioning will be provided for 20 hours per day. Air conditioning is proposed to be 57 x 18000 BTU, 115 volts/60 Hz. Window units are 19 x 12000 BTU and 114 x 24000.	Same
Ventilation	Natural ventilation	Natural ventilation. The modules will be windowed allowing enhanced air flow.
Operation	Operation for the camp will be 24 hour with staff rotation.	Operation for the camp will be 10 hours per day.
Energy	Power proposed is at the rate of 2 kV per person generated exclusively from a bank of diesel powered generators supported with 100% back up. An assumed efficiency of 38% has been made for the diesel generators.	Same, although it is possible that power will be sourced from Kenyan municipal supplies.
Water supply	To be provided either through abstraction from the ground followed by treatment, or purchased from a local provider depending upon a number of parameters including security of supply, environmental impact and source contamination.	Same, although it is possible that water will be sourced from Kenyan municipal supplies.
Water treatment	To be provided from a single potable treatment unit, 5000 litres per hour maximum capacity, referred to as module 1. Discharge is likely to be to an evaporation pond. 4.5 l/d consumption of potable water, 80 l/d chlorinated water for washing will be allotted.	Same, unless sourced from the municipal supply.
Water heating	To be provided from 6 x 250 l water tanks at 10 hours per day. It is assumed that the hot water tanks are not insulated.	Same
Solid waste	To be disposed of in an onsite landfill with minor volumes being recycled or sold to local contractors.	Same, unless it is transported from the camp and disposed of in a Kenyan municipal disposal site.
Liquid waste	To be treated using an on site sewerage treatment plant and then disposed of in evaporation ponds or discharged to local water courses. Some grey water will be re-used for non-sensitive purposes.	Same
Other	Workshop, power centre, waste disposal/sorting, water purification (potable) and water treatment (sewerage) will be based in the outside compound but within the perimeter security fence.	Same

Note: It is understood that measures are currently being introduced to make provision for various resource reduction features to be fitted into existing and new camps. These include, the installation of solar thermal units on ablution units, use of light emitting diode (LED) lights and enhanced insulation properties on pre-fabricated units. These provisions have not been included in the calculation of the current baselines.

Figure 1. Screen shots from the camp development spreadsheet as used by DFS engineers based on 200 person occupancy



There are two major design differences between the two sites. First, to maximize security, the HQ Camp will be constructed out of reinforced concrete with brick partition walls. The ground floor will be protected by a high earth berm or bund which also provides an almost continuous shadow for the occupants of the camp. The Support Base will be constructed of standardised pre-fabricated units without the protection of a bund. The second difference is that the HQ Camp will be operated on a 24 hour basis while the Support Base will operate for only 10 hours per day.

Energy assumptions

A review of electrical-demand infrastructure was undertaken from the design specifications and camp provision data. A total of 7 sources of energy consumption were assessed including: lighting (external), lighting (internal), cooling, hot water, small power (accommodation), small power (office) and catering. Ventilation requirements were assumed to rely on natural sources.

No provision has been made for power consumption relating to the use of computer servers, communications centres, transport and water treatment. Potential differences in the thermal mass properties of concrete in the HQ Camp and the prefabricated complex of the Support Base require detailed modelling and have not been taken into account. It is assumed air conditioning will run for 10 hours in HQ camp and 10 hours in support camp, respectively, per day. Hot water will be available 10 hours per day in the HQ Camp and 5 hours in the Support Base. The offices in the HQ Camp will be powered on a full time 24 hour occupancy while the Support Base only 8 hours per day. It assumed that all power will be provided through a bank of diesel generators that will provide a constant supply. It is assumed that the diesel generators produce power at an efficiency of 38%.

Water assumptions

Currently 80 litres of water for domestic use and 4.5 litres for personal drinking consumption per day is assumed in line with the provisions of the DFS camp development spreadsheet (Figure 1) and camp design specifications (Table 1). For 200 people, a total of 16,800 litres per day is required for both personal drinking consumption and all other water demanding activities such as cleaning, food preparation, and washing.

Currently it is understood that water will be purchased either from local suppliers or sourced from 'natural' reservoirs such as those available below ground, or from surface water bodies. In selecting the final source, security of supply will be a paramount consideration. It is assumed that an appropriate assessment will be made of the sustainable withdrawal levels from any natural water source will be a critical component to be examined in the context of an EIA and hence of the EMP. The HQ Camp water is likely to come from groundwater sources, whereas the Support Base will likely obtain water from an external supplier.

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Reverse osmosis water purification unit, MONUC

All water will be treated prior to its subsequent use by a single potable treatment unit, with a maximum capacity of 5,000 litres per hour or 120,000 litres per day. The daily output capacity of the water treatment unit significantly exceeds the daily volume required (16,800 litres), as security of water supply is a significant risk to the effective operation of camps. Strong arguments exist to support the need for over-capacity in water treatment units. Indeed, aspects including contamination level of on-site water sources (aquifer abstraction) and associated detrimental impacts to the treatment plant should also be considered. Given these considerations, back-up water treatment plants should be considered as a priority in any camp design to ensure continued supply in the event of breakdown of the main plant. The water treatment unit will not be operated on a constant basis, but rather as required to replenish supplies taken directly from storage tanks.

At present, rainwater harvesting is practiced in some DPKO camps, but only on an ad hoc basis. As a result, no information is available regarding the efficiency of such systems and their potential use for either the HQ Camp or Support Base. This option has been excluded from more detailed assessment within this study as a source of potential water supply. However if the yield is found to be sufficient, considering the low cost and maintenance requirements, its application should be considered.

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Proposed power is at the rate of 2 kV per person generated exclusively from a bank of diesel powered generators supported with 100% back up

Waste assumptions

Given that neither of the sites are currently in operation, waste production volumes cannot yet be calculated. As an interim measure, potential waste baselines have been calculated based on existing waste figures from the UN Mission in Sudan (UNMIS)[1], which should be considered as a "snapshot" indicator at a given time, which may significantly vary depending for example of the development phase of the camp. Existing waste generation profiles based on 15,460 UNMIS staff suggest that on average, 1.2 kg of solid waste is produced per day per person. Nearly 50% of all solid waste is biodegradable, 40% is recyclable and 10% requires treatment (e.g. incineration). Overall, 8 sources of waste were included in the analysis: food, organic miscellaneous, paper, cardboard, plastics, glass, tin and aluminium and scraps/wood/rubber. Hazardous wastes such as oils, cleaning products, batteries and solvents were outside the scope of the analysis due to a lack of data from the UNMIS dataset.

Waste disposal is dependant upon a number of criteria, the principal of which is the need to maintain effective security and camp functionality. The baseline assessment assumed that the safe disposal of solid wastes outside of the HQ Camp boundaries could not be guaranteed due to the adverse security conditions[2]. Therefore, the baseline assessment assumed approximately 82% of the solid waste stream will be disposed of in an on-site landfill within the camp boundaries. This may require daily covering as well as a lining of the excavated landfill combined with leachate collection and some form of treatment (possibly an infiltration bed if soil and groundwater conditions allow). Composting, recycling and returning packaging to suppliers will be used to address the remainder of the waste stream. The same proportions also hold true for the Support Base. However, as the security profile is different, off-site land filling, composting and recycling is also an option. In both cases, the amount of recycling that can be achieved will depend on the security implications relating to the involvement of any local contractors, suppliers, and buyers, by operational restrictions such as storage space, and by the availability of local markets.

Liquid waste production was assumed to be the combination of 80 litres of water for domestic use per day, which includes communal production sources such as dishwashing, food preparation, and laundry, and 4.5 litres for personal consumption per day. In total, liquid waste produced by the combination of domestic use, personal consumption and communal consumption totals approximately 84.5 litres per person per day. It was assumed approximately 37% of this total is black water and 63% is grey water. The following practises were assumed to address these two categories of liquid waste respectively.

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Landfill constructed by Troup Contributing Countries, MONUC, Kindu

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Wastewater is required to be treated on-site or connected to a local communal treatment system to avoid direct discharge to receiving waterbodies

First, black water (water contaminated with human waste) will either be treated on-site or connected to a local communal treatment system, if available. This assumption is based on the DPKO/DFS Environmental Policy for UN Field Missions which states that there will be no discharge of wastewaters directly into streams, rivers or other bodies of water without prior treatment (paragraph 39). Wastewater requiring treatment will be held in a septic tank and, following a sufficient residency time, transferred to the wastewater treatment unit. Following treatment, it is understood that the wastewaters are dealt with in numerous ways and used where appropriate, such as in dust suppression. Excess will be discharged to evaporation ponds or local receiving watercourses. It is assumed that all wastewaters are tested prior to discharge to ensure compliance with wastewater discharge consent criteria.

Second, grey water (water that is not contaminated with human waste) is discharged to an evaporation pond (soakaways) or local receiving watercourse. It is acknowledged that provisions exist within the existing design specifications that some aspect of re-use will be considered3 to the extent possible in non-sensitive areas such as irrigation or toilet flushing. For the purposes of this assessment, and reflecting the absence of design specifications to the contrary, it is assumed that the full volume of grey water is discharged to soakaways.

2.2 Step 2. Evaluation of resource efficiency measures

Following the development of the baseline parameters, step 2 was to undertake a review of resource efficiency measures for reducing energy, water and waste. Each option was reviewed within the context of the operating environment of the two sites. Three main criteria were considered using an equal weighting: practicality (ease of use), technical robustness and financial implications. A 'traffic light' categorisation system was adopted to rank technologies. Within the grading system, initiatives ranked as 'green' are those considered to be applicable in the immediate term and are detailed further within chapter 4 of this report. Initiatives categorised as 'yellow' require further assessment. Some of these options are further discussed in the main text. Finally those classified as 'red' are deemed as not applicable. All of the technology options and best practices considered are listed in appendices 2, 3 and 4.

Figure 2. Explanation of traffic light categories used in the assessment

(green)	**Green:** Initiatives categorized as "green" are considered to be viable and are deemed to withstand the rigours of a peacekeeping operation. This includes cost (initial outlay and operational expenditure), robustness and ease of use. These are recommended for immediate consideration by UNSOA to be included within the design plans for the two sites and for deployment in existing camps.
(yellow)	**Yellow:** Initiatives categorized as "yellow" require further study as one or more characteristics (costs, technical robustness or ease of use) were deemed to be unsuitable for the two sites. They should be re-assessed by DFS engineers and selected measures should be adopted on a pilot basis.
(red)	**Red:** Initiatives categorized as "red" are presently unsuitable in the context of the two UNSOA sites at this time.

2.3 Step 3. Calculation of potential reductions

Based on the traffic light system, step 3 involved calculating the potential energy, water and waste reductions that could be achieved from the adoption of the green ranked resource efficiency measures. A comparison of the baseline parameters with the revised parameters was conducted.

2.4 Other issues addressed by this study

In addition, the assessment also considered best practice for conducting environmental baseline studies that should be conducted prior to the construction of either site (chapter 6) and integrating sustainability into the camp life cycle, including identification of sites, planning, set up, management and decommissioning/ liquidation (chapter 7).

3 Baseline analysis

3.1 Overview

Using information provided in the DFS camp provisions and specifications spreadsheet (Figure 1), the consumption levels for energy and water, as well as the production levels for solid and liquid waste, were estimated. Parameters were calculated for "per person per day", "per day for 200 people" and "per year for 200 people". These figures are presented in Table 2 and are explained in more detail in the following sections.

3.2 Energy

The baseline estimations of the total annual energy demand and carbon production from the respective camps are presented in Table 3. The associated energy and carbon footprint is presented in Figure 3.

Table 2. Parameters used for baseline assessment

Resource	Per Person / Day	200 People / Day	200 People / Year
Energy (HQ Camp)	213 kWh	45, 522 kWh	15, 520, 371 kWh
Energy (Support Base)	113 kWh	22, 683 kWh	8, 279, 448 kWh
Water Consumption (Each site) *	84.5 litres	16, 800 litres	6, 144, 775 litres
Solid Waste Output (Each site)	1.2 kg	240 kg	87, 600 kg
Liquid Waste Output (Each site) *	84.5 litres	16, 800 litres	6, 144, 775 litres

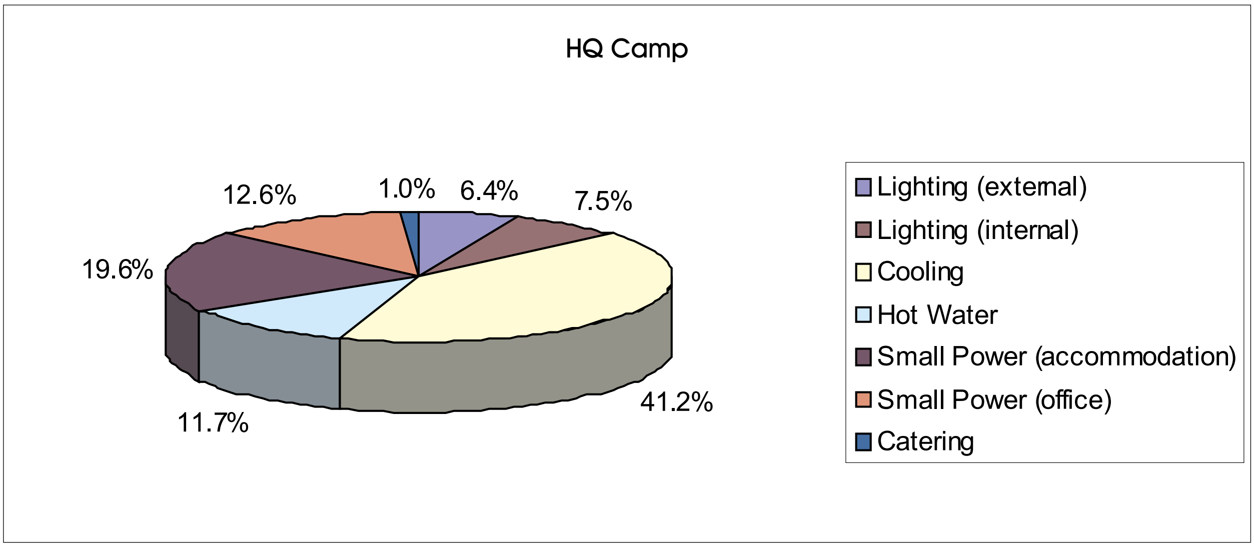
* The standard DFS provision for water states a total of 84.5 litres per day per person. This is detailed further in Table 4. It is recognised that in reality the liquid waste output for each of the sites will be lower than the provision allowed reflecting the losses that would be accrued through operation, such as those associated leakages from pipework. Using the total provision volume allows for an element of conservatism to be built into the assessment work.

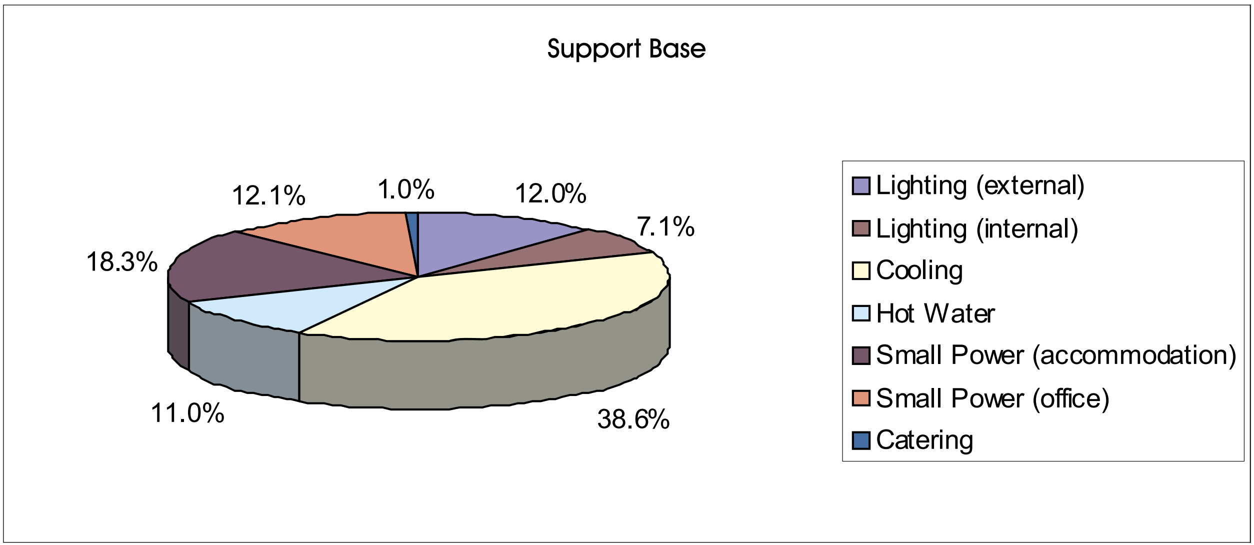
Table 3. Annual Energy Consumption for HQ Camp and Support Base

1. HQ Camp					
End Use	**Size (kW)**	**Hours run**	**Energy (kWh)**	**CO_2 (t)**	**Notes**
Lighting (external)	208	1,825	996,546	249	
Lighting (internal)	61	7,300	1,168,000	292	
Cooling	333	7,300	6,387,500	1,597	
Hot Water	189	3,650	1,815,395	454	
Small Power (accommodation)	158	7,300	3,038,008	760	
Small Power (office)	82	7,300	1,959,474	490	
Catering	16	Various	155,449	39	
Ventilation (fans)	0	0	0	0	Assumed natural ventilation
Transport	NA	NA	NA	NA	Outside scope - no baseline calculated at this stage
Total	**1,046**	**34,675**	**15,520,371**	**3,880**	

2. Support Base					
End Use	**Size (kW)**	**Hours run**	**Energy (kWh)**	**CO_2 (t)**	**Notes**
Lighting (external)	208	1,825	996,546	249	
Lighting (internal)	61	3,650	584,000	146	
Cooling	333	3,650	3,193,750	798	
Hot Water	189	1,825	907,697	227	
Small Power (accommodation)	158	3,650	1,519,004	380	
Small Power (office)	84	3,650	998,947	250	
Catering	16	various	79,504	20	
Ventilation (fans)	0	0	0	0	Assumed natural ventilation
Transport	NA	NA	NA	NA	Outside scope - no baseline calculated at this stage
Total	**1,048**	**18,250**	**8,279,448**	**2,070**	

Figure 3. Energy footprints for HQ Camp and Support Base





The footprints for each camp are almost alike in profile, reflecting the modular approach and standardised provisions of the design. The differences can be largely explained by the different operating parameters (24 hours for HQ Camp versus 10 for the Support Base) and needs for lighting, cooling and office equipment. In addition, cooling in the Support Base is positively impacted by enhanced natural ventilation, reducing the amount of air conditioning. Hot water is also reduced from 10 hours in the HQ Camp to 5 hours in the Support Base. A summary of the assumptions and parameters used to calculate the energy demand is provided in Appendix 1.

3.3 Water

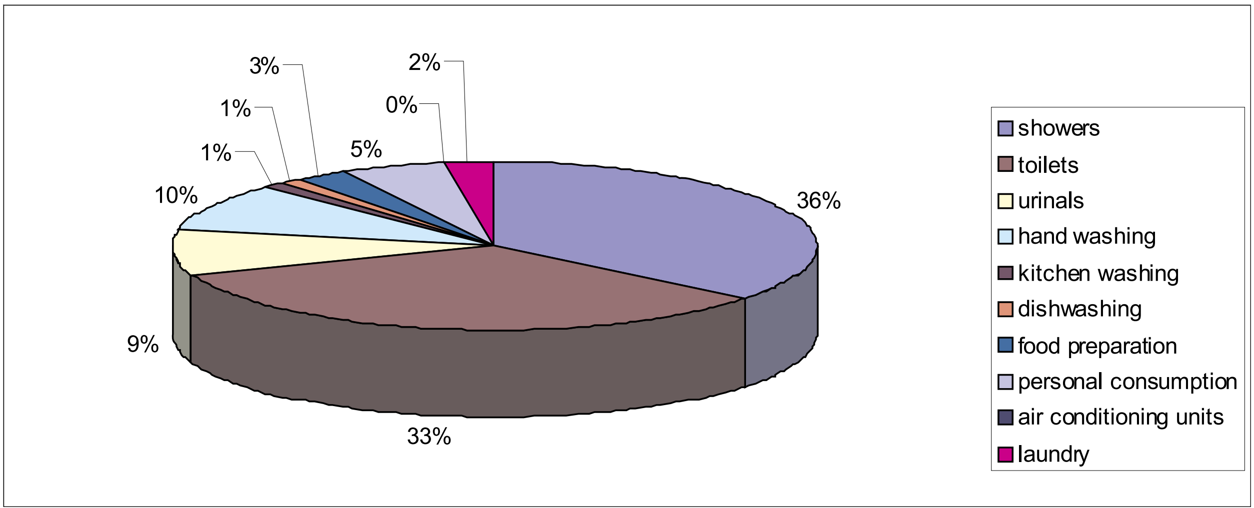
The baseline estimates for water consumption based on an assessment of the consumption profile for two sites are presented in Table 4.

The associated water footprint is presented in Figure 4. The table takes into account principal water demand usages and utilizes standard volumes of water consumption based on UK reference values[4].

Table 4. Water Consumption for HQ Camp and Support Base

Use	Litres	Units	Litres (per person per day)	Litres (per day for 200 people)	Litres (per year for 200 people)
Variable usage (per person)					
Showers	30	1	30	6000	2190000
Toilets	7	4	28	5600	2044000
Hand washing	2	4	8	1600	584000
Personal consumption	4.5	1	4.5	900	328500
Fixed usage (communal)					
Kitchen washing	50	4	1.0	200	73000
Dishwashing	35	5	0.9	175	63875
Food preparation	70	6	2.1	420	153300
Urinals	180	8	7	1400	525600
External use (exterior)	50	2	0.5	100	36500
Air conditioning units	0	0	0	0	0
Laundry	60	5	2	400	146000
TOTALS			**84**	**16800**	**6144775**

Figure 4. Water footprints for HQ Camp and Support Base



3.4 Solid Waste

The volume of expected solid waste streams has been calculated based on information provided in the waste characterisation study by UNMIS and on the experience of the authors of this report. A solid waste stream of 1.2 kg per person per day has been assumed as the baseline figure. The anticipated waste composition for each site can be estimated by % weight for Municipal Solid Waste (MSW) as presented in Table 5. The associated waste 'footprint', by proportion of waste type per person is presented in Figure 5. While the possible production of hazardous waste is an important issue, it was beyond the scope of this analysis. However, hazardous substances will inevitably be produced and this has to be factored into the base camp design. The availability of contracted services to safely dispose of or treat hazardous waste also has to be evaluated.

Table 5. Estimated Waste Composition By % Weight

Material	% by weight (For MSW)	Baseline Disposal Option	Kilogrammes (per person per day)	Kilogrammes (per day for 200 people)	Kilogrammes (per year for 200 people)
Putrescibles (Food)	31%	Landfill	0.37	74.4	27156
Paper & card	21%	Recycle and landfill	0.25	50.4	18396
Other combustibles	11%	Landfill	0.13	26.4	9636
Other non-combustibles	8%	Landfill	0.10	19.2	7008
Plastic	7%	Landfill	0.08	16.8	6132
Glass	6%	Landfill	0.07	14.4	5256
Metals	6%	Recycle	0.07	14.4	5256
Fine material	5%	Landfill	0.06	12.0	4380
Textile	2%	Landfill	0.02	4.8	1752
Electrical equipment	2%	Recycle	0.02	4.8	1752
Other MSW	1%	Landfill	0.01	2.4	876
TOTAL	**100%**		**1.2**	**240**	**87600**

Figure 5. Estimated solid waste footprint for HQ Camp and Support Base by % Weight

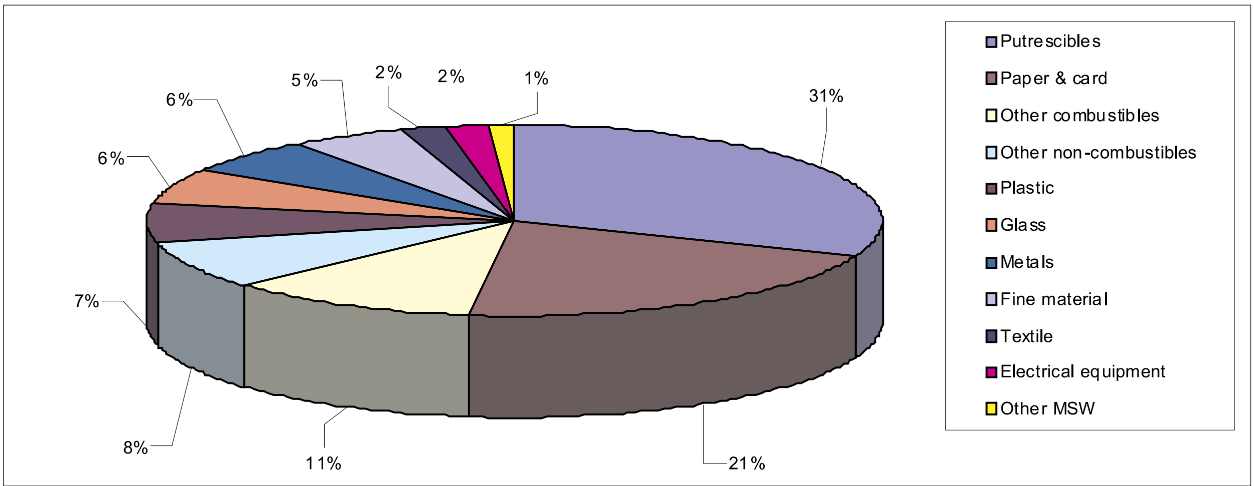
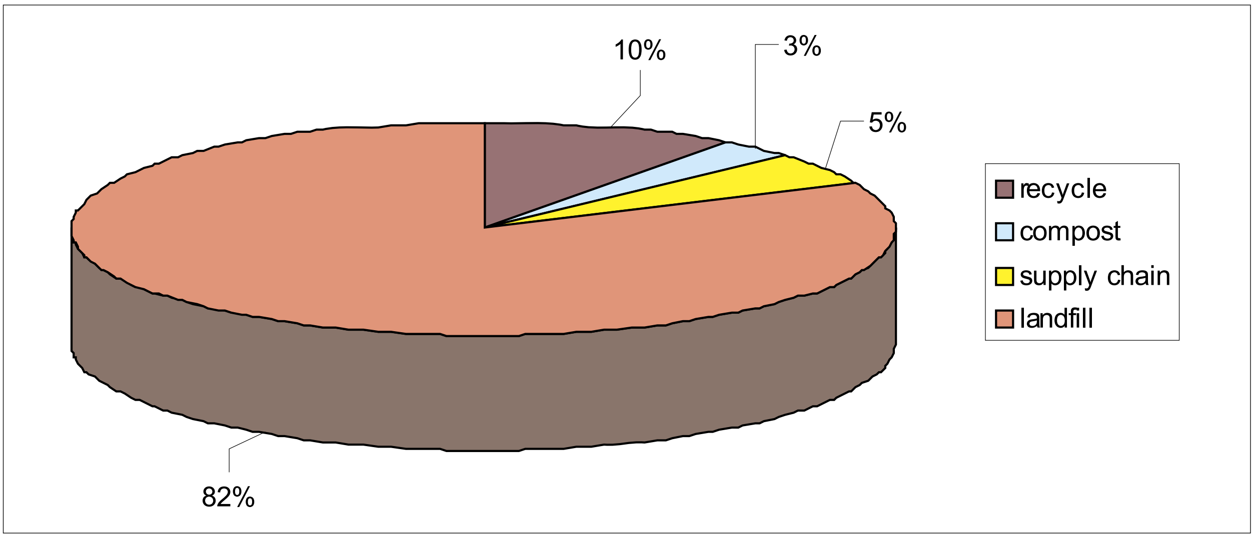


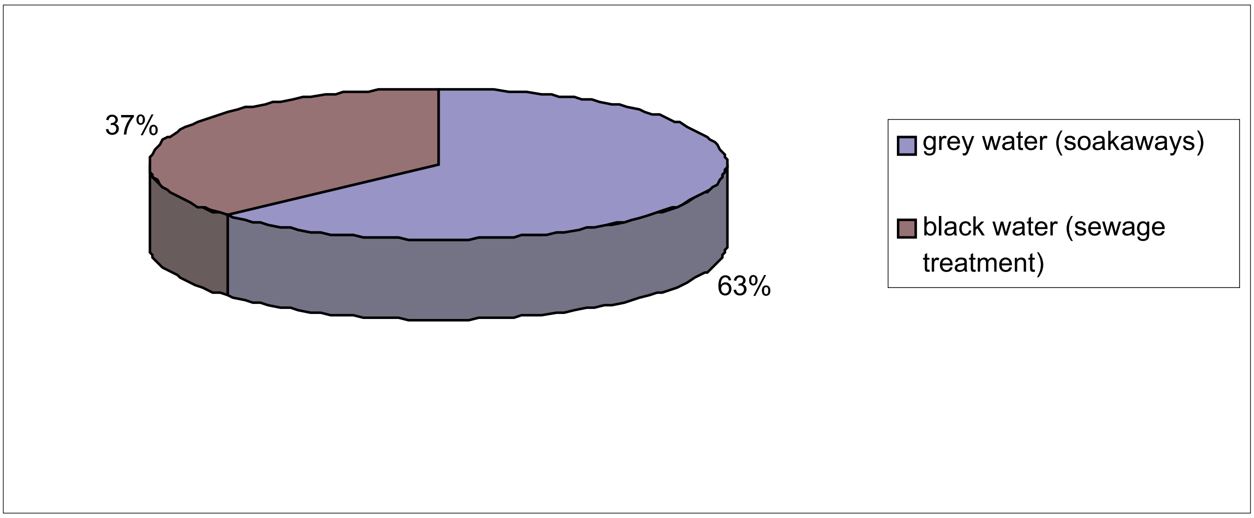
Figure 6. Baseline solid waste disposal pathways for HQ Camp and Support Base



3.5 Liquid Waste

The volume of liquid waste requiring treatment before exiting the camp has been calculated at 84.5 litres of wastewater per person per day. This figure takes into account communal consumption. Figure 7 presents the proportion of liquid waste disposed as black water (37%) and as grey water (63%).

Figure 7. Estimated liquid waste footprint for HQ Camp and Support Base



4 Resource efficiency measures

4.1 Overview

A total of 132 potential resource efficiency measures for energy, water and waste reduction were identified and reviewed for possible application in the HQ Camp and Support Base. A 'traffic light' categorisation system (see Table 6) was adopted to rank technologies based on three equally weighted criteria: practicality (ease of use), technical robustness and financial implications. Measures ranked as 'green' are those considered to be applicable in the immediate term and are detailed further within the following sections of this chapter. Some of the yellow ranked options requiring further study and pilot testing are also discussed.

4.2 Energy

A total of 64 energy efficiency technologies have been assessed and ranked for use within a peacekeeping camp context. For the HQ Camp, 40 were ranked as green, 18 as yellow and 6 as red. For the Support Base, 37 were ranked as green, 22 as yellow, and 5 as red. The green ranked measures are presented in Tables 7 and 8. These measures would collectively reduce energy demand through small scale renewable power generation, installation of automatic controllers, or by changes in operations. However, these measures must also be supported by educational initiatives to inform occupants of the need to conserve energy. The complete traffic light analysis for energy is available in Appendix 2. The most significant potential savings at both sites come from the adoption of the following four resource efficiency measures. A fifth measure, the Coolerado-type system for air conditioning, is applicable only to the Support Base.

- **Improved controls:** Provision of improved central or local controls such as occupancy sensors and zoning can lead so significant energy reductions at low cost.

- **Solar cooling or cooling from waste heat from generators:** Using either solar thermal technology of using the waste heat from the diesel generator (installation of a Combined Heat and Power (CHP) unit) can be utilised within an absorption chiller to generate cooling. These technologies utilise the abundant available heat sources at the site to minimise cooling load, which is the largest energy demand.

- **Solar water heating:** Solar water heating systems are generally composed of solar thermal collectors and a fluid system to move the heat from the collector to its point of usage. In many climates, a solar hot water system can provide up to 85% of domestic hot water energy. Given the regional climate,

Table 6. Number of resource efficiency measures considered and breakdown of ranking

Resource	Location	Number of Resource Efficiency Options Assessed	Green Ranked	Yellow Ranked	Red Ranked
Energy	HQ	64	41	17	6
	Support		37	22	5
Water	HQ	18	10	8	0
	Support		10	8	0
Solid waste	HQ	48	23	15	10
	Support		23	20	5
Liquid waste	HQ	2	1	1	0
	Support		2	0	0
TOTAL	HQ	130	74	42	16
	Support		74	49	9

solar water heating systems are an excellent method to reduce electricity consumption.

- **External lighting based on solar or wind energy:** Stand alone lamps powered with renewable energy (either photovoltaic or wind) offer an excellent way to meet lighting needs while reducing energy consumption. Although they can have high capital outlays, cost savings should be realized by reduced cabling and operating costs.

- **Evaporative Cooling, including the Coolerado-type cooling system:** At the Support Base only, evaporative cooling, such as the Coolerado-type cooling system could also be used to meet air conditions needs. This technology uses the evaporative properties of water which uses about one tenth of the electricity of traditional air conditioning systems. However, the system requires constant supply of water meaning it may not be suitable in water-scarce environments. For this reason, it is not recommended for the HQ Camp.

Five potentially important resource efficiency measures could be used for on-site energy production. However, they require further study before they could be adopted in a peacekeeping context. These include:

- **Biodiesel generators:** Fuels using part or all biofuel can reduce emissions and be a cost-effective method for electricity production (see UNEP report *Towards Sustainable Prodcution and Use of Resources: Assessing Biodiesels*, 2009). However, issues over supply, sustainability of production, cost and carbon content need to be addressed at each site before the technology could be adopted.

- **Waste to energy systems:** Potential to use waste to energy systems depends on surpassing a specific threshold of waste generation. This study recommends that a detailed feasibility study be undertaken to evaluate optimum processes and technologies that could be integrated, to produce a "closed-loop" system to help manage energy, water and waste in a more sustainable fashion within the context of peacekeeping missions. A closed-loop system could also help increase the self-sufficiency of on-site energy production, whilst minimising environmental impacts from diesel fuel. The proposed feasibility study should consider potential energy yields from:

  – anaerobic treatment processes in the form of biogas;

  – the conversion of biogas to electrical and heat energy using conventional engines, or alternative technologies like fuel cells; and,

  – gasification of varied biomass streams - many types of organic waste are suitable for use with this technology to produce energy.

- **Solar Arrays:** A networked system of photovoltaic solar panels can provide a significant source of on-site renewable energy production, thereby reducing dependency on fossil fuels and external supplies. Either solar farms or new generation thin solar films could be integrated into roofing designs during the manufacturing process if adopted in the baseline design specifications for supplemental energy production.

- **Wind Turbines:** Wind energy could be transformed into electricity from either roof-mounted or stand alone wind turbines. However, there is a need to ensure compatibility with the current electrical design of each site. Also, as the turbines provide intermittent power, they will require back-up supplies. This technology can be used at off-peak hours or to generate hydrogen for a fuel cell. The threshold depends on wind speed, suitable location for siting turbine, security risk (height of turbine), and skills for installation. There is a need to consider the use of wind to make hydrogen in off-peak hours for a fuel cell.

- **Hydro and geothermal power:** Those two technologies have not been assessed in this report. It is however encouraged to study more closely the possibility of hydro power especially for missions' camps located near consequent streams.

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Stand alone renewable powered lamps (either photovoltaic or wind) offer security enhancement and potential cost savings due to decreased cabling costs and demand on generator fuel

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Coolerado-type, a new technology that makes use of the evaporative properties of water for cooling, is a very efficient technology in the right setting. It was assumed to be viable only for the Support Base in Mombasa, which has access to sufficient and suitable water resources

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Solar thermal collectors, such as those seen on the roof of this ablution container in MONUC, Kinshasa, were ranked favourably as a low energy solution

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While significant on-site renewable energy could be produced by solar farms and wind turbines, implementation in a peacekeeping context requires further study

Table 7. Green ranked technologies for energy efficiency for the HQ Camp

Use	Suggested improvements	Comments
Lighting – internal	LED (reduced wattage)	LED lights are higher efficiency than fluorescent tubes. Confirmation is required of the suitability of LED technology with power generation and light requirements. Lights may dim with high current. Electrical design needs to take account of this.
	Occupancy sensors	Lights controlled by occupancy. Can be through Passive Infra-Red (PIR) sensors, timers, or occupancy settings (which only work if door closed or key installed).
	Use of natural lighting	Add roof lights to module units to reduce consumption through passive measures.
	Have lighting requirements reviewed by experts. Find out if luminaries can be reduced in wattage and number but still meet desired lighting levels. Undertake an assessment of daylight factors.	Lighting designed to maximise use of light and efficiency.
Lighting – external	Stand alone renewable powered lamps (either photovoltaic or wind) with security lamp posts	Despite high capital outlays, a practical solution providing security enhancement and cost savings should be realised e.g. reduced cabling costs.
Cooling	Centralised system	Centralised system allows for increased control and greater efficiency. Design and build contract being pursued.
	Air conditioning with occupancy sensors	Air conditioning is occupancy controlled by keys or sensors.
	Zoning	Separate air handling unit for each zone, but increased centralisation from individual units.
	Free cooling	(Enthalpy Cooling) To reduce energy consumption, sensors detect cooling capacity of external- air. Draws in more than basic fresh air requirement which reduces mechanical cooling. Use of solar shading to reduce the ambient temperature in tents.
	Air ducts/earth tubes	Deliver air through a series of tunnels or ducts underneath the building. Lowers air temperature before use of air conditioners.
	Air tightness	Minimise loss of treated air and ingress of outside air through good air tightness in the construction of openings such as doors and windows.
	Insulation on internal partitions	Minimises cooling loads between separate units.
	Solar cooling using solar thermal collectors or waste heat from generators (Combined Heat and Power) (CHP) to power absorption chillers	These technologies utilise the abundant available heat sources at the site to minimise cooling load, which is the largest energy demand.
	Orientation	Organize building so that high occupancy areas are in North of building (south in South Hemisphere).
	Solar tinted glass	Use coated glass that lets in sunlight but reflects heat from the building.
	Refrigerants	Ozone-depleting substances and greenhouse gas (GHG) emissions are associated with leakage of refrigerants – replace with non-ODS and non-GHG components.
Ventilation	Zoning	Separate air handling unit for each zone, increased centralisation from individual units.
	Variable speed drives on fans	Large fans and pumps should all be fitted with variable drives to reduce energy consumption.
Domestic hot water	Solar thermal	Use solar thermal panels to produce hot water.
	Insulated thermal immersions	Ensure all hot water stores and pipe work have sufficient insulation.
	Reduced water consumption	Low flow taps, catering with pull taps, dishwashers.
	Control	Only allow hot water to be used at certain times of day, and put hot water units on timers.
Server rooms	Temp control and layout	Use free-cooling where possible and do not overcool. Server rooms are often over-cooled and designed to block cooling pathways. Clear design and guidance on temperature settings will reduce energy consumption.
Kitchen appliances	A+ rated appliances	Appliances are highest efficiency.
	Thermal isolation	Ensure fridges and freezers are thermally isolated from ovens.
	Kitchen energy management plan	Ensure the kitchen has an energy efficiency management plan; equipment is switched off after usage; and kitchen fan have VSD.
Small power	A+ rated appliances	Use of high efficiency appliances.
	Timers on printers/photocopiers and recreation equipment	Add timers to link with occupancy.
	Small photovoltaic chargers for mobiles and non-essential IT equipment	Use of small renewables to save on generator fuel demand.
Controls	Centralise control into a single management system. Ensure local controls have sufficient occupancy and temperature controls	Form single temperature and time controls to total Building Management System (BMS) for centralised control of cooling, lighting, and ventilation.
Transport – operational restrictions on vehicles	Restrict idling of vehicles	Appropriate vehicle management and operation plans to reduce energy consumption.
	Operational restrictions – Speed limiters	Appropriate vehicle management and operation plans to reduce energy consumption.
	Regular maintenance	Following a clear maintenance regime to reduce energy and use of alternative fuels.
Pumps and fans	Any large fans or pumps should have VSD	Large fans and pumps should all be fitted with VSD to reduce energy consumption.
Renewable and low carbon technologies	Photovoltaic cells should be kept within draft specification	Photovoltaic systems convert energy from the sun into electricity through semi-conductors cells, most commonly made of silicon. To be used in conjunction with battery back-up. The selected battery system should not include any form of water and lead batteries. A solar thin film could potentially be incorporated into roof design at the manufacturing phase.
	Solar thermal (see sections on Solar Cooling and Hot Water)	
Metering	Meters on main plant and across main site areas	Measuring energy consumption helps to monitor consumption, and benchmark against similar sites and develop targets for reduction. This will ensure compliance with the UN Chief Executive Board (CEB) decision on Moving Towards a Climate-Neutral UN[5] and the need to undertake GHG emissions inventory and develop an emissions-reduction strategy.
Thermal modelling	Use of thermal modelling	Develop a thermal model to demonstrate energy consumption of future building and the impact of energy saving measures.
Diesel Power Generation	Switchboard flexibility to plan and monitor energy demand and switch on/off the right size and combination of units.	

Table 8. Green ranked technologies for energy efficiency for the Support Base

Use	Suggested improvements	Comments
Lighting – internal	LED (reduced wattage)	LED lights are higher efficiency than fluorescent tubes. Lights may dim with high current, which should be incorporated into the electrical design.
	Occupancy sensors	Lights controlled by occupancy. Can be through Passive Infra-Red (PIR) movement sensors, timers, or occupancy settings, though the latter only works if door is closed or if a key is used.
	Use of natural lighting	Add roof lights and sun pipes to module units
	Have lighting requirements reviewed by experts - can luminaries be reduced in wattage and number but still meet desired lighting levels	Designed lighting to maximise use of light and efficiency.
Lighting – external	Stand alone renewable powered lamps (either photovoltaic or wind) with security lamp posts	Despite high capital outlays, a practical solution providing security enhancement and cost savings should be realised e.g. reduced cabling costs.
Cooling	AC key/occupancy isolators	AC is occupancy-controlled by a key or sensor.
	Phase change materials	Similar to above, but phase change materials could be part of light weight construction material.
	Zoning	Separate air handling unit for each zone, increased centralisation from individual units.
	Coolerado™ cooling	New cooling technology using evaporative properties of water.
	Air tightness	Minimise loss of treated air and ingress of outside air through effective air-tightness in the construction of openings such as doors and windows.
	Insulation on internal partitions	Minimise cooling loads between separate units.
	Solar cooling (photovoltaics) to power air conditioning units	Photovoltaics used to lower the generator-sourced electricity consumption of air conditioning units.
	Orientation	Organize building to ensure that high occupancy areas are in North of building (south in Southern Hemisphere).
	Solar-tinted glass	Use coated glass that allows sunlight and reflects heat from the building, or use of blinds/ shutters.
	Refrigerants	Ozone-depleting substances and greenhouse gas (GHG) emissions associated with leakage of refrigerants.
Ventilation	Zoning	Install separate air-handling unit for each zone, increasing the centralisation from individual units.
	VSD on fans	Large fans and pumps should all be fitted with VSD to reduce energy consumption.
Domestic hot water	Solar thermal	Use solar thermal collectors to produce hot water.
	Insulated thermal immersions	Ensure all hot water stores and pipe work has sufficient insulation.
	Reduced water consumption	Low flow taps, catering with pull taps, dishwashers.
	Control	Limit usage of hot water with a timer and to specific times.
Server rooms	Temp control and layout	Use free-cooling where possible and not overcooling. Server rooms are often over-cooled and designed to block cooling pathways. Clear design and guidance on temperature settings will reduce energy consumption.
Kitchen appliances	A+ rated appliances	High efficiency appliances.
	Thermal isolation	Ensure thermal isolation of fridges and freezers from ovens.
	Kitchen energy management plan	Make sure kitchen has energy efficiency management plan, equipment off when not need and kitchen fan with VSD.
Small power	A+ rated appliances	Appliances are highest efficiency.
	Timers on printers/photocopiers and recreation equipment	Add timers to link with occupancy.
	Small photovoltaic chargers for mobiles and non-essential IT equipment	Use small renewable to save on generator fuel demand.
Controls	Centralise control (simple management system). Ensure local controls have sufficient occupancy and temperature controls	Form of single temperature, application of time control of entire Building Management System (BMS) for the centralisation of cooling, lighting, ventilation.
Transport – operational restrictions on vehicles	Operational restrictions – Idling	Vehicle management and operation plans to reduce energy consumption.
	Operational restrictions – Speed limiters	Vehicle management and operation plans to reduce energy consumption.
	Maintenance	Following a clear maintenance regime to reduce energy.
Pumps and fans	Any large fans or pumps should have a variable speed drive	Large fans and pumps should all be fitted with VSD to reduce energy consumption.
Renewable and low carbon technologies	Photovoltaic cells (also see solar cooling). Within draft specification	Photovoltaic systems convert energy from the sun into electricity through semi-conductor cells, most commonly made of silicon. To be used in conjunction with battery back-up. The selected battery system shall not have possible adverse environmental impacts (e.g. avoid wet and lead batteries). Solar thin film could be integrated into roof at manufacture.
	Solar thermal (see solar hot water sections)	
	Hydrogen Fuel Cells	Can be run with digester system and provide power heating and cooling. Significant CO_2 reduction and versatile enough to run off a variety of different fuels.
Metering	Meters on main plant and across main areas of site	Measuring energy consumption helps to monitor consumption, benchmark against similar sites and develop targets for reduction. This will help to comply with the CEB decision on Moving Towards a Climate-Neutral UN[6] and the need to do a GHG emissions inventory and an emissions reduction strategy.
Thermal modelling	Use of thermal modelling	Can develop thermal model to demonstrate energy consumption of future building and the impact of energy saving measures.
Diesel Power Generation	Switchboard flexibility to plan and monitor energy demand and switch on/off the right size and combination of units.	

4.3 Water

A total of 18 water saving features have been assessed and ranked for use within a peacekeeping camp context. Ten were ranked as green and 8 as yellow. The measures which were ranked by the traffic light system as green are presented in Table 9. These measures should be accompanied by awareness-raising efforts to reduce water consumption. The complete traffic light analysis is available in Appendix 3. Unlike power consumption, the profile of water consumption is the same across the two sites. The most significant potential savings at both sites come from the adoption of the following three resource efficiency measures:

- **Single flush or waterless urinals:** Constant flow urinals consume a significant amount of water and should be replaced with either single flush or waterless urinals to reduce water consumption. Waterless urinals utilize a trap insert filled with a sealant liquid instead of water. The lighter-than-water sealant floats on top of the urine collected in the U-bend, preventing odours from being released into the air. Although the cartridge and sealant must be periodically replaced, the system saves anywhere between 55,000 and 170,000 litres of water per urinal per year.

- **High-efficiency toilets:** Install water saving devices in the toilet cistern to reduce the amount of water used per flush. A high-efficiency toilet uses less than 6 litres per flush, which is 60% less water then conventional toilets, which use approximately 13 litres. Composting toilets, which are waterless and rely on natural bacteria to break down the organic waste, were not green ranked as they require daily attention as well as behavioural training and have not been widely tested in a peacekeeping context. However, they could be used on a trial basis to determine future suitability.

- **Aerated shower heads:** Aerated shower heads maintain a strong stream of water by mixing air in with the water. The resulting flow feels just as invigorating as it would from a normal shower head but uses 30 to 60% less water.

Three potentially important resource efficiency measures could be used for on-site water production. However, they require further study before they can be adopted in a peacekeeping context. These include:

- **Rainwater harvesting:** At present, rainwater harvesting is believed to be rarely practiced and on an ad hoc basis, and no information is available regarding the practical application of such systems on the reuse of collected water. As a result, this option has been excluded from more detailed assessment within this study. Rainwater harvesting is an efficient process that provides an alternative source of water for camp use and is used in a variety of environmental and social settings. However, engineering considerations such as volume capacity, storage, as well as piping requirements are important factors to be further considered.

- **Grey water recycling:** Grey water recycling reuses non-sensitive water, including water that is uncontaminated by faecal or organic matter. Grey water is typically water derived from hand washing, showers, bathing etc, which can be reused for flushing toilets and for the purposes of gardening although consideration needs to be made of contamination by surfactants (e.g. soaps). There is a capital outlay relating to infrastructure enhancement but these costs are repaid through reduced water consumption and output for treatment.

- **Solar distillation:** Solar distillation is the production of drinking water from solar stills and can minimise issues relating to the security of supply, thereby contribution to the overall sustainability of the camps. Although solar distillation could be tested on a pilot basis, it is unlikely that either the space or the demand would be sufficiently met.

Table 9. Green ranked technologies for water efficiency

Use	Suggested improvements	Comments
Showers	Use of aerated shower heads	Retrofitting for existing shower installation, alterations to the procurement specification will ensure roll out across DFS. Pumping may be required to reach 1 bar.
	Install mixer valves to better control temperature regulation	Retrofitting could be achieved although would require more operational resource.
Toilets	Reduce cistern capacity	Install water saving devices in toilet cistern to offset volume.
Urinals	Single flush urinals	These are already common-place and any supplier of toilet ware would be able to supply them.
	Waterless urinals	Odours are eliminated with 'odour blocks.'
Hand washing	Install flow regulators	Spray taps or inserts (tap magic).
Kitchen washing	Install flow regulators	Spray taps or inserts (tap magic).
Dish washing	Install A rated machines	These can be easily obtained and should not prove difficult.
Food preparation	Install flow regulators	Spray taps or inserts (tap magic).
Air conditioning	Review use of Coolerado™	Under consideration for the Support Base only.
Laundry	Install A rated machines	These can be easily obtained.
Metering	Meters on locations within the complex where water use is prevalent: ablution blocks, kitchen, toilets	Measuring water consumption helps to monitor consumption, benchmark against similar sites, and develop targets for reduction.

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Aerated shower heads maintain a strong stream of water by mixing air in with the water. The resulting flow feels just as invigorating as it would from a normal shower head but uses 30 to 60 percent less water

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High-efficiency toilets and single flush or waterless urinals. Collaboration between UNDFS, UNMIS, Swedish Defence Research Agency and the Swedish Armed Forces. Pilot UNMIS, Juba

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Rainwater harvesting can be used to provide an alternate source of water for camp use, engineering considerations such as volume capacity, storage and retention time (to avoid degradation of the quality of the water and subsequent health risks), are important factors to be further considered prior to adopting this technology in a peacekeeping setting

4.4 Solid Waste

A total of 48 resource efficiency measures were considered in order to reduce solid waste production and disposal at the two sites. For the HQ Camp, 23 were ranked as green, 15 were ranked as yellow, and 10 as red. For the Support Base, 23 were ranked as green, 20 as yellow, and 5 as red. The measures which were ranked by the traffic light system as green are presented in Table 10.

As of today, although waste has been assessed as being the biggest environmental concern in peacekeeping missions, it has mainly been disposed on landfills outside the camps, this practice rarely meets adequate environmental standards. However, waste disposal is dependant upon a number of criteria, including the paramount need to maintain effective security and camp functionality. The provision of an enhanced waste management policy embedding the three key components of the waste hierarchy (reduce, re-use and recycle) should be the guiding approach to reduce the volume of waste for landfill disposal in both sites. The adoption of alternative disposal options will have the ultimate effect of reducing the volume to landfill and thereby reducing both the potential long-term environmental impacts and clean-up costs. The most significant potential waste reductions at both sites come from the adoption of the following six measures:

- **Reduce food waste through shredding:** Food waste can be reduced through using maceration systems. These are designed to treat food waste produced from kitchens and are often used in catering establishments as a waste volume reduction system. Certain maceration systems produce an 80 % reduction in the volume of waste to be treated.

- **Segregate and recycle in local markets:** This measure applies to camps in which the security situation permits the development of a local economy for recycling waste products. 'Commodity' wastes such as metals, textiles and in some cases plastics will often have a value to a local market. Segregation of these waste streams and onward disposal to local markets for resale should be encouraged, while also complying with UN procurement rules and regulations. The UN has a duty of care to ensure that the wastes will not unduly impact the environment or the health and safety of the contractor or the final customer. Hazardous wastes, for example, should not be sold.

- **Anaerobic digestion:** The use of anaerobic digesters to divert the organic waste stream from landfills can bring benefits from energy production as well as providing significant environmental gain including the prevention of noxious gases and vermin control. There are many established anaerobic digestion systems that could be readily applied to the camp's operations. However, this solution has to be further investigated taking into account practical operational parameters, including technical maintenance capacity, security concerns related to the presence of gas such as methane, and the lengthy anaerobic process. Note that anaerobic digestion has been excluded from the HQ camp as an option due to security concerns. The utilisation of anaerobic digestion systems to treat solid and liquid wastes derived from the camp's activities could be another "closed-loop" option with regard to the camp. Specifically, biodegradable and putrescible wastes such as sewage and food could be used. The utilisation of such systems would provide the following number of benefits over conventional systems:
  - Divert waste from landfill;
  - Reduce greenhouse gas emissions;
  - Produce electrical and cooling power to service the camps;
  - Reduce the need to discharge liquid wastes;
  - Produce a digestate for use as soil conditioner among other beneficial uses;,
  - Provide benefits to local communities through utilisation of their organic waste products to produce energy.

- **Compost:** Food scraps including egg shells, coffee grinds, fruit and vegetable peels and so forth can be composted to reduce landfill waste volumes. A composting tank with anaerobic treatment for biogas generation could also be explored.

- **Incineration:** Incineration is considered a viable option to reduce some hazardous and other wastes subject to supply of a sufficient source of combustible materials. In some cases, energy gains can be realised from the use of an appropriate waste to energy system. The estimated volumes of waste produced by a 200 person camp indicates that an inadequate supply of suitable waste materials would be generated to justify the use of an incinerator without the use of back-up fuels to enable the incinerator to reach an optimum operating temperature.

- **Supply chain improvements:** There are a number of waste reduction benefits that could be realised through minor modifications to the supply chain. Such measures would not necessitate specific changes to a procurement policy and could be achieved through negotiation with a supplier when facing daily changes within the context of the operation. Such changes could result in potential cost savings, as well as reduced waste output and enhanced environmental protection. A detailed assessment of current supply chains to help identify best practices and subsequent benefits should be undertaken at each site. A few areas where procurement 'improvements' could be made are as follows:

  - Requesting contractors transport supplies in re-usable containers that are then returned once empty (e.g. liquid products such as detergents);
  - Requesting contractors to use bio-degradable packaging material (e.g. use of bio-plastics or paper);
  - Ensuring supply contractors re-export compacted plastic waste;
  - Increasing use of local suppliers to reduce transport miles;
  - Researching and subsequently procuring environmentally friendly products (e.g. the availability of more degradable chemical substitutes which contain less harmful substances and nutrients).

In addition to these six measures, sanitary landfills should provide an adequate level of environmental protection as well as provide the necessary volume for waste disposal. This includes controlling impacts associated with leachate and gas generation as well as preventing wind blown contamination. Additionally, good sanitary design can ensure that health, safety, and nuisance impacts are kept to an acceptable level, such as vector control (rats, rodents, birds, insects etc.), trespass prevention, odour and aesthetic controls. An effective sanitary landfill design has been developed by UNMIS from work undertaken in Sudan (see Appendix 5 for the landfill design). It is recommended that these are used from the planning phase as a model for any proposed camp where sanitary landfills will be required.

With specific reference to the proposed HQ Camp in Somalia, the absence of available space to create a landfill was identified as a challenge. Ideally the landfill should be located at the furthest point possible from the accommodation blocks and airport field. Although the availability of a landfill is considered essential, the study recognizes that if practical waste-reduction measures are carefully observed, the establishment of a landfill site may be less necessary. In view of the security constraints associated with the HQ Camp, the minimisation and incineration of selected items, including the sterilisation of steel cans for later recycling, could also prove to be effective.[7]

Given the potential environmental contamination caused by the improper disposal of waste, it is essential that the UN ensure waste produced by its operations on the ground is labelled and disposed of in accordance with international best practice. From a procurement policy perspective, it is also critical that similar standards are applied to any external agents contracted by the UN to ensure the disposal of waste in a proper and safe manner, minimizing impact on the environment and the local population. In order to ensure this is the case, monitored procedures should be put in place with requisite audit checks.

In order to monitor and confirm the effectiveness of waste reduction measures, accurate recording of the volumes of waste produced, as well as


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The composting of food scraps greatly reduces landfill waste volumes (and can be combined with anaerobic treatment for biogas generation)


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Commodity wastes such as these plastic bottles will often have value to a local market. Segregation of the waste stream and onward disposal in local markets is recommended so long as the wastes will not unduly impact the environment or health and safety of those who receive them

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Although incineration is considered a viable option to reduce some wastes, estimation for a 200 person camp indicates that an inadequate supply of suitable waste materials would be generated to enable the incinerator to reach an optimum operating temperature without the use of back-up fuels

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Cardboard can be bundled, compacted and sent for recycling in return journeys of provision lorries an analysis of the composition of the waste stream will be required. Based on the records of the volumes of produced waste, targets can then be established in line with environmental management strategies. Accurate recording of waste streams also helps to identify high-volume waste producers which can be specifically targeted.

Waste streams can be recorded by counting the number of refuse containers (sacks or bins) disposed of from zones (i.e. domestic, kitchen, maintenance zones) within the camp. If required these zones can be further divided – for instance if recycling of paper is undertaken within the offices, a sub-zone could be created for paper products arising from this disposal route. Gathering baseline data on the pattern of waste streams for an initial 3-month period could help to implement measures towards the ongoing waste reduction to the greatest extent possible.

A number of resource efficiency measures for waste require further study before they can be adopted in a peacekeeping context. These include:

- **Waste to energy systems:** Potential to use waste to energy systems depends on surpassing a specific threshold of waste generation. This study recommends that a detailed feasibility study be undertaken to evaluate optimum processes and technologies that could be integrated to produce a "closed-loop" system to help manage energy, water and waste in a more sustainable fashion within the context of peacekeeping missions. A closed-loop system could also help increase the self-sufficiency of on-site energy production, whilst minimising environmental impacts from diesel fuel. The proposed feasibility study should particularly consider solid and liquid waste volumes, calorific value, and solid and liquid waste storage and treatment. In conjunction with the waste evaluation, the study should also consider potential energy yields from anaerobic treatment processes in the form of biogas and the conversion of biogas to electrical and heat energy using conventional engines, or alternative technologies like fuel cells. Finally, it is recommended that an evaluation of environmental and health

Table 10. Waste reduction and alternative disposal routes

Waste Source	Alternative disposal routes	Comments
Office – paper	Reduce, re-use, recycle High efficiency printers, re-use for informal writing, education	Purchase printers with default double-sided printing, preferably using black and white ink cartridges, procurement of recycled paper. Paper that requires disposal to an incinerator or mobile thermal treatment plant.
Office – cartridges (e.g. printers, photocopiers)	If space allows, these should be stored and returned to the manufacturer. If no space provision, sent to landfill	These are currently recycled.
Cardboard – office and general	Cardboard can be bundled, compacted and sent for recycling in return journeys of provision lorries	Purchase of compactors.
Domestic waste	Food waste macerators in kitchen module, discharge to "sewer", feedstock for anaerobic digester – this can be combined with black water	Use of anaerobic digester can be associated with fuel production like biogas/fuel cell, but this solution has to be further investigated taking into account practical operational parameters such as maintenance capacity, security.
Hazardous waste – batteries	Use rechargeable batteries. Other hazardous wastes should be stored safely and sent for proper disposal in the return leg of provision lorries	Use of rechargeable batteries to reduce overall impact of waste disposal and of power supply.
Hazardous waste – petroleum products	Stored in appropriate containers, use of incinerator. Investigate use of biodegradable products	Emergency response plan should be developed to respond to diesel spills. Above storage tanks (ASTs) with secondary containment may be recommended for storing oil and chemicals rather than underground storage tanks (USTs) which are more prone to contaminating the soil and groundwater.
Recording	Accurately record the volumes and types of waste being produced and analyse the waste streams	With this data measurements can be taken to target high waste producers.

Box 1. Excerpt of the UNMIS waste management guidelines recommendations see below (see also Appendix 7)

Waste minimization is only part of sustainable waste management, which consists of the Four R's Principle: Reduce, Reuse Recycle and Recovery. Due to limited options and supporting facilities in the field, this box will only focus on the *Reduce* and *Reuse* concepts.

Reduction:

Reducing the amount of waste production is by far the most effective way to battle the increasing rate of waste generation. If waste is not created in the first place, the waste control mechanisms will not be necessary.

Waste reduction has the greatest potential for conserving resources and protecting the environment by not producing or purchasing items which are superfluous to requirements. This is based on the simple assumption that items not required or used sooner or later become 'waste'.

Reuse:

Reuse simply means using objects or materials again, enabling continual benefits prior to waste disposal. What we cannot reduce, we should try to reuse.

Based on the two concepts mentioned above, practical actions can be implemented as follows:

- Photocopying and printing of double-sided documents, whenever possible;
- If a computer or word processor is used, on-screen editing is encouraged to avoid printing multiple drafts;
- Reduction of copies by distributing electronic instead of hard copies;
- Replacement of memos with telephone calls, when practical;
- Make use of scrap paper instead of notes and messages or draft printouts;
- Re-usage of batteries when possible. If the used wet-cell battery casing is intact it can be reconditioned for reuse. Reconditioning used batteries generally involves replacement of both the electrolyte solution and water;
- Re-usage of plastic or glass containers;
- Purchasing reductions: selection of supplies which have less wasteful packaging or are less hazardous;
- Make use of physical rather than chemical cleaning methods;
- Prevention of wasting products, such as in nursing and cleaning activities.

impacts, security of supply and legacy issues associated with the design, installation and operation of such systems is undertaken, which will contribute to a more integrated approach to the overall management of waste, wastewater and energy.

- **Centralised waste treatment plants:** The most significant cost benefits from the treatment of wastes may be realized through the use of centralised treatment plants. Treating large quantities of waste results in significant economies of scale. Specifically, this relates to the production of power through the development of waste to energy plants. As the stability of a country returns, the use of such treatment centres would significantly reduce the cumulative environmental impact of individual waste disposal operations. Centralised systems allow for a much greater degree of control and generate efficiencies in design and operation. Indeed, the creation of such a plant could be used to generate energy using bio-digestion[8] of sewage and putrescible wastes. The benefits of such a system include reducing greenhouse gas emissions into the atmosphere, along with the production of electricity and cooling energy for local inhabitants. Residues from the process can be utilised as soil conditioner to enhance soil quality and promote plant growth. One of the possible challenges would be the sustainability of such a project in the country once the peacekeeping mission will have liquidated. It is recommended to study this point and liaise with other UN agencies to see if/how it could be overcome.

4.5 Liquid Waste

Only two resource efficiency measures were considered to address liquid waste production and disposal at the two sites. These included recycling systems for grey water and anaerobic digestion systems for black water. For the HQ Camp, only the grey water recycling option was green ranked whereas at the Support Base both measures were green ranked. The rationale for this ranking is discussed below.

- **Recycled grey water (toilet flushing and outdoor use):** Alternative disposal routes can be developed to effectively re-use the grey water for non-sensitive uses within the operation of the camp, such as toilet and urinal flushing and for outdoor uses such as gardening, vehicle wash down, etc. Such re-use would require some capital cost outlay in the form of tanks, pipework and pumps, and some operational costs to maintain the infrastructure. However, the payback period of this investment should fall well within the lifetime of the camps. This could be accentuated with the use of photovoltaic panels to power the pumps, creating a sustainable closed loop system.

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Based on water and sanitation engineering assessments, mission locations should have two separate plants for the treatment of liquid effluents: an aerobic treatment plant using aeration by compressed air or a superficial aerator; and a physical-chemical treatment plant, composed of an oil-water separator and a neutralization/settling tank

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In accordance with the UNMIS guidelines on liquid waste, grey water from bathroom and washing basins should be directed to soak away pits

- **Black water (anaerobic digestion):** The organic content of black water makes it suitable for use in anaerobic digestion units – indeed the use of black water and solid organic wastes would be advised to assure a suitable volume of feedstock to the units. It has been expressed previously that the use of anaerobic digesters requires confirmation of their applicability within the context of the operating environment of the camps particularly in relation to the security aspects of the HQ Camp. For this reason, anaerobic digestion was only deemed feasible for the Support Base.

The UNMIS Environmental Guidelines on Waste Management (Appendix 7) detail the mechanism through which liquid waste streams should be treated, as per the DPKO/DFS Environmental Policy's requirements (paragraph 39). Excerpts from the guidelines have been reproduced below and it is recommended that these terms are adopted for the establishment of the HQ Camp and Support Base.

The most significant impact of wastewater discharge is the formation of standing pools of water in the form of evaporation ponds. Although such ponds may have positive environmental impacts, including providing a resource for livestock and wildlife for water extraction, if not properly done the negative impacts in the form of nuisance through overflow and flooding, odours and the creation of breeding grounds for insects are substantial in comparison. It is important to dispose of the

Box 2. Excerpt of UNMIS guidelines on liquid waste

Sanitary sewage will be disposed by using the method that maximizes protection of human health and the environment under existing operational conditions. The following disposal alternatives are presented in general order of preference; however, site-specific considerations and operational duration and intensity may take precedence:

Ablution and Field Toilets: Grey-water from bathroom and washing basins should be directed to soak away pits. Septic tanks should be designed and constructed for human excreta only. (See Annex G "Typical Sewage Collection Tanks and Soak Pit System", Layout Plan, Engineering Section, 2006)

Proper septic systems can greatly reduce adverse environmental impacts from the effluent when designed and managed properly. Depending on the number of occupants and type of facility, size of a septic tank can vary greatly. Flow rate can vary between 50 and 200 liters per capita. However, it is important to remember that the depth of a tank should not be greater than 1 meter. Retention time of 36-48 hours must be taken into consideration when determining the size. (See Annex H "Typical Sewage Septic Tank", Layout Plan, Engineering Section, 2006)

Sewerage is collected from either ablution units or septic tanks. Ablution units and septic tanks should be sited to allow easy access for the sewage trucks. Sewage trucks will pump out septic tanks/soak away pits and remove sewerage to an authorized central refuse site selected by Sector Engineer and authorized by RAOs or oxidation ponds.

Based on water and sanitation engineering assessments, mission locations should have two separate plants for the treatment of liquid effluents: an aerobic treatment plant using aeration by compressed air or a superficial aerator; and a physical-chemical treatment plant, composed of an oil-water separator and a neutralization/settling tank. (See Annex I *"Juba Oxidation Pond", Layout Plan, Engineering Section, 2007*)

wastewater in a manner that complies with the functionality of the camp, whilst reducing environmental impact. A list of suggestions with regard to wastewater discharge is as follows:

- The reduction of the overall volume of demand through the implementation of water saving measures will reduce the size of evaporation ponds, which may be the most effective mechanism for reducing the impact of the ponds. With a reduced volume of water the evaporation effects may be optimised, thereby removing the sometimes permanent presence of water;
- The use of dry and composting toilets could significantly reduce the waste volumes;
- The utilisation of an anaerobic digestion system, if applicable, could pre-treat and reduce water discharges;
- Installation of attenuation tanks post-treatment to allow a controlled flow to the disposal areas. By reducing the flow of water to the ponds, soakaways or natural water courses, the effects of infiltration, evaporation or dilution could be optimised;
- The reuse of black water in a non-sensitive manner (e.g. use black water for dust suppression along unpaved roads) will reduce the volume discharged to the receiving waters, and optimise evaporation.

As discussed in the previous section, it is recommended that a detailed feasibility study be undertaken to evaluate optimum processes and technologies that could be integrated to produce a closed loop system to manage energy, water, and waste more sustainably in peacekeeping missions. Such a study should consider the following: solid and liquid waste volumes, calorific value, and solid and liquid waste storage and treatment, as well as potential energy yields from anaerobic treatment processes in the form of biogas. Further, it would evaluate conversion of biogas to electrical and heat energy using conventional engines and alternative technologies like fuel cells.

5 Potential Reductions and Savings

5.1 Overview

A summary of the potential reductions that could be achieved from the application of "green" rank resource efficiency measures are presented in Table 12. The following sections provide more detailed calculations and graphs comparing the baseline and revised figures.

5.2 Energy

A comparison of the energy footprint for the baseline designs and for the revised design incorporating the green ranked resource efficiency measures is provided in Table 11 and Figure 8. The analysis found that energy consumption could be reduced by 26% at the HQ Camp and by 32% at the Support Base if the green ranked resource efficiency measures were adopted.

5.3 Water

A comparison of the water footprint for the baseline designs and for the revised design incorporating the green ranked resource efficiency measures is provided in Table 13 and Figure 9. The analysis found that water consumption could be reduced by 42% at both sites through the adoption of the identified measures.

Table 11. Potential Annual Energy and Carbon Reductions for HQ Camp and Support Base

1. HQ Camp					
End Use	**Baseline Energy (kWh)**	**Revised Energy (kWh)**	**Baseline CO_2 (tonnes)**	**Revised CO_2 (tonnes)**	**% Savings**
Lighting (external)	996,546	664,364	249	166	33%
Lighting (internal)	1,168,000	929,789	292	232	20%
Cooling	6,387,500	4,125,643	1,597	1,031	35%
Hot Water	1,815,395	925,851	454	231	49%
Small Power (accommodation)	3,038,008	2,886,107	760	722	5%
Small Power (office)	1,959,474	1,861,500	490	465	4%
Catering	155,449	152,340	39	38	6%
Ventilation (fans)		–		–	
Transport		–		–	
Total	**15,520,371**	**11,545,596**	**3,880**	**2,886**	**26%**

2. Support Base					
End Use	**Baseline Energy (kwh)**	**Revised Energy (kwh)**	**Baseline CO_2 (tons)**	**Revised CO_2 (tons)**	**% Savings**
Lighting (external)	996,546	664,364	249	166	33%
Lighting (internal)	584,000	464,895	146	116	20%
Cooling	3,193,750	1,526,613	798	382	52%
Hot Water	907,697	462,926	227	116	49%
Small Power (accommodation)	1,519,004	1,443,054	380	361	5%
Small Power (office)	998,947	949,000	250	237	4%
Catering	79,504	77,913	20	19.5	0%
Ventilation (fans)		–		–	
Transport		–		–	
Total	**8,279,448**	**5,588,764**	**2,070**	**1,397**	**32%**

Note: The savings detailed in Table 12 relate to individual savings per technology and do not represent cumulative savings or detailed synergies that can be realised through application of a number of technologies together. In this way the values of 26% and 32% savings should be viewed as target values that can be improved.

Table 12. Comparison of annual baseline figures and revised figures using green ranked resource efficiency measures

Resource	Location	Baseline figures per annum	Revised figures with green ranked technologies	% savings
Energy	HQ	15,520,371 kWh	11,545,596 kWh	26%
	Support	8,279,448 kWh	5,588,764 kWh	32%
Carbon produced	HQ	3,880 tonnes	2,886 tonnes	26%
	Support	2,070 tonnes	1,397 tonnes	32%
Water	HQ Support	6,144,775 litres	3,590,870 litres	42%
Solid waste	HQ	87,600 kg of which 71,832 kg to landfill	70,080 kg of which 28,032 to landfill	20% 61%
	Support	87,600 kg of which 71,832 kg to landfill	70, 080 kg of which 8,760 kg to landfill	20% 88%
Liquid waste	HQ	6,144,775 litres of which 2,273,567 litres of black water requiring treatment and 3,871, 208 litres of grey water to soakaways	3,590,870 litres of which 2,273,567 litres of black water and 1,317,303 litres of grey water to soakaways	0% 66%
	Support	6,144,775 litres of which 2,273,567 litres of black water requiring treatment and 3,871, 208 litres of grey water to soakaways	2,908,800 litres of which 1,591,497 litres of black water and 1,317,303 litres of grey water to soakaways	30% 66%

Figure 8. Potential Annual Energy and Carbon Reductions from Energy Efficiency Measures

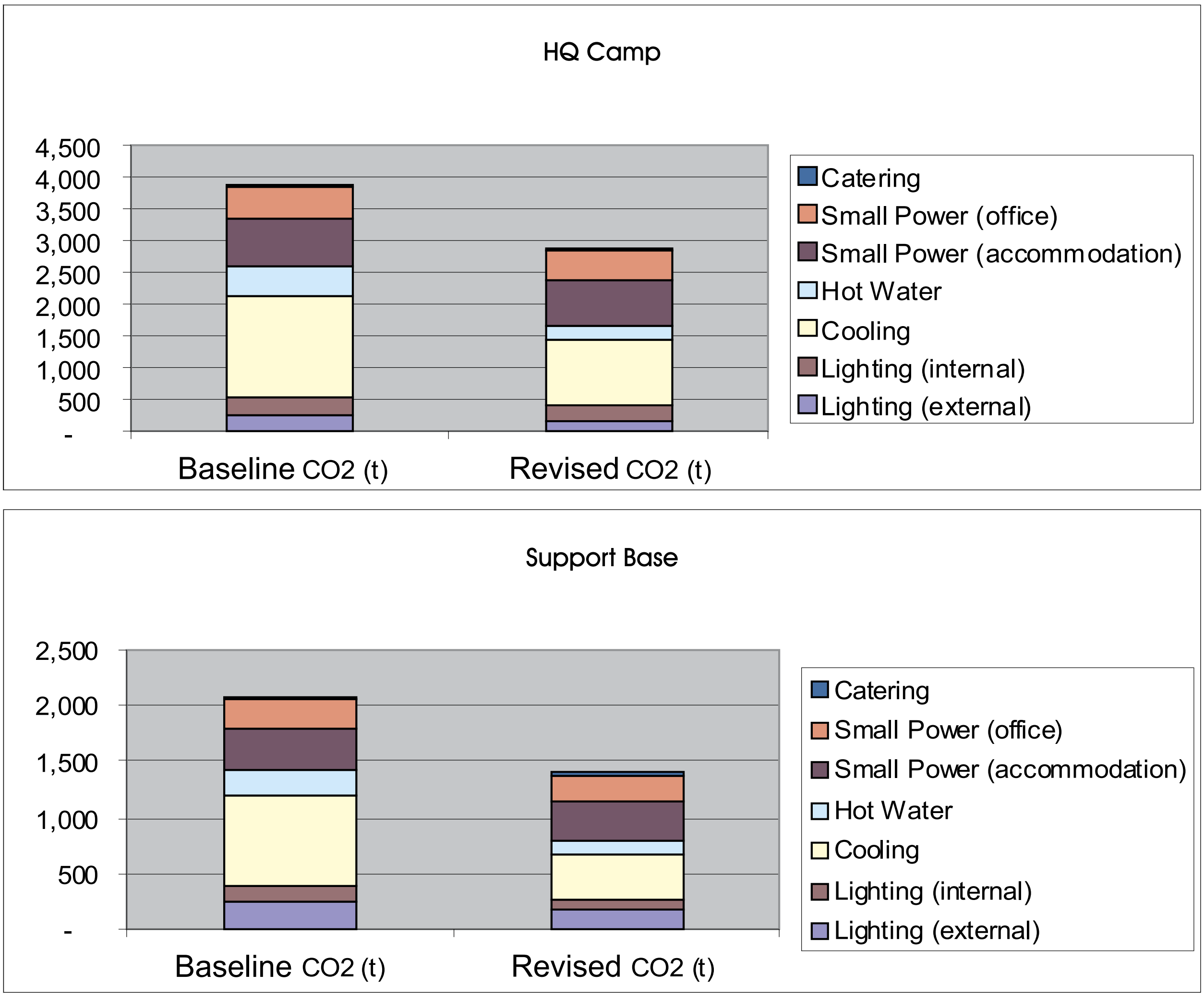
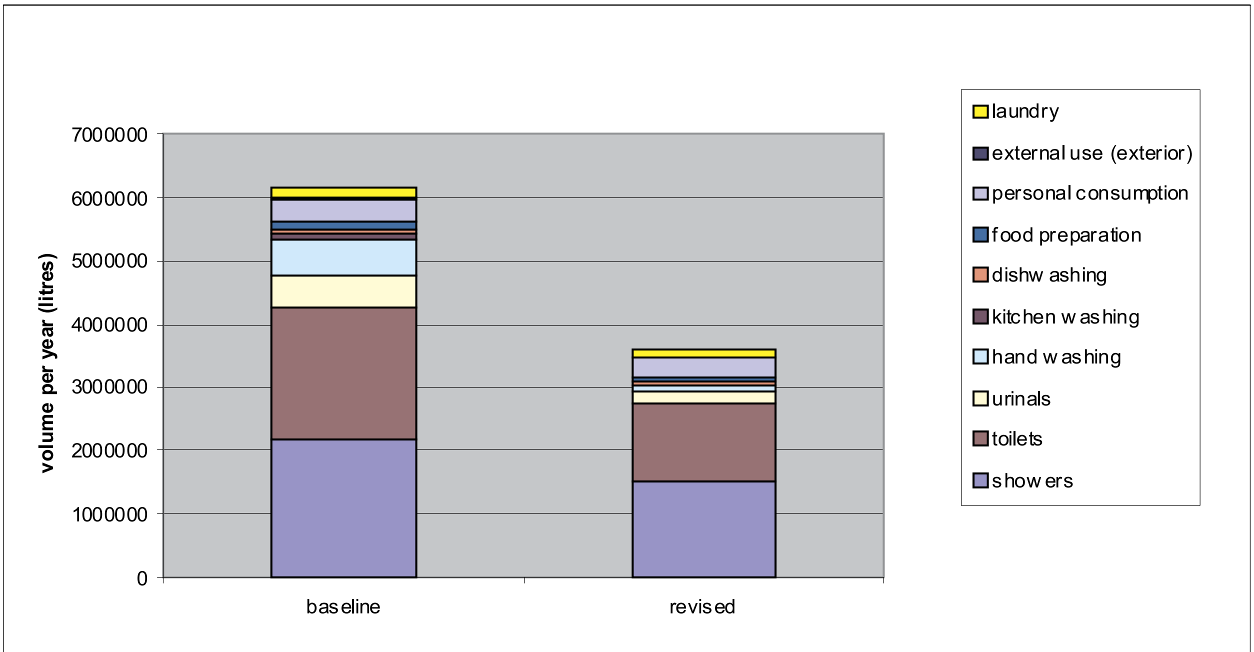


Table 13. Potential Annual Water Reductions for HQ Camp and Support Base

Use	Baseline water (litres per year)	Revised water (litres per year)	% savings
Variable usage (per person)			
showers	2190000	1533000	30%
toilets	2044000	1226400	40%
hand washing	584000	116800	80%
personal consumption	328500	328500	0%
Communal usage (per 200 people)			
kitchen washing	73000	14600	80%
dishwashing	63875	51100	20%
food preparation	153300	45990	70%
urinals	525600	157680	70%
external use (exterior)	36500	0	100%
air conditioning units*	0	166857	
laundry	146000	116800	20%
TOTALS	**6,144,775**	**3,590,870**	**42%**

Note: The air conditioning water consumption in the "revised" column assumes use of Coolerado-type in the supply camp. The Coolerado-type system utilises water rather than refrigerants for its principal cooling operation. A negative figure of 166,857 has been included to show an increase in water use from this technology (but is not captured in the calculation).

Figure 9. Potential Annual Water Reductions from Resource Efficiency Measures



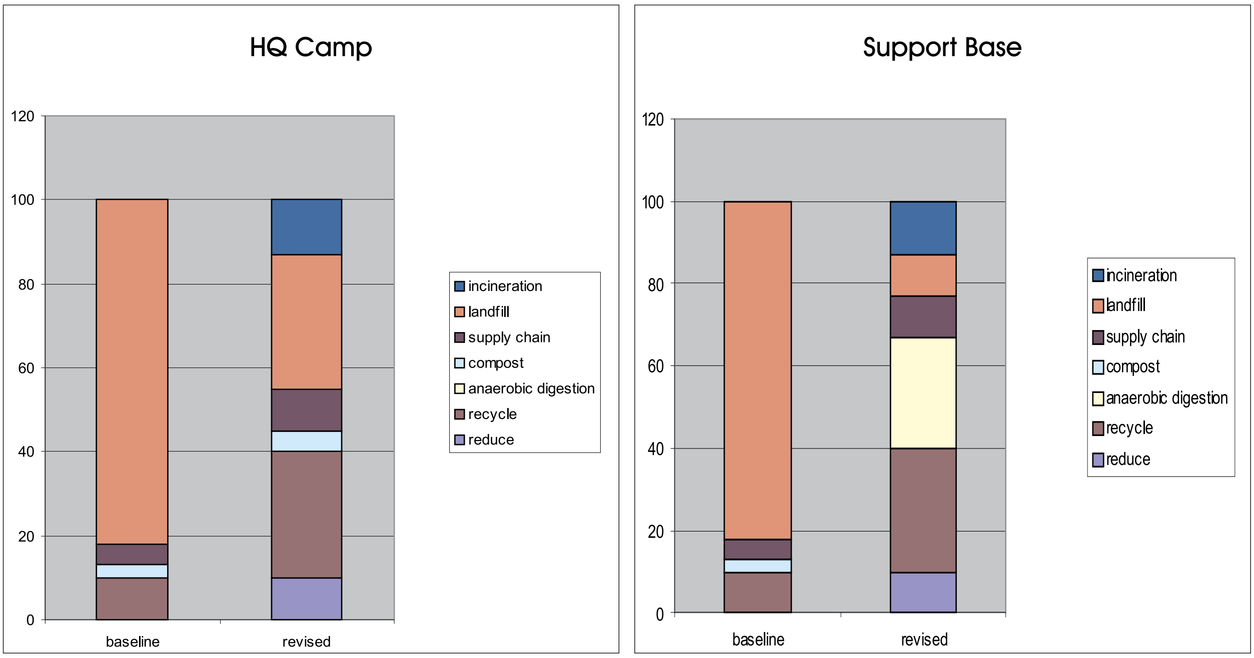
5.4 Solid Waste

A comparison of the solid waste footprint for the baseline design and for the revised design incorporating the green ranked reduction measures is provided in Table 14 and Figure 10. The analysis found that at both locations the estimated total volume of waste produced can be reduced by 15% through maceration of food waste and changes in the supply chain. At the HQ Base, the total amount channelled to landfill can be reduced by up to 61% and at the Support Camp by up to 88% based on the adoption of waste reduction measures.

Table 14. Solid Waste Reduction Measures and Alternative Disposal Routes

Solid Waste	HQ Camp			Support Base		
Management	%age of Total			%age of Total		
Measure	baseline	revised	difference	baseline	revised	difference
reduce	0	10	10	0	10	10
recycle	10	30	20	10	30	20
anaerobic digestion	0	0	0	0	27	27
compost	3	5	2	3	0	-3
supply chain	5	10	5	5	10	5
landfill	82	32	-50	82	10	-72
incineration	0	13	13	0	13	13
TOTALS	**100**	**100**	**0**	**100**	**100**	**0**

Figure 10. Diversion from landfill through the use of solid waste reduction measures



5.5 Liquid Waste

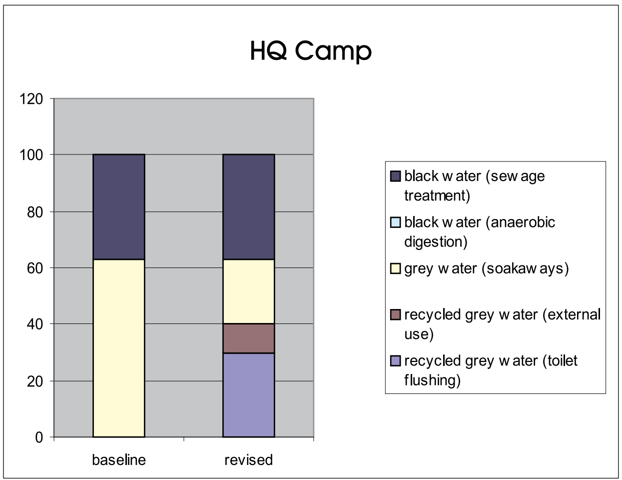
A comparison of the liquid waste footprint for the baseline design and for the revised design incorporating the green ranked reduction measures is provided in Table 15 and Figure 11.

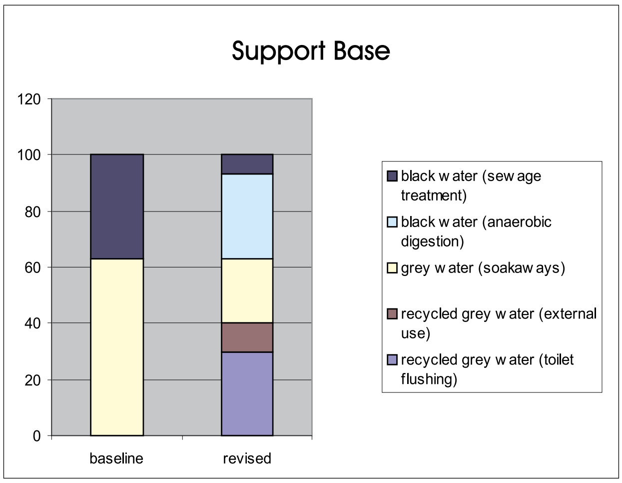
At both sites, the analysis found grey water to soakaways could be reduced by 66% through recycling. At the Support Base, the analysis found that black water could be reduced by up to 30% through anaerobic digestion.

Table 15. Liquid Waste Reduction Measures and Alternative Disposal Routes

Liquid Waste Management	HQ Camp %age of Total			Support Base %age of Total		
Measure	**baseline**	**revised**	**difference**	**baseline**	**revised**	**difference**
recycled grey water (toilet flushing)	0	30	30	0	30	30
recycled grey water (external use)	0	10	10	0	10	10
grey water (soakaways)	63	23	-40	63	23	-40
black water (anaerobic digestion)	0	0	0	0	30	30
black water (sewage treatment)	37	37	0	37	7	-30
TOTALS	**100**	**100**	**0**	**100**	**100**	**0**

Figure 11. Potential liquid waste reduction options





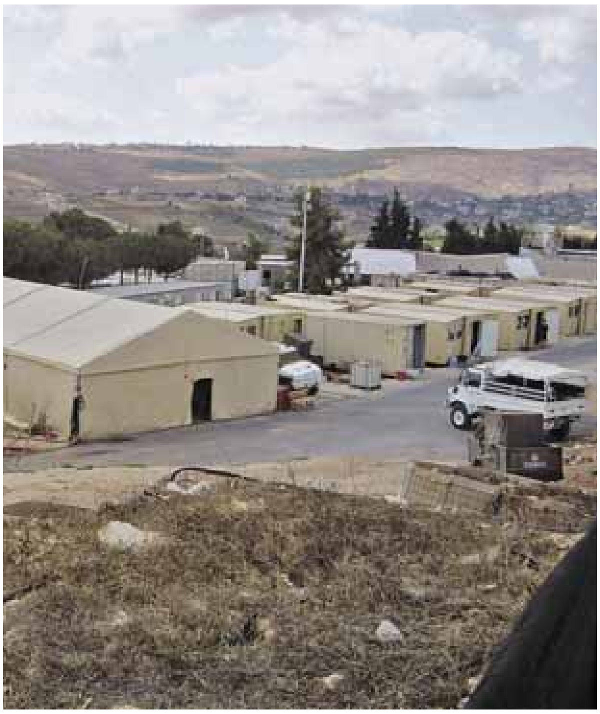
6 Assessing Environmental Conditions and Monitoring Impacts

6.1 Introduction

In order to fully monitor the environmental impact of a peacekeeping operation and the effectiveness of resource efficiency technologies, an environmental impact assessment (EIA) is required prior to the establishment of the HQ Camp and Support Base. Furthermore, site specific baseline studies (EBS) should be undertaken (see paragraphs 23.2 and 23.3 of the DPKO/DFS Environmental Policy). Operational documents are currently being developed by DFS, together with the Swedish Defence Research Agency (FOI) detailing the criteria for the completion of an EIA as well as an EBS.[9]

6.2 Limited environmental baseline study when access is restricted

Given the prevailing security profile in Mogadishu, restricted access to the planned camp site is likely to constrain the effective completion of a full environmental impact assessment. In such conditions, the following basic parameters should be evaluated:



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Typical operations installation (Tibnin, Lebanon)

- Orientation of the camp to maximise passive solar or wind energy;
- Sustainable use of anticipated water supply, including surface, groundwater, or external purchase;
- Sustainable procurement of local building materials including bricks, wood and gravel;
- Position of energy, waste and water treatment areas and receiving water;
- Evaluation of rainfall and expected rainwater harvest, including tank sizing;
- Temperature and humidity profiles;
- Ecological sensitivity of the area;
- Potential urban influences and pollution risks; and,
- Transportation, access and procurement routes.

6.3 Full environmental baselines study when access is possible

Given that the Support Base will be established in an area with a lower security profile, a more comprehensive environmental assessment can be undertaken, including pre-installation site visits and field sampling. In this regard, the following additional parameters should also be assessed:

- Water quantity and quality testing and installation of boreholes for monitoring;
- Soil conditions, soak away tests and drainage routes; and,
- Potential for "closed-loop" energy generation, waste and water treatment using bio-digestion processes.

Findings from environmental assessments would enable the development of an environmental management plan to ensure operational impacts are minimised to the extent possible. In addition, the environmental management plan should also include provisions to ensure that all environmental impacts have been reduced or removed to the extent possible following the closure of the camp.

7 Sustainable identification of sites, planning, set up, management, and decommissioning/liquidation of UN peacekeeping camps

7.1 Background

To implement the new Environmental Policy for UN Field Missions, DFS is in the process of developing a variety of guidelines and working protocols to enhance the sustainable operation of peacekeeping activities. This pilot assessment identified ways to use resource efficiency measures to reduce the energy, water and waste demands of the new HQ Camp in Mogadishu, Somalia and the Support Base in Mombasa, Kenya. As an outcome of this study, a series of practical options to enhance resource efficiency have been identified. The next step in this process is to provide suitable procedures, tools and training to enable requisitioners, procurers, designers, installers and operators of peacekeeping camps to transform these policy recommendations into operational reality, while complying with UN procurement rules and regulations.

UNEP has published numerous guidelines that are already being utilised to aid aspects of sustainable decision-making processes. These include:

- Environmental Impact Assessments
- Sustainable Procurement Product Guidelines[10]
- UN Efficient Lighting Manual
- UN Sustainable Procurement Stories
- UN common GHG calculator for office and air travel"
- "Environmental management system training resource kit"

To support the adoption of sustainable practices across the UN, UNEP also manages the Sustainable UN Facility (SUN)[11]. Numerous other sustainable policies, indicators and design tools are also available. These include:

- Global Reporting Initiative (GRI) [12]
- Re-engineering Assessment Practices (REAP) [13]
- Regional Economy Environment Input Output model (REEIO) [14]
- Leadership in Energy and Environmental Design (LEED) [15]
- Building Research Establishment Environmental Assessment Method (BREEAM) [16]
- Comprehensive Assessment System for Building Environmental Efficiency (CASBEE) [17]
- Greenstar [18]

Each tool has its merits and works at its optimum when applied specifically for its core purpose and in the specific region for which it was designed. However, there is an absence of a practical 'how to' manual to support sustainable UN peace operations. For this reason, this report recommends that a Sustainability Appraisal Camp Toolkit (SACT) is developed specifically for peacekeeping activities. Such a tool kit should be aligned with existing UN policies, procedures and tools, and be designed to help deliver sustainability objectives in a practical manner on the ground. It is important that a holistic approach is formulated covering the five main phases of a camp lifecycle: identification of sites, planning, set up, management and decommissioning/liquidation. Such an approach would assist UN peacekeeping activities on the ground to comply with strategic policy and address the full remit of sustainable development priorities. The ultimate objective is to integrate sustainability considerations into each phase of UN decision-making processes for the camp lifecycle in order to identify, manage and monitor sustainability benefits.

The development of a SACT would facilitate the identification, development and integration of the full suite of resource efficiency measures, indicators and targets within each phase of the camp life cycle. The proposed toolkit would also provide a mechanism for translating, tracking and monitoring progress against agreed sustainability indicators whilst providing the data necessary for future evaluation. In addition, the toolkit could be translated and utilised by other field agencies within the UN System.

This chapter presents the main issues and practices that a SACT would need to address. It is recognised that the level of implementation of some proposals in this chapter will depend on the outcome of the General Assembly (GA) review of the Secretary-General's (SG) report on sustainable procurement. It is also recognized that DPKO and DFS are bound to comply with UN Procurement rules and regulations.

7.2 Evaluation of existing procedures for camp operations

Prior to the development of a SACT, it is recommended that an evaluation of existing procurement mechanisms, procedures and specifications related to identification of camp sites, planning, set up, management and decommissioning/liquidation are undertaken along with the existing procurement mechanisms for each phase. Such an evaluation would provide an overview of the sustainability options and challenges associated with each phase and provide a source of best and worse practice.

7.3 Sustainability targets for UN peace operations

The key to achieving sustainability goals is through the adoption of clearly defined targets and milestones. From an analysis of existing protocols for UN Mission procedures, it is recommended that a range of sustainability indicators appropriate to the identification of sites, planning, set up, management and decommissioning/liquidation of peacekeeping camps be developed. Once agreed, these indicators could be adopted for use in the SACT to help develop and implement sustainable UN peace operations. Specific indicators would then be selected on a case by case basis by the camp design team. The development of sustainability indicators could take into account the following:

- UN Millennium Development goals (especially MDG7) [19];
- HLCM PN Sustainable Procurement Practice Note [20];
- Climate Neutral UN targets [21];
- National sustainable procurement policies and guidelines [22];
- UN Sustainable Procurement Guide [23];
- Outcomes of environmental impact assessments and baseline studies;
- Multilateral Environmental Agreements; and
- UN Global compact principles.

7.4 Developing sustainability guidelines and choice mechanisms

It is important that sustainable development cascade down from the formulation of high-level policy to the integration of sustainability considerations into specific site level projects and activities. The development of a SACT would be based on the UN's commitment to sustainable development and consider internationally recognised good sustainable practices, as well as priorities appropriate to a particular area.

The toolkit would be designed to reflect the specific stages of the camp life cycle as presented in Figure 12. Within each stage of the camp lifecycle, the following sustainability parameters would be assessed and addressed:

- **Identification of Suitable Sites**
  - Ecological sensitivity
  - Maximization of lighting, solar and wind potentials
  - Assessment of disaster vulnerabilities and other environmental risks

- **Sustainable Planning**
  - Environmental impact assessment procedures
  - Review of resource efficiency for energy, water and waste
  - Camp specification fabric and form
  - Existing supply chain and sustainable sourcing of building materials

- **Sustainable Set Up**
  - Material supplies
  - Transportation
  - Environmental baseline studies
  - Waste disposal

- **Sustainable Management**
  - Local supply chains
  - Capacity building of local staff with environmental technology and behaviour
  - Data collection and environmental impact monitoring
  - Maximizing resource efficiency
  - Minimizing environmental impacts

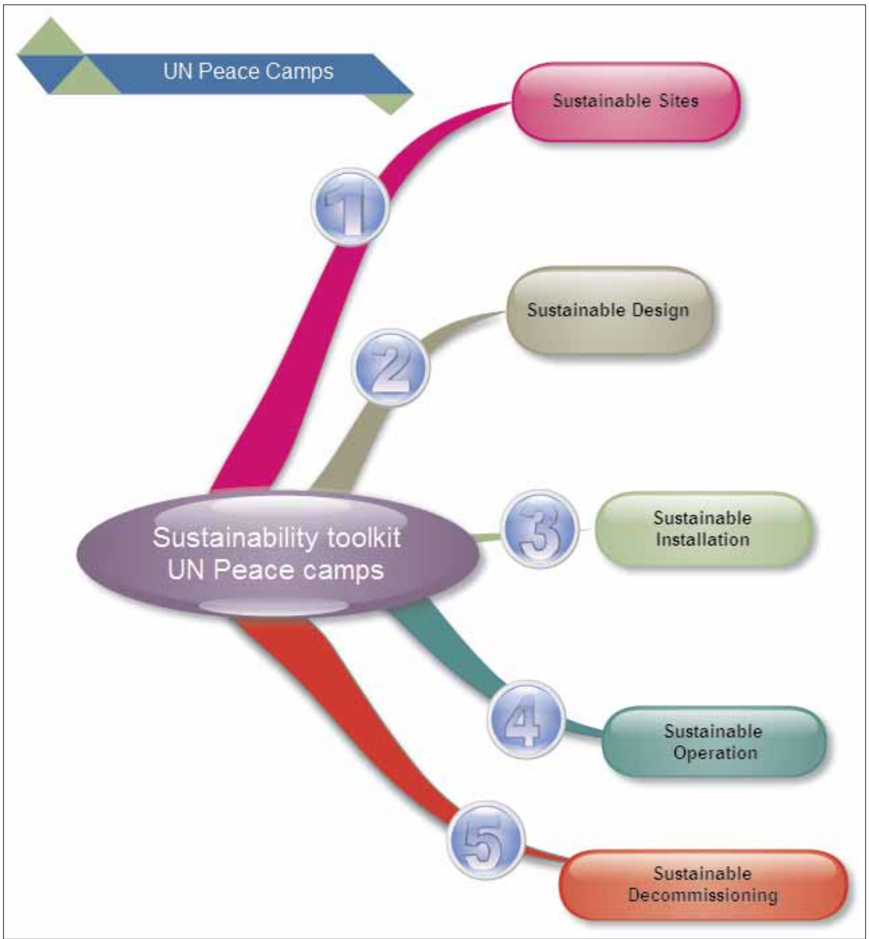
- **Sustainable Decommissioning/liquidation**
  - Clean-up of contaminated sites
  - Restoration of natural landscapes
  - Handover of environmental technology and infrastructure to local communities

To reduce complexity and provide maximum value added, the toolkit should provide a framework of options in each phase that can be used for addressing specific sustainability goals. The options would take into account a range of security situations as well as environmental conditions and be based on lessons learned from specific application in the field. Such a framework would allow engineers to review a range of difference resource efficiency measures that could meet both the sustainability goals of specific camps as well as the operational requirements. Specifications should be provided for construction materials, energy and water efficiency and production, solid and liquid waste management measures, and local supply chains.

7.5 Monitoring and reporting performance

It is envisaged that the use and application of a SACT tool would enable UN peace operations to monitor, evaluate and report on the sustainability performance of a specific camp and report against a number of agreed targets for each phase of the camp life cycle. In this regard, a data collection system for energy, water and waste must also be included within the camp specifications.

Figure 12. Sustainability toolkit for UN peace operations



8 Summary of Findings and Recommendations

8.1 Findings

This assessment has considered a total of 132 different resource efficiency measures to achieve reductions in energy, water and waste at the HQ Camp and Support Base. Significant resource reduction measures were identified through the use of green ranked technologies which could be implemented through modifications to the AMISOM camp design. Furthermore, the assessment identified the need to evaluate the potential for "closed-loop" energy generation, along with waste and water treatment using bio-digestion processes. The study also provided guidance in the implementation of environmental baseline studies prior to the installation of both camps in order that environmental impacts can be effectively monitored. It concluded by recommending the need to develop a Sustainability Appraisal Camp Toolkit, covering the entire lifecycle of peacekeeping camps from identification of sites, planning, and set up to management and decommissioning/ liquidation.

In order for DFS and DPKO to act on the ten recommendations contained in this report, the following sections are divided into immediate actions for the design phase, medium-term recommendations for camp operations, and long-term recommendations for further camp design.

8.2 Immediate recommendations for the design phase

The recommendations offered below relate to the design phase of the HQ Camp and Support Base and are intended to be implemented within the next 3 months, prior to the construction of the camps.

Recommendation	Reasoning	Responsibility
1. Review 'green' ranked measures, select items for immediate application and develop specifications for procurement.	For maximum effectiveness to be realised it will be necessary for more detailed discussions on the practical applicability of some of the 'green' ranked measures to be undertaken.	DFS engineers and UNEP experts
2. Undertake environmental modelling of the HQ Camp and Support Base design, including thermal, daylight, wind and solar.	Thermal modelling will facilitate the selection of the most efficient cooling system while daylight modelling will facilitate the selection of the most efficient lighting. Modelling of wind and solar potential could also be beneficial for the selection of renewable energy technologies.	UNEP experts
3. Review 'yellow' ranked measures and determine if any can be utilized in the main design or tested on a pilot basis at the Support Base.	Given the improved security profile, some of the 'yellow' ranked measures could be pilot tested at the Support Base.	DFS engineers and UNEP experts
4. Conduct a detailed feasibility study to evaluate optimum processes and technologies that could be integrated to produce a "closed loop" bioenergy system to better manage energy, water and waste in UN peace missions.	Such a study should consider solid and liquid waste volumes, calorific value, storage and treatment, as well as potential energy yields from anaerobic digestion processes in the form of biogas. Further, it would evaluate conversion of biogas to electrical and heat energy using conventional engines and alternative technologies such as fuel cells.	UNEP experts
5. Conduct an environmental baseline study at the two camp sites in order to document baseline environmental conditions. Perform an environmental impact assessment (EIA).	Prior to the installation of the HQ Camp and Support Base, an EIA should be undertaken. This assessment will also facilitate the development of an appropriate environmental management plan and subsequent mitigation measures for anticipated impacts. The completion of an EIA will comply with the requirements of the DPKO/DFS Environmental Policy.	DFS/Mission – environmental officer/engineer with assistance from FOI

8.3 Medium-term recommendations for camp operation

The recommendations offered below relate to the operational phase of the HQ Camp and Support Base and are intended to be implemented within the next 3-6 months in parallel with the construction of the camps.

Recommendation	Reasoning	Responsibility
6. Develop and implement an environmental management plan (EMP)	Based on the outcomes of an EIA, the EMP should address all aspects of resource use and reduction, as well as waste management. It should be developed in the early stages of the camp operation and identify specific operational targets for resource efficiency. It should treated as a working document which can be updated as needed based on the outcomes of on-going data collection.	DFS/Mission – environmental officer/ engineer
7. Develop and implement a data collection programme for energy and waster consumption as well as waste production	A comprehensive approach to the collection of data will provide information on the effectiveness of the 'green' ranked items that have been integrated within the design. This is essential in monitoring performance, assessing suitability and identifying subsequent resource savings. This will also facilitate compliance with the UN climate neutrality strategy.	DFS/Mission – environmental officer/ engineer

8.4 Long-term recommendations for future camp design

The recommendations offered below relate to future camp design processes for UNSOA.

Recommendation	Reasoning	Responsibility
8. Modify existing DFS camp development spreadsheet and develop a Sustainability Appraisal Camp Toolkit	The existing DSF camp development spreadsheet can be modified to include resource efficiency measures. This could include active calculations relating to costs of installation and operation and associated reductions on energy, carbon, water and waste. A dedicated "how to" toolkit is also needed for UN peacekeeping activities that would help deliver sustainability objectives in a practical manner on the ground. The toolkit should cover the five main phases of a camp lifecycle: identification of sites, planning, set up, management and decommissioning/liquidation	DFS and UNEP
9. Conduct a resource efficiency review for all new camps at the outset of the design process. This task should be completed by a dedicated member of the DFS engineering team using external resources (including UNEP) as necessary.	Design plans for all new camps should undergo a resource efficiency review for energy, water and waste. The methodology used in this report could act as a template for further elaboration and eventually become a new standard approach. Resource efficient technologies that become embedded in the standard design specifications for all camps should be carefully monitoring for performance and cost-benefits.	DFS
10. Review the use of resource efficiency measures installed in other camps for peace operations	Other camps for peace operations which employ best practice in the use of resource efficiency measures should be identified and monitored. Lessons learned and cost-benefit analysis should be conducted in order to identify best practice and to select suitable measures for integration into standard camp design specifications.	DFS and UNEP

Appendix 1 – Power demand profiles

Assumptions applied to both camps

Accommodation		
width	65	m^2
length	79	m^2
height	3	m^2
total area	5135	m^2
accommodation	1640	m^2
remaining areas	3495	m^2
volume	15'405	m^3

Conversion Factors		
Diesel	0.25	kg CO_2/kWh
Diesel	2.63	kg CO_2/l
Litres to kWh	10.9	litres to kWh
Diesel	38%	% efficient
Gallons to litre	5	g
COP = EER / 3.412	3.412	Refrig eff

BTU to kW		
	0.000293	
BTU	**kW**	
12000	3.516	
18000	5.274	
24000	7.032	
1 ton cooling	**12000**	**BTU**

Air con units		
Units	**BTU**	**Cooling**
19	12000	3.516
57	18000	5.274
114	24000	7.032
190	54000	

Appendix 2 – Endnotes

1 Detailed Mission Guidelines – Environmental Guidelines on Waste Management, United Nations Mission in Sudan, 4 March 2009

2 "Safe disposal" in the assessment refers to the protection of the receiving environment and the local communities

3 The DPKO/DFS Environmental Policy for UN Field Missions "encourage(s) the reuse of treated wastewater by the mission."(paragraph 38)

4 UK Environment Agency - Conserving Water in Buildings, 2007. http://www.environment-agency.gov.uk/static/documents/Leisure/geho1107bnjree_1934318.pdf

5 http://www.unemg.org/sustainableun

6 http://www.unemg.org/sustainableun

7 It is important to note that separate batch processes are required for medical waste. Shredded paper could be used to boost combustion efficiency.

8 Biodegradation is the decomposition of organic matter by micro-organisms such as bacteria, fungi or algae.

9 Reference can also be made to a number of documents from the US Army Engineering School, NATO or the trilateral Finland-Sweden-US Environmental Guidebook for Military operations.

10 http://www.unep.fr/scp/sun/procurement.htm

11 http://www.unep.fr/scp/sun/project/

12 http://www.globalreporting.org/Home

13 http://www.reap.ac.uk/

14 http://www.scpnet.org.uk/reeio.html

15 http://www.usgbc.org/LEED/

16 http://www.breeam.org/

17 http://www.ibec.or.jp/CASBEE/english/index.htm

18 http://www.gbca.org.au/green-star/

19 http://www.un.org/millenniumgoals/environ.shtml

20 http://www.unemg.org/climateneutralun/Portals/24/Documents/BecomingClimateNeutral/EmissionsReduction/Procurement/SPpoliciesHandbk/POLICYSustainableProcurementPracticeNote.pdf

21 http://www.unemg.org/sustainableun

22 http://www.un.org/esa/sustdev/sdissues/consumption/spp_web_info.htm

23 http://www.unemg.org/climateneutralun/Portals/24/Documents/BecomingClimateNeutral/EmissionsReduction/Procurement/TrainingKit/TRAININGResourceBook_UNSustainableProcurementTraining.pdf

Appendix 3 – Ranked energy reduction measures

HQ Camp

Use	Current design	Potential re-design options	Brief specification and design implications	Comments	Strengths	Weaknesses	Modifications required to make viable	Carbon saving	Ranking
External Lighting	Lights rated at 250w, 230 lamp-posts (fitted currently with timers), supplementing 200 x 250w and 250 x 400w sodium flood lights, centrally powered from generators	Stand alone renewable powered lamp-posts	There are a number of manufacturers of renewable lamp stands utilising solar and wind (e.g. windela)	A practical solution providing security enhancement and cost savings (although high capital outlay). Questions over sufficient energy requirement.	The use of stand alone lamps allows for rapid replacement. Cost savings for cable and security enhancements	Low energy output - not sufficient power for use and not sufficient length of use, capital outlay, battery lifetime, brightness not sufficient for application	No threshold size. Light quality and battery life to be investigated.	Low/ medium	
Internal lighting	Conventional fluorescent units; 2 x 40 watts – 800 of each.	LED (reduced wattage)	LED lights are higher efficiency than fluorescent tubes. Lights may dim with high current. Electrical design needs to take account of this.	Further details to follow on progress with LED technology and application with camp lighting	Low energy	May require dedicated fittings and modified electrical design	Further research on light quality and potential impact of changes in current	Low	
		Occupancy sensors	Lights controlled by occupancy. Can be through Passive Infra-Red (PIR) (movement) sensors, timers, occupancy settings (only work if door closed or key installed)	With parts of the camp used at different times, occupancy control can save energy	Lights will turn off if area not occupied	Expensive technology. Some areas not feasible for health and safety concerns.	All modules should be equipped with some form of occupancy controls	Low/ medium	
		Ambient light sensors	Photo receptors respond to levels of light. Would be suitable for ground floor	Potential application on ground floor and perimeter lights. Some areas would not be suitable	Lights reduce in brightness in response to external lighting	Expensive	Would only be suitable to lights with perimeter widows	Low	

Use	Current design	Potential re-design options	Brief specification and design implications	Comments	Strengths	Weaknesses	Modifications required to make viable	Carbon saving	Ranking
Internal lighting	Conventional fluorescent units; 2 x 40 watts – 800 of each.	Use of natural lighting	Add roof lights to module units	Link with occupancy and light sensors	Increased lighting. May increase expense for additional windows	Could increase heat and therefore cooling requirements	No size threshold. Would need to link in with new roof double skin design	Low	
		Expert review	Have lighting requirements reviewed by experts - can luminaries be reduced in wattage and number but still meet desired lighting levels	N/A	Lighting designed to maximise use of light and efficiency	N/A	Threshold for larger camps	N/A	
		Deflectors	Light deflectors can increase lighting levels whilst allow wattage to decrease	Requires design to ensure works effectively	Increased light levels with lower wattage	Can cause glare	No size threshold	Low	
Cooling	Air conditioning is proposed to be 57 x 18000BTU (115volts/60hz, window type units and 19 x 12000BTU and 114 x 24000, Assumed COP of 3.2	Centralised system	Centralised system allows for increased control and greater efficiency. Design and Build contract being pursued	Requires significant design changes. Possible to find half way house with local air supply and centralised Variable Refrigerant Volume chillers (VRF) - Further design consideration required	Allows wider choice of technologies, greater efficiency and controls, reduced noise. Allows connection of low carbon technologies such as CHP and absorption cooling	Requires centralised (or zoned) cooling, centralised air handlings, possibly installation of ductwork or pipework. Will require additional plant secure area. Requires higher levels and cost of maintenance	Requires distribution of chilled water, or refrigerant from plant area to required area. Air can be locally or centrally controlled	High	

Use	Current design	Potential re-design options	Brief specification and design implications	Comments	Strengths	Weaknesses	Modifications required to make viable	Carbon saving	Ranking
Cooling	Air conditioning is proposed to be 57 x 18000BTU (115volts/60hz, window type units and 19 x 12000BTU and 114 x 24000, Assumed COP of 3.2	Air con key/occupancy isolators	Air con is occupancy controlled - like in hotels where air con only works with keys	Would be suitable to both centralised cooling and local supply. Could split between essential and non-essential electrical supply/requirements.	Ensures power only consumed when room is occupied	Requires additional electrical design. May not be suitable for room where some power is required. Comfort conditions may take time to achieve when occupied.	Would not provide steady state environmental conditions. Threshold depends on some thermal isolation of units and acceptance of time to cool. Cooling should be designed to keep room at minimal temp and work harder with detected occupancy. Assumed part of centralised control		
Cooling	Air conditioning is proposed to be 57 x 18000BTU (115volts/60hz, window type units and 19 x 12000BTU and 114 x 24000, Assumed COP of 3.2	Zoning	Separate air handling unit for each zone - but increased centralisation from individual units	Increased controls need to be designed with central air con and ventilation system	Provides increased control and energy savings	Increases complexity and possibly cost to camp design and construction	Part of centralised system	Medium	
		Materials	Use materials with high thermal mass. Assist with night ventilation (cooling) to reuse thermal mass in next day	Materials such as concrete with high thermal mass can be used to increase the thermal mass and provide a method to assist with reducing daytime temperatures and cooling requirement. Already using concrete. Need to make sure design allows for exposed thermal mass to make use of thermal properties.	Energy savings/more comfortable living and working environment	Usually more expensive materials.	Already in spec - must ensure materials are sufficiently exposed to make use of thermal properties	Low/ medium	

Use	Current design	Potential re-design options	Brief specification and design implications	Comments	Strengths	Weaknesses	Modifications required to make viable	Carbon saving	Ranking
Cooling	Air conditioning is proposed to be 57 x 18000BTU (115volts/60hz, window type units and 19 x 12000BTU and 114 x 24000, Assumed COP of 3.2	Phase Change materials	Similar to above but phase change material can be part of light weight construction material	Phase change materials may allow construction with light weight materials but with improved thermal properties. Not necessary as using concrete.	Energy savings/more comfortable living and working environment. May be able to use similar construction materials as current design	Possible expensive - could require night cooling to work	Threshold is if using lightweight construction. However maybe potential for some application with heavyweight construction. Potential to use phase change substances to improve efficiency of central plant	Low/ medium	
Cooling	Air conditioning is proposed to be 57 x 18000BTU (115volts/60hz, window type units and 19 x 12000BTU and 114 x 24000, Assumed COP of 3.2	Night cooling	Alongside use of appropriate materials, night ventilation (cooling) to reuse thermal mass in next day	Higher savings if linked to building materials with high thermal mass	Lowers cooling demand of the building	Needs integrated control with cooling and ventilation strategies. Need to balance energy used against cooling saved	Threshold is centralised plant or central control over ventilation with adequate measures to determine duration of cooling	Low/ medium	
		Coolth recovery	If centralised system warm air or hot water could be used to circulate captured heat to areas where it may be required e.g. kitchen and domestic hot water	Can save energy if application can be found	Saves energy from recovered heat	Low heat demand. Technology may not be economic. May require central store of hot water to work, therefore redesign of current hot water supply	Threshold is sufficient heat requirement and services (i.e. water store) to make use of the heat	Low	
		Air recirculation	Use recalculated and fresh air for 'free cooling' where possible before mechanical cooling. Greater feasibility with centralised system	Most efficient with centralised system	Greater control over the volume and temperature of the supply air	Greater complexity in design	Already in draft spec	Low/ medium	

Use	Current design	Potential re-design options	Brief specification and design implications	Comments	Strengths	Weaknesses	Modifications required to make viable	Carbon saving	Ranking
Cooling	Air conditioning is proposed to be 57 x 18000BTU (115volts/60hz, window type units and 19 x 12000BTU and 114 x 24000, Assumed COP of 3.2	Free cooling	(Enthalpy Cooling) To reduce energy consumption, sensors detect cooling capacity of external air. Draws in more than basic fresh air requirement which reduced mechanical cooling	Requires controls to monitor inside and outside temperatures and facility to increase ventilation without cooling	Energy savings	May increase design complexity	Threshold requires control over air and cooling - more likely to be central control	Medium	
Cooling	Air conditioning is proposed to be 57 x 18000BTU (115volts/60hz, window type units and 19 x 12000BTU and 114 x 24000, Assumed COP of 3.2	Air ducts/earth tubes	Deliver air through a series of tunnels or ducts underneath the building. Lowers air temperature before use of chillers	Would require further design to determine depth and size of earth tubes and to calculate carbon savings. Would require a centralised air handling system	Reduce cooling load	Requires specific building design to include earth tubes. Expensive. Depth needs to be sufficient to benefit from cooler temperatures	Threshold depends on including central air and size of camp to make it cost effective	Medium	
		Use ground source heat pump	Using open (aquifer) or closed (boreholes/building piles) efficiency of cooling can be improved	Significant construction required for either option that probably would not be possible unless permanent camp. Would require centralised system.	Energy savings	Cost/ Requires drilling many boreholes or availability of aquifer water	Only suitable if borehole or suitable water body is available	Medium	

Use	Current design	Potential re-design options	Brief specification and design implications	Comments	Strengths	Weaknesses	Modifications required to make viable	Carbon saving	Ranking
Cooling	Air conditioning is proposed to be 57 x 18000BTU (115volts/60hz, window type units and 19 x 12000BTU and 114 x 24000, Assumed COP of 3.2	Evaporative Cooling	Mechanical process of lowering outside air temperature from process of evaporating stored water. Uses chimneys to create temperature differential .	Cooling output may not be sufficient for building loads. Potential to combine with mechanical chillers and use in evaporative mode to gain best efficiencies	Cheaper to install, easier to maintain, consumes less energy, can provide humiliation, increase air change rate	Works in climates where air is hot and humidity is low. Less suitable for locations with high humidity. May not be sufficient to achieve high cooling demands. Requires a constant supply of water	Would be suited to smaller stand alone buildings. Access to water required (specific quantity to be determined from size of cooling requirement). therefore not suggested as viable at present	Medium/ high	
Cooling	Air conditioning is proposed to be 57 x 18000BTU (115volts/60hz, window type units and 19 x 12000BTU and 114 x 24000, Assumed COP of 3.2	Evaporative cooling chillers	If used with centralised evaporative chillers - evap cooling can still be employed to gain efficiencies	Requires centralised cooling to provide benefits	Higher efficiencies than local air con units. Provides central control and zoning	Works better in Centralised, potentially large item of plant and requires supply of water. Increased maintenance and required water treatment	More common with centralised system. Water requirements to be finalised with more detailed design information. Therefore not suggested as viable at present	Medium/ high	
		Water cooling	Use the pool for improved efficiency of heat exchange	Potential to link the evaporative chillers with installed pool. However water may not be sufficient for required heat transfer and may heat too much to be used for anything else.	Improved efficiency of heat transfer between chillers/air con units	the pool is unlikely to be at sufficient depth that can provide realistic heat transfer	Need to determine cooling load and potential for using water. Appears unlikely that water would be sufficient	Medium	

Use	Current design	Potential re-design options	Brief specification and design implications	Comments	Strengths	Weaknesses	Modifications required to make viable	Carbon saving	Ranking
Cooling	Air conditioning is proposed to be 57 x 18000BTU (115volts/60hz, window type units and 19 x 12000BTU and 114 x 24000, Assumed COP of 3.2	Coolerado ™ cooling	New technology to make use of evaporative properties of water for cooling	In the right situation this is a very efficient technology. However requires constant supply of water	Very energy efficient, suited to dry climates (better at altitude), no refrigerants, can be used with photovoltaic to reduce energy consumption	Products available on small scale, requires constant supply cold water to work	Assumed not viable for the site further assessment on water availability required. Threshold will be whether sufficient and suitable water available.		
Cooling	Air conditioning is proposed to be 57 x 18000BTU (115volts/60hz, window type units and 19 x 12000BTU and 114 x 24000, Assumed COP of 3.2	Air tightness	Minimise loss of treated air (and ingress of outside air) through good air tightness in the construction and airtight openings such as doors and windows	With high levels of air tightness good controls are required and necessary levels of ventilation to ensure comfort conditions. May be difficult to achieve for modular units	Saves energy from reduced cooling loss and enables greater temp control	Requires good ventilation and cooling control. If too airtight will heat too quickly. Therefore balance is required	No threshold	Low	
		Insulation on internal partitions	Minimises cooling loads between separate units	Need balance for thermal insulation between spaces at difference temperatures and benefit of sharing services and temperature zones	Enables tighter zonal control	Areas cannot share services is shut off from each other	No threshold	Low	

Use	Current design	Potential re-design options	Brief specification and design implications	Comments	Strengths	Weaknesses	Modifications required to make viable	Carbon saving	Ranking
Cooling	Air conditioning is proposed to be 57 x 18000BTU (115volts/60hz, window type units and 19 x 12000BTU and 114 x 24000, Assumed COP of 3.2	Solar cooling (1) - Heat dissipation	Solar cooling - Solar thermal technology can also be used to cool a building by dissipating heat collected during the day at night into cool air.	Mature technology. Should be used in conjunction with suitable building materials to realised benefits.	Energy savings. Can be used as solar heating during day	May deliver limited energy savings. Depends on size of array. Requires increased design work to link with cooling and hot water heating	Further research to determine if suitable for this application. Would be most suited to centralised system	Low	
		Solar Cooling (2) - connect solar thermal to absorption chiller	Solar thermal used to drive an absorption chiller	Requires 1.85 m2 for every kW of cooling	Make use of solar thermal technology	Expensive technology with potentially high maintenance	Worth pursuing further research as would be ideal for this application. More detailed research into size and suitability for application required	High	
Cooling	Air conditioning is proposed to be 57 x 18000BTU (115volts/60hz, window type units and 19 x 12000BTU and 114 x 24000, Assumed COP of 3.2	Solar Cooling (3) - Use photovoltaic for electricity	Photovoltaics used to lower the electricity consumption or air conditioning units		Photovoltaic suited to hot, sunny countries	Expensive and requires suitable area	Photovoltaic should be used on site.		
		Solar air conditioning	Utilises thermal energy (from solar collectors) to drive an absorption chiller. This low carbon solution can also be delivered using a Combined Heat and Power unit.	Cost effectiveness will depend on requirements for heat and power and whether solar thermal can provide sufficient heat for cooling. Back-up generator would be required	Could provide low cost cooling	Effectiveness depends of amount of heat available. Could require large solar thermal system to deliver energy. Plant can be expensive	Further investigation required on the array size and appropriateness of application.	Medium/ high	

Use	Current design	Potential re-design options	Brief specification and design implications	Comments	Strengths	Weaknesses	Modifications required to make viable	Carbon saving	Ranking
Cooling	Air conditioning is proposed to be 57 x 18000BTU (115volts/60hz, window type units and 19 x 12000BTU and 114 x 24000, Assumed COP of 3.2	Solar desiccant technology	Uses solar thermal energy to dry a desiccant and air to lower humidity of air (making it feel cooler). Will require new ventilation design with dessication material	More detailed assessment of design implications and potential energy savings required	Will lower cooling requirements	May add cost and complexity to design	Further research required to determine cooling benefits and appropriateness to Mogadishu climate	Low/ medium	
		Orientation	Orientate building so that high occupancy areas are in North of building (south in South Hemisphere).	Best orientation needs to be determined. Energy balance on which areas would benefit from sun shading. Also implications of east/west glare can be included in design	No cost energy saving solution	Needs to be integrated at beginning of design process	All camps should consider orientation to minimise solar gain	Low	
		Solar tinted glass	Use coated glass that allows sunlight but reflects heat from the building	May have limited impact as building designed as bunker	Low cost energy saving solution	May affect window design	Already in draft specification. Use as appropriate	Low	
Cooling	Air conditioning is proposed to be 57 x 18000BTU (115volts/60hz, window type units and 19 x 12000BTU and 114 x 24000, Assumed COP of 3.2	Shading	Use shading/blinds/solar tinted windows to reduce solar gain	Consider most cost effective shading method	Low cost energy saving solution	External shading could be difficult to install on modular design. Shading can be expensive way to reduce solar gain	Should only be for specific areas. Can be expensive	Low	

Use	Current design	Potential re-design options	Brief specification and design implications	Comments	Strengths	Weaknesses	Modifications required to make viable	Carbon saving	Ranking
Cooling	Air conditioning is proposed to be 57 x 18000BTU (115volts/60hz, window type units and 19 x 12000BTU and 114 x 24000, Assumed COP of 3.2	Refrigerants	Carbon emissions associated with leakage of refrigerants	Refrigerant leakage contains GHG emissions. Ensuring good maintenance and choice of refrigerant will lower any climate impact	Part of good practice maintenance regime	If replacing refrigerant need to ensure it can perform to required standard	Draft specification outlined use of zero ozone depleting substances in all air con units	Low	
Ventilation	Current requirement 6 ACH	Zoning	Separate air handling unit for each zone - but increased centralisation from individual units	Increased controls need to be designed with central air con and ventilation system	Provides increased control and energy savings	Increases complexity and possibly cost to camp design and construction	Local control provides zoning - however efficiency gains when this is controlled	Medium	
		VSD on fans	Large fans and pumps should all be fitted with variable drives to reduce energy consumption	Variable speed drives match power demand with load	Reduced energy demand	May not be suitable for small fans and pumps. Most suitable for centralised system or larger air handling units/distribution systems.	should be used on all large centralised pumps and fans	Low/ medium	
Domestic hot water	Point of use heaters - spec to be confirmed	Solar thermal	Use solar thermal panels to produce hot water	Potential change to current design	Low energy solution	Capital outlay. Will require store of hot water and therefore change to current design	Requires water store. Therefore a number of separate systems or one large system (which could be more efficient with diversity) is required	Low/ medium	

Use	Current design	Potential re-design options	Brief specification and design implications	Comments	Strengths	Weaknesses	Modifications required to make viable	Carbon saving	Ranking
Domestic hot water	Point of use heaters - spec to be confirmed	Insulated thermal immersions	Ensure all hot water stores and pipework have sufficient insulation	Probably already included - but worth checking if any pipework insulation specification can be improved	Minimise loss of energy	Size of pipework increase	For all cooling and heating distribution systems	Low	
		Reduced water consumption	Low flow taps, catering with pull taps, dishwashers	Worth ensuring all fittings enable low water consumption	Minimise loss of energy	May be more difficult to user	Measures outlined with draft specification	Low	
		Control	Only allow hot water to be used at certain times of day - put hot water units on timers	Control when water can be used centrally to minimise losses	Minimise loss of energy	Need to be careful that disease control is still taken account of. Users may complain	Link with use	Low	
Server rooms	Two-three server rooms in the camp. Assumed cooled	Temp control and layout	Use free-cooling where possible and do not overcool. Server rooms are often cooled too much and arranged to block cooling pathways. Clear design and guidance on temperature settings will reduce energy consumption		Minimise loss of energy	Need to ensure that server functions are not affected	Design of all server rooms should consider temperature requirement and guidance on placement of servers	Low	
Kitchen Appliances		A+ rated appliances	Appliances are highest efficiency	Should use most efficient equipment	Low energy	Potential increase in capital cost	On all appliances	Low	
		Thermal isolation	Ensure fridges and freezers are thermally isolated from ovens	Fridges and freezers have to work use more energy in hotter environments - therefore is more efficient to isolate	Reduces energy demand of kitchen equipment	Space may not be available	Where feasible. If necessary consider new modal design	Low	

Use	Current design	Potential re-design options	Brief specification and design implications	Comments	Strengths	Weaknesses	Modifications required to make viable	Carbon saving	Ranking
Kitchen Appliances		Kitchen energy manageme nt plan	Make sure kitchen has energy efficiency management plan - equipment off when not need and kitchen fan with VSD	Management reduced emissions	Management reduced emissions	N/A	All sites	Low	
Small power	Assumed standard PC/laptop with docking port. Assumed no switching off	A+ rated appliances	Appliances are highest efficiency	Should use most efficient equipment	Low energy	Potential increase in capital cost	On all appliances	Low	
	Timers	Timers on printers/pho tocopiers and recreation equipment	Add timers to link with occupancy	Reduce energy consumption	Reduce energy consumption	None	On all appliances	Low	
	Micro photovoltaic and battery	Small photovoltaic charges for mobiles and non-essential IT equipment	Use small renewables to save on energy demand	Reduce energy consumption	Reduce energy consumption	Capital cost	Where feasible and does not affect use	Low	
Controls	Assumed all manual control of air con units, lights and equipment	Centralise control (simple management system). Ensure local controls have sufficient occupancy and temperature controls	Form of simple temp, time controls to total Building Management System (BMS) for centralised control of cooling, lighting, ventilation	May only be suitable with more centralised control	Allows timing to be set (relate to occupancy), centrally set room condition (and can limit occupancy changes) can measure consumption, allow for zoning	Expensive, will require dedicated staff to run, expertise required if malfunctions	On local or central systems methods of occupancy and temp control should be employed	Medium	
Transport	No information on vehicle use provided	Operational restrictions - Idling	Vehicle management and operation plans can reduce energy consumption	Reduced energy demand	Reduced energy demand	None	Where feasible	Low	
		Operational restrictions - Speed limiters	Vehicle management and operation plans can reduce energy consumption	Reduced energy demand	Reduced energy demand	None	Where feasible	Low	

Use	Current design	Potential re-design options	Brief specification and design implications	Comments	Strengths	Weaknesses	Modifications required to make viable	Carbon saving	Ranking
Transport	No information on vehicle use provided	Maintenance	Follow clear maintenance regime reduces energy	Reduced energy demand	Reduced energy demand	None	All vehicles	Low	
Transport	No information on vehicle use provided	Biofuel	Biodiesel fuels can reduces transport emissions	All sites should consider using biofuel content of vehicle fuels, biofuels work better in hotter environment	Easy, low cost way to imbed carbon savings	Depending on level of biodiesel can affect engine.	Threshold requires suitable vehicles and access to fuel. A proportion of biofuel will have no detrimental impact to engines.	Low/ medium	
		Electric vehicles	Vehicles used for short distances could be powered from photovoltaic with back-up battery	Increased use of electric vehicles for appropriate uses	Lower local carbon emissions, higher efficiency, lower cost, potential to use photovoltaic to generate electricity	Shorter distances and top speeds	Assessment of vehicles uses are present and whether can be linked to electricity	Low/ medium	
Pumps and fans		Any large fans or pumps should have a Variable Speed Drive	Large fans and pumps should all be fitted with variable drives to reduce energy consumption	Variable speed drives match power demand with load.	Reduced energy demand	May not be suitable for small fans and pumps		Low/ medium	
Renewables and low carbon technologies		Photovoltaic cells (also see solar cooling). Within draft specification	Photovoltaic systems convert energy from the sun into electricity through semi-conductors cells, most commonly made of silicon. To be used in conjunction with battery back-up. Thin film incorporated into roof. Could be integrated into roof at manufacture.	Photovoltaic cells produce electricity. Need to ensure can link with current electrical design	Reduced electrical requirements (and lots of sunshine)	Capital cost is high. Large area may be required to deliver noticeable savings		Low/ medium	
		Solar thermal (see solar cooling and hot water sections)							

Use	Current design	Potential re-design options	Brief specification and design implications	Comments	Strengths	Weaknesses	Modifications required to make viable	Carbon saving	Ranking
Renewables and low carbon technologies		Solar concentration	A number of solar concentrating technologies exist which can lead to high thermal temperatures and the generation of electricity. Mainly uses solar thermal concentration but also with photovoltaics	Further research is required	Suitable for hot climates, can generate power and clean water from solar concentration	New technology, may not be suitable at the small scale	Further research required to determine threshold and optimal technology. Solar chimneys to generate electricity in hot countries appears most viable. Recommended this option is considered in further detail as will be a key future low energy technology	High	
		Solar cooling	Mentioned above - use of solar thermal heat and absorption cooling	Requires 1.85 m2 for every kW of cooling	See above	See above	Worth pursuing further research as would be ideal for this application. More detailed research into size and suitability for application required	High	
		Wind turbines	Either roof mounted or stand alone to provide electricity	Wind turbines can provide free electricity. Need to link with current electrical design. Intermittent power - will require back up supplies. Can be used at off peak hours or generate hydrogen for fuel cell	Reduces energy demand	Rood mounted turbines provide limited energy. Stand alone will require careful siting and foundation. Will also need to link in with electricity generation from site	Threshold depends on wind speed, suitable location for siting turbine, security risk (height of turbine), skills for installation. Need to consider use of wind to make hydrogen in off-peak for fuel cell	Low/ medium/ high - dependin g on size	

Use	Current design	Potential re-design options	Brief specification and design implications	Comments	Strengths	Weaknesses	Modifications required to make viable	Carbon saving	Ranking
Renewables and low carbon technologies		CHP - with heating for hot water or cooling through absorption chiller	A diesel CHP could generate electricity with the waste heat utilised within an absorption chiller.	CHP provides heat and power from one unit increasing the efficiency. In this situation where generator is being used it may be economic to ensure heat is captured - this could be used for cooling. Need to make sure this does not compete for energy demand	Provides heat and power- improves efficiency on current design where heat is wasted from generators	Need continual outlet for heat otherwise may not be economic in design. Hot water load will also compete with solar thermal technology if installed. Large plant may be difficult to deliver to site. Absorption chiller is also large plant	Requires centralised system and absorption chiller to make use of waste heat (if hot water demand is not sufficient). Need to undertake detailed energy modelling to determine viability. Need to consider size and transport feasibility of CHP and absorption chiller. CHP could be specified with heat store to make more efficient. Assumed for now that cooling load not high enough for absorption chiller and solar thermal more suitable for hot water. Threshold for absorption cooling to be determined	Medium/ high	

Use	Current design	Potential re-design options	Brief specification and design implications	Comments	Strengths	Weaknesses	Modifications required to make viable	Carbon saving	Ranking
Renewables and low carbon technologies		Fuel cells - with heating for hot water or cooling through absorption chiller	Like CHP fuel cells produce heat and power. Can run on fossil fuels, hydrogen	An important technology to demonstrate. However expensive	Provides heat and power in higher ratio of electricity: heat than CHP therefore potentially more suitable. If using hydrogen from wind, high savings	Expensive- still considered not commercially viable	Further research into suitable type and fuel source required. Requires centralised system and absorption chiller to make use of waste heat (if hot water demand is not sufficient). Need to undertake detailed energy modelling to determine viability	Medium/ high	
Renewables and low carbon technologies		Biodiesel generators, CHP and transport fuels	Fuels using part or all biofuel can reduce emissions	Biofuels can realise significant carbon savings. But issues over supply, sustainability of production, cost and carbon content need to be resolved	Reduced emissions	Security and cost of fuel supply and use of engine may be compromised unless expert is available	Threshold depends on access to fuel and suitable technology and skilled maintenance staff	High	
		Waste to energy systems	Potential to use energy from waste over a threshold size of camp. This is being looked at in the waste review				Potential to use energy from waste over a threshold size of camp. This is being looked at in the waste review		
Metering	Assumed diesel is monitored for consumption but further sub-metering	Meters on main plant and across main areas of site	Measuring energy consumption helps to monitor consumption, benchmark against similar sites and develop targets for reduction	Metering is essential to energy management	Allows plans to be formalised to reduce energy consumption	Can be expensive to install meters and needs user interface and someone who knows how to use it	Metering should be provided for main plant. Threshold size of camp and load would apply.	zero direct savings but useful tool to monitor savings	

Use	Current design	Potential re-design options	Brief specification and design implications	Comments	Strengths	Weaknesses	Modifications required to make viable	Carbon saving	Ranking
Thermal modelling	No thermal modelling currently employed, but is in new draft specification	Use of thermal modelling	Can develop thermal model to demonstrate energy consumption of future building and the impact of energy saving measures		Assists design and enables measurement and targets for carbon emissions from particular buildings	Requires detailed specification, and details of occupancy use to be accurate, may not include all energy saving measures/idea s	In draft specification. Should be undertaken for all camps. Specifically generic design should be made that could be tested for each location and climatic conditions	zero direct savings but useful tool to design efficient building	

Support Base

Use	Current design	Potential re-design options	Brief specification and design implications	Comments	Strengths	Weaknesses	Modifications required to make viable	Carbon saving	Ranking
External Lighting	Lights rated at 250w, 230 lamp-posts (fitted currently with timers), supplementing 200 x 250w and 250 x 400w sodium flood lights, centrally powered from generators	Stand alone renewable powered lamp-posts	There are a number of manufacturers of renewable lamp stands utilising solar and wind (e.g. windela)	A practical solution providing security enhancement and cost savings (although high capital outlay). Questions over sufficient energy requirement.	The use of stand alone lamps allows for rapid replacement. Cost savings for cable and security enhancements	Low energy output - not sufficient power for use and not sufficient length of use, capital outlay, battery lifetime, brightness not sufficient for application	No threshold size. Light quality and battery life to be investigated.	Low/ medium	
Internal Lighting	Conventional fluorescent units; 2 x 40 watts – 800 of each.	LED (reduced wattage)	LED lights are higher efficiency than fluorescent tubes. Lights may dim with high current. Electrical design needs to take account of this.	Further details to follow on progress with LED technology and application with camp lighting	Low energy	May require dedicated fittings and modified electrical design	Further research on light quality and potential impact of changes in current	Low	
		Occupancy sensors	Lights controlled by occupancy. Can be through Passive Infra-Red (PIR) (movement) sensors, timers, occupancy settings (only work if door closed or key installed)	With parts of the camp used at different times, occupancy control can save energy	Lights will turn off if area not occupied	Expensive technology. Some areas not feasible for health and safety concerns.	All modules should be equipped with some form of occupancy controls	Low/ medium	
		Ambient light sensors	Photo receptors respond to levels of light. Would be suitable for ground floor	Potential application on ground floor and perimeter lights. Some areas would not be suitable	Lights reduce in brightness in response to external lighting	Expensive	Would only be suitable to lights with perimeter widows	Low	

Use	Current design	Potential re-design options	Brief specification and design implications	Comments	Strengths	Weaknesses	Modifications required to make viable	Carbon saving	Ranking
Internal Lighting	Conventional fluorescent units; 2 x 40 watts – 800 of each.	Use of natural lighting	Add roof lights to module units	Link with occupancy and light sensors	Increased lighting. May increase expense for additional windows	Could increase heat and therefore cooling requirements	No size threshold. Would need to link in with new roof double skin design	Low	
		Expert review	Have lighting requirements reviewed by experts - can luminaries be reduced in wattage and number but still meet desired lighting levels	N/A	Lighting designed to maximise use of light and efficiency	N/A	Threshold for larger camps	N/A	
		Deflectors	Light deflectors can increase lighting levels whilst allow wattage to decrease	Requires design to ensure works effectively	Increased light levels with lower wattage	Can cause glare	No size threshold	Low	
Cooling	Air conditioning is proposed to be 57 x 18000BTU (115volts/60hz, window type units and 19 x 12000BTU and 114 x 24000, Assumed COP of 3.2	Centralised system	Centralised system allows for increased control and greater efficiency. Design and Build contract being pursued	Requires significant design changes. Possible to find half way house with local air supply and centralised Variable Refrigerant Volume chillers (VRF) - Further design consideration required	Allows wider choice of technologies, greater efficiency and controls, reduced noise. Allows connection of low carbon technologies such as CHP and absorption cooling	Requires centralised (or zoned) cooling, centralised air handlings, possibly installation of ductwork or pipework. Will require additional plant secure area. Requires higher levels and cost of maintenance	As temporary assumed not centrally controlled	High	
		Air con key/occupancy isolators	Air con is occupancy controlled - like in hotels where air con only works with keys	Would be suitable to both centralised cooling and local supply. Could split between essential and non-essential electrical supply/requirements.	Ensures power only consumed when room is occupied	Requires additional electrical design. May not be suitable for room where some power is required. Comfort conditions may take time to achieve when occupied.	Would not provide steady state environmental conditions. Threshold depends on some thermal isolation of units and acceptance of time to cool. Cooling should be designed to keep room at minimal temp and work harder with detected occupancy		

Use	Current design	Potential re-design options	Brief specification and design implications	Comments	Strengths	Weaknesses	Modifications required to make viable	Carbon saving	Ranking
Cooling	Air conditioning is proposed to be 57 x 18000BTU (115volts/60hz, window type units and 19 x 12000BTU and 114 x 24000, Assumed COP of 3.2	Zoning	Separate air handling unit for each zone - but increased centralisation from individual units	Increased controls need to be designed with central air con and ventilation system	Provides increased control and energy savings	Increases complexity and possibly cost to camp design and construction	Difficult to achieve full zone control without centralised system, However measure in place for some zone control	Medium	
		Materials	Use materials with high thermal mass. Assist with night ventilation (cooling) to reuse thermal mass in next day	Materials such as concrete with high thermal mass can be used to increase the thermal mass and provide a method to assist with reducing daytime temperatures and cooling requirement. Already using concrete. Need to make sure design allows for exposed there	Energy savings/more comfortable living and working environment	Usually more expensive materials.	Assumed lightweight structure with limited thermal mass	Low/ medium	
		Phase Change materials	Similar to above but phase change material can be part of light weight construction material	Phase change materials may allow construction with light weight materials but with improved thermal properties. Not necessary as using concrete.	Energy savings/more comfortable living and working environment. May be able to use similar construction materials as current design	Possible expensive - could require night cooling to work	Worth considering however phase change will need sufficient nigh cooling to be effective	Low/ medium	

Use	Current design	Potential re-design options	Brief specification and design implications	Comments	Strengths	Weaknesses	Modifications required to make viable	Carbon saving	Ranking
Cooling	Air conditioning is proposed to be 57 x 18000BTU (115volts/60hz, window type units and 19 x 12000BTU and 114 x 24000, Assumed COP of 3.2	Night cooling	Alongside use of appropriate materials, night ventilation (cooling) to reuse thermal mass in next day	Higher savings if linked to building materials with high thermal mass	Lowers cooling demand of the building	Needs integrated control with cooling and ventilation strategies. Need to balance energy used against cooling saved	In draft specification. Would be essential with phase change materials	Low/ medium	
		Coolth recovery	If centralised system warm air or hot water could be used to circulate captured heat to areas where it may be required e.g. kitchen and domestic hot water	Can save energy if application can be found	Saves energy from recovered heat	Low heat demand. Technology may not be economic. May require central store of hot water to work, therefore redesign of current hot water supply	Threshold is sufficient heat requirement and services (i.e. water store) to make use of the heat	Low	
		Air recirculation	Use recalculated and fresh air for 'free cooling' where possible before mechanical cooling. Greater feasibility with centralised system	Most efficient with centralised system	Greater control over the volume and temperature of the supply air	Greater complexity in design	Already in draft spec	Low/ medium	
		Free cooling	(Enthalpy Cooling) To reduce energy consumption, sensors detect cooling capacity of external air. Draws in more than basic fresh air requirement which reduced mechanical cooling	Requires controls to monitor inside and outside temperatures and facility to increase ventilation without cooling	Energy savings	May increase design complexity	Threshold requires control over air and cooling - more likely to be central control.	Medium	

Use	Current design	Potential re-design options	Brief specification and design implications	Comments	Strengths	Weaknesses	Modifications required to make viable	Carbon saving	Ranking
Cooling	Air conditioning is proposed to be 57 x 18000BTU (115volts/60hz, window type units and 19 x 12000BTU and 114 x 24000, Assumed COP of 3.2	Air ducts/earth tubes	Deliver air through a series of tunnels or ducts underneath the building. Lowers air temperature before use of chillers	Would require further design to determine depth and size of earth tubes and to calculate carbon savings. Would require a centralised air handling system	Reduce cooling load	Requires specific building design to include earth tubes. Expensive. Depth needs to be sufficient to benefit from cooler temperatures	Threshold depends on including central air	Medium	
Cooling	Air conditioning is proposed to be 57 x 18000BTU (115volts/60hz, window type units and 19 x 12000BTU and 114 x 24000, Assumed COP of 3.2	Use ground source heat pump	Using open (aquifer) or closed (boreholes/building piles) efficiency of cooling can be improved	Significant construction required for either option that probably would not be possible unless permanent camp. Would require centralised system.	Energy savings	Cost/ Requires drilling many boreholes or availability of aquifer water	Only suitable if borehole or suitable water body is available	Medium	
		Evaporative Cooling	Mechanical process of lowering outside air temperature from process of evaporating stored water. Uses chimneys to create temperature differential .	Cooling output may not be sufficient for building loads. Potential to combine with mechanical chillers and use in evaporative mode to gain best efficiencies	Cheaper to install, easier to maintain, consumes less energy, can provide humiliation, increase air change rate	Works in climates where air is hot and humidity is low. Less suitable for locations with high humidity. May not be sufficient to achieve high cooling demands. Requires a constant supply of water	Would be suited to smaller stand alone buildings. Access to water required (specific quantity to be determined from size of cooling requirement). therefore not suggested as viable at present	Medium/ high	

Use	Current design	Potential re-design options	Brief specification and design implications	Comments	Strengths	Weaknesses	Modifications required to make viable	Carbon saving	Ranking
Cooling	Air conditioning is proposed to be 57 x 18000BTU (115volts/60hz, window type units and 19 x 12000BTU and 114 x 24000, Assumed COP of 3.2	Evaporative cooling chillers	If used with centralised evaporative chillers - evap cooling can still be employed to gain efficiencies	Requires centralised cooling to provide benefits	Higher efficiencies than local air con units. Provides central control and zoning	Works better in Centralised, potentially large item of plant and requires supply of water. Increased maintenance and required water treatment	More common with centralised system. Water requirements to be finalised with more detailed design information. Therefore not suggested as viable at present	Medium/ high	
Cooling	Air conditioning is proposed to be 57 x 18000BTU (115volts/60hz, window type units and 19 x 12000BTU and 114 x 24000, Assumed COP of 3.2	Water cooling	Use the pool for improved efficiency of heat exchange	Potential to link the evaporative chillers with installed pool. However water may not be sufficient for required heat transfer and may heat too much to be used for anything else.	Improved efficiency of heat transfer between chillers/air con units	the pool is unlikely to be at sufficient depth that can provide realistic heat transfer	Need to determine cooling load and potential for using water. Appears unlikely that water would be sufficient	Medium	
		Coolerado™ cooling	New technology to make use of evaporative properties of water for cooling	In the right situation this is a very efficient technology. However requires constant supply of water	Very energy efficient, suited to dry climates (better at altitude), no refrigerants, can be used with photovoltaic to reduce energy consumption	Products available on small scale, requires constant supply cold water to work	Assumed viable for the site with access to sufficient and suitable water		

Use	Current design	Potential re-design options	Brief specification and design implications	Comments	Strengths	Weaknesses	Modifications required to make viable	Carbon saving	Ranking
Cooling	Air conditioning is proposed to be 57 x 18000BTU (115volts/60hz, window type units and 19 x 12000BTU and 114 x 24000, Assumed COP of 3.2	Air tightness	Minimise loss of treated air (and ingress of outside air) through good air tightness in the construction and airtight openings such as doors and windows	With high levels of air tightness good controls are required and necessary levels of ventilation to ensure comfort conditions. May be difficult to achieve for modular units	Saves energy from reduced cooling loss and enables greater temp control	Requires good ventilation and cooling control. If too airtight will heat too quickly. Therefore balance is required	No threshold	Low	
		Insulation on internal partitions	Minimises cooling loads between separate units	Need balance for thermal insulation between spaces at difference temperatures and benefit of sharing services and temperature zones	Enables tighter zonal control	Areas cannot share services is shut off from each other	No threshold	Low	
Cooling	Air conditioning is proposed to be 57 x 18000BTU (115volts/60hz, window type units and 19 x 12000BTU and 114 x 24000, Assumed COP of 3.2	Solar cooling (1) - Heat dissipation	Solar cooling - Solar thermal technology can also be used to cool a building by dissipating heat collected during the day at night into cool air.	Mature technology. Should be used in conjunction with suitable building materials to realised benefits.	Energy savings. Can be used as solar heating during day	May deliver limited energy savings. Depends on size of array. Requires increased design work to link with cooling and hot water heating	Further research to determine if suitable for this application. Would be most suited to centralised system	Low	
		Solar Cooling (2) - connect solar thermal to absorption chiller	Solar thermal used to drive an absorption chiller	Requires 1.85 m2 for every kW of cooling	Make use of solar thermal technology	Expensive technology with potentially high maintenance	Worth pursuing further research as would be ideal for this application. More detailed research into size and suitability for application required. Assumed this site would use Coolerado™ technology	High	

Use	Current design	Potential re-design options	Brief specification and design implications	Comments	Strengths	Weaknesses	Modifications required to make viable	Carbon saving	Ranking
Cooling	Air conditioning is proposed to be 57 x 18000BTU (115volts/60hz, window type units and 19 x 12000BTU and 114 x 24000, Assumed COP of 3.2	Solar Cooling (3) - Use photovoltaic for electricity	Photovoltaics used to lower the electricity consumption or air conditioning units		Photovoltaic suited to hot, sunny countries	Expensive and requires suitable area	Photovoltaic should be used on site. Photovoltaic utilised with Coolerado™ is can be very efficient system		
		Solar air conditioning	Utilises thermal energy (from solar collectors) to drive an absorption chiller. This low carbon solution can also be delivered using a Combined Heat and Power unit.	Cost effectiveness will depend on requirements for heat and power and whether solar thermal can provide sufficient heat for cooling. Back-up generator would be required	Could provide low cost cooling	Effectiveness depends of amount of heat available. Could require large solar thermal system to deliver energy. Plant can be expensive	Further investigation required on the array size and appropriateness of application.	Medium/ high	
Cooling	Air conditioning is proposed to be 57 x 18000BTU (115volts/60hz, window type units and 19 x 12000BTU and 114 x 24000, Assumed COP of 3.2	Solar desiccant technology	Uses solar thermal energy to dry a desiccant and air to lower humidity of air (making it feel cooler). Will require new ventilation design with desiccation material	More detailed assessment of design impactions and potential energy savings required	Will lower cooling requirements	May add cost and complexity to design	Further research required to determine cooling benefits and appropriateness to Mogadishu climate	Low/ medium	
		Orientation	Orientate building so that high occupancy areas are in North of building (south in South Hemisphere).	Best orientation needs to be determined. Energy balance on which areas would benefit from sun shading. Also impactions of east/west glare can be included in design	No cost energy saving solution	Needs to be integrated at beginning of design process	All camps should consider orientation to minimise solar gain	Low	
		Solar Tinted glass	Use coated glass that allows sunlight but reflects heat from the building	May have limited impact as building designed as bunker	Low cost energy saving solution	May affect window design	Already in draft specification. Use as appropriate	Low	

Use	Current design	Potential re-design options	Brief specification and design implications	Comments	Strengths	Weaknesses	Modifications required to make viable	Carbon saving	Ranking
Cooling	Air conditioning is proposed to be 57 x 18000BTU (115volts/60hz, window type units and 19 x 12000BTU and 114 x 24000, Assumed COP of 3.2	Shading	Use shading/blinds/solar tinted windows to reduce solar gain	Consider most cost effective shading method	Low cost energy saving solution	External shading could be difficult to install on modular design. Shading can be expensive way to reduce solar gain	Should only be for specific areas. Can be expensive	Low	
		Refrigerants	Carbon emissions associated with leakage of refrigerants	Refrigerant leakage contains GHG emissions. Ensuring good maintenance and choice of refrigerant will lower any climate impact	Part of good practice maintenance regime	If replacing refrigerant need to ensure it can perform to required standard	Draft specification outlined use of zero ozone depleting substances in all air con units	Low	
Ventilation	Current requirement 6 ACH	Zoning	Separate air handling unit for each zone - but increased centralisation from individual units	Increased controls need to be designed with central air con and ventilation system	Provides increased control and energy savings	Increases complexity and possibly cost to camp design and construction	Local control provides zoning - however efficiency gains when this is controlled	Medium	
		VSD on fans	Large fans and pumps should all be fitted with variable drives to reduce energy consumption	Variable speed drives match power demand with load	Reduced energy demand	May not be suitable for small fans and pumps. Most suitable for centralised system or larger air handling units/distribution systems.	should be used on all large centralised pumps and fans	Low/ medium	

Use	Current design	Potential re-design options	Brief specification and design implications	Comments	Strengths	Weaknesses	Modifications required to make viable	Carbon saving	Ranking
Domestic hot water	Point of use heaters - spec to be confirmed	Solar thermal	Use solar thermal panels to produce hot water	Potential change to current design	Low energy solution	Capital outlay. Will require store of hot water and therefore change to current design	Requires water store. Therefore a number of separate systems or one large system (which could be more efficient with diversity) is required	Low/ medium	
		Insulated thermal immersions	Ensure all hot water stores and pipework have sufficient insulation	Probably already included - but worth checking if any pipework insulation specification can be improved	Minimise loss of energy	Size of pipework increase	For all cooling and heating distribution systems	Low	
		Reduced water consumptio n	Low flow taps, catering with pull taps, dishwashers	Worth ensuring all fittings enable low water consumption	Minimise loss of energy	May be more difficult to user	Measures outlined with draft specification	Low	
		Control	Only allow hot water to be used at certain times of day - put hot water units on timers	Control when water can be used centrally to minimise losses	Minimise loss of energy	Need to be careful that disease control is still taken account of. Users may complain	Link with use	Low	
Server rooms	Two-three server rooms in the camp. Assumed cooled	Temp control and layout	Use free-cooling where possible and do not overcool. Server rooms are often cooled too much and arranged to block cooling pathways. Clear design and guidance on temperature settings will reduce energy consumption		Minimise loss of energy	Need to ensure that server functions are not affected	Design of all server rooms should consider temperature requirement and guidance on placement of servers	Low	

Use	Current design	Potential re-design options	Brief specification and design implications	Comments	Strengths	Weaknesses	Modifications required to make viable	Carbon saving	Ranking
Kitchen Appliances		A+ rated appliances	Appliances are highest efficiency	Should use most efficient equipment	Low energy	Potential increase in capital cost	On all appliances	Low	
		Thermal isolation	Ensure fridges and freezers are thermally isolated from ovens	Fridges and freezers have to work use more energy in hotter environments - therefore is more efficient to isolate	Reduces energy demand of kitchen equipment	Space may not be available	Where feasible. If necessary consider new module design	Low	
		Kitchen energy managemen t plan	Make sure kitchen has energy efficiency management plan - equipment off when not need and kitchen fan with VSD	Management reduced emissions	Management reduced emissions	N/A	All sites	Low	
Small power	Assumed standard PC/laptop with docking port. Assumed no switching off	A+ rated appliances	Appliances are highest efficiency	Should use most efficient equipment	Low energy	Potential increase in capital cost	On all appliances	Low	
	Timers	Timers on printers/phot ocopiers and recreation equipment	Add timers to link with occupancy	Reduce energy consumption	Reduce energy consumption	None	On all appliances	Low	
	Micro photovoltaic and battery	Small photovoltaic charges for mobiles and non-essential IT equipment	Use small renewables to save on energy demand	Reduce energy consumption	Reduce energy consumption	Capital cost	Where feasible and does not affect use	Low	

Use	Current design	Potential re-design options	Brief specification and design implications	Comments	Strengths	Weaknesses	Modifications required to make viable	Carbon saving	Ranking
Controls	Assumed all manual control of air con units, lights and equipment	Centralise control (simple managemen t system). Ensure local controls have sufficient occupancy and temperature controls	Form of simple temp, time controls to total Building Management System (BMS) for centralised control of cooling, lighting, ventilation	May only be suitable with more centralised control	Allows timing to be set (relate to occupancy), centrally set room condition (and can limit occupancy changes) can measure consumption, allow so for zoning	Expensive, will require dedicated staff to run, expertise required if malfunctions	On local or central systems methods of occupancy and temp control should be employed	Medium	
Transport	No information on vehicle use provided	Operational restrictions - Idling	Vehicle management and operation plans can reduce energy consumption	Reduced energy demand	Reduced energy demand	None	Where feasible	Low	
		Operational restrictions - Speed limiters	Vehicle management and operation plans can reduce energy consumption	Reduced energy demand	Reduced energy demand	None	Where feasible	Low	
		Maintenanc e	Follow clear maintenance regime reduces energy	Reduced energy demand	Reduced energy demand	None	All vehicles	Low	
		Biofuel	Biodiesel fuels can reduces transport emissions	All sites should consider using biofuel content of vehicle fuels, biofuels work better in hotter environment	Easy, low cost way to imbed carbon savings	Depending on level of biodiesel can affect engine.	Threshold requires suitable vehicles and access to fuel. A proportion of biofuel will have no detrimental impact to engines.	Low/ medium	
		Electric vehicles	Vehicles used for short distances could be powered from photovoltaic with back-up battery	Increased use of electric vehicles for appropriate uses	Lower local carbon emissions, higher efficiency, lower cost, potential to use photovoltaic to generate electricity	Shorter distances and top speeds	Assessment of vehicles uses are present and whether can be linked to electricity	Low/ medium	

Use	Current design	Potential re-design options	Brief specification and design implications	Comments	Strengths	Weaknesses	Modifications required to make viable	Carbon saving	Ranking
Pumps and fans		Any large fans or pumps should have a Variable Speed Drive	Large fans and pumps should all be fitted with variable drives to reduce energy consumption	Variable speed drives match power demand with load.	Reduced energy demand	May not be suitable for small fans and pumps		Low/ medium	
Renewables and low carbon technologies		Photovoltaic cells (also see solar cooling). Within draft specification	Photovoltaics systems convert energy from the sun into electricity through semi-conductors cells, most commonly made of silicon. To be used in conjunction with battery back-up. Thin film incorporated into roof. Could be integrated into roof at manual	Photovoltaic cells produce electricity. Need to ensure can link with current electrical design	Reduced electrical requirements (and lots of sunshine)	Capital cost is high. Large area may be required to deliver noticeable savings		Low/ medium	
		Solar thermal (see solar cooling and hot water sections)							
		Solar concentratio n	A number of solar concentrating technologies exist which can lead to high thermal temperatures and the generation of electricity. Mainly uses solar thermal concentration but also with photovoltaics	Further research is required	Suitable for hot climates, can generate power and clean water from solar concentration	New technology, may not be suitable at the small scale	Further research required to determine threshold and optimal technology. Solar chimneys to generate electricity in hot countries appears most viable. Recommended this option is considered in further detail as will be a key future low energy technology	High	

Use	Current design	Potential re-design options	Brief specification and design implications	Comments	Strengths	Weaknesses	Modifications required to make viable	Carbon saving	Ranking
Renewables and low carbon technologies		Solar absorption cooling	Mentioned above - use of solar thermal heat and absorption cooling	Requires 1.85 m2 for every kW of cooling	see above	see above	Worth pursuing further research as would be ideal for this application. More detailed research into size and suitability for application required	High	
Renewables and low carbon technologies		Wind turbines	Either roof mounted or stand alone to provide electricity	Wind turbines can provide free electricity. Need to link with current electrical design. Intermittent power - will require back up supplies. Can be used at off peak hours or generate hydrogen for fuel cell	Reduces energy demand	Rood mounted turbines provide limited energy. Stand alone will require careful identification of sites and set up. Will also need to link in with electricity generation from site	Threshold depends on wind speed, suitable location for siting turbine, security risk (height of turbine), skills for installation. Need to consider use of wind to make hydrogen in off-peak for fuel cell	Low/ medium/ high - dependi ng on size	
		CHP - with heating for hot water or cooling through absorption chiller	A diesel CHP could generate electricity with the waste heat utilised within an absorption chiller.	CHP provides heat and power from one unit increasing the efficiency. In this situation where generator is being used it may be economic to ensure heat is captured - this could be used for cooling. Need to make sure this does not compete for energy demand	Provides heat and power-improves efficiency on current design where heat is wasted from generators	Need continual outlet for heat otherwise may not be economic in design. Hot water load will also compete with solar thermal technology if installed. Large plant may be difficult to deliver to site. Absorption chiller is also large plant	Requires centralised system and absorption chiller to make use of waste heat (if hot water demand is not sufficient). Need to undertake detailed energy modelling to determine viability. Need to consider size and transport feasibility of CHP and absorption	Medium/ high	

Use	Current design	Potential re-design options	Brief specification and design implications	Comments	Strengths	Weaknesses	Modifications required to make viable	Carbon saving	Ranking
Renewables and low carbon technologies		Fuel Cells - with heating for hot water or cooling through absorption chiller	Like CHP fuel cells produce heat and power. Can run on fossil fuels, hydrogen	An important technology to demonstrate. However expensive	Provides heat and power in higher ratio of electricity: heat than CHP therefore potentially more suitable. If using hydrogen from wind, high savings	Expensive- still considered not commercially viable	Further research into suitable type and fuel source required. Requires centralised system and absorption chiller to make use of waste heat (if hot water demand is not sufficient). Need to undertake detailed energy modelling to determine viability	Medium/ high	
		Biodiesel Generators, CHP and transport fuels	Fuels using part or all biofuel can reduce emissions	Biofuels can realise significant carbon savings. But issues over supply, sustainability of production, cost and carbon content need to be resolved	Reduced emissions	Security and cost of fuel supply and use of engine may be compromised unless expert is available	Threshold depends on access to fuel and suitable technology and skilled maintenance staff	High	
		Waste to energy systems	Potential to use energy from waste over a threshold size of camp. This is being looked at in the waste review				Potential to use energy from waste over a threshold size of camp. This is being looked at in the waste review		
Metering	Assumed diesel is monitored for consumption but further sub-metering	Meters on main plant and across main areas of site	Measuring energy consumption helps to monitor consumption, benchmark against similar sites and develop targets for reduction	Metering is essential to energy management	Allows plans to be formalised to reduce energy consumption	Can be expensive to install meters and needs user interface and someone who knows how to use it	Metering should be provided for main plant. Threshold size of camp and load would apply.	zero direct savings but useful tool to monitor savings	

Use	Current design	Potential re-design options	Brief specification and design implications	Comments	Strengths	Weaknesses	Modifications required to make viable	Carbon saving	Ranking
Thermal modeling	No thermal modelling currently employed, but is in new draft specification	Use of thermal modeling	Can develop thermal model to demonstrate energy consumption of future building and the impact of energy saving measures		Assists design and enables measurement and targets for carbon emissions from particular buildings	Requires detailed specification, and details of occupancy use to be accurate, may not include all energy saving measures/ideas	In draft specification. Should be undertaken for all camps. Specifically generic design should be made that could be tested for each location and climatic conditions	zero direct savings but useful tool to design efficient building	

Appendix 4 – Ranked water reduction measures

Use	Current design	Water consumption (litres - per person/day)	Potential re-design options	Brief specification and design implications	Comments	Strengths	Weaknesses	Water savings	Difficulty of installation	Ranking
showers	non-regulated conventional showers running from hot water tank at 30 litres per shower (average at 6 mins per shower)	30	use of aerated shower heads				requires minimum of 1 bar to operate effectively	30%	retrofitting for existing shower installation - alterations to the procurement specification will ensure roll out across DPKO. Pumping may be required to reach 1 bar	
			install mixer valves to better control temperature regulation		use of mixer valves reduces water demand by reducing water lag time (i.e. residence time of water in pipes)				retrofitting could be achieved although would require more operational resource	
toilets	single cistern siphon flush	10	dual flush toilets		this would involve installation of new cisterns or retrofit of existing single siphon flush		users require education to use the correct function. Prone to leakage and breaking	40%		

Use	Current design	Water consumption (litres - per person/day)	Potential re-design options	Brief specification and design implications	Comments	Strengths	Weaknesses	Water savings	Difficulty of installation	Ranking
toilets	single cistern siphon flush		reduce cistern capacity	install water saving devices in toilet cistern (offsets volume)		low cost		20%	simple devices require minimum installation requirements	
			variable flush	use of a knob rotated around the flush mechanism		effective at variable volumes of water saving	user requires education - not suitable for those lacking incentive	40%		
			compost toilets	compost toilets are waterless relying on natural bacteria to break down the organic waste - waste can be used as compost	this achieves high water savings but requires daily attention	saves 100% water. organic waste can be used as compost once broken down.	needs daily attention to ensure bacteria remain active.	100%	compost toilets will require the development of a new specification - it is felt that they are generally impractical to the requirements of a peacekeeping mission but could be used as a trial	
urinals	urinal continuous flushing system i.e. no controls	180 (litres per urinal per day)	install flush controllers	controllers often are dependant on the presence of people therefore requiring motion or light sensors		the same electrical circuit can be used as for the lighting controls	a complex system compared to the two below with more risks of leaks and/or failures.	50%	installation of infra-red or motion sensors - either specified at procurement stage or extensive retro-fitting	

Use	Current design	Water consumption (litres - per person/day)	Potential re-design options	Brief specification and design implications	Comments	Strengths	Weaknesses	Water savings	Difficulty of installation	Ranking
urinals	urinal continuous flushing system i.e. no controls		single flush urinals	each user activates a flush mechanism	if the flush mechanism is not activated more water will be saved	this can save significant water volumes.		70%	these are already common-place and any supplier of toilet ware would be able to supply these	
			waterless urinals	no water is used - odours are eliminated with 'odour blocks'		total water savings, avoids flooding and potential mis-use	does not deal with blockages as effectively as water - requires use of traps. Requires regular sluicing (weekly). Possible hygiene perception problems	100%	procurement specifications will require revision	
hand washing	use of conventional (non-efficient taps)	5	install flow regulators	spray taps or inserts (tapmagic)		reduces water flow with the illusion of higher flow rates	prone to blocking as a response of calcium build up	80%		
				sensor taps or timed push on - off		prevent flooding and improves hygiene		80%		

Use	Current design	Water consumption (litres - per person/day)	Potential re-design options	Brief specification and design implications	Comments	Strengths	Weaknesses	Water savings	Difficulty of installation	Ranking
kitchen washing	use of conventional (non-efficient taps)	5	install flow regulators	spray taps or inserts (tapmagic) or cartridges installed into single lever taps	flow regulators work by reducing the volume of flow used in handwashing , teeth brushing etc. available at a variety of settings including 8, 6 and 5 litres	reduces water flow with the illusion of higher flow rates	increases the time taken to fill a sink as compared to conventional taps	80%	use of spray taps would require retrofitting or changes to the procurement specification - simple retrofitting can achieve immediate results	
				sensor taps or timed push on - off	removes the flow automatically	prevent flooding and improves hygiene		80%		
dishwashing	use of conventional dishwasher	35 (per machine per operation)	use of A rated machines	these can be easily obtained and should not prove difficult			slightly higher capital expenditure	20%		
food preparation	use of conventional (non-efficient taps)	5	install flow regulators	spray taps or inserts (tapmagic)		reduces water flow with the illusion of higher flow rates		80%		
				sensor taps or timed push on - off		prevent flooding and improves hygiene		80%		

Use	Current design	Water consumption (litres - per person/day)	Potential re-design options	Brief specification and design implications	Comments	Strengths	Weaknesses	Water savings	Difficulty of installation	Ranking
air conditioning units	air conditioning is proposed to be 57 x 18000BTU (115volts/60hz, window type units and 19 x 12000BTU and 114 x 24000, assumed COP of 3.2	3200 per day - all AC units	use of centralised system	further research is required on the relative savings of water against energy for closed or open loop centralised systems						
laundry	use of conventional washing machine	35 (per machine per operation)	use of A rated machines	these can be easily obtained and should not prove difficult			slightly higher capital expenditure	20		

Appendix 5 – Ranked solid waste reduction measures

HQ Camp

Source of Waste	Waste type or Material	Current design	Potential re-design options	Brief specification and design implications	Strengths	Weaknesses	Ranking
Office	paper	re-used where possible	develop re-use opportunities further	purchase printers with default double sided printing, procurement of recycled paper	standard recycled paper suppliers spec	potential security issue? develop waste management/re-use/minimisation plan	
			burn, collect energy	small scale thermal treatment plant	volume reduction, "inert" output/residual	complex plant (spares?), trained operators, throughput too low? combine wastes from a number of camps?	
		recycled	segregate, collect, recycle	contractor vetting, formal or informal arrangements?	adds value to local community	potential security issue?	
		landfill	landfill	design details readily available	easy to handle, dispose	engineered landfill design required, leachate and gas management required	
			compost or anaerobic digester	shredding, mixing with green or food waste	equipment available	market for outputs? Send solids residues to on-site landfill	

Source of Waste	Waste type or Material	Current design	Potential re-design options	Brief specification and design implications	Strengths	Weaknesses	Ranking
Office	paper		burn, collect energy	small scale thermal treatment plant	volume reduction, heat and/or power generation, "inert" output/residual waste	complex plant (spares?), trained operators, throughput too low? combine wastes from a number of camps?	
	printer cartridges	landfill	landfill	design details readily available	easy to handle, dispose	engineered landfill design required, leachate and gas management required	
			collect, return	closed-loop recycling I.e return to suppliers or re-processors	common practice, established mechanism	potential security issue?	
	metallic	recycled	landfill	design details readily available	easy to handle, dispose	engineered landfill design required, leachate and gas management required	
			segregate, collect, recycle	Simple segregation/collection arrangements and equipment	common practice, established mechanism, provides value to locals	potential security issue? spent (and live?) ordnance?	
	non-metallic	landfill	landfill	design details readily available	easy to handle, dispose	engineered landfill design required, leachate and gas management required	
			segregate, collect, recycle	simple segregation/collection arrangements and equipment	common practice, established mechanism, provides value to locals	potential security issue? spent (and live?) ordnance?	

Source of Waste	Waste type or Material	Current design	Potential re-design options	Brief specification and design implications	Strengths	Weaknesses	Ranking
Office	card from packaging	landfill	segregate, collect, recycle	simple segregation/collection arrangements and equipment	common practice, established mechanism, provides value to locals	potential security issue? spent ordnance?	
			landfill	design details readily available	easy to handle, dispose	engineered landfill design required, leachate and gas management required	
			burn, collect energy	small scale thermal treatment plant	volume reduction, heat and/or power generation, "inert" output/residual waste	Complex plant (spares?), trained operators, throughput too low? Combine wastes from a number of camps?	
Domestic	putrescibles	landfill	segregate, collect, compost or anaerobic digester	food waste macerators in kitchen module, discharge to "sewer", feedstock for anaerobic digester	equipment available	market for outputs? facility will require management, trained operator. Solid residues to on-site landfill	
			landfill	design details readily available	easy to handle, dispose	engineered landfill design required, leachate and gas management required	
	paper & cardboard	recycled as much as possible and remainder landfilled	segregate, collect, recycle	reduce packaging, suppliers to provide reusable totes, bins, bags	common practice, established mechanism, provides value to locals	potential security issue?	

Source of Waste	Waste type or Material	Current design	Potential re-design options	Brief specification and design implications	Strengths	Weaknesses	Ranking
Domestic	paper & cardboard		burn, collect energy	small scale thermal treatment plant	energy and heat generation, little landfill required	complexity, trained operators, energy required to reach and maintain adequate combustion temperature	
			compost or anaerobic digester	shredding, mixing with green and food waste	equipment available	market for outputs? facility will require management, trained operator. Solid residues to on-site landfill	
			landfill (no segregation required)	design details readily available	easy to handle, dispose	engineered landfill design required, leachate and gas management required	
	other combustibles	landfill	burn, collect energy (no segregation required)	small scale thermal treatment plant	volume reduction, heat and/or power generation, "inert" output/residual waste	complexity, trained operators, energy required to reach and maintain adequate combustion temperature	
			landfill (no segregation required)	design details readily available	easy to handle, dispose	engineered landfill design required, leachate and gas management required	

Source of Waste	Waste type or Material	Current design	Potential re-design options	Brief specification and design implications	Strengths	Weaknesses	Ranking
Domestic	other non-combustibles	landfill	landfill (no segregation required)	design details readily available	easy to handle, dispose	engineered landfill design required, leachate and gas management required	
	plastic	landfill	segregate, collect, recycle	simple segregation/collection arrangements and equipment	common practice, established mechanism, provides value to locals	potential security issue?	
			burn, collect energy (no segregation required)	small scale thermal treatment plant	volume reduction, heat and/or power generation, "inert" output/residual waste	complexity, trained operators, energy required to reach and maintain adequate combustion temperature	
	glass	landfill	landfill (no segregation required)	design details readily available	easy to handle, dispose	engineered landfill design required, leachate and gas management required	
			segregate, collect, recycle	simple segregation/collection arrangements and equipment	common practice, established mechanism, provides value to locals	potential security issue?	
	metals	landfill	landfill (no segregation required)	design details readily available	easy to handle, dispose	engineered landfill design required, leachate and gas management required	

Source of Waste	Waste type or Material	Current design	Potential re-design options	Brief specification and design implications	Strengths	Weaknesses	Ranking
Domestic	metals		segregate, collect, recycle	simple segregation/collection arrangements and equipment	common practice, established mechanism, provides value to locals	potential security issue?	
	fine material	landfill	landfill (no segregation required)	design details readily available	easy to handle, dispose	engineered landfill design required, leachate and gas management required	
	textile	landfill	segregate, collect, recycle	simple segregation/collection arrangements and equipment	common practice, established mechanism, provides value to locals	potential security issue?	
			landfill (no segregation required)	design details readily available	easy to handle, dispose	engineered landfill design required, leachate and gas management required	
	electrical equipment	landfill	landfill (no segregation required)	design details readily available	easy to handle, dispose	engineered landfill design required, leachate and gas management required	
			segregate, collect, return for recycling	simple segregation/collection arrangements and equipment	common practice, established mechanism, provides value to locals	storage, hazards, potential security issue?	
	other MSW	landfill	design details readily available	easy to handle, dispose	engineered landfill design required, leachate gas management required		

Source of Waste	Waste type or Material	Current design	Potential re-design options	Brief specification and design implications	Strengths	Weaknesses	Ranking
Domestic	other MSW		burn, collect energy	small scale thermal treatment plant	volume reduction, heat and/or power generation, "inert" output/residual waste	complex plant (spares?), trained operators, throughput too low? Combine wastes from a number of camps?	
Hazardous Chemicals	cleaning fluids, solvents, paints, out of date pharmaceuticals	not available	neutralise and landfill OR burn solvents, etc	trained personnel, guidance and facilities	avoids transport of hazardous chemicals	potential for error, mishap, landfill damage	
			collect, bulk like with like, return or transfer for treatment	requires enhanced logistical and security considerations	removes the hazardous wastes from site	risk of theft or terrorist act	
	dry-cell batteries	not available	replace where possible with rechargeable batteries	standard (retail) charger units	avoids frequent disposals	batteries will need to be replaced eventually, cost	
			segregate, collect, return for recycling/recovery/disposal	simple segregation/collection arrangements and equipment	common practice, established mechanism, provides value to locals	potential security issue?	
Vehicle Maintenance	oils	not available	collect, bulk like with like, return or transfer for treatment, recycling or disposal	requires enhanced logistical and security considerations	removes the hazardous wastes from site	risk of theft or terrorist act	
			burn, collect energy	small scale thermal treatment plant	volume reduction, heat and/or power generation, "inert" output/residual waste	complex plant (spares?), trained operators, throughput too low? Combine wastes from a number of camps?	

Source of Waste	Waste type or Material	Current design	Potential re-design options	Brief specification and design implications	Strengths	Weaknesses	Ranking
Vehicle Maintenance	rags	not available	burn, collect energy	small scale thermal treatment plant	volume reduction, heat and/or power generation, "inert" output/residual waste	complex plant (spares?), trained operators, throughput too low? combine wastes from a number of camps?	
			segregate, collect, return for recycling/recovery/disposal	clearly marked drums or boxes	avoids landfill	space for storage, transport arrangements, contamination	
	redundant parts	not available	landfill	design details readily available	easy to handle, dispose	engineered landfill design required, leachate and gas management required	
			segregate, collect, return for recycling/recovery/disposal	simple segregation/collection arrangements and equipment	common practice, established mechanism, provides value to locals	potential security issue?	
	lead/acid batteries	not available	segregate, collect, return for recycling/recovery/disposal	simple segregation/collection arrangements and equipment	common practice, established mechanism, provides value to locals	potential security issue? storage space, transport arrangements?	

Support Base

Source of Waste	Waste type or Material	Current design	Potential re-design options	Brief specification and design implications	Strengths	Weaknesses	Ranking
Office	paper	re-used where possible	develop re-use opportunities further	purchase printers with default double sided printing, procurement of recycled paper	standard recycled paper suppliers spec	potential security issue? develop waste management/re-use/minimisation plan	(green)
			burn, collect energy	small scale thermal treatment plant	volume reduction, "inert" output/residual	complex plant (spares?), trained operators, throughput too low? combine wastes from a number of camps?	(yellow)
		recycled	segregate, collect, recycle	contractor vetting, formal or informal arrangements?	adds value to local community	potential security issue?	(green)
		landfill	landfill	design details readily available	easy to handle, dispose	engineered landfill design required, leachate and gas management required	(yellow)
			compost or anaerobic digester	shredding, mixing with green or food waste	equipment available	market for outputs? Send solids residues to on-site landfill	(green)

Source of Waste	Waste type or Material	Current design	Potential re-design options	Brief specification and design implications	Strengths	Weaknesses	Ranking
Office	paper		burn, collect energy	small scale thermal treatment plant	volume reduction, heat and/or power generation, "inert" output/residual waste	complex plant (spares?), trained operators, throughput too low? combine wastes from a number of camps?	
	printer cartridges	landfill	landfill	design details readily available	easy to handle, dispose	engineered landfill design required, leachate and gas management required	
			collect, return	closed-loop recycling I.e return to suppliers or reprocessors	common practice, established mechanism	potential security issue?	
	metallic	recycled	landfill	design details readily available	easy to handle, dispose	engineered landfill design required, leachate and gas management required	
			segregate, collect, recycle	simple segregation/collection arrangements and equipment	common practice, established mechanism, provides value to locals	potential security issue? spent (and live?) ordnance?	
	non-metallic	landfill	landfill	design details readily available	easy to handle, dispose	engineered landfill design required, leachate and gas management required	
			segregate, collect, recycle	Simple segregation/collection arrangements and equipment	common practice, established mechanism, provides value to locals	potential security issue? spent (and live?) ordnance?	

Source of Waste	Waste type or Material	Current design	Potential re-design options	Brief specification and design implications	Strengths	Weaknesses	Ranking
Office	card from packaging	landfill	segregate, collect, recycle	simple segregation/collection arrangements and equipment	common practice, established mechanism, provides value to locals	potential security issue? spent ordnance?	
			landfill	design details readily available	easy to handle, dispose	engineered landfill design required, leachate and gas management required	
			burn, collect energy	small scale thermal treatment plant	volume reduction, heat and/or power generation, "inert" output/residual waste	complex plant (spares?), trained operators, throughput too low? combine wastes from a number of camps?	
Domestic	putrescibles	landfill	segregate, collect, compost or anaerobic digester	food waste macerators in kitchen module, discharge to "sewer", feedstock for anaerobic digester	equipment available	market for outputs? facility will require management, trained operator. Solid residues to on-site landfill	
			landfill	design details readily available	easy to handle, dispose	engineered landfill design required, leachate and gas management required	

Source of Waste	Waste type or Material	Current design	Potential re-design options	Brief specification and design implications	Strengths	Weaknesses	Ranking
Domestic	paper & cardboard	recycled as much as possible and remainder landfilled	segregate, collect, recycle	reduce packaging, suppliers to provide reusable totes, bins, bags	common practice, established mechanism, provides value to locals	potential security issue?	
			burn, collect energy	small scale thermal treatment plant	energy and heat generation, little landfill required	complexity, trained operators, energy required to reach and maintain adequate combustion temperature	
			compost or anaerobic digester	shredding, mixing with green and food waste	equipment available	market for outputs? facility will require management, trained operator. Solid residues to on-site landfill	
			landfill (no segregation required)	design details readily available	easy to handle, dispose	engineered landfill design required, leachate and gas management required	
	other combustibles	landfill	burn, collect energy (no segregation required)	small scale thermal treatment plant	volume reduction, heat and/or power generation, "inert" output/residual waste	complexity, trained operators, energy required to reach and maintain adequate combustion temperature	

Source of Waste	Waste type or Material	Current design	Potential re-design options	Brief specification and design implications	Strengths	Weaknesses	Ranking
Domestic	other combustibles		landfill (no segregation required)	design details readily available	easy to handle, dispose	engineered landfill design required, leachate and gas management required	
	other non-combustibles	landfill	landfill (no segregation required)	design details readily available	easy to handle, dispose	engineered landfill design required, leachate and gas management required	
	plastic	landfill	segregate, collect, recycle	simple segregation/collection arrangements and equipment	common practice, established mechanism, provides value to locals	potential security issue?	
			burn, collect energy (no segregation required)	small scale thermal treatment plant	volume reduction, heat and/or power generation, "inert" output/residual waste	complexity, trained operators, energy required to reach and maintain adequate combustion temperature	
	glass	landfill	landfill (no segregation required)	design details readily available	easy to handle, dispose	engineered landfill design required, leachate and gas management required	
			segregate, collect, recycle	simple segregation/collection arrangements and equipment	common practice, established mechanism, provides value to locals	potential security issue?	

Source of Waste	Waste type or Material	Current design	Potential re-design options	Brief specification and design implications	Strengths	Weaknesses	Ranking
Domestic	metals	landfill	landfill (no segregation required)	design details readily available	easy to handle, dispose	engineered landfill design required, leachate and gas management required	
			segregate, collect, recycle	simple segregation/collection arrangements and equipment	common practice, established mechanism, provides value to locals	potential security issue?	
	fine material	landfill	landfill (no segregation required)	design details readily available	easy to handle, dispose	engineered landfill design required, leachate and gas management required	
	textile	landfill	segregate, collect, recycle	simple segregation/collection arrangements and equipment	common practice, established mechanism, provides value to locals	potential security issue?	
			landfill (no segregation required)	design details readily available	easy to handle, dispose	engineered landfill design required, leachate and gas management required	
	electrical equipment	landfill	landfill (no segregation required)	design details readily available	easy to handle, dispose	engineered landfill design required, leachate and gas management required	
			segregate, collect, return for recycling	simple segregation/collection arrangements and equipment	common practice, established mechanism, provides value to locals	storage, hazards, potential security issue?	

Source of Waste	Waste type or Material	Current design	Potential re-design options	Brief specification and design implications	Strengths	Weaknesses	Ranking
Domestic	other MSW	landfill	design details readily available	easy to handle, dispose	engineered landfill design required, leachate gas management required		
Domestic	other MSW	landfill	burn, collect energy	small scale thermal treatment plant	volume reduction, heat and/or power generation, "inert" output/residual waste	complex plant (spares?), trained operators, throughput too low? combine wastes from a number of camps?	
Hazardous Chemicals	cleaning fluids, solvents, paints, out of date pharmaceuticals	not available	neutralise and landfill OR burn solvents, etc	trained personnel, guidance and facilities	avoids transport of haz chems	potential for error, mishap, landfill damage	
Hazardous Chemicals	cleaning fluids, solvents, paints, out of date pharmaceuticals	not available	collect, bulk like with like, return or transfer for treatment	trained personnel, guidance and facilities	removes from site		
Hazardous Chemicals	dry-cell batteries	not available	replace where possible with rechargeable batteries	standard (retail) charger units	avoids frequent disposals	batteries will need to be replaced eventually, cost	
Hazardous Chemicals	dry-cell batteries	not available	segregate, collect, return for recycling/recovery/dis posal	simple segregation/collection arrangements and equipment	common practice, established mechanism, provides value to locals	potential security issue?	
Vehicle Maintenance	oils	not available	burn, collect energy	small scale thermal treatment plant	volume reduction, heat and/or power generation, "inert" output/residual waste	complex plant (spares?), trained operators, throughput too low? combine wastes from a number of camps?	

Source of Waste	Waste type or Material	Current design	Potential re-design options	Brief specification and design implications	Strengths	Weaknesses	Ranking
Vehicle Maintenance	oils		collect, bulk like with like, return or transfer for treatment, recycling or disposal	requires enhanced logistical and security considerations	removes the hazardous wastes from site	risk of theft or terrorist act	
	rags	not available	burn, collect energy	small scale thermal treatment plant	volume reduction, heat and/or power generation, "inert" output/residual waste	complex plant (spares?), trained operators, throughput too low? combine wastes from a number of camps?	
			segregate, collect, return for recycling/recovery/disposal	clearly marked drums or boxes	avoids landfill	space for storage, transport arrangements, contamination	
	redundant parts	not available	landfill	design details readily available	easy to handle, dispose	engineered landfill design required, leachate and gas management required	
			segregate, collect, return for recycling/recovery/disposal	simple segregation/collection arrangements and equipment	common practice, established mechanism, provides value to locals	potential security issue?	
	lead/acid batteries	not available	segregate, collect, return for recycling/recovery/disposal	simple segregation/collection arrangements and equipment	common practice, established mechanism, provides value to locals	potential security issue? storage space, transport arrangements?	

Appendix 6 – Ranked liquid waste reduction measures

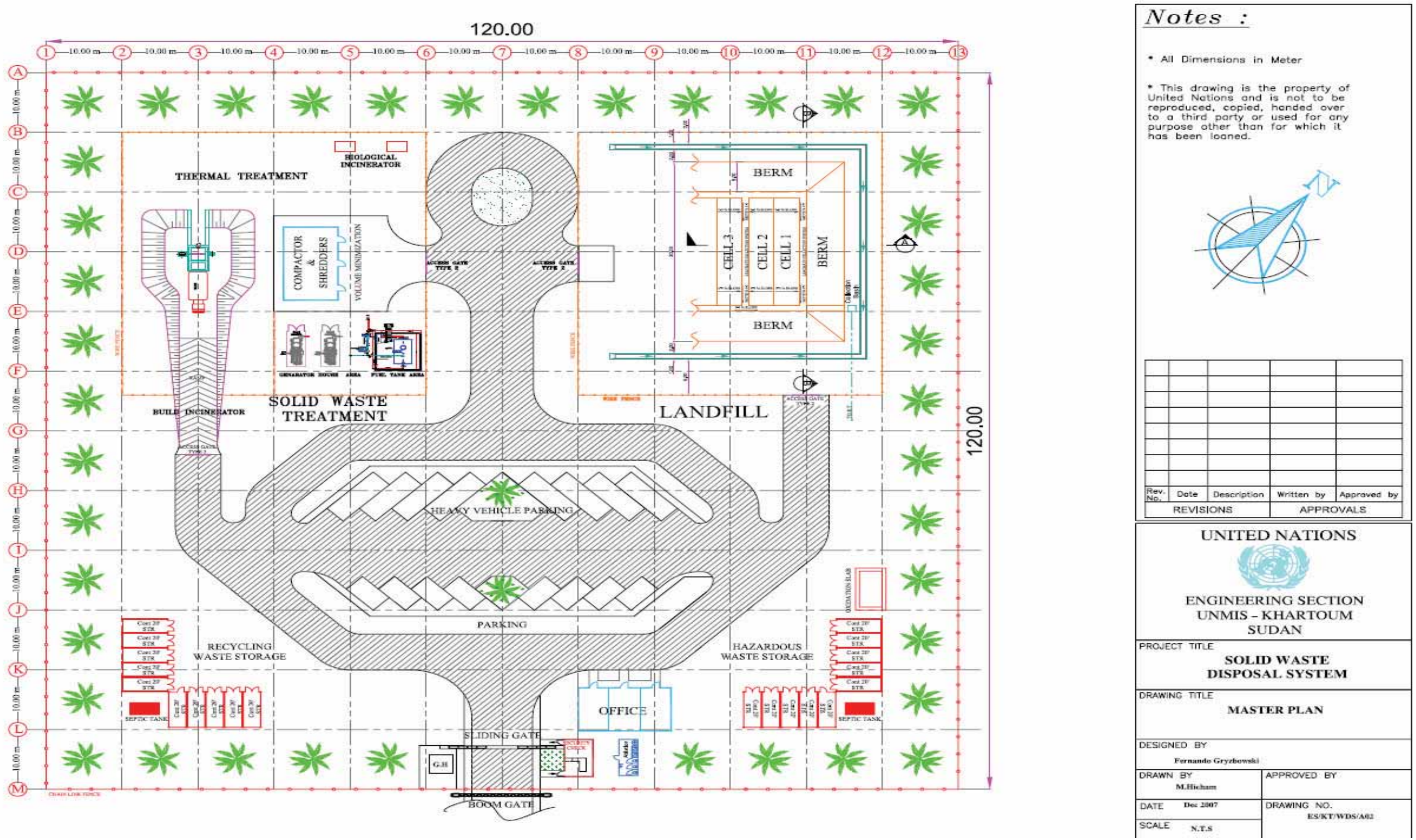
HQ Camp

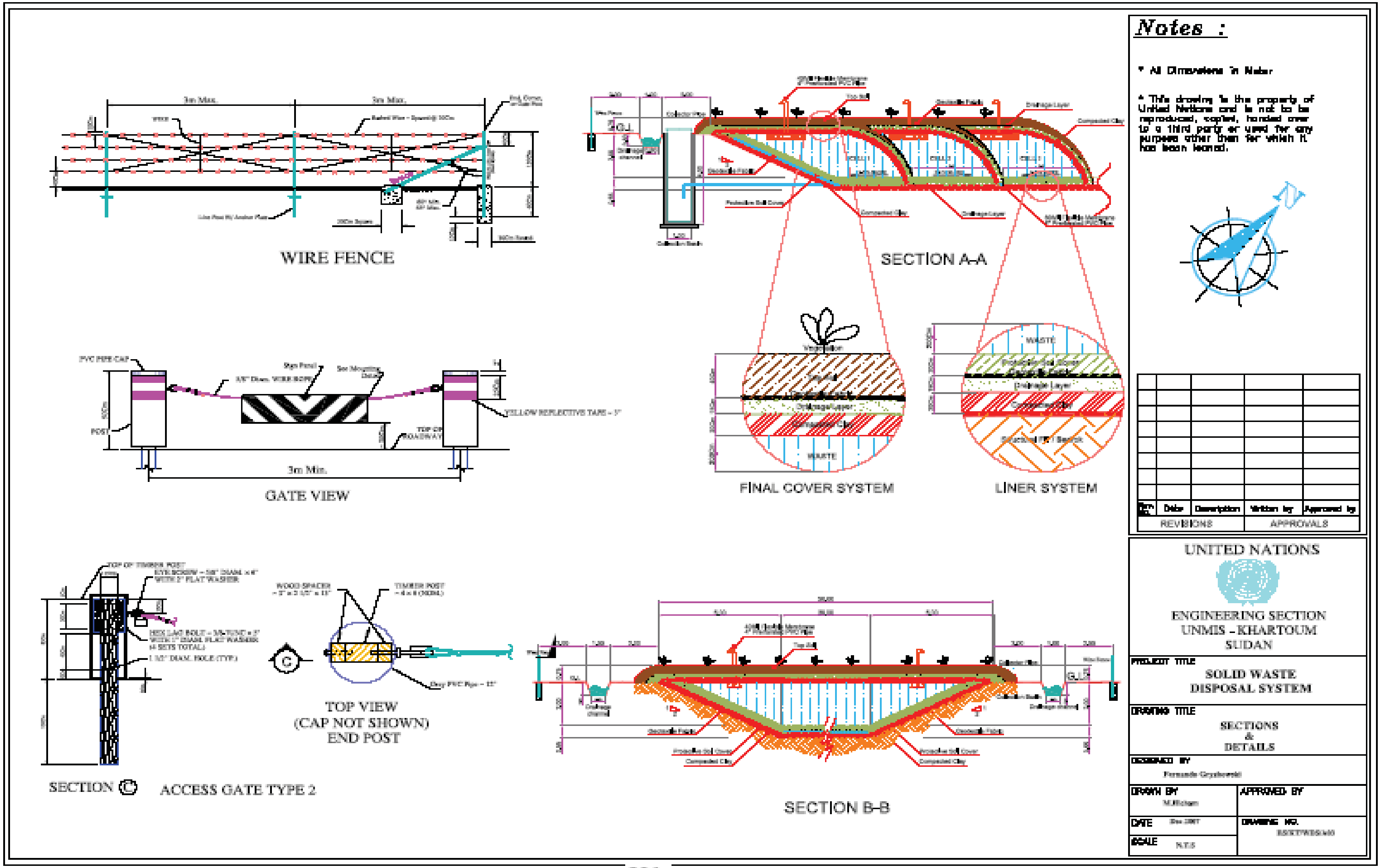
Type of waste	Source	Current design	Potential re-design options	Brief specification and design implications	Strengths	Weaknesses	Ranking
Black water	urinals	sewerage system	anaerobic digestion system (AD) - biosolids to agriculture	AD system uses bacterial activity to reduce organic wastes to methane and carbon dioxide - methane can be used to generate energy	AD systems can utilise solid as well as liquid waste and reduce greenhouse gas emissions with a potential for positive energy impact, reduces disposal of organic waste to landfill - positive impact on vector (vermin) and nuisance problems	questions remain on the validity of this system for security reasons - storage of methane as an explosive gas. Operating temperatures may inhibit natural biological activity	
	toilets	sewerage system					
Grey water	showers	soakaway/evaporation	recycling system and remainder to soakaway or evaporation	the provision for grey water recycling will require the installation of tanks, pipework and pumps	obvious benefits in water reduction, increased perceptions of sustainability - use of photovoltaics can make the system closed loop for energy intensity	potential 'cultural' conflict for water re-use. Initial capital outlay for tanks and pipework and pumps. On going operational requirement	
	handwashing	soakaway/evaporation					
	kitchen washing	soakaway/evaporation					
	food preparation	soakaway/evaporation					
	dishwashing	soakaway/evaporation					
	laundry	soakaway/evaporation					

Support Base

Type of waste	Source	Current design	Potential re-design options	Brief specification and design implications	Strengths	Weaknesses	Ranking
Black water	urinals	sewerage system	anaerobic digestion system (AD) - biosolids to agriculture	AD system uses bacterial activity to reduce organic wastes to methane and carbon dioxide - methane can be used to generate energy	AD systems can utilise solid as well as liquid waste and reduce greenhouse gas emissions with a potential for positive energy impact, reduces disposal of organic waste to landfill - positive impact on vector (vermin) and nuisance problems	it is assumed that Mombasa is a lower security risk than Mogadishu and therefore AD is more applicable	
	toilets	sewerage system					
Grey water	showers	soakaway/evaporation	recycling system and remainder to soakaway or evaporation	the provision for grey water recycling will require the installation of tanks, pipework and pumps	obvious benefits in water reduction, increased perceptions of sustainability - use of photovoltaics can make the system closed loop for energy intensity	potential 'cultural' conflict for water re-use. Initial capital outlay for tanks and pipework and pumps. On going operational requirement	
	handwashing	soakaway/evaporation					
	kitchen washing	soakaway/evaporation					
	food preparation	soakaway/evaporation					
	dishwashing	soakaway/evaporation					
	laundry	soakaway/evaporation					

Appendix 7 – UNMIS landfill design




WIRE FENCE
3m Max.
3m Max.
SECTION A-A
FINAL COVER SYSTEM
LINER SYSTEM
WASTE
Drainage Layer
GATE VIEW
PVC PIPE CAP
POST
3/8" Diam. WIRE ROPE
YELLOW REFLECTIVE TAPE - 3"
TOP OF ROADWAY
3m Min.
SECTION C
ACCESS GATE TYPE 2
TOP VIEW
(CAP NOT SHOWN)
END POST
SECTION B-B
Notes :
* All Dimensions in Meter
* This drawing is the property of United Nations and is not to be reproduced, copied, handed over to a third party or used for any purpose other than for which it has been loaned.
Rev. No. | Date | Description | Written by | Approved by
REVISIONS
APPROVALS
UNITED NATIONS
ENGINEERING SECTION
UNMIS - KHARTOUM
SUDAN
PROJECT TITLE
SOLID WASTE
DISPOSAL SYSTEM
DRAWING TITLE
SECTIONS
&
DETAILS
DESIGNED BY
DRAWN BY
APPROVED BY
DATE
DRAWING NO.
SCALE
N.T.S

Appendix 8 – UNMIS operating guidelines on waste management (table of contents)

United Nations Misssion in Sudan
Engineering Section
Environmental Engineering

Detailed Mission Guidelines

Environmental Guidelines on Waste Management

Approved by:	Director of Mission Support, UNMIS OIC
Approval date:	04 March 2009
Contact:	Environmental Engineering
Review date:	

Detailed Mission Guidelines

Environmental Guidelines on Waste Management

CONTENTS:

WASTE MANAGEMENT GUIDELINES BY CLASS OF WASTE

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