Challenges presented by obsolete pesticide collection operations in Africa - The Mozambique experience -

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Abstract

The gross product recovery and clean-up process associated with obsolete pesticide stockpiles present a number of planning, health & safety, logistical, technical and organisational challenges that are not frequently addressed in forums as these. Organisations tasked with the product's recovery and clean-up functions are confronted with a daunting range of challenges and influences, both inside and outside their control. These include issues like logistics, supporting infrastructure, weather, terrain, transport corridors, socio-political conditions, regional conflict, disease, technology and, more than frequently, budget limitations.

The collection phase of the 1998 "Mozambique Obsolete Pesticide Clean-up Project" graphically demonstrated some of the issues and considerations that influence these operations with particular reference to the African region. This paper sets out to highlight some of the project's more pertinent activities and share some of the lessons learned.

Threats defined

Obsolete pesticide clean-up operations are characterised by a wide range of potential threat conditions that start as intimate as the product itself and ripples out to influences related to the particular country, region or season. We briefly review some of the more salient issues.

Firstly there is the product itself. Pesticides on their own harbour the following potential threats:

- They are poisonous.
- They are frequently flammable.
- Some are corrosive.
- Some are water or moisture reactive.
- Under the right conditions, they can be explosive.
- Some are gasses stored under pressure stored.

The immediate storage environment adds to this profile as the majority of stockpiles feature:

- Unknown or unlabelled products.
- Unknown chemical "cocktails" as a result of spilled product from deteriorated packaging.
- Product packaging is more than often seriously deteriorated prone to disintegration or featuring sharp edges or protrusions.
- Storage conditions feature physical risks like unstable stacking and racking or slippery floors, bad illumination, bad electrical wiring and ventilation.
- Stores invariably contain inventories of non-pesticide hazardous materials, fertilisers, foodstuff, seeds and foreign materials like agricultural implements as well as the possibility of wildlife including insects, rodents, reptiles and small mammals.
- Access to stocks, stores and even premises may be restricted through structural design, foreign materials, implements and vehicles, vegetation, road conditions, topography and weather.
- And then the stores in themselves may be hazardous as a result of structural deterioration featuring collapsed, or soon to be, roofs, doors, windows, walls and floors.

As if the threats contained within the work area do not complicate matters enough, the proximity of life risk exposures uncomfortably close to the work area provides a further burden for the safe and responsible management of these operations. It is not uncommon to find residences directly neighbouring effected premises, open and subterranean water sources, subsistence crops and livestock, to name a few.

And then there are the wide-ranging influences that will be unique to the territory and society that the operation is hosted in. Issues that have direct or indirect impact on planning, organisation, scheduling and operations:

- Logistical infrastructure and services.
- Communications.
- Road systems.
- Harbours.
- International shipping services (airline carriers, shipping lines, etc).
- Weather patterns and ambient temperatures.
- Terrain & topography.
- Elevation.
- Medical support.
- Diseases.
- Crime.
- Poverty.
- Education.
- Labour ethics.
- Armed conflict and its legacy.
- Cultural and religious diversity.
- Xenophobia.
- Fiscal policies and financial facilities.
- Bureaucracy.
- Corruption.

Top: Seriously deteriorated packaging creates chemical "cocktail" spills as this case at Villa Ulongwé in Mozambique's Tete Province. Bottom: Bad stacking practices and packaging deterioration contains a physical safety threat to clean-up crews during recovery operations.

It should be stressed that the above issues highlight the most pertinent influences and may dramatically vary from country to country and, in some instances, even region to region within a country.

The Mozambique scenario

Country profile

The Republic of Mozambique covers 799,380 km^2 and occupies the majority of Southern Africa's eastern seaboard with a 2,500 km coastline and borders Swaziland, South Africa, Zimbabwe, Zambia, Malawi and Tanzania with Madagascar and the Comoros Islands lying across the Mozambique Channel.

Formerly a Portuguese colony the region was originally settled through the southerly Bantu migration from the Central African Lake region in 1st to 4th century AD. The Portuguese were the first Europeans to call on the area (1497). The region was declared as part of Portuguese Africa in 1751 and, later in the 19th century, proclaimed as Portuguese East Africa colony. Independence from Portugal was obtained through the war of the revolution (1962 - 1975) followed by a civil war between Frelimo and Renamo until 1992. In 1994 Mozambique hosted its first democratic elections.

Project background

A study conducted in 1996 by the Mozambican Ministry of Agriculture, with the support of the Danish and German Development Agencies (Danida and GTZ), identified 69 stores of obsolete pesticides spread across the Mozambican countryside. Later in the same year the Mozambican Government approached the Danish Government with a proposal to re-drum and destroy the products contained in the 69 offending stores. The Danish International Development Agency, Danida, appointed the European Environmental Research Group out of Denmark to conduct a feasibility study and prepare a project outline. This effort resulted in the project going to tender in mid 1997 with Monberg & Thorsen A/S of Copenhagen, Denmark appointed as project turnkey consultants.

For collection purposes the project categorised obsolete pesticide stocks into one of two categories, i.e. obsolete but "good" products, i.e. those products that were known (labelled) and in packaging with integrity, and obsolete but "bad" products, i.e. those in deteriorated packaging, unknown or has caused contamination through product release. Two separate contractors were appointed to deal with the segregated risk classes, IS&S a general contractor based in Mozambique for the "good" products and Waste-tech, the industrial waste division of Enviroserv Waste Management based in South Africa. For the purpose of this paper we will focus on the collection of the "bad" product class.

It soon became apparent to the Mozambican Plant Protection Department that further stockpiles existed that were not included in the 1996 survey. Project Action Plan (PAP) missions were utilised to simultaneously survey old and new inventory as well as define contractors' scope of work for each store. These missions were conducted over two separate tours to accommodate the start of the collection process. The two PAP missions have successfully unearthed a number of additional stores and identified substantial deviations from the 1996 inventory.

The PAP missions' output bumped the "Bad" collection crew's assigned stores from 30 to 65 stores translating to 310 tonnes of product from 206 tonnes. The "Bad" collection schedule was routed to kick off in the Maputo area, located at the southern end of the country, and steadily progress north. Collection operations for both product classes commenced in May of 1998 with all operations completed by November of the same year.

A representation of the locations of the various stores serviced during the Mozambique Pesticide Project is shown in the Appendix 1.

This example of "Bad" obsolete products is located at the Boror Store in Matola near the city of Maputo. This particular Lot constitutes some of the worst examples of packaging deterioration handled during the project.

Challenges defined

Following are described some of the specific conditions presented by the Mozambican clean-up project:

- The most pertinent of challenges associated with the project was life exposures, i.e. the presence of permanent occupants on the effected promises, the proximity of direct neighbours or subsistence resources like open water bodies, water wells, crops and even livestock. A number of stores had permanent residents on the same premises consisting of whole families that lived off of subsistence crops or used wells located in directly next that housed severe product releases. In the case of the store at Zambezia Commercial located in Villa Ulongwé in Tete Province, two families had to be relocated while collection was performed due to their homes being located within the site management system's "isolated area" or "hot zone". Over and above residents and neighbours, operations provided huge spectator value attracting large crowds to the effected area requiring permanent security patrols to establish and maintain a secure perimeter around work areas for both public safety and security.

This photo of operations illustrates both the risks of residences in proximity to stores as well as the spectator appeal that collection operations provided.

- Pesticide's most pertinent health threat is undoubtedly its toxicity which includes, (i) extreme acute toxicity through all exposure routes as well as, (ii) cumulative and, (iii) hereditary toxic effects. Stores invariably featured a "who's who" of the virulent poisons with non-pesticide toxins like cyanide and arsenic making a guest appearance at several instances.
- The "bad" stores in the Mozambique project were characterised by severely damaged and deteriorated packaging which produced not only a large ratio of unlabelled thus unknown products but also extensive product release "cocktails"

containing a witches brew of several released pesticides blended with, not only eachother, but also foreign materials and other chemical products in the storage area. Also prevalent were large inventories of foreign materials that include agricultural chemicals, gasses, fuel and lubricants as well as vehicles, farm, office and workshop implements. These were frequently intermixed with product stockpiles. Then there was the issue of snakes, rodents, insects and other critters that in some cases had found refuge in the abandoned stores.

Yet another example of severely deteriorated pesticide stocks in Tete Province, Mozambique. Most of these drums physically disintegrated when man-handled.

- Not to be ruled out is the fact that a cross section of the inventory is by nature flammable and, at that, moderately volatile liquids thus prone to vapour generation provide explosion, fire and migratory/emission concerns. Solid products in dust form further provided a remote but not dismissible dust explosion risk in confined areas especially in the presence of other organic dusts like seeds, maize and common household dusts. Three stores then presented a further surprise in the form of methyl bromide found in 68-kilogram cylinders as well as 700-gram canister form. A store in Malema located in the northern Nampula province contained no less than 6,000 of the canisters in a severely deteriorated condition.

An example of the structural neglect found in some stores. At this store located in Nampula Province crew's were required to excavate compacted product and soil from an unlined floor.

- Storage areas featured a wide range of physical safety threats. Slippery floor surfaces, corroded or deteriorated vessels, unstable product stacking, weak and deteriorated racking and unsafe electrical installations are but a few. In several cases the stores featured wall collapses and in no less than two instances products had to be excavated from collapsed roofing and wall materials. From an occupational hygiene perspective, the majority of work environments invariably featured bad interior and site illumination, lacking ventilation and rogue dust.
- Three decades of war, lacking maintenance and natural phenomena was responsible for the deterioration and destruction of sizeable number of Mozambique's roads and bridges. While extensive repairs have been effected in the recent past (and are still underway) many kilometres of roads were severely potholed, corrugated and, in sections, washed away due to weather erosion. Further, a large number of bridges were demolished during the war temporary repaired with military engineers bridges providing frequently tight and less than comfortable passage.

Examples of travel conditions. The top photo shows a damaged low-water Bailey bridge in Nampula Province. The bottom photo shows the fleet negotiating a dust-top mountain pass in Tete Province en-route to Malawi.

- These features coupled to an annual rainfall of 560mm (in Niassa up to 2,000 mm) makes for frequently impassable conditions, especially in the northern provinces during the period December to April. This limited the window-of-opportunity to the dry season and provided an incentive for collection to be completed and clear of the north before December.
- Temperatures are about as diverse as Africa can provide. Extremes ranged from as low as 2°C and as high 50°C with saturation levels of up to 98%. On average day temperatures were in the mid to upper 30's providing a severe heat stress risk to staff especially as almost all operations were conducted in chemical protective ensembles.
- With the regions recent history in mind Mozambique, at the time, contained the world's third-highest density of landmines preceded only by Angola and Afghanistan. While extensive clearing-up operations were in progress vast charted and uncharted fields as well as old munitions stores were and are still in existence. In one case at Inhasune, Inhambane Province, crews operated less than fifty meters of an uncharted minefield that formed part of the town's defences during the civil war.

- Definitive medical care facilities to manage the potential injury and exposure profile associated with projects of this nature were not available in Mozambique at all. Medical facilities were more than frequently aimed at basic health care, limited in their services and facilities and overburdened.
- The medical services dilemma was severely compounded by the prevalence of communicable and tropical disease. Ebola fever, malaria, meningitis, cholera and TB are but some of the more virulent and prevalent health risks identified for Mozambique at the time. This reality was dramatically brought home when a total of 21 crewmembers contracted malaria of which 8 had to be evacuated by aero-medical services from Mozambique.
- As the territory was ravished by wars for more than three decades it is not unexpected that infrastructure like accommodation, fuel, food, potable water, parts, materials and repair facilities was limited to larger centres and scarce to non-existent in rural areas. Fuel could at times not be found for distances up to 500 - 700 kilometres.

The operation

Based on the work environment demands outlined in the preceding section we adopted three values as basis for planning for the project's "bad" collection activities. They were:

1. Provide a working environment that offers staff with the confidence to optimally perform in and the client with peace-of-mind.
2. Provide of Health & Safety measures appropriate to the risk profile and country influences in compliance with international acceptable principles and practices.
3. Provide independence from local infrastructure for the majority of the time.

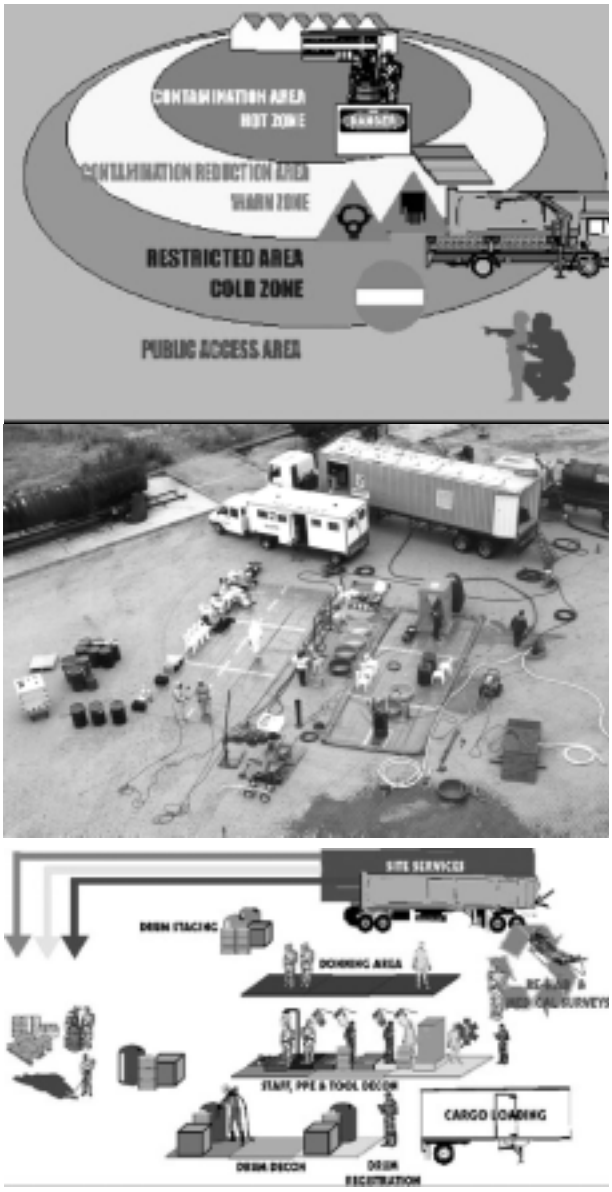
Herewith an overview of some of the planning and operational elements that were implemented during the operation:

Site organisation

The need to provide order, discipline and a logic to site activities is elemental to managing pesticide collection and clean-up operations considering that a large number of parallel activities occur on a site at a single moment whilst processing and handling large inventory of hazardous materials compounded by the proximity of life and health exposures.

A site management structure was developed for this purpose and was characterised by the following features:

- A three-tier isolation system that regulated and excluded the free movement of staff, officials and public on and through the hazardous and work area.
- Uniform staging and work areas that were arranged to accommodate the logical and ordered flow of staff, resources and recovered inventory in and out of the effected work area.
- A regimented organisation structure in which staff are assigned and rotated through a regime of fixed tasks on site. Supervision and control included a site supervisor, safety officer (also site medic) as well as mission team leaders.



The top sketch illustrates the principles of isolation zones utilised to secure work areas. The sketch at the bottom illustrates the logic and organisation of resources while the photo in the middle shows the layout in practice.

The site management structure was intrinsic to the project's health & safety program and was as such defined in the project's quality manual and work instructions. As can be expected, not all premises accommodated a standard set-up thus requiring procedure and staff alike to be adequately flexible to adapt the system to local conditions and circumstances.

Recovery & clean-up process

Product recovery was restricted to overpacking of the effected product into virgin packaging vessels. The selection of overpacking materials was limited to 100 litre and 210 litre open-head drums, 95-gallon salvage drums, Cliplok™ crates and 950 litre IBC's. Very little bulking or repackaging of product was done in the field as the products were destined to be repackaged at a waste processing facility created for the project in Maputo.

It took approximately one month of operations to achieve a constant productivity of approximately 2 tonnes/day once staff had adequately acclimatised and in-suit fitness had improved. While the collection rate appears to be surprisingly low, compared to mechanised operations, it should be kept in mind that each tonne is manhandled up to 5 times from store floor to container. This all performed in PPE under exhausting as well as prohibiting work and environmental conditions.

A collection crew overpacking a mixture of products stored in a 20' shipping container at Empressa Nobre in Chimoio, Manica Province.

Clean-up of storage areas was limited to loose surface product collection, superficial surface scrubbing with either solvents or detergents followed by high-pressure wash-down and collection of wash effluent. Soil was removed in a few instances while contaminated, but combustible, foreign materials like pallets, racking and cardboard was burned in controlled bonfires on site. Impermeable materials like corrugated roof sheeting and farm implements were scrubbed and weathered on premises and returned to the storage area. At least three stores had to be destroyed after collection as a result of the serious levels of contamination to structural materials.

For product identification, verification and accountability a project labelling system was created that incorporated the required elements of the IMDG code but also provided for project specific information like unique product Lot numbers, Store numbers, date of collection and product name. In conjunction with a collection manifest system and container Bill of Lading's products could be accounted for and tracked through their shipping regime.

Health & safety

The following principles will be universally applied to the project during the planning phase:

- Implementation of the Enviroserv Health & Safety policy.
- Customisation of project specific procedures based on the unique operating conditions presented by the project.
- Implementation of a Safety Management System integrated into the project's quality assurance system.
- Provision of a medical monitoring program for all employees that included entry, exit, annual, periodic and post-exposure surveys.
- An effort to engineer the majority of risks out of the project through planning, facilities and mechanisation.
- Empowerment of staff through training and guidance.
- Adoption of a "No-Protection/No-Work" policy on all operations.

In excess of the conventional content of a comprehensive Health & Safety Program, particular attention was applied to the following elements:

- Health Risk Assessment.
- Baseline Sampling.
- Written Work Instructions.
- Personal Protective Equipment (PPE) selection and matrix.
- Medical surveys.
- Staff selection, training and conditioning.
- Heat stress program.

Herewith a summary of the more pertinent Health & Safety facilities provided during the project:

Medical services

The health risks outlined previously underscores the significance of a responsibly managed medical program for operations of this nature. Extreme importance was attached to this area service and viewed intrinsic to the success of the project. The following medical services formed part of this service package:

- Pre-mobilisation planning: A reputable, experienced medical rescue contractor was tasked and briefed on potential service demands around surface and aero evacuations of staff. A South African receiving medical facilities was briefed on anticipated product exposure, trauma and tropical disease incidents. Airports and landing strips in proximity to travel routes and work sites were identified as well as the protocols, drug schedules and materials relevant to the product inventory.
- Site entry & exit medicals: Entry crews missions were logged in conjunction with a regime of surveys performed before and direct following in-suit activities in compliance to the project's heat stress program. In the event of inadvertent exposures a survey protocol was followed and, where required, biological sampling would be performed.
- Site medical rescue services: The acute and severe life threatening nature of pesticide exposures demanded that a suitable level of medical rescue service be made available on site during collection and clean-up operations. For this purpose the crew included an Advanced Life Support qualified medical officer. This individual also doubled as Site Safety Officer. This service came with a full suite of resuscitation, trauma, toxicology, tropical disease and common ailment hardware, materials, drugs and medicines appropriate to the anticipated spectrum of on-site emergencies. Complimentary to this service was the fact that a large number of the crew had intermediate or basic life support training and experience.

The Project Medic performing a premedical survey on staff member before an entry mission inside the project's mobile medical station.

- RSMO: A Residing Supervising Medical Officer supported the field medical crews in diagnosis, prognosis and carried the accountability for scheduled medication and protocols in terms of South African medical policy. The RSMO was fully briefed on the project and formed part of the project planning team.

Sidebar 1

PPE Classification

#	DERMAL	RESPIRATORY	ASSESORIES	APPLICATION
A.	Gastight encapsulating suit	SCBA Or Airline	• Helmet • Boots • Gloves (Inner & Outer) • Flash cover suits • Non-gastight encapsulating over suit • Inner garment	High risk operations and operations involving: • Gases • Volatile liquids • Major personal exposure to liquids or fine solids (splash or immersion) • Unknown products • High degree of dermal threat
B.	Boiler cut one-piece with hood, splash guarded booties & Zipper, Strapped or NSR seams suit	SCBA Or Airline	• Helmet • Boots • Gloves (Inner & Outer) • Flash suits (Lymae/ Pbi) • Non-gastight encapsulating over suit	• Operations involving liquids. • Operations involving substances/ products with lower dermal threats. • Operations in oxygen deficient atmospheres. • Decontamination and Warm Zone support operations.
C.	Boiler cut one-piece with hood, splash guarded zipper & booties, Sealed or Stitched seams suit. For liquid exposures, seam must be Strapped or NSR.	Full face respirator	• Helmet • Boots • Gloves (Inner & Outer)	• Operations involving solids. • Operations involving indirect or remote exposures. • Operations in free ventilated atmospheres. • Operations involving products with no or negligible dermal threat and moderate respiratory threat. • Decontamination and Warm Zone support operations.
D.	Work wear coverall	Respirator &/or dust mask optional	• Helmet • Boots • Gloves	Operations where no known threats exist.

- Aero-medical evacuation: The planning and organisation around the patient evacuation from site to a suitable medical facility was discussed previously. As facilities for the management of severe trauma and exposure related emergencies did not exist, in Mozambique provisions were made for the evacuation of patients to Milpark Hospitals in Gauteng, South Africa where Level 1 trauma facilities did exist. These arrangements were thoroughly tested when eight pyrexic staff members had to be evacuated from various locations in the country as a result of malaria infection.

Crews kitted up in Level B ensembles preparing to enter a store at Monapo in Nampula Province. Ambient temperatures were approximately 40 °C at the time.

- Heat stress program: The Mozambican climate constitutes high-risk conditions for in-suit operations and demanded a strong and comprehensive heat stress program. Enviroserv's program include elements like on-site TWBG monitoring, core control, entry/exit medical surveys as well as rehabilitation and rehydration of exhausted crews.

Protective equipment

The intimate nature of obsolete pesticide collection operations places particular high demands on the selection and quality of PPE ensembles.

Enviroserv utilises the US-OSHA Standard CFR 29.1910 PPE classification system for high-risk operations of this nature (please view an adapted matrix in Sidebar 1). Gastight, or Level A ensembles had to be utilised at two instances when handling methyl bromide and a third in a store with sever product mixture including cyanide. The majority of the project's operations was however conducted in Level B ensembles with airline due to (i) the large volumes of moderately volatile liquids or fine dusts present on premises, (ii) large mixed inventory of smaller volume products and, (iii) the extent of released product. Level C ensembles with full-face respirator masks was utilised for smaller stores or stores featuring only solid products. Double gloving and taping of garment interfaces was standard practice for all stores. All body garments, gloves and respirator cartridges were considered disposable and utilised on a once-use virgin basis.

A view of the project's staff and PPE decontamination system on the right hand side, the PPE donning area on the left and the mobile medical station in the background.

Decontamination

Decontamination is the process of rendering staff, equipment and materials exposed to product clean for safe exit from the effected area and ready for re-utilisation if demanded. With these criteria as background a system was designed that would satisfy the multi-faceted demands of operations while keeping portability, flexibility and robustness in mind. The following decontamination services were provided on site for the duration of the project:

- Entry Crews on exit from the work area.
- Protective equipment for re-use.
- Laden overpacking vessels exiting the contaminated area.
- Hardware for re-use.
- Plant and rolling stock where and when required.
- Non-permeable foreign materials.

An entry-crew member going through a "rinse-cycle" after a detergent scrub-down.

Emergency procedures

Research and planning was conducted around reasonably anticipated emergencies and unplanned events. Procedures and training reinforced by drill were put in place supported by inventories relevant to the operational unit's function and anticipated threat. Addressed, amongst others, where issues like fire, spills during transport, trauma and medical emergencies, natural emergencies (flood, inclement weather, etc.), unexploded ordinance and mines as well as force "majeur" in the event of civil unrest or war. These preparations were then thoroughly tested when a fire ravaged the accommodation camp's kitchen early one morning. The crew successfully contained the fire and had the kitchen operational by in less than 48 hours.

The success of our attitude towards Health & Safety was convincingly demonstrated as not a single reportable injury occurred during 52,600 man-hours of high-risk operation and 337,000 km of collective travel.

Staff welfare

The preservation of staff moral and incentive to excel is without a doubt a project priority. It must be recognised from the onset that the success of such complex, physically and, more than often, mentally challenging operation is intrinsically dependent on the motivation, commitment, dedication and drive of its staff. To achieve and maintain staff motivation and, if nothing else, provide as comfortable working and living environment as circumstances allowed, our planning, resources and field management considered the influence of accommodation, food and liquids, rest and recreation, after-hours entertainment, rotation and home breaks, home-front support/influence, communication, mental health as well as survival and life support contingencies.

At the core of these provisions was the project's mobile camp. This facility was built into three customised 40' shipping containers. The camp consisted of living facilities for 32 souls as well as ablution, laundry, pantry and kitchen facilities supported by generators, a water purification plant, 10 cubic metre water tanker and a sewerage cart. Two dedicated chefs prepared up to 120 meals a day in the camp's kitchen, frequently under less than ideal conditions.

Top photo: The mobile camp system in a typical set-up as seen on the camping area used at Nacala (Nampula Province).
Bottom photo: The interior of the one of facility's sleeper quarters.

This system was selected above hotels and renting accommodation for the following reasons:

- Assures a minimum level of amenities and facilities regardless of the location of the crew. This is deemed as of critical importance as crews have little desire to endure further hardships than those associated with the operational content (collection and travel).
- Creates a life-style benchmark that, once adapted to, stays largely consistent for the project duration regardless of location.
- Offers staff a "home" reference with private space over which ownership can be taken.
- On a more practical level, this system offers extreme mobility (deploys under one hour) and makes the unit independent of large centres or a minimum level of infrastructure allowing crews to camp and operate practically anywhere.

Communications

Effective communications is of critical importance for a project as geographically and logistically isolated as the Mozambique pesticide project. Not only are communications essential to guarantee good management and safety but they are an intrinsic contributor to staff moral. The fact that positive communications could be obtained from almost anywhere in the bush provided a critical psychological crutch to staff and their families. During the Mozambique project we utilised satellite communications based on the Inmarsat D system for both voice and data communication allowing person-to-person dialogue, e-mail and Internet communication.

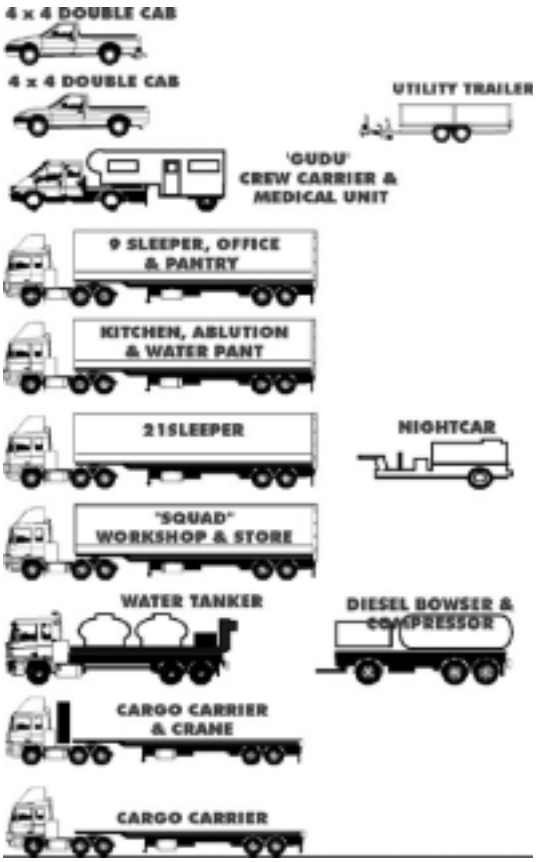
Logistics

Obsolete stock clean-up operations are manpower, rolling stock, hardware and material intensive. This high demand on resources necessitates a supportive infrastructure that is more than frequently lacking in Africa's developing countries. And this starts at the most basic of requirements, i.e. reliable food, potable water and fuel. Faced with exactly this reality in Mozambique extensive planning was allocated to logistics.

The vast volumes of overpacking and cleaning materials as well as PPE called for by the project was accommodated by pre-packing 40' shipping containers for regions and depositing them at the harbours of Beira and Nacala for collection when demanded (the project consumed some 3,500 overpacking vessels and more than 2,000 pieces of PPE). The majority of perishable and dry foodstuffs were imported from South Africa and supplied by road or air to crews (vegetables and other fresh produce like fish and milk was acquired locally). A water treatment plant attached to the camp allowed the project to extract water from any source and render potable thus limiting the project's dependency on reliable water sources.

Mobility and assured scheduling demanded that adequate fuel stocks be on hand at all times. A 10,000 litre diesel bowser was part of the fleet and allowed for refuelling in the field or en-route without any reliance on local fuel stations. A buffer supply of essential parts accompanied the project supported by a drop-ship facility from South Africa. A mobile workshop and a dedicated technical officer kept with all vehicles in service seeing some 42 major breakdowns and 79 minor repairs effected in the field. Only one and a half day out of 167 workdays was lost due to vehicle breakdown.

Top Photo: Field re-fuelling of a truck tractor in progress at the campsite in Beira (Sofala Province). Bottom Photo: The mobile workshop and parts



A graphic representation of the "Bad" collection fleet.

Travel & shipping

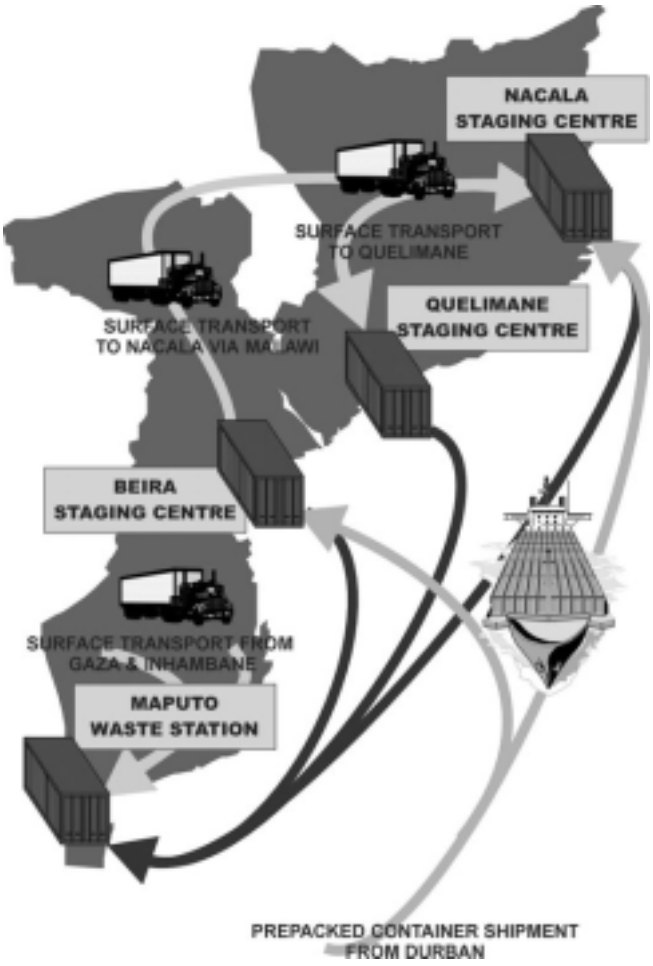
The "Bad" collection rolling stock resources consisted of seven heavy goods vehicles, one medium goods vehicle and two light delivery vehicles. These resources provided amongst others: all stores, workshops, fuel, water, plant and breathing air, high pressure washing, decontamination, vacuum, raw materials and even sewerage management.

Relocation between centres was conducted in convoy for logistics, safety and management purposes. Route planning inherently received substantial attention to detail. Issues like river crossings, bridge conditions, road surface conditions, drainage, weather and local populations were all factors that influenced route assessment necessitating in several instances the selection of substantially longer detours to reduce delays, risk of breakdowns and wear-and-tear on rolling stocks. Risk reduction was further achieved when, in a number of regions where local knowledge of road conditions was scarce or unreliable, route reconnaissance team were used to reconnoitre travel corridors for suitability before mobilisation of the convoy.

As previously discussed, virgin overpacking vessels were shipped in 40' shipping containers from Durban and staged at Beira and Nacala. These containers were collected from the respective ports and shuttled to the work sites on demand. Laden containers were shuttled to the closest or most appropriate ports for dispatch to Maputo by sea. Products collected in the southern provinces, were shipped in flatbed/break-bulk configurations directly into Maputo.

The wedge formed by Malawi between Mozambique's northern provinces as well as the absence of a reliable or safe crossing over the Zambezi river between Beira and the northeast provinces required that products collected in Tete Province had to be transported back to the harbour in Beira (a 2,000 km round-trip). As an alternative the products could be transported through Malawi that had obvious Basel Convention, diplomacy and customs implications. The latter option was decided on resulting in a two day escorted passage through Malawi following bilateral negotiations between the Mozambican and Malawian Governments.

In its travels the "Bad" collection fleet crossed three frontiers and passed through no less than 12 border posts during the execution of the project. These border crossings proved to be particularly trying considering the size and unconventional nature of the fleet compounded by Africa's notorious bureaucracy.



A graphic representation of the logistics associated with managing the project's bulk materials and, following collection, the shipping of the waste product to the Maputo Waste Station.

Lessons learned

Herewith a few of the lessons learned during the project:

- Do not underestimate the importance of issues related to staff welfare. A demotivated or distracted crew can add to the already mounting hurdles and challenges such a project creates. Pay attention to issues like a hearty but balanced diet, adequate home breaks as well as rest & recreation time, remuneration packages, personal incentive, contact with the outside world as well as news from and news too their respective families.

A clean-up crew scrubbing a contaminated floor at the Boror Store in Chokwé, Gaza Province. This store was totally submerged by floodwater during the devastating floods of February 2000.

- Communications and information technology needs to be matched to the working environment. Anticipate that these already temperamental devices will be exposed to the same diverse elements, dust, shock and abuse as the fleet and staff - not a good combination. The project further highlighted the need for HF or short-wave radio communications, as the satellite-based system was not only excessively expensive, but also burdened with several pragmatic limitations inherent to the current technology (mobility, satellite angles, fragile technology, etceteras).
- Provide adequate redundancy for critical hardware, parts and supplies. Heavy usage compounded by the ravages of travel and environment takes it out of even the most robust of designs. Couple to this that, in spite of the best planning and organisation, assistance or re-supply can be days away. And in this spirit, do not economise on quality of rolling stock, hardware and materials like overpacking vessels and PPE. The value of buying cheap demonstrates itself at the most inappropriate moments.
- Working with highly toxic materials under uncontrolled conditions without the support of established emergency response services, definitive care medical facilities and good transport corridors places a huge responsibility on management to build health and safety measures into the operation that will meet both demands of the operating environment as well as provide staff with the confidence to optimally perform under such parameters. Measures like evolved protective systems, medical services as well as rescue facilities, top of the line PPE and safety briefings all assisted in being able to execute such an operation without any reportable injury or exposures.

- Output was seriously compromised by environmental conditions. Ambient temperatures of up to 50°C played havoc with productivity and scheduling alike. This exposure can be reduced through mechanisation of activities, ergonomics studies and staff quality control (selection, fitness and heat stress management).
- Carefully consider the suitability of rolling stock to the task and environment. Work output, transmission, axle loading, service support, road clearance, availability of parts and complexity of electronics are but some of the issues that have to be carefully considered before selecting rolling stock. All-wheel drive for prime movers may not be out of order and don't underestimate the importance of accessories like bull-bars, spotlights, long distance tanks, spare tyre racks and auxiliary hydraulics. Also, do not dismiss issues influencing driver fatigue lightly.
- Do not underestimate the diversity of contamination and contaminated materials you may have to manage. Provide adequate range of techniques with supportive hardware and materials for clean-up activities. Mechanise as far as possible as cleansing activities can become extremely laborious with little results to show for a lot work in cases of hardy contamination.
- Pay careful attention to staff selection. Over and above skills and experience suitability, take time to explore a staff member's social compatibility, family structure, endurance to hard living and work conditions, discipline, self-motivation and social nature. Staff disillusionment, family pressure and "project burn-out" can influence productivity, moral and good management. Make pains to brief staff and their families on the work environment, demands placed on family structure and mutual expectations. Remove any romantic illusions that staff may harbour of adventures in exotic locations right at the beginning.

The fleets water/diesel combination unit preparing to cross a low water bridge in Sofala Province, west of Beira.

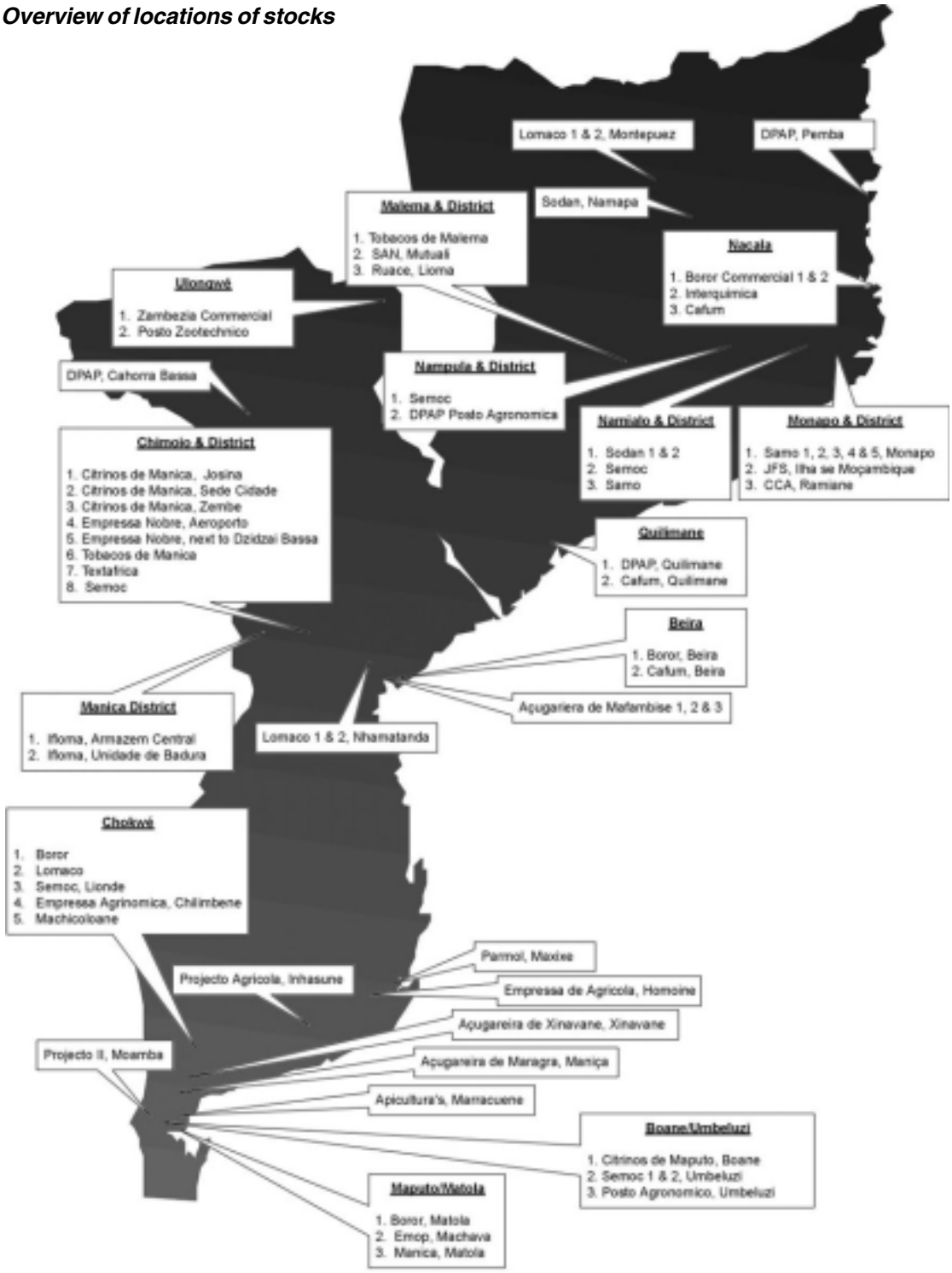
- Logistical independence from local infrastructure is only achievable with great costs. By taking the time to research local suppliers, arranging for stockholding on high usage items and identifying operations in the area with similar rolling stock or hardware, some of the "supply" burden can be managed and relieved without unnecessary risk. The importance of an experienced, street-wise shipping agent cannot be stressed enough. Identify transport operators that do regular supply runs too and from your location and piggyback emergency consignments on their Bill-of-Lading. Plan re-supply schedules with adequate safety margins. Delays due to custom clearance, holidays, breakdowns, bureaucracy and even inclement weather could leave you stranded for days on end. Provide for losses en-route and budget for excessively expensive "scarce" items and emergency acquisitions.

Conclusion

The planning, organisation, inventory and contingencies built into the Mozambican "Bad" Collection operation embraced a philosophy of guaranteed service delivery, risk reduction and providing a quality service regardless of location and limitations. In preparing for this project, and subsequently, we have studied a number of similar operations in other parts of the world. It was quite apparent that projects similar to the Mozambique operations are executed with widely varying attitudes, quality levels and practices. We trust that this paper provided an insight into one way of getting the job done and demonstrated some of considerations when formulating, planning and executing obsolete pesticide collection operations in regions that present challenging operating conditions.

The intimate nature of obsolete pesticide collection operations places particular high demands on the selection and quality of PPE ensembles.

Appendix 1 - Overview of locations of stocks



Contract volume of product	205.8 tons
Actual volumes collected 108 tonnes solids & 203 m^3 liquids	108 tonnes solid & 203 m^3 liquids
Contract number of Stores	30
Actual number of Stores serviced	65
Contract Work days	99
Actual Work days	105
Contract Travel days	51
Actual Travel days	56