


Targeted Interventions on Low Volume Rural Roads in Mozambique

AFCAP Project Phase 2

QUARTERLY PROJECT PROGRESS REPORT NO.3

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Quarterly Project Progress Report No 3

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This Report has been prepared for AFCAP and ANE for the sole purpose of Project Report Review.

The views expressed are those of the author(s) and not necessarily those of AFCAP or ANE.

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1 Introduction

The activities in this reporting period included:

1. Construction supervision
2. Materials testing
3. Design reviews and modification during construction
4. On-site training and review of work procedures
5. Preparation for the monitoring of the performance of roads constructed during Phase 1 and Phase 2 of the project.

The report gives details of the work carried out, including the challenges and lessons learnt during its execution.

TRL's role on the project is to provide technical assistance in developing adequate designs and specifications which will enable ANE to utilise the 'non-conventional' materials that are abundantly available in Mozambique to deal with the problem of shortages of conventional road-building materials. This includes the following main activities:

1. Carry out research through trialling and monitoring of the performance of sections designed and built using marginal materials.
2. Supervise construction works, especially trial sections which will be instrumental in the development of appropriate specifications for the development of low volume roads.
3. Develop specifications that are appropriate for non-conventional materials.
4. Provide work norms for the provision of low-volume roads, both unpaved and sealed, that enable appropriate work standards to be achieved.
5. Train and impart knowledge on designs and work norms to ensure high standards of engineering and high quality workmanship.

The following aspects of the project are of note in this reporting period.

1. Some important trial sections were completed in the previous reporting periods and some of these were opened to traffic. In most cases there has been more traffic than was anticipated. If the traffic loading is much higher than expected, there is a danger of relatively early deterioration (in terms of time). This can jeopardise the project unless there is a full understanding by all concerned of the in-service response of the pavements and surfacing options that were designed and constructed.
2. The capacity of the practitioners to implement work methods for which they have little knowledge and experience provided a training challenge. Failure to implement the work in a satisfactory manner also jeopardises the project, seriously affecting the sustainability of the approach.
3. The use of non-conventional materials, especially for surfacing, is not without its sceptical detractors. Subjecting the trial sections to some adverse conditions, especially bad weather, is important for demonstrating the

durability and reliability of the designs. In this reporting period some of the trials experienced periods of intense and prolonged rainfall, including very heavy storms and floods. This puts the drainage systems to the test but, more importantly, the performance of the pavements and the surfacings is judged by their performance in-service during such periods of adverse weather conditions.

4. Several site visits were carried out and observations were used to optimise the monitoring processes.
5. The impact of using locally available materials on construction costs is shown by the increased outputs as compared with the sections constructed during Phase 1 (i.e. longer sections of road now being built at lower costs).
6. Maintenance is an important aspect of the project. There should be substantial maintenance cost savings when using low cost surfacings compared with the maintenance costs of unpaved roads. This is already a common belief even before the data are collected and analysed.
7. Increased confidence on the part of the contractors and consultants in the designs and work processes emanating from the quality of road produced during construction will aid future development of the technology.
8. There has been increased support from ANE on realisation of the potential future impact of the project on road provision and management.
9. Increased political and funding support is necessary for the sustainability of the initiative. At the moment the scale of the project is quite small in comparison with the need. The approach now needs to be implemented more widely.

2 Background

Phase 2 of the AFCAP project expanded on the work that was carried out in Phase 1 and the main focus has been on innovation, i.e. developing innovative solutions for the provision of sustainable rural roads through spot improvement approaches and low cost surfacing. The concept involves provision of all weather access to rural communities.

The designs of the interventions are carried out by TRL in conjunction with provincial consultants who have overall responsibility for the works. The project has a training component which involves the general training of the contractors and is carried out mainly by the consultants Scott Wilson. TRL's training component is related to the implementation of the innovative designs and appropriate work norms necessary during execution of works. This training is essential for the success for the project because without good workmanship and the adoption of appropriate work norms the success of the innovative designs can be jeopardised.

The project has posed a number of challenges that have been discussed in previous progress reports. These are summarised below:

1. The commitment of some of the contractors is questionable, partly as a result of capacity limitations due to lack of equipment and qualified and experienced personnel. This is common with small to medium scale contractors. The large scale contractors also pose a challenge because they view the works as too small and therefore do not give them sufficient priority when compared with large projects that they are undertaking.
2. Inexperienced operators also posed a challenge during construction because the workmanship mostly depends on the level of skill of the operators and their supervisors. Everyone requires a period of time to adapt to new methods and to improve on their initial skill level.
3. The shortage of road construction materials is also a problem but it is slowly being overcome as the project progresses with the development of designs and work norms that make it possible for practitioners to use locally available materials for the construction of these low volume roads. These materials are considered "marginal" or "poor" in the conventional materials classification systems.
4. Lack of robust supervision capacity during execution of work has also been a major problem. Poor supervision gives way to poor workmanship to an extent that even an experienced contractor may be tempted to lower the quality of the works.

3 Plan for reporting period

The plan for the reporting period is given in Figure 3-1

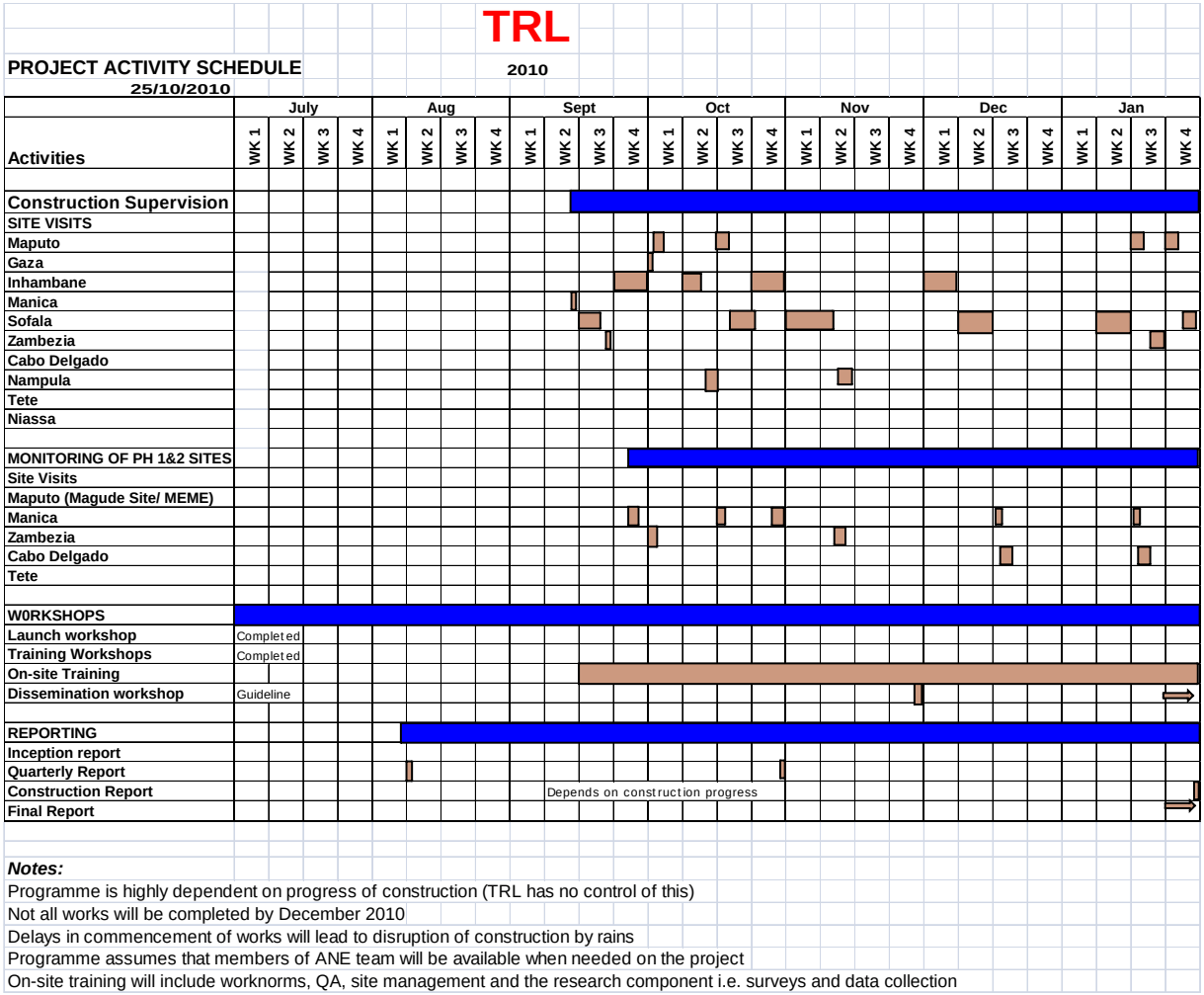


Figure 3-1 Programme for reporting period

The activities that were planned for the period include;

1. *Supervision of construction of the Phase 2 trial sections*. Supervision of the construction has been given high priority because poor construction is usually the main cause of failures on highways. Strict supervision has contributed to the successful completion of the trial sections that have been completed. However, this success is attributed to teamwork that ensued on site between the supervising team which includes TRL, the provincial consultants and ANE staff.

2. *Assessment and distribution of testing and survey equipment*. TRL assisted ANE in the assessment of the equipment required which was then procured. However, the quality of some of the pieces of equipment leaves a lot to be

desired. The equipment has been distributed to ANE delegations in the provinces and some of it is being used but there is need to make a follow-up because some of the intended beneficiaries are not able to use some of it. Training is required.

3. *Training of ANE and consultants*. In Phase 2 of the project training has become a continuous engagement. This has been necessitated by the need to carry out on-site training which has proven to be effective. Practical training is always better than theoretical training not only for operatives and site personnel but for the provincial staff as well. Thus a hands-on approach to the training was adopted and that has continued in this reporting period.
4. *Training in regional workshops*. In this component of the project TRL has participated in workshops that are being conducted by Scott Wilson who are the main training consultant on the project.
5. *Monitoring*. This is a very important component because this is where the data and evidence of performance trends can be obtained. The process involves carrying out surveys on site which include:
    a. Visual condition surveys which included condition of carriageway and surfacing, drainage, etc.
    b. Structural tests such as DCP tests and Benkleman beam tests.
    c. Topographical surveys including cross-sectional surveys.
    d. Sand patch tests for texture measurement.
    e. Rut depth measurements.
    f. Roughness surveys with the bump integrator.

The equipment for the monitoring is now available in the provinces.

4 Progress for the reporting period

Significant progress was achieved during this reporting period. The rainy season started during this period and this marks an interesting but critical stage of the trials. Usually, performance of low volume sealed roads depends on their resilience to deterioration factors during their weakest condition i.e. condition of high moisture content in the pavement structure.

Also, construction of low volume sealed roads is not recommended during the wet season because it compromises the quality of the marginal materials as laid. However, as part of the research it is important to build trial sections in the most adverse of conditions in order to deal with the worst case scenario. For this reason construction was allowed to continue unabated during the rainy season.

This reporting period has seen significant achievements towards the development of sustainable guidance on specifications and work norms for Otta seals with the completion of works on the Cumbana Chacane site, which involves the use of calcrete aggregate for Otta seal surfacing.

Numerous monitoring visits were also carried out to the completed sites in order to visually check for early defects. Early defects are an indication of construction problems which should be rectified by the contractor during the defects liability period. It may also be a result of serious design problems especially where innovative designs have been used. It is important for the team to keep a close observation in order to develop a full understanding of any performance deficiencies that might occur.

4.1 Supervision

Supervision of the projects did not proceed as planned but good progress was realised.

4.1.1 Beira Savane Project

This is the most important project for the research component because of the number of separate trials included on the road. The trials include:

1. *Construction of the embankment and subbase using coastal sand*. The construction of embankment and subbase was completed before the onset of the rainy season. This was good for the project because the rainy season in Beira is usually prolonged and it is difficult to carry out any works during this period. The quality of construction was good and the lower limit specification for field densities of 93% was met. Averages were in most cases above 95%. Some of the borrow areas for the sand contained a little clay and therefore the sand that was used to build the embankments was slightly plastic (3<PI<8). In other places plasticity was low (PI<3).

   The resulting subbase made of slightly plastic sand was a very strong layer. However, it was susceptible to moisture ingress. When the rains started the road was at subbase level and traffic volumes increased as a result of the improved passability. However, the subbase deteriorated as a result of the prolonged trafficking and the effects of weather. There are potholes on the

surface which fill up with water during the rain. This inherently weakens the subbase and subgrade and prolonged trafficking should be discouraged.

This is actually a setback because the subbase layer will need to be reworked before the base can be placed on top of it.

2. *Emulsion treated base (ETB)* – The most important component is the emulsion treated base (ETB) which, in this case, is a sand base treated with emulsion. The initial plan was to construct the ETB before the onset of the rainy season but this did not happen. There were delays due to a number of reasons.

   a. The previous rainy season took much longer to come to an end. It was still raining until the end of August 2010.

   b. When the rainy season ended the contractor did not proceed with the works diligently to make use of the short window of dry weather. At times the contractor withdrew equipment from site without authority from the supervising consultant and this compounded the delays.

   c. The contractor did not plan the procurement of the bitumen emulsion properly and this complicated the situation in that there were further delays in the supply of the emulsion.

   d. The contractor had promised to use the concrete plant in Beira Town to mix the ETB, Figure 4-1~~Figure 4-1~~. This would have been the best option because plant mixing produces better quality of ETB and productivity is usually high at about 8m^3 in 20mins. However, it has come to light that the plant is now committed to other works and will not be available for the project.

      The bitumen emulsion has since been supplied to site and is stored in a large tanker (>15,000 litres). This poses another problem because emulsion is a suspension of bitumen in water that is kept in suspension by an emulsifying agent. The proper way of handling and storing it is to agitate it once every two weeks to prevent coagulation, i.e. bitumen droplets coming out of suspension and lumping up. If this happens the bitumen emulsion is considered spoiled and there is no simple remedy thereafter. This is likely to happen because the tanker has been sitting on site for more than two months with minimal agitation of the emulsion. If coagulation occurs the emulsion may be condemned for use on this important site resulting in a huge loss both to the contractor and to the project in general.

Figure 4-1 TCO's Concrete Plant for ETB Mixing

Figure 4-2 Trial section for ETB Construction

3. *Extraction of borrow material (sand) from borrow pits* – As highlighted in the previous reports, the borrow pits for the sand that is being used for construction on this site become inaccessible during the rainy season because of the raised flood waters and unstable ground. Work was carried out in accordance with the recommendations given by the consultants, i.e. for the contractor to extract the sand from the borrow pits during the dry season. There are two stockpiles of the sand that have been dumped on the side of the road. These dumps have all-weather access. The supervising consultant has been requested to ensure that the quantities are adequate for the construction of part of the subbase repairs, untreated base and the ETB. This information is not yet available.
4. *Drainage* – There have been some issues regarding the inadequacy of the existing drainage.
   a. One of the sections was moved from the original chainages starting at 10+500 and is now starting at about 8+700. According to the provincial authorities, the move was necessary because the section starting from 8+700 was worse than that of the section starting from 10+500 and needed improving. Drainage improvements were part of Phase 1 works and therefore the original chainages had been targeted for improvement. The new section therefore needed additional drainage improvements which, unfortunately, had not been included in the budget.
   b. The existing culverts in both sections are about 5m in length and the carriageway was designed to be 6m wide. Since there is no budget for drainage improvements it was suggested that the carriageway be narrowed to 5m with 0.5m sealed shoulders in between the culverts. The general carriageway width for other sections built under RRIP/AFCAP project was 5m with 0.5m shoulders. The difference in design on this project of a 7m wide road was due to the high water levels during flood periods. A wide road reduces the extent of moisture ingress from the sides and this helps to keep wheel tracks at below optimum moisture content. There are 4 culverts, two on each section which are less than 4.5m long and will need to be extended, Figure 4-3.

Figure 4-3 Culverts needing extension

5. *Materials testing*. Tests have been carried out in the laboratory in Maputo based on the request letter and procedure given by TRL. However, the volume of the sample was not adequate to carry out all the tests as requested. The results were not satisfactory and more tests will be carried out in Beira now that they have adequate equipment in the laboratory.
6. *Overall progress of works*. The commitment of the contractor is in question and several meetings have been held to try and get the contractor to proceed with the works but these have been fruitless. More pressure needs to be applied on the contractor by ANE within the confines of the contractual requirements. TCO is a big contractor and this lack of progress is attributed to the contractor being committed to larger projects.
7. A small trial section has been carried out on site on the construction of the ETB, Figure 4-2~~Figure 4-2~~. A concrete mixer (0.75m^3) was used. The content of the emulsion was about 4%. Though the section laid was small, important information was obtained from this trial.
   a. The design of 4% emulsion content for the ETB was found to be satisfactory based on the ETB that was produced. This is a very positive outcome because the sand is very fine and there had been concerns as to

whether 4% emulsion would be adequate. Previous recommendations suggested that the minimum emulsion content would be 6%.

b. The workmanship was poor and a lot needs to be done to improve it. The mixing was inadequate and there are portions in the ETB layer matrix with little bitumen and others portions which are rich in bitumen.

c. The construction of the ETB was slow and cumbersome. The contractor was advised to increase the mixing capacity by either using the concrete plant in Beira city or by bringing more mixers to site, otherwise the work will take many months to complete.

d. The strength of the ETB as laid showed good resilience against traffic and weather elements. This is illustrated in the ETB blocks, Figure 4-4~~Figure 4-4~~, sampled from the cured trial sections. The ETB cannot be used as wearing course but the trial section has been open to traffic and weather elements for more than two months and there has been very little damage. Some of the ETB which fell on the side slopes has been submerged in water for almost two months since the flood waters rose and these have maintained much of their strength. This is a good sign.

Figure 4-4 Block of cured ETB from trial section

4.1.2 Cumbana Chacane Project

Good progress was achieved during this reporting period. The construction of the Cumbana Chacane project has been completed successfully. It was a challenging undertaking that require concerted effort to produce results.

The project is located in the coastal sandy plains in Inhambane Province. The main source of materials is the vast red sand deposits and some limited sources of calcrete. The project involves the use of a blend of red sand and calcrete in a ration of 50:50 proportions. There are sealed and unsealed sections on this project. The blend performs the functions of a wearing course on the unsealed sections and as road base on sealed sections.

The design of the wearing course was based on performance-based specifications which were developed in a previous project carried out by ANE and TRL on the performance of unpaved roads. The product was good with very high strength, suppressed dust pollution and was resistant to wearing. The surfacing was designed to be a single Otta seal using graded calcrete aggregate.

There were some concerns regarding this project.

1. The same blend proportions were used for the base and wearing course. The blend was more appropriate for the wearing course because of the high plasticity levels. Recommended plasticity for the base course is $0 \leq PI \leq 6$, but the resultant PI of the blend was between 5 and 13. Some cracks were noticed at the end of the second sealed section where the blend with higher levels of plasticity was used.
2. The drainage system also posed a challenge. The existing road levels were lower than the surrounding ground and this worsened because the commencement of the works was delayed and the level of road lowered further under traffic action. The result of this was that the quantities in the contract were not enough to achieve the minimum required crown height of 0.75m.
3. The strength of the aggregate is a critical parameter and there was the concern that the aggregate might not be strong enough to withstand rolling. The contractor had intended to use a steel-wheeled roller in non-vibratory mode. This was discouraged because, during trial rolling, the aggregate crushed. The contractor obtained a pneumatic roller and this worked well i.e. the aggregate did not crush during rolling. A 12 tonne roller was used for this purpose.

4.1.2.1 Priming

The construction of the base was completed in the previous reporting period. Unfortunately the completed base was trafficked for a long time before priming. As a result, the surface of the base became rough. Nevertheless priming was applied on the rough base. The newly-acquired binder distributor was used and it worked well, producing a prime coat that met the specifications (an application rate of 0.6L/m^2 of MC30 is specified for the Otta seals on trial sections under AFCAP). The prime cured properly before surfacing was applied, Figure 4-5~~Figure 4-5~~.

Figure 4-5 Primed section ready for Otta seal surfacing

4.1.2.2 Surfacing

The section was prepared for surfacing. The section was swept using hard brooms and marked with small stones to guide the driver of the binder distributor (BD).

The chip spreader was fixed onto the body of the tipper truck and that meant that only one tipper truck could be used for the surfacing activity. This was not a major setback because only 2km were earmarked for surfacing. The chip spreader worked well.

The BD was new and had not been used before so the team had to be cautious. The BD needed to be calibrated first before using it for the surfacing. A trough test was used to determine the delivery rate of the BD. The delivery rate was constant and the application rates could be varied by changing the speed of the BD.

The process involved a number of stages

1. *Preparation of materials* – the preparation of materials was accomplished during the previous reporting period. The sieved calcrete aggregate was hauled and dumped on site and the stockpile was protected from rain. This was particularly important because the aggregate had too much fines. At high moisture content the fines turned into mud. It was therefore important to apply the aggregate dry or with very low moisture.

   Before the start of construction, samples were collected and sent to the Maputo laboratory for further tests or rather confirmatory tests on ACV. The ACV was 26.5. A wet test was also carried out and the value was approximately 36. The aggregate is also well-graded with nominal maximum size of 13mm.

   The dust in the aggregate was of major concern, Figure 4-6~~Figure 4-6~~, but there was not much that could be done without escalating costs through repeated sieving. However, the nature of the dust is such that it could act as a filler because of its gritty nature. It was decided to use the aggregate as it was.

Figure 4-6 Dusty calcrete aggregate

2. *Application of the Otta seal* – After preparation of the section the bitumen was heated to about 150°C. Bitumen was then applied at different

application rates on each subsection of about 100m length. The rates were varied between 1.2L/m^2 and 2.8 L/m^2 with two outliers of 0.6L/m^2 and 3.1L/m^2. There are 16 different sections with different application rates. The variations include application rates of 1.5l/m^{2,} 1.6L/m^2, 1.7L/m^2, 1.8L/m^2, 2.0L/m^2, and 2.6L/m^2. Details of variations in application rates and chainages of the corresponding sections are given in **Appendix A.3**. The first sealed section has lower application rates of stone. Aggregate was over-applied on the second sealed section. The first sealed section is curing more rapidly.

The application rates of stone were measured using the tray and balance, Figure 4-7~~Figure 4-7~~. This measurement was carried out regularly in order to control the application rates of the aggregate.

Figure 4-7 Tray test for control aggregate application rate

4.1.2.3 Challenges

The construction of the Otta seal was not without challenges.

1. *Operational*. There were some operational problems related to inexperienced staff.
    a. The contractor's staff, especially the operatives, were not experienced and that caused problems during construction.

b. The contractor did not employ adequate staff on site, especially casual labourers.

c. The supervising consultant's site personnel were also on a steep learning curve

2. *Equipment*. There was a major problem with the BD. The spray bar clogged frequently and it took a long time to unblock. This is actually an inherent problem with the equipment. The spray bar had no insulation and therefore the bitumen cools down rapidly and becomes too viscous to flow properly (Figure 4-8~~Figure 4-8~~). Clogged nozzles adversely affected the even distribution of bitumen. This normally shows up as stripping in areas starved of bitumen. The contractor did not have adequate tools on site. The burner which was supposed to be used to heat and unblock the spray bar was too small and not useful at all. The BD did not have a hand lance which is used for corrective spraying. There weren't enough hard brooms. The chip spreader was also, at times, clogging up and sometimes not spreading aggregate uniformly.

Figure 4-8 Binder application and illustration of blocked nozzle

3. *Materials*: the calcrete aggregate was too dusty and remedial measures were required to make the application work. Prolonged rolling was necessary to produce the necessary mosaic.

The status of the projects is given in Table 4-1~~Table 4-1~~,

Table 4-2~~Table 4-2~~ and

Table 4-3~~Table 4-3~~. The location of the sites can be seen highlighted in yellow in Figure 4-1.

Table 4-1 Projects in the Southern Region

Project	Problem	Intervention	Project Status

MAPUTO PROV. Maracuane Macaneta project (MAMA 1,2,3,4,5,6)	Swampy, flooding, expansive clays and sandy	Construction of stabilised sand base and slurry seal. Construction of embankment through blending sand with clay (matope).	The project was about 40% complete. Construction of the embankment with the sand/matope blend was 30% complete but compaction was very poor. Four pipe culverts were constructed including road bed. The previous contract was terminated due to poor performance by the contractor and the project was re-tendered. A new contractor has been engaged and work has resumed. Work is proceeding but at a very slow pace. The new contractor does not have adequate equipment and is probably worse than the previous contractor
GAZA PROV. Macaritane Chicualacuala Project (MECA 1,2,3,4,5)	Flooding and slippery	Embankment built with red sand. Base constructed with blend of plastic quartz and red sand. Surfacing with Otta seal, surface dressing and penetration macadam with natural quartz aggregate.	Remarkable progress had been achieved on this project. The construction of embankment was at an advanced stage. The project was stopped by ANE. The whole road is to be upgraded to an asphalt pavement under Portuguese funding. An alternative road Chinhacanine Nalazi Road has been selected for inclusion in RRIP Phase 3.
INHAMBANE PROV. Cumbana Chacane Project (CACE 1,2,3,4)	Quick sand. Road level too low	Embankment built with in-situ sand. Base constructed with blend of calcrete and red sand. Otta seal with varied application rates.	Construction has been completed. The construction of subgrade and road base (calcrete/red sand blend) is completed. Compaction of the road shoulders was not satisfactory nor was the final cutting. Construction of Otta seal with calcrete aggregate has been completed successfully and variations in bitumen application rates ranged from 1.2L/m2 to 2.6L/m2

Table 4-2 Projects in the Central Region

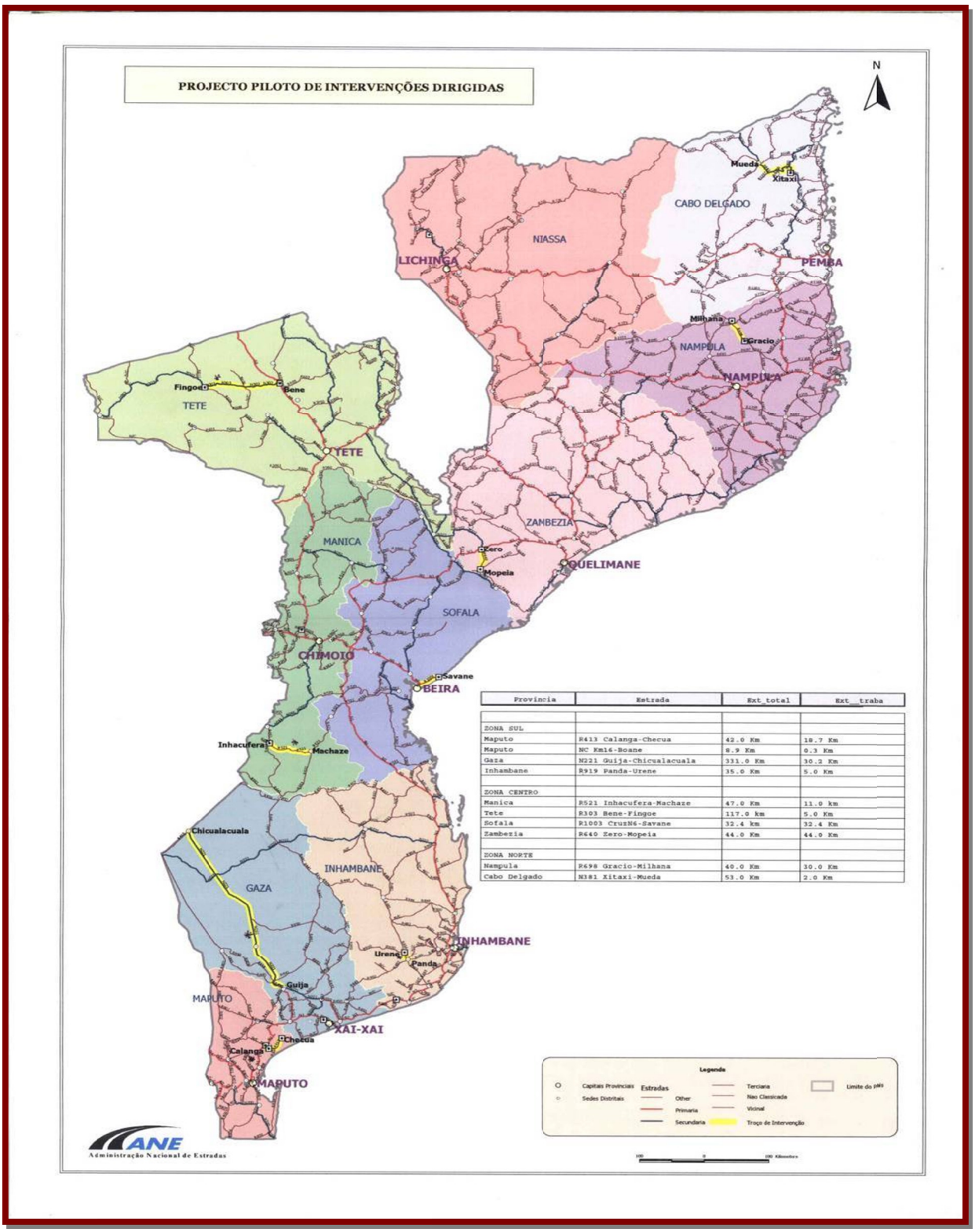
Project	Problem	Intervention	Project Status
MANICA PROV. Inhacufera Machaze Project (IAMA 1,2,3,4)	Very coarse gravel.	Reprocessing of existing gravel. Construction of Otta Seal with varied application rates 2.0, 1.8, 1.6, 1.4 L/m^2 MC3000	The project has been completed successfully. There were several variations on the bitumen application rates 2.0, 1.9, 1.7, 1.6, 1.4L/m^2. Also there are sections with high fines content and washed aggregate including 300m of sand seal. A total length of 6km was completed. All structures and protection works have been completed. All sections are open to traffic and performing well (latest visit was on in January 2011)
SOFALA PROV. Beira Savane Project (BASE 1,2,3,4,5,6,7,8)	Flooding and erosion of sand embankments.	Construction of embankments with sandy fill soils + structures. Emulsion treated base (ETB) on part of the section. Surfacings are slurry seal, sand seal and surface dressing on ETB and untreated sand base.	Construction started and was progressing well until the completion of the subbase. The contractor has supplied bitumen emulsion on site and one 0.75m3 concrete mixer for the construction of ETB. The contractor has since stopped work and it is attributed to lack of commitment.
ZAMBEZIA PROV. Zero Mopeia Project (ZOMA 1,2,3,4)	Some sections are too low and subject to flooding	Construction of quartz base. Surfacing is an Otta seal with different bitumen application rates and fine quartz aggregate.	The project has been completed. The application rates for bitumen were varied 1.8, 1.7, 1.6, 1.5, 1.4, 1.3, and 1.2 L/m^2. So far no problems have been observed. The Otta seal is curing rapidly and it is looking very good and better than on Inhacufera Machaze with coarse

			aggregate. The surfacing is performing well after many months of trafficking.
TETE PROV. Bene Fingue Cachombo Project (BEFE)	Steep hill with slippery materials	Construction of stone paving with ribbed concrete screed.	This project is a low priority for the province.
TETE PROV. Matema Furancungu Daca MAFUDA	Steep eroded ramps and deep overflows on structures.	Surfacing with stone paving or concrete slabs. Increase capacity of structures	This project is a low priority for the province.

Table 4-3 Projects in the Northern Region

Project	Problem	Intervention	Project Status
NAMPULA PROV. Naguema Chocasmar (NACR)	Flooding during high tide.	Raised embankment and Otta seal surfacing.	Project ongoing but low priority
NAMPULA PROV. Milhana Crossing (continuation from Ph1) (GOMA 2)	No existing structures, flooding, expansive soils.	Proposed embankments > 3m high. 2 Causeways	Project ongoing and prioritised Construction has started. A visit to this project has been planned but it's still pending.
NAMPULA PROV. Mecane Pirivili Road (MEPI)	Flooding, collapsing structures.	Construction of new structures. Raised embankment and surfacing with Otta seal.	Project ongoing but low priority
CABO DELGADO PROV. Xitaxi Moeda Project (XIMA 5)	Very steep hill. Erosion	Construction of Cape seal on steep sections.	Project prioritised and ongoing
NIASSA PROV. Mavago Musawise Road (MOME 1,2,3,4)	Badly deteriorated and almost impassable.	Reshape and construct base with quartz and laterite gravel. Surfacings are Otta seal, surface dressing with natural aggregate, penetration macadam.	Project incorporated in Phase 3 and yet to commence
NIASSA PROV. Nova Madeira – Cz Lupiliche	Quick sand making road impassable especially in the dry season	Form road and import base with some plasticity or use geogrid to hold the sand together	Project is a low priority for the province.

The locations of the sites are given in Figure 4-9~~Figure 4-9~~.



Provincia	Estrada	Ext_total	Ext__traba
ZONA SUL			
Maputo	R413 Calanga-Checua	42.0 Km	18.7 Km
Maputo	NC Km16-Boane	8.9 Km	0.3 Km
Gaza	N221 Guija-Chicualacuala	331.0 Km	30.2 Km
Inhambane	R919 Panda-Urene	35.0 Km	5.0 Km
ZONA CENTRO			
Manica	R521 Inhacufera-Machaze	47.0 Km	11.0 km
Tete	R303 Bene-Fingoe	117.0 km	5.0 Km
Sofala	R1003 CruzN6-Savane	32.4 km	32.4 Km
Zambezia	R640 Zero-Mopeia	44.0 Km	44.0 Km
ZONA NORTE			
Nampula	R698 Gracio-Milhana	40.0 Km	30.0 Km
Cabo Delgado	N381 Xitaxi-Mueda	53.0 Km	2.0 Km

Figure 4-9 Map of Mozambique showing site locations

4.2 Training

4.2.1 Training workshops

No training workshops have been carried out in this reporting period.

In previous periods TRL participated in the regional training workshops in collaboration with ANE and the training consultant Scott Wilson. Issues covered by TRL included:

1. Aspects and items on site that the site supervisors should pay attention to, including camp and site establishment. While these have no direct impact on the construction activities they can affect the running of the project and reduce efficiency.
2. Aspects relating to inspections of works and detecting construction flaws. Also covered are the remedies for such flaws.
3. Interpretation of quality test results. It was noticed during the training that the site supervisors had difficulties in interpreting the test results and subsequently making decisions on whether to fail or pass construction works.
4. Highlights of the quality that is expected by giving examples of good quality work that had been carried out on some of the projects.

4.2.2 On-site training

This was carried out on the Beira Savane and Cumbana Chacane projects.

4.2.2.1 Beira Savane

On-site training included the following aspects:

1. *Materials* – aspects related to surfacing stone; the quality and nature of stone and preparation for application of ETB. This was done at the contractor's mixing plant in Beira.
2. *Work norms for ETB Construction* – A training section was contacted by TRL at the provincial office

4.2.2.2 Cumbana Chacane

The following aspects were covered:

1. *Preparation of base before application of surfacing* – this was carried out on site with the contractor and the consultant in attendance. It should be noted that the blended base was trafficked for some time before surfacing could be applied owing to the delay in importing the surfacing equipment and bitumen. Hence thorough preparation was necessary to minimise surface defects resulting from traffic action. It also included sweeping, light showering with water, etc. This is important because the application rate for the prime was reduced from 1L/m^2 to 0.6L/m^2 and these techniques would help to ensure uniform distribution of the prime.

2. *The requirement to calibrate surfacing equipment* – it is important to achieve the required application rates of the binder within reasonable tolerance limits, especially for the trial sections. Any uneven distribution of binder may affect the performance of the surfacing, especially the Otta seals.
3. *Trialling of equipment and work procedures* – this is a very important aspect because trialling of work procedures is necessary to develop a method statement which can then be followed for the rest of the works.
4. *Work processes and quality control during construction* – The contractor's site personnel and the consultant's site staff were all on steep learning curves and on-site training was necessary to deliver the works in accordance with the designs. Training on work norms included the application of bitumen and determination of actual application rates through dipping and calculations of the application rates, control of speed of traverse of the BD, etc. The training also included the sequence of activities, the timing, finishing and rolling. The fiscal and the rest of the supervising consultant's staff on site were trained on inspection of works and on site instructions to the contractor.

4.3 Equipment for the AFCAP Project

A list of equipment and specifications were provided to Crown Agents and has been procured. The equipment has since been supplied and distributed to the provinces. This will go a long way towards enhancing the quality of works on site including the design process.

There is, however, a delay in the calibration of some of the equipment and it is of no use if this is not carried out properly and in a timely manner. The main problem has been the delay by the suppliers to demonstrate the calibration processes to ANE staff. TRL has assisted in the calibration process. It is important to note is that the counter for the bump integrator failed to count and the suppliers were supposed to sort this problem out. Unfortunately this has taken a long time and has, in turn, affected the commencement of the monitoring surveys.

Some of the intended beneficiaries of the equipment do not know how to use it and training will be necessary in order to ensure its full utilisation.

5 Plans for the next reporting periods

The programme for the next two reporting periods is shown in Figure 5-1~~Figure 5-1~~.

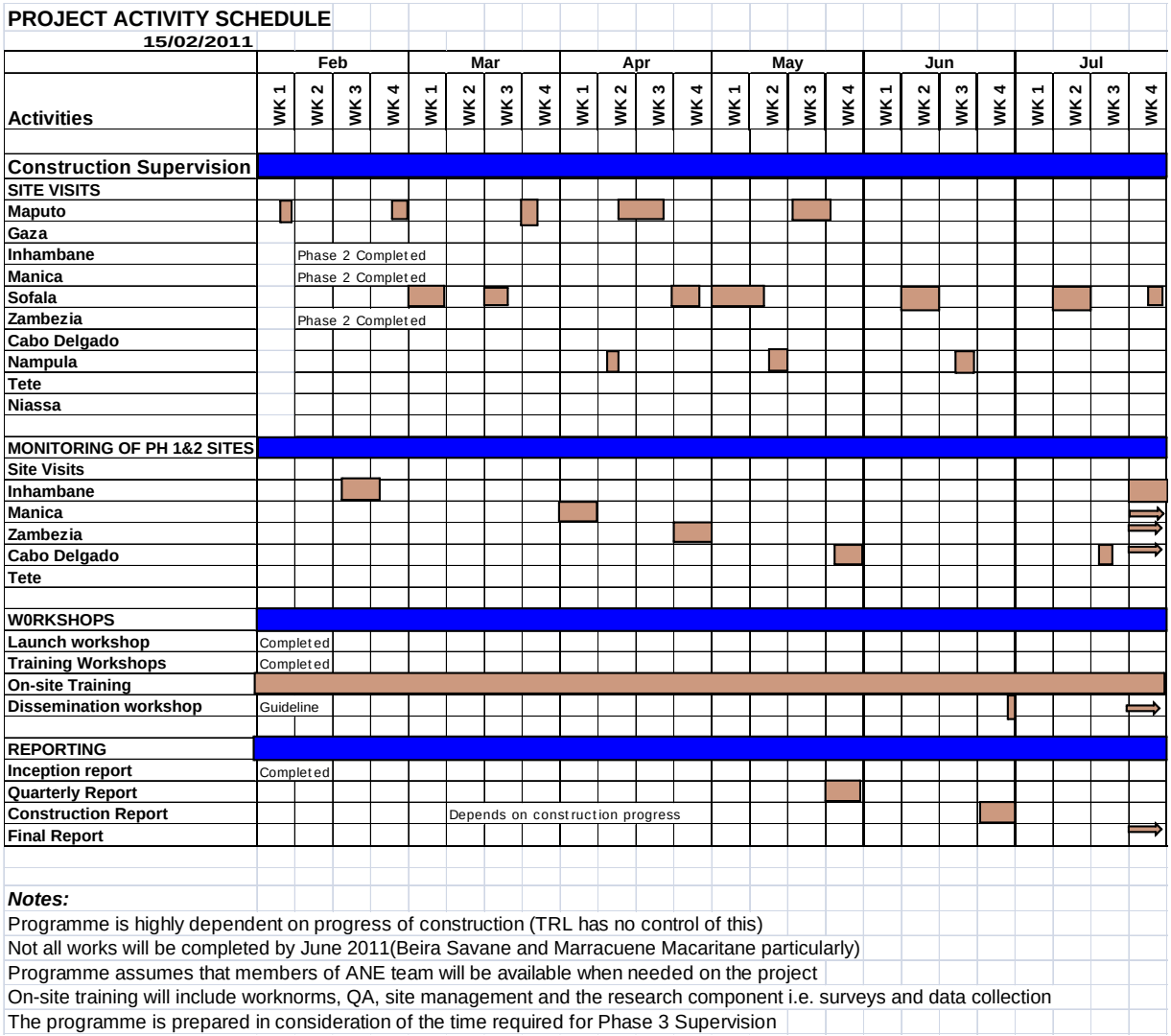


Figure 5-1 Programme for next reporting period

5.1 Supervision of construction works

TRL will focus more on the following projects:

1. *Beira Savane Road Project*. It is expected that the contractor will start works again in the next reporting period with concerted pressure from ANE. It will be necessary to assist the contractor and the consultant since both are inexperienced with the construction of ETB and the thin surfacings. While the ETB design tests have been carried out in the Maputo laboratory the results were not satisfactory. Further tests will be carried out in this reporting period. The province now has adequate equipment and it will be possible to

carry out most of the tests in ANE's laboratory in Beira. Carrying out tests in Maputo caused some logistical problems in providing an adequate sample for all the requested tests. Several visits will be made to the project so that good progress can be achieved in the next reporting period.

2. *Milhana Causeway*. Construction has started on this important structure and it is important to ensure that the treatment of expansive soils is carried out properly in order to ensure a sound foundation for the structure and embankment. The protection works are also a critical aspect to prevent wash-aways. Some supervision visits will be carried out to this site.

3. *Maracuene Macaneta Road Project*. This project involves blending matope (clay) and sand for the construction of the embankment through a swamp and construction of a slurry seal. These are important trial solutions as part of the research component of the AFCAP Project. A new contractor has been engaged to complete the works after the first contract was terminated because of poor performance by the contractor. The contractor has been concentrating on drainage works so far. However, the rainy season has seriously delayed earthworks and there are concerns that the contractor does not have adequate equipment. Monitoring of this construction will be carried out to ensure good quality of works.

   Designs have been changed on the first sections (0+000 to 0+700). The base will now be ETB instead of cement stabilised sand base. The design tests have been carried out in the provincial laboratory in Maputo. Results are yet to be made available. The surfacing will be a slurry seal, 15mm thick. The province will need assistance during the construction of the ETB and slurry seal.

4. *Monitoring of completed trial sections i.e Phase 1 and Phase 2 sections* – The monitoring of completed sites has been initiated with reconnaissance visits and preparation of field forms. Calibration of the bump integrator has been carried out. Details of the monitoring will be included in the next quarterly report.

5.2 Training

Training will focus on the following:

1. On-site training will be carried out on the on-going projects especially Beira Savane and Maracuane Macaneta.

2. Training will be carried out on the monitoring procedures and techniques. A session will be planned for ANE, especially DIMAN, to discuss issues relating to the innovative designs and the experience gained so far. QA procedures and specifications will also be a topic of discussion.

5.3 Monitoring

TRL has commenced the monitoring of completed sites. However, it is now understood that the training will take much more time than was previously envisaged because the provincial staff are unable to use some of the equipment,

e.g the automatic levels. Training in the use of sophisticated modern equipment and training to take reliable and accurate measurements with any scientific equipment is relatively time consuming.

The data that is being collected includes:

1. *Visual condition survey data*. The data must be sensitive enough to culminate in the development of deterioration indices and/or performance trends.
2. *Roughness measurements*. This is being carried out with a bump integrator (BI) and the MERLIN machine (for very short sections). The MERLIN has been used for calibration of the BI. TRL will train ANE staff in calibration procedures.
3. *DCP tests*. These are important tests to determine the seasonal strength variations in the pavement.
4. *Moisture content variations*. Moisture affects pavement strength and checking moisture variation in the pavement is important in the assessment of pavement behaviour.
5. *Rut depth*. Rutting is a structural failure and gives vital information about the appropriateness of the designs for the level of traffic.
6. *Rate of gravel loss*. This will be measured on unpaved sections for development of life-cycle costing comparisons.

TRL has prepared the necessary forms for data collection and excel spreadsheets for data processing.

6 Issues

There are several issues relating to the project that need to be raised.

1. *Contractors' commitment, capacity and competence* – This is a major issue and it has caused problems with productivity on the RRIP sites. The big contractors sometimes delay works when they are over-committed with larger contracts and do not give any priority to the RRIP projects. The small to medium contractors tend to have limited capacity in terms of personnel and equipment. Another related problem is lack of experience and this is a great challenge when it affects most the operatives.
2. *Quality Assurance.* There is significant improvement in QA but what is lacking is a proper standardised system with checks and balances. There is little coordination. For example, there is no proper process for reporting that QA procedures have been used and that data have been properly checked and verified before reaching the central office in DIMAN. There are no standards for QA so variations have been noted from one province to another. However, it is apparent that the provinces and, in particular the consultants, have shown a change of approach. Testing for quality control is becoming more common and that is good for the project in general.
3. *Compaction* – Compaction remains an issue of concern. The quality of low volume roads depends heavily on the levels of compaction achieved, not necessarily in terms of achieving high densities but appropriateness of the level of compaction for the materials. This is an important aspect considering that most of the natural road-building materials in Mozambique are considered marginal to poor. The lack of testing has been a major issue even though there have been significant improvements in many provinces. If quality tests are not carried out then the client does not know what the work is really worth, i.e. value for money.
4. *Site management* – This remains an issue. The contractors are still unable to produce realistic programmes of works, which is the most basic necessity before works commence. This has been a major setback. It is suggested that any assistance to these contractors should be practical and demonstrated in real situations rather than classroom-theoretical. The absence of adequate documentation is affecting project execution. The qualification and experience of site personnel is still weak. Practical on-site training is likely to have a greater impact than formal classroom training.
5. *Work output* – the low rate of delivery of works is of great concern. There are various causes.
    a. Poor planning.
    b. Limited knowledge and experience of the works and lack of resources.
    c. Lack of commitment and general incompetence.
    d. Lack of enforcement contracts.

7 Conclusion

The intended outcome of the AFCAP project is to bring change to the road sector in relation to the provision of sustainable low volume roads. There are certain indicators which show whether the project is on track towards the planned outcome or not, sometimes referred to as performance indicators.

1. The development of appropriate and implementable designs for low volume roads including locally viable low-cost surfacings. These will lead to new specifications and work norms which will lead to mainstreaming and further upscaling of the initiative.
2. Increased interest from the road sector entities. The increased support from the Road Fund and ANE is an indication that the initiatives have a future in Mozambique.
3. There is also a marked increase in political support particularly in Inhambane Province where the Provincial Governor has thrown his weight behind the project after noticing that the project has a provided a viable solution to the problems being faced in the province of poor road networks in the rural areas.

The stakeholders in Mozambique have placed great importance on the project and have sought additional funds from ASDI for a Phase 3 for supervision and monitoring. The cooperation between ANE, Provincial Consultants, TRL and Scott Wilson is helping the smooth running of the project.

8 APPENDIX

Field Forms for Monitoring Activity

Compaction Judgement Form

A.1 Condition Survey Forms

DCP Test Form

Project Title:							Survey Number:			
Province:					Road Name:					
Section:					Chainages:					
Length:					Date:					
Test Position:					Zero Error:			Surveyor:		
No.	No. of Blows	Total Blows	Reading (mm)	Penetration Depth (mm)		No.	No. of Blows	Total Blows	Reading (mm)	Penetration Depth (mm)
1	0					42				
2						43				
3						44				
4						45				
5						46				
6						47				
7						48				
8						49				
9						50				
10						51				
11						52				
12						53				
13						54				
14						55				
15						56				
16						57				
17						58				
18						59				
19						60				
20						61				
21						62				
22						63				
23						64				
24						65				
25						66				
26						67				
27						68				
28						69				
29						70				
30						71				
31						72				
32						73				
33						74				
34						75				
35						76				
36						77				
37						78				
38						79				
39						80				
40						81				
41						82				

PROJECT _____

PROVINCE _____

ROAD _____

SECTION _____

CHAINAGES _____

LANE _____

LENGTH _____

WHEEL PATH _____

OPERATOR _____

SURVEY NUMBER _____

DATE _____

ROUGHNESS MEASUREMENTS
Bump Integrator

PROJECT:						SHEET:			
PROVINCE:						DATE:			
ROAD NAME:						SURVEY NUMBER:		OPERATOR	
ROAD SECTION	CHAINAGES	LANE	LENGTH (m)	TIME (s)	AVERAGE OPERATING SPEED (km/hr)	BI COUNTER READING	IRI CONVERSION EQUATION	CONVERTED READING (IRI)	REMARKS

Conversion equation takes the form y = mx+c obtained through Calibration by MERLIN

where x = the bump integrator readings
y = merlin IRI
c = constant that applies to the specific BI obtained through calibration
m = conversion factor obtained through calibration

VISUAL CONDITION SURVEY FOR MONITORING

PROJECT:		SHEET:	
PROVINCE:		SURVEY NUMBER:	
ROAD NAME:		DATE:	
ROAD SECTION:		INSPECTOR:	

Chainage		X-section	Road Width*	Surface type	Ravelling/Stone Loss				Potholes / Surface Loss (including binder)				Cracking							Slips		Geometry	Depressions / Subsidence			
Km	m	0,1,2,3	(m)	S/U	Position RWT, LWT, A, U	Length (m)	Average Width (m)	Area (m)	Position L,C,R,A	Number	Total Area (m2)	Average Depth (mm)	Type Ln, Tr,Cr	Position L,C,R,A	Number (Tr, Ln)	Average Width 1,2,3,4,5	Length (m)	Area (Cr) (m^2)	Overall Cracking Index	Position L,C,R,A	Severity 1,2,3	Bend, Slope, Flat	Position L,C,R,A	Number	Total Area (m2)	Average Depth (mm)

X-section		Surface type		Position		Type of cracking		Position		Crack Width	
0	3% (Original camber)	CM	Cold mix	RWT	Right Wheel Track	Ln	Longitudinal	L	Left	1	≤1mm
1	> 1% (Deformed camber)	DSD	Double surface dressing	LWT	Left Wheel Track	Tr	Transverse	C	Centre	2	1<cw≤3
2	0% (Flat)	SSD	Single surface dressing	A	All Over	Cr	Crocodile	R	Right	3	4<cw≤5
3	<0% (reverse camber)	Us/BL	Unsealed and Blended	U	Undefined			A	All Over	4	>5mm
		OS	Otta Seal								
		SS	Sand Seal								
		DOS	Double Otta Seal								
		1.5S	1.5 Otta Seal								
		PM	Penetration Macadam								

Sand Patch Test Form									
Project Title:							Sheet:		
Province:					Road Name:				
Section:					Chainages:				
Length:					Date:				
Surveyor:					Survey Number:				
Chainage	Test Position (offset from mark) (m)	D 1 (mm)	D 2 (mm)	D 3 (mm)	D 4 (mm)	Average D (mm)	Area (mm^2)	Volume of Sand (mm^3)	Texture Depth (mm)

CROSS SECTION SURVEY FORM FOR GRAVEL LOSS MEASUREMENT

Project Title:		Sheet:	Profile Number:	
Province:		Road Name:		
Section:		Chainages:		
Length:		Date:		
Surveyor:		Survey Number:		

Point	Tape Measure Reading	Staff Reading	Base Elevation	Current Elevation	Gravel Loss (mm)

RUTTING MEASUREMENTS

Project:		Sheet:		Survey No.:	
Province:		Surveyor:			
Road Name:		Date:			
Section:		Direction of counting on each wheel path			

Chainage:										
	Outer Wheelpath					Inner Wheelpath				
LEFT	Offset on straight edge					Offset on straight edge				
	S1	S2	S3	S4	Rut (mm)	S1	S2	S3	S4	Rut (mm)
Reading:										
RIGHT	Offset on straight edge					Offset on straight edge				
	S1	S2	S3	S4	Rut (mm)	S1	S2	S3	S4	Rut (mm)
Reading:										

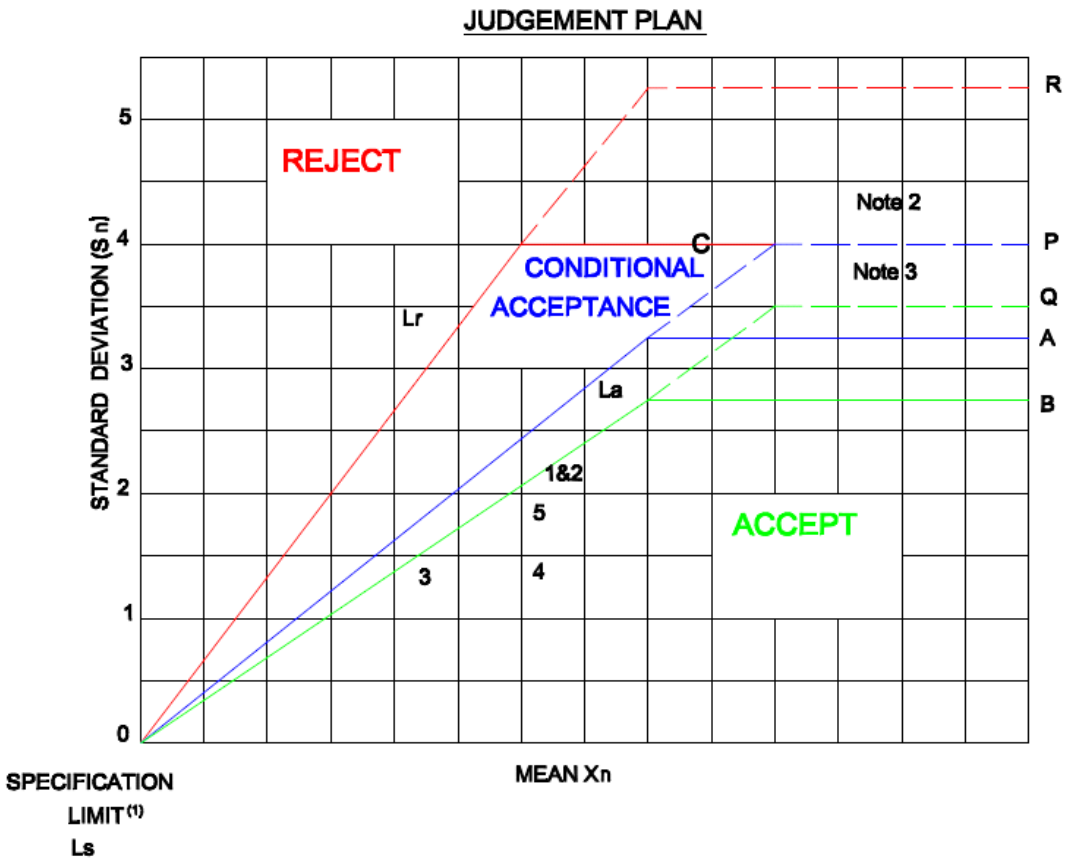
Chainage:										
	Outer Wheelpath					Inner Wheelpath				
LEFT	Offset on straight edge					Offset on straight edge				
	S1	S2	S3	S4	Rut (mm)	S1	S2	S3	S4	Rut (mm)
Reading:										
RIGHT	Offset on straight edge					Offset on straight edge				
	S1	S2	S3	S4	Rut (mm)	S1	S2	S3	S4	Rut (mm)
Reading:										

Chainage:										
	Outer Wheelpath					Inner Wheelpath				
LEFT	Offset on straight edge					Offset on straight edge				
	S1	S2	S3	S4	Rut (mm)	S1	S2	S3	S4	Rut (mm)
Reading:										
RIGHT	Offset on straight edge					Offset on straight edge				
	S1	S2	S3	S4	Rut (mm)	S1	S2	S3	S4	Rut (mm)
Reading:										

Chainage:										
	Outer Wheelpath					Inner Wheelpath				
LEFT	Offset on straight edge					Offset on straight edge				
	S1	S2	S3	S4	Rut (mm)	S1	S2	S3	S4	Rut (mm)
Reading:										
RIGHT	Offset on straight edge					Offset on straight edge				
	S1	S2	S3	S4	Rut (mm)	S1	S2	S3	S4	Rut (mm)
Reading:										

Chainage:										
	Outer Wheelpath					Inner Wheelpath				
LEFT	Offset on straight edge					Offset on straight edge				
	S1	S2	S3	S4	Rut (mm)	S1	S2	S3	S4	Rut (mm)
Reading:										
RIGHT	Offset on straight edge					Offset on straight edge				
	S1	S2	S3	S4	Rut (mm)	S1	S2	S3	S4	Rut (mm)
Reading:										

A.2 Compaction Judgement Form



	87	88	89	90	91	92	93	94
2&3	89	90	91	92	93	94	95	96
1	91	92	93	94	95	96	97	98
5	93	94	95	96	97	98	99	100
4	95	96	97	98	99	100	101	102
	97	98	99	100	101	102	103	104
	99	100	101	102	103	104	105	106

VARIABLE SCALE FOR RELEVANT L_s

A = Initial submission limit $L_s \geq 93$ P = Initial submission limit $L_s \leq 91$

B = Resubmission limit $L_s \geq 93$ Q = Resubmission limit $L_s \leq 91$

C = Rejection limit $L_s \geq 93$ R = Rejction limit $L_s \leq 91$

NOTE (1) Circle relevant L_s and put reference number of lot next to L_s

(2) Reject for $L_s \geq 93$ Conditional for $L_s \leq 91$

(3) Conditional for $L_s \geq 93$ Accept for $L_s \leq 91$

A.3 Sections on Cumbana – Chacane Road

Section	Start Chainage	End Chainage	Section Length (m)	Application rate for MC30 (L/m^2)
1	18+200	18+500	300	0.62
2	18+500	19+200	700	0.59
3	23+700	24+200	500	0.60
4	24+200	24+700	500	0.60

Section	Start Chainage	End Chainage	Section Length (m)	Application rate for MC3000 (L/m^2)
1	18+200	18+250	50	2.82
2	18+250	18+350	100	1.54
3	18+350	18+500	150	2.10
4	18+500	18+600	100	1.24
5	18+600	18+700	100	1.71
6	18+700	18+800	100	1.88
7	18+800	19+000	200	1.29
8	19+000	19+100	100	0.60
9	19+100	19+150	50	3.12
10	19+150	19+200	50	1.58
11	23+800	23+900	100	2.9
12	23+900	24+000	100	2.16
13	24+000	24+100	100	1.87
14	24+100	24+250	150	1.80
15	24+250	24+466	216	1.51
16	24+466	24+586	120	1.42
17	24+586	24+700	114	1.76

Sections 19+200 to 23+700 and 24+700 to 24+800 have blended wearing course and sections 19+200 to 20+200 and 24+700 to 24+800 is being monitored for gravel loss and roughness.