

Maintenance Sustainability Concept Paper

Introduction

The actions, ideas and concepts discussed in this document are aimed specifically at addressing the “sustainability” of road improvements being funded by USAID in Liberia. The concepts discussed are evolving, and are offered for the purpose of supporting the informal general LCIP discussions leading up to the annual LCIP strategy planning, scheduled to take place sometime in June 2008¹.

USAID-Liberia has expressed a desire to fund road maintenance activities for two years on the Todee Road and Greenville-Buchanan Road projects, and perhaps on other evolving LCIP road projects. Road maintenance is of course vital to the sustainability of access: Further, ‘sustainability’ itself requires at minimum, the initialization of a long-term mechanism ensuring that resources required for road maintenance are available. To this end this document discusses the concepts for implementing the desired two-years of road maintenance within an expanded concept of Road Maintenance Management as the first step in ensuring ‘sustainability’.

Definitions

As is the case with all programs and concepts there are common terms employed, but not necessarily common definitions or understandings by all participants or stakeholders: Often these ‘terms’ are used interchangeably, clouding the intended concept. For the specific purpose of this document the following definitions are developed:

Maintenance: Maintenance is a critical function in any asset management program. The term ‘maintenance’ in this document is intended to refer primarily to ‘routine’ maintenance, most commonly performed on rural or low volume roads on a weather dependent basis.

It is important to make a clear distinction between maintenance (routine and periodic) and repair works. Proper maintenance is clearly time linked, and to be efficient is carried out before major damage takes place. This involves activities relating to supervision and monitoring of the road assets while they are still in good condition. It also requires that road authorities are sufficiently responsive and capable² of taking action when required - as opposed to a response in terms of repairing the road when access has finally been cut off or becomes overly difficult.

¹ The operational word is ‘evolving’. The concepts, ideas, and approaches presented in this document are not the formal ideas of LCIP: They are the result of the author compiling a collection of thoughts gathered through a series of informal discussions, as one tool for further strategizing and project development.

² Being ‘responsive and capable’ implies securing sufficient funding before repairs and maintenance become an urgent issue. The most effective form of maintenance is achieved when an organization is capable and prepared to carry out appropriate interventions at an early stage of deterioration and thus limit the extent of damages. This implies that the responsible authority has access to the necessary human and financial resources to effectively manage all facets of the maintenance works. However, the problems of rural road maintenance are not uniquely related to finance, there are also major institutional factors, world-wide, relating to the lack of clear responsibility at different deconcentrated, delegated, or devolved levels for maintenance planning, budgeting, and implementation.

It is also important to make a clear distinction between ‘routine’ maintenance and ‘recurrent/periodic maintenance’. ‘Routine’ maintenance of ‘rural’ roads (e.g. low volume roads) is a widely dispersed activity, requiring small resource inputs over a large number of geographically dispersed locations. For this reason, this operation is very well suited for labor-based work methods thereby relying to a high extent only on locally available resources.

Routine maintenance includes activities such as:

- Repair, fill and compact pot holes and ruts
- Erosion control of shoulders and slopes
- Clear side and other drains to allow free passage of water
- Clear culverts and other water ways
- Cut grass and bushes
- Maintain road signs in place
- Perform minor repairs to culverts and retaining structures
- Repair and replace scour checks
- Light reshaping of carriageway (camber formation, corrugation, ruts, etc.)
- Road assessment for ‘recurrent’ maintenance needs

‘Recurrent or ‘Periodic’ maintenance involves more comprehensive and costly activities such as reshaping of the road surface, re-surfacing and major repair or reconstruction of cross-drainage structures. Depending on the type and quality of a road, the level of use and the types of vehicles leading to the level of wear and tear, periodic maintenance works are commonly scheduled at intervals of 3 to 7 years.

Recurrent maintenance includes activities such as:

- Major repairs to structures;
- Signing repair and installation
- Reshaping prior to resurfacing;
- Re-graveling/resurfacing of sections or entire road;
- Spot improvement/rehabilitation of failing sections;
- Installation of new culverts;
- Stockpiling gravel for use during routine maintenance.

Further, it is important to note that LCIP will by necessity be limiting ‘maintenance’ to ‘routine’ maintenance activities during an accelerated program, e.g. only one full cycle of a program. The objective of the LCIP approaches (one for Greenville-Buchanan Road, and one for Todee Road) is to leverage the USAID road maintenance requirements into a first-step TA effort.

Labor based, labor intensive³: The terms “labor-based” and “labor intensive, as well as similar terms, refer to an approach whereby the labor content of infrastructure works or services is maximized, while still producing good quality and cost-effective outputs. An optimal mix of labor and equipment in the labor-based approach means that the (mostly unskilled) labor input is supported by appropriate equipment. It is the opposite in capital-intensive works, where equipment is supported by (mostly skilled) labor to operate the machines. Labor-based initiatives are commonly associated with community-based initiatives and it is often taken that “labor-based” means “community-based”, which is not the case.

³ The terms ‘labor-based’ and labor-intensive’ are used interchangeably for purposes of this document. The term ‘labor-intensive’, however, refers more to any project whereby labor is the predominant component, whether planned or by ‘accident. The term ‘labor-based refers more specifically to a project that has been designed from the start to be ‘labor-intensive’

“Community based” refers to the creation, or in the case of existing governmental responsibilities- the devolution, of defined responsibilities and accountabilities to a non-governmental ‘Community’ Based Organization (CBO). The CBO can be comprised of groups of individuals living in close proximity to each other and/or other social groups, grassroots entrepreneurs or associations that are able to identify a need and come together to access or create project/service/maintenance funds. The size of the ‘community’ varies depending on the type of project and includes people from all areas that make direct use of the facility, service, or infrastructure works. Often a CBO is an umbrella organization for several smaller Community Development Committees.

- All “community based” initiatives are considered to share certain key characteristics and goals:
 - ‘Community’ members are involved in identifying needs and for the example of maintenance, establishing a budget, schedule, logistics (labor, materials, equipment), and procedures and methods of implementation,
 - Further the ‘community’ is responsible for overseeing and implementing the maintenance, which is usually done through a ‘community’ management or business/committee/unit / that, would oversee the business activities associated with providing maintenance.

Road classifications⁴:

- Main, primary, strategic roads: Main road networks are fundamental to national economies. Main roads are defined as roads under the direct responsibilities of the central government and in some instances county governments. They link the main administrative and economic centers together, provide the backbone of a country's road network and generally support traffic above 200 vehicles per day.
- Secondary roads: Secondary roads are also of national import and can be considered strategic in the sense that they would also link major or significant administrative and economic centers, perhaps as satellite roads to the primary roads. Generally they would be through roads and be accessible from at least two intersections with either primary roads or other secondary roads.

Rural/tertiary/feeder/penetration roads: The definition of what constitutes rural roads in Liberia is fuzzy and varies depending on the particular circumstances. Rural roads would normally be under the responsibility of local governments and communities and link rural communities together or rural communities to agricultural production areas. The term ‘Rural’ roads are often used interchangeably with the term ‘Low volume Roads’, with a range of 20 or under vehicles/day, to a maximum of 200 or under vehicles/day: Thus the wear occasioned by traffic is relatively slight, compared to medium or high volume roads. For purposes of this document a ‘rural’ road is defined as a ‘publicly owned road whose primary purpose is to provide direct access for rural villages and communities to economic and social services’.

⁴ Currently, road classifications in Liberia are somewhat informal, and without a benefit of a comprehensive uniform post-conflict review and re-classification – with roads appearing to be classified as ‘primary’ or ‘major’ depending on the source, and as ‘unclassified’ for all other roads. The classifications and definitions offered in this document are based on a somewhat loose ‘functional’ description of the roads, and are intended only for the purposes of this document.

Discussion⁵ - General

Based on the above general definitions, the Greenville-Buchanan Road would be considered a ‘Primary’ road, and the Todee Road⁶ would be considered a ‘Rural’ road.

Based on the classifications of the Greenville-Buchanan Road and the Todee Road two general concepts (models), specifically for the implementation of three seasons (1-dry, 2-rainy) of routine maintenance funding by USAID, are under consideration.

When formulating a road routine maintenance program in Liberia it is important to recognize that such maintenance has not been performed for at least 20-years and that institutional memories and records, as well as those of individuals, are non-existent. Further Liberian contractors are not familiar, in particular, with the *on-demand* logistics and requirements for providing routine maintenance during the rain-season, as well as for the requirements during other times (see Table1: Seasonal Routine Maintenance – Description – Priority): During the rain season it is anticipated that it will be necessary to monitor the roads frequently and to respond early to situations that can lead to damage or deterioration, e.g. clean debris from culverts and water crossings, repair excessive erosion, and repair damage to the carriageway.

Further, the effect of extremely high rainfall on road deterioration and subsequent maintenance needs is basically unknown: The Liberia average rainfall⁷ ranges between 4770 mm along the coast to 2030mm in the interior, values significantly higher than in other areas: For example, in Uganda where there has been considerable experience with routine maintenance of Laterite roads, the average rainfall in the wetter areas is only about 1500mm.⁸

Table1: Seasonal Routine Maintenance – Description – Priority

Season	Priority	Description
Before Rains	1	Clean culverts and water crossings
	2	Clean side and miter drainage ways
	3	Repair side drain erosion and scour checks
	4	Fill potholes
During Rains	1	Inspect and remove obstacles
	2	Clean culverts and water crossings
	3	Clean side and miter drainage ways
	4	Repair side drain erosion and scour checks
	*1	Monitor and repair excessive slope erosion and carriageway damage
Post Rains	1	Repair erosion on shoulders (verges) slopes, and on drainage ways

⁵ The concepts presented herein are based on implementing the proposed USAID maintenance funding in a TA framework. In reality LCIP will have only one season (one full cycle of TA) in which to implement. Most TA initiatives are structured to be implemented over a three to five year period. LCIP and USAID will need to consider the structuring of the LCIP TA initiative within the context of continuing the initiative through at least one subsequent full TA cycle under a subsequent program.

⁶ Todee Road served as access for Tubman Military Academy. It is also considered a ‘Major’ road by Montserrado County and could have at one time possibly have been considered a secondary road. Today, Todee Road serves ‘functionally’ as a rural service or ‘penetration’ road. Even though plans are underway to connect the Todee road with Bensonville this document considers Todee Road as ‘Tertiary’ and ‘Rural’

⁷ “Liberia National Adaptation Programme of Action –NAPA”, Liberia EPA, 2006

⁸ See Attachment A – recent unsealed road sustainability findings

	2	Reinstate scour checks
	3	Reshape carriageway
	4	Fill potholes and ruts in carriageway
	5	Trim vegetation
Dry season	1	Repair structures
	2	Reshape and restore carriageway
	3	Trim vegetation
All seasons		Emergency work

Road maintenance involves interventions or works required to keep the road, its structures and property within the road margins as near as possible to their as-constructed or rehabilitated condition. The continuous need for routine maintenance interventions, particularly in the rain-season, tends to make their management and monitoring more complex than that of construction, especially considering the unpredictability of events or response needs. In effect, this makes ‘maintenance management’, especially in the rain season, more of process *management*’ than that of ‘project *management*’, for example the following process tasks are anticipated:

- Delivering (response implementing and monitoring) a defined *quality* of service
- Response allocation and logistics of resources (personnel, materials and equipment)
- Definition of response activities and procedures
- Response logistics depending on location
- Response to, and timing of interventions
- Continuous budget monitoring and updating

The formulation of a routine maintenance program involving two modalities, one for Greenville-Buchanan Road, and one for Todee Road, is in essences a *pilot program* of such activities for all of Liberia.

Discussion - Road Specific

Greenville-Buchanan Road

Being a ‘National’ road linking vital economic and administrative centers, Greenville-Buchanan Road is of strategic importance to the functioning of government and the economic growth and security of Liberia.

Rehabilitation along the Greenville-Buchanan Road has varied from specific or isolated improvements, to the provision of a Laterite surface course, and new culverts, for the [full 30Km](#) Cestos spur. Undertaking of routine maintenance, during the rainy season, will involve first determining which sections of roads are to benefit from the maintenance initiative, and further, how are the maintenance services to be delivered in each section.

Realistically, there are several mechanisms open for the service delivery:

- Contracting to a private contractor
- Force Account (by LCIP)
- Community involvement

There are no Liberian contractors trained or even familiar with the work tasks, response requirements, logistics, and administrative and documentation needs of a routine maintenance program. Therefore, any involvement of contractors, other than to simply procure labor, will involve a high degree of training (both contractor and labor) and significant oversight by LCIP. LCIP will also have to develop technical specifications or ToRs and full contract documents with which to procure and sub-contract.

Force Account by LCIP will involve establishing a reliable labor base (conceivably full time in the rainy season), and obtaining an on-demand commitment of equipment from contractors or other sources. The LCIP supervisors and retained labor would have to be trained and, at least initially, have a high degree of oversight. LCIP will have to prepare guidelines and work procedures. LCIP will need to bolster the Monrovia staff as well as make any necessary staff additions for Buchanan based staff.

Community involvement would involve a high degree of participation in developing a program and the establishment of Community Based Organizations (CBOs), or micro-enterprises: Which itself would require the initiation of a program to develop the CBOs or micro-enterprises. Further, this approach is expected to be feasible only on sections of the road where there is a significant community. For these reasons, this approach is not being considered for Greenville-Buchanan Road at this time.

Further, recognition of the different requirements between the rainy and the dry seasons allows for creation of immediate program services only for rainy season services, with dry a season program and services being developed during the rainy season: An approach which LCIP is considering.

Envisioning the program as a ‘pilot program’, and anticipating resource and logistic concerns, LCIP is considering providing Force Account rainy season services on the Cestus spur, and sub-contracting for rainy-season services on the remainder of the road sections which are to be included in the routine maintenance program: Should the sub-contracting approach prove not feasible at this time, LCIP will have to be prepared to expand the Force account services. LCIP is considering that both approaches, for rainy-season maintenance are labor intensive, with equipment for support or as needed for emergency services. This is illustrated in Table 2, “Potential Work Methods for Routine Road Maintenance” which provides a general comparison of the applicability of either equipment (not including light vehicles) or Labor as being the predominant category.

Table 2: Potential Work Methods for Routine Road Maintenance

MAINTENANCE ACTIVITY	POTENTIAL WORK METHOD	
	Equipment	Labor
Drainage way cleaning and reshaping	Good	Good
Minor bridge and culvert repairs	Poor	Good
Minor bridge and culvert debris removal	Poor	Good
Major bridge and culvert debris removal	Good	Fair/Good
Repairing or installing scour checks	Poor	Good
Repair of limited carriageway damage	Poor	Good
Re-grading damaged surfaces	Good	Poor
Filling of unpaved surfaces and slopes	Poor	Good
Grass cutting	Good	Good
Repair and replacing traffic signs	Poor	Good
Stockpiling laterite and fill	Good	Fair

Procurement of sub-contractors and labor can either follow the FAR/AIDAR procedures for full and open competition or, as an option, justification for other than full and open competition

(JOFOC) can be provided and permission requested. Given the limited experience and capability of Liberian contractors and the need to secure labor from a reliable source(s), LCIP is seriously considering pursuing JOFOC(s). This will entail discussing the situation with the Contracting Officer (CO) and developing a course of action for the acquisition of the services. For either acquisition path, LCIP will have to ascertain the availability of contractors in the Buchanan area, the availability of reliable labor resources, and the potential suppliers of the labor resources (LCIP is not considering the direct hire of unskilled labor for routine maintenance services).

Todee Road

Currently, LCIP has ongoing, in addition to the construction of Todee Road, a pilot initiative (intervention) within the entire Todee Road Development Corridor. The elements, aspects, and objectives of this initiative are fully described elsewhere. This initiative lends itself to the provision of routine road maintenance through a community involvement approach. The nature of the work being envisioned as mostly labor-intensive for the Todee road also lends itself to significant ‘community’ involvement.

Community Development Committees (CDCs) have been established within the Todee Road Corridor. Further, Community Based Organizations (CBOs) each comprised of representative members from several CDCs have been established and registered with the government. These CBOs are intended to have the necessary internal organization and capacity to provide for a range of services, including road maintenance services.

Through the Todee Road Development Corridor initiative LCIP intends to engage the CBOs for the performance of routine maintenance, initially during wet weather, and again during dry weather. Working closely with LIDA, the NGO providing services, LCIP will train the CBOs^{9,10} administrative staff on routine maintenance functions, while LIDA will train the CBO in business and administration. LCIP will also provide training to the community residents on technical issues and procedures for routine maintenance. As a slightly modified approach, consideration will also be given to engaging one of the technical NGOs currently working on the Todee Road construction to perform the maintenance, perhaps as an output/performance based grant, who in turn would engage the CBOs.

Conceivably, LCIP would provide needed TA to both the MPW County level and pertinent District level personnel. The types of TA are envisioned as being similar in concept to the TA discussed under Greenville-Buchanan Road. Through the pilot Todee Road Development Corridor Initiative, the social NGO LIDA, along with other consultants and internal and external experts, the CBOs and technical NGO would be provided with the necessary TA.

⁹ A major point yet to be discussed is that of the exact business nature of the CBOs, and that of the concept of payment for labor obtained through the CBOs, both for administrative and manual services. Such concepts might involve USAID policy decisions regarding in-kind services (e.g. sweat-equity) and the general policy regarding a fully ‘volunteer’ approach to road maintenance

¹⁰ LCIP envisions that for purposes of road maintenance the CBOs would be provided with a modicum of equipment and small vehicles, along with the necessary TA

Discussion – Other Matters

MPW

LCIP intends as part of a TA program to involve the Ministry of Public Works (MPW) in the routine maintenance program. At minimum it is envisioned to actively include the respective Regional Engineers. In the short term such TA would largely comprise:

At regional/county level:-

- Direct assistance in day to day management of maintenance works;
- Assistance in supervision of maintenance works under the direct force account (during the rainy season) and by contract;
- Assessment of maintenance needs, planning of works at field level;

At the MPW HQ level: -

- Involvement in planning, budgeting and scheduling of maintenance works.

LCIP intends to initiate discussions with MPW regarding its involvement. At this point opportunity will be taken to assess the capacity of the County Level MPW Establishment expected to be responsible for future maintenance.

Training Program

Most routine maintenance programs benefit from having had a substantial training and capacity building effort prior to the start of the maintenance per se. LCIP intends to prepare guidance and training manuals and other documents to be used in an accelerated training program for Greenville-Buchanan Road Force Account administration and labor, and for contractor administration and labor, including the importance of on-demand response. In addition, LCIP will prepare ToRs to be used for the acquisition of contractors, and for the acquisition of labor.

Reporting, Monitoring, Oversight, and Documentation

Having a good reporting system is essential for effectively managing the processes involved in routine maintenance. LCIP intends to establish a rainy season Reporting and Documentation system, including the necessary forms to: Assess maintenance needs, provide task orders, and provide assessment and approval of work completed, including response. LCIP intends to establish documentation and retrieval of pertinent information, including event types, locations, activities carried out, work-days per task order, and materials used. For sub-contractors LCIP will have to provide another layer of monitoring to help ensure the accuracy of their reporting and documentation.

LCIP is considering providing bi-weekly summary reports to MPW on the overall metrics of the routine maintenance, such as: total work days, work days for work types, average work days per task, etc.

LCIP will monitor the effectiveness and efficiency of the routine maintenance.

Networking

Currently, DAI is networking with other donors (e.g. World Bank, ILO, EU) to ascertain if their programs can be leveraged. For example, the ILO has had considerable experience training on

labor based road tasks and, as available, it might prove feasible to leverage their expertise and resource materials.

To Do/Checklist

Below is an initial check list based on the several days of internal LCIP maintenance discussions. The items on the To Do/Checklist will need to be expanded and added to.

Check on:

- Labor availability (full time, on-demand), in relation to road locations
- Labor provider (available, interest, capability)
- Equipment availability (full time, on-demand)
- Contractors (available, suitable, interested)
- Safety requirements
- Environmental requirements
- Acquisition and procurement process (full and open competition, JOFOC)
- Provisions for emergency work
- Preparation of training and guidance materials technical, safety, environmental
- Preparation of ToRs and contract documents
- Reporting and monitoring requirements
- Logistic requirements
- Vehicle requirements
- Office and operation space requirement and availability
- MPW discussions e.g. Regional Engineers, etc.

References and Suggested Readings

The following readings are suggested as background for the strategy session. Electronic copies are available at DAI.

MAINSTREAMING APPROPRIATE LOCAL ROAD STANDARDS AND SPECIFICATIONS AND DEVELOPING A STRATEGY FOR THE MPWT RESEARCH CAPACITY, SEACAP 3, APPLICATION OF LVRR STANDARDS AND SPECIFICATIONS, Laos Ministry of Public Works and Transport, (2008)

ROAD MAINTENANCE SUSTAINING THE BENEFITS OF IMPROVED ACCESS, Chris Donnges, Geoff Edmonds, Bjorn Johannessen, ILO (2007)

WHY ROAD MAINTENANCE IS IMPORTANT AND HOW TO GET IT DONE, Sally Burningham and Natalya Stankevich, World Bank Transport Note No. TRN-4, (2005)

LIBERIAN LOCAL GOVERNMENT DEVELOPMENT PROGRAMME: TOWARDS DECENTRALIZATION, Ms. Mou Charles, Mr. Maxwell Poe (Former Deputy Minister Ministry of Internal Affairs), UNCDF/UNDP, (2006)

COMMUNITY-BASED APPROACHES AND SERVICE DELIVERY: ISSUES AND OPTIONS IN DIFFICULT ENVIRONMENTS AND PARTNERSHIPS, Tom Slaymaker, Karin Christiansen, Isabel Hemming, Overseas Development Institute, Background paper DFID Sudan Desk, (2004)

COMMUNITY-BASED CONTRACTING: A REVIEW OF STAKEHOLDER EXPERIENCE, Samantha de Silva, The International Bank for Reconstruction and Development/The World Bank, (2000)

RURAL ROAD MAINTENANCE MANAGEMENT, Bjorn Johannessen, Rural Infrastructure Improvement Project, Cambodia, (1999)

BUILDING LOCAL GOVERNMENT CAPACITY for RURAL INFRASTRUCTURE WORKS, Bjorn Johannessen, Geoff Edmonds, International Labor Organization, (2003)

FINANCING RURAL TRANSPORT INFRASTRUCTURE, C. Malmberg Calvo, World Bank (1998)

FINANCING OFF ROAD MAINTENANCE IN SUB-SAHARAN AFRICA, Reforms and progress Towards Second Generation Road Funds, Mustapha Benmaamar, SSATPP Discussion Paper No. 6 (2006)

EXPANDING LABOR-BASED METHODS FOR ROAD WORKS IN AFRICA, SSATPP Working Paper No. 22, Elisabeth A. Stock & Jan de Veen (1996)

OPTIONS FOR MANAGING AND FINANCING RURAL TRANSPORT INFRASTRUCTURE, WORLD BANK TECHNICAL PAPER NO. 411, Christina Malmberg Calvo

Concept note, LCIP Infrastructure programme July '08 – Dec 2009, internal DAI document

Community Access Development Paper, internal DAI document

Discussions with World Bank (WB), European Union (EU), International Labor Organization (ILO), and Liberian Agency for Community Empowerment (LACE) regarding their past projects, lessons learned, information resources, personnel resources, and status, strategy and implementation modalities of proposed programs and projects.

ATTACHMENT A

Adapted from - “Mainstreaming Appropriate Local Road Standards and Specifications and Developing a Strategy for the MPWT Research Capacity, SEACAP 3”, Laos Ministry of Public Works and Transport, (2008)

Unsealed road sustainability

Traditionally developing countries have relied on the use of unsealed natural gravel/laterite as a rural road surface, due to its initial low costs and relative simplicity of construction. However recent research confirms the serious problems relating to maintenance and sustainability of such surfaces in many road environment situations common in South East Asia¹. There are also health and environmental concerns regarding the widespread use of gravel as a road surface.

Gravel is a ‘wasting’ surface and material losses due to the effects of alignment, traffic and weather can be 3cm of thickness per year or more, even for good quality surfacing material. The use of poor quality material will result in increased rates of gravel loss. Furthermore, haul distances from suitable deposits can be long, and will inevitably increase as available or accessible gravel deposits are worked out. This type of surfacing can create a substantial periodic maintenance liability. Unsealed gravel should *ideally* only be used for rural road surface applications in situations where sustainability conditions are fulfilled. These are summarized below:

1. **Adequate maintenance is guaranteed** – Gravel is a high maintenance surface requiring both routine reshaping/grading and expensive periodic re-gravelling. The regular maintenance of cross-sectional shape is a particular requirement that must form part of routine maintenance programs.
2. **Gravel quality adequate** – Gravel should comply with grading and plasticity requirements and not break down under traffic, otherwise it will be lost from the surface at a high rate. Gravel quality varies substantially within each pit location. Great care is essential to ensure that only suitable material is selected, and that mixing in of marginal/unsuitable material is avoided.
3. **Adequate gravel deposits are available** – Gravel is a natural and finite resource, usually occurring in limited quantities. Once deposits are used up, subsequent periodic re-gravelling will involve longer hauls and higher maintenance costs.
4. **Compaction and thickness is assured** – Poorly compacted gravel will be less durable. Supervision arrangements should ensure that the full specified properly compacted thickness is placed.
5. **Haul distances are short** – Hauling gravel for routine and periodic maintenance causes damage or further maintenance liabilities to the haul routes.
6. **Low to moderate rainfall** – Gravel loss is related to rainfall and may be excessive with intense storms or where annual precipitation is *greater than 2000mm²*.
7. **No dry season dust problems** – Long dry seasons can allow the binding fines to be removed from the surface by traffic or wind, allowing the gravel to be more mobile. Further this is a particular health problem where communities live beside the road or their crops and property are regularly coated in dust. Inhalation of road dust is unhealthy and there are also safety-visibility issues.
8. **Low traffic levels** – Gravel loss is related to traffic flows. It is unlikely that a gravel surface will be cost-effective at traffic flows of more than 200 motor (2 or more axles) vehicles per day.
9. **Low Longitudinal Gradients** – Gravel should not be used in on gradients more than 6%

¹ A region having a tropical hot wet humid climate, resembling to some extent that of Liberia

² Liberia’s annual coastal rainfall averages about 4700mm

(LVRR Standards and Specifications Part I: Table 3). In medium to high rainfall areas (1500-2000mm/yr) gravel loss by erosion will be high on gradients more than 4%.