# REPORT OF ENGINEERING REVIEW

# LANDSLIDE AND SOIL STABILIZATION PROJECT

# FAR WESTERN HILLS ROADS

Godavari to Dadeldhura, Nepal

USAID Project No.367-0138

Completed July 15, 1982

by

Martin C. Everitt, P.E.

Geotechnical & Materials Engineer

December 1983

Kathmandu

BEST AVAILABLE COPY

Persons Contacted:

Mr. Jaya Bahadur Bada, Overseer, Godavari

Mr. D.P. Banstola, Deputy Regional Engineer,

Mr. Jitendra Bahadur Basnet, Chief District Officer, Dadeldhura

Mr. Ram Dutta Bhatta, Assistant Engineer, Bhatkanda-Doti Road Project

Mr. Bishnu Bhatta, Overseer, Bhatmanda-Doti Road Project

Mr. Ganesh Prasad Bhatt, Panchayat Chief, Dadeldhura

Mr. Ghambhir Chand, Assistant Engineer, Bhatkanda-Doti Road Project

Mr. Madhav D. Joshi, Zonal Engineer, Seti Zone, Godavari

Mr. S.D. Nepali, Divisional Engineer, Kathmandu, formerly LSS Project Manager

Mr. B.R. Pant, Divisional Engineer, Dhangarhi

Mr. Maheshwar Shrestha, Acting Divisional Engineer Bhatkanda-Doti Road Project

Mr. M.B. Shrestha, Divisional

Mr. Shankar Govinda Shrestha, Acting Chief, Mechanical Section, Godavari

Mr. D.J. Thapa, Superintending Engineer, Foreign Cooperation Division, Department of Roads

Mr. Naresh Singh Thapa, Kailali District Forest Controller, Dhangarhi

Mr. Shiva Hari Upadhyaya, Senior Accountant, Godavari

ENGINEERING REVIEW

Table of Contents


| | | Page |
|---|---|---|
| I | LSS CONSTRUCTION | 1 |
| | INTRODUCTION | 1 |
| | MATHUR'S RECOMMENDATIONS, FINDINGS AND COMMENTS | 3 |
| | MAJOR CONSTRUCTION ITEMS PROPOSED BY KOJAN AND MATHUR | 9 |
| | Peripheral Drains | 9 |
| | Gabion Buttresses and Breast Walls | 10 |
| | Counterfort Drains | 10 |
| | Side Ditches and Subdrains | 10 |
| | Cross Drains | 11 |
| | Horizontal Drilled Drains | 11 |
| | Rock Bolts | 11 |
| | Removal of Slide Material | 11 |
| | Slide Shed at Km 126 + 100 | 12 |
| | CONCLUSION | 12 |
| II | OPERATION AND MAINTENANCE | 14 |
| | INTRODUCTION | 14 |
| | MAINTENANCE OBJECTIVES | 15 |
| | Level 1 | 16 |
| | Level 2 | 16 |
| | Level 3 | 16 |
| | Level 4 | 16 |
| | Level 5 | 17 |
| | MAINTENANCE EQUIPMENT AND PARTS | 17 |
| | Present Situation | 18 |
| | Equipment | 18 |
| | Tools | 20 |
| | Selection of Maintenance Equipment | 20 |
| | Recommendations | 21 |
| | ORGANIZATION, PERSONNEL AND TRAINING | 22 |
| | Present Situation | 22 |
| | Recommendations | 25 |

| | | Page |
|---|---|---|
| | PLANNING AND BUDGET | 26 |
| | Present Situation | 26 |
| | Recommendations | 28 |
| III | IMPROVEMENTS | 31 |
| IV | OTHER ENGINEERING ITEMS | 33 |
| | Rubble Masonry Walls | 33 |
| | Concrete Culvert Pipe | 34 |
| | Debris Racks on Pipes | 35 |
| | Paving | 36 |
| | Chart - Rainfall at Godavari by Month | 37 |
| V | APPENDIX | |
| | Reference List | |
| | Persons Contacted | |
| | List of Equipment | |
| | Photographs | |

# I. LSS CONSTRUCTION

## INTRODUCTION

One of the primary missions of the team was to review the construction done under LSS to determine whether it was done substantially as specified, whether or not it was successful, and what might be done differently another time. The team was fortunate in the presence of some DOR engineers and overseers who were generally able to distinguish between LSS installations and those done under the original construction projects.

It was much harder to distinguish damage caused by the recent, very intense storm of 26 and 27 Bhadra, 2040 (11 and 12 September, 1983) from that still remaining from earlier more or less normal monsoon storms, which had not been totally removed, and the team's judgement may not have been completely correct on occasion.

In evaluating the LSS designs reliance was placed primarily on the reports by Kojan (1)* and Mathur (2). Some difficulty in identifying specific sites occurred because chainages have been revised since the earlier reports and distance variations of three to six kilometers were encountered. Some reliance was placed on Kojan's photos of specific sites as well as the recollections of the accompanying DOR personnel.

* Refers to items in the Reference List.

Kojan's recommendations were stated in general terms both for individual sites and broader areas. Mathur modified to some extent, and translated those generalities into site specific work items tabulated in his report, and displayed on plan and profile sheets which he signed. Later some additional modifications were proposed by DOR engineers, and endorsed by AID. Most of those were made necessary by budget limitations.

The team did not attempt to check each and every item, but rather, representative installations of each item were found and checked and an overall impression of the total project was developed by six days spent on the road, both walking and riding. The major landslides, given individual names by Kojan were examined and photographed. Some of the photos are included in this report.

It is evident that both Kojan and Mathur, and also this writer in an earlier visit to Nepal, tended to underestimate the ability of DOR and Nepali Contractors' personnel to execute quality work and to understand that does work in the Nepali environment.

Mathur is to be complemented on his standard designs for gabion walls, ditches, subdrains, interceptor drains and other facilities as presented in his report. These designs were well executed and nearly all have performed as well as, or better than should have been expected. Some walls which

at first appear to have failed did not fail, but were overtopped and buried by slide debris from higher on the slope.

Where failures did occur, most are attributed to the intense storm of September 11 and 12 which clearly exceeded design parameters.

Kojan and Mathur were somewhat unrealistic in specifying items such as rock bolts, plastic membranes, horizontal drilled drains and sophisticated blasting techniques which are not readily available in Nepal. At the same time however, there is a reluctance on the part of the DOR to acquire unfamiliar technology, even that which is not excessively expensive and has a very high probable benefit.

MATHUR'S RECOMMENDATIONS, FINDINGS AND COMMENTS:

The following section discusses each of Mathur's final recommendations, which are derived from Kojan's earlier study. The recommendation is summarized or paraphrased, followed in each case by the team's findings and then by additional comments as appropriate.

1. Recommendation: No construction or reconstruction work should be allowed to proceed unless there are working drawings for each site technically reviewed and approved by the project manager or other competent authority.

   Finding: Plan and profile sheets were prepared for all LSS work. These plans were generally adequate, though

rudimentary by US standards. Details of standard items, such as Mathur's gabion buttresses, were provided separately. Detail drawings of one-of-a-kind special treatments, for example, the "Big Muther" landslide, apparently were not provided. At least, none were seen in the plans which were spot checked. Not all plans have survived, and not all of those that did were reviewed.

Comment: The amount of plan preparation and review done for LSS is said to be exceptional for a DOR project. Whether review by officials higher than the Project Engineer would be beneficial is difficult to say, since the Project Engineer is generally considered to be more competent technically than administrators. However, complete and detailed plans are essential and should be required in AID projects.

2. Recommendation: Surveying, geotechnical investigations and geologic mapping should be done for all major landslide areas.

Finding: Mathur signed all of the plan sheets seen by the team which indicates his acceptance of the design work done in each case.

Comment: Mathur's meaning is not clear. If he intended that DOR adopt the LSS standards nation-wide, this team

cannot comment on whether or not that has been accomplished. Certainly, it would be worthwhile objective.

3. Recommendation: Pilot slope stabilization works .. .. .. .. should be monitored .. ..

   Finding: There is no surviving record of any systematic monitoring of these sites. However, the overall success of the LSS works suggests that any results would have been generally positive.

4. Recommendation: Alternative locations proposed by Kojan should be considered.

   Finding: The alternatives were considered, and some survey work was carried out. Amendment No.1 to the Project Grant Agreement, dated 12/30/80 states that designs would be prepared for relocations "if deemed necessary ... and retained in DOR and utilized if further landslides occur." However, it was concluded that the cost was not likely to be justified by the savings over the existing route, and none of the relocations was built. To date, the decision appears to have been supported by events.

5. Recommendation: All slope stabilization works should be completed in three working seasons.

Finding: The project was declared completed in July 1982 approximately three years after Mathur's report.

6. Recommendation: At least 3 engineers should visit the US .. .. ..

Finding: This was done. All three are believed to be still with DOR and one (B.B. Deoja) is now Project Engineer on the Rapti Zone road work sponsored by AID.

7. Recommendation: A short course on rock bolting and horizontal drains should be conducted for about 10 DOR engineers. This should be followed by site visits to projects in India.

Finding: Several engineers visited India to investigate blasting technique but there appears to have been no follow-up technology transfer to others in DOR and no purchase of drills, etc. to implement blasting technique.

There was apparently no actions on the horizontal drain or rock bolting proposals. DOR engineers seem to feel that India does very little road work in the hill country and so has little to offer Nepal in terms of hill country experience or training.

8. Recommendation: "Geometrical constraints should not be clamped routinely in the case of mountainous roads .. .. unless supported by proper justification.

Comment: The function of the transportation system planner is to predict the kind and amount of commodities which are likely to be transported over a road during the analysis period. The optimum vehicle(s) can then be determined and the geometric characteristics of the road based on the size, weight, gradability and other characteristics of these vehicles. Every reduction in standards below those optimums has a cost which can be predicted, and the final compromise between construction cost, maintenance cost and user costs can be analyzed if data exists. If the geometric standards are reduced occasionally, for short segments, the cost is low and signs can be placed to warn drivers of hazards. If standards are too low, the cost of using the road will increase and consumers will be forced to pay more for their goods. Standards must consider realities, but should not go too far toward minimums.

9. Recommendation: The width of road in mountainous terrain should be kept as small as possible to satisfy traffic criteria.

Finding: This item is closely related to recommendation 8 preceding. The Western Hills Road was designed to have a 6.5 m travelled way with an additional 1.0 m for the inside ditch. The team agrees with the philosophy

of the recommendation but doubts, as a practical matter, that a reduction of more than 1.0 m would have been possible.

10. Recommendation: The road should be outsloped wherever feasible.

Finding: There are many kilometers of beautifully laid, grouted rubble masonry ditches which are non-functional for two reasons: (1) they are blocked by slide debris, which in some cases has not been cleared for more than a year or (2) the road surface has eroded below the ditch edge so that water cannot get into them.

Comment: Outsloping generally would improve the surface drainage, especially since there are far too few culverts. However, it probably would be detrimental in the area of unstable sandy soils, roughly from the temple near Melkhara to km 130. If the 40 km/hr design speed is ever to be achieved, superelevation of the curves will force inside drainage in many places.

Team Recommendation: The paved or lined ditches should be abandoned, primarily because they must be cleared by hand labor. Outsloping should be used where the soils will not be excessively eroded, and a steady improvement program aimed at eventually achieving a cross culvert at intervals of no more than 100 m, usually

more frequently, should be begun using maintenance personnel. Where inside ditches are used, they should be designed for machine maintenance for speed and economy.

11. Recommendation: An effective maintenance crew should patrol the road during the monsoon period to clean culvert inlets and other maintenance activities.

Finding: This is apparently done to some extent, though not as regularly and systematically as would be desired.

Comment: This is the single most important item toward keeping the Western Hills Road in service. The drainage and machine maintainable ditches mentioned earlier are an important component of the preventive maintenance concept which will be discussed further in another section of this report. The local overseer should cover his section at least daily during the monsoon and several times weekly in other seasons. He should be assigned a jeep for the purpose. Consideration should be given to installing a mobile radio system for maintenance activities.

CONSTRUCTION ITEMS PROPOSED BY KOJAN AND MATHUR:

Peripheral Drains: These were shown on plans signed by Mathur and many were noticed in the field. The team did not attempt to verify each and every item, but accepts

that these were generally built as planned. Several failed for various reasons and appear to have caused the problems they were supposed to prevent. Peripheral drains, both open and rock filled are a qualified success. Failures should be investigated to determine what, if any, design elements should be modifieid.

Gabion buttress and Breast Walls: These appear to have been built as planned. The quality of the gabion work is exceptionally good and those responsible should be complimented. No serious trouble due to rusting wire, as has been reported in Dang, was noted and very few installations have failed.

Counterfort Drains: An effort was made to observe these in the field but only a few installations were located. Plan sheets did include the counterfort drains and since most of them could have been buried either by design or accident, it is possible that many are in place and functioning. Due to lack of specific memories of these units on the part of local overseers, who are usually knowledgable, the writer suspects that some counterfort drains were omitted. Omission in many cases probably would not be greatly detrimental to the walls.

Side Ditches and Subdrains: In some cases side ditches have failed due to later movement of the slides, or because

of sloughing and filling. Subdrains were built, in general, though in some cases to lesser depth than was specified by Mathur, because of hard rock excavation.

One overseer and an engineer noted that subdrains worked well for a year or two and then apparently failed by clogging. Time did not permit digging any out to verity this situation or to examine the aggregate filling to see whether it was as specified.

- Cross Drains: Included in the above remarks.
- Horizontal Drilled Drains: None have been attempted.
- Rock Bolting: None have been attempted.
- Removal of Slide Material: In several places Mathur specified removal of a substantial part of a slide mass to reduce the driving forces. This was never recognized to have been done and in several cases, a gabion wall was built to support the material in lieu of removing it.

Removal of the material probably would have been cheaper and more effective than the walls, but disposal of the waste material is a problem in many places.

However, many walls are now supporting surcharge loads far in excess of those considered in the designs. These loads have been caused by new material falling on to the body of the slide above the wall, or by deliberate raising of the roadgrade as a means of disposing of excess materials.

Since some buttresses on the cut side of the road (Mathur's Types A,B, and C) are designed for relatively steep sloping surcharges, the probable overstress may not be too serious except in scattered cases during the monsoon. However, many of the walls used on the fill side (Types D,E,F & G) were designed for only slight surcharges. It is possible that some of these are highly overstressed and subject to failure with minor additional loads. Several walls of both types have already yielded noticably.

Maintenance engineers and overseers should review the plans and prepare an "as built" listing of all walls which precisely describes the allowable surcharge. They should then assure than maintenance forces remove all recognized overloads as well as all material which will probably erode and run onto the road during normal rains. If this is not done consistently, there is a strong probability of an increasing number of wall failures as the project ages.

Slide Shed at Km 126 + 100: This was not built and does not appear to have been necessary. There are a number of spots in the vicinity where such a structure would be useful but the team did not recognize the specific site.

## CONCLUSION

The overall conclusion is that the engineering works prescribed were generally built as designed and to a high level of quality workmanship. The works have performed

to or beyond the design requirements in all cases but continued maintenance will be necessary to preserve the investment in these facilities.

# II OPERATION AND MAINTENANCE

## INTRODUCTION

Since the Western Hills Road is the first to be constructed by Nepali Engineers and Contractors, so it must also be the first to be operated and maintained by Nepali forces. The team reviewed maintenance planning and equipment and found that the present situation is not adequate and that much improvement is necessary if the road is to be a useful, substantially all weather, facility. Some government policies should be changed and overall a "maintenance ethic" must be created where none now exists.

Any successful road maintenance effort is largely preventive in nature. That is, the engineer and his overseers must be personally familiar with every meter of the road and must concentrate on recognizing potential problems before they become major, and taking corrective actions immediately. This is more art than science.

Organizations, personnel staffing, equipment selection and location, budgeting, and virtually all other aspects of road maintenance develop in response to the behavior of the road. While a history of performance accumulates over time, it is already apparent that most of the serious landslide problems are North of Budar and so one might anticipate that Budar, near the middle of the road, may

evolve into the most important maintenance station. Bhatkanda, at the Doti road junction, may well become another major maintenance station while Godavari becomes an administrative center and equipment repair station with a lesser role in road maintenance operations.

MAINTENANCE OBJECTIVES

The DOR must develop a series of maintenance objectives for this, and all other roads. These objectives will govern, directly and indirectly all aspects of the maintenance activity and, as will be seen in the following paragraphs, the cost of the maintenance program will depend on the chosen objectives.

Objectives must be chosen on the basis of Government policy, the needs of the people served by the road and the costs and benefits of the road. A higher standard of maintenance will have higher maintenance costs, but also greater benefits to the people and lower user costs for fuel, tires, truck repairs and driver time.

The choice of the appropriate maintenance objective is ultimately based on an economic analysis of maintenance cost, user cost, and the capital cost of improvements such as pavement, with some recognition of political considerations.

An example of several possible maintenance levels or objectives follows; based loosely on those of the US Forest Service. It is recognized that some of these are not appropriate for the Western Hills Road but they are included to complete the illustration. Modifications should be made as appropriate.

Level 1: Custodial maintenance only. Drainage structures are maintained and environmental damage prevented but the road will not be reopened if closed by landslides.

Level 2: The road is kept passable for four wheel drive vehicles with high clearance but speed or passenger comfort are not factors. Drainage is maintained and fallen trees, rocks, etc., are removed if they are a hazard to traffic or block drainage. Closures of several weeks duration are permitted, with public notice posted.

Level 3: The road is kept passable for ordinary autos and trucks. All obstructions are removed from the travelled way, shoulders and ditches. The surface is maintained so that autos can pass, but speed or comfort are not factors. Closures of a few days duration may be permitted.

Level 4: The road surface is maintained to permit moderate speed. Passenger comfort is considered. Dust is abated in congested areas. Any closures or obstructions are removed within one day.

Level 5: The road is maintained for the full design traffic volume at the design speed. Passenger and driver comfort are a major considerations, closures of more than a few hours are not permitted, and dust is controlled if the road is not paved.

Based on the writer's understanding of the situation, and the impacts of the road on the people served as described by T.B. Thapa elsewhere in this report, maintenance objectives similar to Level 3 should be the present goal. Level four or five might be the ultimate goal, to be achieved some years in the future after additional improvements are made, particularly in drainage facilities. The present capability is no more than Level 2.

It is strongly recommended that the DOR determine the appropriate maintenance objectives for the Western Hills Road and state these objectives as a matter of official policy. The above examples are incomplete but could form a basis for the development of appropriate local policy.

## MAINTENANCE EQUIPMENT AND PARTS

The team visited the offices and shop at Godavari and met with several individuals. Unfortunately the Zonal Engineer and the Deputy Regional Engineer were away and while they were met briefly on the road, they were not available for lengthy interviews. It is hoped that their views were accurately presented by others.

The maintenance stations at Budar and Bhatkanda were also visited as were the two tree nurseries. The nurseries will be discussed in another section by Paul Winkelaar.

Present Situation

Equipment: The list of equipment currently on inventory at the Godavari Division Headquarters is included in the appendix. It includes 106 pieces of various kinds, built by at least 30 different makers in six nations. Thirty-two pieces are in working order, fifty are awaiting repair parts, twenty-three are beyond repair and one, a pile hammer, is idle for lack of appropriate work. Three machines are on the Doti road and the rest are listed as being at Godavari or Budar, though the team did not see anywhere near the number of pieces of equipment listed.

Except for perhaps a dozen pieces, mostly trucks, all of the equipment is more than ten years of age and under the best of conditions would be at the end of its economical service life. The unservicable items have been cannabalized to keep the others running and authority has been sought to sell this junk equipment at auction.

There is a substantial inventory of parts on hand and it appears to be well organized and efficiently cataloged. However, about 1/3 of the items are for equipment which is no longer located at Godavari. This same problem was noted by D.J. Gephart in a trip report dated 11/20/79. For

some reason, the DOR has not authorized disposal of these parts which would release valuable storage space for other uses and possibly generate some revenue through sales.

Persons contacted indicated that most or all of the parts needed to place the fifty repairable machines in service can be obtained in Kathmandu or India if purchase were authorized. The authorization must come from Kathmandu and action is unnecessarily slow. Apparently the approving officials are not aware of the cost of idle equipment. They should be required to act more quickly.

The Chief Mechanical Engineer has an annual emergency parts budget of 15,000 rupees and can make single purchases for up to 5,000 rupees on the basis of three quotes. Purchases exceeding 5,000 rupees must be tendered. Since a single truck tire costs about 7,300 rupees, it is obvious that the Chief Mechanical Engineer cannot do much to expedite parts supply.

There is no accounting system to amortize the equipment throughout its life-span and to provide repair or replacement money. When a piece of equipment must be replaced, the entire process must begin from point zero, despite the fact that the need can easily be predicted well in advance of the fact.

To illustrate by an example, the US Forest Service has a working capital fund (WCF) for this purpose. When a piece

of equipment is bought, it is assigned an estimated service life and estimated maintenance costs. Whenever the equipment is in use, the using project is charged a monthly rate which is set aside in a fund for eventual replacement of the machine, and a daily or hourly rate which pays for fuel and routine maintenance. If a machine is no longer needed, it is transferred to another location or sold.

Use rates charged are reviewed periodically and adjusted to reflect the actual costs of the individual machine, which may be more or less than was originally estimated. When it is time to replace the machine, funds are available in WCF to pay for the new item.

Mechanics Tools: No special tools or equipment were in evidence. There are no engine analyzers, test gauges or any of the special lifts, dollies, or other apparatus usually found in a heavy equipment shop. No lube truck was seen, though it was not specifically requested.

Hand tools are in poor condition and not plentiful. In 1983 some 5,000 to 6,000 rupees was spent on new tools but that probably purchased only about what a weekend auto hobbyist would have in the U.S.

Selection of Maintenance Equipment

Maintenance equipment must fulfill a different mission than construction equipment. Speed and maneuverability are

usually more important than high production rates, so more small pneumatic tired equipment might be expected. Large earthmovers probably will be absent. A few specialized items may be necessary, such as a small truck crane with a clamshell bucket for clearing culvert inlets.

The following items would be basic to any maintenance operation:

Crawler Bulldozer D-7 or D-8 size, with transport readily available;
Pneumatic Tired Front Loaders, medium size;
Patrol Graders - Cat. #12 size;
Backhoe-Case CK or equivalent;
Dump Trucks - 5 CY single axle;
Fuel and Lube Truck.

One problem with the present fleet is the multiplicity of different makes and models which greatly complicates mechanic training and parts supply. In selecting and distributing equipment, the DOR should try to keep the variety of makes and models of similar equipment to a minimum.

Recommendations

The following actions are recommended with respect to the maintenance equipment fleet equipment to be located on the Western Hills Road:

1. After establishment of the maintenance objective, and consideration of labor vs. machine intensive operations, determine the type and numbers of machines needed, and the placement of these at various locations.

2. Purchase the equipment as rapidly as possible, but limit the number of different manufacturers and models.

3. Purchase a generous inventory of spare parts and any special tools recommended by the manufacturers.

4. Establish some form of revolving fund to provide for repair and replacement of equipment. The US Forest Service Working Capital Fund is suggested as a model, though the Nepali version should be less complicated.

5. Dispose of any existing unservicable equipment and any other equipment not required for the Western Hills Road by sale or transfer to other locations. Also dispose of unnecessary spare parts.

## ORGANIZATION, PERSONNEL AND TRAINING

### Present Situation

Maintenance of the Western Hills Road is under the overall direction of the Deputy Regional Engineer for the Far Western Development Region located at Godavari and the Zonal Engineer for the Seti Zone, also located at Godavari. These two men are also responsible for the other roads in

their Region or Zone, totaling some 342 km in addition to the subject project. The Godavari equipment shop and the inventory of equipment previously described also serve these other roads.

Staff positions on the WHR include District Maintenance Engineers at Dhangarhi and Budar who are responsible for km 0 to 73 and km 73 to the end respectively. They are assisted by overseers at Dhangarhi and Khani Dada. Some organizational changes are under consideration by DOR, but are not yet decided.

The following positions are presently on the regular payroll at Godavari, though presumably the individuals could be working on any of the roads under by the Godavari Regional Office.

| | |
|---|---|
| Fuel Man | 1 |
| Storekeeper | 1 |
| Loader Operator | 3 |
| Bulldozer Operator | 3 |
| Senior Mechanics | 7 |
| Junior Mechanic | 2 |
| Helpers | 10 |
| Mechanical Engineer | 1 |
| Radio Operator | 1 |

In addition, the following daily wage or seasonal hires are authorized as needed:

| | |
|---|---|
| Machinist | 1 |
| Helper | 8 |
| Chowkidar | 9 |
| Electrician | 1 |
| Generator Operator | 2 |
| Pump Operator | 1 |
| Roller Operator | 3 |
| Office Assistant | 4 |

Laborers as needed to budget limit.

These lists include both road and shop workers. Obviously, the equipment operators and laborers generally would be on the road and the others would be based in the office or repair yard, though mechanics would make many repairs on-site.

The team is not competent to assess skills and training needs. Because of the Tihar Festival there was little activity in progress. However, the mechanics' ability to keep at least some of the equipment functional should not be overlooked. Apparently most of the mechanics have been trained in either Kathmandu or India.

No equipment operators were seen in action. Since the most difficult maintenance machine to operate skillfully is the motor grader, special training and incentives should be considered for the men assigned to these machines.

It is assumed that there is a need for training in the area of maintenance management which probably will be most directly performed by the District Engineer. Maintenance management, in addition to intimate knowledge of the road and all of its trouble spots, requires thorough knowledge of the cost of each of a large number of specified work items regularly done, and the tools, equipment and supplies needed for each. It is essentially a cost accounting system.

While a "Maintenance Management System" as the term is currently in vogue in the U.S. probably is excessively sophisticated for Nepal, it may be useful for several maintenance engineers to visit the U.S. to study maintenance in rural countries in the western mountain states, in the U.S. Forest Service, or some smaller State Highway Departments. The National Association of County Engineers probably could suggest an itinerary.

Alternatively, a maintenance engineer could be brought here on a PASA or a contract to help set up a maintenance plan for the WHR which could be expanded to the rest of the country. Since some of the best maintenance men are not graduates in engineering, but simply very experienced "old hands" it is not necessary that high academic requirements be established.

Recommendation

The team has no recommendations in the area of organization because the needs of the WHR have not yet fully emerged.

1. It is recommended that the DOR consider sending some maintenance specialists to the US to study all aspects of maintenance operations and management in rural country organizations in the mountain areas.

2. Some form of maintenance accounting and management system should be established using the principals, if not the details and computer storage, of a Maintenance Management System.

## PLANNING AND BUDGET

### Present Situation

There are two parallel Zonal budgets for DOR. One is called the Development Budget and the other is the General Maintenance Budget. The Development Budget generally includes improvement and capital items while the maintenance budget includes road maintenance activities, fuel, supplies and labor. Only two years of history are available for the WHR since in previous years the road was under the construction budget, rather than maintenance.

Available figures are as follows:

| | | Dev. Budget | Maint. Budget |
|---|---|---|---|
| FY 2039/40 | Budgeted | Rs. 3,540,000 | Rs.1,118,000 |
| | Spent | Rs. 3,435,000 | Rs.1,118,000 |
| FY 2040/41 | Request | Rs.13,455,000 | Rs.1,500,000 |
| | Budgeted | Rs. 3,990,000 | Rs.1,400,000* |

* Includes Rs. 700,000 for storm damage clearing. Remaining maintenance budget is Rs. 700,000 for routine work vs. Rs. 1,118,000 last F.Y. Persons interviewed indicated that Rs. 5,000,000 would be a realistic figure for the current Fiscal Year.

A major problem lies in the budget process. Only the present fiscal year is budgeted so there is no opportunity for future programming. Due to the festivals early in the F.Y. the final budget advice is not released to the field until about 3 months have passed and even then expenditures must be resubmitted for final review and approval. Late in the F.Y. cuts not previously anticipated may be imposed arbitrarily so that final spending often falls short of the original authorization. Much of the engineer's time is spent in manipulating the budget process instead of the work.

After the Zonal Engineer submits his budget request for the coming F.Y., the Headquarters office normally makes cuts by line item. These cuts are usually not coordinated with field priorities. Thus, the Engineer has little or no authority to shift or reallocate funds within his overall spending limit, or to readjust his priorities in the face of changing field conditions.

Since the budget advice lags behind the start of the F.Y. and also the Monsoon, the field engineers have minimal authority to spend money for emergency damage control work. Since preventive maintenance during the monsoon has been

strongly recommended several times in this and other reports, some provision for emergency funding must be made.

With respect to equipment purchases, there is no orderly system for planning acquisitions or for paying for them other than by line item in the current budget. Since a large item such as a bulldozer is easy to cut from the budget request, it is difficult to make capital purchases on a timely or logically planned basis. Given the lead time required for delivery of a major item from outside Nepal, the lack of budget carryover authority beyond the end of the F.Y. is a major handicap. All orders must be placed immediately after the start of the fiscal year to assure delivery before the end of the F.Y. when all spending authority is automatically frozen.

Recommendations

In addition to the specific budget and planning recommendations presented here, the reader is requested to review related items stated earlier under the equipment heading. It is anticipated that some of these recommendations will require changes of government policy.

1. Persons having responsibility should also have the authority to fulfill their responsibility. Spending authority for emergency items should be delegated to the Zonal or District Engineer, subject to audit by Headquarters, and some realistic overall limits.

a. The Chief Mechanical Engineer should be given authority to purchase parts up to at least Rs. 50,000 with tenders required on single items above some higher limit than at present, for example, Rs. 15,000. DOR should maintain stocks of common items such as tires.

b. Eliminate headquarters review on small purchases and require that reviews on all except very large purchases (say 1 lakh or more) be completed within five days.

2. Remove equipment from the annual budget and place it in a working capital budget.

3. Begin the budget process two or three years in advance so that long range planning can be systematically accomplished.

a. Get final budget advice to the field before the start of the Fiscal Year with adequate authority for emergency work during the Monsoon.

b. Reduce line item detail so that Zonal and District Engineers have authority to reprogram funds within guidelines and overall spending limits.

c. Permit year end carryover of authorized funds.

4. Begin a system of maintenance cost accounting and develop a maintenance budget based realistically on the performance of the road. Accept the fact that the WHR probably will require a higher annual maintenance budget than most other roads in Nepal due to the unstable terrain which it crosses.

## III IMPROVEMENTS

Maintenance forces always find some slack time during a year and during these periods they can be useful in making small improvements to the road. Such items as,

- Replacing undersize culverts with larger culverts or small bridges (slab culverts);
- Building new gabion buttresses;
- Adding crushed rock to the surface;
- Stockpiling emergency supplies in areas of expected use;
- Improving camp facilities;
- Painting signs and equipment;
- Clearing debris from streams above culverts; and
- Underdrain installations in soft areas

are appropriate activities for maintenance forces.

Maintenance engineers should always have several such projects planned and if necessary budgeted, so that their forces can be put to work for a few days whenever a slack period develops.

While there seems to be an underlying awareness that this kind of work is necessary, there appears to be no provision for it in the planning or budgeting process.

The WHR needs a very large number of additional culverts where there are none now. In addition, a few pipe culverts

should be replaced with larger structures such as slab (box) culverts or small bridges. A supply of pipe segments should be stockpiled at every maintenance station and culvert installation should be pursued systematically by maintenance forces until the total job is completed.

# IV OTHER ENGINEERING ITEMS

## Rubble Masonry Walls

A local engineer has indicated that partially grouted rubble masonry walls are cheaper to build than gabions and has proposed that they be used in lieu of gabions.

There is no difference in the design analysis between the two wall systems. Both are analyzed as gravity structures and no structural credit is taken for the wire in the gabions. Sliding at the base, shear through the structure and overturning are calculated in exactly the same way.

The gabion baskets are a construction convenience. Their use permits smaller rock, rounded rock, and less carefully fitted rock to be used. Steeper frontslopes are also possible, even to the vertical in some applications.

The major benefit of the wire is in its behavior at the point where the structure has yielded slightly. The gabions then mobilize the strength of the wire to hold the rocks in place, even after displacements of ½ meter or more. Some of the interlocking and friction between the rocks is thus retained and the wire ties the entire wall together preserving its integrity. The rubble wall probably will fail under much less movement. Individual stones will drop out of the structure and cracks will widen until part or all of the wall fails.

So long as design stresses are not exceeded and neither wall yields, the rubble masonry wall will be as good as the gabion wall and well justified by cost. At the point of impending failure, where a little movement has occurred, the gabion system is most superior and response by maintenance forces in removing part of the sliding mass above the structure can save it from further damage.

Local field engineers should be able to recognize when rubble masonry can be used and when gabions should be used. Generally rubble masonry would be appropriate where the designed safety factor is conservative, the slope to be protected is not excessively steep or unstable, and the apparent consequences of a failure are not major.

Concrete Culvert Pipe

R.F. McDonald, in an appendix to Kojan's report dated April 26, 1978 was critical of the quality of the concrete culvert pipe being manufactured at the Chunepani pipe casting yard near Godavari. The present writer visited the yard on November 7, 1983 and found conditions to be about the same as described by McDonald though there was no activity due to Tihar.

All culverts on the WHR were installed under the original construction contract. At the most, only one or two may have been installed under LSS so McDonald's remarks about the quality of installations, and the inlet or outlet

conditions are still appropriate. All pipes are thus five to ten years old, and some, where exposed at the ground surface were seen to have partially failed, apparently by disintegration of the concrete. However, no culvert installations are known to have totally failed due to collapse of the pipe or erosion by water leaking out through holes, misplaced or damaged joints.

Only two sizes of pipe, about 60 cm and 90 cm, are available. Larger pipes clearly are needed. It is unfortunate that corrugated metal pipe (CMP) of the sort usually used in the US cannot be obtained. Its ease of manufacture and installation, adaptability to nearly any site condition and comparatively light weight are powerful advantages.

If galvanized steel of the appropriate grade and weight is available in India, the DOR should consider purchase of the corrugating and forming machinery to manufacture CMP. The equipment is made by Armco Steel Co., of Butler, Pa. Nepali Engineers visiting the US can see CMP manufacturing plants in many cities.

Debris Racks on Pipes

The problem of plugging or burial of culvert inlets by debris remains as difficult today as it was several years ago. Transportation Research Board Compendium No. 9(3) includes articles on treatment of culverts which will be of interest to DOR engineers.

Paving

It is understood that DOR wants to apply a bituminous pavement structure to the WHR as soon as possible. Bituminous pavements are attractive but for the present, the writer believes that the disadvantages outweigh the advantages.

Some typical advantages for a bituminous pavement structure include:

- Higher traffic speed resulting in lower user costs,
- Waterproofing the surface resulting in all weather capability,
- Reduction of maintenance, and
- Reduced surface erosion and dust.

Some disadvantages include:

- Cost of construction,
- Cost of maintenance and patching,
- Loss of capability for machine maintenance,
- Damage by falling rocks and cleanup equipment, and
- Inability to work on culverts without pavement cuts.

The last two disadvantages seem compelling for the present. First of all, large rocks falling on to the road surface will do considerable damage. This will be a particular problem from around km 90 to 130. Secondly, where slides do fall on the road surface, it is totally destructive to use a crawler bulldozer for slide cleanup on a bituminous

surface. Pneumatic tired equipment must be used. Finally there is the recommendation elsewhere in this report for the addition of many more culverts before a bituminous surface is constructed.

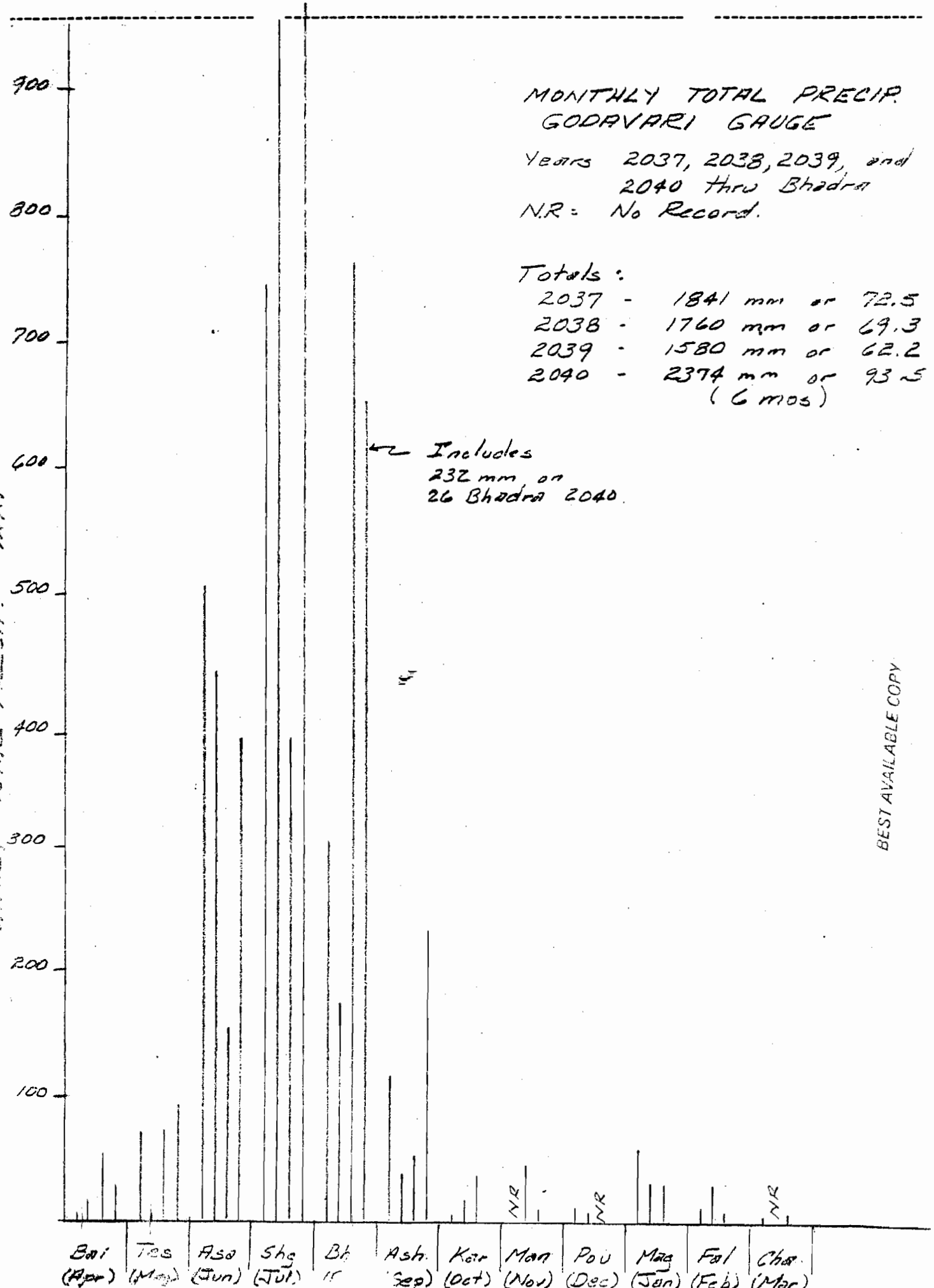
Therefore, until the remaining slide stabilization work is completed and additional culverts are installed, it is recommended that the road be operated with a crushed rock surface which can be maintained by a motor grader. Considerable work in completing the roadbed to finished grade and replacing soil lost to erosion must be done before a crushed rock surface may be placed.

Priority items for the Feeder Road Project could include:

1. Finishing the subgrade and gravel or crushed rock surfacing
2. Equipment procurement
3. Maintenance Management Training.

BY_____ DATE_____ SUBJECT_____ SHEET NO._____ OF____

CHKD. BY_____ DATE_____ JOB NO._____




BEST AVAILABLE COPY

BEST AVAILABLE COPY

Km 59 ± One of several shallow mudflows discussed by Kojan. Gabion buttress and rock filled trench drains are generally successful, though buttress has moved slightly at the center, and rutting in wheeltracks suggests that some water is passing under drains which either were built too shallow or are clogged.

BEST AVAILABLE COPY

Km 91 ± Kojan's "Big Mother" slide. Gabion wall has yielded from excess loading, but except at ends, has not failed. New slide activity is mostly along right and left flanks where drains and check dams have been destroyed. Central mass of slide body is semi-stable and partially revegetated but should be about 50% removed to reduce overstress on wall.

BEST AVAILABLE COPY

Km 98 ± Rock filled interceptor drain above Kojan's "Elsie" has failed and caused headward migration of the slide. Probable cause of the failure is that trench intersected the contact between soil overburden and rock surface and so conducted water into the zone of weakness rather than away from it.

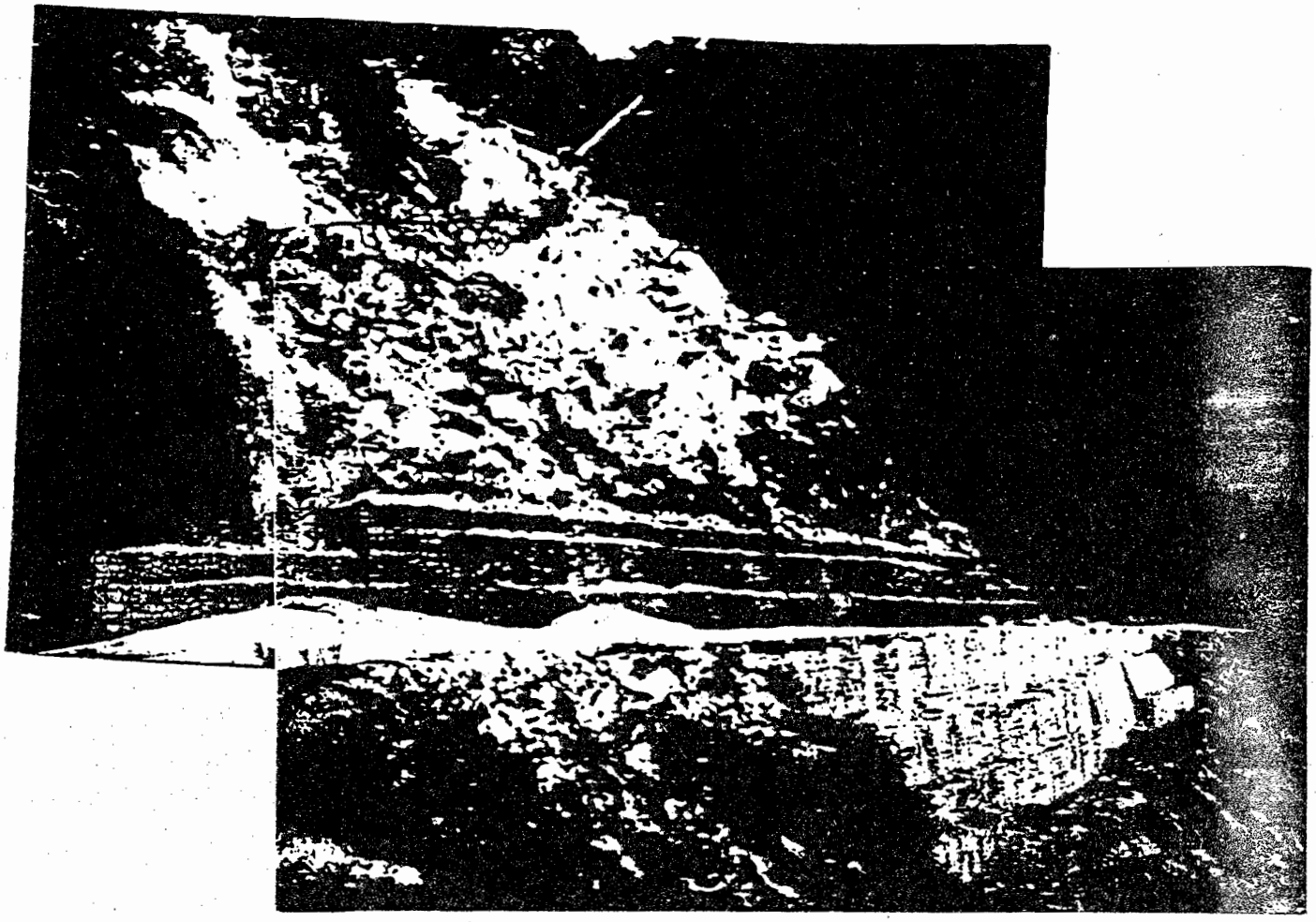
BEST AVAILABLE COPY

Km 99 ± Kojan's "Topsie" slide. Comparison with Kojan's pictures suggests that removal of 1/3 of slide body was not done and larger gabion buttresses above and below the road were built instead. New activity has ruined scarp drains and head has moved upslope. Erosion continues to wash material onto road and promotes damage below road.

BEST AVAILABLE COPY

Km 102 + 500 Kojan's "Old Man" rockslide. Essentially all of the loose rock material has been removed from the slide body. New activity is shallow and limited to light areas. Natural and planted vegetation had made a good start on old scarp and multiple check dam system has reduced damage at, and below the road.

BEST AVAILABLE COPY

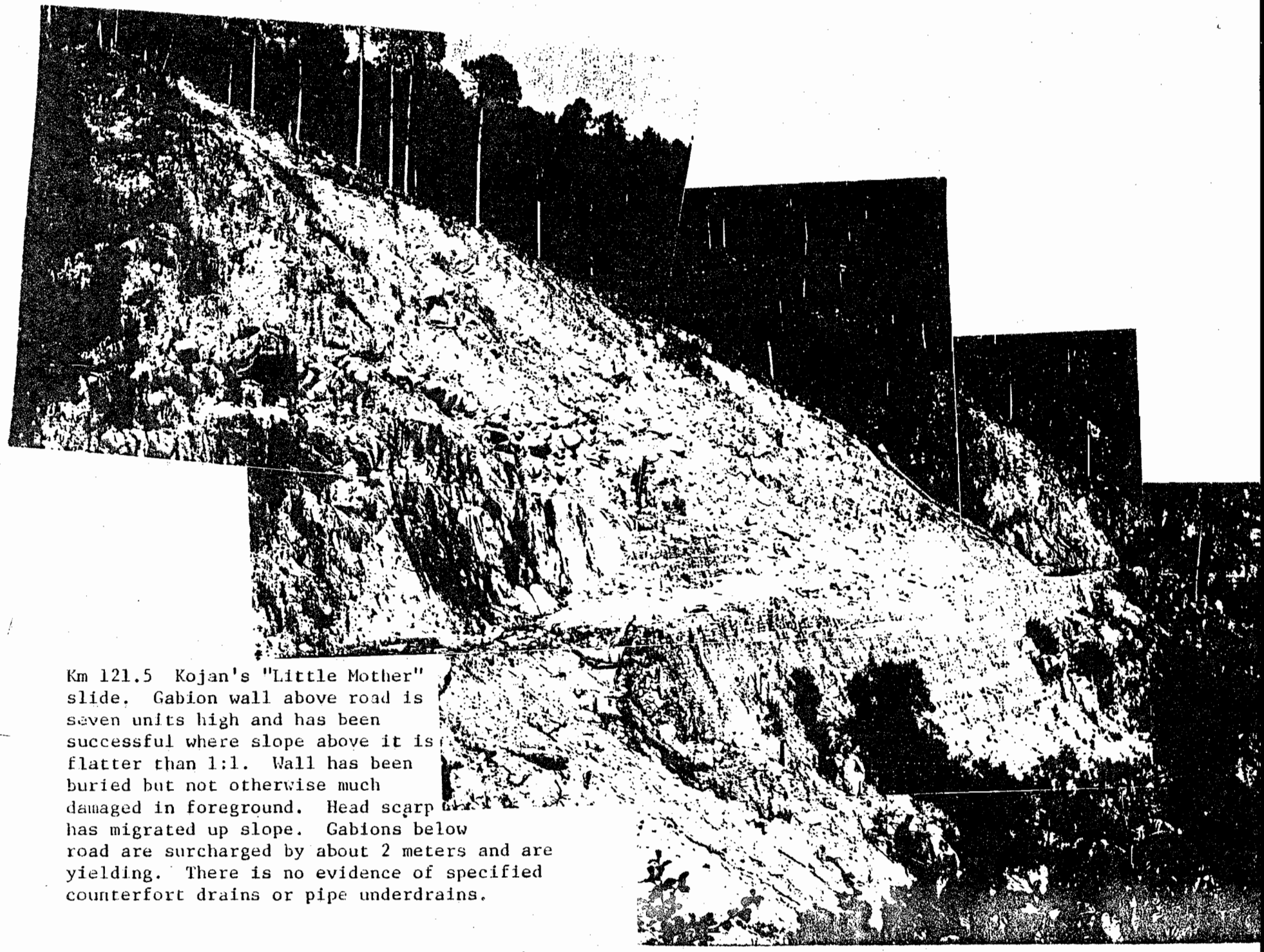


Km 106+500 5 unit gabion wall built under LSS above masonry wall built under original project. Masonry wall has failed in background. Slide debris has reached a slope of about 1½:1 above gabions and except for erosion visible in foreground is working well.

BEST AVAILABLE COPY

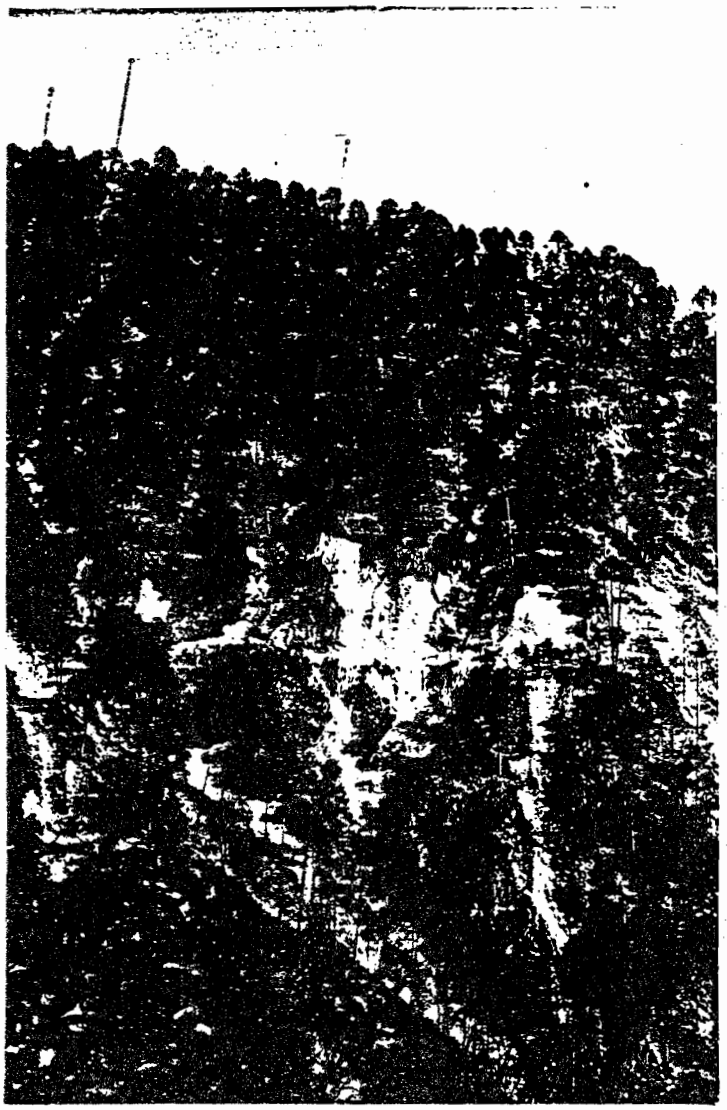
Km 118 ± Rubble filled trench interceptor drain appears generally successful though a small slide on the right is working upslope. Ground surface is not as steep and natural vegetation is more vigorous than in failed ditch at km 98 pictured earlier.

BEST AVAILABLE COPY



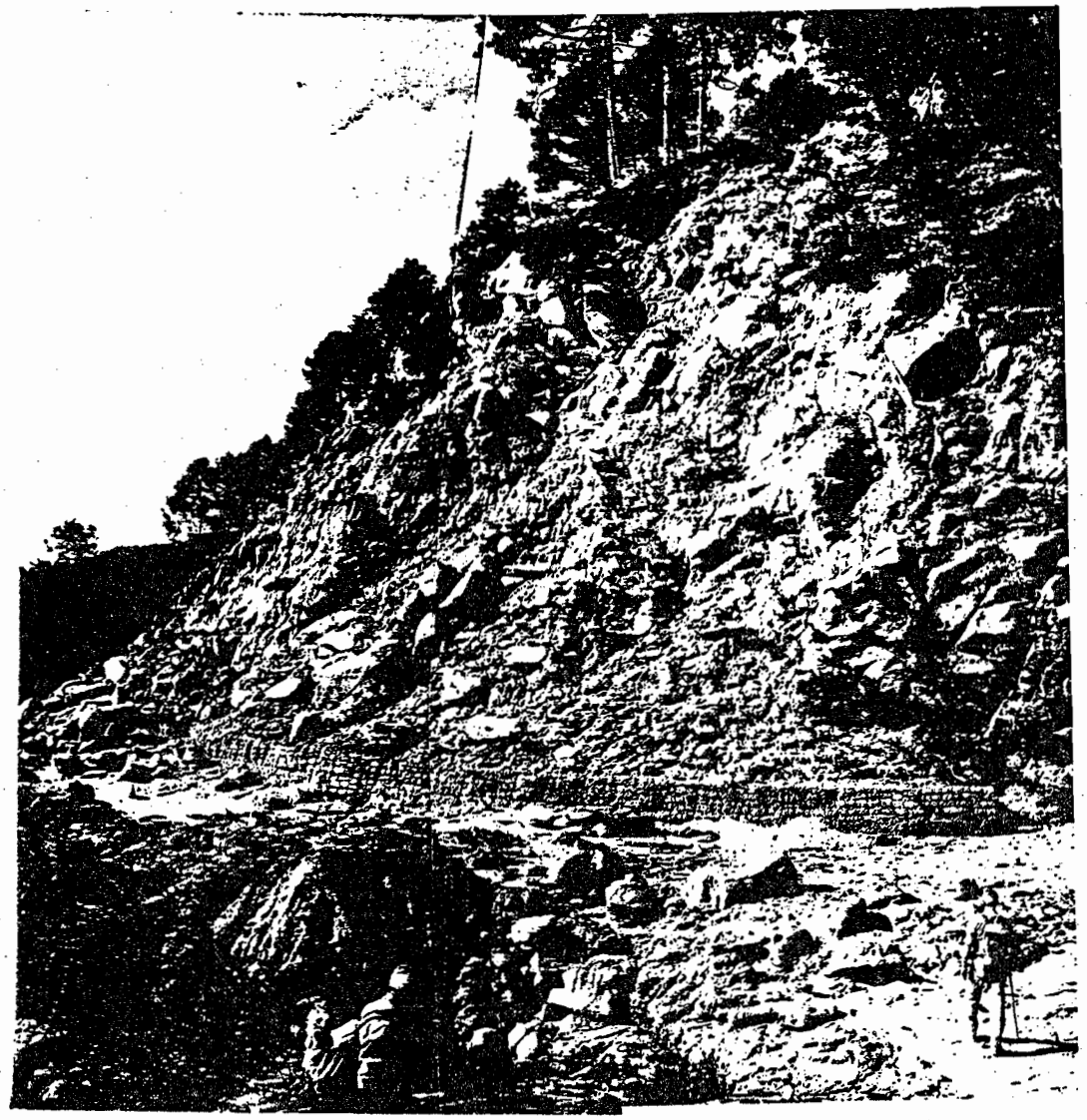
Km 121.5 Kojan's "Little Mother" slide. Gabion wall above road is seven units high and has been successful where slope above it is flatter than 1:1. Wall has been buried but not otherwise much damaged in foreground. Head scarp has migrated up slope. Gabions below road are surcharged by about 2 meters and are yielding. There is no evidence of specified counterfort drains or pipe underdrains.

BEST AVAILABLE COPY



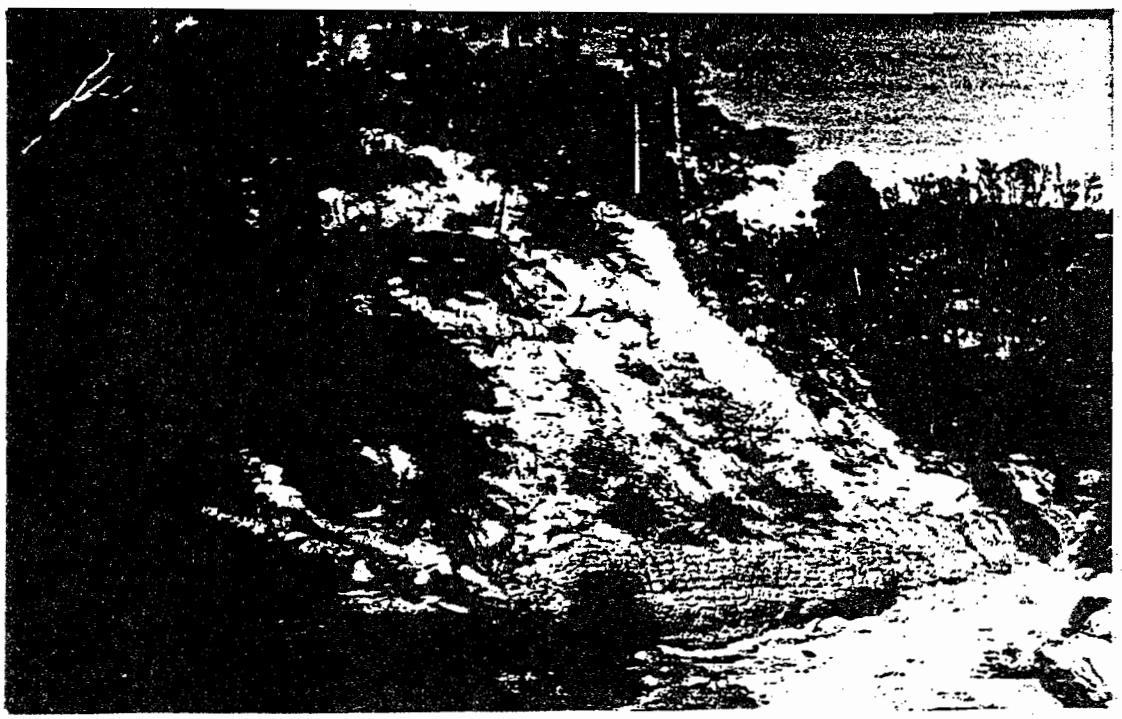
Km 122.5 ± White scars through timber to the skyline are tracks of debris avalanches which plugged ditches and culverts at the road causing erosion around ends of walls etc. This is a common situation especially North of Budar. The problem should be considered in drainage design.

BEST AVAILABLE COPY



Km 122.5 Larger than usual rockslide with two unit gabion buttress. Buttress was buried on left but except for some wires broken by impacts is undamaged. In this kind of situation, the buttress will catch some small spalls, but rolling boulders will pass over. The buttress probably is or marginal value here since the volume of rock retained compared to the size of the slide is not very significant.

BEST AVAILABLE COPY



Km 123 + 100 Typical situation where gabion wall is yielding under surcharge load of slide debris. About half of the sliding material, up to the trees just above the men should be removed to reduce load on the wall. Planting above near end of the wall has been fairly successful.

BEST AVAILABLE COPY