Report on Visit to North Eastern October 2009

By Oliver Hawes (Geotechnical Engineer)

Introduction

I was invited to visit Northeastern India by Shantanoo Bhattacharyya of the Eastern Vetiver Network India (EVNI) and spent one month in the area between 4 and 28 October 2009. Shantanoo and Dipak Das (Secretary of the EVNI), guided myself and my son to sites in the states of Assam, Meghalaya and Anunachal Pradesh.

We visited sites where vetiver is being used, and is proposed to be used for river bank stabilisation and slope erosion protection. Our purpose was to see the sites that have already been planted, learn about the specific issues and ground conditions in Northeast India, meet the local engineers and District Commissioners to explain the advantages of vetiver, and integrate other appropriate geotechnical technology with vetiver on sites where vetiver alone may not work.

Eastern Assam – Brahmaputra South Bank 5 to 9 October

We made visits to sites in Eastern Assam on Majuli (one of the largest river islands in the world, and World Heritage site), Dibrugarh, Tinsukia and Saikhoa Ghat.

All the sites in this area are on river banks of the Brahamaputra River and its tributaries. The issues that arise here are the highly erodable alluvial silts, the large range of the river between high and low water (often greater than 5m), the high silt load in the river, the scarcity of hard rocks in the area for rock riprap. The conditions are so severe that the river has in many places totally changed its course over night.

As well as looking at the river banks on Majuli we also considered proposals for stabilisation of the abutments to a bridge with vetiver. The embankments had partly been constructed without compaction and failure had occurred. Some removal of the failed soil and recompaction was required before the vetiver could be planted.

At Saikhoa Ghat we visited a site at Dhola – Hatighula where a dyke constructed with sandbags is proposed to divert the Dibang River. Built within a depth of up to 4.5m at low water, the embankment is proposed to extend 6m above low water i.e. a total height of some 10.5m. Reinforcement of the sandbags with geogrid and sandbags is being considered.

In addition to the erosion caused by the flow of water, the river banks tend to slump when the water level in the river starts to recede after the floods. This is because the soils are relatively impermeable so that the pore pressures remain high; this causes the effective stress on the shear surfaces to be low, resulting in a low shear strength. The failures often show themselves as initial tension cracks at generally less than 1m but up to about 2m behind the slope crest.

The worst erosion occurs at the bends in rivers and this is sometimes made worse by man's intervention with inappropriately applied hard erosion control measures or flow deflection works.

The proximity of dwellings, religious shrines, flood embankments and tracks to the river banks sometimes makes trimming the river banks to the ideal slope of 1v:2h for pure vetiver impossible. Therefore, other slope stabilisation measures were recommended to enhance the probability of vetiver's success. These additional measures included geogrids and coir mat laid on the surface. The coir mat provides addition erosion protection, whilst the geogrid provides additional restraint against the soil slumping. In addition, in some situations

the toe of the slope is not exposed at low water level making planting of vetiver to protect the toe impossible. Stone pitching of cobble filled baskets would normally be used in this situation, but because of the scarcity of the stone in Eastern Assam these are expensive and environmentally unsustainable options. The proposal is therefore to try to protect the toe with sandbags wrapped in geogrid to about 1m vertical depth below low water level. Low water level being defined as the lowest level at which vetiver will not be submerged for more than 4 months. .

Other issues we noted were the soil and water contamination caused by tea plantations and uncontrolled landfill sites directly on the river banks. The tea trees can not tolerate having their roots submerged so that the plantations are often on raised areas of ground with drainage channels linking with the river. The pesticides and herbicides used in the tree plantations thus runoff directly into the river. Vetiver may therefore have a role in absorbing these contaminants before they reach the river.

An interesting local issue is that Assamese cows apparently don't like vetiver.

Porcupines

The use of reinforced concrete porcupines is common in the area. These consist of reinforced concrete members 3m long with a square section of 100mm. These members are provided with 2No. holes at the third points so that the members can be bolted together to form pyramid shapes with protruding spikes. These pyramids are then joined together to form long strings, which are placed in the river to attract silt at strategic locations.

An alternative design is to use bamboo to create a similar shape.

The success of the porcupines seems to be mixed.

Already Constructed Vetiver Sites Around Guwahati (10 October)

I've written a separate paper on these sites but this is a summary.

Four stretches of river were visited where vetiver was planted in February 2009. Three of these stretches were at Kelipi (Site A) and the fourth site was on the Kolong River at Telaki (Site B).

Three sites at Kepili (Site A)

The locals did not want the slopes trimmed so it was necessary to plant the vetiver on slopes of 45 to 70°. The slope was also irregular in all dimensions. The river bank was in two terraces with an upper steeper slope and then a lower shallower slope some distance into the river. (The lower slope and part of the upper slope was submerged by flood water during our visit). A 1m x 1m grid measured on the slope was planted, with bare rooted plants, DAP fertilizer and cow manure.

Some cracking was visible behind the crest line but there were no open cracks and no bank retreat had occurred over the monsoon period.

RC Porcupines were at about 15m spacing over some portions. The river was in flood at the time of our visit with a rise of 3m reported by villagers.

The vetiver appeared to be growing well except where cultivation at the crest of one area was encroaching on the first vetiver rows. Some trimming was needed soon now that the monsoon season was almost over. Hopefully once the local people are convinced of the benefits of vetiver they will take ownership of the maintenance requirements.

Telahi (Site B)

A stretch of some 470m had been planted on a uniform slope of between 30 and 35 degrees.

The river was in flood at the time of our visit (4m rise) so that the lower portion of the slope could not be seen.

The vetiver again looked very healthy and was about 2m tall having not been pruned since planting.

From Left to Right in the foreground at Telehi, Assam, October 2009; Dipak Das, Aidan Hawes, Oliver Hawes, Shantanoo Bhattacharyya

We were interviewed by the local news channel and newspaper at the site.

On 22 October we had report that a small section had slipped (5x5m). I've prepared a separate paper on these sites.

State of Meghalaya – Barapani – Nr. Shillong (18 October)

We visited a site operated by the state hydroelectric company. They have a slope below a switch yard that has developed a major erosion gully. Although they have now diverted the water that was creating the gully and the site is heavily vegetated they are concerned that further erosion may occur in the future. We were unable to see the slope because of the vegetation so it was not possible to confirm that the problem is only an erosion problem. Nevertheless, if after clearance the problem is confirmed to be erosion only, the proposal would be to cut the existing vegetation, leaving the roots in place to provide reinforcement, and plant vetiver. The existing vegetation would be controlled by using a herbicide for wide leaved plants that doesn't affect vetiver. No trimming or filling of the slope is planned.

There was also a slip on an access road to the switchyard in a residual soil with some cohesive and some granular sand areas. This is proposed to be treated by trimming the slope to 1v:1h 4m high benches with 2m wide berms and then planting vetiver. The assessment that the slope is safe at 1v:1h is based on slopes in apparently similar material in the local area being stable at slopes of steeper than this. However, no study has been carried out to determine whether these materials are in fact similar and there is always the risk that some failure may occur.

Centre for Plasma Physics (21 October)

Visited the site of an access road upgrade at the base of a slope that erodes due to uncontrolled house building on the upper slope side. A toe drain is required on the upslope side of the road and a couple of lines of vetiver are proposed to control the quantity of silt that is washed into the drain.

Guwhati – Community Track (21 October)

An access track has been constructed within a steep slope with a small stream at its base. The slope above the road is too steep to be treated and there is no scope for reprofiling due to dwellings and electrical poles. Below the road the slope is generally about 40 to 45% with some occasional portions steeper than this where failures have occurred. There is a problem with surface water from the road eroding the lower slope and this needs to be controlled prior to planting vetiver. There is an open channel drain on the up slope side of the road and two outlet channels take water under the road and down the slope. These have been poorly constructed and need to be reconstructed as stepped channels with energy absorbtion. Some portions of the lower slope may need gabions placed at the base and backfilled in order to create a maximum slope of 1v:1h.

Eastern Assam – Brahmaputra North Bank (22 October)

In the Lakhimpur area we spoke to the District Commisioner and Chief Engineer and then visited 2 river bank sites and a park site. The rivers in this area are prone to flash floods from mountains during periods of heavy rainfall and when the dam sites release water.

The river bank material on the Dikrong river site was more sandy than those that we observed on the south side tributaries of the Brahmaputra, and with more cobbles and gravel in the river bed indicating higher velocity flows. This is because this river is closer to the Himalayan Foothills with a steeper gradient. A combination of cut and fill would be necessary to create the 1v:2h slope, using selected finer material from the adjacent river bed and mixing this with a more cohesive soil to retain moisture and add cohesive strength. Cow manure to be mixed with the fill.

The other river site was only seen in the dark after a short motorbike ride. The site was challenging with a sharp bend where some repairs with bamboo stakes had been carried out. The bank was some 6 to 8m high. A straightening of the channel may be an option.

The park site vetiver had already been planted some one month previously. The slopes were shallow, possibly 1v:3h and an average of about 3m long so that erosion is not a serious problem. Bare rooted plants had been used, and a 10% failure rate had been experienced. The weak plants will be replaced with pot plants and all will be trimmed to 1 foot high. Manure had been used at planting but no fertiliser. A surface dressing of fertiliser will be used once the plants have grown a little more.

Arunachal Pradesh 23 to 26 October

We visited sites in the hills at Ziro and near to Naharlagun where erosion was undermining electrical transmission towers. These were for NEEPCO and Powergrid Corporation respectively. These sites were unsuitable for vetiver because the slopes were too steep and in addition the second site was shady. There was a possibility that vetiver may work to stabilise the slope behind Powergrid's compound but again this is also very steep.

We visited some sites on the river Dikrong where erosion had already meant the relocation of one power transmission tower and several others were under threat. Vetiver is a feasible option at some of these sites.

Recommendations

1. In order to develop an empirical design methodology appropriate to local conditions it is recommended that projects are carefully documented as they are executed. This will allow success and failure to be explained and a learning process to occur. As a minimum the following should be recorded for each project where possible:

- Photographs throughout the process
- Topographic survey before and after planting
- Bank profile (optical clinometer device, which I gave to Shantanoo is more accurate than a visual esti mate)
- Main current location
- Maximum flood level
- Low water level
- Level at which vetiver will be submerged for more than 4 months
- Soil description using a standard soil mechanics system such as Indian, British, or American Standard.

- Soil particle size distribution (% clay, silt and sand)
- Plasticity Index
- Susceptibility to erosion (standard test e.g. pin hole)
- Flow velocity
- Plant grid spacing
- Other enhancements (e.g. geogrids, coir, sandbags)
- Type and Location of other techniques such a porcupines
- Pruning times

2. Slope profile is critical. Carefully control angle of trimming so that the design slope is actually achieved. Use for example, batter boards.

3. A smooth profile is important, and in the case of river bank protection it is less likely to create turbulence.

4. Where space allows 2 rows of vetiver planted behind the crest of the slope may be beneficial in some areas to assist the reduction of pore pressure as the river level goes down.

5. Filling with loose soil to create the profiled slopes is generally not advised, as this loose soil tends to be eroded rapidly.

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Vetiver Systems Application - A Technical Reference Manual

Some observations in using it in Northeast India

1. It would be beneficial to have more technical details of the projects in Vietnam in Part 3, section 5. For example; slope angles, how long the lowest level of vetiver is submerged each year, soil type description to some standard soil mechanics description (eg BS 5930), particle size grading curve (% clay, silt, sand), plasticity index (indicator of shear strength), water channel velocity, water level rise in flood, suseptability to erosion by some standard test.

2. I was not able to find a reference to how long the vetiver can be submerged and still survive. Also how this might be affected by local conditions such as hours of sunlight, temperature, groundwater level, etc.

3. Part 3, Section 4.5.2, third bullet point, would it be better to talk about the level at which the vetiver will not be submerged for more than x months? It seems there is no point in planting vetiver where it will not survive being submerged for x months?

3. Is any intervention helpful in improving the chances of survival after submergence such as removal of silt and trimming?

4. Photo 14 on page 46, do the rows of sticks in the water have any purpose?

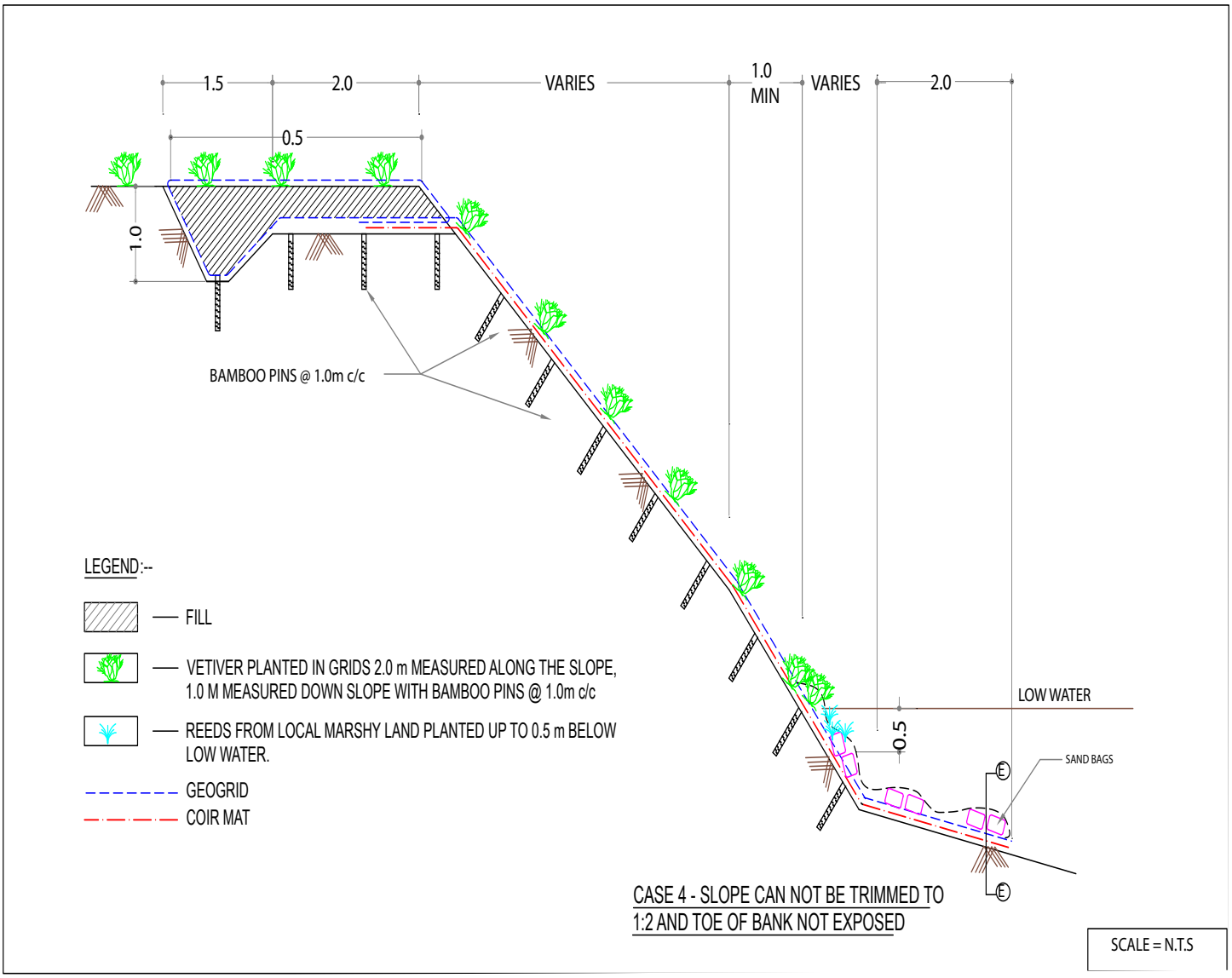
5. Have any steeper slopes been reinforced with other materials such a geogrids and geotextiles (e.g. coir mat) to augment the vetiver? Are there any specifications available? eg geogrid type (strength, grid size), coir weight per m2)

6. Rock riprap is shown to be used to protect the toes of slopes below the level at which vetiver can be planted / survive submergence. In Assam rock is not available and I was proposing that sand bags wrapped in geogrid may be an alternative in this situation. Has this or any similar technique been tried out? I've done some sketches to illustrate the different situations.

7. I couldn't find a reference to the minimum number of days of sunshine and the minimum sunshine hours per day.

8. How far below groundwater level do the roots generally grow?

9. Is there some guidance on the maximum water channel velocities that vetiver can sustain and how long these can be sustained?


1.5
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BAMBOO PINS @ 1.0m c/c
LEGEND:--
FILL
VETIVER PLANTED IN GRIDS 2.0 m MEASURED ALONG THE SLOPE, 1.0 M MEASURED DOWN SLOPE WITH BAMBOO PINS @ 1.0m c/c
REEDS FROM LOCAL MARSHY LAND PLANTED UP TO 0.5 m BELOW LOW WATER.
GEOGRID
COIR MAT
LOW WATER
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SAND BAGS
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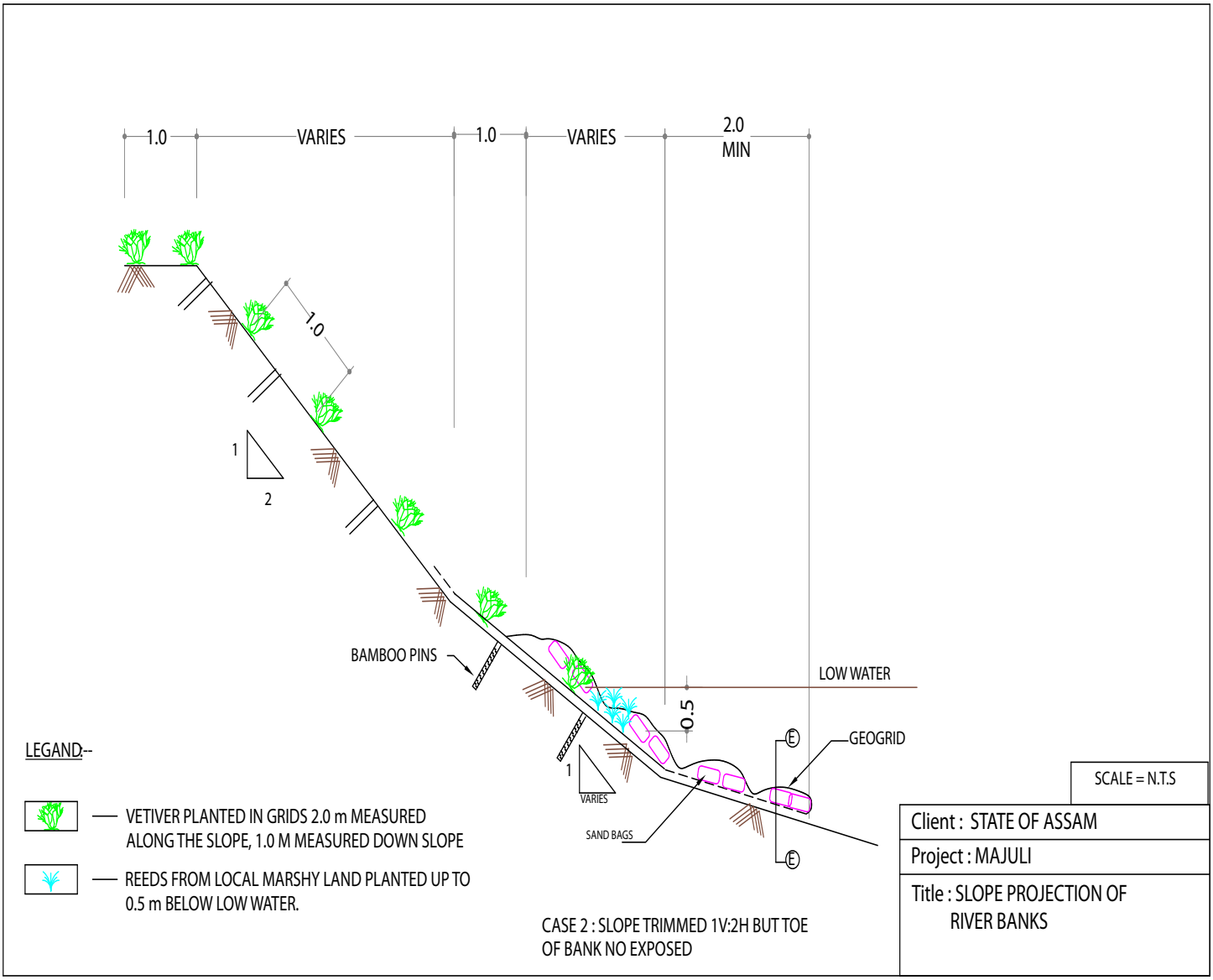
E
CASE 4 - SLOPE CAN NOT BE TRIMMED TO 1:2 AND TOE OF BANK NOT EXPOSED
SCALE = N.T.S


1.0
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BAMBOO PINS
LOW WATER
0.5
GEOGRID
1
VARIES
SAND BAGS
LEGAND--
VETIVER PLANTED IN GRIDS 2.0 m MEASURED ALONG THE SLOPE, 1.0 M MEASURED DOWN SLOPE
REEDS FROM LOCAL MARSHY LAND PLANTED UP TO 0.5 m BELOW LOW WATER.
CASE 2 : SLOPE TRIMMED 1V:2H BUT TOE OF BANK NO EXPOSED
SCALE = N.T.S
Client : STATE OF ASSAM
Project : MAJULI
Title : SLOPE PROJECTION OF RIVER BANKS

The Players:

From Left to Right in the foreground at Telehi, Assam, October 2009; Dipak Das, Aidan Hawes, Oliver Hawes, Shantanoo Bhattacharyya (Coordinator, East India Vetiver Network)

Aidan Hawes holding a potted vetiver plant at the Nursery near Guwahati, Assam, Oct 2009

The Problem

Tipling, Assam, October 2009 - A high priority area for the District Commisioner because homes are having to be abandoned. In the picture a representative of the Water Resources Department"

Above and below: Typical problems of river bank erosion

Repaired and stabilized with Vetitiver hedgerows (vertical and horizontal). Vetiver after first season's grouth and before trimming, Telehi, Assam, October 2009

Slumping caused by undercutting of bank below low water level. Telehi, 28 October 2009, after the flood water had gone down and the vetiver was trimmed

Telehi, Assam, October 2009, a steep section of the bank that failed, note water seepage at the base of the slope from adjoining ground and length of Vetiver roots recovered from the failed area

100 to 150mm of clay sediment was deposited within the river bank planted with vetiver during the monsson season 2009, Telehi, Assam, October 2009

Tension cracking develops as the the river goes down - Dirak, Assam, October 2009

Olive Hawes, the author, with a excellent stand of vetiver behind him