# THE USE OF GROYNES FOR RIVERBANK EROSION PROTECTION AND RIVER STABILISATION: STATE OF ART REPORT 2015

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**ABSTRACT**

In many parts of the Western Cape rivers are seen as being out of control. During the annual floods, farmers lose expensive infrastructure and developed land when riverbanks erode, bridge approaches are damaged and communities are cut off from the outside world. It is becoming ever clearer to those working frequently with these rivers that the greatest threat posed by the soil loss at individual sites, is not so much the loss at the site but rather the effect of the abnormal sediment pulse as a result of the erosion on the behavior of the river as a whole. With the spectre of global warming looming, it seems that these problems will only get worse.

Various types of erosion control methods have been employed in the Western Cape to curb the erosion of riverbanks. Of these, in some situations, the use of groynes has been found to be most suitable. Unfortunately, although a lot of research has been published describing the flow of water between groynes, great reliance has been placed on model studies for the planning of groynes and a comprehensive design procedure is not available. This was initially a major impediment to the use of groynes in the Western Cape but experience gained has enabled the use of groynes to become common.

Since the year 2000, groynes have been constructed in the Western Cape as part of emergency flood relief river bank erosion control projects, as well as poverty alleviation projects. Effectively these have been full scale model tests. Based on this work the author has compiled a design procedure for planning the layout and structure of groynes and this, together with case studies, is presented in this paper. As part of an effort to better understand the functioning and application of groynes, the author has recently visited the planners of groyne projects in Europe and South America.

This paper starts by looking at the need for river bank erosion control in the Western Cape, general river rehabilitation objectives, and an overview of many types of bank erosion control methods that could possibly be *used*, before focusing on the use of groynes. The main purpose of this paper is to illustrate the use of groynes for river bank erosion control (part of the river stabilization strategy) by the Western Cape Department of Agriculture.

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## 1. THE NEED FOR RIVER STABILIZATION IN THE WESTERN CAPE

A range of factors contribute to the unnaturally high level of instability of rivers in the Western Cape. Some are natural and some are as a result of human intervention.

Firstly, rainfall in the Western Cape is very seasonal and there is a great difference between the normal flow and flood peak flow in the rivers. Commonly the peak flow from a 1 in 10 year return period storm is in the order of 50 to 100 times the normal flow. Given that a lot of the rivers are steep (they rise in the Cape fold-mountains which are between 1000m and 2000m high, and head for the sea often only 50 to 200 km away), flow velocities during floods can be high. Flow velocities during floods in the foothills of the mountains of 4 to 6 m/s are not uncommon, neither is it uncommon to experience conditions of supercritical flow at these times. As a result of this, the potential for erosion and sediment transport during floods is great.

Secondly, a variety of human interventions have altered the natural state of rivers in the very recent past (40 to 100 years) increasing the flow velocity and the mobility of sediment of the rivers. These include the following-

- The destruction of indigenous vegetation (with its deep root system which bound the riverbed material) because it was seen to be causing an obstruction to the flow of water in the river channel
- The condensing of shallow braided rivers into single narrow and deep channels to make land available for development, and to facilitate the quicker discharge of flood water
- The proliferation of dense stands of woody alien plant species which grow quickly, in the river beds and on the river banks which are dry for most of the year
- The extraction of a large proportion of the base flow of rivers for irrigation and municipal use

**Figure 1** Palmiet reed that originally covered the bed of the Duiwenhoks River.

**Figure 2** The Duiwenhoks River as it is today, the river bed is devoid of vegetation, alien vegetation infests the banks and erosion of the banks is common

**Figure 3** Infrastructure typically built too close to allow a river to function naturally

The result is rivers have a reduced flow in the dry months and increased flood peaks in the wet months. The rivers flow along river beds no longer bound together by the roots of traditional vegetation, and this makes the river bed and banks prone to erosion.

Urban and agricultural development along rivers is understandable. Urban development started along rivers because of the availability of water. Intensive agricultural developed along rivers also because of the availability of water, but in particular because that is where the deep fertile soil is to be found. The close proximity of human development to rivers has left too little space for rivers to function normally (i.e. to push into flood plains during high flows, to meander etc.), and this is why the impact of normal flood events is becoming more and more serious.

## 2. RIVER REHABILITATION OBJECTIVES

The dilemma with stabilizing or rehabilitating these disturbed rivers is that it is usually not possible to re-establish the pre-existing slow flowing river conditions because of the development adjacent to the rivers, and to stabilize rivers a compromise has to be reached. It is believed very strongly by the Western Cape Department of Agriculture that some engineered structures such as groynes and weirs have to be built in rivers to stabilize the unnatural flow of sediment, but ultimately the stability must come from a combination of slowing down flow velocities and increasing the natural resistance of the riverbed to erosion. This is done by the provision of more space for rivers, the removal of alien vegetation, the re-introduction of indigenous vegetation, and the cessation of the regular disturbance of river beds with bulldozers.

The Western Cape Department of Agriculture has also found that it is pointless addressing individual hotspots of river bank erosion without considering why the erosion occurred in the first place. Observations in various rivers post the floods since the year 2000 have highlighted that very often erosion at a given site is closely linked to the presence of pulses of sediment coming down the river from the large scale erosion of a river bank elsewhere upstream. Thus to encourage a state of stability in a river, a more natural movement of sediment must be established, and it is essential to address erosion problems from the source of the river and work downstream. Trying to address problems on a catchment-wide scale supports this objective.

This understanding that river instability problems are caused by the increased flood flow velocities and the decreased vegetative cover of the river bed, has been instrumental in promoting the use of groynes over longitudinal protection when mechanical interventions are needed, because groynes reduce flow velocities, facilitate wider flow channels, and create spaces on river beds and banks where indigenous riverine vegetation can be re-established. When disaster management funding is made available by the National Department of Agriculture in response to severe flood events, this gets used to construct projects aimed at reducing river instability and reduce the vulnerability of communities to future disasters as a result of flooding.

One of the biggest obstacles to successful river management is the difficulty in getting all role players to be properly informed about river management issues, and to engender a culture of treating rivers with a higher status than simply a drainage line in a landscape. While adequate flow space is not given to rivers, alien vegetation not removed and indigenous vegetation not promoted, smaller floods will continue to cause disproportionately large damage.

A big opportunity exists within river management for job creation. Many job opportunities can be created, not only in the clearing of alien vegetation and the construction of erosion control structures, but in the running of nurseries for indigenous vegetation and the ongoing maintenance of rivers as well.

## 3. DIFFERENT TYPES OF RIVERBANK PROTECTION

Many different methods for stabilizing river banks are available, yet not all are desirable. River bank erosion protection works can be classified according to whether they are direct or indirect protection methods.

- Direct erosion protection methods increase the resistance of the river bank to the erosive power of water flowing against it. Direct erosion protection methods include a variety of techniques ranging from landscaping and vegetating, to the use of erosion control mats, to flexible bank armoring systems, to riprap, and finally retaining walls (dry stacked blocks, gabions, as well as reinforced concrete) and full canalization of streams.

- Indirect erosion protection methods reduce the velocity of water flowing along the bank, and in this way facilitate the stabilization of it. Indirect erosion protection methods include a variety of techniques ranging from landscaping the riverbed, to groynes (permeable or solid), to Iowa vanes and micro-groynes.

These different methods of river bank protection all have their own advantages and disadvantages and are illustrated in the table below:-

| **Bank stabilization intervention** | | **Comment**<br>**See** (1) **for more information on alternatives** |
|---|---|---|
| **DIRECT METHODS** | | |
| Landscape and vegetate |  | • Ecologically most desirable.<br>• Can be a low cost solution.<br>• May not be sustainable where bends in river are relatively tight, or other places where the flow velocity is too high for the soil to be stabilized this way.<br>• Not practical where floods may wash landscaped soil away prior to full establishment of vegetation. |
| Erosion control mat |  | • This is attractive when a microclimate has to be provided until such time that the vegetation has established. It reduces the need for watering the young plants.<br>• It does not significantly help stabilize the soil during floods.<br>• It is expensive. |
| Flexible armor<br>(concrete blocks) |  | • This is a quick way to stabilize a channel, providing that the capacity of the structure is not exceeded.<br>• It is similar to full concrete lining but can be more ecologically acceptable due to the growth of vegetation between the blocks.<br>• The ability to withstand high flow velocities is less than that of reinforced concrete.<br>• This is an extremely expensive option. |

| | | |
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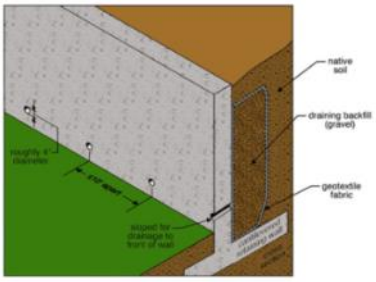
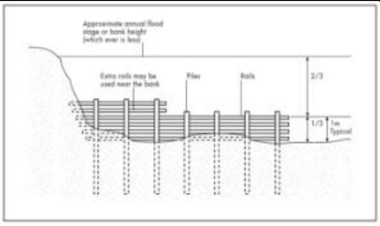
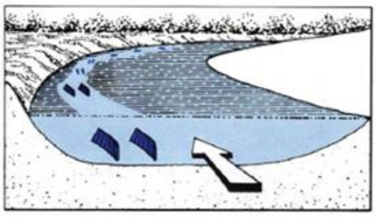
| Flexible armor<br><br>(gabion mattress) |  | • This is similar to riprap but because smaller stones can be used, there is a greater potential for covering it with vegetation, making it ecologically more acceptable.<br>• It is relatively easy to install.<br>• The wire baskets can be subject to degradation by abrasion and are best protected with vegetation planted in the mattress.<br>• Although the wire baskets are expensive, the stone can be significantly cheaper than stone required for rip-rap. |
| Riprap |  | • Properly designed riprap provides a durable protection to erosion.<br>• Riprap can be ecologically acceptable when below the waterline where it is not visible. It can be improved by the planting of vegetation but this is not common.<br>• Rip-rap is expensive and transport and handling costs are high.<br>• Underwater, rip-rap construction can be easier than placing gabion mattresses. |
| Retaining wall<br><br>(dry stacked block) |  | • Many systems are available and each has its own advantages and disadvantages.<br>• Dry stacked block retaining walls can be constructed relatively quickly.<br>• These walls can be vegetated, but the size of soil pockets within the wall often limit the types of vegetation that can be established there.<br>• They are generally expensive, especially when transported over long distances.<br>• The biological connectivity between the river and the bank via these structures is limited.<br>• Users are cautioned to make sure that a progressive collapse due to local foundation failure or failure of the ends of the structure is guarded against. |
| Retaining wall<br><br>(rock filled gabion) |  | • Gabion walls are quick and easy to construct by semi-skilled labor providing that some basic rules are followed.<br>• They can have the advantage of using locally available stone and in that way reduce costs.<br>• The wire baskets can be subject to degradation by abrasion and are best protected with vegetation planted in the foundation mattress.<br>• The biological connectivity between the river and the bank via these structures is limited. |
| Retaining wall<br><br>(reinforced concrete) |   | • Properly designed concrete retaining walls provide a durable protection to erosion.<br>• They are particularly useful when a bank must be stabilized in a very confined area (such as an urban setting).<br>• They are very expensive.<br>• The biological connectivity between the river and the bank via these structures is extremely limited and apart from full canalization, they are the least desirable option from an |

| | | |
|---|---|---|
| | | ecological point of view. |
| Channelization |  | • From an ecological and cost point of view this is the last option solution for conveying water through an area within the least possible space. |
| **INDIRECT METHODS** | | |
| Groynes<br>(permeable) |  | • Permeable groynes can present a low capital cost option for river bank stabilization.<br>• The durability of the option is limited because of the timberwork rotting, and getting washed out during extreme floods.<br>• Providing that appropriate vegetation is established between the structures, it may present a longer term solution. |
| Groynes<br>(solid) |  | • By encouraging the deposition of sediment, groynes cause riverbanks to be restored rather than eroded.<br>• Groynes create an environment where disturbed rivers may be revegetated.<br>• Groynes are expensive but in combination with the re-establishment of indigenous vegetation, can provide sustainable and ecologically acceptable solutions. |
| Iowa vanes (2)<br>(steel plates) |  | • The concept of Iowa vanes is important because they demonstrate that river banks may be stabilized by reversing the helical current that exists around river bends.<br>• It is unlikely that Iowa vanes would be acceptable from an ecological point of view because of the safety hazard that they pose, as well as inappropriate nature of the structures in a natural environment (vertical steel plates fixed in river) |
| Micro-groynes (3)<br>(very large boulders) |  | • Micro-groynes are very large rocks set into the riverbed to disturb the flow of water around bends (like Iowa vanes), and promote river bank stability.<br>• The rocks would have to be quarried and transported specially, and would be very expensive.<br>• These structures have had only limited application and appropriate design information is lacking. |

## 4. A NOTE REGARDING THE POSITIONING OF RIVER BANK PROTECTION

### 4.1 CASES WHERE THE RIVER IS VERY WIDE IN RELATION TO THE SCALE OF INTERVENTION

With large and very wide rivers (such as the Amazon, Rhine and Congo), relatively small erosion protection structures on one bank will not influence the stability of the opposite bank, irrespective of the position or alignment of the structure. For these wide rivers, the erosion protection must be positioned and aligned such as to perform the task intended.

**Figure 4** Erosion control groyne on bank of Upper Amazon at Campanilla, Peru. The river is too wide for the structure to influence the opposite bank

### 4.2 CASES WHERE THE RIVER IS NOT WIDE IN RELATION TO THE SCALE OF INTERVENTION

Especially for rivers which have limited flow width, when rehabilitating a bank using one or another form of construction, the question should arise as to where the rehabilitated bank must be positioned and oriented? The eroded position of the bank can be used, or a pre-erosion position could be more suitable but would have an extra cost implication assuming that a lot of earth fill will be required. Although it is important to control the cost of the rehabilitation work, it is also important that the bank does not get stabilized in a position and orientation that it directs the flow of water into the opposite bank and cause erosion there.

**Figure 5** A typical situation where river rehabilitation work on one bank can influence the stability of the opposite bank

With rivers of limited main channel capacity, it is often useful to determine the natural discharge capacity of the main channel nearby where the proposed rehabilitation is to take place, preferably at a relatively undisturbed section. The main channel where the rehabilitation is taking place should be designed to accommodate at least this flow so that the rehabilitated section does not constrict the channel and cause water to exit the channel to the floodplain unnaturally. As a general rule, in agricultural areas the main channel should accommodate at least the flood expected once in ten years and in urban areas once in fifty years.

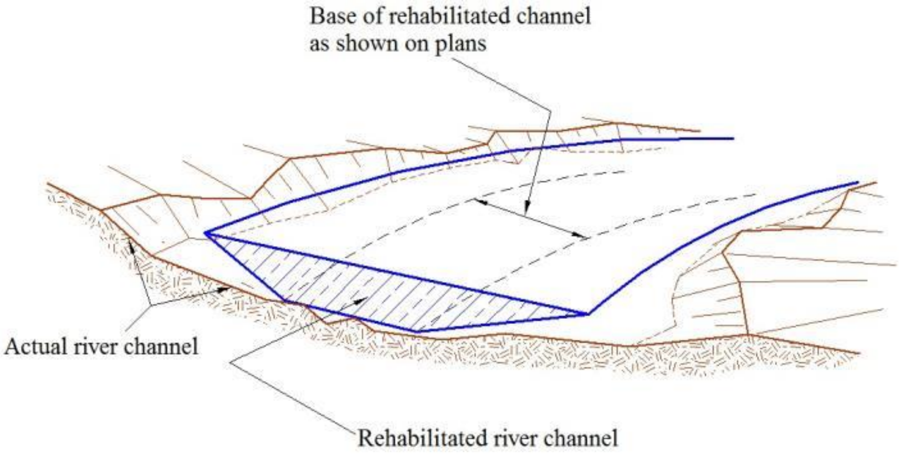



**Figure 6** The theoretical rehabilitated river channel within surveyed river

The horizontal layout of the rehabilitated channel must be comprised of a collection of straight sections and tangential bends along which the river could flow (see Figure 7(b)). This approach has also been suggested by Zimmermann (4) . This planned channel should fit within what is known as the river channel, either the existing or that which existed prior to flood damage (see Figure 7 (c)). Historical aerial photography is very useful for motivating the position of the rehabilitated channel. Experience of a given river and catchment's behavior is essential when choosing the radius of rehabilitated channel bends. For European rivers (5) a bend radius of twice the river width could be suitable, but these are wide and generally slow flowing rivers. In the Western Cape with faster flowing narrow rivers (6) a bend radius of around four times the river width is used. This is discussed further in Section 8.2.

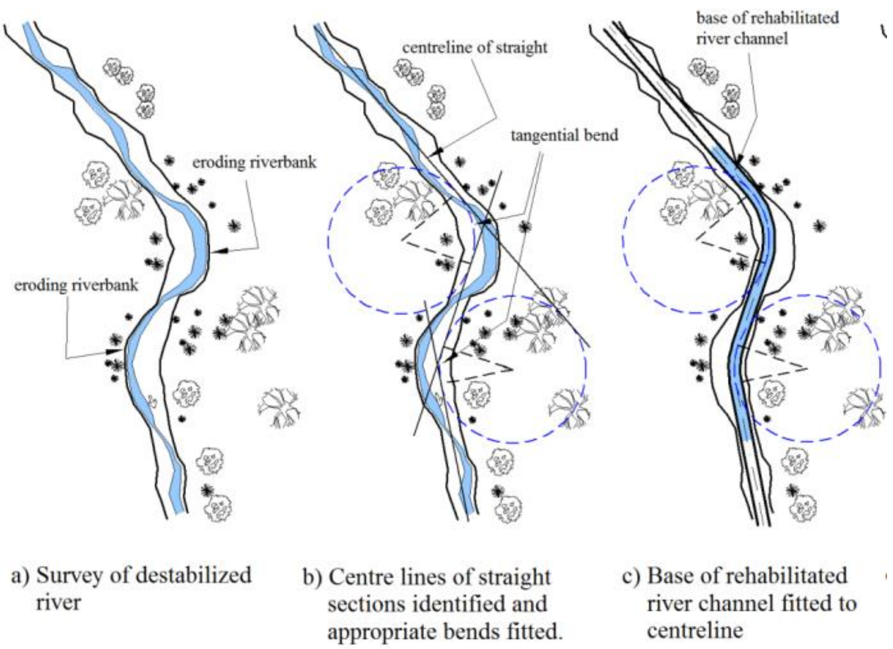



**Figure 7** Development of the rehabilitated channel horizontal layout

The constructed bank erosion protection (groynes, retaining wall, riprap etc.) would then be employed especially on tight bends to assist the rehabilitated river channel to remain on this alignment. It must be understood that because of the dynamic nature of rivers and the movement of sediment that the river will not always follow this planned path, but with the assistance of properly planned bank stabilization interventions, it is likely that the main channel will tend to keep to the rehabilitated channel.

## 5. WHAT ARE GROYNES AND HOW DO THE FUNCTION

A groyne (also called "groin", "retard", "spur dike", "spur dyke" etc.) is a wall-like structure constructed from the riverbank of a river some distance into a river, more or less perpendicular to the flow direction, with the objective of causing the water to flow some distance from the riverbank where the structures are anchored. A field of groynes is a group of structures that act together to control the flow path of a river and the location of sediment deposits.

**Figure 8** Groynes on the Waal River at Zaltbommel (Netherlands)

On a more local scale, groynes even if they are submerged, displace the focus of potential energy in the river (the path of steepest slope) away from the riverbank to the tip of the groynes, and thus deflect the main flow channel of the river. Seen from a larger scale, a field of groynes roughens the riverbank, reducing the flow velocity immediately against the bank, and increasing the likelihood of sediment deposition as opposed to erosion.

### 5.1 Groyne types classified by orientation

The orientation of groynes is often debated and Przedwojski et al (5) give a balanced view on this issue. Table 2 shows different groyne orientations and their relative advantages. The Department of Agriculture has found that the most practical solution is to use groynes oriented at right angles to the flow direction.

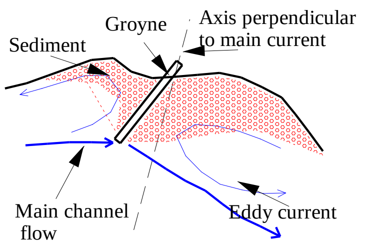
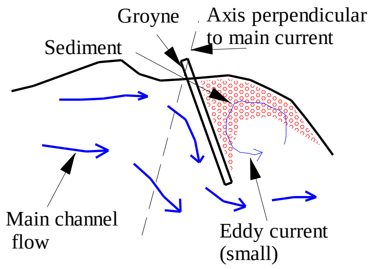
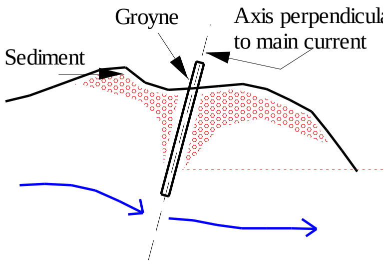
| | Sketch | Comments |
|---|---|---|
| Groyne pointing upstream |  | • Attracts silt upstream and downstream of structure<br>• Pushes main current away from bank<br>• Has great potential for scour hole at head. |
| Groyne pointing down-stream |  | • Attracts only silt downstream of structure.<br>• Does not form much eddy current and pulls main current to bank<br>• Has relatively low potential for scour at head<br>• Definitely not recommended for concave bend |
| Groyne perpendicular to the flow direction |  | • Groyne attracts moderate amount of sediment upstream and downstream<br>• Keeps current more or less parallel to bank<br>• Has medium potential for scour at head |

**Table 2: Groyne orientation**

There is a popular misconception that groynes deflect water in the same way that a ball would bounce off a wall would –for instance that a downstream oriented groyne would deflect water away from the bank where the groyne is rooted. Especially for a conventionally spaced field of groynes oriented perpendicularly to the flow direction, or inclined a small amount upstream or downstream this is not so. For flow depths up to that when the groyne becomes submerged, water flowing past the groynes is directed by the slowly rotating pool of water trapped between the groynes (see Figure 9). When the groynes are submerged, the flow direction of the water passing over the groynes tends to be directed perpendicularly to the orientation of the groyne, depending on the depth of flow over the groyne and the depth of the pool between the groynes.

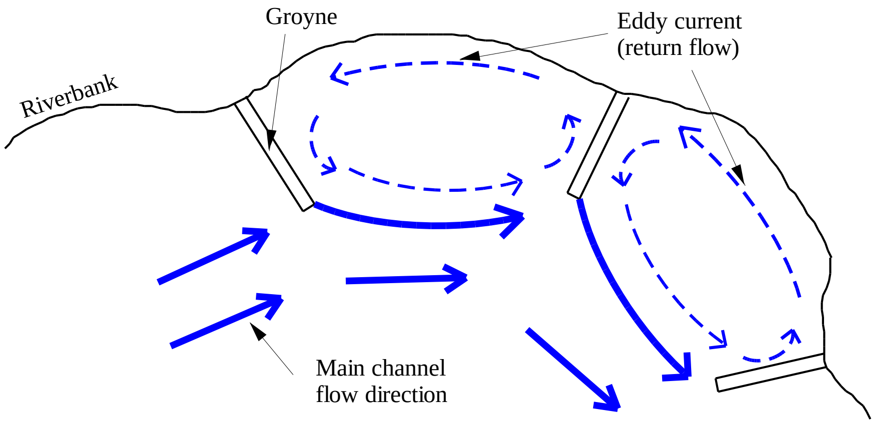
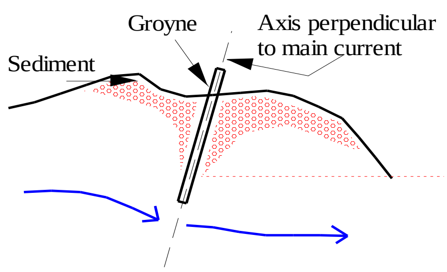
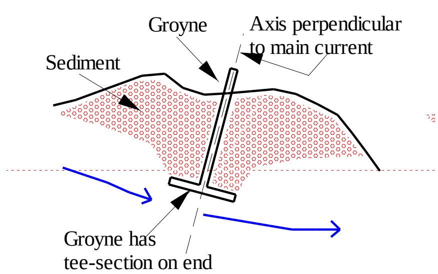



**Figure 9** Idealized flow between groynes while groynes are not submerged (depending of groyne spacing)

## 5.2 Groyne type classified by layout of groyne

Groynes can be classified according to their plan layout. Table 3 shows different layouts and relative advantages. In the South African context, this discussion is largely academic and not used in practice. In the Western Cape most groynes constructed by the Department of Agriculture are straight.

| | | |
|---|---|---|
| Groyne straight in plan |  | • Keeps main current away from bank<br>• Has medium potential for sedimentation |
| Groyne has hammerhead shape in plan |  | • Wide head creates greater eddies which encourage the deposition of more silt |

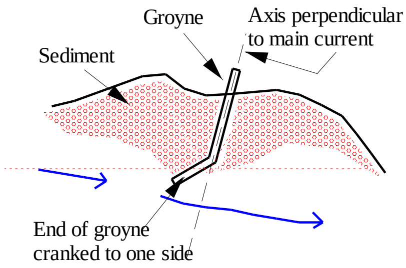
| | | |
|---|---|---|
| Groyne has L-shape in plan (bayonet) |  | • Upstream cranked head causes groyne to behave as a 'upstream oriented' or "repelling" groyne, but has lower cost than conventional "upstream oriented" groyne. |

**Table 3: Groyne plan layout**

## 6. HOW DOES THE USE OF GROYNES COMPARE TO OTHER RIVERBANK PROTECTION METHODS

Most forms of riverbank protection have an application to which they are best suited. In the Western Cape (South Africa) the advantages of the use of groynes are as follows:-

1. Groynes promote environmentally friendly solutions.
    a. Groynes facilitate the stabilizing of the location of the river channel while still allowing the wider floodplain to be inundated during large floods.
    b. Groynes create zones of riverbank (between the groynes) that have greatly reduced erosion hazard, and this is an ideal condition for the re-establishment of indigenous river vegetation. This supports the use of rivers as biodiversity corridors through agricultural landscapes.
    c. Groynes encourage the deposition of sediment
    d. Groynes constructed with gabion baskets are more likely to allow the use of locally sourced stone, and avoid having to import stone for construction.
2. Groynes can offer a solution that is more stable than longitudinal river bank protection during times of extreme flooding (because they are anchored more deeply into the riverbank, and that the energy of the water flowing along the bank is a lot less).
3. Direct bank erosion protection methods (retaining walls, riprap etc.) are often attractive, because they are seen to be addressing the problem directly (i.e. hardening the riverbank). A drawback of this approach is that longitudinal protection often encourages a deep channel with high flow velocity to be always situated directly against the structure. During low flow conditions, sediment is deposited, and vegetation colonized on the inside of the bend effectively narrowing the channel.
4. Groynes have been proven to be unsuitable in rivers where the channel is so narrow that it cannot even accommodate the small floods (such as the 1:10 year flood). Groynes are also not suitable where river flow velocities during floods are extremely high (e.g. Jan du Toit River where the average flow velocity exceeds 6.5 m/s), because river bed incision is a greater problem than bank erosion, and in such a case slope controlling weirs would be more appropriate

## 7. GROYNE DESIGN TECHNIQUES

### 7.1 MODEL TESTING

Rivers are highly dynamic environments and many factors influencing the design of riverbank protection works are difficult to quantify (flow conditions vary drastically from river to river, the three dimensional nature of turbulence downstream of obstructions, the amount of sediment and flood debris moving during floods, the growth of alien vegetation etc.). This complexity of the situation has encouraged reliance on model testing for the planning of structures, as opposed to describing a design approach based on empirical formulae. To date there is no single document outlining the design of groynes for riverbank erosion protection.

### 7.2 INTERNATIONAL PRACTISE

Groynes in Germany and the Netherlands (in the Rhine, Waal and other rivers) are used to control the location of the main channel and sandbanks in the river, and thus enable the safe navigation of the rivers by barges. A lot of recent research into groynes has focused on determining how many of the existing groynes can be removed, such that the groynes still function as needed, but trap less pollutants in the river. Research has been done using physical models as well as numerical models. The groynes seen were constructed with tipped rock fill covered with appropriately sized riprap.

Groynes in Brazil and Peru are used for riverbank erosion protection. They are used most commonly for bank protection around to public infrastructure such as bridges, as well as where rivers pass close to towns and the meandering of the river threatens the town. The groynes were planned using the method proposed in the Maccaferri manual (where the spacing of weirs is determined graphically on a layout of the river), using a flow divergence angle at the groynes tip between 9 and 14 degrees (7). Some groynes here have been visited and were found to be constructed in water at least two to four meters deep. These were constructed by pioneering a rock fill from the bank and then later covering this with gabion mattresses or rip-rap.

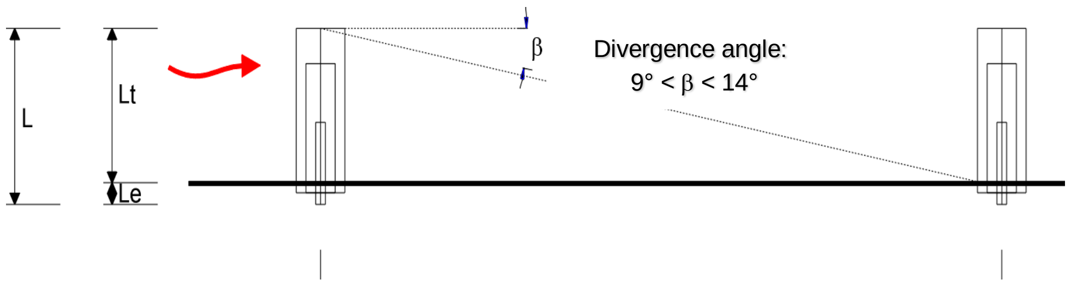



**Figure 10** Groyne spacing on straight channel based on a flow divergence angle (Maccaferri)

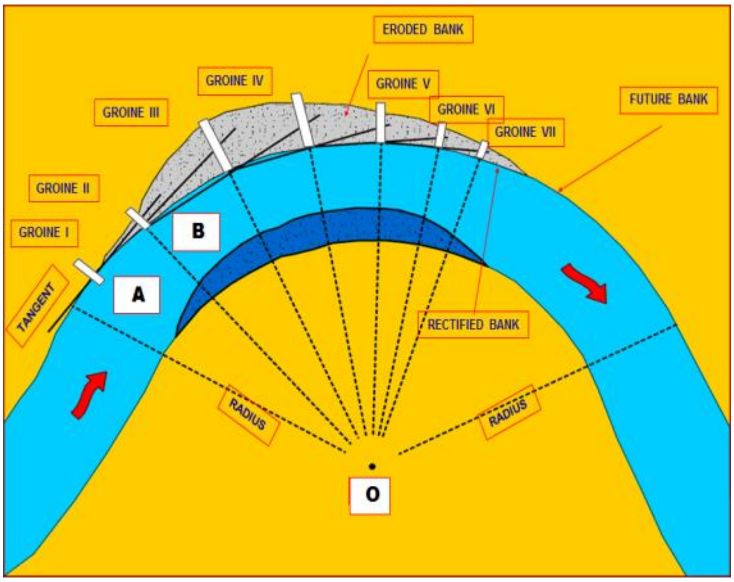



**Figure 11** Bend layout relating groyne spacing to lines tangential to bend at groyne tip (Maccaferri)

**Figure 12** Groyne on the Huallaga River at Campanilla (Peru)

### 7.3 WESTERN CAPE PRACTICE

Groynes for river bank erosion control have been planned and constructed in the Western Cape for more than twenty years. Initially only very small structures were planned, but with time they became larger up till what is seen today. Groynes have been designed using published empirical relationships along with design details determined from local experience.

In brief, the Western Cape practice is to provide a streamlined path (collection of straight sections with tangential bends) for the river, and to ensure that the channel provided is not smaller than the channel found nearby in the same river (refer to Section 4). This process ensures that the flow of the river is not going to be directed into the bank and cause fresh erosion, and that the river will not flood the floodplain at a stage earlier than what would have happened prior to the construction of the groynes.

The major difference between the Western Cape design approach and the Maccaferri design approach is that the Maccaferri approach does not ensure a minimum discharge capacity of the rehabilitated river channel. The reason for this could be that this approach was intended for much wider rivers. In the Western Cape, where rivers tend to have been condensed into narrow and deep channels, this approach would be inadequate. The design process used by the Western Cape is presented in more detail in Section 8.

## 8. THE WESTERN CAPE DESIGN PROCEDURE IN DETAIL

The practice of planning groynes in the Western Cape is described below in terms of preliminary studies that are carried out, the planning of the location of the rehabilitated river channel, and the detailing of individual structures.

### 8.1 PRELIMINARY STUDIES

#### 8.1.1 Topographic survey, hydrological study, flood height analysis and bed material.

A topographic survey is carried out so that it is extensive and detailed enough to:-

- Extract cross sections through the watercourse to compute flood heights with HEC-RAS or similar software. The survey must extend far enough downstream so that the flood routing calculation can begin at a suitable control point in the river (usually 300-500 m from the site). During the survey, the hydraulic roughness of various parts of the river and floodplain must be assessed for flood routing calculations.
- Extract long sections along a river to determine the required foundation depth of the groynes.
- Determine the position of the eroded bank, the rehabilitated bank and the projection length of the proposed groynes at any possible position, so that the required groyne spacing may be designed.
- Extract detailed sections along the centerlines of proposed groyne positions for the design of the individual groynes.
- Determine earthworks volumes.

#### 8.1.2 Hydrological study

A hydrological study is performed to determine the peak flood discharges for the 1:10, 1:20, 1:50 and 1:100 year return period floods. The hydrological study as far as possible takes into account changes to rainfall patterns brought about by global warming (or at least considers the consequences of changing weather patterns). In the Western Cape a form of the Rational method (Taylor-Schwartz) is used for this purpose, with a lot of information (catchment area, slopes, flow path length, mean annual rainfall) being prepared using ArcGIS. In the Overberg and Eden areas the rainfall intensity determination has been modified to take into account the nature of storms experienced since the mid 1990's– the storm runoff here was previously determined assuming frontal rain (i.e. coastal) but the severe flooding experienced is usually associated with thunderstorms, so the "inland" dataset is used.

#### 8.1.3 Flood height analysis

Flood levels and average flow velocities for the peak flood discharges are determined. Ideally this should be done for three cases, the situation prior to erosion, the situation existing at the design stage, and the post construction situation. In practice only the second case gets computed, unless the size of the groynes is large relative to the size of the river channel, then the third case is computed as well. In the Western Cape the HecRas software is used to determine flood heights (although this is a crude tool for computing the third case because it cannot simulate 3-dimensional flow effects).

#### 8.1.4 River bed material

The $d_{50}$ of the riverbed material should be determined or estimated for scour depth predictions. This is in practice difficult because of the variability of sediment nature with location (for example fine sediments dominate on the inside of bends while coarser material is on the outside). In the Western Cape when groynes are planned in boulder-bed rivers, the $d_{50}$ is not determined, but to reduce scour the tips of groynes are sloped and the foundation is set to one meter below the normal pool depth (see later in text).
The position and extent of rock outcrops must be clearly indicated on the topographical survey. The presence of rock outcrops in the river is significant because they may influence the flow direction of the river, they will influence the ability of the river to incise once the flow width is constricted, and they may provide a strategic location to construct groynes with less expensive scour protection.

### 8.2 PLANNING THE REHABILITATED RIVER CHANNEL

#### 8.2.1 Horizontal alignment

If the scale of intervention (size of groynes) is large in relation to the size of the river (probably if the projection of the groyne from the bank is more than 10% of the normal river width), then a rehabilitated channel needs to be planned to ensure that:-

- The flow of water is not directed into the opposite bank and causing new erosion
- Flooding of the floodplain does not occur at an earlier stage than what would have happened before it became necessary to stabilize the river bank.

To do this the principles set out in Section 4.2 regarding the production of a horizontal layout for the river must be adhered to. Considerable trial and error iterations for the horizontal layout are usually needed before a satisfactory design can be produced. The reason for this is that the distance which a groyne projects into a stream has a large influence on the spacing of the groynes, and the position of the rehabilitated channel determines the length of the groynes, and in that way influences project costs. In order to minimize the number of groynes and the project costs, it is often necessary to revise the rehabilitated channel layout to enable the use of longer and fewer groynes, while still keeping the rehabilitated channel in what has been known as the river channel.

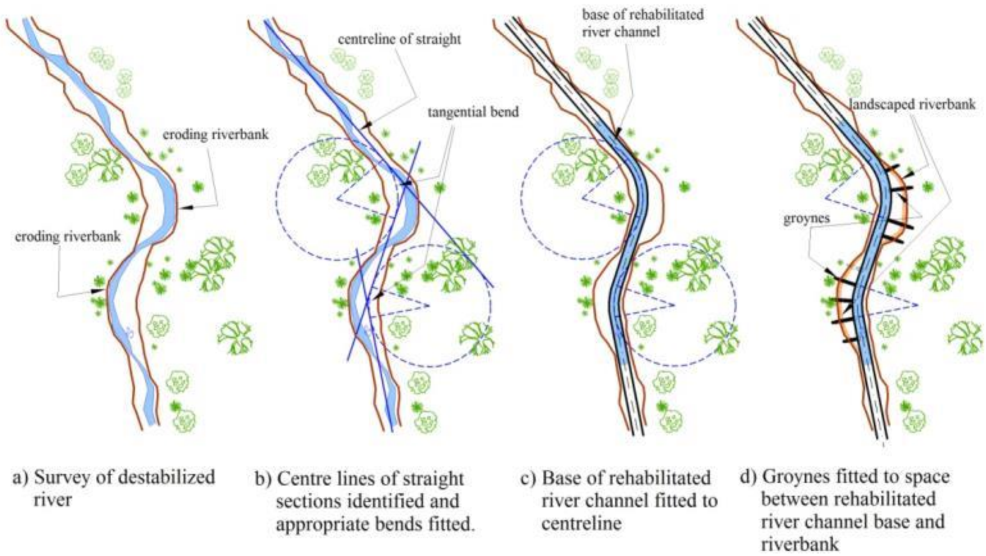



**Figure 13**: The development of a river's horizontal alignment for the design of groynes

#### 8.2.2 Bend radii

The choice of bend radius has a significant impact on the cost of the project as well as the stability of the groynes. The tighter the radius, the shorter the groynes needed to support it, but the number of groynes increases as the projection length of the groynes into the river reduces (see **Figure 14**). In addition, rivers with tighter radius bends have a greater tendency to deposit sediment on the inside of the bend, which gets colonized by alien vegetation in the dry months and destabilizes the river. On the other hand, should too large a bend radius be selected, the rehabilitated river channel is more likely to encroach into the bank on the inside of the bend. It is useful to remember that the more groynes there are, the more capital is spent constructing groyne tips and anchors into the bank, so a more cost-effective solution can often be found using bend radius greater than the minimum, with fewer groynes.

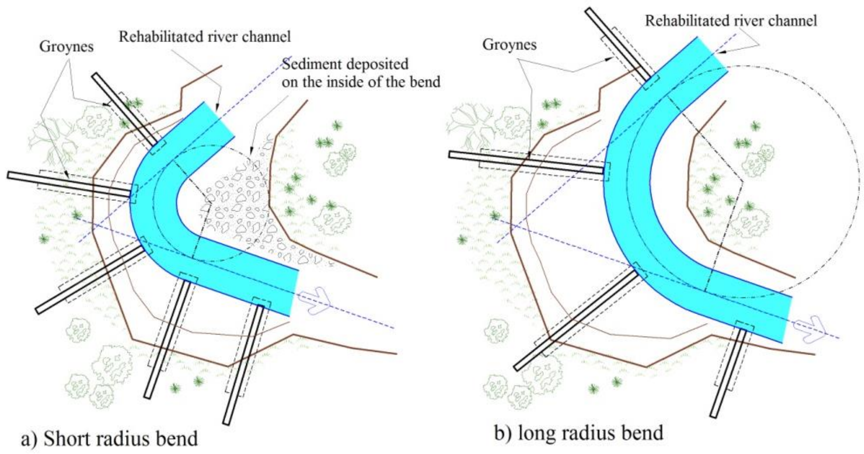



**Figure 14**: Different groyne layouts for a bend as influenced by bend radius

According to Przedwojdski et al (5) the minimum bend radius should not be less than twice the width of the river. It is quite likely that a bend radius of three to four times the river width yields a more practical arrangement, providing that the inside bank is not encroached upon too seriously and the construction costs are acceptable.

### 8.2.3 Vertical alignment

The vertical alignment of the rehabilitated river channel (which is used for planning the foundation level of the groynes) must be determined from the long section of the existing river. Providing that the riverbed is stable, a line connecting all the lowest points of pools on the surveyed long section in the river indicates the potential bed-level of the un-rehabilitated river (as observed between floods – during floods depending on circumstances, the river bed will be mobile to a certain depth). The foundations of the groynes must not be higher than this level.

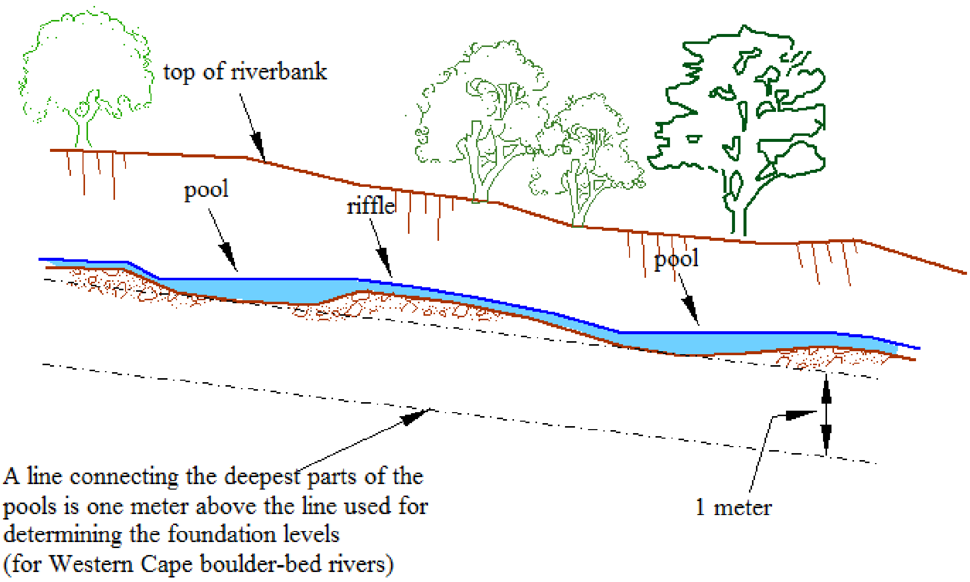



**Figure 15** The determination of the groyne foundation level

Remember that during floods the river bed gets mobilized, the level where the sediment is not moving may be even deeper than the potential bed-level identified above, and if possible the groynes should be founded at a deeper level than that given by the line. In the Western Cape, the foundation of the tip of the groynes is set to one meter below this line. In rivers where the riverbed is unstable (i.e. the riverbed is dropping due to erosion) it is advisable to address the instability of the riverbed with the introduction of a weir first before trying to stabilize the banks.

### 8.3 Planning a field of groynes

#### 8.3.1 The refinement of the location of the rehabilitated river channel when planning a field of groynes

The layout of a field of groynes is planned to support the flow of water along the rehabilitated river channel as described in 8.2 above. With particular reference to planning the river channel for protection with groynes, Figure 16 illustrates the iterative process needed to plan the rehabilitated channel position.

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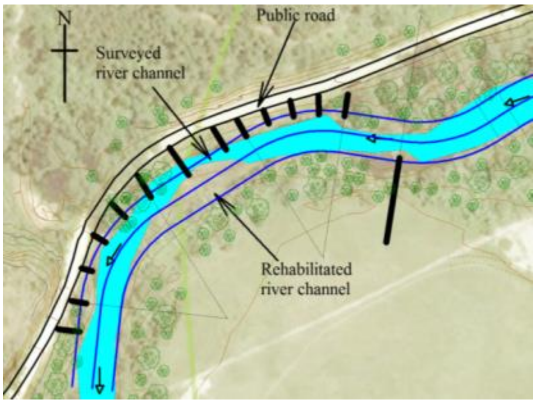
**TRIAL LAYOUT 1 : KEEP TO EXISTING CHANNEL AS MUCH AS POSSIBLE**

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- This option involves the least disturbance to the south bank
- The proposed groynes are short, their projection into the flow little, and so the spacing between the groynes is short
- It is not a desirable option because of the number of groyne tips that get dug deep into the river for scour protection.

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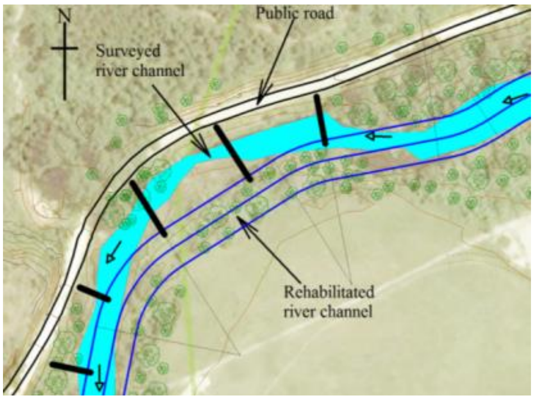
**TRIAL LAYOUT 2 : STRAIGHTEN RIVER AS MUCH AS POSSIBLE**

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- This option involves a maximum disturbance to the south bank. Almost the entire river channel has to be dug 4 m deep into virgin soil.
- The proposed groynes are long, their projection into the rehabilitated river is significant, and so the spacing between the groynes is large.
- The option is attractive because apart from the cost of excavating the south bank, the groynes are long and shallow, and the deep tips are few. The option also provides a large area for wetland rehabilitation and biodiversity enhancement.
- The option is undesirable because of the extreme disturbance of the south bank, and the legal implications of relocating the river to a position where it has not been for a long time.

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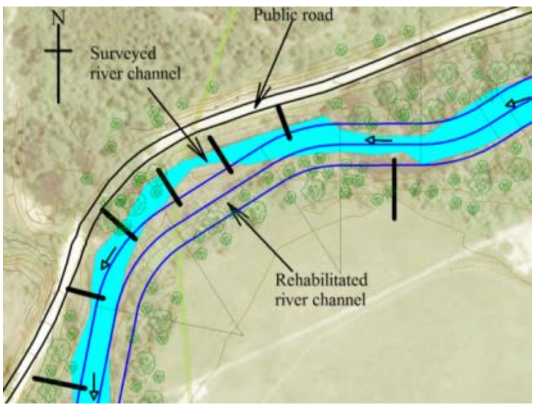
**FINAL LAYOUT**

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- This option involves a limited disturbance of the south bank.
- Most of the groynes are of a length that they can adequately influence the flow direction of the river. The spacing of the groynes is acceptable.
- The option is attractive because the amount of groyne tips are not excessive, and the disturbance of the south bank can be shown to be only in an area where the river bed was positioned in the last 10 or so years (from historical aerial photography).

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**Figure 16** Typical considerations for planning the layout of a field of groynes (Bottelierskop project 2014: Project objective to protect road from frequent wash-aways)

### 8.3.2 The positioning of structures within a field of groynes

#### 8.3.2.1 Start and end position of a field of groynes

Generally a field of groynes begins at the beginning of a curve of the rehabilitated river channel, continues to the end of the curve, and then an additional groyne is placed beyond the end of the curve to align the water with the straight section that follows (see Figure 17).

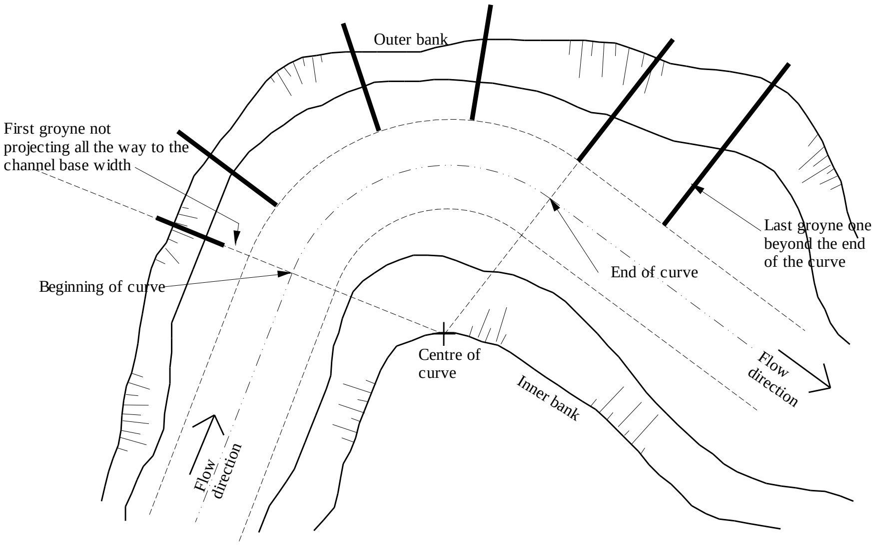


**Figure 17** The positioning of groynes relative to the start and end of a bend in the rehabilitated channel

It can be prudent sometimes to not position a groyne on the actual beginning of the curve, maybe just before or just after depending on conditions, and the same for the end of the curve. Observe that the sharper the bend and the greater the angle of deflection of the bend, the more groynes will be needed to achieve the desired result.

#### 8.3.2.2 Groyne spacing

The generally accepted rule for groyne spacing is three times the groyne 'projection length' on bends, and six times the 'projection length' on straight sections of river. A good discussion of different researcher's recommendations is presented by Przedwojski et al (5). It is of interest to note that these recommendations have been made largely by researchers of Northern Hemisphere rivers, which do not necessarily behave like Western Cape rivers. These recommendations have also probably been influenced by the Northern Hemisphere need to use groynes to provide permanently navigable channels in rivers, and not for river bank rehabilitation so it is possible that a different standard will be developed for the Western Cape with time. There is definitely room to improve the recommendations – for instance defining when a bend radius is large enough to treat the river as straight. The author is looking into the use of greater groyne spacing as a norm.

The groyne spacing is related to the groyne 'projection length'. The 'projection length' is a measure of how far the groyne protrudes into the river to influence the flow. This is not bound by hard rules and experience with the use of the structures and knowledge of local river behavior as influenced by these structures helps very much when choosing this value. For instance where rivers are wide enough, the author prefers long low groynes with the main objective of holding the fast flowing channel away from the river bank, but allowing the groynes to be submerged at an early stage so that the full valley bottom gets used for flow capacity. In the case of the Frankenhof 2 project (see Case Study 10.1.5) , the top of the shank of the groyne has been designed at just below the 10 year flood level, these groynes have been significantly submerged several times and there has been no sign of erosion of the river bank.

#### 8.3.2.3 The level to which groynes are constructed

The foundation level of groynes has a significant impact on the stability and durability of the structures and must be chosen with care. Choosing a foundation level below the water line can necessitate an expensive construction technique. Choosing a foundation level too high will make the structure susceptible to failure by undermining even if scour protection is provided. The foundation level must be determined by considering the natural depth to which the river is inclined to make pools, as well as making provision for additional depth to account for bed mobility during floods and scour around the tip of the structure.

In the Western Cape the foundation of the tip of the groyne gets placed 1 meter below the line connecting the underside of the pools in the pool and riffle sequence (see Section 8.2.3) – this is appropriate for the boulder-bed rivers. The "anchor" (gabion) below the upstream edge of the scour protection mattress is below this level.

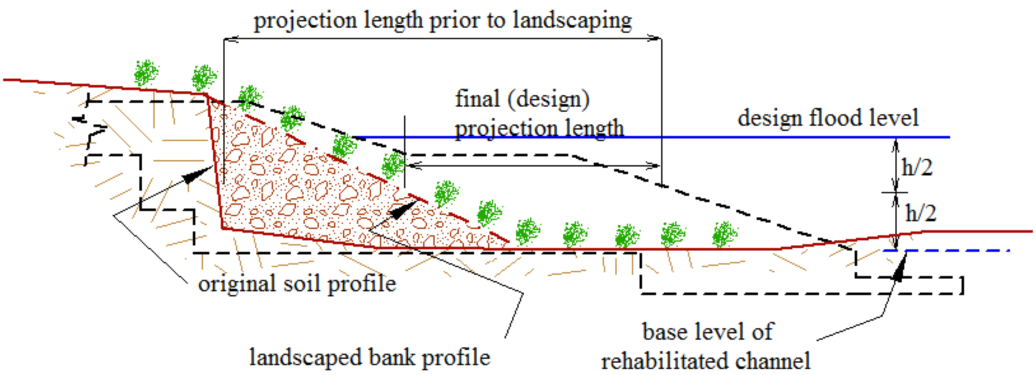


**Figure 18** A long section of an idealized groyne showing the projection length

The crest level of the groynes has a significant impact on the functioning of the groyne field. Uijttewaal reports that significant changes to the flow pattern of water between groynes occur after the flood water rises and the groynes become submerged (8). When not submerged, a 2-dimensional eddy forms between groynes with the most serious turbulence only at the groyne tip. When submerged (depending on the degree of submergence), an unstable 3-dimensional state of flow develops with serious turbulence at places other than the tip. For this reason the main body of the groyne must be constructed to at least the level of the 1:10 year flood (or higher unless the space between the groynes has been well covered with indigenous riverine vegetation).

The crest of the shank is designed to be at roughly the 10 year flood level (in other words the groyne shank is only submerged when floods are greater than the 10 year flood). As mentioned earlier in this section, there can be value in keeping this level even lower should the groynes be very long, and the objective of the groynes is to only locate the fast flowing portion of the stream away from the bank.

The crest of the root of the groyne is planned to be at the 100 year flood level, or the top of the bank, whichever is reached first.


**Figure 19** Side view of a groyne showing design level of different components (flood return periods)

#### 8.3.2.4 Length of groynes

The horizontal alignment of the rehabilitated channel determines the groyne projection length, as the groyne tip is placed at the edge of the rehabilitated channel. If the river width is not much wider than the rehabilitated channel width, and difficulty is being experienced obtaining sufficient projection length and groyne spacing, the tip of the groyne plus that portion of the groyne which is planned to be below the rehabilitated river bed level, may intrude into the rehabilitated channel space (as it in theory does not influence the flow in the channel). To this the root length of the groyne must be added to get the total length.

#### 8.3.2.5 The embedment of groynes into the river bank (groyne root)

Early groynes in the Buffeljags River were only embedded 2 to 4 meters into the bank to save costs. When high level flooding was experienced and water flowed behind the weirs, soil behind the weirs was washed away, outflanking the groynes. In the Western Cape, depending on conditions, the top layer of a groyne is embedded 8 to 20 meters into the lands behind the groyne. Sometimes the top of the root is kept 500 m below the soil surface so that the land may be cultivated.

#### 8.3.2.6 Orientation of the groynes relative to the flow direction

The orientation of groynes is discussed in Section 5.1. In the Western Cape it has been found most practical to orient groynes at right angles to the flow direction of the river. This not only provides a shorter and more cost effective groyne, but because the Western Cape groynes are kept low and submerge relatively often, the orientation of the groyne maintains the flow in the direction of the river.

#### 8.3.2.7 Scour protection

The most serious scour takes place at the head of the groyne – the flow of water in the channel shears past the relatively stationary water pooled between the groynes. If this shear plane is vertical, it initiates the formation of vortices (see Figure 20). The turbulence of these vortices can cause serious localized erosion of the river bed and result in scour holes that threaten the stability of the tip of the groyne. The depth of the scour-hole increases until a state of equilibrium is found between the amount of material being removed from the hole and that being deposited in the hole.

Although the formation of the scour hole can be controlled with gabion mattresses or riprap, it is best to limit the formation of the vortices in the first place. This can be done very effectively by sloping the top surface of the tip of the groyne, first proposed by Maza Alvarez (9), where the flatter the slope the more the shear forces are distributed over a wider contact area and the weaker are the vortices. Maza Alvarez recommends a slope of between 4:1 and 10:1, Uijttewaal recommends 6:1 (8). In the Western Cape a slope of 4:1 is usually used (10), except if a river channel has limited width and then this may be reduced to 3:1. Figure 21 and Figure 22 show early and more recent groyne tips layouts, the difference was motivated by the need to reduce the scour at groyne tips.

The normal practice when providing gabion mattresses for scour protection is to provide a width of mattress equal to 1,5 times the estimated scour depth. The available relationships for computing scour depth are discussed by Przedwojski et al (5), and are mainly applicable to structures with vertical faces, not the sloping tips used by the Western Cape, so the scour depth determination has been abandoned in the Western Cape and a standard four meter wide gabion mattress is provided around the tip of the groyne (in addition to the sloping of the tip) to ensure that the tip does not get undermined by scour.

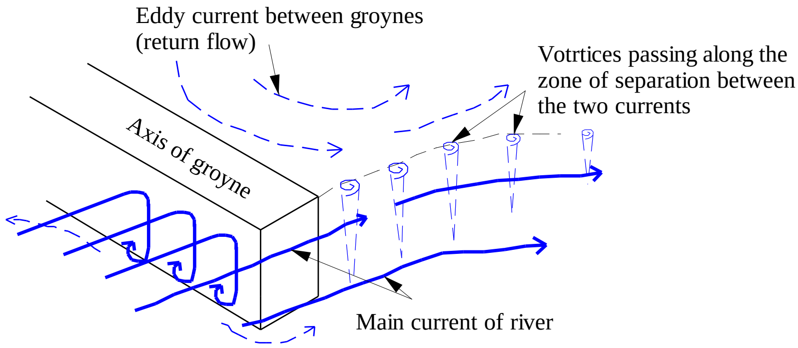


**Figure 20** Illustration of the formation of vortices at the tip of a groyne with vertical edges

**Figure 21** Early Western Cape groyne with vertical edges at the tip that promoted the formation of deep scour holes

**Figure 22 A m**ore recent Western Cape groyne showing the sloped tip which greatly reduces scour.

### 8.3.2.8 Structural stability of groynes

When groynes are submerged, it is commonly found in the Western Cape that the water level difference from the upstream side to the downstream side of the groyne is in the order of 500 mm. This in itself does not represent a large force in relation to the self-weight of the structure, especially when the groyne section is wider than it is high. More serious considerations for the design of the thickness of the groyne section are damage that occurs as a result of floating trees during floods, and instability as a result of the undermining of the foundation (upstream or downstream).

To address these needs, in the Western Cape, unless groynes are less than 2m high, they are usually constructed with a four meter thick base. The four meter thick section is convenient because it provides for 'cellular construction', in other words two parallel skins of rock filled gabions joined top and bottom by a roll of two meter wide gabion mesh, and the void is filled with geotextile wrapped, compacted granular fill (Figure 23 and Figure 24). Care must be taken during construction this that the geotextile wrap firstly that the fill cannot leak, and secondly that the geotextile is not exposed to sunlight which will cause it to degrade. This section has been found to be very robust and cost effective. The tip of the cellular section groynes is constructed with solid gabions.

**Figure 23** Preparing envelope for cellular construction - note the mesh below the geotextile envelope

**Figure 24** Compacting the granular fill in the envelope before closing and sealing

**8.3.2.9 Protection of gabion baskets from abrasion**

The abrasion of the wires of the gabion baskets and mattresses by rolling rocks and floating trees during floods has been a problem, especially around the tip of the groynes. For this reason the horizontal and sloping surfaces of the tips of groyne structures are now covered with a matrix of concrete pads 500mm x 500mm x 100 mm thick (40 mm below gabions wire), with 50 mm gaps between the pads. The use of pads in place of a continuous concrete skin has been chosen so as to maintain some of the flexibility of the gabion structure, especially the mattresses.

**Figure 25** The provision of concrete abrasion pads to gabion matresses around tip of groyne

#### 8.3.2.10 Where the use of groynes is not appropriate

When riparian land-users have confined a river in a narrow channel, such that the channel can discharge only the 10 year flood or less, it is believed by the Department of Agriculture that the placing of groynes in the channel will only cause floods to exit the channel at an earlier stage. In such a situation it is not recommended to use groynes unless more space can be returned to the channel.

**Figure 26** Parts of the Hex River can scarcely discharge the 10 year flood without spilling into the vineyards

### 8.4 FINALIZING THE CONSTRUCTED RIVER BED LEVEL

The groyne foundation levels are planned according to an analysis of the long section of the river (see Section 8.2.3). A certain amount of soil is required from the river bed to create terraces between the groynes, with the top of the terrace between 0,5 m and 1,0 m above the level of the finished riverbed. The purpose of the terrace is to provide an environment where the riverine vegetation may be planted without immediate disturbance by water in the river.

Usually if the rehabilitated channel is excavated to the designed rehabilitated channel level, more cut material is produced than what is required to fill the terraces between the groynes. This is an unnecessary cost, and can create contractual problems due to the amount of the variation in tendered quantities should it be reduced after the tender has been awarded. To resolve this issue, a trial-and-error process must be followed during the design phase, to establish a level somewhere higher than the level anticipated in Section 8.2.3 (i.e. the "rehabilitated channel level"), where the cut from the river bed is sufficient to create the berms between the groynes and not have an inordinate quantity of surplus once the construction is complete. Discretion must be used in determining this because the haul distance also has to be taken into account.

## 9. CONCLUSION

The design process for planning groynes in the Western Cape was born out of a need to stabilize river banks in an environmentally sensitive and sustainable way. The projects undertaken by the Western Cape Department of Agriculture can be seen as full scale model tests, they began on a small scale and once successful they grew in size and complexity. The use of groynes has been met very favorably by a wide group of role players, because of the environmental, job creation and agricultural sustainability benefits.

The use of groynes has proven itself as a means of environmentally sensitive bank stabilization with many structures performing well while under severe flood conditions. As with all river stabilization structures, there is however room for a lot of improvements and these are discussed in Section 11.

## 10. CASE STUDIES

A series of case studies are presented. The purpose of which is to outline the development of the Western Cape design approach.

Earlier projects such as the Rotterdam and Calitzdorp projects had stepped groynes tips. This is how groynes tips were detailed until the strength of vortices, and the resulting scour holes, developed at the vertical front face of the tip were observed. A paper by Maza Alvarez was found (9) which referred to the sloping of the structure to reduce the strength of the vortices. As a result a tip slope of 4:1 was decided on as a practical compromise between reducing the vortex strength and producing a groynes of length suitable to the limited river widths in the Western Cape.

More recent projects such as Frankenhof (Case Study 10.1.5), Klipdrift (Case study 10.1.7 ) and Bottelierskop (Case study 10.1.6 ) reflect the current thinking of producing long low structures, being just enough to keep the main flow channel away from the bank, and providing space to re-establish indigenous vegetation.

#### 10.1.1 Rotterdam (Buffeljags River) 1997

**DATE:** 1997

**FUNDING:** No government assistance

**COMMENTS:**

- The farmer lost 10-30 m of riverbank to erosion every year.
- The farmer funded the project entirely.
- Problems were experienced with scour related to the vertical layer steps.
- The structures survived floods until 2006 when tips subsided and the structures were outflanked by extreme flooding.
- The structures were repaired with updated standards in 2008.

**Figure 27 Post construction 1997**

**Figure 28 Aerial view 2009**

#### 10.1.2 Calitzdorp (Gamka River) 2000

**DATE:** 2000

**FUNDING:** Mainly state funding.

**COMMENTS:**

- More than 1km of riverbank with an irrigation canal feeding more than 600 hectares of vineyards was washed away in 2000. The canal was reinstated and to prevent it washing away again the groynes were constructed.
- This was the first groynes project constructed with state funding, as a poverty alleviation project.
- Since construction, this project has not been subjected to extreme flooding.

**Figure 29 Post construction 2000**

**Figure 30 Aerial view 2003**

#### 10.1.3 Mullersrus (Buffeljags River) 2008

**DATE:** 2008

**FUNDING:** Mainly state funding.

**COMMENTS:**

- In 2004 the farmer reported that a 30 m width of riverbank washed away at this site, and in 2006 a further 40 m.
- It was identified that it was necessary to stop the erosion her not only to aid the farmer, but to protect downstream neighbors from the effects of unnatural sediment movement as well.
- In 2008, just 2 weeks after construction was complete, a bank full flood was experienced (between 1:50 and 1:100 year event), with no soil loss to the banks.

**Figure 31 Post construction 2008**

**Figure 32 Aerial view just after the 2008 flood**

#### 10.1.4 Riool (Hex River) 2011

**DATE:** 2011

**FUNDING:** Mainly state funding.

**COMMENTS:**

- In 2008 a large flood caused a lot of damage in the Hex River.
- As part of the overall plan to stabilize the river, groynes were constructed in the vicinity of the de Doorns sewage works.

**Figure 33 Post construction 2011**

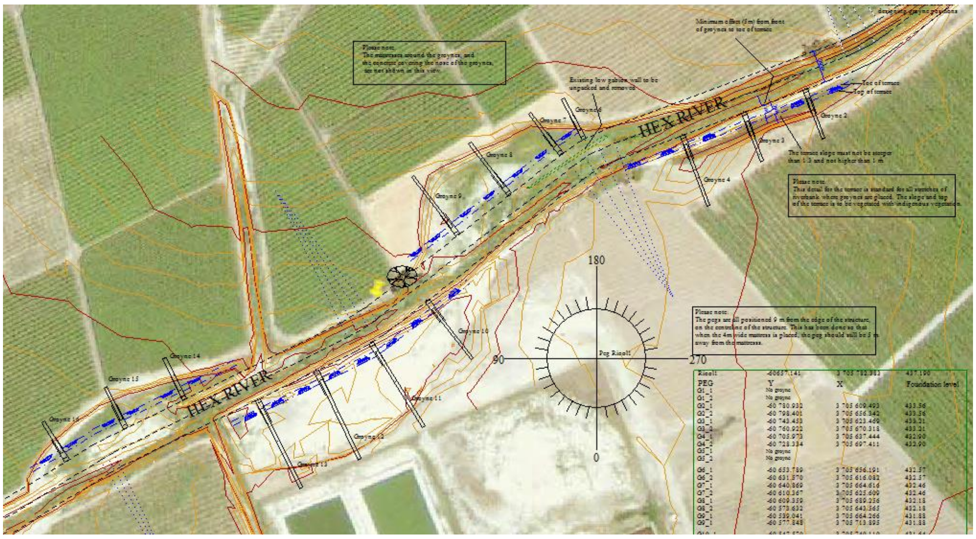


**Figure 34 Layout of rehabilitation plan**

#### 10.1.5 Frankenhof (Buffeljags River) 2012

**DATE:** 2012

**FUNDING:** Mainly state funding.

**COMMENTS:**

- During the 2008 and following floods the riverbank at this site became ever more unstable. It was the cause of a great increase in the sediment load of the Buffeljags River, which was destabilizing the river downstream.
- Construction was completed in 2012.08.
- This site is a good example of groynes which keep the smaller floods on the original watercourse, but allow large floods to use the full width of the now wide riverbed

**Figure 35** Prior to construction 2011

**Figure 36** Post construction 2012

**Figure 37 Aerial view post first flood 2012**

### 10.1.6 Bottelierskop (Moordkuil River) 2014

**DATE:** 2014

**FUNDING:** Western Cape: Department of Transport

**COMMENTS:**

- The riverbank at this site had a history of instability and flooding caused frequent damage to the adjacent public road. During the 2012 floods a large quantity of flood debris was deposited next to the road with a lot of ensuing damage.
- On the instruction of the Department of Transport, Kantey and Templer planned the upgrade of the road and managed the construction phase, the Department of Agriculture planned the river stabilization works.
- Construction was completed in 2014.

This case study is referred to in the text – see Figure 5, see Figure 16.

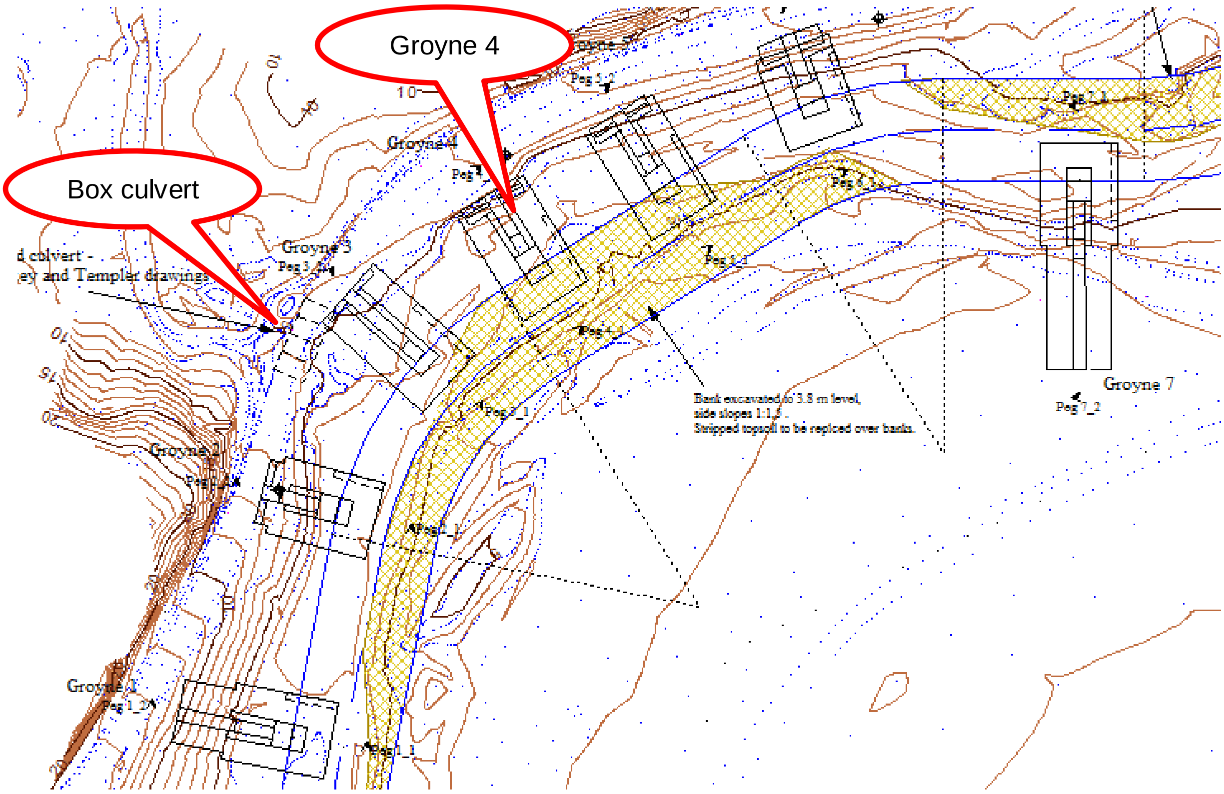


**Figure 38** A portion of the layout of the Bottelierskop project (Kantey and Templer, Department of Agriculture)

**Figure 39** Bottelierskop site 2 : post flood - 2012

(photo R Tyndall, Kantey and Templer)


**Figure 40** Bottelierskop site 2 : post construction - 2015

#### 10.1.7 Klipdrift (Duiwenhoks River) 2015

**DATE:** 2015

**FUNDING:** Western Cape: Department of Agriculture

**COMMENTS:**

- Over the last few years the riverbank at this site has moved towards the public road perched on a slope some 10 meters above the river. During the 2012 flood the road finally collapsed into the river.
- With the combined objectives of protecting the public road and reducing the amount of sediment moving unnaturally down the Duiwenhoks River, the Western Cape Department of Agriculture planned the project and sourced funding to execute it.
- Bergstan South Africa were already working with the road upgrades in the area post the flood, and agreed to manage the project.
- With the first of two river bends in this project, very long and low groynes were used to locate the high velocity flow channel away from the river bank.
- Construction was completed in 2015. The revegetation of the site is in progress.

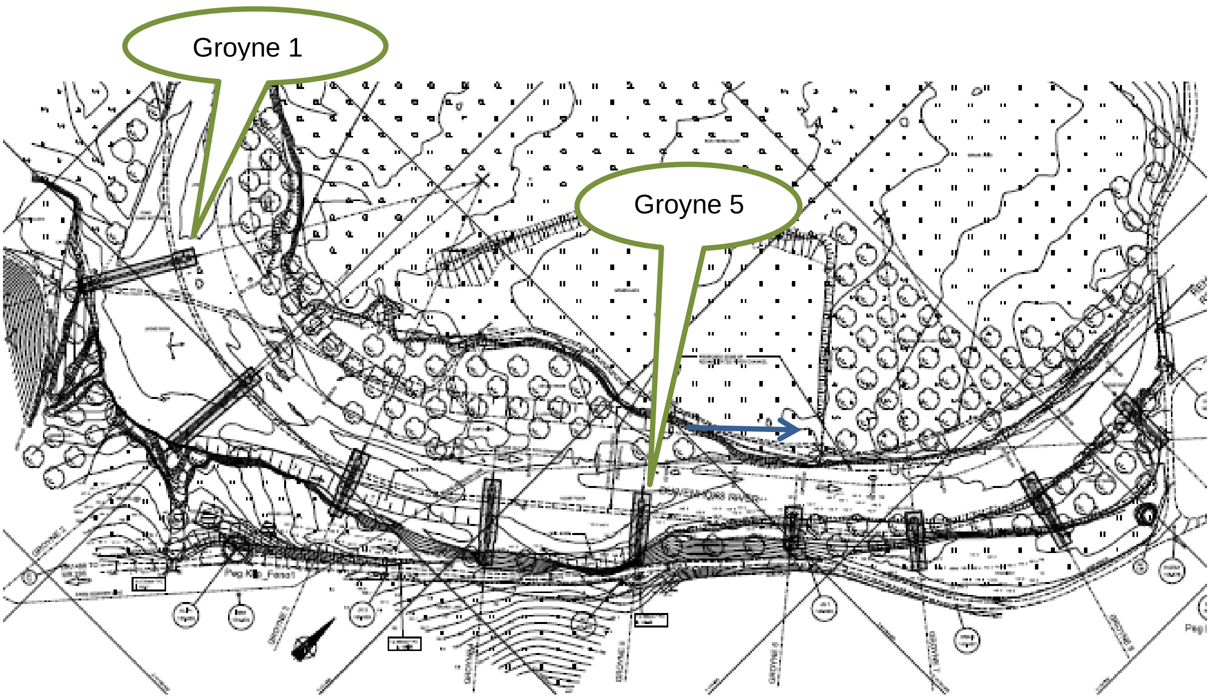


**Figure 41** Portion of layout plan Klipdrift project (Bergstan South Africa; Department of Agriculture)

**Figure 42** The road wash-away 2014


**Figure 43** Groyne 5 2015


**Figure 44** View of most upstream groyne (groyne 1) showing its length relative to its height – its function is mainly to locate the fast flowing channel away from the river bank

## 11. FUTURE DEVELOPMENT

The following is a discussion of improvements that can be made to the current process of river bank stabilization with groynes.

1. Groyne spacing:
   It is mentioned in the text that the groyne spacing relationships have been possibly established for groynes which maintain navigation canals and were not really intended for river bank stabilization. The groyne spacing relationships are also independent of flow velocity and river bed material. The groyne spacing relationships are also open to interpretation when groynes are being inundated frequently or not. This leaves a lot of room for refinement of the relationships for local conditions and expectations.

2. Groyne foundation depths:
   Groyne tip foundation depths have a large impact on the cost of a project. From a cost point of view it is desirable to keep them as shallow as possible. From the point of view of using groynes in soils other than boulder-beds, work needs to be done to calibrate a standard for suitable foundation depths.

3. Scour protection:
   The current scour protection system of gabion mattresses around the tip of the groyne, sunk a meter below the anticipated level of the river bed and covered with concrete pads for abrasion protection, is working but is very expensive and a more cost effective alternative needs to be sought. It would be helpful to achieve a better understanding of the flow around the sloping tip of the structure with and without the presence of flood debris attached to the tip of a groyne.

4. Alternative construction materials:
   There are many advantages to using gabion baskets to construct groynes (job creation, using naturally occurring materials, flexibility of the structure should foundation subsidence occur etc.) but using only gabions can also present problems (they are expensive, suitable stone in the river gets used up quickly in large projects, etc.), so a suitable alternative needs to be available.
   The author is currently looking at using concrete structures (pre-cast elements, or cast in-situ), but combinations of other erosion protection types also present an attractive alternative (for instance earth berms clad with vegetated dry stacked concrete blocks, and a flexible gabion tip). Alternatively the European concept of rubble filled groynes clad with riprap or rock filled mattresses is also possible.
   When looking at these different construction materials, it will also be necessary to look at how the groyne is expected to function (not submerge at all, submerge at an early flood stage). Quite likely the vegetation used and the management thereof will help make some alternatives more attractive.

5. Landscaping and revegetation:
   The use of groynes for river stabilization is very closely linked to the idea that the groynes are needed in some areas of degraded and transformed rivers where revegetation, which will lead to river stability, can no longer take place naturally, and that the groynes provide a more stable environment where this can be facilitated. The question then arises that once the groynes have been constructed, does the river get left as is, or should there be a measure of landscaping and revegetation?
   The current practice is to construct low terraces between the groynes with material excavated from the river channel, to provide a zone where the revegetation may be kick-started. The intention is to keep the alteration of the river to a minimum, and to move the least amount of material to achieve this objective, but to also initiate a healthy growth of vegetation between the groynes to stabilize the sediment that is trapped there. The refinement of this practice can lead to greater cost savings as well as better management of the river environment.

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