Assessment Of Flooding And Bank Erosion At Berridale, Rio Grande, Portland, Jamaica

Ridge to Reef Watershed Project

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ASSESSMENT OF FLOODING AND BANK EROSION AT BERRIDALE, RIO GRANDE, PORTLAND, JAMAICA

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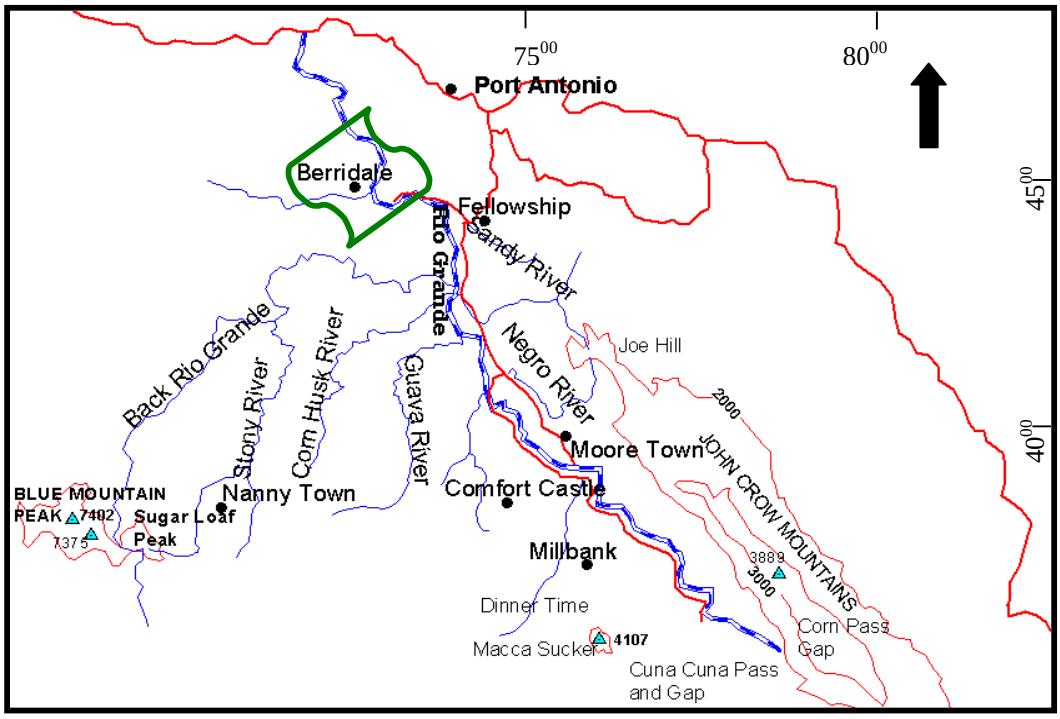
1.0 Introduction

Figure 1a. Locality map of Berridale and surrounding areas. Highlighted in green is the main area of study.



The Rio Grande can be classified as a typical meander-braid transition channel, with large and variable discharges, a relatively steep stream gradient and large sediment loads where the bed load, comprising gravel, pebbles and cobbles, is a significant fraction. Meander-braid transition river channels are also characterized by thalweg shift and bank erosion, while braid bar development can alter flow alignment to change the location of bank erosion. The steep stream gradient also favours the development of a wide-shallow channel, where secondary circulation cells within the main flow become multiplied, leading to bar development. Medial bars then divert the main flow towards the banks, causing bank erosion. Bank erosion is common in meander-braid transition channels, as the banks often consist of non-cohesive sediments.

The Rio Grande is also a gravel-bedded montane-tropical drainage system which is prone to flooding during extreme weather conditions. Flooding and bank erosion are therefore natural processes within such a system and the hazard cannot be completely eliminated.

Field assessment of the extent of bank erosion in Berridale area was carried out and the flood-prone areas identified. Local residents were interviewed informally to ascertain their perceptions of the flooding and erosion problem.

2.0 Extent of Flooding

The main flood prone area in Berridale occurs immediately downstream of a pronounced meander bend of the river (Figure 1a), where the outer concave bank has been protected by gabion baskets. During high river discharges, the Rio Grande bursts its banks at this point to engulf the gabions and flood the road behind them. Figure 1b shows a local resident indicating where the gabion baskets were breached during the Hurricane Ivan flooding, while in figure 2 he estimates the height of the floodwaters which inundated the road. At this locality, the road level is at least 4.0-4.5m above normal river stage.

Figure 1b. Berridale resident, Mr. Miller, indicates where the gabion baskets were breached during the Hurricane Ivan flooding.

Figure 2. Mr. Miller estimates the height of floodwaters which inundated the Berridale main road.

Other flood-prone areas occur a short distance upstream on the roadside near to the gravel-mining operation. During Hurricane Ivan, river discharges exceeded bankfull at this locality, flooding the road and nearby houses. The floodwaters also washed away sand and gravel stockpiles at the mining operation.

3.0 Bank Erosion

3.1. Extent of Bank Erosion

Bank erosion is commonplace along the entire river reach in the Berridale area. It is prevalent at meander bends, particularly on the outer concave bank of the river; though it is not confined to bends (Figure 3), but also occurs on relatively straight reaches on both the left and right banks of the river, especially where the channel contains medial braid bars (Figure 4).

Figure 3. Extensive bank erosion (bank collapse) on cultivated terraces of the Rio Grande River at Berridale.

Figure 4. Extensive bank erosion on relatively straight reaches of the Rio Grande River at Berridale.

Bank erosion and undermining has also led to the destruction of physical infrastructure marginal to the river, such as drains and sewer lines (Figures 5 and 6).

Figure 5. Destruction of physical infrastructure induced by bank erosion at the Berridale Rafters Rest.

Figure 6. Destruction of physical infrastructure induced by bank erosion at the Berridale Rafters Rest.

3.2. Causes of Bank Erosion

3.2.1. Erosion at Meander Bends

Meandering rivers and meander-braid transition channels have the ability to migrate across their floodplains as a result of selective bank erosion on the outer bend and deposition on the inner bend as point-bars. The channel cross-section at a meander bend is normally asymmetrical, where the stream is deeper on the outer concave bank. The line of maximum stream velocity and depth, or thalweg, becomes concentrated on the outer bank, such that the greatest stream velocities, stream power and water pressure are experienced at the concave bank. In addition to the thalweg being concentrated on the outer bank, intense secondary circulation cells in the form of helical flow also develop at meander bends, leading to an excess of water pressure on the outer bank and a deficit on the inner bank. A zone of flow separation also occurs immediately downstream of the axis of the meander, on the inner convex bends, leading to the development of a shear layer, with spiral vortices, reducing the effective width of the main current and concentrating water flow towards the outer concave bank. The net effect of the concentration of water on the outer bank is erosion, while point-bar deposits are laid down on the corresponding inner bend, where lower velocities, stream power and water pressures are experienced (Figures 7 and 8).

Figure 7. Meander bend erosion on the right bank of the Rio Grande River, 150m north of Rafters Rest, Berridale.

Figure 8. Meander bend erosion on the right bank of the Rio Grande River, 240m north of Rafters Rest, Berridale.

3.2.2. Erosion on Straight Reaches

Bank erosion on the straight reaches of the river around Berridale is associated with flood events, where the channel is at bankfull- discharge or where floodplain inundation occurs at stages higher than bankfull. The banks are easily erodible as they consist of non-cohesive sediments, which are not particularly well-protected by riparian vegetation. Some straight reaches are also associated with medial- and braid-bars, dividing the channel in two threads and diverting them towards the channel banks. This leads to a concentration of flow towards the banks, leading to undermining and collapse, especially at high flow.

3.3. Bank Erosion Protection Measures

Extensive bank erosion protection measures have been constructed in the past, ostensibly to protect the Berridale road from erosion and river bank collapse. Gabion baskets have been used extensively in the past to prevent bank erosion and they are particularly evident along the right bank of the river, not only at meander bends, but also on the straight reaches. Some gabions are relatively recent structures, having been constructed within the last year or two, while others appear to have been there for a much longer period of time.

Within the area most prone to flooding, downstream of the main meander bend, gabion baskets have been recently constructed to extend from the level of the road to the bed of the channel (Figures 8 and 9). The baskets protrude into the channel itself by some 5-6m, presumably to act as a buffer to flow and to reduce the asymmetry of the channel. Vegetation has also been planted in conjunction with the gabion baskets (Figure 8).

Figure 9. Gabion baskets recently constructed, along the right bank of the Rio Grande River. To the immediate right, ruptured gabions are exposed by an erosion scar.

Figure 10. Dr. David Miller demonstrates the poorly constructed nature of gabion baskets at Berridale. Here, mesh size > cobble and boulder material

These gabion baskets are well-located as they afford some protection to the outer meander bend. However, they are poorly constructed, as the cobble and boulder material used to fill the baskets is commonly finer than the mesh of the holding basket (Figure 10). Gabion baskets are generally filled with materials from the local area to reduce haulage costs, in this case rounded river cobbles and boulders. It is best to use rounded materials when infilling gabion baskets to minimize damage to the steel mesh, however a finer mesh should have been used in this instance to conform to the grain size of the material locally available. Some of the gabions are already useless and undermined because they have totally (Figure 11), or at least partially, lost their infill. Many of the older gabions upstream of the main meander bend have also been ruptured by natural processes, such as bed load bombardment during flood events. Some gabions around the sand mining operation at Berridale may have been damaged by mining

machinery during the stockpiling and loading of sand and gravel, leaving a substantial area of the right bank vulnerable to meander-style bank erosion (Figure 12) .

Figure 11. Ruptured gabions induced by massive bank collapse on the right bank of the Rio Grande River at Berridale.

Figure 12. Damaged gabions around the sand mining operation at Berridale induced by stockpiling and loading of sand and gravel.

Figure 13. Mining operation at Berridale. To the immediate left, deliberate diversion of the river course to facilitate mining activities is evident.

3.4. Sand and Gravel Mining

The mining activity on the right bank of the Rio Grande River at Berridale may create a net shift in erosion concentration on the right bank meanders, thus proliferating bank undercutting, though bank erosion was no more prevalent at or downstream of the mining operation compared to upstream. Erosion of the left bank opposite the mining operation is evident and the may be related to a deliberate diversion of the river course to facilitate the mining of a large lateral bar (Figure13).

4. Residents' Perceptions

Residents in the area particularly affected by flooding indicated the extent of the Hurricane Ivan related flood event and pointed out the overwash-sands that had seeped through and overtopped the gabion baskets. Residents perceive that the gabion baskets are not high enough to protect the road or their properties from flooding during high river stage. The overwhelming suggestion was that the gabions should be raised. Another general perception amongst residents was that the river bed had "lowered" in recent times and this lowering had also contributed to an increase in flood events and a greater vulnerability to flooding.

5. Conclusions and Recommendations

Bank erosion and floodplain inundation are naturally occurring processes within both meandering rivers and meander-braid transition channels. Channel bank erosion may be minimized by erosion control measures which have already been put in place in the Berridale area. However, many of the gabions have fallen into disrepair, having been damaged by bed load impact during flood events, while others were poorly constructed using inappropriate mesh-size for the size of materials locally available. Some of the newer gabions were also planted with vegetation which helps to further stabilize the channel banks. Gabion baskets are not an effective control against flooding, as they are both porous and permeable and as such, the residents' perception that raising the gabions would minimize flooding is erroneous, unless a concrete wall or similar structure were constructed, which could in itself be undermined by erosion.

Erosion on the outer banks of meander bends can, in some instances, be reduced by mining the point-bar on the opposing inner bend; this tends to alleviate the pressure on the outer bank by reducing the asymmetry of the channel. However, in this case mining of the point bar would make the gabion baskets on the outer bank more vulnerable, as the thalweg would shift downstream slightly, and the gabions would receive the full force of the flow at high stage.

It is recommended that the damaged gabions on the right bank of the river be replaced, while areas of bank erosion on the left bank could be stabilized by planting riparian vegetation.

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