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The Failure of the Nqoga Channel Between Hamoga and Letenetso Islands, Northeastern Okavango Delta

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Abstract

The Nqoga channel has been failing from its distal end since the early 1920s. The reach between Hamoga and Letenetso Islands is currently in severe decline. This article provides a pictorial and numerical record of the decline of this reach between 1985 and 1993.

Introduction

Channels of the Okavango Delta, especially those south of the Panhandle, are not only important navigation routes, but serve as an arterial system, supplying water to sustain surrounding wetlands. They have a limited lifespan, however, and in the longer term are prone to failure.

We have documented the processes which lead to channel failure (McCarthy *et al*, 1988, 1992; Ellery *et al*, 1989) and have described the end results (McCarthy *et al*, 1987). Briefly, channel failure results from deposition of bedload sand on the channel bed, which occurs as a result of the loss of water from the channel through the permeable channel margins. This causes the channel and the surrounding swamp to aggrade. Gradients away from the channel increase as a result, accelerating water loss from the channel. Downstream gradients are also reduced by the process, which results in a decrease in flow velocity in the channel. Vegetation gradually encroaches into the channel, further decreasing discharge. Ultimately, the channel fails completely and becomes overgrown. Deprived of a water supply from the channel, the surrounding swamp desiccates and accumulated peat catches fire and burns off, usually leaving dry land.

The failure of the lower reaches of the Nqoga channel in the northeastern region of the Okavango Delta (Figure 1) has been a source of concern since the 1920s when the process first started. Magau and members of his village were forced to abandon their homes on the lower Nqoga as a consequence of this channel failure. Moreover, the failure deprived the Mboroga and Santantidibe of much of their inflow (Wilson, 1972). The continued deterioration of the channel has created problems for Water Affairs staff and tour operators, as access from the Maunachira Channel to the Nqoga has become extremely difficult. Water Affairs staff have resorted to drastic clearing of the upper reaches of the Maunachira to facilitate access to the Nqoga, but after each clearing, the channel rapidly grows over. The process of channel failure is continuing and over the last eight years we have recorded significant changes in the Nqoga channel between Hamoga and Letenetso or (Letetemetso) Islands (Figure 2a). In this paper, we present measurements of channel characteristics and a pictorial record of these changes as we believe these may be of value to future naturalists.

History of the Lower Nqoga

An oral tradition exists in the region that the Nqoga Channel came into existence during the reign of Chief Letsholathebe I (ca1840-1874), when "hippopotami in great numbers breaking through and trampling a big 'hippo-path' created the initial Nqoga Channel

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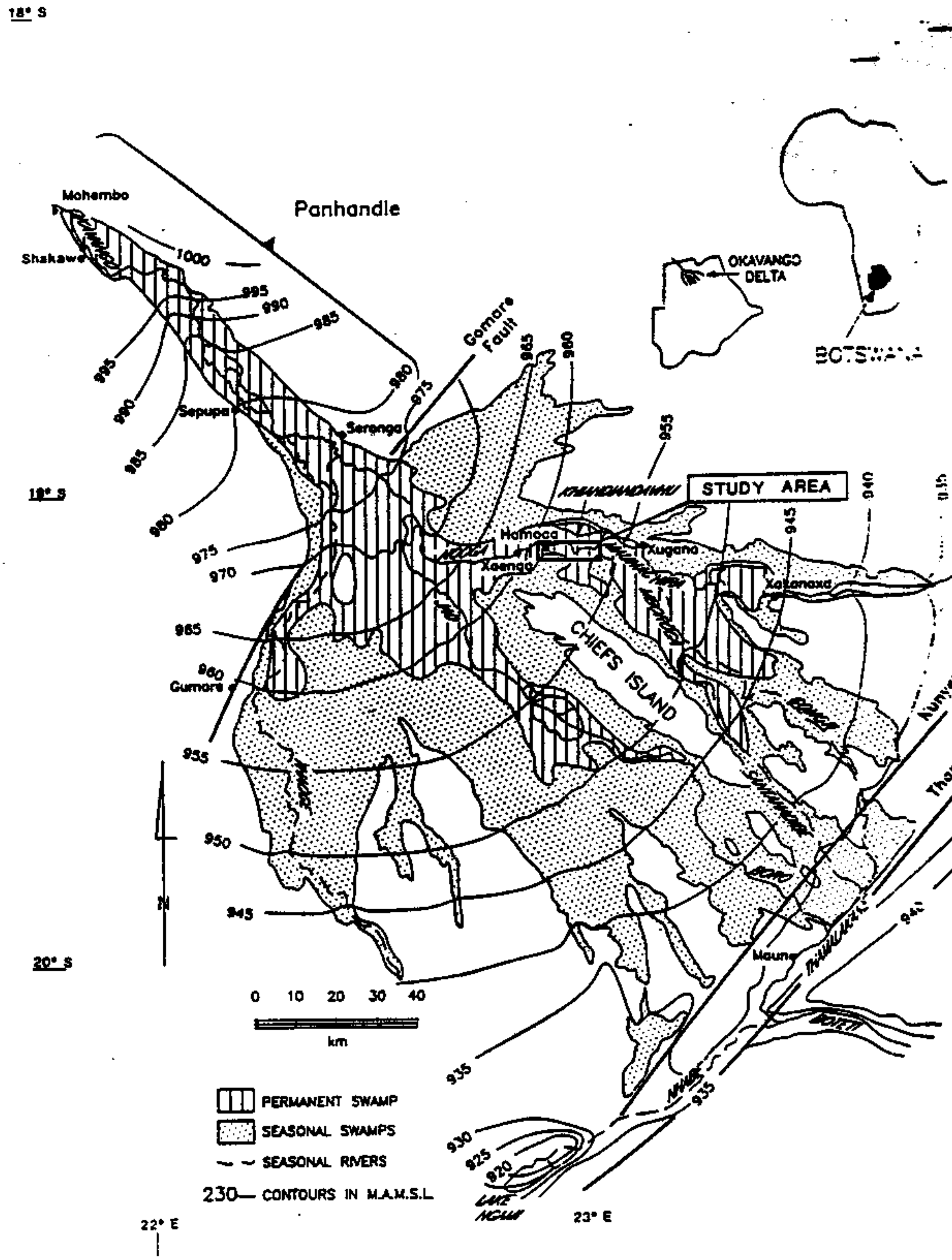


Figure 1: Location of the Nqoga Channel

and the inflowing water did the rest" (Stigand, 1923). At that time, the Thaoge Channel was the major distributary of the Delta and this channel discharged directly into Lake Ngami. From about 1880 water ceased to flow into the lake from this source (Stigand, 1923) and over the period since then, the Thaoge has progressively dried out from its distal termination.

Flow shifted to the Nqoga as the Thaoge failed and the Nqoga channel became the major waterway of the Delta, feeding water into the upper reaches of the Mboroga-Santantadibe system. Stigand (1923) recorded dimensions of the channel during an extensive survey of the swamps made during 1921. At its distal end, the Nqoga Channel was 35m wide and 2.4m deep, with a flow velocity of 0.13 m/s. South of the Bokoro Lake, in the vicinity of Letenetso Island, he recorded channel dimensions of 32m wide and 5.2m deep, with a flow velocity of 0.76 m/s. In the 1920s, the lower reaches of the Nqoga began to experience blockages. These progressed further upstream over the succeeding years.

In the 1940s, flow was diverted into a hippo trail leading to a small lake in the vicinity of Letenetso Island (Figure 3) and thence by way of Bokoro Lake into the Maunachira Channel. The small lake closed rapidly and by 1969 (Figure 3B) had disappeared, while Bokoro Lake had been substantially reduced in size. By 1983 (Figure 3D) most of Bokoro Lake had disappeared. The processes involved in the closure of lakes have been described by McCarthy *et al* (1993). The original hippo trail linking the Nqoga with the lakes and the Maunachira Channel was by this stage a fairly substantial channel, here termed the Cross-cut Channel. Downstream of the confluence of the Cross-cut and Nqoga Channels, failure of the Nqoga was complete. The channel became overgrown with papyrus and the surrounding peat dried out and was burnt off in slow burning, subsurface peat fires (Ellery *et al*, 1989), eventually exposing the former channel bed (McCarthy *et al* 1987, 1988).

Failure of the Nqoga Channel continued, notwithstanding the connection of the Nqoga Channel to the Maunachira Channel, and the reach between Letenetso Island and Hamoga Island became prone to severe surface blockages, creating problems for Water Affairs staff. P A Smith created a by-pass around this region in the early 1970s by excavating a short canal across Hamoga Island, thereby linking the Nqoga Channel directly to the headwaters of the Maunachira Channel. At the time of excavation a difference in water level of about 1.5m existed across Hamoga Island. The excavated canal was rapidly widened by erosion (Smith's Channel, Figure 2a) leading to fears that a major disturbance in water distribution had been created. However, these have proved to be unfounded, because by the mid 1980s this channel had become prone to natural closure by vegetation and has had to be artificially maintained.

Letenetso Island served as a Water Affairs hydrogauge station, but had to be abandoned in the early 1970s because of the difficulty of access. Channel width during the final period of measurement at this station in 1970 was 16.9m and flow velocity was 0.54m/s. The water level was recorded as 2.52m (range 2.49-2.54m over the year) on the gauge, but it is unlikely that this is the channel depth. This location is close to the position where Stigand (1923) had recorded the channel dimensions reported above, and indicate that the channel width had been reduced by half between 1921 and 1970. After the excavation of Smith's Channel, a hydrogauge was erected at Hamoga Island. The records for this station are shown in Figure 4. In this region of the Delta, seasonal water level fluctuations are generally less than 20cm (Wilson and Dincer 1976; McCarthy *et al*, 1991) and create only minor perturbation on the general trend. It is evident from these records that channel water level has been rising steadily since recording commenced, at a rate of about 5cm per year.

Table 1: Channel Dimensions and Flow Velocities of the Nqoga, Cross-cut and Maunachira channels. Site Locations are Shown in Figure 2.

Site	Flow velocity (m/s)	Width (m)	Depth (m)	Discharge (m^3/s)	Date
50	0.38	18	3.7	25.3	1985
51	0.50	18	3.6	32.4	1985
52	0.56	14	3.8	29.8	1985
53	0.43	18	3.4	26.3	1985
56	0.48	12	3.8	21.9	1985
57	0.43	14	3.7	22.3	1985
58	0.60	12	3.8	27.4	1985
6C	0.36	9	2.8	9.10	1989
7M	0.32	11	2.9	10.2	1989
54	0.36	17	3.5	21.4	1985
55	0.38	17	3.6	23.4	1985
6M	0.27	13	3.6	12.6	1989
59	0.46	18	3.5	29.0	1985
60	0.48	24	3.6	41.5	1985

The Channel After 1985

By 1985, when we first commenced our work in the area, the Cross-cut Channel was flanked by a papyrus "sea" (Figure 5) and had completely assumed the function of the Nqoga. All that remained of the former Nqoga channel downstream of the junction was a ribbon of more lush papyrus near the confluence (Figure 7). Peat fires had progressed to within a few hundred metres of the junction (Figure 7), exposing the channel bed.

The Cross-cut Channel and the Nqoga Channel between Hamoga and Letenetso Islands varied between 10 and 25 metres wide and from 3 to 4 metres deep (Figure 2b and Table 1). Flow velocity varied between 0.3 and 0.6 m/s, and discharge was of the order of $25m^3/s$ (Table 1). The channels were flanked by dense stands of papyrus up to 4m tall with small abundances of the fern *Thelypteris interuptus* growing around the culms (Ellery *et al*, 1990). Hippo grass (*Vossia cuspidata*) occurred as a narrow ribbon along one margin of the channel, usually on inner channel bends. Figures 8 and 9 show the channel at this stage.

Surface blockages were a feature of the channel and consisted of floating papyrus debris (Figure 10). Water continued to flow beneath these blockages, producing scour features in the channel bed below the blockages (Cairncross *et al*, 1988). These blockages made navigation by boat impossible. The blockages were typically short lived, generally having a life of six months or less. Break-up of the blockages is believed to result from decomposition of the debris, especially at the lower end of the blockage (Ellery, 1988). A typical blockage during this phase is shown in Figure 11.

Over the following years, the width of the hippo grass fringe gradually increased (Figures 12, 13) in the lower reaches below Hamoga Island, severely narrowing the width of open water (Figures 14, 15). By the late 1980s the hippo grass had become sufficiently dense to support papyrus rhizomes which extended from the margins across the former channel (Figure 15). Near Hamoga Island, constriction of the channel by hippo grass was less pronounced, but papyrus debris blockages were of substantial length (Figure 16). Discharge in the Cross-cut Channel had been reduced to 9m ^{3}/s (Table 1).

Meanwhile, the peat fires, which had progressed along the course of the Nqoga as it failed, encroached into the region around Letenetso Island, and by 1993, the papyrus "sea" which had characterised the region of the junction of the Nqoga and Cross-cut Channels had been destroyed by peat fires and the extent of papyrus was limited to a fringe along the channel a few tens of metres wide. Areas behind the fringe were being encroached by woody plants, particularly *Vernonia*, which were probably rooting in ash generated by the peat fires (Figures 17,18).

Changes to the Islands

Wilson (1973) noted a rise in water level at Letenetso Island, but access to this island became difficult after 1970, so events on the island were not recorded. The situation is somewhat better in the case of Hamoga Island, which became a gauging station in the late 1970s. Here, continued access has been possible because of the regular clearing of Smith's Channel by Water Affairs staff.

The gauge record for Hamoga Island from 1977 to 1990 (Figure 4) shows a steady rise in water level and reflects a total rise of just over 50cm during the recording period. The effect of this rise on island vegetation has been catastrophic, especially for the broad-leaved trees. Many of these plants had already died prior to 1985, but a few survived in the centre of the island (Figure 19). Palms, (*Hyphaenae ventricosa*) were at this stage unaffected. By 1993, however, virtually all of the broad-leaved trees had died (Figure 20). Many palms, especially those closest to the island fringe adjacent to Smith's Channel, had also died. The grassland fringe surrounding the island had become inundated and had been invaded by papyrus (Figure 21) as the island fringe was replaced by permanent swamp.

Vegetation Succession

Papyrus is the dominant species in the middle and upper channels of the Okavango. Its growth habits vary widely. In channels which receive water and sediment directly from the Okavango River, papyrus is robust, attaining heights of over four metres (Ellery *et al*, 1994), whereas in more distal areas, these plants are smaller, often no more than a metre tall. Papyrus is generally absent from backswamp areas. Ellery *et al* (1990) attribute this to nutrient availability, which is related both to the source of the water and its flow rate through the swamp.

Ellery *et al* (1994) examined the relationship between papyrus encroachment of channels and flow velocity, and found that rapid flow inhibited channel encroachment by papyrus. Although papyrus was found to grow more vigorously in rapidly flowing channels, rhizomes which propagated out into such channels eventually broke off and were washed downstream, so that channel encroachment was very limited. The study by Ellery *et al* was of limited duration (2 years). The data compiled here enable a longer term assessment to be made of papyrus encroachment. In the vicinity of the confluence of the Cross-cut and Nqoga

Channels, channel width was reduced from 32m to 16m over a period of 64 years, while channel flow velocity declined from 0.76m/s to 0.45m/s. This represents an average encroachment rate of 25cm/y or 12.5cm/y on each margin. Flow velocities reported here are unfortunately not directly comparable to those recorded by Ellery *et al* (1994), as theirs relate to the papyrus fringe, while those recorded here are an average for the channel. Nevertheless, their data suggest that the rate is unlikely to have been uniform over the 64 years and has probably accelerated as velocity has declined. Papyrus therefore plays an important part in the gradual process of channel failure.

The second most important species involved in channel failure is hippo grass (*Vossia cuspidata*). This plant is bottom rooted and has long, rope-like stolons which extend to the water surface and culminate in a cluster of blade-shaped leaves. Like papyrus, hippo grass only grows in those channels which receive water directly from the Okavango River and is rare or absent in backswamp areas and distal channels (Ellery *et al*, 1990). It is unable to colonise rapidly flowing channels because it becomes uprooted. However, as a channel deteriorates and flow velocities decline, hippo grass is able to take root in channels, initially downstream of river bends, but gradually it becomes more extensive as flow velocity declines further. It serves as an important trap for floating debris (Figure 10) and contributes significantly to the formation of debris blockages. Over a period of years, hippo grass gradually encroaches across the entire width of the channel (Figure 15). Its stolons provide support for papyrus rhizomes, which eventually grow across the hippo grass, completely covering the channel. Colonisation by hippo grass therefore hastens the demise of a channel. Once overgrown by papyrus, the hippo grass rapidly dies off due to shading.

Future Prospects

From observations in the region of the Nqoga channel below its confluence with the Cross-cut Channel, and the events recorded here, it seems likely that water will in time cease to flow into the Nqoga Channel below Hamoga Island. Deprived of moisture, the peat flanking the channel will desiccate and burn off and the swamp will revert to dry land. The ash thus generated will produce fertile grassland (Ellery *et al*, 1989).

Channel failure has been progressing steadily from the lower reaches of the Nqoga, and it is probable therefore that the Nqoga Channel upstream of Hamoga Island (Figure 22) will start to fail next. The early signs of this process are already evident at Xaenga Island, situated some 12km upstream of Hamoga island, where water level has been rising at a rate of about 2cm/year (McCarthy *et al*, 1992) and the island is being inundated (I Muzila, pers comm, 1993).

It is appropriate here to comment on the impact which the excavation of Smith's Channel has had on the region. At the time of its excavation, the Nqoga Channel had already connected to the Maunachira Channel, by way of the Cross-cut Channel (Figure 3). Smith's Channel served as a second connection, in this case to the headwaters of the Maunachira. Smith's Channel has not proved to be a viable link, however, and has to be maintained artificially. The fact that this practice is followed attests to the usefulness of this channel to the Department of Water Affairs. From a sedimentological point of view, Smith's Channel has increased the discharge of the Nqoga Channel at Hamoga Island, thereby reducing the rate of sediment accumulation in the reach immediately upstream of Hamoga Island. It is therefore likely that Smith's Channel has acted to prolong the life of this section of the Nqoga, albeit briefly. As the Nqoga Channel above Hamoga Island fails, so too will Smith's Channel. Overall, therefore, we are of the opinion that the excavation of Smith's Channel has had no material effect on the evolution of the Nqoga Channel system.

The failure of the Nqoga Channel upstream of Hamoga Island will deprive the upper reach of the Maunachira Channel of water, and this reach will in all probability cease to flow and may become overgrown with aquatic vegetation. This decline is already evident, as discharge in the upper Maunachira almost halved between 1985 and 1989 (Table 1). We anticipate that the Khiandiandavhu Channel, a tributary of the Maunachira which lies to the north of the upper Maunachira, will become increasingly important as a distributary in the years ahead (McCarthy *et al*, 1992).

Conclusion

The changes in channels recorded here are part of the natural evolution of the Delta system and have probably been in operation for millennia. They are ecologically very important as they result in renewal of the ecosystem. In particular, the ash generated by peat fires creates relatively fertile soils over wide areas in this generally infertile environment. Important grazing grounds for large herbivores are thus created. It has also been shown that prolonged flooding results in accumulation of toxic salts, especially in the ground water and soils beneath islands, which has a profound effect on island vegetation (McCarthy *et al*, 1991; McCarthy *et al*, 1993; Ellery *et al*, 1993). Channel failure results in lowering of the water table beneath islands. Toxic salts are flushed from the soils by rainfall during these periods of dormancy. Therefore, although channel failure may inconvenience human inhabitants of the Delta, the process is essential for the long term well being of the ecosystem.

References

Cairncross, B; Stanistreet, I G; McCarthy, T S; Ellery, W N; Ellery, K & Grobicki, T S A (1988). "Palaeochannels (stone-rolls) in coal seams: Modern Analogues from Fluvial Deposits of the Okavango Delta, Botswana, Southern Africa". *Sed. Geol. 57*: 107-118.

Ellery, W N (1988). *Channel Blockage and Abandonment in the Northeastern Okavango Delta: The Role of Cyperus Papyrus*. Unpublished MSc Thesis, University of the Witwatersrand, Johannesburg, pp 98.

Ellery, W N; Ellery, K & McCarthy, T S (1989). "A Peat Fire in the Okavango Delta, Botswana, and its Importance as an Ecosystem Process". *Afr. J. Ecology*, 27: 7-21.

Ellery, W N; Ellery, K; Rogers, K H; McCarthy, T S & Walker, B (1990). Vegetation of Channels of the Northeastern Okavango Delta, Botswana. *Afr. J. Ecology*, 28: 276-290.

Ellery, W N; Ellery, K; Rogers, K H & McCarthy, T S (1994). "The Role of *Cyperus Papyrus L* in Channel Blockage and Abandonment in the Northeastern Okavango Delta". *Afr. J. Ecology*. In press.

McCarthy, T S; Ellery, W N; Ellery, K & Rogers, K H (1987). "Observations on the Abandoned Nqoga Channel of the Okavango Delta". *Botswana Notes and Records*, 19: 83-89. (Gaborone: Botswana Society).

McCarthy, T S; Stanistreet, I G; Cairncross, B; Ellery, W N; Ellery, K; Oelofse, R and Grobicki, T S A (1988). "Incremental Aggradation on the Okavango Delta-fan, Botswana". *Geomorphology*, 1: 267-278.

McCarthy, T S; Stanistreet, I G & Cairncross, B (1991). "The Sedimentary Dynamics of Active Fluvial Channels on the Okavango Fan, Botswana". *Sedimentology*, 38: 471-487.

McCarthy T S; Ellery, W N & Stanistreet, I G (1992). "Avulsion Mechanisms on the Okavango Fan, Botswana: The Control of a Fluvial System by Vegetation". *Sedimentology*, 39: 779-795.

Stigand, A G (1923). "Ngamiland". *Geog. J.* 62: 401-419.

Wilson, B H (1973). Some Natural and Man-made Changes in the Channels of the Okavango Delta. *Botswana Notes and Records*, 5: 132-153. (Gaborone: Botswana Society).

Wilson, B H & Dincer, T (1976). An Introduction to the Hydrology and Hydrography of the Okavango Delta, in: Symp. on the Okavango Delta, pp 33-48 (Gaborone: Botswana Society).

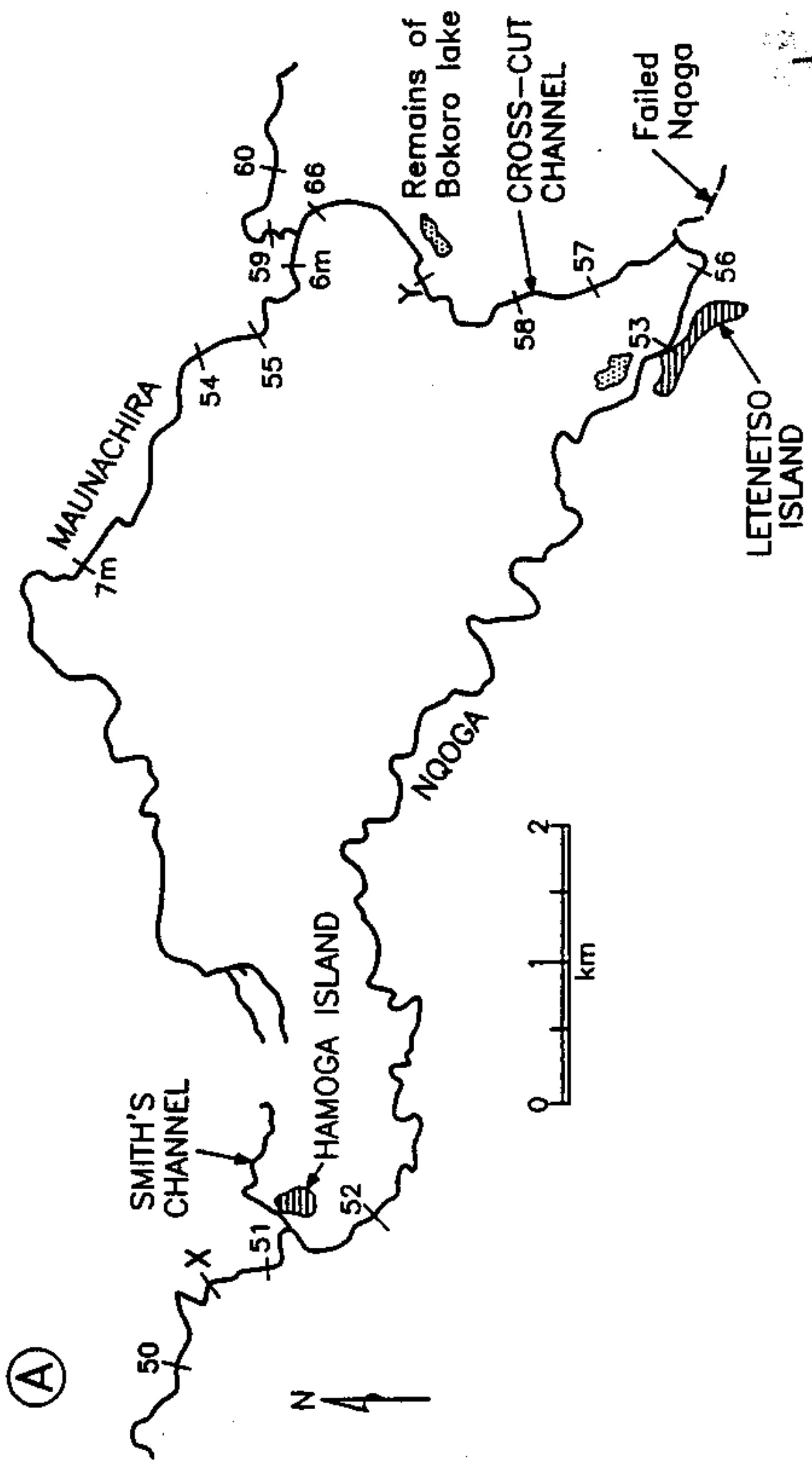


Figure 2A: **The study reach between Hamoga and Letenetso Islands. The numbers refer to study sites where channel parameters have been measured (see Table 1).**

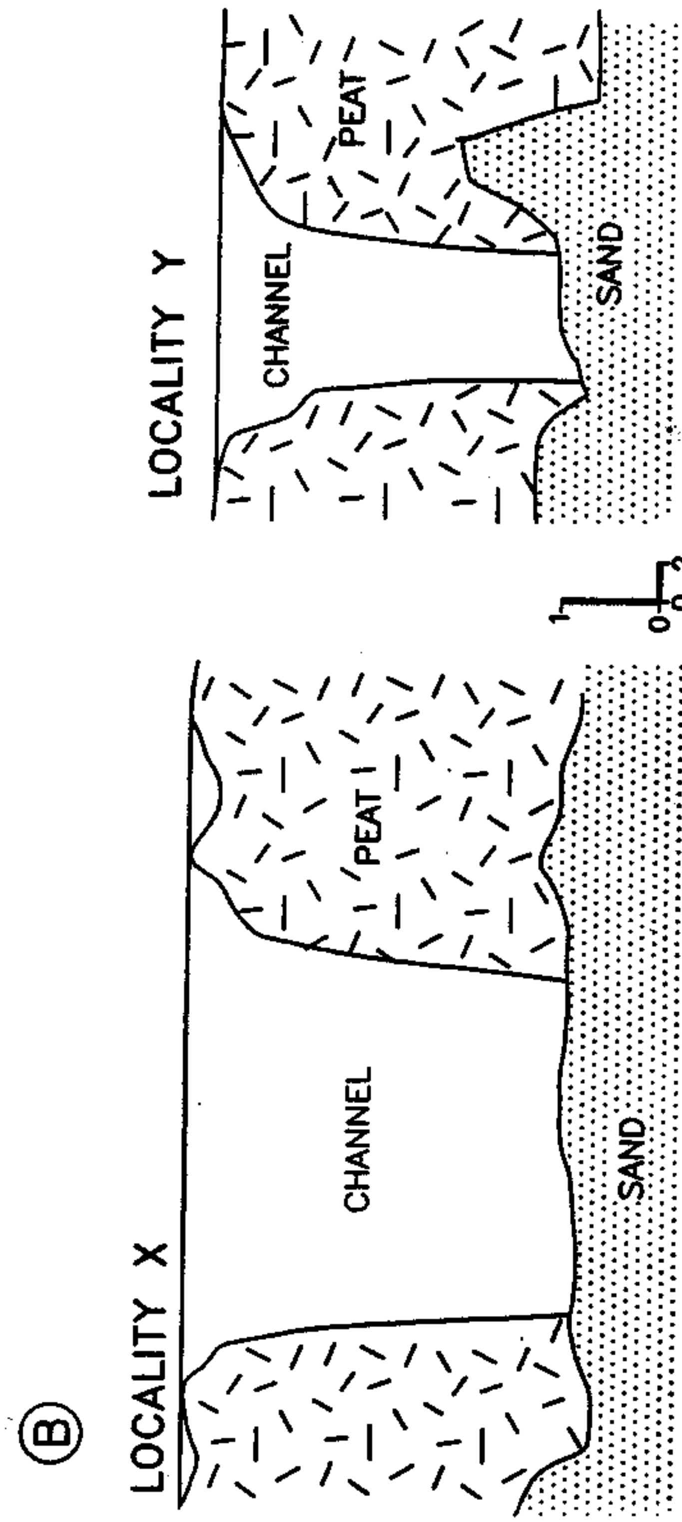
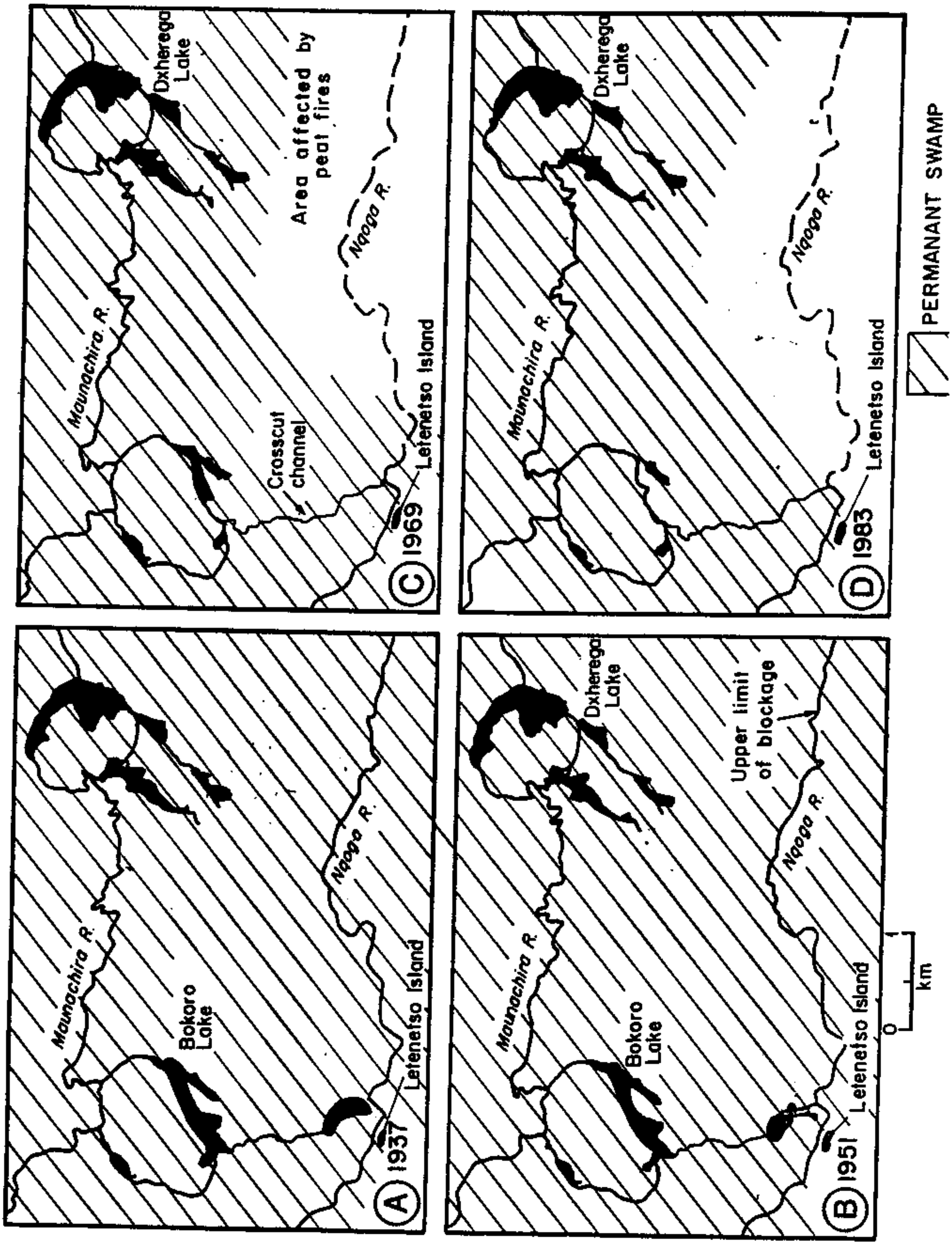


Figure 2B: **Typical channel profiles, measured at localities X and Y, Figure 2A. The channel margins consist largely of peat.**

Figure 3: A sequence of diagrams constructed from aerial photographs, showing the diversion of the Nqoga channel into the Maunachira channel between 1937 and 1983.



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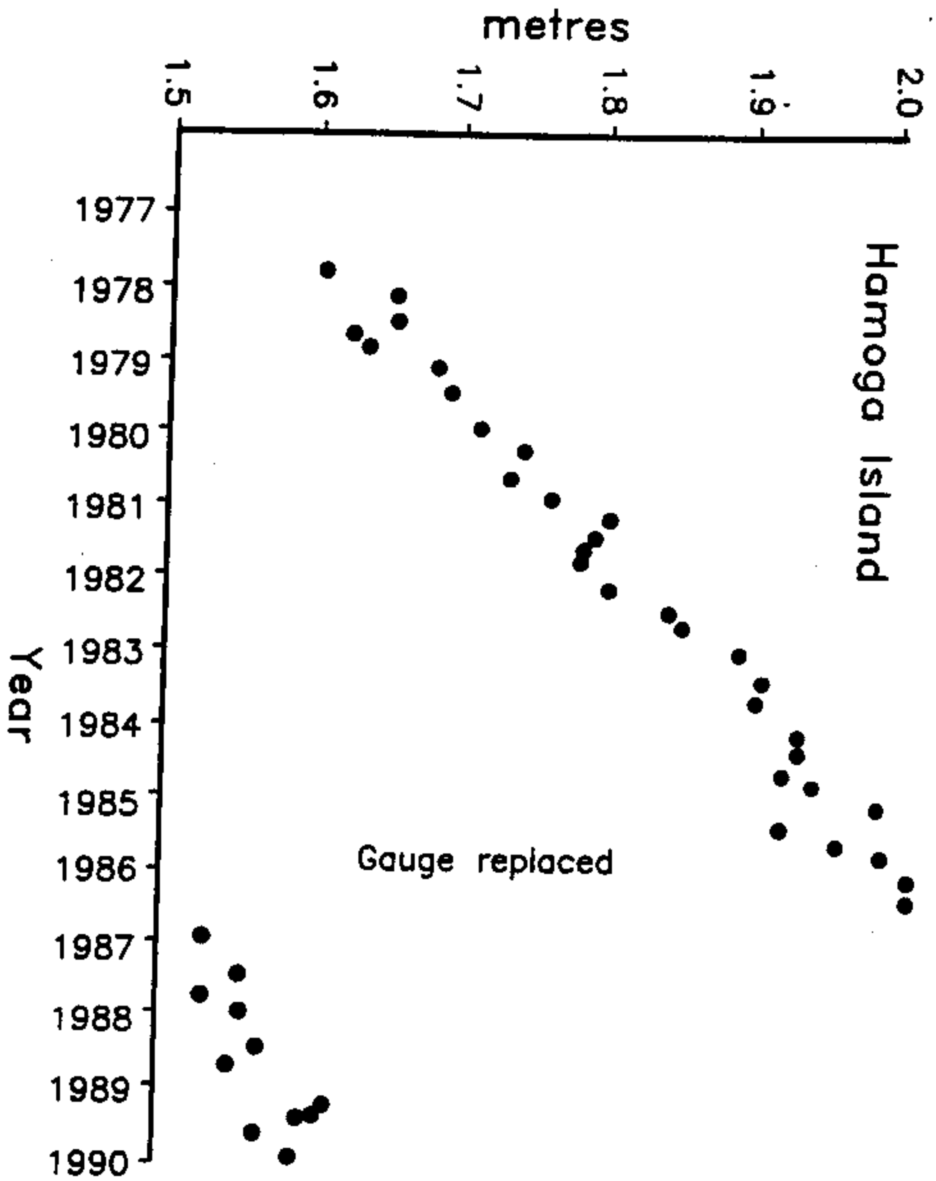

Figure 4: **Hydrogauge recordat Hamoga Island.**

Figure 5: **Papyrus "sea" flanking the Cross-cut (foregound) and Nqoga (right, middle) Channels in 1985. See Figure 6 for location of photograph.**

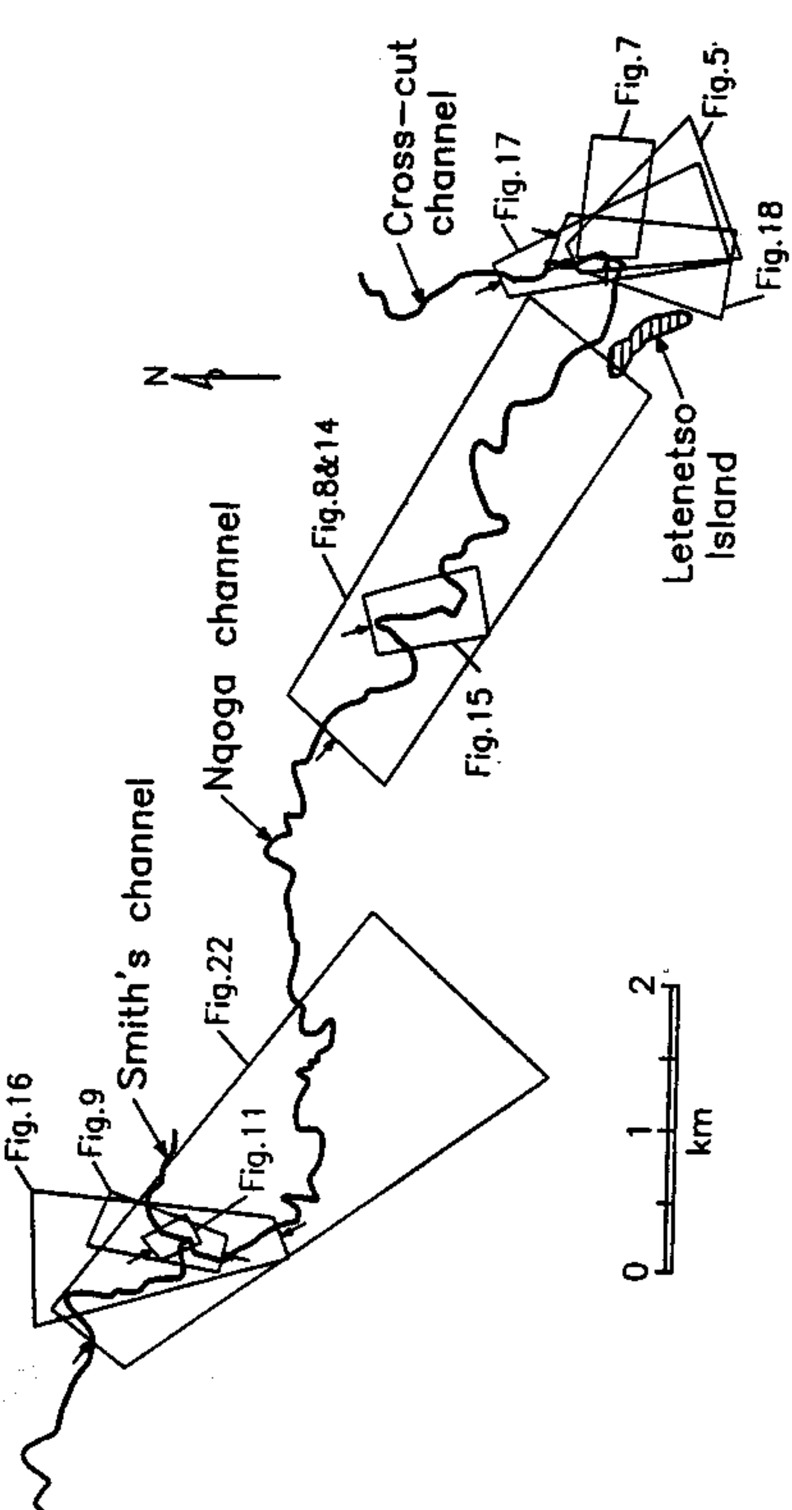

Figure 6: **Plan showing location of the aerial photographs included in this work. The boxes show the fields of view and the arrows the direction of view.**

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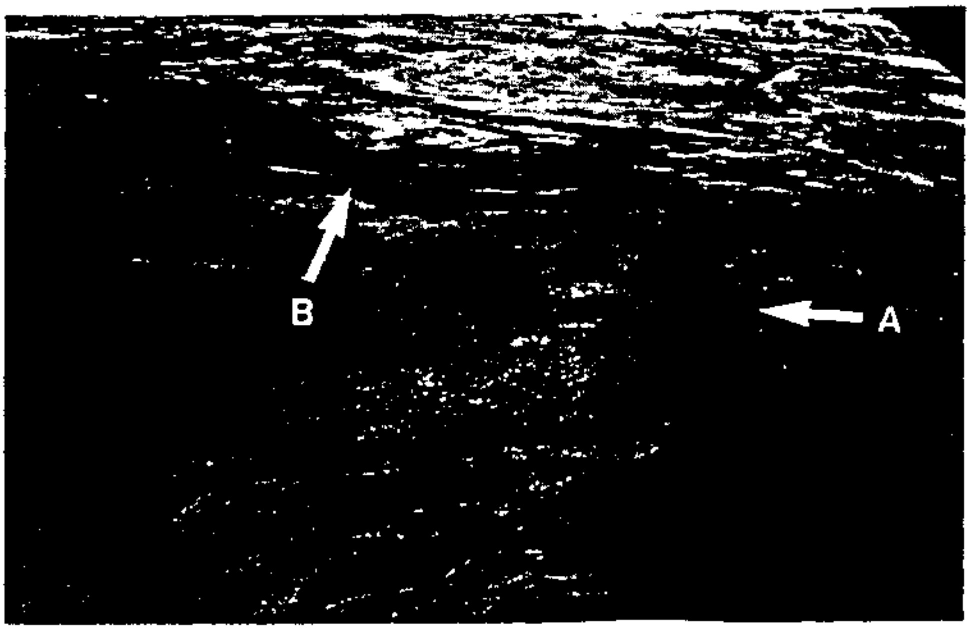

Figure 7: **Confluence of the Cross-cut (foregound) and Nqoga (right) Channels. Arrow A marks the papyrus filled trace of the former Nqoga Channel and arrow B marks the channel bed which has been exposed by peat fires. See Figure 6 for location.**

Figure 8: **Channel upstream of Letenetso Island in 1985. See Figure 6 for location.**

Figure 9: **A view of the Nqoga Channel in the vicinity of Hamoga Island (arrow A) and Smith's Channel (arrow B) in 1985. See Figure 6 for location.**

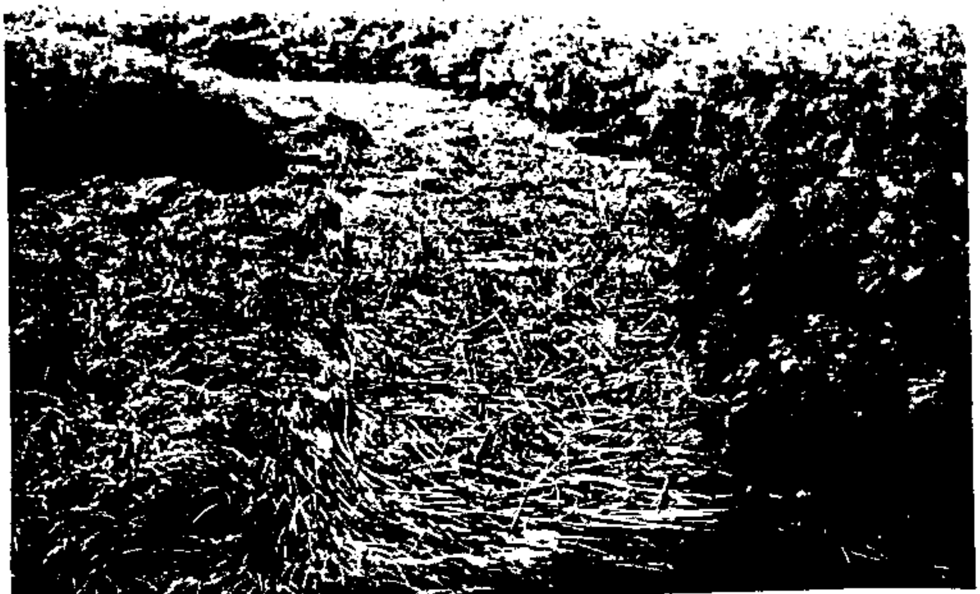

Figure 10: **A blockage consisting of floating papyrus debris on the Nqoga Channel (1987). Hippo grass (left foreground) has reduced the channel width and its stolens have acted as a trap for floating papyrus debris.**

Figure 11: Aerial veiw of a papyrus debris blockage (arrowed) on the Nqoga Channel at Hamoga Island (1985). See Figure 6 for location.

Figure 12: Hippo grass (right foregound) reducing the width of the Nqoga Channel (1987).

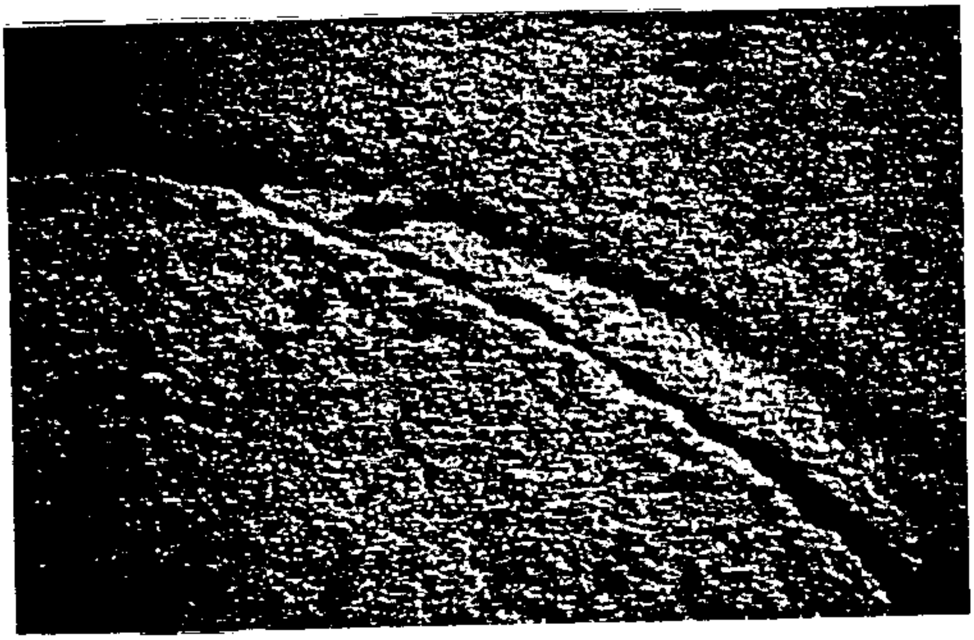

Figure 13: **Enchroachment by hippo grass has reduced the width of open water (1989).**

Figure 14: **The Nqoga Channel upstream of Letenetso Island in April 1993, showing almost total overgrowth of the channel by hippo grass. See Figure 6 for location.**

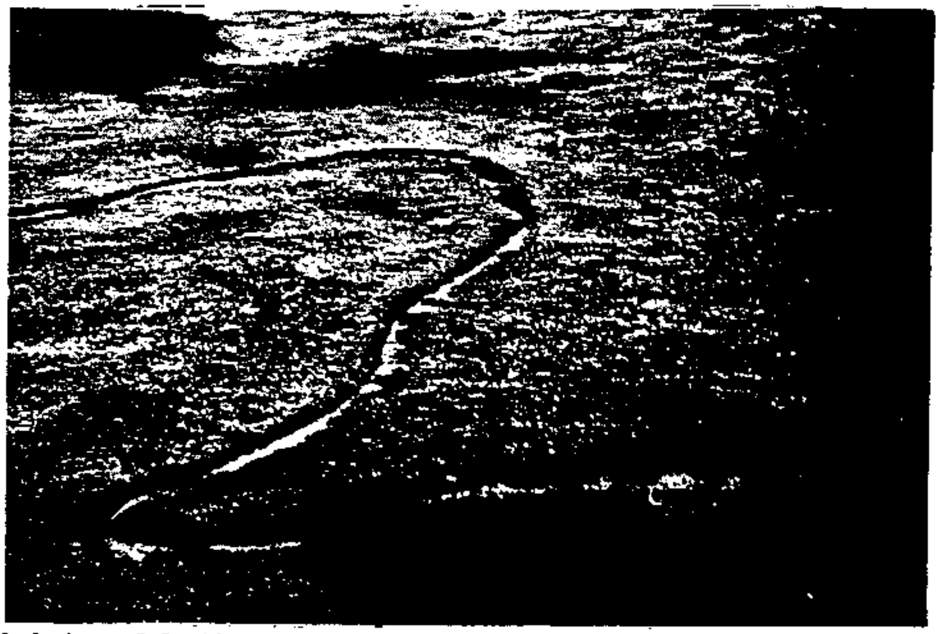

Figure 15: **Detailed view of the Nqoga channel in April 1993, severely encroached by hippo grass. In certain areas, papyrus has completely overgrown the channel. See Figure 6 for location.**

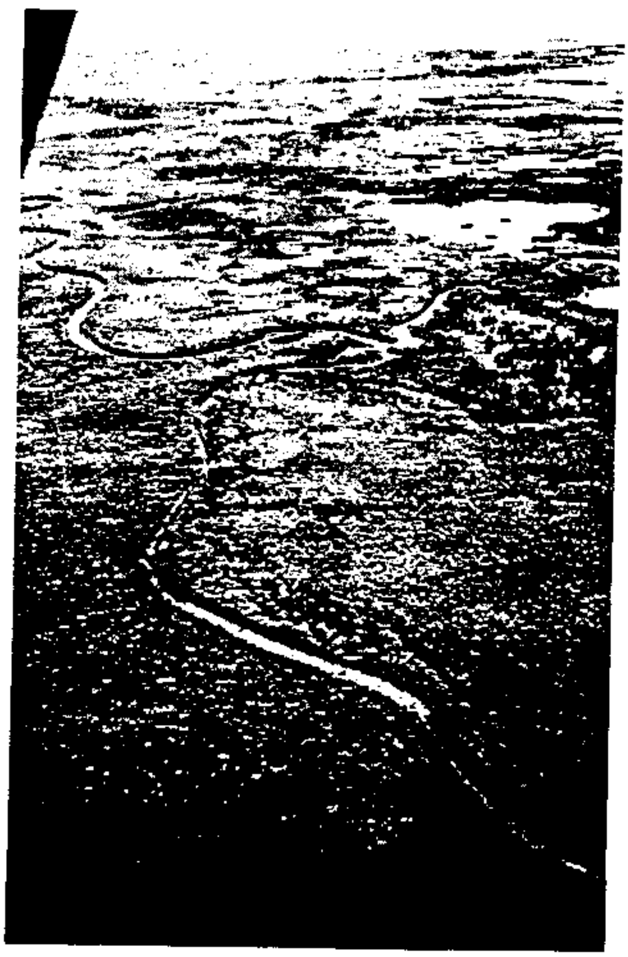

Figure 16: **A view of the Nqoga channel below Hamoga Island, showing the increased length of papyrus blockages (1993). See Figure 6 for location.**

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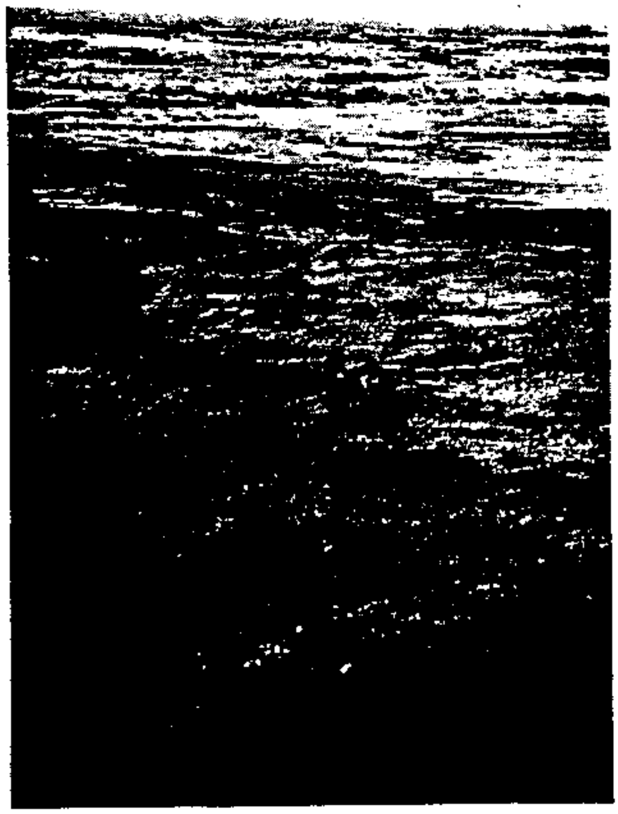

Figure 17: **A view down the Cross-cut Channel towards its junction with the Nqoga (1993). Papyrus is restricted to a very narrow fringe along the channel. Areas further away have been affected by peat fires and woodly plants have become established. See Figure 6 for location.**

Figure 18: **Detailed view of the junction of the Cross-cut and the Nqoga Channels in 1993. See Figure 6 for location.**

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Figure 19: Aerial view of Hamoga Island in August 1985, showing grassland fringe around the island and many dead trees on the island itself. Papyrus is restricted to a position beyond the flood plain grassland.

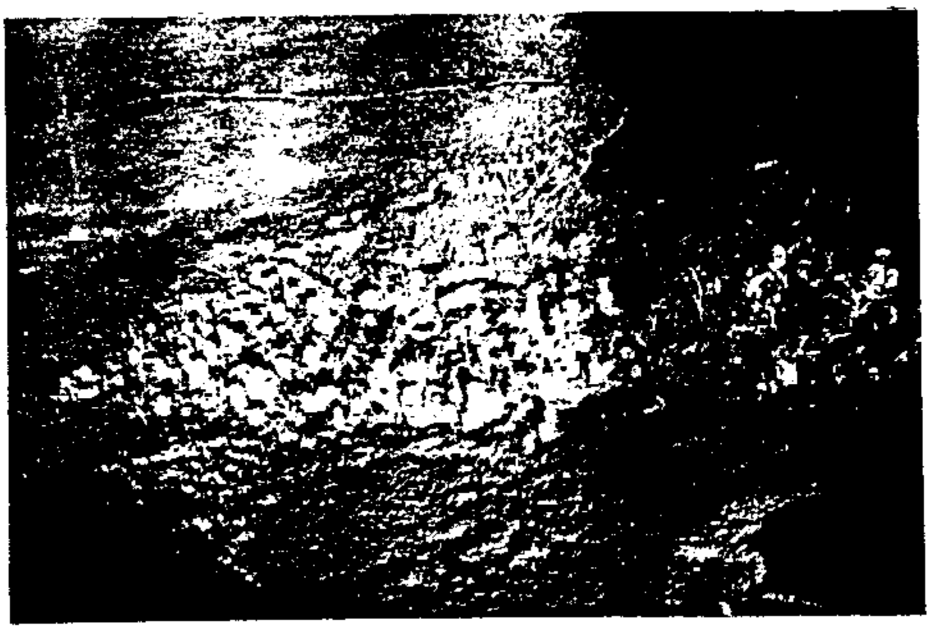

Figure 20: Aerial view of Hamoga Island in August 1993. Most of the broad leaved, woody plants are dead and the flood plain grassland is much reduced. Note the encroachment of papyrus around dead trees on the right hand side of the island.

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Figure 21: **Hamoga Island in August 1993. The trunks of dead palms and a broad leaved tree are surrounded by papyrus.**

Figure 22: **The Nqoga Channel looking south east towards Hamoga Island (centre) in September 1985. Smith's Channel diverges to the left at Hamoga Island. It is probable that this reach of the Nqoga will fail in the near future.**