Incorporating Floodplain Inundation as a Strategy in Flood Mitigation Plan

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Abstract - This paper is promoting the awareness that nature and engineering structure can co-exist together. Natural floodplain inundation is usually restrained to separate floodplain lands for human uses. In contrary to conventional flood control systems, a vision of restoring floodplain inundation in Kuching Bypass Floodway is presented as a flood mitigation plan. Modelling of the approach indicates a reduction of flooded areas up to 61%. By means of modelling, portions of floodplains are virtually preserved in their natural states and functions, a role that often has been undervalued. Floodplain permits storage and conveyance of floodwaters. At the same time, it provides replenishment of the adjoining wetlands. The strategy proves beneficial to both human and natural systems. It also calls for a systemic change in flood management that we can live with the natural forces instead of forbidding them.

***Keywords*:** Floodway, Modelling, Nature conservancy, River, Water.

I. Background

A floodplain is the area adjoining a river that is naturally covered by seasonal floodwater. A floodway is a channel and parts of the floodplain connected to a river that is reasonably required to efficiently carry the floodwater of a river. Conventionally, flood control systems favour compounded river and floodway, prohibiting spills over the river bank to protect heavy human settlements in the floodplain. Even so, flood remains common to every corner of the world.

Take the example of Red River Floodway in Canada, the 48 km channel is recognized as one of the 16 engineering achievements that shaped the world since biblical times [1]. The floodway, first used in 1969, takes part of the Red River flow around the city of Winnipeg, Manitoba to the east and discharges it back into Red River below the Lockport Dam (see Figure 1b). Used over 20 times in the 37 years from its completion to 2006, the floodway has saved an estimated $10 billion (CAD) in flood damages. The 1997 Red River flood, termed as the “Flood of the Century”, resulted in volume of water exceeded the safe capacity of the floodway and water lapped within inches of the city’s dikes. The Winnipeg city suffered little flood damage primarily as a result of the floodway was capable of containing the floodwater to enter the city (see Figure 1c) [2]. The Red River upstream cities of Fargo and Grand Forks of North Dakota, US had been suffering lengthy recovery processes from the disastrous flood. However, the maximum spring discharges of Red River have shown a rising trend, indicating that the flood hazard is becoming more severe than was initially assumed [3]. If this trend continues, future benefits of the floodway will continue to exceed expectations. The increasing vulnerability of the floodplain inhabitants poses new challenges. The flood diversion may influence flood levels in areas which are not normally flood-prone [4].

Another example is the Manggahan Floodway of Manila, Philippines. The metropolis of Manila is covered by formerly tidal flats along Manila Bay. During flood time, the excess floodwater is diverted from the Marikina River via the 9 km long Manggahan Floodway to sea since 1984 (see Figure 2a). Discharge exceeding 600 m^3/s inundates the low lying areas of Manila aggravated by the tidal fluctuation in Manila Bay. The greatest challenge in Manila is its rapid urbanization that encourages massive movement of rural dwellers to urban centres. It has resulted in overcrowding of urban poor settlements in the metropolis-floodplain. The scarcity of affordable build-able lands and living spaces has led squatter communities encroach on the floodway canals (see Figure 2b). An estimated 25,000 squatter houses are situated along the floodway, causing inaccessibility for dredging activities and solid wastes accumulate in the waterways. Originally 260 m wide, the floodway is narrowed down to only 220 m. With less space in the floodway, water quickly breached its bank [6]. In October

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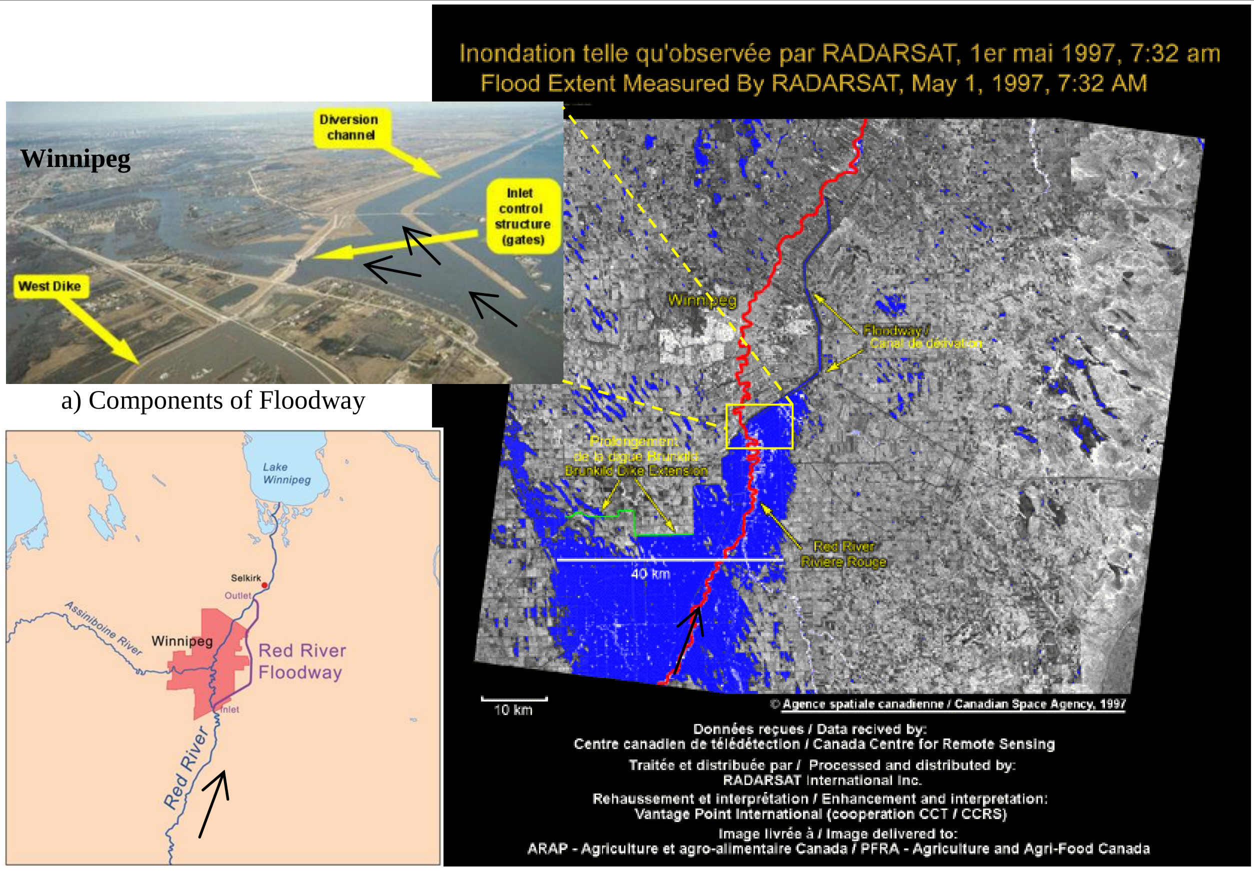
2009, the onset of Ondoy Typhoon had the city suffered the most devastating flood the metropolis had ever seen. Many believe the floodway would not have overflowed had there been no informal settlers.



a) Components of Floodway

b) Locality of Floodway

c) Imagery of 1997 Flood Extent

Figure 1 Red River Floodway, Canada [5]

It is clear that standard engineering design intends to isolate the floodplain from the river channel to make space for human activities. Manmade structures like dikes are erected to protect floodplain communities. Therefore once overflow happens, it would cause damages and losses to many as illustrated in the examples.

II. Motivation

Recent guidelines [7], however, has encouraged portion of floodplains to be reclaimed to bring back flooding during wet seasons. This allows the natural function of the floodplain to reoccur as the communities realize that we can live with natural forces instead of forbidding them. This paper explores a nature-sensitive approach on the Kuching bypass floodway to incorporate floodplain inundation as part of the local flood mitigation plan. Having valuable floodplain lands for seasonal flooding is a luxury endeavour and usually not an option for the decision makers, take the Manggahan Floodway for an instance. In order to counter changing climates, they tend to build bigger and deeper floodway, or adding higher dikes to existing floodway, which are costly and unsustainable in long term well-being. Alternatively, allowing natural flooding to take place could avoid these choices.

In the case of Kuching city of Malaysia, the 8 km manmade floodway would be built across a broad plain of deep peat swamp, diverting floodwater from the Sarawak River to the Salak River (see Figure 3). The former is a freshwater system, while the latter a coastal river lined with mangroves. The structure is expected to be in full operation by 2015. Technically, the floodway is capable of alleviating the flooding of Kuching city centre [8]. The lowland peat swamp is found unsuitable for agriculture and physical infrastructure development. Management of peat swamp in its natural condition and conservation of its biodiversity is the best land use choice from a long term perspective [9]. We argue here, floodplain inundation would be a major process to replenish the wetland ecosystems [10]. On the other hand, incorporating floodplain inundation in the Kuching bypass floodway would cease the pressure in floodwater flushing and reduce the flooding vulnerability in the urban floodplain along the Sarawak River.

a) Manggahan Floodway and Metro Manila

b) Close Up on Manggahan Floodway

Figure 2 Manggahan Floodway, the Philippines [14]

III. METHOD

A 1-D hydrodynamic model – InfoWorks River Simulation (RS) is utilized for modelling the hydraulics of Sarawak River systems. Examples of such modelling are reported by Mah et al. [11]. What river modelling means in practical terms is that software incorporates the fundamental laws of moving water bodies along an open channel (in this case, St. Venant Equations) into a simulated environment where flows and water levels change over time. Researchers then feed in time series of river flows and water levels about the real world into the model and see how accurately the computer-generated results resemble what actually happens.

Hydrological monitoring stations are distributed along the Sarawak River which provide the necessary flow data for the upstream boundaries [12]. With that, a base model representing the existing conditions has been calibrated and validated to at least 80% of confidence. The base model, carefully calibrated against river flows for one event, can be utilised to predict flows for the second event, and including the flood bypass channel and associated floodplain inundation for investigation. The bypass is modelled as an extended river channel from the oxbow of Sarawak River to the outlet of the bypass, excluding the Salak River. No gauges are available at the tidally Salak River at the moment. However, a tide table is accessible from the marine department [13] to represent the flows at the outlet of the bypass.

IV. RESULTS AND DISCUSSION

The most recent flood that hit the Kuching flat happened in January 2009. This devastating 100-year return period flood has prompted the Sarawak State Government on the determination to construct a bypass before the city centre. Computer modelling of the extreme event has its flood extent drawn to a background map in Figure 4. Consequently, a modelling scenario of including a conventional bypass floodway design is superimposed in the same figure for comparison. The bypass is lined with earthen bunds on its both sides. The computed flood extent as a result of the control system against the repeating January 2009 flood indicates a reduction of 53% of flooded lands. Flooding is expected to persist in Lower Sarawak River due to high astronomical tides experienced in the Kuching Bay. Low lying areas like Batu Kawa town in Upper Sarawak River remain to be effected by flood risk.

An alternative approach is depicted in Figure 5. By disallowing floodplain inundation, the floodway acts as a bottleneck during high flow events, causing a jam of floodwaters upstream and subsequently flooding in the upstream stretches. It should be noted that the Second Barrage would block any floodwaters flowing downstream to Kuching city in such cases. The bunds in the downstream bypass floodway are virtually removed from the computer model to permit connection of waterway and its floodplain. Floodplain lands and adjacent water form a dynamic physical and biological wetland system. The connection increases the area available to store and convey floodwaters and can reduce flood risk for nearby areas. From the technical point of view, a compounded bypass floodway has capacity limit. By allowing floodplain inundation, the bottleneck mentioned above is lessened and thus ceases the pressure of floodwater flushing. An encouraging reduction of

61% of flooded lands is further estimated in Batu Kawa town, comparing the alternative approach to the conventional control system. Such natural processes cost far less money than it would take to build facilities to correct flood. It also suggests that by restoring flooding in floodplain, the design life cycle of current flood mitigation plans can be lengthened, instead of adding larger and larger structures to accommodate flood control in ever-changing climatic conditions.

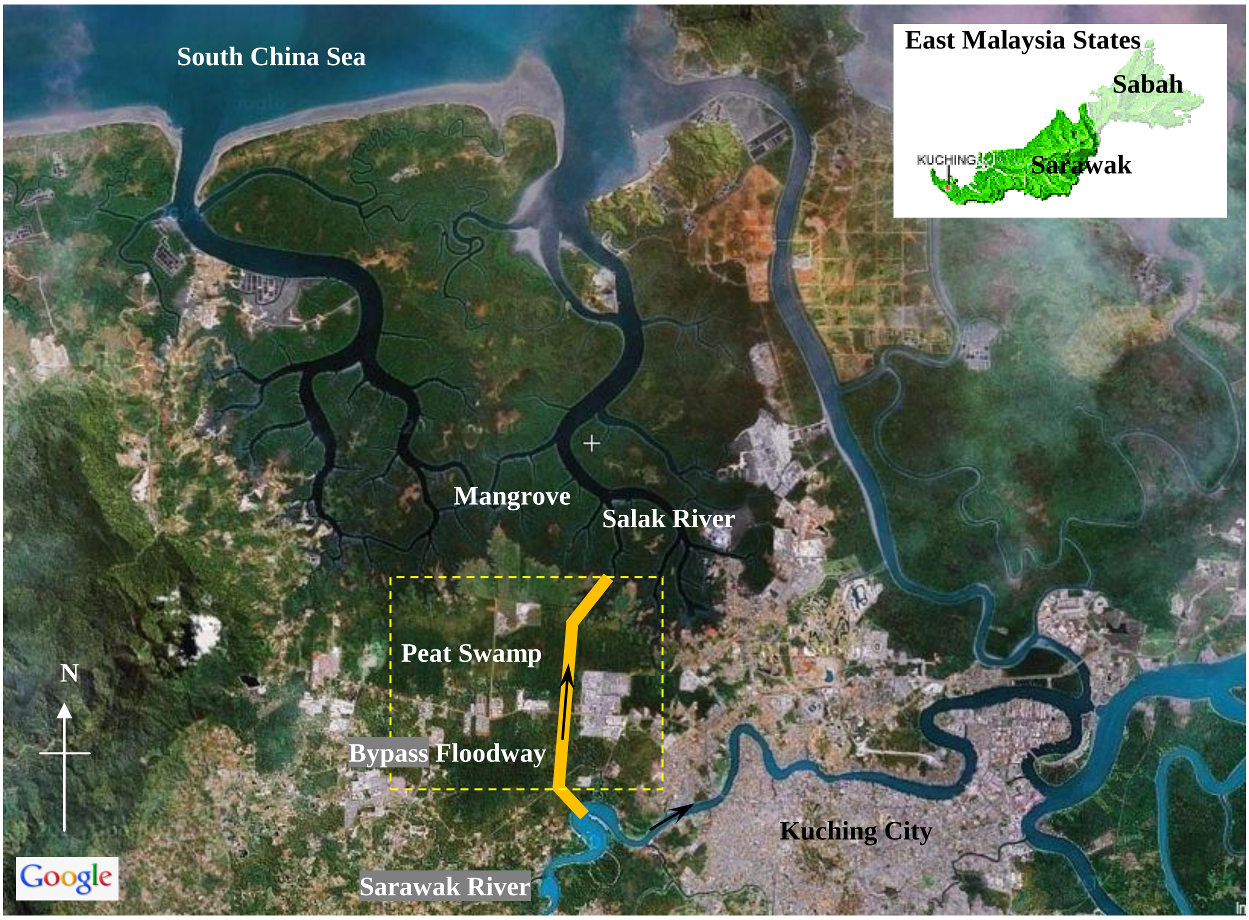


Figure 3 Kuching Bypass Floodway (http://www.wikimapia.org)

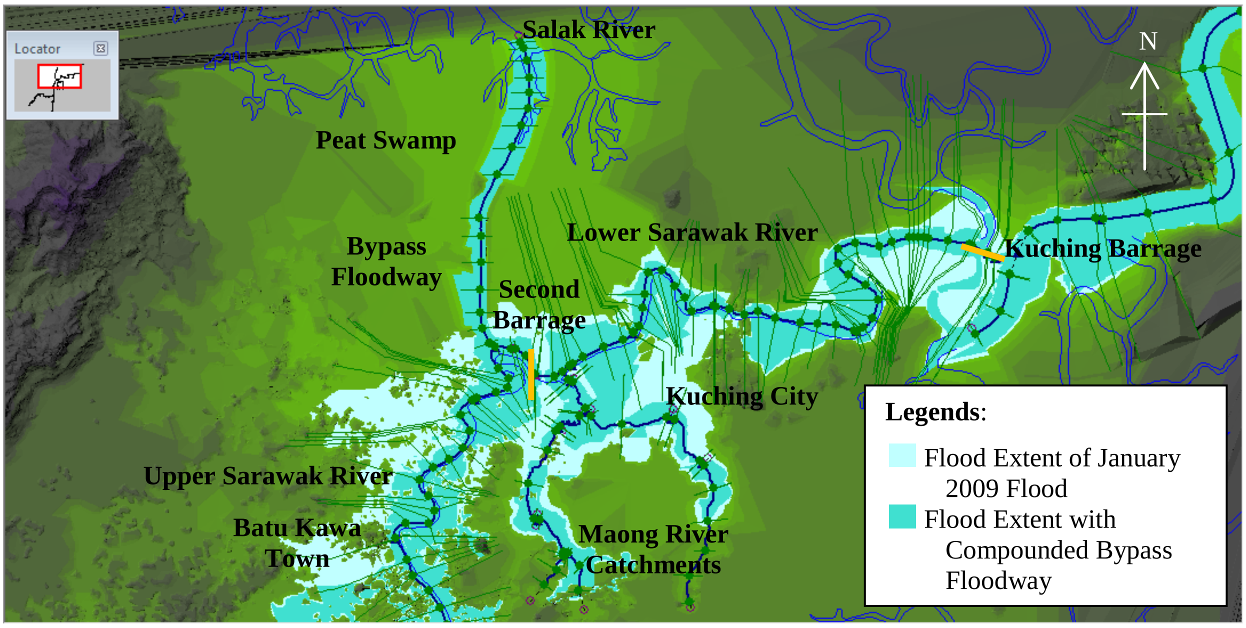


Figure 4 Modelling of Flood Extent of January 2009 Flood and Conventional Flood Control

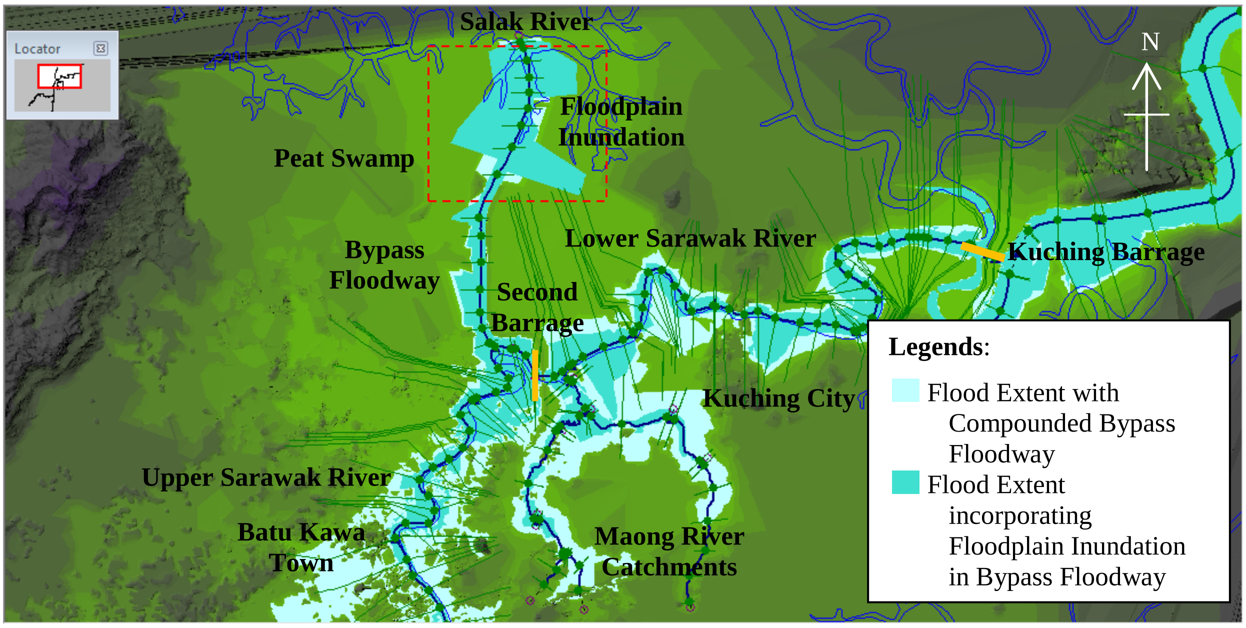


Figure 5 Modelling of Flood Extent Incorporating Floodplain Inundation

V. CONCLUSION

A demonstration has been brought forward for floodplains management to permit flooding, a transition from trying to prevent disturbances to managing disturbances. This paper promotes the strategy further in an engineering structure. A manmade Kuching bypass floodway is tried to incorporate floodplain inundation by means of computer modelling. The effort indicates a better choice in reducing flood risk but also increasing the resilience of water infrastructure and enhancing the associated wetland ecosystems.

ACKNOWLEDGMENT

The authors express gratitude to opportunity, research, financial supports rendered by Universiti Malaysia Sarawak.

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