CHAPTER 6

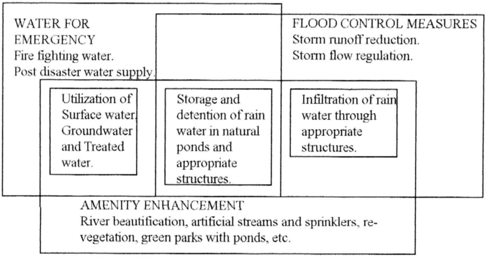
Recommendations and conclusions.

6.1: An integrated concept of urban drainage- 'Urban Oasis'.

Flood prevention and mitigation measures can no longer rely on structural measures only. The common structural measures are drainage improvements (enlargement), channel diversions, retention ponds and dams, levees and pumps. All these measures are useful but they have their limitations.

The common concept of drainage planning is to discharge off rain water as quickly as possible to prevent or mitigate flooding. Under this concept, the runoff water is often wasted. The 'urban oasis' concept seek to prevent or mitigate flood, but at the same time utilize the surface runoff (Figure 6.1).

Fig. 6.1
The 'urban oasis' concept.



Increase in stocks of water within urban area by introducing the multi purpose aspect.

Source: Musiake K., 1991.

However, this 'urban oasis' concept has to be suited to the local conditions. Not every aspect of it can be fully implemented especially on existing built up area without costly restructuring. Local physical and cultural landscape can be limiting factors.

6.2: Major limiting factors for Nibong Tebal.

6.2.1: Terrain.

This area is generally flat and located within tidal range. This simply means storm runoffs cannot be freely discharged off.

The usual flow velocities are below 1 m/s for most streams and drains. Consequently, the storm runoffs are retained for longer periods.

Bed levels cannot be deepened to increase drainage gradient (in order to increase flow velocity) because the existing levels for most sections are already below the mean low tide level. Most of the existing drains are having partial flow because of tidal influence. The widening of the existing drains will only increase their water holding capacities but not velocities. Drain widening is not a simple process. The existing drainage reserves (free boards) may not be wide enough for major improvements especially within town area.

The flood prone areas are actually natural depression, making flood prevention and mitigation difficult.

6.2.2: Soils.

The soil type for this area is basically clay. Hence, the average infiltration rate is low, 6.6 mm/hr. Under the normal condition, the soil moisture content is high. This is because the water table is just within 1 to 2m below surface. Fluctuations of the water table levels are minimal because of sea water intrusion into the ground water storage. As a result, the surface runoffs are considerably high even on non urban areas.

6.2.3: Limited available land area.

Available land within the Town is very limited and most of them are not state land. Therefore, there difficulties in acquiring land for flood mitigation purposes.

6.3: Recommendations.

The recommended flood mitigation and prevention plan involved combination of measures as following.

1-New urban layout involving landscaping and storm flow management for future urban areas.

2-Drainage improvements for the existing drainage lines (including flow diversion or re-networking the current drainage network) .

3-Construction of retention ponds.

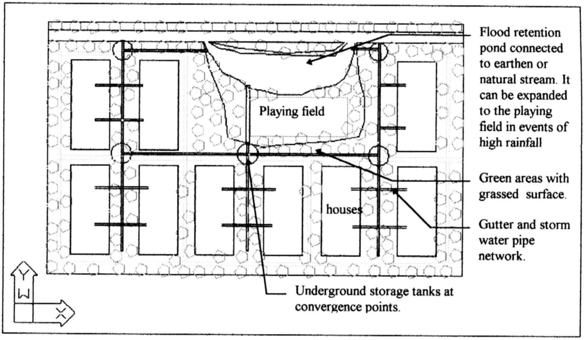
4-Tidal gates and pumphouse upgrading.

6.3.1: New layout: landscaping and storm flow management for future urban areas.

The internal drainage network must be planned first before the layout for buildings and other structures are made. Space should not be maximized for buildings only. Space for 'green areas' (to increase interception and infiltration) and artificial ponds (for flood retention) have to be allocated.

Natural streams and earthen drain do not need to be converted to impervious concrete drains. Concrete drains can discharge more efficiently. However, the discharge will reach and accumulate at the outlet faster. As a result, the drain capacity dowstream is likely to be exceeded, causing flood. The conceptual layout is shown in Figure 6.2.

Figure. 6.2
Conceptual layout for new urban area.



This future urban area will not be closely built. In order to accommodate more people, the houses are mostly double story or condominiums.

The rain waters that fall on the roof are collected by the gutter system. Part of the water will be channeled into a storage tank located at the backyard of each house. This water can be utilized for watering plants, washing, etc. The tanks will be higher than ground level. Therefore no pumping is needed as water can be drawn out by gravity. This method is used in the long houses of Sarawak where piped water supply is limited. The rest of the rain water will be channeled into a storm water pipe. At the point where storm pipes converge, there will be an underground storage tank that act as a buffer to slow down discharge. The water from this storage tank can be use for cleaning streets, watering parks, etc. There âre overflow valves connecting the storm pipes to the open channel. In case of overflow, part of the water can be channeled directly into the main drain. The storm pipes will eventually discharge into the flood retention pond and not into the trunk drain immediately. As a result, the peak discharge from a particular drainage unit will be lowered and delayed.

The retention pond can be used for recreation purposes. In events of a major flood, the retention pond can be extended to the playing field. The playing field is located lower than the houses. It is actually part of the retention pond. The inlet and outlet weirs are connected to the main drain or natural stream. The weirs can be open and closed to regulate flow.

Some of the rain water will drip from the roof instead of flowing into gutters. To reduce its contribution to surface runoffs, a narrow strip of gravel and sand are laid around the building. This narrow strip will trap the water and release it slowly into the ground and open drain.

Open areas should remain vegetated. In most housing projects today, all the vegetation is cleared for earthwork. Replanting of trees will be done only after completion of project. In this new concept, the vegetation in the designated green areas will not be cleared. This will save clearing and replanting cost. This concept is widely use in developing golf courses. These green areas will be used to intercept rainfall.

Almost all the plantations found in Nibong Tebal are oil palm plantations. If some of them are retained when the land is converted into an urban area, they can be effective in intercepting rainfall. Oil palms can intercept up to 35% of rainfall.

The ground surface will be grassed. This will increase surface roughness coefficient to 0.8 compared to a paved surface, 0.02 (Manning's roughness coefficient). This in turn will lengthen the time for overland flow. Part of the water will be retained on the grass itself, reducing the surface runoffs.

Moreover, the soil surface will be protected from direct impact of rain drops. Therefore, the surface pore structure will be maintained and clogging by inwash of soil particles will be minimized. As a result infiltration rate will decrease at a slower phase. This is very important because the infiltration rate is generally low for this area.

The car parks for this future urban area will be laid with permeable tiles and grass instead of tarmac to further reduce the surface runoffs.

Conclusively, the effect of tree and grass cover will increase interception and surface retention, maintain the infiltration rate, resulting in lower surface runoffs and lengthen the concentration time.

Wastewater from the houses will not be discharge into the storm pipes but into open drains connected to the open channel.

The aim of this layout is the reduction of surface runoff, concentration time and better utilization of rain water.

6.3.2: Drainage improvements and diversion for existing drainage lines.

The drain sections with capacities lower than their peak flows (for return period of 10 and 50 years) were pointed out in Chapters 4 and 5. The locations of drainage units, networks and design points are in Chapter 3.

All the suggestions discussed below will be based on the future potential condition.

Serious attention is needed at drainage units CC3, CC6, CC7b (Tong Hai village, Taman Nibong Tebal and former Post Office), CA1 (Air Lintas, Veterinary Department) and CA 51/52 (Taman Grand and Taman Camar).

In the case of drainage unit CC3, the peak discharge from the unit itself does not exceed its drain capacity. However, the accumulated peak flow from upstream exceeds its capacity by factors of 8.068 and 17.7 times (1 in 10 and 50 years return period).

Currently, DID is considering enlarging the existing drain to 1.8 x 1.5 m from 1.4 x 0.5m presently. This is not sufficient. To fully contain the highest peak flow, the drains need to be enlarged by 17.7 times from its current capacity or to 6 x 2.1 m for the whole 400m section. However, this cannot be done without going through the difficulties of acquiring strips of private land. Therefore, it is suggested here that this whole section to be enlarged by 4 x 1.5m. Together with the suggested enlargement, a section of this drain will have to be diverted to flow through drainage unit CC5 (High Road) into drainage unit CB1 (Bahru Road). This diversion was suggested under 'Alternative B' of DID's plan.

As for drainage unit CC6, drain enlargement is impossible. There is a strip of private buildings located just 2 metres from both sides of the drain.

For drainage unit CC7b, the accumulated peak flows exceeded their drain capacity by factors of 4.0 and 7.0 times at DP3 (1: 10 and 50 years return period). Under DID's plan, this section (from former post office to Sri Sentosa Primary School) will remain an earthen drain. It is suggested that this drain is to be enlarged to 8 x 1.7m to increase its storage capacity (to mitigate the backwater effect). However, this improvements will not be sufficient without diversion of upstream flow from drainage units CC1 and CC2.

For drainage unit CA1, its drain capacity is exceeded by 24.5 and 6 cumecs or 40 times (1 in 10 and 50 years return period). To enlarge the drain to 12 x 5.6m or 24.5 times (without altering the gradient) is not possible. The gradient need to be increased to 1:2500 and drain widened from 2 to 4m. This will reduce the exceedence factor to 6.5 and 11.7

times (1 in 10 and 50 years return period). Thus, the flash floods that could occur here are mitigated.

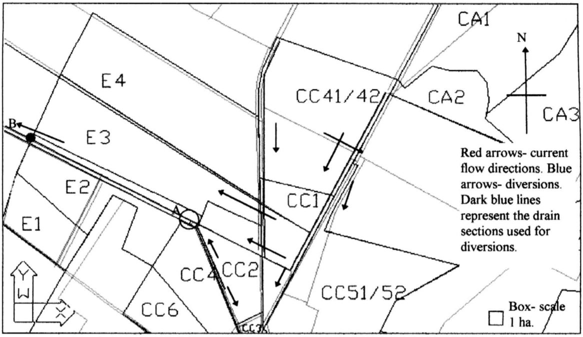
Further diversions could be made to divert flow from the upstream drainage unit CC1 from flowing into the town area and drainage unit CA41/42 from flowing into unit CA31.

For drainage unit CA51/52, its drain capacity is exceeded by factors of 10.6 and 13.4 (1: 10 and 50 years return period). Currently, DID was suggested to improve this section to a 3m x 2.2m reinforced concrete drain. This is insufficient. Instead, this section should be enlarged to 12m x 2m (bottom width 8 m), but the drain should remain earthen. This would reduce the exceedence factors to 7.09 and 8.9 at DP3. However, this improvement must include upgrading of tidal gates, flow diversions and construction of a retention pond. Without them, a more severe flooding would occur at the outlet of drainage units CA1-CA6 (Sang Lang village).

Together with drainage improvements suggested above are flow diversions. The suggested flow diversions are stated below.

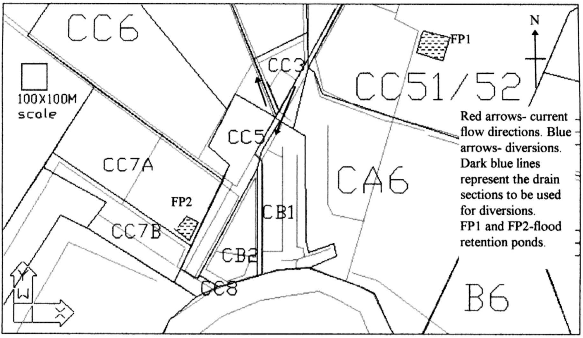
The Caledonia diversion is to divert flow from drainage unit CA 41/42 into unit CC1. From drainage unit CC1 the flow will be diverted into units E2 and E3. Flow from unit CC2 will be diverted into unit E2 by reconstructing the drainage partition wall at Shaik Adam village. The drain sections to be used for these diversions are shown on Map 6.1.

Map 6.1
Drainage units CA41/42-CC1 and CC2 diversion.



Currently a culvert has been constructed at drainage units CC2-E2 (purple circle) to enable unit CC2 to discharge into unit E2. Currently the flow direction for section A-B is from B to A (backflow resulting from blockage at the Changkat-Sungai Daun Road culvert -marked by green spot). Presently, this section does not connect with Daun River at the end. Therefore, from point B to Daun River, a new channel need to be constructed. The drain on unit E2 is not capable to handle high peak flows accumulated from unit CC2, CC1 and CC41/42 after diversions are made. This existing drain cannot be enlarged because the existing freeboard is narrow. Some of the sections involved (along unit CC41/42, CC1 and A-B) are not well maintained. They are greatly incapacitated by dense vegetation, sedimentation and inconsistent gradient. Improvement is needed in order to divert the flow.

Map 6.2
Drainage unit CC3 diversion.



Tong Hai diversion is to divert flow from drainage unit CC3 to CB1. The diversion is shown on Map 6.2.

6.3.3: Construction of flood retention ponds.

Drainage improvements and diversions alone will not be sufficient. Flood retention ponds are needed. Their suggested locations are given on Map 6.2.

Flood retention pond for drainage units CC3-CA6 (FP1) is located at Lot 509, neibouring Taman Camar-Taman Grand. The suggested volume is 40,000 m^3, covering about 2 hectares of land. Average bed level is to be -1.00m R.L and ground level 1.00m R.L. FP1 will handle discharge from drainage unit CA1, CA2 and CA3. Discharge from drainage unit CA41/42 will be diverted to units E3 and E2. Combined with drainage improvement, the overflow during peak discharge at DP1, DP2 and DP3 could be minimized. The accumulated peak discharge at DP4, however, would only be lowered slightly (24.6 to 24.0 cumecs). Therefore, the tidal gate critical discharge capacities need to be upgraded from 14.7133 to 29.4 cumecs at mean tide level. Pumps (2 cumecs) need to be installed. Pumps are needed here because discharge can only occur at low tide. At mean tide conditions, the head waters have to reach the critical depth before discharge is possible. As a result, flooding is expected to occur at outlet until critical depth is reached. Therefore, the pumps are needed to mitigate flood.

Flood retention pond for drainage units CC3-CC8 (FP2) is located at part of Lot 410 and 413, near Taman Sentosa. The suggested volume is 20,000 m^3, covering 1 hectare of land. Average bed level is to be -1.5m R.L and ground level 0.6m R.L. FP2 will handle discharge from drainage unit CC4, CC5, CC6 and CC7a and part of unit CC3. Discharge from drainage unit CC1, CC2 and part of CC3 will be diverted to units E2 and CB1. Combined with drainage improvement, the flash floods at DP1, DP3 and DP4 could be (theoritically) prevented. Drain overflow would still occur at DP2, but it would be reduced to 8.325 from 9.3 cumecs. However, its duration will be shortened and depth lowered because of the retention pond. The accumulated peak discharge at DP4 would be reduced to 2.89 from 15.275 cumecs. The pumps currently under construction will be able to discharge it off quickly. The maximum excess flood volumes would be reduced to 1,068 m^3 and pose no serious backwater effect.

6.3.4: Tidal gates and pumphouse upgrading.

Tidal gates B, B1 and E need upgrading. Gate B: its maximum discharge capacities have to be increased from 9.77 to 19.5 cumecs. Gate B1: Its critical discharge capacities need to be doubled and pumps installed. Gate E need to be repaired and desilted.

6.3.5: Limits to drainage improvements.

Drainage improvements have a limit to them. More efficient discharges from upstream can have adverse effect downstream. Consequently, the peak discharges downstream will be increased.

In Table 6.1, the hypothetical effects of full drainage improvements to peak discharges at the outlet of each drainage network are given. Except for units E1-E4, all other units indicate increases ranging from a moderate 15% to an extremely high 571%. Units CA1-CA6 have extreme changes ranging from 162% to 571% or 6 to 56 cumecs.

The effects of such increases are severe flash floods downstream . It must be noted that these outlets do not discharge freely most of the time because of the tidal condition. Hence, the above consequences are aggravated.

Conclusively, this would mean mitigation measures can not rest fully on drainage improvement because the consequences can be adverse. Therefore, the construction of retention ponds, upgrading of tidal gates and diversion channels are suggested above.

Table 6.1
Peak discharges with 100% drainage improvements.

Drainage units.	Potential peak discharges for rainfall intensity of various return periods (cumecs).						Percentage of change.		
Present.	Tr=1	change*	Tr=10	change	Tr=50	change	Tr=1	Tr=10	Tr=50
A1-A2	1.054	0.0075	11.24	0	18.82	7.435	0.57252	0	46.2088
B13-B6	7.079	4.42875	21.5	10.25	37.3	13.815	100.198	61.6541	42.1061
CA1-CA6	7.97	6.1725	25.4	24.104	41.5	41.595	162.863	315.25	404.621
CC1-CC8	6.4	2.875	18.2	8.325	25.95	21.7625	56.0976	57.7123	203.864
CD1-CD4	6.9	2.25	23.7	12.5	32.2	22.12	35.2941	72.9927	122.008
CB1	0.433	0.10825	1.254	0.3135	1.86	0.465	25	25	25
CB2	0.25	0.0625	0.677	0.16925	0.983	0.24575	25	25	25
E1	0.64	0	1.76	0	2.6	0	0	0	0
E2	1.5	0	4.05	0	5.9	0	0	0	0
E3	1.5	0	3.98	0	5.84	0	0	0	0
E4	1.8	0	4.8	0	7	0	0	0	0
Future.									
A1-A2	3.89	0.0025	16.36	0	25.44	0	0.05144	0	0
B13-B6	11.15	6.7575	24.25	4.1475	40	23.875	94.1156	15.8513	91.3876
CA1-CA6	12.9	11.915	42.2	44.9	64.85	56.4025	283.017	571.975	228.721
CC1-CC8	7.36	3.8	20.24	13.79	31.5	24.1	70.3704	119.809	157.774
CD1-CD4	11.2	6.34	29.8	20.09	44	30.5	82.7676	117.075	124.49
CB1	0.51	0.1275	1.4	0.35	2.03	0.5075	25	25	25
CB2	0.25	0.0625	0.68	0.17	0.98	0.245	25	25	25
E1	1.12	2.2E-16	3.1	0	4.5	0	1.6E-14	0	0
E2	2.4	0	6.5	0	9.45	0	0	0	0
E3	2.8	0	7.6	0	11	0	0	0	0
E4	3.54	0	9.66	0	14	0	0	0	0

Note: * as compared to potential peak discharges without 100% drainage improvement. Tr - return period.

6.4: Conclusions.

The study area is designated to be an urban growth centre for Seberang Prai Selatan. Hence, it will continue to experience rapid urbanization. The urban process and the resulting flash floods (potential) under different scenarios for present and future conditions had been discussed. Without appropriate mitigation and preventive measures the resulting flash floods would be severe. Therefore, careful urban planning is needed to mitigate and prevent flooding. For this purpose, a number of mitigation and preventive measures had been recommended for the study area.