(十一)洪災風險圖上機實作

本次短期研習課程，以 Baxter Rive 為範例，依序練習如何製作洪災風險圖，其步驟如下：

- 相關軟體準備
- 利用 Arc-GIS 建立數值地型模型(digital terrain map, DTM)
- 建立 HEC-RAS 模型
- 製作洪泛圖(flood inundation map)
- 製作洪泛範圍及淹水深度圖(flood extent and depth map)
- 增加洪水速度(velocity)圖層
- 增加洪水拖曳力(drag force)圖層
- 製作洪水危險圖(flood danger map)
- 增加人口資料(population)圖層
- 增加脆弱度圖層(例如脆弱設施、交通運輸、高風險設施、環境等)
- 增加防洪措施(flood defences)資訊
- 增加經濟風險(economic risk)資料
- 出圖產製報告

上述步驟大略可區分為四大部分，分別為：

- 利用 Arc-GIS 建立數值地型模型(digital terrain map, DTM)
- 建立 HEC-RAS 模型
- 製作洪泛圖(flood inundation map)
- 增加不同圖層於洪災圖

各步驟分述如下：

1.相關軟體準備

為製作洪災風險圖，我們需要運用如下軟體：

- Arc-GIS(v.9.3)，含有空間分析(spatial analyst)及 3D 分析(3D analyst)模組。
- HEC-RAS(v.4)
- HEC-GeoRAS(v.4)

2.利用 Arc-GIS 建立數值地型模型(digital terrain map, DTM)

開啟 Arc-GIS，輸入數值地型模型；並依序執行下列步驟：

1. 新增一圖，並加入下列圖層：
   a. 河川
   b. 岸壁
   c. 洪水路徑
   d. 斷面線
   e. 橋梁
   f. 無效通水區域
   g. 土地利用
2. 劃定河道中心線(Delineate river centre lines)
3. 命名河段
4. 建立岸壁
5. 建立洪水路徑
6. 建立斷面
7. 增加橋梁
8. 建立無效通水區域
9. 建立障礙物
10. 建立脆弱度設施(例如學校、醫院、核電廠等)
11. 設定糙度係數(Manning's n 值)

12. 輸出 GIS 資料(Export GIS data)

若完成上述步驟則畫面顯示如圖 58 所示。

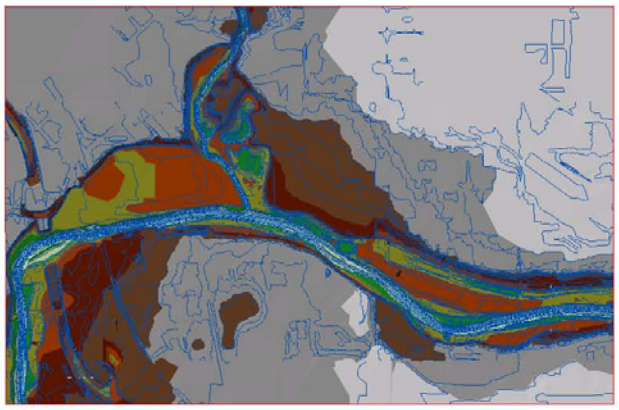


圖 58 數值地形圖

3.建立 HEC-RAS 模型

目的：將前一步驟所產製 GIS 資料，輸入(import)HEC-RAS。

步驟如下：

- 開啟 HEC-GeoRAS，選取 Edit/Geometric Data，載入檔案(前項步驟所產生檔案)，其畫面如圖 59。
- 儲存地形資料(geometry data)
- 可利用 HEC-RAS 的 Graphical Cross-section 工具，將斷面繪出，檢查斷面資料(如圖 60)。
- 建立流量資料
- 執行 HEC-RAS，並將結果輸出，提供給 GIS 用。

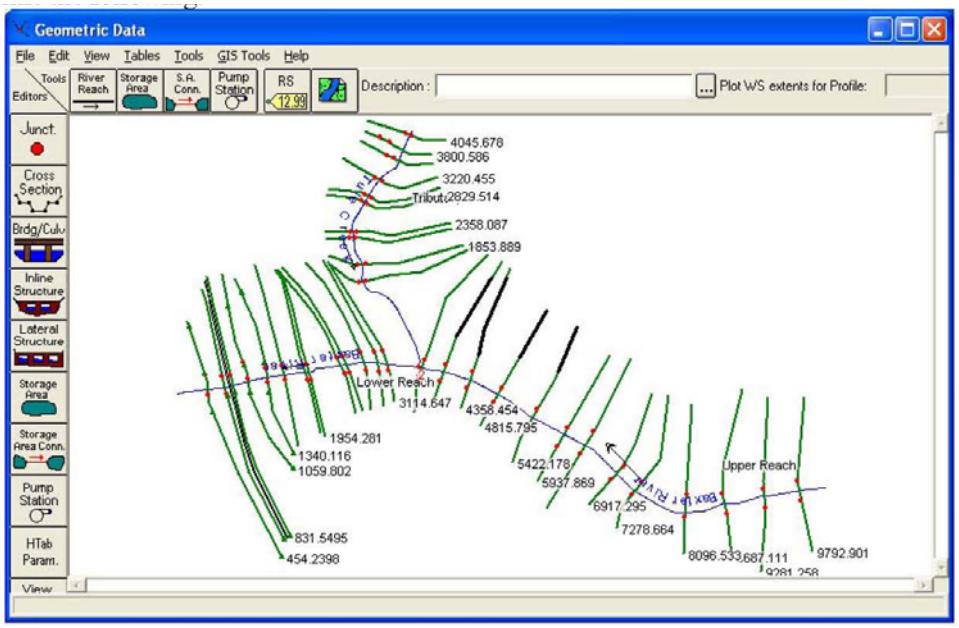


圖 59 HEC-RAS 河系圖

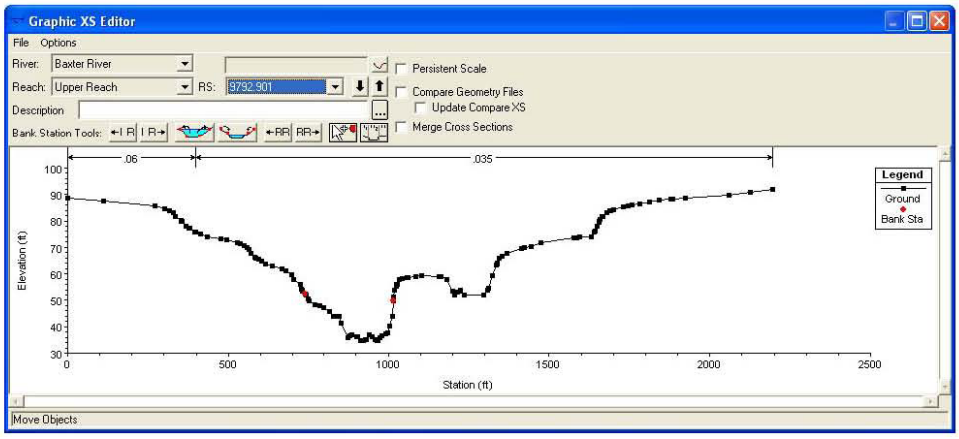


圖 60 利用 HEC-RAS 檢視斷面圖

4.製作洪泛圖(flood inundation map)

目的：利用 Arc-GIS 地形資料，以及 HEC-RAS 執行成果，製作洪泛圖。

需要相關檔案：

- 前項 HEC-RAS 執行成果
- 前項所建立 ArcMap 圖資

步驟：

- 安裝 HEC-GeoRAS
- 執行 HEC-GeoRAS，載入 HEC-RAS 執行成果(Import

RAS SDF)

- 執行 RAS Mapping > Inundation mapping > Water Surface Generation，選取特定洪水量(例如重現期距 100 年洪水)，則可產生洪泛範圍(TIN 檔)，其成果如圖 61。
- RAS Mapping>Inundation Mapping>Floodplain Delineation，則可將前述 TIN 檔轉為格網檔(grid)，與原數值地形高程相減，則可得洪水深度(如圖 62)，可調整圖層的屬性(properties)，調整圖例色階顯示。

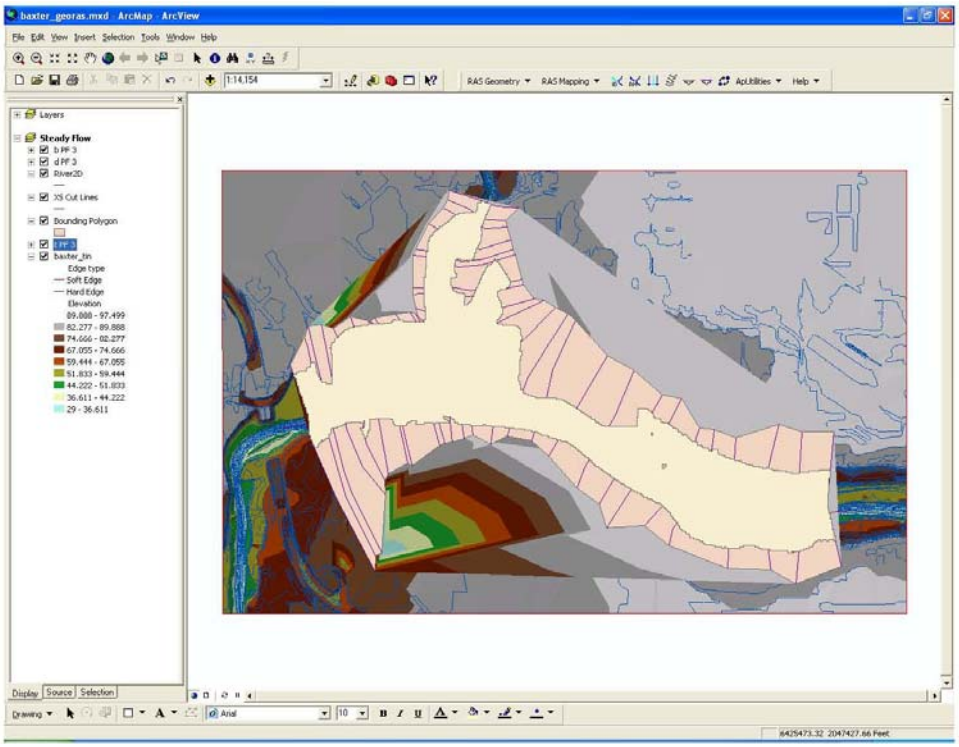


圖 61 洪水範圍圖

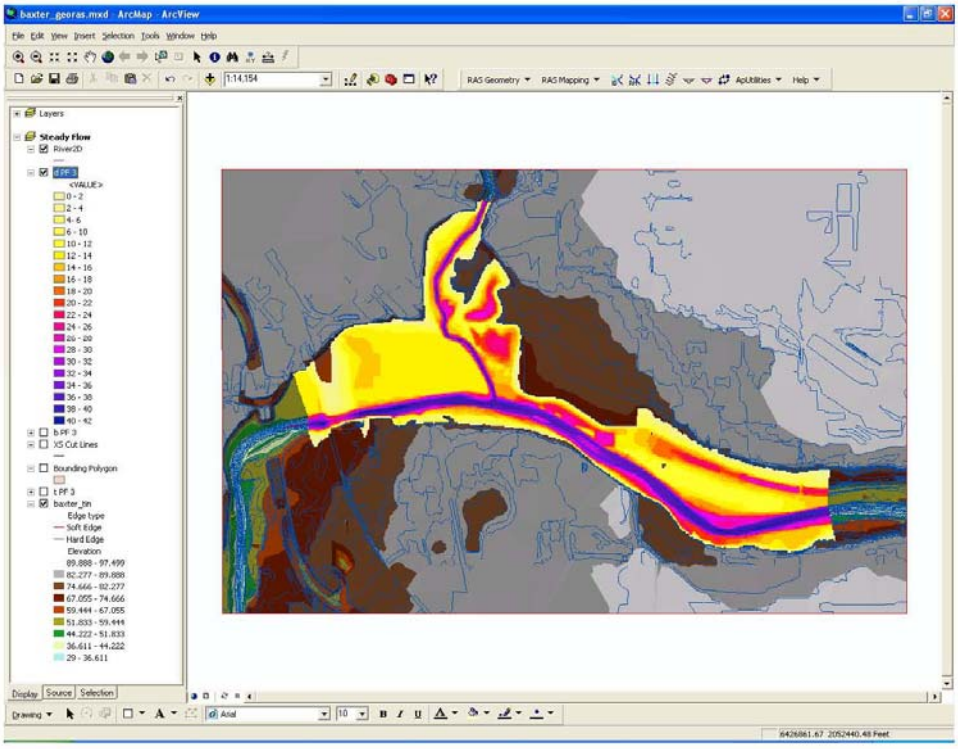


圖 62 洪水深度圖

5.製作洪泛範圍及淹水深度圖(flood extent and depth map)

洪泛範圍及淹水深度，是製作洪災風險圖必需的基本資訊。它須包含各重現期距洪水量(即發生機率概念)。為更清楚了解洪水災害潛勢，圖面上除了顯示洪水可能淹沒範圍外，另應該包含其他資訊，例如道路、高速公路、房屋、聚落等(如圖 63 所示)。

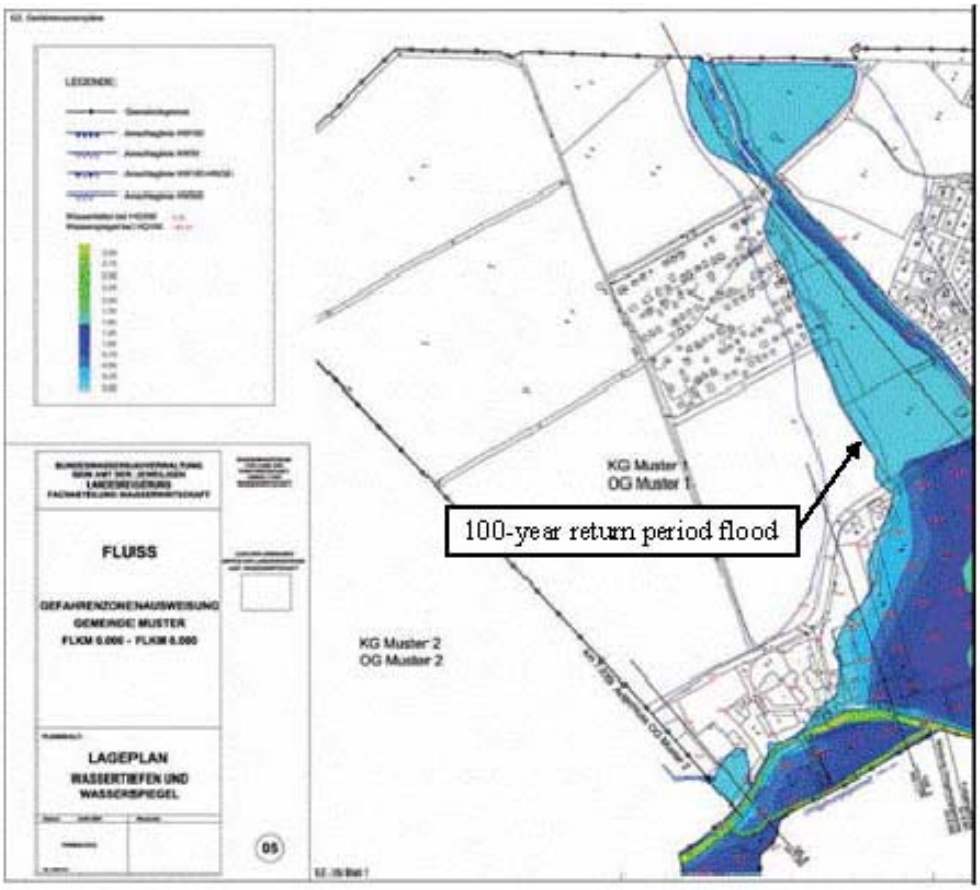


圖 63 洪泛範圍及淹水深度圖

6.增加洪水速度(velocity)圖層

洪水流速圖(flood velocity map)，是洪災風險圖額外的資訊，一般不容易取得流速資料；且非歐盟洪水指令(the EU Flood Directive)所提必要內容，其用途是提供給專家參考，而不對民眾公開。洪水流速一般可用箭頭(vector)方式顯示，箭頭長度(length)代表流速大小；而箭頭方向(direction)則代表流向(如圖 64 所示)。另外也可以用不同顏色色階來顯示流速(如圖 64)。

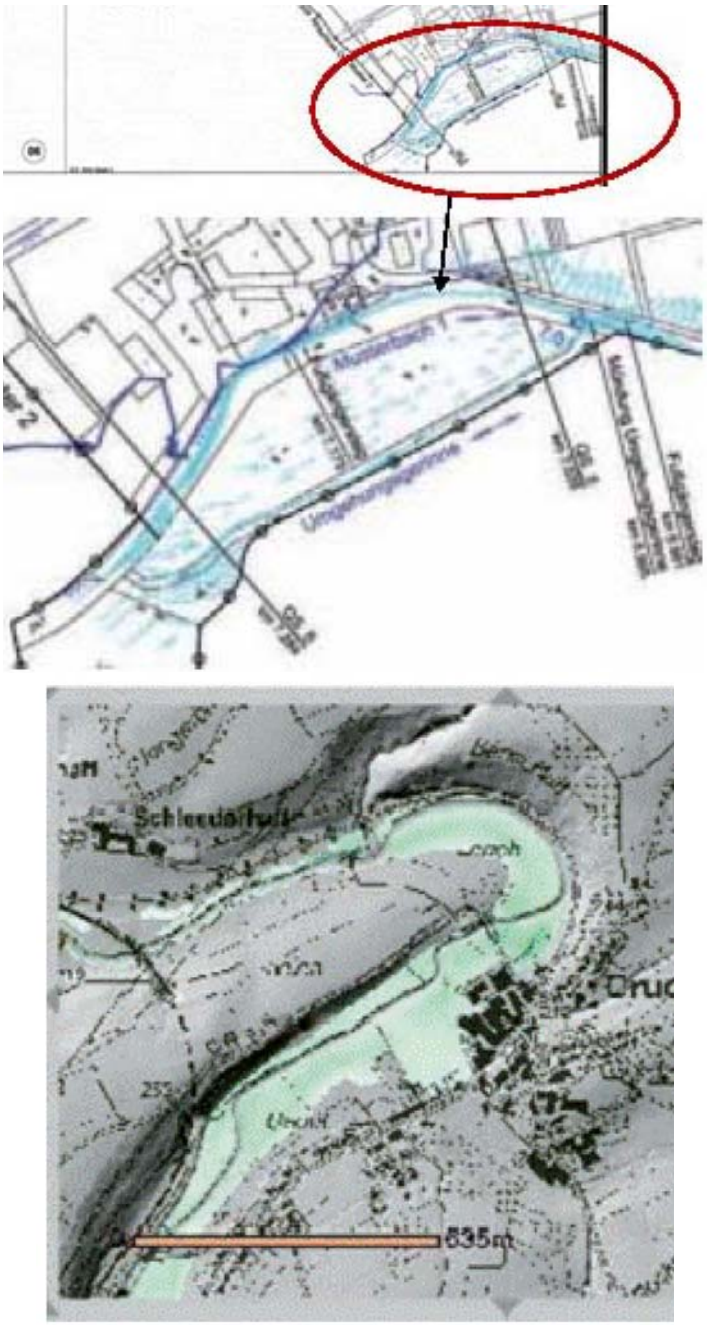


圖 64 洪水流速案例圖

因 HEC-RAS 並未求得洪泛的流速，為取得流速，可採用蔡斯公式(Chezy's equation)推估：

$$V = CS^{1/2}h^{1/2}$$

式中 V：流速、C：係數、S：坡度、h：洪水深度。

假設本案例洪水平原坡度均為 0.00005；蔡斯係數為 147.6($ft^{1/2}/s$)，經整理前式可整理如下：

$$V = 1.0437h^{1/2}$$

所以流速(V)則為淹水深度(h)的函數。

在此使用 ARC-GIS 內空間分析(Spatial Analyst)的工具，即網格計算(Raster Calculator)來計算。

其步驟如下：

- 首先，利用 ARC-GIS 空間分析工具(Arc Toolbox/ Spatial Analyst Tools/ Math/ Square Root)，將前述所得淹水深度圖層資料(h)，計算為$h^{1/2}$。
- 其次，利用空間分析中格網計算器(Raster Calculator)，將前式輸入(如圖 65)，經計算後則可產製洪水流速圖(如圖 66)。

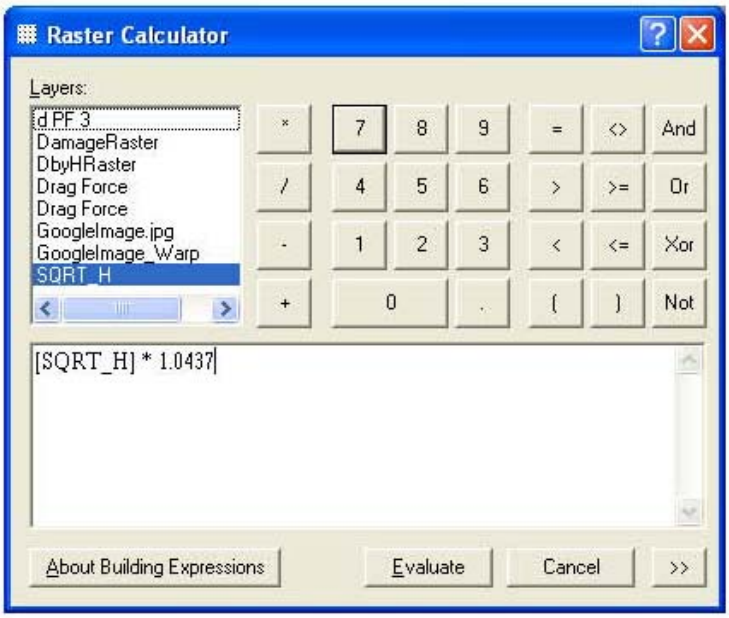


圖 65 格網計算器圖

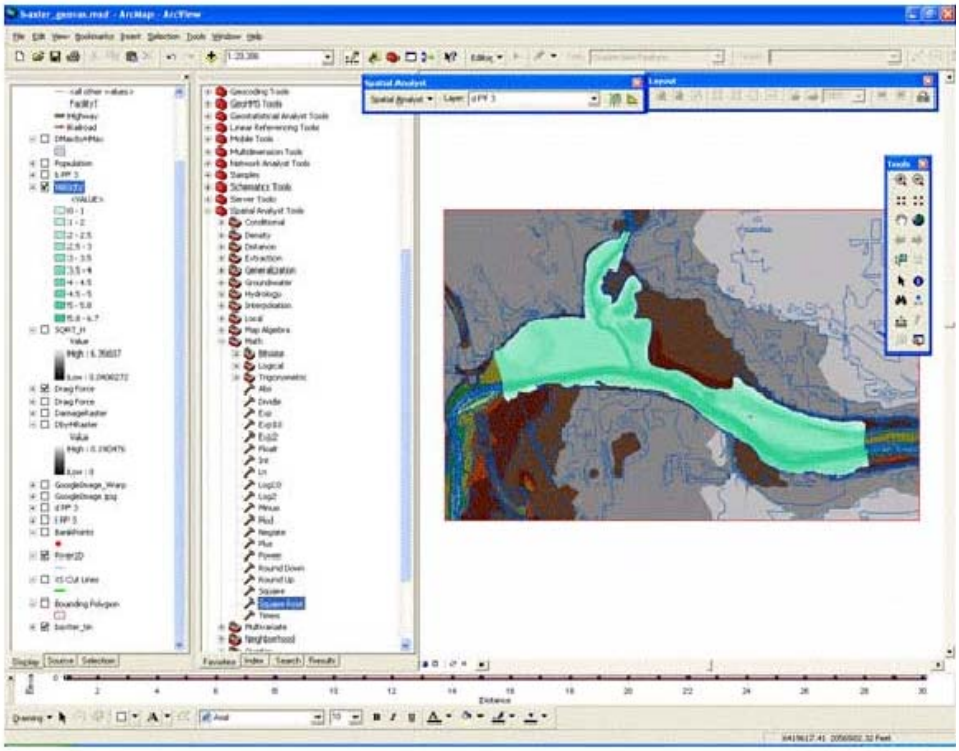


圖 66 洪水流速圖

7.增加洪水拖曳力(drag force)圖層

這項洪水拖曳力(剪應力)圖資，也是非必要的洪水風險圖層，但有些政府會製作，主要可藉此了解，特定防洪工程所處地點的洪水剪應力(舉例如圖 67)。因 HEC-RAS 並未求得洪泛的拖曳力，為取得，可採用下式推估：

$$\tau = \gamma h S$$

式中τ：拖曳力(剪應力)、γ：水的比重、S：坡度、h：洪水深度。

假設本案例水的比重為 62.4(lb/ft^3)；洪水平原坡度均為 0.00005)，經整理前式可整理如下：

$$\tau = 0.00312h$$

所以拖曳力(τ)則為淹水深度(h)的函數。

在此使用 ARC-GIS 內空間分析(Spatial Analyst)的工具，即網格計算(Raster Calculator)來計算。經計算後則可產製洪水剪應力分布圖(如圖 68)。

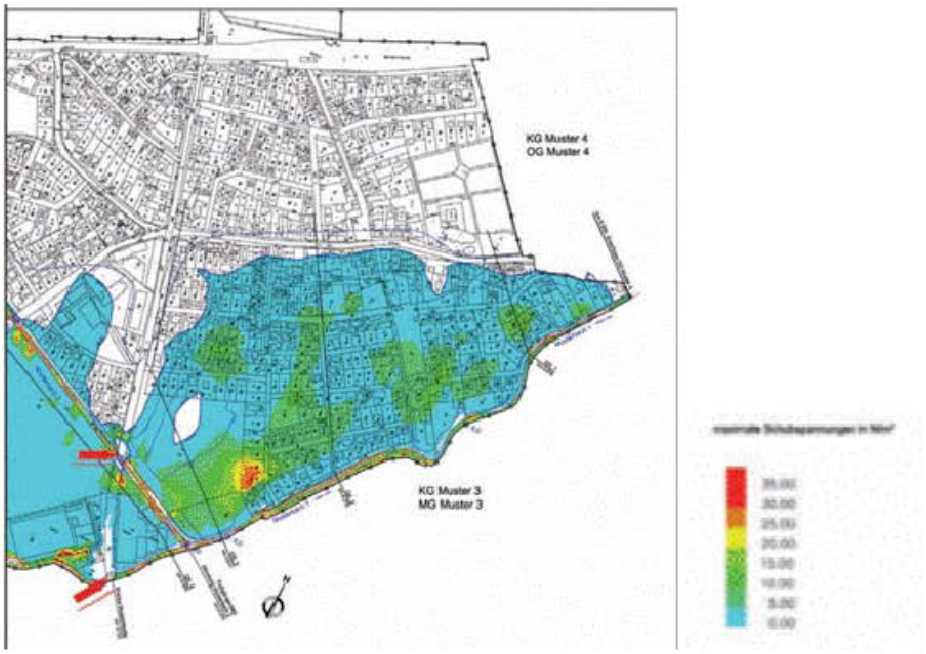


圖 67 洪水剪應力分布案例圖

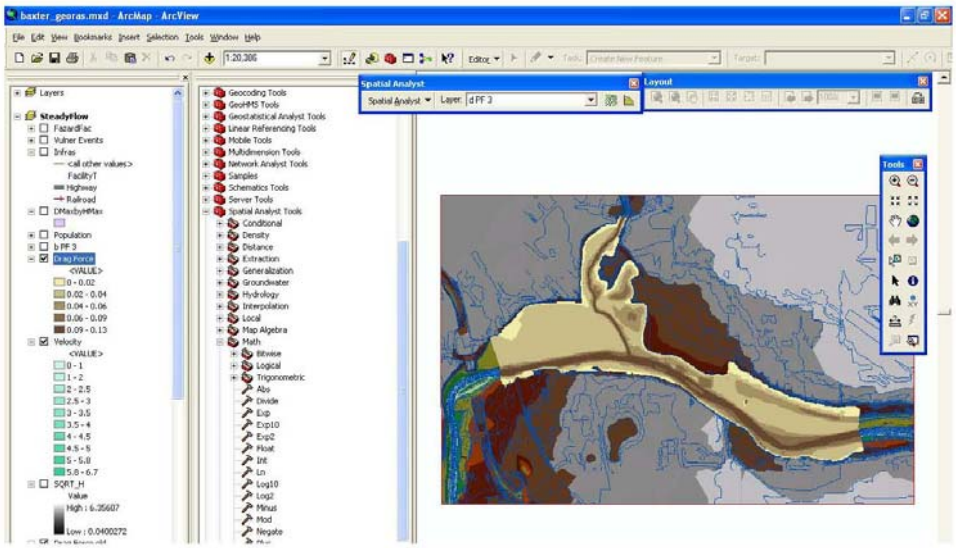


圖 68 洪水剪應力圖

8.製作洪水危險圖(flood danger map)

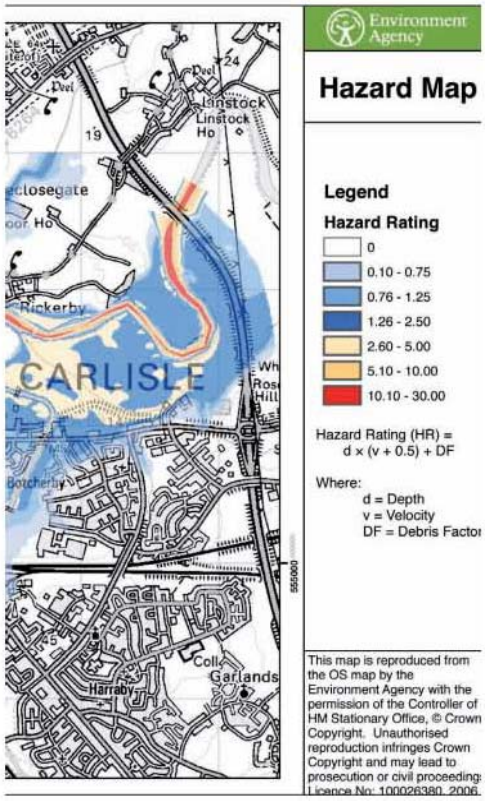
洪水危險圖(flood danger map)，包含眾多參數用來描述危險指標，例如常見的洪水流速、深度等。該圖並非歐盟洪水指令(the EU Flood Directive)所提必要內容，然而有些政府會製作並提供，主要用於洪災緊急應變管理；及對可能增加人口區域的警告。

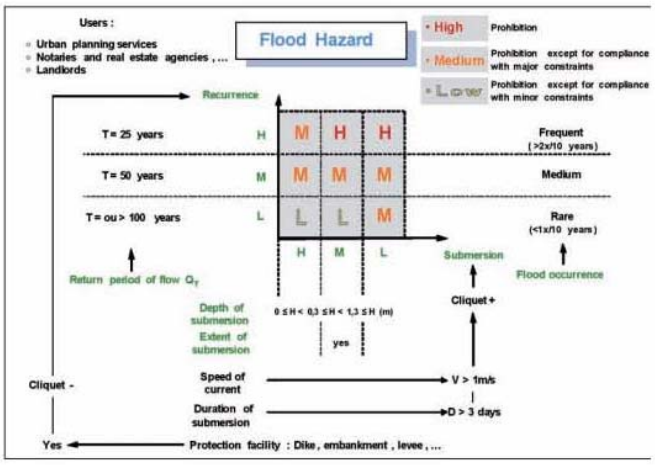
以英國洪水危險圖為例，英國採取下式計算洪水危險(如圖 69)：

$$HR = h + (v + 0.5) + DB$$

式中 HR：風險等級(hazard rating)、h ：洪水深度、v：洪水速度、DB：土石流指數。此式採用的單位是公制系統。

在此使用 ARC-GIS 內空間分析(Spatial Analyst)的工具，即網格計算(Raster Calculator)來計算(如圖 70)，經計算後則可產製洪水危險圖。我們可參考英國環境署的洪災危險分類(如表 7)，將洪水危險圖層屬性分類，並增加相關圖例(例如洪水危險圖利、指北針、比例尺等)，使圖資更完整(如圖 71)。





洪水危險圖　　危險指標定義

圖 69 英國洪水危險圖

圖 70 洪水危險指標計算圖

表 7 英國洪水危險指標定義表

d x (v + 0.5)	Degree of Flood Hazard	Description
<0.75	Low	Caution "Flood zone with shallow flowing water or deep standing water"
0.75 – 1.25	Moderate	Dangerous for some (i.e. children) "Danger: Flood zone with deep or fast flowing water"
1.25 – 2.5	Significant	Dangerous for most people "Danger: flood zone with deep fast flowing water"
>2.5	Extreme	Dangerous for all "Extreme danger: flood zone with deep fast flowing water"

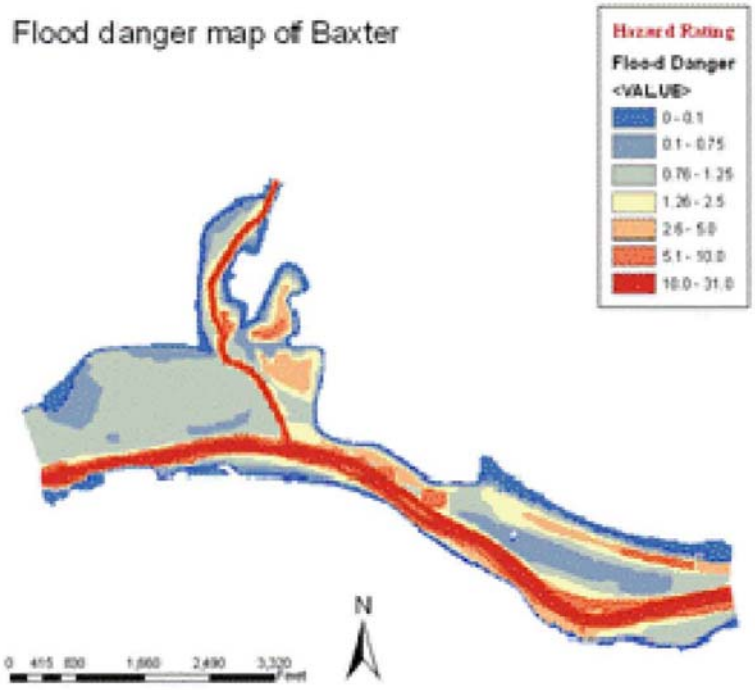


圖 71 洪水危險圖

9.增加人口資料(population)圖層

因歐盟戶政同郵政，係均採用郵遞區號(Postcode)方式管理，在此假設我們已經獲得郵政分區圖資，人口的部份則以新增欄位方式增加；並計算人口密度(如表 8)。 因為流域內分區人口分布圖資範圍大於洪泛範圍，故我們須進行切割，可採用 ARC-GIS 功能進行(Arc Toolbox/Analysis Tool/ Extract/ Clip)。

此外，為計算社會洪災脆弱度指標(Social flood vulnerability index, SFVI)，我們引用了英國環境署的定義，該指標包含了社會及經濟層面，社會方面包含了下列人口：

- 年紀大於 75 歲
- 單親家庭
- 長期生病

若增加經濟因素的考量，則包含下列人口：

- 失業
- 居住在過於擁擠的房子
- 沒有車子
- 沒有房子

針對上述 7 項參數(人口類別)，分別給予評分，綜合後則為社會洪災脆弱度指標。該指標依據不同數值，可分為 5 種類別，如表 9。最後繪製社會洪災脆弱度指標圖(圖 72)。

表 8 分區人口及人口密度表

LUCode	Shape_Area	Population density	Total population	LUCode	Shape_Area	Population density	Total population
	Sq ft	/million sq ft			Sq ft	/million sq ft	
Nearstream	47884074	4.648	223	Industrial	15707807	18.590	292
Nearstream	77091525	4.648	358	HDResidential	18722787	92.951	1740
Nearstream	3890745	4.648	18	GolfCourse	6363515	4.648	30
Urban	37360770	74.360	2778	Industrial	1585359	18.590	29
Farming	132969468	13.943	1854	Industrial	1364746	18.590	25
Urban	80210915	74.360	5965	Orchards	3304478	9.295	31
Urban	131147302	74.360	9752	HDResidential	65833049	92.951	6119
Farming	569365177	13.943	7938	School	1616451	92.951	150
Farming	582945503	13.943	8128	OpenSpace	1000215	4.648	5
Urban	194373174	74.360	14454	Industrial	761053	18.590	14
Farming	88342218	13.943	1232	Urban	5352265	74.360	398
Farming	388565989	13.943	5418	HDResidential	6898335	92.951	641
Urban	44559471	74.360	3313	Orchards	4935957	9.295	46
Urban	105386332	74.360	7837	HDResidential	878329	92.951	82
Nearstream	18744923	4.648	87	Urban	1545240	74.360	115
Farming	128069786	13.943	1786	Crop/Pasture	19135006	9.295	178
Urban	3597366	74.360	268	Crop/Pasture	34895872	9.295	324
HDResidential	21645098	92.951	2012	HDResidential	4372023	92.951	406
HDResidential	6767180	92.951	629	Industrial	2735070	18.590	51
Industrial	1721705	18.590	32	Commercial	3618339	92.951	336
Orchards	50989002	9.295	474	GolfCourse	5053763	4.648	23
Orchards	16911348	9.295	157	GolfCourse	2727100	4.648	13
OpenSpace	2388435	4.648	11	Urban	2603077	74.360	194
Crop/Pasture	41444365	9.295	385	WWTP	2781978	4.648	13
Crop/Pasture	7681981	9.295	71	Crop/Pasture	6603500	9.295	61
Commercial	4079362	92.951	379	HDResidential	89434532	92.951	8313
HDResidential	328375	92.951	31	Urban	1493862	74.360	111
School	542738	92.951	50	Crop/Pasture	441149507	9.295	4101
OpenSpace	739210	4.648	3	Park	1023238	4.648	5
Industrial	54852278	18.590	1020	HDResidential	5991219	92.951	557
Floodplain	1470515	65.065	96	Commercial	3435879	92.951	319
Industrial	7408749	18.590	138	Commercial	62	92.951	0
HDResidential	11911371	92.951	1107	HDResidential	51439503	92.951	4781
Commercial	4532347	92.951	421	Orchards	15976396	9.295	149
HDResidential	62641647	92.951	5823	Orchards	112375782	9.295	1045
Urban	2159635	74.360	161	Airport	16337733	46.475	759
Floodplain	4936539	65.065	321	Floodplain	3182930	65.065	207
Commercial	19206957	92.951	1785	Orchards	214702251	9.295	1996
OpenWater	4239	0.000	0	OpenWater	21588168	0.000	0
Commercial	7164	92.951	1	OpenWater	16846983	0.000	0
HDResidential	298960645	92.951	27789	Industrial	7336333	18.590	136
Commercial	4466501	92.951	415	HDResidential	4998150	92.951	465
School	3958199	92.951	368	OpenSpace	3481887	4.648	16
Commercial	842027	92.951	78	Commercial	26266954	92.951	2442
Commercial	8551385	92.951	795	OpenWater	2469682	0.000	0

表 9 SFVI 值說明

SFVI 值	代表意義
>=5	非常高
4	高
3	中等
2	低
<=1	非常低

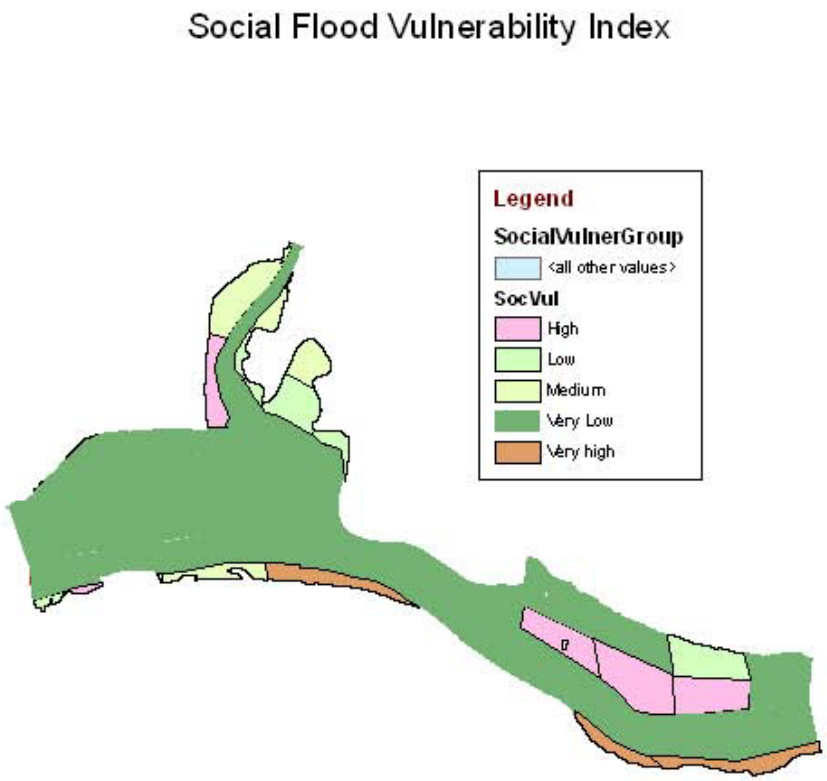


圖 72 社會洪災脆弱度指標圖

10.增加脆弱度圖層(例如脆弱設施、交通運輸、高風險設施、環境等)

洪災風險圖除了前述災害潛勢及脆弱度外，尚須包含一些基礎設施，例如：

- 住宅區：例如都市、鄉村等聚落。
- 維生系統：例如道路、電力、電話、瓦斯管線、下水道、自來水系統、醫院、學校、高速公路等。
- 特殊經濟區：例如工業區、商業區等。
- 農業區

某些國家採用地形圖來當作底圖，如圖 73 所示。

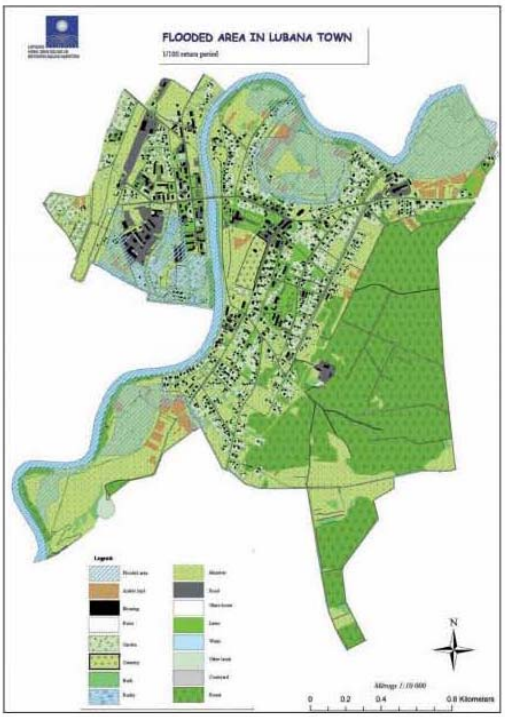


圖 73 洪水災害圖(以 Latvia 為例)

依前述，首先我們需要得到脆弱設施的地形資料(如坐標等)，倘若未能藉由測量得到高精度的資料，則可藉由 SRTM(全球 DEM 資料)或是 Google Earth 獲得，例如圖 74 則是荷蘭台夫特圖資。

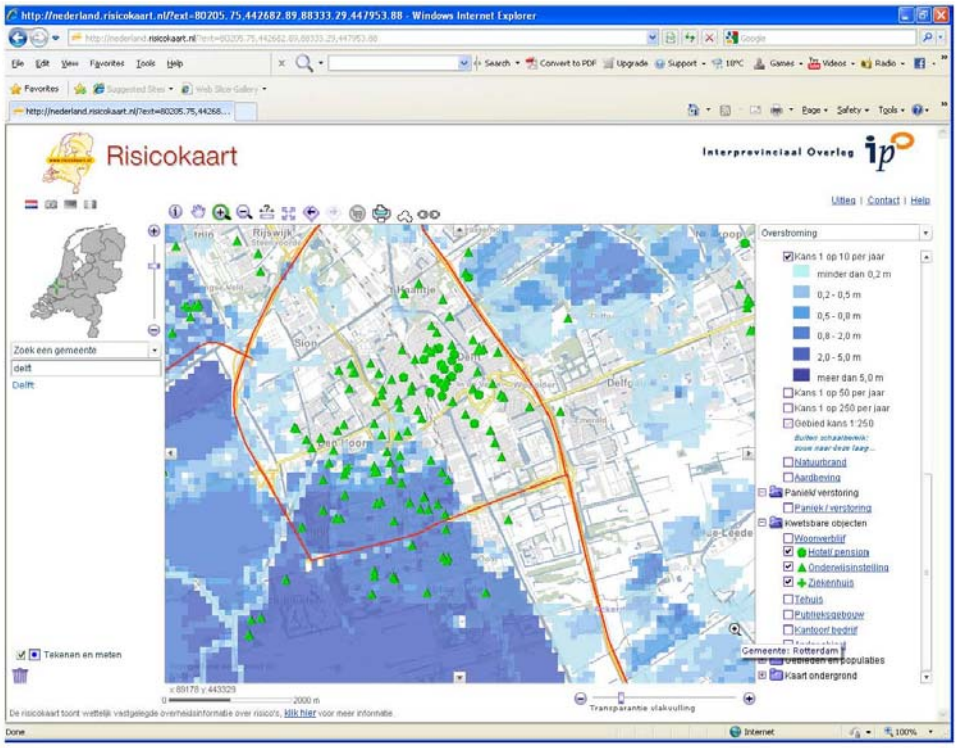


圖 74 脆弱設施分布圖(以台夫特為例)

其次，藉由前項被背景資料蒐集，可得知相關脆弱設施位置，我們可

藉由 ARC-GIS 輸入坐標(add XY data)，編輯新的圖徵。則可完成脆弱設施圖層(如圖 75 所示)。同前步驟，我們可新增道路網路(如圖)。

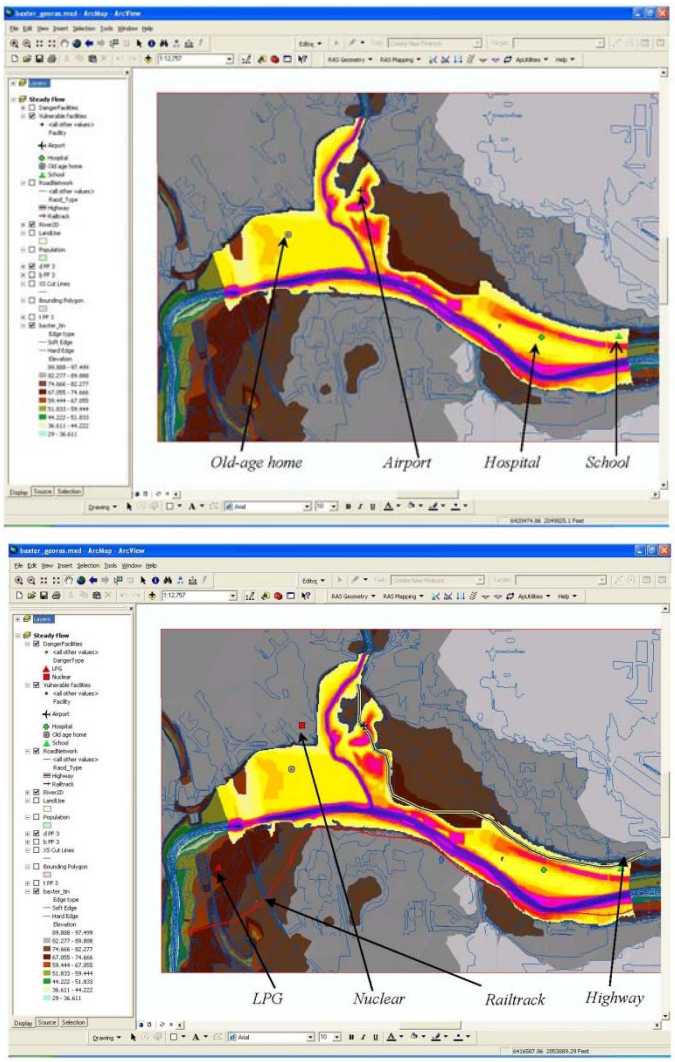


圖 75 脆弱設施分布圖

此外一些因洪災而可能造成危險的設施，也需納入，例如污水處理廠、核電廠、加油站、化學原料儲存場、化學或工業廢棄物堆置場等。納入危險設施的災害風險圖，可用於下列方面：

- 決定災損和風險
- 緊急應變管理
- 規劃防洪措施
- 土地使用規劃及管理

例如荷蘭台夫特洪災風險圖(如圖 76)，則顯示可能因洪災而導致危險設施的位置。

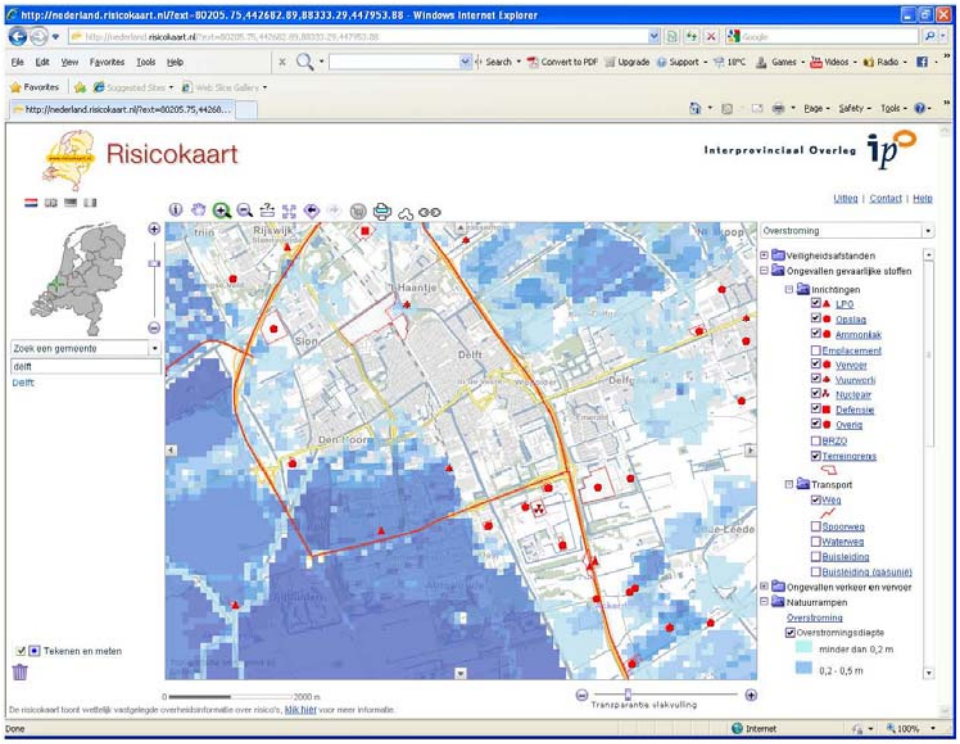


圖 76 台夫特洪災風險圖

最後，若考量洪災對環境生態影響，則可考量下述資訊(此非必要圖資)：

- 對棲地及野生對物可能災損
- 保育類或珍稀動植物
- 國家公園或其它保護區域

11.增加防洪措施(flood defences)資訊

許多位在洪水平原的城市，通常有防洪措施(例如堤防等)，用以抵禦特定保護標準(重現期距)的洪水，例如圖 77 可呈現英國倫敦的防洪措施。

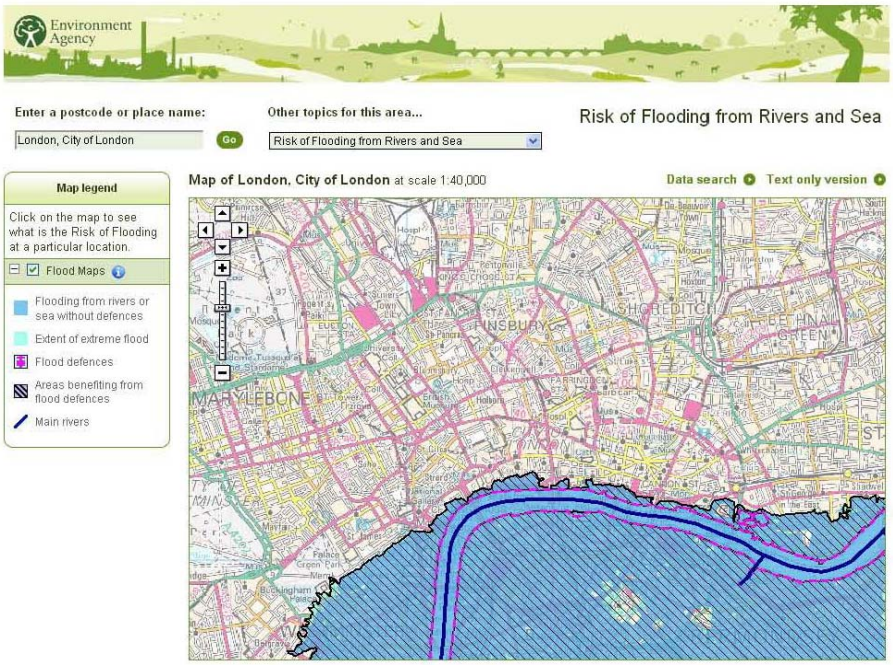


圖 77 防洪措施圖資(以英國倫敦為例)

另一種考量方式，則可以設定特定防洪措施失敗後(例如潰堤)，模擬其所造成的影響(例如洪泛)，如圖 78 所示。

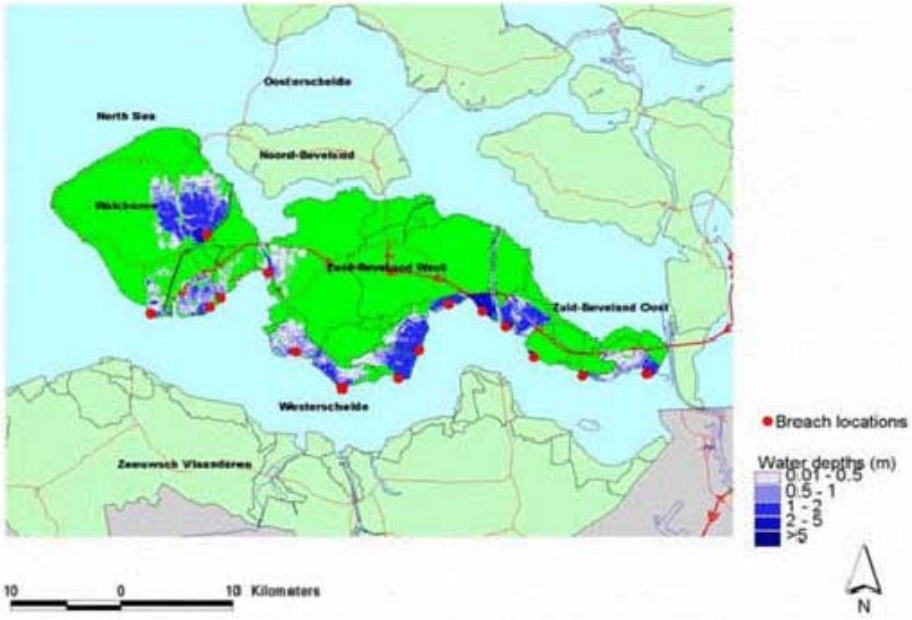


圖 78 防洪措施失敗模擬圖資(以荷蘭倫敦為例)

12.增加經濟風險(economic risk)資料

我們可概略以土地利用來估計經濟損失，如下所示：

工業區，可分為中度及嚴重災損

- 中度災損：10 歐元/平方公尺

● 嚴重災損：25 歐元/平方公尺

住宅區：

● 低度災損：10 歐元/平方公尺

● 中度災損：30 歐元/平方公尺

● 嚴重災損：50 歐元/平方公尺

農業區：則設定為無災損

以上要視各流域狀況，予以調整。圖 79 則顯示德國經濟風險圖資。

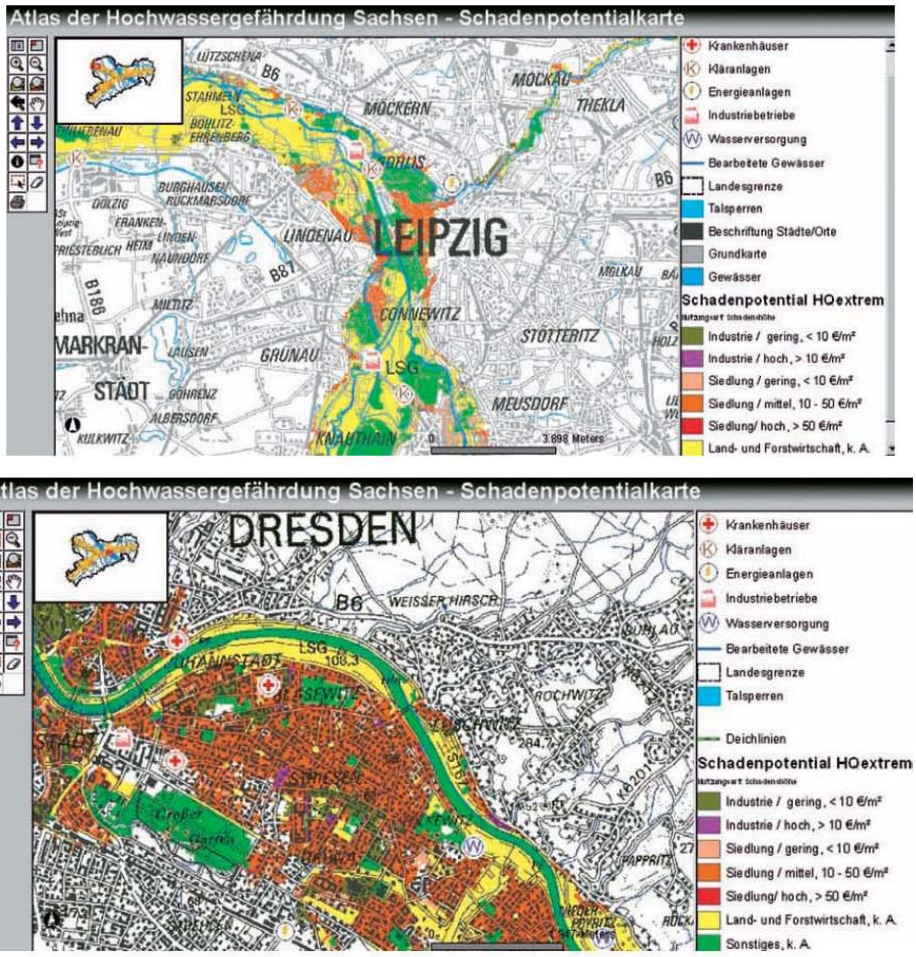


圖 79 經濟損失圖資(以德國為例)

有關實際洪災損失(D)，我們假設是一個位於特定區域包含洪水深度及經濟活動的函數(如式)，該函數可能是非線性，並可繪製洪水深度-災損曲線圖(depth-damage curve)(如圖80)。

$$D_j = h_j * D_{\%} * D\,Max_i$$

式中D_j：位置 j 的洪災損失、h_j：位置 j 的實際洪水深度、$D_{\%}$：坡度、$D\,Max_i$：

區域 i(包含位置 j)的最大可能災損。

假設本案例其函數關係是呈線性，則上式可改寫如下：

$$D_j = h_j * D\ Max_i / h_{max}$$

我們可依土地利用分區，假設不同分區其最大可能災損(maximum probable damage)如表 10。

最後，我們可依前述方法，製作洪災損失圖(如圖 81)。

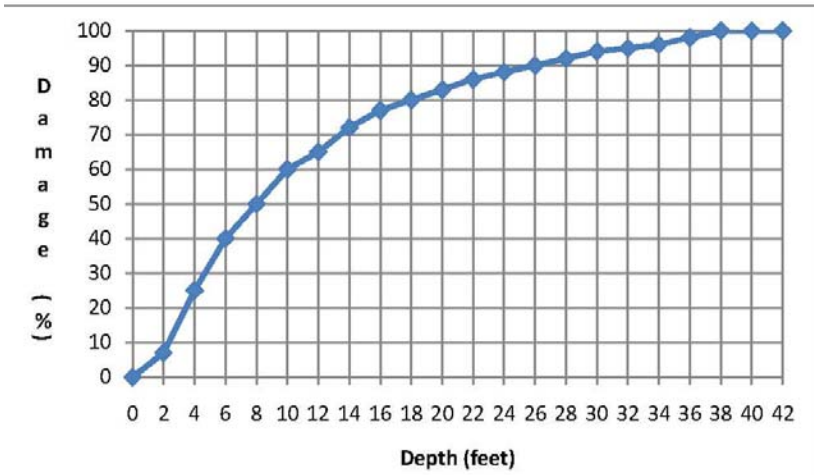


圖 80 洪水深度-災損曲線示意圖

表 10 不同土地利用最大可能災損表

Land use type	DMax (million Euro)
Airport	10
Commercial	8
Crop/Pasture	6
Farming	4
Floodplain	6
GolfCourse	3
HDResidential	9
Industrial	8
Nearstream	1
OpenSpace	0
OpenWater	0
Orchards	3
Park	2.5
School	7
Urban	7
WWTP	6.5

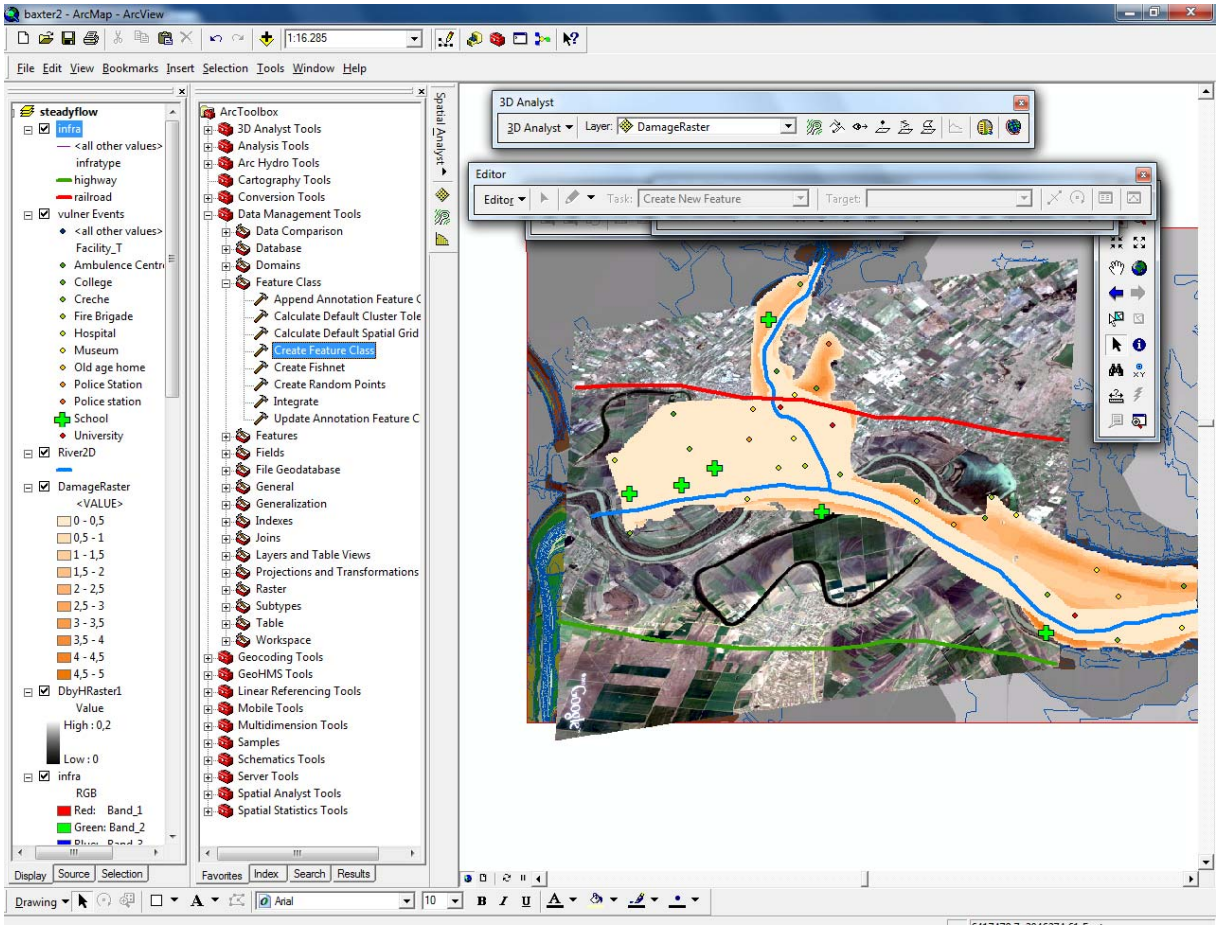


圖 81 洪災損失圖

13.出圖產製報告

依前述步驟完成洪災風險圖相關圖資建立，則可視需求予以出圖。

(十二)現地參訪-馬仕朗防潮閘(Maeslant Barrier)

我們參訪了位在鹿特丹附近的馬仕朗防潮閘(Maeslant Barrier)。驅車抵達了防潮閘的解說中心，包含了三角洲計畫、馬仕朗防潮閘解說(看板、模型等)、歷史洪災體驗館等；另外再到戶外實地參觀防潮閘，以及週遭環境。

首先中心解說員為我們說明防潮閘興建緣由、過程及構造，以及歷年操作過程。

1.興建緣由及過程：

1953 年荷蘭發生大洪水，導致 2000 多人喪生，荷蘭政府因而通過三角洲法(the Delta Act)，該法案指示對於荷蘭海岸線必須築堤保護，然關於荷蘭西南部一帶(詳圖 82)，因須保持鹿特丹港口的航運(即”新航道”(the New Waterway))，所以必須保持開放。1985 年荷蘭政府重新檢視計畫洪水；並檢討該區域河堤，發現為因應保護標準提高，需加強堤防保護，然此項工程需到 2020 年才完成，因此荷蘭政府發起一項研究，考慮在新航道設置一個可移動的暴潮屏障，以抵禦洪水。

經過 5 家顧問公司競圖(如圖 83)，最終於 1989 年由 BMK 公司獲得 3.2 億歐元的設計及建造費，設計概念很簡單，主要是易維護的結構、絕大部分是乾燥的，僅有少部分結構是"浮”在船塢。防潮閘於 1991 年興建，於 1997 年完工啟用。

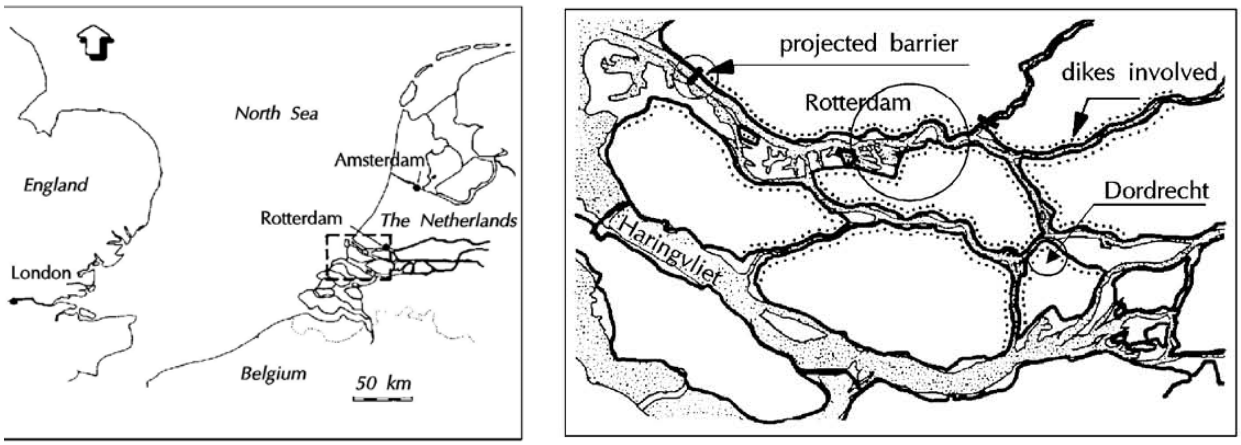


圖 82 防潮閘位置示意圖

資料來源：J.P.F.M. JANSSEN THE MAESLANT BARRIER:Design, Construction and Operation

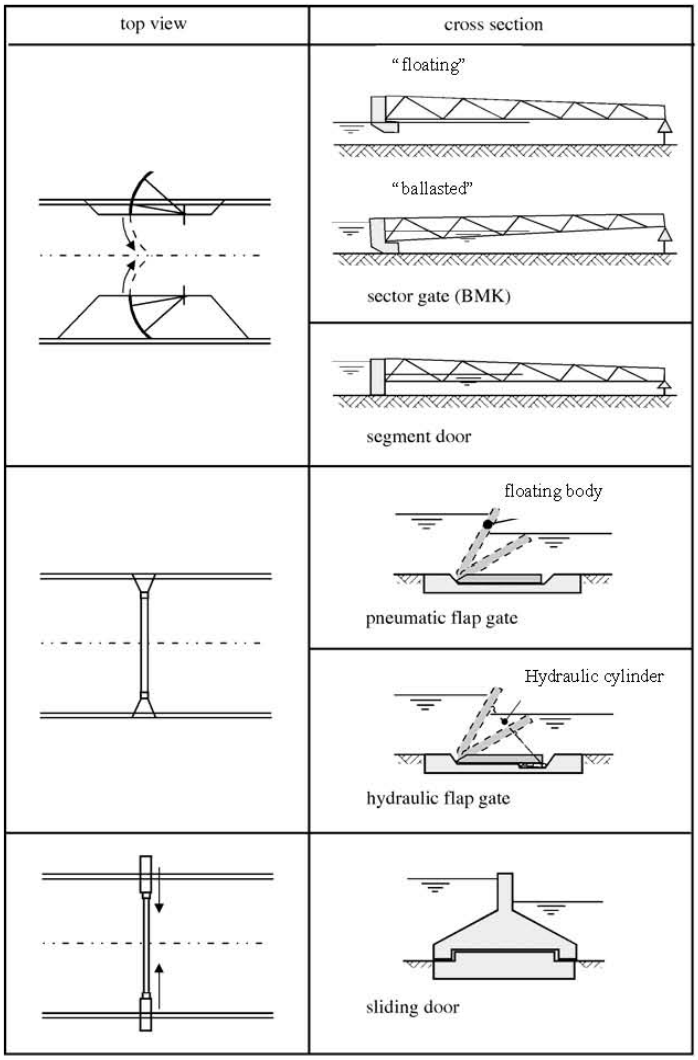


圖 83 防潮閘方案設計圖

資料來源：J.P.F.M. JANSSEN THE MAESLANT BARRIER:Design, Construction and Operation

2.防潮閘構造：

其構造包含如下(如圖 84 所示)：

1.閘門：牆高 22 公尺，長約 210 公尺

2.閘門桁架：軸長約長 240 公尺，是艾菲爾鐵塔高度，重量則是其 4 倍；高約 20 公尺

3.軸承：直徑 10 公尺，重量約 680 公噸

4.船塢：長約 200 公尺

5.控制中心

圖 84 防潮閘空照圖

(摘自 http://www.keringhuis.nl/網頁資料)

3.防潮閘操作過程：

當暴潮來臨時，防潮閘電腦系統會自動偵測並預測未來外海暴潮位，若高於平均海平面 3 公尺時，防潮閘則開始啟動。首先，在船塢注水，此刻中空的閘門桁架則會開始上浮，兩端軸承將驅動閘門鏈條將閘門閉合(如館內模型圖 85 所示)，之後再把中空閘門桁架注水，約莫 2 小時後，

閘門則下沉靜置河床。似外海暴潮退去後，在開啟閘門。防潮閘啟用至今，除每年 9~10 例行操作演練外，真正只關閉過兩次，其中一次是 2007 年，成功抵擋暴潮入侵。

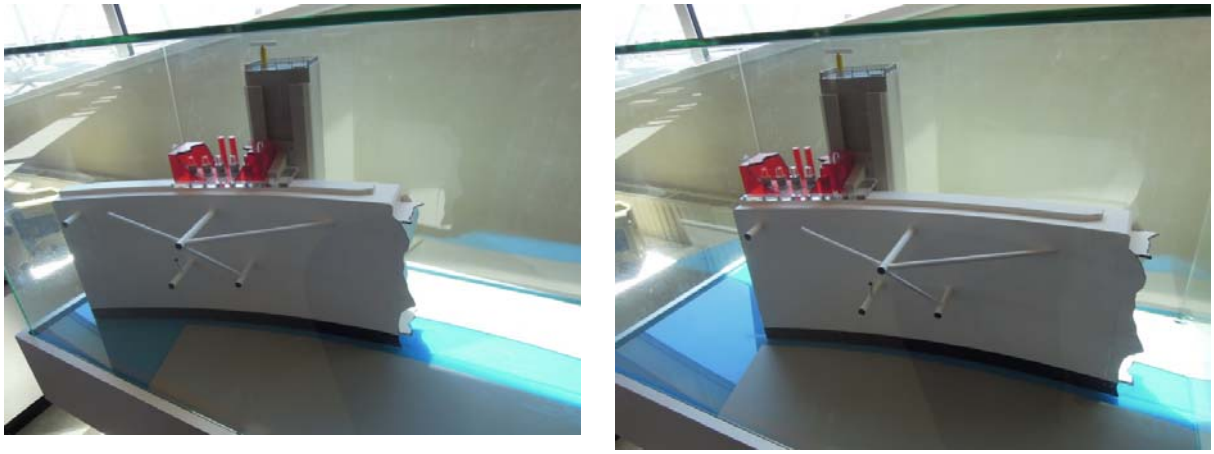


圖 85 防潮閘局部模型

防潮閘桁架　　船塢

圖 86 防潮閘現地參訪

此外，解說中心另包含了歷史洪災體驗館(如圖 88)，該館佈置如 1950 年代淹水洪災擺設，並展示該年洪災照片及影片，讓人更深刻體會洪水災害。

圖 87 解說員解說防潮閘

圖 88 歷史洪水災害體驗館

而防潮閘自從啟用後，吸引眾多民眾及觀光客參訪，其中當然包含了學童，為能讓孩童更生動了解防潮閘，該中心也推出了兒童繪本及漫畫(如圖 89、圖 90)。然而在戶外，更設置了兒童教育親水區(圖 91)，彎曲的水泥複式斷面相當於河川渠道；水槽蓄水則代表了降雨；水龍頭一開，則象徵洪水發生；一旁的小砂袋，則可作為防禦工事...參觀學員一到現場，興起玩性，而老師則扮演起”老天”角色，在水槽注水並放水，考考大家如何洪災風險管理，大夥則是手忙腳亂的趕緊用小砂袋構築防禦工事！這一種親身體驗的小型水工模型，寓教於樂，更能讓小朋友藉由動手實

作中學習防洪觀念。

圖 89 防潮閘教育宣導兒童繪本

圖 90 防洪教育宣導漫畫

圖 91 兒童親水教育區

第參章 心得與建議

一、心得

(一)荷蘭防洪策略改變

荷蘭地處低地，全國有一半以上的國土低於海平面，為捍衛土地以利耕作，早期挖掘許多排水渠道，並以風車將積水往外頭排放。因為 1953 年大洪水，荷蘭政府於 1960 年代發起了長達 30 年的「三角洲計畫」，建立北海海堤，禦潮於外，荷蘭人引以為豪。然 20 世紀末期，仍發生洪水事件，在洪水頻率分析後，發現計畫流量可能增加，荷蘭政府因而思索，是否再啟動下一波人定勝天式的防洪工程？抑或有新的思惟？在此狀況下，「還地於河」政策焉然成形。本次研習，觀察到荷蘭「還地於河」政策有兩點值得學習。

首先，所謂的還地於河，從字面上看來，似乎是限縮既有洪水平原上人類可使用空間，其實不然。由荷蘭還地於河 Waal 河案例來說，將瓶頸段河堤退縮，所增河道除可排洪外；更營造水域空間，進而改變地貌及環境，不僅降低防災風險，更營造城市發展新風貌。因此，所謂還地於河，應是洪水平原空間的重新配置，非只基於防洪思惟，建議若能納入考量地方新的願景及發展，更有利於推展。

其次，是採用規劃模擬數值模式 Planning Kit，該模式主要核心仍是水利模式，但因操作親切、可線上操作、迅速、可自行設計方案、輸出模擬結果等優點，則可成為一個有助於公眾溝通討論的工具。也因此，民眾可自行操作，測試自己初提的方案，成效如何，有益於防災教育及推廣。

(二)歐盟洪災風險管理機制及政策

因歐洲各國已結合成歐盟，如萊茵河等大型河川，更是不分國界，初期，為了解決河川上下游污染跨國境問題，而成立相關跨國溝通平台；近期，則利用該平台進行洪災風險管理相關合作交流。2007 年歐盟公佈了洪水指令(the EU Flood Directive)，呼籲各會員國對於洪水風險管理採取一致的行動，並擘劃了進程(2011 年完成初步洪災風險評估、2013 年完成洪災風險圖、2015 年達成洪災風險管理)，並因此成立相關組織平台，進行技術及研究交流；以及增進溝通。

(三)脆弱度與民眾防災意識

本次研習，老師提出一個「洪災風險及防洪支出循環」觀點，即政府若防洪工程成功->民眾漸漸無洪災經驗(脆弱度提升)，亦不覺得防災值得投資->發生洪災->政府投資防洪…，一直循環。對應到國內情勢，常常某處堤防興建後，民眾認為住在堤防後是安全的(未知其風險)，因此越住離堤防越近(增加脆弱度)。又例如，若民眾知道所處區域可能有淹水潛勢(知其風險)，可能會在一樓加裝防水閘門(減少脆弱度)。

因風險即是災害、脆弱度及產生後果的集合，故增加脆弱度，意味增加洪災風險。而民眾常常因為不知道災害風險，因而其行為可能增加脆弱度，最後增加洪災風險，故「如何讓民眾知道所居住地方其洪災風險為何？」是個重要課題，除製作洪災風險圖以供管理外，是否能透過相關資訊公開，並佐以民眾容易了解的說明，讓國人瞭解所處之地其風險為何？值得進一步研析。

二、建議

1. 有關洪災風險圖，我國已有相關計畫開始進行(如水利署，101 年，「台灣脆弱度及風險地圖製作與整合應用(1/2)」計畫、本所，102 年，「台灣南部地區水災危險地圖之製作-以台南市為例」計畫等)，然就本次研習經驗，建議：(1)增加脆弱度圖層(包含脆弱設施、交通運輸、高風險設施等)及防洪措施圖層、(2)最終成果除產製洪災風險圖外，建議建立 GIS 系統，將各圖層予以建置，以便比較及管理、(3)可嘗試以格網為單位，計算各指標數值。
2. 洪災風險管理為世界各國重視課題，依歐盟洪水指令進程規劃，2013 年底預計完成洪災風險圖；2015 年底將達成洪災風險管理，建議持續蒐集歐盟各國洪災風險管理成果，作為台灣洪災風險管理業務參考。
3. 亞洲各國河川環境及面臨課題較為相似(如地窄人稠、暴洪等)，建議可加強與亞洲鄰近各國(如日本、印度、孟加拉等國)，關於洪災風險管理領域的國際技術合作及經驗交流。

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9.歐盟環境部網站(http://www.eea.europa.eu)

10 荷蘭 Room for the river 網頁 (http://www.ruimtevoorderivier.nl/meta-navigatie/english.aspx)

附錄一 參訓證明

UNESCO-IHE
Institute for Water Education

CERTIFICATE

Short Course on
Flood Risk Management

This is to certify that

Chang, Yi-Fan

born on [redacted] in Taiwan, Taiwan of China

has followed and successfully completed the short course on
Flood Risk Management held at UNESCO-IHE, Delft, the Netherlands
from 10 June 2013 – 28 June 2013.

Prof. A. Szöllösi-Nagy, PhD, DSc
Rector

Dr. B. Bhattacharya
Course Coordinator

Delft, the Netherlands, 28 June 2013

附錄二 重要文獻
歐盟洪水指令(EU Flood Directive)

DIRECTIVES

DIRECTIVE 2007/60/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL

of 23 October 2007

on the assessment and management of flood risks

(Text with EEA relevance)

THE EUROPEAN PARLIAMENT AND THE COUNCIL OF THE EUROPEAN UNION,

Having regard to the Treaty establishing the European Community, and in particular Article 175(1) thereof,

Having regard to the proposal from the Commission,

Having regard to the Opinion of the European Economic and Social Committee [1],

Acting in accordance with the procedure laid down in Article 251 of the Treaty [2],

Whereas:

(1) Floods have the potential to cause fatalities, displacement of people and damage to the environment, to severely compromise economic development and to undermine the economic activities of the Community.

(2) Floods are natural phenomena which cannot be prevented. However, some human activities (such as increasing human settlements and economic assets in floodplains and the reduction of the natural water retention by land use) and climate change contribute to an increase in the likelihood and adverse impacts of flood events.

(3) It is feasible and desirable to reduce the risk of adverse consequences, especially for human health and life, the environment, cultural heritage, economic activity and infrastructure associated with floods. However, measures to reduce these risks should, as far as possible, be coordinated throughout a river basin if they are to be effective.

(4) Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy [3] requires river basin management plans to be developed for each river basin district in order to achieve good ecological and chemical status, and it will contribute to mitigating the effects of floods. However, reducing the risk of floods is not one of the principal objectives of that Directive, nor does it take into account the future changes in the risk of flooding as a result of climate change.

(5) The Commission Communication of 12 July 2004 to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions 'Flood risk management — Flood prevention, protection and mitigation' sets out its analysis and approach to managing flood risks at Community level, and states that concerted and coordinated action at Community level would bring considerable added value and improve the overall level of flood protection.

(6) Effective flood prevention and mitigation requires, in addition to coordination between Member States, cooperation with third countries. This is in line with Directive 2000/60/EC and international principles of flood risk management as developed notably under the United Nations Convention on the protection and use of transboundary water courses and international lakes, approved by Council Decision 95/308/EC [4], and any succeeding agreements on its application.

(7) Council Decision 2001/792/EC, Euratom of 23 October 2001 establishing a Community mechanism to facilitate reinforced cooperation in civil protection assistance interventions [5] mobilises support and assistance from Member States in the event of major emergencies, including floods. Civil protection can provide adequate response to affected populations and improve preparedness and resilience.

[1] OJ C 195, 18.8.2006, p. 37.
[2] Opinion of the European Parliament of 13 June 2006 (OJ C 300 E, 9.12.2006, p. 123). Council Common Position of 23 November 2006 (OJ C 311 E, 19.12.2006, p. 10) and Position of the European Parliament of 25 April 2007. Council Decision of 18 September 2007.
[3] OJ L 327, 22.12.2000, p. 1. Directive as amended by Decision No 2455/2001/EC (OJ L 331, 15.12.2001, p. 1).
[4] OJ L 186, 5.8.1995, p. 42.
[5] OJ L 297, 15.11.2001, p. 7.

(8) Under Council Regulation (EC) No 2012/2002 of 11 November 2002 establishing the European Union Solidarity Fund [1] it is possible to grant rapid financial assistance in the event of a major disaster to help the people, natural zones, regions and countries concerned to return to conditions that are as normal as possible. However the Fund may only intervene for emergency operations, and not for the phases preceding an emergency.

(9) In developing policies referring to water and land uses Member States and the Community should consider the potential impacts that such policies might have on flood risks and the management of flood risks.

(10) Throughout the Community different types of floods occur, such as river floods, flash floods, urban floods and floods from the sea in coastal areas. The damage caused by flood events may also vary across the countries and regions of the Community. Hence, objectives regarding the management of flood risks should be determined by the Member States themselves and should be based on local and regional circumstances.

(11) Flood risks in certain areas within the Community could be considered not to be significant, for example in thinly populated or unpopulated areas or in areas with limited economic assets or ecological value. In each river basin district or unit of management the flood risks and need for further action — such as the evaluation of flood mitigation potential — should be assessed.

(12) In order to have available an effective tool for information, as well as a valuable basis for priority setting and further technical, financial and political decisions regarding flood risk management, it is necessary to provide for the establishing of flood hazard maps and flood risk maps showing the potential adverse consequences associated with different flood scenarios, including information on potential sources of environmental pollution as a consequence of floods. In this context, Member States should assess activities that have the effect of increasing flood risks.

(13) With a view to avoiding and reducing the adverse impacts of floods in the area concerned it is appropriate to provide for flood risk management plans. The causes and consequences of flood events vary across the countries and regions of the Community. Flood risk management plans should therefore take into account the particular characteristics of the areas they cover and provide for tailored solutions according to the needs and priorities of those areas, whilst ensuring relevant coordination within river basin districts and promoting the achievement of environmental objectives laid down in Community legislation. In particular, Member States should refrain from taking measures or engaging in actions which significantly increase the risk of flooding in other Member States, unless these measures have been coordinated and an agreed solution has been found among the Member States concerned.

(14) Flood risk management plans should focus on prevention, protection and preparedness. With a view to giving rivers more space, they should consider where possible the maintenance and/or restoration of floodplains, as well as measures to prevent and reduce damage to human health, the environment, cultural heritage and economic activity. The elements of flood risk management plans should be periodically reviewed and if necessary updated, taking into account the likely impacts of climate change on the occurrence of floods.

(15) The solidarity principle is very important in the context of flood risk management. In the light of it Member States should be encouraged to seek a fair sharing of responsibilities, when measures are jointly decided for the common benefit, as regards flood risk management along water courses.

(16) To prevent duplication of work, Member States should be entitled to use existing preliminary flood risk assessments, flood hazard and risk maps and flood risk management plans for the purposes of achieving the objectives and satisfying the requirements of this Directive.

(17) Development of river basin management plans under Directive 2000/60/EC and of flood risk management plans under this Directive are elements of integrated river basin management. The two processes should therefore use the mutual potential for common synergies and benefits, having regard to the environmental objectives of Directive 2000/60/EC, ensuring efficiency and wise use of resources while recognising that the competent authorities and management units might be different under this Directive and Directive 2000/60/EC.

(18) Member States should base their assessments, maps and plans on appropriate 'best practice' and 'best available technologies' not entailing excessive costs in the field of flood risk management.

[1] OJ L 311, 14.11.2002, p. 3.

(19) In cases of multi-purpose use of bodies of water for different forms of sustainable human activities (e.g. flood risk management, ecology, inland navigation or hydropower) and the impacts of such use on the bodies of water, Directive 2000/60/EC provides for a clear and transparent process for addressing such uses and impacts, including possible exemptions from the objectives of 'good status' or of 'non-deterioration' in Article 4 thereof. Directive 2000/60/EC provides for cost recovery in Article 9.

(20) The measures necessary for the implementation of this Directive should be adopted in accordance with Council Decision 1999/468/EC of 28 June 1999 laying down the procedures for the exercise of implementing powers conferred on the Commission [1].

(21) In particular, the Commission should be empowered to adapt the Annex to scientific and technical progress. Since those measures are of general scope and are designed to amend non-essential elements of this Directive, they must be adopted in accordance with the regulatory procedure with scrutiny provided for in Article 5a of Decision 1999/468/EC.

(22) This Directive respects the fundamental rights and observes the principles recognised in particular by the Charter of Fundamental Rights of the European Union. In particular, it seeks to promote the integration into Community policies of a high level of environmental protection in accordance with the principle of sustainable development as laid down in Article 37 of the Charter of Fundamental Rights of the European Union.

(23) Since the objective of this Directive, namely the establishment of a framework for measures to reduce the risks of flood damage, cannot be sufficiently achieved by the Member States and can by reason of scale and effects of actions be better achieved at Community level, the Community may adopt measures, in accordance with the principle of subsidiarity as set out in Article 5 of the Treaty. In accordance with the principle of proportionality, as set out in that Article, this Directive does not go beyond what is necessary in order to achieve that objective.

(24) In accordance with the principles of proportionality and subsidiarity and the Protocol on the application of the principles of subsidiarity and proportionality attached to the Treaty, and in view of existing capabilities of Member States, considerable flexibility should be left to the local and regional levels, in particular as regards organisation and responsibility of authorities.

(25) In accordance with point 34 of the Interinstitutional Agreement on better law-making [2], Member States are encouraged to draw up, for themselves and in the interest of the Community, their own tables illustrating, as far as possible, the correlation between this Directive and the transposition measures, and to make them public,

HAVE ADOPTED THIS DIRECTIVE:

CHAPTER I

GENERAL PROVISIONS

Article 1

The purpose of this Directive is to establish a framework for the assessment and management of flood risks, aiming at the reduction of the adverse consequences for human health, the environment, cultural heritage and economic activity associated with floods in the Community.

Article 2

For the purpose of this Directive, in addition to the definitions of 'river', 'river basin', 'sub-basin' and 'river basin district' as set out in Article 2 of Directive 2000/60/EC, the following definitions shall apply:

1. 'flood' means the temporary covering by water of land not normally covered by water. This shall include floods from rivers, mountain torrents, Mediterranean ephemeral water courses, and floods from the sea in coastal areas, and may exclude floods from sewerage systems;

2. 'flood risk' means the combination of the probability of a flood event and of the potential adverse consequences for human health, the environment, cultural heritage and economic activity associated with a flood event.

Article 3

1. For the purposes of this Directive Member States shall make use of the arrangements made under Article 3(1), (2), (3), (5) and (6) of Directive 2000/60/EC.

2. However, for the implementation of this Directive, Member States may:

(a) appoint competent authorities different from those identified pursuant to Article 3(2) of Directive 2000/60/EC;

(b) identify certain coastal areas or individual river basins and assign them to a unit of management different from those assigned pursuant to Article 3(1) of Directive 2000/60/EC.

[1] OJ L 184, 17.7.1999, p. 23. Decision as amended by Decision 2006/512/EC (OJ L 200, 22.7.2006, p. 11).

[2] OJ C 321, 31.12.2003, p. 1.

In these cases, Member States shall, by 26 May 2010, communicate to the Commission the information referred to in Annex I to Directive 2000/60/EC. For this purpose, any reference to competent authorities and river basin districts shall be taken as references to the competent authorities and unit of management referred to in this Article. Member States shall inform the Commission of any changes in the information provided pursuant to this paragraph within three months of the change coming into effect.

CHAPTER II

PRELIMINARY FLOOD RISK ASSESSMENT

Article 4

1. Member States shall, for each river basin district, or unit of management referred to in Article 3(2)(b), or the portion of an international river basin district lying within their territory, undertake a preliminary flood risk assessment in accordance with paragraph 2 of this Article.

2. Based on available or readily derivable information, such as records and studies on long term developments, in particular impacts of climate change on the occurrence of floods, a preliminary flood risk assessment shall be undertaken to provide an assessment of potential risks. The assessment shall include at least the following:

(a) maps of the river basin district at the appropriate scale including the borders of the river basins, sub-basins and, where existing, coastal areas, showing topography and land use;

(b) a description of the floods which have occurred in the past and which had significant adverse impacts on human health, the environment, cultural heritage and economic activity and for which the likelihood of similar future events is still relevant, including their flood extent and conveyance routes and an assessment of the adverse impacts they have entailed;

(c) a description of the significant floods which have occurred in the past, where significant adverse consequences of similar future events might be envisaged;

and, depending on the specific needs of Member States, it shall include:

(d) an assessment of the potential adverse consequences of future floods for human health, the environment, cultural heritage and economic activity, taking into account as far as possible issues such as the topography, the position of watercourses and their general hydrological and geomorphological characteristics, including floodplains as natural retention areas, the effectiveness of existing man-made flood defence infrastructures, the position of populated areas, areas of economic activity and long-term developments including impacts of climate change on the occurrence of floods.

3. In the case of international river basin districts, or units of management referred to in Article 3(2)(b) which are shared with other Member States, Member States shall ensure that exchange of relevant information takes place between the competent authorities concerned.

4. Member States shall complete the preliminary flood risk assessment by 22 December 2011.

Article 5

1. On the basis of a preliminary flood risk assessment as referred to in Article 4, Member States shall, for each river basin district, or unit of management referred to in Article 3(2)(b), or portion of an international river basin district lying within their territory, identify those areas for which they conclude that potential significant flood risks exist or might be considered likely to occur.

2. The identification under paragraph 1 of areas belonging to an international river basin district, or to a unit of management referred to in Article 3(2)(b) shared with another Member State, shall be coordinated between the Member States concerned.

CHAPTER III

FLOOD HAZARD MAPS AND FLOOD RISK MAPS

Article 6

1. Member States shall, at the level of the river basin district, or unit of management referred to in Article 3(2)(b), prepare flood hazard maps and flood risk maps, at the most appropriate scale for the areas identified under Article 5(1).

2. The preparation of flood hazard maps and flood risk maps for areas identified under Article 5 which are shared with other Member States shall be subject to prior exchange of information between the Member States concerned.

3. Flood hazard maps shall cover the geographical areas which could be flooded according to the following scenarios:

(a) floods with a low probability, or extreme event scenarios;

(b) floods with a medium probability (likely return period $\geq$ 100 years);

(c) floods with a high probability, where appropriate.

4. For each scenario referred to in paragraph 3 the following elements shall be shown:

(a) the flood extent;

(b) water depths or water level, as appropriate;

(c) where appropriate, the flow velocity or the relevant water flow.

5. Flood risk maps shall show the potential adverse consequences associated with flood scenarios referred to in paragraph 3 and expressed in terms of the following:

(a) the indicative number of inhabitants potentially affected;

(b) type of economic activity of the area potentially affected;

(c) installations as referred to in Annex I to Council Directive 96/61/EC of 24 September 1996 concerning integrated pollution prevention and control [1] which might cause accidental pollution in case of flooding and potentially affected protected areas identified in Annex IV(1)(i), (iii) and (v) to Directive 2000/60/EC;

(d) other information which the Member State considers useful such as the indication of areas where floods with a high content of transported sediments and debris floods can occur and information on other significant sources of pollution.

6. Member States may decide that, for coastal areas where an adequate level of protection is in place, the preparation of flood hazard maps shall be limited to the scenario referred to in paragraph 3(a).

7. Member States may decide that, for areas where flooding is from groundwater sources, the preparation of flood hazard maps shall be limited to the scenario referred to in paragraph 3(a).

8. Member States shall ensure that the flood hazard maps and flood risk maps are completed by 22 December 2013.

CHAPTER IV

FLOOD RISK MANAGEMENT PLANS

Article 7

1. On the basis of the maps referred to in Article 6, Member States shall establish flood risk management plans coordinated at the level of the river basin district, or unit of management referred to in Article 3(2)(b), for the areas identified under Article 5(1) and the areas covered by Article 13(1)(b) in accordance with paragraphs 2 and 3 of this Article.

2. Member States shall establish appropriate objectives for the management of flood risks for the areas identified under Article 5(1) and the areas covered by Article 13(1)(b), focusing on the reduction of potential adverse consequences of flooding for human health, the environment, cultural heritage and economic activity, and, if considered appropriate, on non-structural initiatives and/or on the reduction of the likelihood of flooding.

3. Flood risk management plans shall include measures for achieving the objectives established in accordance with paragraph 2 and shall include the components set out in Part A of the Annex.

Flood risk management plans shall take into account relevant aspects such as costs and benefits, flood extent and flood conveyance routes and areas which have the potential to retain flood water, such as natural floodplains, the environmental objectives of Article 4 of Directive 2000/60/EC, soil and water management, spatial planning, land use, nature conservation, navigation and port infrastructure.

Flood risk management plans shall address all aspects of flood risk management focusing on prevention, protection, preparedness, including flood forecasts and early warning systems and taking into account the characteristics of the particular river basin or sub-basin. Flood risk management plans may also include the promotion of sustainable land use practices, improvement of water retention as well as the controlled flooding of certain areas in the case of a flood event.

4. In the interests of solidarity, flood risk management plans established in one Member State shall not include measures which, by their extent and impact, significantly increase flood risks upstream or downstream of other countries in the same river basin or sub-basin, unless these measures have been coordinated and an agreed solution has been found among the Member States concerned in the framework of Article 8.

5. Member States shall ensure that flood risk management plans are completed and published by 22 December 2015.

Article 8

1. For river basin districts, or units of management referred to in Article 3(2)(b), which fall entirely within their territory, Member States shall ensure that one single flood risk management plan, or a set of flood risk management plans coordinated at the level of the river basin district, is produced.

[1] OJ L 257, 10.10.1996, p. 26. Directive as last amended by Regulation (EC) No 166/2006 of the European Parliament and of the Council (OJ L 33, 4.2.2006, p. 1).

2. Where an international river basin district, or unit of management referred to in Article 3(2)(b), falls entirely within the Community, Member States shall ensure coordination with the aim of producing one single international flood risk management plan, or a set of flood risk management plans coordinated at the level of the international river basin district. Where such plans are not produced, Member States shall produce flood risk management plans covering at least the parts of the international river basin district falling within their territory, as far as possible coordinated at the level of the international river basin district.

3. Where an international river basin district, or unit of management referred to in Article 3(2)(b), extends beyond the boundaries of the Community, Member States shall endeavour to produce one single international flood risk management plan or a set of flood risk management plans coordinated at the level of the international river basin district; where this is not possible, paragraph 2 shall apply for the parts of the international river basin falling within their territory.

4. The flood risk management plans referred to in paragraphs 2 and 3 shall be supplemented, where considered appropriate by countries sharing a sub-basin, by more detailed flood risk management plans coordinated at the level of the international sub-basins.

5. Where a Member State identifies an issue which has an impact on the management of flood risks of its water and that issue cannot be resolved by that Member State, it may report the issue to the Commission and any other Member State concerned and may make recommendations as to how the issue should be resolved.

The Commission shall respond to any report or recommendations from Member States within a period of six months.

CHAPTER V

COORDINATION WITH DIRECTIVE 2000/60/EC, PUBLIC INFORMATION AND CONSULTATION

Article 9

Member States shall take appropriate steps to coordinate the application of this Directive and that of Directive 2000/60/EC focusing on opportunities for improving efficiency, information exchange and for achieving common synergies and benefits having regard to the environmental objectives laid down in Article 4 of Directive 2000/60/EC. In particular:

1. the development of the first flood hazard maps and flood risk maps and their subsequent reviews as referred to in Articles 6 and 14 of this Directive shall be carried out in such a way that the information they contain is consistent with relevant information presented according to Directive 2000/60/EC. They shall be coordinated with, and may be integrated into, the reviews provided for in Article 5(2) of Directive 2000/60/EC;

2. the development of the first flood risk management plans and their subsequent reviews as referred to in Articles 7 and 14 of this Directive shall be carried out in coordination with, and may be integrated into, the reviews of the river basin management plans provided for in Article 13(7) of Directive 2000/60/EC;

3. the active involvement of all interested parties under Article 10 of this Directive shall be coordinated, as appropriate, with the active involvement of interested parties under Article 14 of Directive 2000/60/EC.

Article 10

1. In accordance with applicable Community legislation, Member States shall make available to the public the preliminary flood risk assessment, the flood hazard maps, the flood risk maps and the flood risk management plans.

2. Member States shall encourage active involvement of interested parties in the production, review and updating of the flood risk management plans referred to in Chapter IV.

CHAPTER VI

IMPLEMENTING MEASURES AND AMENDMENTS

Article 11

1. The Commission may, in accordance with the regulatory procedure referred to in Article 12(2), adopt technical formats for the purpose of processing and transmission of data, including statistical and cartographic data, to the Commission. The technical formats should be adopted at least two years before the dates indicated respectively in Articles 4(4), 6(8) and 7(5), taking into account existing standards as well as formats developed under relevant Community acts.

2. The Commission may, taking into account the periods for review and updating, adapt the Annex to scientific and technical progress.

These measures, designed to amend non-essential elements of this Directive, shall be adopted in accordance with the regulatory procedure with scrutiny referred to in Article 12(3).

Article 12

1. The Commission shall be assisted by the committee established under Article 21 of Directive 2000/60/EC.

2. Where reference is made to this paragraph, Articles 5 and 7 of Decision 1999/468/EC shall apply, having regard to the provisions of Article 8 thereof.

The period laid down in Article 5(6) of Decision 1999/468/EC shall be set at three months.

3. Where reference is made to this paragraph, Article 5a(1) to (4) and Article 7 of Decision 1999/468/EC shall apply, having regard to the provisions of Article 8 thereof.

CHAPTER VII

TRANSITIONAL MEASURES

Article 13

1. Member States may decide not to undertake the preliminary flood risk assessment referred to in Article 4 for those river basins, sub-basins or coastal areas where they have either:

(a) already undertaken a risk assessment to conclude, before 22 December 2010, that a potential significant flood risk exists or might be considered likely to occur leading to the identification of the area among those referred to in Article 5(1) or

(b) decided, before 22 December 2010, to prepare flood hazard maps and flood risk maps and to establish flood risk management plans in accordance with the relevant provisions of this Directive.

2. Member States may decide to make use of flood hazard maps and flood risk maps finalised before 22 December 2010, if such maps provide a level of information equivalent to the requirements of Article 6.

3. Member States may decide to make use of flood risk management plans finalised before 22 December 2010, provided the content of these plans is equivalent to the requirements set out in Article 7.

4. Paragraphs 1, 2 and 3 shall apply without prejudice to Article 14.

CHAPTER VIII

REVIEWS, REPORTS AND FINAL PROVISIONS

Article 14

1. The preliminary flood risk assessment, or the assessment and decisions referred to in Article 13(1), shall be reviewed, and if necessary updated, by 22 December 2018 and every six years thereafter.

2. The flood hazard maps and the flood risk maps shall be reviewed, and if necessary updated, by 22 December 2019 and every six years thereafter.

3. The flood risk management plan(s) shall be reviewed, and if necessary updated, including the components set out in part B of the Annex, by 22 December 2021 and every six years thereafter.

4. The likely impact of climate change on the occurrence of floods shall be taken into account in the reviews referred to in paragraphs 1 and 3.

Article 15

1. Member States shall make available the preliminary flood risk assessment, the flood hazard maps, the flood risk maps and flood risk management plans referred to in Articles 4, 6 and 7, as well as their review and, where applicable, their updates to the Commission within three months after the dates indicated respectively in Articles 4(4), 6(8), 7(5) and 14.

2. Member States shall inform the Commission of the decisions taken in accordance with Article 13(1), (2) and (3) and make available the relevant information thereon by the dates indicated respectively in Articles 4(4), 6(8) and 7(5).

Article 16

The Commission shall, by 22 December 2018, and every six years thereafter, submit to the European Parliament and to the Council a report on the implementation of this Directive. The impact of climate change shall be taken into account in drawing up this report.

Article 17

1. Member States shall bring into force the laws, regulations and administrative provisions necessary to comply with this Directive before 26 November 2009. They shall forthwith inform the Commission thereof.

When they are adopted by Member States, these measures shall contain a reference to this Directive or shall be accompanied by such reference on the occasion of their official publication. The methods of making such reference shall be laid down by Member States.

2. Member States shall communicate to the Commission the text of the main provisions of national law which they adopt in the field covered by this Directive.

Article 18

This Directive shall enter into force on the 20th day following its publication in the *Official Journal of the European Union*.

Article 19

This Directive is addressed to the Member States.

Done at Strasbourg, 23 October 2007.

For the European Parliament	*For the Council*
The President	*The President*
H.-G. PÖTTERING	M. LOBO ANTUNES

ANNEX

A. Flood risk management plans

I. Components of the first flood risk management plans:

1. the conclusions of the preliminary flood risk assessment as required in Chapter II in the form of a summary map of the river basin district, or the unit of management referred to in Article 3(2)(b), delineating the areas identified under Article 5(1) which are the subject of this flood risk management plan;

2. flood hazard maps and flood risk maps as prepared under Chapter III, or already in place in accordance with Article 13, and the conclusions that can be drawn from those maps;

3. a description of the appropriate objectives of flood risk management, established in accordance with Article 7(2);

4. a summary of the measures and their prioritisation aiming to achieve the appropriate objectives of flood risk management, including the measures taken in accordance with Article 7, and flood related measures taken under other Community acts, including Council Directives 85/337/EEC of 27 June 1985 on the assessment of the effects of certain public and private projects on the environment [1] and 96/82/EC of 9 December 1996 on the control of major accident hazards involving dangerous substances [2], Directive 2001/42/EC of the European Parliament and of the Council of 27 June 2001 on the assessment of the effects of certain plans and programmes on the environment [3] and Directive 2000/60/EC;

5. when available, for shared river basins or sub-basins, a description of the methodology, defined by the Member States concerned, of cost-benefit analysis used to assess measures with transnational effects.

II. Description of the implementation of the plan:

1. a description of the prioritisation and the way in which progress in implementing the plan will be monitored;

2. a summary of the public information and consultation measures/actions taken;

3. a list of competent authorities and, as appropriate, a description of the coordination process within any international river basin district and of the coordination process with Directive 2000/60/EC.

B. Components of the subsequent update of flood risk management plans:

1. any changes or updates since the publication of the previous version of the flood risk management plan, including a summary of the reviews carried out in compliance with Article 14;

2. an assessment of the progress made towards the achievement of the objectives referred to in Article 7(2);

3. a description of, and an explanation for, any measures foreseen in the earlier version of the flood risk management plan which were planned to be undertaken and have not been taken forward;

4. a description of any additional measures since the publication of the previous version of the flood risk management plan.

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[1] OJ L 175, 5.7.1985, p. 40. Directive as last amended by Directive 2003/35/EC of the European Parliament and of the Council (OJ L 156, 25.6.2003, p. 17).
[2] OJ L 10, 14.1.1997, p. 13. Directive as last amended by Directive 2003/105/EC of the European Parliament and of the Council (OJ L 345, 31.12.2003, p. 97).
[3] OJ L 197, 21.7.2001, p. 30.