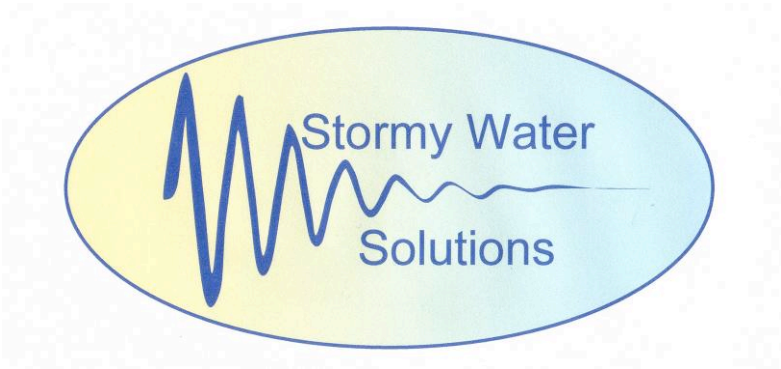

Armstrong Creek West Precinct

Review of Stormwater Management Strategy

31 October 2011

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1. Introduction

In September 2011 the City of Greater Geelong requested that Stormy Water Solutions review the Stormwater Management Strategy for the Armstrong Creek West Precinct (ACWP) prepared by Water Technology Pty Ltd and Neil M Craigie Pty Ltd.

This review consisted of:

- A site visit to assess the existing creek and catchment condition, configuration and constraints in regard to strategy implementation,
- Reviewing the report entitled “Armstrong Creek, West Precinct Structure Plan, Flooding Investigations, Water Technology October 2011, Stage 2” which set out the key flooding investigation results and proposals,
- Reviewing the report entitled “Stormwater Management Strategy, Version 3, 28 October 2011, Neil M Craigie,” which described the environmental flow and stormwater pollutant requirements and provisions,
- Review of the key hydrological modelling (RORB, MIKE Flood and MUSIC) to assess if input and output values were realistic and consistent with best practice,
- Telephone calls, meetings and emails with Neil Craigie (Neil M Craigie Pty Ltd) and Luke Cunningham (Water Technology Pty Ltd) to ensure full understanding of what is being proposed,
- Assessing key input parameter values to ensure the models will represent what is proposed on the ground (detailed hydrologic and hydraulic modelling was not completed),
- Assessing model output results in regard to meeting the intent of the strategy requirements,
- Assessing whether the space allocated for drainage infrastructure was compatible with land topography, site constraints (trees and road locations etc), and
- Overview checking using quick assessment procedures to confirm some basic estimating quantities.

The author of this report has no previous involvement in the site.

Stormy Water Solutions considers that drainage infrastructure opportunities and constraints have been appropriately identified in this case. Performance objectives as detailed in the reports are consistent with current best practice. The overall stormwater management strategy contains sufficient flexibility and can allow variation in the functional and detailed design phases of the project to suit actual circumstances and development of subdivisional design.

2. Reviewer Qualifications

The author of this report is Valerie Mag, principal of Stormy Water Solutions. Valerie's expertise is in hydrology, hydraulics and Water Sensitive Urban Design and her educational qualifications are as follows:

- Bachelor of Civil Engineering, Monash University (1989)
- Master of Water Resources and Environmental Engineering, Monash University (1993)

Valerie has twenty two years experience in both public and private organisations. She has substantial hydrologic and hydraulic engineering experience, particularly in the areas of:

- Preparing complex urban and rural flood plain strategies,
- Preparing Water Sensitive Urban Design Strategies,
- Major catchment analysis, including flood flow and flood level estimation,
- Planning and assessment of development within flood plain and overland flow path systems,
- Reviewing drainage strategies prepared by other consultants for Melbourne Water, Catchment Management Authorities and councils, and
- Regularly preparing and conducting training in drainage and WSUD for the Municipal Association of Victoria, Vic Roads, Melbourne Water Corporation (MWC), the Department of Tourism Arts and the Environment (Tasmania) and others.

In relation to Valerie's expertise regarding the content of this report, from 1989 to 2001 she worked as a hydrologist with the Dandenong Valley Authority and Melbourne Water. Since 2001 she has continued to work as a hydrologist in private consultancy. In both these roles she has undertaken numerous flood plain modelling exercises (in the order of 10 – 15 every year). Almost all of these exercises involved applying hydrological models to analysis and set flood levels and flood flow velocities along urban and rural floodplains. During her time with the Dandenong Valley Authority and Melbourne Water, she used the results of the hydrological analysis to assess various planning proposals relating to development within floodplains. In addition, in the last 11 years Valerie completed many WSUD strategies and designs (e.g. wetlands, bioretention systems, sediment basins etc).

3. Proposed Stormwater Management Strategy Objectives

The adopted Stormwater Management Objectives are:

1. Stormwater quality from the ACWP land is treated to best practice objectives (retention of 80% TSS, 45% TN and 45% TP),
2. The 100 Year ARI stormwater discharges in Armstrong Creek must be no higher than under existing conditions at Airport Road and Surf Coast Highway), and
3. As far as practically feasible, Armstrong Creek must be protected from the impacts of altered hydrology arising from urbanisation.

The Neil Craigie/ Water Technology team also added the following objectives to ensure appropriate form and location of management assets

- retention and enhancement of Armstrong Creek and its floodplain within a creek, habitat and passive recreation corridor upstream of Surf Coast Highway,
- no direct connection of stormwater drainage systems to Armstrong Creek itself,
- creation of storm flow mitigation storages that avoid the use of high embankments,
- protection of key flora/fauna habitat areas and sites of cultural heritage value,
- consolidation of drainage management assets wherever possible to minimise ongoing maintenance costs,
- encouragement for reuse of stormwater.

In regard to Objective 3 above, the Neil Craigie pointed out that the only way to really achieve this goal is to use significant stormwater on site or return the stormwater to the groundwater system. I agree that large scale infiltration is not appropriate here. A strategy of this type was used in Torquay recently, and has failed as adequate infiltration rates cannot be assured during rainfall events. Also, due to the proposed use of Class A recycle water supply, stormwater reuse uptake can only be assumed to be minor in the long term.

In light of the above constraints and unknowns regarding reuse opportunities, the adopted strategy for ACWP proposes flow diversion systems to protect creek hydrology.

Stormy Water Solutions considers the above objectives to be consistent with best practice. In addition, the methodology is consistent with a total catchment management approach as advocated within the Melbourne Water Corporation Development Services Scheme designs. Meeting the above objectives should ensure a functional and robust and self sustaining drainage system for developed areas, while maintain the existing environmental attributes of Armstrong Creek.

4. Stormwater Management Strategy Components

Table 1 below reiterates the stated Stormwater Management components and includes a comment in relation to these initiatives by Stormy Water Solutions.

Table 1 Comments of Adopted Stormwater Management Components

Stormwater Management Component	Stormy Water Solutions Comments
Retention and restoration of the Armstrong Creek waterway and floodplain as an environmental corridor.	Consistent with current best practice.
A network of tributary pipelines arranged to best suit asset treatment locations and land ownership boundaries.	Consistent with the principle of development of Development Services Schemes (Melbourne Water Corporation)
A network of sediment basins and wetlands located on line to tributary pipe drainage systems and integrated with the Armstrong Creek floodplain corridor.	Consistent with current best practice. Wetland and Sediment pond concept design plans appear consistent with "Constructed Wetland Guidelines, Melbourne Water 2010". Wetland areas are dual purpose - flood retardation and stormwater pollutant retention roles are ensured.
Provision of a pipe bypass system on both sides of Armstrong Creek, linking the various sediment basins and wetlands so that existing creek hydrology in ACWP can be protected as far as practicable from altered hydrology.	Strategy does protect the remnant section of Armstrong Creek upstream of the Surf Coast Highway. The Strategy consistent and complementary to the adopted strategy downstream of the Surf Coast Highway.
Connection of creek bypass flows to the “bridge pool” at Surf Coast Highway from whence it is to be connected back into the pipe diversion on the south side of the creek in the ACEP. This pipe directs development drainage low flows to treatment systems downstream of Horseshoe Bend Road. Hence the ACWP and ACEP assets effectively retain protection for the whole remnant reach of Armstrong Creek as an integrated system.	Strategy does protect the remnant section of Armstrong Creek upstream of the Surf Coast Highway. Strategy consistent and complementary to the existing adopted strategy downstream of the Surf Coast Highway.
Enhanced floodplain storage created by a culvert restriction under the proposed north-south road crossing midway between Airport Road and Surf Coast Highway.	A standard procedure used to maximise flood storage in natural reaches without impacting on the existing geomorphology of the creek.
Enhanced protection of Surf Coast Highway from flooding via provision of a low barrier along the ACWP frontage.	A drainage component which ensures an advantageous result to both Council and Vic Roads.

As detailed within Table 3, Stormy Water Solutions considers that the adopted strategy is robust and addresses all objectives detailed in Section 3 above. It is a very good example of a drainage strategy which clearly aims to ensure **ALL** objectives of Water Sensitive Urban Design are met, often within one drainage element (such as a wetland). For instance the wetland systems will incorporate flood retention, stormwater pollutant retention, ecological enhancement of the local area and landscape enhancement of the local area.

The concept design of all elements appears to have fully considered these WSUD duel benefits in hand with the objectives detailed in Section 3 and the site constraints (flora/fauna communities and cultural heritage sites etc).

Stormy Water Solutions considers that the proposed Stormwater Management strategy should ensure that the final development will meet all “engineering” objectives, while offering the opportunity for major ecological enhancement of Armstrong Creek and its surrounds.

The remainder of this report reviews in more detail the hydrological and hydraulic models and the results used to assess the proposed strategy detailed above.

5. RORB Model Review

Water Technology has used RORB to calculate input hydrographs for the MIKE Flood Model. Stormy Water Solutions has reviewed the “Developed” conditions model (which was based on the original “Existing Conditions” CMA model).

RORB modelling is detailed in the “Armstrong Creek, West Precinct Structure Plan, Flooding Investigations, Water Technology October 2011” report. Stormy Water Solutions also investigated the actual RORB File (ArmstrongSept11.catg) and checked the RORB subarea and reach plan as provided by Water Technology.

The review was not intended to inspect every aspect of the modelling process (that is, as in a quality control exercise). Rather the intent is to assess if input parameter values are reasonable (given the strategy detailed) and if output values are realistic. Parameters such as catchment areas and reach lengths have not been checked in detailed, however random checks of these parameters has been performed to gain overall confidence that the modelling process has been robust and prudent.

Table 2 below details the results of the review.

As detailed in Table 2 below, Stormy Water Solutions considers that the RORB model developed will produce inflow hydrographs which are suitable for input into the MIKE Flood model.

Table 2 RORB Model Review

Input Parameter/ Results	Value	Appropriate Parameter/ Result?	Comments
Total Catchment Area to Surf Coast Road	14.4 km^2	✓	Checked roughly against catchment plan
Fraction Imperviousness	0.6 - 0.65 for PSP classifications of residential land	✓	Consistent with current 2010 MWC MUSIC Guidelines and MUSIC model developed by Neil Craigie
Reach types	In general: "Natural" - Creek, "Pipes" in development, "Drowned" for wetlands	✓	Consistent with development proposals and should produce realistic results
Catchment Delineation	N/A	✓	Consistent with development proposals and proposed drainage strategy (i.e. link pipes and wetland systems servicing development prior to discharge to the creek upstream of Surf Coast Highway).
Kc and m	Kc =7.32 - Developed Conditions m = 0.8	✓	Within range advocated by MWC and Australian Rainfall and Runoff. Kc/Dav ratio conversion from existing conditions model is appropriate.
C_{perv}	100 yr - 0.6 10 yr – 0.35 5 yr – 0.25	✓	C_{perv} consistent with current MWC advice.
Rainfall Data	IFD parameter input into ARR Volume 2 as defined in report	✓	Consistent with parameter set as required by Bureau of Met. for an area south of Geelong.
Predevelopment Design flow	24 m^3/s at surf Coast Highway	✓	Probably conservative in regard to ensuring post development flow is less than predevelopment flow. Department of Conservation and Natural Resources' 1% flood flow versus catchment area equations/curves (Reference: Hydrological Recipes, Estimation Techniques In Australian Hydrology, 1996) suggest a value of in the order of 35 m^3/s may be what could typically be expected in a catchment of this size.

6. MIKE Flood Model Review

Water Technology has used MIKE Flood (a combination of MIKE 11 and Mike 21) to:

- Determine the flood extent under developed conditions,
- Determine the flood levels under developed conditions,
- Determine flood velocities under developed conditions,
- Determine the flood retardation effect afforded to all proposed wetland systems and the flood storage areas on Armstrong Creek.

MIKE Flood modelling is detailed in the "Armstrong Creek, West Precinct Structure Plan, Flooding Investigations, Water Technology October 2011" report. Again, the review what not intended to inspect every aspect of the modelling process (as in a quality control exercise). Rather the intent is to assess if input parameter values are reasonable (given the strategy detailed) and if output values are realistic.

Table 3 below details the results of the review.

As detailed in Table 3 below, Stormy Water Solutions considers that the MIKE Flood model developed can adequately predict 100 Year ARI flood levels adjacent to Armstrong Creek and the proposed wetland systems. Council will be required to ensure adequate fill level requirements are set given the flood levels detailed in the Water Technology Report.

The combination of retaining the natural flood plain, adding flood retention areas on Armstrong Creek and using the wetlands as retarding basins results in the peak flow at Surf Coast Highway = 25.3 m^3/s which is 5% greater than the predevelopment flow rate.

A 5% increase in the 100 Year ARI flow is considered to meet the intent of ensuring no increase in the predevelopment flow rate at the Surf Coast highway given:

- The estimated predevelopment flow rate appears relatively low when compared with "rule of thumb" check and as such restricting post development flow to this value is probably a conservative assumption in this case,
- The site constraints of limiting excessive head losses over major culvert systems (as is good hydraulic design practice), and
- The probable use of tanks within the development (as advocated by the developer) which should further aid in retarding flood flows.

Table 3 MIKE Flood Model Review

Input Parameter/ Results	Value	Appropriate Parameter/ Result?	Comments
Use of a 2 two dimensional model to use as the assessment tool for both flood level determination and flood mitigation attributed to all off line and on line retarding basins	N/A	✓	Appropriate Use of MIKE FLOOD model. Verbally Water Technology confirmed Lidar information used to define waterway etc, with manual input of wetland modification etc. Water Technology has indicated that the Lidar information was consistent with detailed site survey information
Mannings n - watercourse and flood plain	0.075	✓	Consistent with natural, shallow watercourse exhibiting scrub/sedge understory and a large amount of trees in the flood plain.
Mannings n - wetland areas	0.05	✓	Consistent with roughness associated with a well drowned vegetated system as per the recommendations in WSUD Engineering Procedures, CSIRO, 2005.
Flood Level Determination	N/A	✓	Figure 3.6 details flood levels which is in form which can be used by council to set final flood and fill levels etc.
Creek Culvert Design	Varies as defined in report	✓	Culvert sizes detailed result in very little retardation upstream of western culvert and retardation consistent with stated head loss upstream of the Eastern culvert and Surf Coast Highway.
Flood Retardation Effect	N/A	✓	Combination of retaining the natural flood plain, adding two flood retention areas on Armstrong Creek and using the wetlands as retarding basins results in the peak flow at Surf Coast Highway = 25.3 m^3/s which is 5% greater than the predevelopment flow rate.

7. MUSIC Model Review

Neil Craigie has used the MUSIC model to:

- Determine is the proposed drainage strategy elements can treat the ACWP to current best practice, and
- Determine the required link pipe capacities (i.e. low flow bypass of Armstrong Creek) between wetland systems to ensure protection of the environmental flow rates both upstream of the Surf Coast Highway.

The MUSIC modelling is detailed in the "Stormwater Management Strategy, Neil M Craigie, October 2011," report. Stormy Water Solutions also investigated the actual MUSIC File (ACWP SWMS Sep 11 Trial 1974 6 min.sqz). As above, the review what not intended to inspect every aspect of the modelling process (as in a quality control exercise). Rather the intent is to assess if input parameter values are reasonable (given the strategy detailed) and if output values are realistic.

Table 4 below details the results of the review.

As detailed in Table 4 below, Stormy Water Solutions considers that the MUSIC model has been adequately constructed and is representative of the physical drainage strategy as described. The results indicate that the proposed drainage strategy can meet the two objectives detailed above.

Table 4 MUSIC Flood Model Review

Input Parameter/ Results	Value	Appropriate Parameter/ Result?	Comments
Catchment areas and Fraction imperviousness	Consistent with RORB model	✓	
Catchment area Pervious area soil models	Soil storage capacity = 30 mm, Field Capacity = 20 mm	✓	Consistent with the MUSIC manual definition for Melbourne Catchments, and consistent with "MUSIC Guidelines, Recommended input parameters and modelling approaches for MUSIC users, December 2010, Melbourne Water Corporation"
Pollutant Generation parameters	MUSIC default values	✓	Consistent with "MUSIC Guidelines, Recommended input parameters and modelling approaches for MUSIC users, December 2010, Melbourne Water Corporation"
Wetland Areas		✓	Appear consistent with concept design plans and consistent with report.
Wetland Extended Detention	0.5 m	✓	Within range specified within "MUSIC Guidelines, Recommended input parameters and modelling approaches for MUSIC users, December 2010, Melbourne Water Corporation"
Wetland Extended Detention time	50 - 55 hours	✓	Less than the 72 hours specified within "MUSIC Guidelines, Recommended input parameters and modelling approaches for MUSIC users, December 2010, Melbourne Water Corporation". However appropriate given the strategy largely consists of wetlands in series.
Sediment Pond Definitions	500 - 750 m^2	✓	Sizes Consistent with retention and cleanout requirements as specified in "WSUD Engineering Procedures, CSIRO, 2005".
Bypass Definitions	N/A	✓	Modelled appropriately to ensure protection of the remnant section of Armstrong Creek. Link pipe bypass definition produce the pipe and overflow volumes as detailed in Table 2.
Rainfall Definition and reference year	Geelong 1974	✓	578 mm/yr consistent with Geelong Average Rainfall.
Model Pollutant Retention Results	82% retention of TSS, 67 % retention of TP and 45 % retention of TN	✓	Model run by Stormy Water Solutions. Results exported match with those detailed in Table 3.
Model Pollutant Environmental Flow Results	Flow in Armstrong Creek (upstream of Surf Coast Road) is less than the predevelopment annual flow volume.	✓	Model modified by Stormy Water Solution to assess undeveloped flow volume and post development volume in the creek. Consistent with results quoted by Neil Craigie.

8. Concluding Remarks

Stormy Water Solutions considers that the proposed ACWP Stormwater Management Strategy is robust and addresses all objectives detailed in Section 3 above. It is a very good example of a drainage strategy which clearly aims to ensure **ALL** objectives of Water Sensitive Urban Design are met.

The proposed drainage strategy incorporates flood retention, flood protection, stormwater pollutant retention, ecological enhancement of the local area and landscape enhancement of the local area. The concept design of all elements appears to have fully considered these WSUD duel benefits in hand with the objectives detailed in Section 3 and the site constraints (flora/fauna communities and cultural heritage sites etc).

Stormy Water Solutions considers that drainage infrastructure opportunities and constraints have been appropriately identified in this case. The overall stormwater management strategy contains sufficient flexibility and can allow variation in the functional and detailed design phases of the project to suit actual circumstances and development of subdivisional design. The proposed Stormwater Management Strategy offers the opportunity for major ecological enhancement of Armstrong Creek and its surrounds.

The hydrological and hydraulic models used to assess the strategy (RORB, MIKE Flood and MUSIC) have been reviewed by Stormy Water Solutions. It is considered that the models have been applied prudently and to current guideline recommendations. Results are considered realistic and indicate the proposed drainage strategy can meet all “engineering” objectives detailed in Section 3.