# Sunshine Coast Council – Local Government Infrastructure Plan (Stormwater)

# Supporting Material

This report was prepared by a representative of Switchback 48 Consulting

Switchback 48 Consulting
PO Box 151
CALOUNDRA QLD 4551

Telephone: +61 408 725 826
Email: leon@switchback48.com.au

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# Contents

# 1. Background and Context

Sunshine Coast Council (SCC) is currently revising the network planning supporting the Local Government Infrastructure Plan (LGIP) for trunk stormwater quality infrastructure. Underpinning this work are fundamental assumptions about the costs and treatment performance of the trunk infrastructure.

The categories of trunk stormwater infrastructure identified in the LGIP are:

- Wetlands and Bioretention
- Gross Pollutant Traps (GPT's)
- Swales and Vegetated Channels
- Riparian Rehabilitation

This report utilises current best-practice modelling techniques and information about construction costs to quantify treatment performance (in terms of treatable area) and identify appropriate *replacement values* for each of the identified treatment technologies. This is undertaken for the three catchment scales adopted by the LGIP, being *small, medium and large*.

## 2. Methodology

The LGIP network planning assumes that a catchment is effectively treated if it is provided with any one of the four technologies (i.e. GPT, bioretention/wetland, swale or riparian). In order to determine the impervious area which can be treated for a given cost/replacement value a consistent basis for sizing these devices/technologies needs to be established. This needs careful consideration as each technology has different spatial requirements, performs differently and has differing costs of pollution abatement at different catchment scales.

The Sunshine Coast Planning Scheme 2014 specifies performance targets for new developments which are percentage load reduction targets. These numerical targets would be inappropriate as a blanket approach for sizing the technologies for the LGIP planning as:

- The targets would result in some technologies being well beyond their maximum cost effectiveness in terms of dollars per mass of removed pollution – and would therefore result in an inefficient spend of collected contributions
- The targets are unattainable for some technologies
- Full achievement of the targets would require a spatial footprint for some technologies which is impractical in many existing urbanised catchments

Instead the sizing criteria (and hence treatable impervious area) were considered and are documented separately for each technology based on the physical characteristics of the technology and ensuring treatment performance is optimized having due regard to the economic performance of the technology. This approach is consistent with the stated standards of service for the Stormwater Trunk network which is acknowledged as contributing to the load reductions stated in the Planning Scheme but not necessarily fully achieving these for each catchment.

The methodology used to determine replacement costs for each technology is therefore summarised as follows, with further detail in the report sections relating to each technology.

### 2.1 Bioretention/Wetlands

Each device (bioretention and wetlands) was sized and costed separately using MUSIC and unit rates. For the purposes of LGIP planning, it would be conservative (maximum cost) to size these devices to achieve the pollutant load reduction targets of the planning scheme. However it will be rare for space to be available for full-sized bioretention/wetlands in retrofit situations and it is also recognized that bioretention and wetlands are more cost-effective (in terms of cost per mass of removed pollution) at smaller scales. Therefore, an analysis was also undertaken to determine a more ‘economic’ sizing criteria for these devices and corresponding treatable impervious catchment areas were also determined according to this criteria.

## 2.2 GPT's

These devices are sized based on a treatable flowrate which is typically selected as the flowrate which will ensure treatment of 90% of the annual average runoff volume. While this could be determined in MUSIC, it is more accurate to determine design flowrates using the Rational Method due to MUSIC's poor representation of peak flows. A series of case studies for 'typical' Sunshine Coast catchments were therefore undertaken to determine the required treatable flowrate for each of the 3 nominated catchment scales, based on the Rational Method. The treatable flowrates were then be used to size/select GPT's and compare prices to those obtained (supply only) from a range of manufacturers.

## 2.3 Swales and Vegetated Channels

The sizing and hence costs of swales can vary significantly depending on whether there is a stormwater conveyance function in addition to the primary stormwater quality function. For example, swales within roadways require a fairly small capacity to fulfill a stormwater quality function but significantly greater capacity is required to meet the minor/major event criteria of QUDM associated with flow within the roadway. The context of the swale use is therefore important. For this assessment it has been assumed that the swale retrofit projects will occur within parks or other council land where the swale capacity is only required to fulfil a stormwater quality function. Swale lengths were estimated using the limits of cost-effective sizing identified in relevant guidelines.

## 2.4 Riparian Rehabilitation

Both the costs and pollution abatement of riparian restoration works are known to vary significantly depending on the specifics of the project. A literature review was undertaken to determine available data on both the equivalency of riparian works to other treatment options and also typical costs of works. From these figures, estimates were derived of the equivalent impervious area which is treated.

# 3. Wetlands and Bioretention

The LGIP network planning includes bioretention and wetlands as a common inter-changeable technology. Both are examined separately in this report.

Indicative sizing for bioretention and wetland devices has been derived by developing performance curves using the software MUSIC. The model parameters were selected in order to reflect the fact that most of the existing urban density (and hence most of the retrofit LGIP projects) are likely to occur in the coastal areas of the Sunshine Coast. The adopted parameters were based on the recommended parameters of the *MUSIC Modelling Guidelines* (Water by Design, 2010) for the Sunshine Coast as follows:

- Rainfall was based on 6-minute rainfall data for Caloundra WTP for the period 1/1/1997-31/12/2006, as recommended for the eastern regions of the Sunshine Coast
- A fraction imperviousness of 60% was adopted, which is higher than the recommended range of 45-55% for residential areas so-as to allow a measure of conservativeness and allow for the presence of some commercial or industrial within the retro-fit catchments
- Rainfall-runoff and pollutant-export parameters were specified consistent with a predominantly urban residential landuse

Varying bioretention and wetland sizes were then run through the model in order to establish how pollutant reduction performance varies with device size. In the case of bioretention, results were obtained for extended detention depths of both 0.1m (reflecting at-source streetscape devices) and 0.3m (representing larger end-of-line devices). For bioretention devices the limiting pollutant was fund to be TSS, while for wetlands the limiting pollutant was TN.

These performance curves are shown in Figures 3.1 and 3.2 and show that in order to achieve the load reduction targets specified in the SCC Planning Scheme 2014, the following devices sizes are required:

- Bioretention basins sized at approximately 1% of the contributing catchment area
- Wetlands sized at approximately 7% of the contributing catchment area.

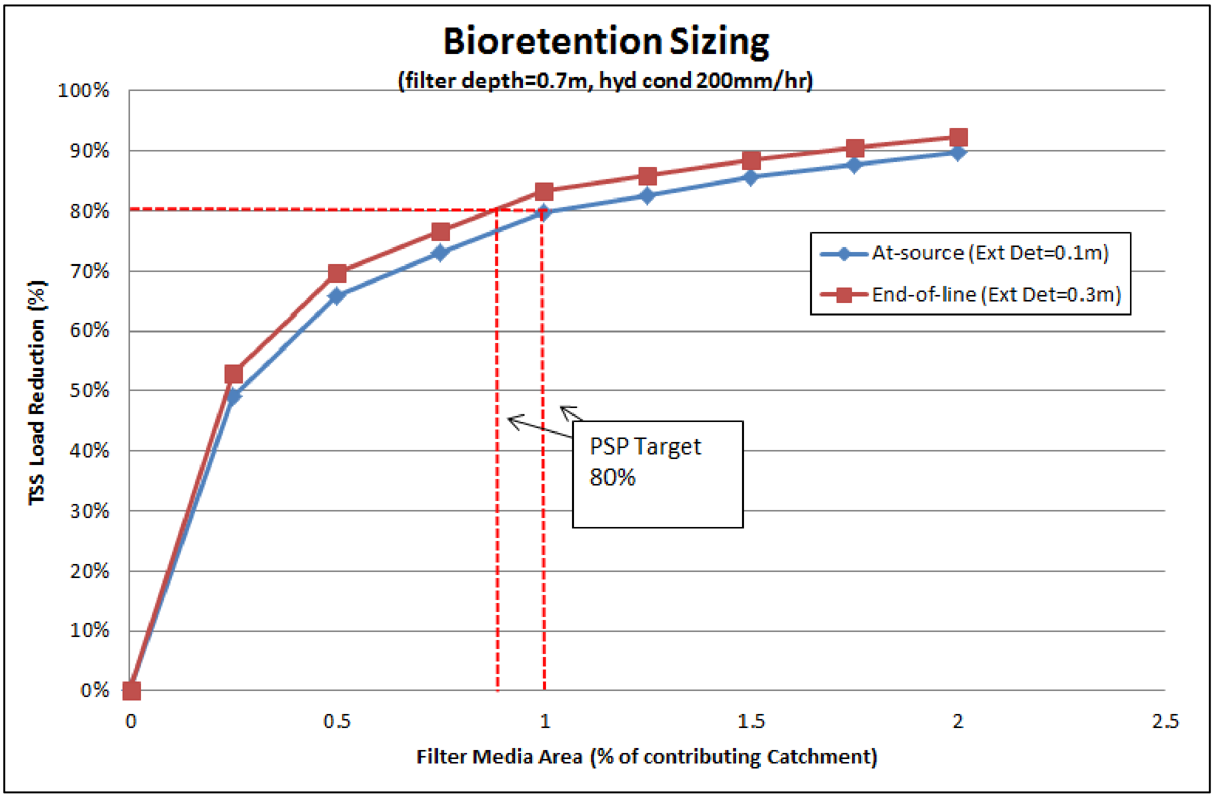


**Figure 3.1 – Bioretention Performance Curves**

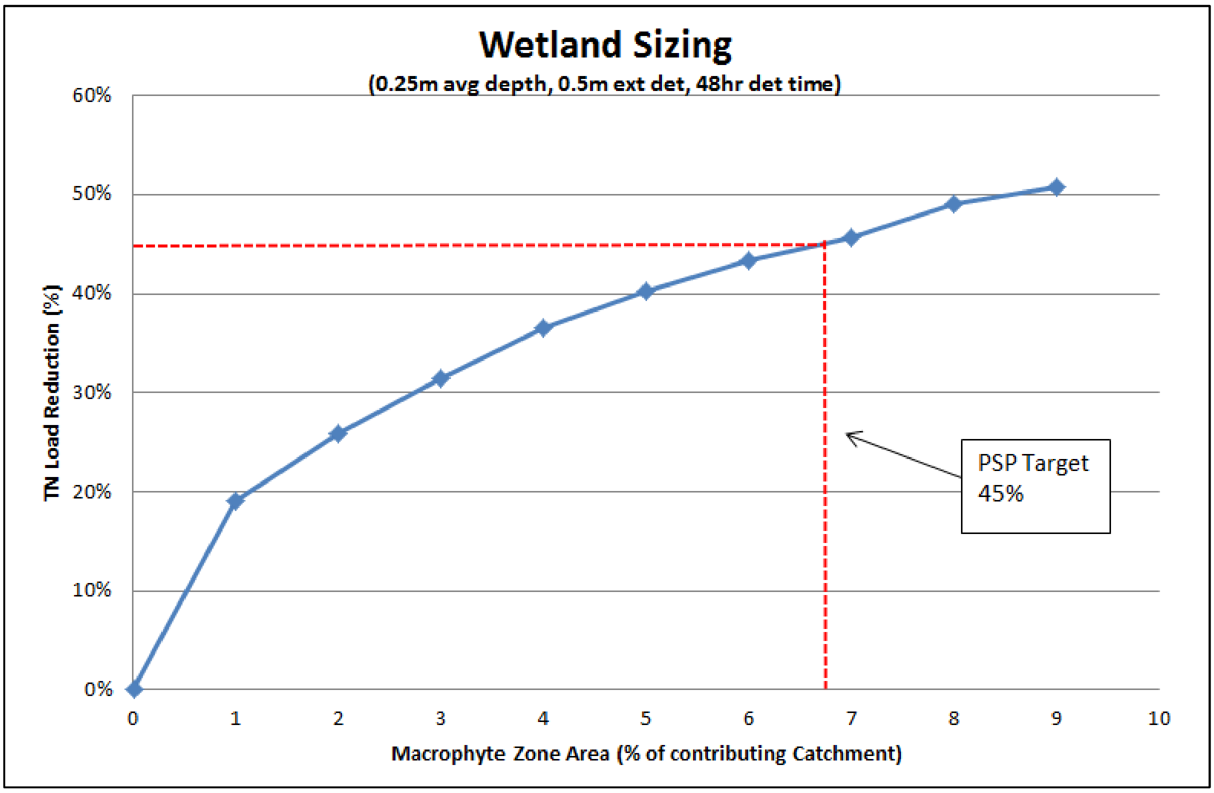


**Figure 3.2 – Wetland Performance Curves**

Retrofit opportunities for wetlands which are sized to achieve the full SCC Planning Scheme 2014 targets are likely to be rare. It is also worth examining whether the planning scheme targets result in the most cost-effective spend of collected contributions. In order to answer this question pollution abatement cost curves were derived for both bioretention and wetland devices. These curves look at the cost of removed pollution at different device sizes. These curves were derived using the performance curves of Figures 3.1 and 3.2 combined with construction unit rates provided by Water by Design (2014) in the *Off-Site Solutions Discussion Paper*, which are:

- $300/m2 for bioretention
- $100/m2 for wetlands

The resulting pollution abatement cost curves are shown in Figures 3.3 and 3.4. From these curves it can be seen that the marginal cost of pollution abatement rapidly increases for device size above 3% of catchment for wetlands and 0.5% of catchment for bioretention. These values therefore represent upper-limits for the economic provision of this infrastructure and are hereafter referred to as the ***"economic sizing criteria"***. In other words, bioretention and wetland devices provide a more economical removal of pollution when sized at approximately 50% of the size required by the SCC Planning Scheme 2014. Adopting this sizing criteria can potentially maximise the overall pollution removal achieved by the pool of funds collected through the LGIP and maximise outcomes for the community.

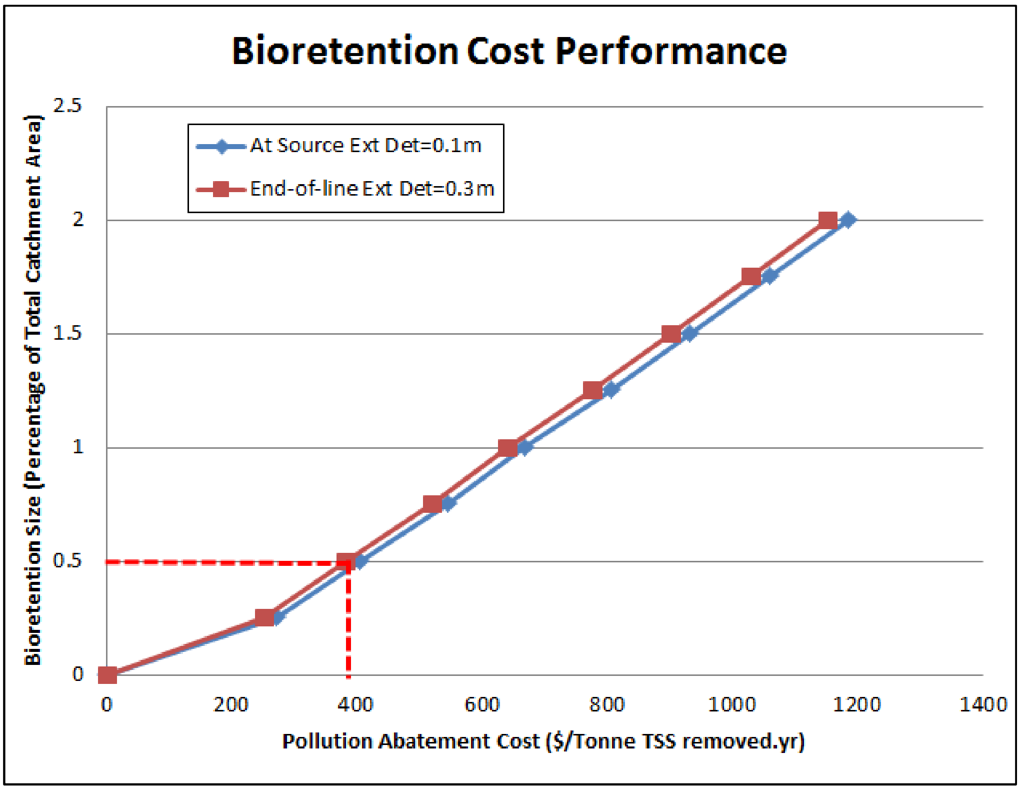


**Figure 3.3 – Pollution Abatement Cost Curves for Bioretention**

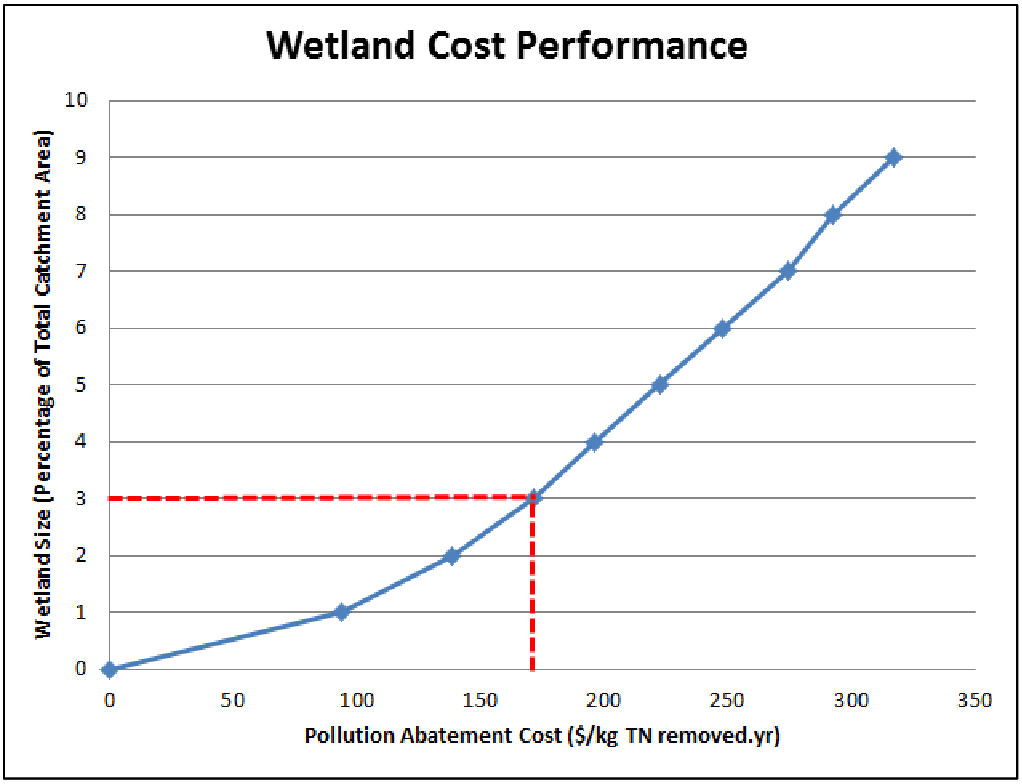


**Figure 3.4 – Pollution Abatement Cost Curves for Wetlands**

Based on the above construction unit rates and sizing criteria, it is possible to determine the amount of contributing catchment which a device can treat given an available quantity of funds. For the LGIP network planning the following replacement values have been specified for each catchment scale:

- Small: $65,000
- Medium: $300,000
- Large: $1,500,000

For each replacement value the following process was followed:

1. Replacement value was divided by construction unit rates to determine area of bioretention or wetland
2. Bioretention/wetland area was then divided by the percentage sizing criteria to establish total contributing catchment area
3. Contributing catchment area was multiplied by fraction imperviousness to get impervious catchment area
4. The process was repeated for each replacement value and for each of the sizing criteria (i.e. either size required for full compliance with Planning Scheme targets or the economic sizing criteria)

The results of that analysis are shown in Table 3.1

**Table 3.1 – Maximum Impervious Area Catchments by Device and Catchment Scale**

| Catchment Scale | Replacement Value | Impervious catchment area based on meeting Planning Scheme Targets (Ha) | | Impervious catchment area based meeting economic sizing criteria (Ha) | |
|---|---|---|---|---|---|
| | | Bioretention | Wetland | Bioretention | Wetland |
| **Small** | $65,000 | 1.3 | 0.6 | 2.6 | 1.3 |
| **Medium** | $300,000 | 6.0 | 2.6 | 12.0 | 6.0 |
| **Large** | $1,500,000 | 30.0 | 12.9 | 60.0 | 30.0 |

Based on the above results, the recommended impervious catchment areas for each catchment scale and the nominated replacement costs are provided in Table 3.2.

**Table 3.2 –Recommended Impervious Area Catchments**

| Catchment Scale | Replacement Value | Impervious Area of Catchment Treated |
|---|---|---|
| **Small** | $65,000 | 1Ha |
| **Medium** | $300,000 | 6Ha |
| **Large** | $1,500,000 | 30Ha |

# 4. Gross Pollutant Traps (GPTs)

The primary function of gross pollutant traps is to remove floatable and non-floatable anthropogenic debris and coarse sediment. Within a locality such as the Sunshine Coast, where a high value is placed on waterway amenity and recreation, the removal of a high proportion of floatable debris is of particular importance.

The Sunshine Coast Planning Scheme 2014 identifies a target for new development of 90% load reduction of all gross pollutants greater than 5mm in diameter. All major GPT manufacturers have claimed efficiencies for removal of 5mm material approaching 100% for flows up to the design flowrate. Essentially this criterion therefore requires GPT's to be sized with a treatable flowrate capable of treating 90% of the average annual runoff volume. This target is also considered an appropriate and achievable design standard for retro-fit projects as part of the LGIP due to:

1. The importance of anthropogenic litter to waterway amenity and recreation
2. The low spatial requirements of GPTs which place few restrictions on their location

Engineers Australia (2006) identify that 90% of the average annual runoff volume is able to be treated by having a design flowrate equivalent to a flow having a return period of 1 in 3 months. This flowrate is commonly approximated as half the 1 in 1yr ARI flow and is used by GPT manufacturers to size devices.

For the LGIP network planning the following impervious catchment areas have been specified for GPT's for each catchment scale:

- Small: 5Ha
- Medium: 15Ha
- Large: 30Ha

In order to determine a GPT replacement value for each scale, the Rational Method was used to calculate the $Q_{3\text{-month}}$ for 'typical' coastal urban catchments on the Sunshine Coast. The resulting treatable flowrates were then compared to the unit-prices supplied by 2 major GPT manufacturers in order to determine a range of replacement values, with the results provided in Table 4.1.

**Table 4.1 – Cost Range Associated with Typical Coastal Urban Catchments**

| Impervious Area of Catchment (Ha) | Total Catchment (Ha) | $Q_{3month}$ ($m^3/s$) | GPT Unit (Humegard/Cleansall) | Indicative Unit Supply Costs ($) |
|---|---|---|---|---|
| 5 | 8 | 0.6 | HG18/KA750 | $25,500-$47,000 |
| 15 | 25 | 1.9 | HG45/KA1200 | $89,000-$122,000 |
| 30 | 50 | 3.2 | NA | NA |

It can be seen in Table 4.1 that at a total catchment size of 50Ha the treatable flowrate is greater than that catered for by any of the available GPT units. For this catchment size (50Ha) it was therefore assumed that treatment would be provided by two units corresponding to the 'medium' catchment scale. From these results the following recommended replacement values for each impervious catchment value were determined as nominated in Table 4.2.

**Table 4.2 –Recommended Replacement Values – GPT's**

| Catchment Scale | Replacement Value | Impervious Area of Catchment Treated |
|---|---|---|
| **Small** | $38,000 | 5Ha |
| **Medium** | $110,000 | 15Ha |
| **Large** | $220,000 | 30Ha |

In order to value the existing stormwater quality network, it is also necessary to categorise the existing GPT models into either 'small, 'medium' or 'large'. The list of existing GPT models installed was obtained from SCC and were categorised according to the treatable flowrate of each model as supplied by the manufacturer. The categorisation was based on the treatable flowrate for each catchment scale derived in Table 4.1. The results are shown in Table 4.3.

**Table 4.3 – Existing GPT Network Categorisation**

| Unit | No. Devices | Category |
|---|---|---|
| CDS 3000 | 1 | GPT-M |
| CDS P0708 | 8 | GPT-S |
| CDS P1009R | 21 | GPT-S |
| CDS P1012 | 2 | GPT-S |
| CDS Unit | 2 | GPT-M |
| Cleansall | 13 | GPT-M |
| Cleansall 1200 | 8 | GPT-M |
| Cleansall 375 | 38 | GPT-S |
| Cleansall 600 | 72 | GPT-S |
| Cleansall 750 | 38 | GPT-S |
| Cleansall 900 | 40 | GPT-M |
| Cleansall 900L | 1 | GPT-M |
| Downstream Defender | 5 | GPT-M |
| GPT | 1 | GPT-L |
| HG12 | 2 | GPT-S |
| HG15 | 1 | GPT-S |
| Humeceptor | 14 | GPT-S |
| Humeceptor STC18 | 2 | GPT-M |
| Humeceptor STC2 | 5 | GPT-S |
| Humeceptor STC3 | 2 | GPT-S |
| Humeceptor STC4 | 2 | GPT-S |
| Humeceptor STC5 | 1 | GPT-M |
| Humeceptor STC7 | 2 | GPT-M |
| Humegard | 2 | GPT-S |
| Humegard HG 12 | 2 | GPT-S |
| Humegard HG 15 | 1 | GPT-S |
| Humegard HG 18 | 9 | GPT-S |
| Humegard HG 24 | 1 | GPT-M |
| Humegard HG 45 | 1 | GPT-M |
| Humegard HG12 | 2 | GPT-S |
| Humegard HG12/HG12A | 1 | GPT-S |
| Humegard HG12A | 2 | GPT-S |
| Humegard HG15 | 1 | GPT-S |
| Humegard HG15/HG15A | 1 | GPT-S |
| Humegard HG18 | 7 | GPT-S |
| Humegard HG24 | 4 | GPT-M |
| Humegard HG27 | 3 | GPT-M |
| Humegard HG35 | 1 | GPT-M |
| Humegard HG35A | 2 | GPT-M |
| Humegard HG45 | 2 | GPT-M |
| Humegard HG45A | 3 | GPT-M |
| Q-Guard A1 | 1 | GPT-S |
| RSF4300 | 14 | GPT-S |

| | | |
|---|---|---|
| RSF4450 | 9 | GPT-S |
| RSF4600 | 6 | GPT-S |
| RSF4600 (TBC) | 1 | GPT-S |
| RSF4750 | 2 | GPT-M |
| RSF6000 | 5 | GPT-M |
| Stormceptor | 7 | GPT-L |

# 5. Swales and Vegetated Channels

This category includes both swales and vegetated channels. In a retro-fit context, these devices are likely to be implemented in the following ways:

1. Swales are shallow grass-lined channels with grades of 1-4% and catchment areas not exceeding 2Ha (Water by Design, 2006). The reason for these limitations is to restrict velocities within the swale such that sedimentation is effective and erosion of the swale from excessive velocities does not occur. Swales are likely to be implemented either to replace or supplement an existing pipe system or table drain or to provide treatment for a new small-scale capital works project such as a carpark.
2. Vegetated channels in this context are likely to be implemented at larger scales than swales in order to replace or rectify an existing open channel flowpath that is eroding and/or which has low ecological function.

The performance and costs of traditional grassed swales can be determined using MUSIC software. For vegetated channels, the best estimates of both cost and efficacy are provided according to the 'riparian rehabilitation' estimates provided in Section 6.0. The 'large' catchment scale values in Table 5.1 are therefore estimated using the riparian methodology and are not discussed further here.

For the 'small' and 'medium' catchment scales the following replacement values have been nominated:

- Small: $10,000
- Medium: $50,000

MUSIC provides the following algorithm to estimate total acquisition/capital cost for swales:

*TAC ($ 2004) = 387.4 * A* $^{0.7673}$

*Where A= Surface area of swale at top width*

This algorithm was adjusted to account for CPI in order to bring the estimates into current-day dollars and has been used to determine an area corresponding to each replacement value as follows:

- Small: corresponding swale area of 33m$^2$
- Medium: corresponding swale area of 262m$^2$

Water by Design (2006) identify that the economic limit of performance of swales is at 0.5% of the total contributing catchment area, even though at this size the pollutant load reduction targets of the Planning Scheme will not be met for all pollutants. Based on this sizing ratio and multiplying by the assumed imperviousness of the retro-fit catchments (i.e. 60%) the equivalent treatable impervious areas in Table 5.1 were derived. It should be noted that the treatable area for the 'medium' scale is beyond the usual upper limit for swales and in practice would be implemented as either a number of individual swales servicing smaller catchments or as a vegetated channel.

**Table 5.1 - Recommended Impervious Area Catchments for Swales and Vegetated Channels**

| Catchment Scale | Replacement Value | Impervious Area of Catchment Treated |
|---|---|---|
| **Small** | $10,000 | 0.4Ha |
| **Medium** | $50,000 | 3.1Ha |
| **Large** | $150,000 | 5-10*Ha |

*A range is provided due to the uncertainty associated with riparian rehabilitation

# 6. Riparian Rehabilitation

In this context, riparian rehabilitation refers to works which range in scale from revegetating and restricting access to the riparian corridors adjacent to waterways, through to works that involve extensive re-profiling/battering or rock armouring of channels.

It must be acknowledged up-front that there is a lack of reliable data validating the efficacy of riparian rehabilitation to improve water quality within waterways (Water by Design, 2014; CSIRO, 2014). While monitored reductions in sediment yield of 30-90% have been reported in some studies, CSIRO (2014) noted that almost as many studies showed no improvement. This lack of reliability is a significant consideration in determining whether to include this technology in the LGIP.

Arguably, this lack of reliability could be considered sufficient justification for not including riparian revegetation in stormwater offsets schemes, or at least limiting its use such that it is not the dominant offset mechanism. This is because offset schemes seek to replace an on-site technology with proven efficacy (e.g. bioretention) with a regional solution. In that context the lack of reliable efficacy plus the significant time delays until it becomes effective would make riparian rehabilitation undesirable as the dominant offset solution.

The LGIP is different to an offset scheme however as it does not replace on-site obligations and hence reliable efficacy and temporal considerations are not as critical. There are also significant multiple-benefits from riparian revegetation such as creating ecological corridors and landscape enhancement which make it both desirable and appropriate for consideration as part of the LGIP.

As noted previously, efficacy and costs of riparian rehabilitation works vary considerably in the literature. The recent work by Olley et al (2015) has been the basis for recent policy and implementation work by proponents of riparian work such as SEQ Catchments and Ipswich City Council and is used cautiously here. The main issue with the work of Olley et al (2015) is that it uses field monitoring of existing catchments (vegetated and unvegetated) to surmise that by revegetating riparian zones in cleared catchments, the same benefits will be achieved as exist for existing riparian vegetation. This hypothesis has not been adequately tested in practice and the efficacy derived based on this work is significantly higher than indicated in earlier work by Water by Design (2014).

Olley et al (2015) provide the following formula to estimate the load from a catchment with varying proportions of riparian vegetation intact, as follows:

$$L_A = \left(10^{a+b.P}\right)\left(R^c\right)$$

Where;
$L_A$ = Area weighted load (tonnes/km$^2$)
P = proportion of stream network draining remnant vegetation (0-1)
R = Runoff (mm)
a,b,c = regression coefficients

By completing the formula with values of P=1 (fully intact riparian network) and P=0 (no riparian vegetation), the load reduction achieved by fully revegetating a riparian zone having no existing vegetation can be obtained. This yields an estimated load reduction of 8462kg-TSS/Ha.yr.

Olley et al (2015) also identify the total length of stream network (km) and total catchment area ($km^2$) in the study catchments. From these figures a ratio of stream length:catchment area can be derived as 2.1:1. From this ratio, the load reduction achieved per length of rehabilitated stream can be obtained as 398,419kg-TSS/km-stream.yr.

CSIRO (2014) provide indicative rehabilitation costs which vary depending on the level of intervention as between $43,880-$5,143,880/km-stream. Using the higher-end of the cost estimates for conservativeness, a pollution abatement cost for riparian rehabilitation can therefore be established as $12.9/kg-TSS.

From the pollution abatement cost, the load removed for each of the nominated replacement values can be obtained. This load can then be converted into an 'equivalent treated impervious area' by dividing the load removed by riparian rehabilitation by the removal rate of bioretention devices (kg/impervious-Ha). For bioretention devices sized according to the economic criteria in Section 3.0 this removal rate is 2177kg-TSS/impervious-Ha.yr). The resulting figures are provided in Table 6.1.

**Table 6.1 – Equivalent Treated Impervious Areas**

| Catchment Scale | Replacement Value | Riparian Load Removed (kg TSS/yr) | Equivalent Treated Impervious Area (Ha) |
|---|---|---|---|
| **Small** | $50,000 | 3876 | 1.8 |
| **Medium** | $150,000 | 11,628 | 5.3 |
| **Large** | $300,000 | 23,256 | 10.7 |

There is also a need for the LGIP planning to value and quantify the performance of the existing riparian vegetation network. The value of existing riparian vegetation can be obtained using the cost estimates of CSIRO (2014). For valuing the existing riparian vegetation the lower-end estimates have been used. The resulting equivalent existing riparian areas, treated impervious areas, and ratio between the two are provided in Table 6.2.

**Table 6.2 – Existing Riparian Area Equivalency**

| Catchment Scale | Replacement Value | Equivalent Existing Riparian Area (Ha) | Equivalent Treated Impervious Area (Ha) | Ratio Treated Area: Riparian Area |
|---|---|---|---|---|
| **Small** | $50,000 | 11.4 | 1.8 | 1:6 (16%) |
| **Medium** | $150,000 | 34.2 | 5.3 | 1:6 (16%) |
| **Large** | $300,000 | 68.4 | 10.7 | 1:6 (16%) |

Although every effort has been made to provide the most accurate estimates in Tables 6.1 and 6.2, it must again be stated that the data on which these estimates has been based varies hugely in the literature. As such, departure from the values in Table 6.1 and 6.2 by +/-100% would be well within the margins of error and could be considered consistent with this analysis. In particular, adoption of a value in the range of 16-32% for the ratio of (treated area):(riparian area) would be consistent with this analysis.

# 7. Conclusions and Recommendations

The major findings of the study and recommended values for use in the LGIP planning are summarised below according to each grouping of technologies.

**Wetlands and Bioretention**

- Bioretention and Wetland devices for the LGIP are recommended to be implemented at approximately half the size required by the Planning Scheme in order to maximise cost-effective use of the collected charges
- Recommended Treatable impervious areas for each of the nominated catchment scales and replacement values are:
  - Small 1Ha
  - Medium 6Ha
  - Large 30Ha

**GPT's**

- GPT's should be sized with a design treatment flowrate with a return period on 1 in 3 months
- Recommended treatable impervious areas for each of the nominated catchment scales and replacement values are:
  - Small 5Ha
  - Medium 15Ha
  - Large 30Ha

**Swales and Vegetated Channels**

- Recommended treatable impervious areas for each of the nominated catchment scales and replacement values are:
  - Small 0.4Ha
  - Medium 3Ha
  - Large 10Ha

**Riparian Rehabilitation**

- Reported costs and efficacy for riparian works vary hugely in the literature, with little consensus
- Recommended Treatable impervious areas for each of the nominated catchment scales and replacement values are:
  - Small 2Ha
  - Medium 5Ha
  - Large 10Ha
- The above values could be varied by +/- 100% and still be considered consistent with this analysis due to the large uncertainty involved
- A ratio of 'equivalent treated impervious area' to 'existing riparian area' of 16-32% could be used. The adopted value in the LGIP planning of 30% is consistent with this analysis

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