Consultation draft

Environmental Protection Act 1994

Point Source Water Quality Offsets Guideline 2018

Not Government Policy

Queensland Government

Environmental Policy and Planning Division, Department of Environment and Science

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July 2018

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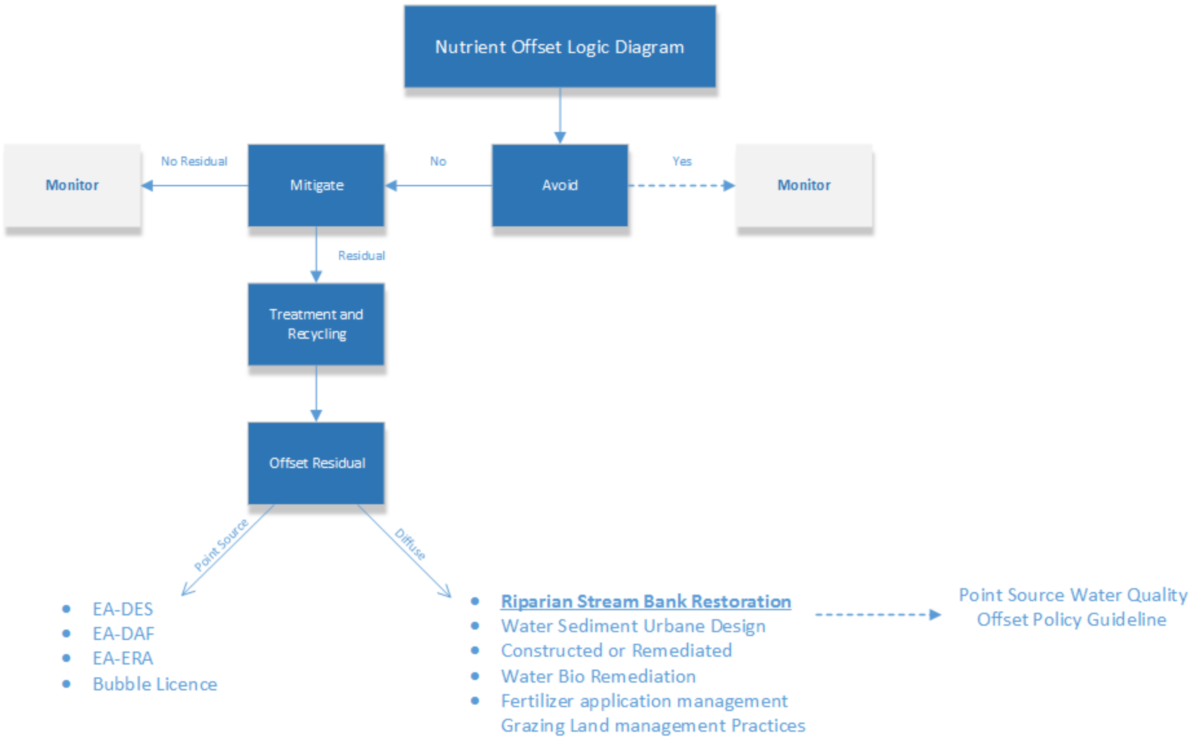
Purpose

The purpose of this guideline is to outline the practical considerations involved in determining an alternative investment option for approved point source operators which uses river restoration approaches to meet water emission discharge requirements under the *Environmental Protection Act 1994* (EP Act) while delivering an improvement in water quality and stream-bank stability.

The guideline is designed to support the Queensland Government's Point Source Water Quality Offsets Policy 2018 (the Policy).

Figure 1 below, outlines the management hierarchy for nutrient and sediment offsets as noted within the Policy, as stated under the *Environmental Protection (Water) Policy 2009* (EPP Water).



Background

The Policy objectives are:

- Deliver a net improvement to catchment receiving waters by providing offset solutions to production increments under existing or new EAs from **environmentally relevant activities (ERAs)**.
- Provide voluntary alternative investment options that may provide more cost effective solutions for ERAs to meet EA conditions.
- Allow for growth and innovative development, while improving water quality across the catchment/sub-catchment receiving waters, depending on the offsets type/location, in accordance with local[1] and national water quality standards[2].
- Maximise ecologically sustainable whole of catchment outcomes under regional planning frameworks; including for example statutory regional plans, Local Government total water cycle

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[1] Refer to Schedule 1 of the *Environmental Protection (Water) Policy 2009*

[2] Under the *Environmental Protection (Water) Policy 2009*, water quality objectives for toxicants at differing levels of aquatic ecosystems protection are stated in the Australian and New Zealand Guidelines for Fresh and Marine Water Quality 2000 (as amended)..

management plans and water quality improvement plans developed by a recognized entity.

- Maximise the benefit of an investment for improved waterway health by co-locating offsets works, where relevant, under this Policy with that required under other legislative or policy instruments.
- Minimise transaction costs and regulatory burden.
- Partner with proponents in developing offsets proposals in accordance with the Policy to provide confidence in the offset approach:
  a. discussing technical requirements including identifying appropriate sites and required site assessments, and
  b. considering joint marketing and publicity to demonstrate the benefits of offsets to the broader environment and affected communities.

To achieve these objectives, the Policy recognises the main classifications of water quality offsets as between two or more point sources managed by the same regulated point source entity (bubble licence), two or more point sources regulated by different regulators (e.g. between a sewage treatment plant point source and another point source), and between a point source regulated entity and a diffuse source provider.

The type of actions that may provide a water quality offset include, for example:

- Riparian streambank restoration,
- Constructed treatment wetlands,
- Bio-remediation technology to further treat wastewater. For example aquaculture farm water bioremediation management to treat pond water before release,
- Improved fertiliser application management above any required minimum standards,
- Improved grazing and other land management practices above any required minimum standards,
- Bio-reactor technology implementation to reduce nutrient emissions to receiving waters,
- Water sensitive urban design (beyond meeting the design objectives under the *State Planning Policy 2017, State Interest Water Quality*)

This guideline primarily provides information on delivering a water quality offset between a point source regulated entity and a diffuse source provider using riparian streambank area restoration.

However an example of a potential offset solution using a wetland approach on a tributary of the Maroochy River in south east Queensland is included and other potential offset solutions are summarised included under **Technical considerations.**

Best practice approaches

Best practice in the *Environmental Protection Act 1994* (EP Act) (Section 5) is defined as the "management of the activity to achieve an on-going minimisation of environmental harm through cost effective measures assessed against the measures currently used nationally and internationally for the activity". Internationally, best management practices (BMP) are used to avoid environmental harm; for example, in Germany lowland catchment areas, point source catchment offsets are used within agricultural practices where a point source can create a mixing zone, leading to point source pollution. The diffuse source of Total Nitrogen (TN), Total Phosphorus (TP) and Total Suspended Solids (TSS) are effectively controlled through the BMP by creating models such as the Ecohydrological soil and water tools model. This ensures best land use management, grazing management practices, field Buffer Strips and a Nutrient management plan states (*L, Q et al* 2011).

Nationally, Australia Uses BMP to reduce its point source pollution (TN, TP and TSS) in riverine and estuarine catchment areas. In the Barrier Reef region, 90% of farmers strive to reach BMP by 2018 (*Commonwealth of Australia 2015* p.39) which will reduce pollution entering the reef lagoon. Strategies such as comparing BMP industry standards and identifying opportunities for improvements are a constant pressure for innovation. There is room for improvement; for example, the 2014 Reef report card outlined that only 13% of the 3,100 farmers in the Reef Catchment met BMP criteria for nutrient and suspended load management *(DEHP* 2015).

In Victoria, Melbourne Water provides storm water quality offsets to target key pollutants such as TN, TP, TSS in catchment, riverine and estuarine areas. Following a set of criteria, the offset is calculated by looking at the concentration in kilograms required to meet BMP. For healthy water the catchment areas larger than 5 Ha must be treated in the area and cannot be treated off-site. The designs for the BMP is developed by specific water quality offset rates. These are based on the combined cost of the works and the reduction in point source pollution and point of concern pollution (*R, S et al* 2006).

With increasing land development and the increase in urbanisation in catchments, the quantity and quality of water and resultant sediment accumulation in downstream urban areas has become more prominent. Therefore, it is important to look at Low Impact Development practices (LID) as this is a type of BMP created by a planning and engineering design method which was applied in managing storm water runoff to reduce flooding as well as simultaneously improve water quality. LID includes techniques to predict suspended solid loads in surface runoff generated over impervious urban surfaces.

A calibrated hydrodynamic model was developed by using (Victorian) Environmental Protection Agency Storm Water Management Model (EPA SWMM) to assist this process. For model calibration and validation, a rain gauge and a flow meter was used in the field and obtained rainfall and flow rate data. By selecting several LID types such as retention basins, vegetative swales and permeable pavements, we can calculate their influence on peak flow rate and pollutant build-up, and wash off for TSS. The LID BMP implementation in watershed, results in a decrease in the peak of the hydrograph and “pollutograph” (TSS) and total amount of surface water and TSS over the catchment (*Gülbaz, S et al* 2015).

Innovative approaches

Innovative approaches on water quality offsets have been used to improve and maintain the environment for riverine and estuarine systems. For example, the Minnesota River basin had 339 contributors to sediment and nutrients loads occurring in their waterways. 80 – 90% of these loads were travelling to the nearby Pepin Lake, where within the last 170 years, sediment loads have increased tenfold. The Minnesota River basin is dominated by grass prairie and wetlands used for agricultural purposes, with 78% of the catchment being flat agricultural land. Many farmers suggested that the high sediment and nutrient loads derived from high level hillslope erosion.

The National Centre for Earth Surface Dynamics (NCED) and Minnesota Government funded a sediment budget analysis which indicated 2880km^2 of the catchment was 70% influenced by eroding hillslopes and banks. By using geochemical tracers in sediment cores from Lake Pepin, a major shift was seen from near channel sediment sources domination from 170 years ago, to the current agricultural field sediment domination where in the mid-twentieth century artificial drainage was created and precipitation increased and amplified near-channel sediment erosion *(Belmont, P* et al 2017).

The innovative approaches taken in this case included the development of a reduced complexity model (RCMs) that focuses on transport and transformation in river systems which indicates the relationship with the agricultural land and the catchment outlet. By identifying geomorphic hotspots and ‘bottle-necks’, priority locations in need of restorative activities were identified. The RCM Morphodynamic model simulates how channels change with flow, sediment supply and the importance of flood flow events and channel adjustments. The model indicates that the instillation of water detention features in only 5% of the land scape could reduce sediment loading by half. Another innovative approach was to reintroduce a small percentage of the original wetland ecosystem which reduced the export of TN, TP and TSS (*Belmont, P* et al 2017).

Furthermore, controlled drainage strategies in agricultural lines such as spatially orientated low-grade weirs show promise to significantly improve nutrient (e.g., nitrate, $NO3^{-}$-N) reductions by expanding the area available for biogeochemical transformations, as well as providing multiple sites for runoff retention. Taking into consideration that certain surface drainage lines are hundreds of meters long with variable slopes, the installation of low-grade weirs within the drainage line at multiple spatial locations within the agricultural landscape created a continuous stepwise increase of water levels that improve retention and control of drainage. This concept provides drainage management on an annual and spatially gradated basis, rather than on a single slotted riser occurring during the dormant season. The location of the weirs has theoretical improvements over the conventional drainage line systems features of the agricultural landscape, and act as major conduits for surface and subsurface nitrogen flows from agricultural lands to receiving waters.

Drainage lines are essential for wetlands as they are the link between agricultural fields and riverine and estuarine waterways (Moore et al 2001). They possess hydric soils, support a diverse community of hydrophytes, and are subject to the unpredictable changes in soil saturation because of hydrological variability. Controlled drainage practices such as flashboard risers (Evans et al 1992), (Gilliam and Skaggs et al 1986), controlled sub-irrigation (Bonaiti and Borin et al 2010) and low-grade weirs (Kröger et al 2008, 2011) within drainage lines have been proposed as best management practices/innovative approach primarily aimed at reducing nutrient concentrations and loads in lines reaching receiving waters by reducing total outflows (Kröger, R et al 2012).

In Queensland, the work to understand sediment sources is well advanced and the main contributors are understood in most of the east coast situations. Work is also underway to better understand the nutrient and sediment story in waterways with ground-breaking research being delivered in partnership with the Department of Environment and Science and the Australian Rivers Institute. In the meantime, the Queensland Government and the Port of Brisbane have encouraged the development of pilot projects to achieve innovative nutrient and sediment outcomes.

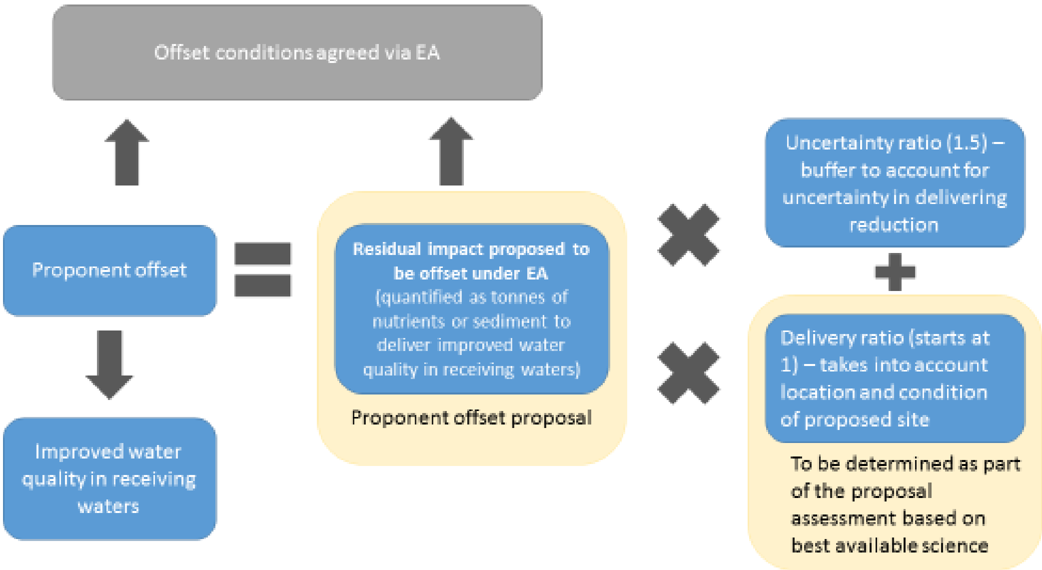
The Beaudesert Pilot Program was the first in Queensland to use the earlier version of the Policy "Flexible options for managing point source water emissions: A voluntary markets based mechanism for nutrient management". The pilot uses an innovative approach to nutrient offsets using point source to diffuse source offsets option in the Policy. The pilot was developed to provide a lower cost alternative to meeting the Beaudesert Wastewater Treatment Plant license conditions using riverbank restoration rather than a more expensive treatment plant upgrade. It identified in the modelling that the total annual sediment load entering the Logan River was 13,771 tonnes/year for the section identified. Soil analysis and in stream modelling techniques were employed to establish an annualised amount of nitrogen and phosphorous.

In another example in Queensland, the Unitywater Nutrient Offset at Bellmere near Caboolture calculated to have a total annual erosion rate of 3,595.5 tonnes/year. It is proposed that the project will achieve a nutrient offset at the Caboolture South Wastewater Treatment Plant point of discharge of 1.51 tonnes of TN and 0.79 tonnes of TP annually. In all riverine offset projects to date, an attenuation factor of 1:1 has been applied based on the proximity of the offset project to the point source.

Policy considerations

A diagrammatic representation of the Policy is at Figure 2

Figure 2. Point source water quality offsets policy – conceptual diagram



Management hierarchy.

Under the *Environmental Protection Regulation 2008*, section 51 (1) (c) the administering authority must, for making an environmental management decision relating to an environmentally relevant activity, consider each of the following under the EPP Water:

- *The management hierarchy*;
- Environmental values;
- Quality objectives;
- The management intent (i.e. high ecological value waters); and….

Under the EPP Water section 15, *the management hierarchy* of preferred procedures for an ERA releasing wastewater to receiving waters is:

- Evaluate water conservation measures to reduce the use of water and the production of wastewater; and
- Evaluate and implement appropriate waste prevention measures; and
- If waste prevention does not eliminate the release of wastewater to receiving waters, evaluate and implement treatment and recycling options; and
- If treatment and recycling does not eliminate the release of wastewater or contaminants to waters, evaluate the following options for wastewater—
  (i) appropriate treatment and release to a waste facility or sewer; and
  (ii) appropriate treatment and release to land; and
  (iii) appropriate treatment and release to surface waters or ground waters

Policy requirements:

- **Additionality** must be demonstrated for water quality offsets that are designed to meet multiple legislative or policy requirements. For example, if a water quality offset is designed to meet requirements of this policy **and** meet stormwater management design objectives under the *State Planning Policy 2017 (SPP) State Interest Water Quality*; then the offsets solutions must be

designed to meet the requirements of this policy **and** the requirements of the SPP State Interest Water Quality. That is 'double–dipping' proposals not accepted.
- The **additionality** requirement may extend to other considerations, e.g. co-benefits requirements under a Land Restoration Fund proposal. The Department encourages water quality offset proposals that consider multiple ecological benefits or co-benefits (e.g. biodiversity or carbon benefits), that support whole of catchment outcomes.
- **Support sustainable whole of catchment outcomes** under regional planning frameworks; including for example statutory regional plans, Local Government total water cycle management plans (or equivalent) and water quality improvement plans developed by a recognized entity. For example, by **locating** offsets works in accordance with regional planning frameworks where relevant to the offset solution and **co-locating** offset works being delivered under other policy instruments, again where relevant.
- For water quality offsets, proponents must demonstrate the offsets solutions will achieve **water quality improvements** that deliver a net decrease in nutrient/sediment loads to the catchment/sub-catchment receiving waters.
- The consideration of water quality offsets would normally be based on **compliance with existing EA conditions**.
- **Proposed increases in point source discharge should not occur in waters that have been mapped as high ecological value** under the *Environmental Protection (Water) Policy 2009* or in water supply buffer areas.
- **The policy does not allow for water quality offsets in the form of a direct financial contribution to an entity**. However under EA conditions the administering authority will approve the provision of offset solutions being contracted to third party, in accordance with the policy and noting under section 7.8 of the Policy the enduring responsibility for offset performance remaining with the EA holder.

Wet weather

The policy refers to wet weather days and dry weather days as defined under standard conditions in an environmental authority.

Wet weather days as stated in the *Environmental Protection Act 1994* (Section 5) occur when "rainfall exceeds the millimetres predicted by any rainfall measuring station recognised by the Commonwealth Bureau of Meteorology (BOM) or nearest station closest to the point source location. Best practice environment management should be applied to all wet weather days as proposals are encouraged to adopt a total recycled/beneficial re-use of point source release on wet weather days. With proposed discharge on wet weather days the water quality offset must counterbalance total point source discharge on wet weather days with an offset solution designed to offset discharge such as erosion controls."

To establish a wet weather offset using the riverbank restoration approach to offsetting, it is necessary to understand the amount of nutrient and sediment needed to be provided for a valid offset. This can be obtained through careful consideration of the point source treatment capacity, the life of the treatment method, the cost of any potential upgrade to meet licensing conditions, and the license conditions themselves. Once the amount of nutrient and sediment potentially available for an offset approach is known, the next step is to identify candidates for a riverine restoration project. The process to achieve a valid offset site is set out in the Site Selection section below.

The Beaudesert Pilot, the Laidley Creek Wastewater Treatment Plant offset at Mulgowie and the Caboolture South nutrient offset proposal at Bellmere are all examples of successful wet weather offsets in riverine systems. The key pre-condition for such an offset solution is that the cause of the sediment and nutrient generation is wet weather related. In the case of the above examples, the erosion was caused by major flow related events which could be measured and/or modelled to derive an annualised erosion rate. Once the erosion rate was understood, then an understanding of the soil chemistry provides the evidence for the nutrients contained within the sediment.

In all cases, the major benefits of these types of offset projects lie beyond just the nutrient and sediment aspects, the projects also provide stabilised streambanks, habitat and carbon benefits. Some of these benefits can be directly measured such as amelioration of soil loss in the case of the Mulgowie example.

The adjoining farms lost over $1 million in soil during the 2011 event. Stabilising the riverbanks and adding some cross-floodplain structures avoids the potential for such losses. The recent spotting of two platypus at the remediation site provides another clear example of the values which can be demonstrated in a well-designed offset solution.

Lastly, the Policy works on the assumption that the equivalence measure relies on the dissolved inorganic nitrogen (DIN) found at the point source must be equivalent to the amount of DIN at the diffuse source; that is, DIN equals DIN. This relationship must be determined using evidenced based methods to the satisfaction of the Department. While the science behind the nitrogen story is still being settled, this relationship forms the underlying principle for the Policy to work in its current form.

All weather

The Policy (EP Act 1994, Section 7.9) states that "Best practice environmental management should be addressed in all proposals.

Additionally, proponents are required to address the management hierarchy under the EPP Water evaluating waste water avoidance/prevention and treatment/recycling/re-use options before release to land or water.

The evaluation of recycling/treatment/beneficial re-use of point source discharge under dry weather conditions and release only on wet weather days is required under the EPP Water management hierarchy evaluation.

Should an offset be proposed for discharge to waters on defined dry weather days, then the water quality offset must counterbalance point source discharge on dry weather days.

For proposed discharges on wet weather days, the water quality offset must counterbalance total point source discharge on wet weather days.

In both of the above cases, delivery and offset equivalency ratios apply in accordance with the policy.

The process for identifying a suitable point source offset is similar to the riverine example set out below in the wet weather license condition approach; however, the processes which cause the erosion are caused by factors other than a wet weather major flow event. Examples of this may be wave erosion caused by boat wake or wind in a tidal reach of a river.

Department of Environment and Science has recently approved an environmental amendment to the Caboolture South Wastewater Treatment Plant for Unitywater in the estuarine section of the Caboolture River (from the weir adjacent to the city centre, to the mouth of the river). While the approval is conditioned, it reinforces the appropriateness of the methodology. Sediment erosion calculations identified the annual erosion rate to be 2,742 tonnes/year and the annualised sediment is 6,767.6 tonnes/year which will provide an offset of 5.11 tonnes of TN 0.85 tonnes of TP.

Bubble licenses

The Policy states that "Bubble licenses offer point source entities the opportunity to combine licenses within a catchment in order to provide flexibility between different point sources. The Policy states that "Water quality offsets can occur within and between regulated entities. If two or more points of concern are managed by the same regulated point source entity through an amalgamated authority under section 243 of the *EP Act*, they may combine discharge limits to meet an overall reduced discharge limit—commonly referred to as a 'bubble licence'.

Two or more points of concern that are not managed by the same regulated entity can also enter into a water quality offset arrangement—where one regulated entity reduces its limit below that specified on the environmental authority, so that the other/s may increase their discharge load accordingly. The adjusted load limits would be reflected as a condition of the environmental authorities for each entity.

The application of an uncertainty ratio is required for an amalgamated EA, which has a "bubble condition" that combines the individual load limits of point source entities into a single load limit that it less than the sum of the individual load limits. This is to ensure that there will be a broader benefit to the receiving environment in terms of water quality improvements. An uncertainty ratio of 1.5:1 will be applied to ensure that a water quality offset at one point, corresponding with discharges at another point source, generates a water quality improvement in the receiving environment.

The uncertainty ratio may be reduced where environmental equivalency is demonstrated (same chemical form, discharge to adjacent points of concern in the same water type, no delivery lag etc.) The proponent is encouraged to discuss proposals with the Department.

For example, two sewage treatment plants each have a total nitrogen mass load limit of 20 tonnes/year. Under a bubble licence the "bubble" total nitrogen mass load limit for both sewage treatment plants is 30 tonnes/year. This would result in a net reduction in the discharge of nutrients to the receiving environment.

The uncertainty ratio of 1.5:1 will apply for water bubble licences that are located upstream in the same river basin and within the same water type. However, in tidal water types (e.g. estuaries) upstream or downstream locations in the near field, will be considered equal. For proposed bubble licences located downstream or outside of the same water type within the same river basin, or located in adjacent river basin, non-adjacent river basin, adjacent NRM region and non-adjacent NRM region – delivery ratio may increase the 1.5:1 ratio to ensure improved broader environmental water quality outcomes in the receiving environment. The application of the delivery ratio will depend on equivalency demonstration of the bubble condition by the proponent and based on best available science."

Site selection – riverine and estuarine

Riverine sites are selected using historical and current imagery to show anomalies in creek banks and LiDAR where available to identify potential erosion sites. This helps in selecting badly eroded sites; for example, Laidley Creek in Mulgowie. The bed and banks at the Laidley Creek site have deepened and widened to sheer banks of up to 6 meters which during every major flow event causes more erosion. Through bank-battering and intense revegetation, the energy from the flood waters is dissipated for that length of creek. As vegetation matures to 10 years or older, the dissipation of the water energy increases.

The first pass assessments are completed at the desktop level. The aim is to find potential sites with substantial and active erosion so that estimations of annualised erosion can be calculated. The most accurate method for this lies around different LiDAR captures on the same waterway with a reasonable time gap. Modern GIS techniques can be employed to identify the nature and size of potential erosion sites. By using BSTEM modelling, and/or change detection algorithms, the amount of sediment eroded per annum can be calculated. From this annualised estimate, an estimation of potential nitrogen yield can be made based on the amount of nitrogen bound to alluvium sediments in riverine or within estuarine situations.

Sites should be selected based on their likely contribution to a nutrient and sediment offset and will therefore likely require several thousand tonnes of sediment annualised to ensure a viable offset.

In estuarine scenarios boat wake is a major all-weather causing erosion impact as well as some wind-wave erosion. Site selection in the estuarine situation also requires allowance for tidal influences as it is this tidal pulsing nature of estuarine systems that allows the potential for an all-weather offset solution.

Technical considerations

Regardless of whether estuarine, riverine (or wetland) based, the process to assess and develop a riverbank restoration offset solution requires careful soil testing, and erosion and sediment modelling. This ensures the TSS is assessed to provide a valid and evidenced based annualised erosion rate. The following sections set out the methodology to achieve an annualised erosion rate and resultant nutrient or sediment loads for use in conditioning a point source environmental authority with an offset.

A secondary consideration for a point source entity is the treatment of the offset solution financially. In designing a point source offset using a bank restoration offset method, the installation and commissioning of works may be considered to be a capital expenditure and the maintenance of the works out to the life of the license conditions may be considered operational expenditure. For the accounting process, this financial treatment is important and the scoping of any project needs to consider which parts of the offset solution will be capital expenditure and which parts will be operational expenditure. This then forms an important aspect of the business case for such a project.

While the Policy is silent on the financial considerations for the offset approach, the viability and return on investment aspects in considering whether a riverbank restoration offset solution is needed becomes crucial.

a. Riverine

The methodology developed as part of the Beaudesert Pilot Project (and employed in two other approved projects) is employed to ascertain the nutrient concentration of the soil profile along a proposed project area. In brief, the nutrient concentration of the soil profile is identified through the direct measurement of Total Carbon (TC), Total Nitrogen (TN) and Total Phosphorus (TP) concentrations in the soil at a range of locations along the target project area. These concentrations are assessed at 50cm intervals to the depth of the erodible bank profile of the area modelled.

Sampling elements

The sampling technique needs to ensure traceability of the samples taken in the soil profile from drilling, profile description and sample analysis to ensure the quality of the process. The aim is to measure at regular sites along the potential project bank length and where there is a clear change in soil type visible. To carry out this work, a qualified soil scientist with access to a calibrated Geoprobe or similar soil profiling device is critical.

Usually, the sampling process is carried out with project management supervision to ensure the soil samples are appropriate for coverage of the site. The analysis should be carried out be a suitably accredited laboratory and analysis for TN, TKN, TP, TC and particle size. The result of the analysis should be a series of percentage content figures for each soil profile as well as an analysis of the profile particle size. From these results, the average percentage content for each nutrient can then be established and calculated to give the soil nutrient yield on an annualised basis.

This work must be clearly documented to ensure the regulator and their science advisors can be assured that the methodology and results are credible.

Bulk Density

The modelling and annualised erosion rates are calculated in cubic metres of sediment eroding. It is necessary to convert this into a tonnage to ensure the nutrient calculations can be made using the soil analysis results. To achieve this, the bulk density of the soil needs to be calculated using an accepted methodology. Again, the advice of a qualified soil scientist is helpful. Using the particle size analysis (PSA) outlined above, samples are assessed to calculate an average PSA; for example, a typical analysis of alluvium soils in the Laidley Creek systems is: 15.56% coarse sand, 43.98% fine sand, 20.17% silt and 20.29% clay.

The bulk density average percentage soil composition can be entered in soil texture “triangles” to interpret percentage soil composition in to a known bulk density. The percentage soil composition of the samples classified the soil type on average as a sandy clay loam with a bulk density average of 1.5.

The nutrient calculations

The framework depicted below describes the method used to calculate annual nutrient offset. From the modelling the annual offset can be calculated multiplied by the bulk density. The annual sediment offset is then multiplied by the nutrient concentration.

Using the above framework, the nutrient loads bound to the eroding sediment can be calculated. Using an uncertainty factor of 1.5 if the point source is located in the same sub-catchment and an attenuation factor, if needed, to account for the distance from the point source and the potential offset solution site from the project area, the amount of TC, TP and TN can be calculated.

The workings involved in arriving at the calculated annualised nutrient and sediment offsets must be clearly demonstrated and logically presented (usually as an appendix) to ensure the regulators can appropriately assess the potential offset solution.

In all cases to date, the delivery ratio is set to 1:1 as the offset site is only three hours flow time from the point of discharge. In this three hours, the sediments containing the nutrients remain in suspension and therefore, any sediment and bound nutrient loss is considered negligible.

b. Estuarine

While calculation methods for estuarine systems are similar to riverine systems, there are other potential considerations for estuarine nutrient and sediment offset solutions which need to be taken into account. Within estuarine systems, high turbidity can limit the growth of Phytoplankton and favour the flow of nutrients through the estuary to costal zones. Concentration of forms of nitrogen and phosphorus correspond to the dynamics of suspended matter. Characterized by retention during low river flow and the release during floods (Guillaud, J et al 2008). Another study has found that nutrient transported by flood even can induce phytoplankton blooms in rivers, lakes and coastal waters.

Recreational boating in estuaries is the likely source of impacts which can result in significant erosion of the river banks owing to the comparatively high energy and repetitive nature of the activity. As a vessel moves through the water it creates a complex series of waves (wake). The energy contained within the wave train from each boat passage can be transferred to adjacent river banks, contributing to bank erosion. The wake characteristics produced by a vessel will depend on many interrelated factors including the displacement of the vessel, the length of the vessel in contact with the water (e.g. whether or not the vessel is on the plane), the speed of the vessel, the shape of the hull and so on (Maynord, 2001; 2005).

How much energy is transferred from each boat passage to the bank will depend in turn on how close the boat is to the adjacent shore and the relationship between the wave characteristics produced by the boat passage and the topography of the river bottom (Maynord, 2005). The results of field testing by Glamore (2008) found the following:

- A wave train (i.e. a group of fully formed boat waves) initially appears as an accumulation of super-imposed waves travelling away from the sailing line
- Wake waves become fully developed (maximum wave height) at approximately 22m (2.5 to 3 boat lengths from the sailing line)
- As wave propagate further away from the sailing line, attenuation occurs resulting in a decreasing wave height while the wave period remains constant

To estimate the likely wave energy associated with boat wakes, typical boat types and usage can be adopted to form the basis of modelling. In addition to boat wakes, wind generated waves can cause erosion for similar reasons.

Wind Generated Waves

Analysis of wind generated waves by the spectral model, suggests that wind generated waves are unlikely to be causing substantial erosion in smaller estuaries. The main reason is that the area of water available to generate significant wave heights are negligible (<0.1m) when wind speeds are less than 15m/s, water levels are low and winds are not at an optimal angle to generate fetch. Strong (>10m/s) winds perpendicular to a potential estuarine site may need analysis; however, its likely to be uncommon in Queensland estuaries with most perpendicular to the centreline waves are less than 0.2 metres.

Nutrient Ratios

The nutrient calculations follow the same line as the riverine calculations; however, the final nutrient calculations require a slightly different approach to attenuation. Tidal flushing in many Queensland estuaries is slow due to the geomorphology of the deltas of these systems. Typically, longer bank areas will be required due to the generally lower bank heights in estuarine areas; although nitrogen percentages can often be up to double that of riverine alluviums.

For this reason, a nutrient modelling assessment (near field and far field) are needed to determine delivery ratios for the proposed nutrient offsetting scheme involving riparian rehabilitation works in relation to the point source. This analysis is a critical input into the calculation of the attenuation factor for any potential offset solution.

Models such as the CORMIX model can be used to predict both mid and slack (low water) tidal conditions with associated dilution factors and extent for the near field mixing zone. Again, engaging a nutrient modelling expert is important to the success of this process.

However proponents should discuss any proposals with the Department at the earliest opportunity, seeking direction on the type of technical investigations required.

c. Wetland

While this guideline is not aimed at outlining the method to achieve a viable nutrient or sediment offset for a point source, work has been completed on a potential offset solution using a wetland approach on a tributary of the Maroochy River. This work was based on work in the United States. A brief outline of the science and method is provided below.

Accumulation rates of sediment and associated carbon (C), nitrogen (N), and phosphorus (P) were measured in wetlands along the tidal Savannah and Waccamaw rivers in the south-east USA. The river spans an upstream-to-downstream salinification gradient, from upriver tidal freshwater forested wetland (TFFW), through to moderately and highly salt-impacted forested wetlands, to oligohaline marsh downriver. TFFW, also known as tidal swamps, occur at the interface of watersheds and estuaries.

Non-tidal freshwater floodplains occur upriver from TFFW, and downriver are typically a progression of tidal herbaceous wetlands along gradients of increasing salinity towards the coastal zone (Odum 1988). TFFW floodplain ecosystems are extensive, likely occupying more land surface than tidal freshwater marshes in the USA (Field et al. 1991). Their hydrogeomorphic position makes them sensitive to both coastal processes, such as higher water and salinification due to sea level rise and human modifications to estuaries and tidal rivers, as well as watershed processes that influence freshwater discharge and sediment availability. The changing chemical signature of deposited sediment firmly links wetlands along tidal rivers and estuaries to a changing source from watershed to coastal sediment (Noe, G.B et al 2016). This science was employed in an analysis of the Yandina Wetlands by Unitywater in 2015-16.

By way of example, the analysis showed that based on conservative nutrient uptake rates, the modelling predicts that site will uptake 5.3 tonnes TN and 0.3 tonnes TP on an annual basis. The northern block is likely to retain approximately 72% of this mass load due to its more persistent levels of inundation. Based on the scenario results, equivalency ratios for load reductions from the Yandina site and the Coolum Wastewater Treatment Plant were calculated. The marginal differences in the ratios suggest that the Yandina site would have approximately a similar impact on river water quality as load reductions from the Coolum plant.

The key to a potential offset using this methodology is advanced nutrient modelling in an estuarine system. Work will need to be carried out over time to measure and monitor the results of the Yandina Wetland approach.

d. Other point source options

Other options for viable nutrient offset solutions may include bioreactors which have been employed in agricultural settings to remove nitrogen using wood chip trenches which are anaerobic in nature. At this stage in Queensland, more work is needed to prove up the technique; however, areas in Queensland with suitable geomorphology and soil structures may well provide a low cost and efficient method of nutrient offsets. As with all other methods, the attenuation factor and the delivery ratio must be taken into account should this method prove worthwhile.

Some of the other potential offset options which may be available in Queensland may include improving agricultural practice to reduce fertiliser use and/or capture runoff. While this approach has been long used in the Barrier Reef catchments, relating the point source opportunities from aquaculture, mining, agriculture based environment licenses has not been trialled to prove up the approach.

Other approaches include the use of micro-algae and macro-algae to ensure inorganic nitrogen is processed into bioavailable nitrogen for use in the food chain. Again, while some of the preliminary research is promising, the work is yet to be done to prove up the viability of these methods to mitigate or offset nutrient to the satisfaction of the regulators.

e. Diffuse source

The water quality offset is reflected as a condition of the EA under the Policy for the point source entity and at this stage the Policy does not include water quality offsets in the form of a direct financial contribution to an entity based on a trading market.

Diffuse or non-point pollutants are sources that have been carried off land by stormwater or overland flow. Common non-point sources are agriculture, forestry, urban areas, and historical mining sites*, EP Act, 1994* (Section 5). Nutrient related diffuse source pollutant inputs can enhance crop growth and improve soil eutrophication. However, excessive nutrient and sediment input can result in the impairment of water quality.

The potential for setting up nutrient and sediment trading schemes in suitable catchment systems is also available. Some examples such as those in the Tully River system entering the Reef Lagoon and Maryland in the USA show promise; however, much work is needed to create a viable example which can apply across Queensland.

Diffuse source emissions of pollutants by surface runoff, lateral flow and percolation are impacted by catchment properties such as land use/cover types and thus the area occupied by such land uses influences the loading of pollutants. To determine land use types which, have considerable influences on pollutant concentrations in stream, a comparison including the percentage of different land covers and their respective pollutant loads in different sub basins is considered (Lam, Q.D et al 2010).

f. Sediment offset considerations

While the work to establish the nutrient and sediment offsets relies on the analysis of sediment in many of the examples above, the register a valid sediment offset, the relationship between the point source for sediment (or impact site) and the offset site must be clearly established. Extensive scientific analysis methodology has been developed by the Australian Rivers Institute and other research institutions to establish a valid method for determining this relationship.

This method relies on the measurement of radionuclide or similar method of dating and identifying the sediment content in the source and offset sites. Many of the sediment particles involved in these measurements are obtained through soil core samples at both sites. The result of this analysis then allows the ratio between the source and offset site to be determined. For example, in the Brisbane River system, approximately 5% of the erosion within the catchment is transported to Moreton Bay past the Port of Brisbane. The analysis work shows approximately 78% of this sediment passing the Port is generated from the Laidley/Lockyer Creek systems alone.

From this work, the ratio between the offset site sediment generated in Laidley Creek can be compared accurately to that being offset at the impact site. Again, it must be reduced to an annualised basis using an appropriate modelling approach.

Permits and approvals

While the Policy covers the relevant aspects of the EP Act 1994, to deliver a successful nutrient and sediment offset solution using the riverbank protection processes requires compliance with other legislation. While the following list is not exhaustive, it does cover the main regulatory requirements to achieve a successful project.

a. Environmental harm considerations

Environmental management plans describe how an action might impact on the natural environment in which it occurs and sets out clear commitments from the person taking the action on how those impacts will be avoided, minimised and managed so that they are environmentally acceptable. The Department of the Environment and Energy is responsible for a range of regulatory functions under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) (section 16 Subdivision B). Under the EPBC Act an approval is required from the Minister for any proposed action likely to have a significant impact on a matter protected by the EPBC Act. Most river restoration projects will not trigger provisions of the EPBC Act; however, potential project proposals need to address it as part of the due diligence phase.

Under the *Vegetation Management Act 1999* a person must not do any of the following activities unless the person has a riverine protection permit (RPP) to carry out the activities. These include: destroying vegetation in a watercourse, lake or spring; excavation in a watercourse, lake or spring and place fill in a water course, lake or spring. During the interim period, the schedule, definition regrowth, watercourse and drainage feature area is also taken to mean an area located within 50m of a watercourse or drainage feature located in the following catchments identified on the vegetation management watercourse and drainage feature map— An area management plan applies to the catchments mentioned in subsection (1)(a), (b) or (c) in the same way it applies to the catchments mentioned in the definition regrowth, watercourse and drainage feature area, until the end of the plan period for the Vegetation Management Plan. Importantly, ensuring the requirements set out in Part 6 of the Act must be satisfied.

Under the *Water Act 2000* (Section 218) a water use plan is a plan that applies to a part of the State and advances the sustainable management of Queensland's water by regulating water use if there is a risk of land and water degradation, because of rising underground water levels, increasing salinization, deteriorating water quality, waterlogging of soils, destabilisation of bed and bank watercourses, damage to riverine environment and increasing soil erosion.

A Riverine Protection Permit (RPP) must be obtained to do any of the following activities, destroying vegetation in a watercourse, lake or spring; excavation in a watercourse, lake or spring and place fill in a water course, lake or spring. Also, the application must include the written consent of the registered owners of the land, containing the length of the watercourse in which the activity is to take place or the part of the lake or spring where the activity is to take place; or adjoining the watercourse, lake or spring where the activity is to take place. The RPP must be made to the chief executive in the approved form and state the proposed activity and purpose of the activity; and be accompanied by the fee prescribed by regulation.

While some entities have been granted a blanket approval for instream works, it is considered good practice and important to a RPP to be obtained for any works forming the basis of a point source offset project.

b. Construction permits and approvals

The Queensland *Planning Act 2016* (section 4) facilitates the achievement of ecological sustainability includes state planning policies, regional plans, planning schemes, temporary local planning instruments (TLPIs), planning scheme polices and development assessment system. In carrying out work in a riparian zone, care should be taken to ensure the proposed offset does not contravene any of the instruments listed in Section 4.
In the estuarine zone, provisions of the *Fisheries Act 1994, Coastal Protection and Management Act 1995* and *Planning Act 2016* should be taken into account. It is highly likely that a development application will be required and particular note needs to be made of the extra assessment required for fish habitat areas.

From the commencement, the authority has effect as if the authority were a development permit, or if the authority is an aquaculture licence—a material change of use of premises; or
if the authority is a permit for the performance of works in a declared fish habitat area or for the removal, destruction or damage of marine plants—operational works. If the currency period does not end within 6 months after the commencement, the chief executive must, as soon as practicable, issue the holder of the authority—a development permit; and if the development permit was applied for after the commencement, require a resource allocation authority for Queensland waters, unallocated tidal land or declared fish habitat area—a relevant resource allocation authority for the development. A development permit or resource allocation authority issued under subsection must state— the permit— the currency period for, and conditions of, the permit; or for the authority— the term and conditions of the authority.

Under the *Fisheries Act 1994* (Section 261) a person intending to make a development application for the construction or raising of a waterway barrier works in an area may apply to the chief executive for a fish movement exemption notice for the area. The application must be made in the approved form. Accompanied by the prescribed fee and made before the person makes the development application. Under the planning Act 2016 (Section 65), the conditions imposed on a fisheries development approval may include environmental offset conditions to counterbalance the impacts of the development on fisheries resources or fish habitat including, an environmental offset to enhance or rehabilitate a fish habitat, the exchange of another fish habitat for a fish habitat affected by the development and a contribution to fish habitat research.

Some in-stream restoration projects may interfere with fish passage. In these instances, water barrier works in riverine or estuarine areas require extra attention. Provisions of the *Fisheries Act 1994* (Section 242) may require a development application to assess the potential fish passage aspects of the project.

c. Legislative duty of care issues

Compliance with the *Work Health and Safety Act 2011*(Section 18) is critical. A potential project must consider and weigh up all relevant matters including the likelihood of the hazard or the risk concerned occurring; the degree of harm that might result from the hazard or the risk; that the person concerned knows, or ought reasonably to know, about the hazard or the risk; and the ways of eliminating or minimising the risk. To fully satisfy the requirement of the Act, the project should ensure that all safe work methods, toolbox talks, start-up procedures and other WH&S documentation is correctly applied.

In addition to the *Work Health and Safety Act*, Section 319 of the *Environmental Protection Act 1994* outlines the general environmental duty which ensures the responsibility for the actions taken that affect the environment are taken into account. Any activity that causes or is likely to cause environmental harm must not be taken unless all reasonable and practicable measures to prevent or minimise the harm are taken.

To decide what meets the general environmental duty, consideration needs to be given to the:

- nature of the harm or potential harm,
- sensitivity of the receiving environment,
- current state of technical knowledge for the activity,
- likelihood of successful application of the different measures to prevent or minimise environmental harm that might be taken, and

• financial implications of the different measures as they would relate to the type of activity.

Construction matters

Project design requires a detailed geomorphic assessment of the project area which includes a detailed digital terrain model, the development of appropriate instream features such as grade control structures, bank stabilisation pile fields, and cross channel pile fields. Care must be taken to ensure a full fluvial geomorphic understanding of the active process causing the erosion on the stream are understood. Experience shows that qualified fluvial geomorphologists are best placed to fully understand the processes causing the erosion and make recommendations to address the causes.

The river restoration guidelines should be following in any assessment and design work involving instream restoration offset projects. These guidelines are in the process of being upgraded by the Department of Natural Resources, Mines and Energy. The guidelines will take the form of a web based resource which can be tailored to different catchment types within the State. The guidelines are due for release at the end of June 2018. Once released, this guideline will be updated with a relevant link.

All construction work (bank-battering, rock placement and pile installations) must:

- be done in accordance with appropriate approvals,
- a fluvial geomorphologist and/or engineer's plan; and
- be organised in such a manner as to ensure sign off from a register professional engineer in Queensland (RPEQ).

Bank re-profiling is often required to provide a stable substrate for vegetation establishment and to reduce stream power and shear stress (and hence erosion) in the stream reaches (DSE, 2008). Usually, a profile of 1 (high) in three (wide) is preferable unless site specifics determine otherwise. It is always preferable to ensure project design work includes appropriate "hold points" for RPEQ signoff once the site set-out is complete and at the finish of construction.

Native vegetation establishment is a normal part of the construction process and as much as possible, the regional ecosystem which typified the stream reach being remediated should be established with local provenance. A vegetation management plan should be developed specifically for the site. Weed management also needs to be factored and fully costed for the life of the license. Wherever feasible, every effort should be made to retain existing native vegetation if it can be factored in to the design work.

In many locations, large trees can be found on the edge of a steep bank. These trees and their root system can provide important structural reinforcement to the bank soils and hence are a local hard point in the stream system that limits erosion. In some instances, these trees may need to be removed to achieve a stable gradient suitable for vegetation establishment; however, in many instances the bank slope can be steepened to enable trees and their associated root networks to be maintained on the bank along with other vegetation stabilisation methods.

Significant management effort will be required in the vegetation establishment period to manage weeds to level that allows the native vegetation community to capture the riparian zone. Given the likely weed load in the catchment, ongoing management will be required in the project reach to limit the ability of weeds to recolonise the riparian zones. Weed management considerations should be a critical component of the revegetation plan.

Erosion sediment control work should be considered during any works. Depending on the situation (some streams are ephemeral), an erosion and sediment management plan may be necessary and comply with best practice guidelines.

Other considerations in the project construction include the need for soil health measures as some soils in stream banks may not have been disturbed for millennia. Most importantly, it is highly likely that river restoration projects will be carried out on land adjoining a private landholder's property. It is absolutely critical that the permissions and wishes of the adjoining landholder (who is often given up some of his productive land for the project) are respected to ensure the viability of the project. Without landholder support, the project will likely not be deliverable.

Monitoring and evaluation options

The success of any potential in-stream restoration project hinges on the project being able to demonstrate it is meeting the stated objectives of the approved conditions within the point source license. *EA Act, 1994* (Section 7.9) makes it clear that the proponent is responsible for monitoring and reporting water quality effects at the point source location, offset location and other relevant locations specified in the proponent's EA, in order to demonstrate the efficacy of the water quality offset.

The type of monitoring that is required will depend on the water quality offset selected. The costs of all monitoring and reporting activities are to be met by the proponent and are not the responsibility of the department. The department is responsible for reviewing performance and monitoring reports. Monitoring must take place according to best available practice, the environmental authority conditions, and in accordance with the Monitoring and Sampling Manual under the EPP.

The methodologies adopted for the monitoring aspects can include:

- LiDAR change and direct on-ground survey change for demonstrating no net erosion of sediment and bound nutrient from the offset site during the license period
- photo point monitoring and direct vegetation measurement and assessment to ensure the vegetation is meeting expectations given its importance to long term success; and
- ambient and event based instream measurement of nutrient and sediment loads. Reporting frequency is set by the License Regulator, most commonly 6 monthly or annually. LiDAR data is collected either annually or bi-annually.

Liability

In the *EP Act, 1994* (Section 7.10) The proponent is responsible for ensuring that the water quality offset is implemented diligently, is maintained, and meets the design criteria. The proponent may contract manage actions to a third party (e.g. land owner, NRM body, project manager, project broker); however, the legal responsibility for the source and delivery of the water quality offset will remain with the proponent as a requirement of the proponent's environmental authority.

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