Tilligerry Creek Floodgate Assessment

Report to the Hunter-Central Rivers Catchment Management Authority

Project number HCR07_106

Hunter-Central Rivers CMA CATCHMENT MANAGEMENT AUTHORITY

NSW DEPARTMENT OF PRIMARY INDUSTRIES

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January 2009

Executive Summary

NSW Department of Primary Industries (DPI) was engaged by the Hunter-Central Rivers Catchment Management Authority (CMA) to undertake an initial assessment of land upstream of the Tilligerry Creek Floodgates, with the aim of investigating the viability and potential impacts of reinstating a controlled amount of tidal flushing in Tilligerry Creek, upstream of the floodgates.

This assessment follows the release of the *Tilligerry Creek Catchment Management Plan* developed by Port Stephens Council and the Tilligerry Creek Catchment Management Committee (Earth Tech Engineering, 2007). The Plan identified 'De-regulation of the tidal flushing regime at Tilligerry Creek' as the highest priority action to achieve water management targets in the Tilligerry Creek Catchment. The proposed method of restoring controlled tidal flushing is to install an auto-tidal floodgate on at least one of the existing floodgates.

The proposal to allow a controlled amount of tidal water exchange into Tilligerry Creek addresses number of key issues impacting on water quality and aquatic habitat:

- Reducing aquatic weed growth (particularly Alligator Weed),
- Minimising potential acid sulfate soil (ASS) oxidation,
- Increasing fish habitat availability, and
- Improving water quality attributes in the drains (pH, Dissolved Oxygen).

Assessment methods undertaken include analysis of landscape elevation, water level gauging, and water and soil testing to determine the presence and severity of ASS and the soil's hydraulic conductivity.

Assessment results confirm that potential acid sulfate soils are present in the catchment, however they appear to remain unoxidised in the area between the floodgates and Oakvale Drive (500m upstream of the floodgates). Further assessments are required to confirm that this is also the case further upstream in the catchment.

These initial results indicate that the current management of the Tilligerry Creek drainage system does not appear to be over-draining the landscape or causing ASS oxidation. Any future changes, for example extended low rainfall and/or drain deepening, resulting in the lowering of the ground water table could risk exposing the shallow PASS to oxidation and mobilising acid and heavy metals. Any decrease in drain levels could potentially lead to severe impacts on the environment downstream of the floodgates.

Analysis of the area's digital elevation model revealed that the landscape is very low lying behind the floodgate (between 0 and 2m AHD), hence any modification to the floodgate would require additional works to prevent levees being overtopped and to ensure tidal water is confined to the drain. Further detailed surveying would help to determine the level to which the levees would need to be raised to manage the risk of saltwater intrusion onto private farmland.

The soils immediately upstream of the floodgates have a low conductivity, meaning that brackish water can be introduced into the drainage networks without fear of saline water travelling through the groundwater table into adjacent paddocks. Further assessment of hydraulic conductivity adjacent to drains further upstream would confirm low conductivity across the catchment.

In summary, recommendations for the management of the Tilligerry Creek floodgates are:

1) Liaise with landholders to determine interest in tidal flushing and identify any issues, such as impacts of salinity on stock watering and overtopping of low points;
2) On ground surveying is required to confirm LiDAR heights and to determine the extent of earthworks required;
3) Levee works need to be carried out to build up low points in the existing levees upstream of the floodgates, particularly between the floodgates and Oakvale Drive, to ensure estuarine water does not inundate properties.
4) Conduct further soil and K_{sat} testing on properties upstream of Oakvale Drive to determine acid sulfate soil risk and hydraulic conductivity of soils;
5) Develop a management plan with relevant landholders and agencies for the installation and management of at least one auto-tidal device fitted to the current gates;
6) Design and install an automatic tidal gate on at least one of the four cells;
7) Riparian rehabilitation works, such as revegetation, fencing and providing alternative stock watering points, would complement floodgate management works.

Table of Contents

1 Background

1.1 Tilligerry Catchment

Tilligerry Creek is located within the Port Stephens Council Local Government Area on the Lower North Coast of NSW, approximately 20km north-east of Newcastle (Figure 1). The catchment covers an area of 130km^2 encompassing Fullerton Cove, Bobs Farm, Williamtown, Salt Ash, Tanilba Bay and Lemon Tree Passage. Tilligerry Creek flows generally north east within a low elevation swampy landscape, extending between the Hunter River and Port Stephens estuaries. During periods of higher sea level it is likely this area would have existed as an estuarine lagoon system behind Stockton sand dunes (Chapman, *et al*, 1982).

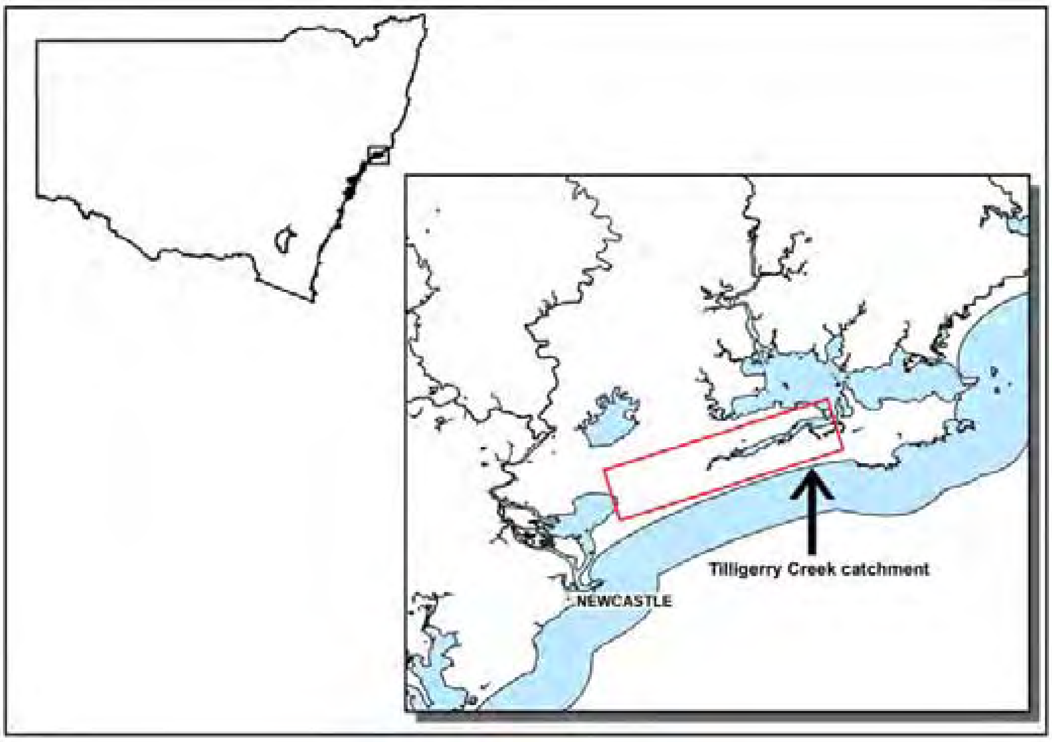


Figure 1 Location of the Tilligerry Creek catchment

A recent study conducted by Wetland Care Australia (2007) identified that Tilligerry catchment maintains high conservation values, and is an important wetland in the Hunter region. The presence of mangroves and saltmarsh increases estuarine productivity and provides essential habitat and protection for juvenile fish and prawns.

However the catchment is highly susceptible to threats. The modern day catchment has become highly modified as a result of agricultural and mining landuse practices and the constructed drainage network (see section 1.2 below).

The creek itself starts in the south west of the catchment, along the eastern shore of Fullerton Cove (near Nelson Bay Road) and extends north east for 11km to the Tilligerry Creek Floodgates. Upstream of the floodgates the creek and its tributaries exist as a series of constructed agricultural drains, maintained by the NSW Government, Local Council and local landholders to drain off excess surface runoff. The lack of variation in surface elevation across the valley means runoff at the top (western) end of the creek may, at times, flow towards the Fullerton Cove floodgates and into the Hunter River Estuary.

Downstream of the Tilligerry Creek floodgates the creek becomes estuarine, extending 15km to the mouth of the creek at Ports Stephens. This section of the creek is within the Port Stephens Marine Park. Major tributaries Fenninghams and Wallis Creeks are also within the Marine Park.

1.2 Tilligerry Creek Floodgates

Tilligerry Floodgates (Figure 2) were identified as one of 46 barriers identified within the Tilligerry Catchment in a recent NSW DPI study '*The assessment and management of floodgates on the NSW South Coast, 2007*' (NSW DPI, 2007). Figure 3 shows the locations of these floodgates. The Tilligerry Creek floodgates are one of the larger, more significant floodgate structures. The Tilligerry Creek floodgates consist of four hinged flap floodgates mounted on 1.8m diameter circular pipes, which seal to prevent tidal inundation on the incoming tide, and allow water to drain out on the ebb tide. The floodgates are maintained by NSW Department of Environment and Climate Change under the Lower Hunter Valley Flood Mitigation Scheme.

The floodgates provide an artificial tidal limit, preventing tidal exchange beyond the gates. This has reverted the upper reaches of the creek into a freshwater system, while below the floodgates the creek remains estuarine. Constructed drains are used to remove stormwater from agricultural land, converting low lying swampy land into dryland farming areas, allowing agriculture to diversify and improve production.

Along the NSW coast, drainage of low wetlands has commonly led to exposure of acid sulfate soils to air (see section 1.3), either through excavation or by lowering the watertable via drainage and drought. The acid and associated iron and aluminium can then leach from the soil and accumulate in drains and waterways behind floodgates.

Figure 2 Tilligerry Creek Floodgates, adjacent to Nelson Bay Road, Salt Ash.

Figure 3 Tilligerry Creek catchment area and the location of 46 floodgates identified by NSW DPIs review of floodgates.

Floodgates prevent the inflow of saltwater and floodwaters, which would otherwise act to dilute or neutralise pollutants, and then allow a concentrated discharge of acid water during the ebb tide (Johnson, *et al*, 2003). Floodgates act as a fish passage barrier, inhibiting fish from accessing upstream habitat.

To resolve these environmental issues in the Tilligerry Creek catchment, Port Stephens Council has recently proposed to 'De-regulate the tidal flushing regime at Tilligerry Creek' as the highest priority action to achieve water management targets in the Tilligerry Catchment (Earth Tech Engineering, 2007). In order to achieve this it is proposed to retrofit an auto-tidal floodgate to at least one of the existing floodgates.

Auto-tidal floodgates (Figures 4 & 5) are commonly used to treat environmental problems on floodplains such as poor water quality, acid sulfate soils and fish passage barriers. Many projects on the NSW North Coast have demonstrated marked improvements in water quality following the installation of auto-tidal floodgates on systems similar to Tilligerry Creek.

A tidal floodgate remains open during low flows, and closes automatically when water levels reach a pre-set height (i.e. floods or king tides). The tidal gate also maintains the flood mitigation capacity of the floodgate, keeping flood waters from inundating the farms on the floodplain.

Figures 4 & 5 Auto-tidal floodgate on Windeyers Creek (Raymond Terrace) similar to the recommended management recommendation for Tilligerry Creek floodgates.

1.3 Acid Sulfate Soils

Acid sulfate soil (ASS) is the common name given to naturally occurring soil and sediment containing iron sulfides or acidic products of the oxidation of sulfides. When sulfides are exposed to air, oxidation takes place and sulfuric acid is ultimately produced when the soil's capacity to neutralise the acidity is exceeded. As long as the sulfide soils remain under the water table, oxidation cannot occur and the soils are quite harmless and can remain so indefinitely (NWPASS, 2000).

Coastal ASS occurs in every Australian state and the Northern Territory. Using information on conditions necessary for the formation of ASS, together with the known geomorphology of the Australian coastline, it can be predicted that ASS should be found in coastal embayments and estuarine back swamps, with surface elevations less than about 10 m above mean sea level (<10m AHD). Extensive occurrences of ASS are found along the eastern and northern coastline of Australia with smaller areas in southern Western Australia, South Australia, Victoria and Tasmania.

Sulfidic sediments are formed in vegetated, low-lying tidal environments when sulfate from sea water is reduced to sulfides by microbes. Sulfides react with iron in the sediments to form iron sulfides (mostly iron pyrite) (Sammut *et al,* 1996). Holocene-age (<10,000 years before present) sulfidic sediments were formed in estuarine lowlands following the last major sea-level rise and can be found in back-swamps, coastal floodplains, estuarine embayments and coastal wetlands characterised by shallow water tables (Sammut *et al*., 1996).

Pyrite is stable under anoxic conditions (i.e. when water-logged) but on exposure to air, the wet sulfidic soil horizon known as potential acid sulfate soils (PASS) will oxidise, forming sulfuric acid (Sammut *et al*., 1996). ASS becomes oxidised by a range of floodplain alteration processes as detailed in Figure 6. Oxidised soil layers are characterised by yellow mottling and are known as actual acid sulfate soils (AASS).

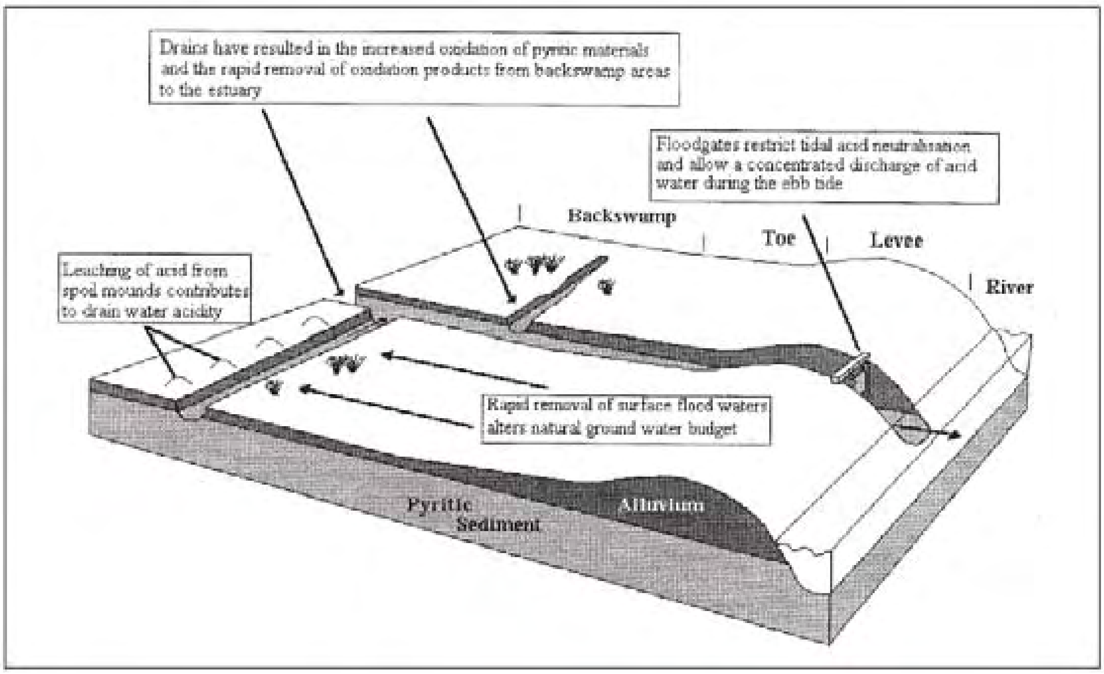


Figure 6 ASS production as a result of floodplain alteration (source: DLWC, 1998)

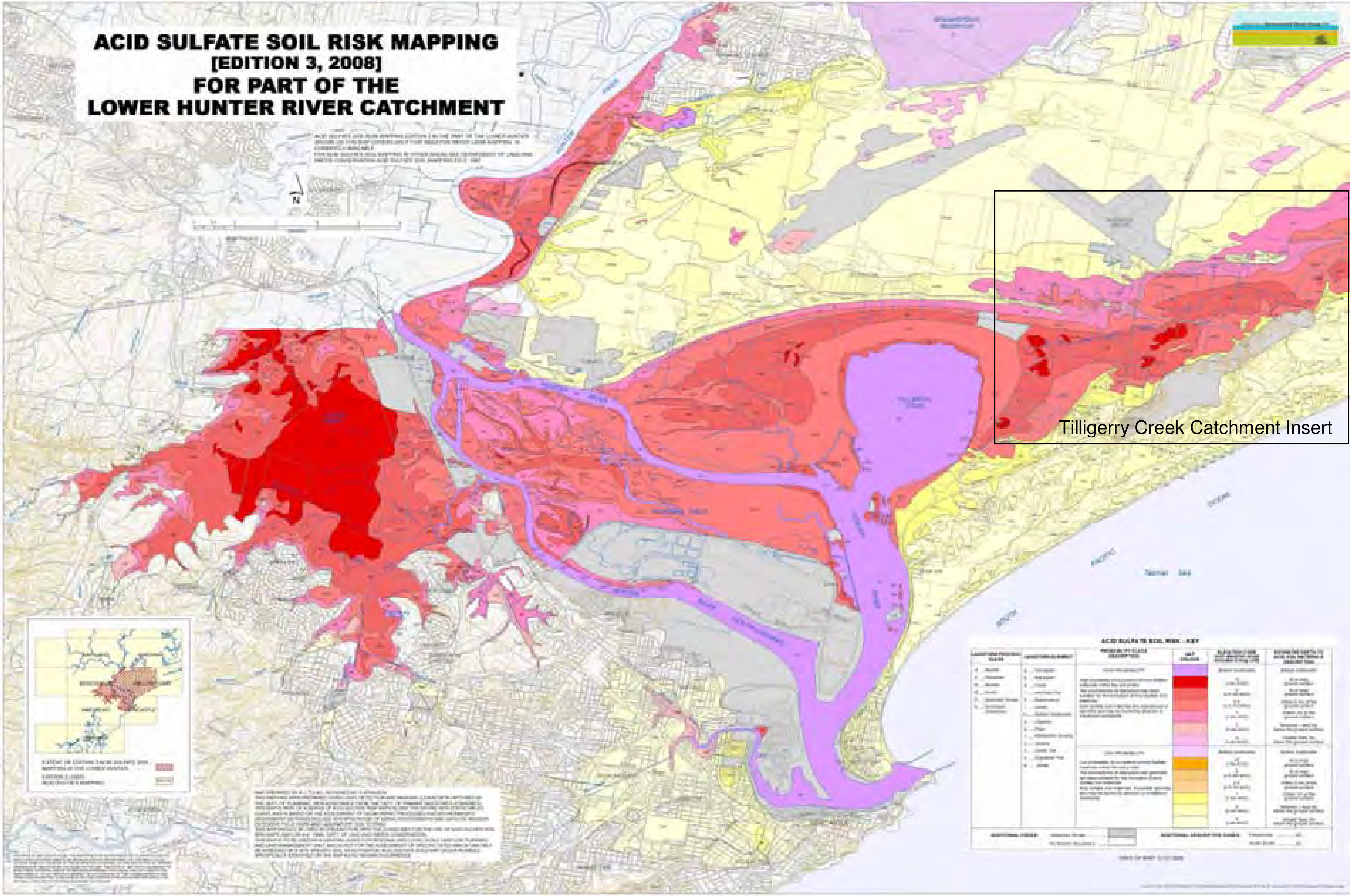


Figure 7 Revised Acid Sulfate Soil Risk Map (Source DECC, 2008).

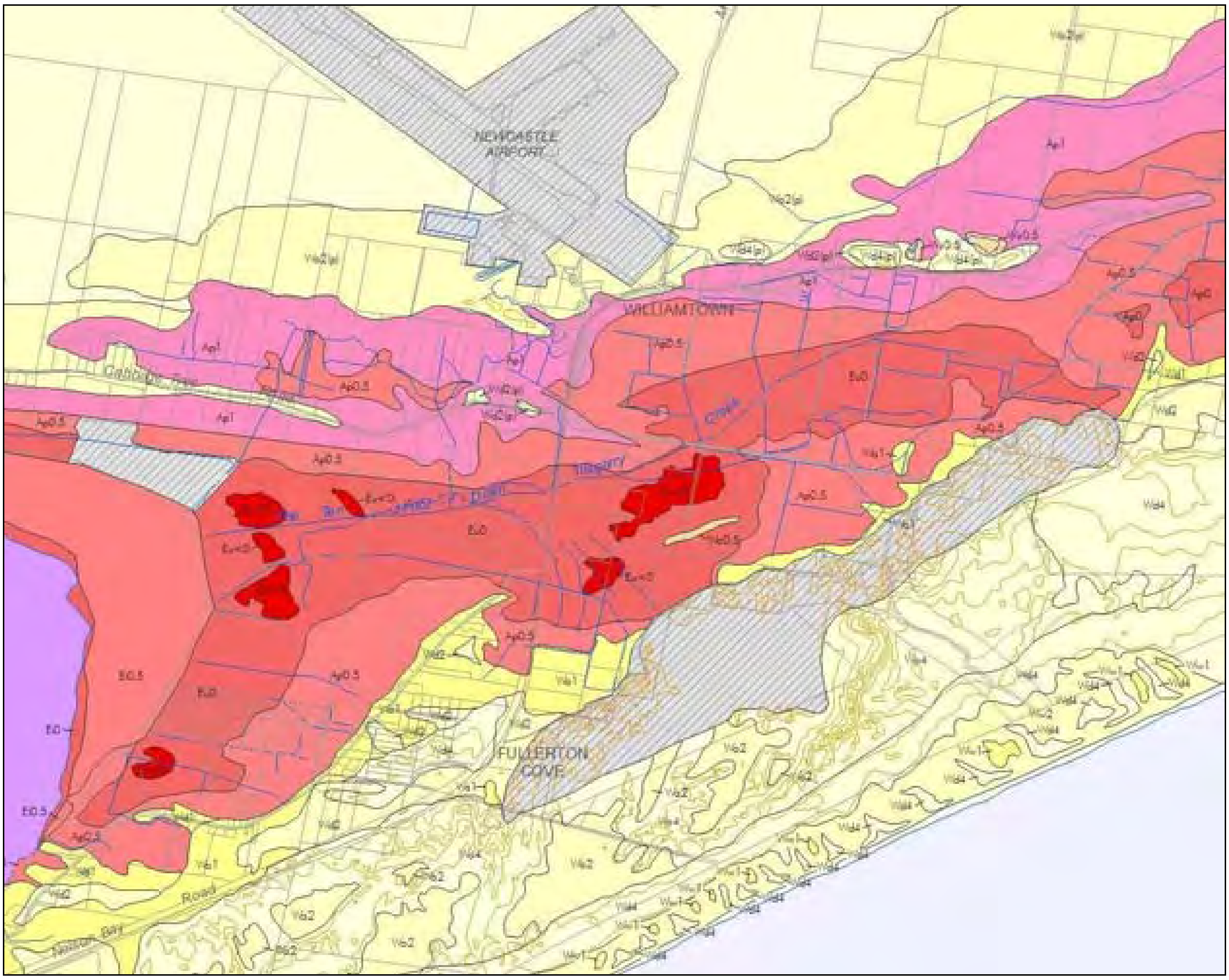


Figure 8 Tilligerry Creek Insert: Acid Sulfate Soil Risk Map (Source DECC, 2008).

The acid in turn mobilises iron, aluminium and other metals present in the soil (Indraratna *et al.*, 2005) which leaches into ground water and adjacent drains. Exported iron can oxidise again in waters that are considerable distances away from the source, producing iron oxyhydroxide or hydroxide flocculate (iron flocculate) that coat and smother benthic communities and stream banks (Sammut *et al.*, 1996).

In 2008, the Department of Environment and Climate Change revised the acid sulfate soil risk map for the Lower Hunter region, including the western end of the Tilligerry Creek catchment (Figure 7). The risk map confirmed that there is a high probability of ASS occurrence in the Tilligerry catchment, particularly in the low elevations adjacent to the creek. As shown those areas in red and dark pink have a high probability of ASS occurrence at or near the ground surface where the elevation is 0m AHD or lower. In these areas the depositional environment was at one stage suitable for the formation of ASS materials, and may now be buried under alluvial or windblown sediments.

1.4 Water Quality History

Water quality in Tilligerry Creek has been a concern to stakeholders for some time due to contaminated runoff from surrounding agricultural practices and potential impacts of acid sulfate soils. Long-term land use pressures in the Tilligerry Creek catchment have resulted in a continual decline in water quality and biodiversity in the area (Earth Tech Engineering, 2007).

In 2005 the upstream section of Tilligerry Creek was closed to oyster harvest by the NSW Food Authority. Tilligerry Creek was found to have high levels of faecal coliform bacteria and some human viruses. Key sources were identified as failing septic systems and poultry, horse and cattle farms (Lucas *et al*, 2007).

In response to this problem, in 2007 Port Stephens Council upgraded all failing septic tanks (Earth tech Engineering, 2007). More recently the Council has administered small grants to landholders for riparian rehabilitation projects, including fencing and revegetation (Figure 8). As the riparian zone establishes it will become a filter for runoff, capturing nutrients and preventing bank erosion and waterway sedimentation.

In June 2006 there was extensive estuarine acidification of Fenninghams and Wallis Creeks (both tributaries of Tilligerry Creek) that resulted in fish kills and incredibly low pH levels (3-4 pH) in the creek with pH's as low as 2 recorded in the drains.

In response, in 2008 NSW Department of Primary Industries conducted on ground assessments in these subcatchments to determine causes and identify management options (NSW DPI, 2008a). An area of particular concern was identified upstream of Anna Bay (Wallis Creek) floodgates. Remediation recommendations include reinstating tidal exchange upstream of the floodgates and raising the sill level of drainage channels to prevent further draw down of the groundwater. These actions are being further investigated and implemented at present in conjunction with Anna Bay Drainage Union.

Prior to this assessment at Tilligerry Creek there has been relative lack of previous studies into the presence and impacts of acid sulfate soils upstream of the Tilligerry floodgates.

Figure 8 Tilligerry Creek fencing and revegetation site

2 Site Assessment Methods

Prior to any on-ground works being conducted on the Tilligerry Creek floodgates, it is essential that site assessments are undertaken. Assessments were carried out on particularly low level land between the floodgates and Oakvale Drive (500m upstream), where there is considerable landholder concern about saltwater intrusion on the properties if the gates were managed for tidal exchange.

Landholders have reported saltwater on their properties in the past when the gates have been leaking due a blockage or corroded seals. In these cases tidal water has moved upstream unimpeded, increasing water levels in the drain and overtopping low points in the levy banks.

These assessments aim to assist in determining the feasibility of managing the floodgate to allow tidal exchange of waters without reducing the flood mitigation capacity of the drainage system and impeding on properties upstream. This project has undertaken a range of assessments as described in Table 1 and located in Figure 9.

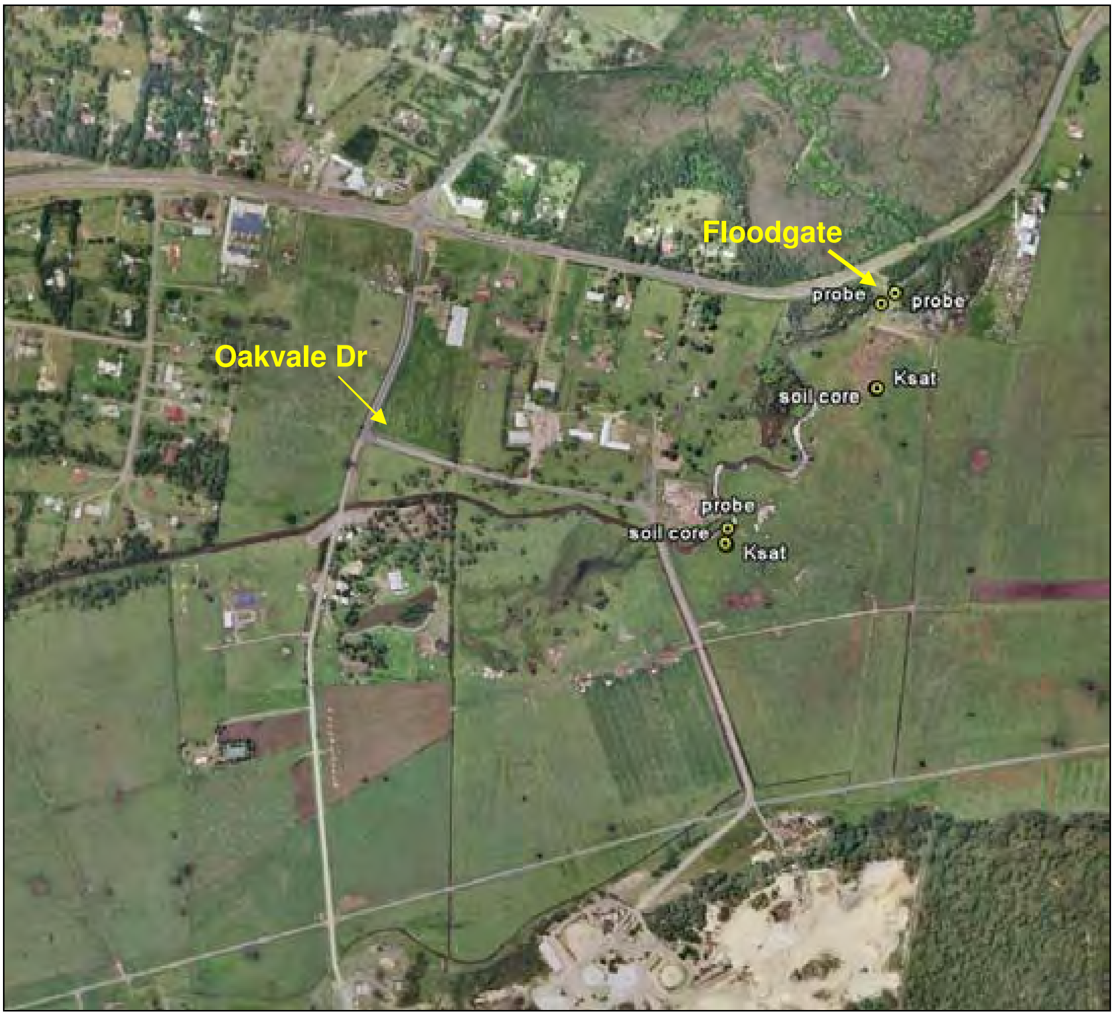


Figure 9 Locations of site assessments at the Tilligerry Creek floodgates (Imagery: Google Earth)

Table 1 Site assessment methods

Method	Rationale
Water levels	Establish water levels upstream and downstream of the floodgates, over a range of climatic conditions and tidal variations; determine existing gate leakage.
Water quality	Regular 'snapshot' sampling at various locations to establish quality of water discharging from the system.
Soil cores	Determine if potential acid sulfate soils are present and at what elevation compared to surface elevations.
K_{sat} pits	Determine soil hydraulic conductivity adjacent to the drain, and the potential for saline groundwater intrusion.
LiDAR (Digital elevation model)	Provide broad-scale elevation data accurate to +/- 0.15m and assess landscape elevation and low points along the levees.

2.1 Water levels

Three Odyssey capacitance water levels probes were deployed in Tilligerry Creek from 13th August - 22nd September 2008 and 24th October - 26th November 2008. The probes were located immediately upstream and downstream of the floodgates and one approximately 0.6km upstream adjacent to the lowest point of land (Figure 10). Loggers were surveyed to enable interpretation of results in relation to AHD.

The second installation was necessary due to failure of the downstream probe to record during the initial deployment. A new probe was used for the second deployment.

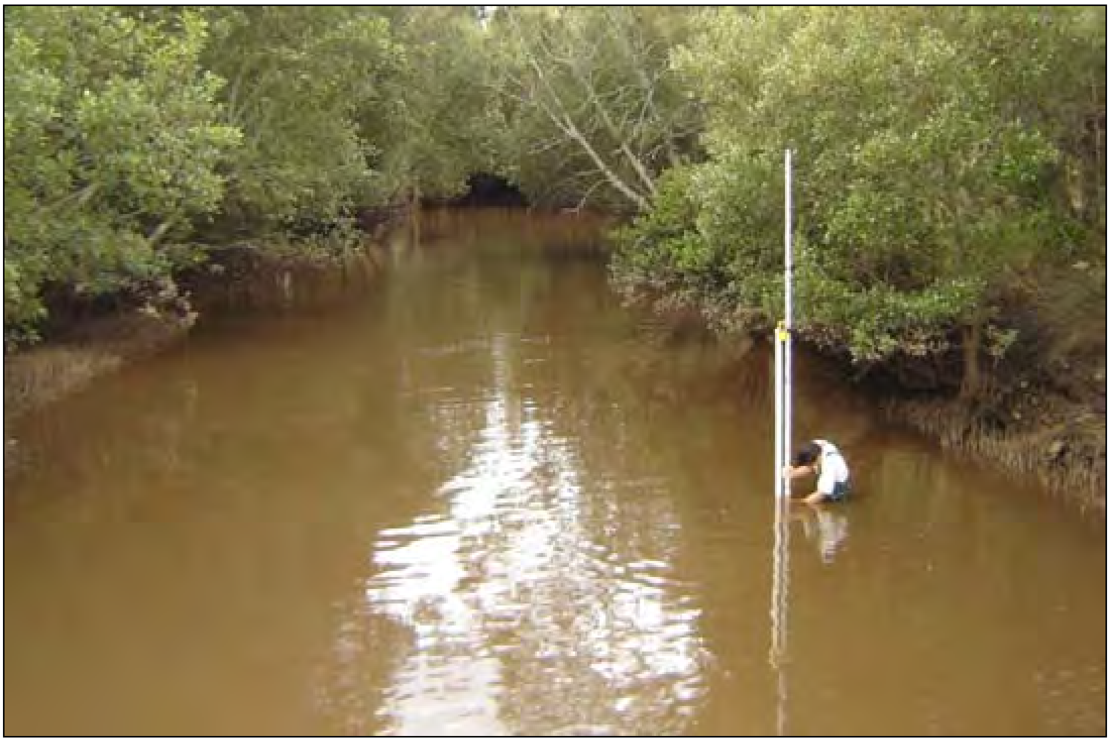


Figure 10 Water level probes were deployed upstream and downstream of the floodgates to record changes in water level with tide.

2.2 Water quality

Water quality measurements were taken with a Horiba probe when the water level probes were installed and removed. Attributes recorded include pH, electrical conductivity, temperature and dissolved oxygen. Where possible, measurements of groundwater quality were also taken when testing hydraulic conductivity of the soils (see below). Testing was not conducted for faecal contamination. Measurements were taken upstream of the floodgates on an outgoing tide as the system was discharging. Water quality downstream of the gates was measured on a high tide to confirm estuarine waters are reaching that point.

2.3 Soil cores

Soil cores were taken with a gouge auger in order to record soil morphology and soil profile descriptions, and to establish the presence and depth of sulfuric (actual ASS) and sulfidic (potential ASS) horizons.

Observations recorded included indicators of AASS (presence of jarosite, iron oxide mottling) and PASS (pyrite, shells). Hydrogen peroxide was used on samples of soil taken at 10cm intervals down the soil core, to test for the presence and depth of PASS in the soil profile.

In total, two soil cores were taken at low land elevations adjacent to the floodgate and the low point water level probe (Figure 9).

2.4 Hydraulic conductivity

Hydraulic conductivity (K) of the soil is a measure of the potential for groundwater movement both laterally and vertically through the soil profile. Hydraulic conductivity can greatly influence the behaviour of shallow groundwater and therefore potential management options for areas with acid sulfate soils (ASS). For example, the reintroduction of tidal flushing in a former wetland creek can benefit the system immensely. However, in some sites where the hydraulic conductivity is high (due to the presence of macro-pores), flushing with salt water can lead to detrimental impacts on wetland vegetation, surrounding productive pastures and potentially to the export of heavy metals associated with ASS / salt interactions.

The soils hydraulic conductivity was assessed using the method for K_{sat} pit tests as described by Johnston & Slavich (2003), Figure 11.

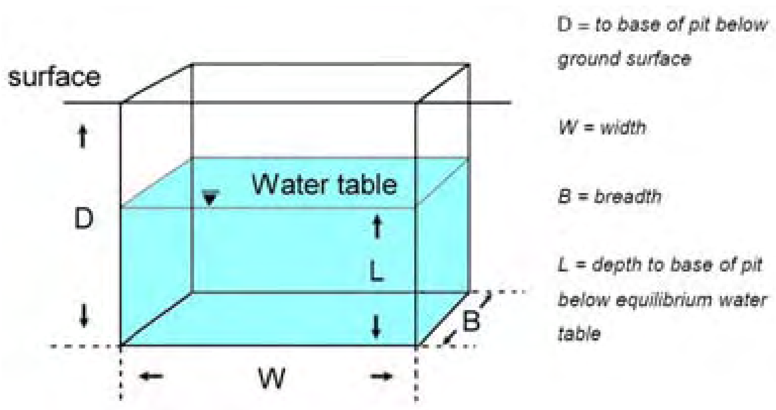


Figure 11 Example of pit geometry (Source: Johnson and Slavich, 2003).

Applying the Bouwer and Rice (1983) calculation methods to the data collected provides a quantitative assessment of K_{sat}. The K_{sat} measurement falls into one of four categories:

Low =	less than 1.5m/day
Moderate =	1.5 to 15m/day
High =	15 to 100m/day
Extreme =	greater than 100m/day

2.5 LiDAR

LiDAR (Airbourne Laser Scanning) data has been used to establish elevations of the Tilligerry Creek catchment. The data covering the Port Stephens Council Local Government Area was purchased jointly by NSW DPI, Port Stephens Council and Hunter Water Corporation from Fugro Spatial Pty Ltd.

LiDAR data in the form of high resolution digital elevation model was used to determine elevations of paddocks, drains and levees in order to assess implications for reinstating tidal exchange upstream of the floodgates.

3 Results

3.1 Water levels

The three Odyssey capacitive water level recorders were removed from their locations and the data downloaded on 26th November 2008.

Figure 12 shows the tidal variations recorded by all three in-stream probes. At high tide both the upstream and low point recorders appear to show tidal influence. While the floodgates allow some leaking, this is not significant and does not reach the low point. The fluctuations in water levels observed for the upstream and low point probes occurs while the gates are forced shut during the in-coming tides. During this time, water backs up in the drain at least as far as the low point until the out-going tide allows the gates to open and the system discharges.

Immediately downstream of the floodgates, the highest tide reached 1.041m AHD and a minimum of -0.782m AHD. The highest water levels measured upstream of the gates were much less than downstream. Immediately upstream of the gates recorded a maximum of -0.054 m AHD and the low point reaching -0.082 m AHD. The lowest water levels were similar at these locations to the downstream water level, with upstream recording -0.719m AHD and the low point recording -0.752m AHD. Water levels downstream of the gates were observed overtopping the floodgate headwall during a high tide but not the levy between upstream and downstream.

Heavy rainfall events were not experienced in the catchment while the water level probes were installed. The maximum rainfall was 28.6mm in late October though rainfall was not sufficient enough to increase low tide water levels at the upstream and low point probes. Slight increases during low tides at these locations are observed after several days of low rainfall in early November. This may be due to a build up of surface water which then seeps into the drain. The increases are also observed after 19mm of rain fell in mid November.

3.2 Water quality

Water quality measurements of the Tilligerry Creek drain show the water to have an almost neutral pH immediately upstream of the gates and at the low point probe, with levels an average of 6.82 and 6.87, respectively. These levels are slightly lower, but comparable to the expected pH of estuarine waters in south eastern Australia, which ranges between 7 and 8.5 (ANZECC, 2000).

Levels of dissolved oxygen (DO) were satisfactory at 7.59mg/L at the upstream side of the gate and 7.50mg/L further up the drain at the low point (Table 2).

Table 2 Average water quality results from the Tilligerry Creek drain

Location	Tide	pH	EC (mS/cm)	DO (mg/L)
Upstream probe	outgoing	6.82	1.90	7.59
Low point probe	outgoing	6.87	1.66	7.50
Ksat pit 1	outgoing	6.74	17.4	-
Downstream probe	incoming	6.92	34.2	4.68

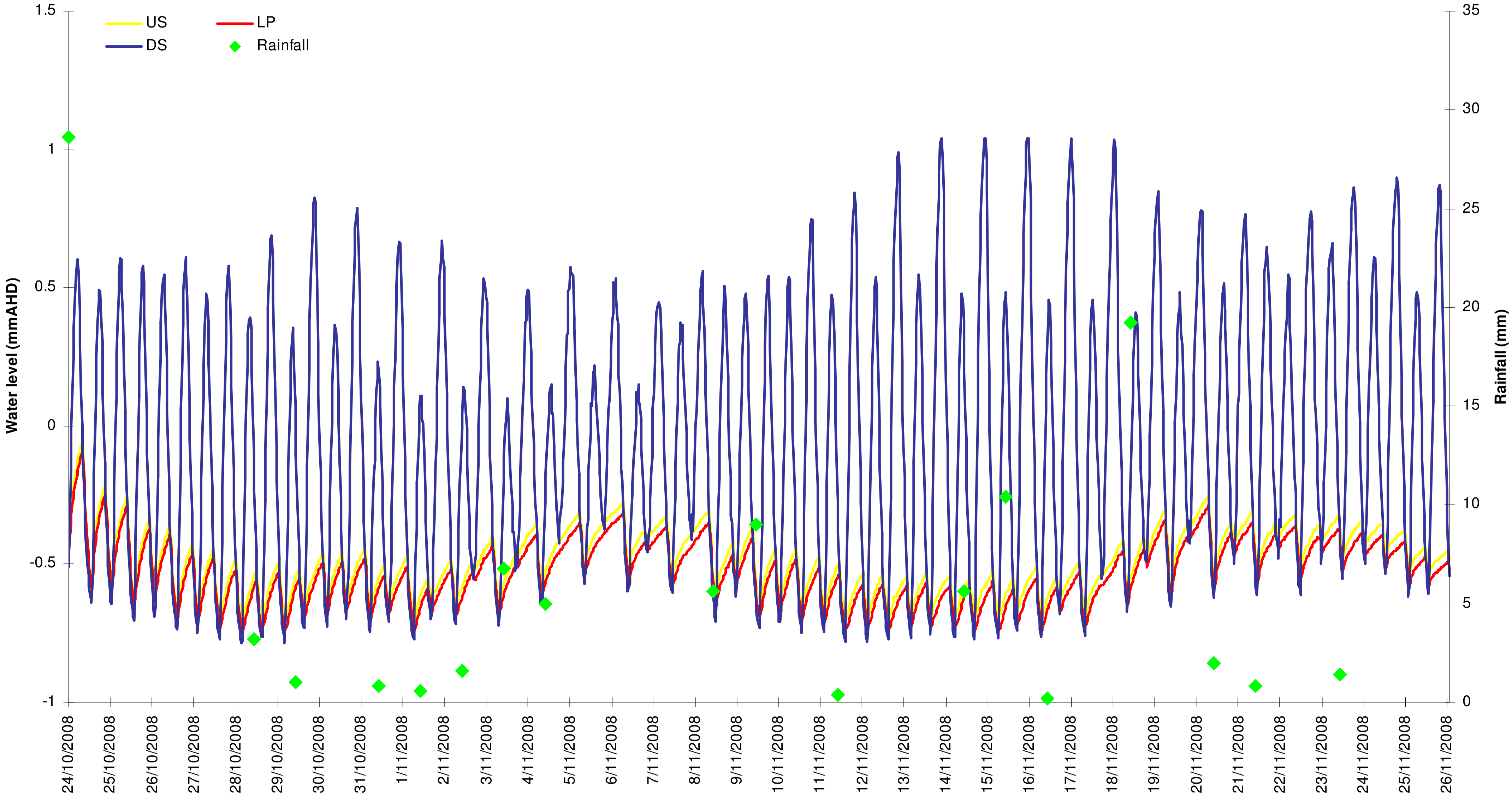


Figure 12 Water levels (m AHD) recorded at the Tilligerry Creek floodgates from 24th October to 26th November 2008.

Electrical conductivity (EC) of the water was low within the drain on the outgoing tide as freshwater was discharged through the gates. Water immediately upstream of the gates had an EC of 1.90mS/cm with a similar measurement of 1.66mS/cm further upstream at the low point.

At high tide, water downstream of the gates was estuarine with a pH of 6.92, DO level of 4.68mg/L and an EC level of 34.2mS/cm.

3.3 Soil cores

Two soil cores were taken in order to conduct field peroxide tests to establish the depth of the potential acid sulfate soils (PASS). Sites were selected in low land elevations.

The field tests confirmed the presence of PASS at varying elevations. Core 1 was taken in low land close to the floodgate and PASS was identified at 0.60m below the surface at an elevation of -0.306m AHD. Soil above the PASS was a sandy loam. Core 2 was taken in low land adjacent to the low point probe. PASS was identified at 0.20m below the surface at an elevation of -0.038m AHD.

In both cores, the PASS displayed vigorous effervescence when reacting with the peroxide, creating orange froth (rather than cream coloured like that observed in the Anna Bay catchment where oxidation of PASS is occurring). The orange colour is a result of iron flocculating from the soil due to the reaction with the peroxide (Hirst pers. comm.).

In general, ASS affected areas where pyrite oxidation has, or is, occurring iron floc is visible in the drain water, on vegetation along the drain banks and on any structures in the water such as culverts and floodgates. It can also be seen on the surface of land which has low elevations and pooling water.

This has not been observed in the Tilligerry Creek drain and surrounding land. However, where landholders had excavated shallow drains to help remove pooling surface water more quickly, pyrite can be observed in the drain walls and in drying spoil removed from the main drain.

Due to the high annual rainfall (1200mm on average) and the low elevation landscape (see section 3.5 below) the surface water often remains for long periods of time after a rain event. The presence of pooled water is aiding in keeping the PASS waterlogged and thereby preventing oxidation.

A range of signs indicate that pyrite oxidation has not previously occurred in the area – iron flocculate resulting from the peroxide tests, low land elevations, regular water logging, water with high pH, and no iron floc observed in or along the drain. This assessment period coincided with higher than average rainfall patterns. This affects the system by maintaining groundwater levels above those exhibited during drier climatic conditions. It is important to note that a higher groundwater table would also manifest in less visible signs of ASS presence including pH indicators. Nevertheless, oxidation is likely to be being prevented by the low PASS elevations compared to drain water levels and the high average rainfall received by the catchment.

In comparison, previous soil testing undertaken at the Fullerton Cove end of the Tilligerry catchment near the Fullerton Ring Drain and Fullerton Cove floodgates, concluded that a very shallow ASS layer is present (0.45m below the surface, and -0.12m AHD) (NSW DPI, 2008b). Because the major drainage system in this area is actively maintained, the ASS risk in this area is considered high and has been identified the highest priority site for ASS management out of the five wetland sites tested in the Lower Hunter Catchment.

3.4 Hydraulic conductivity

Hydraulic conductivity (K_{sat}) testing was conducted in two locations where land elevations are low. Results of testing indicate the soils at pit 1 have low conductivity with lateral seepage expected to be less than 1.5m a day, possibly due to the sandy nature of the soils (Fig 13). Sandy soils can often lack the macropores (old tree roots) found in clay soils that give the latter high hydraulic conductivities (Hirst, pers comm.). This is expected as the drain is less than 1km from the Stockton dunes and as such the soil is predominately sandy and underlaid by marine and estuarine mud and sands (Environmental & Earth Sciences, 2000).

The low hydraulic conductivity recorded in pit 2 could not accurately show the conductivity of the soil as K_{sat} testing relies on reaching the groundwater at a maximum depth of 0.5m. This was not achieved at this site and retesting after a period of heavy rainfall could have different results when the groundwater level has increased to a sufficient level for testing. Heavy rainfall was experienced in the catchment in the days prior to the testing, though sufficient time may not have passed to affect the groundwater level.

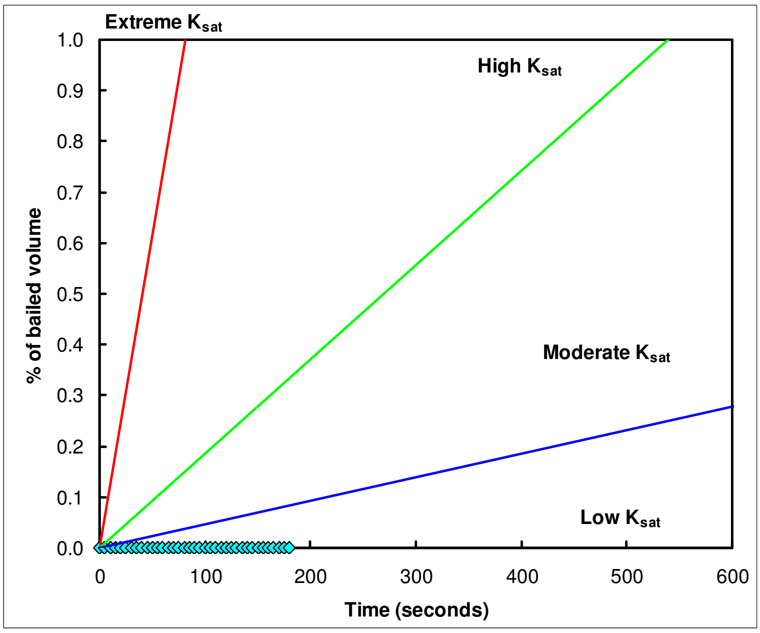
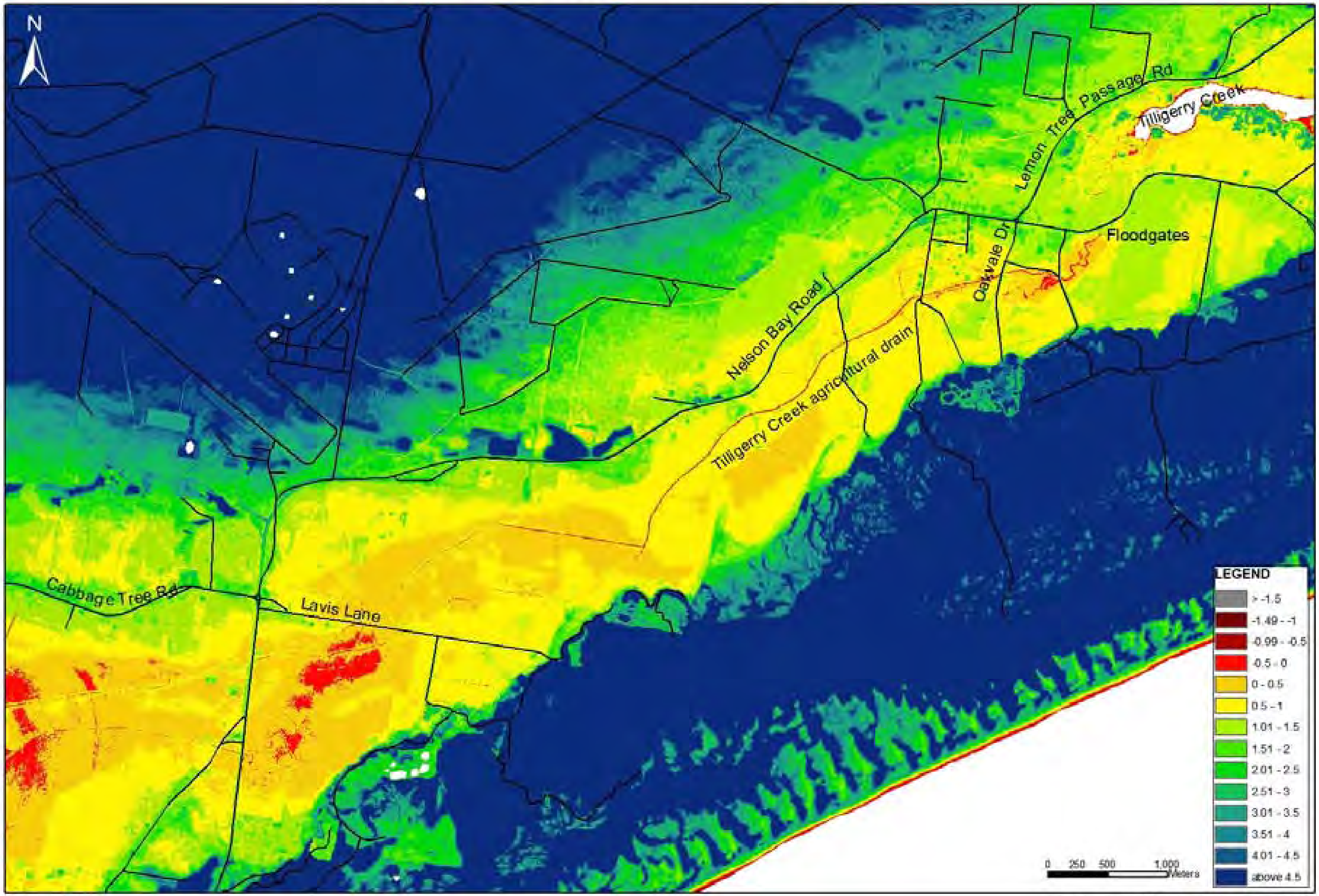


Figure 13 Ksat pit results showing low hydraulic conductivity.

3.5 LiDAR

Analysis of the LiDAR data revealed that the catchment is very low-lying with elevations generally between 0 and 2m AHD (Figure 14). Land between Oakvale Drive and the floodgate is particularly low, between -0.5 to 0.5m AHD and increasing up to only 1m AHD further up the catchment towards Fullerton Cove. The levee banks along the drain are also very low, between 0 and 0.5m AHD between the floodgates and Oakvale Drive and 0.5 and 1m AHD further up the drain.

Digital Elevation Model for the Tilligerry Creek catchment



Scale: 1:40,000

Map created by A Burke 19 November 2008

Figure 14 Digital Elevation Model of the Tilligerry Creek catchment

4 Discussion and Recommendations

4.1 Acid Sulfate Soils

The results of the testing in this preliminary study indicate that while potential acid sulfate soils are present in the catchment, they appear to remain unoxidised in at least the area 500m upstream of the floodgates. Field observations confirm that the common signs of oxidation – such as iron flocculate in the drain water, on drain banks and in low lying areas of pastures, and the sulphurous smell to groundwater and soil samples – are largely absent. Further testing is required to confirm that this is also the case further upstream in the catchment, particularly the low lying areas south of Lavis Lane, Williamtown.

The apparent lack of oxidised PASS indicates that the Tilligerry Creek drainage system does not presently appear to be over-draining the landscape. Current conditions are maintaining anoxic conditions in the landscape necessary to prevent oxidation.

However, the top of the PASS layer is located above the entire range of water levels found at the low point monitoring station. This means that under certain conditions the PASS layer has the potential for oxidation. While there may currently be enough rainfall to keep the PASS layer moist (and limit oxidation), the situation is likely to change dramatically with the next period of extended low rainfall and/or changes to the hydrology of the system through an enhancement of the drainage system.

Changes such as these, which result in the lowering of the ground water table, could risk oxidation and the mobilisation of acid and heavy metals into the estuary. A decrease in the drain water levels could increase the risk of exposing the shallow PASS to oxidation which would lead to severe impacts on the environment downstream of the floodgates, similar to those currently occurring in the Anna Bay catchment. Caution should be applied when undertaking drain maintenance activities in the Tilligerry Catchment to avoid exposing the PASS layer to oxidation.

4.2 Tidal exchange

The digital elevation model (Figure 14) and the recorded downstream water levels, demonstrate that without the presence of the floodgates, headwalls and associated infrastructure, estuarine inundation would occur over the areas shaded in red, bronze and yellow. While this may offer benefits for environment by restoring the natural water regime, the number of landholders who would be negatively impacted would prove to be untenable. As such, the presence of the floodgates is necessary to continue agricultural activities in these low lying areas.

To provide improvements in water quality upstream of the floodgates, however, controlled tidal exchange necessary. This is achievable with an auto-tidal floodgate, which can be manipulated to achieve the optimal amount of water exchange to benefit the environment and landholders.

According to the digital elevation model levels (Figure 14) the current height of the levees adjacent to the drain between the floodgates and Oakvale Drive are not high enough to prevent tidal water overtopping them, should the floodgates be modified.

The proposed floodgate modification requires a high degree of confidence, to mitigate against adverse impacts on agricultural activities. Floodgate modifications would need to be accompanied with earthworks to raise levees on either side of the drain to a sufficient level to prevent saltwater intrusion into private farmland. Further detailed surveying would help to determine the level to which the levees would need to be raised.

It is recommended that the maximum level of tidal water permitted to enter the drain through the auto-tidal floodgate is 0m AHD (i.e. mean sea level or medium level tide). This would allow the rising tide to enter the drain up to 0m AHD, at which level the auto-tidal gate would shut to exclude high and king tides and floodwaters.

The soils immediately upstream of the floodgates have a low conductivity potentially due to the sandy nature of the soils in the area. This low conductivity, if consistent across the sub-catchment, means that brackish water can be introduced into the drainage networks without fear of saline water travelling through the groundwater table into adjacent paddocks. Further assessment of hydraulic conductivity adjacent to drains further upstream would confirm low conductivity across the catchment.

In summary, recommendations for the management of the Tilligerry Creek floodgates are:

1) Liaise with landholders to determine interest in tidal flushing and identify any issues, such as impacts of salinity on stock watering and overtopping of low points;
2) On ground surveying is required to confirm LiDAR heights and to determine the extent of earthworks required;
3) Levee works need to be carried out to build up low points in the existing levees upstream of the floodgates, particularly between the floodgates and Oakvale Drive, to ensure estuarine water does not inundate properties.
4) Conduct further soil and K_{sat} testing on properties upstream of Oakvale Drive to determine acid sulfate soil risk and hydraulic conductivity of soils;
5) Develop a management plan with relevant landholders and agencies for the installation and management of at least one auto-tidal device fitted to the current gates;
6) Design and install an automatic tidal gate on at least one of the four cells. This could be undertaken in a staged approach with one auto-tidal gate fitted and set to a level at which all stakeholders are satisfied with, and if additional flushing is required, a second gate could be installed;
7) Riparian rehabilitation works, such as revegetation, fencing and providing alternative stock watering points, would complement floodgate management works.

To improve water quality and environmental attributes of the Tilligerry Catchment, it is necessary to install an auto-tidal floodgate to at least one of the floodgates. A coordinated effort on the part of all stakeholders involved (landholders, Council, State Government) will ensure the above recommendations can be implemented to benefit water quality, while having minimal impact on agricultural activities in the catchment.

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