INCREASING THE RESILIENCE OF HORTICULTURAL AND AGRICULTURAL SYSTEMS TO FUTURE FLOOD EVENTS IN THE HIGHLY PRODUCTIVE LAIDLEY CREEK VALLEY

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Abstract

The January 2013 floods badly affected the Laidley Creek Valley in South-east Queensland, causing significant channel bank and bed erosion, floodplain scour and loss of farm infrastructure. The valley is a highly productive horticultural area within the nationally important Lockyer Valley, with production occurring in the narrow, partly confined floodplains.

For many producers losses were aggravated by: (i) failure of bank/levee systems resulting in large, uncontrolled pulses of flood waters breaking out across the floodplain; and (ii) farm infrastructure planning that has been tailored to the management of normal rainfall runoff, rather than flood flows along the floodplain.

SEQ Catchments is working with Government and corporate partners to assist landowners increase on-farm resilience to future flood events. To assist this process, a two dimensional stream and floodplain model of flood flow hydraulics and behavior for the 10 km target reach was developed. This model has subsequently been used to develop and test options for better managing both the Laidley Creek channel and the floodplain. This quantitative approach to understanding channel and floodplain dynamics across an extensive catchment area is the first of its kind in south east Queensland, and SEQ Catchments is leading the way in this approach to floodplain management.

The focus of works has been to address the bank/levee instability and the weaknesses in traditional farm and infrastructure planning that have aggravated flood losses. SEQ Catchments is working with landowners and Government to remediate degraded riparian areas through use of grade control structures, bank battering and revegetation. In addition, innovative work aimed at increasing floodplain roughness through strategic installation of cross-floodplain roughness structures (vetiver and post hedges) is being adopted together with recommendations for maintaining crop cover in high risk areas during those times of the year when flooding is more likely to occur.

The project is funded from the State Government's On-farm Productivity and Riparian Recovery Program, which forms part of the Natural Disaster Relief and Recovery Arrangements. The work has provided the opportunity to leverage learnings to inform resilient floodplain management elsewhere in the Lockyer Valley.

Introduction

Flood events have been described as causing immediate and ongoing severe impacts to agricultural lands, infrastructure and operations globally (Quast et al., 2011, Chau et al., 2013, Levy and Hall, 2005). While floods are a natural component of the South-east Queensland landscape, they continue to be a regular threat to agricultural and horticultural production in the region (ABARES, 2011, SEQ Catchments, 2013a). Impacts to production from flooding are diverse and can include; crop damage from inundation, topsoil movement and loss resulting from high energy flood flows, sediment deposition, direct loss of productive land from lateral creek bank erosion, damage to farm infrastructure and changes to the soil nutrient balance and soil physical properties.

Planning and design of farms in the Laidley Valley have typically been guided by a traditional soil conservation approach, with the design of roads, drainage, row directions and other infrastructure being optimised for normal summer rainfall and runoff management. One consequence of this rainfall runoff focus is that farm infrastructure planning may not be designed for the best management of flood-flows along the floodplain.

In addition, it is not uncommon for production systems to be focused on the floodplain quite independently of the condition of the abutting Creeks. This is particularly the case if levees are present, which act to isolate many reaches of the creek from farm operations. Flood damage of floodplain agricultural lands is often aggravated by the unstable and degraded state of the creek system, with dramatic losses of productive land resulting from channel processes (Alluvium, 2013a).

Historic and ongoing land use changes, such as widespread clearing of catchment and riparian vegetation, have resulted in significant changes to catchment hydrology, with channel incision (widening and deepening) a frequent consequence in systems globally (Bledsoe et al., 2002, Gregory, 2006) and across Australia's eastern seaboard (Brooks and Brierley, 1997). Uncontrolled bank erosion (widening) results in a loss of land, increased sediment load downstream and potential impacts to public and private infrastructure (Brooks and Brierley, 1997). In addition, where levees have been built on top of the high banks, they have similar failure risks as those banks on which they are constructed. Channel deepening can erode the toe of banks, leading to further destabilization and channel widening. Internationally recognized best management practice guidelines outlining options to manage channel incision processes are available (Hubble et al., 2006, Department of Sustainability and Environment, 2007). Practices recommended in these guidelines, for creeks experiencing incision, include a combination of bank battering, grade control structures and the establishment of a diverse suite of native vegetation (Hubble et al., 2006) (Department of Sustainability and Environment, 2007).

Recovery and restoration of flood affected farms is expensive and time consuming, with potential ongoing land productivity losses. A number of studies have investigated practices to reduce the impacts of erosion through either (i) moderating the scour potential of flood flows by increasing the hydraulic roughness of the floodplain (Dalton et al., 1996, Dalton et al., 1998, Smith et al., 1991), or, (ii) increasing the resilience of the floodplain to erosion through increasing cover and/or reducing disturbance of the soil (Zhou et al., 2009, Prasuhn, 2012)

Increasing hydraulic roughness can reduce velocity and shear stress of flood flows, thereby reducing the likelihood and severity of scour, and potentially induce sedimentation. Field trials of the use of vetiver (*Chrysopogon zizanioides*), a stiff leafed, asexually propagated, fast growing grass, planted to form dense, semipermeable hedges perpendicular to the direction of flood flows have been undertaken on the Darling Downs, Queensland (Dalton et al., 1996, Truong et al., 2009). These vetiver hedges have been shown, both through flume and field trials, to have flow-retarding and sediment trapping abilities.

Alternate cropping practices, such as strip cropping, have also been trialed in South-east Queensland (Smith et al., 1991). This practice maintains crops interspaced with fallow and stubble strips to ensure strips of higher hydraulic roughness are in place at regular intervals across the field. This acts to spread flood waters laterally, reducing the velocity and depth of the flood water across the field (Smith et al., 1991). Strip cropping, while reported to be successful with broad acre cropping on the extensive floodplains of the Darling Downs has limited practicality in the Lockyer Valley due to the narrow floodplains and high frequency crop rotations of intensive vegetable production.

Strip or zonal tillage, a conservation tillage practice in which only the area to contain the seed row is disturbed, facilitates the retention of some stubble and reduces disturbance to the soil structure (Queensland Government Department of Agriculture Fisheries and Forestry, 2010, Vyn and Raimbault, 1992) . Strip till has been found to reduce erosion potential (Zhang, 2012, Zhou et al., 2009, Queensland Government Department of Agriculture Fisheries and Forestry, 2010), however these studies have not focused on high power flood flows across the floodplain, but rather on considering rainfall runoff situations. This practice is being utilised in a number of different cropping systems in Australia however it has not been widely adopted in intensive horticulture crops in South-east Queensland.

This paper details an ongoing project being undertaken by SEQ Catchments, with Government and corporate partners, to assist landowners of the Laidley Valley to increase the resilience of their floodplain production systems to future flood events and to incorporate flood planning and flood risk management into standard farming practice. To achieve this, the study focuses on farm management practices on the floodplain in addition to considering the condition of the creek, while optimising ongoing production.

Study site

The Laidley Creek catchment is an elongated catchment which covers an area of 488 km2. It is a sub-catchment within the Lockyer Creek system, the largest tributary of the Brisbane River which drains to Moreton Bay, South-east Queensland. This study was focused on an approximate 15 km reach of Laidley Creek located in the mid-catchment which has a partly confined valley setting with narrow floodplains (in the order of 1 km) (Figure 1). Within this zone, the creek is a low sinuosity gravel bed system, with silty-clay banks, and for significant lengths of the target reach the channel is bounded by artificial, generally historic, levees perched at the top of the natural banks. The riparian zone is highly degraded, with native riparian vegetation either absent or of low density and generally poor condition. The valley experienced a significant flood in January 2011, two years prior to the January 2013 flood. While the 2011 flood was reported to have minimal impact to floodplain production, it acted to further degrade the riparian corridor of Laidley Creek through removal of much of the riparian vegetation and resulted in significant extents of bank erosion.

The area has a subtropical climate, with mean annual rainfall of 771 mm reported for Gatton (nearest Bureau of Meteorology gauge, located 20 km from study site) (Bureau of Meteorology, 2014). It has a summer predominant rainfall, with frequent, high intensity storm events regularly occurring during this period (December to January) (Bureau of Meteorology, 2014).

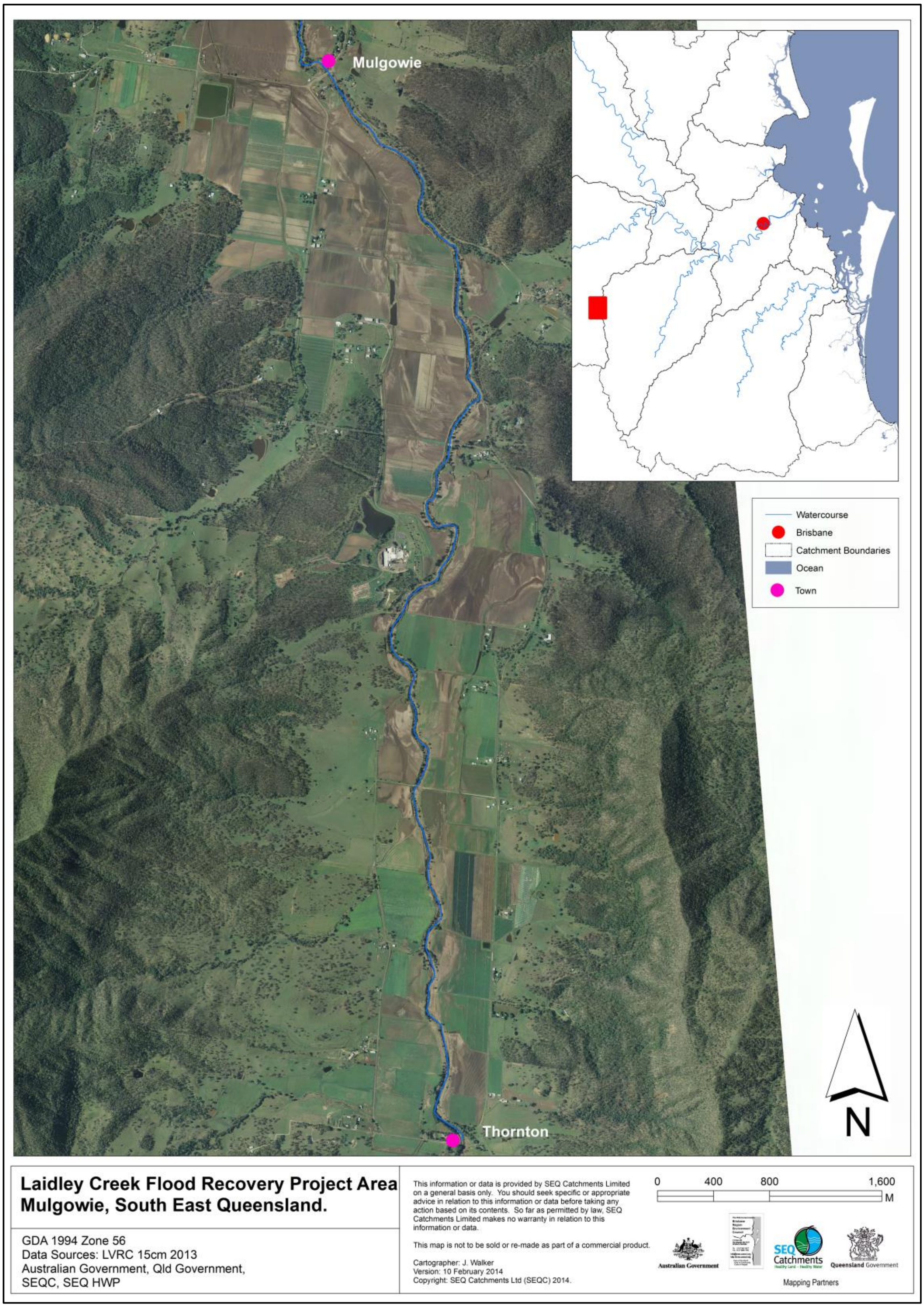


Figure 1: Map showing project reach of Laidley Creek, with insert indicating project location within the broader South-east Queensland region. Immediate post 2013 flood imagery shows topsoil movement down floodplain.

Agriculture in the study area

The Laidley Creek floodplain has fertile, alluvial soils which support a diversity of commercial primary production systems including vegetable cropping and beef and dairy industries. The valley is a significant horticultural sub-catchment within the Lockyer system, which is a nationally significant horticultural production area accounting for 26.5% of vegetable commodity value output for Queensland in the 2010-2011 year (Queensland Government Department of Agriculture Fisheries and Forestry, 2013).

Agricultural production across much of Laidley Valley has intensified through recent time, with large sections of the target reach currently under intense vegetable production with cropping generally extending to the channel boundary, or to the base of levees if they are present. Corresponding higher rates of tillage (up to eight times per year) and minimal use of cover crops has accompanied this intensification of agriculture.

January 2013 flood event

The Flood

Dry conditions preceded the January 2013 flood, with the Laidley Creek flow gauge, located just upstream of Mulgowie, recording only minimal flow in Laidley Creek (Queensland Government Department of Natural Resources and Mines, 2014). Ex-Tropical Cyclone Oswald resulted in intense rainfall in the upper Laidley Creek catchment on 26 and 27 January 2013, with 944 mm recorded at Mt Castle in the upper catchment in the 48 hour period to 9 am on 28 January 2013 (SEQWater, 2013). An in-channel flow gauge in Laidley township (approximately 15 km downstream from the project reach) recorded the highest flows since records commenced in 1990 (Bureau of Meteorology, 2013).

The Mulgowie flow gauge in the target reach has been found to substantially under-represent large, out of channel flow events (Alluvium, 2013a). To overcome this limitation design flood flows were determined as part of this investigation, with the magnitude of the peak flow of the January 2013 flood being calculated at approximately 1010 m^3s^{-1}, corresponding to an average return interval (ARI) of approximately 100 years for the Mulgowie reach of Laidley Creek (Alluvium, 2013a). This flow was calculated through re-creation of the out of channel flow events at the Mulgowie gauge based on a 2D hydraulic model for the creek and floodplain. This model was calibrated through reference to flood inundation mapping derived from aerial photographs flown by Lockyer Valley Regional Council immediately post the 2013 flood (Lockyer Valley Regional Council, 2013).

Impacts of the January 2013 flood

The January 2013 flood had significant immediate and ongoing impacts to infrastructure and agricultural production in Laidley Valley (Figure 2). Flood water inundated a significant portion of the floodplain within the project reach (Figure 3), resulting in crop loss, extensive damage to farm equipment and substantial areas of floodplain erosion and sediment accretion. Floodplain scour was most severe in areas of channelized flow, which in numerous locations was aggravated by levee breaches (due to the creek bank eroding from beneath the levees), resulting in large, uncontrolled pulses of flood waters breaking out across the floodplain. Areas which were recently cultivated, fallow, or had minimal cover such as immature crops, sustained the most acute topsoil erosion.

Figure 2: Damage sustained in the January 2013 flood of Laidley Valley (a) erosion of agricultural fields down to the controlled traffic line and, (b) undermining the foundations of bridge infrastructure caused by deepening of the Laidley Creek.

Topsoil erosion, up to 45 cm in depth (down to the controlled traffic line), was experienced across a number of production fields and downstream sediment deposition of up to 100 cm depth occurred over a number of fields. In addition to affecting the physical form of the field (drainage, level and bed form), the soil nutrient balance and physical properties (such as texture) were also impacted. A permanent loss of productive land also occurred as a result of stream bank erosion, with lateral erosion of up to 20 m experienced on some meanders (Figure 4). Anecdotally, producers in this 15 km stretch of floodplain spent in excess of $1M in immediate recovery efforts, and substantial further costs associated with capital value of lost land, equipment replacement and ongoing lost production. Some fields have not returned to production more than one year after the event.

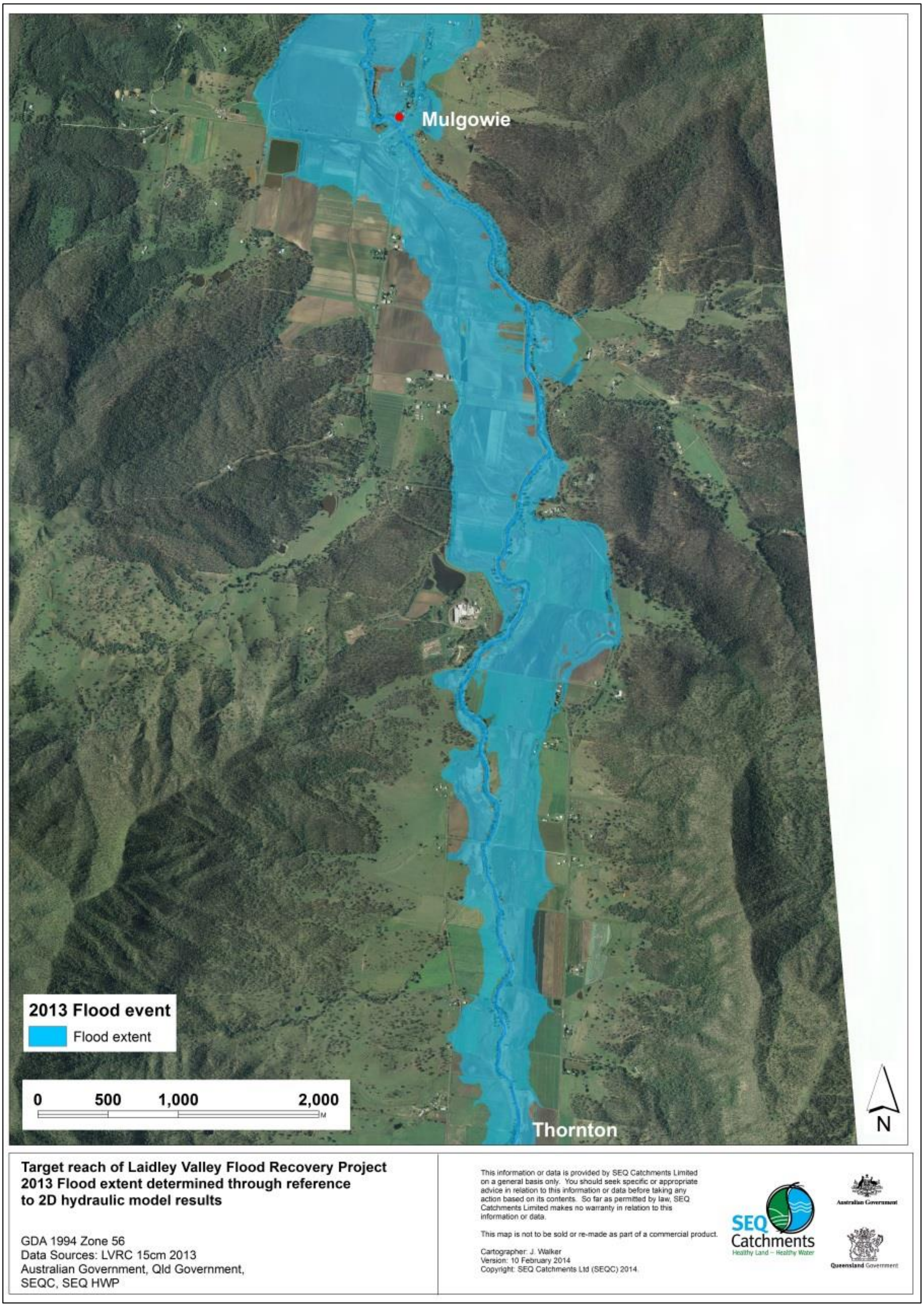


Figure 3: Maximum floodplain inundation in the project reach during the January 2013 flood. Flood extent given by 2D hydraulic model output, with landowners in target reach indicating support for model results.

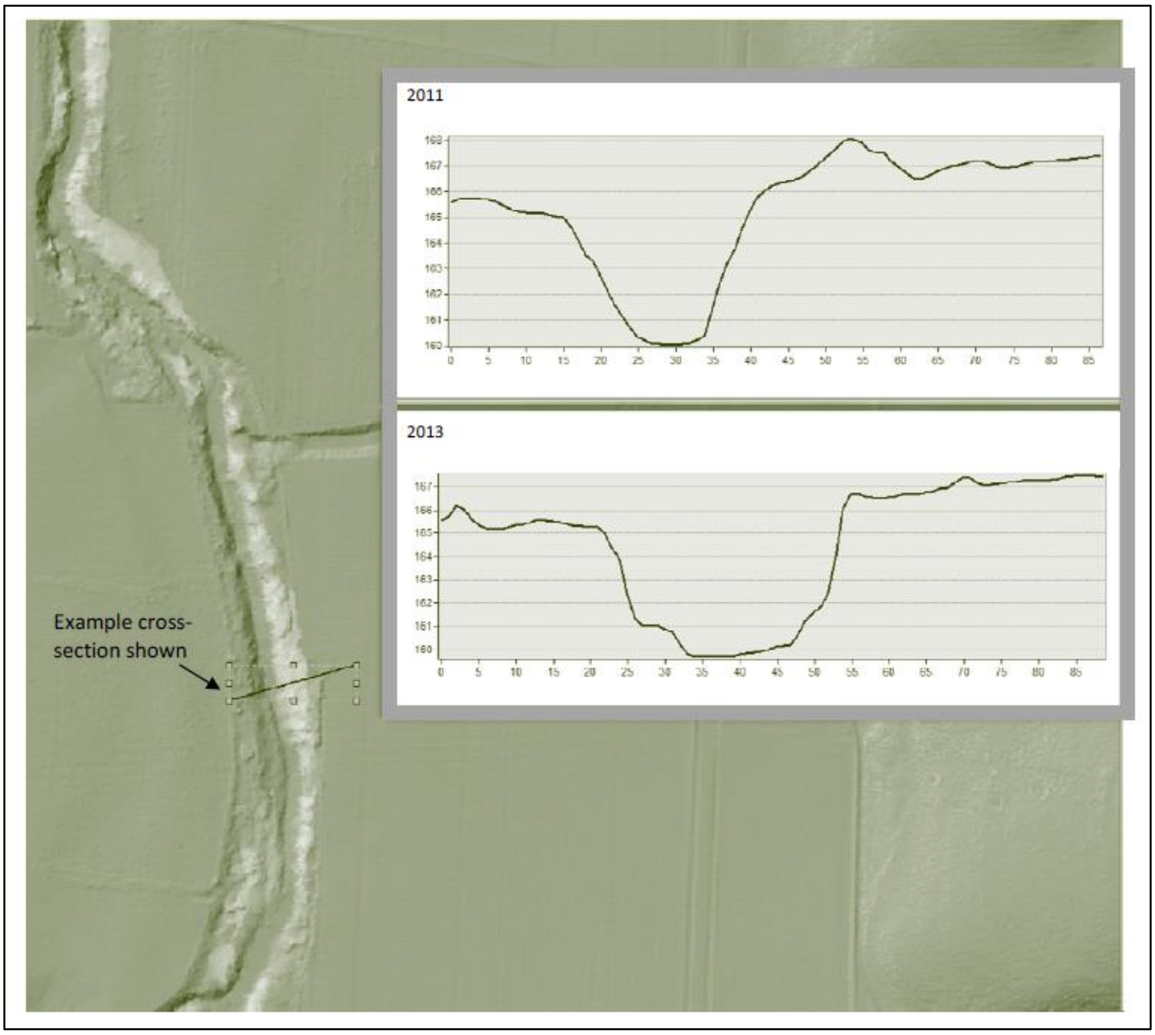


Figure 4: Example view of changes between 2011 and 2013 LiDAR in the subject reach. Widening of >20 m in some areas occurred as a result of the January 2013 event. Cross sections from 2011 and post 2013 flood shown in insert.

Sediment eroded from Laidley Creek Valley (creek bank and floodplain) in times of flood contributes to the large volumes of sediment transported downstream to Lockyer Creek. An estimated 12,000 m^3 of sediment entered the Laidley Creek system from a single 800 m reach just upstream of the project target reach (Alluvium, 2013b, Alluvium, 2013a). Lockyer Creek in turn supplies significant sediment loads to the Brisbane River and Moreton Bay (Olley et al., 2013, Douglas et al., 2003). The high sediment load of the Brisbane River during the January 2013 flood forced the closure of the Mount Crosby water treatment plant (SEQ Water, 2013), threatening the water security of Brisbane, and significantly affecting water quality in Moreton Bay (TERN, 2014).

Laidley Valley flood recovery project

Project Process

Following the 2013 floods, a number of producers in Laidley Valley approached SEQ Catchments seeking assistance and advice surrounding on-farm productivity recovery and options to increase the resilience of their farms to future flooding. This project was developed, with support from the Queensland and Australian Governments, to overcome an apparent absence of focused expertise and capacity in the field of building flood resilience into production systems located on the floodplain of high energy creek systems, such as those commonly found in South-east Queensland.

Active engagement with landowners and producers in the target reach has underpinned all stages of the project; from project inception, collection of information surrounding the 2013 flood event, through to development of possible management practice options and how these can be accommodated into production systems. Through this project, SEQ Catchments brought landowners together with the best available science and expertise.

The initial phase of the project was to increase our understanding of the project reach and of the key threatening processes.

Channel erosion potential

A geomorphic stability assessment to determine channel erosion potential in the study reach was undertaken (Alluvium, 2013b). Bed grade was determined through reference to post-flood 2013 LiDAR (SEQ Catchments, 2013b) and stream powers were estimated through development of a one-dimensional hydraulic model (HECRAS). These results were compared to reference data for stable streams (Hardie, 2005, Zavadil et al., 2014 (in review)) and used to identify potential areas and the magnitude of likely erosion.

Results from this assessment indicate that active channel incision (deepening and widening) is ongoing through the project reach, with much of the mid to upper catchment expected to experience widening in the order of 20-80 m and bed lowering in the order of 1-4 m if current management practices continue (Alluvium, 2013a). This channel adjustment will likely occur episodically, associated with large flood events and will have direct implications for producers in the target reach, and for stakeholders downstream. In the project reach, channel widening will also continue to impact the security of existing levees, with levee failure as a result of bank erosion continuing to be a threat.

2D hydraulic model of project reach

A two-dimensional (2D) hydraulic model of the stream and floodplain of the project reach was developed to understand flood flow behaviour under current conditions. It has also been utilizing to model possible floodplain management arrangements and the manner in which they would impact future flood flows and their corresponding floodplain inundation, shear stress (scour potential) and deposition. The model was developed using XPSWMM software, with a 4 m cell size. The land surface geometry was derived from LiDAR captured in May 2013 (SEQ Catchments, 2013b). The model was calibrated, using an iterative approach, to the 2013 flood event through reference to high resolution aerial imagery captured immediately post flood (Lockyer Valley Regional Council, 2013). The calibration run included the levee breaches which occurred during the 2013 flood, as these would have been present at the peak flow of the flood event.

Management practices to improve resilience of floodplain production in Laidley Valley

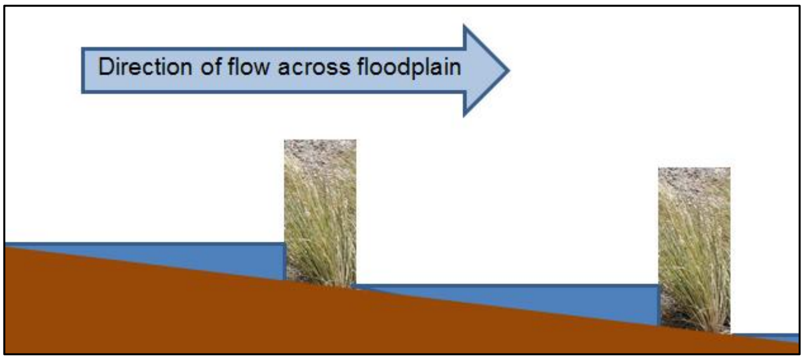
A number of diverse management practice options were developed and tested using the 2D hydraulic model under several design flow scenarios and through reference to the geomorphic stability assessment. Results indicate that a combination of integrated floodplain and channel management practices are required to increase the resilience of productive lands in the Laidley Creek Valley to future flood events.

Cross floodplain roughness structures

Innovative cross floodplain roughness structures, composed of pole and vetiver hedges (Figure 5), were conceived as a means to increase cross floodplain roughness at strategic locations on the floodplain. These structures were built into the 2D hydraulic model as semi-impervious barriers, of 50% porosity, with a mannings *n* value of 0.15. Results indicate a significant reduction in shear stress extending 100 m to 200 m upstream of the structures as a result of a backwater zone being created upstream of the hedge (Figure 6). This will decrease the risk of scour and encourages sedimentation in the backwater zone. In addition, the structures are expected to laterally spread the flood water behind the hedge, thereby reducing the concentration of flow in the lowest lying areas and potentially reduce scour on the downstream side of the hedge. Seven structures were modelled at various locations on the Laidley Creek floodplain, with a prioritization of these structures being made based on the magnitude and extent of their reduction to potential scour.

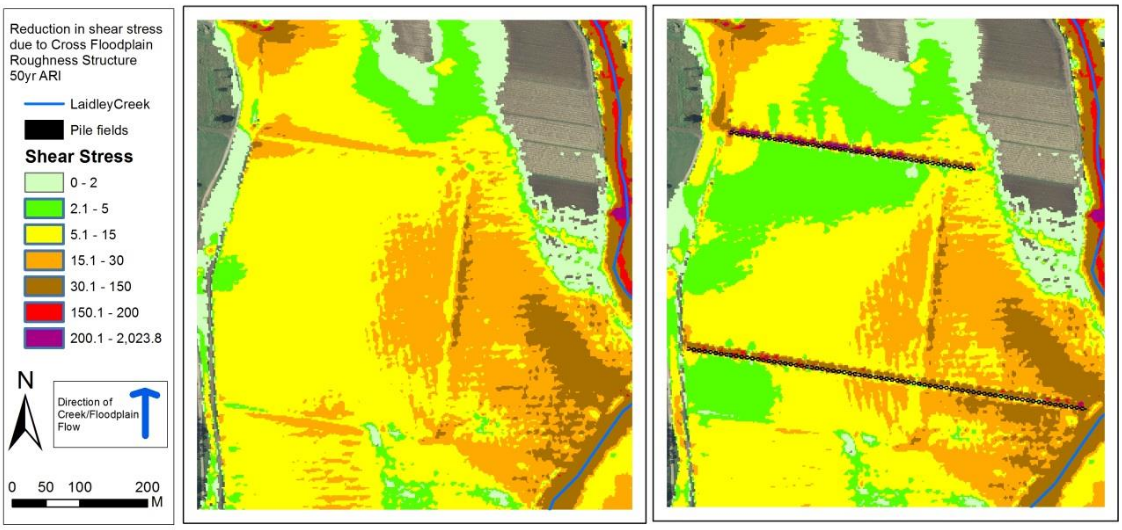
The roughness structures are most suited to locations which have a high risk of floodplain flood flows and where they are able to be placed perpendicular to the expected direction of flood flow and in production systems that face a greater risk of topsoil erosion, for example intensive vegetable production. The relative narrowness (approximately 2-3 m) of these structures ensures only minimal forfeiture of land from production. Two of these structures have been installed at key locations on the Laidley Creek floodplain.

(a)



(b)

Figure 5: Cross floodplain roughness structure positioned perpendicular to the direction of flow. (a) Design of cross floodplain roughness structure composed of row of hardwood posts and vetiver (Chrysopogon zizanioides) hedge. Image shows recently planted vetiver, with expected height of mature vetiver, to be around 1 m, and (b) Stucture creates a backwater zone behind the structure.



(a) Base case **(b) Structure installed**

Figure 6: Modelled influence of cross floodplain roughness structure with a reduction in shear stress for this focal area being evident between (a) the base case with no roughness structure installed, and (b) with a roughness structure installed.

Strategic cropping practices

The hydraulic roughness of crops varies, generally being greater for those with a significant above ground structure and more dense foliage. Results from the 2D hydraulic model indicate that the placement of crops with high hydraulic roughness in identified high flood risk areas reduces the erosion potential in those areas. High risk areas were identified through reference to design flow scenarios in the 2D hydraulic model and are generally areas which have a likelihood of receiving concentrated flood flow from the overtopping of levees. These areas were confirmed by landowners through reference to the 2013 and other historic flood events.

These results guided the development of recommendations for strategic cropping practices which place crops of high hydraulic roughness, such as mature corn, in identified high flood risk areas during the higher risk period of the year (December to February for the Laidley Valley). These practices were adopted by the major producer in the project reach for the 2013-2014 wet season, where mature corn was maintained over the key high risk areas (*pers. comm. Farmer target reach*). In addition, this producer reduced the extent of fallow areas on the floodplain throughout this higher risk period.

Tillage management

The high rates of tillage employed by a majority of vegetable producers in the target reach results in the removal of a protective cover (stubble) from the soil surface and results in a loose, non-cohesive soil structure. As a result, these fields potentially have a heightened risk of sheet and rill erosion during flood flows. There is no known uptake of reduced or minimal tillage practices within the project reach, and while controlled traffic farming has been partially adapted by many producers, there remains a tendency to till the entire field between crops, re-forming the beds prior to each rotation. This project is working with Government and corporate partners to examine if alternative tillage options, such as strip tillage, are suitable for adaption to the vegetable crops and farming systems utilised in the Laidley Creek Valley.

Infrastructure design and placement

Laser levelling, design and location of internal roads and drainage lines, paddock layout, design and location of irrigation equipment are all critical to effective production. The primary determinants of design for each of these factors are farm husbandry and marketing needs. It is important however, that potential interactions with flood flows are considered in order to ensure the greatest resilience to future flood events. Ongoing conversations with producers in the target reach are examining possible alternative farm design and equipment placement strategies to improve farm resilience to future flood events.

Stream restoration works

Control of the incision process in Laidley Creek will require a broad program of works, including grade control structures, bank battering and extensive revegetation of the riparian zone (Alluvium, 2013a). These interventions are internationally recognised as best practice for managing the geomorphic processes identified in Laidley Creek

(Department of Sustainability and Environment, 2007). Stabilising channel banks will also increase the security of existing levees thereby reducing the significant risk of future levee failure and the associated channelized flow and floodplain scour this can trigger.

Bank battering

Bank battering creates a more stable grade of the bank by setting back the top of the bank and increases the security of levees if they are have been constructed on top of the high banks (Figure 7)(Department of Sustainability and Environment, 2007). In an actively eroding system, battering also assists to increase channel width in a controlled manner, and therefore reduces the likelihood of uncontrolled widening in future flood events. Works were undertaken through 'cutting back' the bank, and minimizing instances of placement of fill on the batter. In previous stream restoration works, SEQ Catchments has found the practice of 'cutting back' to result in banks being more resilient to future erosion when compared to utilising fill. Where existing levees were present, these have been set back at existing elevation. Revegetation with a complex suite of ground cover and native shrubs and trees has been undertaken immediately following works.

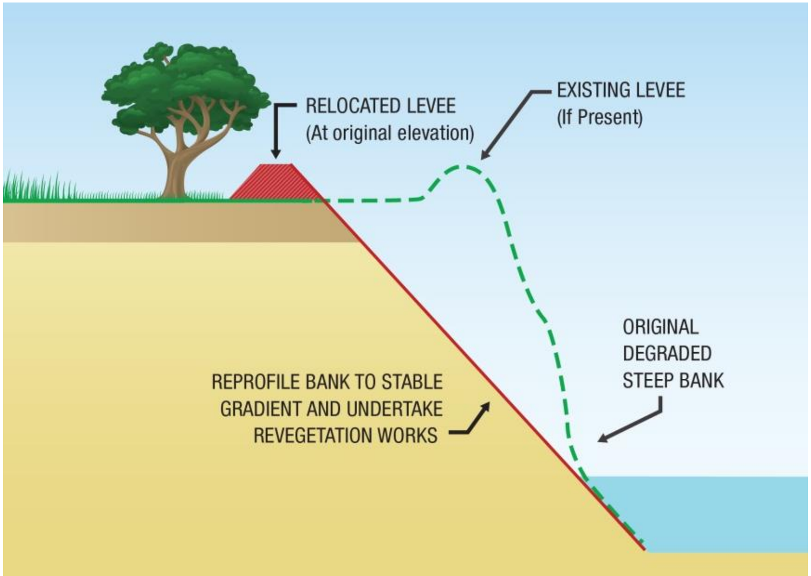


Figure 7: Design of bank battering to reprofile steep banks to a more stable grade

Rock chute grade control structure

Rock chutes provide a controlled elevation drop over a rock reinforced chute, generally with the chute crest being designed to sit above bed level. These structures stop channel deepening from migrating upstream and the backwater created behind the chute crest creates a low velocity zone to encourage sediment deposition and provides added protection to the toe of the upstream banks (Figure 8)(Department of Sustainability and Environment, 2007).

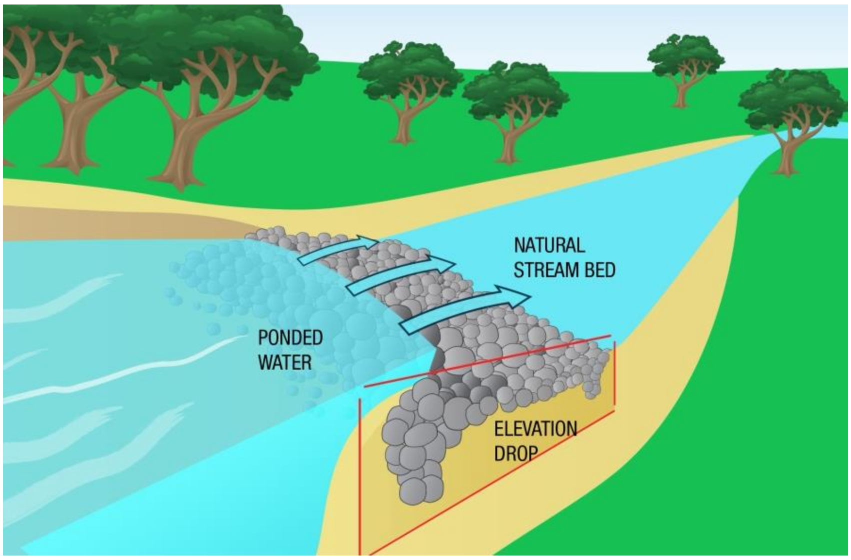


Figure 8: Rock chute grade control structure. This provides a controlled elevation drop over a rock reinforced chute to reduce the upstream migration of channel deepening.

Revegetation

The presence of a complex suite of native vegetation in the riparian zone is recognised as providing increased stability and assisting in the control of channel erosion and migration (Hubble et al., 2006, Hickin, 1984, Department of Sustainability and Environment, 2007). Roots act to reinforce the banks' sub-soil, reducing the likelihood of mass failure, with a diversity of root depths and increased root density increasing stability to the overall bank (Hubble et al., 2006). Re-establishing vegetation and ground cover immediately following creek restoration works is important to improve the resilience and provide ongoing stability to the channel.

Prioritization of stream restoration works

A prioritization of works within the project reach has been proposed, based on addressing the key drivers associated with managing stream processes, reducing erosion across all reaches and protecting infrastructure and existing investment into works (Alluvium, 2014). Works have commenced, with the installation of three grade control structures, 1,000 m of bank battering and associated revegetation at sites of works being achieved in 2013. Further works have been identified as a priority and will be undertaken in partnership with Government and landowners.

Whole of farm management – development of individualised Farm Plans

The development of individualised Farm Plans to translate learnings from the project into practical management practice recommendations tailored to specific properties has been a key focus of this project. These are designed to guide producers' investment decisions for ongoing on-farm works to increase the resilience of the farm to flood flows while fitting within agronomic farm operation and optimising ongoing production.

Farm plans have been developed with producers, with the initial step being to identify their objectives and acceptable levels of risk to future flood events. Table 1 provides an example of landowner objectives included in their Farm Plan. Key threatening processes and likely high risk areas in times of floods were identified for individual properties, with reference to the results from the design flood flow outputs of the 2D hydraulic model and current condition of the channel and floodplain.

Table 1: Example of landowner objectives with respect to level of acceptable risk in future floods

Producer's objective for level of acceptable risk to farm in future flood events
Avoid inundation of croplands for flood intensities with a less than 1:10 year recurrence interval
Minimise scour for flood intensities with a less than 1:20 year recurrence interval
Reduce risk of uncontrolled levee failure in a 1:50 year event (and intensities less than that of the January 2013 floods which was around 1:100 year recurrence interval)
Eroded soils to be deposited on farm to allow return to productive fields post flooding for 1:50 year flood intensities

Management practices to best address the producers' objectives and identified threatening processes were considered, and recommendations made with reference to a number of factors: (i) potential effectiveness of the measure in addressing the threatening process relevant to the individual property, (ii) how well it could be accommodated into the production systems (agronomic considerations), (iii) initial implementation costs, and, (iv) ongoing costs of implementation (such as land removed from production). Farm plans generally include a suite of integrated floodplain and channel management practices (those outlined in this paper) to increase the overall resilience of individual properties to future flood events.

Uptake of changed management practices in agricultural industries by farmers has been considerably researched, with uptake affected by many social, cultural and economic factors (Guerin, 2000, Vanclay and Lawrence, 1994). Implementation of recommended changed management practices by producers in this project has been encouraging. To date, this project has included the installation of creek channel works including grade control structures, bank battering and revegetation and floodplain works including two cross-floodplain roughness structures, strategic cropping practices and changes to infrastructure placement and design. Key findings and learnings from this project relating to implementation of changed management practices are:

- Many farmers are prepared to take a long term view and invest small amounts of resources over time when capacity arises.
- All change needs to be supported during design and implementation, to allow capture into standard farm management practices.
- Most farmers will support best practices that also achieve environmental gain.
- Economic reasons, not social or agronomic considerations, are the major barrier to implementing the more costly management practices.
- Many of the high cost enhancements have significant off-site benefits, for example stream restoration reduces sediment pollution with strong social benefit to downstream bulk water, industry and conservation values. It is probably unrealistic to expect individual farmers to bear the full cost of correcting historical poor catchment management.

Conclusion

The Laidley Creek Valley, a significant horticultural production area of South-east Queensland, was significantly impacted by major flooding in January 2013. This flooding resulted in large extents of alternative floodplain scour and deposition, productive land lost from creek bank erosion, crop inundation and farm infrastructure damage and loss. In addition, channel and floodplain erosion resulted in increased sediment loads in Laidley Creek, which were transported downstream and contributed to the threat to Brisbane's water security and impacts on Moreton Bay. Impacts were aggravated by the degraded and unstable condition of Laidley Creek and by farm design and management not traditionally being guided by consideration of floodplain flood flows.

A need exists to consider management practice options that increase the resilience of horticultural and agricultural systems in Laidley Creek and the broader South-east Queensland region to future flood events. This study, undertaken by SEQ Catchments, with support from Government and corporate partners, has worked with landowners to identify management practices that increase the resilience of their production systems to future flood events and to promote the incorporation of flood planning and flood risk management into standard farming practice and business.

A key finding has been the need to integrate management of the unstable creek system with the consideration of farm management practices designed to better cope with flood flows. Recommended stream restoration works include bank battering and the installation of grade control structures to manage the active channel incision (deepening and widening). These works will have the complimentary benefit of increasing the security of levees at risk of failure from bank erosion. In addition, this study has developed a number of farm management practices to reduce the impacts from floodplain flood flows including: undertaking strategic cropping by maintaining mature crops over the most high risk areas of the farm over the higher risk period of the year; the installation of cross floodplain roughness structures at strategic locations to reduce floodplain scour and induce sedimentation and the consideration of alternative tillage practices. Tailored Farm Plans have been developed for individual properties, to translate learnings from the project into practical management recommendations that best address the identified threatening process specific to individual properties. These have been designed to guide producers' investment decisions for ongoing on-farm works to increase the resilience of the farm to flood flows.

SEQ Catchments will continue to work with its partners to capture learnings from the project and extend key findings throughout South-east Queensland.

This project acknowledges the support of the Queensland and Commonwealth Governments. The On-Farm Productivity and Riparian Recovery Program supports primary producing areas severely impacted by flooding following Ex-Tropical Cyclone Oswald 2013 and is funded by the Queensland and Commonwealth Governments through natural disaster relief and recovery arrangements.

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