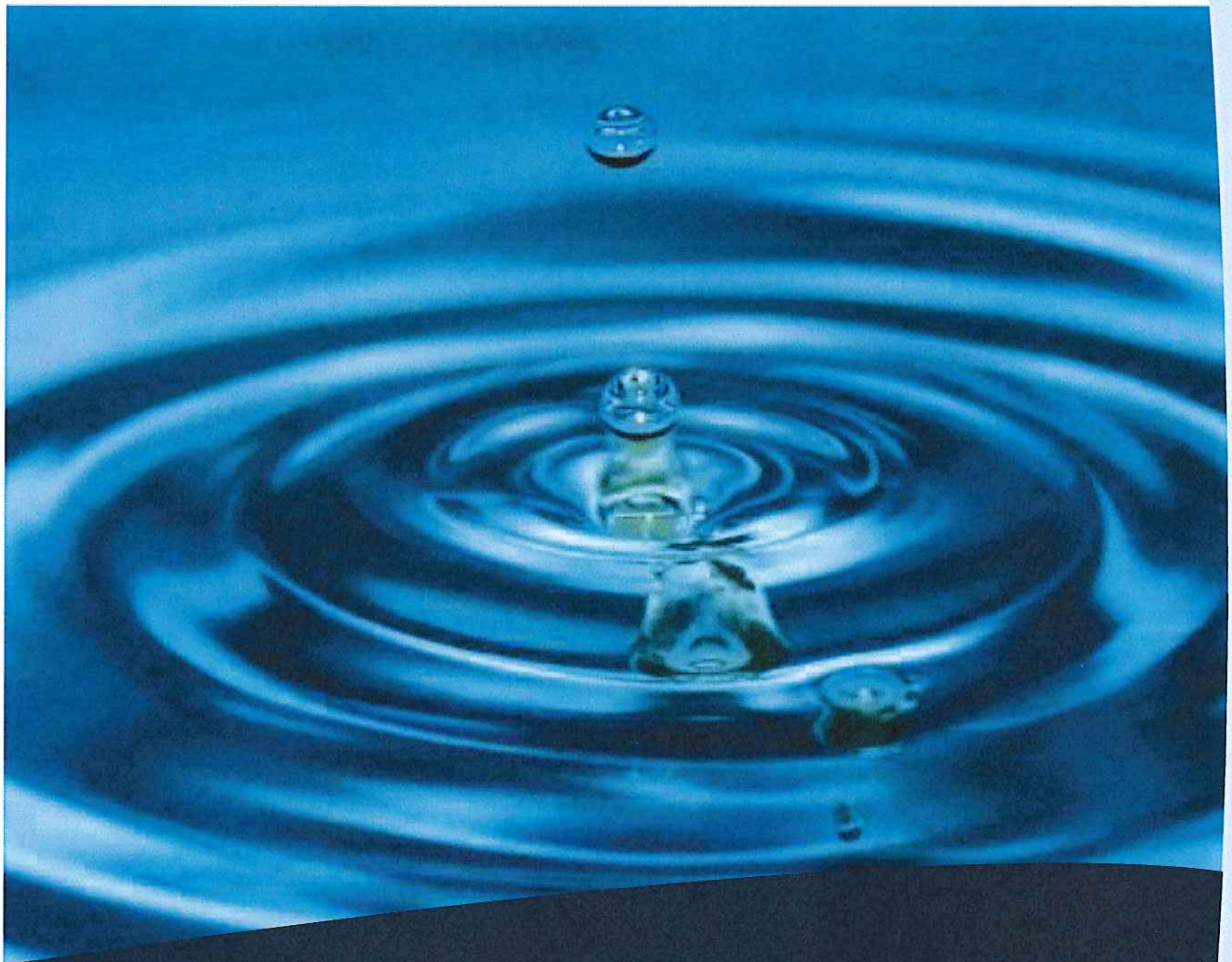
Cardno
Shaping the Future



# QUEENSLAND FLOODS 2011

## STORMWATER BACKFLOW

Job Number J11058

Prepared for Queensland Floods Commission of Inquiry

September 2011

**QFCI**

Date: 21/09/11

Exhibit Number: 577

**Cardno (Qld) Pty Ltd**
ABN 57 051 074 992
Level 11 Green Square North Tower
515 St Paul's Terrace
Fortitude Valley Qld 4006
Locked Bag 4006 Fortitude Valley
Queensland 4006 Australia
Telephone: 07 3369 9822
Facsimile: 07 3369 9722
International: +61 7 3369 9822
cardno@cardno.com.au
www.cardno.com.au

# QUEENSLAND FLOODS 2011
# STORMWATER BACKFLOW

## TABLE OF CONTENTS

# 1 INTRODUCTION

1 The Queensland Floods Commission of Inquiry was established by the Queensland Government on 17 January 2011 to examine and review the causes and impacts of the major flooding which occurred throughout Queensland in the 2010/11 wet season.

2 Dr Trevor Johnson of the consulting firm Cardno (QLD) Pty Ltd was engaged by the commission in September 2011 to provide technical advice on a range of matters relating to backflow issues in urban stormwater drainage systems. In particular, the following questions were posed:

- Whether flooding can be caused or exacerbated by backflow of stormwater?
- Is it likely to continue to be a problem? Is the problem only related to older infrastructure, or do local authority drainage design requirements still not address the issue?
- Are there mechanisms to deal with and/or mitigate the impact of backflow in stormwater systems? What measures are available to minimise infrastructure and property impacts resulting from this type of flooding?
- What are the advantages and disadvantages of each of these measures?
- What should local authorities such as Brisbane City Council be doing in relation to this issue?

3 These questions are considered and answered in turn in the following sections.

4 I state that I am a civil engineer with over 30 years experience in the fields of hydraulics, water quality and engineering infrastructure. I am a Director of Cardno, and I hold the degrees of Bachelor of Engineering (Civil), Master of Engineering Science and Doctor of Philosophy, all obtained from the University of Queensland.

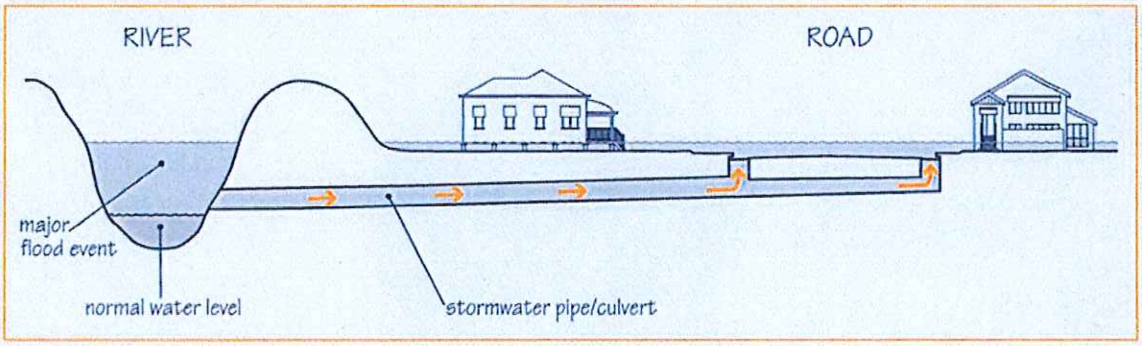
# 2 FLOODING CAUSED BY BACKFLOW OF STORMWATER

5 Flooding caused by backflow through the municipal stormwater drainage network has been identified as a significant cause of inundation experienced in some Brisbane suburbs such as Milton, New Farm and the CBD [Brisbane Flood 2011 Independent Review of Brisbane City Council's Response, Brisbane City Council, 2011]. Backflow from the Brisbane River was the initial source of flooding impacts in many cases, particularly in the inner urban areas noted above. However, in the majority of instances, higher flood levels were later caused by surface inundation when the River actually broke its banks.

6 Brisbane City Council has produced the following illustration which demonstrates how backflow flooding occurs.

**Backflow flooding**

During the January 2011 flood, parts of Brisbane were affected by water which came up from the river through the drainage networks and into our streets. This is commonly referred to as backflow flooding.




Backflow flooding diagram

7 Effectively, backflow flooding occurs only in those situations where there is a stormwater or other pipe connection between a source of flooding (in this case, the Brisbane River) and an area of land which is lower than the bank level of the watercourse. It can, of course, also occur with suburban creek flooding in Brisbane, although it is noted that this was not a cause of flooding in January 2011 because the local creek systems were not in flood at that time.

8 The Queensland Urban Drainage Manual [Department of Natural Resources and Water, 2007] has been formally adopted by all Queensland local authorities as the principal reference for stormwater management and design in this state. QUDM requires the underground drainage system to be designed to convey the discharge for the design minor storm with road flow limited to the point where it does not pose a risk to pedestrians. This can be approximately expressed as a requirement that the maximum depth of flow in the roadway during the minor event does not exceed the kerb level. According to QUDM, the recurrence interval of the minor storm should be between 2 and 10 years, depending upon the degree of urbanisation of the catchment being serviced (the greater the proportion of impervious area, the higher the recurrence interval). However, in many cases in Queensland, including older sections of Brisbane, the existing systems do not comply with the current design requirement.

9 The underground stormwater drainage system is therefore intended to manage a minor storm event without causing inundation of allotments or building floors, while allowing limited inundation of roadways. Prior to the 1990s, historical engineering design required the stormwater drainage system to be as efficient as possible, since the primary motive was to move runoff downstream away from developed areas as quickly as possible. While design criteria have now altered to include the concept of a legal point of discharge from one property to another, efficient design still dictates that the drainage system should be as free of obstructions as possible. This makes the incorporation of backflow prevention devices problematic, as discussed in Sections 3 and 4 below.

10 There is one further key point which needs to be taken from the illustration on page 2. It is apparent that, if the flood level in the waterway exceeds the bank or levee level, the connection via the stormwater pipe system is irrelevant, since flooding will occur by surface inundation anyway. Although initial flooding may occur by backflow, the later and higher river flood will cause greater depth of flooding.

11 However, in circumstances where there is consistently higher land between the river and the affected property (ie there is no surface connection at a lower level), backflow flooding may certainly become an issue for smaller events.

# 3 OCCURRENCE OF THE PROBLEM

13 Backflow flooding will continue to be a problem for most near-coastal local authorities in Queensland, and will be significantly exacerbated if climate change predictions for sea level rise become reality. The Queensland Government has determined [Draft South East Queensland Climate Change Management Plan, Department of Local Government and Planning, 2009] that current sea levels will rise by approximately 0.3 m by 2050 and 0.8 m by 2100. The Highest Astronomical Tide (HAT) is the highest tide level predicted to occur under average meteorological conditions. For the Brisbane River at the Port Office Gauge in Edward Street, HAT is currently about 1.54 m AHD. While this maximum level is reached only about once per year on average, there are many tides which will generally approximate it. For example, in 2011 there will be 20 individual tides at the Port Office with a peak water level in excess of 1.44 m AHD. With the onset of climate change, HAT is predicted to increase to 2.34 m AHD by 2100.

14 Significant parts of Brisbane, particularly around New Farm, Milton and Rosalie, have existing ground levels which are lower than 2.34 m AHD. These areas will therefore be subject to increasing tidal inundation as sea levels rise. Flooding from this source is well recognised in lower-lying parts of Brisbane around the time of very high tides in December each year.

15 The rise in sea level will also increase flood levels, although generally by a lesser amount than the 0.8 m in static water level rise. Consequently, these areas will be far more prone to inundation than occurs currently. Even in the situation where steps are taken to prevent surface runoff inundation (eg by building low banks and levees along the river), the uncontrolled stormwater drainage system will allow backflow to occur. Backflow prevention devices will therefore need to be increasingly used to prevent this phenomenon from occurring.

16 Current drainage design practices do not include making allowance for backflow prevention. There are two reasons for this. Firstly, the inclusion of backflow prevention devices leads to increased head losses within the stormwater drainage systems, and therefore reduced capacity. Backflow devices therefore may increase the level and extent of flooding which occurs from local runoff. Secondly, the problem is primarily limited to existing areas and older drainage systems. New design practices would normally require higher ground levels for development purposes, therefore obviating the potential for inundation by backflow means.

17 In addition, it is also the case that backflow flooding generally does not result in inundation of habitable floors in residences. It is most often public infrastructure such as road, footpaths and parks which is adversely affected. While such impacts are obviously undesirable, they are significantly less important than the flooding of people's houses. Alleviation and management of this problem remains the principal focus of engineering drainage design. However, normal engineering design practices would identify the potential for an effect, and allow for suitable remediation processes to be adopted.

# 4 BACKFLOW CONTROL VALVES

18 Backflow prevention valves are in common use in water supply systems, particularly where there is the potential for cross-contamination of potable water from the use of recycled water in the domestic situation. While the use of such devices in stormwater drainage lines is less common, there are a number of valve designs which have been used for this purpose both within Australia and overseas.

19 The simplest valve used for backflow prevention is known as a flap gate. This generally consists of a circular plate which is connected to the pipe outlet at the river end with a hinged connection. When the river water level (known as the tailwater level) is low, the force of stormwater running through the pipe is sufficient to open the valve and maintain it in that state. When the tailwater level is above the invert level of the pipe and the pipe is not carrying stormwater, external water pressure and counterweights are sufficient to close the valve and thereby prevent backflow.

20 Flap gates (see below, made by Hume-King in Australia for example) are simple and inexpensive, but relatively prone to failure. Firstly, debris may jam open the gate, thereby allowing tidal waters to enter the pipe as the tailwater level increases. Secondly, many stormwater systems have outlets which are below HAT level, ie the outlets are submerged at some stage of the tidal cycle. In the marine environment, the flap gates are frequently fouled by intertidal marine organisms such as barnacles which prevent a watertight seal from occurring. This allows tidal waters to leak back into the stormwater system, significantly affecting the efficiency of operation. Thirdly, the gate imposes some additional head losses into the stormwater system, thereby reducing the capacity of the pipe and potentially increasing upstream water levels. The significant advantage of flap gates over other types of backflow prevention devices is that they are relatively cheap to purchase and simple to install.

*Floodgates - above 900mm*

21 The "duck bill" check valve (see below) is an elastomer rubber system which is again fitted onto the outlet end of the stormwater system. The valve has a vertical slot which is both flexible and stiff, such that the valve is closed in its relaxed position. The valve is designed to open and close under relatively low pressures, such that the head loss in the system is significantly lower than for the corresponding flap valve. The elastomer may also be treated to prevent fouling by barnacles for installations below tide level. Duck bill valves (Tideflex or Fuller brands for example) are considered to be significantly more reliable than flap gates, but they may also be prone to debris or silt blockage which keeps the vertical slot open when it should be closed. Duck bill valves are more expensive than flap gates.

22 Other mechanical and electrically-actuated check valves can also be used to prevent backflow, but these generally rely on either direct human intervention to close the valve during a high tailwater level event, or sophisticated (and expensive) electronic level sensing devices. In general, valves which need the touch of a human operator are only effective in situations such as industrial installations or sewage treatment plants where operators are on site for 24 hours per day. Similarly, automatic electrically-actuated devices will be ineffective if power is lost for the local area, as sometimes happens during major flooding events. These valves are generally installed in-line (ie not at the outlet from the system), and are more expensive that duck bill valves to both supply and install.

23 Non-powered automatic internal backflow protection valves are used in some sewerage systems, to prevent sewage backing up into houses during severe flood events. Contamination from this source is a common problem in low-lying areas, where there may be extensive surface or groundwater infiltration into sewer lines which reduces capacity. These in-line valves are installed into the sewer house connection, and are activated if backflow is sensed by the device. While these systems are effective, they are somewhat susceptible to blockage and therefore require regular maintenance to keep them operational. In addition, sewerage pipes are much smaller than stormwater drainage pipes, and the effectiveness of such valves for large stormwater pipelines may be limited because of size and cost constraints.

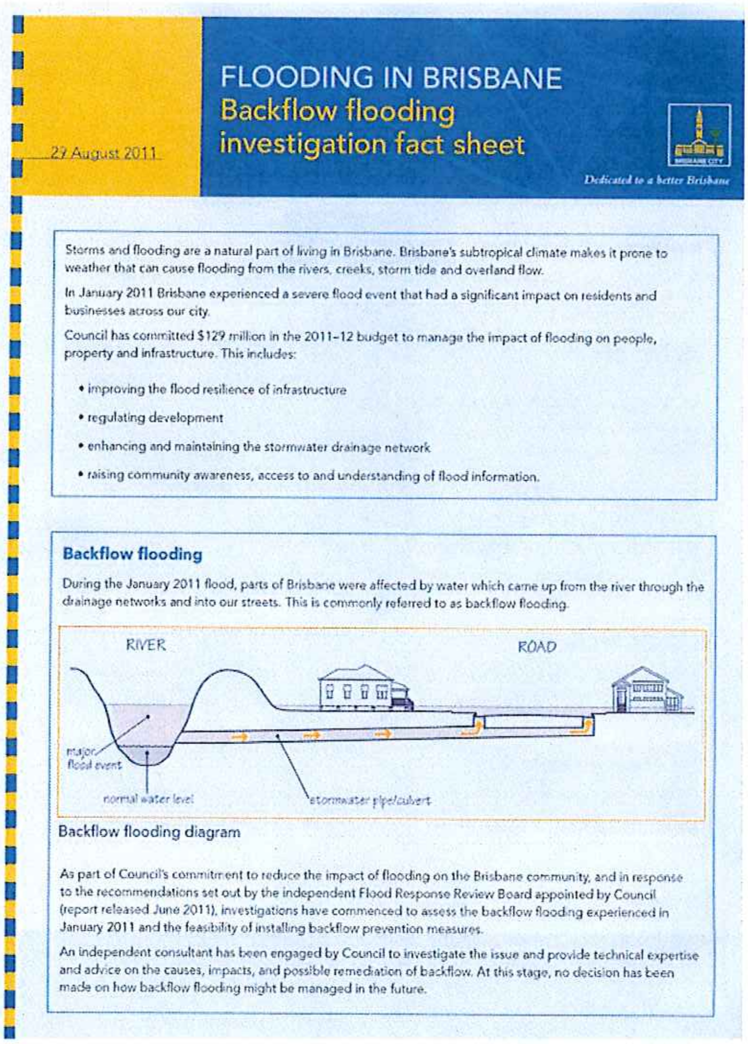
24 Backflow prevention devices are effective at preventing/reducing inundation from backflow events. However, their major disadvantage is that they will tend to increase the level of flooding from local rainfall events. Since the inclusion of a backflow valve increases head losses in the stormwater drainage systems, their installation on existing stormwater pipes will cause upstream flood levels to increase when local storm events occur. While the amount of increase may be relatively low, any flood level increase in an area where significant flooding already occurs would be seen as significantly detrimental.

25 It would therefore be necessary for local authorities to undertake relevant risk assessments before determining to retro-fit backwash control valves. The increase in performance in relation to the prevention of backflow needs to be weighed against a potential increase in flood level for local catchment storm events.

# 5 RECOMMENDED ACTIONS BY LOCAL AUTHORITIES

26 As noted in paragraph 13 above, climate change impacts are likely to significantly exacerbate both the rate of occurrence and magnitude of backflow flooding events. Steps such as levee construction are likely to be taken to address the potential direct impact of sea level rise. However, the effectiveness of these solutions will be limited in areas subject to backflow inundation unless control systems are put in place to prevent reverse flow in the stormwater drainage systems.

27 It is noted (see below) that Brisbane City Council has already identified the backflow problem and is actively taking steps to determine the magnitude of the issue and the potential for it to be alleviated.



29 August 2011

FLOODING IN BRISBANE
Backflow flooding investigation fact sheet

*Dedicated to a better Brisbane*

Storms and flooding are a natural part of living in Brisbane. Brisbane's subtropical climate makes it prone to weather that can cause flooding from the rivers, creeks, storm tide and overland flow.

In January 2011 Brisbane experienced a severe flood event that had a significant impact on residents and businesses across our city.

Council has committed $129 million in the 2011–12 budget to manage the impact of flooding on people, property and infrastructure. This includes:

- improving the flood resilience of infrastructure
- regulating development
- enhancing and maintaining the stormwater drainage network
- raising community awareness, access to and understanding of flood information.

**Backflow flooding**

During the January 2011 flood, parts of Brisbane were affected by water which came up from the river through the drainage networks and into our streets. This is commonly referred to as backflow flooding.



Backflow flooding diagram

As part of Council's commitment to reduce the impact of flooding on the Brisbane community, and in response to the recommendations set out by the independent Flood Response Review Board appointed by Council (report released June 2011), investigations have commenced to assess the backflow flooding experienced in January 2011 and the feasibility of installing backflow prevention measures.

An independent consultant has been engaged by Council to investigate the issue and provide technical expertise and advice on the causes, impacts, and possible remediation of backflow. At this stage, no decision has been made on how backflow flooding might be managed in the future.

28 It is recommended that all near-coastal local authorities in Queensland should investigate for the potential occurrence of backflow, and undertake relevant assessments for alleviation of the problem if necessary. A detailed risk assessment should be undertaken in all instances to ensure that any proposed installation of backflow prevention devices will not unreasonably exacerbate existing local runoff flooding problems.