

Grantham Floods Commission of Inquiry

Submissions of West Grantham Residents

1. In May 2015 the Queensland Government established the Grantham Floods Commission of Inquiry (“the Inquiry”) to consider the circumstances of the flooding in Grantham on 10 January 2011 (“the flood”), namely whether the Grantham Sandplant (being the quarry and concrete batching plant) and any other man-made features within Grantham caused or contributed to the flooding in Grantham.
2. Maddens Lawyers represent various residents of West Grantham. These submissions are made on their behalf.

A. INTRODUCTION

3. Over the years Grantham has been impacted by various significant floods, including February 1893 flood, January 1974 flood, April 1988 flood and May 1996 flood.
4. The January 2011 flood was incomparable in terms of the devastation and loss of life at Grantham. This town of 700 in the space of about an hour lost 12 members of their community.
5. The Grantham Sandplant is located in the horseshoe bend (or ox-bow) of the Lockyer River, to the west of the Grantham township and south of Gatton-Helidon road and the railway line.
6. Wagners acquired the Grantham Sandplant (being the site which contained the quarry and concrete batching plant) in November 1998.
7. All of the major floods outlined in paragraph 3 occurred prior to the Wagners acquisition of the site.
8. Multiple residents have recalled that in previous flooding events, the water would break the horseshoe bend of the creek and flow across the length of the horseshoe bend. A simplistic view, without the benefit of modelling, would suggest that interfering with the water flow in this area by constructing embankments and raising natural topography, would inhibit the dispersing of water across the floodplain and increase the intensity of downstream flooding, especially if the embankment failed after a build-up of flood waters.
9. Subsequent to acquiring the quarry Wagners built up or continued to build up a levee bank (hereafter called the western embankment) to the west of the quarry. The benefit

of this embankment was to limit flooding into the quarry area and the associated loss of production as a result thereof.

10. At the Inquiry Dr Macintosh confirmed that the western embankment of the Grantham Sandplant did have an affect on the flood which was to increase the flow and intensity of the flood. It is the magnitude of that increase, which is now the subject of debate and conjecture.¹
11. We submit that the existence of the Grantham Sandplant increased the intensity of the flood, and increased the property damage.
12. The railway line north of Gatton-Helidon Road also contributed by constricting the flow of the flood water on 10 January 2011 and channelled it towards Grantham, increasing the depth and intensity.

B. THE WESTERN EMBANKMENT

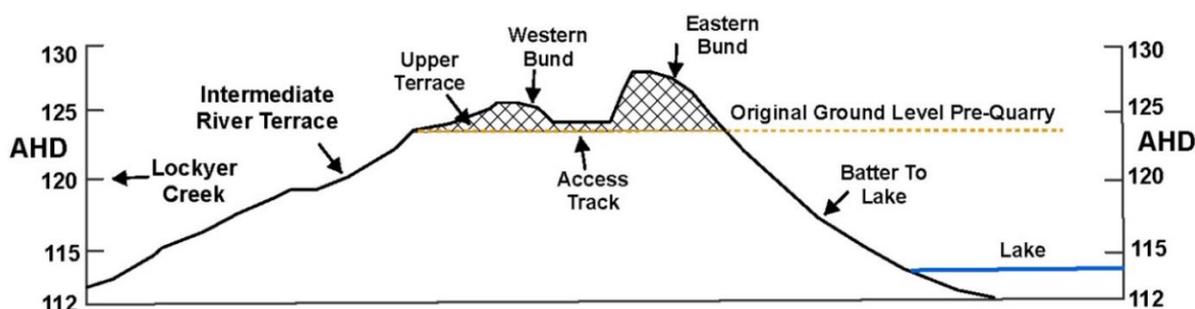


Plate1: Schematic cross-section through western levee, Grantham Quarry

Inset: Exert from the report of Mr Starr depicting the western embankment / levee

13. On 20 October 1981, the Gatton Shire Council advised Sullweis Pty Ltd that the application for the sandmining plant had been approved subject to conditions, including:²

“9. BUFFER ZONES

The buffer zone between the Lockyer Creek and any excavated area to be 40 metres, except where pegged to retain the natural water exit on the south east corner in case flooding of the lower terrace...

10. WORKING MADE SAFE

Overburden is not permitted to be placed so as to form a levee bank unless approval is obtained from the Water Resources Commission...³

¹ Transcript, page 1217 at paragraph 20.

² Exhibit 51 – Conditions of Approval for a sandmining operation.

³ Exhibit 51 – Conditions of Approval for a sandmining operation.

14. In or about late 1990 or early 1991, the Gatton Shire Council approved an application made by Sellars, the then owners of the site, when they applied for and obtained approval for a concrete batching plant.⁴ The approval was granted on the basis that conditions 1 to 16 of the 1981 approval be complied with.⁵
15. In or about 1996 a licence was issued to CSR Limited, the then owners of the site, for an environmentally relevant activity of extraction of rock and other material and screening of materials.⁶
16. The inclusion of these conditions which prevents the quarry owner / operator from building a levee bank and changing the topography close to the Lockyer Creek is presumably due to the foreseeability that such artificial alterations to the topography could interfere with the water flow and increase the potential of any flood.
17. The question of whether Wagners breached the permit conditions is relevant to the Inquiry.
18. Mr Wagner during oral evidence confirmed his understanding of the purpose of a levee bank, defining it as *“a structure that is built up to keep water out or stop the flow of water.”*⁷ Mr Starr agreed that a levee bank is an embankment built to prevent flooding to low lying land.⁸
19. It was argued by the Wagners that the western embankment was a safety bund and was between one to three metres in height.⁹ None of the Wagners employees in evidence to the Inquiry conceded that Wagners built the bunds on the western embankment. No evidence was adduced as to the importance of safety bunds, or any evidence as to the design of the supposed Grantham “safety” bund. Varying accounts were provided as to how high a safety bund ought to be.
20. Dr Macintosh in his report states *“in my opinion, the system of bunds / stockpiles and spoil, in conjunction with the natural creek bank, serves to prevent smaller floods from entering the Quarry.”*¹⁰ Indeed, Dr Macintosh states that these bunds restricted the flow of the flood in the Lockyer Creek waterway on 10 January 2011.
21. Contrary to the submissions made by the Wagners, the report of Mr Starr found that the eastern bund on the western embankment was approximately 4 metres in height above the natural ground level and varied between 2 metres to 6 metres.¹¹

⁴ Exhibit 52 – Town Planning Consent from the Gatton Shire Council to Sellars.

⁵ Exhibit 52 – Town Planning Consent from the Gatton Shire Council to Sellars.

⁶ License number 5080000093 dated 1 July 1996.

⁷ Transcript - page 550, at paragraph 20.

⁸ Transcript – page 1036, paragraph 5.

⁹ See statutory declaration of Mr Fowler declared on 1 July 2015 at paragraph 18. See statutory declaration of Mr Duff declared on 2 July 2015 at paragraph 11.

¹⁰ Exhibit 144 – Dr Macintosh hydrology report, page 66, paragraph 202.

¹¹ Exhibit 53 – Mr Starr’s first report, page 1, paragraph 9.

22. With the assistance of test pit 113, which was located on the eastern bund, Mr Starr found that the construction of the bund probably developed over time in stages.¹² Mr Starr found that the construction of the bunds either side of the access track along the western embankment of the quarry site commenced after August 1997 and before June 2001, and the levees construction continued from 2001 until about 2005.¹³
23. The findings of Mr Starr should be accepted, in that they are consistent with the eye-witness accounts of the Grantham community, for example:
- a. Mr Warburton who undertook a delivery to the quarry in approximately 1993 did not observe any embankment;¹⁴
 - b. Mr Gallagher who started walking around the quarry pit in about 1986. Mr Gallagher first noticed changes to the quarry wall in approximately 2000 and believes the build-up started in 2002 and became significant in 2005;¹⁵
 - c. Mr Arndt who had consistently been fishing at the quarry and noticed the embankment in or about 2005;¹⁶
 - d. Mr Sippel who noticed the western embankment upon purchasing his property in 2005;¹⁷ and
 - e. Mr Stephenson who previously worked at the quarry until April 1998, at which point there were *“definitely no bund walls at all.”*¹⁸
24. In contrast, Mr Wagner does “not specifically” recall whether the bunds on the western embankment were there in 1998 when the quarry was purchased.¹⁹
25. Mr Wagner’s evidence about why a bund or levee was not built on the western embankment is scattered and conflicting, Mr Wagner provided evidence that:
- a. the presence of the power lines would preclude a bund or levee being built - *“in a practical sense it would be very difficult to put material under a power line.”*²⁰
 - b. denied the existence of the bund or levee altogether – *“but I probably still don’t consider that there is such a thing as a western bund. There may be some soil there, but it’s not a bund in the way I would refer it to be a bund.”*²¹
 - c. stated a bund could be built for safety reasons or noise attenuation;²²
 - d. he is unsure of whether he saw the bund or levee in 1998, but if he had seen the bund or levee in 1998, he would have been unlikely to take any notice of it as it would not have been uncommon or out of order;²³

¹² Exhibit 53 – Mr Starr’s first report, page 45, paragraph 164.

¹³ Exhibit 53 – Mr Starr’s first report, page 2, paragraph 12.

¹⁴ Transcript – page 408, at paragraph 10.

¹⁵ Transcript – page 463.

¹⁶ Transcript – page 337.

¹⁷ Exhibit 25 – Witness Statement of Jon Sippel.

¹⁸ Transcript – page 705, at paragraph 5.

¹⁹ Transcript – page 554, at paragraph 20.

²⁰ Transcript – page 555.

²¹ Transcript – page 557, at paragraph 10.

²² Transcript – page 559, at paragraph 45.

²³ Transcript – page 559, at paragraph 15.

- e. he is not aware of any radical change to the method of operation of the Grantham Sandplant after the operation of the plant was taken over by Wagners;²⁴ and
 - f. instructions were given to operators of the Grantham Sandplant as to what they would do each day, specific instructions were not given to operators at the Sandplant to not put overburden on the western embankment.²⁵
26. Mr Wagner's evidence was intermittently vague, conflicting and guarded. The inferences that can be drawn from Mr Wagner's evidence are:
- a. he is unsure of whether a bund or levee existed when the quarry was acquired from CSR Limited; and
 - b. should a bund have been constructed on the western embankment during Wagners ownership / operation of the Grantham Sandplant, it would not have caused Mr Wagner concern as he is likely to have viewed it as a not uncommon occurrence or a safety bund and beneficial to the operation of the quarry in inhibiting the potential for the flooding of the quarry.
27. Another more far-fetched explanation was put forward by Mr Athol Fowler, a Wagners employee, who stated that the western embankment as "*more of a rill than a bund. It wasn't very high*".²⁶ According to Mr Fowler the rill may have been created when he cleared a track for the power company to inspect (which was in 2007).²⁷ The evidence of Mr Fowler that a track was built purely for the inspection by a power company, should not be accepted.
28. Interestingly, Mr Wagner provided that from acquiring the site in 1998 until 2011, in accordance with "*good industry practice*" the material was stockpiled on the southern side of the pit beyond the extremity of the sand.²⁸ This is the area where the natural topography levels were not obtained by Mr Starr. Wagners have not denied that there is stockpiling in this area and the Concrete Batching plant area, and we say this is of significance to the flood that eventuated.

C. THE HYDROLOGY REPORTS

29. Numerous hydrological reports explored the impact of the Grantham Sandplant on the 10 January 2011 flood event. With a few exceptions, these hydrology reports largely relied upon the same sets of data, assumptions and modelling. It is therefore unsurprising that the results of these reports are fairly consistent.
30. It is indisputable that a significant rainfall event(s) occurred in the days leading up to and on 10 January 2011, saturating the catchment and resulting in significant inflows to the catchment upstream of Grantham on 10 January 2011. It is also indisputable that any modelling which contains the topography as at 10 January 2011 will depict flows of significant depth and velocity inundating Grantham. This will of course be

²⁴ Transcript – page 617, at paragraph 40.

²⁵ Transcript – page 619.

²⁶ Transcript – page 662, at paragraph 4.

²⁷ Transcript – page 665.

²⁸ Transcript – page 569, at paragraph 45.

consistent with eye-witness accounts – no one can dispute the intensity with which the flood occurred.

31. What is disputed is a consideration of what would have occurred in a without Grantham Sandplant and / or railway embankment scenario. In order to understand what “would” have been, key assumptions need to be correct, namely the:
 - a. natural topography of the Grantham Sandplant area (AHD levels);
 - b. volume of water; and
 - c. timing.
32. As Dr Macintosh commented, on numerous occasions the sensitivity of the model and the reliance of the model on key assumptions is significant. Therefore, it is frustrating that all of the hydrologists relied upon the same TUFLOW model, which always had the same limitations and data, which only differ by a minimal degree.²⁹
33. To determine what impact man-made structures had on the Grantham flood, it is therefore imperative that the natural topography of the pre-Sandplant site is accurately considered. Merely running a “without quarry” scenario using estimated topography which in some areas is of poor quality, is insufficient.³⁰
34. Frustrating to our clients, is that the TUFLOW models used by all of the hydrologists relied upon the 2010 LiDAR survey at the Grantham Concrete Batching Plant. This is surprising given that the Inquiry’s Terms of Reference clearly identify that the impact of “man-made” structures on the flooding of Grantham is to be considered.
35. Perhaps ignoring the impact of the Grantham Sandplant, may be explained by Dr Macintosh’s belief that there would not be a significant difference if the levels of the batching plant were dropped half a metre lower, as the presence of the natural water channel would not have affected the break out.³¹ In essence, the water will always find the lowest point and flow through that point first.
36. By “natural water channel” Dr Macintosh referred to the topography between the Besley’s property and the concrete batching plant which he believes created a natural channel that water flows along between the quarry and Grantham.
37. Whether or not this “water channel” was natural was not considered. Whether the artificial raising, lowering, excavating and building of bunds in this area has impacted upon this so-called “water channel” has not been considered. In fact, aside from the levee bunds and the pit, the topography of the remaining area of the Grantham Sandplant particularly the extent that it has been altered by commercial activities has been ignored.

²⁹ While some of the assumptions relating to timing and method / duration of the failure were considered, significant amendments were not made more broadly across the reference test case scenario of the natural topography of the floodplain, which is a key assumption.

³⁰ Exhibit 53 – Mr Starr’s first report at page 27, paragraph 115.

³¹ Transcript - page 1338.

38. When determining whether the Grantham Sandplant exacerbated or impacted upon the flood, only the western embankment wall and part of the pit was considered. This does not adequately address the Terms of Reference, as to whether manmade features exacerbated or contributed to the flood.
39. Mr Starr concedes that the contours in the southeast of the quarry area have been extrapolated beyond available data points and other interpretations are possible.³²
40. Therefore, the “without quarry” scenario is very limited in scope, with only a few scattered assumptions being changed with the examination focussed almost solely on the levee. The impact of the Grantham Sandplant more widely has been completely ignored. It is not surprising then that with only a small number of the key assumptions changed in a small area, there was minimal difference to the modelling on a “without quarry” scenario.
41. Given that the township of Grantham is located on a floodplain within a high flood hazard zone and is susceptible to flooding, due care and diligence ought to be taken when artificially altering the topography around the horseshoe bend of the creek, upstream of a township.
42. It was conceded by Dr Macintosh that every little change to the model has some effect.³³ If this is so, then with all of the hydrologists considering the artificial topography to the south-east of the pit and at the Grantham concrete batching plant, it remains unknown what would have been the effect of the flood without the interference of man-made structures.³⁴
43. We submit that when determining whether man-made structures in Grantham exacerbated the impact of the flooding, consideration should be had to the entirety of the area known as the Grantham Sandplant. The artificial raising, lowering, excavating and building of bunds within the Grantham Sandplant area has clearly changed the natural topography. Given that this area is so crucial in the modelling of the downstream flows within Grantham, it is disappointing that the geotechnical investigation as to the natural topography did not extend to this area.

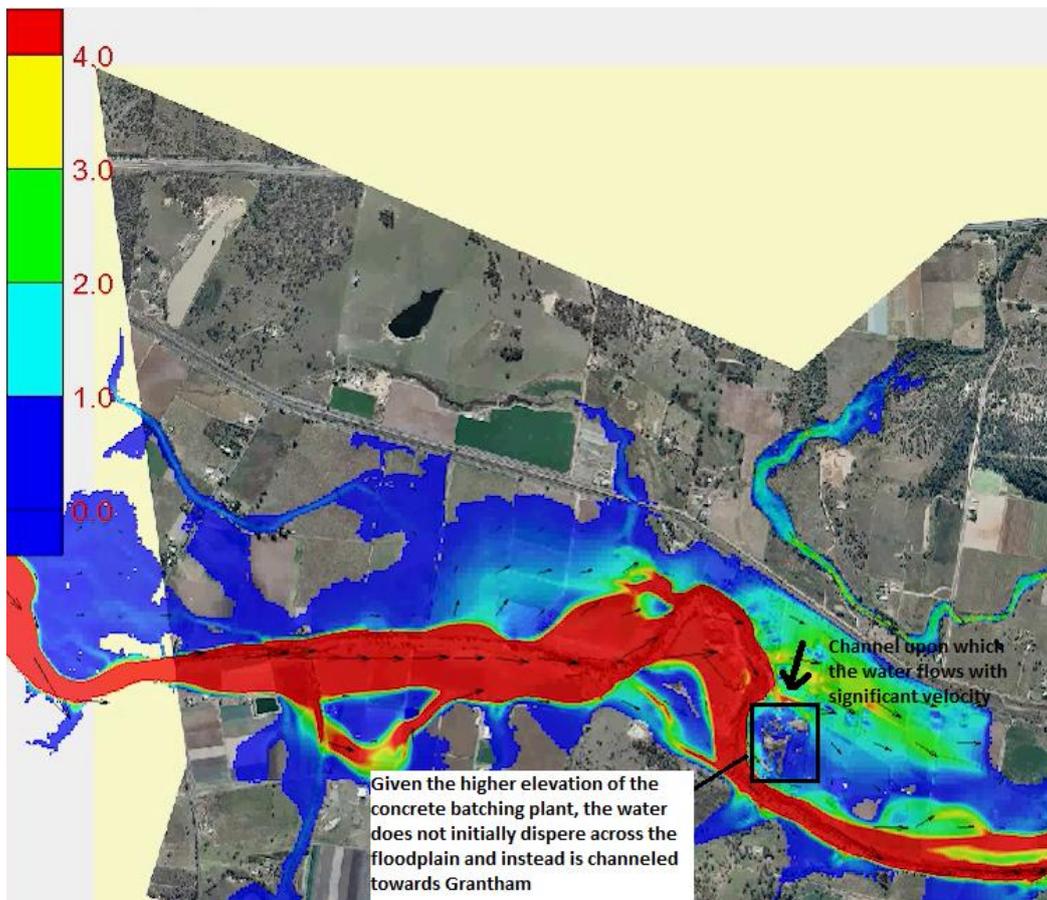
³² Exhibit 53 – Mr Starr’s first report at page 27, paragraph 115.

³³ Transcript - page 11321, at paragraph 29.

³⁴ Transcript - page 11321, at paragraph 7 to 11.



Inset: Dip in topography from gate to quarry along the Access Track. Date: Friday, 28 August 2015



Inset: without quarry scenario at 4.00PM

D. ADEQUACY OF THE MODEL

44. Dr Macintosh is confident, firstly, that the existence of the levee has influenced the flooding on 10 January 2011 in creating a damming of the Lockyer Creek. Secondly, that the existence of the levee has affected the flow from the Lockyer Creek to flow to the east by a route north of the Lockyer Creek. Thirdly that the levee has influenced the volume of water going into the system, and that influence is over a relatively short period of time.
45. Dr Szykarski agrees:
- a. that the quarry and the western levee have an influence,³⁵
 - b. that the influence of the creek bank, the quarry bank plus the levee was to cause a damming effect on the flow of the creek causing it to back up behind the quarry;
 - c. that the magnitude of the damming effect was, in part, a product of resistance of the bank whether it be the levee and the creek banks and the volume of water that was coming into the system at the time. This causes a blockage; and
 - d. the total blockage causes the water to change direction and stops the rate of flow of the water and therefore the water builds up compared to the no quarry case.³⁶
46. This has the effect of delaying the onset of the flood and increasing the intensity of the flood.
47. Given the evidence of Dr Szykarski and Dr Macintosh, we respectively submit, that the question which remains unresolved is the magnitude of the effect of the Grantham Sandplant on the downstream flooding.
48. As Mr Holt put to Dr Macintosh, the model is a schematisation of reality and “all models are wrong, but some are useful..” To which Dr Macintosh agreed.³⁷
49. There are several shortcomings of the TUFLOW model which were discussed at the Inquiry, namely the limitation of TUFLOW to only model water and the inability of TUFLOW to model steep fronted waves. Of further concern is the weakness of some of the data and key assumptions upon which the TUFLOW model relies.

(i) TUFLOW's inability to mode debris flows and hyper concentrated flows

50. According to Dr Szykarksi, once a liquid has more than 5% concentration of sediments, then the density of the liquid starts to diverge and the viscosity changes.³⁸ Once a fluid has 30% to 40% sediment, then the fluid is a non-newtonian fluid which flows with a different behaviour and flows with fairly low resistance.³⁹ Should water have more than 50% sediment a “debris flow” is formed. Once water has approximately 40% sediment the phenomena of “hyper concentrated flows” occurs.

³⁵ Transcript – page 1366, at paragraph 5.

³⁶ Transcript – page 1366.

³⁷ Transcript – page 1264, at paragraph 30.

³⁸ Transcript - page 1358, at paragraph 15.

³⁹ Transcript - page 1358, at paragraph 25.

51. Dr Macintosh and Dr Szykarski accepted that water behaves very differently to debris flows and hyper concentrated flows.
52. Counterintuitively debris flows and hyper concentrated flows, flow much faster than water without sediment.⁴⁰ Their visual appearance can be like that of a crest or waves.
53. Despite it being accepted, that debris flows and hyper concentrated flows behave differently to water flows, TUFLOW can only model water flows. Given that 36,780 metres net of the western embankment was washed away and formed part of the water flows,⁴¹ it is of concern that the TUFLOW model was unable to adequately model this water.
54. Multiple eye-witness accounts discuss the appearance of the flood water, for example Mr Spierling's account describes:
- a wall of water from Lockyer Creek as *"it was moving, but it was only moving at the same level, it was like a wave rolling in at a beach. It was only probably, I think, knee height to most of the people in the street."*⁴²
 - the texture of the water being *"muddy like a thickshake"*⁴³; and
 - the third wall of water, being *"filled with lots of debris. I remember the Keeps and the Longs trying to hold onto the fence with one hand and shield themselves from the debris hitting them at one stage."*⁴⁴
55. Ms Mahon who similarly describes the damming of Lockyer Creek upstream of the Grantham Sandplant states that *"It just looked like it was damned up... all flood debris just sitting there."*⁴⁵
56. Dr Macintosh states that if a debris flow occurred, there would have been a substantial amount of debris left around.⁴⁶ Dr Szykarski said we would see "sludge" left behind.⁴⁷ We note that multiple West Grantham residents have described significant amounts of debris, sediment and sludge left at their properties as depicted in the below photographs.

⁴⁰ Transcript - page 1283, paragraph 25.

⁴¹ Transcript – page 1218, at paragraph 25.

⁴² Transcript – page 73, at paragraph 5.

⁴³ Transcript – page 80, at paragraph 5.

⁴⁴ Transcript – page 74, at paragraph 40.

⁴⁵ Transcript – page 258, at paragraph 5.

⁴⁶ Transcript - page 1284.

⁴⁷ Transcript - page 1358, at paragraph 15.



Inset: Photograph supplied by John Gallagher – Gallagher’s residence



Inset: Photograph supplied by John Gallagher – Gallagher’s residence

57. It is estimated that 36,780 metres net of the western embankment was washed away by the flood.⁴⁸ This material along with the material which was picked up from the stockpiles of material at the quarry, formed part of the flood water. Presumably this would have changed the viscosity of the water and prevented the model from accurately modelling the water around the quarry pit, where the sediment / debris levels would have presumably been at their peak.

58. We query the competence of the model to properly undertake a comparative analysis, when it cannot model debris flows or hyper concentrated flows which appear to have occurred in at least the infancy of the flood. Given that hyper concentrated flows and

⁴⁸ Transcript – page 1218, at paragraph 25.

debris flows flow faster than “water”, we also query the extent that the material from the western embankment may have increased the rate of flow at Grantham.

(ii) TUFLOW’s inability to model steep fronted waves

59. The TUFLOW modelling software cannot pick up the effects of steep fronted wave behaviour.⁴⁹ However, the TUFLOW model is adequate once the depths are half a metre deep. The eye-witness accounts talk about some breaking waves. Evidence by Dr Szykarski suggested that these breaking waves have not substantially changed the behaviour of the flood. The flood itself is said to be controlled by the volumes moving around the system.⁵⁰

60. It is again curious that a flood which is frequently described as being “a wall of water”, and behaving like “waves”, is sought to be understood by a model which is incapable of modelling this phenomena.

(iii) Quality of Assumptions

61. The effectiveness of the model is also reliant on the quality of the assumption and the data upon which it relies. Although this Inquiry had the benefit of significant amounts of data and information, our clients have some lingering concerns about certain aspects of the data.

62. An example is that of the Helidon gauge. It is noted that SKM and Dr Macintosh, two very competent and qualified hydrologists, relied upon two very different rating curves based on the available data of the Helidon Gauge.⁵¹

63. Given that the Helidon gauge is the only upstream data that is available to assist in the modelling of the flood, the limitations of this data are understandably of significant concern to our clients.

E. RAILWAY LINE EMBANKMENT

64. Dr Macintosh’s modelling confirms that the raised Grantham railway line embankment increased the velocity and depth of the flooding to various properties to the south of the railway in Grantham.

65. Dr Macintosh undertook modelling at Mr Bruce Marshall’s property⁵² and found that without the railway embankment, in the general area – and not within the property of Mr Bruce Marshall – the average depth would have been approximately 0.4metres

⁴⁹ Transcript – page 1353.

⁵⁰ Transcript – page 1354.

⁵¹ Transcript- page 1289.

⁵²It is noted that Mr Bruce Marhsall was not chosen because it was a point of hydraulic significance, rather it was chosen because the records which existed to corroborate the accounts.

lower.⁵³ The velocity without the railway embankment would have been a little less than 1 metre per second.

66. Dr Macintosh concluded that in the absence of the railway embankment, there would have also been a greater delay in the onset of the flooding. For some individuals, this may have made a significant difference in terms of evacuating to higher ground.

F. UNCORROBORATED MODELLING

67. Given the acknowledged sensitivity of the model, we draw the Commissioner's attention to several areas of uncorroborated modelling upstream of the Grantham Sandplant.

68. Upstream examples of inaccurate upstream modelling have been identified in the Statutory Declaration of Mr Tony McIntosh dated 20 August 2015.⁵⁴ Mr McIntosh identifies areas of inconsistency at Harry Castles' residence, Klucks Road and Reg Klucks' residence. The inconsistencies are significant in nature and would appear to reveal shortcomings in the modelling. For example, Mr McIntosh states that water which is shown to originate from Flagstone creek, flowing across the floodplain down a gully and into the Lockyer did not behave in this manner at all. Mr McIntosh states that the gully initially filled due to the damming upstream of the quarry. The water filled the gully from an easterly direction travelling west.

69. In considering the accuracy and adequacy of the model to reconstruct the 10 January 2011 flood, we ask the Commissioner to consider the Statutory Declaration of Mr McIntosh and the supplementary model comparison as contained in exhibit 164.

70. As identified by Dr Macintosh the model should be tested against observations to determine whether it produces a simulation consistent with expectations.⁵⁵ Where the model produces a simulation outcome different from observations, there is something with the model that is not right and is not simulating properly.⁵⁶ In such instances it is submitted that the primary evidence provided by eye witnesses should be preferred over the artificiality of the reconstruction produced by a model. Given the frequent reference points upstream which are inconsistent with observations, it leads one to speculate how accurate the model is upstream and in close proximity to the Grantham Sandplant in the "most likely" and "without quarry" scenarios.

G. THE INFLUENCE OF MAN MADE STRUCTURES AT THE GRANTHAM SANDPLANT

70. The Commissioner should on the evidence find:
- a. that there was constructed on the western bank of the quarry by Wagners a levy which caused a damming of Lockyer Creek;

⁵³ Transcript – page 1308, at 25.

⁵⁴ Exhibit 164 – Statutory Declaration of Tony McIntosh.

⁵⁵ Transcript - page 1324.

⁵⁶ Transcript – page 1324.

- b. that there were constructed at the quarry and in the sandplant area various other stockpiles and structures which affected the flow of water into and through the quarry;
- c. that by reason of the manmade structures in and around the quarry the depth and intensity of flood waters was increased in that:
 - (i) in that the damming of the creek caused water to flow north of the creek between the roadway and the creek which it would not have if the damming had not occurred;
 - (ii) through the quarry and from the northern embankment of the creek by reason of the damming of the creek and then the release of water with the failure of the levy;
 - (iii) in that the flow of water through the creek to the flood plain was restricted by reason of the build-up in and around the area of the sandplant.
 - (iv) in that water flowed from the north east portion of the creek in the horseshoe to the east and at a greater volume and intensity than would have been the situation if there were no contour alterations around the quarry;
- d. the combination of the water flow to the north of the creek and the increase flow through the north east area of the creek caused an increased level and intensity of the flow to the east and associated with such increased flow a greater impact of the water upon properties particularly just east of the Grantham quarry and the damage done to those properties.

H. CONCLUSION

71. In summary, we submit that the Commissioner should make the following findings:

- a. the western embankment was constructed, in whole or in part, by Wagners. The western embankment was between 2 to 6 metres in height and construction commenced after August 1997 and before June 2001, and the bund construction continued from 2001 until about 2005;
- b. the bunds constructed by Wagners on the western embankment formed a "levee bank" (whose purpose was to prevent smaller floods from entering the quarry pit) which dammed the waters flowing from the west;
- c. the Grantham Sandplant exacerbated the flow and intensity of the flood event of 10 January 2011 particularly to properties north and east of the quarry in close proximity thereto;

- d. the TUFLOW model whilst confirming there was an increase in volume and intensity of the flood affecting properties in close proximity to the north and east of the Grantham Sandplant cannot adequately define the extent to which the intensity of the 10 January 2011 flood was increased;
- e. the increase in volume and intensity of flood to the north and the east of the Grantham Sandplant caused increased damages to those properties;
- f. the railway embankment constricted the flow of water and increased the intensity of the flood event restricting the capacity of Grantham residents to evacuate.

T P Tobin SC