Commission of Inquiry
PARADISE DAM

PARADISE DAM COMMISSION OF INQUIRY

Commissions of Inquiry Act 1950
Section 5(1)(d)

STATEMENT OF STEVEN PELLS

Name of Witness:	**Dr Steven Edward Pells**
Date of birth:	[redacted]
Current address:	**C/- Pells Sullivan Meynink** **6a Level 6, 500 Queen St** **Brisbane Qld 4000**
Occupation:	**Principal Water Engineer**
Contact details (phone/email):	[redacted]
Statement taken by:	**Jane Menzies, Counsel Assisting**

I, Dr Steven Edward Pells, Engineer, make oath and state as follows:

Background

1. I am a Principal Water Engineer and Principal Hydrologist at Pells Sullivan Meynink (**PSM**).

2. I have been an engineer for close to 20 years with experience in civil hydraulics, hydrology and groundwater studies. I have particular expertise in applying water

e: secretary@paradisedaminquiry.qld.gov.au
w: www.paradisedaminquiry.qld.gov.au

engineering principles to geotechnical and civil engineering problems, whether in water resources, mining, environmental, dams, groundwater or civil design.

3. I hold a Bachelor of Engineer (Civil), a Master of Engineering (Hydrogeology and Coastal Engineering) and a Doctorate of Philosophy (**PhD**).

4. A copy of my curriculum vitae is attached and marked "**SP1**".

5. From 2011 until I finished my PhD, I consulted with my father in a firm called Pells Consulting.

6. In 2016, I completed my PhD examining erosion and scour within chutes and channels, with particular focus on rock materials in dam spillways. My studies were industry-prompted because of a need to refine scour assessment methods at that time.

7. I started in my current position at PSM when I finished my PhD. The discipline of scour assessment involves rock mechanics and hydraulics. My expertise is on the hydraulics side. I joined PSM because there are people there who are skilled in rock mechanics, so my skills complement theirs for scour assessment work.

8. Since 2016, I have worked on various dam spillway erosion and problems. During my PhD, I studied about 30 dams. Since then I have considered a further ten in a consulting capacity.

Approach to scour assessment

9. Dams have always been designed to mitigate spillway erosion. Designers have to exercise their judgment to decide when the rock mass is of sufficient capacity to withstand the anticipated hydraulic loading.

10. The idea is to allow for some amount of erosion. If a dam was designed to have no erosion in a probable maximum flood, that would constitute an over-design. There is always a

trade-off to be made because a river downstream of a dam cannot be lined forever. The philosophy is that some degree of erosion in a flood event is acceptable, so long as the dam's stability and safety are not compromised. Any erosion damage can be rectified later.

11. The standard historical approach to solving this problem was to compare the rock mass at a dam site to precedent dams and spillways. This approach relied on people having sufficient experience of precedent dams. The spillway would be designed based on that comparative analysis. The approach was inexact but was mostly successful.

Studies during the 1970s and 1980s

12. In 1976, the Copeton Dam in New South Wales (which I am currently engaged to look at) had a much bigger erosion event than was expected from quite a small flow. That was the impetus for many studies at the time.

13. In the early 1980s in South Africa, there were also studies being undertaken after a dam there suffered a similar erosion event to the Copeton Dam. Dr Hendrik Kirsten had developed a rock mass index as an index of excavatability of rock (how easily a rock mass may be excavated). This index (referred to often as the "Kirsten Index") reflected other existing "Rock Mass Indices" that have been developed since the 1970's. Rock Mass Indices are a numerical way of characterising a rock mass as an engineering (as opposed to a geological) material. In around 1988, Dr Kirsten proposed to use the Kirsten Index for characterising erodibility of rock masses. He then worked with a Dr Moore (I am unsure of his first name) and Dr George Annandale to collate a data set of historical erosion. I understand that Dr Annandale proposed the use of stream power dissipation to represent hydraulic loading and that was where the idea to combine the concepts began.

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Annandale method

14. A number of further studies then followed in South Africa and the United States. Most of the case study data was compiled by studies led by Dr van Schalkwyk in South Africa. A number of publications on rock mass erosion were presented in the 1990's which used Dr van Schalkwyk's data. All of those publications adopted a common methodology whereby they would use the Kirsten Index to characterise the rock mass conditions and stream power dissipation to characterise the "erosive power" of the flow of water. For each case study, the amount of erosion that had occurred was correlated to the interpreted Kirsten Index and stream power dissipation that was thought to exist at the spillway prior to its removal by erosion. In these studies, the design method arises from comparing the assessed Kirsten Index and stream power dissipation at the site under consideration against the case study data presented in the publications.

15. Of these, the most widely adopted method was published in 1996 by Dr Annandale and is often referred to as the 'Annandale method'. Dr Annandale interpreted a single threshold for the onset of erosion based on fitting a curve to the case study data. It should be noted that different researchers reported different interpreted "thresholds" despite using largely the same data set for cases of rock erosion, as this highlights some of the uncertainty and limitations in this methodology. In my experience, the Annandale method is used almost ubiquitously on dams since it was published in 1996, at least in Australia and the United States.

Dr Bollaert's studies

16. In around 2003, Dr Erik Bollaert in Switzerland researched whether high frequency pressure fluctuations in the water flow might unravel rock masses. He developed a different analytical method of fracturing of a rock mass from flows plunging from high dams.

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17. Dr Bollaert's method was initially welcomed by the industry. However, based on my own experience and discussions with many industry colleagues, I believe that Dr Bollaert's method is now met with reduced enthusiasm because of its almost impenetrable complexity, and the numerous assumptions that are made.

18. Most practitioners do not have the time or expertise to review or understand Dr Bollaert's model and, therefore, the model is only really implemented by Dr Bollaert himself. In my opinion, the publications and reports that have been prepared by Dr Bollaert are opaque about the parameters he has chosen. This makes his model difficult to review or subject to scientific test. The result is that the dam owner is asked to trust Dr Bollaert's judgement.

19. During my PhD studies, I undertook a comprehensive review of Dr Bollaert's method. His method represents rock masses using somewhat proprietary analytical models, rather than adopting principles of rock mechanics as currently practiced within the engineering geology and rock mechanics fields. He reduces complex hydraulic turbulent fluctuations to a peak instantaneous pressure. There are as many as 25 'unknowns' in Dr Bollaert's equations, few of which can be measured in a laboratory (or in any other way). My finding was that it provides some insight into hydraulics, but it is an inadequate and unsuitable representation of most rock masses. Due to the uncertainty in parameters used in Dr Bollaert's model, in my view it is not a confident predictive tool.

20. Dr Bollaert was not involved in the design of Paradise Dam, nor was his method available at the time the Dam was designed. He was engaged later to review the scour at the Dam in 2013 and he prepared a report. I was given Dr Bollaert's report by Sunwater as part of briefing documents for the Technical Review Panel (**TRP**).

Witness	Taken by

My PhD

21. The basis of my PhD was to provide the industry with improved methods for assessing rock scour. I reviewed the Annandale method and other similar Rock Mass Indices based approaches. Through my inspection and collection of data from dams in Australia and South Africa, I produced a more robust data set and provided a revised rock mass index method. However, my method suffers from the many of the same limitations as the Annandale based methods. In my work, I cautioned the industry to consider this type of method as a 'rule of thumb' approach whereby the dam spillway under design is compared to other spillways based on fairly rudimentary criteria. The method should be used as a first pass assessment.

22. I also reviewed analytical kinematic type methods such as Dr Bollaert's method (as discussed above) and reached the finding that the entire rock mass of a spillway cannot be adequately represented by analytical methods. I undertook detailed laboratory testing for estimation of pressures in and around rock masses to develop direct modelling or kinematic / coupled modelling assessments of rock mass erosion.

23. While my PhD did not change the face of the industry, it produced a method that was slightly improved as well as detailed case study data and detailed hydraulic laboratory measurements for further development of direct modelling approaches. I expect that the data that I collected will be used in the future to develop better methods.

Current developments

24. The industry is currently attempting to couple hydraulic modelling with numerical representation of rock mass as a finite element model using methods from mining engineering. That approach is untested internationally. It is currently being developed and was not available when Paradise Dam was designed.

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25. I am in favour of better surveillance through the use of drones and, in the future, developing coupled numerical and rock mass models. This is work that is being done now.

Involvement on the TRP

26. I started as a member of the TRP about a year ago. I am involved to comment on GHD's work in computational fluid dynamics (**CFD**) modelling and hydraulic studies. I also comment on scour predictions and GHD's analysis of what has previously happened.

27. I signed the Technical Review Panel Report No 2 dated 23 September 2019 (**Report No 2**) and agree with its contents. I wrote a draft of section 8 – "*Hydraulics and scour*" – and sent that to Peter Foster who edited and compiled the report. This section contains opinions honestly held by me.

28. I also signed Technical Review Panel Report No 3 dated 9 December 2019 (**Report No 3**). The first three paragraphs of section 6 of that report, which is titled '*Hydraulics and scour*' reflect written commentary that I provided to the TRP (Peter Foster) by email on 29 Nov 2019. The fourth (final) paragraph are not my words but I consider that they do reflect findings presented by GHD in the TRP review meeting.

GHD's hydraulic modelling and scour assessments

Hydraulic modelling

29. There has been a great deal of good quality work done by GHD in hydraulic modelling. GHD has done a Computational Fluid Dynamics (**CFD model**), which is a state-of-the-art 3D flow model. With a CFD model, the flow is analysed over a grid covering the whole dam spillway, which can provide a high resolution representation of hydraulics.

30. A CFD model can provide data on pressures, velocities and shear stress used in the design. The model can also supply visualisations which are often relied upon in design.

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It depicts flow velocities, eddies and fluctuations in the stream. A CFD model will show locations where there is a high degree of interaction between the flow and the rock surface. For example, one can see where high velocity flows plunge directly onto the rock surface. Then one looks at the rock mass at that location to see, for example, that those high velocity flows occur at the intersection of two geological faults.

Scour assessment

31. In my opinion, scour assessment needs to involve hydraulics and rock mechanics expertise.

32. GHD's digital rock mass model, as presented in the TRP meetings to date, is primarily a presentation of factual data. GHD has plotted the position of boreholes and interpreted the conditions at that those locations. Hand drawn concepts of interpreted geological conditions were presented. I understand that the digital model has not included interpolation of the rock mass conditions between the boreholes.

33. I also understand that GHD intends interpreting the rock mass and doing an analytical assessment of scour. One of the GHD engineers who did the CFD modelling, Dr Shayan Maleki, also recently did his PhD in scour assessment relating to the concrete aspects of spillways. He has published papers in the last year about how to apply that to rock mass. I understand that GHD is proposing to use that method.

34. So far, I have not seen a coherent geological explanation for why the scour in 2013 occurred in the way that it did. The studies made available to me (that were done after that event) have focussed on hydraulics but have not presented a coherent geological explanation for why the scour occurred. I have not been able to determine from the material provided to me what the rock mass that was eroded in 2013 actually looked like.

35. This problem is not unique to Paradise Dam. Scour assessment is a developing practice. For all the historical erosion events that I have looked at, there has been limited

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documentation of the geological conditions prior to the scour occurring. People generally do not survey unlined dam spillways very closely until there is a problem.

36. In my experience, geological mapping tends to be focused upon the area underneath the dam structure. There is typically less attention paid to the rock mass of the unlined spillway and the area underneath the apron. I have not reviewed the extent of the original geological mapping at Paradise Dam. In any event, I would be unable to comment on it because that analysis would be outside my area of expertise. As discussed below, I am of the opinion that the dissipator slab was undersized.

37. The question of the rock immediately downstream of the existing apron may be a moot point for GHD's purposes. If repairs were done to make the dissipator slab suitably larger, the extended apron would cover the region of rock mass that appears to have been most vulnerable to erosion / scour during the 2013 flood event.

Spillway apron

38. In section 8 of Report No 2, I wrote that from studies to that point it was evident that the existing spillway basin was too short. That statement was based on my review of:

    (a) a report by URS Australia Pty Ltd titled "Paradise dam spillway damage, independent technical review" dated 9 October 2014; and

    (b) presentation of the hydraulic modelling by GHD during the TRP workshop meetings.

39. The URS report referred to a method promoted by the United States Bureau of Reclamation for spillway design, referenced as "Design of Small Dams (USBR 1987)". Based upon that method, the calculations in the URS report demonstrated that the apron was too short. Also, the CFD modelling conducted by GHD has shown that it is too short.

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40. To explain the findings of these studies, it is initially important to distinguish the terms "apron", "dissipator" and "stilling basin". An apron refers to a section of concrete lining downstream of a spillway which offers some protection against erosion of the underlying natural materials. A dissipator is designed to cause a reduction in hydro-mechanical energy of water overtopping a spillway by promoting aeration and turbulence. A stilling basin is a particular form of dissipator. The principle of a stilling basin design is to create a hydraulic jump and then ensure that the stilling basin is of sufficient size to contain much or all of the hydraulic jump, including its "length". An apron is often used to form the base of the stilling basin (as it was at Paradise Dam). However, an apron may also be used in other dams simply as protection, without forming part of a stilling basin.

41. The "length" of a hydraulic jump varies depending upon the flow conditions at the particular site but typically ranges from 4.5 to 6 times the tailwater depth. The publication by USBR referred to in the URS report presents design methods for a stilling basin that rely upon the classical analytical methods to determine a design for the stilling basin length and details of features (such as the height of any end sill) to create a hydraulic jump and contain its length. By contrast, the CFD modelling undertaken by GHD is a visual process that does not provide definitive dimensions that are supported by design standards. Rather, it provides a better view of the how the structure will perform but requires a degree of engineering judgement to determine the dimensions and features required of the stilling basin. Both methods have been used to analyse the original dimensions of the spillway at Paradise Dam and both have demonstrated that the structure is too short to contain the length of the hydraulic jump or to be effective in energy dissipation.

42. The critical flood for scour and spillway design might not be the biggest flood. It can be somewhere in between. There is a debate whether CFD or physical modelling should be used to determine what the critical flood is. Neither approach is perfect. A CFD model

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runs specific windows of steady-state flow, whereas in physical modelling one can sweep through possible flow conditions and look for the worst scour conditions. Measurements can be made in physical models of pressures and flow velocities, and CFD models can output detailed estimates of pressure, velocity and shear stress. These can guide assessments, but there is a component of design in either method that relies upon visual appraisal of flow conditions.

43. When I said in TRP Report No 2 that the stilling basin was too short, I was expressing my view, which also reflects the findings of URS and GHD (discussed above). It is too short according to analytical methods and it appears too short compared to the visual conditions of flow as represented by the CFD modelling.

44. The CFD modelling results presented to the TRP by GHD demonstrate that the flows over the spillway in certain flood events (1 in 100 year ARI events and above) are drowned by the tailwater levels but that, despite the presence of tailwater, a high velocity jet penetrates the water column and extends beyond the apron and its end sill. Additionally, for the larger floods modelled (1 in 1000 year ARI events), the flows over the spillway begin to detach from the face of the spillway and over reach the length of the apron.

45. The idea of stilling basin design is that by the time flows reach the end of the basin, they have had much of the hydro-mechanical energy taken out of them. If the apron is effective, by the end of the apron, the flows that pass through the apron are sub-critical, deep and slow flows. At Paradise Dam, flows downstream of the apron exhibit high-energy characteristics. That is a problem if the rock mass has insufficient competence to resist this hydraulic loading.

46. I note that 'Section 4 – hydraulic design, subsection 4.2.1.8' of the Detail Design Report indicates that a 20 metre wide apron performed satisfactorily, based on the hydraulic

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model studies presented in the Preliminary Design Report. I have not seen the Preliminary Design Report. The model study report presented in Appendix D of the Detail Design Report does not present sufficient detail to demonstrate the suitability of a 20 metre wide apron. Therefore, it is difficult to comment on why the 20 metre wide apron length was considered satisfactory.

47. On my reading of the Detail Design Report, it may be that the designer considered that the stilling basin needed only to be of sufficient length to accommodate the *inception* of the hydraulic jump, rather than the full jump *length*. The report contains statements that "A hydraulic jump occurred *on* the apron for all flood events tested" and "The improvement in performance is measured by reduced erosion downstream of the apron through formation of a hydraulic jump *on* the apron" (my emphasis), which suggests that the focus of the designer may have been on the *inception* of the jump. However, this would be a matter for the designer to explain and I may be reading too much into those words.

48. It should be noted that there are examples of other dams that do not feature stilling basins and discharge directly upon unlined rock that have performed satisfactorily against scour / erosion. For example, the Catagunya Dam, in Tasmania (although this does feature a ski jump), and Burdekin Falls Dam, in Queensland, are two examples that I have personally viewed. I understand Julius Dam in Queensland receives plunging flows onto the rock mass and has experienced some erosion but has performed satisfactorily, although I have not personally viewed its performance. These dams demonstrate that it is not universally required that a stilling basin is present or that it causes (and contains) the complete dissipation of hydro-mechanical energy before flows are directed onto an unlined section of spillway. But for the design to operate successfully, sufficient energy should be reduced in accordance with the competence of the downstream rock mass that

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will receive the flows. I do not believe that the design of the stilling basin at Paradise Dam achieves this objective.

49. I have not calculated what the length of the apron ought to be.

50. One curiosity of the Dam is that, looking downstream, the apron rises as it goes towards the left abutment. Normally, there would be such a rise where the geology is perceived to be more competent in that area. The scour event in 2013 suggests otherwise. I have not found reasoning for this design decision in either the provided documentation or TRP discussions. This feature does influence hydraulic behaviour and could possibly be important in understanding the scour that occurred. Based on the documentation that I have reviewed, it remains unclear to me whether this design feature influenced the vulnerability to scour.

Tailwater studies

51. Tailwater levels can usually be calculated satisfactorily. The various studies of tailwater levels were summarised and presented to the TRP during the first TRP workshop meeting. I recall that the tailwater had differing levels and, as I understood it, the different levels arose primarily from different representations of the river conditions downstream of Paradise Dam. Tailwater heights can be predicted using a physical model, a CFD model, one dimensional and two dimensional numerical models and even with one dimensional analytical models. It has been done a few different ways for Paradise Dam.

52. Tailwater levels are important in assessing dam stability. However, the effect of tailwater level on scour is not always clear. Looking at a CFD model undertaken by GHD for Paradise Dam, when the flow velocities in the water are contoured a jet that penetrates the water column is seen. In contrast, one dimensional hydraulic analysis assumes that the velocity is uniform through the tailwater depth. While that is perfectly acceptable

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practice for assessing tailwater *levels*, it says nothing about *velocity distribution*. A physical or CFD model is needed to see how that velocity is distributed. It is not immediately clear from the water level what is actually going on underneath it. From the studies I have seen, the uncertainty in calculated tailwater levels was not perceived to be a critical issue in assessing the scour vulnerability at Paradise Dam. Given the observed jet characteristics, I am inclined to agree that the uncertainty of assessed tailwater levels is not critical to assessment of scour in this case.

53. CFD technology was available when Paradise Dam was designed. The technology has been around since the 1960s, but increased computing power has allowed it to be used in this field. While much slower in the past, it was certainly around in the early 2000s, although may or may not have been used in design of dams as a matter of preference.

54. In my understanding, it was standard practice to undertake physical model studies at the time when Paradise Dam was designed to support dam design, but CFD modelling would have been an optional addition. CFD models are accepted more in dam engineering than any other hydraulic areas I know of. They are used a lot in spillways, but it is a developing area. Most dam designs today rely upon physical modelling with some supplementary CFD modelling in some cases. The industry still has reluctance to rely upon CFD modelling alone.

55. According to the Detail Design Report, physical model testing was used in the original Paradise Dam design. No mention is made of CFD studies in this report. While CFD modelling technology was available, reliance on physical modelling alone is, in my view, acceptable practice, providing the physical modelling studies are appropriately undertaken. When the scour event occurred at the Dam in 2013, a new physical model was developed to examine it. No CFD modelling was done at that time by the then TRP to my knowledge, although upon re-reading of the URS report, I note that URS reported on undertaking CFD modelling as part of their independent review process.

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Right abutment

56. The current CFD model extends over the whole dam, including the right abutment where the secondary spillway comes into play for bigger floods. There is a question about how to use the second spillway in future. For example, can the design solution send more water over this spillway and less over the main spillway? Various scenarios were examined by GHD using a CFD model and there is a trade-off to be made. You can alleviate some of the flow going over the main spillway by sending it over the secondary spillway. However, that raises the question whether the secondary spillway will be subject to its own erosion risks.

57. The little that is known about the geology under the right abutment means that we cannot be comfortable sending a whole lot of flow over onto it. This is reflected in section 6 of Report No 3 where it refers to the "*extremely weathered foundation materials on the right abutment*".

58. Section 8 of Report No 2 discussed designs that included concrete-lined sections to contain the secondary spillway flow. Those concrete walls were very extensive, so that was not a great solution. Either you would push a whole lot of flow over a geology that you are not sure about or build an enormous structure.

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Commission of Inquiry
PARADISE DAM

***OATHS ACT* 1867 (DECLARATION)**

I, Steven Edward Pells, do solemnly and sincerely declare that:

(1) This written statement by me dated 27 February 2020 is true to the best of my knowledge and belief; and

(2) I make this statement knowing that if it were admitted as evidence, I may be liable to prosecution for stating in it anything I know to be false.

And I make this solemn declaration conscientiously believing the same to be true and by virtue of the provisions of the *Oaths Act 1867.*

.. Signature

Taken and declared before me at NORTH RYDE **this** 27th **day of** February **2020.**

Taken By .... JP# 191632

Justice of the Peace / Commissioner for Declarations / Lawyer

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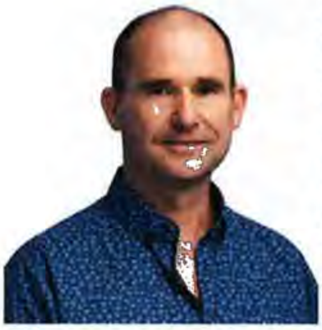
e: secretary@paradisedaminquiry.qld.gov.au

w: www.paradisedaminquiry.qld.gov.au

SP1

Curriculum Vitae

Steven Pells
Principal Water Engineer



Steve is a Principal Water Engineer at Pells Sullivan Meynink and has 20 years' experience in civil hydraulics, hydrology and groundwater studies. Steven's formative years were spent crafting hydraulic scale models and various roles in consulting developed his particular specialisation in applying water engineering principles to geotechnical and civil engineering problems. In 2016, Steven completed PhD studies at the University of New South Wales, examining erosion and scour within chutes and channels, with particular focus on dam spillways. Steven has authored/co-authored over 30 papers in various fields of civil engineering, including hydraulics, hydrology, groundwater and rock mechanics. He undertakes adjunct lecturing on open channel flows and river systems at Sydney University. Steven remains engaged with research in hydraulic design and scour / erosion within the dams engineering community and in groundwater studies.

Steven is currently based in PSM's Sydney office.

Educational Qualifications:

- Bachelor of Engineering (Civil) (Hons), UNSW Australia, 2000
- Masters of Engineering Science, UNSW Australia, 2001
- Doctor of Philosophy, UNSW Australia, 2016

Professional Associations:

- Member, IAH – International Association of Hydrogeologists
- Member, ANCOLD – Australian National Committee on Large Dams
- Research Affiliate / Adjunct Lecturer, Sydney University

Experience:

- 2017 to Present: Principal Water Engineer, Pells Sullivan Meynink
- 2011 – 2017: Associate, Pells Consulting / Adjunct Lecturing, Sydney University
- 2009 – 2011: Senior Project Engineer, WRL
- 2008 – 2009: Senior Water Engineer, Cardno
- 2006 – 2008: Senior Water Engineer, Ove Arup
- 2001 – 2006: Project/Senior Project Engineer, WRL
- 1997 – 2001: Graduate Geotechnical Engineer, Pells Sullivan Meynink

Field of Competence:

- Scour / Erosion of rock masses
- Hydraulics
- Hydrodynamic modelling, numerical and physical
- Spillways and hydraulic structures
- Hydrogeological investigations and analysis

DAMS, HYDRAULICS AND HYDRAULIC STRUCTURES AND SCOUR / EROSION PROJECTS

Hydro-Geotechnical Scour Risk Assessment, Copeton Dam, NSW

Leading of a comprehensive prediction for scour vulnerability at Copeton Dam. Key task is development of a coupled multi-physics rock mass model and CFD hydraulic model to predict future scour for various design events.

Preliminary hydro-geotechnical Scour Risk Assessment, Blowering Dam, NSW

Review of historical scour at Blowering Dam and advice on ongoing scour risk, based on initial site inspections and application of comparative scour assessment techniques.

Specialist guidance on CFD and Physical model studies, Rookwood Weir, QLD

Provision of specialist advice to regulators on the sufficiency of relying on CFD modelling alone for design purposes, and the possible need for additional physical hydraulic model studies.

Preliminary hydro-geotechnical Scour Risk Assessment, Araing Dam, France

Review of scour risk at Araing Dam in the French Pyrenees based on review of available geological information and CFD modelling.

Paradise Dam, Queensland

Member of Technical Review Panel for Paradise Dam Improvement project

Petit-Saut Dam, French Guiana

Assessment and prediction of current and future risks from scour at the main dam outlet. Tasks included development of a geotechnical model, hydrodynamic modelling (1D, 2D and 3D CFD models) and scour risk assessments.

Guidance on scour assessments, Teemburra Dam, QLD

Technical steering / review for spillway review and scour assessments at Teemburra dam

Design of sedimentation basins – various

Hydrological analyses and site selection for sizing detention basins at various mining sites. Analyses for spillway design also accompanied these designs.

Design of rip-rap lined chutes – various

Hydrologic and hydraulic analyses for sizing of chutes and designing appropriate lining for resistance to erosion at various mining sites.

Long-term hydrodynamic analysis of scour

Analysis of headcut development and long-term channel scour to support mine closure studies. Pilbara region for FMG.

Review of scour potential and remediation options, Burdekin Falls Dam

Member of technical review panel for assessing scour risk at Burdekin Falls Dam. Recommendations were provided on required stabilisation works based on UAV surveys, hydraulic studies, geotechnical assessments and scour assessments.

Design of high-wall diversion channels

Hydrologic and hydraulic analyses for design of high-wall diversion channels, Maules Creek.

Dam safety review

Tallong dam, NSW

Review of erosion risk and stability, Somerset Dam QLD

Technical review and assessment of hydraulics regarding overtopping of abutments at Somerset Dam. Assessment of dam stability in sliding and overturning under extreme flood events.

Review and redesign of a 7.5GL mine-water dam, Goonyalla QLD

Technical review of embankment construction in expert witness context. Tasks essentially required complete re-design of the embankment, including material selection and placement, zoning, 3D visualisation and volume calculations, detailed seepage analysis, detailed stability analysis and various supporting hydraulic and geomechanics assessments.

Expert review of embankment failure, Newnes NSW

Expert review of overtopping / piping failure of a tailing facility. Tasks included forensic site inspection, supported by detailed hydraulic, seepage and stability analyses.

Review of embankment seepage / stability, Wilton NSW

Review of potential piping failure, and detailing of solutions for a private embankment dam.

Erosion of unlined spillways, PhD studies

An industry linkage grant was awarded to develop improved design methods for assessment of scour on unlined spillways. Investigations have been based on laboratory testing and field studies. Laboratory testing comprised detailed studies on pressure transients in open channel flows under various conditions, and relating the observed measurement to hydraulic indices such as tractive force and stream power dissipation. The measurements are used to develop kinematic models of stability of unlined rock chutes. Field studies included review of erosion at over 30 dam spillways in Australia, South Africa and the USA. Investigations include geological review and mapping, rock mechanics assessments and detailed hydraulic assessments, typically using HEC-RAS. New methods of assessment of erosion were developed based on these investigations.

Hydraulic analysis of the Balikera Tunnel, Hunter Region NSW

Hydraulic analysis of discharge through a stream diversion tunnel, including assessment of the impacts on hydraulics from rock-falls / tunnel collapse.

Dam safety assessment, Narara NSW

Undertaking of a dam safety assessment, and preparation of dam safety management plan for the Narara Horticultural Dam, New South Wales.

Dam safety assessment, Hazelwood VIC

Undertaking of a dam safety assessment of the Hazelwood Cooling Pond, Victoria, in accordance with the Australian National Committee on Large Dams (ANCOLD) guidelines.

Expert Review of Embankment Dam, Dorrigo NSW

Expert (legal) review of the embankment and hydrology of a 15 m earth embankment dam to advise legal proceedings; witness in court.

Physical Model of Outlet Works, Adelaide Desalination Plant, SA

Design, construction and testing of a physical model of the outlet works (drop structure) from a desalination plant. The model was primarily of clear acrylic piping and, at the scale of 1:6, was over 4 storeys in height.

Lined Storages – Caustic Soda, Gladstone QLD

Hydraulic modelling and specialist advice on scale modelling of caustic soda storage and distribution networks.

Remediation of Tidal Weir Structures, East Trinity QLD

Assessment of existing tidal control structures and design of new structures to support tidal flushing of acid sulphate remediation activities.

Testing of Tidal Energy Turbine, Australia

Laboratory testing of power output and efficiency from turbine designs.

Assessment of Hydraulic Forces on Causeway Structures, QLD

Hydraulic assessments were used as a basis for preparation of guidelines.

Physical testing of large diameter valves, Australia

Physical testing to determine headloss characteristics of large diameter flow valves.

Physical testing of large diameter pipe plug, Australia

Physical testing of the effectiveness of purpose built apparatus to plug and decommission an operating underground pipeline.

Physical modelling of a detention basin / weir, Kellyville NSW

Management, supervision, design and construction of a physical model of instream flood control basin.

Assessment of dam intake structures for Jindabyne Dam, NSW

Management, design, construction and testing of a physical model to assess the performance of a proposed dam intake structure.

Design of scour protection for rock chutes, Australia

Large scale physical modelling and analysis to develop specifications for rock scour protection for weir structures.

WATER RESOURCES (HYDROLOGY AND HYDROGEOLOGY) PROJECTS

Specialist hydrology and hydrogeology guidance, Ok Tedi Mine, PNG

Provision of specialist guidance and training for ongoing hydrology and hydro-geological analyses at Ok Tedi Mine, Papua New Guinea

Lead hydrogeologist, Rozelle Interchange Project, Sydney

Lead hydrogeologist for design services of Rozelle Interchange Project. The role was to coordinate and provide design advice on tunnel inflows, drawdowns and design pressures for a network of 19km of road tunnels in the Sydney CBD based on supervision, undertaking and interpretation of site investigations and aquifer tests and 2D and 3D hydrogeological modelling.

Prediction of mine inflows, Broadmeadow QLD

Review and prediction of groundwater inflows and risks for longwall mining operations.

Mining impacts on water resources, Newnes NSW

Detailed review of potential impacts on groundwater and surface water resources (i.e. endangered swamps) due to of dewatering, subsidence and cracking from longwall mining.

Mining impacts on water resources, Bylong NSW

Review of predicted impacts on groundwater and surface water resources from proposed longwall mining.

Mining impacts on water resources, Williamtown NSW

Review of predicted impacts on groundwater and resources from proposed sand mining.

Mining impacts on water resources, Capertee NSW

Review of predicted impacts on groundwater and resources from proposed longwall mining.

Flood studies, various locations

Design flood levels and flood risk, various residential properties in Sydney.

Expert review of coastal/seasonal groundwater, Ichthys Project NT

Expert (legal) review of groundwater dynamics and impacts to earthworks planning and progress.

Mine water balance assessments, Gregory Crinum QLD

Development of regional surface water models and preliminary groundwater models to examine site-wide water balances to guide a mine closure plan.

Groundwater impacts, Longwall mining, Moss Vale NSW

Development of regional hydrogeological model and undertaking of 3D transient numerical groundwater modelling (MODFLOW) to assess impacts to groundwater from a proposed longwall mine.

Impacts to groundwater from coal seam gas extraction, various locations

Independent review of predicted effects on groundwater from proposed coal seam gas (CSG) projects. Reviews typically supported by 2D and 3D numerical groundwater modelling.

Assessment of basement seepage issues, Maroubra NSW

Appraisal of major seepage issues for a major development in the Botany Sands. Design of dewatering using 3D numerical groundwater model (MODFLOW). Representation of client at legal mediation.

Groundwater impact assessments, various locations

Various minor projects to report on groundwater conditions and risks from proposed developments, including roads and pipelines to assist with EIS document preparation.

Review of surface and groundwater effects from longwall mining, Springvale Colliery NSW

Field reconnaissance, data review and surface water modelling tools were used to provide advice on potential impacts to surface water systems from longwall mining effects.

Expert review of groundwater impacts from longwall mining, NRE Gujarat NSW

Independent review of environmental assessments of impacts of mining subsidence on groundwater and surface water resources.

Review of hydrology of Thirlmere Lakes, Southern Coalfields, NSW

Undertaking of an independent review of the hydrology of Thirlmere Lakes, and on the evidence for impacts from longwall mining.

Ranger Uranium Mine – Flow Modelling of Post-Closure Conditions, Ranger NT

Construction and calibration of a hydrologic and 1D hydraulic flow model of catchments adjacent to the Ranger Uranium Mine.

Groundwater Characterisation and Numerical Modelling for Rainbow Beach Estate, Rainbow Beach NSW

Specification of a groundwater investigation and monitoring scheme for characterisation of a coastal aquifer near Port Macquarie. A 3D numerical groundwater model was assembled to simulate the aquifer and to assess impacts from a proposed development.

Design of flood detention ponds, Cecil Hills NSW

Hydrologic analyses for design of flood detention ponds to support large residential subdivisions.

Urban flood hydrology, Stanmore NSW

Development of 1D stormwater network models to assess flood risk and design flood mitigation options for an urban catchments in Sydney.

Flood modelling and design, Porters Creek NSW

Supervision of hydrologic and 2D flood models for flood studies of the Porters Creek catchment.

Review of Catchment Processes, Flemington ACT

Installation and operation of field equipment and development of water balance models for the catchment.

Review of seawater intrusion of coastal aquifers, Christchurch NZ

Literature review on the processes, international experience and management of seawater intrusion of coastal aquifers to guide policy development in the Christchurch region, New Zealand.

Managed aquifer recharge investigations, Borambil Creek NSW

Scoping studies to evaluate and advise on aquifer management, enhanced recharge and stream restoration, Borambil Creek in the Upper Namoi catchment, New South Wales.

Aquifer Storage and Recovery Feasibility Assessment, Ipswich QLD

Desktop studies to assess the feasibility and potential yield of a proposed Aquifer and Storage Recovery Scheme near Ipswich, Brisbane.

Perth Airport Drainage Strategy, Review of Groundwater, Perth WA

Review of surface water-groundwater in the superficial aquifers in the Swan Coastal Plain to assist with flood modelling of the Perth Airport site.

Review of Geothermal Heat Pump Applications, Energy Australia Building, Sydney NSW

The design of a large ground-source heat pump system was reviewed based on site characterization and the derivation and application of analytical techniques to simulate heat transport.

Design of Stormwater Capture and Treatment Ponds, Eraring NSW

Desktop analysis of catchment hydraulics to prepare preliminary design of stormwater capture and treatment infrastructure.

Physical Modelling of flooding and evacuation, Penrith Lakes, Penrith NSW

Management, supervision, design and reconstruction of a physical model to examine flood characteristics, floodplain risk planning and evacuation timing for large lakes development scheme in Western Sydney.

Feasibility of flood harvesting, Broken Hill NSW

Desktop studies and field investigations to assess feasibility of flood capture infrastructure.

Water Resource Assessments, Far North Queensland

Preparation of a water supply strategy for the Far North Queensland region to meet regional forecast demands over 50 years. Technical sub-studies to assess the yield / reliability of supply options, ranging from large dams to residential rainwater tanks and stormwater harvesting.

Assessment of surface – ground water connectivity, Centennial Park NSW

Field investigations, monitoring and analysis to provide recommendations to irrigators regarding the impacts to groundwater from the abstraction of water from a public lake systems.

Feasibility of Saline Intake Bores for Seawater Desalination, Central Coast NSW

Detailed field investigations and interpretation to assess feasibility of large intake bores for a planned seawater desalination scheme. Tasks included undertaking resistivity surveys, drilling supervision, supervision and interpretation of aquifer pumping tests, slug tests and groundwater level and quality monitoring.

Assessment of Groundwater Pollution Sources, Location confidential

Presentation and interpretation of resistivity survey data to assess location and extent of groundwater pollution from industrial sources. Advice was used to support litigation.

Groundwater System Characterisation, Blue Mountains NSW

Supervision of field investigations to characterise groundwater hydraulics and quality in sandstone aquifers in the Blue Mountains, NSW for a proposed quarry. Tasks included supervision of drilling, bore logging, groundwater sampling, and undertaking packer and slug tests and associated analysis to estimate hydraulic properties.

Perth Airport Drainage Strategy, Review of Groundwater, Perth WA

Review of surface water-groundwater in the superficial aquifers in the Swan Coastal Plain to assist with flood modelling of the Perth Airport site.

Impacts of Effluent Disposal on Groundwater in Coastal Aquifers, various locations

Detailed field investigations into groundwater hydraulics and quality in coastal aquifers to support effluent disposal schemes at various sites in New South Wales, including Hat Head, South West Rocks, Iluka, Hastings Point and Sussex Inlet.

Assessment of Groundwater Seepage for Tunnel Design, Sydney NSW

Undertaking of permeability testing of sandstone bores in the CBD of Sydney. Results were interpreted to provide parameters to support design of tunnelling works.

Design of a Groundwater Effluent Disposal Scheme, Iluka NSW

Detailed field investigations and associated interpretation to assess feasibility and support design of an effluent disposal scheme. Tasks included supervision and interpretation of aquifer pumping tests, and assessment of planned infrastructure development locations with respect to coastal processes.

COASTAL ENGINEERING PROJECTS

Coastal stability assessment, Central Coast NSW

Assessment of coastal damage / risk to public infrastructure after extreme coastal event.

Seawall design, Central Coast NSW

Site inspection, site characterisation and stability analysis supporting design of public beach stair access and coastal revetment.

Review of dredging and excavability, Darwin NT

Expert (legal) analysis of field data to support legal proceedings related to dredging.

Design of geobag seawalls, Byron Bay NSW

Numerical finite-element and kinematic stability assessment of geo-bag seawall designs.

Risk assessment of seawalls, Manly NSW

Review and risk assessment of geotechnical stability of 18 seawalls in accordance with statutory procedures.

Physical Modelling of Desalination Brine Outlet, Perth WA

Design, construction and application of a physical model to examine diffusion processes of brine discharge from a large scale desalination plant.

Foreshore Embankment Stabilisation, Penrith NSW

Provision of specialist advice on options for stabilisation of foreshore regions against erosion around a series of inland lakes.

Appraisal and Design of Coastal Protection Structures, Green Island QLD

Project manager for the review of the function and condition of a sediment control groyne on Green Island (Great Barrier Reef).

Assessment of Greenwater Overtopping of Offshore Structures, Browse WA

Technical studies to investigate the extent and impacts of green water overtopping of a number of large scale offshore structures.

Burwood Beach Ocean Outfall Modelling, Newcastle NSW

Detailed analyses of meteorological conditions were undertaken to predict the statistical frequency of pollution events at beaches adjacent to an ocean outfall.

Review of Sub-Aerial Landslide Tsunami Generation and Propagation, Lihir Gold Mine, PNG

A tsunami event, caused by a sub-aerial landslide, was recorded at a local tidal monitoring station. Analyses of the characteristics of the tsunami event were undertaken and used to postulate on the extent, velocity and timing of the landslide.

Breakwater / Revetment Design, Sydney Airport, Sydney NSW

Undertaking physical model studies for optimisation of toe scour protection requirements for a breakwater / revetment structure at Sydney Airport.

Estuarine Numerical Modelling, Auckland NZ

Set up and calibration of 2D numerical hydrodynamic model for examination of tidal currents and estuarine processes in a region of Auckland Harbour to allow examination of impacts of proposed developments.

Numerical and Physical Modelling of Mooring Structure, Darwin NT

Numerical and physical modelling studies to assess amplification or modification of currents adjacent to a large wharf structure during the mooring of large sea vessels.

Ocean Outfall Assessment, Wollongong NSW

Undertaking physical modelling of a section of proposed outfall design for examination of saline intrusion.

Wind-Wave Growth and Dissipation Studies and Research, Australia

Physical testing and research to investigate the physics of wind – wave interactions and the processes of wave growth and dissipation. Studies resulted in the publication of new research into the growth and dissipation of wind waves.

Seawall Assessment and Design, Manly NSW

Detailed assessment of the stability and long term performance of a public seawall in Manly, Sydney.

Coastal Erosion Assessment Glenelg SA

Numerical assessment of coastal longshore sediment transport to support expert advice for litigation following coastal erosion issues at Glenelg, Adelaide.

Design of Wave Paddle System, Australia

Design, construction and calibration of a wave generation system for undertaking wave basin modelling studies.

Assessment of Sediment Response to Offshore Reef Structures, Australia

Research into the shoreline response to offshore reef structures. Tasks included design, supervision and testing of a movable bed physical model.

CIVIL AND GEOTECHNICAL DESIGN PROJECTS

Bowen Mountain, NSW

Field inspections, UAV surveys, hydrologic and hydraulic modelling and conceptualisation of energy dissipation designs to guide relocation of roadway runoff infrastructure.

Prediction of tunnel inflows and groundwater pressures for tunnel design, various

Site investigations, interpretation, and various analytical and numerical (2D and 3D) modelling to predict inflows and design pressures to support design of various major tunnel works including Cross River Rail (Brisbane); Snowy 2.0 (NSW); Sydney Metro (Sydney); Westconnex (Sydney) and Northconnex (Sydney).

Geotechnical risk assessment, Narara NSW

Assessment of general geotechnical risks and constraints for site subdivision.

Review of longwall mining design, Mandalong

Assistance with expert review of legal claim pertaining to planning and design of longwall mining excavations.

Review of tunnel design, Wynyard Walk

Assistance with expert review of design of pedestrian tunnel.

Jet grouting / excavation, Cowper Wharf NSW

Expert (legal) review of claim regarding jet-grouting and excavability and disposal of material.

Tunnel construction supervision, Point Piper NSW

Routine inspection of construction of private pedestrian tunnel.

Forensic investigation of piping failure, Yalourn Vic

Support for expert review of piping-failure of embankment at Yallourn. Tasks included: compilation and management of detailed GIS database of all data relevant to the claim; development of 3D conceptual models; finite element stability assessments, and; numerical seepage modelling.

Review of site development options, Hornsby NSW

3D GIS mapping of geology and earthworks and detailed analysis to assess excavation design and quantities for a legal claim at Hornsby Quarry.

Mine effect monitoring. Wollongong, NSW

Member of technical committee panel for monitoring and protection of public infrastructure (roads) for impacts from longwall mining.

Review of major pit failure, Mulia Indonesia

3D GIS mapping of geology and earthworks and undertaking finite element analysis to examine options for responding to major earth slip at a mine site

Review of excavation designs, Sydney Opera House NSW

3D GIS mapping of geology and earthworks and detailed analysis to assess excavation design and quantities for a legal claim at the Opera House carpark.

Review of basement design, Dee Why NSW

Review of basement piling and waterproofing to support legal claim.

Excavation stability appraisal, Sydney CBD

Review of potential settlement from planned deep excavation in Sydney CBD.

Tunnel lining investigations, M2 tunnel NSW

Forensic investigations of existing tunnel lining through undertaking of specialist coring and fourier analysis of drummyness testing.

Pond design, Kenny ACT

Design of pond lining options for proposed instream basin.

Residential access tunnel, Point Piper NSW

Routine monitoring of a residential tunnelling project.

Publications, Articles and Patents

1. PELLS, S.E and DOUGLAS, K. (in publication) Hydro-geotechnical assessment of scour of rock Book chapter from an international workshop on behalf of the European Group of ICOLD and the French Committee on Dams and Reservoirs, Aussois, France, 11th to 14th December 2017
2. PELLS, S.E and DOUGLAS, K. (2019). Guidelines for assessment of scour in unlined spillways. Africa 2019, conference for the International journal on hydropower and dams, 2-4 April 2019, Windhoek, Namibia
3. DOUGLAS, K, PELLS, S.E., FELL, R. and PEIRSON, W.L. (2018). The influence of geological conditions on erosion of unlined spillways in rock. Quarterly Journal of Engineering Geology and Hydrogeology, vol. 51, pp. 219 - 228, http://dx.doi.org/10.1144/qjegh2017-087
4. PELLS, P.J.N., BIENIAWSKI, Z.T., HENCHER, S., PELLS, S.E. (2017). RQD - Time to rest in peace. Canadian Canadian Geotechnical Journal, 2017, 54(6): 825-834, https://doi.org/10.1139/cgj-2016-0012
5. PELLS, S., DOUGLAS, K., PELLS, P.J.N., FELL, R., PEIRSON, W.L. (2016). Rock mass erodibility. J.Hyd.Eng. ASCE. HYENG-9857 https://doi.org/10.1061/(ASCE)HY.1943-7900.0001243
6. PELLS, S.E. (2016). Erosion of Rock in Spillways (Doctoral Thesis). UNSW Australia, Kensington, N.S.W. http://handle.unsw.edu.au/1959.4/56008
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9. PELLS, PJN and PELLS, S.E. (2016). The water levels of the Thirlmere Lakes. Proc. 20th Cong. Asia Pac. Div. Int. Assoc. Hydro Env. Eng. & Res. IAHR APD 2016, August – 28 to 31 2016. Sri Lanka.
10. PELLS, S.E. (2016). Assessment and surveillance of erosion risk in unlined spillways. Proceedings, 84th ICOLD Annual Meeting, International Committee on Large Dams 15 -20 May 2016, Johannesburg, South Africa
11. PELLS, S.E, PELLS, P.J.N., PEIRSON, W.L., DOUGLAS, K. and FELL, R. (2015). Erosion of unlined spillways in rock – does a 'scour threshold' exist? Proceedings, ANCOLD annual conference, Brisbane, 5-6 November 2015
12. PELLS, P.J.N and PELLS, S.E. (2015). Hydrogeologists and Geotechnical engineers – lost without translation. AGS / IAH Symposium, Sydney 13 November 2015
13. PELLS, S.E. and PELLS, P.J.N, (2015). Application of Dupuit's Equation in SWMM to simulate baseflow. Technical note, ASCE Journal of Hydrologic Engineering,
14. PELLS, S.E. and PEIRSON, W.L. (2014). DISCUSSION: "Evaluation of Overtopping Riprap Design Relationships" by Steven R. Abt, Christopher I. Thornton, Bryan A. Scholl, and Theodore R. Bender Journal of the American Water Resources Association (JAWRA) 11 Nov 2014.
15. CARLEY, J. T., MARIANI, A., COX, R., SHAND, T., & PELLS, S. (2013). History and Future of Seawalls in the Manly Local Government Area. In I. L. Turner (Ed.), Coasts and Ports 2013: 21st Australasian Coastal and Ocean Engineering Conference and the 14th Australasian Port and Harbour Conference. Manly NSW Australia.
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