AN ASSESSMENT OF ENVIRONMENTAL IMPLICATIONS FOR THE LANG LANG RIVER RESULTING FROM THE ESTABLISHMENT OF A BROILER FARM AT 230 SOUITH YANNATHAN ROAD, YANNATHAN

VCAT PRACTICE NOTES

EXPERT EVIDENCE BY

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for

Victorian Civil Appeals Tribunal

(November-December 2004)

STATEMENT BY THE AUTHOR OF THIS REPORT

I, Robert H.M. van de Graaff, PhD, have produced this report at the request of the Environment Defenders Office (Vic) Ltd, which has asked me to assess a number of environmental issues associated the proposal for the establishment of a broiler farm at 230 South Yannathan Road, Yannathan. I have no financial or other material interest in this matter and have produced my work *pro bono*.

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INTRODUCTION

1) Name and address of the expert

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2) Expert's qualifications and experience in making this report

Academic qualifications:

PhD (1971), Cornell University, Ithaca, N.Y., majoring in Soil Science (Dept. of Agronomy); minor subjects Terrain Analysis, Air photo Studies, Soil Mechanics (Dept. of Civil Engineering), Geomorphology, Mineralogy and Petrology (Dept. of Geology), with additional two semesters of Physical Chemistry.
M.Sc. (1959), Agricultural University Wageningen, The Netherlands, in Tropical Agriculture; major subjects Tropical Crop Agronomy, Soil Science, Soil Chemistry, Soil Physics, Soil Fertility and Land Reclamation.
B.Sc. (1956), Agricultural University Wageningen, The Netherlands, in Tropical Agriculture.

I have been working as a consultant in the area of soil science and environmental science since 1989, first with ACIL Australia Pty Ltd, and then, after September 1999, as a self-employed consultant. Before that, starting with my first job after graduation, I worked as:

- Research Officer for the CSIRO Division of Land Research & Regional Survey, Canberra, mapping broad tracts of land using a combination of aerial photo interpretation and field work, 1959-1963;

- Graduate Assistant, Dept. of Agronomy, Cornell University, while engaged in doctoral studies in soil science, paid work consisted of detailed soil survey and land inventory, laboratory work and teaching, 1963-1968;
- Visiting Assistant Professor in soil science and aerial photo studies, Dept of Geography, Queens University, Kingston, Ontario, 1968-1970;
- Research Officer, involved with irrigation, waterlogging, drainage – i.e. movement of water through soil – and soil salinity issues, International Institute for Land Reclamation and Improvement, Wageningen, The Netherlands, 1970-1974;
- Senior Research Officer, involved with land system[1] and soil mapping, combating dryland salinity and effluent disposal, Soil Conservation Authority, Dept of Conservation, Melbourne, 1974-1988;
- Partner in a short-lived partnership making compost from sewage sludge at the MMBW Sewage Treatment Plant at Carrum Downs.

I was with ACIL Australia Pty Ltd until the company became exclusively a project manager rather than a technical consultancy, at which time I resigned and set up my own company.

The Soil Conservation Authority, under its Act, had responsibility for protecting the soils and water bodies in Victoria with particular emphasis on water quality protection in proclaimed water catchments. It therefore had an interest in improving its knowledge of the potential impacts of a range of land uses from agricultural applications to rural residential uses. It carried out research on the nature and causes of land degradation, from soil erosion to stream bank erosion and dryland salinity.

I was personally involved in seasonal waterlogging and associated dryland salinity research and the mapping of soils and land systems, as well as assessing their susceptibility to land degradation. The mapping of the soil types and land systems always had an ecological basis where the mapping units were characterised by bedrock type, land forms (geomorphology), kinds of soils, kinds of native vegetation communities, with the observed forms of land degradation related to the past and present land uses. The description of the native vegetation types in cleared land often relied on reconstructing the original ecology from scattered remnants of that vegetation.

Since having been self-employed, my main fields of activity have been in applications of soil science, geology and geomorphology to the re-use of treated effluents on land for irrigation, contaminated soils, and urban soil suitability for street and park plantings in new urban developments, and (in China) the rehabilitation of mine tailings for agriculture and park plantings.

I have appended a list of selected publications of which I was an author or co-author, relevant to the matter at hand.

3) Area of expert's experience

Soil science, wastewater disposal or re-use on land, horticultural aspects of soils, contaminated sites assessment.

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[1] A *land system* is defined as an area of land, distinct from surrounding terrain, that contains particular classes of land characteristics with maximal covariance between them, expressed as a recurring sequence of particular *land components*. *Land components* are areas of land, distinct from surrounding terrain, having an integrated assemblage of particular classes of geological material, landform, soil and native vegetation. Natural processes within land systems are assessed to provide an understanding of the inherent properties and natural dynamics of the land, and probable responses to management.

4) Expert's expertise to make the report

- I have used the expertise described above in carrying out my assessment and writing my comments.

5) Instructions defining the scope of this report

I have been instructed to assess the proposed establishment of a broiler farm at 230 South Yannathan Road, Yannathan, by Mr Barnaby McIlrath of the Environmental Defenders Office (Vic.) Ltd, Level 1, 504 Victoria Street, Melbourne. The objectors to the proposal, who have called in the Environment Defenders Office, are concerned about the potential impact of the development on water quality in the Lang Lang River, water quality in the groundwater below the site, and effects on Westernport Bay where the Lang Lang River discharges its water.

6) Facts, matters and assumptions on which this report proceeds

1. Site visit on 22 November 2004;
2. Cardinia Shire Planning Committee Meeting Recommendation Notes on Scharolla Investments application entitled, 'Broiler Farm Six (6) Sheds, Outbuilding, Dam & Dwelling, 230 South Yannathan Road, Yannathan (T040118) 4785750600.
3. Victorian Code for Broiler Farms, September 2001, State Government of Victoria, ISBN 0 7311 8715 6.
4. Planning Permit Application for Scharolla Investments Pty Ltd to, 'Use the land for a 300,000 bird broiler farm and develop thereon up to six broiler sheds, ancillary facilities, a dam and a dwelling, Prepared by David Proctor-Consultant, New Zalia Pty Ltd, February 2004.
5. Response from of Melbourne Water (Kerrie Homan, Land Development) to the town planning application from Mr James Noy (Senior Planner) of Shire of Cardinia, dated 15 July 2004.
6. Cardinia Shire Inter Office Memorandum to James Noy (Senior Planner) from Ken White (Development Engineer), dated 14/07/2004, Regarding Town Planning Application – Engineering Requirements (for the proposed broiler farm South Yannathan Road, Yannathan).
7. Coleman R and Pettigrove V, "Waterway Assessment in the Western Port Catchment: The Health of the Lang Lang River," commissioned by Melbourne Water.
8. Guidelines for Development within the Koo Wee Rup Flood Protection District, Melbourne Water Corporation.

8) Identity of persons carrying out tests upon which this report relies

There are no tests specifically carried out for this assessment.

9) Summary of opinions of the expert

I prefer to hold on to the precautionary principle of not carrying out an action when there is serious doubt about the results of that action, but no doubt that if these results eventuate their impact is undesirable.

The proposal to establish the broiler farm on a flood plain such that an overflow of contaminated water or chlorinated water cannot fail to flow directly into the "new" Lang Lang River (also called the Cut), or seepage from a dam holding such contaminated or chlorinated water to the groundwater, is bound to have undesirable ecological impacts on the receiving body of water.

The Victorian Code for Broiler Farms of September 2001, p. 22, states:

> *Broiler sheds and associated earthworks must not be located in areas designated as subject to inundation under any planning scheme, and must not adversely affect flood plain capacity or natural drainage lines.*
>
> *[The underlining of the words 'must' is by me and in Victorian regulations this indicates that this carries a mandatory meaning.]*

The proposal does exactly the opposite. It requires earthworks to raise the level of the shed floors and presumably all working areas around the shed to be 600 mm above a nominated flood level (Melbourne Water), which means the capacity of the flood plain to store flood waters and allow these to move down stream is diminished. This in turn puts a greater stress on the actual channel of the Lang Lang River. The earthworks will act as a partial obstacle to downstream flow and so can increase the depth of flooding upstream.

The earthworks create a fill pad, an artificial 'island', with an elevation of at least 600 mm above the nominated flood level, and hence significantly more than 600 mm above present flood plain. It will have an extent of at least the surface area of 6 sheds (internal floor area more than 1.4 hectares) plus associated traffic and working areas, perhaps some 3 or more hectares in all.

The farm dam required to contain rainwater runoff from the shed roofs must hold at least:

> 858 mm x 14076 m^2 = 12,077,208 L of water or about 12 ML

in an average rainfall year *if no water from it is used for the chickens or for cooling the shed.*

In a 90-percentile high rainfall year, this volume will be about 30-35% greater.

I do not know, as the proposal does not provide the information, how much water will be required on a daily basis for drinking water for the chickens, for cooling the sheds and for washing down or cleaning between removal of the broilers and the start of a new cycle. However, the rainfall distribution provides a much higher roof water harvest from April to October than in the remaining months, when due to hot weather more will be needed. The proposed dam, I understand, will be about 1.6 hectares in size. Since the annual rainfall is somewhat smaller than annual potential evaporation, the dam cannot be filled from rainfall alone, but must be fed from water harvested elsewhere.

This dam must have walls above the nominated flood level as well, and hence it too acts like an elevated pad that diminishes the flood plain's capacity to store and move flood water. As the proposal, to the extent it is in my possession, does not provide further details as to the dam's capacity and size, it is not possible to estimate its areal extent.

Thirdly, one may question the accuracy of Melbourne Water's nominated flood level because:

- the period of observation of flood levels may have been too short to predict the 1 in 100 year flood level with enough precision,
- it may apply to a measuring location that does not represent the subject land and immediate vicinity,
- it apparently does not take into account local effects as obstruction by willows etc. in the channel of the 'new' Lang Lang River, and
- it may be inadequate as weather patterns move to more violent events due to atmospheric warming.

This Tribunal should not accept the Melbourne Water flood level data and associated recurrence periods at face value.

Runoff from the site containing nutrients and other dissolved or suspended materials must inevitably flow to a culvert under a bank of soil that discharges directly into the ‘new’ Lang Lang River. Therefore, any major accident resulting in a release of contaminated water will affect river water quality in the space of a few days.

Moreover, the site chosen by the proponent appears to be located in the most flood prone section of the entire Lang Lang River flood plain.

Lastly, I understand that the land in question is part of a flood plain - wetland area which is to be protected in terms of remaining native vegetation and because there is a RAMSAR wetland further downstream.

10) Provisional opinions not fully researched

Any opinions expressed in my report that may be considered provisional would be related to my current understanding of the aims of the Code of Practice mentioned above and any documents that have been given to me and appear in the list above.

11) Questions outside expert’s expertise

My brief has been limited to assessing the site on the basis of what is there now on the property that may be sold to the proponent.

List of publications by the consultant follows on the next pages

ROBERT VAN DE GRAAFF – RELEVANT PUBLICATIONS

van de Graaff, R.H.M., Suter, Helen C. and Lawes, Sophy J. (2001). Long-term effects of municipal sewage on soils and pastures. Proc. Int. Conf. On Environmental Concerns and Emerging Abatement Technologies, Beijing, China, 9-12 October 2001.

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van de Graaff, R.H.M., Mme Dai Hong Wen, and Zhou Lianbi (1995). The Good Earth Restored: Rehabilitation of copper mine tailings at Zhong Tiao Shan, China. Poster paper, Proceedings 5th International KfK-TNO Conference on Contaminated Soils, Maastricht, The Netherlands, pp1452-1453.

van de Graaff, R.H.M. (1991). Composting Melbourne's sewage sludge. *Waste Management and Environment*, Vol. 2, No. 7, pp. 19-20.

van de Graaff, R.H.M. (1990). Contaminated Industrial Sites. *AustPlan*, February 1990.

van de Graaff, R.H.M. (1990). Ardeer - Human Sloppiness and Fear. *Planning News*, November 1989.

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Artificial soil Mixtures for Horticulture, 1974. Mimeographed lecture notes for the 4th International Course on Vegetable Growing, Wageningen, Netherlands.

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1. DESCRIPTION OF THE SUBJECT LAND AND ITS NATURAL PROCESSES

1.1 Reasons for the flood proneness

The land that is proposed to be used for siting the broiler farm is part of the flood plain of the Lang Lang River. The Lang Lang River is a small, extremely meandering river. Its flood plain has an extremely gentle gradient towards Westernport Bay. Meandering of rivers is normally associated with these very gentle gradients. I quote from Skinner, B.J. and Porter, S.C. "Physical Geology" 1987, John Wiley & Sons:

> *….meanders are not accidental, …they occur most commonly in channels having gentle gradients in fine-grained alluvium, and … they occur even in streams having no load at all. The meandering pattern reflects the way in which a river minimizes resistance to flow and dissipates energy most nearly uniformly along its course. Therefore, it is a pattern of equilibrium.*

This description matches the behaviour of the Lang Lang River.

A map generated by DPI on 13 September 2004 of the general area within which the proposed broiler farm is to be located shows numerous drains which were constructed to facilitate the removal of surface water from land that has been utilised for grazing, both under dairying and for meat cattle. The flood plain is likely to have shallow seasonal (perched?) water tables in winter and spring.

The 1:100,000 scale topographic map, Warragul Sheet, shows the entire catchment of the Lang Lang River. We have included a scanned copy of a section of this map at approximately its original scale (Figure 1). At this scale a distance of 10 mm on the map equals a distance of 1 km in the field. It can be seen that between about 3 km to the east (upstream direction) and 4 km to the west (downstream direction) the river channel is highly meandering. There is another section that has many meanders further upstream extending almost to the point where the river comes out of the hills. The land on both sides of the River extending roughly for 9 km in an east-west direction is highly flood prone, most probably much more so than any other part of the Lang Lang flood plain.

In the early part of the 1900s, presumably to alleviate the flooding a straight channel, called the 'new' Lang Lang river, also called 'The Cut', was dug to the south of the original river channel (See also Figure 2). I understand that originally this channel was only a meter or so deep and quite narrow. In those times, a number of River Trusts believed that rivers could be 'improved' by straightening them and removing all obstacles to flow, and the practice was common and often led to severe erosion and channel degradation. In the case of the Lang Lang River, the equilibrium of the river was completely destroyed and the cut channel, being so much shorter than the meandering channel, but having the same fall between beginning and end point, became a much steeper channel allowing very high stream velocities. It eroded out in the first few years and formed a very large, deep gully. Today it is a channel about 8 m deep and perhaps 20 m wide at the top. The old channel still exists and still carries water.

Although the new channel contains only a little water at times of low flow, and should be able to pass a large amount of flood water during high rainfall events, the flood plain still floods. This is evidence that the flooding is not exclusively caused by the Lang Lang River spilling water over its banks.

Figure 1: Section of the Warragul Topographic Mapsheet showing part of the catchment of the Lang Lang River and the highly meandering channel section

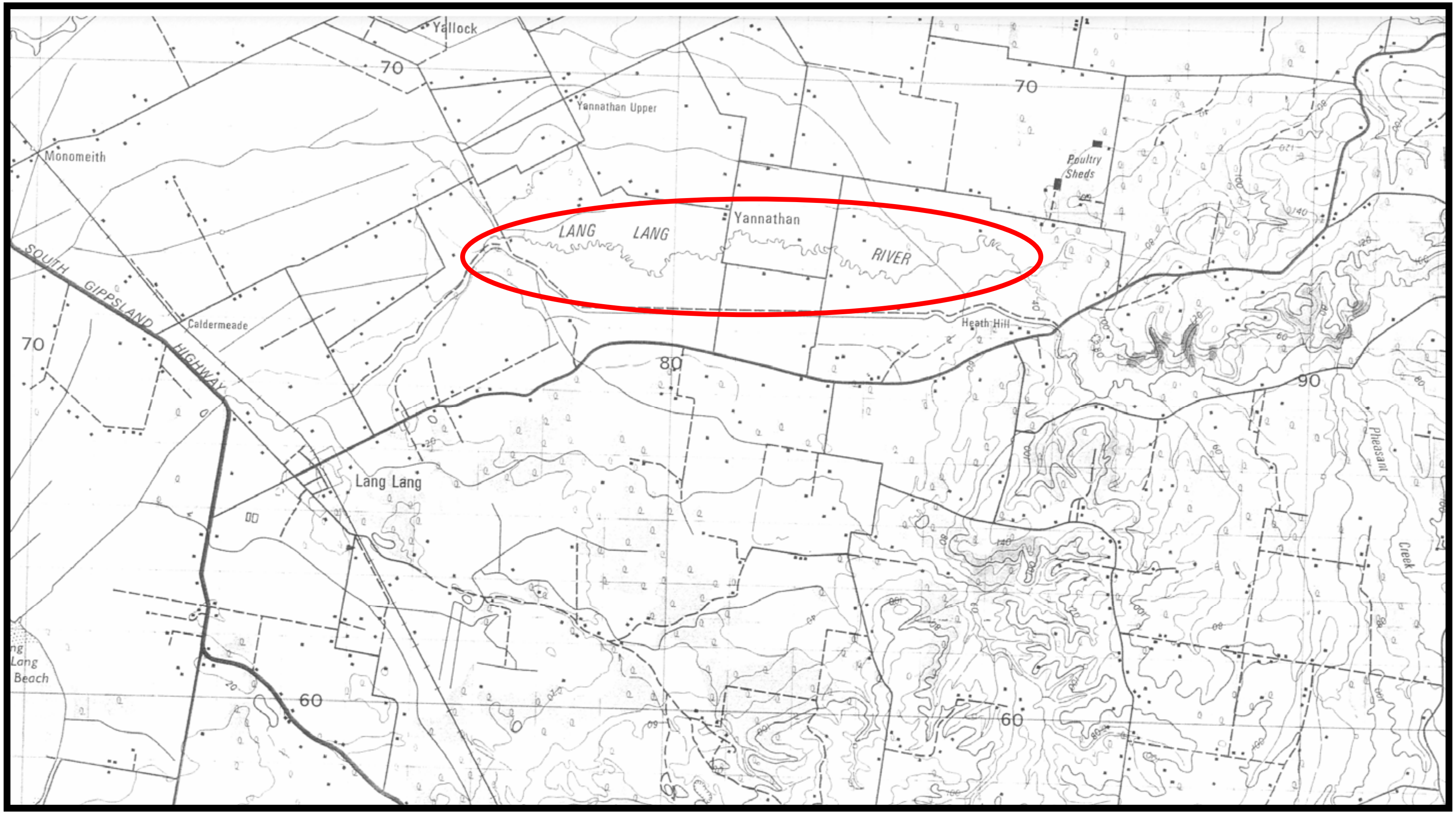
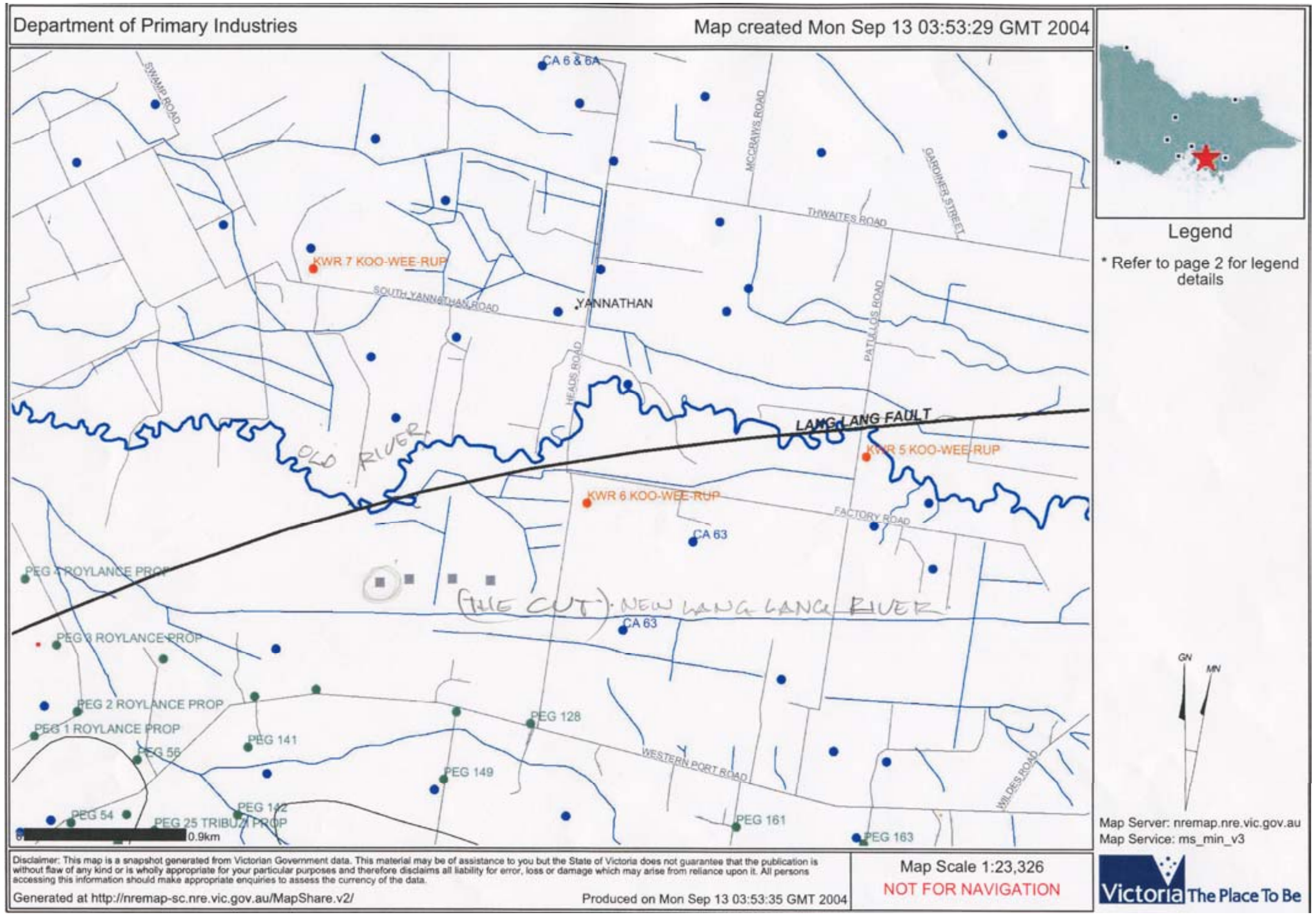


Figure 2: Department of Primary Industries map of the Yanathan Area showing the numerous drains created to divert surface water form the area.



Characteristic of the lack of understanding by the responsible authorities then, and the complete lack of care today, the new channel has been allowed to become colonised by willows, blackberries and other vegetation. On those occasions that there is another high flow event, debris such as uprooted trees, branches, etc., are washed down the new channel and get hooked up in the trees that are now forming dense thickets. These debris act like a series of dams, blocking the flow, and cause the water behind them to rise even higher and increase the frequency of severity of flood plain inundation.

An aspect of the flooding which the authority or authorities excavating the new channel in the early twentieth century may not have understood is that in a flood plain that has such a low overall gradient, and may have largely clayey soils of low permeability, any severe rainfall event will cause local inundation, as the runoff concentrates in the slightly lower areas.

As the flood plain was formed by deposition of alluvium, the meandering caused the channel to occupy constantly different parts of the flood plain. All rivers form levees next to their channel at times they overtop their banks. Thus the flood plain is not strictly speaking a flat but sloping planar surface. It has slightly elevated parts and depressions. When the entire flood plain is inundated, the slightly elevated parts hinder the down slope movement of the entire sheet of water.

A closer analysis of the rainfall and evaporation regime of the Yannathan area, using data from the Bureau of Meteorology shows that mean total potential evaporation (about 1041 mm) is slightly larger than mean total rainfall (858 mm). The spreadsheet with the rainfall and evaporation data has been attached to this report in Appendix 1. Therefore, if a dam were excavated and sealed with an impermeable liner, it could never contain water all year. It would fill during the colder and wetter months and empty again during the remainder of the year.

The high rainfall during the colder months, from April to October, produces a seasonal excess, which the grass pastures are unable to transpire. This excess increases the moisture content of the soils and causes them to be come saturated early in winter. Once saturated, a soil acts like a tin roof and sheds or ponds all additional water. When the land is as flat as this flood plain, water stagnates as shallow ponds in the slight depressions on the land. There will be slow surface drainage to lower lying areas, but the velocity of drainage is controlled by the available gradients (these are very low) and friction by the vegetated ground surface.

At Yannathan, the rainfall is in excess of water demand by the pasture for seven out of twelve months. The mean cumulative excess is more than 300 mm of water per year.

The bore log data for a number of bores in the Yannathan area (Appendix 2) indicate that in the case of all seven bores, the “topsoil” tends to be less than 0.5 m deep over very thick layers of clay. These clay substrata with their yellow and grey colours indicate materials of very low permeability and prolonged anaerobic condition.

If a topsoil thickness of 0.5 m is assumed to be typical for the area, and its texture is assumed to be that of a silty clay loam, its ability to store “plant available water” will be around 12-13% by volume (Table 10.5, Charman, P.E.V., and Murphy, B.W., “Soils – Their Properties and Management”, Oxford University Press, 2000). Thus, in a topsoil of 500 mm thickness the plant available water storage will be around 0.12 x 500 mm = 60 mm and 0.13 x 500 mm = 65 mm, say the latter value. Any water in this topsoil that cannot be extracted by the pasture will stay in the soil throughout summer. However, during the wetter and colder months, the excess rain water will start to fill the soil reservoir.

As can be seen from the spreadsheet in Appendix 1, the reservoir for 65 mm of water will be filled by about the middle of May or earlier. From that time onwards, the excess water will cause severe waterlogging and localised water ponding in depressions. The land has no capacity to cope with abnormally high rainfalls except by widespread inundation.

Thus a local occurrence of prolonged very wet weather can easily cause flooding regardless of the fact that an artificial gully has been created some distance away. The flood waters may not easily drain towards that gully.

1.2 The significance of a nominated river flood level and recurrence period

Melbourne Water, it is understood, provides nominated flood levels based on the 1 in a 100 year high flood. To predict floods of various magnitudes it is necessary to have a long period of observations that can be analysed statistically.

I do not know for how many years Melbourne Water has records of flood levels. To extrapolate flood levels from shorter observation periods is obviously less reliable than from long periods. In Appendix 3 I have reproduced two pages (p.128-129) from Brown, Carla W., “Environmental Geology”, 1992, Wm C. Brown Publishers.

The author, Ms Brown, demonstrates in an example based on the Big Thompson River, as measured near Estes Park, Colorado, that the predicted discharge during the 100-year flood can vary between 1000 and 1800 cubic feet per second depending on which 10 year period out of a 25 year length of observations is selected. The American author makes the point that it is rare to have a hundred years of records for a given stream, and I believe that it is even rarer for that to exist in Australia, especially for a stream in the “bush” such as the Lang Lang River.

Furthermore, it is important to specify the location along the river channel where these observations are or have been made. This is why the example above specifies the location as being “near Estes Park”. The most useful prediction for the subject land would be from an observation location near the proposed broiler farm. I do not know where Melbourne Water has its observation locations.

Finally, when the severity of inundation is not exclusively related to water arriving in a swollen river channel, but may be exacerbated by local rainfall that cannot get away due to near-flat terrain gradients and low micro-relief, then river observations are of reduced value.

Anecdotal photographic evidence (Appendix 4) shows that a recently built house, established at the recommended elevation above the nominated flood level, was nearly inundated during a recent period of wet weather. I do not know how much rain fell in that period, and whether it fell over the entire catchment of the Lang Lang River or merely in the locality of the house. Therefore I am unable to say whether this actual flood level equates with the 100-year flood or represented a worse and less frequently occurring event, or that it was an event that will occur more often than once in a hundred years. If it is the latter, the 100-year flood would have inundated the house, even though presumably it was built at the appropriate elevation.

In my opinion, therefore, the Tribunal should not accept the flood levels nominated by Melbourne Water at face value. It should consider them in the light of the remarks made above. Anecdotal information, if it can be confirmed by subsequent measured levels, has the advantage of being much more realistic than statistical information based on a minimal data base.

The Tribunal should consider if it is in any party’s interest to establish a broiler farm in the most flood prone section of the Lang Lang River flood plain and if it is contradictory to the hydrological function and ecological values of the flood plain downstream of the proposed broiler farm.

2. ASSESSMENT OF IMPACTS OF THE PROPOSED BROILER FARM

2.1 Water supply, farm dam(s), water quality issues

Climatic data provided by the Bureau of Meteorology have been used to develop a water balance for the site. Rainfall data are for Lang Lang (Met. Station #086063) and evaporation data have been synthesised from two other stations, Tooradin (Met. Station #086116) and Devilbend (Met. Station #086357), as there is no evaporation pan at Lang Lang. Towards Kooweerup (Met. Station #086062) the rainfall decreases, with the annual mean being 788 mm. All data are long term means.

The water balance for Yannathan shows that in an average year the 1.4 hectare of roof surface (it will be larger as the value above is based on internal shed floor area) can collect about 12 ML of water. Due to the distribution of rainfall over the year, the lowest rainfall availability occurs when the need for drinking water and cooling water is greatest. It is possible that the water supply for the broiler farm has to be augmented from a bore or other source. The daily rainwater availability, expressed per animal, like 0.07 L in January, would appear to be extremely low to a non-chicken grower such as I. For this reason also, I am unable to estimate whether there will be any rain water available for storage in a dam.

If a farm dam of 4 acres or 1.6 hectare surface area were to be constructed, it would suffer a net loss of water over the year of nearly 3 ML as shown in Appendix 1. Therefore, a farm dam will not produce a gain by storing roof runoff. It would be more beneficial to use any rain water immediately.

If a farm dam were to be used for storing additional water imported from outside, or obtained from a bore, as a balancing supply, it must be sized on assumptions not available to me.

If a farm dam is to be used for capturing contaminated water, it must be designed so as not to overflow during exceptional wet weather events.

Once runoff is generated, the topography of the land would appear to direct it to a culvert in the bank of earth that has resulted from the digging of the “new” Lang Lang River. From here it will reach the lower lying wetlands in vert little time.

2.2 Ground water issues

The presence of very thick layers of clay in the sediments making up the geology of the Lang Lang flood plain in this area would appear to be a safeguard to the ground water.

However, this true and deep ground water should not be mistaken for perched water tables that most certainly occur in the flood plain over long times during the year. It is these perched water tables that prevent the ready percolation and absorption of rain water and make the area so prone to inundation.

3. CONCLUSIONS

I believe that the proponent has made a very poor choice for the location of its broiler farm. A more flood prone site in this catchment can hardly be imagined.

The proposal is in conflict with the mandatory requirement of the Code of Practice for Broiler Farms in that it would cause development within a designated inundation area in a flood plain.

Literal reliance on Melbourne Water's nominated flood levels for planning and designing the raised fill pad upon which the sheds and work areas have to be sited is unwise. Any nominated flood levels must be applicable to the immediate vicinity of the subject land. Much more weight should be given to the experience of local farmers in terms of flooding severity.

If due to mistakes in design there is a discharge of contaminated water from the broiler farm, the effect on the receiving area or body of water will be quick and probably dramatic.

The proponent should look elsewhere for a suitable site.

APPENDIX 1

WATER BALANCES FOR YANNATHAN

Water balance for Yannathan														
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Number of days in month		31	28	31	30	31	30	31	31	30	31	30	31	365
Crop Coefficient (Grass)		0.75	0.75	0.75	0.6	0.6	0.6	0.5	0.6	0.75	0.75	0.75	0.75	0.68
Tooradin (086116) 1957-1974 Pan Evaporation (Eo) in mm		161.5	129.6	113.5	74.1	46.2	34.3	31.7	45.0	54.8	79.7	108.4	138.0	1018.6
Devilbend (086357) 1982-1999 Pan Evaporation (Eo) in mm		157.5	142.5	112.6	63.3	42.3	34.1	37.6	54.4	67.3	95.9	122.4	143.8	1064.2
Mean for Tooradin and Devilbend Pan Evaporation (Eo) in mm		159.5	136.05	113.05	68.7	44.25	34.2	34.65	49.7	61.05	87.8	115.4	140.9	1041.4
Evapotranspiration for grass pasture (Et) in mm		119.6	102.0	84.8	41.2	26.6	20.5	17.3	29.8	45.8	65.9	86.6	105.7	707.3
Net gains of soil moisture in mm		0	0	0	37.8	58.5	49.5	59.7	53.2	39.2	20.2	0	0	317.9
Lang Lang (086063) Mean Rainfall (mm)		45	57	55	79	85	70	77	83	85	86	69	67	858
Volume roof runoff from 14076 m^2 in ML		0.63	0.80	0.77	1.11	1.20	0.99	1.08	1.17	1.20	1.21	0.97	0.94	12.08
Rain water available per chicken for drinking & cooling in L per day		0.07	0.10	0.08	0.12	0.13	0.11	0.12	0.13	0.13	0.13	0.11	0.10	0.11
Water required per chicken for drinking & cooling in L per day		?	?	?	?	?	?	?	?	?	?	?	?	?
Additional water requirement per chicken in L per day		?	?	?	?	?	?	?	?	?	?	?	?	?
Excess water to be stored in dam in ML per month		?	?	?	?	?	?	?	?	?	?	?	?	?
Water gains in dam with surface area of 1.6 hectare in ML from rain		0.72	0.91	0.88	1.26	1.36	1.12	1.23	1.33	1.36	1.38	1.10	1.07	13.73
Water losses in dam with surface area of 1.6 hectare in ML from evaporation		2.55	2.18	1.81	1.10	0.71	0.55	0.55	0.80	0.98	1.40	1.85	2.25	16.66
Net water losses in dam with surface area of 1.6 hectare in ML		1.83	1.26	0.93	-0.16	-0.65	-0.57	-0.68	-0.53	-0.38	0.03	0.74	1.18	2.93
90%ile Rainfall		62.0	62.0	68.0	76.0	77.0	72.0	70.0	78.0	85.0	92.0	83.0	76.0	901.0

APPENDIX 2

BORE LOGS FOR SEVEN DEEP BORES NEAR YANNATHAN

ID	log_seq_no	type	geol	date	auth	from_m	to_m	mat	cond	descrip		
106252	20753	D	unk	31/07/1978	Unknown	0	1	480	U	TOPSOIL		
106252	20753	D	unk	31/07/1978	Unknown	1	14	403	U	GREY CLAY		
106252	20753	D	unk	31/07/1978	Unknown	14	37	471	C	LIGNITE		
106252	20753	D	unk	31/07/1978	Unknown	37	42	471	C	BROWN COAL AND WOOD		
106252	20753	D	unk	31/07/1978	Unknown	42	45	410	U	COARSE SAND		
106316	14786	D	unk	28/09/1985	Unknown	0	0.3	480	U	TOPSOIL		
106316	14786	D	unk	28/09/1985	Unknown	0.3	4	403	U	SOFT GREY CLAY		
106316	14786	D	unk	28/09/1985	Unknown	4	14	403	U	MOTTLED CLAY		
106316	14786	D	unk	28/09/1985	Unknown	14	14.2	410	U	COARSE SANDY DRIFT		
106316	14786	D	unk	28/09/1985	Unknown	14.2	20	403	U	BROWN CLAY		
106316	14786	D	unk	28/09/1985	Unknown	20	23	410	U	COARSE SAND		
106316	14786	D	unk	28/09/1985	Unknown	23	23.5	471	C	COAL & WOOD		
106316	14786	D	unk	28/09/1985	Unknown	23.5	27	410	U	COARSE SAND		
106316	14786	D	unk	28/09/1985	Unknown	27	27.5	471	C	COAL		
106316	14786	D	unk	28/09/1985	Unknown	27.5	35	410	U	COARSE SAND		
106316	14786	D	unk	28/09/1985	Unknown	35	49.7	403	U	GREY CLAY		
106316	14786	D	unk	28/09/1985	Unknown	49.7	57	410	U	COARSE SAND		
107582	5382	D	unk	1/01/1970	Unknown	0	0.3	480	U	TOPSOIL		
107582	5382	D	unk	1/01/1970	Unknown	0.3	8	403	U	GREY PUGGY CLAY		
107582	5382	D	unk	1/01/1970	Unknown	8	10	403	U	GREY SANDY CLAY		
107582	5382	D	unk	1/01/1970	Unknown	10	18	410	U	FINE BROWN SAND		
107582	5382	D	unk	1/01/1970	Unknown	18	19.5	NA	X	WOOD		
107582	5382	D	unk	1/01/1970	Unknown	19.5	22	471	C			
107582	5382	D	unk	1/01/1970	Unknown	22	45	471	C	BROWN COAL		
107582	5382	D	unk	1/01/1970	Unknown	45	46	471	C			
107582	5382	D	unk	1/01/1970	Unknown	46	48.5	403	U	BROWN CLAY		
107582	5382	D	unk	1/01/1970	Unknown	48.5	53.6	410	U			
107582	5382	D	unk	1/01/1970	Unknown	53.6	54.15	403	U	BROWN CLAY AND COAL		

333614	41734	G	unk	17/05/1977	Unknown	0	0.7	480	U	TOPSOIL
333614	41734	G	unk	17/05/1977	Unknown	0.7	3.3	403	U	YELLOW & GREY MOTTLED CLAY
333614	41734	G	unk	17/05/1977	Unknown	3.3	5	403	U	GREY MOTTLED CLAY
333614	41734	G	unk	17/05/1977	Unknown	5	7	410	U	CLAYEY SAND
333614	41734	G	unk	17/05/1977	Unknown	7	7.2	403	U	COARSE SANDY CLAY
333614	41734	G	unk	17/05/1977	Unknown	7.2	8.5	403	U	GREY SANDY CLAY
333614	41734	G	unk	17/05/1977	Unknown	8.5	13	410	U	GREY CLAYEY SAND
333614	41734	G	unk	17/05/1977	Unknown	13	25	410	U	FINE SAND
333615	36282	D	unk	21/05/1977	Unknown	0	0.5	480	U	TOPSOIL
333615	36282	D	unk	21/05/1977	Unknown	0.5	4	403	U	YELLOW & GREY MOTTLED CLAY
333615	36282	D	unk	21/05/1977	Unknown	4	8	410	U	GREY CLAYEY SAND
333615	36282	D	unk	21/05/1977	Unknown	8	9.5	403	U	YELLOW & GREY MOTTLED CLAY
333615	36282	D	unk	21/05/1977	Unknown	9.5	12	403	U	RED, YELLOW & GREY MOTTLED CLAY
333615	36282	D	unk	21/05/1977	Unknown	12	16.5	403	U	GREY CLAY
333615	36282	D	unk	21/05/1977	Unknown	16.5	17	403	U	LIGNEOUS CLAY
333615	36282	D	unk	21/05/1977	Unknown	17	25	471	C	BROWN COAL
333616	41735	G	unk	28/05/1977	Unknown	0	0.5	480	U	TOPSOIL
333616	41735	G	unk	28/05/1977	Unknown	0.5	3	403	U	YELLOW & GREY MOTTLED CLAY
333616	41735	G	unk	28/05/1977	Unknown	3	6	403	U	YELLOW & GREY SANDY CLAY
333616	41735	G	unk	28/05/1977	Unknown	6	6.5	410	U	GREY CLAYEY SAND
333616	41735	G	unk	28/05/1977	Unknown	6.5	7.5	403	U	GREY CLAY
333616	41735	G	unk	28/05/1977	Unknown	7.5	12.5	403	U	
333616	41735	G	unk	28/05/1977	Unknown	12.5	13.8	403	U	GREY CLAY
333616	41735	G	unk	28/05/1977	Unknown	13.8	15.5	410	U	CLAYEY SAND
333616	41735	G	unk	28/05/1977	Unknown	15.5	22	403	U	LIGNEOUS CLAY
333616	41735	G	unk	28/05/1977	Unknown	22	25	410	U	COARSE SAND
333617	41736	G	unk	14/12/1977	Unknown	0	0.5	480	U	TOP SOIL
333617	41736	G	unk	14/12/1977	Unknown	0.5	4.5	403	U	YELLOW & GREY MOTTLED CLAY
333617	41736	G	unk	14/12/1977	Unknown	4.5	6.5	403	U	YELLOW AND GREY SANDY CLAY
333617	41736	G	unk	14/12/1977	Unknown	6.5	8	403	U	GREY CLAY

333617	41736	G	unk	14/12/1977	Unknown	8	9	410	U	CLAYEY SAND	
333617	41736	G	unk	14/12/1977	Unknown	9	13	410	U	FINE SAND	
333617	41736	G	unk	14/12/1977	Unknown	13	18	410	U	MEDIUM SAND	
333617	41736	G	unk	14/12/1977	Unknown	18	19	410	U	CLAYEY SAND	
333617	41736	G	unk	14/12/1977	Unknown	19	22.5	410	U	MEDIUM SAND	
333617	41736	G	unk	14/12/1977	Unknown	22.5	25	410	U	SAND	

APPENDIX 3

PHOTOCOPY OF PAGES 128-129 FROM "ENVIRONMENTAL GEOLOGY"

CARLA W. BROWN
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APPENDIX 4

PHOTOGRAPHS SHOWING ACTUAL FLOOD LEVEL ON 28 AUGUST 2004 AT NEARBY NEW HOUSE