Review of proposal to drain Lake Knox & replace it with a constructed stormwater lake/wetland complex: ecological considerations

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Summary

Lake Knox is a man-made lake, ~60 years old, located on the grounds of the former Knoxfield Horticultural Research Institute in eastern metropolitan Melbourne. The land was rezoned as a Comprehensive Development Zone in 2018 to allow for development of residential housing and mixed-use, small retail and community spaces. As part of the proposed development, Lake Knox will be drained and in-filled, and a new stormwater-treatment lake/wetland complex constructed to (1) retard and treat urban stormwater and (2) replace the high-value aquatic habitat lost following the in-filling of Lake Knox. Part of the footprint of the existing lake will also be developed for residential housing.

This report reviews the ecological values of Lake Knox and the likelihood that the new lake/wetland complex will adequately replace the foregone biodiversity and ecological values if the water body were to be destroyed. Other topics (e.g. stormwater retention and nutrient removal, claims as to improved flood protection, etc) are addressed in passing, but are not the focus of the review.

The report's main findings are:

1. NO TIME LINE OR MONITORING REGIME FOR HABITAT TRANSITION

If an existing aquatic system that already provides high-quality habitat, especially for listed species of waterfowl, is to be drained and in-filled (i.e. destroyed) to make way for a new housing estate, it has to be demonstrated that the replacement lake/wetland system is effectively providing aquatic habitat of equivalent or better quantity before the original aquatic system is done away with.

The timeframe for the draining and infilling Lake Knox remains unclear and what schedules have been provided are likely to be too short for the replacement lake/wetland system to replicate existing aquatic habitat in Lake Knox. It seems the replacement habitat wetland will be constructed (and planted?) over a 12-month period (Engeny Water Management, 2017, page 10), at least 12 months before Lake Knox is drained (Ecocentric Environmental Consulting, 2018a, page 47). In my view, a gap of one year between the digging and planting of the new lake/wetland complex and the draining and infilling of Lake Knox is insufficient to allow adequate aquatic habitat, let alone high-quality breeding habitat and replacement feeding opportunities for listed species of waterfowl, to evolve in the new aquatic systems.

It is worrying that Lake Knox seems to be destined for draining and in-filling before independent monitoring has shown that the new lake/wetland stormwater-treatment complex is effectively performing its role in providing suitable breeding and feeding habitat for wildlife, especially for the listed Blue-billed Duck.

2. CLAIMS FOR GUARANTEES OF ECOLOGICAL SUCCESS LARGELY INCONSISTENT WITH SCIENTIFIC LITERATURE

In its publicly available documentation, Development Victoria paints a highly positive scenario for creation and evolution of the new lake/wetland complex. In contrast, the peer-reviewed scientific literature provides a rather less flattering picture of the likely ecological success of wetlands created *de novo* in terrestrial settings, or indeed of rapid wetland rehabilitation more generally. In short, the chances are slim that the ecosystem-offsetting approach inherent in the development proposal for Lake Knox will rapidly provide a suitable replacement for existing high-value aquatic habitat. There are at least three problems with the implicit assertions that the replacement lake/wetland complex will inevitably and rapidly provide high-quality replacement aquatic habitat.

First, wetland creation and rehabilitation require an explicit projection of the expected trajectories of ecological establishment and performance over time. Instead, the position adopted by Development Victoria seems to be that the creation of the new lake/wetland complex is deterministic, guaranteed, and will follow only one trajectory, the pathway to rapid and successful replication (indeed, improvement) of the biodiversity and ecological values that currently exist in Lake Knox. That such a process will apply to the replacement lake/wetland complex has not been demonstrated.

Second, there are few empirical or theoretical grounds in the peer-reviewed scientific literature to support such an optimistic position about rapid wetland evolution. A thorough review of meta-analysis papers in the peer-reviewed scientific literature indicates that it would likely take many years, perhaps decades, for the new lake/wetland system to perform to the same ecological standard as a comparable natural or long-established aquatic system. This prolonged time frame is inconsistent with the very rapid schedules provided in the documentation made available for review.

Third, the central assumption in the development proposal, that it is possible to 'offset' biodiversity and ecological losses by creating new wetland areas in lieu of those lost to development, is without strong empirical support. Not only is the offset approach deeply flawed in terms of fundamental ecological principles, but the on-ground implementation of offset projects, be they in Australia, Canada, France or the USA, has demonstrably failed to halt wetland loss and decline. The causes for the various failures are many, and the available documentation provides little hope that the proposed development will not similarly fail to achieve a successful offset.

3. DOUBTS OVER DEVELOPMENT VICTORIA'S CAPACITY TO DELIVER HIGH-QUALITY REPLACEMENT AQUATIC HABITAT FOR LISTED SPECIES

Section 4 of the review assesses the likely success with which the new lake/wetland complex will replicate or as claimed, improve on, the ecological values already present in Lake Knox. It shows that there are significant doubts about the likely success of the proposed lake/wetland complex, in terms of:

- Feeding and breeding habitat for Blue-billed Duck
- Habitat for other aquatic animals
- Plant (aquatic and fringing) biodiversity and extent
- Whether the new lake/wetland will represent an improvement on the current Lake Knox in terms of Index of Wetland Condition scores.

Development Victoria claims in its publicly available documentation that it "has a proven track record of delivering enhanced and thriving waterbodies throughout Victoria" (see Section 6.1). This may be true for constructed stormwater-treatment wetlands and sedimentation ponds, but that is not the same thing as the *de novo* creation of large wetlands having the sole rationale of providing high-quality aquatic habitat for listed species of waterfowl.

I have serious concerns with the likelihood with which suitable high-quality replacement habitat can be replicated in the new lake/wetland complex. It is by no means clear from the available documentation, for example, that the anticipated (and ecologically critical) establishment of extensive beds of Eel-grass(*Vallisneria australis*) can be achieved rapidly in the "habitat wetland". It is merely assumed that this species (and potentially others, such as pond-weeds *Potamogeton* spp., Water Ribbons *Cycnogeton procerum*, etc) will establish and spread quickly in the new water bodies. Proof needs to be provided that this will be the case.

Moreover, the sediments in the "habitat wetland" will have to support species-rich and numerically abundant cohorts of the aquatic macro-invertebrates that provide food for larger animals. Again it is assumed that these will develop quickly in the sediments and aquatic vegetation of the new lake/wetland complex, but there is a distressing lack of proof that they will.

The implication of these concerns is that, as noted in Conclusion 1, if Lake Knox were to be drained and in-filled as proposed, such an action should take place only after independent monitoring has shown that the new aquatic systems are performing their required roles in maintaining biodiversity and in providing other ecological functions. There seems to be no provision for this ecologically sensible approach in the documentation available for review.

4. MANY ASSERTIONS ABOUT LAKE KNOX & ITS DEVELOPMENT ARE QUESTIONABLE

Many of the claims made on the Development Victoria webpage as to the way the new lake/wetland complex will lead to beneficial ecological and environmental outcomes require further analysis. A representative subset is queried in Section 6 of this report. Two examples are:

(a) the rationale given for draining and in-filling Lake Knox and constructing the new lake/wetland complex centre on the supposedly better animal habitat it will provide. In fact, the sole reason for building the 1,100 m^2 sedimentation pond and 4,500 m^2 treatment wetland is to retard and treat the large volumes of stormwater generated by the extensive impervious surfaces of the new housing estate.

(b) claims that the new lake/wetland complex will improve water quality in Blind Creek and Port Phillip Bay. Even if the constructed lake/wetland system were to perform as modelled, not only now but into the distant future, it will still result in 14.5 kg of total phosphorus and 176 kg of total nitrogen being discharged into Blind Creek each year as effluent (Engeny Water Management 2017, Table 3.2).

The claim is made repeatedly that the development will result in cleaner water being discharged into Blind Creek. This assertion can be demonstrated only by comparing the current nutrient load discharged into Blind Creek against the nutrient load modelled to be discharged after the site has been developed to provide for 450 new domestic dwellings, the mixed-area business use, and associated impervious surfaces associated with all these uses (e.g. roads and footpaths). As far as I can see, such a quantitative comparison has not been made.

Regarding the claim that the development will result in smaller nutrient loads being discharged to Port Phillip Bay, if the grey water and black water originating in the 450 houses of the new estate are sent to the Eastern Treatment Plant for processing, the treated effluent (which will be of very high quality) will be discharged into Bass Strait, not into Port Phillip Bay. Under these conditions, it is difficult to see how the proposed development will have any effect on reducing the amount of pollutants discharged into Port Phillip Bay.

5. SUPERIOR ECOLOGICAL COURSE OF ACTION IS TO RETAIN AND IMPROVE LAKE KNOX

In my view, an alternative course of action that should be seriously investigated is to maintain Lake Knox and improve its current (and well-substantiated) biodiversity and ecological values while still allowing for the creation of the sedimentation pond and treatment wetland needed to retard and treat stormwater. This approach is likely to be superior from many ecological perspectives to the proposed scheme.

The advantages of maintaining and rehabilitating Lake Knox are that existing biodiversity and ecological values are more-or-less guaranteed to be maintained and improved, unlike with the proposal to drain and in-fill the lake, in which case these values are certain to be lost and there is only the unsubstantiated hope that the new lake/wetland complex will provide an adequate replacement. This recommendation is broadly consistent with that reached by Lorimer (2017) and Ecocentric Environmental Consulting (2018a).

Using the criteria provided by Development Victoria itself as to the putative beneficial outcomes that would accrue by the destruction of Lake Knox and the construction of the new lake/wetland complex in its place, it is demonstrated in Section 2.4 of this report that two out of three objectives and six out of seven objectives in different pieces of publicly available documentation, respectively, can be met by the retention and careful rehabilitation of Lake Knox. In other words, the lake does not need to be drained and in-filled to meet almost all of the ecological objectives set by Development Victoria.

There would then remain only the matter of constructing "a range of settling, sediment and water retention ponds to treat stormwater, mitigate flooding and protect Blind Creek", an action that is required in any case to treat the ~80 ML of stormwater generated annually by the new housing estate and associated mixed-use facilities. Engeny Water Management (2017) has shown that this can be achieved to a standard required by Melbourne Water with the construction of a 1,100 m^2 sedimentation pond and 4,500 m^2 treatment wetland. It is conceivable that these stormwater-treatment wetlands could be constructed on available land to the north-west of Lake Knox, where the "Open water wetlands (Blue-billed duck open-water habitat)" component (Area A in Figure 3) is proposed to be built.

1 Lake Knox & its history

Lake Knox is a man-made lake located on the grounds of the former Knoxfield Horticultural Research Institute, near the Corner of Burwood Highway and Scoresby Road, Knoxfield in eastern metropolitan Melbourne (Figure 1). The lake has an area of 1.6 ha, a volume at full supply level of 31 ML, and an average and a maximum depth of 1.5−2.0 m and >4.0 m, respectively (Engeny Water Management, 2017, 2018).

Figure 1: Aerial view of Lake Knox and the former Knoxfield Horticultural Research Institute. Source: Google Earth Pro (Date of imagery: December 2018; image viewed 7/09/2020).

The land on which the lake is situated is owned by the Department of Environment, Land, Water and Planning (DELWP). It was rezoned as a Comprehensive Development Zone (CDZ) in 2018 to allow for development for residential housing and mixed-use small retail and community spaces (Development Victoria, no date). The fate of the lake under the proposed development is outlined in Section 2, below.

Lake Knox was an integral part of the Knoxfield Horticultural Research Institute. The institute was established in 1950, originally as the Scoresby Horticultural Research Station, to undertake research into the commercial growing of fruit and ornamental trees (Anderson, no date). In 1993 the research activities of the Plant Research Institute at Burnley were transferred to the Knox facility, and in 2003 it became part of the Institute of Horticultural Development, along with the horticultural research centres at Ovens and Toolangi. In 2003 it was renamed the Knoxfield Centre.

Historical information on the creation of Lake Knox is sparse, but an examination of aerial photographs suggests it was constructed in the mid-late 1950 or early 1960s. Its most likely function was to store water for use in irrigating research crops at the institute, and the limited amount of anecdotal information available on the water body supports this conclusion.

The land surrounding Lake Knox is part of a relic floodplain of Blind Creek, and has an elevation of ~77 m AHD (Ecocentric Environmental Consulting 2018a). The lake discharges via spillway pipes into Blind Creek, a tributary of Dandenong Creek, which eventually joins the Patterson River and discharges into Port Phillip Bay north of Frankston.

Lake Knox receives water from a small inlet drain to the south-east, which channels runoff from a nearby area of mown pasture (Ecocentric Environmental Consulting, 2015, page 6) and from a stormwater pipe through the inlet drain (Engeny Water Management , 2017, page 40). It is likely that stormwater is the sole source of water for the lake, which derives from runoff from nearby residential, industrial and commercial areas, roads, and the adjacent grassed slope. Engeny Water Management (2017, page 4) states that the local catchment is <60 ha, but allowance will be made also for water coming in from a 28 ha external catchment in plans for stormwater treatment.

2 Overview of development proposal

The total area of land affected by the proposed development is 19.2 ha. As outlined in the Engage Victoria webpage (Engage Victoria, no date), the development aims to deliver:

> "a vibrant new neighbourhood with a diverse range of housing, an improved wetland and generous public open space", "[450] new homes and public open spaces" and a "mixed use area for small retail & community spaces".

The destruction of the existing lake and the creation of a new constructed stormwater-treatment lake/wetland complex, partially on the site of the old lake and partly on adjacent terrestrial sections of the development site, are central components of the proposal. According to text on

the 'Summary tab' of the webpage of Development Victoria (no date) that outlines the proposed development:

> "Central to the new development will be an improved wetland area with an enhanced habitat for the endangered Blue-Billed duck [sic] and other local species. Once the habitat wetland is established, the existing dam on the site – sometimes referred to as 'Lake Knox' – will be partially filled in via a staged construction process to allow for development including adittional [sic] waterbodies required to treat and retard stormwater run-off" (emphasis added).

The statement that the lake will be "partially filled in" seems not to be completely accurate; Lake Knox will be completely drained and reconfigured in order to make way for the waterways associated with stormwater treatment and to create additional space for residential housing. Engeny Water Management (2017, page 3), for example, points out that the medium-density residential development will cover most of the site, the potential mixed-use area will be located at the southern end, and the "area for water treatment and habitat adjacent to Blind Creek" will occupy all of the northern section of the site. The functional design in Appendix C (page 54) of Engeny Water Management (2017) shows the sedimentation basin and the treatment wetland occupying the footprint of the northern section of the existing lake, and Figure 2.1 of the same report shows the southern section will be fully developed for residential uses. In other words, Lake Knox will not be "partially filled in", but will be destroyed completely in order to provide for stormwater retention and treatment (northern part) and for residential housing (southern part).

2.1 Physical characteristics & timeline for the destruction of Lake Knox & the creation of the new stormwater-treatment lake/wetland complex

There is surprisingly little information available to the public on the Development Victoria or the Engage Victoria webpages on plans for the new constructed stormwater-treatment lake/wetland complex, in terms of either (1) the physical characteristics and operation of the complex and its expected performance, or (2) of the anticipated timeline for its creation and the draining and related in-filling of Lake Knox.

The 'Resources' tab of the Development Victoria webpage (no date) shows six documents potentially relevant to these two questions: (1) three fact sheets (Spring 2019, Summer 2020, Winter 2020), (2) two July 2020 responses to FAQs (one for the masterplan, one for the proposed wetland), and (3) "Designs Board" further titled "Community Engagement Session A1 Landscape X5" and providing a project overview and year-by-year timeline. Detailed information on engineering aspects of the constructed wetlands (size, expected nutrient interception efficiency, flood mitigation etc) is provided in Engeny Water Management (2017, 2018), but neither document seems to be available on the Development Victoria or the Engage Victoria webpages for the wider public to view and assess.

Physical characteristics and operation of the new lake/wetland complex

Figure 2 shows the draft masterplan available on the Engage Victoria webpage (no date). It shows that the new lake/wetland complex will be constructed at the northern end of the development and will consist of three water bodies, traversed by a pedestrian walkway. The schematic is consistent with Figure 2.1 of Engeny Water Management (2017).

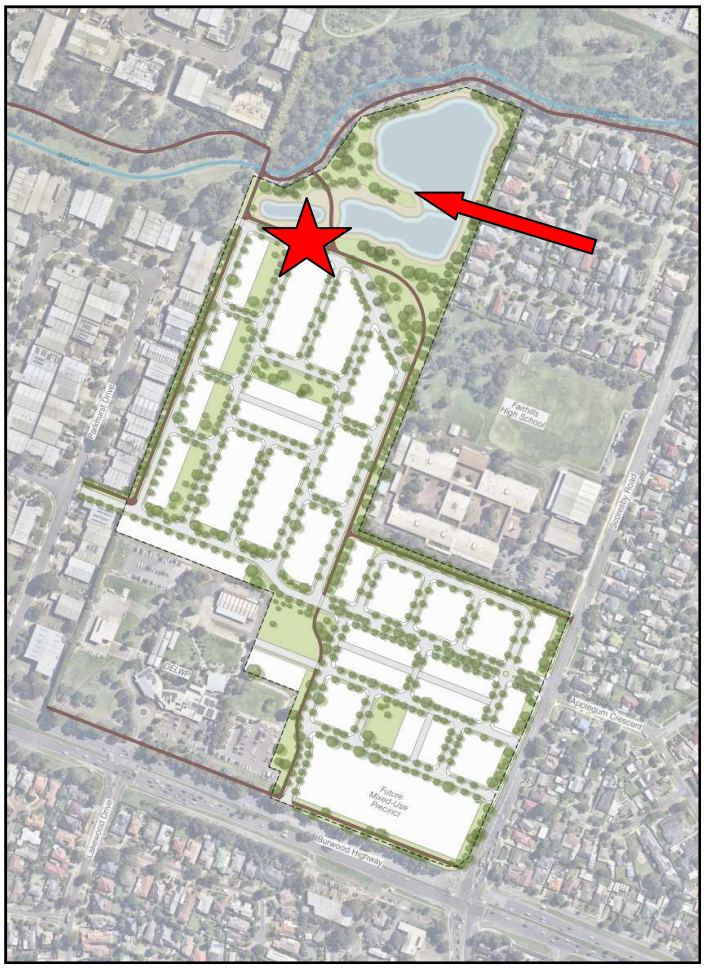

Figure 2: Draft masterplan diagram. The proposed wetland/lake complex is indicated with the red arrow; the location of Lake Knox with the red star. Source: Development Victoria (no date a). https://s3.ap-southeast-2.amazonaws.com/hdp.au.prod.app.vic-engage.files/5215/9174/7847/EngageVic_Knoxfield_draft_Masterplan_Web.pdf

Ecocentric Environmental Consulting (2018a) reported that "Under the proposed development, approximately half of the existing dam will be removed and substituted with an equivalent area of habitat wetland, while the remaining half will be re-purposed as wetland habitat for stormwater treatment purposes".

A meagre amount of additional detail on the physical characteristics of the new lake/wetland complex is available on the Engage Victoria webpage, under the 'The New Wetland' tab (Engage Victoria, no date). The conceptual diagram showing the proposed 'The new wetland' is

reproduced in Figure 3. It shows that three water bodies will be constructed in the northern end of the development:

- "Open water wetlands (Blue-billed duck open-water habitat)"
- "Stormwater treatment wetland reed beds/tall marsh(Blue-billed duck breeding habitat)"
- "Sedimentation pond'.

These three water bodies are indicated with the letters A, B and C, respectively, in Figure 3.

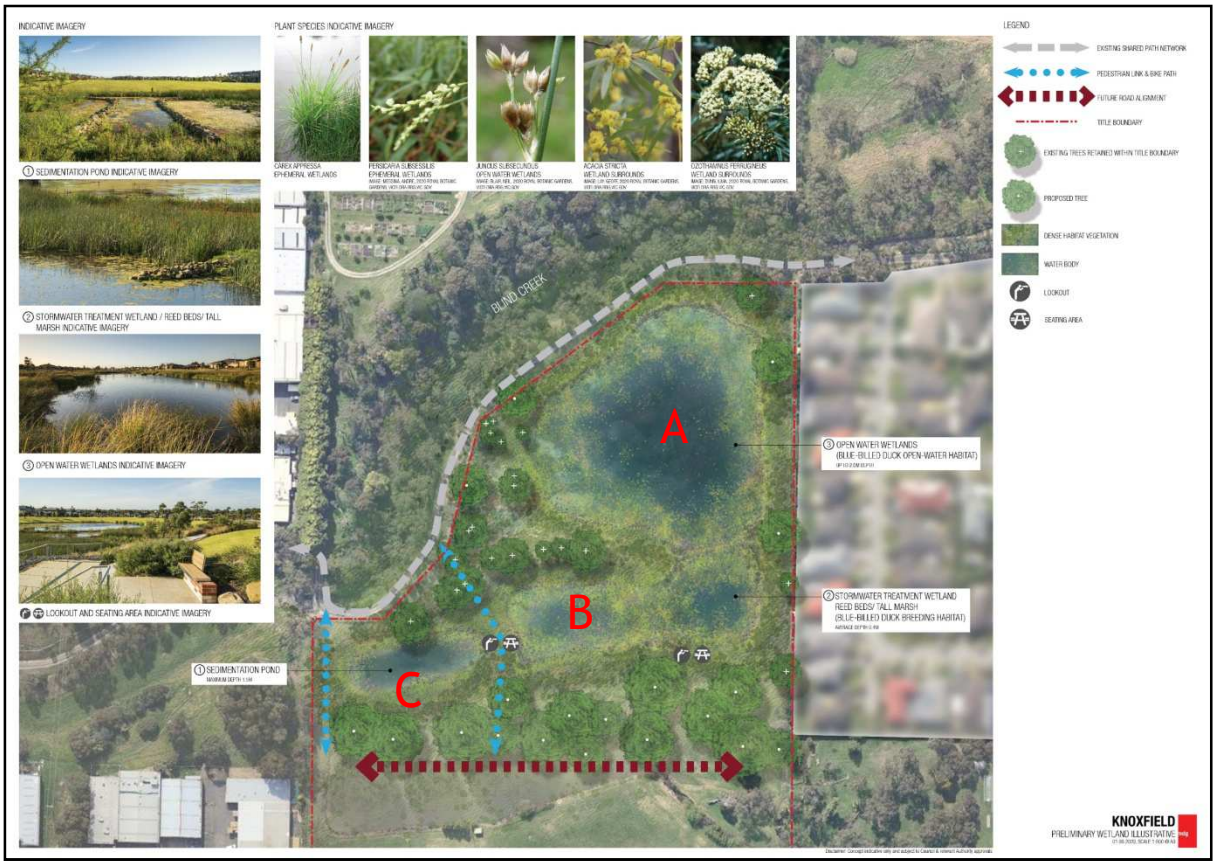

Figure 3: Detail of proposed wetland/lake complex, titled 'The New Wetland' on the Engage Victoria webpage. The three types of water body/habitats are indicated with the letters A, B and C. Source: Engage Victoria (no date). https://engage.vic.gov.au/new-community-knoxfield-feedback-draft-master-plan

Engeny Water Management (2017, 2018) provides much more detail on the three water bodies, with the comment (2018, page 3) that although aspects would be further refined once the masterplan was developed, "it is not expected that there would be any significant changes required to the stormwater management strategy".

The wetland functional design illustration in Appendix B of Engeny Water Management (2018) indicates the following characteristics for the three components of the new lake/wetland complex:

- the "Sediment pond" (Area C in Figure 3 above) will cover an area of 1,100 m^2 and have a maximum depth of 1.5 m
- the "Stormwater treatment wetland reed beds/tall marsh(Blue-billed duck breeding habitat)" component (Area B in Figure 3) will have an area of 4,500 m^2 and an average depth of 0.4 m
- the "Open water wetlands (Blue-billed duck open-water habitat)" component (Area A in Figure 3) will have an area of 10,480 m^2 and a depth of, variously, 1.5−2.0 m.

I could find no publicly available material on the webpages of either the Development Victoria (no date) or the Engage Victoria (no date) on the expected performance characteristics of the new lake/wetland complex in terms of critical topics such as projected nutrient-removal efficiency, expected water quality and sediment quality in the new water bodies, planting regime, or bathymetry and hydroperiod etc.

This type of information, however, is available in Engeny Water Management (2017), which reports on the iterative process used in order to obtain the desired 80% reduction in total suspended solids, 45% in each of total nitrogen and total phosphorus and 70% in gross pollutants entering in a typical urban stormwater load. The MUSIC modelling program was used in Engeny Water Management (2017) to determine that a combination of a 1,100 m^2 sediment pond and a 4,500 m^2 densely vegetated stormwater-treatment wetland could meet these objectives. Even so, the stormwater-treatment complex will still pass (on the basis of the MUSIC modelling), 14.5 kg of total phosphorus and 176 kg of total nitrogen each year as effluent to be discharged into Blind Creek (Engeny Water Management 2017, Table 3.2).

These nutrient loads are important to remember, as the claim is made repeatedly on the Development Victoria webpage that the development will result in cleaner water being discharged into Blind Creek. This assertion can be demonstrated to hold only by comparing the current nutrient load being discharged into Blind Creek with the nutrient load modelled to be discharged after the site has been developed to provide for 450 new domestic dwelling, the mixed-area business use, and associated impervious surfaces associated with all these uses (e.g. roads and footpaths). As far as I can see this comparison has not been made, and so the claim regarding a decreased nutrient load consequent to the development of the site must remain merely that, an untested assertion.

The origins of the 10,480 ha "Open water wetlands" alluded to in the Engage Victoria webpage are clarified in Engeny Water Management (2017, page 8), which notes that "In addition to the stormwater treatment area of the wetland an additional 10,400 square metres of habitat wetland is proposed. This will provide a total wetland and sedimentation pond area with a footprint at the normal water level of 16,000 square metres. The current design allows for all of these areas to function as one large wetland area with a uniform normal water level".

According to Engeny Water Management (2017, page 9), the stormwater-treatment wetland will be densely vegetated with emergent macrophytes (80% plant cover, 20% open water) but the sedimentation basin and open-water wetland will be mainly open water.

Hydrological characteristics of the new lake/wetland complex are shown in the flow exceedance curve in Engeny Water Management (2017, Figure 3.1). Water levels are modelled to be rather constant, with the "normal water level" exceeded only 20% of the time (at which frequency they will be ~0.1 m higher than "normal"). The expected residence time is ~8 days.

Timing of the draining/infilling of Lake Knox & its relationship with the construction and operation of the new lake/wetland complex

The 'Timeline' tab of Development Victoria (no date) states that civil construction is expected to commence in late 2020 and "Construction, subject to approvals" in 2021. Presumably the latter date will be delayed because of the ongoing covid-19 situation. Regardless, there is little detail on the anticipated time line other than the statement on the 'Summary' tab of Development Victoria (no date) that:

> "Once the habitat wetland is established, the existing dam on the site – sometimes referred to as 'Lake Knox' – will be partially filled in via a staged construction process to allow for development including aditional [sic] waterbodies required to treat and retard stormwater run-off",

in the 'Winter 2020 fact sheet' that:

> "Construction will be carefully staged so wildlife will have continual access to a waterbody throughout the process. After the first phase of the improved wetland is established, the existing dam will be partially filled and redeveloped as part of an overall water retardation, filtration and habitat system",

and in the 'Proposed wetland FAQ − July 2020' that:

> "Staged construction will enable vegetation to be established in the new wetland prior to any works on the existing dam. This will also allow the wildlife currently using the existing dam to transition to the new wetland during the overall construction process".

The biodiversity assessment undertaken by Ecocentric Environmental Consulting (2018a) contains advice (page 47) that "The new wetlands are to be constructed and planted at least 12 months prior to the clearance of the current dam. This will ensure that any displaced fauna species have nearby habitat to move into and that significant plant species from the old (extant) dam can be translocated to the new site". The estimated 12-month construction period is repeated in Engeny Water Management (2017, page 10), but only for the habitat wetland.

Questions remaining unresolved regarding the creation of the new lake/wetland complex

These various reports raise three questions that, to me, remain unresolved:

1. Will Lake Knox be drained and in-filled completely, as indicated by the location of it *vis-a-vis* new housing indicated in Figure 2, or will it be "partially filled in via a staged

construction process" (emphasis added), as declared unequivocally in the 'Summary tab' of the webpage of Development Victoria (no date)? All other documentation (e.g. Ecocentric Environmental Consulting, 2018a; Engeny Water Management, 2017, 2018) indicates the lake will be completely drained and reconfigured to make way for the new stormwater-treatment lake/wetland complex and for domestic housing lots, so it is unclear to me why the webpage of Development Victoria states it will be only partly in-filled (with the implication that it will be partly retained).

2. The rationale for the schedule of draining and in-filling Lake Knox is uncertain, possibly ambiguous. It is claimed that the habitat wetlands will be constructed (and planted?) over a 12-month period (Engeny Water Management, 2017, page 10), at least 12 months before Lake Knox is drained (Ecocentric Environmental Consulting, 2018a, page 47). In contrast, Engeny Water Management (2017, page 21) concluded that the construction of the wetland habitat could be staged so that Lake Knox was maintained throughout the construction period. It seems that no further details on the sequence, timing or rationale for the draining and in-filling are available.

3. The central question associated with these 2 x 12 month periods is whether Lake Knox will be drained and in-filled only after ecological monitoring has shown that the new lake/wetland complex is performing its crucial role in providing suitable breeding and feeding habitat for wildlife, especially for Blue-billed Duck. It is unclear whether the process and timing of draining and in-filling is conditional upon it being independently demonstrated that the new lake/wetland complex is functioning appropriately from ecological and biodiversity perspectives, or whether the existing lake will be destroyed under a non-negotiable timeframe dictated by engineering timetables and, one expects, the economic imperative to sell blocks of land at pre-determined intervals, as soon as possible they are available. As I outline in Sections 4.4, 4.6 and 5.2, I have very serious doubts as to whether the new constructed lake/wetland complex will be able to achieve its required outcomes within the proposed timeframe, indeed even within a period of many years.

2.2 Rationale for draining & in-filling Lake Knox

The draining and infilling of Lake Knox and its replacement with the new constructed stormwater-treatment lake/wetland complex is predicated on a variable suite of assumptions and rationales, many of which do not stand up to detailed scrutiny.

Four rationales are outlined on the 'Recent assessment of the existing dam' tab of the Development Victoria (no date) webpage:

> "A recent assessment of the existing dam found:
> - The dam is structurally unsound, and at risk of collapse within two years
> - The current dam does not provide for stormwater treatment and water retardation
> - Untreated stormwater is currently flowing directly into the Blind Creek corridor, and there is a flood risk to the adjacent light industrial area

- The dam is very deep with steep banks − creating a safety risk making it inaccessible to the public".

The 'Proposed wetland FAQ − July 2020' document available under the 'Resources' tab of Development Victoria (no date) provides a slightly different rationalisation:

- "The existing dam is in a fair to poor condition and therefore considered not fit for purpose.
- The dam is not able to manage moderate rainfall, leading to flooding.
- The dam is lacking the dense vegetation and reed beds necessary for successful breeding of the Blue-billed Duck".

Engeny Water Management (2017, pages 18−19) provides another rationalisation, and identifies seven reasons for draining and in-filling the lake: (1) the lack of knowledge about the construction materials of the embankment; (2) its apparently poor condition; (3) an inadequate spillway; (4) the proximity of the embankment to existing development to the west; (5) inability to provide stormwater treatment; (6) inability to provide flood mitigation, and (7) the steep batter of its edges.

Questions remaining unresolved regarding the necessity to drain and in-fill Lake Knox

A number of the claims made in these documents regarding the reasons why it is thought to be necessary to drain and in-fill Lake Knox require further scrutiny. Three topics stand out: (1) the safety of the embankment to the north and west of the dam and whether it can be rejuvenated adequately to meet modern-day standards; (2) whether Lake Knox currently intercepts pollutants in the stormwater it receives; and (3) supposed deficiencies in the habitat values of Lake Knox for Blue-billed Duck.

Regarding the matter of dam-wall safety, according to the third paragraph of the 'Proposed wetland FAQ − July 2020' document, the assessment report of the existing dam wall was undertaken in July 2017. But it is also stated in the 'Recent assessment of the existing dam' tab of the Development Victoria (no date) webpage that the dam wall was at risk of collapse within two years. (Presumably this relates to the failure of the existing embankment to withstand a 63% AEP event: see the report by Engeny Water Management 2018, discussed below.) I find it hard to reconcile this statement by Development Victoria − that the dam wall could collapse within two years − with the fact that the safety assessment was undertaken more than three years ago, and apparently the wall hasn't collapsed in the intervening period.

The matter of dam-wall safety and the question of whether the embankment could be rejuvenated to modern-day standards was examined in Engeny Water Management (2018, Appendix D). The assessment examined three aspects of potential dam failure:

- embankment instability
- overtopping failure (spillway capacity)
- overtopping failure (flood immunity from Blind Creek).

The desktop assessment of embankment stability returned factor-of-safety values of 2.53 (upper bound strength parameters) and 1.75 (conservative, lower bound strength parameters). It was concluded (Appendix D, page 9) that "… the factor of safety (FoS) against dam embankment instability, for even lower bound assumed strength parameters, is greater than 1.50, which is typically considered to be the minimum acceptable FoS for a dam under steady state condition". No further mention was made of these calculations in the assessment report, so the reader is forced to draw his or her own conclusions as to what they mean in practice. I am not a specialist in dam-wall safety, but I interpret the findings reported on page 9 of Appendix D to mean that the dam wall has an acceptable factor of safety in terms of embankment stability, even using conservative strength parameters, and is unlikely to fail in the foreseeable future on account of this potential mechanism.

The second aspect of dam safety − spillway capacity − was also assessed, and it was concluded that the low section in the north-western corner of the lake could be regularly overtopped by lake water, potentially leading to a breach in the dam wall (Appendix D, page 10). Again the implications of the analysis are largely left to the reader to interpret, but it is noteworthy the report adds the comment that it was expected that such events ("multiple dam crest wave overtopping events") "have occurred over the life of the cam [sic, dam]" anyway (obviously without failure occurring in the past).

The third aspect of dam safety − ingress of flood water from Blind Creek into the dam − could be expected during a 5% AEP rainfall event, and "during a 2 % AEP event the predicted flood levels in Blind Creek would overtop the dam embankment crest" (Appendix D, page 11). It concluded that typically a dam the size and locations of Lake Knox should be expected to withstand an expected 1% AEP flood-ingress event.

The report concluded that the dam wall (i.e. the embankment) was in only fair-to-poor condition and would likely continue to deteriorate unless invention (e.g. upgrades or remedial work) were taken. Recommendation, however, were made as to the ways in which the dam wall could be rejuvenated effectively, including upgrading the spillway, repairing the existing structural defects, and developing an operational plan for the dam (Appendix D, page 13). Engeny Water Management (2017, page 16) concluded that maintaining the dam "poses a number of challenges", but that by itself does not rule out the possibility that it could be maintained or rejuvenated.

The question regarding whether Lake Knox currently performs some role in the interception of stormwater nutrients is also poorly resolved. The existing water body probably does perform some stormwater treatment, given that it is deep and quiescent, conditions that will lead to the sedimentation of suspended particles from the water column and with them the sedimentation of adsorbed phosphorus that enters the lake from the drainage channel to the south-east.

I could find no evidence of any analysis of the likely performance of Lake Knox with regard to nutrient interception over the presumed ~60 years of its existence in comparison with the modelled efficiency of the new lake/wetland complex, which is still modelled to pass 14.5 kg of total phosphorus and 176 kg of total nitrogen each year as effluent into Blind Creek (Engeny

Water Management 2017, Table 3.2). As argued in Section 2.1, there seems to have been no modelling undertaken to calculate the current nutrient load into Blind Creek and thus whether the proposed development will, as claimed repeatedly, result in cleaner discharges and thus, presumably, lower nutrient loads being discharged to the waterway. Given that the land surrounding Lake Knox is currently vegetated with grasses and trees (Figure 1), it is difficult to see how replacing them with 450 new houses and associated infrastructure will lower nutrient loads into either Blind Creek or Port Phillip Bay.

The third supposed reason for draining and in-filling Lake Knox − that Lake Knox is somehow sub-par ecologically because it does not provide breeding habitat for Blue-billed Duck − is simply a *non sequiter*. The lake probably does not provide breeding habitat for Australasian Bittern either, but that does not lessen the value of the habitat or the plant and animal species that it does provide for, or for the excellent feeding habitat it provides for Blue-billed Duck. The argument presented by Development Victoria about the lack of breeding habitat for Blue-billed Duck is specious: it's analogous to describing a Toyota LandCruiser as an inadequate 4WD vehicle on the basis that it cannot accelerate as fast as a Ferrari. It does what it does, and it seems to do that very well.

2.3 Putative advantages of the new lake/wetland complex

Building on the rationalisation outlined in the texts cited above, the 'Wetland FAQ− July 2020' document claims that:

> "The proposed new wetland will address these issues and significantly improve the available bird breeding habitat, with more dense vegetation and reed beds to be provided within both the treatment and habitat areas of the wetland. Attempting to maintain the existing dam poses several challenges. The best environmental outcomes will be achieved through the repurposing of the existing dam and the construction of a proposed new wetland system".

The 'Wetland FAQ − July 2020' document declares that the new lake/wetland complex will achieve the following seven (desirable) outcomes:

> "The proposed new, improved wetland would provide a better environmental outcome for the site. It will be safe for the community and will significantly improve the available breeding habitat for the endangered Blue-billed Duck and other species. The proposed new wetland would provide:
>
> - An enhanced habitat for the endangered Blue-billed Duck and other species, resulting in a better overall environmental outcome for residents of the area.
> - An improvement to the water quality and available breeding habitat for local species through targeted planting which is currently absent at the existing dam.
> - Dense vegetation and reed beds planted to encourage Blue-billed Duck breeding.
> - A range of settling, sediment and water retention ponds to treat stormwater, mitigate flooding and protect Blind Creek.

- The new wetland will ensure the area is safe and not at risk of collapse which is a high possibility for the existing dam.
- A public pathway through the wetland to Blind Creek, creating a new recreational link to the area that is safe for people and wildlife.
- The potential for viewing platforms and informational signage [sic] on the types of vegetation incorporated and the wetland systems in use".

Finally, the 'Wetland FAQ− July 2020' document summarises its position by claiming that:

> "The proposed new wetland is expected to significantly improve the water quality, and in turn improve the available breeding and nesting habitat for the Blue-billed Duck. This breeding habitat is currently absent on site. The new wetland will provide a larger, healthier and safer waterbody for the Blue-billed Duck and other wildlife".

The extent to which the positions and claims made in these documents and on the webpages of Development Victoria and Engage Victoria are variously questionable, lacking in foundation, or simply irrelevant, as I demonstrate on a case-by-case basis in Section 6.

2.4 Focus on biodiversity conservation roles for the new lake/wetland complex

The question that arises from the text in Sections 2.2 and 2.3 is, "What is the real primary versus the putative stated role of the new lake/wetland complex?

The webpages of Development Victoria and Engage Victoria make considerable efforts to stress that the beneficial outcomes of the new aquatic system are ecological. For example, the 'New wetland will provide' tab of Development Victoria (no date) identifies three functions the new lake/wetland complex will provide: (1) enhanced habitat for Blue-billed Duck; (2) "a diverse environment that will encourage more wildlife"; and (3) "a range of settling, sediment and water retention ponds to treat stormwater, mitigate flooding and protect Blind Creek". Given that two of the three stated functions relate to an ecological topic, the reader is entitled to conclude that the main function of the new lake/wetland complex is, indeed, ecological.

This focus is continued in the Wetland FAQ document (pages 1−2), which identifies seven desirable outcomes the new water bodies, commencing with the statement that the new aquatic systems will "… provide a better environmental outcome for the site". The seven outcomes are: (1) "enhanced habitat for the endangered Blue-billed Duck"; (2) "an improvement to the water quality and available breeding habitat for local species"; (3) "dense vegetation and reed beds planted to encourage Blue-billed Duck breeding"; and (4) "A range of settling, sediment and water retention ponds to treat stormwater, mitigate flooding and protect Blind Creek". Rationales 6 and 7 relate to improved recreational opportunities; Rationale 5 refers to improved safety. Of these seven putative benefits, three are purely ecological, two are recreational, one is safety-related, and only one refers at all to waste water treatment.

To summarise, the reader is given the (false) impression that the new lake/wetland complex is being constructed in the main for ecological purposes, almost as a public good donated by a generous benefactor.

In fact, the core reason for building the new lake/wetland complex is to retard and treat the stormwater generated by the extensive impervious surfaces of the new housing estate. Engeny Water Management (2017, page 4) is unequivocal on this matter when it states under the 'Stormwater quantity management' subheading that:

> "The primary objective of the major drainage system is to provide flood protection for the allotments based on the 1 % AEP (1 in 100 year ARI) storm event and to ensure that the overland flow can be safely conveyed through the development" (emphasis added).

This is the principal − but unfortunately, unglamorous − reason for constructing the sedimentation pond and stormwater-treatment wetland, but it has been dressed up by conflating it with a series of secondary outcomes that all relate to supposedly improved ecological values derived from building an associated "habitat wetland".

Put bluntly, the development cannot proceed without retardation and treatment of the copious volumes of stormwater it will generate (~80 ML year^{-1}, as calculated in the footnote[1]), and this is the fundamental reason why the new lake/wetland complex and the related drainage system needs to be constructed. Claims about improved ecological quality are, in my view, simply distractions from the real reason for constructing the new lake/wetland complex: to retard and treat the stormwater generated by the huge area of impervious surfaces required by the development. Moreover, the functional design in Appendix C (page 54) of Engeny Water Management (2017) shows the sedimentation basin and the treatment wetland occupying the footprint of the northern section of the existing lake, and Figure 2.1 of the same report shows the southern section will be fully developed for residential uses. In other words, Lake Knox is to be drained and in-filled to make way for the sedimentation pond and stormwater-treatment wetland and to make room for additional residential housing lots (see also Figure 2). This rationale is explained but poorly in the publicly available documentation from Development Victoria.

3 Biodiversity values of Lake Knox

The biodiversity and habitat values of Lake Knox have been well described in a series of recent documents (e.g. Ecocentric Environmental Consulting 2015, 2018a, b; Lorimer 2017). Because the subject land and the area around it has been developed and modified for ~150 years following European colonization, the lake and its surrounds are highly modified compared with the presumed pre-European condition.

[1] The estimate of 80 ML year^{-1} is obtained by using the runoff coefficients presented in Figure 2 of Walsh *et al.* (2012) and assuming that the development has a total impervious area of 10 ha and experiences an average annual rainfall of 1,000 mm. It is intended to be a rough estimate only.

Nevertheless, the lake and its surrounds do retain significant biodiversity and broader ecological value:

- The lake provides excellent feeding habitat for small numbers of Blue-billed Duck (*Oxyura australis*), listed as 'Threatened' under the Victoria FFG Act and as 'Endangered' under the 2003 Advisory List of Threatened Vertebrate Fauna in Victoria
- The lake and its surrounds support a diverse community of indigenous plants (38 species identified by Lorimer 2017), including:
    - Floodplain Groundsel (*Senecio campylocarpus,* listed as 'Rare' in Victoria
    - six other plant species listed as 'Endangered' or 'Critically endangered' in Knox, including the Small Mud-mat (*Glossostigma elatinoides*) and Hairy Knotweed (*Persicaria subsessilis*)
- Extensive areas of Eel-grass (*Vallisneria australis*), a submerged vascular plant species listed variously as 'Rare' or 'Critically endangered' in Knox or the Melbourne area, occur in the lake, and which provide exceptionally valuable habitat and food-supply functions
- Fringing areas vegetated with emergent non-woody plant species such as rushes (*Juncus* spp.) and knotweeds (*Persicaria* spp.)
- A complete lack of exotic plant taxa or weeds in the lake
- A number of old Swamp Gum (*Eucalyptus ovata*), including one of "exceptional size" (129 cm DBH: Ecocentric Environmental Consulting, 2018a) which, as hollow-bearing specimens, provide excellent animal habitat, located within an area of remnant Swampy Woodland (EVC 937)
- A number of old trees of other species, including Mealy Stringybark (*Eucalyptus cephalocarpa*) and Manna Gum (*Eucalyptus viminalis*)
- A diverse range of water birds and terrestrial birds (22 species identified by Ecocentric Environmental Consulting 2015), 12 species of which are in some way listed as Endangered or Vulnerable.

Ecocentric Environmental Consulting (2018a) undertook an Index of Wetland Condition assessment of the lake in 2017 and found that it scored as Excellent for Physical Form (20/20) and for Soils (19.8/20), Good for Water Properties(15/20) and for Biota (17.6/20), and Very Poor for Wetland Catchment (0/20) and for Hydrology (5/20). The report's authors noted that the Wetland Catchment score could be readily improved by increasing the width and density of the buffer of native vegetation around the lake. The very low Hydrology score was principally a function of the lake now being almost permanent, a shift from the expected seasonal inundation pattern that would have been experienced under pre-European conditions.

It is illuminating to cite three sets of conclusions made in the detailed review by Lorimer (2017, pages 1, 2 & 10) to summarise the biodiversity and broader ecological values of Lake Knox and its immediate surrounds:

1. "The ecological significance of the site relates largely to the presence of rare wetland plants and habitat for the endangered Blue-billed Duck. All 1.6 hectares of the dam is covered with native submerged plants, including rare species. Those plants underpin the aquatic ecosystem by forming the base of the food chain for the rest of the wetland

organisms, from microorganisms to frogs, fish and waterbirds such as the Blue-billed Duck".

2. "The dam provides habitat for native waterbirds, pond life and aquatic vegetation. The vegetation around the dam includes substantial numbers of wild, indigenous plants that provide habitat for wildlife. These features and the waterbody itself provide amenity for users of the adjacent Blind Creek trail".

3. " The most important environmental threats associated with a new or modified wetland system are:
    - The potential frightening and permanent displacement of Blue-billed Ducks by increased proximity to humans and dogs once the land becomes publicly accessible; and
    - Loss of the significant vegetation in the dam and between the dam and the Blind Creek Trail".

Also relevant is the conclusion reached by Ecocentric Environmental Consulting (2018a) that:

> " The Biota index scored relatively highly – all lifeforms were present and unmodified, there are very few weeds extending into the water, there are no evident altered processes and the structural dominants was moderately healthy".

4 Likelihood of constructed lake/wetland complex replacing the existing biodiversity values of Lake Knox

As noted in Section 2, what is proposed for Lake Knox by Development Victoria focuses strongly on the *de novo* construction of a new lake/wetland complex on what is partially on the site of the existing lake and partly on what is currently dry land to the north of the lake. This new lake/wetland complex is said to be created, in large part, to compensate for the high-quality aquatic habitat that will be foregone when Lake Knox is drained and in-filled, although as argued in Section 2.4, the real reason it seems to me for destroying Lake Knox is to construct a sedimentation pond and stormwater-treatment wetland and to create additional space for residential housing.

4.1 Validity of habitat creation & offsetting claims

The creation of the new lake/wetland complex has a very strong offsetting component, although those words seem not to occur in the webpages of Development Victoria or Engage Victoria, or the related documents provided on those webpages. That the destruction of the existing Lake Knox and its replacement with a new lake/wetland system is an offsetting activity is, however, explicitly noted in Ecocentric Environmental Consulting (2015, 2018a).

Given that two of the three justifications for the new lake/wetland complex on the Development Victoria (no date) webpage relate solely to ecological outcomes, as do three of the

seven justifications provided in the Wetland FAQ document, it is fitting to examine the likelihood of these ecological outcomes being realised. In particular, there are two sets of problems with offsetting the projected biodiversity values that require further interrogation:

1. It has to be demonstrated that the proposed new lake/wetland complex will replace, and as claimed in various of the documents on the Development Victoria (no date) webpage, improve, the biodiversity values of Lake Knox in a timely manner. This matter can be investigated in two ways:
    - by assessing whether the specific ecological outcomes proposed for the new lake/wetland system are likely to succeed (discussed next in the text that follows, Sections 4.2−4.5)
    - by looking more generally, to determine whether past efforts in de novo wetland creation or in wetland rehabilitation have been successful, using a thorough review of the scientific literature on the topic (discussed in the end of this section, Section 4.6)

2. It has to be substantiated that offsetting more generally has been effective in maintaining, and with the current development proposal for Lake Knox, in improving, biodiversity outcomes (discussed in Section 5).

4.2 Feeding & breeding habitat for Blue-billed Duck

Lake Knox currently provides 1.6 ha of aquatic environment well-suited to provide feeding and loafing habitat for Blue-billed Duck, as demonstrated by the repeated observation of the species noted by Ecocentric Environmental Consulting (2015, 2018a, b) and Lorimer (2017).

The habitat requirements for feeding of Blue-billed Duck are well known (e.g. Birdlife Australia, no date; Office of Environment and Heritage, 2017): open, fresh, deep-water lakes or wetlands, well vegetated with submerged aquatic plants, having soft-mud sediments that provide aquatic insects and other prey. The birds feed on a wide variety of food, including aquatic insects (e.g. chironomid larvae, caddis flies, dragonflies, flies and water beetle larvae), and the seeds, buds, stems, leaves and fruit of aquatic plants. Office of Environment and Heritage (2017) notes that "The species is completely aquatic, swimming low in the water along the edge of dense cover. It will fly if disturbed, but prefers to dive if approached" and that it "feed(s) by day far from the shore, particularly if dense cover is available in the central parts of the wetland".

Habitat requirements for Blue-billed Duck breeding differ from those for feeding. The birds breed in "secluded, densely vegetated situations with the nest constructed in cumbungi (bullrushes, *Typha* sp.) beds or other vegetation generally over water" (Birdlife Australia, no date) or in "Cumbungi over deep water between September and February. They will also nest in trampled vegetation in Lignum, sedges or Spike-rushes [sic]" (Office of Environment and Heritage, 2017). Lake Knox does not provide habitat suitable for Blue-billed Duck breeding, but it does provide excellent habitat for feeding and loafing. Although large congregations of the species can occur on large open water bodies, the small size of Lake Knox indicates that it cannot attract or support large numbers of birds.

The question of whether the new lake/wetland complex can provide suitable replacement feeding and new breeding habitat for Blue-billed Duck depends strongly on two factors:

1. The degree to which the planting of the two new water bodies is successful.

2. The degree to which the sediments of the "Open water wetlands (Blue-billed duck open-water habitat)" provide the macro-invertebrate and plant food supplies that the birds require.

According to Engeny Water Management (2017, page 9), the 4,500 m^2 stormwater-treatment wetland will be densely vegetated with emergent macrophytes (80% plant cover, 20% open water. In contrast, the 1,100 m^2 sedimentation basin and the 10,480 m^2 open-water (habitat) wetland will be mainly open water.

Although the open-water wetland is described as being of "mainly open water", this does not mean that it is devoid of plants. For it to provide the feeding opportunities currently provided by Lake Knox, it will have to be densely vegetated with submerged vascular plants. Plantings of submerged macrophytes in the open-water wetland, therefore, must be so complete and so successful within the first year that the new water body faithfully replicates the extensive areas of submerged vegetated habitat (e.g. provided by Eel-grass, *Vallisneria australis*) foregone when Lake Knox is drained and in-filled. That this will occur rapidly is debatable, perhaps highly unlikely, as outlined in Section 4.4. At the very least, it has not been demonstrated that such success will be achieved, or how it will be achieved within the stipulated timeframe of 12 months.

For breeding, the tall emergent non-woody species planted in the "Stormwater treatment wetland reed beds/tall marsh (Blue-billed duck breeding habitat)" will have to develop rapidly and completely into dense, continuous stands of reeds, rushes and sedges. No-where in the available documentation could I see a projected trajectory for the development of these types of plants over time (see Section 4.6, below, on why these types of ecological trajectories have to be developed and tested).

The second factor arguably presents even greater difficulties and ambiguities. The type of sediments on the bed of the "Open water wetlands (Blue-billed duck open-water habitat)" is not described in any available documentation, and the chances of a species-rich and, more importantly, abundant macro-invertebrate fauna evolving in the water body within the first year are minimal. At the very least, it has not been demonstrated by the developer that abundant populations of macro-invertebrates will develop within the projected time frame. Put simply, the new lake/wetland complex is unlikely to be able to provide the food currently provided by the existing lake for Blue-billed Duck for many years, if at all.

4.3 Habitat for other aquatic animals

The suite of other animal species currently living, and in some cases breeding, in Lake Knox will be confronted with a similar set of problems as to those described above for Blue-billed Duck. For these species also, it has to be demonstrated that submerged and tall emergent vegetation

develop quickly enough in the new lake/wetland complex to provide good-quality feeding and breeding habitat, and the sediments will have to quickly support species-rich and numerically abundant cohorts of aquatic macro-invertebrates to provide food for larger animals. Again it is assumed that these elements will develop quickly in the new lake/wetland complex, but there is a distressing lack of proof that they will.

4.4 Plant (aquatic and fringing) biodiversity & extent

Of particular concern to the provision of feeding habitat for animals is the destruction of the extensive and healthy beds of Eel-grass (*Vallisneria australis*) that currently grow in Lake Knox. Eel-grass is Critically Endangered in Knox and is considered rare in the Melbourne area (Ecocentric Environmental Consulting, 2018a). There is some evidence that Eel-grass has declined markedly through-out many regions of south-eastern Australia over the past ~50 years (e.g. see Roberts & Sainty, 1996, 1997; Rea *et al.* 2002), possibly as a result of decreased water clarity and of nutrient enrichment, exacerbated by the action of carp (Roberts *et al.* 1995; Morris *et al.* 2003a, b, 2004).

It is by no means clear from the available documentation that the anticipated (and ecologically critical) establishment of extensive beds of Eel-grass can be achieved rapidly in the new lake/wetland complex. It is merely assumed that this species (and potentially others, such as pond-weeds *Potamogeton* spp., Water Ribbons *Cycnogeton procerum*, etc) will establish effectively and spread quickly in the new water bodies. Proof needs to be provided that this will be the case.

4.5 Will be new lake/wetland represent an improvement on the current Lake Knox?

As outlined in Section 3, an Index of Wetland Condition assessment of Lake Knox was undertaken in 2017 by Ecocentric Environmental Consulting (2018a). Physical Form and Soils both returned Excellent scores; Water Properties and Biota were rated as Good. The lowest scores were returned for Wetland Catchment (0/20) and for Hydrology (5/20).

For there to be a marked improvement in the IWC score-card over the existing water body, the new lake/wetland complex would have to continue to generate Excellent scores for Physical Form and Soils, and Good scores for Water Properties and Biota. None of these requirements are guaranteed.

The sub-indices with greatest room for improvement are Wetland Catchment and Hydrology. As noted in the Ecocentric Environmental Consulting (2018a) report, the Wetland Catchment score could be improved by increasing the width and density of the buffer of native vegetation around the existing lake. Although it would involve a short-term disturbance to the biota of the existing lake, this could be undertaken for Lake Knox, without the need to create *de novo* a whole new lake/wetland complex. It is difficult to see how the Wetland Catchment score could be improved for the new lake/wetland complex by creating a 450-lot residential development along its southern border.

The very low Hydrology score for Lake Knox was principally a function of the lake being almost permanently filled, a shift from the expected seasonal inundation pattern that would have been experienced under pre-European conditions. A similar set of hydrological conditions will prevail in the new lake/wetland complex (see the flow exceedance curve, Figure 3.1, in Engeny Water Management 2017), so there is little opportunity to improve the IWC score in that sub-index.

To conclude, there are few indications that the new lake/wetland complex would return a higher IWC score than has been given to Lake Knox, and the potential exists at Lake Knox to improve the Wetland Catchment score with a judicious program of planting emergent vegetation (e.g. reeds, rushes and sedges) around the margins.

4.6 The published record of past success in de novo *wetland creation or rehabilitation*

The Wetland FAQ document on the Development Victoria (no date) webpage states that:

> "Development Victoria has a proven track record of delivering enhanced waterbodies which are now home to a range of flora and fauna including the threatened Blue-billed Duck. Our goal is to deliver a better overall environment outcome for the current man-made dam in Knox".

If this is indeed the case, Development Victoria would be one of the very few organisations around the world that has been able to reliably and repeatedly achieve this remarkable feat. The claim, of course, depends on at least two factors: (1) what criteria have been used to assess success in "delivering enhanced waterbodies"; and (2) what timeframes are used in undertaking that assessment. Until details are made available on both points as to how Development Victoria has measured success of its past efforts, the claim must remain unverified.

The peer-reviewed scientific literature paints a rather poorer picture as to the ecological success of wetlands created *de novo* in terrestrial settings, or indeed of wetland rehabilitation more generally. An assessment of this question involves four sets of considerations:

1. The degree to which wetlands, lakes and other aquatic systems have been monitored ecologically in Australia

2. Ecological trajectories of created wetlands or of degraded sites subject to investment into rehabilitation or restoration

3. The published literature on the ecological success and other biodiversity outcomes of created or rehabilitated wetlands

4. Empirical information on how long will it take for a created or rehabilitated wetland to perform the same suite of ecological functions as a natural wetland.

Ecological wetland and stream monitoring in Australia

A large number of scientific articles published over the past quarter of century has shown that the ecological monitoring of freshwater aquatic systems in Australia, especially those subject to some form of rehabilitation investment, is spatially and temporally very limited and, even at the best of times, is fraught with methodological limitations and interpretative difficulties (e.g. Streever 1997; Finlayson and Mitchell 1999; Webb & Erskine 2003; Brooks and Lake 2007; Lake *et al.* 2007; Westgate *et al.* 2013). Even in those few cases where ecological monitoring has been undertaken, it almost always piecemeal and has lasted for only a few years, until the interest of the funding body or the management agency is diverted to other topics or to other study sites.

The resultant lack of high-quality empirical monitoring data makes it almost impossible to demonstrate the long-term effectiveness of wetland creation or rehabilitation. It thus also casts serious doubt over the foundational principle that offsets will result in a net improvement in biodiversity over time, let alone reproduce the biodiversity values foregone when existing wetlands, lakes or other aquatic systems are lost to development (see Section 5).

Ecological trajectories of created or rehabilitated wetlands

The creation *de novo* of wetlands in terrestrial settings, indeed the restoration or rehabilitation of degraded aquatic systems more generally, requires that a likely trajectory of performance over time be anticipated and explicitly modelled. This 'conceptual model' is a critical step in wetland creation and rehabilitation because it provides a template against which success can be measured (e.g. see Matthews & Spyreas 2010; Elliot *et al.* 2016; Johnson *et al.* 2017; Moore & Rutherfurd 2017; Roberts *et al.* 2017).

Nowhere in the available documentation could I find any indication of the anticipated ecological trajectory for the new lake/wetland complex. For any system created *de novo*, or even for an existing system subject to rehabilitation or restoration intervention, there exist a very complex suite of possible trajectories. There is the strong possibility that the creation effort will be unsuccessful from the beginning; there is also the possibility that it can stall (and then even reverse) at an early stage. Other well-documented possibilities include ecological condition changing in an unexpected cyclical way or being variable over longer time periods, or that the entire system could 'flip' into a different ecological state. That a given aquatic system can exist in a number of 'stable states' under a single environmental set of conditions, and that these could represent quite different end-points of an assumed single trajectory, is well established in the ecological literature (e.g. Petraitis 2013), as is the idea that hybrid or even novel ecosystems may develop, unexpectedly (e.g. Hobbs *et al.* 2006).

The relevance of this discussion to the question of Lake Knox is that Development Victoria seems to have taken the position that the creation of the new lake/wetland complex is deterministic, guaranteed, and will follow only one pathway, the pathway to successful replication (indeed, improvement or enhancement) of the biodiversity and habitat values that currently exist in Lake Knox. This assumption is implicit in the statement by Development Victoria that "Once the habitat wetland is established, the existing dam on the site – sometimes referred to as 'Lake

Knox' – will be partially filled in via a staged construction process… ". There is no 'If' in this prescription: it is assumed that the new wetland/lake will be immediately successful (in whatever way that is measured). The clear lack of a clear and defensible schedule for the new lake/wetland to be shown to be functioning ecologically as required (Section 2.10) is especially worrying. The confidence implicit in the approach adopted by Development Victoria is not consistent with, for example, the precautions and considerations outlined by Roberts *et al.* (2017) in their recent report *The feasibility of wetland vegetation recovery*. The required assumption of 'guaranteed and rapid success' is, however, quite consistent with the five 'myths of restoration' collated by Hildebrand *et al.* (2005) and summarised in Table 1.

Table 1: The 'myths of restoration' and their central assumptions. Source: derived from Hildebrand *et al.* (2005, Table 1).

Restoration myth	Central assumptions
1. It is possible to make a carbon copy of an existing system	1. Community assemblage rules are predictable 2. There is only a single end-point possible
2. Field of Dreams: build it and they (animals and plants) will come	1. Sole focus on physico-chemical conditions 2. Assumptions that systems self-organise
3. Fast forward to the end result	1. Ecosystem development can be accelerated with fertilizers, weed control etc
4. A single cook-book exists for creation or rehabilitation	1. A single method or approach is suitable for all systems or situations 2. No need to validate the method or approach for the current situation
5. Command & Control is an appropriate management approach	Nature is infinitely controllable Treating symptoms will address core problems

As elaborated subsequently by Turner (2009), Hilberbrand *et al.* (2005) recognized that the underlying problem with almost all restoration-rehabilitation-*de novo* creation schemes was the failure to explicitly recognise the critical role played by uncertainty. Central to all offset programs involving existing and high-value natural systems is that it is possible to make a carbon-copy of the original, on short time-frames and with guaranteed success. Once the necessary physico-chemical conditions have been created, it is necessary to assume that a self-organising community will develop rapidly and reliably, a variation of the 'Field of Dreams' expectation − build it (the physico-chemical environment) and they (the animals and plants) will come (Palmer *et al.* 1997). The roles of contingency, of random change, and of a suite of alternative trajectories (Figure 4) is forgotten, or conveniently ignored. Kahneman (2011, page 255) called this a "planning fallacy" that was inevitably part of "a pervasive optimistic bias", where "most of us view the world as more benign than it really is … [w]e also tend to exaggerate our ability to forecast the future, which fosters optimistic overconfidence".

Published information on the ecological success of created or rehabilitated wetlands

The peer-reviewed scientific literature contains many meta-analyses and reviews of the success with which wetlands have been created *de novo* or subject to some form of rehabilitation or restoration from a degraded condition. Table 2 shows some recent examples I located following

a search of the 'Web of Science' bibliographic database, using the 'All databases' option and a range of key search terms for the period 1900−2020.

Table 2: Some recent examples of how created, restored or rehabilitated wetlands differ from comparable natural wetlands.

Wetland location	Difference between created, restored or rehabilitated wetlands versus natural sites	Reference
Middle East	Phytoplankton diversity lower	Ameen *et al.* (2019)
Canada	Waterbird community composition different Lower β diversity	Anderson & Rooney (2019)
Denmark	Lower long-term retention of phosphorus	Audet et al. (2020)
New York State (USA)	Edaphic (i.e. soil) properties different	Ballantine & Schneider (2009)
Europe & North America	Amphibian diversity and breeding success (global review)	Clevenot *et al.* (2018)
Everglades (USA)	Frog species richness lower	Dixon *et al.* (2011)
Coastal marine wetlands	Highly variable responses according to location, wetland type and biodiversity indicator (global review)	Elliot *et al.* (2016)
South-east England	Lower diversity of saltmarsh plants	Garbutt & Wolters (2008)
United Kingdom	Microtopography less diverse	Lawrence *et al.* (2018)
Illinois (USA)	Greater long-term weed invasion	Matthews & Spyreas (2010)
California	Various ecosystem processes in riparian zone lower	Matzek *et al.* (2016)
Global	Plant biomass and carbon storage lower (global review)	Moreno-Mateos *et al.* (2012)
Global	Biogeochemical functionality lower (global review)	Moreno-Mateos *et al.* (2015a)
New South Wales (Australia)	Saltmarsh plant biomass lower Soil organic carbon similar	Santini *et al.* (2019)
South-west Spain	Waterbird diversity lower	Sebastián-González & Green (2016)
Global	Soil organic carbon lower (global review)	Xu *et al.* (2019)
USA	Soil carbon and nitrogen lower (whole of country met-analysis)	Yu *et al.* (2017)

The conclusion to draw from these papers can be neatly summarised in the review by Kaiser (2001) in the prestigious journal *Science*, "Wetland restoration: recreated wetlands no match for original".

Published information on the time frame for performance to match that of natural wetlands

An important question that arises from the collation of outcomes presented in Table 2 is, "How long will it take for a created or rehabilitated wetland to show a similar ecological performance to natural reference sites?. The available documentation for the Lake Knox proposal assumes that it will be very rapid, of the order of 12 months or less (see Section 2.1).

A number of peer-reviewed scientific papers have addressed this question. Below I list conclusions as to the time periods required for created or rehabilitated wetlands to achieve an ecological structure and function that approaches that of natural wetlands:

1. Mitsch & Wilson (1996, page 77): "Mitigation projects involving freshwater marshes should require enough time, closer to 15−20 yr than 5 yr, to judge the success or lack thereof".

2. Garbutt & Wolters (2008, page 335): "Salt marsh plants will colonise formerly re-claimed land relatively quickly on resumption of tidal flooding. However, even after 100 years regenerated salt marshes differ in species richness, composition and structure from reference communities".

3. Ballantine & Schneider (2009, page 1467) "The results indicate that some soil properties critical for water quality functions take decades or centuries to reach natural reference levels".

4. Moreno-Mateos *et al.* (2012, pages 3−6): " Plant assemblages in restored and created wetlands were slowest to recover. Plants took on average 30 y to converge statistically with reference states; although again, absolute average values of structural features of plant assemblages remained lower than reference levels even after 100 y following restoration".

   "After 20 y … carbon storage in restored and created wetland soils was still significantly lower (by 50%; p= 0.008) than in reference wetlands. … Organic matter accumulated slowly … so that average values remained only 62% of the value at the reference wetlands 20–30 y following restoration…".

   " After 50 y to 100 y, restored wetlands recovered only to an average of 74% of their biogeochemical functioning relative to reference wetlands …".

   "Biological structural variables appeared recovered 5 y after restoration, while even 30 y after restoration, biogeochemical functions had only recovered to 79% of reference levels".

   "Riverine and tidal wetlands, linked to larger hydrologic regimes by natural flow variation, recovered biogeochemical functions and biological structure after 20 y and 30 y…".

"In many wetlands, however, ecosystem services may not be fully recovered even when wetlands appear to be biologically restored".

5. Moreno-Mateos *et al.* (2015a, page 1531): "… recovery trajectories of biogeochemical functionality of restored and created wetlands remained significantly below that of corresponding reference wetlands … This difference persisted up to 30 years after restoration or creation had been initiated…".

6. Moore & Rutherfurd (2017, Figure 7): 40−120 years for natural inputs of large woody debris into stream to start to mimic inputs from natural riparian zones.

7. Moreno-Mateos *et al.* (2020, page 667): " A meta-analysis of >600 restored wetlands showed that animal and plant assemblages and biogeochemical functions only recovered to 74% of the reference level after 50 to 100 years" … " Another meta-analysis of 89 lake and coastal ecosystem restoration projects reported a recovery of 24% and 34% of their biodiversity and biogeochemical functions after 16 and 12 years, respectively".

The conclusion to draw from the findings of these papers is that it will take, years, possibly decades, for the new lake/wetland system to perform to the same ecological standard as a comparable natural aquatic system. For some environmental variables, it may be simply impossible within any reasonable time frame to recreate all the components and interrelationships of a well-functioning wetland: the creation of hydric soils, which presumably took millennia of sediment deposition, biological reworking and alternating wet and dry cycles to generate, is one example (e.g. Stevenson 2000).

4.7 Conclusions to Section 4

The central message to derive from this review of the proposal to drain and in-fill Lake Knox and to replace it with a new constructed stormwater lake/wetland complex and housing blocks is that the existing lake should be destroyed − if at all − only years after the construction of the new lake/wetland complex at the northern end of the development site. Only then would the new lake/wetland system be likely to be performing a similar suite of ecological functions as those provided by the foregone lake, and whether this is the case can be determined only after a prolonged period of independent monitoring of diverse aspects of the new lake/wetland complex. Anything less than this is simply a case of 'hoping for the best', and the available literature on the topic suggests this will be a forlorn and probably unsuccessful hope.

5 Have biodiversity offset approaches been successful in the past?

The introduction to Section 4 pointed out that there were two problems with offsetting the projected biodiversity values of the new, constructed water bodies against the known biodiversity values of the existing lake: (1) will the new lake/wetland complex adequately replace the

biodiversity and ecological values foregone when Lake Knox is drained and in-filled; and (2) the wetland strategy proposed for the development is fundamentally an 'offset' approach.

The question as to whether *de novo* wetland creation has been successful in the past was addressed in Sections 4.2−4.6, above. The second question, regarding the likely effectiveness of the wetland biodiversity offset strategy more generally, is addressed in the following section of the review.

5.1 The scale of wetland loss globally and in Australia

The record of wetland conservation across the globe is exceptionally poor (Davidson 2014; Davidson & Finlayson 2018; Davidson *et al.* 2018; Davidson *et al.* 2020). The record is little better in Australia, with many assessments over the past two decades pointing out serious losses in wetland area or condition across the country (e.g. Davis & Froend 1999; Finlayson & Rea 1999; Kingsford & Thomas 2002; Sinclair & Boon 2012; Burgin *et al.* 2016; Kingsford *et al.* 2016; Brandis *et al.* 2018).

5.2 The biodiversity offset approach to wetland conservation

Almost all of the area of wetland lost in Australia since European colonisation has been a consequence of agricultural, pastoral or urban development. As a result, and in an attempt to minimise further losses, market-driven offsets and compensatory habitat policies have developed into critical elements of biodiversity-conservation policy in many States of Australia (Maron *et al.* 2012, 2015). In Victoria, for example, offsets were established under the overarching policy provided by the *Victoria's Native Vegetation Management Framework* (Department of Natural Resources and Environment 2002) and updated in Department of Sustainability and Environment (2008). In almost all cases of their implementation, offsets are required when development leads to the 'unavoidable' destruction of native vegetation (e.g. see Devictor 2015 for a review).

The question then arises: How effective have wetland offset programs been at halting the loss of wetlands, globally and in Australia? If offset approaches, such as those implicit in the development proposal for Lake Knox, have been shown to be effective at halting or even reversing wetland loss, there might be grounds for believing that the new lake/wetland complex will be an effective replacement for the ecological values foregone when Lake Knox is drained and in-filled. If, on the other hand, the biodiversity-conservation record of offset programs is poor, there are grounds additional to those earlier outlined in Section 4.6 for predicting that the approach proposed for Lake Knox is unlikely to be successful.

A review of the published literature indicates that the success of biodiversity offset programs has been, on average, far below expectation. Below are summarised the conclusions from typical examples I identified during a literature review undertaken with bibliographic database 'Web of Science':

1. Beder (2006, page 250) reported on the success of wetland offset programs in the USA, noting that although the ratio of wetlands lost to those offset was legislated to be 1.00:1.78, in practice only 134 ha of this nominal 178 ha of offset wetland proceeded to even the most limited degree. Of this area, a pitiful 19 ha was assessed as functionally equivalent to the foregone wetlands.

2. Burgin (2010), reviewing the effectiveness of wetland mitigation banking (a process that includes offsets, along with other activities such as biological set-asides) in the USA, identified data which showed that (pages 49, 51) "Almost 55% of the projects did not comply with regulations. Of these no attempt had been made to build 22%, 30% were of insufficient size or hydrology, and 65% did not meet size requirements". … "I conclude that although the concept has merit, even in the USA where the processes have been evolving for over 30 years, the outcomes frequently fall short of the target of a 'like for like' swap of habitat. While the outcome for wetland mitigation may not be an 'unmitigated disaster' it is, at best, apparently only modestly successful".

3. Maron *et al.* (2010) examined the effectiveness of offsets to maintain endangered Red-tailed Black Cockatoo bird habitat in Queensland. They concluded that the offsetting approach had completely failed, and that "… the most plausible offset scenarios were inadequate to compensate for habitat loss at year-100, when resource availability was lowest".

4. Suding (2011), in a global review of the success of rehabilitation and restoration activities, concluded that ". . .although restoration is often possible and results in net positive benefits, it often does not go as well as planned. The inability to meet set criteria in many projects occurs at a high enough frequency to bring into question our ability to set realistic goals and our confidence in meeting these goals".

5. Moreno-Mateos *et al.* (2012, page 6), in another global review of wetland restoration and offsetting success, concluded that "If markets for ecosystem services and mitigation offsets from restored or created wetlands are used to justify further wetland degradation, net loss of global wetland services will continue and likely accelerate".

6. Moreno-Mateos *et al.* (2015b, page 552): "Considering this range of values, we summarize the multiple ecological, regulatory, and ethical losses that are often dismissed when evaluating offsets and the "no-net-loss" objective. …we argue that offsets cannot fulfil their promise to resolve the trade-off between development and conservation. If compensation for biodiversity loss is unavoidable, as it may well be, these losses must be made transparent and adequate reparation must embrace socio-ecological uncertainty".

7. Quétier *et al.* (2014) reviewed the effectiveness of offset and no-net-loss biodiversity policies in France and concluded (page 127) that "Our analysis shows, however, that the NNL [no net loss] policy's ambition is not immediately operational. It did not fully tackle some of the key design elements for effective implementation, in particular concerning the long term commitments to ecological performance that offsets require if they are to

achieve NNL". … " Little detail is provided on enforcement and the consequences of technical or financial failures of offsets. This is not specific to France, and such inadequacies be considered in any offset-based NNL policy. "

8. Goldberg & Reiss (2016), reviewing the effectiveness of wetland mitigation legislation in Florida (USA), concluded (page 383) that "The reliance of mitigation banks may be misplaced due to the improbability in returning wetland function to historical conditions prior to silvicultural and grazing activities. This study supports increasing concerns that the 'no net loss' policy of wetlands (in terms of both area and function) under Section 404 of the Clean Water Act is not being realized".

9. Poulin *et al.* (2016) reported on the near-complete failure of wetland offsetting policies in the province of Quebec (Canada), where the practice was so inadequate that a mere 15 ha of compensatory wetland habitat have been restored or created to offset wetland losses of 2,870 ha. The practical outcome of the offsetting policy in Canada was the net loss of 99% of the impacted wetland area. They concluded (page 1263) that "There is a lack of clear examples where [offsetting] best practice has, beyond reasonable doubt, delivered no-net-loss outcomes".

10. Gibbons *et al.* (2017), reviewing a decade of offsetting programs in New South Wales, concluded that "Over 10 years, a total of 21,928 ha of native vegetation was approved for clearing under this policy and 83,459 ha was established as biodiversity offsets. [Despite this] we estimated that no net loss in the area of native vegetation under this policy will not occur for 146 years".

11. Levrel *et al.* (2017) undertook a comprehensive assessment of the benefits and risks of wetland mitigation banking in Florida (USA) and concluded (page 146) that " … a second, more worrying, conclusion is that the question is still pending whether or not there is real achievement of No Net Loss of wetlands, including through MB [mitigation banking]".

12. May *et al.* (2017), reviewing the effectiveness of biodiversity offset programs in Western Australia, found that (page 249) "Of the past offsets, we conclude that at most 39% of the offsets studied delivered an outcome and can be considered effective, with land acquisition comparing favourably to other offset types. The outcomes of many offsets were unknown due to reporting too soon after implementation (14%) and inadequate reporting (18%). Thirty percent of past offsets during this time period were found to be ineffective through non- or inadequate implementation".

13. Thorn *et al.* (2018) examined the effectiveness of offsets to maintain Red-tailed Black Cockatoo bird habitat in Western Australia. As with the Maron *et al.* (2010) study of this species in Queensland, the Western Australian experience was not positive, and it was concluded (page 299) that "…the offset package was not successful in satisfying the State and Commonwealth offset requirements and ecological outcomes, resulting in a net loss of environmental value. The offset package can be seen as a rushed and expedient

solution in a highly politicised and controversial development planning process.", and that "Suggestions for improving future offset packages include: a checking process to confirm ecological outcomes of an offset, a contingency plan or provision for if an offset does not provide sufficient ecological outcomes, greater consideration of the necessary ecological requirements of species affected, and stricter adherence to underlying principles in offset requirements and ecological outcomes. Otherwise offsets will merely provide a convenient way in which biodiversity conservation is subverted by ongoing human alteration of the planet".

14. Bezombes *et al.* (2019), reviewing the effectiveness of offset projects in France, demonstrated that of the 91 projects reviewed, only one-third included sufficient information to be assessed, and of the 22 projects available for deeper analysis, none included any information on the initial state of the area to be offset. Six of the 22 projects didn't even have a management plan to guide and assess the offsets. They concluded (page 28) that "Even for projects that had been surveyed, available information was not sufficient to verify if the offsets provided the expected gains".

These 14 examples drawn from the peer-reviewed literature demonstrate convincingly that a market-driven offset approach for maintaining wetland biodiversity has not worked in practice, regardless of where it has been implemented (e.g. Australia, Canada, France, USA). The current state-of-play is well summed up by Dorrough *et al.* (2019): "The modest estimates of total benefits suggest that offset schemes should adopt a precautionary approach and avoid optimistic estimates of either averted loss or management gain".

To conclude, I believe the approach adopted by Development Victoria – to claim it can rapidly offset the demonstrated biodiversity and ecological values of the existing Lake Knox by creating a new lake/wetland complex – is not supported by the published, peer-reviewed literature. At the very least, a detailed program of ecological monitoring will need to be put into place in order to (1) identify when the new lake/wetland complex has developed sufficiently to adequate replace the biodiversity and habitat values existing in Lake Knox; and (2) to continue that monitoring in order to demonstrate that the offset approach has been successful over the long term. There is no evidence I can see in the available documentation for the proposed development to suggest that either requirement has been considered adequately.

6 Veracity of some specific claims by Development Victoria

6.1 Statement 1

'Summary' tab of Development Victoria (no date):

> "Development Victoria has a proven track record of delivering enhanced and thriving waterbodies throughout Victoria".

Response: detailed monitoring reports from prior developments are required to support this statement. The literature summarised in Sections 4.6 and 5.2 indicate that it will likely take many

years, possibly decades, for created wetlands *de novo* to mimic the ecological structure and function of natural or long-established wetlands. It may be the case that Development Victoria has successfully built sedimentation ponds and stormwater-treatment wetlands, but that is not the same thing as the *de novo* creation of large wetlands having the sole rationale of providing high-quality aquatic habitat for listed species of waterfowl.

6.2 Statement 2

'Recent assessment of the existing dam' tab of Development Victoria (no date):

> "The current dam does not provide for stormwater treatment and water retardation. Untreated stormwater is currently flowing directly into the Blind Creek corridor, and there is a flood risk to the adjacent light industrial area".

Response: the new lake/wetland complex will reduce the risk of flooding of some areas around Lake Knox, but the beneficial effect is concentrated in the residential development zone to the south and in the light-industrial area to the west. Extensive areas to the north, north-west and north-east remain subject to flooding. Figure 3, from Appendix C of Engeny Water Management (2018), show this pattern clearly (Figure 5). Areas indicated in black are those that cease to be flooded but formerly were subject to inundation, but areas in various shades of red, green and blue remain at significant flood risk even after the proposed development has proceeded to completion. Note also the area in white, showing land that will now be newly flooded.

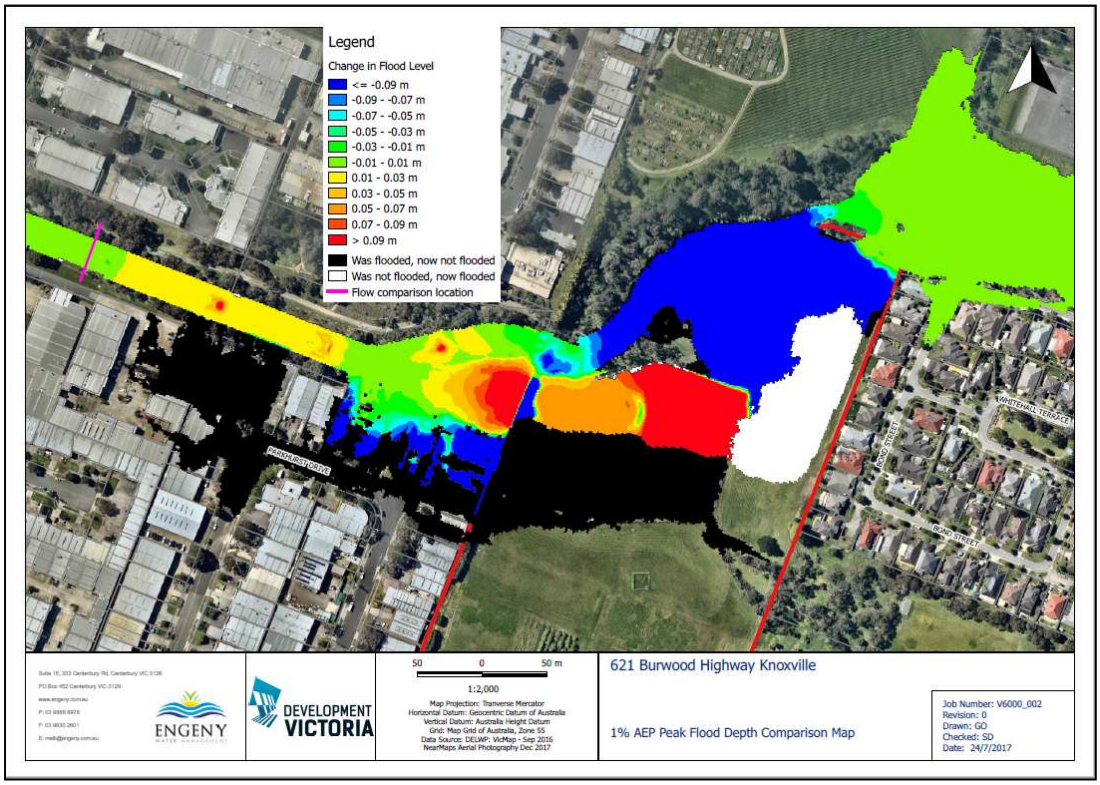

Figure 5: Reproduction of "1% AEP Peak Flood Depth Comparison Map" from Engeny Water Management (2018, Appendix C).

6.3 Statement 3

'The new wetland will provide' tab of Development Victoria (no date):

> "An enhanced habitat for the endangered Blue-Billed duck through targeted planting. A diverse environment that will encourage more wildlife to live and visit, and create a safer outdoor area for local residents to enjoy".

Response: the new lake/wetland will not necessarily provide "enhanced habitat" for Blue-billed Duck, as shown in Section 4 of this report. It may provide enhanced breeding habitat − and even this is not guaranteed − but feeding habitat could remain, at best, unaltered or more likely will be very markedly reduced until species-rich and abundant macro-invertebrate communities develop in the habitat wetland.

6.4 Statements 4−6

Winter 2020 fact sheet (on 'Resources' tab of Development Victoria (no date) webpage):

> 4. "The design of a new improved wetland and associated habitat which provides enhanced flora and fauna outcomes".
>
> 5. An improvement to the water quality and available breeding habitat for local species through targeted planting which is currently absent at the existing dam. "
>
> 6. "A range of settling, sediment and water retention ponds to treat stormwater, mitigate flooding and protect Blind Creek".

Response: as per the response to Statement 1, Statements 4 and 5 are more statements of hope than accurate predictions supported by peer-reviewed scientific assessments. The implication in Statement 5, that improved water quality is linked with improved animal habitat, is not supported by the observation that some of the most eutrophied water bodies in Victoria, the treatment ponds at the Western Treatment Plant, are simultaneously excellent breeding and feeding habitat for waterbirds (e.g. Loyn *et al.* 2014).

Statement 6 requires calculation of current-day versus post-development nutrient loadings from the subject land. As calculated in Section 4.2, the proposed development is likely to generate ~80 ML of stormwater annually, about four times what would be generated by an undeveloped (e.g. grassed or forested) site. It is difficult to see how this will "protect Blind Creek" as claimed. Moreover, the stormwater-treatment complex will still generate a (modelled) load of 14.5 kg of total phosphorus and 176 kg of total nitrogen each year that will be discharged into Blind Creek (Engeny Water Management 2017, Table 3.2). Until a comparable calculation has been made for the current nutrient loadings into Blind Creek from the undeveloped site, the claim of reduced nutrient loading from the site must be taken as unsubstantiated.

6.5 Statements 7−16

Proposed Wetland FAQ (on 'Resources' tab of Development Victoria (no date) webpage):

> 7. "Development Victoria intends to deliver a more vibrant waterway system to ensure the wetland is fit for purpose and safe for the local community to use".

Response: the term 'vibrant' remains to be defined from an ecological perspective. Indeed, the entire development is also described as "vibrant" on the Engage Victoria webpage: see Section 2 of this report.

> 8. "The dam is lacking the dense vegetation and reed beds necessary for successful breeding of the Blue-billed Duck".

Response: as noted in Section 2.2, the statement that Lake Knox is somehow sub-par because it does not provide breeding habitat for Blue-billed Duck is simply a *non sequiter*. The provision of wider and more continuous bands of emergent non-woody vegetation around the edges of the existing lake would improve its IWC Wetland Condition score (see Sections 2.1 & 4.5), but it remains to be shown why this could not be achieved without draining and in-filling the entire lake.

> 9. "The best environmental outcomes will be achieved through the repurposing of the existing dam and the construction of a proposed new wetland system"

Response: this claim is highly debatable, and arguably better ecological outcomes could be obtained if the lake were retained and improvements made to its edges and fringing vegetation, as outlined in Lorimer (2017) and Ecocentric Environmental Consulting (2018a).

> 10. "The proposed new, improved wetland would provide a better environmental outcome for the site. It will be safe for the community and will significantly improve the available breeding habitat for the endangered Blue-billed Duck and other species".

Response: as above for Statement 9.

> 11. "Treating the stormwater will improve the quality of the runoff flowing into the waterway by removing pollutants such as suspended solids, nitrogen, phosphorus, litter and heavy metals. This will provide cleaner water which will allow for a wider range of plants and animals to live within the wetland and also within Blind Creek. It will also help to reduce the amount of pollutants being discharged into Port Phillip Bay, helping to improve the health of the Bay".

Response: see response to Statement 6, above regarding nutrient loads from stormwater generated on the developed site. The statement also ignores the fact that stormwater is only one of a number of waste streams emanating from new residential developments. Waste water from urban housing will consist of stormwater, black water (i.e. faecal waste water from toilets) and

grey water (e.g. shower and sink waste, all containing a wide range of contaminants: see Tjandraatmadja *et al.*, 2020). If the grey water and black water from the housing estate are sent to the Eastern Treatment Plant for processing, the treated effluent (which will be of very high quality) will be discharged into Bass Strait, not into Port Phillip Bay. Under these conditions, it is difficult to see how the proposed development will have any effect on reducing the amount of pollutants discharged into Port Phillip Bay.

> 12. "It is proposed that construction of the new wetland will occur in a staged manner, providing continual access to a waterbody for wildlife currently using the existing dam. This aims to reduce the impact on local flora and fauna, providing a habitat for their preservation throughout. This will be managed and overseen by technical experts".

Response: is demonstrated in Sections 4.6 and 5.2, it will likely take decades for the constructed lake/wetland to approach the biodiversity and ecological values of a natural or long-established wetland. Even allowing for the 12 months period between the planting of the new wetlands and the draining and infilling of the existing lake (Ecocentric Environmental Consulting, 2018a, page 47) is far too short a time for wildlife to have "continued access" to suitable aquatic habitat, nor will it provide "a habitat for their preservation throughout".

> 13. "The proposed new wetland is expected to significantly improve the water quality, and in turn improve the available breeding and nesting habitat for the Blue-billed Duck. This breeding habitat is currently absent on site. The new wetland will provide a larger, healthier and safer waterbody for the Blue-billed Duck and other wildlife".

Response: as above for Statements 9 and 10.

> 14. "It is proposed that once construction of the new open wetland at the northern end of the site is finished, technical experts will carefully relocate the flora and fauna from the current dam to the new wetland, where possible".

Response: this may be possible for some of the plant species, as noted by Ecocentric Environmental Consulting (2018a) but it remains to be seen how waterbirds will be captured and moved (by mist nets?) or how fish will be translocated (fyke nets?). The caveat "where possible" is, of course, the Get-out-of-Gaol card, and it gives licence to a range of other actions.

> 15. "Development Victoria has a proven track record of delivering enhanced waterbodies which are now home to a range of flora and fauna including the threatened Blue-billed Duck. Our goal is to deliver a better overall environment outcome for the current man-made dam in Knox".

Response: as per response to Statements 1, 3 , 4 and 5 etc.

> 16. "Detailed studies have been undertaken by environmental scientists to understand the extent of any contamination on the site due to its former use a Horticultural Research Centre and general agricultural uses which occurred from 1900s. It was identified that the

majority of the site is characterised as having a low or low to medium contamination risk. The site was deemed suitable for development for residential purposes and there is no danger to surrounding communities".

Response: this report needs to be made available to the public, so it can be scrutinized by water- and sediment-quality specialists. If only "the majority of the site is characterised as having a low or low to medium contamination risk", what is the status of the sites that fall outside this "majority"? Are they heavily polluted with, for example, long-lived pesticides? Did the "detailed studies" include also the sediments in Lake Knox or was it restricted to sampling terrestrial areas? Given the long history and location of Lake Knox, it might be expected that it accumulated appreciable loads of toxicants and nutrients over its ~60 years of existence. If this is the case, is it expected that the toxicants will be buried by up to 4 m of top soil before the land is turned over to housing lots, as would seem to be the fate of a portion of the lake on the basis of the juxtaposition of the development and the lake in Figure 2?

7 Conclusions

There are many serious ecological drawbacks to the proposal to drain and in-fill Lake Knox and to replace it with a new lake/wetland complex constructed *de novo*. Section 4 of this review assessed the likely success with which the new lake/wetland complex would replicate or as claimed, improve on, the ecological values already present in Lake Knox. It showed that there are significant doubts about the likely success of the proposed lake/wetland complex, in terms of:

- Feeding and breeding habitat for Blue-billed Duck
- Habitat for other aquatic animals
- Plant (aquatic and fringing) biodiversity and extent
- Whether the new lake/wetland will represent an improvement on the current Lake Knox in terms of Index of Wetland Condition scores.

Moreover, the published record of wetlands created *de novo* in mimicking the ecological structure of natural or long-established wetlands is very poor (Section 4.6), and the offset approach inherent in the development proposal also has, at best, a chequered history of success (Section 5.2).

In my view, an alternative course of action that should be seriously investigated is to maintain Lake Knox and improve its current (and well-substantiated) biodiversity and ecological values while still allowing for the creation of the sedimentation pond and treatment wetland needed to retard and treat stormwater. It is admitted in the Development Victoria literature that retaining Lake Knox will "pose several challenges" (e.g. 'Proposed wetland FAQ − July 2020', page 1), but these should be no more difficult than those posed by the creation of a large new housing estate on the site and the construction of an entirely new lake/wetland complex to retard and treat its stormwater, the real reason for needing to create *de novo* these new aquatic systems. This approach is likely to be superior from many ecological perspectives to the proposed scheme.

The advantages of maintaining − and rehabilitating Lake Knox − are that existing biodiversity and ecological values are more-or-less guaranteed to be maintained and improved, unlike with the proposal to drain and in-fill the lake, in which case these values are certain to be lost and there is only the unsubstantiated hope that the new lake/wetland complex will provide an adequate replacement.

This recommendation is consistent with that reached by Lorimer (2017, page 1):

> "Any residential development of the former horticultural research station will require a wetland system on the floodplain to manage stormwater. The existing dam could contribute to stormwater management but it would need modification. Modification would also be required to improve the public safety of the currently tall, steep banks on the south, west and east. Shores with more gradual slopes would also be ecologically beneficial".

Ecocentric Environmental Consulting (2018a) similarly concluded that:

> "There is an opportunity therefore to mitigate the impacts of the proposed development through an upgrade of the dam and its wall, and the redevelopment of wetland habitat. This action will be the principal measure adopted on site for the mitigation of impacts associated with the re-purposing of the existing dam area".

There are acknowledged matters of public safety (e.g. drowning risk) to be considered, but the major potential impediment to retaining Lake Knox and subjecting it to a program of ecological rehabilitation (e.g. modifying the slope of the edges and planting the fringes with dense bands of tall, emergent on-woody vegetation) would seem to be the condition of the embankment along the lake sides. The report on the condition of the dam wall (Engeny Water Management 2017, Appendix D) made a suite of recommendations as to how the dam wall could be rejuvenated and made safe.

Retaining Lake Knox and improving its ecological value by revegetating its fringes with dense beds of reeds, rushes and sedges would maintain the high value the water body has for Blue-billed Duck feeding and loafing, and may create suitable breeding habitat. Such actions would address the first two reasons for creating the new lake/wetland complex as provided in the 'New wetland will provide' tab of Development Victoria (no date): (1) "enhanced habitat for Blue-billed Duck; and (2) "a diverse environment that will encourage more wildlife". There would then remain only the third outcome to be met: "a range of settling, sediment and water retention ponds to treat stormwater, mitigate flooding and protect Blind Creek".

Similarly, the retention and rehabilitation of Lake Knox would meet the first three of the seven objectives provided in Development Victoria's 'Wetland FAQ document': (1) "enhanced habitat for the endangered Blue-billed Duck"; (2) "an improvement to the water quality and available breeding habitat for local species"; (3) "dense vegetation and reed beds planted to encourage Blue-billed Duck breeding". The remedial work on the edges of the lake would also resolve some, perhaps all, of the issues related to public safety and recreational access.

There would then remain only the fourth outcome to be met: "a range of settling, sediment and water retention ponds to treat stormwater, mitigate flooding and protect Blind Creek". This is arguably not an ecological matter, but is a civil engineering issue related solely to the need to handle the large volumes of stormwater generated by a new housing estate with extensive areas of impervious surface and thus markedly increased run-off.

In summary, using the criteria established by Development Victoria itself as to the putative beneficial outcomes that would accrue by the destruction of Lake Knox and the construction of the new lake/wetland complex as its replacement, it can be seen that two out of three objectives and six out of seven objectives, respectively, can be met by the retention and then careful rehabilitation of Lake Knox. The lake does not need to be drained and in-filled to meet almost all of the ecological objectives set by Development Victoria.

There would then remain only the matter of constructing "a range of settling, sediment and water retention ponds to treat stormwater, mitigate flooding and protect Blind Creek", an action that is required in any case to treat the ~80 ML of stormwater that will be generated annually by the new housing estate and associated mixed-use facilities. Engeny Water Management (2017) has shown that this can be achieved to a standard required by Melbourne Water with the construction of a 1,100 m^2 sedimentation pond and 4,500 m^2 treatment wetland. As noted by Engeny Water Management (2018, page 8): "Retrofitting the existing dam to provide stormwater treatment is not considered to be feasible without significant disturbance to the dam as stormwater treatment wetlands require shallow areas with significant vegetation". It is conceivable that these stormwater-treatment wetlands could be constructed on available land to the north-west of Lake Knox, where the "Open water wetlands (Blue-billed duck open-water habitat)" component (Area A in Figure 3) is proposed to be built. These actions would then achieve all the beneficial outcomes listed on the 'New wetland will provide' tab and the 'Proposed wetland FAQ − July 2020' document provided on the Development Victoria webpage.

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9 About the author

Professor Paul I. Boon is the principal of Dodo Environmental, an environmental consulting business that has operated in Victoria since 2000.

I have worked on aquatic systems for over 40 years, variously as a post-doctoral tutor (= lecturer) at Monash University in the mid-1980s; a research scientist/senior research scientist at the CSIRO Division of Land & Water in the late-1980s and early-1990s; a senior lecturer/associate professor and, finally, full professor at Victoria University in the mid-1990s to 2017; a senior ecological consultant with the engineering consulting firm Sinclair Knight Mertz in 2000; and, since 2000, as the principal of Dodo Environmental. Since retiring from full-time academic work in 2017, I have held a 5-year position of Honorary Professorial Fellow in the School of Geography at the University of Melbourne.

My academic qualifications include a BSc(Hons) degree from the University of Sydney, with majors in Botany & Microbiology and a Honours I thesis (1979) in the School of Botany on the physiological ecology of mangroves. My PhD (Griffith University, 1981−1984) was on the biogeochemistry of seagrass beds in Moreton Bay, south-eastern Queensland. My post-doctoral studies (Monash University, 1985 & 1986) were on the biogeochemistry of coastal saltmarsh sediments of Western Port.

I have been a member of the editorial advisory boards of three scientific journals over the past 25 years: *Marine & Freshwater Research* (1994−2018), *PLoS One* (2014−2017) and *Pacific Conservation Biology* (2017−present). Some peer-reviewed publications in the scientific literature over the past 10 years include:

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11 Statement of limitations

This report was prepared on behalf of and for the exclusive use of First Friends of Dandenong Creek. Dodo Environmental accepts no liability or responsibility for or in respect of any use of or reliance upon this report by any third party. The report is not intended as an expert witness statement to be used in, for example, VCAT, but instead as critique of the ecological aspects of the proposed development, intended to inform First Friends of Dandenong Creek. The report was prepared in accordance with the scope of work and for the purposes outlined in the proposal dated 6 July 2020. It is based on generally accepted practices, knowledge and standards at the time of preparation. No other warranty, expressed or implied, is made as to the professional advice included in this report. The approach taken and sources of information used by Dodo Environmental are provided in the report; Dodo Environmental has made no independent verification of this information other than that obtained during the brief site inspection of 27 July 2020. The report is based on information available and conditions encountered at the time of preparation; Dodo Environmental disclaims any responsibility for any

changes that may have occurred since then. Dodo Environmental does not warrant this document is definitive nor free from error and does not accept liability for any loss caused, or arising from, reliance upon the information provided herein.