SUPPLEMENTARY EPA RESPONSE: SYDNEY ZOO

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Prepared for:

Sydney Zoo

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Australia

Client: Sydney Zoo
Project: SYDNEY ZOO
Project No: 00012082

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1. Introduction

Sydney Zoo is seeking approval under Part 4 of the Environmental Planning and Assessment Act 1979 (EP&A Act) for the construction of a zoo (Sydney Zoo) within the Bungarribee Precinct of the Western Sydney Parklands.

The project was nominated as State Significant Development (SSD). Assessment and approval is being pursued in accordance with the EP&A Act. The Secretary's Environmental Assessment Requirements (SEARs) for the project have been issued and set out the environmental assessment requirements for the project.

A Stormwater Management Report was prepared by Lindsay Dynan Consulting Engineers Pty Ltd (Lindsay Dynan) to address the relevant SEARs. Following this, it is understood that Sydney Zoo, via JBA Urban Town Planning Consultants Pty Ltd (JBA Urban), provided a Response to Submissions (RtS) report addressing comments from regulatory authorities following submission of the Environmental Impact Statement (EIS).

The NSW Environment Protection Authority provided input to the SEARs and also provided comments following submission of the EIS. Most recently the EPA has issued a letter (EPA letter) to Sydney Zoo, via the NSW Department of Planning and Environment, dated 9 June 2016, reinforcing their concerns relating to water pollution risks associated with the project.

This report provides additional commentary regarding water pollution risks and aims to specifically address the initial SEARs raised by the EPA, as well as additional requests made within the EPA letter.

2. EIS Submission

Lindsay Dynan provided inputs to the EIS submission relating to stormwater management for the zoo. The Lindsay Dynan report 'STORMWATER MANAGEMENT PLAN: SYDNEY ZOO' (SWMP), dated 3 December 2015, covered the stormwater management requirements outlined by the local government authority, Blacktown City Council (BCC), in their Development Control Plan (DCP). These requirements related to water pollution, as well as flooding, on-site detention and stormwater harvesting and re-use.

With respect to water pollution, the requirements of BCC are based on a percentage reduction of specific pollutants common to stormwater runoff. The reduction in pollution is calculated by comparing the quantum of pollutant generated from the "source" to the quantum discharged from the site after having been directed through various "treatments".

A summary of the pollutants that BCC are concerned with, as well as the respective pollution reduction targets that they have set, are provided in Table 1 below.

Table 1 - Pollutant Reduction Targets

Pollutant	Reduction Target
Gross Pollutants	90 %
Total Suspended Solids (TSS)	85 %
Total Phosphorous (TP)	65 %
Total Nitrogen (TN)	45 %
Total Hydrocarbons	90 %

With the exception of Total Hydrocarbons, the industry accepted method for determining pollutant reduction is through modelling using the software package 'MUSIC', produced by eWater Ltd.

2.1 MUSIC Source Nodes

The source concentrations of pollutants that can be transported by stormwater runoff is known to vary across various land use types. MUSIC aims to account for this by providing three different default source nodes, relating to Urban, Industrial and Agricultural land uses. The default nodes feature an array of parameters that can be manually adjusted, although it is generally considered that the default parameters are appropriate for most development applications.

BCC have elected to generate their own set of source nodes for application on developments within their Local Government Area (LGA). These nodes are made publically available and, similar to the default nodes, account for land use types. The BCC nodes produce pollutants in higher concentrations than the default nodes across the full set of pollutant types and land use types. BCC adopt these more stringent nodes to enforce a higher quantity and quality of pollution reduction devices within their LGA.

At the time of submission of the EIS, there was no publically available Agricultural source node from BCC. This Agricultural node has been subsequently obtained by Lindsay Dynan and assessed for its applicability to the Sydney Zoo context. On comparison with the BCC Urban node, it was found that the BCC Agricultural node provided greater pollutant generation. As such the BCC Agricultural node has now been adopted for use for modelling exhibit areas as we believe it is the most relevant.

2.2 MUSIC Treatment Nodes

The treatment of pollutants is modelling MUSIC through implementing treatment nodes. There are a broad range of treatment nodes available as default nodes. The type of node a designer adopts generally depends on the specifics of the development. Examples of default treatment nodes are sediment basins, wetlands, bio-retention basins and grassy swales. A range of treatment nodes are also available by manufacturers of proprietary treatment devices.

Similar to source nodes, BCC have their own set of approved treatment nodes and generally are found to be less efficient than their respective MUSIC default counterparts. Again, BCC adopt these more stringent nodes to enforce a higher quantity and quality of pollution reduction devices within their LGA.

The MUSIC model developed by Lindsay Dynan that was submitted with the EIS implemented multiple different types of treatment in series to create a “treatment train”. One of the predominant devices implemented were bioretention beds, due to their high treatment capabilities for the range of pollutants analysed in MUSIC.

2.3 MUSIC Results

The results of the MUSIC model analysis from the EIS submission are provided below. These results match those that were presented in the EIS Stormwater Management Report.

Table 2 - EIS Pollution Reduction Results

Pollutant	Sourced	Residual	Reduction	BCC Requirements
	kg/yr	kg/yr	%	%
Total Suspended Solids	33,600	3,750	88.8	85
Total Phosphorus	24.3	5.39	77.8	65
Total Nitrogen	141.0	38.9	72.5	45
Gross Pollutants	1,310	0	100	90

3. EPA SEARs

The EPA letter of 9 June 2016 noted that the SEARs issued in respect of the project required the proponent to:

a) assess existing surface water and groundwater quality against relevant criteria for the environmental values of Eastern Creek identified in ANZECC Guidelines for Fresh and Marine Water Quality 2000;

b) identify pollutants likely to be generated by project activities, including stormwater runoff, and estimate the concentration and quantity of those pollutants reported against the environmental values and criteria referred to in paragraph (a) above;

c) assess the impact of any pollutants referred to in paragraph (b) on surface and groundwater, including Eastern Creek and its tributaries;

d) include details of practical measures proposed to be adopted to prevent, control, abate and mitigate any water pollution arising from the project activities; and

e) include details of any proposed discharge (nature, volume and location) to receiving waters, including Eastern Creek and its tributaries.

These SEARs have been addressed in the following sections of this report.

3.1 Existing Water Quality

The groundwater quality has been assessed and reviewed against the ANZECC Guidelines for Fresh and Marine Water Quality 2000, as part of an assessment carried out by Consulting Earth Scientists Pty Ltd (CES). The CES Environmental Site Assessment has been undertaken at two locations: MW01 and MW03 in the western portion of the site and was intended to provide a baseline groundwater quality assessment.

A revised suite of water quality screening criteria for groundwater and surface water has been developed CES and has been attached to this report as Appendix A. The suite has been derived based on the likely chemicals to be used and potential contaminants arising from operations at Sydney Zoo. The criteria are generally sourced from the following documents:

1. Table 3.3.2 (lowland river) and 3.4.1 of the Australian and New Zealand Environment Conservation Council (ANZECC) Guidelines for Fresh and Marin Water Quality 2000; and
2. Healthy Rivers Commission, "Independent Inquiry into the Hawkesbury Nepean River System" 1998; and
3. National Health and Medical Research Council (NHMRC) Guidelines for Managing Risks in Recreational Waters 2008.

With regards to pathogens, CES has provided a single assessment criteria value for the assessment of enterococci. This assessment value is based on the NHMRC guideline value and is used as a screening criteria to identify gross contamination.

In June 2016, CES carried out surface water monitoring in Eastern Creek. In summary, surface water samples were collected from three locations at Eastern Creek, downstream, upstream and at the point of potential discharge to assess the baseline water quality of Eastern Creek. The laboratory concentrations were as follows:

- Total Nitrogen – All three results were elevated above the 0.5mg/L criteria (Reference: ANZECC Table 3.3.2) with concentrations ranging between 1.9 and 2.1 mg/L;
- Ammonia - All three results were elevated above the 0.02 mg/L criteria (Reference: ANZECC Table 3.3.2) with concentrations ranging between 0.026 and 0.047 mg/L;
- Enterococci – All three results were elevated above the 35 CFU/100mL (Reference: ANZECC Table 5.2.2 with concentrations ranging between 90 and 140 CFU/100mL;
- Total Phosphorous - All three results were elevated above the 0.05 mg/L criteria (Reference: ANZECC Table 3.3.2) with concentrations ranging between 0.1 and 0.2 mg/L;
- Other determinands such as DO (>5), BOD (<15mg/L), pH (between 6.5 and 8.0), TSS (<40mg/L) and chlorophyll (<5 ug/L) were lower than the laboratory limit of detection or lower than the ANZECC criteria.

In consideration of the results above, the surface water quality appears to be degrading as Eastern Creek flows to the north, where total suspended solids, Total Nitrogen, Ammonia and Enterococci concentrations increase from south to north.

Existing groundwater quality was assessed and discussed in the CES Environmental Site Assessment (June 2015). In summary,

- All groundwater samples collected and analysed reported concentrations of contaminants of potential concern below the site screening levels and/or laboratory reporting limits.

In consideration of the above, the current groundwater quality is good.

3.2 Pollutants Generated by Project Activities

The source concentrations of pollutants that can be transported by stormwater runoff is known to vary across various land use types. Whilst the zoo will be a unique development, the land use types that comprise the zoo can be isolated to obtain a more accurate representation of source pollutant generation.

The MUSIC modelling used to assess water pollution has separated the zoo site into four different source node types. The node types and a brief description of the land use for each are provided below:

- BCC Urban (Impervious)

  Sealed and unsealed roads within the zoo, Concrete/gravel footpaths and roof areas
- BCC Urban (Pervious)

  General grassed areas, picnic areas and environmental protection areas
- BCC Road

  Main and overflow carpark areas
- BCC Agricultural

  Animal enclosures

Through implementation of these tailored source nodes, the pollutant generation takes into account the specifics of the land use type and applies an appropriate event mean concentration (EMC) and standard deviation (SD) for each of the modelled pollutants (gross pollutants, total suspended solids, total phosphorous and total nitrogen).

The input parameters for each of the applied source nodes are presented in Appendix B.

In addition to the pollutants that are analysed within MUSIC, another pollutant source will be hydrocarbons in the carpark areas. In the preparation of the EIS, Lindsay Dynan collaborated with industry leaders in oil/water separation, SPEL Environmental Australia Pty Ltd (SPEL), to develop a strategy to achieve the BCC target of 90% hydrocarbon reduction.

The prediction of the pollutants that may be used or leaked/spilt at the site during operation will be determined by the specific requirements of Sydney Zoo for chemicals and their management (and release to groundwater/migration in groundwater to surface water) and as such both the range of chemicals and their concentrations could vary widely (determined by management and groundwater attenuation factors).

As outlined in the Response to Submissions (JBA, May 2016), chemicals likely to be used during the operation of the zoo include :

- Liquid petroleum gas (LPG), acetone, methylated spirits, petroleum, kerosene, mineral turpentine, cleaning products such as bleach, acids and alkalines.

Other pollutants likely to be generated (and recommended to be considered by the EPA) are those pollutants typically associated with animal manure and urine, and include:

- Nitrogen & Phosphorous compounds (e.g. nitrates, ammonium, phosphates, dissolved N and P), TSS, pathogens, BOD and COD

In all instances we expect that the type and volume of chemicals used would be less than that of a typical golf course and orders of magnitude less then nearby manufacturing or industrial facilities. The operation of the zoo will minimise chemical use due to the risks these chemicals may provide to the exotic and endangered animals that will be exhibited.

3.3 Impact of Pollutants

It is not the intention of Sydney Zoo to release any contaminants to groundwater. All discharges via the stormwater system will be controlled from impermeable surfaces (for example, walkways, roads, building roofs and car parks) or surfaces where drainage systems have been incorporated into the detailed design and this water will be subject to monitoring.

As highlighted in Section 3.5.2 of this report, it is expected that discharge from the operational site will limit pollution concentration to acceptable levels. Mitigation measures to create a 'treatment train' for stormwater runoff are outlined in Section 3.4. In this sense the intention is for discharge from the zoo to have no negative impact on the receiving waters.

3.4 Adopted Measures to Control Water Pollution

A MUSIC model has been developed to incorporate multiple treatment nodes. These nodes are reflected in the set of civil engineering drawings developed by Lindsay Dynan submitted with the EIS. The model generally features the following treatment devices:

- Primary grassy buffers/swales, particularly at the downstream end of exhibits
- Secondary bio-retention basins which collect and filter runoff from exhibits following primary treatment, as well as general open spaces throughout the zoo
- First flush devices will be applied to all roof catchments to avoid this load being connected to the pit and pipe stormwater network
- Proprietary oil/water separators and nutrient filters adopted in the carpark catchments
- Stormwater harvesting ponds which will collect pre-treated stormwater runoff and reticulate it through the site for the various re-use demands (refer to the EIS Stormwater Management Report). Prior to reticulation the harvested runoff will undergo tertiary mechanical treatment using, for example, filtration and UV disinfection, to ensure relevant recycled water quality limits are achieved.

The MUSIC model layout schematic can be seen below:

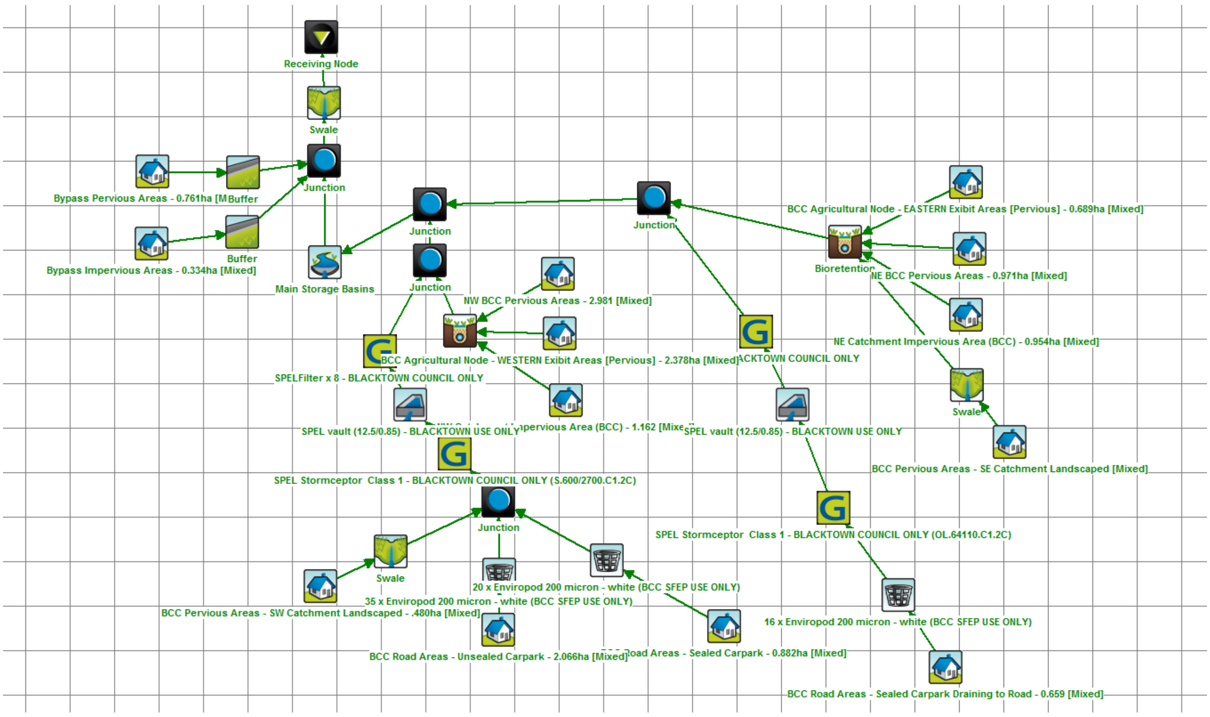

Figure 1 - MUSIC Layout Schematic

With the arrival of the BCC approved Agricultural source node in the public domain since the time of the EIS submission, Lindsay Dynan have amended the EIS MUSIC model to incorporate this slightly more stringent node.

Proprietary devices for hydrocarbon removal, manufactured by SPEL, were nominated in the EIS submission. BCC assessed the suitability of the nominated devices and, whilst the SPEL analysis calculated the units were satisfactory, BCC provided responses to the EIS suggesting the nominated units would need to be increased in capacity. BCC have provided specific details of the units they would like adopted and, whilst Lindsay Dynan and SPEL both believe them to be conservative, the BCC preferences will be adopted for the final design.

Revised MUSIC modelling results, incorporating the BCC Agricultural node and the larger SPEL devices, are provided below:

Table 3 - Pollution Reduction Results for Updated MUSIC Model

Pollutant	Sourced	Residual	Reduction	BCC Requirements
	kg/yr	kg/yr	%	%
Total Suspended Solids	30,100	876	97.1	85
Total Phosphorus	22.3	3.19	85.7	65
Total Nitrogen	133	27.1	79.6	45
Gross Pollutants	1,150	0.0	100	90

The results show that the pollution protection proposed to be implemented for the zoo are far in exceedance of the requirements set by BCC.

3.5 Nature of Proposed Discharge to Receiving Waters

3.5.1 Points of Discharge

The points of stormwater discharge from the proposed development have been distributed around the site to mimic the pre-developed site runoff. Stormwater discharges from the site will be controlled using on-site detention (OSD) storage, such that the pre-developed peak site discharge will not be exceeded, in accordance with the requirements of BCC. Results from the analysis of pre-developed and post-developed peak discharge were provided in the EIS Stormwater Management Report.

Points of stormwater discharge for the site are generally located close to the OSD storages within the site. The location of each OSD storage and the sub-catchments contributing to each OSD storage are addressed in the EIS Stormwater Management Report. Points of discharge include:

- OSD Storage 1 will discharge to the west via a low level piped culvert draining to a level spreader to help disperse the flow to the natural ground surface uphill from the alignment of Eastern Creek. Erosion controlling rock mattresses provided at the level spreader will stabilise the outlet and facilitate dispersion of concentrated flows.
- OSD Storage 2 will discharge via a piped culvert to a proposed easement to the east. Due to the nature of the development, and its interaction with proposed neighbouring development occurring simultaneously, the details of this proposed easement are not confirmed at this stage. The easement would drain water, either below or above ground, to the existing wetlands to the east.
- OSD Storage 3 will discharge via a piped connection to the stormwater pit and pipe network for the new access road to the east of the site boundary. Due to the nature of the development, and its interaction with proposed infrastructure design occurring simultaneously, the details of this proposed road connection are not confirmed at this stage.

3.5.2 Pollution Concentrations at Points of Discharge

The MUSIC modelling was undertaken on each of the three site sub-catchments contributing to the three discharge locations. The raw results from the MUSIC modelling are presented as annual loads. These results have been used to estimate the average concentration of discharge over the course of any given year. These results are presented below, alongside the recommended discharge limits set by the ANZECC guidelines as well as the background concentration of pollutants in Eastern Creek (taken as an average of the results from the samples taken):

Table 4 - Summary of Discharge Concentrations & Targets

Pollutant	Design Annual Average Concentration	ANZECC Guideline	Background Concentration
	mg/L	mg/L	mg/L
Total Suspended Solids	40.37	40.0	17.0
Total Phosphorus	0.15	0.05	0.17
Total Nitrogen	1.25	0.50	2.00
Gross Pollutants	0.0	N/A	N/A

These results highlight that, further to meeting the BCC requirements for percentage pollution reduction, the calculated discharge from the site will be either at or below accepted guidelines, or well below the background concentrations in Eastern Creek.

The above results take into account the proposed on-site stormwater harvesting storage. The MUSIC modelling includes the analysis of the fluctuating levels within the storage volume due to supply (rainwater runoff) and demand (re-use on-site). Due to the day-to-day re-use demands for the site being relatively large, it would be highly likely that low intensity, high frequency runoff will be captured in available harvesting storage. Only when all storage volume is full will runoff actually discharge from the site (with the exception of the main carpark discharging from OSD Storage 3).

In this sense, runoff that is most likely to contain elevated levels of pollutants will be pre-treated then stored in the harvesting volume. A full harvesting volume would correspond to times of recent rainfall, with most pollutants having already been flushed from the catchments. As such, any overflow from the harvesting storage would be less likely to discharge pollution at the higher end of the concentration spectrum.

4. Suitability of Proposed Water Treatment Measures

In its letter of 9 June 2016, the EPA recommended that the proponent should be required to:

a) provide a detailed description of and justification for the nodes and settings used in the modelling; and

b) discuss the underlying assumptions and limitations of the modelling when reporting the results of that modelling."

These points have been addressed in the following sections of this report.

4.1 Justification for MUSIC Nodes & Settings

4.1.1 MUSIC Modelling

MUSIC modelling has become the industry standard for assessing the effectiveness of pollution reduction techniques on stormwater runoff, particularly for the assessment of Total Suspended Solids, Total Phosphorous, Total Nitrogen and Gross Pollutants. The settings used in MUSIC modelling are able to be modified to suit specific land usage.

Due to best practice operation and maintenance techniques that will be implemented at the zoo, it is considered that actual pollutant generation in stormwater runoff on-site will actually be less than MUSIC default settings. Nonetheless, a conservative approach has been taken, whereby the BCC 'Urban' and 'Agricultural' nodes have been adopted, which actually produce more pollutant loading than default settings.

4.1.2 Comparison of Wuhan Zoo, China

It is noted that the EPA have referenced a previous study (Zhao et al., 2006) which presents data collected from a zoo in Wuhan, China. Whilst this study does seem applicable in name, on researching the practices implemented at the Wuhan Zoo, it became clear that any results obtained regarding pollution concentrations in discharge from this site would be irrelevant to this proposal. The information we have collected includes a collation of photographs and visitor reviews that describe the atrocious conditions at Wuhan Zoo. This information is contained in Appendix C of this report.

The Wuhan Zoo practices quite obviously will not reflect the strict operation and maintenance regimes that will be applied to Sydney Zoo. The concentration in pollutant loads from Wuhan Zoo are considered completely extraneous in the context of Australian practices.

4.1.3 Comparison of Stocking Densities

An applicable measure of assessing the suitability of the nodes adopted in the MUSIC modelling is a comparison against farm stocking densities. A study (Peukert et al., 2009) of water pollution generated from farmland associated with sheep and cattle production in the UK identified pollutant event mean concentrations as shown below.

Table 5 – Normalised EMC of Pollutants from Isolated Fields (Peukert et al., 2009)

Pollutant	Field 2	Field 5	Field 8	Average
	mg/L	mg/L	mg/L	mg/L
Total Suspended Solids	19.9	38.0	17.8	25.2
Total Phosphorus	0.16	0.22	0.18	0.17
Total Oxidised Nitrogen	0.20	0.20	0.10	0.17

The farm was managed as a conventional production system and was considered to represent standard management practice for grassland systems.

Sydney Zoo advised Lindsay Dynan they have previously carried out an analysis on the expected manure production from animals within zoo exhibits. The analysis considered range of species, number, food type, food consumption and feed conversion rate. The resulting calculation determined the zoo would produce approximately 1,180kg of manure per day. Using an average rate of 2kg of manure produced by a sheep per day, it has been calculated that the 16.05ha zoo site equates to an equivalent stocking rate of 37 sheep per hectare.

Recommendations by the Department of Primary Industries suggest an ideal carrying capacity of 14-24 sheep per hectare in coastal improved pastures. Given the high maintenance regime that will be applied to Sydney Zoo, it is considered that the exhibits are an appropriate comparison. The calculated 37 sheep per hectare equivalent for the zoo is higher than the DPI recommendation but it is known that the zoo will supplement food for all grazing animals.

The higher stocking rate in the zoo compared to the conditions in the fields investigated by Peukart et al, suggest that higher EMC of pollution in runoff could be expected. This is reflected in the slightly higher concentrations determined from Lindsay Dynan's MUSIC modelling (Table 4) compared to the findings in Table 5.

4.1.4 Visual Inspection & Monitoring of the Stormwater Harvesting Basin

The stormwater re-use strategy for the zoo relies on a stormwater harvesting basin located adjacent to OSD Storage 1 at the western end of the site. Harvested stormwater is systematically pumped from the basin, undergoes mechanical treatment to improve its quality to suitable levels before it is used as recycled water throughout the site.

Water entering the basin undergoes pre-treatment at source upstream. The pre-treated water is expected to have nutrient levels reduced such that adverse effects of high nutrient concentrations within the basin are not experienced (eg. algal blooms).

Sydney Zoo will incorporate an operation and maintenance regime for the harvesting basin that will involve regular visual inspections of the basin to check for any signs of reduced water quality. If encountered, the stored water will be tested to determine the water composition and likely causes of pollution.

This regime for the basin will act as an early warning that runoff from the zoo catchments are resulting in pollution levels that are higher than the MUSIC modelling is predicting. Steps to be taken in this event are highlighted in Section 4.3 of this report.

4.2 Assumptions & Limitations of MUSIC Modelling

On their website, eWater state:

"MUSIC is an easy to use modelling tool for both simple and highly complex urban stormwater systems using water sensitive urban design. It can simulate urban stormwater systems ranging from a suburban block up to a whole suburb or town (0.01 km2 to 100km2). The time scale can start at 6 minutes and stretch up to 24 hours".

MUSIC has become the industry standard for modelling pollution removal from urban runoff. The currency of the modelling is achieved through the release of regular version updates that reflect the development of scientific theory and industry requirements.

eWater do recognise however that MUSIC is a conceptual modelling tool. With the gradual introduction of water sensitive urban design (WSUD) principles into new development controls over the last decade, there has been and will continue to be an implementation of water quality improvement devices throughout urban catchments. As more and more data becomes available on actual performance, it is expected that advances in MUSIC modelling will result in something that could be considered as more of a detailed design tool.

Further, Sydney Zoo will involve exhibit catchments that will likely not reflect the typical source node pollutants associated with the default MUSIC parameters.

For the above reasons, Lindsay Dynan have undertaken a literature review of water pollution from related activities and compared the adopted source nodes to satisfy ourselves that appropriate modelling parameters have been adopted.

It is recognised that the zoo activities may result in pollutant loads that are higher than the modelled parameters. In this unlikely event, a strategy has been devised to incorporate additional treatment measures as outlined in Section 4.3 below.

4.3 Proposed Operation & Maintenance Procedures

Sydney Zoo will operate under conventional commercial practices with regard to maintenance of general site areas (eg. litter collection, gardening, etc). Further, conventional operation and maintenance procedures will be adopted for the stormwater management elements of the stormwater drainage system, including testing of bioretention filtration rates and inspection of the OSD facilities.

It is recognised however that site specific operation and maintenance procedures will need to be implemented for the exhibit and back of house areas. These areas will involve conditions that will either be difficult to maintain due to safe access, or include a higher concentration of pollutants from animal activities.

Sydney Zoo have committed to having each exhibit and back of house maintained on a daily basis. Sydney Zoo qualified staff will enter the exhibit each morning and physically collect the manure that is visible on the ground. Manure will also be collected from the back of house prior to it being washed down to sewer each day.

The collected manure will be managed in accordance with a composting management plan that is being developed by Sydney Zoo. The plan is to be verified prior to the receipt of an Occupation Certificate. In the event that a management plan is not agreed upon, the fall-back position will be to transport the manure offsite to a transfer station.

As mentioned previously, the stormwater harvesting basin will be inspected to identify any visual signs of increased nutrient levels. In the event that elevated nutrient concentrations are identified the stored water will be pumped to the mechanical treatment system to reduce the nutrient levels to acceptable levels prior to discharge from the site.

Lindsay Dynan have collaborated with Sydney Zoo to identify locations throughout the site that could readily have additional stormwater treatment devices introduced to the treatment train. A plan drawing identifying these elements has been attached to this report as Appendix D. The additional treatment areas have mainly been focused on the exhibit areas which present the most uncertainty with regard to the accuracy of the MUSIC model.

In this sense it is considered that the zoo has significant redundancy in its design to address any elevated discharge results in the unlikely event that they occur during the operational

Should you require any further advice or clarification of any of the above, please do not hesitate to contact us.

Yours faithfully
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Reviewed by

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APPENDIX A – Screening Criteria for Discharge & Creek Waters

Screening Criteria for Groundwater, Eastern Creek and Discharge	
Parameter	**Criterion (µg L^{-1} unless otherwise stated)**
Metals and Metalloids (95% Species, Freshwater Table 3.4.1, ANZECC 2000)	
Arsenic (V)	13
Cadmium[A]	0.2
Chromium VI	1
Copper[A]	1.4
Nickel[A]	11
Lead[A]	3.4
Zinc[A]	8
Mercury (inorganic)	0.06 (99% Species)
Non-metallic Inorganics (95% Species, Freshwater Table 3.4.1, ANZECC 2000)	
Nitrate	700
Cyanide	7
Sulphide	1
Ammonia	900
Physical and Chemical Stressors	
Biological Oxygen Demand	<15 mg/L (Table 9.4.4, ANZECC 2000)
Chlorophyll	7 (HRC, 1998)
Total Phosphorous	35 (HRC, 1998)
Filterable Reactive Phosphorous	20 (Table 3.3.2, ANZECC 2000)
Total Nitrogen	700 (HRC, 1998)
Oxides of Nitrogen (NOx)	40 (Table 3.3.2, ANZECC 2000)
Ammonium	20 (Table 3.3.2, ANZECC 2000)
Dissolved Oxygen	<5 mg/L (Table 9.4.7, ANZECC 2000)
Conductivity	300 µS/cm (Table 8.2.9, ANZECC 2000)
pH	6.5-8.0 (units) (Table 9.4.10, ANZECC 2000)
Total Suspended Solids	50 mg/L (Table 8.2.12, ANZECC 2000)
TRH and BTEX (95% Species, Freshwater Table 3.4.1, ANZECC 2000)	
Benzene	950
Toluene	180 (LR)
Ethylbenzene	80 (LR)
m -xylene	75 (LR)
p - xylene	200
o-xylene	350
Polycyclic Aromatic Hydrocarbons (95% Species, Freshwater Table 3.4.1, ANZECC 2000)	
Fluoranthene	1 (LR)
Phenanthrene	2 (LR)
Anthracene	0.4 (LR)
Fluoranthene	1.4 (LR)

Screening Criteria for Groundwater, Eastern Creek and Discharge	
Parameter	**Criterion (µg L^{-1} unless otherwise stated)**
Benzo(a)pyrene	0.2 (LR)
Naphthalene	16
Polychlorinated Biphenyls (99% Species, Freshwater Table 3.4.1, ANZECC 2000)	
Aroclor 1242	0.3
Aroclor 1254	0.01
Volatile Organic Compounds (95% Species, Freshwater Table 3.4.1, ANZECC 2000)	
Carbon disulphide	20 (LR)
1,2- Dichloroethane	1900 (LR)
1,1,2-Trichloroethane	6500
Chloroethene (VC)	100 (LR)
1,1-Dichloroethene	700 (LR)
1,2 - Dichloroethene	700 (LR)
Tetrachloroethene (PCE)	70 (LR)
Trichloroethene (TCE)	330 (LR)
Phenol (95% Species, Freshwater Table 3.4.1, ANZECC 2000)	
Phenols	320
Organophosphate Pesticide	
OPP	0.01
Organochlorine Pesticides (95% Species, Freshwater Table 3.4.1, ANZECC 2000)	
Aldrin	0.001 (LR)
Chlordane	0.08
DDE	0.03 (LR)
DDT	0.01
Dieldrin	0.01 (LR)
Endosulfan	0.2
Endrin	0.02
Heptachlor	0.09
Lindane	0.2
Methoxychlor	0.005 (LR)
Mirex	0.04 (LR)
Toxaphene	0.2
Lindane	0.2
Other Parameters	
Colour	30-40 platinum-cobalt units (Table 9.4.6, ANZECC 2000)
Enterococci [Pathogens[B]]	40 (cfu/100mL) Table 5.7, NHMRC, 2008

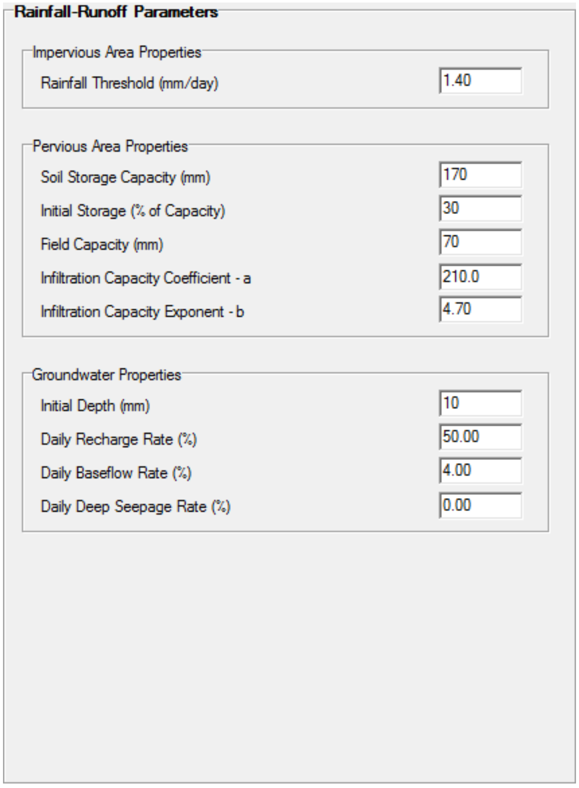
[A] - The receiving water (Eastern Creek) should be tested for hardness ($CaCO_3$) to allow a Hardness Modified Trigger Value (HMTV) to be calculated and applied.

[B] – Enterococci has been used as an indicator of pathogenic contamination.

LR – Low Reliability

APPENDIX B – MUSIC Model Parameters

BCC URBAN (IMPERVIOUS)



Rainfall-Runoff Parameters

Impervious Area Properties

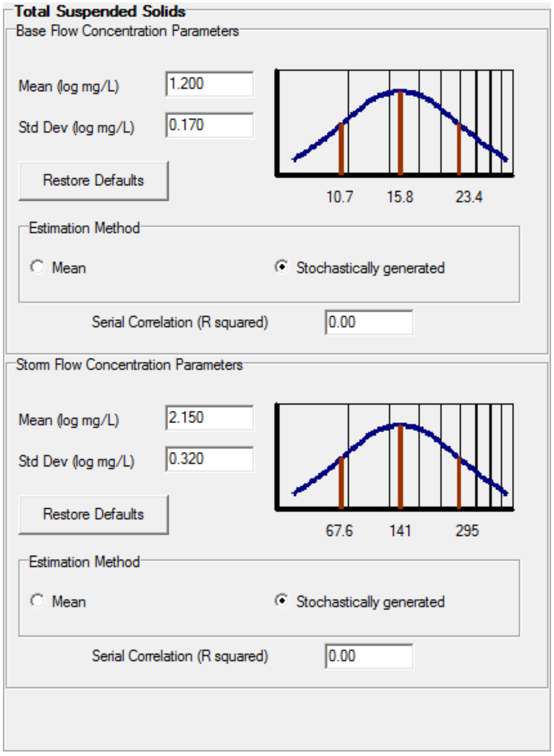
Rainfall Threshold (mm/day): 1.40

Pervious Area Properties

Soil Storage Capacity (mm): 170
Initial Storage (% of Capacity): 30
Field Capacity (mm): 70
Infiltration Capacity Coefficient - a: 210.0
Infiltration Capacity Exponent - b: 4.70

Groundwater Properties

Initial Depth (mm): 10
Daily Recharge Rate (%): 50.00
Daily Baseflow Rate (%): 4.00
Daily Deep Seepage Rate (%): 0.00



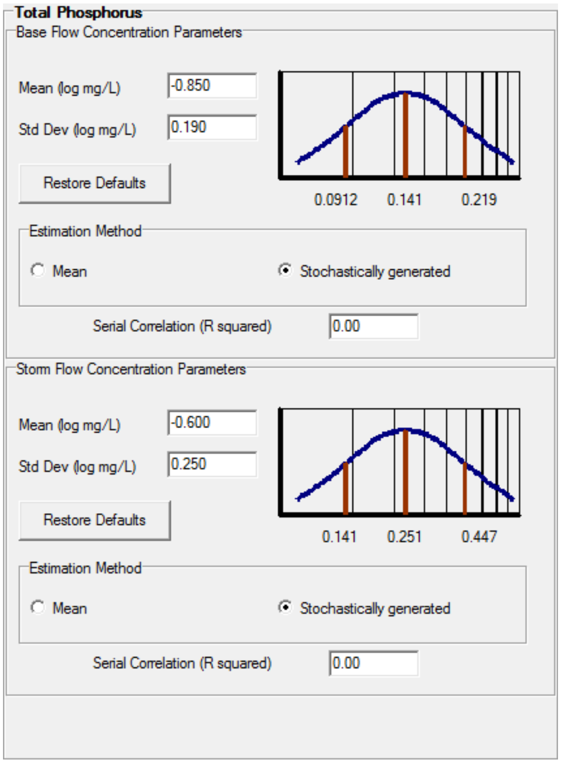
Total Suspended Solids

Base Flow Concentration Parameters

Mean (log mg/L): 1.200
Std Dev (log mg/L): 0.170
Restore Defaults
10.7 15.8 23.4
Estimation Method
Mean
Stochastically generated
Serial Correlation (R squared): 0.00

Storm Flow Concentration Parameters

Mean (log mg/L): 2.150
Std Dev (log mg/L): 0.320
Restore Defaults
67.6 141 295
Estimation Method
Mean
Stochastically generated
Serial Correlation (R squared): 0.00



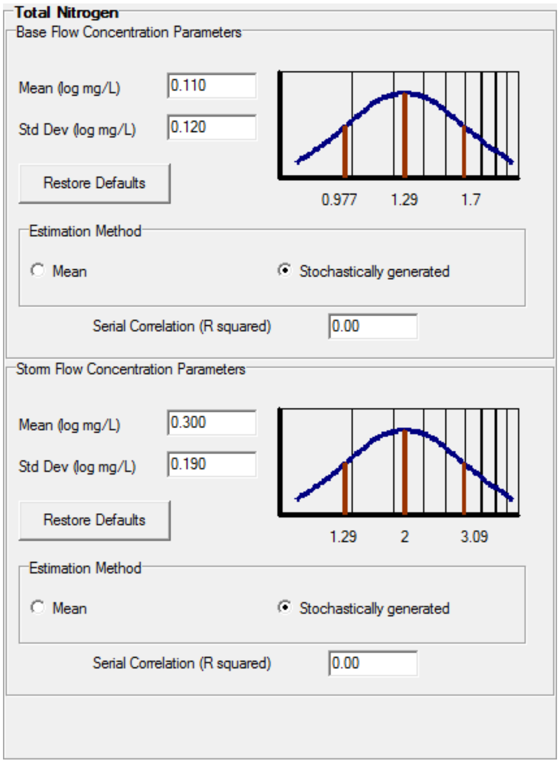
Total Phosphorus

Base Flow Concentration Parameters

Mean (log mg/L): -0.850
Std Dev (log mg/L): 0.190
Restore Defaults
0.0912 0.141 0.219
Estimation Method
Mean
Stochastically generated
Serial Correlation (R squared): 0.00

Storm Flow Concentration Parameters

Mean (log mg/L): -0.600
Std Dev (log mg/L): 0.250
Restore Defaults
0.141 0.251 0.447
Estimation Method
Mean
Stochastically generated
Serial Correlation (R squared): 0.00



Total Nitrogen

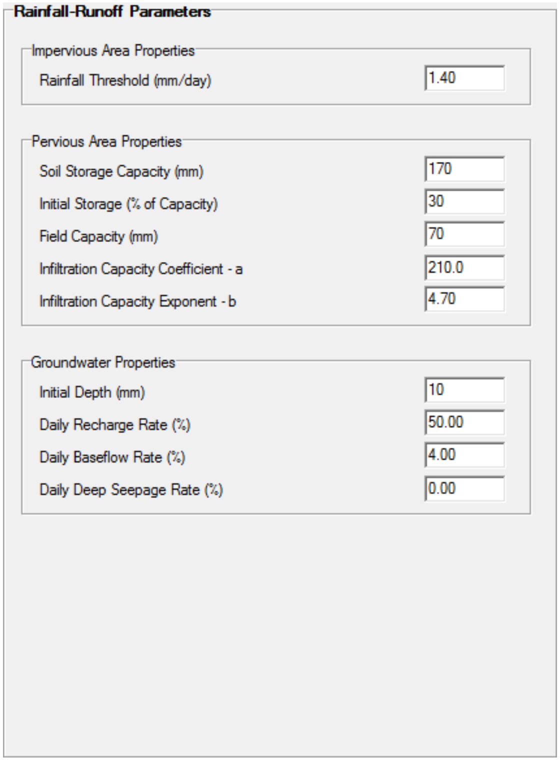
Base Flow Concentration Parameters

Mean (log mg/L): 0.110
Std Dev (log mg/L): 0.120
Restore Defaults
0.977 1.29 1.7
Estimation Method
Mean
Stochastically generated
Serial Correlation (R squared): 0.00

Storm Flow Concentration Parameters

Mean (log mg/L): 0.300
Std Dev (log mg/L): 0.190
Restore Defaults
1.29 2 3.09
Estimation Method
Mean
Stochastically generated
Serial Correlation (R squared): 0.00

BCC URBAN (PERVIOUS)



Rainfall-Runoff Parameters

Impervious Area Properties

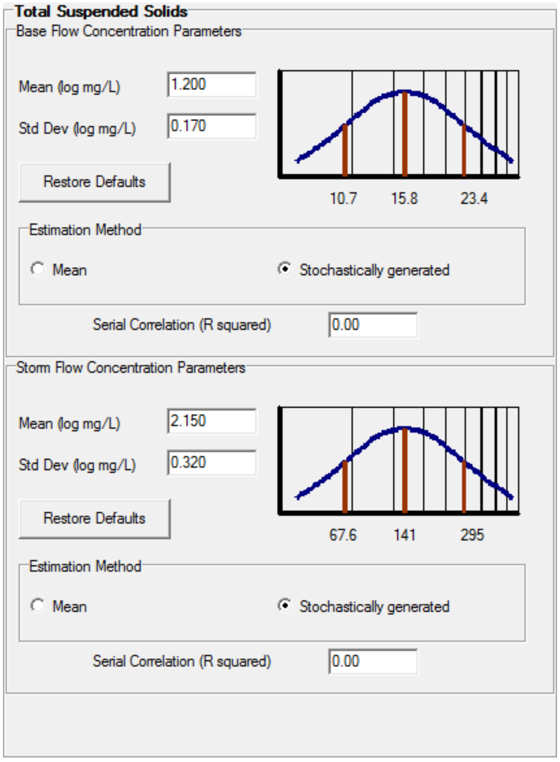
Rainfall Threshold (mm/day)	1.40

Pervious Area Properties

Soil Storage Capacity (mm)	170
Initial Storage (% of Capacity)	30
Field Capacity (mm)	70
Infiltration Capacity Coefficient - a	210.0
Infiltration Capacity Exponent - b	4.70

Groundwater Properties

Initial Depth (mm)	10
Daily Recharge Rate (%)	50.00
Daily Baseflow Rate (%)	4.00
Daily Deep Seepage Rate (%)	0.00



Total Suspended Solids

Base Flow Concentration Parameters

Mean (log mg/L) 1.200

Std Dev (log mg/L) 0.170

Restore Defaults

10.7 15.8 23.4

Estimation Method: Mean / Stochastically generated (selected)

Serial Correlation (R squared) 0.00

Storm Flow Concentration Parameters

Mean (log mg/L) 2.150

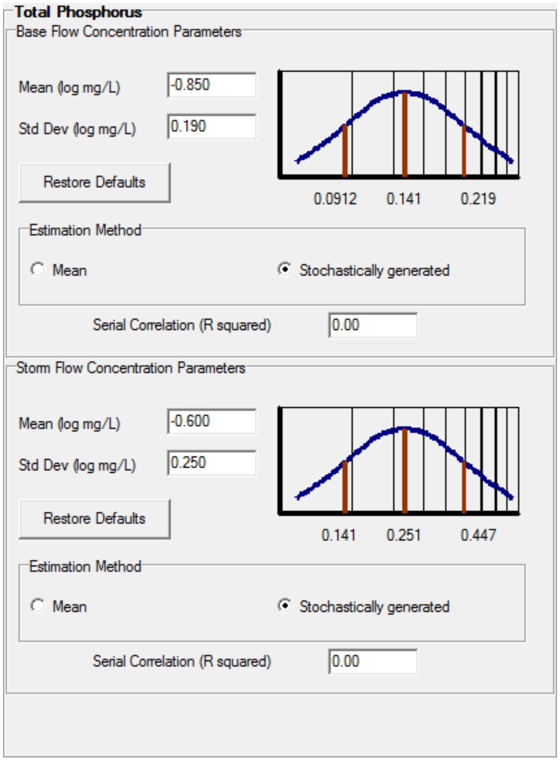
Std Dev (log mg/L) 0.320

Restore Defaults

67.6 141 295

Estimation Method: Mean / Stochastically generated (selected)

Serial Correlation (R squared) 0.00



Total Phosphorus

Base Flow Concentration Parameters

Mean (log mg/L) -0.850

Std Dev (log mg/L) 0.190

Restore Defaults

0.0912 0.141 0.219

Estimation Method: Mean / Stochastically generated (selected)

Serial Correlation (R squared) 0.00

Storm Flow Concentration Parameters

Mean (log mg/L) -0.600

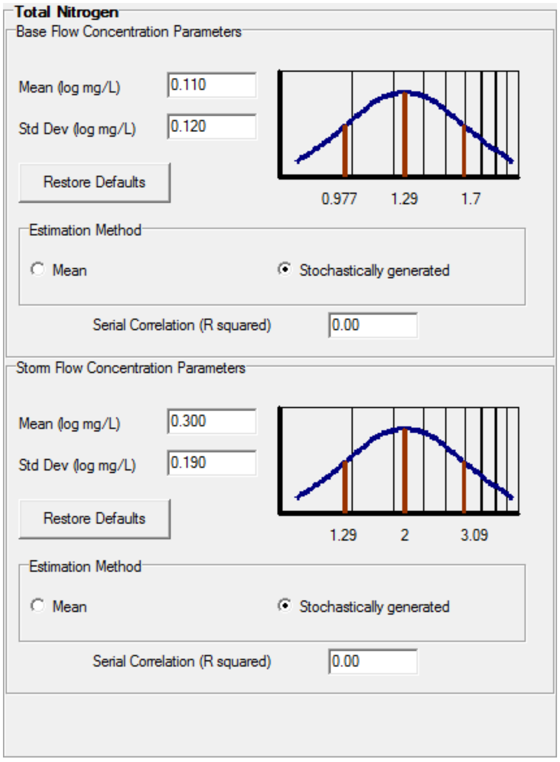
Std Dev (log mg/L) 0.250

Restore Defaults

0.141 0.251 0.447

Estimation Method: Mean / Stochastically generated (selected)

Serial Correlation (R squared) 0.00



Total Nitrogen

Base Flow Concentration Parameters

Mean (log mg/L) 0.110

Std Dev (log mg/L) 0.120

Restore Defaults

0.977 1.29 1.7

Estimation Method: Mean / Stochastically generated (selected)

Serial Correlation (R squared) 0.00

Storm Flow Concentration Parameters

Mean (log mg/L) 0.300

Std Dev (log mg/L) 0.190

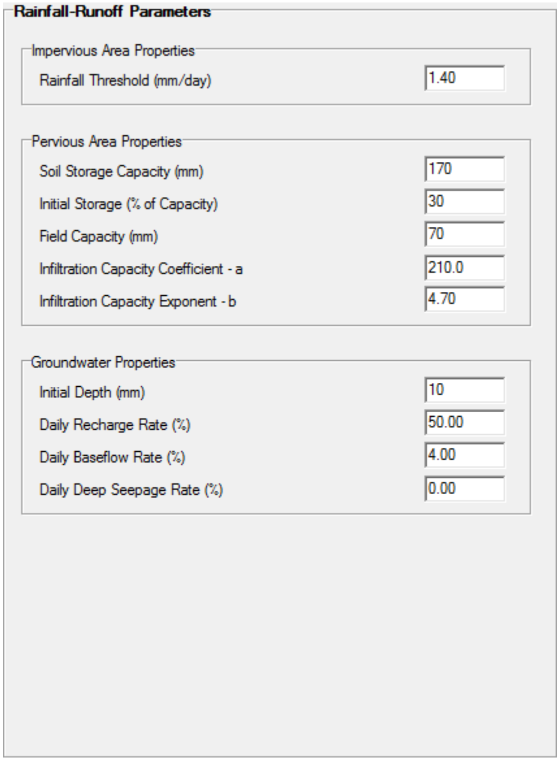
Restore Defaults

1.29 2 3.09

Estimation Method: Mean / Stochastically generated (selected)

Serial Correlation (R squared) 0.00

BCC ROAD


Rainfall-Runoff Parameters

Impervious Area Properties

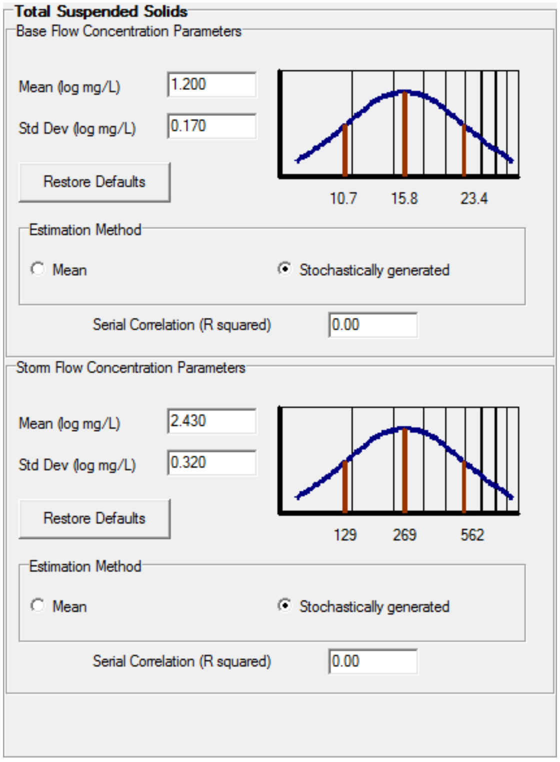
Rainfall Threshold (mm/day)	1.40

Pervious Area Properties

Soil Storage Capacity (mm)	170
Initial Storage (% of Capacity)	30
Field Capacity (mm)	70
Infiltration Capacity Coefficient - a	210.0
Infiltration Capacity Exponent - b	4.70

Groundwater Properties

Initial Depth (mm)	10
Daily Recharge Rate (%)	50.00
Daily Baseflow Rate (%)	4.00
Daily Deep Seepage Rate (%)	0.00


Total Suspended Solids

Base Flow Concentration Parameters

Mean (log mg/L) 1.200

Std Dev (log mg/L) 0.170

Restore Defaults

10.7 15.8 23.4

Estimation Method: Mean / Stochastically generated (selected)

Serial Correlation (R squared) 0.00

Storm Flow Concentration Parameters

Mean (log mg/L) 2.430

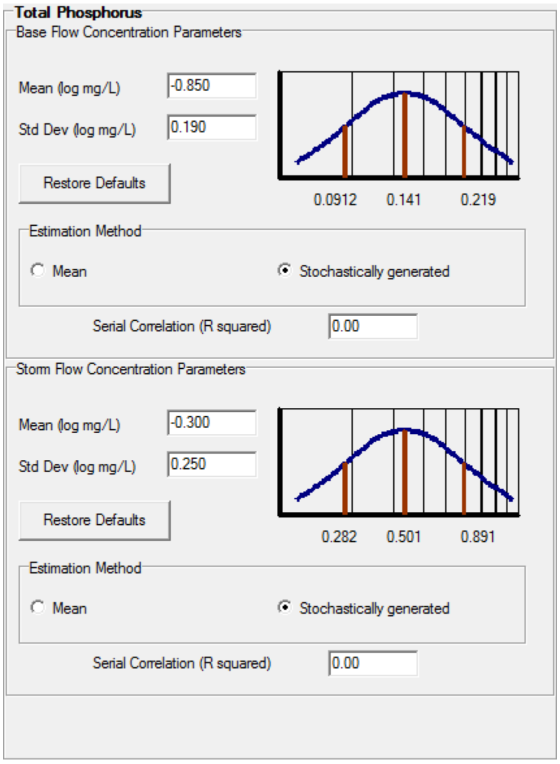
Std Dev (log mg/L) 0.320

Restore Defaults

129 269 562

Estimation Method: Mean / Stochastically generated (selected)

Serial Correlation (R squared) 0.00


Total Phosphorus

Base Flow Concentration Parameters

Mean (log mg/L) -0.850

Std Dev (log mg/L) 0.190

Restore Defaults

0.0912 0.141 0.219

Estimation Method: Mean / Stochastically generated (selected)

Serial Correlation (R squared) 0.00

Storm Flow Concentration Parameters

Mean (log mg/L) -0.300

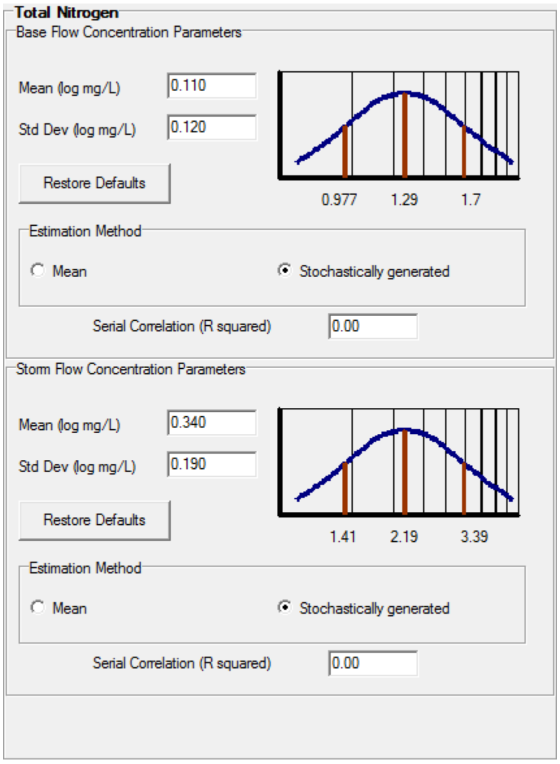
Std Dev (log mg/L) 0.250

Restore Defaults

0.282 0.501 0.891

Estimation Method: Mean / Stochastically generated (selected)

Serial Correlation (R squared) 0.00


Total Nitrogen

Base Flow Concentration Parameters

Mean (log mg/L) 0.110

Std Dev (log mg/L) 0.120

Restore Defaults

0.977 1.29 1.7

Estimation Method: Mean / Stochastically generated (selected)

Serial Correlation (R squared) 0.00

Storm Flow Concentration Parameters

Mean (log mg/L) 0.340

Std Dev (log mg/L) 0.190

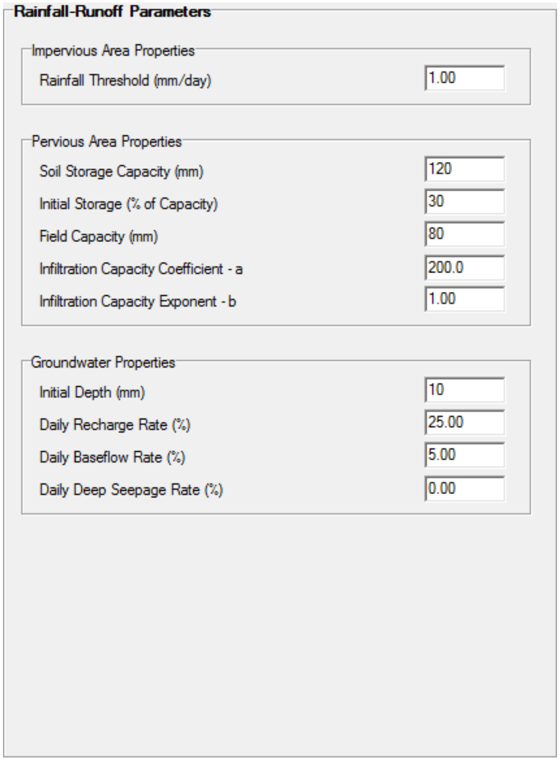
Restore Defaults

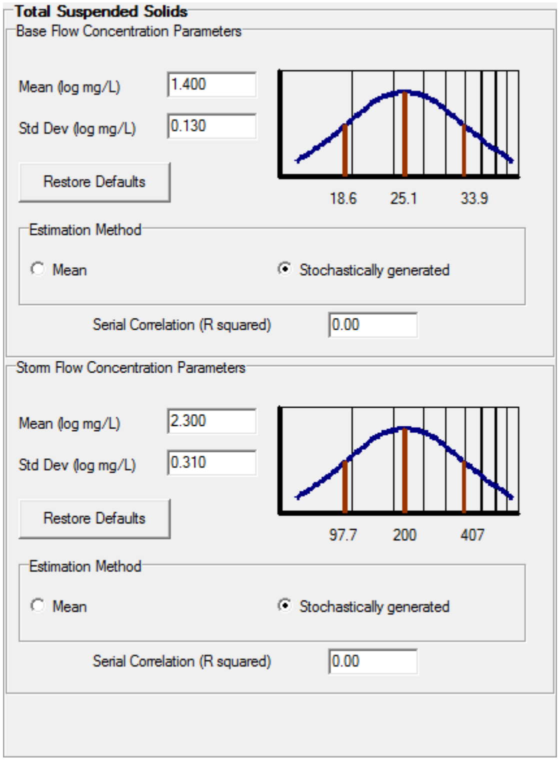
1.41 2.19 3.39

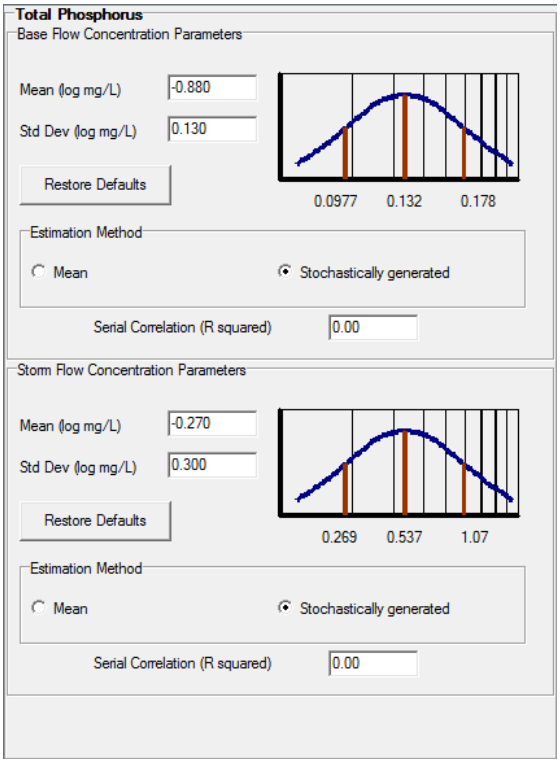
Estimation Method: Mean / Stochastically generated (selected)

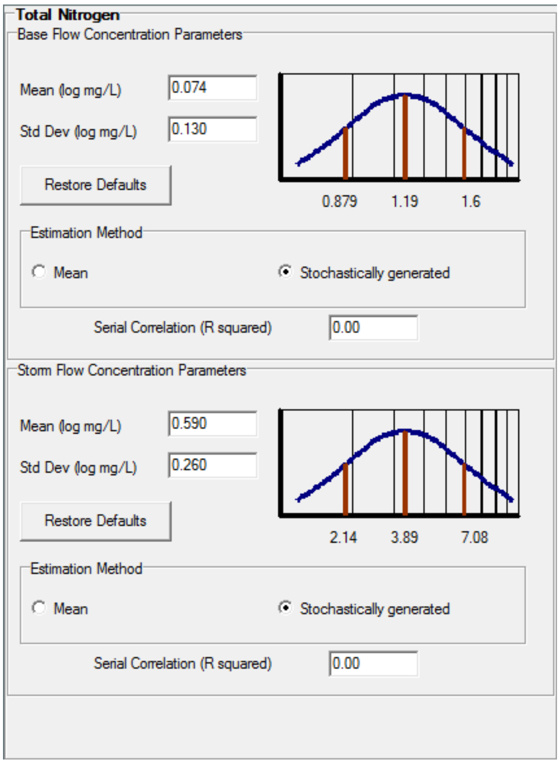
Serial Correlation (R squared) 0.00

BCC AGRICULTURAL









APPENDIX C – Wuhan Zoo Investigation Findings

TripAdvisor testimonials highlight a number of issues with smell, litter and cleanliness:

*"the worst zoo ever. It was so bad **we thought some exhibits were closed but if you climbed over down limbs and piles of trash**, you could get in a nasty exhibit hall to see a f ew animals. **Smelleded horrible, people dropping litter** and spitting everywhere, a wasted day"*

*"The management is so bad, **all the animals smell, peopel throw rubbish everywhere**. It is really a bad experience for me and my 2 year old son."*

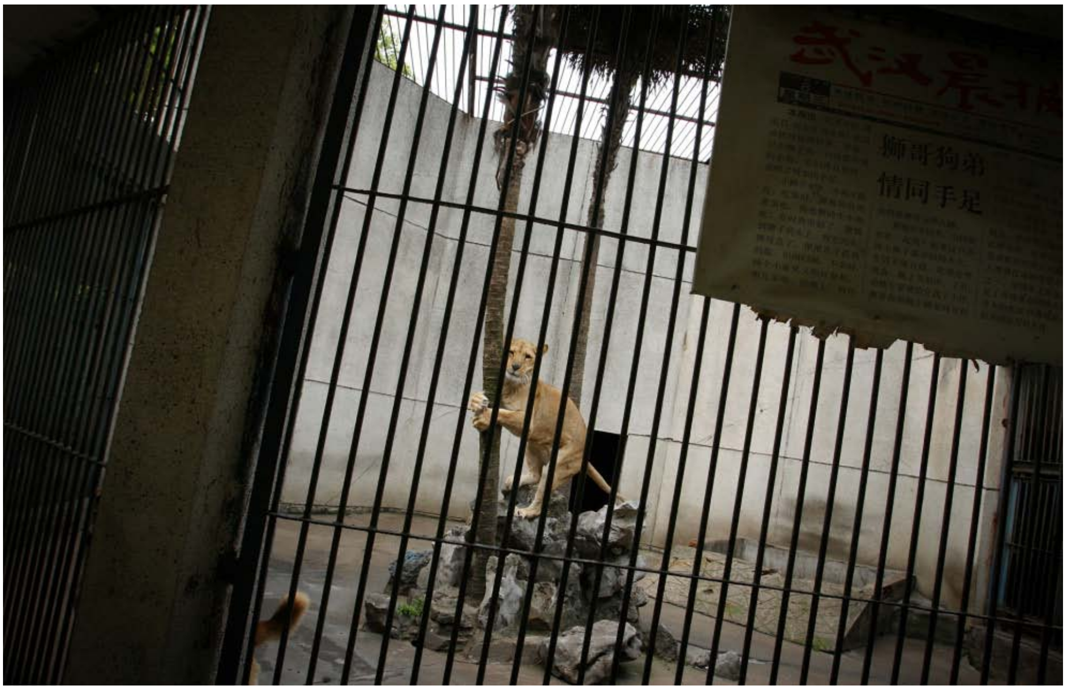
*"Wow. What to say about this zoo. Um, well, it has animals. Actually, the landscaping of the zoo is nice and widespread. The same cannot be said for the animal habitats. Very small enclosures. Despite multiple signs posted everywhere, people throw food at the animals. I'm not sure why, but there are peacocks wandering around random animal cages. The "zookeepers" seem completely clueless about the diets of certain animals. I saw a worker give a chimpanzee a bottle of Sprite. Without opposable thumbs, the chimp opened it and took a drink. Most of the animals look sickly. **I have been in plenty of zoos in my lifetime, but I have never been to one that smelled as bad as this one**. I have gone multiple times to this zoo (it is very affordable for a family of 5), but I always leave feeling like I just witnessed animal cruelty. Also, the toilets in this place are the worst in all of China. I will "hold it" for up to 8 hours to avoid getting near the nasty urine trough! If you have nothing better to do and want to see what a "people for the ethical treatment of animals" nightmare, by all means, stop by."*

*"This is truly a sorry excuse for a zoo. Please do NOT pay it a visit. **The cages of these animals look like they haven't been cleaned since the opening of the zoo**, or fed either! It was so sad to see these animals sitting in their own dung, looking so depressed and underfed. Don't support an organisation such as this, as I speak I am looking for a Chinese equivalent of the RSPCA to report the zoo to!"*

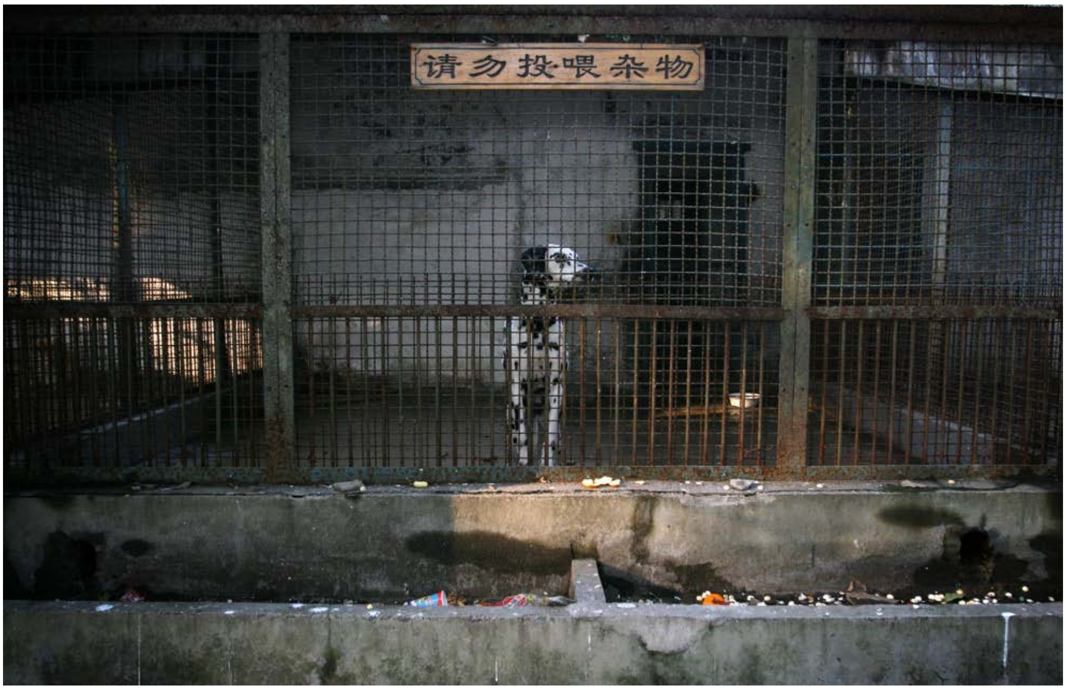
***"Zoo is rather terribly maintained** and is not somewhere to go if you care at all about animal rights. People feed the animals to try and make them be more attentive, or you can pay to throw chopped vegetables at the monkeys. Also, if you are not Chinese beware that you will be an object of interest to the other zoo goers."*

These visitor testimonials are supported by photos showing significant amounts of litter, faeces and algal growth in the pondages, all of which indicate relatively poor operational practices that would not be acceptable at Sydney Zoo. This uncleanliness would contribute to higher pollutant loads in rainfall runoff:

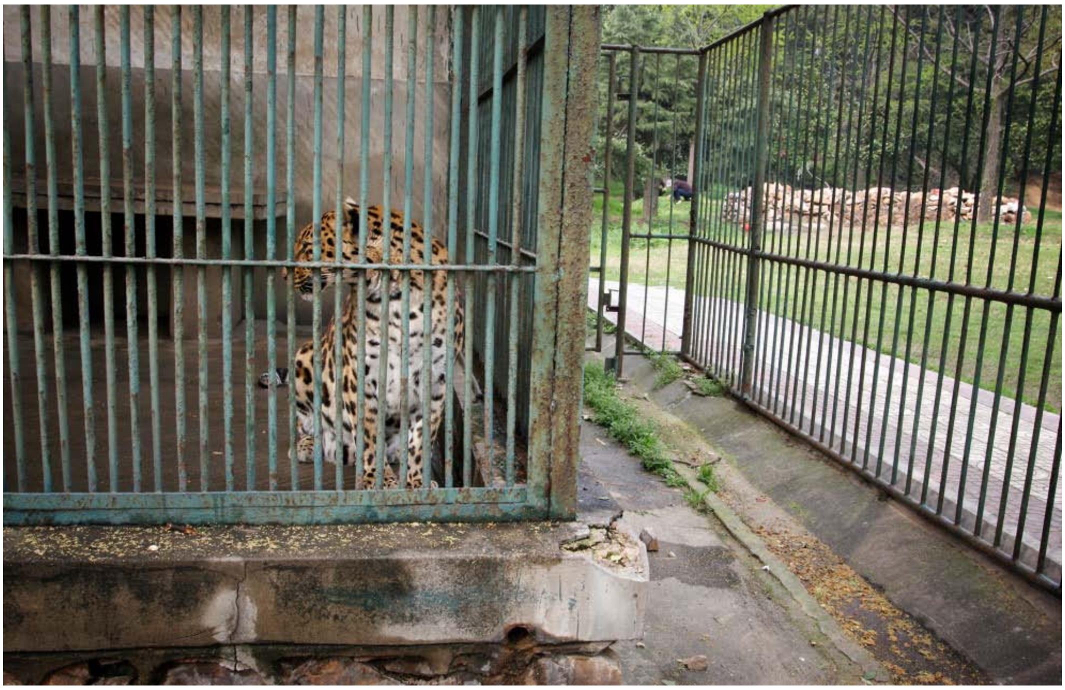
Photograph 1 - Wuhan Zoo vulture enclosure showing guano build up on ladders and floor



Photograph 2 - Wuhan Zoo lion enclosure showing concrete floor with liquid on it, and open roof to allow rain in



Photograph 3 - Wuhan Zoo dog enclosure with a significant amount of litter in the front of it


Photograph 4 - Wuhan Zoo leopard enclosure showing what appears to be faeces at the front and also in the bottom of the drain at right


Photograph 5 - Wuhan Zoo bear enclosure showing faeces on right and significant leaf litter on ground in front left of image


Photograph 6 - Wuhan zoo chimpanzee enclosure showing liquid on floor and food on floor to the left of the animal

Photograph 7 - Wuhan Zoo giant salamander enclosure showing unknown liquid on floor at top left

APPENDIX D – Additional Treatment Options Site Plan

DO NOT SCALE - THIS DRAWING MAY BE A REDUCED COPY

NOT FOR CONSTRUCTION

REV	DATE	DRN	CHK	APP	DRAWING STATUS
A	1/8/16	BR	BR	TW	ISSUED FOR CONCEPT

REVISIONS

SUSTAINABLE CERTIFICATION
ISO 9001 : 2008 Endorsed Quality Management System

Member of: CONSULT AUSTRALIA

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Web - www.lindsaydynan.com.au

Sydney I Perth I Newcastle I Central Coast

CLIENT
SYDNEY ZOO

TITLE
POTENTIAL FUTURE BIO-RETENTION BED LOCATIONS

PROJECT
XXXXX
XXXXX
XXXXX

DRAWING STATUS			SHEET SIZE
DRAFT COPY			A1
DRAFTSMAN BR	DESIGNER BR	PROJ MANAGER TW	SCALE 1:1000
PROJECT REF No. 12082	DRAWING No. BIO-BED SKETCH		REVISION X