CONSULTING EARTH SCIENTISTS

18 December 2017

CES Document Ref:
CES150404-EXC-AR

Sydney Zoo,
3 Wills Avenue,
Waverley NSW 2024

For the attention of Jake Burgess

Re: Proposed WATER QUALITY MONITORING PROGRAMME
Sydney Zoo site, Bungarribee Super Park, Doonside NSW.

Dear Sirs,

1 INTRODUCTION

The purpose of this letter is to provide a Water Quality Monitoring Programme (WQMP) for the future sampling and analysis of surface water discharges during and after establishment of the proposed Sydney Zoo. This WQMP, which incorporates comments from the NSW EPA and Department of Planning & Environment, outlines the locations, frequency and analytes which will form the basis of the water sampling programme, to satisfy the requirements of Condition C12 in Schedule C, from the development consent for the project.

2 OBJECTIVE AND PROPOSED SCOPE

The purpose of the surface water sampling and analysis programme is to facilitate a water quality assessment of the discharge waters from the site in the context of the wider environment. The assessment of the analytical results will inform decisions relating to possible additional pollutant mass load reduction measures for the animal enclosures or further treatment (such as the construction of additional bio-retention or reed bed ponds) to minimise any adverse impacts to surface water quality off-site.

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The baseline quality of Eastern Creek is currently being determined through the collection of surface water samples from the creek and subsequent analysis. Groundwater quality will be assessed against the ANZECC criteria.

Water quality monitoring will be conducted in accordance with the NSW EPA/DEC 2004 Guideline '*Approved Methods for the Sampling and Analysis of Water Pollutants in NSW.*

This WQMP is based on information contained in a report prepared by Lindsay Dynan Consulting Engineers (LD) - *Supplementary EPA Response: Sydney Zoo* (Project 00012082, 16 August 2016) (the 'LD Report). That report was prepared in response to the EPA's comments on the project Environmental Impact Statement, and also to the EPA's letter via the Department of Planning & Environment dated 9 June 2016 relating to concerns regarding the water pollution risks associated with the project. The LD Report was also part of a parcel of Supplementary Information submitted to the Department by JBA Planning, dated 22 August 2016.

The Supplementary Information included details of existing water quality in Eastern Creek, contained in a letter from CES dated 13 July 2016 following some baseline surface water sampling at three locations on Eastern Creek in the vicinity of the proposed zoo site, in June 2016. (*Baseline Surface Water Sampling, Eastern Creek, Proposed Sydney Zoo site, Bungarribee Super Park, Doonside, NSW.* CES150404-EXC-AG, 13 July 2016). The sampling indicated that the waters of Eastern Creek showed some influence from urban run-off and/or animal grazing, and that water quality appeared to reduce as the Creek flows to the north, in that TSS, total nitrogen, ammonia and enterococci concentrations increase from south to north. Additional background water sampling has been undertaken since project approval was granted on 8 September 2017 in accordance with section 5.2. The results of this programme are discussed in Section 5.4 below, and the sample points are shown on Figure 1.

The LD Report also provided information on the likely pollutants to be generated by the project, the adopted measures to control water pollution and the modelling carried out to assess pollutant loads and impacts on Eastern Creek. The results of the modelling show

that in addition to meeting the Blacktown City Council requirements for percentage pollution reduction, the discharges from the site will either satisfy the accepted ANZECC guidelines or will be below the current background concentrations in Eastern Creek.

3 CATCHMENT DETAILS

The Zoo site drains mostly to Eastern Creek, but a small area drains in an easterly direction to an ephemeral tributary of Bungarribee Creek, which flows north-westerly to join Eastern Creek about 1 km to the north of the site. The catchment of Eastern Creek upstream from the site includes a variety of land uses such as the Eastern Creek (Genesis) waste management centre and landfill, large areas of industrial estate which incorporate a variety of industries, a motor racing circuit, numerous agricultural operations, open space, several major roads and motorways, some extractive industries and residential areas. In the area close to the site, Eastern Creek is bounded on both sides by woodland being remnant Cumberland Plain Woodland community.

4 PROPOSED MEASURES FOR WATER POLLUTION CONTROL

4.1 Potential Sources of Water Pollution

During the construction stage, the main potential sources of water pollution are from earthworks activities (leading to erosion, sedimentation, turbidity etc) and miscellaneous other activities, as would be typical of any major excavation and construction project. The construction activities that could lead to water pollution include the following:

- Clearing of vegetation and excavation, causing areas of exposed soil subject to erosion and sedimentation from stormwaters;
- Stockpiling of soil and other materials;
- Storage, use and possible spillages of fuels, oils and other liquids or chemicals;
- Waste water, such as from toilets and amenities;
- Storage and control of solid wastes.

During the operational phase of the Zoo, potential sources of water pollution include animal wastes, chemical storage and use, fuels and oils, solid wastes and surface runoff from paved areas, grassed areas, animal enclosures, roadways and car parks.

Chemicals likely to be used in the operation of the zoo include:

- LPG, acetone, methylated spirits, petroleum, kerosene, mineral turpentine, cleaning products, bleach, acids and alkalines.

Other pollutants likely to be generated are those typically associated with animal manure and urine, including:

- Nitrogen and phosphorus compounds, total suspended solids, pathogens, BOD and COD.

The operators of the zoo will minimise chemical use due to the risks these chemicals may pose to the exotic and endangered animals that will be exhibited.

All fuels, oils and other liquids will be stored and handled in accordance with regulatory requirements and dangerous goods standard practices.

4.2 Measures for Controlling Water Pollution

4.2.1 Construction Phase

During the earthworks and construction phase, standard techniques will be used to control run-off and stormwater, as for any large construction project, including temporary sedimentation ponds, silt fencing, berms to prevent runoff waters entering disturbed and excavated areas and bunded areas around chemical and fuel storages or waste materials.

Drainage controls for storm water runoff onsite shall be installed according to an Erosion and Sedimentation Plan (ESCP), which shall be designed in accordance with: Department

of Housing publication "*Managing Urban Stormwater*, Soils and Construction, 2006" (Blue Book) and also to satisfy the requirements of Blacktown City Council's DCP (2006). Additional control measures will be installed during construction as required:

- All control measures will be installed prior to commencing works as per the ESCP;
- Disturbance onsite will be minimised by clearing marking boundaries and designating areas for construction activities and traffic movements;
- Works will be appropriately staged to minimise potential for erosion and sedimentation during the project;
- Temporary diversion drains will be installed to divert clean run-off around the works area;
- Drainage system outlets will be directed to temporary or permanent retention basins;
- Exposed surfaces will be stabilised as soon as possible by hydro mulching or other means;
- Stockpiles to be sited away from drainage paths, water bodies, and high-risk areas;
- Silt fencing will be erected along batter slopes, stockpiles, and any disturbed surfaces that may drain into any adjacent water bodies and stormwater systems;
- Sandbags and other sediment controls shall be installed around stormwater inlets and outlets to prevent dirty discharge from works area entering stormwater systems;
- Trucks transporting materials shall be inspected before leaving or entering the site to prevent spillage of soil and other materials on roads and footpaths;
- All sediment basins are to be managed as per dewatering requirements; this includes treatment and testing of water to ensure quality targets are met; and
- On project completion, the site will be left protected by temporary measures as required. Once permanent measures (i.e. revegetation) have been established the temporary measures may be removed.

4.2.2 Operational Phase

The Zoo catchment areas will be broken up into sub-catchments, as shown in Figure 2, for the purpose of stormwater management, each of which incorporates grassy buffers/swales as primary treatment of stormwater pollutants, with runoff from each of the sub-catchments directed to bio-retention basins for secondary treatment. The following treatment measures are proposed for stormwater:

- For general areas of the zoo complex, including exhibits, footpaths, roadways, public areas etc, following filtration in the bioretention basins, treated runoff water will be directed to the stormwater harvesting storage areas;
- Runoff from new roof catchments within the Zoo footprint will be collected and diverted (via a first flush device) directly to the pit and pipe subsurface drainage network connecting the bioretention basins, and onward to the stormwater harvesting storage areas; and
- Runoff from the carpark catchments will be conveyed via sheet flow to various stormwater pits incorporating primary treatment of stormwater pollutants, before diverting to a gross pollutant trap for secondary treatment and then directed to the stormwater harvesting storage areas.

Harvested stormwater will be generally collected at two locations being a large open water storage basin at the western end of the Zoo, and wetland in the north-east corner. The harvested stormwater will be pumped on demand from both locations to the holding basin adjacent the restaurant building. Stormwater re-use demands for the site (irrigation, top-up of wet moats, greywater for toilet flushing and hose down areas) will be drawn via a pump from the holding basin. Greywater demand and moat top up will receive additional treatment via proprietary mechanical filtration and UV disinfection prior to reticulation through the site. Further details of the modelling undertaken for assessing and controlling stormwater and water pollution are outlined in the Lindsay Dynan (LD) Report, along with the assumptions adopted and justification for the nodes and settings used in the modelling.

5 PROPOSED WATER QUALITY MONITORING PROGRAMME

The proposed Water Quality Monitoring Programme (WQMP) is as follows:

5.1 Sampling Locations

Sampling is to be undertaken at five sampling points, as shown in Table 1 below and on the attached plan (Figure 1). The sampling is to be carried out in accordance with EPA approved methods, at the frequency outlined in 5.2 below. It is acknowledged that discharges at some sampling points will probably occur only after rainfall, and therefore those sampling points will be sampled by on-site personnel on an ad-hoc basis during discharge events following rainfall.

Table 1: **Locations of Proposed Water Sampling Points**

Sampling Point No.	Sampling Point	Eastings	Northings
1	On-Site Wetland discharge (north west)	302125.983	6259354.503
2	On-site Wetland discharge (north east)	302638.981	6259300.335
3	South of Western Discharge Point (50m upstream)	302156.525	6259044.73
4	West of Western Discharge Point	302050.439	6259196.627
5	North of Western Discharge Point (50m downstream)	302018.32	6259504.157

* The exact locations will be confirmed post construction of the Zoo

5.2 Sampling Frequency

Prior to the commencement of construction, sampling is to be conducted at each point (where water is flowing) on a minimum of 3 occasions, at least one month apart, to provide baseline data. This part of the programme is almost completed.

During construction, sampling will be conducted twice per month at each point where water is flowing for the first 3 months, then monthly, and at points 1 and 4 when any discharge occurs after rainfall.

Table 2: Sampling Frequency during Construction Phase

Sampling Point No.	Sampling Point	Sampling Frequency during construction
1	On-Site Wetland (north west) - Outlet	Twice monthly (first 3 months), then monthly; plus any discharge after rainfall
2	On-site Wetland (north east)	Twice monthly (first 3 months), then monthly
3	South of Western Discharge Point (50m upstream)	Twice monthly (first 3 months), then monthly
4	At Western Discharge Point	Twice monthly (first 3 months), then monthly; plus any discharge after rainfall
5	North of Western Discharge Point (50m downstream)	Twice monthly (first 3 months), then monthly

Sampling Locations 1 and 4 will be identified by fixed signs erected on site following completion of the works, with 'Sampling Point 1' and 'Sampling Point 4'.

Sampling will continue during the operational phase at least twice per month until the performance of the system and consistency of results has been validated by the EPA.

5.3 Analytical Suite

The analytical suite proposed for the water quality monitoring plan is as follows:

- Biological oxygen demand (BOD);
- Total suspended solids (TSS);
- Enterococci;
- Total phosphorus;

- Filterable reactive phosphorus;
- Total nitrogen;
- Oxides of nitrogen;
- Ammonia; and
- Chlorophyll.

All analyses will be undertaken in a laboratory holding NATA certification for the tests conducted. In addition, field measurements of standard water quality parameters, including pH, dissolved oxygen, electrical conductivity and redox potential will be carried out at the sampling locations.

Results of the sampling and laboratory analyses should be provided to the NSW EPA within 2 weeks of each sampling event. An annual report will be prepared which will document the first nine sampling rounds and review the frequency (if necessary) of any additional monitoring.

5.4 Baseline Water Quality in Eastern Creek

Information on existing water quality in Eastern Creek has been obtained from sampling in June 2016 and in September, October and November 2017, all prior to construction commencing. The results of the analyses of samples are shown in Table 3, and sampling locations are shown on Figure 1. It appears that generally, water quality does not vary greatly from south to north on each monitoring occasion, but some analytes show a deterioration in quality towards the north (i.e. downstream) – including Enterococci and suspended solids. However, the water quality does vary over time, presumably in relation to hydrologic conditions.

It is noted that the following baseline parameters in Eastern Creek exceed the conservative ANZECC criteria, prior to any construction activities by Sydney Zoo:

- Electrical conductivity criterion - all (twelve of twelve) baseline concentrations exceed the ANZECC (2000) trigger value (300 µS/cm);

- Phosphate criterion - six (all Eastern Creek samples on the 25/10/17 and 16/11/17) of nine baseline concentrations exceed the ANZECC (2000) trigger value (0.02 mg/L);
- Oxides of nitrogen criterion - seven of nine baseline concentrations exceed the ANZECC (2000) trigger value (0.04 mg/L);
- Total nitrogen criterion - nine of nine baseline concentrations exceed the ANZECC (2000) trigger value (0.35 mg/L);
- Ammonia criterion - nine of twelve baseline concentrations exceed the ANZECC (2000) trigger value (0.02 mg/L);
- Chlorophyll-a criterion - six of twelve (the detection limit exceeds the ANZECC criteria for the remaining six samples) baseline concentrations exceed the ANZECC (2000) trigger value (3 mg/m3); and
- Total phosphorus criterion – twelve of twelve baseline concentrations exceed the ANZECC (2000) trigger value (0.025 mg/L).

5.5 Discharge and Groundwater Quality Assessment Criteria

The assessment criteria applied to the assessment of groundwater and discharges will be as per ANZECC (2000). These criteria are presented as Table 4.

5.6 Protocol for Remedial Actions

In the event that satisfactory treatment performance of waters intended for discharge is not achieved, Sydney Zoo will assess the extent of the problem and work with the EPA to modify or improve the stormwater system through additional treatment systems, as appropriate. In such a case, a protocol detailing the specific remedial action/s that will be undertaken will be prepared, including when each triggered remedial action would be completed.

The ‘trigger’ for remedial actions will be exceedance of the adopted assessment criteria, unless the exceedance is found to be caused by an external or random event not related to the Zoo’s construction or operations.

For the construction phase, should significant negative changes in the monitored parameters be detected during the bulk earthworks and/or the assessment criteria be exceeded, the contractor will immediately implement mitigation measures. These would typically include:

- Installation of additional sediments fencing;
- Review stockpile stabilisation and management;
- Installation of additional check dams along surface water catch drains;
- Additional use of sand bags, straw bales, coir logs (or similar) to reduce the velocity and control the flow of surface water and provide localised erosion protection; and
- Dosing of retained water with environmentally sustainable flocculants (Floc blocks or similar).

For the operational phase, the following would apply:

- The remedial action in the event of any monitoring result at Sampling Locations 1 and 4 that exceeds the nominated assessment criteria (being the ANZECC trigger Values) is for the Environmental Manager of the zoo to undertake a review of:
    - The nature of the exceedance of the assessment criteria, including the environmental conditions at the time of the exceedance, and whether it is an isolated exceedance event; and
    - The effectiveness of the stormwater controls at the time of the exceedance, including consideration of the stormwater management practices and operational procedures at the zoo.
- The review would make recommendations in relation to whether further action was warranted, including whether stormwater management practices and operational procedures at the zoo should be changed, or whether changes to treatment methods and controls should be investigated. A copy of the review would be supplied to the EPA with the monitoring results within four weeks of the sampling event.

- If changes to treatment methods and controls are deemed to be warranted, after consultation with the EPA, then the Secretary would be notified. At the request of the Secretary, Sydney Zoo would provide the EPA and the Secretary with a Stormwater Management Upgrade Report within 3 months of being requested. The Stormwater Management Upgrade Report would set out options for upgrading the on-site stormwater management system, including details of the relevant advantages and disadvantages of the respective options (e.g. timing, costs, likely effectiveness given the nature of the exceedances occurring), and nominate a preferred option. The preferred option may include addition of further treatment processes, including additional bioretention ponds and/or proprietary mechanical filtration and disinfection systems.

6 CLOSURE

If you have any questions or require any further details, please contact the undersigned or Mark Challoner on 02 8569 2200.

For and on behalf of Consulting Earth Scientists Pty Ltd,

David Johnson
Principal Environmental Scientist

Figures

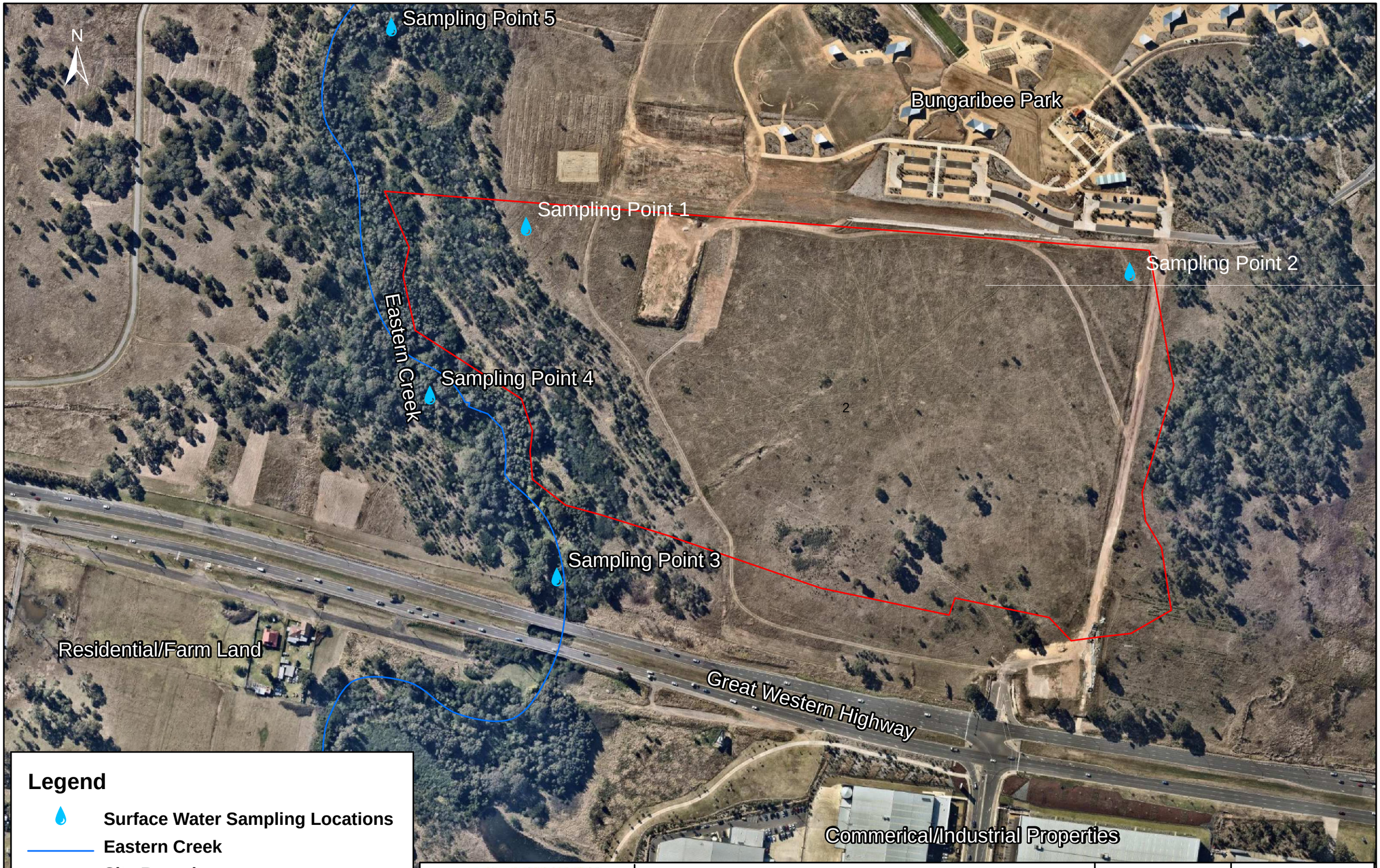

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Figure 1: Site Layout Plan

Source: NearMaps 2017

CES Project ID:	Date:
CES150404-EXC	13/10/2017
Prepared By:	Checked By:
E. Millar	D. Johnson

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Figure 2: Site Catchments

Reference: Lindsay Dynan (2015). Stormwater Management Plan: Sydney Zoo. Project No. 00012082.

CES Project ID:	Date:
CES150404-EXC	10/11/2017
Prepared By:	Checked By:
E. Millar	M. Challoner

Tables

Table 3: Baseline Water Quality Results - Eastern Creek

		Description:	Sampling Point 5 - North of Discharge Point				Sampling Point 4 - Proposed Discharge Point				Sampling Point 3 - South of Discharge Point			
		Sample:	SYDZOO-N-SW	SYD200-N-140917	SYDZ00-N-251017	SYDZOO-N-161117	SYDZOO-DP-SW	SYD200-DP-140917	SYDZ00-DP-251017	SYDZOO-DP-161117	SYDZOO-S-SW	SYD200-S-140917	SYDZ00-S-251017	SYDZOO-S-161117
		Lab Report Reference:	149263	175675	178415	161117	149263	175675	178415	161117	149263	175675	178415	161117
		Date Sampled	29/06/2016	14/09/2017	25/10/2017	16/11/2017	29/06/2016	14/09/2017	25/10/2017	16/11/2017	29/06/2016	14/09/2017	25/10/2017	16/11/2017
Analyte	**Units**	**PQL**												
pH (field)	pH units	0.01	6.99	7.91	7.16	7.1	6.81	7.76	7.21	7.27	6.61	7.47	7.3	7.2
Electrical Conductivity (field)	µS/cm	1	903	1170	715	959	915	1150	739	884	944	1930	739	957
Dissolved Oxygen (field)	mg/L	0.01	7.25	<0.01	5.98	1.26	7.27	1.83	4.64	3.3	8.26	0.83	3.55	3.07
Redox Potential (field)	mV	0.1	128	106.3	114.9	93	124	102.4	88.4	98	128	110.2	127.2	112
Temperature (field)	°C	0.1	10.9	11.9	18.1	19	10.9	11.5	18.4	20	11.9	13.4	18.7	18.6
BOD	mg/L	5	<5	<5	11	13	<5	<5	12	21	<5	<5	18	10
Total Suspended Solids	mg/L	5	23	28	11	<10	17	12	8	14	12	<5	6	<10
Phosphate as P in water	mg/L	0.005	nt	0.006	0.1	0.09	nt	<0.005	0.11	0.07	nt	0.008	0.11	0.1
NOx as N in water	mg/L	0.005	nt	0.3	0.3	0.01	nt	0.65	0.3	0.03	nt	0.51	0.3	0.05
Total Nitrogen	mg/L	0.1	2.1	nt	1.1	0.9	2	nt	1.1	0.8	1.9	nt	1.2	0.8
Ammonia as N in water	mg/L	0.005	0.047	0.026	0.076	0.045	0.033	<0.005	0.11	<0.005	0.026	0.028	0.11	0.012
Chlorophyll a	mg/m3	5	<5	40	<5	170**	<5	86	6	10	<5	6	<5	<5
Phosphorus - Total	mg/L	0.05	0.2	0.1	0.3	0.3	0.1	0.1	0.2	0.2	0.2	0.07	0.2	0.2
Enterococci	cfu/100mL	1	140	10 Approx	160	33	130	9	26	2 Approx	90	16	36	38 Approx

Table 4 - Screening Criteria for Sydney Zoo Discharge and Groundwater Assessment	
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 Phosphate	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)

Table 4 - Screening Criteria for Sydney Zoo Discharge and Groundwater Assessment	
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